



الجمهورية اللبنانية
وزارة الطاقة والمياه

دراسة محطة معالجة مياه بحيرة المسيلحة ومحطات الضخ وخطوط
النقل والدفع والخزانات وتصميم محيط الأشغال أسفل سد المسيلحة بما
فيها القلعة - قضاء البترون

الجزء الأول: دراسة محطة معالجة المياه وضخها إلى الخزانات الرئيسية

1-4 الخرائط التنفيذية وملفات التلزم

1-4-2 دفاتر الشروط الفنية وملفات التلزم

TENDER DOCUMENTS FOR DESIGN, BUILD, OPERATE
AND MAINTAIN CONTRACT

VOLUME 2: EMPLOYER'S REQUIREMENT

حزيران 2017



DAR AL HANDASAH NAZIH TALEB & PARTNERS
دار الهندسة نزيه طالب وشركاه

Founded 1995

Mseilha WTP and Main Pumping Stations

Volume 2: Employer's Requirement

Table of Contents

Section 1	General Requirement
Section 2	Process Requirement
Section 3	Civil Requirement
Section 4	Mechanical Requirement
Section 5	Electrical and ICA Requirement
Section 6	Plant Performance Requirement
Section 7	Operation and Maintenance Requirement

QC	Ref: L1402 / 1852	
	Revision: 01	Date: June 07, 2017
	Signature:	

SECTION 1 – GENERAL REQUIREMENT

CONTENTS

1.1	General Requirement	4
1.1.1	Preamble.....	4
1.1.2	Objective of the Works.....	4
1.1.3	Abbreviations and Standards	5
1.1.4	Right of Way.....	8
1.1.5	Interpretation of Drawings.....	9
1.1.6	Responsibility of Contractor	9
1.2	Scope of Work and Contractor's Obligation	9
1.2.1	Scope of Work.....	9
1.2.2	Description of Works to be Undertaken	9
1.2.3	Requirement for Future Phases of Construction	10
1.3	Contractor's Obligations	11
1.3.1	General	11
1.3.2	HVAC Requirement	12
1.3.3	Specific Requirements.....	12
1.3.4	Location of Contract Offices and Other Contract Facilities	13
1.3.5	Service Authorities	13
1.4	Plant Interfacing	13
1.5	General Site Data	13
1.5.1	Master Datum	13
1.5.2	Climate Conditions	14
1.5.3	Site Investigation and Survey Data	14
1.5.4	Extent of Site.....	14
1.5.5	Sound Insulation of the Buildings	14
1.5.6	Design for Seismic Activity	14
1.5.7	Defining and Maintaining the Site	15
1.6	Design of Work	16
1.6.1	General	16
1.6.2	Special Design Requirements	17
1.6.3	WTWs Construction	18
1.6.4	Noise Control	18
1.6.5	Corrosion Control.....	18
1.6.6	Design Standards.....	19
1.6.7	Asset Life.....	19
1.6.8	Site Works.....	20
1.6.9	Pipe Lines	20

1.6.10	Architectural and Landscaping Requirement.....	20
1.6.11	Site Boundary.....	20
1.6.12	NOCs	20
1.6.13	Minimum Technical Requirement	21
1.7	Contractor's Documents for Review by the Engineer	22
1.7.1	Design Documents	22
1.7.2	Construction and Installation Method Statements.....	23
1.7.3	Production and Submission Procedures	24
1.8	Materials and Manufactured Items	25
1.8.1	Quality of Materials, Manufacture and Standards.....	26
1.8.2	Approval of Materials and Manufactured Items.....	26
1.8.3	Approval of Construction and Testing Methods	27
1.8.4	Contractor's Staff.....	27
1.8.5	Submittals	27
1.9	Notice of Operations.....	36
1.10	Traffic Safety and Control.....	37
1.11	Compensation for Damage to Property	37
1.12	Existing Services.....	37
1.13	Continuous Working	38
1.14	Temporary Staging for Structures.....	38
1.15	Filling in Holes and Trenches	38
1.16	Protection of Works from Weather	39
1.17	Keeping the Works free from Water	39
1.18	Templates.....	39
1.19	Interpretation of Drawings.....	39
1.20	Programme of Works.....	39
1.20.1	Effective Date.....	39
1.20.2	Commencement Date	39
1.21	Assistance to the Engineer	39
1.22	Specific Obligations.....	40
1.22.1	Sequence of Design and Construction	40
1.22.2	Progress Reports, Photographs and Site Records	42
1.22.3	Contract Correspondence	43
1.23	materials and workmanship.....	43
1.23.1	Local and Environmental Requirements	43
1.24	Quality Assurance	44
1.24.1	General	44
1.24.2	Outline Quality Plan	44

1.24.3	Contractor's QA System & Full Quality Plan	44
1.24.4	Quality Audits.....	45
1.24.5	Quality Reports	45
1.24.6	Tests on Completion	45
1.25	Training, Maintenance, Manuals, Spares, Etc.....	45
1.25.1	Training Facilities.....	45
1.25.2	Maintenance	45
1.25.3	Operation and Maintenance Manuals.....	46
1.25.4	Spare Parts and Special Tools	46
1.26	As-built Records.....	46
1.27	Performance Guarantees	46
1.28	Project Management	46
1.29	Construction Documents for Approval.....	46
1.29.1	General	46
1.29.2	Submissions During Contract.....	47
1.29.3	Preliminary Design Drawings and Documents	47
1.29.4	Detailed Design Drawings and Documents	48
1.29.5	Calculations.....	48
1.29.6	Requirements for Instrumentation Drawings	49
1.29.7	Requirements for Mechanical and Electrical Drawings and Documents	50
1.29.8	Drawings and Documents before Tests on Completion	51
1.29.9	Approval of Main Equipment	51
1.29.10	Review of Construction Methods	52
1.30	Final Drawings and Manuals.....	52
1.30.1	Manuals	52
1.30.2	Drawings	54
1.30.3	Revisions to Manuals and Drawings	54
1.30.4	Spare Parts and Special Tools	54

SECTION 1 – GENERAL REQUIREMENT

1.1 General Requirement

These Specifications shall be read in conjunction with the other documents of the Tender and Contract Documents and Drawings. The Contractor shall comply with all the provisions contained within these Documents. The Contractor shall take note of the Appendices contained in these Specifications. Where items of the Specifications are also covered in the Appendices the requirements of the Appendices shall take precedence.

Any clause in these Specifications which relates to work or materials not required by the Contract shall be deemed not to apply.

In order to avoid needless repetition of such phrases as "to the Engineer" and "by the Engineer" or "the Engineer's Representative" throughout these Specifications it shall be understood that when an order, instruction, decision, exercise of judgment or other similar act, which falls within the Engineer's duties and responsibilities, is indicated, such order, instruction, decision, exercise of judgment or other similar act will be issued, given, made or referred to the Engineer or the Engineer's Representative.

1.1.1 Preamble

Volume 2 of the Tender Documents comprises the following specification documents:

Section 1 - General Requirement;

Section 2 - Process Requirement;

Section 3 - Civil Requirement;

Section 4 - Mechanical Requirement;

Section 5 - Electrical & ICA Requirement;

Section 6 - Plant Performance Requirement

Section 7 - Operation and Maintenance Requirement

The Employer's Requirements may be amended or amplified during subsequent correspondence with Tenderers prior to the award of Contract. They may also be amended or amplified after award by the issue of a variation order. The Employer's Requirements are to be found in this section and are amplified in the Specifications and Drawings which shall be considered as part of the Employer's Requirements.

1.1.2 Objective of the Works

There are two separately identifiable elements of the Works forming the Mseilha Water Treatment Plant and Main Pumping Station included in this Tender. They are:

- Provision (Design and Build) of water treatment works based on the given effluent quality. As an example, the following conceptual process design is developed in the present tender documents and is based on coagulation, flocculation, clarification, filtration and disinfection process and associated sludge/ backwash water treatment works including flow controller, flash mixing, flocculation tanks, clariflocculators, gravity filter, chlorine disinfection, treated potable water metering and transfer, chemical storage and dosing system, sludge/ backwash holding pumping station, sludge tank, emergency outfall and all ancillary and support services;
- Operation and Maintenance of above mentioned facility for one year.

1.1.3 Abbreviations and Standards

The following abbreviations are used in the Specifications:

cm	Centimeter
CP	Code of Practice
d	Day
SCADA	Supervisory Control and Data Acquisition
dia	Diameter
FSD	Full Scale Deflection
ha	Hectare
h	Hour
HMI	Human Machine Interface which includes Visual Display and keyboard/pad devices called by other names such as Man Machine Interface (HMI) Touch panel (TP)
kg	Kilogram
kN	Kilo Newton
kW	Kilowatt
l	Litre
MDD	Maximum Dry Density
m	Metre
m ² , sq m	Square Metre
m ³ , cu m	Cubic Metre
mg	Milligram
mm	Millimetre
months	Months
MPa	Mega Pascal
Nr	Number
Sec	Second
Set	Set
t	Tonne
MLD	Million Litre per day
AMSL	Above Mean Sea Level
CDR	Council for Development and Reconstruction

Reference to a technical society, institution, association or governmental authority is made in the Specifications in accordance with the following abbreviations as well as these indicated on the Drawings.

AA	Aluminium Association
AABC	Associated Air Balance Council
AAN	American Association of Nurserymen
AAMA	Architectural Aluminium Manufacturers Association
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADC	Air Diffuser Council
AFI	Air Filter Institute

AFBMA	Anti-Friction Bearing Manufacturers Association
AGCA	Association General Contractors of America
AGA	American Gas Association
AGMA	American Gear Manufacturers Association
AIA	American Institute of Architects
AIMA	Acoustical & Insulating Materials Association
AIEE	American Institute of Electrical Engineering
AISC	American Institute of Steel Construction
AISI	American Iron & Steel Institute
AITC	American Institute of Timber Construction
ALS	American Lumber Standards
AMCA	Air Moving & Conditioning Association
ANSI	American National Standards Institute
ANS	American National Standard
AOAC	Association of Official Agricultural Chemists
APA	American Plywood Association
API	American Petroleum Institute
ASA	American Standard Association
ARI	Air Conditioning & Refrigeration Institute
ASAHC	American Society of Architectural Hardware Engineers
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air conditioning Engineers
ASME	American Society for Mechanical Engineers
ASSE	American Society of Sanitary Engineers
ASTM	American Society for Testing and Materials
AWI	Architectural Woodwork Institute
AWPA	American Wood Preservers Association
AWPI	American Wood Preservers Institute
AWG	American or Brown and Sharpe Wire Gage
AWS	American Welding Society
AWWA	American Water Works Association
BHMA	Builders Hardware Manufacturers Association
BIA	Brick Institute of America
BRI	Building Research Institute
BRE	Building Research Establishment
BS	British Standard
BSCP	British Standard Code of Practice
BS EN	European Standards approved as a British Standard
BSI	British Standards Institution
CDA	Copper Development Association
CEE	International Commission on Rules for Approval of Electrical Equipment (Europe)
CIRIA	Construction Industry Research and Information Association
CRSI	Concrete Reinforcing Steel Institute

CS	Commercial Standard, US Department of Commerce
CSI	Construction Specifications Institute
CTI	Cooling Tower Institute
DIN	Deutsche Institute for Normung, Germany
EHS - CDR	Environmental Health & Safety, CDR
Fed. Spec.	Federal Specifications issued by the Federal Supply Service of the General Services Administration, Washington, D.C.
FGMA	Flat Glass Marketing Association
FPL	Forest Products Laboratory
FSIWA	Federation of Sewage and Industrial Waste Association
FTI	Facing Tile Institute
GA	Gypsum Association
GTA	Glass Tempering Association
HPMA	Hardwood Plywood Manufacturers Association
IBR	Institute of Boiler and Radiator Manufacturers
IEC	International Electro-technical Committee
IEE	Institute of Electrical Engineers of London
IEEE	Institute of Electrical & Electronics Engineers
IES	Illuminating Engineering Society
IPS	Iron Pipe Size
ISA	Instrument Society of America
ISO	International Organisation for Standardisation, Switzerland
JIC	Joint Industry Conference Standards
MIA	Marble Institute of America
MLMA	Metal Lath Manufacturers Association
MSSVFI	Manufacturers Standardization Society of the Valves and Fittings Industries
NAAMM	National Association of Architectural Metal Manufacturers
NAFM	National Association of Fan Manufacturers
NAPF	National Association of Plastic Manufacturers
NBGQA	National Building Granite Quarries Association
NBHA	National Builders Hardware Association
NBS	National Bureau of Standards
NCMA	National Concrete Masonry Association
NEC	National Electrical Code (NFPA No.70)
NEMA	National Electrical Manufacturers Association
NEMI	National Elevator Manufacturing Industry Inc.
NFC	National Fire Code
NFPA	National Fire Protection Association
NFPA	National Forest Products Association
NHLA	National Hardwood Lumber Association
NHPMA	National Hardwood & Pine Manufacturers Association
NPA	National Particleboard Association
NPT	National Pipe Thread
NRMCA	National Ready Mixed Concrete Association

NSC	National Safety Council
NSF	National Sanitation Foundation
NTMA	National Terrazzo & Mosaic Association
NWC	National Water Council, UK
NWMA	National Woodwork Manufacturers Association
OSHA	Occupational Safety & Health Administration
OS&Y	Outside screw and yoke
PCA	Portland Cement Association
PCI	Prestressed Concrete Institute
PDI	Plumbing & Drainage Institute, USA
PEI	Porcelain Enamel Institute
PS	Product Standard, US Dept of Commerce
ROS	Redwood Inspection Service
RTI	Resilient Tile Institute
SCMA	Southern Cypress Manufacturers Association
SDI	Steel Door Institute
SIGMA	Sealed Insulating Glass Manufacturers Association
SJI	Steel Joint Institute
SMACNA	Sheet Metal & Air Conditioning Contractors National Association
SMFMA	Sprayed Mineral Fibre Manufacturers Association Inc
SPIB	Southern Pine Inspection Bureau
SPR	Simplified Practice Recommendation, US Dept of Commerce
SSPC	Steel Structure Painting Council
SWFPA	Structural Wood Fibre Products Association
TCA	Tile Council of America
TEMA	Tubular Exchange Manufacturing Association
TIMA	Thermal Insulation Manufacturing Association
TPI	Truss Plate Institute
UL	Underwriters Laboratories Inc
UPC	Uniform Plumbing Code
USCGS	US Coast & Geodetic Survey
USS Gage	United States Standard Gage
WCLB	West Coast Lumber Inspection Bureau
WRI	Wire Reinforcement Institute
WOG	Water, Oil, Gas
WPA	Western Wood Products Association
WSP	Working steam pressure

1.1.4 Right of Way

The Contractor shall make all the necessary arrangements for any land required for working areas outside the site, including payment when necessary, and the Employer does not accept any liability in connection with such land. This includes land for compounds, temporary roads, detours, diversions and stock piling materials.

1.1.5 Interpretation of Drawings

The Employer and the Engineer accept no responsibility for any omissions from or for correctness of the representation of existing features on the Drawings.

1.1.6 Responsibility of Contractor

Where the approval of the Engineer is required under these Specifications such approval shall not relieve the Contractor of his duties, responsibilities or liabilities under the Contract.

1.2 Scope of Work and Contractor's Obligation

1.2.1 Scope of Work

The Contract is for the design, construction and operation and maintenance for one year of water treatment works at Mseilha to treat raw water from Mseilha Reservoir prior to transmission to Batroun Caza.

The location of the proposed water treatment works is at Mseilha approximately 60 km North of Beirut at an elevation of approximately 40 m AMSL. The Site is located just downstream the Mseilha Dam. The location of the works is shown on the Tender Drawings.

Access to the Site is currently from the road to Mseilha Dam.

The contract will include all process, mechanical and electrical engineering, instrumentation, control and automation, civil engineering, architectural, landscaping design, construction, supply and installation of mechanical and electrical equipment, testing and commissioning, operation and maintenance for one year, the training of the Employer's operations personnel and the as-built drawings.

The Contract Period will be 4 years (2 years for design and construction, 1 year for operation and maintenance including training of personnel and 1 year for defect liability).

1.2.2 Description of Works to be Undertaken

The water treatment works is to be capable of treating the raw water to comply with LIBNOR NL 161 and/or 98/83/EC Standards as described in Volume 2 Section 2.

The treatment works shall have an output capacity of 0.35 m³/sec (net) with provision for future expansion to 0.7 m³/sec (Phase 2). Site development for Phase 2 is to be included in the Contract. Contractor should submit the design of water treatment works for the ultimate phase (0.7 m³/sec).

The layout of the treatment works and sizes of individual structures and buildings are shown on the Tender Drawings. Bidder has to present its own design and solution in compliance with the Tender Drawings, Employer's requirement and particular specifications given in this document.

Based on the conceptual design a list of major components of the treatment works for Phase 1 is given, as an example, below:

- (a) 1 No. cascade aerator
- (b) 2 No. flash mixers
- (c) 2 No. clariflocculators of reinforced concrete construction
- (d) 2 No. streams of 4 rapid gravity filters of reinforced concrete construction
- (e) 1 No. reinforced concrete storage tank (5,000 m³)
- (f) Sludge tank of reinforced concrete construction
- (g) Main pumping station

- (h) Interconnecting pipework and ancillary fittings and chambers
- (i) Controls and instrumentation
- (j) Chemical storage and dosing buildings
- (k) Administration building
- (l) Power supply switchgear, transformer and standby generation
- (m) Drainage, overflow and waste discharge pipework.
- (n) Access roads, site roads, Guard House and fencing.
- (o) Landscaping.
- (p) Site development of Phase 2 area.

The Works are described in the Employer's Requirements and Tender Drawings and comprise the design, construction, installation and commissioning of the following:

- The complete water treatment plant and main pumping station comprising buildings, process tanks, process equipment, chemical storage, handling and dosing equipment, associated control equipment, power supply and interconnecting pipework.
- Connections to existing raw water pipe from the intake tunnel of Mseilha Dam, overflows, drains and all other pipework.
- Access roads, site roads, hard landscaping, earthworks, site development and planting.

The Contractor is required to provide performance guarantees for the Treated Water Quality, Power Consumption, Chemical Consumption and Quantity of Flow. Details are given in the appendix to volume 1.

1.2.3 Requirement for Future Phases of Construction

Although the treatment works are to be designed for Phase 1 and 2 (0.7 m³/sec output) and constructed for the requirements of Phase 1 (0.35 m³/sec output) some works and facilities that may be used for Phase 2 (0.7 m³/sec output) as well, are required to be constructed and implemented under this contract. These works should include the extension of Civil Works for buildings in order to allow incorporation of future needs for administration, control, and storage of mechanical equipment in Phase 2.

The following table gives the requirements to be provided under this contract for each Phase based on the conceptual process design developed in the present tender documents:

Work Description	Phase 1 (0.35 m ³ /sec)	Requirement for Future Phase 2
Earthworks	✓	✓
Raw water inlet pipeline	✓	✓
flash mixers	✓	-
clariflocculators and equipment	✓	-
Rapid gravity filters and equipment	✓	-
Clear water tank	✓	-
Sludge Tank	✓	✓
Interconnecting pipework	✓	Connection points only
Controls and instrumentation	✓	Provision for future expansion only

Work Description	Phase 1 (0.35 m ³ /sec)	Requirement for Future Phase 2
Chemical house and equipment	✓	Service water pipework capacity, space for storage and preparation and dosing equipment only, including MCC panels
Chlorine house and equipment	✓	Space for storage and dosing equipment only, including MCC panels
Administration and control building	✓	✓
Power supply switchgear, transformer and standby generation building and equipment	✓	Space for future switchgear, transformer and standby generation
Drainage, overflow and waste discharge pipework	✓	To accommodate future expansion
Chemical dosing line and electrical ducts and drawpits	✓	Capacity for future expansion
Main Pumping Station	✓	-

1.3 Contractor's Obligations

1.3.1 General

The Contractor shall take full responsibility for the design, construction, testing and commissioning and operation & maintenance of all elements of the works to the specific technical requirements of the Contract and to the time scales required by the contract.

The Contractor shall ensure that full attention is paid to access and health and safety requirements for personnel including due consideration of ambient temperatures.

The Contractor shall provide materials, equipment and workmanship, which are fit for purpose to suit the conditions and environment of the project site and the operational and performance requirements of these specifications.

Volume 3 of these tender documents is a guide for the minimum quality and level of materials and workmanship required under prevailing conditions. The Contractor/ Engineer can improve upon the same and in either case of following the specifications or improving upon does not relieve the Contractor of his obligation to ensure that all the works are "fit-for-purpose" and meet the design life and performance requirements.

The contract shall include but not be limited to the following:

- (a) Survey, design and detailed engineering, including soil investigation as deemed necessary, process design, hydraulic design, geotechnical design, structural design, architectural design, mechanical, electrical, instrumentation and automation design and drawings including preparation of working and shop drawings.
- (b) Construction of special geotechnical works such as Diaphragm walls, sheet piling wall, piles etc. required to build a safe complete WTWs and associated ancillary structures.
- (c) Construction of civil engineering works for requisite units and ancillary structures as per the design to meet the requisite performance and specifications.
- (d) Supply, erection, testing and commissioning of mechanical equipments as per the design to meet the requisite performance and specifications.
- (e) Supply, erection, testing and commissioning of electrical and instrumentation equipments as

per the design to meet the requisite performance and specifications.

- (f) Supply and installation of HV/ MV cabling, LV cabling and associated works.
- (g) Supply, installation, testing and commissioning of site pipelines, valves and specials as per the design to meet the requisite performance and specifications.
- (h) Supply and provision for SCADA.
- (i) Supply, construction, erection, testing and commissioning of HVAC, water supply, sewerage, drainage, roads, fire fighting, street lighting, plant area lighting, building lighting, telecommunication etc. and the supply and erection of associated landscaping and gardening.
- (j) Hydraulic testing of water retaining structures and pipelines.
- (k) Testing and commissioning until satisfactory performance is established as per the Performance Tests required. Satisfactory performance of the treatment plants for a continuous period of 21 days meeting all the parameters of operation in full automatic mode is required.
- (l) Provision of equipment drawings, technical specifications/ catalogues.
- (m) Provision of as- built drawings and other construction documentation after completion.
- (n) Provision of all the equipment testing, startup, commissioning and acceptance reports.
- (o) Provision of all equipment, tools, furniture, supplies and any other items, which are necessary, desirable or required by statutory requirement or by the operation and maintenance manuals necessary for the proper, safe and efficient operation and maintenance of the treatment facilities and associated infrastructure.
- (p) Preparation and provision of Operation and Maintenance manuals including manufacturers' manuals of the specific equipment supplied (in hard copy and digital database form)
- (q) Provision of 3 nos. stationary automatic programmable refrigerated samplers as specified. Sampler shall be housed in GRP (IP55) kiosk having ventilation

1.3.2 HVAC Requirement

All process buildings, control buildings, working areas, passage, area etc. shall be provided with temperature controlled air-conditioning system.

Working areas such as kitchen, washroom, toilets shall be provided with adequate ventilation.

1.3.3 Specific Requirements

- (a) The Contractor shall be responsible for making all arrangements and payments in respects of any land required for the site of the building, that the Contractor plans to occupy outside the Treatment Plant site.
- (b) The Contractor shall be responsible for the security of the building and its contents at all times and shall employ watchmen for this purpose.
- (c) The Contractor shall supply the Engineer's representative staff with all safety clothing and equipment that shall be necessary for site working such as safety helmets, reflective waistcoats, etc.
- (d) The building shall be well constructed, burglar proof, mosquito proof and weather proof and shall have sufficient doors and glass covered windows for proper light and ventilation. Floors shall be covered with suitable, approved flooring.
- (e) The Contractor shall retain on site for the exclusive use of the Engineer all codes and standards referred to in the Specification.

- (f) The building and services shall be available, fully maintained, until 12 months after the issue of the Taking Over Certificate for the whole of the Works.
- (g) Following the completion of the whole of the Works, the operation & maintenance and the Defects Liability periods respectively, the Contractor shall remove the offices from the Site and reinstate the area to a natural condition or as directed by the Engineer.
- (h) The building and all equipment, materials, fittings, etc., shall become the property of the Contractor after the completion of the Works.

1.3.4 Location of Contract Offices and Other Contract Facilities

Within seven days of the date of the Letter of Acceptance of preliminary design issued by the Employer the Contractor shall liaise with Employer and Engineer for the allocation of land area for various facilities and submit a plan or plans showing his proposed locations for and details of:

- Offices for the Engineer and Engineer's Representatives.
- The Contractor's Site Offices.
- The Contractor's Stores, Plant and Maintenance Yard, Concrete Batching and Materials Stockpiling Facilities.
- Principal routes for heavy plant and lorries.
- Areas for the temporary storage and permanent dumping of excavated material.
- The Offices of the Contractor's Project Manager will normally be adjacent to or close to those of the Engineer for ease of communication.
- The plan(s) shall be submitted to the Engineer in three (3) copies for approval. Any reasonable changes or modifications suggested by the Engineer shall be incorporated. All locations shall be subject to the approval of the Employer.
- Departures from the approved details shall not be permitted unless written consent is obtained from the Engineer.

1.3.5 Service Authorities

Arrangements for mains water supply, mains electricity supply and telephone connections shall be made by the Contractor through respective local authorities:

1.4 Plant Interfacing

Project interfacing points are shown on drawing under Volume 5 and are briefed below:

- Contractor shall start his raw water pipeline from the exit of raw water tunnel outlet structure of Mseilha Dam, which will be provided by others.
- Contractor shall end the pumping lines from the main pumping station inside the limits of the Water Treatment Plant.

1.5 General Site Data

1.5.1 Master Datum

The levels shown on the Tender Drawings are related to the National established datum. Setting up bench marks for construction shall be undertaken by the Contractor and checked by the Engineer's Representative on commencement of the Site works.

1.5.2 Climate Conditions

The following information is provided as a guide only. The Employer and Employer's Representative accept no responsibility as to the accuracy or interpretation of the information given.

The annual mean temperature is 20°C with monthly variations ranging from 12.5°C in January to 27.5°C in August. Temperatures above 30°C and below 0°C are very seldom. The difference between day and night temperatures is generally moderate and amounts to 7°C on average.

Due to the Mediterranean cyclonic disturbances in winter and the monsoonal air masses in summer, the relative humidity is fairly constant throughout the year at a rather high level of about 67%, with mean monthly values ranging from 63% to 72%.

The prevailing wind direction in Mseilha is south-west nearly throughout the year. The appertaining frequency amounts to more than 30% followed by winds from all other directions at more or less the same frequency level ranging from 1% to 9%. In general, the wind velocity is small with less than 5 m/s during more than 70% of the year. Wind velocities above 15 m/s are rare with < 1% on average. However, during storms, velocities of more than 20 m/s have been observed.

The mean monthly wind velocity varies from very low in October, when in about 90% of all cases the wind velocity is lower than 5 m/s, to higher ones in March, when approximately 50% of the wind has a velocity of more than 5 m/s, and 10% of more than 10 m/s.

1.5.3 Site Investigation and Survey Data

A Site investigation has been carried out and the factual geotechnical information and ground conditions are presented in a separate report and included with the Tender Documents (Volume 6).

The Contractor shall be responsible for making his own interpretation and judging the completeness of the information given.

A topographical survey of the Site has been carried out and is included in the Tender Drawings. The Contractor shall be responsible for the accuracy of any information derived from the survey that is used in the design of the works and shall carry out his own survey prior to commencement of design and construction.

1.5.4 Extent of Site

The extent of the Site for the Works is shown on the Tender Drawings along with the Contractor's working area and area for Site accommodation and storage.

1.5.5 Sound Insulation of the Buildings

It is the Contractor's responsibility to design the works to ensure the levels of noise emitted from the plant can never exceed those specified in the Building and Landscaping Specification under any circumstances or methods of operations. This may include the local sound insulation of noise generating items of plant. He shall submit details of such noise insulation and noise suppression of the plant with his Tender.

1.5.6 Design for Seismic Activity

The design of all structures and pipelines shall allow for seismic activity likely to be experienced in the location of the works. The following information is given as a guide only:

Horizontal acceleration 0.3 g

Vertical acceleration 0.2 g

where g is the acceleration due to gravity.

1.5.7 Defining and Maintaining the Site

1.5.7.1 Setting Out and Checking the Works

Works temporary bench marks shall be established at suitable locations on the Site. During the progress of the Works the value of the bench marks shall be periodically checked against the value of the Master Datum. Temporary bench marks shall be located clear of construction works.

1.5.7.2 Interference with Land Interests

Constructional operations shall be confined within the Site, or such other areas of land as may be negotiated. Contractor's employees shall be instructed not to trespass.

1.5.7.3 Interference with Access to Properties

Before obstructing the access to any property, satisfactory alternative arrangements must be provided.

1.5.7.4 Works Layout

The works shall be arranged to provide safe access for operation and maintenance. Major electrical and mechanical items and pipe work shall be laid out in a logical, orderly manner to assist operation and maintenance. The layout shall be optimized for easy access and long term efficiencies.

Access to and from the buildings shall be designed for 24 hour 7 day week operational requirements and periodic maintenance. Walkways accessed by stairs or ladders where appropriate shall be provided for safe access to items of plants and treatment works where daily monitoring, inspection and maintenance is required. All other items shall be accessible via temporary scaffolding or mobile equipment.

1.5.7.5 Plant Access

Access routes shall be provided for the removal of large plant components on trolleys or similar handling appliances. Stairways shall be provided for access. For areas where stairways are not practical, cat ladders or other means shall be provided for access.

Pipes and cables inside buildings shall be located in trenches, ducts or shall be supported at high level to ensure clear access to major plant items. Connections to plant shall be arranged to minimize the obstruction. Overhead gantry cranes shall be provided for equipment maintenance.

Contractor shall provide mobile crane access layouts. Crane turning radii and loads shall be shown on this layout.

1.5.7.6 Temporary Site Fencing

The Contractor shall provide temporary fencing to the Site of the Works and his Site accommodation and storage area. Where the Works comprise deep excavations or work likely to cause a danger to the public the fence shall be regularly inspected and maintained.

Temporary fencing shall be of a type adequate to prevent entry by unauthorized personnel.

1.5.7.7 Signboards

Signboards shall be provided, erected, maintained and moved as required at the Site, at the offices of the Employer's Representative and at the offices of the Contractor. The construction, size and wording of all signboards shall be subject to the approval of the Employer's Representative.

1.5.7.8 Site Cleanliness and Environmental Protection

The Site shall be maintained in a clean and orderly manner and particular attention shall be paid to

the protection and conservation of local environmental features and local habitats.

Contractor's refuse shall not be deposited indiscriminately and arrangements shall be made for all waste such as bags, packing cases, surplus concrete, waste timber and tins to be transported to an authorized tip. No refuse is to be deposited into trenches before backfilling. Local facilities for recycling of wastes shall be investigated and adopted wherever possible.

The public highways leading to the Site which are used for access shall be kept clean and free from spoil and rubbish and shall be regularly brushed and washed.

Site personnel shall be prohibited from urinating or defecating on Site except in properly constructed toilets provided by the Contractor.

The Contractor shall ensure that no caravans or huts are brought on to the Site for use as sleeping accommodation except as may be approved by the Employer's Representative. The Contractor shall ensure that all workmen leave the Site at the conclusion of each day.

1.5.7.9 Site Drainage

At all stages of the work the Site shall be properly drained so that standing pools of water are not allowed to form.

Silt traps shall be provided as required on any permanent or temporary drains which may be required for the removal of water during the construction period. All drains shall be maintained clear of silt until completion of the Contract. Any silting of watercourses, whether within the Site or not, which arises from the failure to observe this clause shall be removed.

1.5.7.10 Billposting and Advertising

Billposting or advertising of any kind shall not be permitted on the Works without the written consent of the Employer's Representative.

1.5.7.11 Demolition, Damage and Making Good

Care shall be taken when demolishing or cutting away existing work such that no adjacent work is unnecessarily damaged. Any work so damaged shall be made good.

Old materials shall not be re-used in the new work, except where so specified or ordered.

Exposed raw faces of existing concrete or blockwork which will not have new work built on to them shall be made good with cement rendering or new blockwork as applicable.

All trees and shrubs shall be protected, if necessary with fencing, unless written permission is given to fell or lop in which case the roots shall be grubbed up and destroyed and the branches and trunks disposed of. The holes resulting from the grubbing up of the roots shall be backfilled with approved materials and consolidated in 200 mm layers.

Where any building, land, hedge, wall, fence or other existing feature is disturbed or damaged in any way the permanent reinstatement shall be made with materials similar, and not inferior, to those in the undamaged portion.

1.6 Design of Work

1.6.1 General

The design of the works shall be developed in accordance with these Employer's requirements, Specifications, the Contractor's proposals and other requirements of the Contract.

The works shall be designed and constructed using proven up to date good practice and to the highest internationally recognized standards available. The Contractor's proposal shall in any case not specify standards which, in the Engineer's opinion, are less than or inferior to those described

in the Employer's requirement.

Without limiting any other clause of the tender and agreement, the following applies to the Design and Construction Works:

- The Design and Construction works with all materials, equipment and facilities must conform to the relevant sections of the Contract for its requirement and specifications;
- The Project Facilities must be designed to Good Utility Practice including all health and safety features and energy efficiency.
- The Project Facilities must be designed to cope with the local conditions.
- The Project Facilities must be designed taking seismic loading into consideration;
- The Project Facilities must be designed to operate in automatic mode with minimal operator intervention;
- All equipment supplied must be designed to meet the needs for satisfactory operation under all variations of operating loads, pressures and temperatures including variation in the ambient temperature;
- All materials must be new, must be of the best quality, and must be designed to withstand the stresses imposed by the working and the ambient conditions without distortion or deterioration affecting the efficiency and reliability of the plant;
- It is the responsibility of the tenderer to ensure that the electrical equipment and instruments offered is completely satisfactory for use with the mechanical equipment offered and vice versa;
- Each component or assembly must have been proven in service in a similar application and under conditions no less arduous than those specified herein. The Client has the right to request the tenderer to justify its selection of equipment. Where it is shown that material and plant are of a standard lower than that necessary to meet compliance with the specification, the tenderer must modify or replace the equipment concerned at its own cost;
- There must also be sufficient room to enable any item of plant to be dismantled for repair without interfering with the operation of adjacent items of plant;
- Liquid retaining structures must be designed to be of sufficient height so that in the event of flow shut off or pump failure the structure does not spill its contents;
- There must be sufficient redundancy built into the design to enable the treated potable water standard to be met at all times;
- Equipment and instruments must not be located in positions where they are vulnerable to falling objects or water drips. Sun and rain shields must be provided where necessary to protect equipment and instruments;
- The tenderer is responsible for the full detailed design of the Design and Construction Works; testing of materials, etc.; and
- The Project Facilities must be designed to be visibly and environmentally discreet. All process structures must be suitably screened with appropriate embankments and landscaping. All architectural finishes must be in harmony and in character with the surroundings.

1.6.2 Special Design Requirements

The tenderer is to provide HAZOPS, HAZCONS and HAZCOMM studies, 'Incidents, Safety, Quality and Environmental Plans', a Functional Design Specification and a Hazardous Area Classification.

The tenderer must employ an Independent Safety Specialist who must review the design at all stages.

The result of the HAZOP, HAZCON and HAZCOMM studies must be implemented in the design and construction of the Project Facilities

1.6.3 WTWs Construction

The Contractor shall take full responsibility for the plant design, based on the footprint provided to construct the Works.

The Contractor shall focus on the operability and maintainability of the plant in its design.

The plant shall also be equipped with fire fighting facility to meet the local authority requirements.

1.6.4 Noise Control

Noise evaluation must be carried out to demonstrate by calculation that the specified internal, external and site boundary noise levels are complied with. All plant items that generate significant noise must be included in the evaluation, taking into account the following aspects to demonstrate the suitability of the design:

- 'worst-case' combinations of plant operation;
- The layout of plant rooms;
- The arrangement and acoustic properties of plant room walls and doorways;
- The layout of external plant items within the Site;
- Any proposed external acoustic features (e.g. concrete baffle walls); and
- The effect of wind, temperature and humidity on the predicted noise levels at the site boundary.

The noise levels generated by the Project Facilities must not exceed the following permissible noise levels, in the following order of priority:

- The external noise level measured at any point beyond the Site boundary must be not more than 40-50 dB(A);
- the noise level in rooms subject to regular occupation such as control rooms and mess rooms must be not more than 60 dB(A);
- Plant noise must comply with the local Environmental Control Rules and Regulations.
- The tenderer must take action to minimize the noise created during construction of the Project Facilities and the noise from operation of the permanent equipment installed at the Project Facilities.

As well as boundary conditions the tenderer must control the local noise levels for operator health and safety issues. Therefore, all mechanical equipment must achieve as a minimum <85 dBA at 1 m. This will require in some cases acoustic enclosures or attention made to pump / blower speed and selection. Consideration should be given at location of the blower rooms.

1.6.5 Corrosion Control

The Contractor shall be deemed to have appraised himself of the particular problems of corrosion of materials in the project area by study of this Specification and visiting the site.

All materials must be appropriate to withstand the corrosive effects of their environments.

1.6.6 Design Standards

Wherever in the Specifications tests on materials, tests on completed work and construction control tests are called for or implied, they shall be carried out accordingly to, and the materials shall comply with, the requirements of the Specifications (latest edition) with the priority of latest edition of standard shall be as follows:

- International standard such as ISO
- National standard such as BSI & DIN
- Others as stated in this Specification such as ASTM, etc.
- Safety, Health and Environment Regulations of Council for Development and Reconstruction, Republic of Lebanon
- Environment Protection and Safety Section Environmental Standards and Allowable Limits of Pollutants on Land and Air Environment, Marine Water Quality Objective, Sea and Coastal Zones (May 2003)

In case of conflict in standards the most stringent standard shall be followed.

The Contractor shall provide for the exclusive use of the Engineer copies of each and any codes of practice, international standard, test methods etc. relevant to the works

In addition the Contractor shall retain on site for the use of the Engineer all manufacturers' literature relating to all the products to be used in the works, current BSI Handbook No. 3, and manufacturers' installation instructions for all relevant products, material components and installation.

1.6.7 Asset Life

The Contractor shall ensure that the design complies with the requirements of the Specification and the following design lives:

Facility	Design Life
New civil work including pipelines, sewers, chambers, roads, buildings and concrete structures	50 years
Pipelines	60 years
Mechanical Plant	20 years
Electrical Plant	20 years
Instrumentation and Control Systems	10 years
Analytical and Process Instruments	10 years

The intention of the Employer is that the Contract shall be the means of obtaining from the Contractor, a plant not necessarily at the lowest capital cost, but plant which will entail the lowest annual charge coupled with efficiency, ease of running, control and ease of maintenance.

The general mechanical and electrical design of the plant and particularly that of wearing parts, shall be governed by the need for long periods of service without frequent maintenance and attention being necessary.

Unless otherwise stated, all items of plant shall be rated for continuous service at the specified duties and operating conditions. Process structures and related equipment shall provide the necessary redundancy in case of failure or maintenance of individual units without affecting the operation of the plant and also the treated effluent water quality.

1.6.8 Site Works

The Contractor shall investigate on site and verify all available information and inform the Engineer of any discrepancies with information provided in the Tender Documents prior to finalization of his design.

The Contractor shall use this information to design the proposed Works.

The design shall be undertaken using current best practices and shall comply with the Employer's Requirements, local authority design regulations and all construction standards currently in force in Lebanon.

The Contractor shall be responsible for confirming all necessary site levels and geotechnical information pertaining to the Works prior to tendering. The Contractor shall undertake investigations necessary for the design and construction of the Works.

The design of all Works shall facilitate inspection, cleaning and repair and maintenance in a safe environment to ensure satisfactory operation under all service conditions.

1.6.9 Pipe Lines

Pipe work and pipelines shall be designed for all foreseeable load cases including the following:

- maximum working pressures on completed pipelines;
- field test pressure on completed parts of the pipeline and the whole of the pipeline (field test pressures) at 1.5 times maximum working pressure;
- required hydrostatic test pressure on individual pipes and fitting at the place of manufacture (works hydrostatic test pressures).

1.6.10 Architectural and Landscaping Requirement

The Contractor shall fully design and construct the plant with a view to the local architectural requirements. The Architectural plans and rendering submitted during tendering shall be reviewed between the Employer, Engineer and Contractor prior to commencement of the works and the detailed design shall be developed to follow the approved proposal.

Landscaping and planting shall also be provided by the Contractor to an arrangement proposed by the Contractor during Tender stage and approved by the Engineer during Tender discussions. In particular the Contractor shall ensure that the landscaping provided is adequate and satisfactory beautification of this major facility.

The reception area to the Mseilha Water Treatment Works shall be welcoming and pleasant for visitors. The Contractor shall develop detailed design of the Reception Area to the Plant as per the approved Architectural detail.

1.6.11 Site Boundary

The boundary to the site shall be marked by a decorative wall construction that is sympathetic to the local architecture. The Access wall shall be illustrated in the Architectural and Landscape renderings submitted at tendering stage. These renderings shall be reviewed, amended or approved during Tender Discussions and the final approved drawings shall form the basis for the Contractors design.

1.6.12 NOCs

Contractor shall be responsible of arranging design and construction approval Certificate (NOC) from concerned regulatory authorities. All cost related to documentation, follow up and approval of NOCs from different departments shall be borne by the Contractor.

1.6.13 Minimum Technical Requirement

The Contractor must demonstrate experience on the similar nature of work. This should be via a reference or a key personnel. The key personnel must have designed experience in the processes of equivalent size, this should be presented on the CV and also a contact must be submitted to allow the extent of involvement to be audited.

The Material and Workmanship specifications are not exhaustive. It does not involve all the likely process, works, materials and equipment likely to be selected by the Contractor for delivering the project. Additional specifications may be given in the form of Minimum Technical Requirements to be complied by the Contractor any time during negotiation and/or execution of the Contract.

Minimum design requirement for process, civil, mechanical, electrical and instrumentation and control system for the project is given under Volume 2- Employer's requirement of the Tender.

To meet the intended requirement of the scope, the material and workmanship specifications are provided in the Volume 3 of this Tender. These specifications delineate good engineering requirement to be followed by the Contractor to complete the works. Complying with these specifications does not relieve the Contractor of the responsibility to deliver the performance standards stated in the Tender.

The minimum technical requirements are intended to include the basic design principles, concept and requirements for the Works but do not include the final, detailed design, plans, drawings or specifications or indicate or describe each and every item required for full performance and for achieving acceptance. The Contractor shall prepare all necessary complete and detailed designs, plans, drawings and specifications and to furnish and perform, without additional compensation of any kind, all work in conformity with the minimum technical requirements and the final designs, plans, drawings and specifications based thereon. Furthermore, the Contractor agrees that it shall not have the right to bring any claim whatsoever against the Employer or any of its consultants or subcontractors, arising out of any design drawings, specifications or design requirements intended in the Tender, the Contract or made available during the procurement process.

The Contractor shall be responsible for delivery of works that meet all of the requirements of the Tender as well as any and all permits, regulatory, applicable laws, and requirements, to the Employer's/ Engineer's acceptance. The project shall incorporate the minimum technical requirements specified for process, mechanical, structural, building, mechanical, electrical, and instrumentation and control.

The structural design and construction of all the components – special geotechnical works, water retaining structures, buildings, pavements, roads, infrastructure shall be designed as per the requirement of British Standard (BS) and other international standard equivalent requirements.

The design philosophy shall be at minimum, based on the following:

- All water retaining structures shall be designed as per the recommendation of BS EN 1992-3 (latest edition) and BS EN 1992-1.
- All construction, contraction and expansion joints shall be provided as per the recommendation of BS EN 1992-3 (latest edition).
- All buildings shall be analyzed and designed as per the recommendations and guidance of BS EN 1992-1 (latest edition).
- All dead and imposed loads shall be as per BS EN 1991-1-1&7 (latest edition).
- Wind load and its analysis shall be as per BS 1991-1-4 (latest edition).

- Structures shall be analyzed and designed for the combinations of the worst loading cases as per the recommendations of BS EN 1992-1 (latest edition).
- All buildings shall be designed as per Limit State Method.
- Calculations for earthquake forces will be as per Uniform Building Code (UBC) 97.
- All the British Codes for civil engineering for design and construction shall be followed.
- If the buildings are resting on tanks the dead weight of such units shall be accounted for in the uplift/ stability (if any) calculation of tanks.
- Foundations of the various structures located below water table shall be designed for the uplift pressure and all other aspects by the contractor's geotechnical expert.
- Unless otherwise specified the fire resistance period for the structural design purpose for all concrete structures shall be a minimum of 2 hours.
- Unless otherwise stated, the minimum concrete cover to all reinforcement shall be 50mm.
- Plant items and pipe work operating at elevated temperatures shall be insulated such that the surface temperature shall not exceed 55 Degree Centigrade.

1.7 Contractor's Documents for Review by the Engineer

1.7.1 Design Documents

The Contractor shall submit to the Engineer for his approval complete working drawings, all design calculations and details of construction of the works and other apparatus and all other parts as may be required to give full information to the Engineer regarding the proposed design. Three paper copies and a copy in electronic format shall be submitted for approval by the Engineer if applicable at least 2 weeks prior to the programmed activity commencement or for approval.

Submissions shall be numbered using an agreed referencing system and shall comprise but not be limited to the following:

- Site Layout and General Arrangement drawings with dimensions and setting out details.
- Details of treatment plant elements including mechanical and electrical equipment, schematic layout of plant, details of pipe layouts, diameters, flow direction, invert levels and cover levels.
- Process design calculations for the water treatment plant.
- Hydraulic design calculations for the plants.
- Drawings and schedules showing all pipe work, fittings, chamber and trench details and thrust block arrangements, with alignments and crossovers of cables and duct detailed.
- Manhole/access chamber schedules, schematic layout of each manhole/ access chamber providing details of pipe profile, layout, diameters, flow direction, invert levels and cover level.
- Drawings, calculations and method statements for all road crossings and connections to existing pipe work.
- Design criteria and methods covering the structural and geotechnical design of the Works.
- Details of road construction and reinstatements.
- General arrangement and foundation drawings, complete with dimensions, for all buildings, tanks, plant and associated equipment.
- Structural calculations and drawings including foundation design.

- Reinforced concrete details, structural steelwork and masonry drawings.
- Reinforcement drawings and calculations for insitu and precast concrete.
- Fabrication drawings for any structural steelwork/metalwork
- Architectural and building works drawings including masonry, cladding, roofing, etc, and all specified fixtures and finishes both externally and internally.
- Details of protective coating design.
- Road construction drawings including kerbing and drainage details and street lighting.
- Landscaping, land drainage, sub and top soiling and all ancillary works.
- Details of temporary and permanent fencing/ boundary wall and external lighting.
- Details of site irrigation and fire fighting system.

1.7.2 Construction and Installation Method Statements

Construction and installation method statements shall be prepared for the principal elements of the Works and shall be submitted to the Engineer for review at least 28 days prior to the programmed activity commencement.

Construction and installation method statements shall make due allowance for all requirements and restrictions imposed by the Contract. Each method statement shall comprise a step-by-step schedule of specific operations or activities with description, date, times and duration of each step. The statements shall be supported by sketches, diagrams or other supportive detail as necessary to enable a clear understanding of the method and significance of each step of work or operation.

The construction and installation method statements shall include, but not be limited to:

- the method of working;
- construction equipment to be used;
- measures for controlling noise and vibration;
- hours of working;
- layouts of compounds storage facilities;
- sources of Materials;
- methods of movements and storage of bulk materials and spoil;
- haulage routes;
- site organization;
- measures of controlling dust;
- temporary lighting details;
- temporary works details;
- details of all disposal sites;
- maintaining and cleaning of Site roads;
- safety procedures and risk assessments;
- pedestrian, light vehicular and emergency access;
- any proposed demolition methods.

- Method statement shall include for dealing with storm drainage and dealing with groundwater.

1.7.3 Production and Submission Procedures

The Contractor shall provide the Engineer with three paper copies of all technical documents for review and one copy in DWG format on a 3 CD or DVD where applicable. On submission, the Contractor shall clearly identify previously submitted inter-related technical documents and also changes to previously reviewed technical documents.

All designs, drawings and documents submitted by the Contractor to the Engineer for review shall be checked by the Contractor before submission and shall be signed by a senior member of the Contractor's staff in accordance with approved QA procedures, to confirm that the check has been conducted. The Contractor shall likewise check submissions from his sub-Contractors or from any other source before passing such submissions to the Engineer.

A drawing and document register shall be kept and updated continuously by the Contractor. A copy of the register shall be submitted to the Engineer every time a drawing or document is issued.

Where it is considered that the technical documents do not comply with the requirements of this Contract, the Engineer shall return one copy to the Contractor indicating where the proposals are considered to be non-compliant. Where a Document requires alteration, the Contractor shall make the necessary alterations and submit three copies of the altered document to the Engineer. Any revisions to drawings and documents shall be clearly highlighted by the Contractor. Drawing amendments shall be listed in the title box. Amendments to Documents shall be redlined, struck out or marked in the margin.

All drawings submitted by the Contractor to the Engineer for consent shall be on ISO standard size sheets with a maximum size of A0 with an electronic copy of the drawings on CD or DVD. Every drawing shall have a title box in the bottom right corner showing:

- Employer's name;
- title of scheme;
- title of Contract;
- Contractor's name;
- title of work location;
- title of drawing;
- drawing number;
- date;
- author;
- scale;
- a separate revision box;
- signature of Contractor to the effect that the drawing, whether his own or from any other source, has been checked by him before submission to the Engineer.

All layout and arrangement drawings submitted by the Contractor shall be drawn to scale and dimensioned and shall include a graphical scale to aid the use of photographic reproductions. All clearances required for the installation, routine operation and maintenance of items of Works shall be noted on the drawings.

The Contractor shall use the metric international system of units (SI units).

Designs and documents submitted by the Contractor to the Engineer for review shall include:

- contents list;
- scope (description of the contents and purpose of the submission);
- conclusions and recommendations;
- references, specification requirements, codes, manuals and supporting documents used, drawing numbers and titles of drawings which are based on the design;
- description of design approach;
- criteria, parameters and methods used;
- test procedures, analyses and results;
- calculations and schedules;
- qualitative description and comments on results;
- any other relevant information.

A statement explaining the principles of design and type of analysis adopted shall preface all design calculations prepared by the Contractor. The statement shall also indicate the Codes of Practice or Standard(s) upon which the design is based. Any computer programs used in the design shall be fully described, and details of inputs and printouts shall be presented in a manner that can be readily understood. Program manuals and any instructions to program users shall be made available to the Engineer upon request.

Electronic copies of all design calculations shall be provided in commonly available format, pdf or equivalent.

Final works inspection reports shall be submitted to the Engineer before dispatch of the Works from manufacturer.

The following documentation will not be specifically required for review but may be subject to a random audit at the request of the Engineer:

- All civil and structural calculations;
- Services clash checks;
- Services routing diagrams;
- Safety Plan and Safety File.

1.8 Materials and Manufactured Items

Materials and manufactured items shall be suitable for the climate and environmental conditions described in this specification.

The environmental conditions may be different in different parts of the Works and materials shall be selected and manufactured items designed accordingly to withstand the relevant corrosive elements. In particular all products or materials in contact with sewage or a sewage environment shall be non- biodegradable.

All local customs, laws and regulations laid down by the Employer or other governing body relating to the supply or source of materials shall be complied with.

All materials and equipment specified in the Contract Documents which are to be incorporated in the Works must be obtained from or through a Local supplier and /or manufacturer. If such specified materials or equipment is not available from the local market then any other source is

acceptable.

The contractor shall be responsible for liaising with the suppliers; obtaining, checking for accuracy and issuing all drawings and other documents and for co-ordination of supply and installation.

Materials delivered to the Site for the purpose of the Works, shall be accompanied by a "Certificate of Guarantee" signed by the authorised representative of the manufacturer, which will legally bind the manufacturer to the product delivered.

Such Certification shall state that the materials specifications and test results are in compliance with the specified requirement of the pertinent designations of the most recent edition of ASTM, BS or any other approved equivalent National Standard unless otherwise directed.

Falsification of such Certificates, Materials, Specifications or Test Results shall be just cause for the rejection of the materials.

1.8.1 Quality of Materials, Manufacture and Standards

All materials and manufactured items supplied for incorporation into the permanent works shall be new, of high quality and of sound workmanship. They shall be purchased only from approved suppliers who shall be capable of demonstrating the suitability of their products by reference to similar works and certified test results, and be suitable for the purpose for which they are intended as stated in the Specification.

Materials and manufactured items shall normally be certified as complying with relevant specifications of a recognized national or international standards (ISO) organization which shall be subject to the approval of the Engineer but in dimensional respects they shall be compatible with ISO standards. Where pipes and access covers are produced to British Standard (BS) or DIN they shall be kitemark certified or similarly approved.

All materials and manufactured items shall also have an approved national certificate of conformance similar to BSI or DIN quality kite mark or national agreement certificate such as BBA for non – standard products and systems which shall be subject to the Engineer's approval and verification by Employer.

Materials not covered by a third party product certification scheme shall be assessed by acceptable tests on each batch. Sampling and testing shall be carried out by an organization independent of the producer at the producer's works or in the stockholder's yard.

The Contractor shall provide, for the sole use of the Engineer, original copies of the latest editions of any national or international standards, in English, which may be called for as being required in the execution of the Contract. These may include alternative standards to those to which the materials are manufactured for use as a comparative quality guide. The standards will become the property of the Engineer and will not be returned to the Contractor at the end of the Contract. The rates inserted in Volume 4 shall be deemed to cover provision of any standards so provided.

1.8.2 Approval of Materials and Manufactured Items

The Contractor shall submit to the Engineer full information as detailed below, for all proposed materials and manufactured items.

- Prior to the placing of any order for materials or manufactured items, the Contractor shall submit, in triplicate, a Request for Approval. The information shall be clearly and neatly presented in a standard format to be agreed with the Engineer. No orders of main equipments shall be placed until one copy of the Request for Approval has been returned duly signed and dated. The information required is as follows:
 - Name and address of proposed supplier or manufacturer.

- Reference numbers and titles of relevant specifications of a recognized national or international standards organization with which the materials or manufactured items will comply together with relevant copies of the specifications in English.
- Samples of materials representing the quality of the bulk of such materials the Contractor proposes to use.
- Manufacturer's literature and data sheets for articles and fabricated items.
- Sufficient information to demonstrate that the materials or manufactured items are suitable and comply with Specification.
- For all main equipments a minimum of three different suppliers are requested for the Client to choose from. All three should be of acceptable quality with the performance guarantee as required from the Contractor.
- Following approval of an order for manufactured items designed for incorporation in the Works the Contractor shall submit detailed drawings and installation drawings for approval. Following approval three copies of such drawings shall be submitted.
- Prior to dispatch to site or to a designated place of storage the Contractor shall provide the following:
 - Facilities for inspection and testing at suppliers' pits or quarries, manufacturers' works or approved independent testing centres as appropriate. Inspection and or witness testing may be carried out by the Engineer or other appointed Inspector.
 - Details of the supplier's or the manufacturer's quality control test procedures and copies of test certificates.
 - Shipping and consignment identification details.

1.8.3 Approval of Construction and Testing Methods

For all elements of the Works the Contractor shall submit to the Engineer in duplicate, fully detailed method statements describing his proposed construction and testing techniques and program for execution. These shall be supported, where applicable, by calculations for temporary works for supporting excavated faces and shuttering of concrete.

Approval of the Engineer shall be sought.

1.8.4 Contractor's Staff

Contractor shall provide adequate staff in all disciplines for the completion of the project throughout the contract period. The proposed staff should include but not limited to the Project manager, design engineers, process engineer, civil construction supervising engineers, material engineer, mechanical and electrical engineer, safety officer, engineering geologist, O&M engineer, etc.

1.8.5 Submittals

This Section includes:

- Submittal Procedures
- Product Data
- Shop Drawings
- Samples

- Operation and Maintenance Manuals
- Certificates and Affidavits
- Miscellaneous Submission

Definitions

A. Product Data and Shop Drawings

- Includes drawings, diagrams, illustrations, brochures, schedules, bill of materials, and other data prepared specifically for the Work.
- Information may be prepared by Contractor, his subcontractors, suppliers or distributors, equipment manufacturer, or fabricators.
- Information must illustrate or describe manufacture, fabrication, construction, and installation of the Work or a portion thereof.

B. Manufacturer's Representative

- Person actively working at manufacturer's factory with minimum 5 years experience
- Familiar with actual problems of manufacturing, installing, and operating the product.
- Sales representative or agents are not acceptable.

C. Working Drawings

- Contractor prepared plans for temporary structures and facilities.
- Elements of work which may affect the safety of persons or property shall be certified by a qualified engineer.
- Calculations demonstrating adequacy of Contractor's design shall be submitted with the working drawings.
- Follow submittal requirements for shop drawings.

D. Samples

- Physical examples illustrating materials, plant/equipment, or workmanship for permanent Works.
- Establish standards by which the Work will be judged.

E. Manuals

- Manufacturer's written installation, start-up, operating, maintenance and repair instructions.
- Include parts lists, pictures, sketches and diagrams specific to the equipment supplied to document the manufacturer's requirements.

1.8.5.1 Submittal Procedures

Contractor shall make submissions only to the Engineer. All submittals, requests for action, notifications, etc. shall be through the Engineer.

All data and correspondence prepared by subcontractors and suppliers shall be submitted through the Contractor as follows:

- All submittals shall be in English.
- Make all corrections and changes to submittals as required by the Engineer and resubmit until

approved.

- Review submittals returned by the Engineer.

The Contractor shall ensure the following:

- Determine if changes requested by the Engineer result in extra cost.
- Notify Engineer in writing within 5 days of receiving submittal if contractor believes extra costs are incurred.
- Failure of the contractor to notify the Engineer of the extra costs or Contractor's proceeding with the work waives Contractor's claim for compensation.

The Contractor shall review and approve all shop drawings, product data, samples and manuals required by the contract documents prior to submitting them to the Engineer. Review and approval shall be for compliance with the contract requirements and shall have the following significance:

- Approval indicates Contractor has verified all materials, field measurement, field construction criteria and similar items.
- Approval also indicates Contractor has co-ordinated information contained in submittal with Work requirements of other trades and with the Contract Documents.

Submissions of manufacturer's data, including data specified as "for information only" shall be made prior to beginning any portion of the work using materials contained in the submittals.

Contractor shall submit shop drawings and product data in accordance with approved submittal schedule for the Engineer's approval.

Contractor shall submit shop drawings and product data for related equipment items and integrated system components at the same time.

Partial submissions may be returned to the Contractor without review.

Contractor shall co-ordinate shop drawings and products:

- Co-ordination shall include:
 - Drawings and data previously submitted.
 - Drawings and data being prepared.
 - Drawings and data previously approved.
- Contractor's approval and submission of shop drawings and data to the Engineer indicates that such co-ordination has been performed and completed.

The Contractor shall direct Engineer's attention either in writing or on the re-submitted documents to each and every revision including those requested by the Engineer on previous submittals and explain, in writing, the reasons for the revision. The Contractor shall not deliver materials or equipment either to storage or at the project site and not incorporate into the works until such items have been approved or authorised in writing by the Engineer.

The Contractor shall not perform any work until shop drawings have been submitted to and approved by the Engineer.

All submittals from the Contractor shall include a label or stamp which indicates that the submittal has been reviewed and approved by the Contractor for conformance to the contract requirements.

- The labels or stamp shall generally conform to the following:

SUBMITTAL NO. _____

FOR CONTRACT NO. _____

PROJECT NO. _____

CONTRACTOR: _____

REVIEWED AND APPROVED for Conformance with the Contract Documents

By: _____ DATE: _____

(Signature)

REFERENCE: _____

DRAWINGS NOS. _____

SPECIFICATION NOS. _____

ACTIVITY SCHEDULE NOS. _____

- A ten-character submittal identification and numbering system shall be used. Submittals for Civil, Mechanical and Electrical items shall be submitted separately.
 - The first character shall be either “D”, “S”, or “M” representing shop or working drawing (D,) sample (S), and operation/ maintenance manual (M).
 - The next five digits shall be the applicable specification Section number.
 - The next three digits shall be the numbers 001 through 999 sequentially number each separate package submitted under each specific Section number.
 - The last character shall be the letter “A” through “Z” indicating whether the submittal is the first submission (A) or a re-submission (B through Z).

The letter “B” indicates the second submission (first re-submittal), “C” the third submission (second re-submittal), etc.
- an example of a submittal number is D-03300 – 008 – B which indicates:
 - D - Shop Drawing
 - 03300 - Specification for Concrete
 - 008 - The eighth separate submittal under this Section.
 - B - The second submission (first re-submittal) of that particular information

Engineer’s Review

The Engineer’s Review of all submittals shall be in accordance with the following procedures and requirements:

- Revised submittals will be returned to the Contractor with the Engineer’s comments, if any.
- Engineer’s review is for general conformance with the contract requirements only.
- All works are still subject to the detailed requirements of the Contract Documents.
- Engineer’s review is to help the Contractor by discovering errors and omissions.
- The Engineer’s review does not relieve the Contractor of the obligation and responsibility to co-ordinate and plan the details of the Work and fulfill the intent and purpose of the Contract.

- The Engineer's review shall not relieve the Contractor of the responsibility for accuracy, proper fit, or proper functioning and performance of the work.
- The Engineer reserves the right to require written confirmation from the Contractor that the comments placed on submittals stamped "Approved as Noted" will actually be implemented.
- The Engineer will make every reasonable effort to process and return each submittal within 30 calendar days after its receipt in the Engineer's office.
 - Large or multiple submittals may require up to 45 calendar days.
 - Contractor may prioritize submittals and Engineer will review and return them in the order of the highest priority.
 - Individual drawings from large submittals with numerous drawings may be returned as they are reviewed rather than waiting for the entire review to be completed.
 - The need for re-submissions or delays in obtaining the Engineer's review or approval shall not entitle the Contractor to a time extension for contract completion.
- Categories used by the Engineer to evaluate submittals for Approval as defined in (Volume 2, Section 1, 1.1 General Requirements) are defined below:
 - **Approved:** No discrepancies have been identified.
 - **Approved As Noted:** The submittal is acceptable subject to incorporation of the comments listed.
 - **Disapproved:** The submittal is unacceptable for the reasons cited.
 - **Incomplete:**
 - The submittal is being returned without review.
 - Insufficient information has been provided or the submittal does not comply with the contract requirements.
 - Noted:
 - The submittal is not required by the contract documents.
 - The Engineer will include it in the project files for information only.

Incomplete submittals including those not correctly transmitted, incorrectly titled and identified, or not bearing the Contractor's review and approval stamp may be returned to the contractor without review. This may not be used by the Contractor as a cause for delay.
- Minimum Copies for Engineer's Review:
 - Two (2) copies plus CD or DVD copies of all design submission needed.
 - Four (4) copies of all product data and manuals.
 - The Engineer will return one (1) one copy or print of each shop drawing and two (2) copies of product data or manuals to the Contractor.
 - The Engineer may require additional copies of all submittals (in either electronic or hard copy format) by notifying the Contractor in writing and such additional copies will be at no extra cost.

1.8.5.2 Product Data

Product data shall be provided in accordance with the following requirements:

- Shall be explicit with regard to details of the actual products being furnished.

- Provide sufficient information to the Engineer to determine that the products submitted conform to the specification requirements.
- The country of origin for all equipment and material to be used on project.
- Affidavit from manufacturer of each equipment item that it has been installed and is successfully operating in at least five facilities of a similar size and type as specified.
- Submittals with more than one style, size, capacity, etc. of a product on a page shall clearly indicate which product type is being submitted for approval. Failure to do this shall be cause for disapproval.
- Present information on pages not larger than size A4.
- Include the name of the product manufacturer on all catalogue data.

1.8.5.3 Shop Drawings

- Provide detailed drawings and written descriptions of both the assembly and all components.
- Drawings shall indicate proposed installation of Work as well as materials and equipment being furnished.
- Identify proposed deviations from the details or component arrangement as specified or shown on the Drawings and:
 - Present reasons for the proposed deviations.
 - Explain why proposed deviation is "equal to" that specified.
- Information shown on shop drawings shall be complete and sufficient for Engineer to review for compliance with contract requirements. Information shall include but not necessarily be limited to the following:
 - Layout dimensions and component sizes including bases, foundations, anchors, and similar items.
 - Design criteria.
 - Materials of construction.
 - Component and assembly weights.
 - Utility requirements (power, water, etc.).
 - Manufacturer's rating or performance curves.
 - Wiring diagrams and control schematics.
 - Recommended spare parts.
 - Special tools.
 - Deviations from contract requirements.
 - Additional requirements contained in individual specification sections.
- Copies of the Contract Drawings are not acceptable for submission as component arrangement (layout) drawings.
- Manufacturer's model numbers or catalogue numbers alone shall not be acceptable for describing equipment or components.

1.8.5.4 Samples

- Furnish samples as required by the individual specification section.
- Unless otherwise specified, samples shall be submitted as follows:
 - Submitted to Engineer as specified.
 - Labeled and properly identified as follows:
 - Date.
 - Project / Work Area for which offered.
 - Specification section and applicable paragraph numbers.
 - Contractor.
 - Supplier / Manufacturer.
 - Product Identification (Trade Name).
- Samples shall be accompanied by an approved transmittal form, specifications and other pertinent data required for Engineer to determine that the material conforms to the specification.
- Three sets of samples shall be submitted unless otherwise specified.
 - One set of approved samples and all disapproved samples will be returned to the Contractor.
 - If requested in writing by the Contractor, samples of value will be returned to the Contractor after completion of the Work.
 - Approved samples returned to the Contractor may be incorporated into the work upon written approval of the Engineer.

1.8.5.5 Operation and Maintenance Manuals

The Contractor shall:

- Submit manuals for all equipment and components specified.
- Manuals shall be as specified.
- Submit two copies plus an electronic copy for review.
 - The Engineer will return one copy of the reviewed manual to the contractor for correction.
 - The Engineer will retain one copy for project files.
- Submit six copies of approved manuals incorporating all of Engineer's comments and corrections prior to beginning training.

1.8.5.6 Certificates and Affidavits

- The Contractor shall provide the original and three copies of manufacturer's certificates in accordance with the requirements specified in the Specification.
- Definitions
 - Certificate indicates test results, component manufacture, or installation complies with specified standards.
 - Affidavit is a sworn statement by an officer of the company manufacturing the product indicating that the information on the certificate is true and accurate.

- An affidavit shall accompany all certificates.
- A statement from the contractor, sub-contractor, equipment supplier, or agent indicating the product meets the requirements of the Contract Documents shall not be considered as a certificate.
 - Such submittals shall not be approved.
 - Corresponding equipment, products, or components shall not be accepted.

1.8.5.7 Miscellaneous Submissions

- Manufacturer's guarantees and warranties
 - Submit 3 copies unless otherwise specified.
 - Submit prior to final acceptance.
- Work plans
 - Submit 3 copies, unless otherwise specified, at least 30 days prior to beginning work.
- Submittal Schedule
 - Show the proposed date the contractor will deliver each required submittal to the Engineer for review.
 - Submit within 10 calendar days of receiving notice to Commence.
- Health, Safety and Fire Protection Plan
 - Submit 3 copies unless otherwise specified.
 - Plan shall also incorporate all requirements of client's staff.
- Accident Reports
 - Submit 3 copies unless otherwise specified.
 - Refer to relevant Section for specific requirements.
- Progress Reports (refer to paragraph 1.22.2.1)
 - Prepare and submit the Progress Reports described hereinafter in a form provided by the Engineer.
 - Work activities and procurement reports should be referenced where relevant to the approved Contractor's Construction Schedule.
 - Submit 3 copies unless otherwise specified.
 - Daily Construction Reports:
 - Submit on a daily basis.
 - Describe labour force and its allocation.
 - Describe material and equipment utilised.
 - Describe work progress during the day.
 - Describe temperature and weather conditions.
 - Describe any occurrence which may affect the progress of the Works.
 - Procurement Status Reports:
 - Submit on a weekly basis.

- Include a list of materials and items procured.
- Include list of items delivered to the site.
- Provide references to all correspondence and transmittals between the Contractor and the Engineer regarding the approval of such materials and items.
- Monthly Report:
 - Reflect monthly progress and status of the Work.
 - Describe problem areas.
 - Describe current or anticipated causes of delay along with their estimated impact on progress and the corrective measures taken or proposed.
 - Include construction photographs.
- Inspection and Test Reports
 - Submit 3 copies unless otherwise specified.
- Survey Data
 - Submit 3 copies unless otherwise specified.
 - Survey data is required to develop quantitative record of actual work constructed, as part of damage and settlement surveys, surveys of adjacent construction and similar efforts.
- Close-out Submittals
 - Refer to Section or specific requirements.
 - Record (As Built) Drawings
- Schedule of Values
 - Submit 3 copies unless otherwise specified.
- Letter of Authority
 - Submit within 10 days after receipt of the Letter of Acceptance.
 - Identify the Project Manager and detail the extent of his authority and responsibility.
 - All work to be under direct supervision of Contractor's on-site representative who shall be the Project Manager.
 - Project Manager shall be present at the job site whenever Work is underway.
 - Project Manager shall have full authority to represent the Contractor.
 - Communication given to or received from the Project Manager shall be as binding as that given to or received from the Contractor.
- Organization Chart
 - Submit to the Engineer not later than 14 days after receipt of the Letter of Acceptance.
 - Show the executive, administrative, and construction supervision organization.
 - Include all personnel from Project Manager through foreman level.
 - Describe personnel duties.
 - Amplify details provided after submission of Tender.
 - Provide qualifications and experience of all personnel shown on the Organization

Chart.

- Update the Organization Chart whenever key personnel are reassigned.
- The Engineer may interview any of the Contractor's proposed staff prior to approval.
- The Engineer may direct the Contractor to remove personnel from the site who, in the Engineer's sole opinion,
 - Exhibit inappropriate conduct.
 - Are incompetent or negligent in the performance of their duties.
 - Are otherwise considered undesirable.
- Site Layout for Contractor's Facilities
 - Submit within 14 days after receipt of the Letter of Acceptance.
 - Site plan should include but not necessarily be limited to the following:
 - Temporary facilities including accommodation.
 - Storage areas including permanent dumping of excavated material and all debris
 - Crane positioning.
 - Fences, gates and security lighting.
 - Access for other Contractors, vendors, plant staff, visitors, etc.
- Evidence of Insurance as required in Conditions of Contract.
- Correspondence
 - Provide one original and three photocopies of transmittals and letters including attachments and enclosures.
 - Submit on A4 size whenever possible.
 - Clearly indicate the following on each document.
 - Contract Number.
 - Title of Project.
 - Contractor's Name.
 - Date.
 - Correspondence Reference Number.
- Submit Copies of building permit, completion certificate and/or any other related authorities certificate prior to commencement

1.9 Notice of Operations

The Contractor shall, when required, supply in writing full information regarding the localities in which the materials are being obtained and in which the work is being prepared.

No permanent work shall be carried out without the consent in writing of the Engineer's Representative. Full and complete notice, in writing, shall be given 24 hours in advance of the time of the operation in order to make such arrangements as deemed necessary for inspection.

1.10 Traffic Safety and Control

- The Contractor shall provide, erect and maintain such traffic signs, lamps barriers and traffic control signals as may be necessitated by the construction of the Works in accordance with Local Traffic Police requirements. The Contractor shall submit proposals for dealing with such situations to the Engineer, Local Traffic Police for consent. Compliance with this Clause shall not relieve the Contractor of any of his other obligations and liabilities under the Contract.
- The Contractor shall, after consultation with any statutory or other authority concerned, submit to the Engineer for approval a programme based on such consultation. The programme should show the scheme of traffic management he proposes for carrying out the Works before commencing any work which affects the use of the public highway rights of way or parking areas and thereafter furnish such further details and information as necessitated by the Works or as the Engineer may require.
- The Contractor shall not commence any work which affects the public highway until all traffic safety measures necessitated by the work are fully operational.
- The traffic diversion and signs, lamps, barriers and traffic control signals shall be in accordance with the requirements of Local Traffic Department or Local Police.
- Traffic signs shall comply with the requirements of local traffic division. The flashing rate for flashing lamps shall be within the range 120 – 150 flashes per minute. The minimum luminous intensity of the lamps shall be 0.5 candelas for steady lamps, 1.0 candela for ripple lamps at their peak, and 1.5 candelas for flashing lamps at their peak.
- The Contractor shall keep clean and legible at all times all traffic signs, lamps, barriers and traffic control signals and he shall position, re position, cover or remove them as necessitated by the progress of the Works.
- Where road diversions roads are approved these must be maintained at frequencies to suit the traffic volume using them. A good running surface must be maintained and must at all times be free from ruts and potholes.

1.11 Compensation for Damage to Property

The Contractor shall reinstate all properties whether public or private affected by the Works, Temporary Works, constructional plant, labour materials or transport to a condition at least equal to that existing before his first entry on to them.

If in the opinion of the Engineer the Contractor shall have failed to take reasonable and prompt action to discharge his obligations in the matter of site clearance or reinstatements the Engineer will inform the Contractor in writing of his opinion in which circumstances the Employer reserves the right to carry out the reinstatement himself or to arrange for it to be carried out by others or to make payments to the owners and occupiers in respect of such matters for which the Contractor is responsible. All such costs incurred and payments made will be deducted from any monies due or which shall become due from the Employer to the Contractor.

1.12 Existing Services

Drains, pipes, cables and similar existing services encountered in the course of the Works shall be protected from injury or damage by the Contractor at his own cost so that they may continue to function uninterruptedly to the satisfaction of the owners thereof and the Contractor shall not store materials or otherwise occupy any part of the site in any manner likely to hinder the operations of such owners.

- The Contractor shall protect and support, during the progress of the Works, all pipe mains,

cable wires and other apparatus which might be endangered by his operations. The approximate positions and alignments of known services are indicated on the Drawings, but no guarantee of exact location can be given, and the Contractor must communicate with the authorities and/or proprietors concerned to locate them exactly, and he shall then prepare shop drawings 1/500 scale for each Utility as directed by the Engineer. When approaching each indicated position, the Contractor shall search, by safe methods which will not endanger the service, to determine its precise position.

- The Contractor shall make his own arrangement with the owners of the services and with other persons interested, for any diversions, temporary stoppages and reinstatements, and he shall allow in his programme for all such arrangements.
- If any underground service is encountered unexpectedly, excavation shall cease, and the Engineer's Representative shall be notified immediately. Emergency work, as necessary, should be put in hand without delay and without prejudice to the indemnity of the Employer.
- The Contractor shall give notice, in writing, to the Engineer and to the appropriate service company of all damages to existing services caused by him or by any Sub Contractor in the course of the Works. He shall be held responsible for any such damage and shall immediately have such damage made good at his own expense and shall relieve the Employer of all claims in respect of any loss or interruption involved.
- If in the opinion of the Engineer, it is necessary or expedient that any pipe, drain, ditch, cable or overhead wire (including supports) should be broken out, stopped up, diverted, taken down, or altered, the cost of doing so shall be the responsibility of the Contractor. Such work shall be executed only on the written instruction of the Engineer.
- All existing sewers, culverts, water courses and drains of every kind and condition that have been altered, extended or otherwise interfered with either directly or indirectly by the work, or that may by leakage, silting, stopping of free flow or otherwise interfere with or delay the execution of the work, shall be made good, cleaned, placed in working order, supported, maintained, and protected and the Contractor shall provide everything necessary for efficiently dealing with, protecting, pumping or removing, as the case may be, all water, sewage, or spoil there from.

1.13 Continuous Working

If in the opinion of the Engineer it is necessary for the safety of the Works or for any other reason, the Contractor shall, when so ordered, carry out the Works, or any portion thereof continuously by day and night. The Contractor will be reimbursed the agreed extra costs, provided the necessity for the order is not a result of the Contractor's negligence.

1.14 Temporary Staging for Structures

Temporary staging shall be provided by the Contractor to enable the construction operations to be performed in the required sequence. The staging shall be properly designed and constructed for the loads which it will be required to support, and complete details of the arrangements proposed shall be submitted to the Engineer for approval.

Such approval, however, will not relieve the Contractor of his responsibility for the adequacy of the staging. The cost of such staging is to be included in the tendered rates and prices entered in the Bill Of Quantities (Volume 4).

1.15 Filling in Holes and Trenches

The Contractor, immediately on completion of any part of the work, shall, at his own expense, fill

up all holes and trenches which have been made or dug by him and are not part of the Works. Holes, cavities, trenches or depressions shall be backfilled with suitable materials and compacted to the grade required or as directed by the Engineer. The Contractor shall clear away all rubbish and materials that is no longer required for the execution of the work, whether his own or any other party to the satisfaction of the Engineer.

1.16 Protection of Works from Weather

The Contractor, at his own expense, shall protect all works and materials from damage by weather. All damage caused by adverse weather conditions, whether by flooding or intense heat or any other weather conditions shall be rectified by the Contractor at his own expense. Abnormal weather conditions shall not be considered any reason for a claim by the Contractor for compensation for damage.

1.17 Keeping the Works free from Water

The Contractor shall at his own expense keep the works at all times well drained and excavations whether above or below the normal water level of the water table free from storm or percolating water which may accumulate on the Site and which may interfere with progress of construction or has or is likely to have deleterious effect on the work in progress or the use thereof, by provision of temporary open drains and sub soil drains, diversion of ditches and other surface water channel or by pumping or other means as required.

1.18 Templates

When necessary the Contractor shall provide at his expense sufficient and approved templates for the purpose of controlling the finished shape of certain work. The templates will be in accordance with the Specifications and Drawings where such are provided.

All templates must be approved and shall be maintained in good order to provide the section required for the entire works. Templates may be checked from time to time and any deficiencies noted shall be rectified immediately.

The Contractor shall also supply straight edges and lines when required to control the work.

1.19 Interpretation of Drawings

The tender drawings referred to in this document are given in Volume 5.

The Employer's Representative accepts no responsibility for any omissions from or for correctness of the representation on the drawings of existing features.

1.20 Programme of Works

1.20.1 Effective Date

Unless otherwise stated in the Employer's letter of acceptance of Tender, the Effective Date shall be the date of that letter.

1.20.2 Commencement Date

The Commencement Date shall be the date on which the notice to commence is received by the Contractor.

1.21 Assistance to the Engineer

- The Contractor shall provide and maintain for the use of the Engineer such surveying and

engineering instruments as the Engineer may require for his duties. The Contractor shall provide the Engineer with all necessary assistance in checking the setting out of the Works and interpreting any information used by the Contractor for this purpose including the sole use of a minimum of three (3) chainmen.

- The Contractor shall provide the Engineer with all assistance, equipment and material required to document and record progress of the Works.
- The Contractor shall provide all assistance, equipment and material required by the Engineer for all the measurement of the Works for monthly valuation and for the final certificate payment.
- The Contractor shall be responsible for all follow up and co ordination with all the service departments. (Electricity, Water, Drainage, Street Lighting, Telephone, Horticulture, etc.).
- The Contractor shall provide all unskilled labour and necessary tools as directed by the Engineer.
- If at any time before the commencement or during the progress of the work it appears to the Contractor that for the proper execution of a specified part of the Works, shop drawings are necessary, these drawings shall be established by the Contractor and submitted to the Engineers' Representative for approval. The Engineer's Representative shall have authority to order at any time and the Contractor shall agree to provide any number of shop drawings which, in the opinion of the Engineer's Representative are necessary for the proper execution of a specified work. The Contractor shall not proceed with the above mentioned work until these shop drawings are approved by the Engineer's Representative. The Contractor shall not be entitled to any extra compensation or extension of time for the preparation of the above mentioned drawings.

These details shall be dimensioned in the metric system and shall describe accurately the method of fabrication, applied finish and sizes of all members and fixings and shall indicate methods of marking of components for site erection.

1.22 Specific Obligations

1.22.1 Sequence of Design and Construction

The Contract Programme to be submitted proposing in comprehensive detail a sequence of design and construction taking into consideration the staged construction required. The programme shall be accompanied by histograms showing the Contractors expected regular interim work valuations and the proposed variation in manpower necessary throughout the Contract Period to meet the Contract Programme.

The Contract Programme shall take account of all safety requirements and liaise with other Contractors working within or next to the area in order to minimise interference with the other Contracts and to keep disruption of public access within the area to a minimum.

The works are to be left in a safe and tidy condition to the complete satisfaction of the Engineer. Any road closures or traffic diversions must be arranged between the Contractor and the Roads Department and all costs involving any road closures or traffic diversions are deemed to be included in the Contractors rates.

The programme shall also make due allowance for the maintenance of access to all residential and commercial properties and for a sequence of work satisfactory to the Emergency Service Authorities in maintaining facilities for their operations should the need arise, and for the general safety of the public.

Particular attention is drawn to the problems, which may arise with the disposal of flows from

dewatering operations. Careful consideration must be given to the minimisation of surface disruption and obstruction and to the likelihood that permission for dewatering or other stabilisation operations from or through the surface of paved areas is unlikely to be granted.

Disruption of the existing service networks in the area must be avoided and this particularly applies to the existing water, sewerage, drainage and irrigation systems, and buried and overhead electricity cables. Consideration for maintaining the existing systems shall be allowed for in preparing the Contract Programme.

The Contractor shall take all necessary precautions and responsibility while crossing or carrying out works close to the vicinity of high voltage transmission towers and overhead transmission lines. No claim for damages or additional work arising from such damages will be considered by the Employer.

The Contractor shall pay particular attention to the problems of vehicular access in the areas of work. Vehicular access shall be maintained along roads affected by the works so far as possible. Should it become necessary to close a road then the Contractor shall obtain the necessary permits and arrange an alternative detour for the duration of the road closure. The details of road closures for traffic diversion should be submitted to the authorities and the Engineer for approval at least 14 days(2weeks) in advance of commencement of the works.

The Contractor shall restrict his hours of work to daylight hours only unless specific approval has been obtained from the authorities to carry out work during night time hours.

1.22.1.1 Confined Space Entry Safety Requirements

The Contractor's attention is directed to the requirements of safety during the execution of the Contract the following information is specifically required to be submitted as part of the Contract Program. No approval to the programme will be given until the Engineer is satisfied that adequate safety procedures exist.

- Entry procedures and instructions to staff working in confined spaces.
- It should be noted that there is NO confined space which may be considered safe and EVERY entry or re-entry into chambers, drains etc. should be treated with as much respect as entry into an obviously dangerous atmosphere such as a live sewer. There is ALWAYS the risk of accidental spillages/discharges upstream, which may cause contamination of an otherwise safe environment. These can occur at any time and without notice.
- Details of training provided to staff together with dates of original training and dates of subsequent refresher courses.
- Procedures to be followed in case of an incident, accident or emergency including liaison with the Emergency Service Authorities.
- Details of special safety equipment held and names of personnel certified for its use.
- Chart detailing both the Company and the contract management chains of command together with clearly defined areas of responsibility.
- All procedures must be in writing with clearly defined areas of responsibility. Where appropriate they should conform to accepted practices and procedures.

Copies of certain relevant publications are held by the Resident Engineer, in a bound volume entitled, 'Entry into confined spaces: Hazards and Precautions', to which reference may be made.

Particular problems of health and safety may arise with respect to non-disruptive methods of trenchless construction employed for new pipeline construction or for pipeline replacement or manhole renovation and the Contractor must ensure that adequate precautions and satisfactory working practices are adopted in the execution of such works to protect the health and safety of all

personnel engaged in executing the works and in their supervision.

1.22.1.2 Setting Out

The Contractor shall note that the alignment of pipelines and the location of chambers and other structures as indicated on the drawings are for guidance only. The specific setting out details, alignment and location, will be confirmed on site following the review of actual site conditions, detailed design, trial trenches and existing and proposed services.

1.22.2 Progress Reports, Photographs and Site Records

1.22.2.1 Progress Reports and Photographs

The Contractor will be required to submit to the Engineer, in an A4 format unless otherwise indicated, weekly and monthly progress reports (including progress photographs) as detailed below.

Reports shall be neatly presented and shall be submitted in triplicate along with an electronic copy on CD or DVD.

a. Weekly Reports

Weekly reports shall be submitted on the first working day of the following week. Weekly Reports shall include but not be limited to the following:

- Average, maximum and minimum daily ambient temperatures and humidity; all readings to be taken at one time.
- Rainfall data and general weather report.
- Contractors labour and plant returns in an A4 format to be agreed with the Engineer.
- Brief summary of work completed.

b. Monthly Reports

Monthly reports, including mounted selected photographs shall be submitted by the twenty-eighth day of the month concerned.

Monthly Reports shall include but not be limited to the following:

- Description of the extent and nature of the months work.
- Details of any problems relating to the Works with substantiating documentation if relevant
- Cumulative summaries of excavation and concrete quantities and lengths of pipeline laid and tested.
- Records of materials, equipment and plant tested with copies of test results where relevant.
- Charts illustrating progress achieved compared to the Contract Programme in an A4 or A3 format to be agreed with the Engineer.
- Charts illustrating the financial status of the Contract including value of works completed, certified and monies received in an A4 or A3 format to be agreed with the Engineer.
- Copies of site instructions and variations issued by the Engineer.
- Progress Photographs as detailed below.
- A detailed programme of work to be carried out in the following month in chart form to an A3 or A4 format to be agreed with the Engineer and a general summary of work for the

coming three months.

- Copies of the agreed weekly labour and plant returns.

c. Progress Photographs

The Contractor shall arrange to take monthly record photographs of the Works in progress. These photographs shall cover such extent of the Works as the Engineer shall direct and shall be sufficient to illustrate progress and work completed on each section of the Works. The days upon which the photographs are to be taken shall be decided by the Engineer.

The Contractor shall provide the Engineer on the last day of each month one set of progress photographs, with dates imprinted on it, which shall comprise the following:

- One colour negative of each photograph for an anticipated maximum of fifty exposures per month.
- Ten colour prints (294 x 210 mm) of each of a maximum of twenty of the negatives as selected by the Engineer.
- Electronics copies of the photographs in jpg format on CD or DVD.

The prints are to be processed by an approved professional and shall be in colour on heavy weight paper with matt finish. The photographs shall have computer produced descriptions incorporated thereon. Each photograph shall be provided with an approved clear plastic cover for binding.

The copyright of all photographs shall be vested in the Employer and the negatives, CD/ DVD and prints shall be delivered to the Engineer within 4 days of exposure.

1.22.3 Contract Correspondence

Unless the Contractor wishes to correspond directly with the Engineer on specific subjects all correspondence will be addressed to the Engineer's Representative and be submitted in duplicate.

1.23 materials and workmanship

1.23.1 Local and Environmental Requirements

All materials and manufactured items shall be suitable for the climatic and environmental conditions described in this specification.

The environmental conditions may be different in different parts of the Works and materials shall be selected and manufactured items designed accordingly to withstand the relevant corrosive elements. In particular:

- all products or materials in contact with sewage or a sewage environment shall be non-biodegradable.
- all products or materials in contact with potable water shall not constitute a toxic hazard, shall not support microbial growth, shall not cause taste or odour, cloudiness or discolouration of the water, and shall be approved by a recognised certifying authority as being suitable for use in potable water supply systems.
- all products and materials in contact with chemicals shall be suitable to withstand the corrosive effect of that chemical.

All local customs, laws and regulations relating to the supply or source of materials shall be complied with.

1.24 Quality Assurance

1.24.1 General

The Contractor shall apply a Quality Assurance system to the Contract and shall submit with his Tender details of his Company's Quality Assurance (QA) System, together with an Outline Quality Plan for the Contract.

1.24.2 Outline Quality Plan

The Outline Quality Plan submitted shall include:

- Company QA Policy Statement.
- Company Organizational Structure.
- Authority and Responsibility Schedule for the Contract.
- A programme for the preparation of the Full Quality Plan for the Contract and a programme for the execution of Quality Procedures on the contract, and any key sub-contracts.
- List of Quality Procedures and Instructions to be undertaken to assure quality standards (to be expanded in the Full Quality Plan).
- An Inspection and Test Plan where appropriate.

1.24.3 Contractor's QA System & Full Quality Plan

The Contractor's QA System and Full Contract Quality Plan shall meet the following requirements:

- (a) Be in accordance with the relevant requirements of ISO 9000.
- (b) Cover all aspects of the Contract works.
- (c) Co-ordinate his QA Systems with those of this Sub-Contractors and Suppliers to assure the quality of the works/services under the contract.
- (d) The Full Quality Plan shall give full details of:
 - Items (a) to (d) of the Outline Quality Plan
 - Procedures and Instructions to assure quality standards for all works on and off Site in respect of:
 - Contract Review
 - Design Control
 - Document Control
 - Purchasing
 - Sub-contract Administration and Control
 - Identification and Traceability
 - Supervision of Construction and Erection
 - Inspection, Measuring and Testing of Equipment
 - Non-conformances
 - Corrective Action
 - Handling, Storage, Packaging and Delivery

- Internal Quality Audits and Audit Programme
 - Programme
 - Training
- (e) The Full Quality Plan shall be submitted for approval within 4 weeks of the date of commencement of any Site works. Any changes to the Full Quality Plan shall be agreed in writing prior to implementation.
- (f) The Contractor's QA System shall be applied at all times to all aspects of the Contract and shall only be changed or not applied with the agreement of the Employer's Representative.

1.24.4 Quality Audits

- All of the Contractor's Internal Quality Audit findings shall be made available to the Employer's Representative on request.
- All non-conformances shall be reported to the Employer's Representative with proposals for resolution.
- The Contractor shall co-operate with all audits undertaken or organised by the Employer's Representative.

1.24.5 Quality Reports

The Contractor shall prepare and submit monthly Quality Reports for the approval of the Employer's Representative no less than 3 days prior to the monthly regular Progress Meeting.

1.24.6 Tests on Completion

Tests on completion shall form part of the Commissioning procedure and shall include tests on plant and structures followed by tests on the whole water treatment works to demonstrate that all items of plant and systems are capable of operating in accordance with the Specification and Works Operation Manuals provided by the Contractor. A Taking Over Certificate shall be issued by the Employer on satisfactory Commissioning and Tests on Completion.

Details of the Tests on Completion are given in Volume 2 Section 6.

1.25 Training, Maintenance, Manuals, Spares, Etc.

1.25.1 Training Facilities

Comprehensive training facilities shall be provided for the Employers operation and maintenance personnel, to enable them to become familiar with the operation and maintenance of the plant. Training shall be carried out during the one year operation period following commissioning and will include on Site training of the Works Manager designate and operatives who will form part of the operations staff supervised by the Contractor as described in Volume 2 Section 7.

The programme of training shall also include a course of lectures, instructions, demonstrations, and actual fault finding exercises covering both hardware and software aspects of the plant.

The course shall also include fault finding, replacement and assembly techniques and the development of programmes for maintenance purposes.

1.25.2 Maintenance

The whole of the plant shall be designed such that maintenance in situ is reduced to a minimum. Equipment should be easily removable from service and readily replaced by standby/spare equipment.

Routine checking and maintenance of all equipment should not be necessary more than once per 3 month period.

Comprehensive maintenance documentation including fault tracing and clearance procedures shall be provided.

Diagnostics and test programmes shall be provided for the equipment.

1.25.3 Operation and Maintenance Manuals

Four sets of fully detailed operation and maintenance manuals covering all items of equipment comprising the whole data acquisition, monitoring and control system shall be provided.

1.25.4 Spare Parts and Special Tools

The Contract shall include for recommended spares for five years' operation as specified in the tender document.

Any special tools necessary for the assembly, dismantling, alignment, calibration and maintenance of the equipment shall also be included.

1.25.4.1 Commonality of Plant

To minimize training and spares holding the Contractor shall reduce to a minimum the number of equipment manufacturers/suppliers and the model types of components used throughout the works at no significant additional price.

1.26 As-built Records

Complete and As-Built Record Drawings shall be prepared by the contractor for submission to the Employer.

The Contractor shall supply three sets of finalised and approved record upon completion of the works in the latest CAD DWG format on CD or DVD. The record drawings will use the prevailing co-ordinate system unless otherwise specified by the Engineer.

1.27 Performance Guarantees

The Contractor shall provide Performance Guarantees as set out in the appendix to Volume 1.

1.28 Project Management

The Contractor shall be required to use a suitable PC - based project management software package for the production and revision of programmes, cashflow programmes and "earned value" progress/cost reporting.

In addition to the requirements of Clause 4.15 of the Conditions of Contract the Contractor's Monthly Progress Reports shall include an updated detailed programme together with a corresponding revised cash flow forecast, an Activity Completion Report and "earned value" progress/cost reports.

Details of the format for submission of the above information shall be determined and agreed between the Employer's Representative and the Contractor before construction commences.

1.29 Construction Documents for Approval

1.29.1 General

Construction documents required for approval by the Employer's Representative shall be submitted in accordance with the provisions of Clause 5.2 of the Conditions of Contract.

All drawings submitted by the Contractor shall be provided on an on-going basis as the design proceeds and in the form of black lines on a white background and shall bear a title block, the format of which will be agreed. Drawings shall not exceed A0 size.

All drawings shall be produced, checked and quality assured by the Contractor in accordance with an approved quality assurance system.

All layout and arrangement drawings shall be to scale and shall include a graphical scale to aid the use of photographic reproductions. All dimensions shall be given in metric units.

All drawings issued for construction shall be produced on a CAD system, with software that includes a DXF file interchange facility.

A programme of drawing production shall be provided by the Contractor within four weeks of award of contract giving clear details of his schedule for completion of the remaining drawings.

1.29.2 Submissions During Contract

Under Part 2, Clause 5.2 (Construction Documents) of the General Conditions (Part I) the Contractor shall submit drawings to the Employer's Representative for his approval at the stages described in this Clause as follows:

- General Layout and Process Design
- Preliminary Design Drawings and Documents to allow detailed design to proceed.
- Detailed Design Drawings and Documents before the start of Construction.
- Concrete Mix
- List of suggested supply of main equipments (minimum 3 qualified suppliers of equipment for each item)

The Contractor shall submit a submittal register showing the submittal number, title, first issue date, revision/date status, issue/date status. All revisions to submittals shall show the revision number and area of change.

1.29.3 Preliminary Design Drawings and Documents

Within the period stated in Volume 2 Section 1 - Clause 1.20 (Programme of Works) of the Employer's Requirements), the following Preliminary Drawings and Documents shall be submitted by the Contractor for approval:

- Architectural elevations and plans
- Outline foundation and building drawings
- Road and hardstanding layout drawings
- Landscaping
- Process flow diagrams
- P & I diagrams of the plant for water treatment works
- General layout of mechanical and electrical equipment
- Hydraulic profile for water treatment works
- General pipework layouts
- General electrical wiring and schematic diagrams
- Cable routing diagrams

- M&E Plant Performance Data
- Detailed Contract Programme of Work
- Contract Cash Flow Programme

The Contractor's Cash Flow Programme to be submitted to the Employer's Representative shall be derived from the Schedule of Prices (Part 4) and from the Contractor's Programme of works. The two shall be presented in such a manner as to facilitate ready monitoring of costs of the whole scheme by the Employer's Representative, by the addition of each individual element of the works (as defined in the Schedule of Prices with time). This is especially necessary since individual elements of work may shift in time scale within the overall programme for the scheme. Each item in the schedule of prices shall be itemised on the Cash Flow Programme. The cost of an item shall be spread out over the relevant number of months; and by addition of the monthly totals for all items, the grand monthly total shall be calculated and indicated.

Both the Detailed Contract Programme of Work and the Contract Cash Flow Programme shall be updated monthly by the Contractor and submitted to the Employer's Representative in accordance with Clause 4.15 of the Conditions of Contract.

1.29.4 Detailed Design Drawings and Documents

The following Detailed Drawings and Technical Documents shall be submitted for approval before the start of construction:

- Water Treatment Works design
- Building details
- Structural details
- Longitudinal pipeline sections and hydraulic gradients
- Pipeline layout and connection details
- Instrument locations, layout and schedules
- Cable block diagrams, schedules and termination schedules
- Routing diagrams of all services
- Switch and control gear general arrangements, line diagrams and schematic wiring diagrams
- Earthing arrangements
- Site lighting
- Building services details including details of lighting, small power, fire alarm system
- Schematics for electrical building services
- Landscaping
- A document outlining the application of Safety considerations to the design of the Plant.

1.29.5 Calculations

The following calculations shall be submitted for information before the start of construction:

- Structural design of substructures, superstructures and pipelines including the basis upon which the structural design of the plant has been prepared including details of:
 - Concrete exposure categories for each surface.

- Cover to reinforcement.
- Type of reinforcement.
- Type of cement and maximum and minimum cement content.
- Water cement ratio.
- Interpretative report of the ground conditions.
- Assumptions made for the behaviour of the structures for the structural design of the plant.
- Hydraulic and process design of the water treatment works.
- Electrical calculations including those for all installations subject to the 16th Edition of IEE Wiring Regulations, including:
 - Cable sizing
 - Volt drop
 - Short circuit protection
 - Shock protection
 - Earthing
 - Electrical protection grading
- Transformer sizing calculations.
- Electrical building services calculations.
- All system curves for pumping system incorporating specific pump characteristics.
- Chemical storage calculations.
- Dosing pump sizing and chemical feeder calculations.
- Air blower sizing calculations.
- Any other calculations requested by the Employer's Representative.

1.29.6 Requirements for Instrumentation Drawings

Instrumentation schematic diagrams shall show the connections between all apparatus included in the Contract and also those connections to associated equipment which may be existing or supplied by the Employer. These schematics shall also show all ferrule numbers. Symbols shall comply with BS EN 60617, BS 7845, BS 1646 (or approved equivalent).

All wiring diagrams shall include a schedule of apparatus which shall explain any symbols or abbreviations used, and shall show clearly the details of multicore cables terminated in the equipment, whether such multicore cables are supplied under the Contract or not.

The Drawings covering the instrumentation and process control installation shall comprise the following:

- Engineering flow diagrams, which are schematic diagrams of the equipment, piping and control systems making up the plant or process.
- Simple symbolic instrumentation loop schematic (BS 1646 Part 1).
- Detailed symbolic interconnection schematics (BS 1646 Parts 1 to 4 inclusive).
- Instrumentation loop schematics showing the connection between the components of

instrument and control loops, and identifying pneumatic and wiring connections, terminals, cable and core numbers (as applicable).

- Logic Diagrams and control schematics showing the schematic logic interlock, shut-down systems and special control circuits.
- Instrumentation location drawings. Area layout drawings showing the approximate location of the instruments, tapping points, panels, control valves, the routing of air headers, transmission wiring.
- Instrumentation installation drawings showing mounting arrangements for the various instruments, with an itemised materials list for each arrangement.
- Panel layout drawings showing the positions of instruments mounted on panels and overall panel dimensions.
- Panel piping and wiring diagrams. Panel layout and the position and connections for incoming multicore cables.
- Multicore cable routing. Overall plot plan showing the approximate locations of the main junction boxes and the routing of the multicores. Cable trench cross sections and cable tray layouts shall also be shown
- Junction box layout drawings showing details of individual junction boxes, showing location, cabling connections, terminal details and identification.
- Line diagram of earthing arrangements.
- All instrumentation diagrams shall include the following details:
 - Instrumentation nomenclature
 - Instrument duty
 - Type of instrument and manufacturer
 - Range
 - Count factor (where applicable)
 - Basic specification
 - The level of all inputs, and power supplies
 - Comments
- ICA and SCADA system architecture and communications.
- SCADA system mimic and trend displays and report formats.
- Software/ladder logic diagrams for PLCs.
- Any other calculations requested by the Employer's Representative.

1.29.7 Requirements for Mechanical and Electrical Drawings and Documents

The drawings for Mechanical and Electrical works shall include:

- Plant layout drawings for each treatment process.
- Full details of all items of mechanical and electrical plant together with the manufacture's literature, specifications, and drawings for each item.
- Electrical single line diagrams.

- Schematic diagrams (one drawing for each motor starter).
- Power cable layouts and schedules.
- Equipment and earthing layouts.
- Distribution board schedules.
- Method statement detailing the proposed method of construction of the Plant, the connection to existing plant, giving particular consideration to any procedures necessary to maintain the output of the existing plant.
- Protection discrimination curves and calculations for the whole plant including co-ordination with electricity suppliers supply and protection.
- A schedule itemizing all materials proposed for inclusion in the Works that come into contact with potable water, together with approval reference.
- A document itemizing all sampling proposals through the process stream.
- A draft document giving proposals for connections to and diversions of operational mains and services, testing proposals (construction completion, take-over and performance) and training to be carried out by a designated Training Manager for all Operational Staff involved.
- Data Sheets for instruments, control valves, actuators and primary elements.
- Equipment installation briefs.
- Works and Site acceptance test specifications.
- A document outlining the application of Safety considerations to the design of the Plant.

1.29.8 Drawings and Documents before Tests on Completion

The following Drawings and Documents shall be submitted 6 weeks before the Tests on Completion are due to start.

- A full and detailed program and details of staff and consumables for the Operation and Maintenance of the works for a period of three years following Taking Over.
- A full and detailed program for training the Employers staff in operation and maintenance procedures for the Works.
- A draft of the General Operating Manuals as detailed in 1.30 (Final Drawings and manuals).
- A draft of the Operating and Maintenance Manuals for individual items of Plant as detailed in 1.30 (Final Drawings and manuals).
- A full and detailed program for the Tests on Completion.

1.29.9 Approval of Main Equipment

Full information, as detailed below, for all proposed main equipment shall be submitted to the Employer's Representative (at the beginning of the works or if modified).

- Prior to the placing of any order of the above, a Request for Approval including propositions from three different suppliers for each material or manufactured item shall be submitted in triplicate. The information for each supplier shall be clearly and neatly presented in a standard format to be agreed with the Employer's Representative. Two weeks should be allowed for approval and no orders shall be placed until one copy of the Request for Approval has been returned duly signed and dated. The information required is as follows:
 - Name and address of proposed supplier or manufacturer.

- Reference numbers and title of relevant specifications of a recognized national or international standards organization with which the materials or manufactured items will comply together with copies of the specifications in English where required by the Employer's Representative.
- Samples of materials representing the quality of the bulk of such materials the Contractor proposes to use.
- Manufacturers' literature and data sheets for articles and fabricated items.
- Sufficient information to demonstrate that the materials or manufactured items are suitable and comply with the Specifications.
- Any other information called for in particular clauses of the Specifications.
- Following approval of these main equipment, detailed drawings and installation drawings shall be submitted for approval in three copies.
- Prior to dispatch to Site or to a designated place of storage the following shall be provided:
 - Facilities for inspection and testing at suppliers' pits or quarries, manufacturers' works or at approved independent testing centers as appropriate. Inspection and/or witness testing may be carried out by the Employer's Representative or other Inspector appointed by the Employer.
 - Details of the supplier's or the manufacturer's quality control test procedures and copies of test certificates.
 - Shipping and consignment identification details.

1.29.10 Review of Construction Methods

For all elements of the Works, Contractor's Proposals including fully detailed method statements describing proposed construction techniques and program for execution shall be submitted to the Employer's Representative in duplicate. These shall be supported, where applicable, by calculations for temporary works for supporting excavated faces and shuttering of concrete.

1.30 Final Drawings and Manuals

The following information shall be submitted to the Employer's Representative in draft prior to Commencement of Tests on Completion for the plant. Final copies shall be supplied within one month of issue of Completion Certificate.

1.30.1 Manuals

- Four copies of A4 size hard bound, loose-leaf style General Operating Manuals, giving detailed descriptions of the operation of the plant and of the electrical control scheme. The manuals shall include step by step procedures for the shut-down and start-up of the plant under both manual and automatic control in both normal and emergency conditions. They shall also include a fault finding and rectification procedure chart, and all structural, process and hydraulic design calculations.
- Four copies of Operating and Maintenance Manuals for the individual items of mechanical, electrical, instrumentation and control plant, including manufacturer's technical literature and diagrams. These manuals shall include a comprehensive list of essential and significant spares (for five years operation) and special tools required for the operation and maintenance of the plant.

The manuals shall include maintenance and lubrication schedules and check lists with time

intervals for all equipment.

The individual manuals shall be of A4 size hard bound, loose-leaf style.

The Operating and Maintenance Manuals and spares function shall be based on a computer based "screen enquiry" system.

- Detailed documentation for Mechanical, Electrical and ICA equipment shall generally be in accordance with the Specification also with the following requirements:
 - All bound or loose format documents shall contain an approval sheet and revision history sheet, if any.
 - All loose leaf format documentation shall be page numbered, with each page showing the document number and revision level.
 - All changes to documents shall show the revision number and area of change.
 - Detailed documentation covering the instrumentation and process control hardware installation shall comprise:
 - Instrument schedule listing all instrument nomenclature and specifications for each instrument.
 - Cabling sizes, connection points, core identification and relevant technical information.
 - System documentation describing in detail the hardware configuration of the particular system supplied.
 - Detailed software and facilities documentation for the following:
 1. System software definition - covering the agreed functional description of the system plus the detailed program documents.
 2. Program index - covering all software components comprising the system and related listings.
 3. System build definition - parameters required to create the software system.
 4. System data - general definition of the internal data structure of the system.
 5. Commented program listings:
 - Programmers notes, Variable definitions, I/O Map
 - Minimum one comment per line, rung or instruction
 - I/O tag, description, address, rack/slot/channel, synonyms and mnemonics to be shown
 - Listings to have document name, number and revision status coded into headers
 - Listing to be bound, tabbed and indexed to allow location areas of code from knowledge of I/O and location of I/O from knowledge of code or function
 - 6. Maintenance Manuals:
 - Equipment power-up, power-down
 - Load, boot and reboot
 - Disc (or other medium) load
 - Utilities instruction, Access/security (password) instruction
 - Full operational instruction

Fault finding and troubleshooting in the event of alarms (one by one or grouped), equipment failure, diagnostic messages, etc.

(Proprietary literature may be referred to by number)

7. Operator Manuals:

Start-up/shut-down, Functional descriptions

Operator functions, actions and expected responses

First line diagnostics

- Functional Design Specification, as defined in Volume 3 Part B Section 3 - Standard ICA Specification.
- All manuals shall contain references to tag numbers for all items of equipment, instrumentation and cables.

1.30.2 Drawings

The following drawings shall be submitted:

- A coloured process diagram at least 2 m x 1 m manufactured from colour fast durable materials and covered with transparent perspex and wall mounted in the control room.
- One copy on disk in AutoCAD DWG format, plus one hard copy of all "as installed" drawings and diagrams.

In addition to the record drawings, the Contractor must obtain and provide four sets of manufacturer's detailed drawings of all items of plant and equipment suitably titled, with drawing reference numbers added, and giving the following information:

- dimensions and weights, operating and maintenance clearances
- lifting/cranage detail, cable entry points
- equipment list, internal layouts, front panel layouts
- I/O schedules and rack/card layouts, terminal layouts
- Wiring schedules, wiring/circuit diagrams, cable/cordset schedules

1.30.3 Revisions to Manuals and Drawings

Prior to issue of the Performance Certificate, any revisions to operational and maintenance manuals and drawings found necessary during the Operation and Performance Testing period shall be submitted to the Employer's Representative.

1.30.4 Spare Parts and Special Tools

Prior to the issue of the Taking Over Certificate the Contractor shall supply full details of all the spare parts and special tools to be provided under the Contract in accordance with Volume 2 Section 1, Clause 1.25.4.

SECTION 2 – PROCESS REQUIREMENT

CONTENTS

2.1	General Description.....	3
2.1.1	Mseilha WTW Design Principles.....	3
2.1.2	Raw Water Sources.....	3
2.1.3	Statistical Analysis of Raw Water Data.....	3
2.1.4	Treatment Works Capacity.....	4
2.1.5	Conceptual Approach.....	4
2.1.6	Treated Water Quality Requirements.....	4
2.1.7	Sampling.....	6
2.2	Process Design.....	7
2.2.1	Introduction.....	7
2.2.2	Influent Metering.....	7
2.2.3	Cascade Aerator.....	8
2.2.4	Rapid Mixer.....	8
2.2.5	Clariflocculator.....	9
2.2.6	Skimming Device.....	10
2.2.7	Distribution / Collection Box.....	12
2.2.8	Rapid Gravity Filters.....	12
2.2.9	Clear Water Tank.....	18
2.2.10	Main Pumping Station.....	18
2.2.11	Chemical Dosing Room.....	21
2.2.12	Post Chloriation.....	21
2.2.13	Gantry Cranes.....	21
2.2.14	Chlorination System.....	23
2.2.15	Control Philosophy.....	34
2.2.16	Post Chlorination.....	35
2.2.17	Storage and Pumping.....	35
2.3	Laboratory Facilities.....	36
2.4	Treatment Works Layout.....	37
2.5	Provisions For Future Plant.....	38
2.6	Plant Overflows.....	38
2.6.1	General.....	38
2.6.2	Overflow Locations.....	38
2.6.3	Prevention of Overflows.....	38
2.7	Pipework and Drainage.....	39
2.7.1	General.....	39

2.7.2 Isolation Stop Logs 39

2.7.3 Process Pipework 39

2.7.4 Drainage 39

2.7.5 Service Water System 39

2.7.6 Firefighting Water System..... 40

2.8 Mechanical Lifting Equipment 40

SECTION 2 - PROCESS REQUIREMENTS

Important Note: The conceptual process design provided as part of the present section and in other parts of the tender documents should be considered as base solution; therefore, the contractor should prepare his own design that should be based on the criteria and dimensions and number of structures given in the tender drawings and documents.

2.1 General Description

2.1.1 Mseilha WTW Design Principles

In view of the specific needs in Lebanon it is required that the process plant and ancillary systems are:

- Applicable to the specific water treatment needs, which are defined in this section
- In line with environmental standards
- Not chemically demanding as most chemicals will be imported into Lebanon
- Of appropriate up to date designs but with proven large scale track record
- Not complicated and not highly dependent on machinery that requires much maintenance or regular replacement parts
- Reliably automated.
- Requiring the least area possible.

The Contractor shall be responsible for the detailed process design, sizing and performance of the Works to satisfy Treated Water Quality Requirements and hydraulic constraints also defined in this Section.

2.1.2 Raw Water Sources

The raw water supply to the treatment works will be delivered from the Mseilha Dam Reservoir.

2.1.3 Statistical Analysis of Raw Water Data

As part of tender submission, Contractor has to carry out necessary water analyses and data collection campaign in order to produce a detailed statistical analysis of the seasonal raw water quality to select the raw water parameters as the design basis for water treatment works to achieve the required performance levels. The selected raw water parameters should be based on sound engineering principles, mathematical statistics and should have adequate factor of safety for higher loads.

Contractor is responsible for the selection of raw water quality parameters and design of water treatment plant to achieve the required performance level. Contractor should confirm in his tender submission that the performance levels required under the contract are achievable.

Successful contractor shall further submit the final statistical analysis of the raw water quality analysis to select the raw water parameters for Engineer's approval incorporating comments/recommendations made and agreed during tender evaluation.

2.1.4 Treatment Works Capacity

The treatment works shall be designed to produce 0.35 m³/sec of treated water.

The Works layout shall permit future extension (Phase 2) for a doubling of the capacity to 0.7 m³/sec.

2.1.5 Conceptual Approach

The process consists of the following features:

- Cascade Aeration
- Coagulation - Flash mixing
- Clariflocculation
- Rapid gravity filtration
- Disinfection
- Storage in Clear water tank
- Pumping of treated water to distribution reservoirs.

2.1.6 Treated Water Quality Requirements

The Requirements of the Final Treated Water Quality Parameter Values shall be met by the new treatment plant at all times providing the raw water quality and plant throughout are within the design range. The effluent quality shall be as per LIBNOR NL 161 and/or 98/83/EC Standard.

Table 2-2.1 states the Final Treated Water Quality Parameters. They will form part of the performance guarantees given in the appendix to volume 1.

Table 2-2.1 - WTW Final Treated Water Quality Requirements

Based on LIBNOR NL 161 and/or 98/83/EC Standards for Water intended for Human Consumption (Parameters which can be affected by treatment are specified).

PART A – Microbiological Parameters

Parameter	Parametric value (number/ 100 ml)
Escherichia coli (E. coli)	0
Enterococci	0

The following applies to water offered for sales in bottles or containers:

Parameter	Parametric value
Escherichia coli (E. coli)	0/ 250 ml
Enterococci	0/ 250 ml
Pseudomonas aeruginosa	0/ 250 ml
Colony count 22°C	100/ ml
Colony count 37°C	20/ ml

PART B – Chemical Parameters

Parameter	Parametric value	Unit	Notes ¹
Acrylamide	0.10	µg/l	
Antimony	5.0	µg/l	
Arsenic	50	µg/l	
Benzene	1.0	µg/l	
Benzen(a)pyrene	0.010	µg/l	
Boron	1.0	mg/l	
Bormate	10	µg/l	
Cadmium	5.0	µg/l	
Chromium	50	µg/l	
Copper	1.0	mg/l	
Cyanide	50	µg/l	
1,2-dichloroethane	3.0	µg/l	
Epichlorohydrin	0.10	µg/l	
Fluoride	1.5	mg/l	
Lead	10	µg/l	
Mercury	1.0	µg/l	
Nickel	20	µg/l	
Nitrate	45	mg/l	
Nitrite	0.050	mg/l	
Pesticides	0.10	µg/l	
Pesticides- Total	0.50	µg/l	
Polycyclic aromatic hydrocarbons	0.10	µg/l	
Phenolic Compounds	0.001	mg/l	
Mineral Oil	Nil		
Selenium	10	µg/l	
Tetrachloroethene and Trichlorethene	10	µg/l	
Trihalomethane - Total	100	µg/l	
Vinyl chloride	0.50	µg/l	

PART C – Indicator Parameters

Parameter	Parametric value	Unit	Notes
Aluminium	200	µg/l	

¹ Refer COUNCIL DIRECTIVE 98/83/EC of 3 November 1998 on the quality of water intended for human consumption (Official Journal of the European Communities)

Parameter	Parametric value	Unit	Notes
Ammonium	Nil	mg/l	
Chloride	250	mg/l	
Clostridium perfringens (including spores)	0	number/100 ml	
Colour	Acceptable to consumers and no abnormal change		
Conductivity	1500	$\mu\text{S cm}^{-1}$ at 20°C	
Hydrogen ion concentration	6,5 and 8,5	pH units	
Iron	300	$\mu\text{g/l}$	
Manganese	50	$\mu\text{g/l}$	
Zinc	5	mg/l	
Odour	Acceptable to consumers and no abnormal change		
Oxidisability	5.0	mg/l O ₂	
Sulphate	250	mg/l	
Phosphate (P ₂ O ₅)	1	mg/l	
Sodium	150	mg/l	
Calcium as CaCO ₃	200	mg/l	
Chloride (Cl ⁻)	200	mg/l	
Total Hardness as CaCO ₃	250	mg/l	
Taste	Acceptable to consumers and no abnormal change		
Colony count 22°	No abnormal change		
Coliform bacteria	0	number/100 ml	
Dissolved Solids	500	mg/l	
Organic matter	0.5	mg/l	Note 6
Hydrogen Sulfide (H ₂ S)	0.05	mg/l	
Total organic carbon (TOC)	No abnormal change		
Turbidity	5 NTU*		

2.1.7 Sampling

Facilities for manual sampling shall be provided. 3 nos. automatic sampling will be required for quality measurements i.e. pH, Turbidity, Chlorine.

Manual sampling shall permit running sampling lines to waste for a period sufficient to ensure that old sample water has been displaced.

The sampling tap arrangement shall be such that sample bottles can be flushed with sample water

and fully filled.

Quality monitors shall be provided where specified. Unless there is adequate gravity sample flow, duty and standby sampling pumps shall be provided.

The sample flows shall be continually monitored and if inadequate, the standby sample pump shall be started and the duty pump stopped and an alarm raised.

Sample lines shall be kept as short and small as possible in order to minimise measurement delays.

All quality monitors shall be mounted in a manner in which allows easy servicing and maintenance.

2.2 Process Design

2.2.1 Introduction

Details of the process design and outline drawings of process units and structures are given in the Tender Drawings (Volume 5).

The Process Stream of the Mseilha WTW shall have the following main features:

- Cascade Aeration
- Coagulation - Flash mixing
- Clariflocculation
- Rapid Gravity Filtration
- disinfection
- Works output metering
- Overflows
- Chemical storage, preparation and dosing systems
- Automatic plant operation and control systems

All materials used in the construction of the works shall be suitable for use in contact with potable water and shall be suitable for resistance of chemical attack where in contact and shall be approved by the Employer's Representative.

All process units shall be designed so as to prevent entry by vermin.

2.2.2 Influent Metering

An ultrasonic flowmeter shall be installed in a flowmeter chamber. The flow meter shall have all fittings to allow easy maintenance and isolation. It shall provide local and remote instantaneous and cumulative flows. Both parameters shall be displayed on HMI screen provided with the MCC panel.

2.2.3 Cascade Aerator

Cascade aerator consist of stepped structure with no mechanical or electrical control.

Design Parameter for cascade aerator	Phase I	Phase II
Number of Units	1	2
Inlet channel width (m)	1.2	1.2
Inlet channel depth (m)	1.5	1.5
Outlet channel width (m)	1.2	1.2
Outlet channel depth (m)	1.5	1.5
Number of steps	6	6
Step dimensions (m) Horizontal / Vertical	0.4 / 0.3	0.4 / 0.3
Width per unit (m)	8.8	8.8
Surface area per unit (m ²)	24.64	24.64

2.2.4 Rapid Mixer

The role of the Rapid mixer, or flash mixer or quick mixer is to rapidly and uniformly disperse a coagulant through the mass of the water. The process usually occurs in a small basin immediately preceding or at the head end of the 'coagulation basin'. This process is used to generate a homogeneous mixture of raw water and coagulants which result in the destabilization of the colloidal particles in the raw water to enable coagulation. Mixing can be provided by pumps, venture flumes, air jets or rotating impellers (paddles, turbines, or propellers). Where possible, the rapid mix should be a two-compartment unit. Design parameters for rapid mix are as follows:

- Velocity Gradient 300 – 1500 s⁻¹
- Detention time. 10 – 60 sec
- Basin Depth 2 – 4 m
- Rotational Speed 20 – 100 rpm

The proposed design criteria of the flash mixer are shown in the below Table.

Flash Mixer Proposed Design Data

Design Parameter	Phase I	Phase II
A: Flash Mixer		
Number of Units	2	4
Duty	2 in normal operation	4 in normal operation
Standby	NA	NA

Design Parameter	Phase I	Phase II
Type of Mixer	Mechanical, vertical shaft, paddle type	Mechanical, vertical shaft, paddle type
Flow Per Mixer (m3/h)	687.5	687.5
Velocity Gradient (s-1)	332	332
Peripheral Velocity of paddles (m/s)	1.13	1.13
Type of Motor Control	VFD	VFD
Rotational Speed (rpm)	30	30
Mixer Power (kW)	1 kw	1 kw
Flash Mixing Tank detention time (s)	48	48
Flash Mixing tank volume (m3)	9.07	9.07
Flash Mixing Tank Depth (m)	3.8	3.8
Free Board (m)	0.6	0.6
Flash Mixing Tank Diameter (m)	1.9	1.9
Mixer shaft and paddles material of construction	SS 316	SS 316

The design should allow the coagulant aids to be added first. The raw water should have the proper pH and alkalinity, and have other aids like polymers present before the flow enters the mixer chamber.

It is important to add the coagulant aid far enough upstream that the pH adjustment occurs before the coagulant is added. The raw water should be tested for pH, alkalinity, turbidity, temperature, tastes and odors, and color. pH should also be checked after coagulation.

Jar tests should run on the raw water to determine the optimum coagulant dosage. The amount of coagulant needed for good floc formation can be affected by changes in the raw water quality. Raw water should be checked for turbidity, pH, alkalinity, temperature, color, and tastes and odors. Floc does not form as well or as fast in colder temperatures requiring higher coagulant doses. Changes in pH will change the amount of coagulant aid needed. Changes in turbidity will have an effect on the amount of coagulant required.

2.2.5 Clariflocculator

Clariflocculator is a combination of flocculator and clarifier designed to attain economic and speedy construction. It shall have two concentric tanks where inner tank serves as a flocculation basin and the outer tank serves as a clarifier. Clariflocculators generally are used to perform the chemical primary treatment of effluents. Contractor must use superior quality material for manufacturing the clariflocculator and keep a stringent check during the entire process to make that superior final output is delivered.

The design must enable the clariflocculator to handle heavy slugs while delivering shortest floc settling time.

2.2.6 Skimming Device

A skimming mechanism is required by the client to remove floating debris, solids, which floats on effluent surface. It shall comprise of:

- Rotating Skimmer
- Scum Scraper
- Scum Box.

Neoprene Rubber wipers are generally provided. The scum scraper collects the scum and drops it in scum box, which is connected to withdrawal piping. A scum skimming arm, supported on one of the scrapper arm, is provided for removal of floating debris, solids. The collected scum is pushed by a level-loaded or spring loaded scraper into a scum box. Through this scum box the scum drains off the paddle and pipe. Thus floating scum is taken out from the clarifier.

The Clariflocculator shall consist of a rotation unit with central drive including a gear motor and slewing ring, a high efficiency turbine, a bottom scraper system having two blade holder arms, a central deflector cylinder which defines the mixing and flocculation compartment and a peripheral weir. The control and drive unit is located in the middle.

It shall comprise an electric motor, a multistage reduction unit of coaxial and/or planetary type and a slewing ring with hardened and tempered teeth of adequate size. The protection against overloads is carried out by an electronic torque limit switch for diameters up to 20 meters while as regards the diameter equal to or greater than 20 meter, an adjustable dynamometric torque limit switch complete with alarm signaling device is required. The gear motor to drive the turbine is located in the middle of the slewing ring and since it has a variable speed, the coagulants mixture is optimized and the floc precipitation made easier. The sludge scraper blades remove the sludge precipitated to the sloping bottom of the tank and gathers it in a central ditch wherefrom it is then sucked. The clarified water is removed by means of the weir. The scraper and any moving parts of the bridge are supported and moved only through the central slewing ring bearing.

This way, the sedimentation tank volume, free from any parts in motion allows, for example (if needed in the future), the installation of lamella packs in its inside and it avoids the maintenance on the clarifier edge required if the bridges is peripheral driven type, in correspondence of the traction trolleys. A walkway for the inspection on the central unit shall be provided. Bridge construction shall consist of hot dip galvanized steel. All immersed parts shall be SS316.

The flocculator shall be designed based on the following criteria:

- Detention Time 10 – 40 minutes
- Velocity Gradient 10 – 75 s⁻¹
- Tank Depth 3 – 4.5 m
- Peripheral Velocity of Paddles 0.2 – 0.6 m/s

The proposed design criteria of the clariflocculator are shown in the below table.

Clariflocculator Units Design Data

Design Parameter	Phase I	Phase II
B: Clariflocculator Unit		
General		
Number of Units	2	4
Duty	2 in normal operation	4 in normal operation
Standby	NA	NA
Design Flow per unit (m ³ /hr)	687.5	687.5
Type	Circular, Central Driven	Circular, Central Driven
Flocculator		
Number of Flocculator per unit	2	2
Type of Flocculator	Vertical Shaft, Paddle type	Vertical Shaft, Paddle type
Power of each Flocculator (W)	~ 500	~ 500
Velocity Gradient (s ⁻¹)	36	36
Peripheral Velocity of paddles (m/s)	0.2 – 0.6	0.2 – 0.6
Rotational Speed (rpm)	2 – 4	2 – 4
Detention time (min)	33	33
Volume (m ³)	380	380
Total Area of Paddles (m ²)	~ 14	~ 14
Diameter of Flocculator tank (m)	11	11
Clarification Unit		
Detention Time	3	3
Overflow rate (m ³ /m ² /day)	35	35
Required Clarification Area (m ²)	472	472
Overall Diameter (m)	28	28
Water Depth (m)	4	4
Free board (m)	0.8	0.8
Depth below partition wall	1	1
Depth provided for sludge storage (m)	0.75	0.75
Length of Weir (m)	82	82
Weir Loading (m ³ /h/m)	8.4	8.4
Tip Velocity of Scraper (m/s)	1 – 2 m/s	1 – 2 m/s
Rotational Speed (rpm)	~ 0.1	~ 0.1

Design Parameter	Phase I	Phase II
Floor Slope	8%	8%
Scraper motor Power (kW)	~ 5.5	~ 5.5

2.2.7 Distribution / Collection Box

A Distribution box shall be provided to collect the flow from the Flash mixers and divide it into 2 streams going to the Clariflocculators. The same unit will also allow the collection of the flow coming from the clariflocculators before going to the gravity filters.

2.2.8 Rapid Gravity Filters

Filtration is the final step in the removal of chemical impurities in water. Any organic or inorganic particles that have not been removed during the sedimentation process must be filtered out in order to meet the effluent turbidity requirement. The turbidity of the water in the filter influent should not exceed 15 NTU's, and should actually be less than 5 NTU's, or filter runs will be reduced dramatically. When the filter becomes dirty it must be backwashed. Since the backwash water is treated potable water, the length of the filter run directly impacts the cost of the filter operation. The backwash water must either be returned to the head of the plant or mixed with the raw water flow or impounded so that sludge can be separated.

The filter shall be of the Rapid Gravity Type with a filtration rate not exceeding 12 m/h (or 5 GPM/Sq.ft). The supplier justify that the proposed filter can work under those design conditions to meet the required effluent.

The filter shall be multi media type: Anthracite at the top, Sand in the middle and Gamet at the bottom.

The rapid multi-media filter can be cleaned of accumulated turbidity by reversing the direction of the flow of water. This process is called backwashing. In backwashing, the flow of water expands the sand, scours the bed and carries the accumulated solids to the treatment facility.

The gravity filter shall be of reinforced concrete construction. Its length, width and depth are determined to suit the desired rate of flow. The depth of the filter box is determined by the amount of head or pressure required and also by the type of underdrain. The principal parts, which make up a gravity filter are shown in and include:

- The underdrain system;
- The gravel subfill;
- The filter media; and
- The surface washer, wash troughs and air scour system.

The prime function of a filter is to remove suspended matter and thereby reducing turbidity and removing pathogenic organisms from the water.

Most of these organisms are bound up in the coagulated floc particles entering the filter. The turbidity remaining in the filter effluent is the best indicator of filter performance.

2.2.8.1 Underdrain System

The underdrain system collects the filtered water that passes through the media. The recommended type of underdrain is the Ondeo-Degremont Monofloor HD Underdrain.. It will consist of 6" UPVC supports (spaced at approximately 60 cm), molded polystyrene form, nozzles adaptor, monolithic reinforcement concrete slab, nozzle and construction accessories. Nozzles shall be distributed at an average of 50 nozzles per m². This concentration of nozzles ensure thorough media washing while maintaining uniform backwash water and air distribution. All thread rods to tie the underdrain slab into the base concrete floor shall be stainless steel. .

The backwash flow rate of the average filter is 490 - 610 lpm per sq. m (12 to 15 gpm per sq. ft.) and the operating rate only about 163 lpm per sq. m (4 gpm per sq. ft.) The only head available during the filtration process is the depth of water in the filter. Consequently the holes are sized to handle the filter flow. Adequate distribution of water is ensured at the higher flows encountered in backwashing due to the diffusing effect achieved by the flow and resultant loss of head through the underdrain systems.

2.2.8.2 Gravel Subfill

The subfill performs two primary functions:

- It supports the upper layers of Garnet, sand and anthracite and separates them from the underdrain system, and
- It distributes evenly the flow of water through the filter in both directions. (The depth of gravel required in design of filters is directly related to the distance between the holes and their size in the underdrain system).

Different layers, or size, of gravel make up the required depth. Progressively finer grades of gravel are spread on top of the coarse gravel. The minimum depth of one layer is 2". The final layer of gravel will support the actual filter media.

2.2.8.3 Filter Media

The actual filter media is on top of the gravel bed and varies in depth depending on plant design. Typical multi media filter bed depths shall consist of Garnet, Sand and Anthracite.

Anthracite, hard coal that has been crushed (screened) for size and graded to have a uniform density is the most widely used filter media. Crushed anthracite coal has a lower specific gravity (1.75) than sand (2.65); consequently, a lower velocity is required when backwashing the filter compared to that required to wash a sand filter of equal depth.

Crushed anthracite coal is lighter in weight – 880 kg per cu. m. (55 lbs. per cu. ft.) than sand – 1600 kg per cu. m (100 lbs. per cu. ft.); Garnet has a density (4.5) greater than the sand; therefore, in order to benefit from those media, they are generally used together. They can be readily backwashed together and should always remain separated due to the difference in their specific gravities. The coarse anthracite on top gives the filter a larger capacity for turbidity removal, while the medium sand layer is below the anthracite and the finer Garnet is at the bottom (below sand layer) supported by a gravel support layer. The combination of the three provides a media that will give longer filter runs with a resulting better quality of water. The media replacement period is set to 5 years.

2.2.8.4 Wash Water Troughs

The wash water troughs are located above the surface wash equipment. They are installed, half the bed depth above the bed to provide a free space between the underside of the trough and the top of the bed. This space is normally provided for when the filter is backwashed to allow for the filter media to expand when cleaning without losing filter media.

2.2.8.5 Other Necessary Accessories

Other necessary components include:

- The influent wash water valve;
- The effluent wash water valve;
- A valve to control the flow of water to the surface wash equipment; and
- Pumps.

All of these valves are controlled from a console, usually located in front of and facing the filter.

Built into the control console are gauges showing loss of head, rate of flow through the filter, backwash rate of flow, and effluent turbidity.

2.2.8.6 Filter Operation

2.2.8.6.1 Pre-Treatment

The most important thing to remember about the water arriving at the filter(s) is to condition and pre-treat it thoroughly before it gets there. Without this pre-treatment, or if the pre-treatment is inefficient the operating efficiency of the filter(s) is going to be drastically reduced. Filter runs will be cut short, resulting in a considerable increase in backwashing and the amount of wash water used. Consequently, plant output will be reduced because filters have to be washed with filtered water that could have been delivered to the customer. The filter beds will become overloaded with algae and particulate matter, and mud balls will very likely develop.

As already discussed, the type of conditioning applied to the raw water depends on the quality of the raw water entering the plant. The demand on water treatment plants, however, is continually increasing. If a given chemical treatment produces a good floc, coagulates well, and results in a water passing over the filter with, for example, turbidity of one (1) unit, at a flow rate of 25 MGD, an increase in flow rate to 40 MGD may not produce the same quality water over the filters even if the chemical dosage is increased in proportion to the increase in flow. This is because increasing the flow rate by 60% will allow less time for the floc to settle out. This results in a greater carry-over to the filters, causing shorter filter runs.

2.2.8.6.2 Filtration Rates

Until a few years ago, the normal design filter rate for a rapid sand filter producing potable water, was 80 – 160 lpm per sq. m (2 - 4 gpm per sq. ft.) of filter bed-area. Since then investigations of filter aids have been carried out, using dual and multi-media filters. As a result, operating filter rates are notably increased. It is common today to find filters operating at rates of 245 – 325 lpm (6 - 8 gpm per sq. ft.) of filter bed area.

It is sometimes possible to increase the flow rate through the filter. Filters are normally designed for specific rates of flow, and such things as the inlet flumes, the underdrain system, rate of flow

controllers, and the discharge piping are all sized for this flow plus a factor of safety. Therefore, to double the rate of flow, the total head available in the filter may be sufficient to maintain this flow rate for short periods of time. New filters use a media in which the particle size is greatest at the top. By using various types of filter media, the particle size gets progressively finer, down through the bed to the bottom. Since the voids (or spaces) between the particles will be larger where the particle size is greatest, the voids in the upper portion of the bed are largest. These provide a greater storage area for turbidity particles. As the water proceeds through the bed, the size of these voids becomes progressively smaller due to the accumulation of turbidity particles. At the same time, the storage for the turbidity is becoming less, but the degree of filtration is becoming better.

It is common today to have up to five different layers of material in a filter bed. In other types of media, two layers are used, generally sand and crushed anthracite: two-layer filters are commonly known as dual media filters. The type of filter to be used is determined after a thorough study of the treatment process and raw water conditions.

The conventional rapid sand filter uses one grade of sand (0.45 - 0.55 mm and a S.G. of 2.65) approximately 75 cm (30 inches) thick underlaid by graded layers of gravel as supporting media. Normally under these conditions, the actual entrapment of suspended matter is restricted to the top several centimetres of the sand bed. The remaining sand acts as insurance against a serious turbidity breakthrough, which means the turbidity on the filter has increased to the point where it is being carried through by the water being filtered.

The storing capacity for suspended matter in the conventional rapid sand filter is considerably less than in a dual-media filter where the top 45 cm (18 inches) of the sand bed have been replaced with a coarser and lighter media, such as a graded crushed anthracite (0.8 - 1.2 mm and a S.G. 1.75). Under ideal conditions, the entire 45 cm depth of anthracite plus 3 - 5 centimetres of sand is available for the storage of suspended matter. This means that the head loss, instead of being concentrated in the top 5 cm in the conventional sand bed, is distributed through a depth of 45 cm to 50 cm (18 - 20 inches) in the dual-media bed. This makes it possible to use higher filter rates for longer filter runs.

2.2.8.6.3 Backwashing

Backwashing a filter is the exact opposite to filtration. When backwashing, the water rises up through the filter rather than passing down through it. The backwashing process removes the accumulated turbidity from the filter. Municipal filtration plants always utilize treated water for backwashing. The water is delivered to the filter either from an elevated tower or via a backwash pump (from the clearwell). Either method provides the necessary pressure and volume for carrying out the backwash process.

A normal rate of flow during the backwash cycle for conventional filters is 610 lpm per sq. m

(15 gpm per sq. ft.) of filter bed area. These figures will vary depending on the temperature of the water used to backwash. As the temperature increases, the backwash rate is increased to give the same amount of expansion to the filter bed. The backwash water enters through the underdrain. Rising up through the gravel bed, it enters the filter media. The gravel bed further distributes the water uniformly throughout the entire filter.

It is extremely important to note that in the operation of any filter, all valves have to be opened or closed slowly. As the backwash valve is opened, the amount of water rising up through the filter media gradually increases and as more and more water is forced up through the sand bed, the

pressure on the underside of the individual grains of filter media becomes greater. This pressure eventually overcomes the weight of the particle of filter media and the point at which this occurs is known as the point of fluidity. Once the flow reaches this point, the article will rise and the filter bed will start expanding.

The normal expansion of the filter bed is 30 to 50 per cent during the backwash period.

Backwash space must be provided in the filter to permit this expansion during the washing period. This is why the wash trough must be at a fixed height above the filter bed. The particles of media roll around in the bed, continuously rising and falling. In the process, they rub against each other. The combined action of the water moving past the particle of media and the scrubbing action of the particles rubbing against each other removes the accumulated turbidity from the filter media grains.

It was found from experience that this does not always remove all of the turbidity from the filter media, and that over the years turbidity will accumulate on the media grains, limiting their effectiveness as a filter media. Superior backwashing may be achieved in the winter due to the denser water, however, a savings may be realized by reducing the backwash time because the bed is cleared faster.

Adequate backwashing in every filter operation is extremely important. The backwash flow rate should be as high as possible without losing filter media. The backwash should be carried on until the filter media is substantially cleaned. No media will ever be absolutely clean, regardless of the extent of the backwash.

2.2.8.6.4 Surface Wash System

Auxiliary scour better describes the function of this device as it aids in cleaning much more than the filter surface. The purpose of the surface wash is to aid in cleaning the filter surface and prevent mudball formation by applying a jet of water to the encrusted surface before and during wash cycles.

The most common surface washers are rotary surface washers; the washer is mounted just above the filter bed and begins to rotate when water jets out of the nozzles. As the filter bed starts to expand during backwashing the washer not only cleans the top of the filter bed but becomes immersed in the filter media. Fixed jets are sometimes used as well instead of rotating washers.

Initially the filter media is backwashed at about 245 lpm per sq. m (6 gpm/sq. ft.). This is the point at which the particles of media are in effect "weightless" in the filter bed. The agitator is then turned on and allowed to run for a period of 5 to 7 minutes. The force of the jets of water from the agitator cleans the grains of the filter media and moves them so that the entire bed is gradually turned over and exposed to the jet action.

Following this, the backwash rate is gradually increased and the agitator turned off. The filter is backwashed at its normal backwash rate for as long as economically necessary to remove all accumulated turbidity. The water is then slowly turned off and the media allowed to settle before returning the filter back to operation.

2.2.8.6.5 Air Scour Wash

Another method used to assist in cleaning the filter is accomplished by introducing compressed air into the backwash stream before it reaches the filter. Underdrain systems used for air scour usually have smaller holes, thereby creating a much diffused air-water mixture. This mixture causes

extensive agitation of the media as it passes through the bed. Many feel that the method is more efficient at cleaning the filter bed than is possible by standard backwashing.

Air scour systems blast the filter media with jets of air from the bottom of the filter. The air scour systems are activated prior to backwashing and remains on until the wash water troughs begins to fill with wash water. A common problem with air scour systems is that they inadvertently remove filter media into the wash trough damaging the filter. This can usually be remedied by reducing the backwash velocity, by properly guarding the filter media and by ensuring the air scour is turned off before the backwash reaches the wash water troughs.

The proposed design criteria of the clariflocculator are shown in the below table.

Gravity Filter Design Data

Design Parameters	Phase I	Phase II
C:Gravity Filtration Unit		
General		
Total Output Flow (m ³ /hr)	1,375	2,750
Number of Cells	4	8
Duty	3	6
Standby	1	2
Design Flow per unit (m ³ /hr)	458.3	343
Design Filtration rate (m/h)	5.55	5.55
Type of filter cell	Twin bed	Twin bed
Dimensions of each filter cell (No x m x m)	2 x 7 x 5.9	2 x 5.45 x 5.2
Area of selected cell (m ²)	82.6	56.68
Inlet sluice gate width (mm)	400	400
Inlet sluice gate depth (mm)	400	400
Inlet velocity (m/s)	0.59	0.61
Outlet Sluice Valve diameter (mm)	400	400
Outlet velocity (m/s)	0.76	0.77
Wash water flow rate (Lpm/m ²)	500	500
Wash water rate required (m ³ /min)	20.65	42.51
Air Scour rate (Lpm/m ²)	750	750
Air Flow rate (m ³ /min)	37.75	42.51
Blower head (mbar)	500	500
Air Scouring Pipe diameter (mm)	250	250
Backwash water flow (m ³ /hr)	1240	1700
Number of Duty Backwash Pumps	1	1

Design Parameters	Phase I	Phase II
Number Of Standby Backwash Pumps	1	1
Backwash Pump Capacity (m ³ /hr)	1240	850
Backwash Pump Head (m)	15	15
Number of Duty Air Blower	1	1
Number of Standby Air Blower	1	1
Supporting Bed		
Gravel 8 x 4 mm – Bed depth (mm)	400	400
Gravel 4 x 2 mm – Bed depth (mm)	200	200
Garnet for support 2.5 x 1 mm – Bed depth (mm)	100	100
Media		
Garnet 0.6 x 0.3 mm – Bed depth (mm)	135	135
Sand 0.8 x 0.4 mm – Bed depth (mm)	270	270
Anthracite 1.6 x 0.6 mm – Bed depth (mm)	225	225
Anthracite 2.5 x 1.4 mm – Bed depth (mm)	270	270
Media replacement life cycle	5 years	5 years

2.2.9 Clear Water Tank

The Clear water tank volume shall be 5,000 m³, for phase I, to be pumped to overhead distribution reservoirs via the Main Pumping Station. The reservoir shall be covered complete with access manholes and cover.

Pump start level switch and pump stop level switch shall be installed in this tank to start/stop the pump. The volume between those levels is then 1,000 m³ to make sure that the pumps, in any case, shall have less than 10 starts per hours (this case may never happen). A Low Low Level Switch shall also be installed in the tank to provide dry run protection of the Pumps.

For future extension, Phase II, a second tank with a volume of 5,000 m³ shall be added.

2.2.10 Main Pumping Station

The pumping station will include the following:

- 1 set of pumps (2 duty pumps, 1 stand-by pump and 1 pump for future extension) to transfer water from the dam to the treatment plant in case of low water in the Dam's Reservoir.
- 1 set of pumps (1 duty pumps and 1 stand-by) to transfer water from the dam to the irrigation canal.
- 1 set of horizontal centrifugal pumps, (1 duty and 1 stand-by) to transfer the treated water to overhead distribution reservoir of Ras Nihach.
- 1 set of horizontal centrifugal pumps, (2 duty and 1 stand-by each) to transfer the treated water to overhead distribution reservoir of Hamat.

- 1 set of horizontal centrifugal pumps, (2 duty and 1 stand-by each) to transfer the treated water to overhead distribution reservoirs of Batroun.
- 1 set of backwash pumps (1 duty and 1 stand-by) to clean the gravity filter from accumulated turbidity.

Reservoir	Parameters	Number/Description
W.T.P.	Set of pumps	1
	Duty	2
	Stand-by	1
	For future extension	1
	Type of Pump	Horizontal centrifugal
	Flow Per Pump (m3/h)	690
	Total Dynamic Head (m)	20
For Irrigation	Set of pumps	1
	Duty	1
	Stand-by	1
	Type of Pump	Horizontal centrifugal
	Flow Per Pump (m3/h)	612
	Total Dynamic Head (m)	70
Ras Nhach Reservoir	Set of pumps	1
	Duty	1
	Stand-by	1
	Type of Pump	Horizontal centrifugal
	Flow Per Pump (m3/h)	57
	Total Dynamic Head (m)	338
Hamat Regional Reservoir	Set of pumps	1
	Duty	2
	Stand-by	1
	Type of Pump	Horizontal centrifugal
	Flow Per Pump (m3/h)	418
	Total Dynamic Head (m)	250
Batroun Reservoir	Set of pumps	1
	Duty	2
	Stand-by	1
	Type of Pump	Horizontal centrifugal
	Flow Per Pump (m3/h)	338

Reservoir	Parameters	Number/Description
	Total Dynamic Head (m)	223
Backwash	Set of pumps	1
	Duty	1
	Stand-by	1
	Type of Pump	Horizontal centrifugal
	Pump Capacity (m3/h)	1,240

All pumps connection shall be rated to withstand the surge pressure (but not less than PN 25).

In addition to the level controls mentioned above (which are mentioned below also), the Main Pumping Station shall have the following protection:

- Ultrasonic Level sensor: It shall provide 4 – 20 mA for level reading and control of Low and High Level of the water. At Low level, all the pumps shall stop. At High Level, an Alarm (Visible and audible) shall be energized.
- Low Low Level (LLVL) switch as backup in case the Ultrasonic Level switch fails. The LLVL shall stop the pumps and energize the Low Level Alarm.
- High Level Switch (HLVL) as backup in case the Ultrasonic Level switch fails. The HLVL switch shall energize the High Level Alarm.
- The pumps shall be protected by the following devices:
- No Flow: consisting of limit switch installed the check valve of each pump.
- Closed valves: Valves are automatic and equipped with limit switches. If any valve (at suction or discharge) is closed, the pump will not start.
- Vibration sensor and monitor installed for each pump. This will stop the pump of vibration limit is exceeded
- Hi Pressure switch/Transmitter installed at the discharge of each pump. This protects the pumps against mistakenly closed valves. Also if an altitude valve is installed at the discharge into the remote distribution reservoir, this pressure switch will help in stopping the pump. The altitude valve will mechanically / hydraulically open and /or closed depending on present water level in the reservoir.
- Vacuum switch or Low Pressure switch: to stop the pump if suction valve is closed or there is not enough water in the reservoir.
- Bearing temperature sensor
- PTC thermistor for the motor
- Overload relay
- Oil leak detection for pump.

A chlorine sensor/analyzer shall be installed at the suction of the Pump to give reading of the chlorine value and to automatically increase or decrease the chlorine dosage rate. The chlorine dosage rate at pumps suction shall be 0.5 mg/l to 0.8 mg/l to make sure that residual chlorine will remain in the distribution reservoir. This value can be adjusted during operation if the chlorine residual in the storage reservoir is less than 0.2 mg/l. The chlorine dosage rate is then controlled by

Two devices: flowmeter and chlorine analyzer.

Each Pumping set shall be equipped with the proper surge vessel to prevent high water hammer.

The Motor Control Center (MCC3) for those pumps shall be installed in the Main Pumping Station.

2.2.11 Chemical Dosing Room

It shall include the following:

- Polymer Dosing set to add the polymer to the Flash mixer. It shall include, duty/standby dosing pump, mixer (when needed), level switches, flowmeter, PE or PVC tank, and all necessary control to make it complete in all aspect. Fully automatic three-chamber preparation system for dry and liquid polyelectrolytes, complete with dry powder feeder, agitators, water control station with water meter, level controls and control panel incorporating a PLC unit. The operation of this set shall be linked to the operation of the HLPS pumps. It shall have a capacity to dose 5 mg/L of polymer. Capacity: 1000 L/hr Tank volume: 2 m³.
- Alum Feed System shall consist of Chemical Tank, It shall include, duty/standby dosing pump, mixer (when needed), level switches, flowmeter, PE or PVC tank, and all necessary control to make it complete in all aspect. The operation of this set shall be linked to the operation of the MAIN PUMPING STATION pumps. It shall have a capacity to dose 30 mg/L of Alum. Tank volume: 10 m³. Dosing Pump Capacity: 1000 L/ hr at 3 bars.
- Prechlorination System: Gas chlorine shall be used for pre-chlorination. It shall be able to dose 1-2 and up to 3 mg/l. It shall be as per specifications of section "Chlorination System".
- Chlorinator capacity: 8 Kg Cl₂ /hr. Number of 1 Ton Chlorine Drums: 2 duty / 2 standby

A drench shower shall be provided outside the room.

2.2.12 Post Chloriation

Gas chlorine shall be used for pre-chlorination. It shall be able to dose 0.6 and up to 2 mg/l. It shall be as per specifications of section "Chlorination System".

- Chlorinator capacity: 6 Kg Cl₂ /hr. Number of 1 Ton Chlorine Drums: 2 duty / 2 standby

2.2.13 Gantry Cranes

All lifting equipment shall be provided by the Contractor, at his own Cost, and shall be fully responsible for the operation and maintenance of such equipment. All slings and lifting equipment shall be proof load tested and stamped prior to use on the Site and shall be subject to approval of the Employer, who has the right to prohibit the use of equipment or methods considered unsafe at his sole discretion.

The Contractor shall provide the Employer with copies of the load test certificates for all lifting equipment brought onto the Site.

1. Lifting equipment – hoist unit and end carriages, drives
2. Lifting accessories (slings, grippers, hooks, beam connection plates
3. Equipment rails
4. Equipment rail attachments – rail fixtures, under-rail inserts, under-rail plates and

corresponding embedment, grouting, mortar or setting resin.

5. Rail adjustments
6. End of travel stops with track mounted shock absorbers
7. Pendant and mains panel
8. Festoon Cable System
9. Power supply lines and cable reeling drum
10. Spare parts
11. First-fill oils and lubricants, and all other consumables needed for service
12. Special purpose items for equipment load testing, lifting accessories to enable test load attachment, special purpose tooling
13. Special breakdown repair or maintenance tooling.

2.2.13.1 General Technical Requirements for The Cranes

The crane shall be complete including all specialist equipment necessary for maintaining the crane, inspection facilities, platforms, supporting steelwork, control equipment, power supplies, lighting, lifting equipment, and walkways etc.

The crane shall be designed and constructed in accordance with BS 466. The permissible stresses design of the crane structures and mechanisms shall comply with BS 2573: Parts 1 and 2.

Any cradles used for test weight purposes or similar equipment shall be designed to appropriate international standard and to comply with the appropriate legislation.

The safe working load (SWL) shall be marked on all lifting equipment.

The crane hook envelope coverage and height of lift requirements shall service adequately all plant that needs to be lifted.

The crane shall be designed to operate on a 380V, 50Hz, 3 phase power supply. The electrical installation of the crane shall start at the long travel section. A means shall be provided on the crane for isolating the crane from the power supply close to the power pick-up point. Control circuits shall be supplied at a nominal voltage not exceeding 110V.

The crane shall have push button control from a mobile pendant suspended from its own cable track.

Crane operating speeds shall be selected to allow safe operation while using the pendant. The maximum operating speed for pendant travel operation shall be no greater than 40m/min. There shall be two operating speeds with a fast/slow ratio of 4:1. A variable speed control system may be offered as an option with advantage identified by the Contractor.

The selection of motion speeds for hoisting, cross travel and long travel shall reflect the requirements of both erection and maintenance with due consideration to the cross traverse and long travel distances.

The crane shall be provided with an overload alarm and protection device.

The design shall include a fail-safe braking system incorporating a manual-release mechanism for

emergency lowering in the event of a power supply failure.

The hoist, long travel and cross traverse motion brakes and motion limiting devices shall comply with the requirements of BS 466.

Where the crane cannot gain access to particular items of plant, either due to location or where items of plant prevent floor access, lifting tackle and equipment shall be provided.

The crane and any lifting equipment shall be capable of performing their duties in the hands of normally skilled operators.

Access platforms, walkways, ladders, handholds and footholds shall be provided as necessary to give safe access to parts of the crane requiring routine inspection and maintenance. The outer sides of the platforms, walkways (including openings in platforms and walkways) shall be securely fenced with guard rails. The guard rails shall have a minimum height of 1m above the walking surface and toe boards shall have a minimum height of 50mm about the walking surface. Walking surfaces shall be non-slip. Ladders shall comply with BS 4211.

The crane shall be provided with suitable means of anchoring when left unattended.

The equipment (if installed outside) shall include suitable weather protection consistent with the atmospheric conditions specified. Enclosures shall be provided for all electrical equipment. The motor enclosure rating shall be IP55, and the instrumentation enclosure rating shall be IP65.

The design life of the cranes and associated equipment shall be 25 years.

The crane paint finish shall be Hazard Yellow to BS 4800.

2.2.14 Chlorination System

The chlorination system shall be for ease of operation and for maximum simplicity, reliability and for minimum maintenance.

2.2.14.1 Chlorine Drums

Chlorine shall be delivered and stored in drums with 1000 kg nominal capacity as specified in the earlier sections and/or shown on the relevant drawings. The chlorine drums shall be of the double dished end type and protected with a protection dome for transport. The drums shall be fitted with two outlet valves with dip pipes.

Chlorine drums not in use shall be provided with a purpose made rack to store the drums at a single level close to the floor, the rack position for each drum taking the form of an arc of a circle of greater radius than that of the drum.

Chlorine drums which are connected to a take-off manifold, in use or standby, shall be provided with one set of rollers for online drum rotation for alignment of the take-off valves.

Each set shall comprise 4 rollers of heavy duty construction. Any drum stored outside the main building should be housed in a shaded covered area so as to avoid direct sunlight.

2.2.14.2 Lifting Equipment

If asked for in the Particular Specifications and/or respective drawings, an electrically operated

monorail shall be supplied to allow for lifting of the chlorine drums. The monorail shall comply with the specifications for lifting equipment.

The drums shall be lifted by a purpose made lifting beam suitable for hooking onto the hoist hook, comprising a horizontal bar with center lifting shackle to take the hoist hook and hooks at either end for hooking onto the drum.

Chlorine drums shall be weighed by a crane weigher comprising a dial type indicator, minimum diameter 400mm, range 0-3000 kg, with top lifting eye and bottom hook suitable for operation between the hoist hook and the lifting beam. A wall mounted rack for support shall be provided to retain the crane weigher safely out of the way when not in use. The indicator dial shall be marked with chlorine drum full and empty weights.

2.2.14.3 Chlorine Gas Manifold

The manifold shall be constructed of suitably sized grade 316 seamless stainless steel pipe and shall be suitable for use with dry chlorine gas with screwed or flanged connections.

Screwed joints shall be made with an approved jointing compound only. Gaskets for flanged joints shall be suitable for use with chlorine gas (i.e. PTFE).

All piping used to supply dry chlorine, liquid or gas shall be of grade 316 seamless stainless steel. All fittings shall be forged stainless steel 316.

The pipework shall conform to API 5L or approved equal.

Isolation valves shall be designed for use on chlorine liquid/gas service and shall conform to the recommendations of the Chlorine Institute.

The valves shall be of globe type and have forged stainless steel 316 body with monel spindles and stem and PTFE packing. The valve shall be provided with screwed end connections and shall be full bore sized.

The flexible container connector shall be constructed of 10 mm O.D. cadmium plated, copper tubing. The connector shall be provided with an isolating valve and a header valve, constructed of brass. The flexible connector shall terminate with a valve and union connector set at the drum end. The arrangement will be such as to release the very minimum of chlorine gas into the atmosphere when changing drums or cylinders.

Gaskets for the flanged joints shall be of inert material compatible with the chlorine liquid or gas. A pressure gauge shall be provided on each manifold. The manifolds shall be located at a higher level than the drums to allow liquid chlorine to drain back to the drums.

2.2.14.4 Catchpot

Catchpots shall be connected in the manifold lines immediately before the vacuum regulators.

These shall serve to intercept any liquid chlorine which passes with the gas and allow it to vaporize back into the gas stream.

2.2.14.5 Vacuum Regulators

A wall mounted vacuum regulator with heater assembly shall be provided on each manifold to

reduce the gas pressure to partial vacuum before going into the chlorinators. The vacuum regulator shall include pressure check/pressure relief valve assemblies. Each vacuum regulator shall be complete with a union to allow easy disconnection from the gas manifold for servicing.

The vacuum regulator shall seal off the gas supply in the event of either loss of vacuum or excess vacuum. A pressure relief valve shall be provided to prevent pressures in excess of atmospheric pressure occurring. This shall be independently piped to the neutralizing equipment (if provided), otherwise it shall be directed outside the building.

2.2.14.6 Automatic Changeover Device

The automatic changeover device shall be installed between the two chlorine gas line feeds from the drums to automatically switch from an exhausted chlorine gas source to a standby source without interruption of the chlorination process.

The device shall consist of a motorized ball valve at each inlet (2 in total), diaphragm protected pressure switch, 150mm diameter pressure indicator and one automatic changeover operator. The operator shall be equipped with two red and two green indicating lights, one for each source. The green light shall indicate that the source is in service. The red light shall indicate that the source is exhausted.

The device shall operate such that when both chlorine sources are available, only one will feed chlorine gas. The green indicating light on the changeover operator shall indicate which source is in service.

When the source in service becomes exhausted, the system pressure falls causing the pressure switch to actuate. This action shall automatically change the supply from one source to the other.

The automatic changeover device shall be wall mounted type. It shall be housed in a suitable sealed enclosure (IP 65) designed and manufactured specifically for the purpose stated.

Facility shall be provided to enable both motor driven valves to close on a signal from the fume detector to isolate the chlorine at source in the event of a leak. The change over device should incorporate a manual override feature.

2.2.14.7 Electrically Operated Gas Pressure Reducing & Shut-Off Valve

The gas pressure reducing and shutoff valve shall be of the electrically operated, diaphragm type, and shall be suitable for use with chlorine gas. The valve shall automatically regulate a varying supply pressure to a reduced and constant value. The gas pressure reducing and shut-off valve shall have a maximum capacity to suit the design requirements.

When downstream pressure exceeds the control setting, gas flow shall be shut off. The valve shall close on electrical failure, and also upon alarm or shut-down condition.

The valve shall be of the cartridge type with seat and stem assembly mounted directly into a rigid pipeline without additional support.

2.2.14.8 Electrically Heated Evaporator

The evaporator shall be of the electrically heated type with a thermostatically controlled water chamber. The evaporator shall automatically vaporize and superheat the liquid chlorine at a rate controlled by the usage of the system.

The vaporizing chamber shall be constructed of a steel cylinder immersed in a hot water bath which is heated by electric immersion heaters. The electric heater shall be mounted in the lower portion of the water chamber to ensure proper heat distribution with no additional circulating apparatus required.

The evaporator shall be equipped with a front panel mounted control thermostat, water level gauge, gas pressure and temperature gauges. A front panel mounted low temperature switch shall also be provided to cause the closing of the gas pressure reducing and shut off valve in the event of low water temperature. The thermostat and the temperature switch shall have calibrated gauges for ease of adjustment. Low water level switch shall also be installed in the water chamber which shall cut the power to the heaters if activated. A gas pressure relief valve complete with a safety head/rupture disc and pressure switch with diaphragm protector shall also be provided for venting.

The evaporator shall be housed in a color impregnated, corrosion resistant, fiberglass reinforced polyester cabinet which shall be removable from the front. This shall permit multiple evaporators to be mounted in order to minimize floor space requirements. The unit shall be supplied with 2 inch thick fiberglass insulation for the water chamber in order to conserve energy.

2.2.14.9 Automatic Chlorinator

The chlorinator shall be of the vacuum operated, solution feed type and shall automatically control chlorine gas feed rate in relation to flow and residual signals. The control signal applied to an automatic reversible motor driven V. notch gas flow control valve shall control the chlorine gas dosage, to maintain the preset residual, when selected to operate in the automatic mode. Manual and hand modes of operation shall also be provided.

The chlorinator equipment shall be designed to ensure maximum safety of operating personnel and equipment. The chlorine gas control system shall operate under vacuum to prevent gas leakage. The chlorinator shall consist of floor/wall mounted cabinet containing a flowrate indicator, an ejector vacuum gauge, an electric motor actuated control valve, a vacuum regulator and a flowmeter. The vacuum regulator shall incorporate a positive chlorine gas shut-off valve, a pressure relief valve, and an excess vacuum shut-off valve.

The flowrate indicator and the vacuum gauge shall be mounted on the cabinet face to indicate chlorine flowrate and ejector vacuum, respectively. Switches for manual electric control and auto/manual selection for the automatic control valve shall be mounted on the front of the cabinet. The vacuum regulator shall be provided with an integral liquid trap and removable inlet filter having an effective area of 5 square inches and bore size of 90 microns. An inlet heater shall also be provided to prevent liquid chlorine from reaching the regulator. The heater shall operate on 240 Vac, 50 Hz power. The ejector shall be provided with ball check and diaphragm actuated valves to prevent back flow of water into the chlorinator and vacuum lines. Loss of vacuum and out-of-gas alarm switches shall be provided.

The turn down ratio of the chlorinator shall be at least 20:1 and the flowmeter shall have an accuracy of + 4%. The chlorinator shall be fitted with a secondary check valve to prevent any water entering the chlorinator should the ejector check valve fail. A manual override facility shall be provided that has a 20 to 1 down capability.

The V. notch control valve shall be designed to automatically control gas feed rate in a compound loop control mode. The valve shall incorporate a precisely machined, corrosion resistant plug and orifice which shall provide a linear control characteristic. The valve actuator shall accept an Increment/Decrement control signal from the process controller. In the event of power failure, gas

flow shall be regulated by manual knob adjustment of the automatic valve. No separate manual valve shall be required for this purpose. The chlorinators shall incorporate position feedback potentiometer in order to adjust the dosage accurately on auto mode. It shall operate on 240 Vac, 50 Hz power supply. The valve actuator signal conditioner and positioner shall incorporate state-of-the-art integrated circuitry. All valve actuator components, electronics and terminations shall be housed within a gas tight and corrosion resistant enclosure.

The chlorinator shall contain a process controller mounted in IP67 protective enclosure. The controller shall receive external 4-20 mA analogue signals from the Plant flowmeter transmitter and the chlorine residual analyzer, and an internal signal from the chlorinator that is proportional to gas flow. Suitable spans shall be available and selectable.

The controller shall be microprocessor-based type. It shall compare the measured residual with an operator-established set point, multiply this value by the plant water flow rate signal, and transmit an Increment/Decrement signal to the automatic control valve. All necessary instrumentation shall be installed to achieve stability in positioning the control valve.

The controller shall have a selectable automatic or manual output. It shall display all the selected parameters and process values.

The following alarm signals shall be provided as a minimum:

- high/low residual signals.
- low plant water flow rate.

In addition to the above, a fixed orifice valve shall be provided to manually feed chlorine gas to achieve higher ppm values (10 ppm maximum at reduced water flow rate).

The chlorinator shall be constructed entirely of materials resistant to the corrosive attack of chlorine gas. All operating components of the chlorinator shall be housed within a polyester impregnated fiberglass cabinet.

2.2.14.10 Automatic Duty/Standby Changeover Panel For Chlorinators

Each set of chlorinators (duty/standby) shall include an automatic duty/standby change over panel. It shall include a selector switch to select the duty chlorinator. The 4-20 mA flow and residual signals shall be diverted to the respective duty chlorinators through this unit. In the event of low/high vacuum failure, the standby chlorinator shall start automatically with an alarm (visual) indication on the panel. It shall automatically inhibit the chlorinators in the event of no flow in the mainline.

2.2.14.11 RESIDUAL CHLORINE ANALYZER

The residual chlorine analyzer system shall consist of a sensor assembly and an indicating transmitter. The system shall measure and indicate the residual chlorine concentration of the process liquid and transmit a linear 4-20 mA d.c signal proportional to the residual. High and Low residual switches shall be provided.

The sensor assembly shall be of three (3) electrode type using potentiostatic measurement principle. It shall be constructed of corrosion resistant materials and contain a field replaceable electrode held in place with a threaded retainer ring. The reference electrode shall be immersed in an electrolyte solution. A thermistor mounted in the sensor shall provide a wide range of automatic temperature compensation from 0 to 50°C. The sensor shall be insensitive to varying

hydraulic heads and pH variations encountered during normal process operation. A corrosion and weather resistant cable supplied with the sensor shall be used for connection to the transmitter. The sensor shall permit operation within specifications at process fluid velocities down to 0 m/sec. The analyzer cell shall be of transparent Plexiglas. The sample flow rate to the analyzer shall be automatically regulated at a maximum of 4 liters/min, using a flow control valve.

The pressure of the sampling water shall be reduced through a pressure reducing valve to an acceptable level. The analyzer shall also include a fine screen filter.

The chemical analyzer equipment shall be installed in special designated chemical analyzer cubicles. The chemical analyzer cubicles shall be located such as to ensure a transportation delay of samples as short as possible. Each chemical analyzer cubicle shall house 1 duty / 1 standby residual analyzer system. The analyzer cubicles shall be double enclosure insulated type with proper sun shades. The air conditioning systems in all cases shall be redundant.

The cubicles shall be fitted with the relevant small power and lighting fittings.

The residual chlorine transmitter electronics shall all be of the solid state utilizing integrated circuitry. All components shall be mounted on printed circuit boards. The measured value of the residual concentration shall be displayed on a digital meter mounted in the transmitter case. The meter shall be of the direct reading type and the range shall be selectable from 0 to 5 mg/l. Input/output isolation shall be provided. Power supply shall be 240V ac, 50 Hz.

Degree of protection for the transmitter casing shall be IP65 (min). All analyzer transmitters shall have integral indicators and facilities for checking their calibration. Automatic compensation/correction shall be integrated in the equipment. Zero and span adjustments shall be available for calibration purposes.

The residual chlorine analyzer system shall be of the latest type, reliable and maintenance free. The analyzer shall have the capability to be fully calibrated at site.

A buffer solution feed (if required) shall be provided by a peristaltic pump using a positive head feed. This will be used to eliminate the effects of varying PH on the sample. An electrode cleaning system shall be provided by means of hydro-mechanical action or approved equal. A buffer solution tank with low level alarm shall also be provided.

2.2.14.12 Injection Point

Where chlorine solution is to be injected into a pipeline, an injection pipe of material not affected by chlorine solution shall be provided. The injection fittings shall comprise flanged or screwed pipe branch and isolation valve of suitable diameter to allow the injection pipe to pass through. The outer end of the isolation valve shall be fitted with a compression fitting thus enabling the injection pipe to be partially withdrawn and the isolating valve closed before complete withdrawal of the injection pipe.

2.2.14.13 Chlorine Dosing Pumps (Booster Pumps)

Two (2) chlorine dosing pumps (1 duty/1 standby) shall be supplied for each point of injection.

The dosing pumps shall supply water to the ejector.

Dosing water pumps shall be of single or multistage centrifugal type. The dosing pumps shall have duplex stainless steel casing, shaft and impellers.

The dosing pumps shall generally comply with the standard specifications for water transmission and distribution pumps.

Each pump shall have suction and delivery isolating valves and delivery non-return valve and safety pressure relief valve.

2.2.14.14 Chlorine Sampling Pumps

Two (2) chlorine sampling water pumps (1 duty/1 standby) shall be supplied for each point of sampling to pump sample water to the analyzer (if necessary). The sample water pumps shall be located in the position shown on the drawings.

Chlorine sampling pumps shall be centrifugal single stage pumps. The sampling pumps shall have D.I. casing with duplex stainless steel shaft and impellers.

2.2.14.15 Chlorine Gas Leak Detector

The chlorine gas leak detector shall be of the electro-chemical type, of the low maintenance type and designed to detect and provide a warning of the presence of chlorine gas in air.

The chlorine gas leak detector shall respond in less than one (1) second and be sensitive to chlorine gas at range of concentration from as low as 0.1 ppm to as high as 10 ppm by volume. An alarm condition shall be displayed on the instrument by continuous/flashing light depending on the level of chlorine gas concentration in the air. The alarm circuit shall be provided with two sets of normally open and normally closed auxiliary contacts for actuation of remote alarms and safety devices. The detector shall not be affected by other gases which may be present in the protected area. An alarm shall also be provided to indicate failure of the sensor or control unit. Illuminating and/or alarm indicators shall be provided on the control unit.

The chlorine detector shall not require reagent or buffer solution, specific to chlorine gas and shall be capable of not less than one year of unattended operation. The gas sensors shall be capable of starting extraction fans at low level of chlorine and stopping these fans at high level. The detector heads sensors shall be suitable for close coupled installation next to the control unit or remote mounting away from the control unit.

The control unit/transmitter shall be housed in a molded plastic, fume proof casing which shall have IP65 Protection degree as a minimum. The control unit shall be suitable for wall mounting with all control devices mounted on the front panel. The control unit shall be suitable for operation in the presence of high concentration of chlorine. The control unit shall be suitable for operation from 240V a.c., 50Hz supply system. The control unit shall incorporate battery backup for not less than 5 hours of operation in case of power failure. The control unit shall give history of past alarms with date and hour.

The control unit shall also include push buttons for alarm reset, alarm test and alarm accept.

The control unit shall incorporate digital display of the measured value of chlorine concentration of each sensor head. Resolution of the display shall not be greater than 0.1 ppm.

Two multi-channel control units (1 duty/1standby) shall be installed in the chlorinator room and the sensors shall be wired to both units.

The digital outputs from the control unit shall be used in conjunction with the warning lights and sirens (specified elsewhere) and shall also provide alarms in the control room and other locations

as indicated in the Particular specifications. The control unit should have the facility to transmit all alarms through telemetry system if such system is available.

Alarm control panels shall be mounted in a safe area outside the rooms, and shall operate via an integral battery back up system. Where available, the system may be powered from a central Uninterruptible Power Supply (UPS) system.

Alarm control panels shall incorporate:

- i. A meter displaying the concentration of the gas leak in mg/l.
- ii. Warning lamps or LED's for each gas sensor to indicate.
- iii. 1st stage leak at 3.0 mg/l.
- iv. 2nd stage leak at 10.0 mg/l.
- v. Alarm/control contacts for.
- vi. Controlling Drum Shutdown Systems (where applicable).
- vii. Controlling Ventilation Fans.
- viii. Controlling Door Access Warning Lamps.
- ix. Signalling to Central Control Room or SCADA System.
- x. Signalling to a Site Telemetry Outstation.
- xi. Instrument fault lamp or LED and warning contact.
- xii. Audible/visual warning device.
- xiii. Power 'ON' or instrument 'HEALTHY' lamp or LED.

2.2.14.16 Warning Lights And Alarms

At each entrance to the chlorine store and the chlorination room two warning lights shall be installed.

A green light shall indicate that no alarms are active and thus it is safe to enter.

A red continuous light shall indicate the presence of chlorine gas in low concentrations. The same light shall be used in a flashing mode to indicate the presence of chlorine gas in high concentrations. In the event of a leak detection equipment failure, the visual warning system shall default to high concentration warning.

An external siren shall also be installed adjacent to each entrance which shall operate only on detection of high chlorine level within the room.

A large notice in both English and Arabic shall be fixed adjacent to each entrance station :

- Green Light Safe to enter
- Red Continuous Light NOT safe to enter

- Start extract fans
- Wait until green light shows.
- Red Flashing Light NOT safe to enter unless wearing breathing apparatus.
- All authorised personnel to be evacuated.

Note: It shall not be possible to start the extract fans while the red light is flashing.

2.2.14.17 Ventilation

- a- Drum stores, bottle stores and Chlorinator rooms shall all be provided with forced ventilation systems, design to produce at least 6 volume changes of air per hour, and arranged to provide a negative pressure within the rooms.
- b- Automatic control of the extract fans shall be via the gas leak detection equipment.
- c- Manual control of the fans shall be provided from a safe area outside the rooms. Manual control shall be available regardless of the action of the gas leak detection equipment. The manual control shall be arranged so that it is not possible for ventilation fans to be turned off when the automatic system is calling for the fans to be turned on.
- d- Extract grills and fans shall be positioned at a low level with the fan exhaust arranged to discharge the vented gas away from pedestrian walkways and roadways. If necessary, ducting to a point above building eaves level shall be provided to achieve this. Wet Scrubbing systems for chlorine neutralization to be installed
- e- Intake grilles shall be positioned at a high level and arranged so that the entire contents of the room are fully replenished with fresh air when the extract fans are running.

2.2.14.18 Respirators

10 minutes escape sets for use in low concentration of chlorine shall be provided. This shall comprise of a face mask, an alloy steel cylinder with integral reducing/constant flow valve assembly, carried in either a jerkin or carrying bag. A pressure gauge shall be fitted to the reducing valve and shall give a constant indication of cylinder contents. The cylinder shall comply with the requirements of BS 5045.

Each breathing apparatus set shall be supplied with spare cylinder assembly complete with control valve, pressure gauge and supply hose. The breathing apparatus shall be mounted on the inside wall immediately adjacent to each entrance to the building or on the inside of each entrance door unless otherwise directed by the Engineer. The installation shall be complete with all necessary mounting fixings and a prominent label.

2.2.14.19 Breathing Apparatus

A self-contained breathing apparatus for use in high concentrations of chlorine suitable for duration of 20 minutes shall comprise a full face mask with adjustable straps, a demand valve and air supply hose with contents gauge and quick release coupling for a second air hose and face mask, a compressed air cylinder with back harness and pillar valve, all of a standard pattern suitable for emergency use and rescue work in a chlorine gas contaminated area.

The equipment shall be complete with a GRP or stainless steel wall mounting storage case with

transparent cover and prominent label. These should be wall mounted but stored in a suitable internal location away from the chlorination but easily accessible. This storage case shall be supplied by the system manufacturer.

Each set of breathing apparatus shall be complete with a spare compressed air storage cylinder and pillar valve for storage separately.

Chlorine proof suit with contained breathing apparatus to avoid damage due to contact with chlorine gas shall also be provided. This suit shall be approved/listed/certified for use in chlorine gas contaminated area.

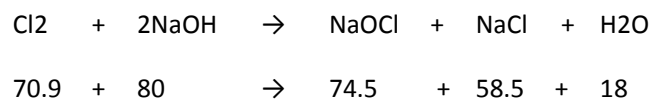
2.2.14.20 Drench Shower

- a) Drench showers shall be swinging chain operated type with a stainless steel valve that locks on.
- b) Each shower shall have a light to indicate its position.
- c) Drench showers shall not be fed directly from the mains, unless a heater is incorporated to reduce any thermal shock to the user.
- d) They shall be fed from surface-mounted water tanks.
- e) An emergency eye/face wash fountain with a flexible hose shall also be incorporated into the drench shower.
- f) Operation of the shower/emergency eye wash shall transmit an alarm to the main MCC/SCADA system/Regional control system.
- g) Safety signs shall be attached securely by each shower.

2.2.14.21 Neutralization Pit

The chlorine storage and handling area in a water treatment/purification plant must have chlorine neutralization facility, viz. neutralization pit as well as scrubber system. The neutralization pit should be constructed close to chlorination site and chlorine storage area. There should be sufficient slope between platform and neutralization pit so that the leaked or defected chlorine cylinder/tonner can be rolled down easily and swiftly into the neutralization pit. The surface area and the volume of pit should be planned in such a manner that chlorine container is immersed completely in the alkali solution.

The caustic solution, sodium hydroxide, is preferred for the neutralization purpose owing to its faster and better absorption efficiency as against lime which cause problem of sludge formation and choking of treatment system pipelines. A ready prepared caustic solution should be used in the pit instead of pouring sodium hydroxide pallets in the pit water as the absorption efficiency in the later case would be less. Ideally the quantity of NaOH needed for the neutralizing one tonner, i.e. 900 kg, would be 1066 kg. The reaction between NaOH and Cl₂ goes as follows :



Considering the stoichiometry and mass balance equation, 1 kg of Cl₂ and 1.3 kg of NaOH will produce 1.05 kg sodium hypochlorite, as evident from the above equation.

The other chemicals that can also be used for chlorine neutralization are as follows :

- Potassium hydroxide
- Sodium carbonate
- Calcium hydroxide
- Sodium sulphite
- Sodium thiosulphite
- Ferrous chloride
- Hydrogen peroxide

The quantity of other chemicals required for neutralization of chlorine is given on the following page:

Chlorine container capacity (Kg)	Caustic Soda	Water Volume	Soda Ash	Water Volume	Hydrated Lime	Water Volume
	Weight (Kg)	Ltr	Weight (Kg)	Ltr	Weight (Kg)	Ltr
45	58	182	136	450	58	566
68	90	270	220	680	82	815
900	1160	3680	2720	9050	1160	11350

2.2.14.22 Chlorine Gas Leak Neutralization System (Wet Scrubber)

In addition to chlorine neutralization pit, all the water treatment plants should have an effective automated chlorine scrubber system which can activate automatically immediately on sensing the chlorine presence in the ambient environment to absorb the leaked gas and neutralize it in the scrubber.

The Chlorine Gas Leakage Detection, Absorption and Neutralization System reduces the risk of chlorine gas spreading into the atmosphere. It automatically controls and absorbs heavy leaks from 100 kg or from 900 kg ton containers to absorb in caustic solution, thus forming hypo chlorite that can be reused as a cleaning agent.

The scrubber/neutralization system consists of a blower, absorption tower packed with rasching rings, an alkali (NaOH) tank, alkali circulation pump, piping valves and light weight FRP and PVC duct. The chlorine gas is sucked by blower and is delivered to the absorption tower where it is absorbed by absorbent and the air is vented at the top of the tower. As the extracted air, contaminated with chlorine gas, is blown up through the column the caustic soda reacts with it to form sodium chloride and sodium hypochlorite. As this absorption is accompanied by a chemical reaction, there is negligible chlorine in the air vent.

It should be ensured that a sufficient quantity of absorbent is continuously circulated in the absorption tower from the absorbent tank till the tonner gets emptied. The spent absorbent, after completion of neutralization of all chlorine, will contain only sodium chloride or sodium hypochlorite which are innocuous.

2.2.15 Control Philosophy

2.2.15.1 General Information

This document describes the control philosophy of the major components of the plant. It shall be used as a guideline to develop the control system. The contractor shall elaborate the control philosophy and submit it for approval.

All equipment shall have Run / Stop / Fault status indication (on MCC and HMI / SCADA).

2.2.15.2 Flowmeter And Valves Chamber

The flowmeter is used for monitoring only for instantaneous and cumulative flows. The flows shall be recorded by the control system and the trend shown on the HMI screen and the SCADA system.

The valves in the valves chamber are electrically actuated with local/remote control and equipped with limit switches to transmit the Open/Close position to the control system. The Open / Close status shall be shown via pilot lights on the MCC and Open / Close indication on the HMI / SCADA. The closed valve signal shall stop the MAIN PUMPING STATION pumps.

The flowmeter chamber and the valves chamber being underground, they shall be equipped with a permanent small drainage pump which runs whenever water is detected in the chamber.

2.2.15.3 Chemical Feed Systems

The Alum shall be dosed at preset value. Dosing pumps are protected by low level switch installed in the dosing / mixing tank. The mixer shall alum mixer shall have On/Off local selector switch. Pumps, mixer and level status shall be indicated on the MCC and HMI / SCADA.

The prechlorination shall be operate at a present dosage rate.

2.2.15.4 Flash Mixer And Distribution Chamber

The flash mixer shall have a VFD start to be able to adjust rotation speed to be able to optimize efficiency and chemical usage. The motor speed shall be adjustable from the remote control only (HMI, SCADA) and the speed displayed. However, it will have a local/remote ON/OFF selector switches. A High High Level (HHLVL) switch is installed in the flash mixer tank to initiate alarm and stop the MAIN PUMPING STATION pumps.

The rectangular weirs in the distribution chamber are automatic type with position indicator. They can be opened / closed locally or remotely.

2.2.15.5 Clariflocculator

The scraper gear of the clariflocculator shall be protected by mechanical and electrical torque limiter. It shall have on / off selector switches on the MCC and local emergency stop push button.

The agitator of the flocculator shall have be functioning based the following:

- On / Off selector switch on MCC and On / Off option on HMI / SCADA.
- Emergency stop push button

The sludge shall be drained from the clarifloccutor as following:

- Automatically at preset interval by opening automatic drain valve.
- Manually: The valve shall have Open / Close local selector switch, Open / Close remote selector switch (on MCC), Open / Close option on the HMI / SCADA, manual override. The valves position shall be indicated on the MCC and HMI / SCADA.

2.2.15.6 Filtration System

Water level indicator is installed in each filter tank to defined minimum and maximum water level, and should be provided with a probe or capacitor level measurement with transmitter and wire connection to the level indicator to be installed in the main panel in the control room. The water level indicator shall signal alarm (light, hazard) to the workers for both minimum and maximum water level.

All filter valves and penstocks are automatic. The filter sequence is as following:

- Service
- Air Scouring
- Backwash
- Rinse.

A turbidity sensor shall be installed at the filter outlet to monitor the treated water turbidity.

2.2.16 Post Chlorination

The filtered effluent shall be chlorinated and sent by gravity to the clear water tank.

Chlorine shall be injected at a preset dosage rate at inlet of the clear water tank. The dosage rate shall also be controlled by the chlorine residual measured at the outlet of the storage reservoir.

2.2.17 Storage and Pumping

The clear water tank volume shall be 5,000 m³ (Phase I) including 4,000 m³ as buffer volume to be pumped to overhead distribution reservoirs. Pump start level switch and pump stop level switch shall be installed in this tank to start/stop the Main Pumps. The volume between those levels is then 1,000 m³ to make sure that the pumps, in any case, shall have less than 10 starts per hours (this case may never happen). A Low Low Level Switch shall also be installed in the tank to provide dry run protection of the Main Pumps.

In addition to the level controls mentioned above (which are mentioned below also), the Main Pumping Station shall have the following protection:

- Ultrasonic Level sensor: It shall provide 4 – 20 mA for level reading and control of Low and High Level of the water. At Low level, all the pumps shall stop. At High Level, an Alarm (Visible and audible) shall be energized.
- Low Low Level (LLVL) switch as back up in case the Ultrasonic Level switch fails. The LLVL shall stop the pumps and energize the Low Level Alarm.
- High Level Switch (HLVL) as back up in case the Ultrasonic Level switch fails. The HLVL switch shall energize the High Level Alarm.

The pumps shall be protection by the following devices:

- No Flow: consisting of limit switch installed the check valve of each pump.
- Closed valves: Valves are automatic and equipped with limit switches. If any valve (at suction or discharge) is closed, the pump will not start.
- Vibration sensor and monitor installed for each pump. This will stop the pump of vibration limit is exceeded
- Hi Pressure switch/Transmitter installed at the discharge of each pump. This protects the pumps against mistakenly closed valves. Also if an altitude valve is installed at the discharge into the remote distribution reservoir, this pressure switch will help in stopping the pump. The altitude valve will mechanically / Hydraulically open and /or closed depending on present water level in the reservoir.
- Vacuum switch or Low Pressure switch: to stop the pump if suction valve is closed or there is not enough water in the reservoir.
- Bearing temperature sensor
- PTC thermistor for the motor
- Overload relay
- Oil leak detection for pump.

A chlorine sensor/analyzer shall be installed at the suction of the Pump to give reading of the chlorine value and to automatically increase or decrease the chlorine dosage rate. The chlorine dosage rate at pumps suction shall be 0.5 mg/l to 0.8 mg/l to make sure that residual chlorine will remain in the distribution reservoir. This value can be adjusted during operation if the chlorine residual in the storage reservoir is less than 0.2 mg/l. The chlorine dosage rate is then controlled by Two devices: flowmeter and chlorine analyzer.

Each Pumping set shall be equipped with the proper surge vessel to prevent high water hammer.

2.3 Laboratory Facilities

A fully equipped secure laboratory shall be provided consisting of the following areas

- General Laboratory
- Micro-Biological Laboratory
- Chemical and Equipment Store
- Office with Computer facility for data logging etc.

Facilities and equipment shall be provided by the Contractor to enable the laboratory staff to carry out the following tests conveniently, efficiently and to the required accuracy for the specified water quality parameters.

- Analysis of all parameters
- in addition:
 - Suspended Solids
 - Chlorine residuals
 - Sludge concentrations
 - Treatment chemicals checks

- Jar tests
- Sludge settling tests
- Sieve analysis (filter media etc.)
- THM's
- Filter media analysis

The Laboratory shall be equipped with:

- Refrigerator
- Drying oven
- Incubator
- Balance (on concrete slab)
- Fume Cupboard
- Gas supply
- Safety equipment - First Aid, Eyewash etc.
- Microscope
- Range of hydrometers
- Vacuum generator
- Waste disposal

All equipment shall include sufficient spares for five years operation, chemicals and other requirements to allow the Laboratory to function as above.

2.4 Treatment Works Layout

The treatment works layout shown on the Tender Drawings has been based on the following factors:

- topography of the Site
- minimum excavation in rock
- hydraulic profile of the treatment works
- dimensions of structures and buildings
- access to plant and buildings
- operability of the works
- future extensions and treatment processes
- architecture and landscaping

Details of the hydraulic profile are given in the tender drawings. Grading (excavation, cut/ fill, leveling etc) of Phase 2 area to finished ground levels shall be carried out as part of this contract.

Access to all parts of the Works shall be such that vehicles up to 38 tonne articulated for the transport of chemicals, sludge and for vehicles for maintenance including mobile cranes shall be

possible at all times. Adequate turning space shall also be provided.

Sufficient parking space for cars for operations personnel and visitors and service vehicles, included in the contract as part of the permanent Works, shall be provided.

Requirements for paving and loading platforms shall be as shown on the Tender Drawings.

Security wall shall be provided around the whole Site and sufficient space between the fence and permanent Works shall be allowed for the maintenance of the works and the fence. The exact position of the fence shall take account of the Tenderers proposals for landscaping and planting. The fence shall also allow space for the construction of Phase 2. A gatehouse shall be provided with security barrier and lockable gates on the single main access road.

Site roads shall connect with existing roads at the Site entrance and access to the treated water tunnel.

2.5 Provisions For Future Plant

Future expansion of the works to an output capacity of 0.7 m³/sec is envisaged (Phase 2) and the layout shall allow for such expansion as shown on the Tender Drawings. Additional capacity for Phase 2 has been included in the Works under this contract .

2.6 Plant Overflows

2.6.1 General

Emergency overflows shall be provided from several points on the treatment works. These overflows shall be collected together into a single discharge to the adjacent Wadi via and outfall structure complete with energy dissipater erosion protection and detention system suitable for the maximum works overflow including future Phase 2 (0.7 m³/sec). A flap valve and vermin screen shall be provided at the outfall.

2.6.2 Overflow Locations

Overflows shall be taken from the following points on the treatment works and shall be designed for the maximum flows given below: (The below needs to be finalized based on the Contractor Design).

Location of Overflow	Maximum Flow
Clarifloculators outlet channels	0.7 m ³ /sec
Rapid gravity filter inlet channels	0.7 m ³ /sec
Clear water	0.7 m ³ /sec

Note: In case of the overflows in the Chlorine Contact tanks, a water seal shall be provided, which shall be continuously replenished by a small flow of make-up water.

2.6.3 Prevention of Overflows

These overflows are to be provided for unavoidable, and unpredicted emergency use only. Overflows shall not occur if the hydraulic throughput is less than 1% above maximum flow of

0.7 m³/sec.

As part of these works a system of early warning or impending/potential overflow shall be communicated to the works ICA system. The raw water input shall be reduced or stopped by manual adjustment.

2.7 Pipework and Drainage

2.7.1 General

The Contractor is to supply and install all pipework, valves, meters and fittings to the inlet and outlet mains, interconnecting pipework and drainage pipework on the treatment works Site, and all other pipework specified.

The Contractor will incorporate sample and dosing point tappings and chambers as required to carry out Commissioning and Tests on Completion

All pipework shall be in accordance with Volume 3. All structures retaining water shall have drains to the appropriate drainage system and shall be sized such that emptying shall be completed in no more than 6 hours.

2.7.2 Isolation Stop Logs

Stop logs, frames and lifting equipment shall be provided and installed to facilitate isolation and cross-over of process stage streams to allow maintenance of penstocks, weirs, etc. and to clean out the associated channels.

2.7.3 Process Pipework

Connection points for the raw water to structures provided by others shall be as shown on the Tender Drawings. The exact position is to be determined on Site. All connections shall be made during times and periods agreed with the Employers Representative.

Testing and disinfection of process pipework and connections shall be as specified in Volume 3.

2.7.4 Drainage

There shall be four separate drainage systems within the treatment works as follows:

- Foul sewerage to cess pit.
- Chemical House and chemical delivery area drainage system to collection tanks.
- Works overflow, emergency drain and sludge centrifuge centrate to the water course.
- Land and road drainage to the water course.

The Contractor shall provide details of all drainage sources, destinations and quantities together with details of anticipated quality or pollutants for the Employer's Representative approval.

2.7.5 Service Water System

A service water system shall be provided for the treatment works.

Service water is required for:

- chemical make-up and dilution
- flushing and washing down points
- domestic requirements
- emergency showers

The supply shall be from a separate connection from the Filter Backwash Water and Service Water Tank via a network of distribution pipes around the Site. The network shall be in the form of a ring main to ensure security of supply.

The Contractor shall determine the requirements for chemical solution, dilution and slurry make up.

Adequate washdown points with hoses and wall mounted hose reels, shall be provided adjacent to each process unit, inside the chemical buildings, filter pipework gallery, plant room and sludge dewatering building.

The Contractor shall supply all pipework and valves as necessary and marker posts with markers giving pipe size and distance from post.

2.7.6 Firefighting Water System

A separate water distribution system for firefighting purposes shall be provided in accordance with local regulations. The system shall be supplied from the Filter Backwash Water and Service Water Tank and include a booster pumping installation as specified in Volume 3.

Sufficient fire hydrants and hoses shall be provided to ensure adequate access to all buildings in accordance with local firefighting regulations. The pipe network shall be in the form of a ring main to ensure security of supply. Marker posts with markers giving pipe size and distance from post shall be provided.

In addition a hydrant shall be provided at the entrance to the water treatment works, on the outside of the perimeter fence with an isolating valve inside, such that fire tenders can fill tanks.

2.8 Mechanical Lifting Equipment

The Contractor shall supply all necessary permanent, portable or self-supporting lifting equipment such that all items of plant within buildings can be serviced, dismantled or removed and replaced.

All plant and equipment shall be designed such that servicing, dismantling and removal and replacement can be carried out within the buildings.

Lifting equipment supplied under the contract shall include all necessary slings, ropes, chains, lifting beams, hooks and pulleys and shall be properly labelled or marked with the Safe Working Load.

SECTION 3 – CIVIL REQUIREMENT

CONTENTS

3.1	Surveying Equipment	2
3.1.1	Expendable Materials	3
3.2	Testing of Materials	3
3.2.1	Minimum Test Requirements	3
3.2.2	Sources of Materials.....	3
3.3	Closing of Roads	3
3.4	NOC from Relevant Authorities	4
3.5	Site Access and Safety	4
3.6	Site Grading	4
3.7	Plant Piping Schedule	4
3.8	CONCRETE PROTECTION AND BUILDING FINISHES	5
3.9	Setting out The Work	7
3.10	Layout Plan and Process Units	7
3.11	Plant Hydraulics	7
3.12	Buildings and Miscellaneous Structures	7
3.12.1	Administration and Workshop Building	8
3.12.2	Chemical Storage and Dosing Facility	8
3.12.3	Diesel Storage and Dosing Facility	8
3.13	Building Services	8
3.13.1	General Requirements.....	8
3.13.2	Small Power.....	9
3.13.3	Air Conditioning.....	9
3.13.4	Potable Water Supply	9
3.13.5	Fire Protection, Detection and Alarm	9
3.13.6	Telephones.....	10
3.13.7	Furniture	10
3.14	Roadworks, Landscaping and Other External Works	10
3.14.1	Roadworks.....	10
3.14.2	Landscaping.....	10
3.14.3	Site Boundary/ Fencing and Security Gate.....	10
3.14.4	Other External Works	10
3.15	Internal Sewerage and Drainage	10
3.16	Handrail, Staircase/Ladder Gratings and Covers	10
3.17	Water Supply for Construction and Testing	11

SECTION 3 – CIVIL REQUIREMENT

3.1 Surveying Equipment

The contractor shall provide and maintain in good condition at all times, the new survey equipment and materials detailed in Table 2-3.1 during the continuance of the Contract for the exclusive use of the Engineer and his staff. All equipments shall be returned back to the Contractor at the end of contract period.

Table 2-3.1: Schedule of Surveying Equipment

No.	ITEM	Quantity
1	Electronic total station with all ancillary equipment, including data logger, tripod, target reflectors etc.	1
2	Autoset level complete with all accessories tripod, levelling staff etc.	3
3	Staff levelling plate	3
4	Steel tape, 50 m length Non-corrosive	8
5	Steel tape, 30 m length Non-corrosive	12
6	Steel tape, 5 m length Non-corrosive	As required
7	Ranging rod, 3 m length	10
8	Conical Plummet	2
9	Steel straight edge, 1 m length	1
10	Spirit level, 1 m length	1
11	Spirit level, 4 m length	1
12	Mason string line, 100 m length	6
13	Portable concrete thermometer, ELE Model EL 34 – 112 or approved equal	6
14	Hammer, 3 kg, weight	2
15	Hammer, 1 kg, weight	2
16	Shovel	3
17	Flask, with thermal insulation, 1 litre capacity	3
18	Water containers, 5 litre capacity	3
19	Weather proof, rubber-cased torch with batteries	3
20	Thermometers, wet and dry bulbs, graduated in degrees C and F	3
21	Crack detection pocket microscope, latest model or approved equal	1
22	Pocket penetrometer ELE latest model or approved equal	3
23	Optical Square	1
24	Fibre tape, 30 m length with case	3
25	Level books, field books, surveying umbrellas	As required
26	Survey stakes, metal pins, paint, making chalk etc.	As required
27	Silica gel bag	As required

3.1.1 Expendable Materials

The Contractor shall provide adequate supplies of expendable materials such as stationery, pencils, inks, drawing paper, pens, pegs, brushes, paint and other similar items required for the satisfactory completion of survey and as required by the Engineer's Representative.

3.2 Testing of Materials

1. For testing of materials, etc., the Contractor shall hire the services of an independent accredited laboratory.
2. All transportation of personnel and materials together with the provision of all assistance to laboratory testing shall be borne by the Contractor. For this purpose one (1) approved long wheel base 4WD vehicle shall be maintained for this specific use by the Contractor to be at the sole and full time disposal of the Engineer. The role of this vehicle will include the delivery and uplifting of all material for the laboratory including test results. Contractor's technician shall not participate in the testing. Notice of tests shall be given to the Engineer at least one day prior to the proposed testing.
3. All charges for testing and/or re testing of material shall be borne by the Contractor.
4. The testing of the Works does not absolve the Contractor of his responsibility for the quality control of workmanship and materials.
5. The Engineer and the Contractor's authorized representative shall be permitted to witness any testing carried out by the Laboratory.

All sampling for such tests shall be carried out by the Consultant's Inspectors and labeled as per the relevant standard sampling requirements.

3.2.1 Minimum Test Requirements

Schedule of tests and inspections for materials shall be carried out as per Construction Materials and Quality Control Guidelines. Should the Engineer's Representative deem it necessary to increase or reduce the number of the mentioned tests, he shall issue his written instructions to the Contractor as and when required, following due consultation with the Employer.

3.2.2 Sources of Materials

The Contractor shall be responsible for obtaining the Approval of the local Authorities for the sources of materials and he shall have no right to claim for any compensation if he is to pay for the material at its source.

3.3 Closing of Roads

The Contractor shall give four weeks notice in writing to the Engineer of his intention to commence work on any public road (which shall include un-made rights-of-way).

The closure of public roads will not be permitted without the written permission of the Roads & Transport Authority, the Local Traffic Police and the Engineer. The Contractor shall submit five (5) copies of his proposals for diverting traffic indicating positions of all signs, cones, lights and anything else which may be necessary. The Contractor shall comply with any Specification for traffic diversion, including surfacing requirements, safety and control laid down by the Authorities in Lebanon and shall be responsible for continuous maintenance.

A period of up to 30 days may be required by the Regulatory Authority to process permits authorising the cutting of existing carriageways.

In the event of such permission being refused the Contractor shall have no claim for any additional payment.

No work will be permitted on a public road verge, central reservation or garden without the SIGNED approval of the respective Authorities copies of which must be submitted to the Engineer before work commences.

The Contractor's work shall be so arranged that use of the roads affected by the work shall be restored to the public with the minimum of delay.

3.4 NOC from Relevant Authorities

It shall be the Contractor's responsibility to obtain all required No Objection Certificates (NOC) from the relevant Authorities and submit them to the Engineer prior to the Engineer issuing a Taking Over Certificate.

3.5 Site Access and Safety

Contractor should investigate the site to evaluate the alternatives of site access. Suitable material temporary roads, if required, will be provided by the Contractor to allow access to all sections of the works at all times. Suitable precautions will be taken to prevent misuse of site roads by the general public. The Contractor shall be responsible for reinstating these areas to their original condition after completion of the work.

Contractor will be responsible for the site work safety from project start until hand over of the site to the Employer.

3.6 Site Grading

Site grading shall be carried out to maintain a balance cut and fill at the WTW site and to provide easy access to plant buildings and units.

Contractor is advised to carryout his own investigation to assess the ground conditions and to estimate the amount of cut and fill required for site grading.

3.7 Plant Piping Schedule

Selected pipe material for the plant should be suitable for its application. Suggested pipe materials should be as given in Table 2-3.2 or equivalent materials as approved by Engineer. Specification for different pipe material is given under "Volume 3". Contractor should take the Engineer's approval before ordering the pipe material.

Table 2-3.2: Schedule of Pipe Application System

Sr.	Applications	Type of Pipe
1	Liquid stream Interconnecting pipe	uPVC (<315mm), DI (350- 1500mm), Steel Pipe (>1500mm)
2	Sludge stream pipe	SS 316L
4	Grit Line	SS 316L
5	Chemical line	SS316 for Polymer, uPVC for Ferric chloride/ Aluminum Sulphate and other chemicals
6	Air Line	SS316L
7	Fuel Line (Diesel)	Carbon Steel
8	Chlorination	Seamless Carbon Steel

Sr.	Applications	Type of Pipe
9	Potable water line	DI (>100 mm dia)/ uPVC (upto 100mm dia)
10	Internal Sewage Line	uPVC (<315mm), GRP (>315mm)
11	Internal Drainage Line	uPVC (<315mm), GRP (>315mm)
12	Fire fighting	DI
13	Irrigation line	DI
14	Pump House internal piping	DI
15	Cable ducting	uPVC
16	Ventilation and ducts	SS 304

3.8 CONCRETE PROTECTION AND BUILDING FINISHES

Specification for various types of corrosion protection systems is given in Volume 3. Recommended concrete protection details for various units are given below.

Table 2-3.3: Schedule of Concrete Protection Details

EXTERNAL PROTECTION FOR ALL MAJOR STRUCTURES		
S.N	Particular	Protection Details
1	Below Ground Level	
a.	Below Blinding	1000 gauge PE Sheet (250 micron thick)
b.	Above Blinding (raft)	Approved bituminous coat (350 micron)
c.	Walls outer surface	Approved bituminous coat (350 micron)
2	Above Ground Level	Approved sealer coat and filler coat and Alkali resistant acrylic based anticarbonation coating (300 micron) thick

Internal protection:

The internal components of Mseilha water treatment works, which are associated with holding and conveying water shall be protected with 350 micron epoxy coating.

Concrete protection of any major and minor units not including under Table 2-3.4 which is given for guidance only, shall be provided to suit the purpose as specified in Volume 3.

Table 2-3.4: Building Finishes Details

Building Type	Flooring	Walls (internal)	Walls (external)	Ceiling	Skirting
Transformer Building	Power floated concrete structural slab No Coating On Floors	Plaster and plastic paint with anti- fungi and anti- bacterial agent Primer - 1 coat Intermediate coat - 1 Finish coat - 1	Cement plastered or fair- faced concrete and weather shield (water resistant, UV resistant, Crack Bridging and flame retardant) acrylic emulsion coating Primer -1 coat Paint - 2 coats	Plaster and plastic paint with anti- fungi and anti- bacterial agent Prime - 1 coat Intermediate coat - 1 Finish coat - 1	100mm high ceramic skirting with chamfered/ rounded edge
Chemical Storage and Dosing Building	3mm thick heavy duty non slip (3 component) epoxy abrasion resistant deck coating + finish coat with anti-fungi and anti-bacterial agents	Cement plastered or fair- faced concrete and epoxy, primer + two coats paint	----do----	----do----	--
Main Pumping Station	3mm thick heavy duty non slip (3 component) epoxy abrasion resistant deck coating + finish coat with anti-fungi and anti-bacterial agents	Cement plastered or fair- faced concrete and epoxy, coat primer + two coats paint	----do----	----do----	--
Generators Building	3mm thick heavy duty non slip (3 component) epoxy abrasion resistant deck coating + finish coat with anti-fungi and anti-bacterial agents	Plaster and plastic paint with anti- fungi and anti- bacterial agent Primer - 1 coat Intermediate coat - 1 Finish coat - 1	----do----	----do----	--
Workshop and Store building	3mm thick heavy duty non slip (3 component) epoxy abrasion resistant deck coating + finish coat with anti-fungi and anti-bacterial agents	Plaster and plastic paint with anti- fungi and anti- bacterial agent Primer - 1 coat Intermediate coat - 1 Finish coat - 1	----do----	----do----	--
Administrative Building	300 x 300 x 8mm thick non-slip ceramic tiles on cement mortar bed	a) Plaster and approved emulsion paint b) Glazed ceramic tiles 200x 200x 6mm thick fixed to plastered walls with approved adhesive for toilets, kitchen & laboratory	----do----	Plaster and approved emulsion paint	20mm thick, 100mm high marble skirting with chamfered/ rounded edge

Building Type	Flooring	Walls (internal)	Walls (external)	Ceiling	Skirting
Building Roof Top Water Proofing Details applicable to building above ground level	As specified under Volume 3				

3.9 Setting out The Work

The Contractor shall set out the work as to lines and grade in accordance with the approved Drawings and secure the “no objection” of the Engineer's Representative before constructing the work. The Engineer's Representative will, if he deems it necessary revise the lines or grades and will require the Contractor to adjust and to stake out accordingly. The Contractor shall give the Engineer's Representative not less than 24 hours notice of his intention to set out or give levels for any parts of the Works, in order that arrangements may be made for checking. The Contractor shall be responsible for obtaining any setting-out data he may require from Employer or Beirut Municipal Council Survey Section. The Contractor shall also be responsible for obtaining Beirut Municipal Council Survey Section's approval on right-of-way. Any costs incurred in this shall be borne by the Contractor.

The Contractor shall, as a requirement of the Contract and without extra charge, provide all necessary instruments, appliances, surveyor personnel and labour, and any other material or staging, which the Engineer's Representative may require for checking the setting out or for any relevant work to be done. Any marks made by the Engineer's Representative or Contractor shall be carefully preserved and, if destroyed, shall be replaced by the Contractor at his own expense and to the “no objection” of the Engineer. Work shall be suspended for the time necessary for checking the lines and levels on any part of the work, and shall proceed only after approval of measurements.

In the case of any variation from the approved works, the Contractor shall give the Engineer three copies of cross sections and profiles of the graphical record or notes and computations of his stake out as required by the Engineer. At his option he may submit cross mark on one copy with his approval of the proposed lines of the work or his revisions thereof and return it to the Contractor. The Contractor shall resubmit for “no objection” any cross sections the Engineer may amend.

3.10 Layout Plan and Process Units

The preliminary sizing and arrangement of the process units is shown on the layout drawing (Volume 5). Detailed description of process units is given under Volume 2 – Section 2 of the tender document.

3.11 Plant Hydraulics

Contractor shall design the plant hydraulics for whole design life as given under Volume 2, Section 2- Process Requirement.

3.12 Buildings and Miscellaneous Structures

Contractor shall design the buildings considering regulatory, functional, operational and maintenance requirements and submit the drawings for “no objection” before starting any work on ground. The building shall be sized to suit the equipment supplied with adequate access to all areas for maintenance. The building structure shall be designed to minimise the noise pollution and vibration.

3.12.1 Administration and Workshop Building

The minimum space requirement for various facilities to be provided is shown in the tender drawings and should be considered for guidance only. The building should be designed with adequate space requirement to fulfill the functional requirement of operation and control, day to day operation of plant and operation and maintenance of plants.

3.12.2 Chemical Storage and Dosing Facility

Chemical storage tank and dosing pumps shall be housed within the reinforced concrete bunded area to contain any leakages from the tank. Volumetric capacity of bund shall be equal to the 110% of the capacity of chemical storage tank. Chemical transfer area shall be designed to contain and transfer any spillage occurring during the chemical transfer, to the bunded area. Facility shall be covered from the top by steel/concrete roof structure.

Eyewash and shower facility shall be provided near chemical storage facility. Facility shall be designed considering health and safety issues.

3.12.3 Diesel Storage and Dosing Facility

Steel Diesel storage tanks for generators shall be housed within the reinforced concrete bunded area to contain any leakages from the tank. Volumetric capacity of bunds shall be equal to the 110% of the capacity of diesel storage tank. Diesel storage area shall be covered from the top.

3.13 Building Services

3.13.1 General Requirements

Building services shall be provided to all buildings, control panel enclosures and generator housings. The building services installation shall generally be in accordance with the electrical and mechanical specifications. In particular the design and installation of all building services shall take into account the requirements of the following standards:

Chartered Institution of Building Services Engineers Guides

CIBSE Guide A - Environmental Design.

CIBSE Technical Memoranda TM04 – Design notes for the Middle East.

CIBSE Guide C – Reference Data.

CIBSE Guide B2 – Ventilation and Air Conditioning.

CIBSE – Code for Interior Lighting.

CIBSE Technical Memoranda TM12 – Emergency Lighting.

British Standards

BS 5266 Part 1 – Emergency Lighting – Code of Practice for the emergency lighting of premises other than cinemas and other specified premises used for entertainment.

BS 5839: All relevant parts - Code of practice for fire detection and alarm systems for buildings.

BS 7430 – Code of Practice for earthing.

BS 7671 – Requirements for electrical installations - IEE wiring regulations.

BS 5250 – Code of practice for control of condensation in buildings.

BS EN 14511: All relevant parts – Specification for rating and performance of air to liquid and liquid to liquid chilling packages.

BS 12897 – Specification for indirectly heated unvented (closed) storage water heaters.

3.13.2 Small Power

Small power services shall be provided in the form of 13A twin switched socket outlets in office type areas, BS EN 60309-2, BS 4343 style socket outlets (240V and 415V) in process areas and switched fused spurs for connection to fixed equipment. The contractor shall submit the small power schemes for the Engineer's "no objection".

The number of socket outlets required in any area shall be determined by the contractor to suit the equipment to be installed/supplied and the requirements for undertaking maintenance operations on the equipment/plant installed. In addition to the socket outlets required the contractor shall install 50% additional socket outlets for future development. The minimum number of sockets to be provided in any area is two.

3.13.3 Air Conditioning

Air conditioning shall be provided to all the process and control buildings, passage, walkways and other working areas as per Volume 2, Section 1- General Requirement. The contractor shall submit the air conditioning schemes for the Engineer's "no objection". The air conditioning system shall be sized and thermostatically controlled to maintain the temperature within each room below 23°C under the specified climatic conditions.

3.13.4 Potable Water Supply

Potable water shall be required for drinking, washing, shower, polymer makeup and emergency eyewash/ shower purpose at various process units and buildings.

Contractor shall provide a dedicated potable water tank of two day storage capacity, pump house and a water ring main to feed potable water to various application areas of plant. The feed connection to the potable water supply system shall be from the outlet of chlorine contact tank.

Buried Pipe material shall be as specified or other material as approved by the engineer.

All pipework and fittings in contact with potable water shall have WRC (or similar international) certification.

All water heaters shall be fitted with thermostatically controlled immersion heaters and connected to suitably rated switched spur units.

Capacity of water tank and pump house shall be designed based on water requirement from different applications.

3.13.5 Fire Protection, Detection and Alarm

Buildings shall be protected by fire protection systems according to local fire and Civil Defence regulations. The contractor shall submit the fire protection, detection and alarm schemes for the Engineer's "no objection".

The control building, blower house, sludge thickening and dewatering building, chemical buildings, intake substation and chlorination building shall be fitted with an automatic fire detection and alarm systems. The detection system shall be based upon optical smoke detectors and where necessary fixed temperature heat detectors. A minimum of two sounder circuits shall be utilised in the design.

All fire detection and sounder circuits shall be wired in fire resistant cabling such as MICC with orange oversheaf. The contractor shall issue test and completion certificates within the test log book for the fire detection and alarm systems installed.

3.13.6 Telephones

Control rooms, Pump rooms and Plant rooms shall have telephone connections. Each telephone connection shall terminate in a RJ-45 socket, the location of which to be agreed on site. The installation of the telephone service shall be in accordance with Local Telephone Authority requirements and standards.

Each telephone socket shall be provided with a Local Telephone Authority compliant handset.

3.13.7 Furniture

The adequate furniture and utilities shall be provided in the Control Buildings, Administration building, Workshop and store house to meet the functional and operational requirement of buildings. Furniture/ utilities shall be new and of good quality. The Contractor shall submit full details of his proposed furniture and utilities for the Engineer's/Employer's "no objection".

3.14 Roadworks, Landscaping and Other External Works

3.14.1 Roadworks

6.0 m wide asphalted roads shall provide vehicular access to the Water Treatment Works. Road shall be designed as per governing regulatory authority standards.

Roads shall be kerbed with gullies at low points. Drainage system for road shall be design in co-ordination with connecting road.

3.14.2 Landscaping

Plant soft and hard landscaping shall be designed to suit the WTW site conditions. The final landscaping scheme shall be subject the Engineer's "no objection".

3.14.3 Site Boundary/ Fencing and Security Gate

Contractor shall provide the boundary wall with lighting arrangement to the plant site. Site boundary wall shall be provided with full road width security gate and security kiosk and architecturally designed to mix with surrounding environment.

3.14.4 Other External Works

Other external works include foundations and base slabs for equipment such as control panels (and enclosures), generators and skips. These shall be designed by the Contractor to suit the equipment being supplied in accordance with the principles described in this specification. Concrete protection shall be as per relevant specification.

3.15 Internal Sewerage and Drainage

Contractor shall provide the internal sewerage system covering control/ process buildings with sanitary facility. Sewage shall be gravitated to the inlet works for treatment.

Site drainage system shall be designed considering surrounding area topography, plant units and road profile and in co-ordination with local infrastructure plan.

3.16 Handrail, Staircase/Ladder Gratings and Covers

Handrail, Staircase and ladders shall be of Stainless Steel grade 316L unless otherwise the Engineer does not object the alternate material.

Open mesh/ solid top grating over channels and units wherever required shall be of GRP. The duty (medium/ heavy) of grating shall be selected based on area of application.

Access covers of manholes, chambers, pumping stations (wet well/ dry well) and other process units for inspection and equipment maintenance shall be of ductile iron (heavy/ medium duty based on area of application). For large openings multiple covers of standard size with removable beams shall be used. Alternatively fabricated stainless steel covers (multiple covers with removable beams) can be provided for large openings subject to Engineer "no objection".

3.17 Water Supply for Construction and Testing

The Contractor shall carry out an investigation prior to submitting his Tender as to the availability of water for the purpose of the construction and testing of structures and shall consult and arrange with the appropriate authorities and consider all legal aspects. The Contractor shall be entirely responsible for the supply of sufficient water of the specified quality at all times throughout the Contract, and the costs shall be deemed to be covered in the Contract prices.

SECTION 4 – MECHANICAL REQUIREMENT

CONTENTS

4.1	Definitions.....	3
4.2	Design Standards.....	3
4.3	Design Life.....	11
4.4	Coordination.....	11
4.5	Project Conditions.....	11
4.6	Performance Requirements.....	11
4.7	Sound And Vibration Measurements.....	12
4.8	Submittals.....	12
4.8.1	Description.....	12
4.8.2	Shop Drawings, Product Data, Samples.....	13
4.8.3	Proposed Product List.....	14
4.8.4	Product Data.....	14
4.8.5	Contractor’s Responsibilities.....	14
4.8.6	Submission Requirements.....	15
4.8.7	Review of Shop Drawings, Product Data, Working Drawings and Samples.....	16
4.8.8	Samples.....	17
4.8.9	Design Data.....	17
4.8.10	Equipment Data.....	17
4.8.11	Manufacturer’s Instructions.....	17
4.8.12	Manufacturer’s Field Reports.....	17
4.8.13	Correspondence.....	17
4.8.14	Distribution.....	18
4.8.15	General Procedures for Submittals.....	18
4.9	Quality Assurance.....	18
4.9.1	Quality Assurance Requirement.....	18
4.9.2	Samples.....	18
4.9.3	Mock- Up.....	19
4.9.4	Materials and equipment.....	19
4.9.5	Shop and Field Testing.....	19
4.9.6	Manufacturer’s Field Services.....	20
4.9.7	Identification Mark-up.....	20
4.9.8	Examination.....	20
4.9.9	Quality Assurance.....	21
4.9.10	Tolerances.....	21
4.9.11	Audits.....	21
4.10	Guarantee and Warranties.....	22
4.11	Control of Materials.....	22
4.11.1	Approval of Materials.....	22

4.11.2	Lubrication	22
4.11.3	Concrete Inserts	23
4.11.4	Sleeves	23
4.11.5	Equipment Foundations, Installation and Grouting	23
4.11.6	Safety Guards	24
4.11.7	Drive units	24
4.11.8	Bearings.....	25
4.11.9	Couplings.....	25
4.12	Delivery, Storage and Handling	25
4.12.1	Transportation and Delivery	25
4.12.2	Storage and Protection.....	25
4.12.3	Equipment Installation	26
4.13	Field Quality Control.....	26
4.14	Starting Of Systems	27
4.14.1	General.....	27
4.14.2	Equipment Tests.....	27
4.15	Operation and Maintenance Data	28
4.15.1	O&M Instructions and Parts Lists.....	28
4.15.2	Contents, Each Volume.....	29
4.15.3	Manual for Materials and Finishes.....	29
4.15.4	Manual for Equipment and Systems	30
4.15.5	Instruction of Employer Personnel	31
4.15.6	Service Manufacturer's Representative	31
4.15.7	Nameplates:	31
4.15.8	Special Tools.....	32
4.15.9	Spare Parts	32
4.16	Training and Commissioning Services.....	32
4.16.1	Description	32
4.16.2	Submittals	34
4.16.3	Definitions	34
4.16.4	Plans and Reports.....	35
4.16.5	Commissioning Services	36
4.16.6	Post-Commissioning Services	36
4.16.7	Records:	37
4.16.8	Training Equipment	37
4.16.9	Electrical Interface.....	37
4.16.10	Installation.....	38

SECTION 4 - MECHANICAL REQUIREMENT

Important Note: All Mechanical equipment should be manufactured in one of the following European countries: Germany, France, Italy or Spain.

4.1 Definitions

Wherever the words defined in this section or pronouns used in their stead occur in the Tender Documents, they shall have the meanings herein given.

As Directed, as Required, Etc.

Wherever in the Tender Documents, or on the Drawings, the words "as directed," "as ordered," "as requested," "as required," "as permitted," or words of like import are used, it shall be understood that the direction, order, request, requirement, or permission of the Engineer is intended. Similarly, the words "approved," "acceptable," "suitable," "satisfactory," and words of like import shall mean approved by, acceptable to, suitable to, satisfactory to/of the Engineer.

Provide:

Wherever in the Tender Documents the word "provide" is used, it shall mean to furnish (or supply) and install.

Elevation:

The figures given on the Drawings or in the other Tender Documents after the word "elevation" or abbreviation of it shall mean the distance in metres above the datum adopted by the Engineer.

4.2 Design Standards

All mechanical equipment shall be designed based on local regulatory standards, guidelines, manuals and following relevant international specifications.

S.N.	Standard	Section	Description
1	American Society for Testing and Materials (ASTM) Publications	A403	Standard Specification for Wrought Austenitic Stainless Steel Piping Fittings
		A105	Standard Specification for Forgings, Carbon Steel, for Piping Components
		A106	Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service
		A126	Standard Specification for Gray Iron Castings for Valves, Flanges and Pipe Fittings
		A167	Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
		A176	Standard Specification for Stainless and Heat-Resisting Chromium Steel Plate, Sheet, and Strip
		A181	Standard Specification for Forgings, Carbon Steel, for General Purpose Piping

S.N.	Standard	Section	Description
		A182	Standard Specification for Forged or Rolled Alloy and Stainless Steel Pipe Flanges, Forged Fittings, and Valves and Parts for High-Temperature Service
		A183	Standard Specification for Carbon Steel Track Bolts and Nuts
		A193	Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service
		A194	Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure and High-Temperature Service
		A197	Standard Specification for Cupola Malleable Iron
		A234	Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service
		A240	Specification for Heat Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels
		A269	Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service
		A276	Standard Specification for Stainless Steel Bars and Shapes
		A295	Specification for High Carbon Anti-Friction Bearing Steel
		A304	Standard Specification for Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements
		A307	Standard Specification for Carbon Steel Externally Threaded Standard Fasteners
		A312	Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes
		A322	Carbon and Alloy Steel Bar Specifications
		A325	Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength
		A36	Structural Steel Specifications
		A47	Ferritic Malleable Iron Castings
		A48	Gray Iron Casting Specifications
		A525	General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process
		A527	Steel Sheet, Zinc-Coated (Galvanized) by Hot-Dip Process, Lock Forming Quality

S.N.	Standard	Section	Description
		A53	Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless
		A530	Specification for General Requirements for Specialized Carbon and Alloy Steel Pipe
		A536	Standard Specification for Ductile Iron Castings
		A554	Specification for Welded Stainless Steel Mechanical Tubing
		A563	Standard Specification for Carbon and Alloy Steel Nuts
		A743	Specification for Castings, Iron-Chromium, Iron-Chromium Nickel, and Nickel-Base Corrosion-Resistant for General Application
		A774	Standard Specification for As-Welded Wrought Austenitic Stainless Steel Fittings for General Corrosive Service at Low and Moderate Temperatures
		A778	Standard Specification for Welded, Unannealed Austenitic Stainless Steel Tubular Products
		A90	Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles
		B139	Standard Specification for Phosphor Bronze Rod, Bar, and Shapes
		B209	Aluminum and Aluminum-Alloy Sheet and Plate
		B221	Specification for Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wires, Shapes, and Tubes
		B271	Standard Specification for Copper-Base Alloy Centrifugal Castings
		B306	Copper Drainage Tube (DWV) (ANSI H23.6)
		B32	Solder Metal.
		B42	Seamless Copper Pipe, Standard Sizes.
		B584	Standard Specification for Copper Alloy Sand Castings for General Applications
		B584	Specification for Copper Alloy Sand Castings for General Applications
		B61	Standard Specification for Steam or Valve Bronze Castings
		B62	Standard Specification for Composition Bronze or Ounce Metal Castings
		B88	Seamless Copper Water Tube (ANSI H23.1).
		B98	Standard Specification for Copper-Silicon Alloy Rod, Bar, and Shapes

S.N.	Standard	Section	Description
		C177	Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus
		C335	Steady-State Heat Transfer Properties of Horizontal Pipe Insulation
		C518	Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus
		C533	Calcium Silicate Block and Pipe Thermal Insulation
		C534	Performed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form
		C547	Mineral Fiber Performed Pipe Insulation
		C921	Properties of Jacketing Materials for Thermal Insulation
		D1056	Flexible Cellular Materials - Sponge or Expanded Rubber
		E84	Surface Building Materials Characteristics of Building Materials
		E96	Water Vapor Transmission of Materials
2	American National Standards Institute (ANSI) Standards	B 1.1	Unified Inch Screw Threads (UN and UNR Thread Form)
		B 16.11	Forged Fittings, Socket-welding and Threaded
		B 16.18	Cast Bronze Solder -Joint Pressure Fittings.
		B16.1	Cast-Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800
		B16.10	Face-to-Face and End-to-End Dimensions of Ferrous Valves
		B16.22	Wrought Copper and Bronze Solder - Joint Pressure Fittings.
		B16.23	Cast Bronze Solder Joint Drainage Fittings - DWV.
		B16.24	Bronze Flanges and Flanged Fittings. 150 and 300 LBS.
		B16.25	Butt- welding Ends
		B16.26	Cast Bronze Fittings for Flared Copper Tubes.
		B16.3	Malleable Iron Threaded Fittings
		B16.39	Malleable Iron Threaded Pipe Unions.
		B16.4	Cast-Iron Threaded Fittings, Class 125 and 250

S.N.	Standard	Section	Description
		B16.5	Pipe Flanges and Flanged Fittings
		B16.9	Factory-Made Wrought Steel Butt Welding Fittings
		B18.2	Design and strength check of bolt connection for threads and gauges
		B2.4	Hose Coupling Screw Threads
		B21	Pipe Threads.
		B3.15	ABMA Standard, Load Ratings and Fatigue Life for Ball Bearings
		B3.16	ABMA Standard, Load Ratings and Fatigue Life for Roller Bearings
		B31.1	Power Piping.
		B31.2	Fuel Gas Piping.
		B31.3	Chemical Plant and Refinery Piping.
		B36.1 0	Wrought Steel and Iron Pipe
		B36.19	Stainless Steel Pipe
		Z358.1-1990	American National Standard For Emergency Eyewash And Shower Equipment
3	AISI	316	Material Classification - Stainless Steel
4	American Society of Mechanical Engineers	ASME-17	Boiler and Pressure Vessel Code
		IX	Welding and Brazing Qualifications
		VII	Boiler and Pressure Vessel Code
		PTC 9	Displacement Compressors, Vacuum Pumps and Blowers Code
5	AWWA - American Water Works Association	C200	Steel Water Pipe 150mm and larger
		C203	Coal-Tar Protective Coatings & Linings for Steel Water Pipelines, Enamel & Tape, Hot-Applied
		C207-78	Steel Pipe Flanges for Water Works Service - Size 4 in through 144 in
		C209-84	Cold Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipelines
		C500	Standard for Gate Valves, 3 in. through 48 in. NPS, for Water and Sewage System
		C560	Cast-Iron Slide Gates
		C502	Standard for Dry-Barrel Fire Hydrants
		C509	Standard Specifications for Resilient-Seated Gate Valves, 3 in. through 12-in. NPS, for Water and Sewage Systems

S.N.	Standard	Section	Description
		MIL 11	Steel Pipe – A Guide for Design and Installation
6	Anti-Friction Bearing Manufacturers Association (AFBMA):	Standard 9-90	Load Ratings and Fatigue Life for Ball Bearings.
		Standard 11-90	Load Ratings and Fatigue Life for Roller Bearings.
7	Hydraulic Institute		Current Edition
8	AWS - American Welding Society	5.8	Brazing Filler Material
		D1.1	American Welding Society Publication "Structural Welding Code: Steel
9	AISC - American Institute of Steel Construction		
10	AGMA - American Gear Manufacturers Association		
11	SSPC - Steel Structures Painting Council		
12	International Standards for stainless steel		
13	NFPA (National Fire Protection Association - USA)	90-A	Installation of Airconditioning and Ventilating systems" and / or British Standards for Fire Protection
14	SMACNA (Sheet Metal and Air Conditioning Contractors National Association - USA)		Low Velocity Duct Standards
15	British Standards	CP 413	Design and Construction of Ducts for Services
16	ASHRAE-American Society of Heating, Refrigerating and Air conditioning Engineers, Inc		
17	ANSI/ASHRAE 15		Safety Code for Mechanical Refrigeration
18	ASHRAE: Handbook 1981 Fundamentals	Chapter 33	Duct Design
19	ASHRAE: Handbook 1983 Equipment	Chapter 1	Duct - Construction
20	Air Conditioning and Refrigeration Institute	ARI 210	Standard for Unitary Air Conditioning Equipment
21	Standards of Expansion Joint Manufacturer's Association		
22	AMCA	99	Standards Handbook.

S.N.	Standard	Section	Description
		210	Laboratory Methods of Testing Fans for Rating Purposes.
		300	Test Code for Sound Rating Air Moving Devices.
		301	Method of Publishing Sound Ratings for Air Moving Devices.
23	SMACNA		Low Pressure Duct Construction Standard
			Medium Pressure Duct Construction Standards
			Fibreglass Reinforced Plastic Duct Construction Standards.
24	UL	181	Factory-Made Air Ducts and Connectors
		555	Fire Dampers and Ceiling Dampers
25	NFPA	90A	Installation of Air conditioning and Ventilating Systems
		90B	Installation of Warm Air Heating and Air Conditioning System
26	BS EN ISO	527	Plastics. Determination of tensile properties. General principles
		604	Plastics. Determination of Compressive Properties
		5199	Technical Specifications for Centrifugal Pumps - Class II
		14121-1	Safety of Machinery – Principles of Risk Assessment
27	BS EN	1993-6	Design and Testing of Steel Overhead Runway Beams
		1677-5	Components for Slings
		12385	Standard Steel Wire Rope
		14985	Specification for Slewing Jib Cranes
		50281-3	Electrical apparatus for use in the presence of combustible dust. Classification of areas where combustible dusts are or may be present
		954-1	Safety of machinery – safety related parts of control systems
28	EN	13463	Non electrical equipment for potentially explosive atmospheres
		1127-1	Explosive atmospheres – explosion prevention and protection
29	94/9/EC		Guideline concerning equipment and protective systems
	98/37/EC		Machinery directive

S.N.	Standard	Section	Description
30	BS	5500	Specifications for fusion welded pressure vessels
		2573	Rules for the design of cranes
		5499-5	Safety Signs and Colours
		6405	Specification for non-calibrated short link steel chain
		7333	Specification for Slewing Jib Cranes
31	ISO	DP527	Tensile testing HOPE
		178	Bend testing HOPE, Elasticity Module HOPE
		2903	Trapezoid screw threads - Tolerances
32	DIN	2632	Welding Neck Flanges
		2642	Lapped Flanges Plain Collars
		2999	Whitworth Tapered Pipe Thread
33	CEMA Standards Conveyor Equipment Manufacturers Association Publication		Belt Conveyors for Bulk Materials
34	NEMA: National Electrical Manufacturer's Association		
35	NEMA Standard Publication for Motors and Generators.		
36	AGMA	6009-A	Gearmotor, Shaft Mounted, and Screw Conveyor Drives
37	ATEX guideline		Guideline concerning equipment and protective system 94/9/EC intended for use in potentially explosive atmospheres
38	European directive for pressure vessels		
39	HSE guideline	847/9	HSE guideline
40	VDI 3673		Pressure venting of dust explosions
	VDI 2263		Dust Fires & Dust explosions; Hazards-Assessment-Protection
41	Chlorine Institute		
42	ADC	1062	ADC Compliance. Test and rate air outlets and inlets in certified laboratories under requirements of ADC 1062" Certification, Rating and Test Manual."
			ADC Seal: Provide air outlets and inlets bearing ADC Certified Rating Seal.

S.N.	Standard	Section	Description
43	AMCA	500	AMCA Compliance. Test and rate louvers in accordance with AMCA 500 Test Method for Louvers, Dampers and Shutters.”
			AMCA Seal. Provide louvers bearing AMCA Certified Rating Seal.

4.3 Design Life

Unless otherwise specified, minimum Design life of equipment shall be as follows:

Motors	15 years
Pumps	25 years
Reduction gears	15 years
Process equipments	25 years
Valves/Piping	20 years
Cranes/Lifting equipments	20 years

4.4 Coordination

The contractor shall coordinate all details of the equipment with other related parts of the work, including verification that structures, piping, wiring and equipment components are compatible and shall be responsible for any alterations required in the work to accommodate equipment.

Equipment shall consist of parts which are designed to act as unit, and the manufacturer shall guarantee that the component parts when assembled into the final unit shall operate satisfactorily.

Except as otherwise provided, the responsibility of manufacturer shall extend to the selection and mounting of gear drive units, motors or other prime movers, accessories, and auxiliaries required for proper operation.

4.5 Project Conditions

Equipment furnished for this project shall be suitable for ambient conditions specified in Section 1. Any evidence of corrosion or rusting noted at the time of startup shall be considered as the basis for rejection; such corrosion shall be corrected or equipment removed from the project.

4.6 Performance Requirements

Materials which will be submerged all or in part shall be resistant to the chemicals in the water.

Bronze components of equipment, which will be in contact with water being treated shall be resistant to dezincification (less than 6% zinc) and de-aluminization.

Stainless steel AIST type 316L or equivalent or low zinc bronze trim shall be used for pumps, valves and other equipment.

All anchor bolts and expansion anchors shall be type SS 316L stainless steel. Anchor bolts shall be long enough to accommodate 38mm of grout beneath and to provide required anchorage into structural concrete.

Wherever belt drive system is specified, the equipment shall be furnished in accordance with clause 4.11.7 of this Section.

4.7 Sound And Vibration Measurements

All equipment shall operate within the maximum limitation of 85 DBA sound pressure level, based upon measurements taken 1 meter from the source. Acoustical wrappings, coatings or enclosures will be permitted, provided there is no limitation placed on access for operation and maintenance of equipment. Full octave band sound level data shall be furnished for the equipment as well as the equipment and driver.

Submit sound power levels determined in accordance with specified manufacturer's procedures and applicable standards. Submittals shall include complete backup documentation to show measurement and calculation procedures used in determining the sound power levels data. Readings and data shall be taken for the actual equipment to be provided and not nearly identical previously tested equipment.

4.8 Submittals

4.8.1 Description

This Section specifies the general methods and requirements of submissions applicable to the following work-related submittals.

- Shop Drawings.
- Product Data.
- Samples.
- Mock Ups.
- Construction Photographs.
- Construction or Submittal Schedules.

The Tenderer shall submit within two weeks after signing Agreement a list of all submittals showing the forecast date for submission of each item.

No work represented by required submittals shall be purchased or commenced until the applicable submittal has been approved by the Engineer.

Drawings and data shall be submitted to meet the time schedules stipulated in these specifications or the approved program.

Detailed submittal requirements will be specified in the technical specifications section.

Submittal copies shall be neatly bound and shall have an index listing the contents.

Unless otherwise specified, each submittal shall include three sets of copies. One copy of the submission will be returned marked with one of the following categories:

A : "Approved" subject to Contract requirements

- B : "Approved except as noted" resubmission not required
- C : "Disapproved" pending corrections, resubmission required
- D : Rejected" not to specification
- E : Incomplete

Identify variations from Tender Documents and Product or system limitations which may be detrimental to successful performance of the completed Work.

Make all required corrections and resubmit the required number of corrected submittals until approved. Direct specific attention in writing to revisions other than the corrections called for on previous submittals.

Whenever a variation causes a change to the information contained in previously approved submittals, submit information and data corresponding to the changed requirements for approval.

4.8.2 Shop Drawings, Product Data, Samples

4.8.2.1 Shop Drawings

Shop drawings include, but are not necessarily limited to: custom-prepared data such as fabrication and erection/installation (working) drawings of concrete reinforcement, structural details and piping layout, scheduled information, setting diagrams, actual shopwork manufacturing instructions, custom templates, special wiring diagrams, coordination drawings, individual system or equipment inspection and test reports including performance curves and certifications as applicable to the work.

All shop and working drawings shall be prepared on standard size, A1 sheets, except those which are made by changing existing standard shop or working drawings.

All shop drawings shall be submitted using the transmittal form furnished by the Engineer.

All shop drawings submitted by subcontractors for approval shall be sent directly to the Contractor for checking. The Contractor shall be responsible for their submission at the proper time so as to prevent delays in delivery of materials.

The Contractor shall check all sub-contractor's shop drawings regarding measurements, size of members, materials, and details to satisfy himself that they conform to the intent of the Drawings and Specifications. Shop drawings found to be inaccurate or otherwise in error shall be returned to the subcontractors for correction before submission thereof.

All details on shop drawings submitted for approval shall show clearly the relation of the various parts of the main members and lines of the structure, and where correct fabrication of the work depends upon field measurements; such measurements shall be made and noted on the drawings before being submitted for approval.

Submittals for equipment specified shall include a listing of all installations where identical or similar equipment has been installed and been in operation for a period of at least one year.

Submittals for equipment furnished under those sections and Divisions shall include maintenance and lubrication schedules for each piece of equipment.

4.8.2.2 Product Data

Product data as specified in individual Sections, include, but are not necessarily limited to, standard prepared data for manufactured products (sometimes referred to as catalog data), such as the manufacturer's product specification and printed installation instructions, availability of colors and patterns, manufacturer's printed statements of compliances including certificates of compliance and applicability, roughing-in diagrams and templates, catalog cuts, product photographs, standard wiring diagrams, printed performance curves and operational-range diagrams, production or quality control inspection and test reports and certifications and recommended spare-parts listing, and printed product warranties, as applicable to the Work.

4.8.2.3 Samples

Samples specified in individual Sections, include, but are not necessarily limited to, physical examples of the work such as sections of manufactured or fabricated work, small cuts or containers of materials, complete units of repetitively-used products, color/texture/pattern swatches and range sets, specimens for coordination of visual effect, graphic symbols, and units of work to be used by the Engineer or Employer for independent inspection and testing, as applicable to the Work.

4.8.3 Proposed Product List

Within two weeks after date of signing Agreement, submit list of major products proposed for use.

Prepare neatly bound itemized, indexed manuals containing details of all items proposed to be incorporated in construction of the Works. Each manual shall cover the items related to a particular aspect of the Works or items which are related. For each item, include the manufacturer's name and address, trade or brand name, local supplier's name and address, catalog numbers and cuts, brochures, terms and conditions of manufacturer's guarantee and warranty, other information to fully describe the item, and supplementary information as may be required for approval. Cuts, brochures, and data shall be marked to indicate the items proposed and their intended use. Unless otherwise specified, each submittal shall include six copies of each manual, two of which will be returned marked to show the required corrections or approval.

4.8.4 Product Data

Product Data For Approval:

Submitted to Engineer for purpose of checking for conformance with information given and the design concept expressed in the contract documents.

Mark each copy to identify applicable products, models, options, and other data. Supplement manufacturers' standard data to provide information specific to this Project.

Indicate Product utility and electrical characteristics, utility connection requirements, and location of utility outlets for service for functional equipment and appliances.

4.8.5 Contractor's Responsibilities

The Contractor shall review shop drawings, product data and samples, including those by subcontractors, prior to submission to determine and verify the following:

- Field measurements
- Field construction criteria

- Catalogue numbers and similar data
- Conformance with the Specifications

Each shop drawing, sample, and product data submitted by the Contractor shall have affixed to it the following Certification Statement including the Contractor's Company name and signed by the Contractor: "Certification Statement: by this submittal, I hereby represent that I have determined and verified all field measurements, field construction criteria, materials, dimensions, catalog numbers and similar data, and I have checked and coordinated each item with other applicable approved shop drawings and all Contract requirements." Shop drawings and product data sheets A3. and smaller shall be bound together in an orderly fashion and bear the above Certification Statement on the cover sheet. The cover sheet shall fully describe the packaged data and include a listing of all items within the package. Provide to the Engineer a copy of each submittal transmittal form for shop drawings, product data and samples at the time of submittal of said drawings, product data and samples to the Engineer.

If a shop drawing shows any deviation from the requirements of the Contract Documents, the Contractor shall make specific mention of the deviations in the Transmittal Form furnished by the Engineer and provide a description of the deviations in a letter attached to the submittal.

The approval of shop drawings, samples or product data by the Engineer shall not relieve the Contractor from his responsibility with regard to the fulfilment of the terms of the Contract. All risks of error and omission are assumed by the Contractor and the Engineer will not have responsibility therefore.

No portion of the work requiring a shop drawing, sample, or product data shall be started nor shall any materials be fabricated or installed prior to the approval or qualified approval of such item. Fabrication performed, materials purchased or on-site construction accomplished which does not conform to approved shop drawings and data shall be at the Contractor's risk. The Employer will not be liable for any expense or delay due to corrections or remedies required to accomplish conformity.

Project work, materials, fabrication, and installation shall conform to approved shop drawings, applicable samples, and product data.

Manufacturer's printed installation instructions, a part of product data submitted to the Engineer will not be reviewed and are for informational purposes only.

4.8.6 Submission Requirements

Make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the Work or in the work of any other contractor.

Contractor shall submit only one submittal for an equipment for review by the Engineer. Should the contractor find it necessary that additional submittal form other manufacturer for the same equipment is required, he shall explain the reasons for such submissions. At the discretion of the Engineer, it shall be reviewed, cost of such reviews shall be borne by the contractor.

All submittals shall be submitted sufficiently in advance of construction requirements to provide no less than ten days, including Saturday and Sunday and legal holidays for review from the time received at the Engineer's reviewing office. For submittals of major equipment, that require more than ten days to review, due to its sheer complexity and amount of detail and also requiring review by more than one engineering discipline, a letter will be sent by the Project Manager or his/her designee to the Contractor informing him/her of the circumstances and the date it is expected the submittal will be returned to the Contractor.

Number of submittals required:

- Shop Drawings: Unless otherwise stated in the respective Specifications Sections, submit six (6) copies.
- Product Data: Unless otherwise stated in the respective Specifications submit six (6) copies.
- Samples: Submit the number stated in the respective Specification Sections.

Submittals shall contain:

- The date of submission and the dates of any previous submissions.
- The Project title and number.
- Contractor identification.
- All calculation justifying selection of equipment, catalogue, curves and all other related technical information.

The names of:

- Contractor
- Supplier
- Manufacturer

Identification of the product, with the specification section number, page and paragraph(s).

Field dimensions, clearly identified as such.

Relation to adjacent or critical features of the Work or materials.

Applicable standards, such as ASTM or Federal Specification numbers.

Identification of deviations from Contract Documents.

Identification of revisions on resubmittals.

200mm x 75mm. blank space for Contractor and Engineer stamps.

Delivery period.

Each shipment of drawings shall be accompanied by a transmittal form furnished by the Engineer giving a list of the drawing numbers and the names mentioned above.

4.8.7 Review of Shop Drawings, Product Data, Working Drawings and Samples

Markings or comments shall not be construed as relieving the Contractor from compliance with the contract and specifications or from departures there from. The Contractor remains responsible for details and accuracy, for coordinating the work with all other associated work and trades, for selecting fabrication processes, for techniques of assembly, and for performing work in a safe manner.

The review of shop drawings, data, and samples will be general. They shall not be construed:

- as permitting any departure from the Contract requirements;

- as relieving the Contractor of responsibility for any errors, including details, dimensions, and materials;
- as approving departures from details furnished by the Engineer, except as otherwise provided herein.

4.8.8 Samples

Unless otherwise specified, each submittal shall include two sets of samples. One set of approved samples and all disapproved samples will be returned. Samples of value retained by the Employer will be returned after completion of the Work if the first transmittal for the sample requests its return. Approved samples of manufactured items returned may not be installed in the Work.

Submit samples to illustrate functional and aesthetic characteristics of the Product, with integral parts and attachment devices. Coordinate sample submittals for interfacing work.

Include identification on each sample, with full Project information.

Samples will not be used for testing purposes unless specifically stated in the specification section.

4.8.9 Design Data

Unless otherwise specified submit 3 copies of Calculations certified by the approved Qualified Designer under all sections.

4.8.10 Equipment Data

Submit six copies, one of which must be an original, of complete technical and catalogue data for every item of mechanical and electrical equipment and machinery to be incorporated in the Works, including components as specified under Sections dealing with mechanical and electric

4.8.11 Manufacturer's Instructions

When specified in individual specification sections, submit printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, to Engineer for delivery to Employer.

Indicate special procedures, conditions requiring special attention, and special environmental criteria required for application or installation.

4.8.12 Manufacturer's Field Reports

Submit reports to the Engineer.

Submit report in duplicate within two weeks of observation to Engineer for information.

Submit for the purpose of assessing conformance with information given and the design concept expressed in the contract documents.

4.8.13 Correspondence

Except where more are required by the Contract, all correspondence to the Engineer shall be submitted as follows:

One original and three photocopies of transmittals and letters including attachments/ enclosures.

All correspondence from the Contractor to the Engineer shall be submitted on A4 size paper whenever possible. All correspondence shall clearly indicate:

- Contract Number
- Title of the Project
- Contractor's Name
- Date and reference number of the correspondence.

4.8.14 Distribution

Distribute reproductions of approved shop drawings and copies of approved product data and samples, where required, to the job site file and elsewhere as directed by the Engineer. Number of copies shall be as directed by the Engineer but shall not exceed 6.

4.8.15 General Procedures for Submittals

Coordination of Submittal Times: Prepare and transmit each submittal sufficiently in advance of performing the related work or other applicable activities, or within the time specified in the individual work sections, of the Specifications, so that the installation will not be delayed by processing times including disapproval re submittal (if required), coordination with other submittals, inspection, testing (off-site and on-site), purchasing, fabrication, delivery and similar sequenced activities. No extension of time will be authorized because of the Contractor's failure to transmit submittals sufficiently in advance of the Work. The typical review period for submittals is two weeks.

4.9 Quality Assurance

4.9.1 Quality Assurance Requirement

Quality assurance responsibilities lie with the Contractor with the exception of those additional inspections, tests, and/or audits that may be required and will be conducted by the Engineer.

Submit prior to procurement of items and materials, a list of suppliers and Sub-Contractors that shall include items to be supplied, item numbers, specifications, inspection and test requirements, performance data, anticipated inspection test dates, and other pertinent information as appropriate.

Unless specifically named in the specifications, a manufacturer shall have furnished equipment of the type and size specified in similar applications which has been in successful operation for not less than the past 5 years.

Any part of mechanical equipment that fails due to wear under specified operating conditions within the first year of operation after final acceptance shall be considered as evidence of defective material or workmanship. Any equipment with such defective part shall be replaced by the contractor with equipment or parts to meet the specified requirements at no cost to the employer.

4.9.2 Samples

All items and materials must be approved by the Engineer and Employer prior to use on the Project.

Verify, through appropriate inspections and tests, that the samples submitted meet the Specifications and provide inspection and test data with the samples.

The review, comments, acceptance or approval will not relieve the Contractor of his responsibility for completion of the Contract.

One sample will be returned to the Contractor and will be stamped in accordance with Section 4.8.

Samples to be corrected are to be resubmitted in the same manner as the original sample submittal.

Ensure items/materials shall be available in quantities required to complete the work, as no change or substitution will be permitted after a sample has been approved unless a request for change or substitution has been submitted in writing to the Engineer and accepted in writing by the Engineer. The submittal process shall then be repeated.

Samples will only be considered if taken at random. Permit Engineer's Representative or a member of his staff to witness the selection of samples. Inspection or tests of items or materials that fail shall be sufficient cause to terminate further inspections/tests of the same brand, make, or source of the product.

4.9.3 Mock- Up

Tests will be performed under provisions identified in this Division and identified in the respective product specification sections.

Assemble and erect specified items with specified attachments, etc

Accepted mock-ups shall be a comparison standard for the remaining Work.

Where mock-up has been accepted and is specified in product specification sections to be removed; remove mock-up and clear area when directed to do so.

4.9.4 Materials and equipment

The Contractor shall maintain control over procurement sources to ensure that materials and equipment conform to specified requirements in the Contract Documents.

The Contractor shall comply with manufacturer's printed instructions regarding all facets of materials and/or equipment movement, storage, installation, testing, start-up, and operation. Should circumstances occur where the contract documents are more stringent than the manufacturer's printed instructions, the Contractor shall comply with the specifications. In cases where the manufacturer's printed instructions are more stringent than the contract documents, the Contractor shall advise the Engineer of the disparity and conform to the manufacturer's printed instructions. In either case, the Contractor is to apply the more stringent specification or recommendation, unless approved otherwise by the Engineer.

4.9.5 Shop and Field Testing

The Contractor is also responsible for providing the shop and field testing specified in the technical specification sections.

The Contractor and its Subcontractor shall perform inspections, tests, and other services as required by the Contract Documents.

Shop testing of under noted equipment shall be witnessed by the Employer and/or his representative, cost of such inspection including travel expenses to and fro from the Employer and/or his representative's location to place of inspection, boarding and lodging expenses, per diem etc shall be borne by the contractor. Duration of such visits shall be restricted to 3 days excluding travel time and for a maximum of 4 persons. The contractor shall give 28 days written notice to the Engineer.

1. Flash Mixing and Flocculation Units
2. Sludge Scraper Mechanism
3. Chlorination equipment
4. Sludge Thickening equipment
5. Sludge dewatering equipment
6. Blowers
7. Chemical preparation and handling equipment
8. Pumps with drive rate at 100 KW or above

The Engineer's witnessing of tests does not relieve the Contractor and/or Subcontractors of their obligation to comply with the requirements of the Contract Documents.

4.9.6 Manufacturer's Field Services

Furnish manufacturers qualified representative to observe site conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment, test, adjust and balance of equipment as applicable, and to initiate instructions when necessary.

Submit qualifications of observer to Engineer two weeks in advance of required observations. Observer subject to approval of Engineer.

Report observations and site decisions or instructions given to applicators or installers that are supplemental or contrary to manufacturers' written instructions.

4.9.7 Identification Mark-up

Manufacturer's product identification marks and the conforming applicable standards, third party product testing and certification marks shall be embossed in each manufactured item arriving at site.

4.9.8 Examination

Verify that existing site conditions and substrate surfaces are acceptable for subsequent Work. Beginning new Work means acceptance of existing conditions.

Verify that existing substrate is capable of structural support or attachment of new Work being applied or attached.

Examine and verify specific conditions described in individual specification sections.

Verify that utility services are available, of the correct characteristics, and in the correct locations.

4.9.9 Quality Assurance

Monitor quality control over suppliers, manufacturers, Products, services, site conditions, and workmanship, to produce Work of specified quality.

Comply with manufacturers' instructions, including each step in sequence.

Should manufacturers' instructions conflict with Contract Documents, request clarification from Engineer before proceeding.

Comply with specified standards as minimum quality for the Work except where more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

Perform Work by persons qualified to produce required and specified quality.

Verify that field measurements are as indicated on shop drawings or as instructed by the manufacturer.

Secure Products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

Copies of applicable referenced standards are not included in the Contract Documents. Where copies of standards are needed by the Contractor for superintendence and quality control of the work, the Contractor shall obtain a copy or copies directly from the publication source and maintain at the jobsite, available to the Contractor's personnel, subcontractors, and Engineer

Quality of Materials: Unless otherwise specified, all materials and equipment furnished for permanent installation in the Work shall conform to applicable standards and specifications and shall be new, unused, and free from defects and imperfections, when installed or otherwise incorporated in the Work. Material and equipment shall not be used by the Contractor for any purpose other than that intended or specified unless such use is authorized by the Engineer.

Where so specified, products or workmanship shall also conform to the additional performance requirements included within the Contract Documents to establish a higher or more stringent standard or quality than that required by the referenced standard.

4.9.10 Tolerances

Monitor fabrication and installation tolerance control of Products to produce acceptable Work. Do not permit tolerances to accumulate.

Comply with manufacturers' tolerances. Should manufacturers' tolerances conflict with Contract Documents, request clarification from Engineer before proceeding.

Adjust Products to appropriate dimensions; position before securing Products in place.

4.9.11 Audits

Perform scheduled internal audits to verify that QA procedures ensure total compliance with the Specifications and reference standards.

Maintain records of internal audits as quality records and make them available to the Engineer upon request. Provide access to the audit locations upon notice by the Engineer.

4.10 Guarantee and Warranties

Guarantee all equipment in accordance with the Conditions of the Contract. In addition to the general guarantee requirements, equipment guarantee shall cover (1) faulty or inadequate design; (2) improper assembly or erection; (3) defective workmanship or materials; and (4) leakage, breakage, or other failure.

Unless specified elsewhere for this project, the nominal equipment guarantee period is one year from the date of the issue of the Substantial Completion Certificate of the whole works.

The guarantee period for equipment furnished under this Contract shall commence upon the date of the Employer's written acceptance of the equipment as it is put into service for each stage of commissioning.

The Contractor shall consider the staging requirements of the project when ordering equipment so that the manufacturer's warranties are not voided due to delay in equipment commissioning.

4.11 Control of Materials

4.11.1 Approval of Materials

Unless otherwise specified, only new materials and equipment shall be incorporated in the work. All materials and equipment furnished by the Contractor shall be subject to the Engineer's approval. Equipment shall be submitted for approval, from three different acceptable suppliers, and the Engineer shall in a maximum 2 weeks period approve the later. Equipment shall not be delivered to the work without prior approval of the Engineer.

As specified in design standards, the Contractor shall submit to the Engineer, data relating to materials and equipment he proposes to furnish for the work. Such data shall be in sufficient detail to enable the Engineer to identify the particular product and to form an opinion as to its conformity to the specifications.

Facilities and labor for handling and inspection of all materials and equipment shall be furnished by the Contractor. If the Engineer requires, either prior to beginning or during the progress of the work, the Contractor shall submit additional samples or materials for such special tests as may be necessary to demonstrate that they conform to the specifications. Such samples shall be furnished, stored, packed, and shipped as directed at the Contractor's expense. Except as otherwise noted, the Employer will make arrangements for and pay for the tests.

Any delay of approval resulting from the Contractor's failure to submit samples or data promptly shall not be used as a basis of a claim against the Employer or the Engineer.

In order to demonstrate the proficiency of workmen or to facilitate the choice among several textures, types, finishes, and surfaces, the Contractor shall provide such samples of workmanship or finish as may be required.

The materials and equipment used on the work shall correspond to the approved samples or other data.

4.11.2 Lubrication

Provide extension fittings and tubing on all grease fittings that are installed in an inaccessible location. The extension is to be located so that equipment can be lubricated from the operating

level without the use of ladders, staging or shutting down the equipment. Tubing: 316L stainless steel.

All equipment including motors, gear reducers, lubrication reservoirs etc shall be shipped to the site with shop oil, or similar expendable lubricant. Each greasing plug will have a relief port. All lube oil reservoirs have level indicators. Immediately before start up, all such reservoirs shall be flushed clean and manufacturer's specified lubricant added.

All grease, oil and fuel required for testing of equipment shall be furnished by with the respective equipment. Also furnish to the employer with a supply of required lubricants including grease and oil of the type as recommended by the manufacturer.

4.11.3 Concrete Inserts

Concrete inserts for hangers shall be designed to support safely, in the concrete that is used, the maximum load that can be imposed by the hangers used in the inserts. Inserts for hangers shall be of a type which will permit adjustment of the hangers both horizontally (in one plane) and vertically and locking of the hanger head or nut. All inserts shall be SS 316L.

4.11.4 Sleeves

Unless otherwise specified, openings for the passage of pipes through floors and walls shall be formed of sleeves of standard-weight, SS 316L Schedule 40 pipe. The sleeves shall be of ample diameter to pass the pipe and its insulation, if any, and to permit such expansion as may occur. Sleeves shall be of sufficient length to be flush at the walls and the bottom of slabs and to project 25mm above the finished floor surface. Threaded nipples shall not be used as sleeves.

Sleeves in exterior walls below ground or in walls to have liquids on one or both sides shall have a 50mm annular fin of 3 mm. plate welded with a continuous weld completely around the sleeve at about mid-length.

All sleeves shall be set accurately before the concrete is placed or shall be built in accurately as the masonry is being built.

4.11.5 Equipment Foundations, Installation and Grouting

The Contractor shall furnish the necessary materials and construct suitable concrete foundations for all equipment installed by him. The tops of foundations shall be at such elevations as will permit grouting as specified below.

All such equipment shall be installed by skilled mechanics and in accordance with the instructions of the manufacturer.

In setting pumps, motors, and other items of equipment customarily grouted, the Contractor shall make an allowance of at least 38mm for grout under the equipment bases. Shims used to level and adjust the bases shall be steel. Shims may be left embedded in the grout, in which case they shall be installed neatly and so as to be as inconspicuous as possible in the completed work. Unless otherwise permitted, all grout shall be a suitable non shrinking grout.

Grout shall be mixed and placed in accordance with the recommendations of the manufacturer. Where practicable, the grout shall be placed through the grout holes in the base and worked outward and under the edges of the base and across the rough top of the concrete foundation to a peripheral form so constructed as to provide a suitable chamfer around the top edge of the finished foundation.

Where such procedure is impracticable, the method of placing grout shall be as permitted. After the grout has hardened sufficiently, all forms, hoppers, and excess grout shall be removed, and all exposed grout surfaces shall be patched in an approved manner, if necessary, given a burlap-rubbed finish, and painted with at least two coats of an acceptable paint.

Unless otherwise specified, all equipment bases shall be installed on concrete bases at least 150mm high. Cast iron or welded steel plate shall be provided for pumps, compressors, and other equipment. Each unit and its driving assembly shall be supported on a single base plate of neat design.

Base plates for pumps shall have a means for collecting leakage and a threaded drain connection.

Jacking screws shall be provided in the heavy equipment bases and the base plates where required elsewhere to aid in leveling prior to grouting.

Contractor shall provide anti vibration accessories as without the objection of the Engineer.

4.11.6 Safety Guards

All equipment driven by open shafts, belts, chains, or gears shall be provided with acceptable all-metal guards enclosing the drive mechanism. Guards shall be constructed of galvanized sheet steel or galvanized woven wire or expanded metal set in a frame of galvanized steel members. Guards shall be secured in position by steel braces or straps which will permit easy removal for servicing the equipment. The guards shall conform in all respects to all applicable safety codes and regulations.

Safety guards shall be fabricated from 1.5 mm or heavier galvanized or aluminum –clad sheet steel or 13 mm mesh galvanized expanded metal.

4.11.7 Drive units

Nominal input kilowatt rating of each gear or speed reducer shall be name plate kilowatt of the drive motor. Drive unit shall be designed for 24 hours continuous operation.

Unless otherwise specified, the use of gear motors will not be acceptable.

Helical, bevel, combination of helical- bevel and worm gear reducers shall have a service factor of at least 1.5 based on the name plate kilowatt of the drive motor. Helical gear reducers shall have a gear strength rating to catalogue rating of 1.5.

Unless otherwise specified, all gearing shall run on oil. Means shall be provided to prevent foaming of the lubricated oil.

Variable speed drives shall have a service factor of at least 1.15 at maximum speed based on the name plate kilowatt of the drive motor. Bracket type mounting for variable speed drives will not be acceptable.

For V-Belt drives, sheaves and bushings which operate at more than 1676 meters per minute shall be dynamically balanced. All pulleys and bushings shall be statically balanced. Pulleys shall be separately mounted on their bushings by means of three pull-up bolts or cap tightening screws. Bushings shall be key seated to the drive shaft.

Belts shall be selected for not less than 150% of rated driver kilowatts .Belts shall be of the anti static type where explosion proof equipment is specified.

V-Belt drives shall have a service factor of at least 1.6 at maximum speed on the name plate kilowatt of drive motor.

4.11.8 Bearings

Unless otherwise specified, all equipment bearings shall be oil or grease lubricated, ball or roller antifriction type of standard manufacture. Each bearing except otherwise specified, shall be rated in accordance with the latest revisions of AFBMA methods of evaluating load ratings of Ball and Roller for L10 rating life of 40,000 hours.

4.11.9 Couplings

Unless otherwise specified, mechanical equipment with a driver greater than 3.7 kilowatt where the input shaft of a driven unit is directly connected to output shaft of the driver, shall have the two shafts connected by flexible coupling which can accommodate angular misalignment and end float; and which cushions shock loads and dampens torsional vibrations. The flexible member shall consist of synthetic tension members bonded together in rubber.

Coupling sizes, unless otherwise specified, shall be as recommended by the coupling manufacturer, for the specific application, considering the specific application, considering horse power, speed of rotation, and type of service.

4.12 Delivery, Storage and Handling

4.12.1 Transportation and Delivery

Transport and handle items in accordance with manufacturer's instructions.

Schedule delivery to reduce long term on-site storage prior to installation and/or operation.

Coordinate delivery with installation to ensure minimum holding time for items that are hazardous, flammable, easily damaged or sensitive to deterioration.

Deliver products to the site in manufacturer's original sealed containers or other packing systems, complete with instructions for handling, storing, unpacking, protecting and installing.

All items delivered to the site shall be unloaded and placed in a manner which will not hamper the Contractor's normal construction operation or those of subcontractors and other contractors and will not interfere with the flow of necessary traffic.

Provide necessary equipment and personnel to unload all items delivered to the site.

Promptly inspect shipment to assure that products comply with requirements, quantities are correct, and items are undamaged. For items furnished by others (i.e. Employer, other Contractors), perform inspection in the presence of the Engineer. Notify Engineer verbally, and in writing, of any problems.

4.12.2 Storage and Protection

Store and protect products in accordance with the manufacturer's instructions, with seals and labels intact and legible. Storage instruction shall be studied by the Contractor and reviewed with the engineer by him. Instruction shall be carefully followed and a written record of this kept by the Contractor. Arrange storage to permit access for inspection.

All structural, miscellaneous and reinforcing steel shall be stored off the ground or otherwise to prevent accumulation of dirt or grease, and in a position to prevent accumulations of standing water and to minimize rusting. Beams shall be stored with the webs vertical.

All mechanical and electrical equipment and instruments to corrosive damage by the atmosphere if stored outdoors (even though covered by canvas) shall be stored in a weather tight building to prevent injury. The building may be a temporary structure on the site or elsewhere, but it must be satisfactory to the Engineer. Building shall be provided with adequate ventilation to prevent condensation. Maintain temperature and humidity within range required by manufacturer.

- All equipment shall be stored fully lubricated with oil, grease and other lubricants unless otherwise instructed by the manufacturer.
- Moving parts shall be rotated a minimum of once weekly to insure proper lubrication and to avoid metal-to-metal "welding". Upon installation of the equipment, the Contractor shall start the equipment, at least half load, once weekly for an adequate period of time to ensure that the equipment does not deteriorate from lack of use.

Lubricants shall be changed upon completion of installation and as frequently as required thereafter during the period between installation and acceptance. New lubricants shall be put into the equipment at the time of acceptance.

- Prior to acceptance of the equipment, the Contractor shall have the manufacturer inspect the equipment and certify that its condition has not been detrimentally affected by the long storage period. Such certifications by the manufacturer shall be deemed to mean that the equipment is judged by the manufacturer to be in a condition equal to that of equipment that has been shipped, installed, tested and accepted in a minimum time period. As such, the manufacturer will guarantee the equipment equally in both instances. If such a certification is not given, the equipment shall be judged to be defective. It shall be removed and replaced at the Contractor's expense.

4.12.3 Equipment Installation

All wedges, shims, filling pieces, keys, packing, grout or other materials necessary to properly align, level and secure apparatus in place shall be furnished by the contractor. All parts intended to be plum or level must be proven exactly so.

Contractor shall furnish all sleeves, inserts, hangers, anchor bolts, etc required for the execution work.

Equipment not intended to vibrate during normal operation shall be rigidly attached to foundation or other adequate support to prevent lateral and vertical displacement. Equipment intended to vibrate during normal operation shall be provided with isolators with mechanical stops which are securely anchored to foundation or other adequate support.

4.13 Field Quality Control

Equipment shall not be installed or operated except by, or with the guidance of, qualified personnel having the knowledge and experience necessary for proper results. Qualified field representatives shall be provided by the equipment manufacturers as required to perform all manufacturer's field services called for the specifications.

The contractor shall give 2 days written notice prior to any field witness testing of equipment.

Unless otherwise specified, the minimum acceptable duration of satisfactory operation shall be 2 calendar weeks, or 100 hours of operation whichever is greater.

4.14 Starting Of Systems

4.14.1 General

All items of Mechanical equipment shall be tested for proper operation, efficiency and capacity. All required adjustments, tests, operation checks and other start up activity shall be provided.

The contractor shall coordinate and observe all tests related to starting of system and report the results to the Engineer in accordance with the Submittal section. The Engineer shall be notified in writing prior to all tests as specified.

4.14.2 Equipment Tests

4.14.2.1 Factory Acceptance Tests (FAT)

All major items of equipment specified in Section 4.9.5, shall be test run at the point of manufacture at the Contractor's expense and not less than 5 copies of test results delivered to the Engineer. Such equipment shall not be shipped until the Engineer has reviewed and approved the test results. Such acceptance of test results shall not be considered as final acceptance which will only be made on the basis of the test results of the equipment after installation.

For equipment which are not witness tested, manufacturer's factory test reports shall be furnished for Engineer's review and approval prior to dispatch of equipment from the manufacturer's works.

4.14.2.2 Preliminary Equipment Tests (Installation Tests, Dry Tests, Wet Tests etc.)

Contractor shall test operate each piece of Mechanical equipment for not less than Eight hours without interruption. All moving parts of equipment shall be carefully tested for operation and adjusted so all parts move freely and function to secure satisfactory operation. All parts shall operate satisfactorily in all aspects under continuous full load and accordance with specified requirements for the full duration of eight hour test period.

If any part of a unit shows evidence of unsatisfactory or improper operation during the eight hour test period, correction or repairs shall be made and the full eight hour test operation as specified, shall be completed after all parts operate satisfactorily.

Field performance tests of all process and pumping equipment, drive motors, including auxiliaries shall be made in accordance with the appropriate and approved test codes such as ASMI, HIS etc.

Field testing shall be conducted after the work is substantially complete so each item of equipment is ready for integrated operation with other equipment at the plant. Testing, measuring and calibrating process shall be submitted to the Engineer for review and acceptance prior to start up and field testing of equipment.

All equipment shall be tested continuously under actual or stimulated operating conditions. The manufacturer's representative shall make all necessary field adjustments and correct defects in materials or workmanship during the test period.

The equipment shall be properly serviced, by the contractor, with oil and grease, and the contractor shall furnish all power, personnel, water, chemicals, fuels, oil, grease and auxiliaries necessary for conducting the testing of equipment for operation, efficiency and capacity.

4.14.2.3 Final Acceptance Test/ Reliability Test

After all equipment is installed and the entire plant is ready to operate per system requirement, the contractor shall test all equipment for a period not less than seven days continuously (168 hours) by operating either under actual or simulated operating conditions, successful completion of which certificate to the effect shall be issued. All defects of material or workmanship which appear during this test period shall be corrected by the contractor. After such corrections are made, the seven day test shall be run again.

The contractor shall supply all power, water, oil, grease, auxiliaries and operating personnel required for these final tests.

4.15 Operation and Maintenance Data

4.15.1 O&M Instructions and Parts Lists

Where reference is made in the Detail Technical Specifications to operating and maintenance and spare parts lists, the Contractor shall furnish for each piece of equipment four complete sets giving the information listed below.

The manual for each piece of equipment shall be a separate document with the following specific requirements:

Contents:

- Table of contents and index
- Brief description of each system and components
- Starting and stopping procedures
- Special operating instructions
- Routine maintenance procedures
- Clean and concise manufacturer's printed operating and maintenance instructions, adjustment, lubrication and other maintenance of equipment including: parts list, illustrations, and diagrams
- One copy of each wiring diagram
- One copy of each approved shop drawing and each Contractor's coordination and layout drawing
- List of spare parts, manufacturer's price, and recommended quantity
- Name, address, and telephone numbers of local service representatives

Material:

- Loose leaf on 60 pound, punched paper
- Holes reinforced with plastic cloth or metal
- Page size A4

- Diagrams, illustrations, and attached foldouts as required of original quality, reproduced by dry copy method
- Covers: oil, moisture, and wear resistant.

Submittals to the Engineer:

- Such instructions and parts lists shall be completely and neatly annotated so that only the specific equipment and features furnished are clearly indicated. References to other sizes and types or models of similar equipment shall be deleted or neatly lined out.
- Such instructions and parts lists shall be delivered to the Engineer at the same time that the equipment to which they pertain is delivered to the site. Each submittal shall be accompanied by a transmittal form identifying the information included. Each submittal shall be reviewed by the Engineer for compliance with the above requirements.
- If a submittal is acceptable, all four copies will be retained by the Engineer. If deficiencies are found, one copy will be retained by the Engineer and three copies with the deficiencies, noted, will be returned to the Contractor. The copy retained by the Engineer shall not count toward the four complete acceptable sets required herein.
- At the Engineer's discretion, he may retain all four copies and request only supplemental information from the Contractor.

4.15.2 Contents, Each Volume

- **Table of Contents:** Provide title of Project, names, addresses, and telephone numbers of Engineer, sub-consultants, and Contractor with name of responsible parties; schedule of products and systems, indexed to content of the volume.
- **For Each Product or System:** List names, addresses and telephone number of Subcontractors and suppliers; including local source of supplies and replacement parts.
- **Product Data:** Mark each sheet to clearly identify specific products and component parts, and data applicable to installation. Delete inapplicable information.
- **A list of all parts for the equipment** with each part identified by a functional name, the part manufacturer's name and a unique part number, (normally the part manufacturer's alphanumeric designation). A list of parts keyed by non-unique item numbers to a sectional drawing will not be adequate to fulfil this requirement.
- **All components of each system**, e.g., pump motor, coupling, and drive, shall be combined in a single submittal with the above data provided for each component.
- **Drawings:** Supplement product data to illustrate relations of component parts, and data applicable to installation. Delete inapplicable information.
- **Type Text:** As required to supplement product data. Provide logical sequence of instructions for each procedure, incorporating manufacturer's printed instructions specified.

4.15.3 Manual for Materials and Finishes

Building Products, Applied Materials, and Finishes: Include product data, with catalog number, size, composition, and color and texture designations. Provide information for re-ordering custom manufactured products.

Instructions for Care and Maintenance: Include manufacturer's printed recommendations for cleaning agents and methods, precautions against detrimental agents and methods, and recommended schedule for cleaning and maintenance.

Moisture Protection and Weather Exposed Products: Include product data listing, applicable reference standards, chemical composition, and details of installation. Provide printed recommendations for inspections, maintenance, and repair.

Additional Requirements: As specified in individual product specification sections.

Provide a listing in Table of Contents for design data, if provided by Contractor, with tabbed fly sheet and space for insertion of data.

4.15.4 Manual for Equipment and Systems

For each Item of Equipment and Each System provide the following:

- Description of unit or system, and component parts. Identify function, normal operating characteristics, and limiting conditions. Include certified performance curves, with engineering data and tests, and complete nomenclature and commercial number of replaceable parts.
- Panel board Circuit Directories including electrical service characteristics, controls and communications, and color coded wiring diagrams as installed.
- Operating Procedures: Include start-up, break-in, and routine normal operating instructions and sequences; regulation, control, stopping, shut-down, and emergency instructions; and summer, winter, and any special operating instructions.
- Maintenance Requirements:
 - Route procedures and guide for trouble-shooting; disassembly, repair, and reassembly instructions; and alignment, adjusting, balancing, and checking instructions.
 - Servicing and lubrication schedule, with list of lubricant type, frequency and method of lubrication. Any components which do not require lubrication or any expendable components which are not normally serviced shall be clearly noted as such.
 - Manufacturer's printed operation and maintenance instructions.
 - Sequence of operation by controls manufacturer.
 - Original manufacturer's parts list, illustrations, assembly drawings, and diagrams required for maintenance.
 - Lubrication and maintenance schedules shall be similar to that specified in Section 4.11.2.
 - Control diagrams by controls manufacturer as installed.
 - Contractor's coordination drawings, with color coded piping diagrams as installed.
 - Charts of valve tag numbers, with location and function of each valve, keyed to flow and control diagrams.
 - List of original manufacturer's spare parts, current prices, and recommended quantities to be maintained in storage.
 - Test and balancing reports as specified.
 - Additional Requirements: As specified in individual product specification section.

Provide a listing in Table of Contents for design data, if provided by Contractor, with tabbed fly sheet and space for insertion of data.

4.15.5 Instruction of Employer Personnel

- A. Before final inspection, instruct Employer's designated personnel in operation, adjustment, and maintenance of products, equipment, and systems, at agreed upon times
- B. Use operation and maintenance manuals as basis for instruction. Review contents of manual with personnel in detail to explain all aspects of operation and maintenance.
- C. Prepare and insert additional data in Operations and Maintenance Manual when need for such data becomes apparent during instruction.
- D. Provide a completed and filled-out Equipment Manufacturer's Certificate of Installation, Testing and Instruction form attached to the end of this section.

4.15.6 Service Manufacturer's Representative

The Contractor shall arrange for the services of qualified service representatives from the company manufacturing or supply the equipment.

After installation of the listed equipment has been completed and the equipment is presumably ready for operation, but before it is operated by others, the representative shall inspect, operate, test, and adjust the equipment. The inspection shall include but shall not be limited to, the following points as applicable:

- Soundness (without cracked or otherwise damaged parts).
- Completeness in all details, as specified.
- Correctness of setting, alignment, and relative arrangement of various parts.
- Adequacy and correctness of packing, sealing, and lubricants.

The operation, testing, and adjustment shall be as required to prove that the equipment is left in proper condition for satisfactory operation under the conditions specified.

On completion of his work, the manufacturer's or supplier's representative shall submit in triplicate to the Engineer a complete signed report of the result of his inspection, operation, adjustments, and tests. The report shall include detailed descriptions of the points inspected, tests and adjustments made, quantitative results obtained if such are specified, and suggestions for precautions to be taken to ensure proper maintenance. The report also shall include a Certificate of Compliance stating that the equipment conforms to the requirements of the Contract and is ready for permanent operation and that nothing in the installation will render the manufacturer's warranty null and void.

After the Engineer has reviewed the reports from the manufacturers' representatives, the Contractor shall make arrangements to have the manufacturers' representatives present when the field acceptance tests are made.

4.15.7 Nameplates:

With the exceptions mentioned below, each piece of equipment shall be provided with a substantial nameplate of non-corrodible metal, securely fastened in place and clearly and permanently inscribed with the manufacturer's name, model or type designation, serial number,

principal rated capacities, electrical or other power characteristics, and similar information as appropriate. This requirement shall not apply to standard, manually operated hydrants or to gate, globe, check, and plug valves.

Each piece of equipment, each vessel, each gate and process valve shall be provided with a substantial tag of non-corrodible metal securely fastened in place and inscribed with an identification number in conformance with the Valve Identification Schedule indicated on the drawings or furnished later by the Engineer. The identification number shall be utilized in the Employer's Asset Registration System. The nameplate shall include a barcode to uniquely identify the device. The barcode shall interface with the Asset Registration System.

4.15.8 Special Tools

For each type of equipment furnished by him, the Contractor shall provide a complete set of all special tools (including grease guns or other lubricating devices) which may be necessary for the adjustment, operation, maintenance, and disassembly of such equipment. Tools shall be high-grade, smooth, forged, alloy, tool steel. Grease guns shall be lever type.

Special tools are considered to be those tools which because of their limited use are not normally available, but which are necessary for the particular equipment.

Special tools shall be delivered at the same time as the equipment to which they pertain. The Contractor shall properly store and safeguard such special tools until completion of the work, at which time they shall be delivered to the Employer.

As directed or permitted, the Contractor shall furnish and erect one or more neat and substantial steel wall cases with flat key locks and clips or hooks to hold each tool in a convenient arrangement.

4.15.9 Spare Parts

If specifically not mentioned in the particular equipment specifications, the contractor shall supply spare parts required for 2 years of normal operation as recommended by the manufacturer and without the objection of the Engineer for those equipments. Contractor shall include in his prices for providing these spares.

4.16 Training and Commissioning Services

4.16.1 Description

- **General:** This section covers furnishing Training and Commissioning (T&C) product and services. Commissioning includes checkout, testing and start up. The services shall be provided during the pre-commissioning and commissioning phases of the project.
- **Schedule:** The Contractor shall give clear visibility of these programs' importance, in the Project Schedule, in order that the services to be provided will proceed in a safe, orderly, and time efficient manner. All activities and deliverables shall be identified in the Project Schedule.
- **Meetings and Reports:** Contractor shall conduct monthly T&C progress meetings and prepare minutes. The Contractor shall prepare Monthly Reports during the Pre-Commissioning period and Weekly Reports during the Commissioning period and Post-Commissioning Periods.
- **Coordination:** The Contractor shall coordinate and cooperate closely at all times with the Engineer and Employer

- **Scope Limits:** Plans, Training, O&M Manuals and Commissioning products and services applies to all facilities on the site.
- **Product Deliverables:** Deliverables include:

Plans.

- Program Plan.
- Training Plan.
- HSE Program Plan.
- Security Program Plan.
- WTW Staffing Plan
- Operating Plan.
- Commissioning Plan.

Reports.

- T&C Monthly Report
- Training Needs Assessment Report
- Training Results Report
- Performance Standards Report
- Testing Reports
- Pre-Startup Audit

Operation and Maintenance Manuals.

- Vendor O&M Manuals.
- Plant O&M Manuals.

Training Materials.

- Student Study Guides
- Lesson Plans

Maintenance Management System.

- Sample Schedules and Reports
- Final Schedules and Reports
- Populated Database

Records.

- Record Drawings
- Training and Commissioning Records

The services and work shall consist of three phases:

- Pre-Commissioning
- Commissioning
- Post-Commissioning, including Final Handover

Objectives:

- Each activity shall have a definitive set of objectives. These shall be developed by the Contractor as part of the various Plans. In addition, during the implementation of the Work, the Contractor shall work with and assist Employer with the objective of assuring successful operation of the facilities and equipment.

4.16.2 Submittals

Report and Plan Copies: Unless otherwise specified, the Contractor shall submit 4 copies of all draft T&C related plans, reports and programs to the Engineer for review. Submit 3 copies of all final documents.

Training Certification Qualifications: The Contractor shall submit to seek the Engineer's approval the qualifications proposed to be awarded to those trained identifying accreditation to any international organizations, which is compulsory, with a list of client references. Each element of training shall require such certification.

All documentation specified shall include draft and final versions and shall be subject to the Engineer's approval.

4.16.3 Definitions

Vendor O&M Manuals: Vendor (or Manufacturer's) Operations and Maintenance (O&M) Manuals which are bound, equipment specific manuals provided by equipment manufacturers that include all items required in the specifications.

Plant O&M Manual: Complete and comprehensive Plant Operations and Maintenance (O&M) Manual that provides a single source for facility specific information in the style and form acceptable to the Employer.

Vendor Training: Vendor (or Manufacturer's) Training provided by specified equipment manufacturers. Vendor training is the formal classroom and field training provided to the Employer's personnel by the manufacturer of specific equipment. This training is specific to the equipment owned by the Employer and does not include entire processes or systems which is covered in the Plant O&M Manual.

Plant O&M Training: Plant O&M training is provided by T&C personnel under the direction and management of the T&C Manager in the style and form acceptable to the Employer and as specified below. Plant O&M training includes formal training, on-the-job training, and technical assistance training as defined below.

Training

- Formal Training: Formal training, performed in the classroom or at the work site, is an organized group of learning activities which allow trainees to learn new knowledge and skills.

- OJT: On-the-job training (OJT) is instruction provided at the work site to small groups during the normal course of their work day.
- Technical Assistance: Technical assistance is training provided to troubleshoot and solve specific problems. The trainee is guided through the troubleshooting process by a technical expert.

Shadow Staff: Employer personnel who, during the Commissioning and Contractor Operation Periods, observe and provide limited assistance to the Contractor personnel. Observation and limited assistance is with the objective of learning.

4.16.4 Plans and Reports

Program Plan: The Contractor shall prepare and submit to the Engineer for approval, a complete plan for all activities involved with commissioning, database building, record documentation, manuals, training and other activities during the pre-commissioning, and commissioning, periods. The plan shall include a narrative section addressing activities scope and responsibility as well as a schedule of events and activities.

Training Plan: The Contractor shall prepare and submit to the Engineer for approval, a complete plan for planned training. The plan shall include vendor training and system training. The plan shall address training scope, organization, assigned personnel, location, timing, class size, visual aids, testing performance measurement and other topics.

Safety Program: The Contractor shall develop a Health Safety & Environment Program. The Contractor shall implement the program during the Commissioning Period. The program shall stress the need for safety awareness and shall address at a minimum:

- Safe working procedures
- Cleanliness and care of facilities
- Accident and hazardous conditions
- Operation and maintenance safety equipment
- Handling of chemicals
- Response to and recovery from health and safety events
- Hazards register

Security Program: The Contractor shall develop a comprehensive security program responding to protection of facilities from, accidental or intentional damage and sabotage. The program shall include emergency response and recovery plans. The program shall be written to address all elements of water system operation security including the following:

- Treated water leakage or loss.
- Accidental treated water supply contamination.
- Facilities damage or sabotage.
- Unauthorized monitoring and control system access.
- Vandalism.

Performance Standards Report: The Contractor shall develop performance standards for the WTW and for specific facilities. As a minimum, performance shall be addressed in terms of overall power

usage, chemical usage, maintenance of storage reserves, sludge disposal, treated water delivery targets and pumping efficiency. Document and submit as a Performance Standards Report.

Operating Plan: The Contractor shall prepare and submit a plan to optimize operations of the new WTW, pumping stations and treated water delivery system.

Commissioning Plan: The Contractor shall prepare and submit to the Engineer for approval, a complete detailed plan for all activities involved with, checkout, testing, startup, performance testing and handing over. The plan shall be detailed in that it shall address the scope, procedures and schedule related to final calibration and checkout (including manufacturers' representatives services), functional testing, acceptance testing, and startup.

4.16.5 Commissioning Services

Commissioning (Startup) Services:

Hydraulic Testing: The Contractor shall perform hydraulic testing during the Commissioning Period.

Functional Testing: The Contractor shall conduct calibration, checkout, functional testing and other preparatory testing in accordance with the Contractor's Commissioning Plan and other sections of the Specifications.

Pre-startup Audit: Prior to the initiation of startup, the Contractor shall conduct a pre-startup audit and prepare a report of findings and a punch list. The Employer, Engineer and representatives of the manufacturers of major equipment shall participate in the audit. The audit shall determine whether:

- The facilities have been constructed as designed and approved,
- The facilities can be safely started without risk to personnel or damage to facilities, and
- The state is such that the processes can be expected to perform as planned.

Acceptance Testing: The Contractor shall perform all acceptances testing as specified as early as is practically possible during the Commissioning Period, or as specified.

Startup: The Contractor shall conduct the startup of the new facilities and equipment in accordance with the Contractor's Commissioning Plan. Startup shall be in accordance with these and other Specifications.

Performance Testing: The Contractor shall perform systems performance testing as scheduled and specified. Performance testing shall consist of 21 days of in spec operation on process fluids.

Test Reports: Provide reports of all performed testing.

Commissioning Period Extension: Should failures in equipment or processes occur for a significant period, as determined by the Engineer, which in the opinion of the Engineer detract from the goals of the Commissioning Period, the respective Commissioning Period will be extended by that period of failure. This will result in the assessment of penalties.

4.16.6 Post-Commissioning Services

Test Reports: Provide reports of all performed testing.

Plant Operation and Maintenance: The Contractor shall operate the new facilities provided under this Contract throughout the Commissioning Period. Contractor shall provide adequate staff and shall be fully responsible for all aspects of operation and maintenance of new facilities and

equipment provided under this Contract for the full duration of the Commissioning Period. The Contractor shall be responsible during the Commissioning Period to purchase and furnish all consumables in order to meet the T&C objective for successful operation. Supplies of consumable materials shall include, but not be limited to, polymer, chemicals, fuel, lubrication oil, grease, filters, office supplies, and spare parts for equipment supplied under this Contract. The Employer will furnish electrical power and pay tipping fees for disposal of residuals.

Plant Monitoring and Control: The Contractor shall perform plant sampling, analysis, monitoring and control throughout the Commissioning Period.

Handing Over: The Contractor shall complete all requirements related to handing over and project close out.

Post-Commissioning Period Extension: Should failures in equipment or processes occur for a significant period, as determined by the Engineer, which in the opinion of the Engineer detract from the goals of the Post-Commissioning Period, the respective Post-Commissioning Period will be extended by that period of failure. This will result in the assessment of penalties.

4.16.7 Records:

Provide test packs including results of all testing and copies of all certifications.

Handover Documentation: Submit all project closeout and handover documentation as required in other parts of the specifications.

The Contractor shall keep detailed records during the T&C period. These records shall be used for historical reference, monitoring and control, reporting, and future planning.

Organize, store and maintain all documentation and records in such a way that the data and information contained in the records can be retrieved and reported in various report formats such as chronological, subject, event, and conditions.

4.16.8 Training Equipment

Audiovisual: The Contractor shall provide audiovisual as required for the training program. The equipment shall be state-of-the art at the time of the purchase. Equipment shall become the property of the Employer at the completion of the Work.

Packaged Modules: Also to be included in this procurement shall be pre packaged training modules utilizing videocassette and CD-ROM recordings. Audiovisual equipment, transparencies, videocassette tapes, CD-ROMs, and all other training materials used for the purpose of providing the services, shall be soundly protected and shall become the property of the Employer at the termination of this program. They shall be consolidated, listed, and indexed for quick reference and use. Damaged diskettes and cassette tapes shall be re-recorded to the best of the Contractor's ability prior to completion of the Contract and turned over to the Employer.

4.16.9 Electrical Interface

All items of electrical equipment that are furnished with process, heating, ventilating, or other equipment shall conform to the requirements specified under Volume 3 of specifications. Enclosures for electrical equipment such as switches, starters, etc., shall also conform to the requirements specified under the applicable electrical sections.

4.16.10 Installation

After motor installation but before connection to power wiring, test motor winding insulation in accordance with the applicable specification requirements.

After connection to power wiring, check for operating temperature, correct rotation, vibration, alignment and operating current drawn under load.

Submit all motor test results for review and record.

SECTION 5 – ELECTRICAL & ICA REQUIREMENT

Table of Content

5.1	ELECTRICAL	4
5.1.1	Introduction.....	4
5.1.1.1	General.....	4
5.1.1.2	Scope of Electrical Works.....	4
5.1.2	Power Supplies.....	5
5.1.2.1	Operating Voltages.....	5
5.1.2.2	Protection and Co-Ordination.....	6
5.1.2.3	Power Factor Correction.....	6
5.1.2.4	Harmonics.....	6
5.1.2.5	Electromagnetic Compatibility.....	6
5.1.2.6	Mains Power Supply to the Mseilha Water Treatment Works.....	7
5.1.2.7	Standby Power Supply to the Mseilha Water Treatment Works.....	7
5.1.2.8	Low Voltage Distribution.....	8
5.1.2.9	Protective/Secure Power Supplies.....	8
5.1.2.10	MCC Buildings/Locations.....	9
5.1.2.11	Standard Designs/Circuit Requirements.....	9
5.1.2.12	Low Voltage Distribution Switchboards.....	9
5.1.3	Electrical Installation.....	10
5.1.3.1	General.....	10
5.1.3.2	Cabling and Wiring.....	10
5.1.3.3	Earthing and Bonding.....	10
5.1.3.4	Field Mounted Equipment.....	11
5.1.4	Electrical Safety.....	11
5.1.4.1	General.....	11
5.1.4.2	Authorized Persons.....	12
5.1.4.3	Permit to Work Arrangements.....	12
5.1.5	Spare Parts.....	12
5.1.5.1	General.....	12
5.1.6	Job Conditions.....	14
5.1.6.1	Sequencing.....	14
5.1.6.2	Coordination.....	14
5.1.6.3	Segregation of Services.....	14
5.2	ICA	15
5.2.1	Scope.....	15
5.2.2	Instrumentation and Monitoring.....	16

5.2.2.1	General	16
5.2.3	Local Area Controls / Scada System	16
5.2.3.1	ICA Cabinet General Design.....	16
5.2.3.2	Control system selection and Design	17
5.2.3.3	Operator Facilities at MCCs.....	17
5.2.3.4	Mode of Operation.....	18
5.2.3.5	Automatic Control of Equipment.....	18
5.2.3.6	Fail Safe Operations	19
5.2.3.7	Programming.....	19
5.2.4	Scada System.....	19
5.2.4.1	General	19
5.2.4.2	Reports.....	20
5.2.4.3	Power Management Controls.....	20
5.2.5	Control System Performance Requirements.....	21
5.2.5.1	General	21
5.2.5.2	SCADA Work Station Operations	21
5.2.5.3	Control Action Responses	21
5.2.5.4	Interfaces with the SCADA controller.....	22
5.2.5.5	Interfaces with Peripheral Devices.....	22
5.2.5.6	Work Station Responses.....	22
5.2.5.7	Verification of System Performance	23
5.3	HEATING, VENTILATION AND AIR CONDITIONING	24
5.3.1	Introduction.....	24
5.3.1.1	General	24
5.3.1.2	HVAC Services	24
5.3.1.3	HVAC Services Design.....	24
5.3.1.4	Design Submissions.....	24
5.3.1.5	Design Criteria.....	25
5.3.1.6	External Design Conditions.....	25
5.3.1.7	Internal Design Conditions	25
5.3.1.8	Acoustic Data	25
5.3.1.9	Description of Systems	25
5.3.1.10	Wet Process Areas.....	26
5.3.1.11	Dry Process Areas (Pump Rooms and Blower area)	26
5.3.1.12	MCC Rooms.....	26
5.3.1.13	Chemical Areas.....	27
5.3.1.14	Administration Area.....	27
5.4	BUILDING AND EXTERNAL SERVICES	28

5.4.1	Introduction.....	28
5.4.1.1	Scope	28
5.4.1.2	Standards and Regulations.....	28
5.4.2	Lighting and Small Power	28
5.4.2.1	Interior Lighting	28
5.4.2.2	Emergency Lighting.....	29
5.4.2.3	External Lighting on Buildings	29
5.4.2.4	Roadway Lighting	30
5.4.2.5	Outdoor Lighting.....	30
5.4.2.6	Small Power Provision	30
5.4.3	Telecommunications	31
5.4.3.1	General	31
5.4.3.2	PABX (Telephone Exchange).....	31
5.4.4	Building and Site Security.....	31
5.4.4.1	Building.....	31
5.4.4.2	Site Security.....	31
5.4.5	Fire Detection, Alarm, Evacuation and Suppression System	31
5.4.6	Lightning Protection.....	32
5.4.6.1	Building Lightning Protection	32
5.4.6.2	Electronic Equipment Lightning Protection.....	32
5.5	Requirements for completion of construction.....	33
5.5.1	Inspection and Factory Acceptance Tests	33
5.5.1.1	MEICA Equipment	33
5.5.1.2	Factory Acceptance Tests.....	33
5.5.1.3	Pre-Commissioning and Inspection at Site.....	35
5.5.1.4	Commissioning.....	36
5.5.2	Training to Employer Staff.....	37
5.5.2.1	Training For Electrical Equipment / Systems.....	37

SECTION 5 – ELECTRICAL & ICA REQUIREMENT

Important Note: All Electrical and ICA equipment should be manufactured in one of the following European countries: Germany, France, Italy or Spain.

5.1 ELECTRICAL

5.1.1 Introduction

5.1.1.1 General

The electrical requirements for the MSEILHA WATER TREATMENT WORKS are contained in the following clauses.

The clauses shall be read in conjunction with the Lebanon Electricity (Electricite du Liban - EDL) regulation, General Electrical and ICA Specification.

5.1.1.2 Scope of Electrical Works

The scope of electrical works shall include the design, supply, installation, testing, commissioning and setting to work a complete electrical and control system for the new Mseilha Water Treatment Works (WTWs).

The scope of electrical and control works for the new Mseilha WTWs shall include but not be limited to:

1. Connection to the mains power supply of Lebanon Electricity (Electricite du Liban - EDL)
2. Main MV distribution switchboards and Ring Main Units and related civil works complete.
3. Control/Metering room (EDL RMU room).
4. Transformer substations.
5. Electrical system protection co-ordination.
6. Main LV distribution switchboards and motor control centres.
7. Standby generator.
8. All associated accessories related with standby generators i.e. switchgears and fuel storage (bulk and day tanks), air supply / extract system, lifting facility etc. as required for generators / generator building.
9. All power, control, instrumentation and communications cabling systems, including cables, fixings, termination and connection etc.
10. All field mounted electrical equipment including local isolators, emergency pushbutton stations, local control panels, junction boxes, cable draw pits, cable ducts, cable tray etc. complete.
11. All control system software development (plant wide SCADA) and programming - fully operational.
12. All control system (plant wide SCADA) hardware.
13. Control system hardware i.e. fibre optic cabling, patch panels, Ethernet switches etc.

14. Fire alarm (including public address system) for all buildings, cable channels etc.
15. Suppression system (Water & foam spray, Deluge and FM200) for equipments, panels, transformers, cable channels/rooms etc.
16. Site communication and public address system.
17. Street / area lighting.
18. Building services lighting and small power and security systems.
19. Earthing
20. Security system inclusive of barrier gate system, intercom system, access controller.
21. Instrumentation
22. Telephone and data network.
23. CCTV systems.
24. Any other work which can be reasonably inferred as necessary for the safe and satisfactory operation of each system, whether such work is specified or not.
25. Arranging and obtaining all necessary approvals with the Lebanon Electricity (EDL).
26. Arranging and obtaining all necessary approvals with the telecom service provider as needed
27. Arranging and obtaining all necessary approvals with the Lebanese Civil Defense as applicable for the Fire Alarm and Fighting System.

All electrical equipment and systems shall be designed and installed in accordance with the appropriate British and IEC standards and manufacturer's recommendation installation guidelines and instructions. In particular the electrical installation works shall comply with the requirements of the current edition of the Institution of Electrical Employer's Representatives Regulations for Electrical Installations BS 7671 and all its amendments and with the UK Electricity at Work Regulations.

The Electrical Sub-Contractor shall be registered by EDL to carry out electrical installation work of similar size and nature.

Testing and commissioning of equipment and services of specialized nature shall be supervised by the manufacturer's technical representative(s).

5.1.2 Power Supplies

5.1.2.1 Operating Voltages

The following nominal operating voltages shall be used for the applications listed below:

- 11 KV ac main powers into the WTWs provided by Lebanon Electricity (EDL). All equipment owned and maintained by EDL will be located in facilities to be constructed by the Contractor as part of the WTWs.
- 380Vac TP and N for all main three phase and three phase and neutral circuits, including motors and drives.
- 220Vac for building services equipment, for single-phase distribution/power circuits, for power supplies to instrumentation transmitters and supplies to ICA panels.

- 110Vac for all control circuits internal to motor starter equipment.
- 110Vac centre tapped (+ 55V) for all portable appliance circuits to power outlets.
- 24Vdc regulated power supplies for signalling circuits and for loop powered instrumentation.
- 60Vdc Main circuit breaker supervision trip supplies.

5.1.2.2 Protection and Co-Ordination

The protection for the electrical distribution system shall be designed to ensure correct co-ordination of protective devices, in particular in relation to the co-ordination of the main LV distribution switchboards and the MV protection devices and co-ordination with the EDL distribution system protective devices supplying the site.

A protection design shall be submitted for the plant, which shall be incorporated into the manuals and shall provide details of the distribution system and its protection. This documentation shall include a schedule of all devices and settings and a set of system curves showing the co-ordination of devices as set up.

5.1.2.3 Power Factor Correction

The complete installation shall achieve a minimum power factor of 0.95 lagging and a maximum of unity under all conditions of plant loads. The power factor of the stations shall never become leading under any circumstances.

Power factor correction shall be achieved by the provision of stand-alone power factor correction facilities installed at each Low Voltage Distribution Board.

5.1.2.4 Harmonics

Total Harmonic Distortion (THD) at the point of common coupling shall comply with the requirements of IEC 61000, or otherwise agreed with Employer. All equipment generating harmonic currents shall be designed such that the specified limits of THD are met at all times and under all operating conditions.

The CONTRACTOR shall submit calculations of the harmonic currents expected before any equipment manufacture commences and obtain the Employer/Engineer approval for this equipment's connection.

When all equipment has been installed and commissioned, the CONTRACTOR shall carry out tests to measure the harmonics generated on the Station. The tests shall be carried out with all main equipment, including the main water pumps, running at full load. The harmonic currents shall be established at each frequency to determine that individual and total values are within the limits stipulated in IEC 61000.

Additional approved equipment/devices shall be installed by the CONTRACTOR without any additional costs to the Employer if the installation is not approved by Employer for connection onto the supply.

5.1.2.5 Electromagnetic Compatibility

All electrical and ICA equipment and systems shall comply with the European electromagnetic compatibility directive 89/336/EEC and all relevant associated British Standards. As such all electrical and ICA equipment supplied under this Contract shall conform to European directives and shall carry the required CE marking.

5.1.2.6 Mains Power Supply to the Mseilha Water Treatment Works

The mains power will be provided by the Lebanon Electricity (EDL) 11000V, 50Hz supplies each rated as follows shall be provided.

The switch room and infrastructure shall be designed and constructed to house EDL equipments. The maximum prospective short circuit current (PSCC) of the mains supply shall be as advised by EDL.

The Contractor shall enter into negotiations with EDL and procure the provision of the mains supply to the Water Treatment Works. In order to do this the Contractor shall compile a complete assessment of the required maximum and average loads and all other documents / information as required by EDL. This shall be presented as load schedules and shall be used to form the data for determining the final ratings for EDL mains distribution equipment and the size of the electrical distribution equipment required under this Contract.

The Contractor shall provide liaison with the Employer/Employer's Representative for all negotiations with EDL and shall provide assistance to the Employer for the selection of appropriate and optimum tariff arrangements.

The EDL supply works will be undertaken under a separate contract let by the Employer with direct payments expended from a Provisional Sum within this Contract.

The Contractor shall liaise with EDL in the timing, installation and commissioning of the new MV supply and intake substation switchgear. Neither the Employer nor the Employer's Representative shall be responsible for any delays to the works due to the Contractors late submission of information required to enable EDL to carry out their works.

The interface between the EDL and the works undertaken as part of this Contract shall be the Contractors connection terminals for receiving 11 kV supply.

5.1.2.7 Standby Power Supply to the Mseilha Water Treatment Works

Standby power shall be provided by a complete centralised diesel generator system be comprised of minimum two generator sets. The system shall allow operation of the full plant in the event of mains power failure.

The new WTWs diesel generator system shall be capable of working at maximum rated capacity for a period of 3 days without replenishment of the bulk fuel storage tanks for both stages of the plant. The maximum allowable period of uninterrupted running shall be at least 30 days.

The generator shall be arranged for automatic start up and changeover of supply on loss of mains supply to the WTWs. The system shall automatically return the WTWs to mains supply on restoration of mains power. The control shall be provided with the appropriate time delays to prevent spurious operation due to surges on the mains and to allow for the appropriate operating regime of the diesel engine.

The diesel generator system shall comply with BS 5514.

The system shall start within 10 seconds of mains failure and connect to the load within 1 minute.

The diesel generator system shall be installed indoors in the building designated for that purpose. The Contractor shall provide adequate room heating, cooling and ventilation to allow the set to start and operate under all external climatic and environmental conditions.

Re-order alarms shall be provided on the fuel storage system.

The standby generator system shall be designed to meet the requirements of the UK Electricity Association recommendation G59/1 (1991) for the connection of embedded generating equipment

to the public electricity supplier's distribution system. Note; although designed with this capability, it is not intended to connect the generating equipment to the public supply network.

The system shall be designed to prevent inadvertent parallel connection to EDL distribution network either for export of power or for synchronising with the mains supply.

The WTWs control system shall take into account the operation of the standby generator in its operation, in particular in controlling appropriate works shutdown and start up procedures for supply changeover situations, both during emergency and maintenance (e.g. black start) operation.

5.1.2.8 Low Voltage Distribution

The mains power shall be connected to the Main Low Voltage Distribution Switchboards, which will distribute power to each of the site areas and to services panels around the Plant.

Low Voltage Distribution Boards and Motor Control Centre's are currently anticipated as the following:

- Main LV Distribution Board (various as required)
- Flash Mixing, clariflocculation MCC
- Gravity Filters MCC
- Chemical House MCC
- Main Pumping Station MCC
- Admin. Building distribution board etc.

5.1.2.9 Protective/Secure Power Supplies

Centralized UPS of adequate capacity with redundant battery system shall be provided to take care of the Plant Control System. The UPS system shall provide back up to all required equipment for a minimum of four hours on full load. The UPS system battery charger shall be up-sized for rapid recharging of batteries.

An UPS system shall be installed to provide protected power supplies to all mains powered computer equipment associated with the main control system, including terminals, printers and communications equipment.

The UPS system shall be provided with its own distribution system and shall terminate in power outlets or connect direct to equipment or via local isolators as is required generally by the specification for electrical installations.

Where power outlets are provided these shall be connected via an appropriate ring main circuit and shall be fitted with non standard pin configurations to ensure that only appropriately selected equipment is connected to the system.

SCADA controller will require UPS supplies but shall operate with power loss/restoration sub routines to safely restart processes on power supply switch-on should the UPS fail. SCADA controllers shall all be fitted with back up batteries for the protection of data tables and program memory to ensure that control can be restored on the return of mains power to the relevant system.

All mains supplies to ICA panel sections shall be provided with mains voltage surge suppression units.

5.1.2.10 MCC Buildings/Locations

The Switchgear / MCC and Control rooms shall be of liberal size and should be provided with dual redundant air condition systems inclusive to overcome the heat generated by the electrical panel, UPS, battery charger & battery, drives and starter etc.

Switchgear / MCC and Control rooms shall be provided with FM200 based Automatic fire suppression systems.

Each MCC room shall be provided with a double glass (toughened/strengthened) window looking out over the equipment controlled by the MCC. Control room shall be provided with double doors to reduce ingress of dust.

The MCC shall face the window. Lighting shall be arranged such that controls and indications on the MCC are not affected by glare from either the window or the MCC room lighting.

5.1.2.11 Standard Designs/Circuit Requirements

A standard approach to MCC internal circuit design shall be developed and enforced on the MCC and control panel suppliers, to ensure that all similar circuit types are used across the plant. This shall include panels provided by package plant suppliers. In particular, the standard requirements for panel construction, wiring and components shall be noted.

This approach shall also be applied to external circuit design, e.g. for instrument loops etc.

All drives and starters shall be provided with the facility for automatic control from the MCC control section, whether used for automatic control or not.

Conventional drives and starters shall be provided with a separate interlock relay for the operation of protective circuits operated from the equipment. Drives and starters utilising intelligent overload logic shall provide interlocks via intelligent overload inputs and outputs.

For conventional drives and starters' auto-control and interlock circuits shall be provided by interposing relays. These shall operate in a failsafe manner at 24Vdc sourced from the control section. The interposing relays shall be installed in the starter/drive compartments. Drives and starters utilising intelligent overload logic shall provide control interlocks, in a fail safe manner, via the intelligent overload units, inputs and outputs.

5.1.2.12 Low Voltage Distribution Switchboards

The LV Distribution switchboards shall provide the following functions:

1. Main low voltage power distribution around the WTWs to area MCC's.
2. Power distribution to area services including building services DBs, alarm systems, HVAC control panel, control room and communications equipment, external services.

As a minimum, the following protection shall be provided:

- Mains incomer:
 - Combined over current and unrestricted earth fault IDMTL relay.
 - Restricted earth fault relay.
 - Auxiliary trip from medium voltage protection equipment.
- Main MCC feeders:
 - Combined over current and unrestricted earth fault relay.

- Services distribution feeders:
 - Combined over current and unrestricted earth fault relay

5.1.3 Electrical Installation

5.1.3.1 General

Electrical installation shall generally be provided in accordance with the requirements of the standard specification.

5.1.3.2 Cabling and Wiring

A complete cabling and wiring installation shall provide all required power distribution, monitoring and control of the WTWs

Where the installation requires the cables to be routed below the floor, then the cables shall be either routed on the racking system in the floor below and rise to the equipment through a sealed floor duct. Cables may also be run in plastic ducts cast into the floor or installed in purpose constructed concrete cable trenches. Cables installed in this way shall not share the same trench as other services, such as chemical dosing lines. Reference should be made to the general arrangements drawings which indicate the recommended arrangements.

Cables installed outside and between buildings shall be installed in cable tunnels sized not less than 1500x2100mm height for cable ladders installed at one side and 2100x2100mm height for cable ladders installed on both side of the tunnel. The tunnel shall be provided with lights (normal & emergency), air supply fans, fire suppression system, fire stop barriers for cable crossing the tunnel, sump pump as applicable and fire rated (1 hour) doors at every entry / exit.

Cables installed around external structures shall be installed on cable tray.

All cables shall be protected from exposure to direct sunlight.

Cables installed in office and personnel areas shall be installed in suitable conduit and trunking systems and shall be installed in a hidden manner, behind partitions, beneath plaster and above ceiling voids, making entry direct to equipment. All fittings including switches, sockets and light fittings in these areas shall be flush mounted.

The control room and associated services room shall be provided with a raised services floor, with all services fed to equipment from beneath.

Cabling feeding equipment mounted on the outside of buildings shall be installed within the building except at the entry point to the equipment, i.e. cable containment such as conduit and trunking on the outside of the building fabric shall be kept to a minimum.

Cable entries to buildings shall be via draw chambers. The cable entries shall be sealed using proprietary cable transit systems.

Cable entry into underground chambers, e.g. flow meter or dosing chambers shall be sealed with proprietary cable transit systems to prevent ingress of ground water via the cable entry.

All cables shall be glanded using cable glands appropriate to the cable type installed.

5.1.3.3 Earthing and Bonding

An earthing system shall be installed to provide a complete and safe electrical system. The earthing system shall be designed and installed in accordance with BS 7430 Code of Practice for earthing installations and BS 7671, IEC Wiring regulations.

The materials used and the method of installation shall be such as to ensure effective and reliable operation over a prolonged period under the conditions appertaining to the WTWs.

The earthing installation shall comprise earth electrode system, main earthing terminals, area earth terminals, earthing circuit protective conductors and equipotential bonding conductors.

The metalwork of all items of electrical plant, electrical system neutral points, power and auxiliary cable armouring and screens and extraneous metalwork including structural steelwork, pipework, fences and gates, shall unless otherwise specified, be connected to the earthing installation.

The Contractor shall carry out an earth resistivity survey and submit calculations to provide an electrode of less than 1 ohms for the site main earth electrode system.

The earthing system shall be designed to comply with the requirements of G59/1 for the connection of embedded generators to regional electricity companies systems.

5.1.3.4 Field Mounted Equipment

All motors and valve actuators shall be provided with local isolators. All motors shall be provided with locally mounted emergency stop pushbutton stations. These may be supplied as combined units.

Motor and actuator power tails shall be cabled through local isolators. Other LV cables connected to the motor or actuator (e.g. motor heater tails, emergency stop pushbuttons) shall be wired through auxiliary contacts on the local isolator so that all LV circuits are isolated using one switching device only. 24Vdc signal and control circuits shall be cabled through a separate, adjacent junction box.

Locally mounted junction/marshalling boxes shall be provided where a multicore or multipair cable is installed to serve more than one item of equipment or more than one connection point to a single item of equipment.

All instrument cables installed on the WTWs shall be terminated, in a junction box adjacent to the instrument location. The instrument signal shall be connected to the junction box via a flexible cable suitable supported and with sufficient length to allow removal of the sensor for maintenance purposes.

Local isolators and control stations shall be mounted adjacent to the equipment controlled, on a 1m high stainless steel stanchion and shall be mounted just inside and to one side of access openings.

Local isolators, pushbutton stations and junction boxes shall be located at an accessible location and shall be fully corrosion resistant within an IP65 enclosure and shall also be provided with stainless steel sunshade if installed outdoor.

Where relevant, all locally mounted electrical equipment shall be certified for use in hazardous areas.

5.1.4 Electrical Safety

5.1.4.1 General

The Contractor shall operate a safe system of working in relation to electrical and ICA works. This shall encompass control of all sites working, in particular in the energising of electrical equipment at MV and LV supply voltages and at ELV voltages when associated with the automatic control of plant.

This system shall involve the use of permits to work to access energised plant to ensure that personal injury is avoided. This permit system shall be presented to the Employer's Representative for approval prior to commencement of any (including temporary) electrical works on site.

The Contractor shall appoint an authorized person or persons at site who shall take responsibility for ensuring safe working of the Contractor's & his subcontractors' personnel and the Purchaser's personnel during construction and commissioning.

5.1.4.2 Authorized Persons

Authorized persons shall be competent, practicing electrical Engineer.

5.1.4.3 Permit to Work Arrangements

The permit to work system shall involve the issue of a permit by an authorized person to the person carrying out the work.

The permit shall have a sign-on and sign-off arrangement and a copy shall always be held by the authorized person to ensure that no more than one permit is ever issued against the same item of equipment at the same time.

5.1.5 Spare Parts

5.1.5.1 General

Spares shall be packed and protected for storage to the appropriate standard. Electrical equipment shall be sealed in polythene or similar bags with a liberal supply of desiccant. Other items shall be protected so as to avoid corrosion and spoilage for a minimum of twelve months after handover to the Client. Machined surfaces of all mechanical components shall be further protected by the application of a protective coating which may be easily removed at the time of installation. Each package shall have attached to it an un-tarnishable metal plate giving information for identification. This shall include the maker's name and reference description as shown on the marked-up drawings supplied.

The packages of items of spares shall be collected together by the CONTRACTOR into consignments of reasonable size and then packed in secure cases each of which shall contain a contents list. Where electrical items are involved the cases shall be of tongue and groove boarding. Each case shall be durably marked with the contract number and site address, and shall be sent to site after detailed instructions have been received. Each package shall be clearly identified as to its contents in both English and Arabic.

Provide sufficient spare parts as specified here-in after.

- Store spare parts in a room designated by the Employer's Representative.
- Contractor shall provide spare parts under this Contract as indicated herein.

MV switchgear, LV panel

- 5% or not less than 1 for each type and rating assist motor starters.
- 5% or not less than 1 for each type and rating magnetic combination motor starters.
- 5% or not less than 1 for each type and rating circuit breakers for different rating of MCCB, ACB and VCB.

- 5% or not less than 1 for each type and rating protective relay (including motor manager) for different rating and type.
- 3% or not less than 1 for each type and rating interposing relay for different rating and type.
- 3% or not less than 1 for each type and rating indicating instruments/display for different rating and type.
- 10% or not less than 1 for each type and rating HRC fuses for different rating.
- 3% or not less than 1 for each type and rating load break switch (isolators) of each size.
- 5% or not less than 1 for each type and rating ELCB of each size.

Instrumentation

- 5% or not less than 1 for each type and rating process and analytical instrumentation for different rating and type.

Disconnecting Switches

- 5% or not less than 1 for each type and rating switch of each size.

Circuit Accessories

- Plug Fuses

Furnish ten percent (10%) of the number of each size and type of fuses installed, but in any case not less than six fuses of each sizes.

- Wall Switches

Provide five percent (5%) of the number of each size and type of wall switch which installed, but shall be not less than two fixture of each type.

- Socket Outlets

Provide five percent (5%) of the number of each size and type installed

- Lamps

Provide ten percent (10%) lamps of each size and type for indicating panels and pilot lights installed for different systems.

Lighting Fixtures

- For lighting fixtures provide the following spare parts.
 - 2% of the total quantity of each type of lighting fixture, but shall be not less than two fixture of each type.
 - Additional diffusers for 5% of the total quantity of each type of lighting fixture provided with acrylic, plastic or glass enclosures. Diffusers shall be identical to those of the installed fixtures. This quantity shall not be less than two diffusers of each type.
 - 10% spare lamps of each wattage of different type.
 - 5% of the total quantity of controlgear (ballasts) of each type and size but in no case less than (6) ballasts of each size and type.

5.1.6 Job Conditions

5.1.6.1 Sequencing

Lay electrical works in advance of pouring concrete slabs and construction of walls. Obtain Employer's Representative approval before commencing builder's work in connection with electrical installation; related shop drawing, coordinated drawing and materials shall be approved prior to the work commencement.

5.1.6.2 Coordination

Check with other trades to ensure equipment and material can be installed in space provided.

Provide other trades with information necessary for them to execute their work.

Coordinate with other trades to ensure work can be installed as approved.

5.1.6.3 Segregation of Services

Electrical services shall be segregated as specified throughout the installation to obviate the following:

1. Electrical interference from one circuit to another.
2. A fault on one circuit affecting another.
3. Unnecessary fire damage.
4. Difficulties in circuit identification.
5. Voltage limits for general safety.

All raceways shall be kept clear of other services except where intentionally earthed or bonded. Generally, raceways shall be kept 150 mm away from and above hot water and 75 mm away from other services.

Unless specifically indicated otherwise, normal, emergency, low voltage cables and wiring shall be segregated throughout the installation generally in the following manner.

1. Armoured and Sheathed Cables: Where more than one tray has been specified or is necessary to accommodate the number of cables on a run. Where practical segregation shall be achieved by dedicating each tray to either normal or emergency services where normal and emergency cables have to run together in trays, ducts or trenches, they shall be formed in two groups, one normal and one emergency.
2. Insulated Conductors. Insulated conductor circuits shall, where possible, be segregated throughout by enclosing in separate conduits, trunking or trunking compartments.

Fire alarm cables shall be segregated from other services throughout and be either armoured and sheathed cable, or insulated conductors enclosed in conduit or trunking, as indicated on the drawings.

5.2 ICA

5.2.1 Scope

A complete instrumentation, control and automation (ICA) system shall be provided to provide the full automatic control of the Mseilha Water Treatment Works constructed under this contract.

This system shall operate with the electrical motor control centres and local control panels to provide a complete control system operating in accordance with the functional design specification / control philosophy of the WTWs approved by the Employer's Representative.

The system shall comprise the following main elements:

- Field sensor and Instrumentation for monitoring process variables, operational variables and status of every equipment and system.
- Refrigerated auto-sampler (3 Nos.).
- A SCADA system shall be provided in the Central Control Room. A suitable hardware platform, software and interfacing equipment shall be installed to allow communications with on-site PLCs and off-site Remote Terminal Units (MTU/CTU/RTUs).
- SCADA based control system providing WTWs automatic control and monitoring including generating alarms requiring operator response.
- The SCADA controller communicates with the central control room Operator (Human Interface Station) over a Local Area Network (LAN). Local HMI's shall be provided with each ICA panel and will be connected to the SCADA controller of that area to provide access to all of the control and information data within the SCADA controller using graphic displays related to that area and MCC.
- The SCADA controller communication is based on an open system concept. LAN network has open standards architecture using Ethernet interface.
- All network hardware requirements (cable, switches, hubs etc) are based on common off the shelf standard equipment.
- System cabling and earthing.
- SCADA system, providing central monitoring of the plant, gathering of information to enable the handling of alarms, historical information and the processing of performance related information for the WTWs. The SCADA system shall also provide operator intervention facilities for the changing of settings and remote intervention in operating sequences. The Human Interface Station runs under the Microsoft Windows 10 Operating System. The MS Windows operating system offers a familiar look and feel to the operator and quickly gains acceptance as an interface to the process plant information and controls.
- Access to control and information data is proposed to be available in both the Central Control Room and at the local equipment areas (Remote Electrical switch rooms). Data is presented to the operator using graphical displays developed to reflect the plant design and geographical layout. Control functions and motor stop/start functions are access via the graphical displays, events such as alarms, starting and stopping of equipment is logged and presented to the operator in a chronological event list. Each event is logged with date; time, event description and event type e.g. event notification, event alarm accepted, event cleared.

- SCADA System is constructed along conventional SCADA lines where the Operator station will be located in the Central Control Room (CCR) and the network communicating with the local SCADA controllers in the remote equipment areas via network cables, routers and switches.
- Communications and data gathering facilities at all levels to enable the transfer of information between levels of the overall ICA system.
- The Plant equipment shall be included in the CMMMS system with proper inventory.

The Contractor shall offer a complete system capable of performing the specified functions and compliant with this Specification and all current, relevant regulations and standards applicable in the Lebanon. Responsibility for successful operation, technical application and compliance lies with the Contractor.

The complete engineering, supply, installation and commissioning of the control system shall be done by the manufacturer with the required warranty.

The Contractor shall in any case engage the services of an ICA manager or project Employer's Representative for the purposes of managing the work of the system integrator. This Manager/PE shall facilitate system and operational liaison with the Purchaser during the whole life of this aspect of the Contract. He shall also manage the co-ordination of the design work between the system integrator and all third party package subcontractors in order to ensure a smooth interface and flow of information between these parties.

5.2.2 Instrumentation and Monitoring

5.2.2.1 General

The Contractor shall produce detailed design of the process for control or monitoring purposes; this shall be provided and installed in accordance with the Specification.

Monitoring instrumentation shall be located as close to the point of measurement as possible without compromising access for maintenance of the instrument.

Instrument transmitters shall be located adjacent to sensors on the plant to provide secure signals to the control systems.

All outputs from instrumentation provided under the Contract shall be monitored remotely by the main control system. These signals shall be provided to the SCADA system via the area SCADA controllers.

Instrument transmitters shall be provided with an indicator so that measured parameters can be read at the relevant location. Where the instrument product has no indicator built into the transmitter unit, a separate indicator shall be provided, located adjacent to the transmitter.

Where instruments require sample systems, the length of the transport systems shall be kept to a minimum in order to minimise sample time delays. Gravity sample systems shall be utilised where possible, but sample pumps shall be installed where a gravity supply cannot provide the required transportation of the sample.

5.2.3 Local Area Controls / Scada System

5.2.3.1 ICA Cabinet General Design

Each area MCC shall be provided with an ICA panel. This section shall be of a "wardrobe" design and shall house a local SCADA controller and operator HMI panel and all necessary power distribution and control equipment associated with the specific area.

The operator HMI panel shall be installed on the front of the ICA section, to provide local indication of all parameters measured

5.2.3.2 Control system selection and Design

All system equipment and software (except for local HMI's and standard computer components) shall be selected from one manufacturer range.

The Contractor shall provide a fully functional control system to provide all control and monitoring facilities in accordance with the approved Contractor's operating and control philosophy and WTWs design.

The system shall be fully networked and integrated to provide the control of the WTWs as a whole and shall incorporate all necessary hardware, software and communications equipment. This shall include means for providing communications between SCADA controller and the SCADA Operator Stations for transfer of data and control actions.

The system shall be designed to enable ease of extension, interconnectivity and compatibility, utilising the ISO standard for open systems interconnection (OSI) model as a basis for system design.

Each SCADA controller shall be designed to re-initialise all programs on restoration of power supply in order to start operation from a known position. However all current equipment and process set-points shall be retained by the SCADA controller when power is lost and subsequently restored.

Safety procedures shall be incorporated in the design of the system hardware and software such that that under fault conditions the most appropriate safe action is employed. In particular the following shall apply:

- The SCADA controller shall continue to hold on to last known analogue values or digital states on failure of a device or instrument.
- The SCADA controller shall shut down the process or move it to a safe state as required by the operating and control philosophy of the WTWs.
- In the event of SCADA controller / network failure, drives and valves will be locally operated, with protection provided by the hardwired interlocks.

5.2.3.3 Operator Facilities at MCCs

The operator HMI panels shall comprise a touch-screen (12" Proface AGP3600 or equivalent) on the front of the ICA section of each MCC to enable the operator to assess the current status/operation of the equipment. The Contractor shall seek the Employer's Representative approval to use 6" touch-screen HMI's (Proface AGP 3300 or equivalent) in application areas with simple process mimics. E.g. Transformer sub-stations.

The following functions shall be provided from the operator HMI panels:

- Indication of local alarms with a 24 hr rollover.
- Indication of analogue values on bar scales and trending of analogue values.
- Status overview in a block diagram format of each process block showing status and Measurement (e.g. a single filter).
- Manual control of local operating sequences such as filter back-washing.
- Overview block diagram showing status and Measurement.

- Duty/standby selection of equipment and the ability to manually alter local set points.
- Manual operation of actuators or drives shall be provided.
- Ethernet and Compact Flash Card connectivity shall be provided as a minimum.

5.2.3.4 Mode of Operation

Automatic motor control: - Automatic duty rotation of plant shall be carried out, with the facility for the Operator to override and edit the required duty sequence from the SCADA. Emergency stops shall be provided for all drives where there is a risk of injuries to authorized users. Except when specifically described otherwise, all motors specified for automatic operation shall be provided with HAND-OFF-AUTO (HOA) selector switches. In HAND position, the motor shall be bypassed. In OFF position, the motor shall be stopped. In AUTO position, the motor shall be dependent on the status of the output contact of the control circuit, which may originate from local control logic or the SCADA commands will be initiated either by manually entered or software control routine generated requests.

Remote control: - When an item of equipment is selected as remote, using the LOCAL REMOTE (L/R) switch, commands will be generated from the SCADA commands will be initiated either by manually entered or software control routine generated requests.

Automatic Standby Operation: - Motors in multiple unit systems shall also be provided with either a DUTY-STANDBY (D/S) selector switch for automatic motors with H/O/A switches or START/STOP (S/S) switches for manually operated motors without H/O/A switch.

- The automatic control circuit shall control automatic motors with selectors on AUTO and DUTY, those selected for AUTO and STANDBY shall operate only if a DUTY motor fails to respond.
- The standby function shall be operated when the H/O/A selection for the standby motor is in AUTO position. For manually operated motors with start-stop (S/S) switches, motors selected for standby shall operate if a motor selected for HAND fails to operate.

Lockout Stop Function: - Any lockout stop switch (LOS) associated with operating equipment shall be utilized to stop the equipment on an emergency basis only and shall not permit operation in any mode until the switch is physically reset. Whenever a LOS switch is actuated, an alarm signal shall be transmitted to the SCADA where the stopped equipment shall be identified.

5.2.3.5 Automatic Control of Equipment

All equipment shall be controlled automatically. The control shall be distributed; i.e. control shall be located at the local areas, operated by the SCADA controller software.

The system shall be designed such that if the SCADA system fails, then the equipment will continue to operate automatically.

Under normal operation the SCADA controller shall run the equipment and the SCADA system shall provide operator management of all control systems.

The equipment shall be provided with a start up and shutdown routine, which can be initiated either from the Operator Station or by automatically set parameters, which can be altered from the SCADA Operator/ENG Station.

The local SCADA controller shall operate local equipment management, e.g. duty standby operation, washing sequences or maintenance cycles, automatic stopping and starting, automatic speed control of dosing pumps, etc.

All settings to enable this control shall be operated from the SCADA system.

In addition, the SCADA controller system as a whole shall operate works shutdown and startup procedures, co-ordinated from the central SCADA system.

5.2.3.6 Fail Safe Operations

All SCADA controller software and hardwired circuits shall be designed for failsafe operation i.e. any failure of an instrument or element in a system shall operate the equipment to a safe position.

Hardwired backup systems shall be provided for systems that are critical to the process, e.g. Chlorination, which shall take over the control of the system on failure of the main control system, whilst alerting operators of the change to control.

5.2.3.7 Programming

The SCADA system engineering function will be located in a Operator Station selected to be the Operator/ENG (engineering Station) located in the Central Control area. The SCADA database will be maintained and controlled from the Operator/ENG. Access to the engineering function is controlled by password protection.

Integrated asset management system (computerized maintenance management system) shall be provided under SCADA system.

All programming tools and software with licensee shall be handed over by the Contractor to client.

5.2.4 Scada System

5.2.4.1 General

The WTWs shall be provided with a fully functional control room located in the administration building. This control room shall be the centre of operation for the plant.

A SCADA system shall be installed in the control room to provide a central location to carry out the following functions:

- Monitoring of all measured values and status of all equipment.
- Historical recording of measured values to provide performance records for the works.
- Alarms handling facilities.
- On line graphical information (mimics, trends etc.) to provide means of "on line" analysis of WTWs condition/performance.
- Setting of WTWs control parameters (e.g. adjustment of flow or level set points, dosing rates, etc.).
- Remote control of equipment

The SCADA system shall be constructed in redundant format with the exception of the field input/output modules.

Operator interface to the SCADA system shall be provided by colour graphical displays, which represent the equipment under control. These shall be based on the PIDs for the plant. All functions shall be mouse operated and the software graphics shall be Windows based to enable operators with PC skills to operate the system with ease.

Any additional Client licences required for the SCADA system shall be provided for portable or desk top PC's, so that key personnel (e.g. operations manager / maintenance superintendent) can

access the SCADA system from remote locations via the internet, in order to initially assess any reported operational problems without having to attend site. This arrangement shall not allow remote operator functions such as control, alarm accept and changing parameters from remote Clients via this communications route. Use of a restricted access webserver facility may be considered as an alternative for the provision of this facility, subject to approval of the Purchaser.

5.2.4.2 Reports

The system shall be configured to produce scheduled reports at specified periods for the following information:

- Total key flows for all process areas and average, maximum and minimum flow rates, daily and weekly.
- Key quality Measurements for all process areas, with average, maximum with time/date, minimum with time/date daily and weekly.
- Chemical usage.
- Water quality parameters.
- Analogues out of range or faulty.
- Plant running hours.
- Electrical consumption and peak demand for all process areas.
- Power generation from standby generation.
- EDL mains import of power daily and weekly.

The Contractor shall prepare proposals for the format and classifications of information to be presented. These shall be forwarded to the Employer's Representative for approval.

5.2.4.3 Power Management Controls

A series of power management control pages shall be provided on the SCADA Operator Stations.

The power management pages shall provide indication of data from the power metering and generator plant controls. This information shall include:

- Power equipment running and status of switchgear, including EDL supply and the on-site generator.
- Output voltages.
- Power output from source equipment including KVA and KVA_r metering at each MCC.
- Main loads connected and power consumed.
- Breakers status open / close / trip.

The system shall also provide a sequencing page that will provide the power management system with controls for the selection of drives and the sequence of starting/stopping of drives when running under standby or restricted power arrangements.

The system shall allow the selection and removal of drives from each list and the SCADA system shall monitor and display the kW loads added or subtracted and shall provide an indication when the loads added to the list exceed a preset kW limit for each condition.

All instrumentation and transmitting facilities to provide the power management data shall be installed in each of the MCC's.

5.2.5 Control System Performance Requirements

5.2.5.1 General

The SCADA including the SCADA controllers and local HMIs shall be designed to work as a complete system and shall meet the following requirements for operational performance.

5.2.5.2 SCADA Work Station Operations

The following performance parameters refer to the operation of controls and display functions by an operator working at a SCADA Operator station.

Item	Description of Action	Average Response Times (Seconds)	Maximum acceptable response times (Seconds)
1	Display refresh time to maintain current data.	1	5
2	Request for a mimic or other display to completion of the display on the screen (including current live data)	3	5
3	Display alarm list.	*	5
4	Display trend (up to 4 items, 7 days at 30 minute intervals)	*	10
5	From request for current data to display the data.	*	5
6	From Screen dump/plot command to start plot	*	10
7	Speed of screen response to keyboard or mouse operation	0.1	0.1
8	Speed of update of information passed between work station and a PLC / controller or HMI and vice versa.	1	1

*Denotes average response times to be notified by the Contractor.

5.2.5.3 Control Action Responses

The following table defines the requirements for the response of control actions by a request from an operator either working at a SCADA Operator station or an HMI terminal.

Item	Description of Action	Average Response Times (Seconds)	Maximum acceptable response times (Seconds)
1	Speed of a control action and acknowledgement	2	5
2	From an alarm occurrence/clear to completion of display	*	5
3	From an alarm occurrence/clear to logging message on alarm printer.	*	5
4	From alarm acceptance to silencing alarm.	*	5
5	From selection of a control point to check back	*	2

Item	Description of Action	Average Response Times (Seconds)	Maximum acceptable response times (Seconds)
6	From issue of an execute command to commencement at the PLC.	*	2

5.2.5.4 Interfaces with the SCADA controller

The following table defines the requirements for updating the SCADA system database and or display to the change of a parameter at the SCADA controller. These times shall also apply to updating the display data on an HMI.

Item	Description of Action	Average Response Times (Seconds)	Maximum acceptable response times (Seconds)
1	Speed of change of state at any site device to display at an operator terminal (SCADA Operator or HMI)	2	5
2	Speed of response from occurrence of an alarm on the WTWs to display on the alarm system (on SCADA Operator and HMI)	3	5
3	Request of data from a source point to the relevant screen display.	1	2

5.2.5.5 Interfaces with Peripheral Devices

The following table defines the requirements for the speed of response of peripheral devices such as printers etc. with operations on a SCADA Operator station.

Item	Description of Action	Average Response Times (Seconds)	Maximum acceptable response times (Seconds)
1	Initiation of a print out of a screen plot or report to a printer or plotter to the start of printing	5	10
2	The retrieval of data from archive storage (either from the hard disc or from a portable storage device) to display on the appropriate screen display	3	10

5.2.5.6 Work Station Responses

The following table defines the requirements for the speed of response of the SCADA Operator stations.

Item	Description of Action	Average Response Times (Seconds)	Maximum acceptable response times (Seconds)
1	Speed of Retrieval of data from the database to the screen	0.5	2
2	Speed of system initialisation (Start up sequence)	10	50

5.2.5.7 Verification of System Performance

The Contractor shall include in his factory and site testing programme certain tests that will verify the performance requirements specified above.

Where a test fails to meet the criteria, the Contractor shall provide the appropriate equipment, software or re-configuration necessary to achieve the performance requirements above.

5.3 HEATING, VENTILATION AND AIR CONDITIONING

5.3.1 Introduction

5.3.1.1 General

The requirements for the design, supply, installation, commissioning and setting to work of the Heating, Ventilation, and Air Conditioning (HVAC) equipment at the WTWs is described in the following clauses.

5.3.1.2 HVAC Services

The HVAC Services shall comprise the systems listed below.

The Contractor shall include all design, selection, supply, and installation of HVAC equipment and sound attenuation units to meet the performance criteria specified.

Wet process Areas	natural ventilation systems and/or mechanical ventilation systems
Dry Process Areas	temperature controlled mechanical ventilation systems
Chemical Areas	mechanical ventilation systems
Electrical Switchrooms	Heating, ventilation and air conditioning systems
Transformer Pens	mechanical ventilation systems
Administration Areas	Heating, ventilation and air conditioning systems
Provision of all temperature and humidity control sensors and instruments (differential pressure switches)	

5.3.1.3 HVAC Services Design

The Contractor shall be responsible for the design, installation and performance of the HVAC services.

5.3.1.4 Design Submissions

The Contractor's design shall be developed from the generic system descriptions and design criteria, the following being submitted for approval:

- Confirmation of design criteria used.
- Schematic layout of each type of HVAC system, clearly indicating the areas covered by each diagram.
- Control philosophy, including reference to heat recovery from 'hot' plant/equipment rooms.
- Schedule of electrical requirements including individual loadings for electric heater batteries and space heaters.
- Schedule of air-handling units and fan units, with provisional air volumes.
- 1:200 line diagram to show main duct routes and duct sizes.
- Proposed location of air handling equipment and external air inlet/outlet louvers, with provisional sizes/areas required.

- Schematic layout of oil-fired boiler, if any, and hot water heating system to administration area. Boiler capacity and oil storage requirements for one month running at full duty should be stated.
- A report detailing proposals for acoustic provisions for all mechanical, electrical, and HVAC equipment and systems, to ensure a fully integrated solution complying with the acoustic design criteria.

5.3.1.5 Design Criteria

The Contractor shall determine and confirm:

- Process water temperatures.
- Heat dissipation from equipment.
- Volumetric flow rates of process air.

5.3.1.6 External Design Conditions

The climatic design parameters are given in Section 1 of this Volume.

5.3.1.7 Internal Design Conditions

(a) Wet Process Areas	Minimal condensation on building fabric.
(b) Dry Process Areas	
Polymer Storage & Mixing	Minimum 5°C
Chemical Areas	as required by Chemical Supplier
Pipe Galleries	Minimum 2°C Maximum 40°C
Plant Rooms (Blowers, Compressors, Pumps)	Minimum 2°C Maximum 40°C
Electrical Rooms	Minimum 10°C Maximum 30°C
Administration Areas	
Offices and Control room	Minimum 19°C Maximum 30 °C
All other areas	Minimum 16°C Maximum 30 °C

5.3.1.8 Acoustic Data

- Internal Noise levels (with all plant running) shall not exceed:
 - Process and Plant Areas 85 dB (A)
 - MCC Rooms 55 dB (A)
 - Administration Areas NR 40
- External noise levels to comply with planning requirements for noise level at site boundary.

5.3.1.9 Description of Systems

The following general descriptions are intended to establish the scope of HVAC installations considered necessary to achieve the performance required.

5.3.1.10 Wet Process Areas

Appropriate forced ventilation shall be provided to prevent condensation in equipment located within the wet process areas.

Natural or mechanical ventilation systems shall be provided to maintain the wet process areas generally free of condensation.

The large volume of stored water should maintain frost-free conditions, but provision shall be made to shut down the ventilation systems automatically should the internal temperature fall to 2°C.

All materials and equipment situated or used within the wet process areas shall be either unaffected by condensation or protected against it.

5.3.1.11 Dry Process Areas (Pump Rooms and Blower area)

Natural filtered air inlets shall be provided to make-up the air requirements of the process plant and mechanical extract ventilation. Mechanical extract ventilation from the various areas shall have intermittent temperature controlled operation. A minimum of two fan units, each rated at 50%, shall be supplied for each area subject to high internal heat gain from process equipment. Plant Room extract fans shall also have manual override facility to enable the fans to run outside of the control limits.

The acoustic enclosures around air blowers shall have independent mechanical extract ventilation that shall be interlocked with the blower motor to ensure that cooling air is available before the blower starts. The associated extract fan should be supplied and installed as part of the blower enclosure package and the warm discharge air ducted to atmosphere with a diversion facility to allow discharge directly into an adjacent wet process area. The diversion facility shall be manually initiated and shall only operate when the extract fan is operating.

Within below-ground plant rooms the air inlet shall be ducted to low level for improved air circulation. Below ground pipe galleries shall have fully ducted mechanical supply air systems to maintain a good environment. The systems may operate intermittently with the facility for manual override.

Large plant rooms subject to significant fabric heat losses and relatively low internal equipment gains shall have local thermostatically controlled electric space heaters to provide frost protection.

Ductwork systems within dry process areas shall be fabricated from standard galvanised mild steel (spiral wound). All brackets and supports shall be hot dipped galvanised after fabrication and all fixings shall be non-corroding type.

5.3.1.12 MCC Rooms

Refrigerant based cooling systems are required in all MCC rooms (in addition to supply ventilation). A minimum of two coolers shall be provided each rated at approximately 66% of the calculated cooling load. The associated condensing units shall be located within an adjacent cool process area where the internal temperature should not rise above 25°C with the full heat rejection from the condensing units.

Natural filtered air louvers shall provide the air make-up requirements of the mechanical extract ventilation system. A minimum of two fan units, each rated at 50%, shall be supplied for each area subject to high heat gain – particularly where temperature sensitive electronic equipment is used. Fans shall operate intermittently when controlled by room temperature. Manual override facility to enable ventilation outside control limits.

Local electric space heaters may be used in MCC Rooms during winter periods and when plant is operating at low loads.

All ventilation ductwork shall be standard GMS with brackets GAM and non-corroding fixings.

All ventilation ductwork shall be positioned away from electrical panels (not directly overhead) so as to avoid condensate falling onto electrical equipment.

5.3.1.13 Chemical Areas

Where required for specific chemicals, mechanical supply and extract ventilation shall be provided. Otherwise, natural ventilation systems shall be utilised, with local electric space heating as necessary to meet the specific requirements of the various chemicals.

Where continuous or frequent ventilation is required, air-handling equipment shall have duty and standby motors.

In potentially corrosive areas, all materials and equipment shall be suitably protected or be fabricated from suitable resistant materials.

5.3.1.14 Administration Area

Heating and ventilation systems to meet the requirements of the Building Regulations and the recommendations of the C.I.B.S.E. Guide. Passive ventilation from opening windows shall provide fresh air for the occupants.

Toilets and Mess Rooms shall have duty and standby extract ventilation with automatic changeover on failure of the duty fan.

Heating to the various spaces shall generally be from wall-mounted electric convector heaters, although the Contractor shall include alternative proposals for an oil-fired boiler plant serving a hot water heating system.

Refrigerant based cooling systems are required (in addition to supply ventilation). A minimum of two coolers shall be provided for each area each rated at approximately 66% of the calculated cooling load for each area.

5.4 BUILDING AND EXTERNAL SERVICES

5.4.1 Introduction

5.4.1.1 Scope

The requirements for the design, supply, installation, commissioning and setting to work of services for the buildings and external areas of the WTWs are covered in the following clauses.

Elements of services covered are as follows:

- Electrical services for lighting and small power.
- Street / area lighting.
- Lightning protection.
- Telecommunications.
- Public Address, Site communication and Intercom System
- Security system inclusive of barrier gate system, intercom system, access controller.
- Fire alarm, evacuation system and protection.
- CCTV systems.

5.4.1.2 Standards and Regulations

The installation shall comply with all relevant statutory instruments and regulations current at the date of commissioning and in particular with the following:

- IEE Regulations for Electrical Installations, 16th Edition (BS 7671), incorporating all current amendments.
- Electricity Supply Company Requirements.
- Electricity at Works Regulations, 1989.
- Health and Safety at Work Act, 1974.
- British Standards Institution Specifications.

5.4.2 Lighting and Small Power

5.4.2.1 Interior Lighting

Interior lighting shall be in accordance with the recommendations given in the CIBSE Code for Interior Lighting 1994.

Industrial style fluorescent lighting shall be used in all main plant areas. The followings luminaries are recommend, equivalent fixtures may be proposed from the specified manufacturer.

- Twin 58W fluorescent tube light fitting, IP65 with diffuser – (Thorn model AQUAFORC 2X58W)
- Twin 58W fluorescent tube light fitting, IP67 with diffuser for dry well & chambers – (Thorn model PM II 258)

- Twin 58W fluorescent tube light fitting, IP65 with diffuser, corrosion proof – (Thorn model CORFORC 2X58W)
- 250W Metal Halide low bay fitting suitable for mounting heights of 5 to 15 mtr, with hinged die cast aluminium control gear housing and aluminium alloy reflector, IP 55 minimum – (Thorn model RADBAY SEALABLE 1X250W)
- Aviation obstruction light on high rising structure – (Thorn model F22)
- Emergency light fitting suitable for 1x8W fluorescent tube, with integral battery and battery charger and with 'Exit' legend – (Thorn model EXLS3NM)
- Emergency light fitting suitable for 2x20W tungsten halogen lamps, with integral battery and battery charger, IP65 – (Thorn model ETSW20)

Lighting in office, messing, laboratory and control room areas shall be fluorescent type, compliant with the requirements for office environments and selected for use with the equipment to be installed in that area.

To allow easy access for maintenance, luminaires shall, wherever possible, be mounted at a maximum height of 2.7 m above floors or landings. Where the above detailed maximum height cannot be achieved, e.g. within process areas, means shall be provided for lowering luminaires to floor or landing level.

Lighting shall be designed to achieve working levels in these areas as follows:

- All main equipment/process areas and walkways, 350Lux.
- All main office areas, including laboratory, messing rooms and control room, 500Lux.

Lighting shall be switched from switches or switching banks (in main equipment halls) located adjacent to each entrance to the room or area. Where an area has more than one entrance, multi-way switching shall be utilised to allow operation of lighting circuits from any entrance. Main process halls shall be provided with lighting on more than one circuit to ensure that lighting cannot be de-energised with one switch operation.

5.4.2.2 Emergency Lighting

The emergency lighting shall be designed in accordance with the requirements of the latest revisions of the British Standard 5266 Part 1 1988. Emergency lights shall be automatically activated on loss of power supply to the appropriate area lighting circuit.

Emergency lighting fittings shall be of the non-maintained type conforming to BS 4533 Part 102.22 with a 3 hour rating following power failure to the lighting circuit.

A key operated test switch shall be provided adjacent to the lighting circuit main switch for testing the operation of the emergency lighting circuits and fittings.

All exits and emergency exits shall have either 'Exit' or 'Emergency Exit' signs as appropriate mounted directly over the exit. Areas where direct sight of the exit is obscured, direction signs with the words 'Exit' or 'Emergency Exit' and direction arrows shall be suitable sited.

5.4.2.3 External Lighting on Buildings

All main exit doors shall be provided with a local exterior light (metal halide bulk head Thorn Wallpack WP270MH) located above the door. An adjacent all weather switches shall be located adjacent to the door to provide local operation. Area lighting (metal halide flood light Thorn

SONPAK 400W mounted on 10M pole) shall be provided for all process tanks, general areas and walkways.

5.4.2.4 Roadway Lighting

All roadways shall be lit by lighting columns manufactured to BS 5649 and fitted with high pressure sodium vapour lanterns. The lighting system shall be designed to minimise the effects of light pollution both beyond the boundary of the STP and also above the level of any particular lantern.

Around the works access road shall be column type lighting (250W HPSV lamp, Thorn Alpha 2000 mounted on minimum 10M pole). All roads shall be provided with lighting in accordance with BS5489 Part 10 Main Carriageway Grid.

Road lighting shall be switchable by selectable manual or automatic control operated as follows:

Manual control – via on off switches on the control section door separated appropriately into areas of the site.

Automatic control - via photoelectric sensors with timer over-ride.

5.4.2.5 Outdoor Lighting

External floodlighting shall be provided for outdoor plant, tanks, chambers, loading areas, access walkways/ladder/staircases, platforms and car parks.

An average illumination level of 50 lux shall be achieved with a uniformity ratio (minimum/average) of better than 0.2: 1.

Floodlights shall be IP 65 metal halide type with integral control gear and non-corrodible housing.

Floodlights shall be mounted on aluminium, hinged lowering columns to BS 3989. Lowering accessories shall be included.

Floodlights shall be arranged for photo-electric/timer and manual override control.

Floodlight columns shall incorporate a base compartment with baseboard, fuse cut-off and lockable cover.

Road lighting columns shall also be provided to achieve 10 lux average on all Site roads.

The Site perimeter fence shall be illuminated along its entirety by floodlights similar to those specified for plant illumination and to achieve an average of 10 lux.

5.4.2.6 Small Power Provision

Small power installations shall be provided for the connection of portable appliances for office and industrial use as appropriate around the WTWs.

240 Vac 13 A switched twin socket outlets to BS 1363 shall be surface mounted in MCC rooms, office areas, control rooms and mess areas, spaced so that no point in the room is more than 3m from a socket. All sockets shall be protected by a 30mA RCD.

110 V BS 4343 16 A socket outlets shall be provided in all equipment rooms, spaced so that no point in the room is more than 10m from a socket.

All power outlet circuits shall be connected as ring mains. Where additional sockets are added to a circuit, the ring shall be extended to incorporate the new outlet.

5.4.3 Telecommunications

5.4.3.1 General

A minimum of 15 PSTN telephone service lines shall be installed into the WTWs.

5.4.3.2 PABX (Telephone Exchange)

The 25 operations service lines shall be controlled via a mini telephone exchange which shall control a number of hand set extensions in each main office/control room area and in each main equipment/process area/building.

The exchange shall be programmed to restrict external line access from certain handsets (e.g. in equipment/process areas).

5.4.4 Building and Site Security

5.4.4.1 Building

Each building shall be provided with a security system which shall include the following as a minimum:-

- Contacts on all external doors and windows.
- PIR movement detectors in all non plant corridors and all office and mess areas, located to detect movement through the rooms.
- Internal and external alarm sounders and visual alarms.
- An input to telemetry for remote monitoring of intruder alarms.
- Control panel with battery back-up facility with self-charging capability.
- Entry keypad at each building main entrance.

5.4.4.2 Site Security

A secure site access system shall be provided which shall incorporate the following main elements:

- Gate control (entrance gate and booms)
- Close circuit television system
- Access control system
- Intercom/alarm system, providing voice communications and attention alarm (audible in the control room), between the security barrier and the control room system.

5.4.5 Fire Detection, Alarm, Evacuation and Suppression System

The Contractor shall develop a fire protection strategy for the WTWs in liaison with the local area fire officer.

The fire detection, alarm and evacuation system shall comprise the component parts complied with the requirements of NFPA 70/72 and shall be UL listed. The system shall be designed and installed in accordance with NFPA 70/72.

An automatic fire suppression system shall be provided in line with the requirements of NFPA 2001.

The areas which are protected with clean agent system shall be provided with air sampling VESDA early warning system for fire detection in accordance with NFPA 72.

Foam-Water Spray Systems for bulk fuel storage facility shall be designed, supplied, installed, tested and commissioned in line with the requirements of NFPA 16.

Portable Fire Extinguishers shall be designed, supplied and installed as per the requirements of NFPA 10.

All transformer bays shall be fitted with a water deluge fire suppression system. The water deluge system shall be designed, supplied, installed, tested and commissioned in accordance with NFPA: 15.

Gas detection shall be provided as per the requirements of local civil defence authorities.

5.4.6 Lightning Protection

5.4.6.1 Building Lightning Protection

All buildings and structures shall be provided with structural lightning protection incorporating bronze finials and tapes as appropriate to the architectural qualities of the building. The tapes shall be connected to series of earth rods installed at strategic points at the base of the building.

All lightning protection shall be bonded to the buildings' electrical earth system in accordance with the IEE wiring regulations.

5.4.6.2 Electronic Equipment Lightning Protection

All instrumentation and SCADA controller systems shall be provided with local mains supply surge/lightning protection devices installed in the SCADA controller panels to protect equipment from either excessive mains surges or lightning induced surges on the mains into the WTWs.

In addition, all incoming communications links from either radio or telecommunications systems shall be fitted with lightning/surge arrestors to protect the connected equipment.

Where optical fibre cables are used for SCADA controller communications within the works there shall be no requirement for installing lightning protection.

All lightning protection equipment shall be selected in accordance with BS 6651.

5.5 Requirements for completion of construction

5.5.1 Inspection and Factory Acceptance Tests

5.5.1.1 MEICA Equipment

All larger items of electrical equipment, all MCCs and switchboards, all diesel generator sets, large pump/motor/vsd string tests, larger flowmeters (over 800mm dia), RTU, PLC/SCADA system integrated test, I/O test and software test shall be tested both on the manufacturer's premises (at factory acceptance tests) and on site (at site acceptance tests).

All tests shall be carried out by the CONTRACTOR, prior to witness testing by the Employer/ENGINEER.

5.5.1.2 Factory Acceptance Tests

The equipment shall be factory tested in the presence of the Employer and the Employer's Representative.

Factory acceptance tests shall be carried out on the manufacturer's premises and shall be coordinated by the CONTRACTOR. Factory acceptance tests shall incorporate the following main elements:

- Pre-test inspections.
- Insulation and energization tests (Electrical equipment).
- Point to point tests (PLC/RTU and SCADA systems, MCC's and control panels).
- Simulated function tests.

5.5.1.2.1 Pre-test inspection shall be carried out in accordance with the following criteria

- All power supplies shall be checked before any testing is initiated.
- Panels and contents shall be inspected to ensure that they have been constructed to the specification and final drawings.
- Check that all labels are correctly located and securely attached.
- Check that power distribution and circuit protection is such that any instrument can be removed safely without affecting equipment on any other loop.
- All breaker/fuse ratings shall be checked and breaker/fuse holders shall be marked with rating and service. The breaker/fuses and isolating switches shall be checked to ensure that they are connected to the correct circuits.
- The circuits shall be checked for correct polarity.
- The voltage at the instrument shall be measured to check that it is within the limits laid down by the manufacturer, for all operating conditions.
- Test points shall be checked to ensure connections to the correct controllers and indicators.
- Earthing shall be in accordance with the latest edition of the BS 7430.

- All mechanical equipment shall be checked for completeness and integrity, first fill of oil to manufacturer's recommended levels and all items lubricated.
- All machinery and drivers shall be checked for alignment.
- The installations shall be subjected to a preliminary safety inspection prior to first energization.

5.5.1.2.2 Insulation and energization tests shall be carried out in accordance with the following criteria

- All wiring shall be tested for insulation resistance, the test voltage being compatible with the circuit being tested. Circuits which have insulation resistance of less than 10 meg-ohms shall be rejected. Equipment which may be damaged shall be disconnected for these tests.
- Once insulation resistance and electrical continuity has been tested and proven to be satisfactory and in accordance with the relevant electrical regulations, the equipment shall be energised and allowed to "soak" with the power on for a period of at least 24hrs.
- Power off and power on tests shall be carried out, followed by checks for component failure and software corruption.

5.5.1.2.3 Point to point tests shall be carried out in accordance with the following criteria

- Each signal input and output shall be tested for continuity through the system under test from the point of generation to the point of display and against all intermediate stages in between.
- These tests shall be carried out against comprehensive point a schedule, which lists all relevant data including input and output addresses, point descriptions, values and ranges.
- This shall be included for tests on all Switchboards, MCC's, RTU, PLC/SCADA systems.

5.5.1.2.4 Simulated functional tests shall be carried out in accordance with the following criteria

- All equipment associated with a particular loop shall be tested as a system (e.g. alarms, integrators, controllers, motor starters and MMI).
- Test equipment shall be connected to field connection terminals only.
- Circuits and functions shall be tested on an individual basis. However, where cascade or similar controls are involved, they shall be tested as one complete system.
- All equipment shall be energised and remain so for the duration of the test. This includes electronic panel mounted indicators which are externally powered. Dummy loads shall be fitted in all electrical loops where this is necessary for observing correct functioning of the loop. These dummy loads shall remain fitted to all circuits except the circuit under test.
- To allow for cable resistance, electrical circuits under test shall include resistance to the maximum value permitted by the manufacturer's specification.
- All indicators, PLC/RTU inputs and controllers shall be checked by varying the input and observing that:
 - The correct receiver operates over its full range.

- There is no interaction with other circuits.
- Where appropriate, simulation test software may be used. Where simulation software is used, the routines used to test the application software shall be fully documented and verified under test before use in the factory acceptance tests.

5.5.1.2.5 Special Requirements

PLC/RTU and SCADA system factory acceptance tests shall be witnessed on the system integrator's premises prior to delivery and following completion of the CONTRACTOR's internal tests. Witness tests shall be attended by a representative of the CONTRACTOR and the Employer's Representative. All tests shall be demonstrated by the system integrator. The following tests shall be presented to the Employer's Representative for witness testing:

- Power on and off tests.
- Duty/Standby changeover operation of equipment where applicable.
- Communications network tests.
- Point to point tests, including data transfer.
- Functional test of each PLC/RTU including all programme sequences including all fault conditions. Sufficient simulation shall be provided to demonstrate a complete area of plant and any interfaces with other areas required.
- All communications interfaces shall be checked using either the equipment to be used on site or a suitable simulator.
- The PLC/RTU's shall be connected as a network and all data transfers between the PLC/RTU's checked.
- The SCADA system shall be assembled complete with network hubs, and switches and all Input/Output points checked during the FAT. This is to be achieved by using simulators on the PLC/RTU inputs and checking the signals through the SCADA graphic displays.

All Pumps subject to factory tests, which are operated by variable speed inverter drives, shall be string tested using the pump, motor and inverter coupled together for the test.

The diesel generator set factory tests shall incorporate the following tests in addition to those specified generally:

- Start up and shutdown operation.
- Temperature rise tests for both diesel engine and generator under load conditions.
- Fuel consumption test running on load for an agreed time period.
- Functional tests of all instruments and tripping devices.

5.5.1.3 Pre-Commissioning and Inspection at Site

Inspection of all installed electrical equipment and systems shall be carried out in accordance with the following criteria:

- That no damage has been sustained during transportation and erection.
- Leaks from equipment, or damage to equipment due to moisture ingress.

- Tightness of electrical connections.
- Continuity and tightness of earthing conductors.
- Correct termination of cable gland

5.5.1.3.1 Pre-commissioning tests

Pre-commissioning tests shall include the following:

- Electrical installations to be compliant with IEC 60364 requirements for Low Voltage Installations.
- Operation of all main electrical distribution protection devices via primary or secondary injection as appropriate.
- Point to point tests between equipment units and supervisory systems, including MCC's, PLC/RTU and SCADA systems. Point tests shall be for 100% of the installed I/O for the plant.
- Calibration of all instruments and transmitters in accordance with their required ranges and operational functions. This shall include all remote indications on panels and on the SCADA system.
- The setting of all discrete control and alarm devices in their operating positions and correct operating sense.
- Conductivity and flash tests on all complete and fully assembled bus-bar systems.
- Operation of all electrical field mounted equipment, e.g. isolators, emergency stops etc.
- Communications network tests, including optical fibre tests in accordance with BS 7718:1996, bit error rate tests and functional tests of network software.

5.5.1.4 Commissioning

5.5.1.4.1 Unit Testing

Unit testing is defined as tests on individual equipment items such as pumps, compressors, deodorisers, blowers, fans, conveyors and all similar equipment items. Tests may be performed simultaneously on groups of identical equipment, items, and groups of items supplied by one manufacturer, if practicable.

Clean water shall be used to fill tanks, wells piping and systems. Where necessary specified chemical shall be used for chemical systems but shall not exceed in-service concentrations.

Tests shall show that all component units operate with the quantities, efficiency, repeatability, and accuracy specified.

Tests shall be carried out continuously for a minimum period of 24 hours.

5.5.1.4.2 System validation tests

System validation tests shall not commence until tests have been satisfactorily completed.

This is defined as testing of complete systems that perform a discrete process function such as pumping systems, emergency power systems, Telemetry SCADA and similar systems. Each system shall include associated structures tanks, piping, utilities, instrumentation and controls, and like

related items. Two or more separate systems shall be validation tested simultaneously when necessary to validate an entire specific function.

Clean water shall be used for system validation tests if it is possible to carry them out satisfactorily with this medium. If the tests require use of the medium used in service, then this shall be used.

Each system validation tests shall be carried out for minimum of 24 hours, unless longer is needed to prove the performance of the system.

5.5.1.4.3 Commissioning and Setting to Work

Commissioning is defined as testing all the equipment and system together under actual operating conditions using all the mediums used in actual operating conditions. Setting to work follows consecutively from this. Once the equipment and systems are operating satisfactorily they are left to work.

Each system shall be tested including standby equipment by continuous operation under the "in-service" condition for not less than 14 consecutive days, with no interruptions except for normal maintenance or corrective work.

Systems shall be operated continuously under constant inspection of trained operators. System operation shall be cycled from full load to light load and back to full load each 24 h. Variable speed equipment shall cycle through the applicable speed range at a steady rate of change. Simulated alarm and failure operating conditions shall be induced. Test controls and protective device shall be tested for correct operation in adjusting system functions or causing system shutdown.

Subject to CONTRACTOR's request and Employer's Representative's approval in each case, the CONTRACTOR may simulate certain operating conditions relating to flow rates, water levels, and malfunctions. Permission for simulations will be granted only where it is unwise or impossible to obtain the conditions covered by the capability of ranges or equipment. The simulation method shall reflect reasonable anticipated operating conditions.

5.5.2 Training to Employer Staff

5.5.2.1 Training For Electrical Equipment / Systems

The CONTRACTOR shall arrange and provide adequate training to Employer staff in operation & maintenance of electrical system, protection and interlocks, MV/LV switchgear, variable speed drives, soft starters, building services system, UPS, diesel generator etc. by the manufacturer specialist engineer.

The CONTRACTOR shall give the Employer at least two month's written notice of the proposed instruction and training programme. Instruction and training covering basic system operation theory, routine maintenance and repair, and "hands on" operation of equipment shall be included. The duration of the instruction and training period shall be based on the complexity of equipment involved and the equipment manufacturer's recommendations. The Employer/Employer's Representative acceptance of the adequacy of training received must be obtained before terminating the programme.

An instruction and training programme shall be conducted for up to 6 operators or as designated by the Employer.

Training for control system shall be provided to Employer staff as specified else where in the contract document.

SECTION 6 - PLANT PERFORMANCE REQUIREMENTS

Table of CONTENTS

6.1 Introduction	2
6.2 Responsibilities In Commissioning	3
6.2.1 Employer’s Responsibilities	3
6.2.2 Contractor’s Responsibilities	3
6.3 PLANNING AND CONTROL OF COMMISSIONING	4
6.3.1 Strategy and Constraints	4
6.3.2 Sequence	5
6.3.3 Outages	5
6.3.4 Temporary Discharges	6
6.4 Testing and Commissioning To Achieve Completion	6
6.4.1 Factory Tests	6
6.4.2 Installation Tests	8
6.4.3 Dry Tests	8
6.4.4 Wet Tests	9
6.5 Training	10
6.6 Acceptance Criteria Prior To Plant Start-Up	11
6.6.1 Hazcomm	11
6.7 Reliability Tests	12
6.8 Plant Start-Up and Process Commissioning	12
6.9 COMPLETION Performance (Commissioned Works) TESTS	13
6.9.1 Sampling and Analysis	14
6.9.2 Commissioned Works Tests	14
6.10 Completion Tests Report	15
6.11 Acceptance Criteria for Completion	16
6.12 Post Completion Testing Prior To Defects Date	16
6.12.1 Post Completion Testing	16
6.12.2 Optimization	16

SECTION 6 - PLANT PERFORMANCE REQUIREMENTS

6.1 Introduction

This section describes the project specific commissioning requirements to achieve Completion (Issue of Taking-Over Certificate and Performance Certificate).

Performance tests will only be carried out once the Engineer has confirmed in writing that all parts of the Water Treatment Works (WTWs) have been adequately commissioned and tested, and that the plant is ready to operate in automatic mode.

Performance tests will involve:

- proving the performance of individual plant components and systems;
- proving that the components within the system operate in the correct sequence in response to inter package changes and changes to package input level signals;
- proving that all relevant systems reset automatically to enable a subsequent automatic start-up;
- proving that all relevant alarms are raised when any part of the system fails to operate as required;
- proving that all relevant alarms are raised when tank levels within the system reaches high, high , low or low level;
- proving that all relevant alarms are raised when items within the system operate outside their normal operating envelopes;
- proving that all operational parameters controlling the entire plant can be easily monitored and adjusted via one common control panel;
- proving that on-line equipment is displaying and recording the correct readings;
- proving that the chemical consumption of the entire system and components within the system does not exceed the agreed figure;
- proving that the electrical power consumption of the entire system does not exceed the agreed figure.

During performance tests various process streams will be routinely analyzed, these analysis will be carried out at an independent accredited laboratory. The Contractor shall also take samples and test them at the site's laboratory; however the independent laboratory sample result will be used for performance test evaluation.

Once the performance test has started no operator intervention will be allowed. If any operator intervention is required during the performance test then the test shall be deemed a failure and shall be required to be restarted as soon as practicable.

The performance test will be carried out by the Contractor under the direct supervision of the Engineer. However, until the performance test has been successfully completed and the Engineer has written to the Contractor to confirm that this is the case, the plant and the operation of the plant shall

remain the property and responsibility of the Contractor. Any chemicals and other consumables required to carry out the commissioning and performance tests shall be supplied by the Contractor

The tests detailed in the following sub-sections shall be in addition to any tests prescribed within the Standard Specifications and elsewhere within the Contract Specific Technical Requirements sections.

Plant inspection, testing and commissioning shall include the following procedures:

- Factory Acceptance Tests (FAT)
- Site Acceptance Tests (SAT):

Dry Tests	Construction Completion
Wet Tests	
- Tests on Completion:
 - Commissioning
 - Reliability tests
 - Process Tests
- Tests after Completion (During maintenance period).

The mechanical and electrical testing requirements are briefly discussed in this section for completeness on the testing sequence overview, specific details on the mechanical and electrical testing requirements are detailed in the mechanical and electrical tender requirement sections (Volume 2, Sections 4 & 5).

6.2 Responsibilities In Commissioning

6.2.1 Employer's Responsibilities

The Employer will be responsible for:

- Provision of pipeline outages to enable connections to be made to existing mains and structures, in accordance with the Contractor's programme and as approved by the Engineer. Outages will be strictly limited period such that the existing treatment process continues to function.
- Access to site

6.2.2 Contractor's Responsibilities

The Contractor shall be responsible for the overall commissioning activities and for the management of the commissioning interfaces, including liaising with the Employer regarding items listed in Section 6.2.1.

The Contractor shall be responsible for the following with regard to his plant:

- Provision of water, chemicals and power for commissioning and testing

- Off-site disposal of wet testing and process establishment (i.e. non-compliant) commissioning waters and chemicals which cannot be diverted to another area of the plant
- FAT and SAT testing
- Installation testing
- Dry testing
- Wet testing
- Reliability, completion and performance testing
- Troubleshooting
- Liaison with the Engineer's Representative on all commissioning issues
- Disposal of excess sludge produced by new process units that cannot be disposed within the system under construction
- Operation and Maintenance of the plant

6.3 PLANNING AND CONTROL OF COMMISSIONING

The Contractor shall submit a detailed Testing and Commissioning Plan detailing his proposals for testing and commissioning, including a programme for the work, for the Engineer's Representative approval.

6.3.1 Strategy and Constraints

The Contractor shall develop his commissioning strategy in conjunction with the Engineer's Representative.

The Contractor shall take into account the following Commissioning Strategy when developing the Mseilha WTWs Commissioning Plan:

- The Contractor shall phase commissioning in accordance with on-site construction activities
- Construction and commissioning shall be sequenced so that raw water source and treated water quality is clearly defined prior to each activity
- The Contractor shall programme for the filling, emptying and disposal of all process fluids for commissioning

The Contractor will arrange all testing and commissioning of the works, giving adequate notice to both the Engineer's Representative and the Employer. The Contractor shall provide a commissioning plan and commissioning schedule that will detail testing and commissioning activities under the headings given below:

- Commissioning Programme
- Factory Tests

- Installation Tests
- Dry Tests
- Wet Tests
- Process Commissioning
- Completion Tests
- Performance Tests during O&M period
- Training

Commissioning of the new works shall be done in stages with logical progression through the process.

Due allowance shall be made in the programme for the inclusion of proving periods once any section is complete prior to it being offered for acceptance. In general a minimum 21 days period shall be allowed following completion to demonstrate continuous, fault free operation under automatic control. In the event of a fault occurring the default shall be remedied and the 21 days trial restarted.

6.3.2 Sequence

The Contractor shall programme in detail and agree with the Engineer's Representative, the commissioning sequence and programme.

The Contractor shall advise on the site-specific commissioning sequence in accordance with the construction programme, for the following process elements:

- Inlet Works flash mixer, clariflocculator
- Rapid sand filter
- Chlorination System
- Contact tank
- Filter back wash
- Chemical system
- Main pumping Station

The Contractor shall present the proposed commissioning strategy to the Employer and the Engineer's Representative prior to commencement of site activities.

6.3.3 Outages

The Contractor shall inform the Employer of the duration of each plant shut down to enable the Employer to manage the treated water supply.

To enable continued commissioning and to avoid total plant shut down the Contractor shall provide adequate temporary pumping arrangements.

The Contractor shall inform the Engineer's Representative of all temporary pipework, pumping and chemical dosing facilities necessary and the duration of use prior to any on-site construction and commissioning activities.

6.3.4 Temporary Discharges

It is the Contractor's responsibility to identify all requirements for temporary discharges and to liaise with the Employer regarding these discharges.

The contractor needs to plan the wet testing and process commissioning such that temporary discharges are minimised or removed. Out of specification treated water should not enter the treated water tunnel.

6.4 Testing and Commissioning To Achieve Completion

The following testing requirements apply to the WTW and shall be successfully completed prior to issue of the Taking-Over Certificate:

- Plant testing
 - Factory tests
 - Installation/dry tests
 - Wet testing
- Training
- Plant start up and process commissioning
- Completion Tests
- Operation and maintenance manuals
- All snags complete
- Successful operation and maintenance of the plant

All phases of testing and commissioning shall be finished prior to Completion with the exception of process optimisation and Maintenance Period Tests, which shall take place during the 12 month period following Completion.

6.4.1 Factory Tests

The Engineer's Representative's nominated representatives shall be invited to witness FAT testing.

All equipment for the works shall be factory tested in accordance with manufacturers' recommendations and the specification.

FATs shall be carried out on all mechanical equipment including, but not limited to:

- All pumps, string tests shall be carried out at the manufacturer's premises. Following the fixed speed 'guarantee test', each pump shall be tested with its own drive and inverter to demonstrate electrical, hydraulic and mechanical stability over the complete design operating range.
- Filtered back wash blowers – String tests shall be carried out at the manufacturers premises. Following the fixed speed 'guarantee test', each blower shall be tested with its own drive and inverter to demonstrate electrical, hydraulic and mechanical stability over the complete design operating range.
- Flash mixer and flocculator
- Chemical storage and dosing system
- Sludge thickening and dewatering equipment

FATs shall be carried out on all electrical equipment including, but not limited to:

- Transformers & switchgears
- MCCs - all MCC FATs are to include the associated Controls and PLC software
- LV Control Gear
- ICA & SCADA systems
- Instrumentation - Manufacturer's standard certification and calibration as appropriate

Certified test certificates shall be issued for all equipment prior to delivery to site and prior to commencement of installation.

All other equipment, switchgear MCC's, control panels and associated equipment shall be Factory Tested in accordance with the relevant specification.

The Employer shall require witness testing of software as described below:

The Contractor shall be responsible for providing the control system so that the works can be run according to the control philosophy provided in this document.

The Contractor shall be responsible for the testing of software associated with his plant.

Tests are to be followed within 7 days by a written test record. Control procedures shall be clarified for application software installed on site. In particular, attention to the backing-up and storage of software versions as described below.

The Contractor shall record all software changes made at each stage of development. The record shall provide a means of logging all the software changes, the originator and the reason behind the change. It will provide an auditable trail for tracing faults or omissions that may arise in the future. All software and any bespoke programming code will be fully Factory Acceptance Tested (FAT) prior to installation at site. The completed FAT document will be submitted including the amendment records and exception sheets for any tests that can only be completed on the fully installed system on site. Records of any plant simulations used to perform the tests will also be submitted with the FAT documents.

The Site Acceptance Testing (SAT) will be based on the FAT but will include the actual plant operation sequence and interlocks, as defined in the Functional Design Specification to be developed by the Contractor.

The SAT will repeat all the FAT plus any tests that could not be performed at the FAT and other additional performance tests to meet the contract specification.

6.4.2 Installation Tests

Installation checks on all new plant and equipment shall, as a minimum, follow the recommendations as contained within the Specifications.

In addition the Contractor shall provide signed documentation for the following installation checks:

- Verification of all safety systems including emergency stops and safety interlocks; checking of push buttons, control switches, and status indication lamps for correct function.
- Check that all safety signs have been installed and warning notices installed
- Calibration certificate for the installed flow meters
- Hazardous zone rating of Ultrasonic level heads, Drives, Mechanical motors / valve actuators, Instrumentation, Cabling and junction boxes within chambers
- Written scheme of examination for pressure vessels
- Correct equipment installation, fixing, alignment and safety features/guarding in place
- Electrical installation in compliance with relevant Specification
- Instrument mounting, location and servicing access
- Correct lubrication of all equipment and levels checked
- Assessment of serviceability and safe operational access to equipment
- Cable ducts sealed
- Labelling and painting of pipework to suit specified requirements
- Statutory testing of installed/supplied lifting equipment and pressure systems

6.4.3 Dry Tests

Dry Testing shall be carried out on all civil, mechanical, electrical and control equipment including, but not limited to, the following:

- All tanks – visual examination for defects
- Blowers – dry running test over full operating range
- Valves and penstocks – operation over full range
- Installation and removal/lift out demonstration of maintainable items

- Chlorine drum replacement demonstration
- Electrical Safety Inspection
- Cable tests
- Verification of all safety systems including emergency stops and safety interlocks and simulation of fault conditions to test adequacy of protective devices
- Pump/motor assemblies checked for alignment; level; setting of seals/couplings; operation of overload devices; setting of limit switches; directional response/rotation; instrument feedback/status indication.
- Motor rotation checks
- Instrument and loop testing including calibration against a factory tested and certified measuring device
- Set up of ultrasonic level transducers and float switches etc
- Verification of telemetry alarm system in accordance with the Specification
- Demonstration of automatic control of all associated equipment
- Instrument loop testing
- Point to Point I/O checks
- Demonstration of hard wired interlocks, where applicable

6.4.4 Wet Tests

The Wet Testing schedule shall be agreed between the Employer/Engineer's Representative and the Contractor before commencing tests. Wet tests shall be carried out on all civil, mechanical, electrical and control equipment including, but not limited to, the following:

- All chemical and other liquid storage tanks will be hydraulically tested after erection on site. The tank shall be filled with a suitable liquid and pressurised to give 30% in excess of design loading for a period no less than 24 hours
- Tanks and water retaining structures
- Pipeline and pipework pressure tests
- Pumps – outputs over operating range or draw time on wet well
- Sludge tanks mixers/mixing – visual inspection of mixing. Additional tests (i.e. dye test, measurement of suspended solids or flow velocity variation throughout the tank) may be ordered by the Engineer's Representative if for any reason the mixing is suspected of being inadequate
- Blowers - turndown to satisfy minimum, average and maximum flow
- Pattern test to demonstrate that the air distribution is even for sand filter scouring area

- Testing of site safety equipment, e.g. safety showers/eyewash units
- Testing of all instrumentation control loops included in the project
- Testing of telemetry systems included in the project
- Demonstrate that at maximum flow to the different process units the flow distribution to each cell does not vary by greater than 10% of the flowrate to the cell taking the lowest flow. The Contractor shall provide a method statement describing how he proposes to verify flow distribution
- The Contractor shall demonstrate that the Plant operates in accordance with the control philosophy. The detailed test requirements shall be developed by the Contractor and submitted to the Employer/Engineer's Representative for approval.
- Functionality of all items of mechanical, electrical and instrumentation equipment. The detailed test requirements shall be developed by the Contractor and submitted to the Employer/Engineer's Representative for approval Integrated System Tests. The detailed test requirements shall be developed by the Contractor and submitted to the Employer/Engineer's Representative for approval.
- Ability of mechanical plants to operate without undue vibration and noise

6.5 Training

The training shall be carried out at the Mseilha WTW site and shall provide comprehensive training covering all aspects of plant operation and maintenance to all the relevant Employer's operation and maintenance staff as nominated by the Employer. Training may be supplied by sub-Contractors as required. The Employer's nominated staff should be invited to attend all training sessions and shall, as a minimum, include the following:

- 1 No. Process Engineer, 1 No. Mechanical Engineer, 1 No. Electrical Engineer, and 1 No. Instrument Engineer
- 1 No. Mechanical Technician, 1 No. Electrical Technician, 1 No. Operation Technician, and 1 No. Instrument Technician
- 1 No. Chemist and 1 No. Microbiologist
- 3 No. Laboratory Technicians
- 6 No. Plant Operators

Training shall be provided prior to Start-up (Initial Training) and at Completion (Final Training).

The Contractor shall submit a training plan and programme for the training modules.

Training cannot commence until the draft O & M manuals have been reviewed by the Engineer's Representative and/or the Employer.

The Final Training session shall be held prior to Completion towards the end of the Operation and Maintenance period. This session shall be used to bring the Employer's Operations and Maintenance

staff up to date with the modifications to the works that have been carried out in the period between the main training sessions and completion.

The training modules shall also include for functionality and SCADA control system.

The training plan shall as a minimum contain the following:

- Plant operation philosophy
- Operation and maintenance of instrumentation
- Operation and maintenance of the SCADA control system and PLC's
- Operation and maintenance of all plant, pumps etc.
- Lab training to cover the new treatment process and optimisation

6.6 Acceptance Criteria Prior To Plant Start-Up

The following items shall be completed before Plant Start up is allowed:

- Construction of all works and equipment comprising the works
- Completion of Factory Acceptance Tests, Installation checks / dry testing, wet testing, including all documentation relating to the testing.
- All critical instruments are operational, calibrated and trended on the SCADA control system
- Preliminary training completed as required by the Contract
- Draft O&M manuals available
- Sampling points installed and safely accessible
- No Class A snags remaining
- HAZCOMM carried out and all risks appropriately addressed and contingencies in place

6.6.1 Hazcomm

HAZCOMM stands for 'Hazards in Commissioning'. The procedure is carried out to ensure that a risk management approach is taken to all environmental, health and safety and discharge quality issues prior to commissioning of a process, either part or whole.

It is carried out by formally reviewing within a dedicated meeting, the risks to personnel, plant and environment and identifying control measures and contingencies where required.

The Contractor shall be responsible for organising the HAZCOMM meeting. The Contractor shall issue commissioning method statements and all relevant documents at least 3 weeks prior to the HAZCOMM meeting, to the Engineer's Representative's Representative and all relevant personnel for review.

The Contractor shall not proceed with Plant Start-up until the Engineer's Representative's Representative is satisfied that appropriate control measures and contingency plans are in place to reduce or eliminate Hazards in Commissioning.

6.7 Reliability Tests

A 7-day continuous reliability test shall be carried out to demonstrate the plant's reliable operational performance under automatic control. This test is also referred to as 'Final Mechanical/Electrical Acceptance Test' within the mechanical and electrical tender requirement sections (Volume 2, Sections 4 & 5).

The process unit shall be deemed to have passed its reliability test if the plant and equipment operates without failure/breakdown during the continuous 7 day test period. For the purpose of the test, any malfunction of duty plant and equipment, bringing into use standby/assist plant and equipment, shall not be deemed a failure. However, a repeat malfunction will be deemed a failure of the reliability test. In this event the 7 day reliability test shall be re-commenced once corrective actions have been carried out by the Contractor.

6.8 Plant Start-Up and Process Commissioning

Plant start up will occur after Dry and Wet Testing is successfully complete. The Contractor shall fully develop his plant start up procedures within his commissioning plan. It is important that the contractor removes the risk of discharges of out of spec treated water.

The purpose of these tests is to demonstrate as far as is practicable that the Plant and equipment are reliable in their operation, their output and performance meets the stipulated criteria and that the Plant is capable of producing treated water of the specified quality.

The start up and process commissioning phase shall be complete after the successful completion of the Reliability Tests. Prior to the start of the Reliability Tests the following conditions shall be met:

- Successful completion of dry and wet testing
- Operating and Maintenance Manuals have been issued for plant start up
- A full and detailed method statement and programme for the Performance and Reliability Tests has been approved by the Employer/Engineer's Representative
- Training Programmes have been issued
- Health and Safety measures are in place to protect employees, plant and environment

During the Reliability Testing, the Contractor shall carry out tests to demonstrate the satisfactory operation of the Contractor's scope in all respects. All facilities shall be provided to the Engineer's Representative and the Employer to allow the witnessing of the Contractor's operations. To comply with these requirements:

- The Contractor shall give the Engineer's Representative 7 working days notice of the date, time and location of each test or inspection

- The Contractor shall provide all labour and equipment required to operate the Contractor's scope during the Reliability Tests. One or more competent Contractor's Representatives whose name or names shall have been notified in writing to the Engineer's Representative/Employer shall be present throughout the whole of the period of the Reliability Tests
- The Contractor shall provide a contingency plan, agreed with the Employer/Engineer's Representative, in the event of Plant failure.

Process Commissioning will be undertaken in order to confirm that the design process is satisfying the specified performance criteria in the Completion Tests and Final Performance Tests. New process units are to be commissioned off line where appropriate. The Contractor shall fully develop his plant start up procedures within his commissioning plan.

6.9 COMPLETION Performance (Commissioned Works) TESTS

The purpose of Completion Performance testing is to demonstrate to the Engineer's Representative and the Employer that the works and all associated equipment can operate satisfactorily and reliably in automatic mode and in accordance with the Operating and Maintenance Manuals and that it can achieve the Completion Performance Test Criteria.

Acceptance criteria for Completion shall include:

- Installation and all commissioning complete and records signed off
- Ensure that no water goes into supply which has not been formally tested and confirmed to wholesome and that the parameters listed in Table 2.2.1 – Final Treated Water Quality Requirements are within the maximum admissible concentrations (MAC) stated therein
- Ensure that water going to supply has a residual free chlorine concentration of 1.0 mg/l minimum, initially, or higher if so requested by the treated water tunnel commissioning engineer
- Water going to waste is limited to essential testing

The date of each test shall be confirmed not less than 14 days prior to the test.

Notice of a change, to the date of any test shown in the Test Schedule, shall be submitted to the Engineer's Representative not less than 2 days prior to the original scheduled date.

Each Test shall commence at 09:00 on the day of agreed commencement. All tests shall be continuous in nature with operation (24 hrs a day, 7 days a week).

The duration of the Completion Performance Tests phase shall be 21 days.

The responsibility for all commissioning rests with the Contractor but all stages shall be confirmed to have been satisfactorily completed by the Employer's Representative.

The Employer's permanent staff shall, as far as it is reasonable, actively be involved in works commissioning and testing under the specific guidance of the Contractor's authorized engineers. Subject to the approval of the Employer's Representative, the Contractor shall appoint an "Acting Works Manager" (AWM) who shall be assisted by the Employer's Permanent Works Manager designate during commissioning, testing and the first year's operation.

The AWM shall approve all commissioning and testing procedures and shall liaise with the responsible commissioning and testing engineer(s) for the raw water and treated water tunnels/pipelines and the Employer's Representative on all matters of receiving raw water into the works and providing treated water from the works.

The Contractor shall make adequate allowances in his commissioning and testing programme for supplying water into the treated water tunnel/piping systems for flushing, testing and sterilisation.

Commissioning shall be deemed to be completed when the Works:

- can provide the design net treated water output continuously the treated water parameters listed in Table 2-2.1 Final Treated Water Requirements are at the target mean values
- all automatic operations are in use

6.9.1 Sampling and Analysis

The Contractor shall provide facilities, connections and sample taps as appropriate and necessary for the taking / drawing-off of samples at the locations indicated in the following sub-sections.

The samples shall be analyzed using the standard methods defined in the current version of "Methods for the Examination of Water and Associated Materials" published by Her Majesty's Stationary Office or "Standard Methods for the Examination of Water and Wastewater" 20th Edition 1998 published by the American Public Health Association. The sampling and testing shall be carried out at a laboratory accredited by the Employer. The laboratory's results shall be provided to the Engineer's Representative and Employer. The Contractor's sampling and testing shall be carried out at the expense of the Contractor.

Samples shall be representative of the sample stream. Composite samples shall be taken from 09:00 on the sample day to 08:45 on the following day. Composite samples shall be taken with an automatic sampler set to extract samples at maximum intervals of 15 minutes for deposition into a single composite sample bottle. The composite sample bottle shall have a minimum volume of 2 liters. Each sample taken from the automatic sampler shall be split equally into 2 separate samples. Prior to the division of the sample, the sample shall be homogenized. One sample shall be taken for analysis and one sample retained in refrigerated storage (at less than 4°C but prevented from freezing) until 7 days after issue of the results.

In the event of a dispute, the sample retained in the refrigerator shall be analyzed by an independent laboratory as directed by Engineer.

6.9.2 Commissioned Works Tests

Following Commissioning leading to water going into supply the following Commissioned Works Tests shall be carried out:

The Contractor shall test the commissioned Works for a continuous period of 21 days when it is possible to deliver water into supply during which time:

- the Works shall operate automatically
- no commissioning adjustments are made to any part of the Works

- the Works output is adjusted as necessary to meet the demand and/or as directed by the Employer's Representative
- the Works are operated by the Contractor's Operators, assisted by the Permanent Operators.

The raw water and final treated water shall be sampled at regular intervals and analyzed as shown in Table 6.1.

Table 6.1: Commissioned Works Tests Schedule of Sampling and Analysis

No	Parameter	Unit	Raw Water Every		Filter Feed water Every	Final Treated Water Every		
			12h	24h	4h	4h	12h	24h
1	Colour	mg/l Pt/Co Scale	4	4				4
2	Turbidity	JTU	4	4	4	4	4	4
3	Odour	Dilution No						4
4	Taste	Dilution No						4
5	Hydrogen Ion	pH	4	4	4		4	4
6	Aluminium	mg/l Ae			4(i)	4(i)	4(i)	4
7	Dissolved Oxygen	% O ₂						4
8	Ammonium	mg/l NH ₄					4	4
9	Oxidisability (KMNO ₄)	mg/1 O ₂		4			4	4
10	Iron	mg/l Fe			4(ii)	4(ii)	4(ii)	4
11	Manganese	mg/1 Mn		4				
12	Total Coliforms	No/100 ml						4
13	Faecal Coliforms	No/100 ml						4
14	E-coli	No/100 ml						4
15	Free Chlorine	mg/l				4	4	4

Note:

- if coagulant is Aluminium based
- if coagulant is Iron based

In addition, the normal operations log sheets shall be completed and all tests specified in Volume 2 Section 2, Table 2.2.1 should be analysed on weekly basis.

6.10 Completion Tests Report

Within 10 days after completion of the Completion tests and submittal of data from the analytical laboratory, four (4) copies of a report shall be submitted with the following information:

- The date and time of the performance tests

- A description of all samples collection and measurement techniques
- Raw data and original copies of all laboratory reports for all parameters
- Descriptions of operations problems, unusual conditions, equipment failures or malfunctions, and other factors adversely affecting performance of the process units.

6.11 Acceptance Criteria for Completion

Acceptance criteria for Completion and issue of the 'Taking-over Certificate' shall include:

- Critical operating parameters satisfied and key performance criteria proved. Specified Completion Performance tests successfully passed
- No major Snags remaining, minor items listed, agreed with the Engineer's Representative and having target dates for completion
- The standby generator facility is available and operates reliably, auto start/stop facility is operational
- The plant is operating in line with the operating plan expectations and is not requiring excessive manpower to operate/maintain, or consuming chemicals or power in excess of that which could be reasonably expected
- The plant meets reasonable requirements for reliability
- The plant meets reasonable requirements for maintenance
- The plant meets Health and Safety requirements
- The plant is not causing an environmental nuisance or subject to reasonable complaints from neighbours

6.12 Post Completion Testing Prior To Defects Date

6.12.1 Post Completion Testing

The Contractor will conduct tests as outlined in Section 6.9 for a period of 21 consecutive days in order to demonstrate the project objectives have been met and to ensure compliance with the treated water quality requirements.

6.12.2 Optimization

Following Completion Testing, the works may require further optimization.

During the Process Optimization period the whole of the plant operating elements will be addressed and adjustments made by the Contractor following joint agreement with the Engineer's Representative and the Contractor.

The Optimization period will be 7 days.

SECTION 7 – OPERATION & MAINTENANCE REQUIREMENT

TABLE OF CONTENTS

7.1	Description of Services	4
7.1.1	Raw Water flows in Mseilha WTW.....	6
7.1.2	Design flows for the Mseilha WTW facilities.....	6
7.1.3	Design loads for the WTW facilities	6
7.1.4	Increases in flows and loads.....	6
7.1.5	Non-compliant Raw Water.....	7
7.2	General Obligations.....	7
7.2.1	Responsibilities.....	7
7.2.2	Project Facilities	8
7.2.3	Approach to Maintenance	10
7.2.4	Legal and Financial Aspects.....	12
7.2.5	Health, Safety and Security	13
7.2.6	Contractor’s Employees	15
7.2.7	Information and Reporting.....	17
7.3	Performance Guarantees.....	18
7.4	Operational Obligations	18
7.4.1	Outline Operation and Maintenance Manual	20
7.4.2	Provision of Electricity, Chemicals, Vehicles and Spare Parts	22
7.4.3	Penalties for Non-Compliance.....	23
7.4.4	Emergency Conditions.....	23
7.4.5	Suspension	24
7.4.6	Notices under the Contract.....	24
7.4.7	Confidentiality, Public Relations and Publicity	24
7.4.8	Copyright and Intellectual Property Rights	25
7.5	Maintenance obligations	26
7.5.1	Management.....	27
7.5.2	Planning and Scheduling	27

7.5.3	Maintenance Personnel	27
7.5.4	Maintenance Instructions	27
7.5.5	Inventory Control of Items	28
7.5.6	Equipment Records	28
7.5.7	Work Control and Outage Planning	28
7.6	Ownership of Raw Water, Treated Portable Water and Products	28
7.7	Insurances.....	29
7.8	Staffing	29
7.8.1	Staffing Levels	29
7.9	Building and General Maintenance	30
7.10	Inspection and Maintenance Plant.....	30
7.10.1	Policy	30
7.10.2	Inspection and Maintenance Procedures	30
7.10.3	Calibrations	30
7.10.4	Records.....	30
7.11	Sampling and Monitoring Programme	31
7.11.1	Independent Sampling and Analysis	31
7.12	Training Of Employer's Staff	32
7.12.1	Execution of Training.....	33
7.12.2	Technical Content.....	33
7.12.3	Contractor's Personnel.....	35
7.12.4	Training Test Period	35
7.13	Permits	36
7.14	Records.....	36
7.14.1	Operations Daily Log	36
7.14.2	Monthly Operation Reports	36
7.14.3	Annual Operation Reports	37
7.14.4	As-fitted Drawings.....	37
7.14.5	Archiving Data	37
7.15	Spare Parts, Tools and Testing Equipment	37

7.15.1 Spare Parts 37

7.15.2 Tools 38

7.16 Handover 38

7.16.1 Handover Procedures..... 38

7.16.2 Final Tests..... 39

SECTION 7 – OPERATION & MAINTENANCE REQUIREMENT

7.1 Description of Services

This tender includes Operation and Maintenance of the Mseilha water treatment works for one year period, the Contractor shall operate the Facilities in such a way that the attainable performance criteria are achieved and maintained at all times.

The Contractor/ Operator shall operate and maintain the WTW and associated infrastructure. The Contractor shall obtain all necessary information concerning the operating and maintenance requirements and conditions of the WTW. He shall possess at least one complete set As-Built Drawing and records as well as operation, maintenance and safety manuals, referenced parts lists and other documents being necessary for the carrying out of his services for Operation, Maintenance and Training. During the O & M period the Contractor shall provide on-site training of the Employer's staff in managing, operating and maintaining the Works.

The O&M method statement and program submitted with the Contractor's Tender shall form the basis of the Contractor's procedures for Operation and Maintenance and shall be used to establish a set of standard operational procedures for the Facilities. Within twelve (12) months from the start of the contract of the construction of WTWs, the following documents shall be prepared by the Contractor and approved by the Employer's Representative, being produced in a user-friendly style and in a format suitable for use in training the Employer's staff in the Operation and Maintenance of the Facilities:

- Resource Allocation Statement: Description of staff (with detailed qualifications), materials, plant and equipment required for operating and maintaining the Facilities (Asset Inventory Report).
- Resource Allocation Programme: Bar chart schedule for the period of use of staff, materials, plant and equipment.
- System Development and Implementation Plan: Management of administration, operation, maintenance and technical services.
- Operations Plan: Operation of the Facilities under normal operation conditions and in cases of outage.
- Maintenance Plan: Maintenance procedures to ensure the continuous operation of the Facilities under normal operation conditions and in cases of outage.
- Comprehensive Safety Policy: Definition of the Contractor's responsibilities regarding safety and health of all authorized people being situated at the Site.
- Standard Procedures Document: Step-by-step implementation procedures for the effective management and operation of the Facilities (e.g. Loss Prevention and Disaster Recovery Plan, etc).
- Laboratory analyses methodology to be carried out by the Contractor.

The training programme shall be submitted for the approval of the Employer's Representative before the actual start of the Training Period.

O&M shall include, but not be limited to the following services:

- Management,
- Provision of manpower,
- Provision of electricity and chemicals,
- Provision of fuel, lubricants and consumables,
- Payment of penalties, damages, levies and other dues in order to comply with all appropriate regulations and the Contract,
- Provision of vehicles,
- Provision of spare parts,
- Operation of the Facilities,
- Adjustment of process whenever necessary,
- Preventive and routine maintenance,
- Repair and replacement work,
- Repainting work,
- Monitoring of performance,
- Reporting,
- Data filing and processing,
- Preparation and execution of training.

The performance of the treatment plant shall be monitored as specified, and shall consider the alterations approved by the Employer's Representative during the Performance Tests Periods and the Operation and Maintenance Period.

All cost in relation to O & M and any training shall be borne by the Contractor. He shall be liable for any damage of objects and persons caused by faults in operation, maintenance and staff training.

The Contractor/ Operator shall service, repair, refurbish, renew and replace the WTWs and associated infrastructure's plant and components and protect and maintain them and generally conserve the WTWs and associated infrastructure such that at the end of the Operational Period a fully operational system is handed over to the Employer.

The services shall comply with this section of the Employer's Requirements, the Operation and Maintenance Manual, optimum conditions in relation to the lifetime of the plant, and, in the absence of any express requirement, in accordance with Good Engineering Practices.

Good Engineering Practice means the exercise of the methods, techniques, standards, skill, diligence, prudence and foresight to be expected to be exercised by a skilled and experienced contractor or operator engaged in similar activities (including project management, design, procurement, construction, operation and maintenance of a similar facility in scope and complexity and in

compliance with its contractual obligations, statutory requirements, reliability, safety, environmental protection, economy and efficiency.

The Operator's services shall include, but not be limited to, the following:

- Provision of management staff and labour,
- Procurement of materials, chemicals and consumables necessary to receive, treat and process the raw water and sludges to the specified standards and quantities,
- Provision of utilities including water, telephone and electricity required to operate the WTWs and associated infrastructure and buildings including, lighting, heating, cooling etc. to ensure proper operation and maintenance,
- Provision of insurances,
- Procurement and on-site storage of fuel for diesel engine generator and spares for repairs and maintenance,
- Transportation and disposal off-site of all sludges, screenings and other waste products produced from the treatment processes,
- Transfer of treated portable water for Engineer's specified purposes,
- All other services and materials described in these documents or reasonably inferred from them, and
- Optimisation of operational parameters such as fuel and chemical consumption, etc..

7.1.1 Raw Water flows in Mseilha WTW

Throughout the Operation and Maintenance period, the Contractor shall accept, convey, treat and discharge all raw water flows which are delivered to the Mseilha WTW up to the hydraulic capacity of the WTW.

7.1.2 Design flows for the Mseilha WTW facilities

The Contractor's operation of the facilities shall be such that flows up to the design flows are able to be conveyed and treated to meet the Employer's requirements, including the treated water quality conditions specified in Volume 2, Section 2 of the Tender Documents.

7.1.3 Design loads for the WTW facilities

The Contractor's operation of the facilities shall be such that loads up to the design loads are able to be conveyed and treated in accordance with the Employer's Requirements, including the treated water quality conditions as specified in Volume 2, Section 2 of the Tender Documents.

7.1.4 Increases in flows and loads

If the flows or loads received in the Mseilha WTW facilities for any period, exceed the influent characteristics quoted in Volume 2, Section 2, the Contractor shall make best endeavors to continue to meet the discharge consent conditions.

In the circumstances described above, if compliance then proves to be impossible, the Contractor shall notify the Employer's Representative with recommendations and await instructions, while continuing to treat all raw water conveyed to the Mseilha WTW Facilities to the highest practicable standard.

7.1.5 Non-compliant Raw Water

During any times when Raw water fails to comply with the influent characteristics, and for reasonable period beyond these times, the Contractor shall not be penalised by any means under the Contract including reductions of payments, provided that the Contractor can demonstrate that any failure to meet its obligations under the Contract was the result of raw water flows and loads delivered by the Employer to the Mseilha WTW facilities exceeded those specified above. Where the Contractor can demonstrate such a failure has had a significant adverse impact on treatment processes the Contractor shall be entitled to its reasonable additional costs, including any costs associated with any investigations, rectification and reinstatement of treatment processes arising from such an event, valued as a Variation.

In the circumstances described above, the Contractor shall submit - not later than 24 hours from such events - a written notification to the Employer's Representative with detailed descriptions of all associated investigations, rectification and reinstatement of treatment processes arising from such an event.

In circumstances wherein the raw water characteristics are less than the average values, the Contractor's shall continue to operate and demonstrate the plant performance at the reduced loads and any investigations, modifications, rectification and associated costs required to meet the plant to meet the performance arising will not be considered as variation as the plant's detail design had to allow for such flexibility of operation as part of the Contractor's obligation of Design and Build.

7.2 General Obligations

7.2.1 Responsibilities

During the Operations and Maintenance Period, the Contractor shall have the responsibility for the operation and maintenance of the Project Facilities in accordance with the Contract.

The Contractor shall operate the Mseilha WTWs Facilities:

- so as to satisfy Performance Standards stated in Volume 2, Section 2 and other Employer's Requirements included in the Contract,
- in accordance with all applicable statutes, regulations and other legal requirements,
- to meet future consent conditions and any other licences. To the extent that such future consent conditions and any other licenses involve activities outside those specified in the Operation and Maintenance Contract, such activities shall be a Variation,
- in a manner which is not likely to be injurious to safety and health nor to cause damage to property,
- in a manner so as not to infringe any of the Employer's rights of access to or use of the Site, or access to assets on private land,

- in accordance with the quality plans, equipment manufacturer's recommendations and the insurance requirements,
- generally so as to minimise wear and tear and plant breakdown,
- so as not to place the Employer at increased risk of any claim by third parties,
- in a manner so as not to hinder the Employer in discharging its statutory duties as a local authority,
- with courtesy to members of the public.

The Contractor shall provide all labour, supervision, management, materials, consumables, equipment and all other things, whether of a temporary or permanent nature, required to satisfy these various responsibilities so far as the necessity for such provision is specified or to be inferred from the Contract. All materials and workmanship shall comply with the Operation and Maintenance Services Contract.

The works and services required under the Operation and Maintenance Services Contract shall be executed by the Contractor in strict accordance with the Contract, failing which the Contractor shall carry out all necessary remedial actions expeditiously and at the Contractor's own cost.

The Contractor shall co-operate with the Employer and the Employer's Representative in all matters connected with the provision of potable water services, also with any Separate Contractors.

During any civil defence emergency situations which may affect the Project Facilities or their surroundings, the Contractor shall co-operate with the responsible authorities and assist with relief operations. To the extent that such co-operation involves activities outside those specified in the Operation and Maintenance Contract, such activities shall be a Variation

7.2.2 Project Facilities

7.2.2.1 Inlet and Outlet Works

The Employer has the right to deliver or have delivered raw water to the Entry Points and to have the raw water conveyed, treated and discharged by the Contractor, in a manner which satisfies the Performance Standards and other requirements of the Contract.

After delivery of Raw Water to the Entry Points, the ownership rights and responsibility for conveyance, treatment and disposal of such Raw Water, and for any residuals from its treatment, vest in the Contractor.

Removal (loading and transportation) and final disposal of the excess sludge products and other waste materials will be the responsibility of the Contractor.

7.2.2.2 Care of Project Facilities

The Contractor shall take full responsibility for the care of the Project Facilities from the Operations Commencement Date until the Operations Expiry Date when the responsibility shall pass to the Employer.

Notwithstanding the Contractor's responsibilities for the Project Facilities, this Contract confers no legal or equitable interest in the Project Facilities and the Site on the Contractor. The Contractor shall

not be entitled to, and shall not attempt to, sell, lease, charge, mortgage, encumber, grant easements or otherwise deal with any of the Project Facilities or the Site.

The Contractor shall indemnify the Employer against any loss or damage to the Project Facilities which may occur during or as a result of actions taken during the Operations Period.

Except where the direct cause of loss or damage lies within the definition of Force Majeure under the Contract Documents, should any such loss or damage occur to the Project Facilities, the Contractor shall rectify the loss or damage. Such rectification shall be carried out without additional payment by the Employer unless and to the extent caused by an Employer's Risk as defined in the Contract Documents in which case it will be a Variation.

The Contractor's responsibility for care of the Project Facilities shall end on the Operations Expiry Date (or on any earlier termination of the Contract), subject to the continuation of the Contractor's obligations in relation to the condition of the Project Facilities on expiry or termination of the Contract.

7.2.2.3 Use of Project Facilities

Throughout the Operation and Maintenance Period, the Contractor has the right to use the Project Facilities for the purposes of the Operation and Maintenance Contract.

The Contractor shall not have exclusive possession of the Site or the means of access to the Site but shall have a right to unimpeded access and occupation. The Employer and the Employer's nominees (Employer's Representative, etc.) shall continue to have access to the Site, subject to complying with reasonable requirements of the Contractor in relation to safety and security.

The Contractor shall establish, operate and maintain a system in order to provide records of the Project Facilities and which meets the requirements for the all the assets. The system shall be fully operational by the Operations Commencement Date and throughout the Operations Period.

If the Contractor wishes to make use of the Project Facilities or Site for carrying out other business activities not directly connected with the Contract, such use shall be subject to the written consent of the Employer's Representative. In giving such approval, the Employer's Representative may require reasonable payment by the Contractor to the Employer for the use of any of the assets and for rental of land.

The Contractor at its own cost may modify the Project Facilities provided he has submitted written proposals and justifications for the modifications to the Employer's Representative and has received the written consent of the Employer's Representative to the proposals. All such modifications shall become part of the Project Facilities.

Where any of the Project Facilities or Site are surplus to the present and likely future requirements for the Project Facilities, the Contractor shall prepare proposals for their de-commissioning and disposal for consideration by the Employer's Representative. If disposal by the Contractor is authorised in writing by the Employer's Representative, the Contractor shall account to the Employer for the proceeds. Alternatively, the Employer may make separate arrangements for such disposal.

7.2.2.4 Facilities and Equipment

Unless otherwise specified, the Contractor shall provide the facilities and equipment required for a proper functioning of Operation and Maintenance, before starting with the Operation and Maintenance.

During the Operation and Maintenance Period, the Contractor shall make use of the following facilities and equipment provided during the works construction period:

- The WTWs,
- Any kind of infrastructure,
- Administration building and other buildings on site including offices, equipment and facilities,
- Workshop including equipment and stores,
- Laboratory including equipment and facilities,
- Mobile equipment,
- Spare parts.

The Contractor shall hand over the facilities and equipment complete and in good condition at the end of the Operation and Maintenance Period.

7.2.2.5 Access to Facility

The Employer's Representative and any person authorised by the Employer's Representative shall have access to the Project Facilities at all reasonable times for the purpose of inspection, testing, measuring and recording.

The Contractor shall provide all necessary assistance in obtaining access for these purposes.

The Employer shall have the right to bring visitors to the treatment plant. The visitors shall be received by the Employer and the Contractor shall not be in charge of such visits. Visitors shall only have access to the meeting room facilities and the special visitors circuit provided in the plant. The Employer shall give notice at least 48 hours in advance for visits.

The WTW lab shall be accessible to all Employer's chemists.

The Contractor shall provide 1 office and a conference room for use by the Employer. The office and conference room shall be accessible to all Employer's personnel

7.2.2.6 Clearance of Site

On or before the Operations Expiry Date, the Contractor shall remove all surplus plant, materials, temporary buildings and temporary works not forming part of the Project Facilities and shall leave the Site in a clean, tidy and safe condition

7.2.3 Approach to Maintenance

The Contractor's approach to maintenance management shall involve three continuous functions: routine maintenance, preventive maintenance, predictive maintenance. Corrective maintenance will be part of routine maintenance or will be required in case of breakdowns, but will be kept to minimum if the maintenance procedure and routine is diligently followed.

Routine Maintenance

A routine maintenance programme shall involve the daily walk-through inspection of all operating equipment areas. Routine maintenance is considered the first echelon. This shall be performed by any member of the operation staff, who is required to stop, look, and listen at every operating piece of equipment. The person will be inspecting the equipment for any signs of oil/water leaks, any unusual noises, and odours. The person may touch the equipment, feeling for heat or vibration. An inspection of operating information being monitored in relation to the equipment, such as pressure, flow, or the elevation controlled, can alert the operator to potential problems. This information shall be part of the routine report log. The record of minor changes to flows or pressures may also alert those reading the report to potential equipment problems.

Preventive Maintenance

A preventive maintenance programme shall involve the scheduled shutdown of equipment for maintenance servicing. Depending on the type of equipment, the maintenance service will be weekly, monthly, semi-annually, or annually. This programme shall be based on the equipment manufacturers' recommendations as well as the Contractor's own recommendations and shall use their recommendations as a minimum requirement. Those recommendations shall then be modified based on the equipment's frequency of operation, operating environment, and chemical or liquid being processed.

The preventive maintenance programme will start with a review of available operating information or report log about the equipment's past operations. The report log will indicate specific areas of equipment to be inspected during preventive maintenance. The plant operations personnel will be notified of the anticipated time the equipment will be out of service. This will allow them to make other arrangements to continue the plant's operation.

The preventive maintenance procedures should be reviewed by the staff performing the maintenance to have a clear understanding of what actions will be taken. This will also allow them to assess if the available spare parts are sufficient to complete the task. These items shall include gaskets, packing, bearings, belts, o-rings, grease, or oil, which are non-restorable and are easily damaged during maintenance procedures.

Predictive Maintenance

The predictive maintenance programme shall involve the use of infrared, ultrasound, and vibration equipment and ampere probes. Predictive maintenance shall provide base-line and continuing information for analysing the operating life of equipment. Information gathered shall be used to detect future equipment failures, schedule preventive maintenance, and budget equipment replacement.

Infrared testing shall provide temperature information on electrical motors, motor control panels, and equipment bearing. Temperature or heat shall be one of the major causes of equipment failure. Heat can be generated from an improperly lubricated bearing (dry spots), a motor starter worn contact surface, or dust collecting on a motor rotor. Equipment life shall be reduced drastically when equipment will be allowed to operate at higher than normal temperatures, which will also require above normal electrical demands on the system.

Ultrasound testing shall provide information on operating equipment high frequency noise. Increased equipment noise shall be a first indication of worn operating surfaces on rotating parts. Although

wearing shall be normal for all operating equipment, the ultrasound information will trend the rate of wear. When detected early, the worn part can be replaced before its failure leads to severe damage to major parts of the equipment.

Vibration testing, like the ultrasound, will be used to monitor the equipment's rotating parts. This shall be especially important on high speed pumps. Increases in equipment vibration can be caused by a shift of pump and motor alignment, worn or loose parts, or foreign material inside the pump. Excessive vibration will lead to bearing damage and premature wearing to other rotating parts.

The ampere probe shall be used to measure actual amperes the equipment is using to operate. The probe will be used to compare the amperes being drawn by the three phases to determine phase balancing, which will indicate the efficiency of the equipment's motor and the condition of the motor windings. It will also confirm whether the equipment is drawing too much current indicating a fault condition.

All the information gathered from the monitoring shall be down-loaded to a microprocessor that will organise the data and develop a trend graph that compares the current conditions to the expected equipment conditions. The trends will be helpful in projecting the expected life of equipment, which will be used for future plant equipment replacement budgeting. Major deviations from the expected conditions will be highlighted and future maintenance can be scheduled.

To achieve maximum equipment life and operating efficiency of the facilities, a desktop software program shall be used. Such a program will provide complete tracking of equipment maintenance including parts inventory, parts specifications and requirements, personnel skills and tools required, and maintenance scheduling. It will also generate reports and records on the activities mentioned above.

7.2.4 Legal and Financial Aspects

The Contractor shall verify and consider all legal aspects concerning staff engagement, disputes and claims with regard to the national and local conditions of law.

During Operation and Maintenance, all capital investment, costs, payrolls and taxes shall be accounted, recorded and paid by the Contractor.

The tasks of the Contractor will also include the general budgeting of Operation and Maintenance, the utilisation of proper audit functions and the administration and payment of assurances.

The Contractor shall be responsible for the payment of all electricity, water, telephone bills and other services utility costs in connection with the Operation and Maintenance of the Facilities as well as any charges for the disposal of sludge and other residuals. Reimbursable from the employer as per Contract agreement will have to be claimed in the routine invoices.

7.2.4.1 Damage

The Contractor shall be responsible for any damage to the Facilities caused by his Operation and Maintenance Services. The Contractor shall eliminate the damage without undue delay and without additional cost to the Employer.

The Contractor shall be responsible for any damage to public properties caused by his Operation and Maintenance Services. The damage shall be searched, identified and repaired on the expense of the Contractor, even if the Employer will receive the relevant invoice from the concerned parties.

7.2.4.2 Loss Prevention and Disaster Recovery

So far as the Site and the Project Facilities are under the Contractor's control, the Contractor shall keep them in an orderly state and in such condition as to avoid danger to persons and property.

Within 3 months after the Operations Commencement Date, the Contractor shall prepare and submit to the Employer a Loss Prevention and Disaster Recovery Plan in respect of the Project Facilities.

The Loss Prevention and Disaster Recovery Plan shall include:

- An analysis of all risks of loss or damage to the Project Facilities, including the occurrence of Force Majeure,
- Consideration of the options for risk mitigation and transfer, and development of a risk management plan,
- A proposal for any changes to the Project Insurances which the Contractor recommends as appropriate in the light of the risk management plan,
- A Disaster Recovery Plan for disaster relief and prompt resumption of services in the event of disaster damage to the Project Facilities,
- Reference to civil defence and any other emergency management plans that the Employer may be obliged to prepare.

The Contractor shall maintain the Loss Prevention and Disaster Recovery Plan up to date in the light of changes to the Project Facilities and other relevant circumstances.

7.2.5 Health, Safety and Security

The Contractor shall submit a Health and Safety Plan as required by local regulatory authority.

7.2.5.1 Safety

The Contractor shall provide a safety specialist being responsible for the preparation, implementation and maintenance of a comprehensive safety programme, which shall be periodically evaluated during Operation and Maintenance and be approved by the Health and Safety Personnel of the Ministry of Labour and the Employer's Representative. The specialist shall develop the safety and health policies, standards and procedures.

The responsibility of the safety specialist included performing safety training and conducting safety inspections, sessions and practice. He will also be responsible for the investigation of accidents.

A safety committee shall be formed and regular safety meetings shall be organised. The minutes of the safety meetings will be copied to the Employer's Representative.

All safety equipment and tools shall be provided and maintained by the Contractor

7.2.5.2 Fire Protection

The safety specialist shall prepare, implement and maintain a comprehensive fire protection and prevention programme, which shall be approved by the relevant Authorities and the Employer's Representative.

The safety specialist will also be responsible for the inspection and maintenance of the fixed and portable fire protection equipment and for the investigation of fire incidents.

During Operation and Maintenance, the safety specialist shall develop and implement a project emergency action plan and fire hazard inspection procedure.

7.2.5.3 Security

In order to protect property, materials and facilities against unauthorised entry and trespass, pilferage and theft, destruction, damage, sabotage, embezzlement, fraud and other dishonest, illegal or criminal acts during the Operation and Maintenance Services, a security programme shall be prepared, implemented and maintained. The Employer's representative shall approve the security programme.

7.2.5.4 Occupational Health and Safety

The Contractor will conduct his activities in an environment which protects the health, safety and welfare of all persons at the workplace and actively encourages safe work practices. To achieve a healthy, accident free working environment, the dedication and co-operation of each employee is essential. To ensure this:

- Management is committed to ensuring the health, safety and welfare of all persons in the workplace and to rectify any substandard practices or conditions.
- All employees, contractors or other persons involved with the operations of Mseilha WTW have a personal responsibility to the Employer, their fellow workers, themselves and to the general public to adopt and maintain appropriate health and safety standards in all their work activities.

To aid in the implementation of this policy, the Contractor will:

- Comply with all relevant legislative and statutory requirements, codes of practice and industry standards, making adequate provision of resources to meet these requirements.
- Implement and maintain an effective health and safety management system based on continual improvement of the Facilities performance.
- Provide information, instruction and training for employees to increase personal understanding of workplace hazards.
- Involve employees on health and safety matters, consult with them in ways to reduce workplace hazards and improve control systems.
- Set short and long term objectives in health and safety management as part of an ongoing action plan and regularly review its performance and that of its personnel, against the objectives of this policy.

No task is so important as to compromise health and safety.

7.2.6 Contractor's Employees

The Contractor shall be responsible for the operation and maintenance of the facilities (works).

The Contractor shall carry out an assessment of his staff requirements and skill set required for O & M.

The Operations Manager will have a minimum experience of five years as Manager of the Operation and Maintenance of similar works and will be responsible for:

- Recruiting staff for the operations of the Project Facilities during the Operations Period
- Operational input into the operation of the Facilities
- Input into start up and commissioning of the new extension works

The Contractor shall engage the employees who are required for carrying out of obligations under the Operation and Maintenance Contract, ensuring the availability of sufficient numbers with the required skills.

The Contractor shall ensure that employees hold the necessary qualifications and permits and are adequately trained and competent to carry out their required duties. The selected staff shall be physically and mentally competent to perform the work required of them and shall possess the necessary ability for specific assigned tasks. Any staff not having the requisite qualifications and abilities shall be substituted, at the cost of the Contractor, within one month after requested by the Employer's Representative.

The Contractor shall at its own cost remove from the provision of works and services under the Contract any person employed by the Contractor or any sub-contractor who is incompetent or negligent in the performance of their duties or who misconducts himself.

The Contractor shall be responsible for industrial relations in relation to its employees, shall carry the cost of any industrial disputes and pay all levies and taxes. The Contractor shall be responsible for complying with the requirements of Laws of the Lebanon, for achieving and maintaining good industrial relations, for establishing and maintaining good order and good conduct among its and its subcontractor's employees associated with the Contract, for directing and controlling all such persons and for taking appropriate corrective action where necessary. The Contractor shall implement such management practices as will minimise the potential for industrial conflict during the Operations Period.

The Contractor shall provide proper round the clock attendance and especially day-and-night availability -if needed- of the key personnel. All absence of key personnel on leave shall be compensated by temporary replacement with adequate staff members. Contractor shall have at least a single person to watch the overall operation of the system in the control room and look after any trespassers after regular working hours.

The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for his labour staff.

The Contractor shall keep the Employer's Representative fully informed of all claims made or other industrial relations matters which may affect the Contractor or the Sites and shall take all reasonable steps to avoid actions or inactions which may prejudice the position of the Employer.

The Contractor shall be responsible for any costs or losses which it may incur as a result of industrial disputes which involve its or its Sub-contractors' workforce or which occur off the Sites and interrupt delivery of supplies.

7.2.6.1 Training

The Contractor shall provide or procure training for its own employees in relation to duties required to be performed by them in relation to the Operation and Maintenance Contract.

Where instructed by the Employer's Representative, the Contractor shall also involve members of the Employer's staff in such training at intervals, so that should it be necessary for the Employer to take over the Project Facilities at short notice this can be achieved with minimal inconvenience.

The Contractor shall maintain records of all training undertaken during the Operations Period.

7.2.6.2 Staff Organisation

The work programme, organisation chart, number of manpower and job descriptions of all staff necessary for O & M as submitted by the Contractor with his Tender will form the basis for the organisation of the services. It may, however be amended by the Contractor to meet the requirements of these services to the approval of the Employer's Representative. Additionally, CV's shall be submitted of the proposed professional staff.

To this regard, 12 months after the start of the Contract for the construction of Mseilha WTW, the Contractor shall submit to the Employer's Representative, for approval, a fully detailed work programme for Operation and Maintenance of the Works. This shall include an organisation chart with number and job descriptions and qualifications for each grade of staff up to and including the Operations Manager.

In order to accomplish the approved work programme, the Contractor shall provide all expertise, staffing and labour being necessary for a continuous efficient performance of O & M. The operation activities shall be programmed and operated accordingly in close co-operation with the Employer's Representative and, if present, with other Contractors.

Staff and labour input may include, but not be limited to, the following indicative categories:

- Operations manager,
- Qualified engineers and experts,
- Qualified technicians,
- Clerical staff,
- Semi-skilled labour,
- Unskilled labour,
- Security personnel,
- Drivers (3 Nos.),
- Laboratory Technician.

7.2.7 Information and Reporting

The Contractor shall monitor compliance with consent conditions and other performance obligations under the Operation and Maintenance Contract and maintain sufficient records of tests and other data to demonstrate this compliance.

The Contractor shall supply the Employer's Representative with information and reports as required to demonstrate compliance, and shall permit the Employer's Representative to have access to and to take copies of any such records, and to audit them.

The Contractor shall prepare and submit reports on compliance as required.

The Contractor shall submit monthly and annual reports including any important details concerning performance, staffing, training and Operation and Maintenance of the Works. After approval by the Employer's Representative, the reports shall be used as a guide for regulation, adjustment and modification of the plant facilities. The reports shall continuously record and demonstrate the performance of staffing, training and Operation and Maintenance. The number of copies of each monthly report shall be three (3), the number of the annual reports shall be six (6). The contents and layout of the reports and other general requirements shall be discussed and agreed with the Employer's Representative and the Engineer after the signing of the contract and before the start of the OMT period, and arranged to their satisfaction.

The shift leaders in charge of operation shall prepare a daily machine journal. The journal shall be a record of all the reading of flow rates, counter readings, pressure values, temperatures, odors etc. for all facilities and equipment of the treatment plant. A file shall be maintained on site for storage of hardcopies from supervisory control panel printouts showing the listed parameters. In addition, all characteristic operation data of any major item of the treatment plant and all remarks and comments of the shift leaders concerning abnormal reading, overloads, stoppage, outages and other operation events shall be recorded in electronic format.

Monthly laboratory reports shall be prepared presenting the results of the records of laboratory tests and continuous quality control measurements.

The monthly reports shall be prepared including, but not being limited to:

- Monthly influent flow rate curves and tables showing daily maximum, average and minimum inflow values,
- Quantities of sludge and other residuals and records of delivery to disposal site,
- Laboratory average daily, weekly and monthly results tabulated with maximum, average and minimum values,
- Diagrams showing the performance of the Works,
- Calculation of monthly penalties for non-compliance with the attainable criteria for the set parameters,
- Daily consumption figures of electricity and chemicals,
- Service hours of main machinery and equipment,

- Times, duration, reason and remedying of emergency operation and outages,
- Other data requested or events of significant importance,
- Statistics of staff members and labor utilization,
- Information on major equipment repair, overhaul and other maintenance works,
- Spare parts used and mobile equipment,
- Health and Safety issues,
- Monthly expenditures.

Annual reports shall be prepared including, but not be limited to:

- Monthly average influent flow rates with maximum and minimum values and annual value,
- Monthly and annual quantities of sludge and other residuals and record of delivery to disposal site,
- Monthly average quality of influent, primary, and secondary treatment effluent, sludge with maximum and minimum values as well as other data as temperatures, etc.,
- Summary of monthly penalties for non-compliance with the attainable criteria for treated water quality etc.,
- Monthly and annual electricity and chemical consumption figures,
- Service hours of main machinery and equipment,
- Monthly and annual staff and labor utilization,
- Times, duration, reason and remedying of emergency operation and outages,
- Information on major equipment repair, overhaul and other maintenance works,
- Spare parts used and a list of remaining spare parts,
- Monthly and annual expenditures.

7.3 Performance Guarantees

Specific guarantees with respect to the capability of the plant to produce treated water to the required standards are required from the Contractor as part of his Tender and this Contract. The required performance guarantee during the O & M period is given under the appendix to volume 1.

7.4 Operational Obligations

The Contractor shall entrust adequately experienced key staff with the responsibility of operating the WTW. The key staff shall plan, establish and administer the organization of the operation of the plant.

The Contractor's employee force will organise and implement an operating system for the Works in order to manage the project's operation efficiently and effectively. Some examples of the operating systems that shall be developed by the Contractor staff for operating the facility are described below:

- Development of a written Process Control Strategy for the Works.
- Develop a written sludge handling plan which shall include implementation of a log book for the handling of the sludge within the Mseilha WTW area.
- Developing a Process Training Plan and Schedule with and for the employees.
- Development of Logs and Log Entry Procedures.
- Develop an Operations Data Format on selected software. Likely software will be Microsoft Word/ Microsoft Excel and / or other specialised operations software (e.g. All Max Operator 10, etc.).
- Developing a sample location and analysis spreadsheets including a written plan for sampling. All sample locations shall be clearly marked in the works Facilities.
- Development of a chemical and energy management plan.
- Implementation of a maintenance system for entry of written work orders and monthly reporting. The maintenance system will specify predictive maintenance as well as update corrective maintenance performed.
- Development of a inventory control system for tools, parts, manuals, plans etc.
- Recommend priority purchase of critical spare parts that have immediate impact on the operation and safety of the Mseilha WTW facilities operation.
- Development of a written Security Plan.
- Prepare Standard Operating Procedures for all Unit Processes including a schedule for updating of the Standard Operating Procedures.
- Unit Process Control Procedures.
- A written Emergency and Incident Response Plan including a Disaster Preparedness Section.
- Development of standard reports to the Employer.

Operator attendance is anticipated during normal working hours Monday to Saturday with minimal attendance over weekends and public holidays. Supervisors and management will be available on call-out should the duty operator need to contact them. Likewise, off duty operators will be rostered to be available for call-outs.

Supervisors who are on on-call duty will be able to remotely monitor the treatment facilities SCADA system.

The level of staffing required for this project may be derived by a detailing of each unit process and the operation and maintenance tasks involved. From a time analysis of these tasks and their frequency, the number of employees required can be determined.

The skills and capabilities of the O&M staff will enable them to be readily able to assist for the WTW.

The Plant operator will have clear vision of key equipment and the liquid stream tanks as well as the Mseilha WTWs perimeter for security purposes from the control room. The SCADA control system will provide real time information on the treatment process as well as the operating performance of the electrical and mechanical equipment for the facilities. The alarm and paging system will also alert the duty operator and/or their supervisor of any problems encountered with the facilities operation

7.4.1 Outline Operation and Maintenance Manual

The guidance outline of operations and maintenance manual will cover all Mseilha WTW facilities as presented in the following table which is presented as an example.

The O&M Manual will include an appendix with all suppliers equipment manuals (original).

Each section of the Equipment Operating Procedures noted below shall include the following:

- Location
- Motor Control Centre
- Controls
- Safety
- Start-up
- Shutdown
- Abnormal
- Troubleshooting
 - Problem
 - Probable Cause
 - Action

Mseilha WTW O&M Manual Sample Table of Contents

General Information	O&M Users Guide Plant Design Summary Plant Flow Schematic Plant Hydraulic Profile Solids (Mass) Balance Staff Responsibilities Figures
----------------------------	--

Preliminary Treatment	<p>Overview Design Criteria Component List Process Control System Operating Procedures Flow control & measurement Flash mixing clariffoculation Sludge transfer Figures</p>
Secondary Treatment	<p>Overview Design Criteria Component List Process Control System Operating Procedures Equipment Operating Procedures Sand filter Clean wash water pumps Flow monitor Figures</p>
Treated Water	<p>Overview Design Criteria Component List Process Control System Operating Procedures Equipment Operating Procedures Disinfection System Flow Metering Figures</p>
Chemical Dosing Storage & Systems	<p>Overview Design Criteria Component List Process Control System Operating Procedures Equipment Operating Procedures Coagulant storage & dosing system Polymer & dosing system Dilution water system</p>

Auxiliary Systems	Emergency Power Potable Water Process Water and Fire fighting and Reclaimed Treated Effluent System Plant Utilities Electrical Systems HVAC Hoists Fire Suppression Plant Drains Control System CCTV System Return Liquors (supernatant) System Buildings Laboratory Vehicles
Appendix	Suppliers Equipment Manuals

7.4.2 Provision of Electricity, Chemicals, Vehicles and Spare Parts

During the entire Operation and Maintenance Period, the Contractor shall provide the necessary supplies of electricity, potable water, chemicals, lubricants, fuel and consumables sufficient to continuously operate the Facilities.

Lubricants shall be supplied in accordance with the recommendations of the various equipment and plant manufacturers.

The Contractor shall limit the various types of lubricants by consolidating these, with the manufacturer's approval, into the least number.

The Contractor shall provide the Employer's Representative with three (3) copies of a list showing the proper lubricants (after consolidation) for each item of equipment and Plant with a schedule giving the estimated frequency and quantity of lubrication required. This will not relieve the Contractor from supplying this information within the Operation and Maintenance Manuals as well.

At the end of the Operation and Maintenance Period, the Contractor shall provide adequate supplies of chemicals, lubricants, fuel and consumables sufficient to continuously operate the Facilities. Such supplies shall cover one (1) month supply of locally available materials and three (3) months' supply of materials not locally available.

Provision of Tools and Appliances

The Contractor shall make use of the tools and appliances supplied under the Contract pursuant to the Employer's Requirements. In addition, the Contractor shall provide two complete sets of such tools and appliances not supplied before, but found to be necessary for proper Operation and Maintenance of the Works.

At the end of the Operation and Maintenance Period, the Contractor shall hand over to the Employer two complete sets of all tools and appliances. The Contractor shall replace tools and appliances which are not in a serviceable condition or which have been lost.

Provision of Spares

The Contractor shall make use of the spare parts supplied under the Contract pursuant to the Employer's Requirements. In addition, the Contractor shall provide at his own expense such spare parts not supplied before, but found to be necessary for proper Operation and Maintenance of the Works.

At the end of the Operation and Maintenance Period, the Contractor on request by the Employer shall hand over to him adequate supplies of spare parts sufficient to operate and maintain the Works for a further period of five years at a cost to be agreed by both parties. The requirement for such spare parts will be based on a comparison of spare parts used during the actual Operation and Maintenance Period carried out by the Contractor and on the manufactures' written confirmation of recommended spare parts, and will have to be agreed with and approved by the Employers' Representative.

7.4.3 Penalties for Non-Compliance

The Contractor shall be responsible for taking whatever steps are necessary to satisfy the Performance Standards conditions stated in Volume 2, Section 6 and other Employer's Requirements included in the Contract, during the Operation of the Works.

The Contractor shall carry out the composite and continuous sampling and testing as necessary to fully control and monitor the performance of the WTW.

Penalties for non-compliance with regard to Performance standards will apply if more than 2 consecutive samples exceed the Performance Standards conditions by up to 10% or if any sample exceeds the attainable criteria by more than 10%.

7.4.4 Emergency Conditions

The Contractor shall establish requirements for dealing with potential hazardous conditions. All possible situations of emergency shall be scheduled within an emergency plan. Herein, the required services, additional required structures, equipment, staff and other resources shall be planned and recorded for the possible situation of emergency. The emergency action plan shall be submitted for approval to the Employer's Representative within ten (10) months from the start of the contract of the construction of Mseilha WTWs.

Every effort shall be made to ensure that any emergency situation at the treatment shall be limited to the shortest possible period to minimize any negative effects on the environment.

Any necessary shutdown of the plant for operational adjustments shall be restricted to the possibly shortest period with minimum flow at the inlet works and shall be approved by the Employer's Representative

If by reason of any accident or failure or other event occurring to or in connection with the operation of the Project Facilities or the construction of New Facilities and if the Contractor's Representative cannot be contacted or is unwilling or is unable to act in time, the Employer's Representative may take such emergency action as the Employer's Representative considers necessary. The Contractor shall be entitled to resume control of the operations or actions as soon as the Contractor is able to do so.

If the emergency action involves work which the Contractor is liable to do under the Contract, the additional cost to the Employer of such action shall be recoverable from the Contractor by the Employer.

The taking of such emergency action by the Employer's Representative shall not relieve the Contractor of any obligations under the Contract.

7.4.5 Suspension

The Employer's Representative may at any time instruct the Contractor to suspend the carrying out of part or all of the works and services under the O&M Contract related to the operation and maintenance of all or a portion of the Mseilha WTWs.

During such a suspension, the Contractor shall protect and secure all parts of the Project Facilities which are affected against deterioration or damage.

Unless the suspension is due to default on the part of the Contractor or is necessitated by a circumstance for which the Contractor is contractually responsible, the suspension shall be a Variation.

If the suspension remains in force for more than 3 months, the Contractor shall be entitled to treat the suspension as a Variation deleting the uncompleted portion of the suspended services for that period from the O&M Contract.

7.4.6 Notices under the Contract

Any notice or other document which is to be served upon the Employer, the Contractor or the Employer's Representative under the Contract as a notice shall be sufficiently served if it is handed to it or to its appointed representative, or delivered to its address as stated in the Contract or subsequently advised in writing. Except where the Contract otherwise provides, all notices to the Employer shall be sufficiently given if it is given to the Employer's Representative.

Except where the Contract otherwise provides, all notices and directions to the Contractor from the Employer necessary for the administration of the Contract shall be given only through the Employer's Representative.

Proof that a document has been sent by prepaid post in a correctly addressed envelope shall be prima facie evidence of delivery in the normal course of post.

A copy of any notice by the Employer to the Contractor, or by the Contractor to the Employer shall at the time of issue also be delivered to the Employer's Representative.

Any communications which are sent by fax or electronically shall be regarded as advance notification only and shall be supplemented by mail or personal delivery, unless the receiving Party has previously agreed in writing to accept fax or electronic transmission alone for communications under the Contract.

7.4.7 Confidentiality, Public Relations and Publicity

Except as required in the performance of the works and services under the Contract, the Contractor shall not without the Employer's prior consent in writing:

- disclose to any third party any of the documents, drawings, data or other records placed at the Contractor's disposal by the Employer or the Employer's Representative,
- use on behalf of a third party or disclose to a third party the documents, drawings, data or other records which it has prepared in connection with the Contract, in so far as the documents, drawings, data or other data contain information placed at the Contractor's disposal by the Employer or the Employer's Representative,
- release any information, including press and publicity releases, to any third party with respect to or pertaining to the Contract.

The above obligations shall continue for a period of 3 years after the expiry or any earlier termination of this contract.

Various statutory or regulatory requirements may require the Parties to disclose information relating to the Contract. Notwithstanding this, any request made to the Contractor by a third party for information relating to the Contract, or any enquiries for information or materials made by a third party (including any request from Local or Government Organizations shall be immediately referred to the Employer's Representative for instructions prior to disclosure of such information or materials.

The Contractor shall co-operate with the Employer in maintaining a liaison with local communities.

7.4.8 Copyright and Intellectual Property Rights

Copyright and other intellectual property rights in the Employer's Requirements and other documents issued by the Employer to the Contractor shall (as between the parties) remain the confidential property of the Employer. The Contractor may copy, use and communicate any such documents for the purposes of the Contract only.

All designs, documents, data and any other information including intellectual property of any kind which is produced by the Contractor and which relates to services required under the Contract shall become the property of the Employer and the Employer shall have the exclusive right to use that property. At the request of the Employer, copies of all such information shall be delivered to the Employer.

Nothing in this clause however shall operate so as to vest any copyright or other intellectual property right in the Employer in relation to proprietary or non-project specific information submitted by the Contractor to the Employer or the Employer's Representative. The Contractor shall ensure that the Employer has an irrevocable license to use such proprietary or non-project specific information.

The Contractor shall obtain any necessary permission from affected persons to use intellectual property which may be required in order to perform the services required under the Contract. Such permission shall include any necessary licenses and approvals.

The Contractor shall indemnify the Employer against any action, claim or costs arising from any infringement of copyright or other intellectual property rights in respect of any design, method, information or article not supplied to the Contractor by the Employer or the Employer's Representative or any failure to obtain necessary licenses or approvals. The indemnity shall not apply where the Employer is aware of the infringement and does not notify the Contractor.

7.5 Maintenance obligations

Administrative maintenance policies shall be prepared and implemented by the Contractor, based on the developed maintenance program.

A basic maintenance management system shall be implemented upon the Employer's approval. It shall include, but not be limited to:

- Planning and scheduling,
- Maintenance personnel,
- Maintenance instructions,
- Inventory control of items,
- Equipment records,
- Forms for costs and budgets.

The Contractor shall periodically carry out maintenance. It shall include, but not be limited to the provision of all required spare parts, materials and personnel.

All items of equipment shall be inspected and maintained in accordance with the manufacturer's specification and to the local conditions. Replacements, repairs and painting shall be carried out immediately and when necessary. Maintenance records showing all maintenance work carried out on each item of equipment shall be updated daily and shall be made available at any time for examination by the Employer's Representative. The installed equipment shall be checked and serviced daily.

The operating conditions of any instrument shall be maintained by function checks and services. Calibration shall be checked and corrected whenever necessary. After submission of the calibration data for approval, the instruments shall be calibrated as required and directed by the Employer's Representative.

Water retaining structures shall be cleaned regularly and free from all clinging matter, which should be disposed at approved sites. Maintenance services shall include, but not be limited to the repair of surfaces and cracks, correction and/or repair of irregularities and defects at construction and expansion joints, corrective measures ensuring the water tightness and painting.

The buildings, HVAC, electrical and sanitary installations shall be kept clean and continuously maintained in a proper and orderly manner. All interior and exterior structures, structural elements, equipment, installations, infrastructural elements and other shall be maintained, repaired, painted and replaced if necessary and/or as directed by the Employer's Representative. The maintenance of site works shall include, but not be limited to the repair, painting and the replacement of defective items for traffic areas, pipes and fittings (including protection), cables, channels, roads, lighting poles and fences and shall also include the maintenance of lawn areas, plants, shrubs, bushes and trees.

7.5.1 Management

The management of maintenance shall include, but not be limited to:

- Implementation and operation of a separate maintenance budget system comparing the budget with the general budget of Operation and Maintenance,
- Planning and controlling the work of subcontractors.
- Establishing of requirements for equipment manuals, for each item of equipment,

Setting out procedures for installation and commissioning of new equipment, instructions for Operation and Maintenance and listing of component part.

7.5.2 Planning and Scheduling

The performance of maintenance shall be administered using a maintenance work package system in which the job priorities, the work assignment and the available personnel are listed. The required daily work shall be scheduled in charts by the hour or more detailed.

The maintenance work package system shall consider the manufacturers' maintenance manuals and also conditions like topography, climate and operation of the wastewater treatment plant.

The maintenance work package system shall include a chart for periodic maintenance of any equipment and Plant on Site. The chart of every equipment and Plant shall indicate any necessary step of preventive maintenance.

The maintenance work package system shall be submitted to the Employer for approval.

7.5.3 Maintenance Personnel

Only authorized, skilled and trained personnel shall be assigned to perform inspections, repairs and preventive maintenance tasks. Specific skills are required for the maintenance of mechanical, electrical and instrumentation machinery and equipment.

7.5.4 Maintenance Instructions

At an agreed central location, all manufacturers' maintenance manuals and other information shall be filed for each item of equipment.

The recorded data shall be well organized and documented together with the relevant general arrangement drawing in order to enable ready availability.

A manual describing the preventive maintenance of the equipment and Plant shall be prepared by the Contractor and approved by the Employer.

All the information mentioned above shall be available to the maintenance staff.

7.5.5 Inventory Control of Items

A central storeroom for spare parts, equipment and supplies shall be maintained. All parts shall be assigned with item identification codes, each of them possibly being an extension of the design and construction documents.

An appropriate system shall be implemented using the item identification code to record all necessary information of any item, to place the items in the storeroom and to re-order the items in case of requirement. This system shall keep a record of the quantity of each item remaining in stock, shall allow a direct comparison with the recommended stock level, as well as shall indicate the replacement lead-time.

7.5.6 Equipment Records

The performance and the future requirements of maintenance shall be recorded daily and updated in the equipment records. All maintenance of equipment, identification of occurred problems and action taken to avoid failure shall be recorded. The records shall be made available at any time for examination by the Employer's Representative.

7.5.7 Work Control and Outage Planning

Work control shall be established by preparing and implementing procedures of corrective and protective maintenance, of tool control and of spare parts issues.

Outages of maintenance shall be bridged or repaired as soon as possible so as to minimize negative effects on the environment. Therefore, the Contractor shall use a standard procedure like the critical plan method (CPM) to sufficiently schedule for maintenance outages.

Resource planning shall be carried out in order to find out the requirements for special materials, special tools and/or special equipment for bridging or repairing any outage as soon as possible.

7.5.7.1 Notice of Inspections/Maintenance

The Operator shall give 30 days written notice to the Employer of all planned inspection, calibration, maintenance and repair work which will;

- necessitate a turndown in the capacity of the WTWs or infrastructure pumping stations to receive, treat or pump flows,
- adversely impact on the quality of the treated potable water,
- restrict the transfer of treated potable water to conveyance tunnel, or
- is likely to create public complaints or a nuisance including excessive vehicle movements, noise or odors

7.6 Ownership of Raw Water, Treated Potable Water and Products

For the avoidance of doubt, between the Employer and the Operator, the Employer owns the raw water, the treated potable, and all waste and by products derived there from. The Operator receives, treats, stores and transfer the treated water and products as appropriate on behalf of the Employer.

Disposal of Sludge and Residuals

The disposal of any sludge, debris and residuals removed from the raw water or generated at the treatment plant shall be the responsibility of the Contractor. The Contractor shall process and dispose of residuals without damage to the environment and in accordance with local laws and regulations. Toxic wastes shall be disposed off by the Contractor at a site to be agreed with the concerned authorities.

Unless a public sanitary landfill site can be used for the disposal non-toxic residuals, the disposal site has to be approved by the public health and/or other concerned authorities.

All costs in connection with the disposal of residuals and transportation of dewatered sludge shall be borne by the Contractor.

The removal (loading and transport) and disposal of dewatered sludge will be the responsibility of the Contractor.

7.7 Insurances

During the Operation Period, the Operator shall effect the following insurances:

- **All Risks Insurance:** of all building, machinery, stock fixtures, fittings and all other property forming part of the WTW and associated infrastructure on an all risks basis against damage resulting from fire, lightning, explosion, storm, wind, tempest, flood, hurricane, water damage, riot, strikes, malicious damage, earthquake, and/or collapse.
- **Machinery Breakdown:** of all machinery, plant and ancillary equipment forming part of the WTW and associated infrastructure against sudden and unforeseen physical loss or damage resulting from mechanical and electrical breakdown, electrical short circuits, vibration, misalignment, excessive current or voltage, abnormal stresses, centrifugal forces, failure of protective or regulating devices, overheating, entry of foreign bodies, impact, collision and other similar causes.

During the Operation Period the Operator shall effect any other insurances required by statute or which he deems necessary including but not limited to the following:

- **Commercial/General Liability:** insurance against legal liability to third parties for bodily injury or damage to or loss of third party property arising out of the operation and maintenance of the WTW and associated infrastructure.
- **Workers Compensation and Employers Liability:** insurance for workers' compensation, temporary disability and other similar insurance required by applicable statutory requirements and additionally include a voluntary compensation and employers' liability endorsement for employees not subject to applicable statutory requirements.

7.8 Staffing

7.8.1 Staffing Levels

The Contractor/ Operator shall ensure that a suitable person is employed full-time at the WTW as the operations manager from the start of the Operations Period.

The Operator will also employ appropriate numbers of the staff for civil, electrical and mechanical works operation and maintenance together with required administrative work.

The Operator may employ independent contractors to provide other associated services e.g. security, secretarial and gardening.

Training

The Operator shall ensure that his operations staff is suitably qualified, skilled and experienced to carry out their duties. Engineers, fitters, technicians and operators shall be trained on the appropriate aspects of the Plant and treatment processes to ensure that they possess sufficient knowledge and skills as are necessary for the proper, safe and efficient operations, maintenance and testing of the WTW and associated infrastructure.

7.9 Building and General Maintenance

The Operator shall maintain all buildings, grounds, gardens, landscaped areas and structures, including, but not limited to, tanks, basins, reservoirs, kiosks, roads, footpaths, masts, fences, walls, gates, pipelines, cable ducts, drains, manholes and chambers

7.10 Inspection and Maintenance Plant

7.10.1 Policy

The Operator shall establish a policy for the inspection and preventative maintenance of all mechanical and electrical plant. The policy will set out the standard(s) of service to be provided for the various types of equipment, and will include for the comprehensive scheduling and recording of the work in a systematic and controlled manner.

7.10.2 Inspection and Maintenance Procedures

The Operator's policy shall be implemented by controlled procedures. These documents will assess the maintenance priorities of units and in particular identify key or critical equipment. The procedures will record, but not be limited to, the level of service allocated to each Plant, taking account of the supplier's or manufacturer's recommendations (and other information contained in the Manuals) and control the stocks of spares to be held on Site. The initial frequencies of inspection and maintenance described in the procedure may be varied in the light of actual operational experience.

7.10.3 Calibrations

The Operator shall ensure that all measuring, monitoring and control equipment, e.g. analysers, flow meters, and weighbridges etc., are regularly calibrated.

7.10.4 Records

The Operator shall keep records of the schedules of inspection and maintenance work, inspection reports, and history cards (to record the actual work, adjustments, repairs, and replacements etc. carried out) to provide for regular analysis of the data. From this analysis, trends may be identified to vary the inspection and maintenance frequencies and implementing corrective action if necessary.

If so instructed, the Operator shall make these records available for audit by the Employer and shall comply with all reasonable requests to assist with such audits.

7.11 Sampling and Monitoring Programme

The Operator shall establish a monitoring, sampling and analysis program for the parameters and at the frequencies as specified under Volume 2, Section 6. The program, testing procedures and protocols, and apparatus shall be documented in a controlled sampling manual.

All measurement instruments shall be checked and rated once a year, in the presence of the Employer's Representative and a rating certificate will be provided according to manufacturer's instructions. Flow meters at the inlet and outlet of the WTW should be calibrated by independent qualified and accredited Authority.

Continuous discharge measurements, with graphic recording, shall be performed at the following points:

- At the plant inlet works: metering of raw water inflow.
- Metering of treated potable water prior to transfer to tunnel.
- Overflow / By-pass, if any.
- Return wastewater from the internal network (sludge supernatant, centrifuge centrate & wash water).
- Metering of chemical consumption.
- Sludge discharge.

7.11.1 Independent Sampling and Analysis

Besides sampling, and analysis carried out at WTW whether with help of on-line analysers or in the WTW laboratory, the Operator shall engage the services of a laboratory (or laboratories) to take samples and carry out independent analyses. Analyses of various parameters, given under Table 2-2.1 of Volume 2 Section 2, shall be carried out by an independent accredited laboratory at least six times per year in order to validate the results and methods used. The cost of these independent tests will be borne by the Contractor. The results of the independent laboratory (or laboratories) shall be copied directly to the Employer. The Operator shall maintain a statistical and historical record of all results from on-line instruments and external analysis.

The laboratory at the Mseilha WTWs shall be equipped and manned by the Contractor, to undertake the necessary chemical, physical and microbiological tests required for the performance monitoring of the Mseilha WTWs. The Contractor will supply all the new laboratory equipment needed to undertake the necessary chemical, physical and microbiological tests required for the performance monitoring of the Mseilha WTWs.

The performance monitoring tests will be conducted in the laboratory by the Contractor. The test results will be used by the Contractor for the daily operation of the plant. The test results will be shared with the Contractor through a common database that will be provided and implemented by the

Contractor. The Employer's Representative or any other specifically appointed person by the Employer shall have unrestricted access to the laboratory and the test results database.

The monitoring of the treated water quality will be carried out by the Contractor, with the staff of the Contractor and at the cost of the Contractor. Twenty – four hour flow/time – proportional composite samples will be collected each day on raw water at the inlet and on treated water after chlorine contact tank.

7.12 Training Of Employer's Staff

During the last year of the Operation Period, or earlier if required by Employer, the Operator shall implement a comprehensive training program for the Employer's operation and maintenance staff. The program will cover detailed procedures for Facility start-up and shut-down together with process adjustments and flow control. The program will also cover planned maintenance, routine servicing, and actual fault finding exercises covering mechanical, electrical and both hardware and software aspects of the WTW and associated infrastructure. The course shall also include equipment removal, disassembly, replacement and assembly techniques. The program methods and techniques will include classrooms lectures, hands-on demonstrations and on the job training.

The Contractor will be required to provide practical instructions to the Employer's staff during this period to ensure that by the end of this period the staff will be considered by the Employer's Representative to be capable of managing, operating and maintaining the Works to the highest internationally accepted standards without additional supervision.

Training shall be based on all the procedures detailed in the Operation, Maintenance and Safety manuals including, but not limited to managing, operating, controlling and performance monitoring of the treatment process, data filing and processing, reporting, assembly, dismantling and maintenance of equipment and Plant as well as fault finding, without affecting the normal Operation and Maintenance. Particular emphasis shall be laid on safety precautions during Operation and Maintenance.

The training shall in general consist of familiarization with the operational aspects of the systems as a whole, followed by familiarization with specific items of equipment.

The training shall be based on the actual plant and the implementation of operation and maintenance schedules outline in operation and maintenance manuals provided by the Contractor.

The training shall also be directed towards the specific requirements of the trainee, as the instruction and familiarization of the various personnel involved will vary with respect to their operational capacity, as the personnel will require different aspects to be emphasized.

All training shall be successfully completed and demonstrated before termination of Operation and Maintenance period can take place. If in respect of progress of works and the daily operation of the plant and systems, it is required that any systems or equipment has to be put into use by the Employer before Taking Over, it is the Contractor's responsibility that all necessary instructions and training have been given to the Employer's personnel, for full understanding of the technology and operation, prior to commencement of the Employer's utilization of such systems or equipment.

The Contractor shall employ a separate representative for the training procedure. This representative shall have an adequate knowledge of the Arabic and of the English language. The Contractor shall

make available to him all procedural documents produced in accordance with the Employer's Requirements.

The representative and the trainees shall be allowed the unhindered access at any time to any part of the Facilities.

The liability for the entire Works during training remains with the Contractor, independently of who may be responsible for any fault or damage.

The Employer will cover all costs in connection with wages and expenses of the Employer's personnel assigned for training and instruction.

The total allowance to cover the Contractor's expenses in connection with training shall be included in the tender.

7.12.1 Execution of Training

To ensure that adequate training is given, the training personnel from the Contractor shall carry out each and every Operation and Maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the Employer's personnel to carry out these activities even if they are not required during the actual operation of the Works.

The Contractor shall pay particular attention to safety training for all assigned personnel. Safety training shall not be limited to personal safety, but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall provide all necessary facilities for training including didactic equipment, simulators video, slide and overhead projection equipment. All training equipment shall become the property of the Employer at the end of the Training Period.

7.12.2 Technical Content

7.12.2.1 Training for Operation of the Water Treatment Works

The Contractor's training shall include:

- 1 week of theoretical training and
- 1 week of on-site training

for a number of operators (at least six) selected by the Employer. It is anticipated that the number of operators to be trained will include process, mechanical and electrical staff.

In addition to the above the Contractor's training shall include:

- a short briefing (4hours) every month,
- 2 day training every year, and
- two days of theoretical training and two days of on-site training before the Operation, Maintenance and Training period.

The on-site training shall take place at the WTW

7.12.2.2 Training on the SCADA System

The Contractor's training shall include 2 weeks of theoretical training and 2 weeks of on-site training for a number of operators selected by the Employer.

The Contractor shall provide for the number of attendees as specified herein – above.

This purpose – designed course is to be held at the site. Training must be provided to:

- Enable the Employer's user staff to participate in the full process commissioning of the system,
- Optimal operation of the Plant, including both sewage and sludge lines,
- Safety operate the plant and maintain the SCADA system.

The course shall be designed to familiarize the participants with the general running of the standard operating system and the SCADA package to include but not be limited to:

- Loading and starting up the Operating System,
- System Operators interface,
- Operator control of program/task execution,
- Operator control of disk files,
- File transfer tasks – archiving, retrieval,
- Operator response to system failure, on-line/off – line diagnostics, transfer of control between the computers synchronization of the system database,
- SCADA system interrogation facilities – alarm lists, log printouts select mimic and trend display etc.,
- Alarm acknowledge accept/delete,
- Control actions, e.g. start pump, close valve,
- All functions associated with each access level of the SCADA system.

The Contractor shall provide a five-day course for the number of attendees as specified herein - above.

To be held at the Works Control Centre prior to the systems hand-over and shall consist of all of the above tasks plus:

- Basic systems design overview,
- The use of computers to perform diagnostics and to tune other parts of the system,
- Changing passwords and access control,
- Sequence verification,

- Preventive maintenance.

The Contractor shall provide 1 No. five day course with the number of attendees as specified here above.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

- The system database structure,
- System database building-configuration,
- Mimic building,
- Applications program interface to the system database,
- Management information system interface,
- Downtime loading of control programs/sequences to PLCs,
- Advanced operating features.

7.12.3 Contractor's Personnel

The Contractor shall provide training personnel for each of the positions required for management, Operation and Maintenance as identified in the training program. All Instructors shall be qualified personnel with at least 15 years of experience in their training field. Their CVs will be submitted to the agreement of the Employer Representative in the Training Program.

The duties of each of the training personnel shall be to manage, operate and maintain that element or those elements of the Works appropriate to his position, and to train the Employer's assigned staff members for that particular position. The emphasis shall be on "hands-on" training.

In addition to his normal training personnel, the Contractor shall also provide specialist trainers who shall be responsible for formal classroom, laboratory or workshop training.

7.12.4 Training Test Period

The last 30 (thirty) days of the Training Period shall be considered as the Training Test Period. During this period, the Facilities are to be entirely managed, operated and maintained by the Employer's assigned personnel. The Contractor shall remain, nevertheless, fully responsible for the successful Operation and Maintenance and his training personnel shall remain on site to act in an advisory capacity if needed.

If, during the Training Test Period, any section of the Facilities fails to achieve the required performance standards or any fault cannot be located or rectified, the training personnel is required to assume "hands-on" operational activities.

If the Employer's Representative considers that the Facilities are not being properly managed, operated or maintained, the Contractor shall immediately provide additional training as necessary. Once this additional training has been successfully completed, the Contractor shall seek the Employer's approval for a repeat of the Training Test Period of 30 days for that section of the Mseilha

WTWs. Training Test Period shall be repeated until the Employer's Representative is satisfied that the assigned personnel is successfully managing, operating and maintaining the WTW.

No additional payment will be made to the Contractor for the repetition of training Test Period as described above, nor will the Contractor have the right to claim any payment in connection with Operation and Maintenance for the repetition of any Training Test Period.

7.13 Permits

Throughout the operation Period the Operator shall give all notices, pay all taxes, duties and fees, and obtain all permits, licenses and approvals required by Law and regulations in relation to the operation and maintenance of the WTW and associated infrastructure.

7.14 Records

7.14.1 Operations Daily Log

The Operator shall establish and maintain a complete and accurate daily log of the operation and maintenance of the WTW and associated infrastructure. The log shall be kept on site and shall include, but not be limited to the following information:

- Results of all analyses, sampling and tests carried out on and off Site;
- Measurements of all gauges and flowmeters;
- All reports generated from the control system;
- An event / alarm log from the control system;
- Description of all maintenance and repairs carried out;
- All operational incidents, stoppages, and breakdowns etc;
- Quantities of all materials, chemicals, products and substances delivered to site,
- Quantities of all sludge and waste products removed off Site
- Quantity of treated water transferred off Site.
- Potable water and electricity consumption of the plant.

7.14.2 Monthly Operation Reports

The Operator shall prepare and submit to the Employer by the 10th day of the following month, a monthly operations report on the previous calendar month. The report shall include information and statistics including, but not be limited to the following:

- A narrative summary of events, problems, incidents, accidents, near misses together with proposals and recommendations.
- Significant or recurring maintenance work

- Payment application,
- Key Performance Indicators, Performance Standards achievements
- Tables of test results, samples analyses, and compliance data
- Tables of influent data, e.g. average/ peak / total daily flows, raw water quality.
- Tables of treated water data, e.g. average/ peak / total daily flows, quality compliance
- Sludge, and waste products daily quantities and disposal arrangements and methods.
- Daily chemical consumption (coagulant, ployelectrolyte, chlorine etc.)
- Any matters relating to Health, Safety, Environment, or Relations.

7.14.3 Annual Operation Reports

The Operator shall prepare and submit to the Employer an annual operations report which shall be a statistical summary of the monthly reports under appropriate headings e.g. Health and Safety, Public Relations etc. The annual report shall also contain an analysis and trends of operational costs components (labor, chemicals, materials, electricity etc) related to volumes treated, turbidity, suspended solids and maintenance costs.

7.14.4 As-fitted Drawings

The Operator shall maintain on site hard and electronic copies of the construction as-built and as-fitted record drawings. When the WTW or associated infrastructure is modified, the Operator shall update the drawings accordingly.

7.14.5 Archiving Data

The Operator shall not destroy any data relating to the STP and associated infrastructure. In particular, all operations and maintenance data such as Facility repair, replacement and maintenance records shall be retained.

7.15 Spare Parts, Tools and Testing Equipment

7.15.1 Spare Parts

Throughout the Operation Period, the Operator shall procure and retain on Site sufficient spare parts for five years operation of all Plant, equipment, machinery and apparatus. The levels and numbers of spare parts shall be based upon the suppliers' and manufacturers' recommendations initially and later based on experience of operation and plant reliability. Replacement components are to be fit for purpose and of the technology that is current at the time of replacement.

Spares used during the O&M period shall be replaced by the Operator as part of the O&M contract at the Operator's cost. All spare parts provided shall become the property of the Employer regardless of whether they are used or not.

7.15.2 Tools

Throughout the Operation Period, the Operator shall procure and retain on Site general and maintenance tools for maintenance, disassembly, stripping and rebuilding all items of equipment wherever required on the WTW and associated infrastructure. All tools shall be contained in a suitable box clearly marked or labeled with its description.

In addition to the general tools, throughout the Operation Period, the Operator shall procure and retain on Site two sets of any special maintenance tools essential for properly maintaining, disassembly, stripping and rebuilding any particular items of Plant and equipment.

7.16 Handover

7.16.1 Handover Procedures

When the Operation and Maintenance Period expires by effluxion of time or is terminated the Operator shall:

- Repeat successfully the commissioning tests, acceptance tests and performance test prior to the handover date
- Carry out the Employer's Training requirements
- Ensure that from the handover date, the Employer shall be able to enjoy complete unhindered access to all areas of the WTW and associated infrastructure, including, without limitation, by the Operator surrendering all keys and disclosing to the Employer all access security codes;
- By the handover date, transfer or assign to the Employer the benefit of all supplier warranties, including, without limitation, on any equipment renewed, replaced or refurbished and still under manufacturer's warranty;
- By the handover date termination or if the Employer requests extended in the Employer's name any maintenance or service agreements including, without limitation, agreements with independent companies for sampling analyses; instrumentation and control equipment repairs, calibrations and servicing; and sludge disposal.
- On the handover date vacate and leave in a clean and tidy condition the Site including, without limitation all structures and buildings.
- On the handover date ensure that the stock levels and quantities of all consumables required for or in connection with the operation of the STP and associated infrastructure shall be sufficient for a minimum of 30 Days operation for locally available material and 90 days operation for imported material.
- On the handover date ensure that all spares, tools and testing equipment sufficient for five years operation are available on Site.

7.16.2 Final Tests

Prior to the end of the Operation and Maintenance Period, the Works will be finally tested for their performance and the condition of the Facilities will be checked. The tests will comprise a further 21 day test in accordance with Volume 2 section 6 (Tests after Completion).

Provided the Mseilha WTWs achieve the performance as guaranteed under the Contract (or the attainable performance if damages have been paid for shortfall or performance), and maintenance with all necessary repairs, replacements etc. as well as staff training has been carried out to the satisfaction of the Employer's Representative, and the spare parts, chemicals, lubricants and consumables as described further above have been provided by the Contractor, and the Contractor has completed all his other obligations under the Contract with regard to OMT (Operation, Maintenance and Staff Training), the Performance Certificate for Operation, Maintenance and Staff Training will be issued by the Employer's Representative, and the Employer or another Contractor will continue to operate and maintain the facilities.