# TABLE OF CONTENTS

**DIVISION 1**

**SCOPE OF WORK**

## 1. GENERAL

.1 Design, supply and delivery of all equipment and appurtenances required for the sequencing batch reactor aeration system.

.2 The initial portion of the Contract shall consist of the supply of design services, which shall include all supporting technical services and products described in this Bid Opportunity and that may be reasonably required by the Contract Administrator and the City. Design services shall include but are not necessarily limited to the following:

.1 Provision of information relating to the sequencing batch reactor aeration system and all ancillary equipment, including but not limited to Shop Drawings, to the Contract Administrator during design to facilitate a Bid Opportunity for the construction of the North End Water Pollution Control Centre upgrade.

.2 Provision of operating and design process information including standard operating procedures, preventative maintenance schedule, equipment data and reference materials, supplier schedules, etc.

.3 Provision of necessary performance specifications for all related processes and equipment material required to ensure optimal function of the sequencing batch reactor aeration system. This will require preparation and development of preliminary layouts for review by the Contract Administrator and the City.

.3 The second portion of the Contract includes the supply of equipment and Site services for the equipment and associated appurtenances as listed below:

.1 Completion of required factory testing of the equipment.

.2 Supply of all ancillary equipment and materials required for proper functioning of the supplied equipment.

.3 Delivery of the equipment.

.4 Provision of all necessary instruction and supervision to ensure satisfactory off-loading, storage, and installation of the equipment.

.5 Witnessing of equipment installation.

.6 Assistance in equipment performance testing.

.7 Guaranteed Performance Testing.

.8 Operation and Maintenance training.

.9 Modification of all supplied Shop Drawings to reflect as-built conditions following installation and commissioning of the subject equipment.

.10 As required and at no cost to the City, modification and or replacement of the equipment to ensure that performance guarantees provided in the Bid are met.

.11 Provision of all technical support for and repair of all defects to the equipment, at no cost to the City, during the warranty period.

.4 The supplied equipment shall include all accessories required to ensure the supplied equipment safely and satisfactorily operates as an integral system as required by the contract documents.

.5 Provide any appurtenances or services not specifically mentioned or included in the contract documents but which are necessary as part of the Work to ensure that the equipment is fully operational when installed.

.6 Notify the Contract Administrator immediately upon discovery of discrepancies or omissions in the contract documents or of any doubt as to the meaning or intent of any part thereof.

.7 To proceed with the Work when an error is suspected or when there is doubt as to the interpretation of the project requirements constitutes full acceptance of any cost associated with any remedial Work that may be required.

## 2. COORDINATION

.1 Other parties or Contractors (and their subcontractors) that will be working within and adjacent to the Site include, but are not necessarily limited to the following:

.1 The City and its appointed representatives

.2 Other Contractors

.2 The Contractor shall provide, for the times designated in the contract documents, the services of a trained and experienced technician (hereinafter referred to as the manufacturer's representative) for:

.1 Equipment delivery

.2 Installation training

.3 Witnessing of equipment installation

.4 Assistance during equipment performance testing

.5 Guaranteed Performance Testing

.6 Training of City staff

.3 The Installation Contractor shall be responsible for:

.1 Receipt of the equipment upon delivery

.2 Off-loading and storage of the equipment

.3 Satisfactory equipment installation

.4 Satisfactory equipment performance testing

.5 Assistance with Guaranteed Performance Testing

.4 The Contractor shall cooperate fully with the Installation Contractor (or City, if the Installation Contract has yet to be assigned) to ensure that the delivery of the equipment and the provision of Site services meet and conform to the Installation Contractor's construction schedule and to these contract documents.

.5 The Contractor will be required to certify:

.1 Satisfactory delivery of the equipment

.2 Satisfactory equipment installation training

.3 Satisfactory equipment installation

.4 Satisfactory equipment performance testing

.5 Satisfactory Guaranteed Performance Testing.

.6 During the Guaranteed Performance Testing for the sequencing batch reactor aeration system, the Contractor shall attend coordination meetings as directed by the Installation Contractor. The Contractor must also take all precautions necessary to ensure that he does not hinder or delay in any way the progress of these parties or cause damage to the Work.

## 3. SCHEDULE AND STATUS REPORTS

.1 It is the responsibility of the Contractor to schedule delivery of the equipment to the Site with the Installation Contractor.

.2 After delivery the Installation Contractor will be responsible for storing and maintaining the equipment in accordance with the Contractor's storage requirements.

.3 The Contractor shall prepare, sign, and submit a typewritten report at the end of each month to the Contract Administrator and the Installation Contractor, stating the status and rate of progress of design, fabrication, shipping and delivery of the equipment and the effect, if any, on the delivery schedule.

## 4. INDEPENDENT INSPECTION AND TESTING AGENCIES

.1 Independent inspection and testing agencies may be retained by the City for the purpose of inspecting and testing portions of the Work. All costs of such services will be borne by the City unless otherwise noted.

.2 Employment of inspection and testing agencies in no way relieves the Contractor of responsibility to perform the Work in accordance with the Contract Documents.

**END OF SECTION**

**SUBMITTALS**

## 1. SHOP DRAWINGS AND PRODUCT DATA

.1 "Shop Drawings" mean custom Drawings, product data, diagrams, illustrations, schedules, performance charts, brochures, and other data, which are to be provided by the Contractor to illustrate details of a portion of the Work.

.2 Arrange for the preparation of clearly identified Shop Drawings as specified or as the Contract Administrator may reasonably request. Shop Drawings are to clearly indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes, and other information necessary for completion of the Work. Where articles or equipment attach or connect to other articles or equipment, clearly indicate that all such attachments and connections have been properly coordinated, regardless of the trade under which the adjacent articles or equipment will be supplied and installed. Shop Drawings are to indicate their relationship to design Drawings and Specifications. Notify the Contract Administrator in writing of any deviations in Shop Drawings from the requirements of the Contract Documents.

.3 Shop Drawings shall be submitted with a copy of the associated Specification. For each specification clause, note compliance or deviation from Specification. Provide full explanation for any deviation. Shop Drawings submitted without the associated Specification Sections will be returned to the Contractor as “Rejected”.

.4 Examine all Shop Drawings prior to submission to the Contract Administrator to ensure that all necessary requirements have been determined and verified and that each Shop Drawing has been checked and coordinated with the requirements of the Work and the Contract Documents. Examination of each Shop Drawing shall be indicated by stamp, date, and signature of a responsible person of the Contractor and any subcontractors. Shop Drawings not stamped, signed, and dated will be returned without being reviewed and stamped "RE-SUBMIT".

.5 Submit Shop Drawings with reasonable promptness and in an orderly sequence so as to cause no delay in the Work. Failure to submit Shop Drawings in ample time is not to be considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default will be allowed. Jointly prepare a schedule fixing the dates for submission and return of Shop Drawings.

.6 The Contract Administrator will review and return Shop Drawings in accordance with the schedule agreed upon or otherwise with reasonable promptness so as to cause no delay in the Work.

.7 Submit six (6) copies of white prints, plus one (1) copy of reproducibles, and six (6) copies of all fixture cuts and brochures.

.8 Shop Drawing review by the Contract Administrator is solely to ascertain conformance with the general design concept. Responsibility for approval of detail design inherent in Shop Drawings rests with the Contractor and review by the Contract Administrator shall not imply such approval.

.9 Review by the Contract Administrator shall not relieve the Contractor of his responsibility for errors or omissions in Shop Drawings or for proper completion of the Work in accordance with the Contract Documents.

.10 Responsibility for verification and correlation of field dimensions, fabrication processes, techniques of construction, installation, and coordination of all parts of the Work rests with the Contractor.

.11 Shop Drawings will be returned to the Contractor with one of the following notations:

.1 When stamped "REVIEWED" or "NO EXCEPTIONS TAKEN", distribute additional copies as required for execution of the Work.

.2 When stamped "REVIEWED AS MODIFIED" or "MAKE NOTED CORRECTIONS", ensure that all copies for use are modified and distributed, same as specified for "REVIEWED".

.3 When stamped "REVISE & RESUBMIT", make the necessary revisions, as indicated, consistent with the Contract Documents and submit again for review.

.4 When stamped "NOT REVIEWED" or "REJECTED", submit other Drawings, brochures, etc. for review consistent with the Contract Documents.

.5 Only Shop Drawings bearing "REVIEWED", "NO EXCEPTIONS TAKEN", "MAKE NOTED CORRECTIONS", or "REVIEWED AS MODIFIED" shall be used on the Work unless otherwise authorized by the Contract Administrator.

.12 After submittals are stamped "REVIEWED", "NO EXCEPTIONS TAKEN", "MAKE NOTED CORRECTIONS", or "REVIEWED AS MODIFIED", no further revisions are permitted unless re-submitted to the Contract Administrator for further review.

.13 Any adjustments made on Shop Drawings by the Contract Administrator are not intended to change the Contract Price. Increases in the Contract Price must be approved by the Contract Administrator prior to proceeding to fabricate.

.14 Make changes in Shop Drawings, which the Contract Administrator may require, consistent with Contract Documents. When re-submitting, notify the Contract Administrator in writing of any revisions other than those requested by the Contract Administrator.

.15 Shop Drawings indicating design requirements not included in the Contract Documents shall be signed and sealed by a Professional Engineer registered in North America. If requested, calculations shall be submitted for review, also signed, and sealed by a Professional Engineer registered in North America.

.16 Only two reviews of Shop Drawings will be made by the Contract Administrator at no cost. Each additional review will be charged to the Contractor at the Contract Administrator's current rates. The Contract Administrator's charges for the additional Work will be deducted from the Contractor's Progress Certificates.

## 2. SAMPLES

.1 Submit samples for the Contract Administrator's review where specified or as the Contract Administrator may reasonably request. Clearly label samples as to origin and intended use in the Work. Reference samples to Drawings and Specifications.

.2 Submit samples with reasonable promptness and in orderly sequence so as to cause no delay in the Work. Failure to submit samples in ample time is not to be considered sufficient reason for an extension of Contract Time and no claim for extension by reason of such default will be allowed. Jointly prepare a schedule fixing the dates for submission and return of samples.

.3 Notify the Contract Administrator in writing, at the time of submission, of any deviations in samples from requirements of Contract Documents.

.4 The Contract Administrator's review will be for conformity of design concept and general arrangement only. Such review is not to be considered relief of responsibility for errors or omissions in samples or of responsibility for meeting all requirements of the Contract Documents.

.5 Any adjustments made on samples by the Contract Administrator are not intended to change the Contract Price. If it is deemed that such adjustments affect the Contract Price, clearly state as such in writing prior to proceeding with fabrication and installation of the Work.

.6 Make changes in samples, which the Contract Administrator may require, consistent with Contract Documents.

## 3. OPERATING AND MAINTENANCE MANUALS

.1 For the guidance of the City's operating and maintenance personnel, the Contractor shall prepare O&M Manuals for the Work, describing in detail the construction of each part of the Work and the recommended procedure for operation, servicing, and maintenance.

.2 Three (3) advance copies of the manuals shall be submitted prior to equipment delivery to Site for review and comments. A minimum of eight weeks after review, six (6) copies of the final manuals shall be supplied. Each copy shall be clearly titled to show all of the information required by the Specifications as well as operational information including: the item of Work concerned, the City's Contract number, the name and address of the Contractor, the issue date, operational information on equipment, cleaning and lubrication schedules, filters, overhaul and adjustment schedules.

.3 All instructions in these manuals shall be in plain language to guide the City in the proper operating and maintenance of this installation.

.4 Submit O&M Manuals in electronic format as well as hard copy. Organize contents into applicable sections of Work, parallel to Specifications breakdown.

.5 In addition to information called for in the Specifications, include the following:

.1 Title sheet, labelled "Operating and Maintenance Instructions", and containing project name and date

.2 List of contents

.1 Brochures and catalogue excerpts of all architectural, mechanical and electrical components of the Work

.2 Documentation of all test results

.3 Complete set of equipment and assembly drawings

.4 Installation, start-up, O&M Manuals

.5 Commissioning data sheets and reports

.6 Lists of spare parts, consumables, and special tools, with prices and names and addresses of nearest supplier

.7 Any specific product or maintenance manual requirements from the technical specifications

.3 Reviewed Shop Drawings of all equipment

.4 Detailed operating and maintenance instructions for all items of equipment, including a preventative maintenance program

.6 The Contractor shall modify and supplement the manual as required by the Contract Administrator.

.7 Provide list of spare parts and consumables, including name and address of nearest supplier.

.8 The O&M Manuals shall be supplied to the City before delivery and provision shall be made for additions and deletions, which may be dictated by the City's operational experience. Where these amendments to the manuals are indicated to be necessary during initial operation before acceptance, the Contractor shall supply the amended sections free of charge.

.9 Payment for this item of the Work will not be issued until all requirements for the O&M Manuals have been satisfied.

## 4. RECORD DRAWINGS

.1 After award of Contract, the Contract Administrator will provide a complete set of Drawings for the purpose of maintaining Record Drawings, electronic files in AutoCAD format will be supplied. Accurately record significant deviations from Contract Documents caused by Site conditions and changes ordered by the Contract Administrator. Update daily.

.2 Record locations of concealed elements of mechanical and electrical services.

.3 Identify Drawings as "Project Record Copy". Maintain in good condition and make available for inspection on-site by Contract Administrator at all times.

.4 On completion of the Work, two weeks prior to final inspection, submit Record Drawings to Contract Administrator for review.

.5 Within one month after return of Record Drawings by the Contract Administrator, obtain and pay for a complete set of original reproducible sepias. Transfer all changes from Record Drawings to electronic Drawings (AutoCAD) and certify accuracy. Deliver electronic Drawings to the Contract Administrator.

## 5. PHOTOGRAPHS AND PUBLICITY

.1 No photographs of the Site or of any portion of the Work will be permitted without prior approval of the Contract Administrator.

.2 No press or publicity releases will be permitted without prior approval of the Contract Administrator.

## 6. PROCEDURES

.1 The Contractor shall, if required by the Contract Administrator, submit for the review of the Contract Administrator statements which describe in detail, supplemented with Drawings where necessary, the methods to be adopted for executing any portion of Work.

.2 These statements shall also include details of constructional plant and labour to be employed. Acceptance by the Contract Administrator shall not relieve the Contractor of any of his responsibilities, nor shall reasonable refusal to approve entitle the Contractor to extra payment or an extension of time.

**END OF SECTION**

**QUALITY ASSURANCE**

## 1. INSPECTION AND TESTING OF WORK

### 1.1 General

.1 The City, the Contract Administrator, and other authorities having jurisdiction shall have access to the Work. If parts of the Work are in preparation at locations other than the Place of the Work, access shall be given to such Work whenever it is in progress.

### 1.2 Laboratories and Agencies

.1 Independent inspection and testing agencies may be engaged by the City for the purpose of inspecting or testing portions of the Work. All costs of such services will be borne by the City; costs of additional tests required due to defective Work shall be paid by the Contractor.

.2 All equipment required for carrying out inspection and testing will be provided by the respective agencies.

.3 Employment of inspection and testing agencies in no way relieves the Contractor of responsibility to perform the Work in accordance with the Contract Documents.

.4 Allow the inspection and testing agencies access to all portions of the Work on the Site and manufacturing or fabrication plants, as may be necessary. Provide facilities for such access.

### 1.3 Reference Standards and Acronyms

.1 Within the Drawings and Specifications, reference may be made to the following standards and organizations by their acronyms, as defined below. Conform to such standards, in whole or in part, as specified.

| | |
|---|---|
| AABC | Associated Air Balance Council |
| AFBMA | Anti-Friction Bearings Manufacturers Association |
| ACI | American Concrete Institute |
| AMCA | Air Movement and Control Association |
| AGMA | American Gear Manufacturers Association |
| AISC | American Institute of Steel Construction |
| AISI | American Iron and Steel Institute |
| ANSI | American National Standards Institute |
| APHA | American Public Health Association |
| ARI | Air-conditioning and Refrigeration Institute |
| ASHRAE | American Society of Heating, Refrigerating and Air-conditioning Engineers |
| ASCE | American Society of Civil Engineers |
| ASME | American Society of Mechanical Engineers |
| ASPE | American Society of Plumbing Engineers |
| ASTM | American Society for Testing and Materials |
| AWS | American Welding Society |
| AWWA | American Water Works Association |
| BS | British Standard |
| CCA | Canadian Construction Association |
| CCMC | Canadian Construction Materials Centre |

**QUALITY ASSURANCE**

| | |
|---|---|
| CEA | Canadian Electricity Association |
| CEC | Canadian Electrical Code |
| CEMA | Canadian Electrical Manufacturers Association |
| CGSB | Canadian Government Specification Board |
| CISC | Canadian Institute of Steel Construction |
| CLA | Canadian Lumberman's Association |
| CPCA | Canadian Painting Contractors Association |
| CPCI | Canadian Prestressed Concrete Institute |
| CRCA | Canadian Roofing Construction Association |
| CSA | Canadian Standards Association |
| CSSBI | Canadian Sheet Steel Building Institute |
| DIN | Deutsche Industrie Norm |
| EEMAC | Electrical and Electronic Manufacturers Association of Canada |
| EJMA | Expansion Joint Manufacturers Association |
| FM | Factory Mutual Engineering Corporation |
| IEC | International Electrotechnical Commission |
| IEEE | Institute of Electrical and Electronic Engineers |
| IPCEA | Insulated Power Cable Engineers Association |
| ISA | Instrumentation, Systems, and Automation Society |
| MSDS | Material Safety Data Sheets |
| MSS | Manufacturers Standardization Society of the Valve and Fittings Industry |
| NAAMM | National Association of Architectural Metal Manufacturers |
| NABA | National Air Barrier Association |
| NACE | National Association of Corrosion Engineers |
| NBC | National Building Code |
| NECA | National Energy Conservation Association |
| NEMA | National Electrical Manufacturers Association |
| NFPA | National Fire Protection Association |
| NLGA | National Lumber Grading Authority |
| RSIC | Reinforcing Steel Institute of Canada |
| SAMA | Scientific Apparatus Makers Association |
| SMACNA | Sheet Metal and Air Conditioning Contractors National Association |
| SSPC | Steel Structures Painting Council |
| TTMAC | Terrazzo Tile and Marble Association of Canada |
| ULC | Underwriters Laboratories of Canada |
| WCB | Workers Compensation Board |
| WEF | Water Environment Federation |
| WHMIS | Workplace Hazardous Materials Information System |

.2 If there is question as to whether any product or system is in conformance with applicable standards, the Contract Administrator reserves the right to have such products or systems tested to prove or disprove conformance. The cost for such testing will be borne by the City in the event of conformance with Contract Documents or by the Contractor in the event of non-conformance.

.3 Where specified standards are not dated, conform to latest issue of specified standards as amended and revised to the Bid closing date.

**QUALITY ASSURANCE**

**1.4 Design Standards, Code Requirements**

.1 Inspection and testing will be performed in accordance with, but not limited to, the following:

.1 Welding to CSA-W59.1 and ASTM E109

.2 Bolted connections to CSA-S16 or CSA-S16.1

**1.5 Tests and Mix Design**

.1 Prior to start of the Work, submit to the Contract Administrator and inspection and testing agency, the following:

.1 Mill test certificates for all structural steel and bolts.

**2. PROCEDURES**

.1 Notify the Contract Administrator well in advance of the requirements for tests in order that necessary arrangements can be made.

.2 Submit samples and materials required for testing with reasonable promptness so as to cause no delay in the Work.

.3 Provide facilities to allow inspection and testing and make available space for storage and curing of the test samples.

.4 If defects are revealed during inspection and testing, then the Contract Administrator may issue instructions for removal or correcting defective Work and irregularities. The Contractor shall notify the Contract Administrator within two working days if such instructions are in error or at variance with the Contract Documents.

.5 Costs for re-inspection and retesting of rejected Work shall be borne by the Contractor.

**END OF SECTION**

**PRODUCTS AND WORKMANSHIP**

## 1. PRODUCTS

### 1.1 Metric Project

.1 Unless otherwise noted, this project has been designed and is to be constructed in the SI metric system of measurements.

.2 During construction, when specified metric elements are unattainable at the time they are required to meet the Construction Schedule, the Contractor shall notify the Contract Administrator in writing and suggest alternative substitutions. Costs due to these substitutions shall be borne by the Contractor.

### 1.2 Quality of Products

.1 Provide new materials, equipment and articles incorporated in the Work, not damaged or defective, and of the best quality compatible with Specifications for the purpose intended. If requested, furnish evidence as to type, source, and quality of products provided.

.2 Defective materials, equipment and articles whenever found may be rejected regardless of previous inspection. Inspection by the Contract Administrator or an independent inspection and testing agency does not relieve the Contractor of his responsibility but is merely a precaution against oversight or error. Costs for removal and replacement of defective materials and responsibility for all delays and expenses caused by rejection shall be borne by the Contractor.

.3 Should any dispute arise as to the quality or fitness of materials, equipment or articles, the decision rests strictly with the Contract Administrator based upon the requirements of the Contract Documents.

.4 Unless otherwise indicated in the Contract Documents, maintain uniformity of Manufacturer for any particular or like item throughout the Work.

.5 Permanent labels, trademarks, and nameplates on materials, equipment and articles are not acceptable in prominent locations except where required for operating instructions and when located in mechanical or electrical rooms.

### 1.3 Availability of Products

.1 In the event of delays in deliveries of materials, equipment or articles, the Contract Administrator reserves the right to substitute more readily available products later in order to prevent delays at no additional cost to the City.

.2 No substitution of any item will be permitted unless the item cannot be delivered to the job site to comply with the Schedule.

.3 To receive approval, proposed substitutes must conform with the requirements of Section B5 in the Bidding Instructions.

.4 Provide documented proof of equality and delivery dates in the form of certified quotations from Manufacturers of both specified items and proposed substitutions.

.5 The Contractor shall be responsible for all costs including any and all revisions required to accommodate such substitutions.

### 1.4 Transportation Costs of Products

.1 Pay all costs for transportation of products required for the Work.

## 2. WORKMANSHIP

### 2.1 General Requirements

.1 Workmanship is to be of the best quality executed by workers fully experienced and skilled in their respective trades.

### 2.2 Fastenings

.1 Provide metal fastenings and accessories in same texture, colour and finish as adjacent material unless otherwise specified.

.2 Prevent electrolytic action between dissimilar metals and materials.

.3 Use non-corrosive, non-staining fasteners and anchors for securing exterior work unless otherwise specified.

.4 Space anchors within their load limit or shear capacity and ensure that they provide positive permanent anchorage.

.5 Keep exposed fastenings to a minimum, space evenly and lay out neatly.

.6 Fastenings which cause spalling or cracking of material to which anchorage is made are not acceptable.

**END OF SECTION**

# EQUIPMENT INSTALLATION

## 1. INTENT

.1 This Section describes general requirements for all equipment supplied under the Contract relating to equipment delivery, equipment installation, Guaranteed Performance Testing and associated training.

.2 At least 30 days prior to commencing Guaranteed Performance Testing the Contractor shall assist the Installation Contractor to prepare and submit a detailed start-up plan to indicate the schedule and sequence of equipment installation checks and tests required for the Contract Administrator's review and input. No testing work can commence until this plan has been discussed by all parties involved and accepted by the Contract Administrator.

## 2. DEFINITIONS

.1 Contractor's Representative: a trained service person empowered by the Contractor to provide:

.1 Installation training

.2 Witnessing of equipment installation

.3 Assistance in Guaranteed Performance Testing

.4 Operation and Maintenance Training (refer to Section 01665)

.2 Guaranteed Performance Testing: for the purpose of this Section, is defined as the testing of the equipment to prove compliance with the standard oxygen transfer efficiency listed in the Bid Opportunity Form. All requirements related to the Guaranteed Performance Testing are outlined in the equipment Specification Section. Upon the successful completion of the Guaranteed Performance Testing, the Contractor, Installation Contractor, Contract Administrator, and the City will sign the "Certificate of Satisfactory Guaranteed Performance Testing" (Form 105).

## 3. EXPERTISE AND RESPONSIBILITY

.1 The Contract Administrator recognizes the expertise of the Contractor.

.2 Should the Contract Administrator issue an Addendum, Notice of Proposed Change, Field Order or Change Order to change the Work which would, in the opinion of the Contractor, compromise the success or safety of the Work, then it shall be incumbent on the Contractor to notify in writing the Contract Administrator to this effect within two days upon receipt.

## 4. EQUIPMENT DELIVERY

.1 All equipment shall be delivered in its entirety in one shipment.

**EQUIPMENT INSTALLATION**

.2 The Contractor shall deliver all equipment required under this Contract to the North End Water Pollution Control Centre, Winnipeg, Manitoba at which point the Installation Contractor will become responsible for taking delivery of the equipment. Written acceptance of receipt, at delivery, by the Installation Contractor shall constitute "Delivery to Site" under this Contract. A representative from each of the following will be in attendance at the time of delivery:

.1 Contractor

.2 Installation Contractor

.3 Contract Administrator

.3 The Contractor shall clearly mark each item to be shipped and identify and reference it to the packing lists and to bills of materials on the Shop Drawings. The lists will be used by the Installation Contractor and the Contract Administrator to check the contents of each delivery. No shipments will be off-loaded until itemized packing lists have been received by the parties mentioned herein.

.4 The Contractor shall adequately pack and crate each component to provide protection during transport, handling, and storage. Equipment suitable for outside storage shall be stored to the satisfaction of the Contractor and Contract Administrator. The Contractor shall identify each component with durable labels or tags securely attached to each piece of equipment, crate, or container.

.5 No item shall be shipped loose or in such a way as to be adversely affected by weather conditions, pilferage, normal transit hazards, or other reasonably anticipated shipping hazards.

.6 Where the equipment is to be stored on-site for any period of time exceeding one week, the Contractor shall instruct the Installation Contractor of the specific storage requirements to ensure there is no uneven wear or distortion of equipment component parts.

.7 The Contractor shall protect polished and machined metal surfaces from corrosion and damage during shipment and storage and shall carefully pack and crate the equipment for shipment. The Contractor shall protect threaded connections with threaded plugs or caps and shall protect open plain end pipes with caps. The Contractor shall especially pack electrical equipment and control panels to prevent scratching, access by dirt, moisture or dust or damage to insulation, and shall cover equipment having exposed bearings and glands to exclude foreign matter.

.8 The Contractor shall give notice to the Installation Contractor and the Contract Administrator ten days before delivery so that arrangements for receipt and inspection. The Contractor shall arrange for delivery during normal working hours.

.9 When the Installation Contractor is satisfied that the equipment has been delivered in its entirety without damage, he shall complete the **"**Certificate of Equipment Delivery" (Form 100) attached to this Specification. The completed form shall be delivered to the Contract Administrator.

.10 The Contractor shall instruct the Installation Contractor in writing on the off-loading, storage and periodic maintenance requirements for the materials and equipment, emphasizing any particular precautions, including any special oils or greases needed, to be taken during the off-loading, storage and pre-start-up periods.

.11 The Contractor shall maintain an inventory of all equipment supplied and delivered to the Installation Contractor.

.12 The Installation Contractor shall examine all crates and packages on delivery and compare them with the packing lists. The Installation Contractor shall inform the Contract Administrator, the Contractor and the carrier in writing of any visible damage, missing items or defects. The Contractor shall arrange to replace forthwith items not delivered or delivered defective or damaged to the Site.

.13 Off-loading and storage of the equipment at the jobsite will be the responsibility of the Installation Contractor.

.14 The Installation Contractor shall arrange for heated and covered storage at the Site as required by the Contractor for sensitive items of equipment. The Contractor shall clearly identify such sensitive items on the packages and crates.

.15 The equipment may have to be stored on the Site for an extended period of time before installation and Guaranteed Performance Testing. Accordingly, the Contractor shall provide any special packaging and protective coatings, lubricants, etc. which the Contractor deems necessary to protect the equipment during the protracted storage and prior to performance testing. The Installation Contractor shall be responsible for removing any protective coatings prior to installation and Guaranteed Performance Testing in accordance with the Contractor's written instructions.

## 5. EQUIPMENT DELIVERY SCHEDULE

.1 Refer to D11 of Part D: Supplemental Conditions.

### 5.2 Installation Assistance

.1 Before commencing installation of the equipment, the Contractor shall provide instructions to the Installation Contractor in writing of all the methods, techniques, precautions, and any other information relevant to the successful installation of the equipment.

.2 The Contractor shall provide advice and instructions to the Installation Contractor on the installation of the equipment but shall not be responsible for the detailed supervision of the installation of the equipment or of the workers installing it. The Contractor shall notify the Contract Administrator in writing immediately in the event of any disputes with the Installation Contractor concerning installation of the equipment.

.3 When the Contractor is satisfied that the Installation Contractor is aware of all installation requirements, he and the Installation Contractor shall so certify by completing the

"Certificate of Equipment Installation Instruction" (Form 101) attached to this Specification. Such certification shall be provided to the Contract Administrator.

.4 Installation of the equipment shall not commence until the Contract Administrator has advised that he has accepted the completed Form 101.

.5 Form 101 is included in this document for information only. The Form 101 that will be signed prior to installation may be worded slightly differently and will be included in the Installation Contract.

## 6. INSTALLATION

.1 If necessary, or if so directed by the Contract Administrator during the course of installation, the Installation Contractor shall contact the Contractor to receive clarification of installation procedures, direction, or any other additional information necessary to continue or complete the installation in an appropriate manner.

.2 If it is found necessary, or if so directed by the Contract Administrator, the Installation Contractor shall arrange for the Contractor to visit the Site to provide assistance to the Installation Contractor during installation, all at no cost to the City.

.3 Prior to completing installation, the Installation Contractor shall inform the Contractor and arrange for the attendance at the Site of the Contractor to verify successful installation.

.4 The Contractor shall conduct a detailed inspection of the installation including alignment, attached pipe work, lubrication, workmanship, and all other items as required to ensure successful operation of the equipment.

.5 The Contractor shall identify any outstanding deficiencies in the installation and shall provide a written report to the Contract Administrator and Installation Contractor describing such deficiencies.

.6 The deficiencies shall be rectified by the Installation Contractor and the Contractor will be required to re-inspect the installation, at no cost to the City.

.7 When the Contractor accepts the installation, he and the Installation Contractor shall certify the installation by completing the "Certificate of Satisfactory Equipment Installation" (Form 102), attached to this Specification.

.8 Deliver the completed Form 102 to the Contract Administrator prior to departure of the Contractor from the Site.

.9 Form 102 is included in this document for information only. The Form 102 that will be signed after installation may be worded slightly differently and will be included in the Installation Contract.

## 7. GUARANTEED PERFORMANCE TESTING

.1 Equipment will be subjected to a demonstration, running test, and performance tests after the installation has been verified and any identified deficiencies have been remedied.

.2 The Installation Contractor shall inform the Contract Administrator at least 14 days in advance of conducting the tests and arrange for the attendance of the Contractor. The tests may be concurrent with the inspection of satisfactory installation if mutually agreed by the Installation Contractor and the Contract Administrator.

.3 The Contractor will conduct all necessary checks to the equipment and if necessary, advise the Installation Contractor of any further Work needed prior to confirming the equipment is ready to run.

.4 The Installation Contractor shall then operate the equipment for at least one hour to demonstrate to himself the operation of the equipment and any required ancillary services. Any remedial measures required to ensure satisfactory operation shall be promptly undertaken.

.5 The Installation Contractor shall then notify the Contract Administrator of his readiness to demonstrate the operation of the equipment. The Contract Administrator shall attend, as expeditiously as possible.

.6 With the assistance of the Contractor, the Installation Contractor will demonstrate that the equipment is properly installed. Alignment, piping connections, etc. will be checked.

.7 The equipment shall then be run for one hour. Local controls shall be satisfactorily verified by cycling the equipment through several start-stop operations, modulating its output, or some combination. Operating parameters such as temperature, pressure, voltage will be checked to ensure that they are within the specified or Contractor's recommended limits, whichever is more stringent.

.8 On satisfactory completion of the one hour demonstration, the equipment will be stopped and the Contractor shall recheck all critical parameters such as piping connections.

.9 Guaranteed Performance Tests will be undertaken. During this period, as practicable, conditions will be simulated which represent maximum or most severe conditions. These conditions will be mutually agreed by the Contractor, the Installation Contractor and the Contract Administrator on the basis of the information contained in the Supply Contract Documents, as well as the methods utilized to create the simulated conditions and the time periods allotted to each.

.10 Guaranteed Performance Tests shall be as dictated in the technical specifications for each item of equipment or as reasonably required by the Contract Administrator to prove adherence to the requirements listed in the Specification.

.11 The Installation Contractor shall submit the results of the Guaranteed Performance Tests to the Contract Administrator, documented and summarized in a format acceptable to the Contract Administrator. The Contract Administrator reserves the right to request additional

testing. No equipment shall be accepted and handed over to the City prior to the satisfactory completion of the Guaranteed Performance Tests and acceptance of the test reports by the Contract Administrator.

.12 All water, temporary power, heating, or any other ancillary services required to complete the initial demonstration and guaranteed performance tests are the responsibility of the Installation Contractor.

.13 All chemicals, instruments, and testing equipment required to complete the initial demonstration and Guaranteed Performance Tests are the responsibility of the Contractor.

.14 Should the initial demonstration or Guaranteed Performance Tests reveal any defects, then those defects shall be promptly rectified and the failed demonstration or Guaranteed Performance Tests shall be repeated to the satisfaction of the Contract Administrator. Additional costs incurred by the Installation Contractor, the Contract Administrator, or the City, due to repeat demonstration, running tests, or Guaranteed Performance Tests shall be the responsibility of the Contractor.

.15 On successful completion of the demonstration, running test, and performance tests, the "Certificate of Satisfactory Guaranteed Performance Testing" (Form 105) attached to this Specification will be signed by the Contractor, the Installation Contractor, the Contract Administrator, and the City.

.16 Process performance testing can commence as soon as the "Certificate of Satisfactory Guaranteed Performance Testing" (Form 105) is completed.

# CERTIFICATE OF EQUIPMENT DELIVERY
# FORM 100

We certify that the equipment listed below has been delivered into the care of the Installation Contractor. The equipment has been found to be in satisfactory condition. No defects in the equipment were found.

**PROJECT:** _____

**ITEM OF EQUIPMENT:** _____

_____

**TAG NO:** _____

**REFERENCE SPECIFICATION:** _____

_____ _____
(Authorized Signing Representative of the Installation Contractor) Date

_____ _____
(Authorized Signing Representative of the Contract Administrator) Date

## CERTIFICATE OF EQUIPMENT INSTALLATION INSTRUCTION
## FORM 101

I have familiarized the Installation Contractor of the specific installation requirements related to the equipment listed below and am satisfied that he understands the required procedures.

**PROJECT:** _____

**ITEM OF EQUIPMENT:** _____

_____

**TAG NO:** _____

**REFERENCE SPECIFICATION:** _____

_____ _____
(Authorized Signing Representative of the Contractor) Date

I certify that I have received satisfactory installation instructions from the equipment supplier.

_____ _____
(Authorized Signing Representative of the Installation Contractor) Date

## CERTIFICATE OF SATISFACTORY EQUIPMENT INSTALLATION
## FORM 102

I have completed my check and inspection of the installation listed below and confirm that it is satisfactory and that defects have been remedied to my satisfaction except any as noted below:

**PROJECT:** _____

**ITEM OF EQUIPMENT:** _____

_____

**TAG NO:** _____

**REFERENCE SPECIFICATION:** _____

**OUTSTANDING DEFECTS:** _____

_____ _____
(Authorized Signing Representative of the Contractor) Date

_____ _____
(Authorized Signing Representative of the Installation Contractor) Date

**Acknowledgement of Receipt of O&M Manuals**

_____ _____
(Authorized Signing Representative of the City) Date

## CERTIFICATE OF SATISFACTORY GUARANTEED PERFORMANCE TESTING FORM 105

We certify that the equipment listed below has been tested and meets the Guaranteed Performance Testing Requirements as set out in the Contract.

**PROJECT:** _____

**ITEM OF EQUIPMENT:** _____

_____

**TAG NO:** _____

**REFERENCE SPECIFICATION:** _____

_____ _____
(Authorized Signing Representative of the Contractor) Date

_____ _____
(Authorized Signing Representative of the Installation Contractor) Date

_____ _____
(Authorized Signing Representative of the Contract Administrator) Date

**END OF SECTION**

# TRAINING

## 1. DESCRIPTION

.1 This Section contains requirements for training the City staff, by persons retained by the Contractor specifically for the purpose, in the proper operation and maintenance of the equipment and systems installed under this Contract.

.2 A training session for the City's staff is required in conjunction with the Guaranteed Performance Testing.

.3 As a minimum, the Contractor is to allow at least 16 hours of training spread over three consecutive working days, as required for each item of equipment or system. Refer to the equipment specifications for specific time periods.

.4 The intent is that the City staff should receive sufficient training on the equipment system that they are going to operate and maintain. The Contract Administrator shall have the authority to determine the duration and content of each training session required.

## 2. QUALITY ASSURANCE

.1 Where required by the equipment specifications, provide on-the-job training of the City's staff. Training sessions will be conducted by qualified factory-trained representatives, with a minimum of two years experience. Training includes instruction of City's staff in equipment operation and preventive maintenance and instruction of maintenance mechanics in normal maintenance up to major repair.

.2 The trainers proposed by the Contractor shall be experienced in training plant operators and shall have relevant experience in similar work.

## 3. SUBMITTALS

.1 Submit the following information in accordance with Section 01300. For phased testing and start-up activities, separate submittals can be prepared for equipment items or systems. The material will receive a "REVIEWED" or "REVIEWED AS MODIFIED" status by the Contract Administrator no later than four weeks prior to delivery of the training:

.1 Lesson plans and training manuals, handouts, visual aids, and other reference materials for the training session to be conducted by the Contractor's trainer(s)

.2 Date, time, and subject of the training session

.3 Training schedule

**TRAINING**

## 4. LOCATION

.1 Where specified, conduct training sessions for the City's staff, operation and maintenance personnel, on the operation, care, and maintenance of the equipment and systems installed under this Contract. Training will take place at the site of the Work and under the conditions specified in this Section.

.2 Field training sessions will take place at the site of the equipment.

## 5. LESSON PLANS

.1 Prepare formal written lesson plans for each training session and coordinate with the Contract Administrator. Lesson plans to contain an outline of the material to be presented along with a description of visual aids to be utilized during the session. Furnish ten (10) copies of necessary training manuals, handouts, visual aids and reference materials at least two weeks prior to each training session. Training format will be such that the operators will be able to obtain CEU credits through Manitoba Conservation’s Operator Certification Program.

## 6. FORMAT AND CONTENT

.1 Include time in the classroom and at the location of the equipment or system for each training session. As a minimum, cover the following topics for each item of equipment or system:

.1 Familiarization

.2 Safety

.3 Operation

.4 Troubleshooting

.5 Preventive maintenance

.6 Corrective maintenance

.7 Parts

.8 Local representatives

## 7. VIDEO RECORDING

.1 The City may video record each training session. After recording, the material may be edited and supplemented with professionally produced graphics to provide a permanent record for the City's use.

## 8. TRAINING

### 8.1 General Requirements

.1 Conduct the training session in conjunction with the Guaranteed Performance Testing.

.2 At least four weeks before the start of Equipment Installation (Form 102) and any associated training. Provide final O&M Manuals, as defined in Section 01300, for the specific equipment to the City.

### 8.2 Classroom Training

.1 As a minimum, classroom equipment training for both the operations and maintenance personnel will include:

.1 The equipment's specific location in the plant and an operational overview

.2 Purpose and function of the equipment

.3 Operating theory of the equipment

.4 Routine start-up and shutdown procedures

.5 Normal and major repair procedures

.6 Equipment inspection and troubleshooting procedures including the use of applicable test instruments and the "pass" and "no pass" test instrument readings

.7 Preventive maintenance and up to and including major repairs such as replacement of major equipment parts with the use of special tools

.8 Routine disassembly and assembly of equipment if applicable for purposes such as operator inspection of equipment

.9 Operator detection, without test instruments, of specific equipment trouble symptoms

### 8.3 Hands-On Training

.1 Hands-on equipment training for maintenance and repair personnel will include:

.1 Reviewing normal test and repair procedures

.2 Performing routine start-up and shutdown procedures

.3 Reviewing and using Manufacturer's manuals in the hands-on training

.4 Contractor is to ensure that the City is present for and participates in the Guaranteed Performance Testing

## 8.4 Training Completion Forms and Payment

.1 Form T1: To be completed for training at the time of the Guaranteed Performance Testing (Form 105)

.2 A sample of Form T1 is attached to this Specification Section.

## CERTIFICATE OF SATISFACTORY TRAINING
## FORM T1

We certify that the initial training for the equipment listed below has been provided as per the Specifications.

**PROJECT:** _____

**ITEM OF EQUIPMENT:** _____

_____

**TAG NO:** _____

**REFERENCE SPECIFICATION:** _____

_____ _____
(Authorized Signing Representative of the Contractor) Date

_____ _____
(Authorized Signing Representative of the City) Date

**END OF SECTION**

**TABLE OF CONTENTS**

**DIVISION 11**

# GENERAL PROCESS PROVISIONS

## 1. GENERAL

### 1.1 Definitions and Interpretations

.1 Where the term "Provide" is used herein, it shall be understood to include labour, materials, and services necessary to supply items or work referenced.

.2 Where the terms "Instructions" or "As Instructed" or "Where Instructed", are used herein, they shall be understood to mean as instructed by the Contract Administrator including supplementary instruction notices and all comments made regarding submittals of Shop Drawings and samples for review.

.3 Where the term "Listed" is used herein, it shall be understood to mean that the materials or equipment have been tested in accordance with applicable standards and methods, have been approved and listed for the intended use by a testing authority which itself has been approved by the authorities having jurisdiction.

.4 Where the terms "Approved", or "Approval", are used herein, they shall be understood to mean approved by authorities having jurisdiction as conforming to codes, standards, bylaws, etc.

.5 Where the terms "Acceptable", or "Acceptance", are used herein, they shall be understood to mean acceptable to the Contract Administrator as generally conforming to the requirements of the Contract Documents.

.6 Where the term "Submit for Review" is used herein, it shall be understood to mean submit to the Contract Administrator.

.7 Where the term "Subject to Review" is used herein, it shall be understood to mean Work shall be laid out for review by the Contract Administrator. No Work shall proceed until instructions have been obtained from the Contract Administrator. Submit further information, Shop Drawings, samples, etc. as specified and/or as may be reasonably requested by the Contract Administrator.

.8 Where the term "Accessible" is used herein, it shall be understood to mean readily approachable by person or tools as required and where obstacles may be removed and replaced without cutting or breaking out materials.

.9 Where working pressure or pressure ratings are specified or shown on the Drawings for valves, piping, fittings, equipment, etc., these items shall be suitable for operating at specified pressures and corresponding temperature unless noted otherwise.

### 1.2 Shop Drawings

.1 Refer to Section 01300 for the general requirements for Shop Drawings.

.2 In addition to the requirements of Section 01300, submit the following specific information with Shop Drawings:

.1 Assembly Drawings showing details of connections and termination of equipment for connection by others.

.2 List of materials of construction, detailing the component parts and reference specifications (ASTM, CSA, ANSI, etc.).

.3 Motor operating data, including motor and insulation ratings, start-up and operating current ratings, operating voltage and amperage tolerances, and description of construction, complete with illustrative drawings.

.4 Gearbox and drive data, including AGMA/ABFMA ratings for components, materials of construction, tolerances and description of construction.

.5 Control schematics, text and wiring diagrams as required to describe control operations.

.6 Required ancillary services including but not limited to electrical, non-potable water and drains.

.7 Installation instructions indicating assembly and mounting requirements, alignment and assembly tolerances and points of connection for ancillary services.

.8 Start-up instructions including lubricant requirements, electrical requirements, etc.

.9 Details of coating systems to be applied.

.10 Details of insulation provided to prevent galvanic corrosion between mating surfaces constructed of dissimilar metals.

.11 A copy of the Contract Agreement process and instrumentation Drawings, with Addenda updates, that apply to the equipment marked to indicate special changes necessary for the supplied equipment. If no changes are required, mark the Drawings "No Changes Required".

.12 A copy of the related Specification Section with Addenda updates, and all referenced Sections with Addenda updates, with each paragraph check marked to show Specification compliance or marked to show deviations.

**1.3 Temporary Usage**

.1 Temporary usage by the City of any process device, apparatus, machinery or equipment prior to interim or final inspection is not to be construed as acceptance.

**1.4 Design Standards, Acceptable Products and Acceptable Manufacturers**

.1 Equipment lists included in the Specifications may be in two parts. The first part is the "Design Standard" equipment items. The second part of the list is comprised of "Acceptable Manufacturers" if the equipment of a specific Manufacturer is specified.

.2 The design has been based on the Design Standard. Quality of workmanship, dimensions, operating protocol, basic materials and ancillary services have been defined on this basis and incorporated in the design.

.3 Where Acceptable Products or Acceptable Manufacturers have been listed after a Design Standard, these products or ranges of products have been accepted by the Contract Administrator as being capable of meeting the basic functional requirements of the equipment, but may not be the same as the Design Standard in detail. Provide all ancillary services, material upgrades, etc. as necessary to satisfy the quality requirements defined by the Design Standard. Make all minor changes in arrangement, piping and electrical connections, etc. as necessary to suit the requirements of the Acceptable Products or Acceptable Manufacturers.

.4 Where Acceptable Products or Acceptable Manufacturers have been listed, but no Design Standard is listed, these products or ranges of products have been accepted by the Contract Administrator as being capable of meeting the basic functional requirements of the equipment. Provide all ancillary services and minor modifications to arrangement, piping connections, electrical connections, etc. as necessary to suit the functional requirements of the equipment.

.5 No additional payment will be made for revisions or alterations made to accommodate the equipment supplied.

## 2. PRODUCTS

### 2.1 Spare Parts

.1 Any required special spare parts not listed in the Contract Agreement shall be identified by the Contractor, with a price list.

**END OF SECTION**

**FINE BUBBLE AERATION SYSTEM**

## 1. GENERAL

### 1.1 Work Included

.1 This Section specifies the design, factory testing, supply, field testing, and commissioning of the fine bubble aeration devices.

.2 The Contractor shall design, fabricate, factory test, and deliver components and mechanisms and all other associated equipment, and appurtenances required to install a fine bubble aeration system in SBR No. 1 and SBR No. 2.

.1 The factory test shall simulate the design conditions (including but not limited to water depth, diffuser density and arrangement, and airflow). Testing procedure and arrangements shall be submitted to the Contract Administrator for review prior to beginning the test.

.3 The Contractor shall also provide Site Services for the components and all other associated equipment and appurtenances related to the installation of fine bubble aeration system in SBR No. 1 and SBR No. 2 as listed below:

.1 Delivery inspection

.2 Installation training

.3 Witnessing of equipment installation

.4 Assistance during equipment performance testing

.5 Guaranteed Performance Testing

.6 Training of City staff

### 1.2 Definitions

.1 Normal cubic metres per minute ($Nm^3/min$): the volumetric flow rate in cubic metres per minute at 20°C, 36 percent relative humidity and 101.3 kPa absolute pressure.

.2 Dynamic Wet Pressure: pressure required to operate the diffuser in tap water at the specified flow rates, less any losses due to submergence and flow control devices.

.3 Absolute pressure, kilopascals (kPaA, or kPa absolute): pressure relative to absolute vacuum of 0 kPa.

.4 Gauge pressure, kilopascals (kPa, kPag, or kPa gauge): pressure relative to normal atmospheric pressure of 101.3 kPa absolute.

.5 All terms in the description of the aeration system field testing (SOTE Testing) are as described in "A Standard for the Measurement of Oxygen Transfer in Clean Water", ASCE, June 1992.

## 1.3 Submissions

.1 Equipment Submittals

.1 All Drawing submittals shall include electronic copies in AutoCAD 2004 format.

.2 Shop Drawings: submit in accordance with Section 01300 and Section 11005. In addition to the requirements of Section 11005, include the following:

.1 A copy of this Section with check to indicate conformance or acceptance of each clause. Non-conformance shall be indicated by a cross "X".

.2 Dimensioned Drawings showing the aeration piping system including the location and elevation of diffusers, manifolds and laterals, pipe supports, expansion joints, droplegs, and purge system.

.3 Manufacturers catalogue information including diffuser type designation and operating characteristics.

.4 Details of anchorage and support design.

.5 Maximum anticipated dropleg loads which must be supported by the upper connection.

.6 Calculations establishing the maximum air flow to each sequencing batch reactor, in $Nm^3/min$, based on the specified maximum oxygen requirements for each tank, the required diffuser depth and the Manufacturer's anticipated oxygen transfer efficiency for each tank. Calculations to be signed and sealed by a Professional Engineer registered in North America.

.7 Verification of the number of diffusers proposed for each tank based on the maximum air flow per tank, and the proposed maximum air flow per diffuser and any other factors, clearly stating any other factors considered which impact the number of diffusers, signed and sealed by a Professional Engineer registered in North America.

.8 Verification that the air flow per diffuser will not vary by more than 2.5 percent within a grid at the minimum and maximum specified blower air flow rate, signed and sealed by a Professional Engineer registered in North America.

.9 Calculations to demonstrate selection of pipe type, material, and rating for the manifolds, headers, and laterals. Calculations to be signed and sealed by a Professional Engineer registered in North America.

.10 Factory testing procedures.

.11 Start-up, testing, and adjustment procedures.

.12 Installation instructions indicating assembly and mounting requirements, alignment and assembly tolerances, and points of connection for service.

.13 List of which components and materials to be shipped pre-assembled and parts lists for the other components and materials. Weights and physical dimensions to be indicated for each part, assembly, and package to be shipped.

.3 Operation and maintenance data: provide for incorporation in O&M Manuals, as specified in Section 01300. Include complete description of operation together with general arrangement and detailed Drawings; parts catalogues, with complete list of repair and replacement parts with section drawings, illustrating the connections and identifying numbers.

.4 Detailed aeration system design: based on the basic design parameters contained in this Section and the verified performance characteristics of the aeration devices proposed, undertake detailed design of the aeration system and submit Drawings and any other explanatory information, signed and sealed by a Professional Engineer registered in North America.

## 1.4 Service Conditions

.1 Diffusers are to be installed into sequencing batch reactors and therefore air will be directed to the diffusers intermittently. Provide diffusers suitable for intermittent operation.

.2 Due to the use of ferric chloride at the North End Water Pollution Control Centre, the contents of the sequencing batch reactors will have an average chloride concentration of 550 mg/L. All material shall be resistant to chloride corrosion.

.3 Wastewater temperature

.1 Average 22°C to 28°C

.2 Maximum 36°C

.3 Minimum 15°C

.4 Relative humidity at maximum temperature: 55 percent

.5 Relative humidity at minimum temperature: 100 percent

.6 Barometric pressure: 98.2 kPa(A) (Altitude 230 m)

.7 Process air temperatures:

.1 Minimum process air temperature: $15^{o}$C (below covers and when blower not running)

.2 Maximum process air temperature: $125^{o}$C

.3 Maximum differential air temperature: 110 °C

**1.5 Shipment, Protection, and Storage**

.1 Ship equipment pre-assembled to the degree practicable.

.2 Provide storage instructions indicating specific requirements to ensure there is no uneven wear, distortion, weathering of components or any other deterioration of the components.

.3 Identify all other special storage requirements.

## 2. PRODUCTS

**2.1 Description**

.1 The fine bubble aeration devices provide air to SBR No. 1 and SBR No. 2.

.2 Furnish equipment under this Section to supply diffused air to sequencing batch reactors which performs nitrification and nitrification-denitrification of centrate generated by the North End Water Pollution Control Center Sludge Dewatering Building.

.3 Each sequencing batch reactor is equipped with three aeration grids.

.4 The process air to each sequencing batch reactor is supplied by its own dedicated positive displacement blower system. Air rates in each sequencing batch reactor will be varied independently to maintain the desired dissolved oxygen concentration.

.5 Mechanical mixers (supplied by others) will operate only during anoxic periods when aeration is not required.

**2.2 Acceptable Manufacturers**

.1 Supply products modified as necessary by the Manufacturer to provide the specified features and to meet the specified operating conditions.

.2 Acceptable manufacturers are:

.1 ITT Sanitaire

.2 Environmental Dynamics Inc.

.3 ABS Nopon Oy Ltd.

.4 OTT GmbH

.3 Provide all fine bubble aeration devices by one manufacturer.

## 2.3 Capacities and Performances

.1 Design the aeration system to achieve the minimum Standard Oxygen Transfer Efficiency (SOTE) for each sequencing batch reactor when operating at the most severe condition. The most severe condition is defined as the maximum standard oxygen transfer rate (SOTR), the minimum residual dissolved oxygen (DO), maximum ambient temperatures, and maximum mixed liquor temperatures. Exceed the following minimum SOTE in each sequencing batch reactor:

| | SOTR ($kgO_2/hr$) | Minimum SOTE (%) | Water depth (from tank floor) (m) | Residual DO (mg/L) |
|---|---|---|---|---|
| Maximum Condition 1 | 1572 | 41.8 | 7.0 | 2.0 |
| Maximum Condition 2 | 1572(1) | 37.2 | 6.3 | 2.0 |
| Average Condition 1 | 1361 | 42.4 | 7.0 | 2.0 |
| Average Condition 2 | 1361(1) | 37.7 | 6.3 | 2.0 |
| Average Condition 3 | 1361 | 31.9 | 5.1 | 2.0 |

(1) To be used for calculating air flow in Form E

.2 Airflow from blower system:

.1 Maximum: 252 $Nm^3$/minute per sequencing batch reactor

.2 Minimum: 63 $Nm^3$/minute per sequencing batch reactor

.3 Air into each blower will be filtered through a cleanable and replaceable dry type line size, inline air filter suitable for 120 percent of the design volume, and capable of retaining at least 98 percent of particles 10 microns or larger (by others).

.4 Maximum air temperature from blower system: 125°C (at maximum water depth and minimum blower speed)

.5 The system shall be designed to require not more than 70 kPa at the flanged connection on the dropleg, above the liquid level, as indicated on the Drawings, after the diffusers have been in service for a minimum of one year.

.6 Set elevation of top of diffuser at a minimum distance above the sequencing batch reactor floor as required to meet specified SOTE and system pressures.

.7 Tank dimensions and critical liquid elevations are indicated on the Drawings.

.1 Due to imperfections in construction, the floor elevation may not be perfectly level in each sequencing batch reactor. Provide mounting system to ensure that the diffuser grids are level and at a minimum elevation as required in 2.3.6.

.8 Provide sufficient allowance for head losses through manifold and distribution laterals, and for diffuser fouling.

## 2.4 Materials

.1 General

.1 Select material appropriate for the high chloride concentration

.2 Select materials appropriate for the specified air and mixed liquor temperatures.

.3 Flexible membranes: EPDM, or silicone

.4 Diffuser holders: polypropylene, PVC, or CPVC

.5 Droplegs: stainless steel, Type 316 L to ASTM A774 and ASTM A778, flanged

.6 Manifolds and headers: stainless steel, PVC or CPVC, as appropriate for the conditions. It is the responsibility of the Contractor to select material type and rating for the piping appropriate for the conditions.

.1 If stainless steel is used, provide Type 316 L to ASTM A774 and ASTM A778.

.2 If PVC or CPVC is used, provide minimum schedule 40.

.7 Gaskets: Neoprene or natural rubber

.8 Distribution laterals: CPVC or PVC SDR-26 to CSA B137.3 or stainless steel, Type 316 to ASTM A774 and ASTM A778. It is the responsibility of the Contractor to select material type and rating for the piping appropriate for the conditions.

.9 Piping supports and anchors: stainless steel, Type 316 embedded in concrete with Sika injection gel or approved equal, use antisieze compound on all stainless steel bolts and nuts

.10 Fasteners: stainless steel, Type 316

.11 Ensure materials conform to ASTM specifications where possible. State all deviations.

.12 All stainless steel components must be pickled and passivated.

.2 Flexible Membrane

.1 Fabricate diffuser membranes of EPDM or silicone, protected against UV, chemicals and weathering

.2 EPDM Membrane

.1 Provide membranes constructed from EPDM-based polymer having a minimum thickness of 2 mm after moulding and finishing. Provide EPDM or silicone membrane material having the following properties:

.2 Minimum tensile strength: 7000 kPa

.3 Minimum elongation: 300 percent

.4 Testing in accordance with ASTM D412

.1 Maximum change allowed in durometer Shore A: 10 points

.2 Maximum loss of tensile strength: 25 percent

.3 Maximum loss of elongation: 25 percent

.5 Testing in accordance with ASTM D395

.1 Maximum compression set: 50 percent

.3 Silicone Membrane

.1 Provide a membrane free of softeners (softeners can be harmful to the environment and cause adverse health effects). Provide FLEX*SIL*® or equal.

.2 Provide a silicon membrane with a tensile strength of 35 N/mm or higher (ASTM D 624 B), and a temperature resistance of up to 140°C.

.3 Provide membranes with a homogenous wall thickness and no grooves.

.4 Provide membranes with a high quality uniform perforation at 80 percent of the circumference of the membrane.

.3 Diffuser Holders

.1 Manufacture diffuser holders of polypropylene, PVC, or CPVC, with additives as necessary to satisfy the requirements for temperature, strength, durability, and UV resistance.

.4 Pipe, Supports and Fittings

.1 For CPVC and PVC piping and fittings: Minimum SDR 26, conforming to CSA B137.3. All joints for CPVC and PVC piping and fittings are joined either with integral anti-rotational fixed joints or full faced solvent welded using primer and solvent welding cement conforming to the requirements of ASTM D2564.

.2 For CPVC and PVC submerged air manifolds: ASTM D1784 and ASTM D1785 Schedule 40 with 1.5 percent titanium dioxide UV inhibitor.

.3 For PVC and CPVC distribution laterals: ASTM D1784 and ASTM D1785 Schedule 40, or ASTM D224, or ASTM D3034 with minimum SDR 26 with 2 percent titanium dioxide UV inhibitor.

**2.5 Equipment Components**

.1 General

.1 Number of aeration diffuser grids per sequencing batch reactor

.1 SBR No.1: 3 grids

.2 SBR No.2: 3 grids

.2 The layout and distribution of diffusers shown on the Drawings are for illustration purposes only. Design the diffuser grids as necessary to meet the requirements of this Specification, within the floor coverage limitations shown.

.3 For each aeration system, supply:

.1 Aeration diffusers

.2 Connection devices between the diffusers and the distribution laterals

.3 Distribution laterals

.4 Manifold piping

.5 Droplegs (to limits identified on the Drawings)

.6 Reducers, if required, between the piping supplied by others and the droplegs provided by the Contractor.

.7 All structural piping supports for items 2.5.1.3.1 through 2.5.1.3.6 required to minimize deflection under installation and operating loads.

.2 Flexible Membrane Diffusers

.1 Provide diffusers of the non-clog flexible membrane type. Diffusers shall be of one of the following configurations:

.1 Circular disk:

.1 Each diffuser to be mounted to a fixed piping grid fastened to the floor of the tanks. Space the diffusers on the piping grid to provide uniform air distribution over the floor of the tanks.

.2 Tubular:

.1 Each diffuser assembly shall consist of two tubes, a minimum 1000 mm long.

.2 Diffuser membranes shall be fully supported over full length and circumference with a PVC, CPVC, polypropylene, or stainless steel support frame. Diffuser membrane shall be held in place by two Type 316 stainless steel clamps. Membranes shall be perforated on top half of unit.

.3 Diffuser mount saddle assembly shall be heavy-duty ABS or polypropylene construction. Saddle mount shall fully encompass air distribution piping reinforcing pipe wall at diffuser connection. Saddle shall attach directly to diffuser assembly.

.2 Incorporate devices or otherwise design the system to ensure even air flow distribution among all diffuser units and to assure that airflow to any one device is ±5 percent of the average value at the minimum and maximum specified air flow rates.

.3 Ensure that all diffusers are of the same type.

.4 Fix the membrane to the membrane holder in a manner which does not introduce unbalanced stresses but which does increase pressures as the air flow rate to the diffuser rises.

.5 Design the diffuser such that when air flow ceases, backflow into the diffuser and air piping is prevented when the aeration system is off.

.6 Ensure the maximum diffuser flux rate is such that the stress in the diffuser material is within elastic loading limits with a safety factory of at least 10.

.3 Manifold and Air Distribution Piping:

.1 Design air distribution piping system for easy field installation and include provisions for level adjustment, for rotational adjustment of the distribution laterals, and for thermal expansion of all piping elements over the specified operating temperature range.

.2 Perform all solvent welding in the manufacturer's shop. Field solvent welding will not be permitted.

.3 Fabricate the submerged air manifold in sections up to 7500 mm long.

.4 Design the manifold piping so that the top of all diffusers is held at a constant elevation throughout the tanks. Use eccentric reducers if changes in diameter are required.

.5 Provide a solvent-welded end cap at the end of each manifold.

.6 Provide connections between sections of the submerged air manifold of fixed pipe couplings designed so that individual manifold sections can be rotated independently of adjacent sections for proper alignment.

.7 Provide fixed joints of the positive locking type with integral anti-rotational mechanism in conjunction with guide-type supports. A fixed joint shall be either a PVC threaded coupling with threaded ring, or 150-lb ANSI flange joint. Slip on rubber sleeve couplings shall not be acceptable. Expansion will take place by the sliding of the lateral pipe through the non-gripping supports.

.8 In lieu of fixed joints with guide-type supports, a piping system utilizing fixed-type supports may be provided. Expansion will take place by the sliding of lateral pipe inside the expansion barrel. To insure no horizontal or rotational movement of the lateral and expansion joints, every lateral and expansion joint shall be secured to the tank floor by at least one pipe support.

.9 Support each manifold by floor-mounted stainless steel anchors and supports at maximum 2500 mm centres.

.10 Connect distribution laterals to the centerline of the manifold at the flanges or couplings provided.

.11 Provide coupled connections at the manifold bottom centreline for connection to the distribution laterals.

.12 Distribution laterals are to be connected to the centreline of the manifold at the couplings provided.

.13 Fabricate laterals for fine bubble diffuser systems in sections not to exceed 6000 mm in length.

.14 Maximum spacing between diffuser laterals for the disk type membrane is 2400 mm. In any event, the lateral spacing shall be provided to meet performance requirements.

.4 Droplegs:

.1 There are three aeration grids per sequencing batch reactor. Provide one dropleg per grid (three per sequencing batch reactor) as indicated on the Drawings.

.2 Fix the dropleg with a fixed joint at the lower connection to the manifold piping.

.3 Supply a flanged connection at the top of the dropleg (refer to the Drawings).

.4 Supply the dropleg with supports to prevent movement.

.5 Provide a 12 mm pressure test (PT) plug at the top of each dropleg. The test plug will be capable of receiving a probe 3 mm nominal outside diameter and rated for zero leakage at a pressure to 200 kPa.

.6 Provide droplegs of diameter no less than indicated on the Drawings.

.5 Anchors and Supports:

.1 Provide support system to securely anchor the manifold and distribution laterals to the tank floor.

.2 Design supports to permit complete removal from the tank (less anchor bolts) to facilitate cleaning and maintenance of tank floor. Supports consisting of threaded rods anchored to tank floor are not permitted.

.3 Support rods shall have a minimum diameter of 12.5 mm and shall not extend above the top of the diffusers. Trimmed rods shall be ground down to eliminate sharp edges.

.4 Support plates shall have minimum thickness of 4.8 mm.

.5 Provide pipe clamps incorporated into supports with minimum thickness of 1.8 mm. Provide each support with a 38 mm wide bearing surface contoured to fit the pipe being supported. For the guide type supports, provide a 6 mm clearance around the pipe and have chamfered edges to prevent binding of the pipe. Worn gear clamps are not permitted for attaching pipe to supports.

.6 Provide supports such that the overall geodetic elevation of the diffusers is constant, regardless of any variations in the tank floor.

.7 In addition to providing supports that accommodate any change in floor elevation over the length and width of the sequencing batch reactor, supports shall have provision for angular alignment adjustment and for ±37 mm of vertical adjustment to allow level installation. Supports to be infinitely adjustable within its limits by raising and lowering of nuts on threaded support rods or by modifying angle of support struts.

.8 Design supports to take into account the height of the supports in their structural design.

.9 Design and fabricate the supports in such a manner that the elevation of the horizontal surfaces of all diffuser elements in each tank are within ±5 mm of a common horizontal plane.

.10 Provide sufficient supports to limit deflection of the laterals to ensure that the tolerance noted on the elevation of diffuser elements is not exceeded.

.11 Secure the supports to the floor with stainless steel expansion-type anchor bolts designed with a pull-out strength safety factor of 10 or more.

.12 Supports shall be designed to withstand forces from mixers and mixed liquor recycle and flow from across tank partition wall draining holes during filling and draining of tanks.

.13 Provide bracing struts for supports in sequencing batch reactors subject to horizontal forces from pumps, or mixers.

.14 For each anchor bolt provide double stainless steel nuts. Each anchor is to be double-nutted to ensure that the connection does not loosen due to dynamic forces through its life.

.6 Purge System:

.1 Design the purge system to drain the entire submerged aeration piping system and blow off moisture collected using aeration air. Provide a minimum of one purge system per grid.

.2 Design the purge system to prevent water infiltration in the event of an interruption in the air supply.

.3 At the end of each aeration grid, install the continuous moisture purging system. Ensure that the continuous moisture purging system is lower than the invert of the air distribution header and air distribution manifold.

.4 Provide a sump and airlift purge eductor at each purge point.

.5 Provide integral drain lines with each grid terminating at the sumps.

.6 Provide purge system eductor piping fabricated of minimum 19 mm CPVC or PVC Schedule 80, or 19 mm flexible tube encased in a minimum 38 mm Schedule 40 CPVC or PVC pipe.

.7 Provide a lever-operated quarter-turn stainless steel ball valve at each blow off.

.8 In addition to the normal clamp system, provide stainless steel clamps on each end of the 25 mm flexible hose, at the connection to the diffuser header and at the connection to the CPVC or PVC pipe, on all purge lines in the sequencing batch reactor.

## 2.6 Protective Coatings

.1 Pickle all stainless steel surfaces to remove carbon deposits, grease, and oil, and to aid the regeneration of a uniform corrosion resistant chromium oxide film. Pickle by means of a full immersion passivation bath.

## 2.7 Spare Parts

.1 Provide, as a minimum, the following spare parts for the first two years of operation:

.1 Diffuser elements and assemblies: 2 percent of total

.2 Diffuser holders: 1 percent of total

.3 Piping supports: 50

.4 Plugs for unused diffuser locations: 10 percent of total

.5 Distribution lateral fixed joints: 1 percent of total

.6 Distribution lateral repair couplings: 20

.7 Four (4) purge valves meeting the requirements of 11531 2.5.6.7

## 3. EXECUTION

### 3.1 Equipment Delivery Schedules

.1 The Contractor agrees to have complete Shop Drawings and other detailed Drawings and descriptive matter for the equipment and materials delivered to the Contract Administrator for review within 21 calendar days from receipt of the reviewed Shop Drawings.

.2 Equipment Delivery Schedule refer to D11 Part D: Supplemental Conditions.

### 3.2 Fabrication

.1 Prevent electrolytic action between dissimilar metals and materials.

.2 Where dissimilar metals are mated, isolate all mating surfaces and bolts, nuts and washers to prevent galvanic corrosion.

.3 Clean and coat surfaces that are to be assembled or bolted together for shipment.

.4 Provide match markings on sections for ease of field erection.

### 3.3 Contractor's Representative

.1 The Contractor's Representative shall be required to attend the Site to train operating and maintenance staff, to witness installation and field testing to ensure the equipment is installed and operated as intended.

.2 The minimum periods of site attendance are identified in the following clauses along with the Form to be completed on each of these trips. A "day" is defined as eight working hours on-site. The trips can be combined into a single trip including a total of six days on-site.

.1 Equipment installation witnessing

.1 Duration: 3 days

.2 Form: 102

.2 Field testing assistance

.1 Duration: 2 days

.2 Form: 105

.3 Operator and maintenance training

.1 Duration: 3 day

.2 Form: T1

.3 The total number of trips will depend on the Installation Contractor's schedule. The cost of additional trips required by the Contract Administrator will be borne by the Installation Contractor.

**3.4 Installation Training**

.1 The Contractor shall train the Installation Contractor in the proper installation methods of the equipment in conformance with the requirements of Section 01650.

**3.5 Installation Witnessing**

.1 The Contractor shall verify that the Installation Contractor installs the equipment plumb, square and true within tolerances specified by the Contractor and as indicated in the Contract Documents.

.2 Structural Test

.1 Test anchors and supports of manifold and air distribution piping to ensure that they have a margin of safety of 10 against calculated buoyant forces. Test anchors and supports of stainless steel manifold and air distribution piping to ensure that they have a margin of safety of 2 against calculated buoyant forces.

.2 Upon installation of the anchors and supports and prior to the installation of piping, test all of the supports for the manifold piping and randomly test 10 percent of the supports for the air distribution piping. Test the anchors and supports in the presence of the Contract Administrator.

.3 Test each support with a lever placed on a fulcrum. Apply the static load to the opposite end of the lever, producing a vertical extracting force on the support anchor equal to either 10 times or 4 times the calculated maximum buoyant force to which the support anchors will be subjected, depending on the pipe material as detailed above.

.4 Structural testing shall include operation of the mixers to ensure the proper installation of the aeration equipment. Operation of the mixers can be undertaken as either part of the Installation Witnessing or field testing, as agreed upon between the Contractor and the Contract Administrator.

.5 Repair or replace supports not meeting the test requirements, and retest in the presence of the Contract Administrator. Test an additional 10 supports for each deficient support.

.3 Leakage and Leveling Tests:

.1 Flood the tanks with clear water to the top of the diffusers. Check the level of the diffusers to ensure that they are at the same elevation to within ±5 mm.

.2 Flood the tanks with clear water to a depth 300 mm above the top of the diffusers. (Note that effluent water is acceptable for use; however, batch chlorination may be required for safety reasons). Turn on a blower and supply air evenly to all manifolds. Visually inspect the surface of the water in the presence of the Contract Administrator to ensure that the airflow is uniformly distributed across the tanks with no air leakage from the piping or diffuser connections.

.3 Repair any leaks in the element holders, elements, piping or the like. Repeat test until the installation is free of any air leaks.

.4 Place each aeration tank in operation with clean water to the design operating depth. Set the blower air flows for maximum and minimum in accordance with the oxygen requirements specified herein.

.5 Measure and record the pressure at each dropleg. The maximum value to be accordance with the requirements specified herein. Provide all taps and pressure sensing devices necessary to perform this test.

.4 Conform to the requirements of Section 01650.

## 3.6 Field Testing

.1 The intent of the field test is to prove compliance with the basic design requirement of achieving at least the minimum SOTE values at the most severe conditions, as listed in the specification Section 2.3 and submitted by the Contractor in the Bid form. The field test will be undertaken using only “clean” water.

.2 Unless otherwise specified, the Installation Contractor will bear the cost for the water and the power used during the field testing.

.3 Contractor to provide the services of an independent testing agency for a minimum of two days duration to witness testing.

.4 Contractor to provide sufficient chemicals and make available the necessary instrumentation for a series of performance verification tests conducted in accordance with “A Standard for the Measurement of Oxygen Transfer in Clean Water”, ASCE.

.5 The Installation Contractor shall provide a means of isolating the tanks to be tested. The internal basin wall is designed for hydrostatic loads.

.6 With the assistance of the Installation Contractor, the Contractor shall conduct one test run in each sequencing batch reactor tank. Conduct tests at 100 percent of the design maximum air flow rate, ±5 percent. If one test fails, retest in the same tank that failed.

.7 Provide a written summary of the test procedures and results. Analyze the results in the manner prescribed in the ASCE Standard and clearly indicate the SOTE value calculated for the test results.

.8 The Contract Administrator will assess the results of the field testing to determine whether the installed aeration system is capable of delivering the specified SOTE. Should the results prove unacceptable, the field test will be redone at no cost to the City.

.9 If the tests demonstrate that the diffusion equipment fails to provide the specified SOTE or fails to distribute air flow uniformly or exceeds the maximum operating pressure requirements, as specified, the Contractor shall provide additional or replacement equipment or make modifications to remedy the deficiency at no cost to the City.

.10 The equipment must be completely retested after addition or modification at no delay or expense to the City.

.11 If the equipment fails to meet performance requirements after the second test, the City may, at their option, accept the equipment with a penalty paid to the City, or replace the equipment with that of an alternative supplier. The Contractor will incur all costs due to replacement and testing.

.12 At the successful completion of the field test, complete Form 105 as specified in Section 01650.

## 3.7 Operator Training

.1 Conform to the requirements of Section 01665.

## FORM F: LIFE CYCLE COST PAGE 1 OF 3

(See B11)

Form F: Life Cycle Cost will be completed by the Contract Administrator and is included for information purposes only.

Life cycle cost will be calculated based on a twenty-year period using a discount rate of four and a half percent and based on information provided in the following tables.

| | Average SOTR[2] (kg/hr) | Guaranteed SOTE (%)[1] | Water Depth ( from tank floor) (m) |
|---|---|---|---|
| SBR No.1 | 1361 | | 6.3 |
| SBR No.2 | 627 | | 6.3 |

1. Guaranteed SOTE (%) as per Form Q

2. The operating conditions of one of the SBRs may be different to the other; hence the different average SOTR values for life cycle cost analysis.

Note: Refer to Part E: Specifications for definition of terms and acronyms.

## FORM F: LIFE CYCLE COST PAGE 2 OF 3
(See B11)

Form F: Life Cycle Cost will be completed by the Contract Administrator and is included for information purposes only.

| **CAPITAL COSTS** | | |
|---|---|---|
| 1B | Total Price (from Form B) | |
| 2B | Related Structural, Process Equipment, Instrumentation and Electrical Costs based on Equipment Plan and Section Drawings Provided by Supplier and Specific to the North End Water Pollution Control Centre Upgrade | Estimate to be provided by the Contract Administrator, if required |
| | **TOTAL CAPITAL COSTS (1B+2B)** | **$** |

| **ANNUAL POWER COST** | | | |
|---|---|---|---|
| | | **SBR No.1** | **SBR No.2** |
| 1C | Annual Operation, Hours | 5110 | 7300 |
| 2C | Total Evaluated Power(1) | | |
| 3C | Power Cost | $0.05/kW-hr | $0.05/kW-hr |
| 4C | **TOTAL POWER COSTS PER SBR (1C x 2C x 3C)** | **$** | **$** |
| 5C | **TOAL POWER COST (4C(SBR No.1)+4C(SBR No.2))** | **$** | |

| **ANNUAL MAINTENANCE COST** | | |
|---|---|---|
| 1D | Diffuser Membrane Replacement Cost(2) | |
| 2D | Number of Membranes Installed | |
| 3D | Average Diffuser or Tube Life, yr | |
| 4D | Time Required to Change Each Membrane, hours | 0.06 |
| 5D | Labour Cost, $/hr | **$**50.00 |
| 6D | Average Number Replaced per year (2D/3D) | |
| 7D | **TOTAL MAINTENANCE COST ((1D x 6D) + (4D x 5D x 6D))** | $ |

| | | |
|---|---|---|
| | **TOTAL ANNUAL COST (5C + 7D)** | ***$*** |

## FORM F: LIFE CYCLE COST PAGE 3 OF 3

(See B11)

FORM F NOTES:

1. Total evaluated power will be calculated using information on guaranteed SOTE provided by Bidder, as follows:

$$P = \frac{wRT_1}{29.7ne} \times \left[ \left(\frac{p_2}{p_1}\right)^{0.283} - 1 \right]$$

Where:

w = weight of flow of air, kg/s

$$Qair = \frac{SOTR}{\rho \times f \times SOTE \times 1440} \text{ Nm}^3/\text{min}$$

w = (Qair x ρ) / 60

ρ: density = 1.2015 kg/m$^3$
f: oxygen fraction by weight = 0.232
T = 15°C

R = 8.314 kJ/k mol °K

$T_1$ = Absolute inlet temperature, °K

n = (k-1)/k = 0.283 for air

29.7 = constant for SI units conversion

e = efficiency, normal range is 0.7 to 0.9

e = 0.72

p1 = absolute inlet pressure, atm

p1 = patm – inlet headlosses estimated at 3kPa
$p_{atm}$ = 98.4 kPa

p2 = absolute outlet pressure, atm

p2 = patm + D + H
$p_{atm}$ = 98.4 kPa
D: average diffuser submergence = 5.7 m
H: blower backpressure = line losses (calculated by Contract Administrator) + required pressure at the dropleg from Form Q

2. Diffuser membrane replacement cost will be calculated based on guaranteed useful life of the diffuser membranes N1 provided in Form Q and cost for diffuser membranes provided in Form F.

**END OF SECTION**