

**SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF THIRTEEN
(13) LABORATORY ANALYTICAL INSTRUMENTS FOR PUB WATER QUALITY
DEPARTMENT**

	Page
1. Content Page	RS-1
2. General Specifications	RS-2 to RS-6
3. Technical Specifications	
a) Specifications for Schedule I	RS-7 to RS-12
b) Specifications for Schedule II	RS-13 to RS-16
c) Specifications for Schedule III	RS-17 to RS-25
d) Specifications for Schedule IV	RS-26 to RS-33
e) Specifications for Schedule V	RS-34 to RS-42
f) Specifications for Schedule VI	RS-43 to RS-50
g) Specifications for Schedule VII	RS-51 to RS-57
h) Specifications for Schedule VIII	RS-58 to RS-63
i) Specifications for Schedule IX	RS-64 to RS-67
j) Specifications for Schedule X	RS-68 to RS-74
k) Specifications for Schedule XI	RS-75 to RS-84
l) Specifications for Schedule XII	RS-85 to RS-89

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF THIRTEEN (13) LABORATORY ANALYTICAL INSTRUMENTS FOR PUB WATER QUALITY DEPARTMENT

GENERAL SPECIFICATIONS

1. GENERAL

- a. This tender consists of **twelve (12)** Schedules of supply of laboratory analytical instruments. **Tenderers are invited to price for the Schedule they want to offer only. If there are no offer for any Schedules, the Tenderers shall indicate “No Quote” for that Schedule in the Form of Tender and GeBIZ.**
- b. The General Specifications for all Schedules in this Contract shall be read in conjunction with the Specifications for each of the Schedules I to XII as stated in the listed pages in previous content page. A commissioning report shall be submitted within 3 working days after the service completed for PUB WQD’s verification.

2. SCOPE OF TENDER

The tender calls for the supply, delivery, installation and commissioning of thirteen (13) laboratory analytical instruments to PUB Water Quality Department at 82 Toh Guan Road East, WaterHub, Singapore 608576.

3. SCHEDULES OF SUPPLY OF LABORATORY ANALYTICAL INSTRUMENTS

The twelve (12) Schedules of supply of laboratory analytical instruments in this tender are as follows:

Schedule I	Supply, Delivery, Installation and Commissioning of One (1) Unit of Flow Cytometer
Schedule II	Supply, Delivery, Installation and Commissioning of One (1) Unit of Floor Standing High-Speed Centrifuge
Schedule III	Supply, Delivery, Installation and Commissioning of One (1) Unit of Automated Biochemical Oxygen Demand (BOD) System
Schedule IV	Supply, Delivery, Installation and Commissioning of One (1) Unit of Automated Chemical Oxygen Demand (COD) System
Schedule V	Supply, Delivery, Installation and Commissioning of One (1) Unit of Fluorescence Microscope
Schedule VI	Supply, Delivery, Installation and Commissioning of One (1) Unit of Automated Digestion System with Accessories
Schedule VII	Supply, Delivery, Installation and Commissioning of One (1) Unit of Total Organic Halides Analyzer System with Accessories

- Schedule VIII Supply, Delivery, Installation and Commissioning of One (1) Unit of Multi-Detector Low Background Alpha/ Beta Counting System with Accessories
- Schedule IX Supply, Delivery, Installation and Commissioning of One (1) Unit of Microplate Reader System
- Schedule X Supply, Delivery, Installation and Commissioning of One (1) Unit of Gas Chromatography-Triple Quadrupole Mass Spectrometer (GC-MS/MS) System
- Schedule XI Supply, Delivery, Installation and Commissioning of **Two (2) Units** of Ultra High Performance Liquid Chromatography-Triple Quadrupole Mass Spectrometers (UHPLC-MS/MS)
- Schedule XII Supply, Delivery, Installation and Commissioning of One (1) Unit of Automated Solid-Phase Extraction (SPE) System

4. DEVIATIONS

The Technical Specifications should be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be deemed as compliance with the requirements of the Technical Specifications.

5. INSURANCES AND CLAIMS PROCEDURE

- a) The Contractor shall note that the Board has made special arrangements under the Contract for the following insurances:
 - i. Contractor's All Risks including Third Party Insurance
- b) In the event of any claims, the Contractor shall comply with the Claims Procedure for Contractors' All Risks Insurance included in Supplement 1

6. VALIDITY OF TENDERS

Tenders are to be valid for a period of **one hundred and twenty (120) days** from the final date for submission of tenders stipulated in the Tender Notice. The Board reserves the right to recall fresh tenders before the expiry of the validity period of the tender.

7. SECURITY-RELATED REQUIREMENTS

7.1 Use of Virus-Free Electronic Media

- 7.1.1 The Contractor shall install, configure and commission the Antivirus software provided by the Board.
- 7.1.2 The Contractor shall warrant that all storage media and software capable of being stored on such media supplied as software or used in performance of the service shall not contain any unauthorised code.
- 7.1.3 The Contractor shall conduct a complete and thorough scan for Unauthorised Code using anti-virus software packages on all software and materials provided under this Contract.
- 7.1.4 The Contractor shall indemnify the PUB fully against all costs incurred in the course of or incidental to removing the unauthorised codes and recovering any lost or damaged data or software.
- 7.1.5 In this Clause 7.1.4: “Unauthorised Code” means any virus, Trojan Horse, worm logic bomb or other software routine or hardware components designed to permit unauthorised access, to disable, erase, or otherwise harm software, hardware or data or to perform any such actions.

7.2 Authentications

- 7.2.1 Account lockout shall be implemented when the maximum number of 10 or less failed authentication attempts is reached.
- 7.2.2 The following features shall be implemented when using password:
 - a. Enforce passwords to be made up of at least 12 characters and contain characters from at least two of the following four categories:
 - i. Upper case (A through Z);
 - ii. Lower case (a through z);
 - iii. Digits (0-9);
 - iv. Special Characters (!, \$, #, %, etc.).
 - b. Enforce password change once every 12 months;
 - c. Prohibit password reuse for a minimum of 3 generations;
 - d. Ensure passwords are not displayed in clear;

- e. Enforce password change upon the first login;
- f. Limit consecutive failed authentication attempts that can be made on a single account to 10 times or less

7.3 Account and Access Control

7.3.1 The Contractor shall install, configure and commission the following software items with complete documentation:

- a. The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights; and
- b. Operating system and necessary system component.

7.3.2 Access to the Systems shall be controlled and granted on a need-to basis. An access control matrix shall be implemented to enforce this requirement.

7.3.3 Create limited account for user, to differentiate the administrative rights to prevent excessive rights given to user and unauthorized installation of software without going through change management process.

7.3.3 Conduct regular reviews of accounts and the associated access rights in the Systems to ensure that unused or obsolete accounts and accesses are removed in a timely manner:

7.3.5 All accounts and accesses to the Systems shall be granted through the authentication mechanism.

7.3.6 Suspend the account when it is unused for at least 90 days, where applicable.

7.3.7 Delete the access rights from the Systems when they are no longer needed in a timely basis to prevent unauthorized access.

[Note: Both accounts and the associating access rights must be removed from the System when they are no longer needed. However, under the circumstance that the account must be retained (such as for traceability of accountability, etc.), then at a minimum, the access rights of these accounts must be deleted from the affected Systems, where applicable.]

7.3.8 All successful and failed accesses to the System shall be logged.

7.4 Standards and Policy Compliance

- 7.4.1 The Contractor shall note the policies, standards and guidelines issued by the Board subsequently and shall comply unless better proposals are provided and accepted by the Board.
- 7.4.2 For all proposals relating to security measures, the Contractor shall provide the performance impact analysis and include all necessary resources required to implement the measures.

7.5 Physical & Logical Access

The Contractor shall adhere to the physical and logical access standards and procedure established by the Board.

7.6 Contractor's Proposal and Responsibilities

If the Services cause any undesirable changes or modifications to the functionality of any Computer System, the Contractor shall at its own costs, take the necessary remedial action within the time frame set by the Board. If the Contractor is unable to effect the necessary repairs or remedial action, the Board shall engage a third party; and all costs shall be recoverable from any monies due to the Contractor or as a debt due from the Contractor in any court of competent jurisdiction.

8. MEASURES FOR COVID-19

The Contractor shall comply with all relevant Authorities' requirements including any latest amendments thereof that are imposed in relation to COVID-19 pandemic so as to enable the Contractor to fulfil all its obligations under the Contract. All costs incurred in compliance with this requirement shall be deemed to be included in the tender price.

TECHNICAL SPECIFICATIONS

1. SPECIFICATIONS FOR SCHEDULE I

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF FLOW CYTOMETER

1.1 SCOPE OF SCHEDULE

- 1.1.1 This schedule calls for supply, delivery, installation and commissioning of one (1) unit of flow cytometer system to PUB, Water Quality Laboratory, 82 Toh Guan Road East, WaterHub, Singapore 608576.
- 1.1.2 All quotes provided by the suppliers shall include all delivery charges, handling fees, etc if applicable.
- 1.1.3 All offers shall clearly state the product information and specifications and/or submitted with attached brochures, without which the offers may be rejected.
- 1.1.4 Full details of the response time and delivery upon receipt of Purchase Order shall be provided.

1.2 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 1.2.1 Supply, delivery, installation and commissioning of one (1) unit of flow cytometer system as specified in Clause 1.3.
- 1.2.2 Provision of all necessary accessories as specified in Clause 1.3 including any other accessories required for the installation and commissioning of the system.
- 1.2.3 Provision of comprehensive training on the operation of the supplied unit by authorized specialist from the manufacturer.
- 1.2.4 Carrying out all other work not specified herein for the successful commissioning of one (1) unit of flow cytometer system.

1.3 TECHNICAL SPECIFICATIONS

The Flow Cytometer System shall include the following features:

1.3.1 Flow Cytometer

- 1.3.1.1 Laser excitation at 488nm & 640nm with laser profile 10 x 75µm
- 1.3.1.2 Capable to detect at least four (4) colours, including FITC, PE, PerCP-CyTM5.5, and APC, BD Horizon BrilliantTM Blue 515 with changeable optical filters
- 1.3.1.3 High fluorescence sensitivity: MESF <75 (FITC) and <50 (PE)
- 1.3.1.4 Data acquisition rate up to 10,000 events/second

- 1.3.1.5 Signal processing: 24-bit data path
- 1.3.1.6 Reliable instrument performance with automated QC
- 1.3.1.7 Automated sample loader for
 - 48-well plates
 - 96-well plates
 - 96-deep-well plates
 - 24-tube rack for standard 12 x 75mm tubes
- 1.3.1.8 Data Acquisition Rate: Up to 10,000 events/second
- 1.3.1.9 Small footprint for easy transportation
 - Dimension: 11 x 14.75 x 16.5-inch
 - Weight: 13.6kg
- 1.3.1.10 Portable, capable to power by battery power bank
- 1.3.1.11 Capable to incorporate with an Oncyt module (<http://oncyt.com/new/products-services/discrete-on-line-flow-cytometry/>) for automated sampling, staining and data acquisition

1.3.2 Data Management

PC is to be provided by awarded tenderer and **it shall come with a three (3)-year warranty.**

- 1.3.2.1 Computer workstation with pre-installed data analytic software
- 1.3.2.2 Remote graphics software (RGS) for Z
- 1.3.2.3 Z2 Mini Serial Port Adaptor
- 1.3.2.4 Z2 Mini G4 Entry Kit US
- 1.3.2.5 Data analytic software shall be upgraded at no extra cost whenever a new version is available
- 1.3.2.6 Wired keyboard and mouse business slim keyboard US
- 1.3.2.7 Processor and Memory
 - Intel Core i7-8700 Entry 3.2/4.6 6C 65W or higher
 - Intel UHD 630 Core Graphics or higher
 - 16GB (1x16GB) DDR4 2666 SODIMM NECC or higher
- 1.3.2.8 Hard Drive and Data Storage Options
 - Turbo Drive 512GB 2280 TLC SSD with remote graphics software (RGS) or higher
- 1.3.2.9 Operating System: Microsoft Windows 10 Enterprise/ Professional (64-bit) or equivalent with BitLocker Encryption
- 1.3.2.10 Display and USB Ports
 - LAN Port Flex IO
 - 135 Watt EPS3-pin
 - Mini Serial Port Adapter

1.3.3 Additional Requirements for Contractor-Supplied PC

1.3.3.1 Setup

- a) The Contractor shall setup the systems, computers and laptops according to the Board's requirements.
- b) The Contractor shall not setup connections (such as Internet connections) unauthorized by the Board for the systems, computers and printers. Wireless connection shall be disabled.
- c) The Contractor shall install the anti-virus software provided by the Board on the system.
- d) The Contractor shall supply latest software with license for perpetual use unless the principal software product vendor does not supply software license for perpetual use or the Board has stated otherwise in the specifications.

1.3.3.2 Hardening

The Contractor shall harden the systems, computers and laptops (such as hardening of operating systems and database) supplied in this contract. The purpose for hardening is to secure systems, computers and laptops by reducing its surface of vulnerability. This includes the removal of unnecessary software, unnecessary IDs and disabling or removal of unnecessary services.

1.3.3.3 Patching

- a) The Contractor shall ensure that the latest patch had been applied to the system prior to production environment.
- b) The Board shall implement periodic security patches according to the timeframe stated below and submit monthly patch status reports.

Type of Patch	Deployment upon availability of Patch
Emergency	24 hours
High	Two months
Medium / Low	Three months

- c) The Board shall implement security patches during a security alert period according to the timeframe stated below:

Type of Patch	Implementation Timeframe (inclusive of testing)	Reporting Timeframe
Emergency	Within 12 hours	Immediate
Critical	Within 1 day	

- d) The Contractor shall support in the resolution of issues that have occurred due to the implementation of the security patches. This shall include reinstallation of the software during warranty period.

1.3.3.4 Log Management

Logs shall be retained for at least 1 year to facilitate incident response investigation.

1.3.3.5 Secure Erasure

- a) The Board shall have the right to conduct a secure erasure by such means as the Board deems fit on any or all hard disks before they are removed from PUB premises for repair or replacement, if the Board deems this to be necessary for security reasons. Secure erasure may entail the physical destruction of the hard disks. The Board shall not be liable to the Contractor for the destruction of or damage (whether caused intentionally, negligently or otherwise) to any hard disk resulting from the secure erasure.
- b) Without prejudice to the generality of any provisions on warranties, or to any other rights and remedies of the Board, where the removal of a hard disk results from a defect covered by the Contractor's warranty obligations or is done for the purpose of facilitating the repair of or investigation into any such defects or any suspected existence of such defects pursuant to the Contractor's warranty obligations:
 - i. the secure erasure of a hard disk shall not render the warranty for any Product (including the hard disk involved even if the hard disk is destroyed or damaged beyond repair by the secure erasure), void or inapplicable; and
 - ii. where the hard disk is destroyed or damaged beyond repair as a result of such secure erasure, the Contractor shall provide a replacement of the destroyed hard disk to PUB without charge and the replacement hard disk so provided shall be subject to the warranty provisions for the remainder of the Warranty Period applicable to the Product to which the destroyed or damaged hard disk belonged.
- c) The hard disk shall be retained by PUB, if necessary, at no additional cost.

1.3.4 Training

The Contractor shall provide hands-on comprehensive training either at the PUB laboratory or at their local training centre at the Contractor's own cost. The training program shall at least include hands-on operation, trouble shooting and routine maintenance of the flow cytometer system. One set of training materials (softcopy or

hardcopy) shall be provided for each trainee. **Details of the training program and schedule** shall be submitted together with the tender.

1.3.5 Power Requirement

- 1.3.5.1 All cables, plugs and wires necessary for the equipment to function must be supplied by contractor.
- 1.3.5.2 Plugs shall fit Singapore's standard requirement.
- 1.3.5.3 The power supply should be 200 - 240 VAC, 50/60 Hz, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the system will be placed.

1.4 REQUIREMENTS TO CONNECT TO STARLIMS

- 1.4.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 1.4.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 1.4.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

1.5 DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Supplier in the Schedule of Deviations. Suppliers shall supply all items as listed in Clause 1.3 above. Absence of comment in the Supplier's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. Details of these deviations shall be furnished in the Schedule of Deviations.

1.6 WARRANTY

- 1.6.1 The Flow Cytometer System and accessories supplied shall be guaranteed against inaccuracy, poor performance and workmanship for a period of 12 months from the date of successful commissioning of the system.
- 1.6.2 During the warranty period, the Contractor shall provide on-site breakdown services, and supply and replacement of parts at the Contractor's cost.

- 1.6.3 Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned.
- 1.6.4 All labour costs shall deem to be included in the tender.
- 1.6.5 Contractor shall provide full details in their tender proposal of after sales services and comprehensive user training of the System supplied.

1.7 HANDOVER

- 1.7.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following
 - a. latest Microsoft security patches
 - b. latest anti-virus definition updates
 - c. hardening documentations
 - d. backup and recovery procedures and mechanisms (includes image)
- 1.7.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following
 - a. Issues resolution
 - b. backup and recovery procedures and mechanisms (includes image)

1.8 PLACE AND PERIOD OF DELIVERY

The supplier shall supply, deliver and install the Flow Cytometer System according to the requirements as specified in Clause 1 to PUB, Water Quality Laboratory, 82 Toh Guan Road East, WaterHub, Singapore 608576 within 4 months from Date of Commencement as specified in the Letter of Acceptance

2. SPECIFICATIONS FOR SCHEDULE II

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF FLOOR STANDING HIGH-SPEED CENTRIFUGE

2.1 SCOPE OF SCHEDULE

- 2.1.1 This schedule calls for supply, delivery, installation and commissioning of one (1) unit of floor standing high-speed centrifuge to PUB, Water Quality Laboratory, 82 Toh Guan Road East, WaterHub, Singapore 608576.
- 2.1.2 All quotes provided by the suppliers shall include all delivery charges, handling fees, etc if applicable.
- 2.1.3 All offers shall clearly state the product information and specifications and/or submitted with attached brochures, without which the offers may be rejected.
- 2.1.4 Full details of the response time and delivery upon receipt of Purchase Order shall be provided.

2.2 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 2.2.1 Supply, delivery, installation and commissioning of one (1) unit of floor standing high-speed centrifuge as specified in Clause 2.3.
- 2.2.2 Provision of all necessary accessories as specified in Clause 2.3.3 including any other accessories required for the installation and commissioning of the system.
- 2.2.3 Provision of comprehensive training on the operation of the supplied unit by authorized specialist from the manufacturer.
- 2.2.4 Carrying out all other work not specified herein for the successful commissioning of one (1) unit of floor standing high-speed centrifuge.

2.3 TECHNICAL SPECIFICATIONS

The floor standing high-speed centrifuge shall include the following features:

2.3.1 The centrifuge

- 2.3.1.1 Control system shall be touchscreen interface and shall have the following features:
 - a) Simple set-up with large, bright interactive touchscreen for all functions
 - b) Multiple programs in the library
 - c) Integrated rotor calculator for protocol modifications and transfers

- 2.3.1.2 Capacity
 - a) Capable to house fixed angle rotors with holding capacity of 4 x 1000mL
 - b) Capable to house swinging bucket rotors with holding capacity of 4 x 1000mL, 40 x 50mL or 96 x 15mL conical tubes
- 2.3.1.3 Speed
 - a) Minimum speed: 500 rpm
 - b) Maximum speed: at least 24,000 rpm
 - c) RCF (relative centrifugal force) shall be up to 68,000 $\times g$
- 2.3.1.4 Operation temperature range shall be -10 to 40°C
- 2.3.1.5 Shall have at least 9 acceleration and deceleration modes
- 2.3.1.6 The drive system shall be high torque with brushless motor
- 2.3.1.7 Ergonomic design with the following features:
 - a) Optimal working height of 860mm
 - b) Integrated surface workspace
 - c) Comply with global safety standards without need to bolt down instrument
 - d) Quiet performance (< 59 dBA)
 - e) Door opens fully and automatically using door open bar
- 2.3.1.8 Performance range : 500 - 24,000 rpm or RCF 7,068 - 68905 $\times g$ at -10°C - 40°C
- 2.3.1.9 The system shall be compact with footprint 95 x 70 x 85 cm (H x W x D), or less
- 2.3.1.10 Touch screen with LCD display
- 2.3.1.11 Safety Features :
 - a) The system shall be tested under the Consumer Protection Safety Requirements in Singapore
 - b) The system shall bear the Safety Mark for use in Singapore

2.3.2 Rotors

- 2.3.2.1 Shall have at least 10 options to meet various applications
- 2.3.2.2 Rotor Locking System shall be Auto-lock
- 2.3.2.3 No tool required when changing rotors
- 2.3.2.4 Auto recognition with immediate identification of rotor when changing rotor
- 2.3.2.5 Rotor specifications shall be automatically loaded into centrifuge
- 2.3.2.6 Shall be lightweight designed for the fixed angle rotors
- 2.3.2.7 Shall be lifted and carried easily and safely
- 2.3.2.8 Shall have Biocontainment certification by authorized party

2.3.3 Accessories

- 2.3.3.1 Three (3) fixed angle rotors that are compatible with the centrifuge supplied according to Clause 2.3:
 - 2.3.3.1.1 Fiberlite 4 x 1000mL rotor: speed up to 9,500 rpm and RCF up to 16,000 $\times g$
 - a) Shall include 4 x 1000 mL fiberlite PPCO high performance bottles with nylon cap and PP Plug
 - b) Shall include four (4) adaptors for using 500mL Corning™ Disposable

Conical Bottle

2.3.3.1.2 Fiberlite 6x 500mL rotor: speed up to 12,000 rpm and RCF up to 24,000 *xg*

- a) Shall include 6 x 500 mL fiberlite PPCO bottles with PPGF cap and PP Plug
- b) Shall include four (4) adaptors for using 250mL Corning™ Disposable Conical Bottle

2.3.3.1.3 Fiberlite 12x 50mL rotor: speed up to 20,000 rpm and RCF up to 50,000 *xg*

2.3.3.2 One (1) swinging bucket rotor that are compatible with the centrifuge supplied according to Clause 3, with accessories:

- a) Stainless steel swing out rotor
- b) Capacity: 4 x 1000 mL
- c) Speed shall reach up to 5,500 rpm with 1500 g per bucket
- d) Four (4) aluminum buckets
- e) Clickseal biocontainment lids (4x)
- f) O-ring replacement kit for clickseal lids (4x)
- g) Rotor stand
- h) Replacement for double biocontainment vessel for 50mL conical tube
- i) Replacement biocontainment cap for double biocontainment vessel for 50mL conical tube (1x)
- j) Replacement O-ring for biocontainment cap for double biocontainment vessel for 50mL conical tube (4x)
- k) Four (4) adaptors for 4 x 1000 mL polypropylene wide-mouth bio-bottles with 126mm x 140mm (ØxL) with 1place/adaptor, and 4 x 1000 mL polypropylene wide-mouth bio-bottles
- l) Four (4) adaptors for 4 x 500 mL corning™ conical bottles with bottle dimensions as 98mm x 133mm (ØxL) with 1place/adaptor, and 4 x 500 mL polypropylene wide-mouth bio-bottles
- m) Four (4) adaptors for 250mL corning conical bottles with bottle dimensions of 62mm x 145mm (ØxL), 1 place/adaptor
- n) Four (4) adaptors for 50 mL conical tissue culture centrifuge tube with tube dimensions of 29.5mm x 116mm (ØxL), 10 places/adaptor
- o) Four (4) adaptors for 15mL conical tissue culture centrifuge tube with tube dimensions of 17.5mL x 121mL (ØxL), 24 places/adaptor
- p) Anti-corrosive oil, lubricant for metal parts

2.3.3.3 Detailed instruction manual

2.3.4 Training

The Contractor shall provide hands-on comprehensive training either at the PUB laboratory or at their local training centre at the Contractor's own cost. The training program shall at least include hands-on operation, trouble shooting and routine

maintenance of the flow cytometer system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee. **Details of the training program and schedule** shall be submitted together with the tender.

2.3.5 Power Requirement

- 2.3.5.1 All cables, plugs and wires necessary for the equipment to function must be supplied by contractor.
- 2.3.5.2 Plugs shall fit Singapore's standard requirement.
- 2.3.5.3 The power supply should be 200 - 240 VAC, 50/60 Hz, 30A electrical line directly or suitable to be connected to the existing power point of the laboratory where the centrifuge will be placed.
- 2.3.5.4 External transformer is not acceptable.

2.4 DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Supplier in the Schedule of Deviations. Suppliers shall supply all items as listed in Clause 2.3 above. Tenders shall not be evaluated if there is only partial offer for items in Clause 2.3. Absence of comment in the Supplier's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. Details of these deviations shall be furnished in the Schedule of Deviations.

2.5 WARRANTY

- 2.6.1 The centrifuge and accessories supplied shall be guaranteed against inaccuracy, poor performance and workmanship for a period of 12 months from the date of successful commissioning of the system.
- 2.6.2 During the warranty period, the Contractor shall provide on-site breakdown services, and supply and replacement of parts at the Contractor's cost.
- 2.6.3 All labour costs shall deem to be included in the tender.
- 2.6.4 Contractor shall provide full details in their tender proposal of after sales services and comprehensive user training of the System supplied.

2.6 PLACE AND PERIOD OF DELIVERY

The supplier shall supply, deliver and install the Flow Cytometer System according to the requirements as specified in Clause 2.3 to PUB, Water Quality Laboratory, 82 Toh Guan Road East, WaterHub, Singapore 608576 within 4 months from Date of Commencement as specified in the Letter of Acceptance.

3 SPECIFICATIONS FOR SCHEDULE III

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF AUTOMATED BIOCHEMICAL OXYGEN DEMAND (BOD) SYSTEM

3.1 OVERVIEW OF THE AUTOMATED BOD SYSTEM

The Automated BOD system shall improve laboratory testing efficiency and productivity, and to provide quality and consistency of test results.

- 3.1.1 The supply of Automated Biochemical Oxygen Demand (BOD) system shall be able to perform analysis workflow as specified in Clause **3.1** and the scope of work specified in Clause **3.2**, and the system shall comply with the technical specifications specified in Clause **3.3**.
- 3.1.2 The automated BOD system shall be able to analyse various water matrices, ranging from reservoir water, raw water, treated water, sludge and effluent water etc.
- 3.1.3 Process Overview is as follows. Procedure step marked with “#” is performed by the user; other steps are carried out entirely by the automated system.
 - a) User place 1L sample bottles (uncapped) in the sample bottle rack of system, and the BOD bottles (capped with stopper) in the BOD bottle rack of system[#]
 - b) User enter identities and dilutions in the software batch table, and allocate positions of BOD bottles for each sample has to be dispensed into[#]
 - c) User starts the system to begin analysis[#]
 - d) The allocated BOD bottle from a specified position is de-capped
 - e) The BOD bottle is filled with specified volume of seed and 4 salt solutions (phosphate buffer, magnesium sulfate, calcium chloride, ferric chloride). No reagent shall be spilled.
 - f) The water sample in 1L sample bottle is stirred to homogenize the sample. A specified volume of sample (according to the dilution factor) is transferred into the allocated BOD bottle from a specified position. No sample shall be spilled. If dilution is required, a specified amount of dilution water (according to the dilution factor) is added into the BOD bottle. The BOD bottle should be filled completely to a mark with the aid of a level detection sensor.
 - g) The filled BOD bottle is then stirred and the initial dissolved oxygen (DO) and temperature are measured by a DO probe (auto switch on stirring mechanism controlled by software) and meter. Replace any displaced contents with enough diluted sample or dilution water to fill the bottle completely to a mark with the aid of a level detection sensor.
 - h) The filled BOD bottle is capped tightly with a stopper. There should not be any air gap / bubble in the BOD bottle.
 - i) Steps (d) to (h) are repeated for the whole batch of samples.

- j) The racks holding the filled and capped BOD bottles are placed in a 20°C incubator in a dark environment for 5 days[#]
- k) After 5 days of incubation, the racks are placed back on the automated BOD system[#]
- l) User starts the system to continue batch analysis[#]. The data software system shall be able to save data and track the existing batch of samples which has been incubated.
- m) Each BOD bottle is de-capped, stirred, and the final dissolved oxygen (DO) and temperature are measured by a DO probe (auto switch on stirring mechanism controlled by software) and meter. The BOD bottle is then capped.
- n) Step (m) is repeated for the whole batch of samples
- o) In between samples and measurements, the probes, stirrers, needles, dispensers are automatically rinsed thoroughly with deionized water to avoid cross contamination.
- p) The BOD value for each sample is then automatically calculated and results are displayed in the data system. The calculation method shall adhere to APHA 5210B method, 23rd edition.

3.2 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 3.2.1 One (1) unit of automated BOD system which can perform BOD analysis in accordance with APHA 5210B method, 23rd edition. It shall carry out the overview of sample processing and BOD analysis are stated in Clause 3.1.3. Sample throughput of the system: at least 10 samples are analysed in 1 hour or better.
- 3.2.2 One (1) unit of YSI MultiLab ProOBOD IDS 626500 probe (or equivalent) and YSI MultiLab meter (or equivalent).
- 3.2.3 To include all lab renovation work needed such as removing existing lab furniture to install the automated BOD system, install piping to connect the automated BOD system with the source of compressed air if compressed air is required for running of system. Any installation of piping shall meet safety standards.
- 3.2.4 Data software system
- 3.2.5 PC will be provided by PUB. The Contractor must ensure the instruments are synchronised with the instrument software after installation
- 3.2.6 Others necessary for installation and commissioning of the automated BOD system

3.3 TECHNICAL SPECIFICATIONS

Robotic system proposed shall comprise of the following and meet the following specifications:

- 3.3.1 Sample throughput: at least 10 samples are analysed in 1 hour or better.
- 3.3.2 Size dimension of the whole robotic system (exclude PC) should not be more than 200 cm (length) by 80 cm (depth) by 110 cm (height).
- 3.3.3 Moving mechanism shall have safety protection features in accordance to national guidelines, such as CE Mark Certification or equivalent (eg. enclosed system, locked protective covers, emergency stop button etc.)
- 3.3.4 Sample bottle racks shall be provided to place at least 20 of 1L sample bottles. The system must be capable of handling the following bottles (**at least one bottle type** shown in *Table 1*). Sample bottles are not required in this tender.

Table 1: 1L sample bottles in Water Quality Laboratory

Type	Dimensions	Photo
1L capacity, plastic bottle	Bottle diameter: 90mm Bottle height: 208mm Cap diameter: 66mm Cap height: 30mm	
1L capacity, glass bottle	Bottle diameter: 90mm Bottle height: 249mm Cap diameter: 33mm Cap height: 18mm	

- 3.3.5 BOD bottle racks shall be removable for loading and unloading, and compatible to accommodate at least 36 BOD bottles (Wheaton or Kimble or other proposed type of 300ml BOD bottles). One additional set of BOD bottle racks to accommodate at least 36 BOD bottles are required.
- 3.3.6 If other types of BOD glass bottle and/or stopper (NOT Wheaton or Kimble 300ml BOD bottle and stopper) are proposed to be analysed by the automated BOD

system, at least 100 BOD incubation glass bottles and/or stopper of ~300 mL capacity specially designed for BOD analyses need to be provided. The bottles shall have a flared mouth to form a water seal around the stopper to prevent air from being drawn into the bottle during incubation.

- 3.3.7 Two separate stirrers to homogenize the sample in the 1L sample bottle and filled BOD bottle. The mechanical stirring shall be user adjustable in terms of speed and interval for flexibility of methods.
- 3.3.8 A calibrated dispensing system for sample; to transfer specified amount of sample (according to dilution ratio stated in batch table) from the sample bottle (uncapped) into the BOD bottle. Accuracy of the dispensing system: 1%. Calibration certificate of the dispensing system shall be provided upon commissioning.
- 3.3.9 A calibrated dispensing system for seed solution; to transfer specified amount (4ml or more) of seed solution from the stock into the BOD bottle. Accuracy of the dispensing system: 1%.
- 3.3.10 A dispensing system for dilution water; to transfer specified amount of dilution water (according to dilution ratio stated in batch table) from the stock into the BOD bottle.
- 3.3.11 Four (4) calibrated dispensing systems for 4 salt solutions; 4 separate dispensing systems are required to transfer specified amounts (phosphate buffer, magnesium sulfate, calcium chloride, ferric chloride of 300ml each) from each stock into the BOD bottle. Accuracy of the dispensing system: 1%. Calibration certificate of the dispensing system shall be provided upon commissioning.
- 3.3.12 A rinsing system for all stirrers, water level sensor, tubings and dispenser needles/parts due to addition of sample, seed, dilution water and 4 salt solutions to ensure no carryover and biological growth.
- 3.3.13 Level detection sensor: Level detection sensor to ensure that the BOD bottle is completely filled to a mark to ensure no air gap / bubble in the BOD bottle when capped with stopper.
- 3.3.14 One (1) unit of YSI MultiLab ProOBOD IDS 626500 probe (or equivalent) and YSI MultiLab meter (or equivalent) to be placed inside the robotic analyser and meet the following specifications:
 - a) Dissolved oxygen (DO) meter: 1 unit
 - b) optical DO module probe with 3-5m cable: 1 unit
 - c) Replacement sensing elements: 4 units
 - d) The optical DO module probe should fit into a standard 300ml BOD bottle
 - e) Probe shall come with auto switch on stirring mechanism, controlled by robotic software
 - f) Calibration retention within probe
 - g) Sensor type: Optical (dynamic luminescence quenching lifetime detection)
 - h) Range of DO: 0 to 50 mg/L.

- i) Accuracy of DO: 0 to 20 mg/L, ± 0.1 mg/L or $\pm 1\%$ of reading, whichever greater; 20 to 50 mg/L, $\pm 10\%$ reading (system)
- j) Resolution: 0.01mg/L 0.1% 0.1° C
- k) Range of air saturation: 0 to 500%.
- l) Range of temperature: 10 to 40° C $\pm 0.2^\circ\text{C}$
- m) Automatic temperature compensation for DO.
- n) Altitude compensation for calibration
- o) Waterproof
- p) Inbuilt data memory and storage
- q) Easy-to-read graphic display on DO meter
- r) Quick response time: 95% in 22 seconds with stirring; 95% in 40 seconds without stirring

3.3.15 Decapping device to cap or decap the BOD bottles with a stopper.

3.3.16 Data software system that shall meet the minimum specifications listed below:

- a) Definable access levels and password protection
- b) Fast set-up of sample worklist in routine operation by dragging the racks to the analyzer and selecting the required application per sample
- c) User definable sample table and print report layout
- d) Customized or pre-defined application files
- e) Addition of tubes, trays and worklist extension during the run
- f) Display status of the sequence events of the automated system (eg. Remaining time for heating/ cooling, rinsing etc.)
- g) Extensive Quality Control criteria including CLP protocols
- h) Direct data transfer or data can be exported into LIMS readable format
- i) Possibility of exporting results during analysis
- j) Automatic back-up of raw and calculated data meeting GLP criteria
- k) Automatic flagging of “out-of-range” results applying pre-defined criteria
- l) Automatic pre-dilution with a pre-dilution factor
- m) Automatic pre- and post-dilution of over range samples with a pre-defined dilution factor
- n) Auto-calculation of results based on the dilution factor written in the sample batch table
- o) Automatic sample result averaging applying pre-defined criteria
- p) Automatic start-up and shut-down using an analyses scheduler
- q) User definable seed solution volume addition
- r) Calculations compliant with APHA 5210B method, 23rd edition
- s) Software shall be compatible for use on Microsoft Windows 10 or higher operating environment

3.3.17 PC will be provided by PUB, with specifications listed below:

HP Z8 G4 Workstation

- a) Intel Xeon 4116 Processor (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
- b) 32GB (2x16GB) DDR4-2666 ECC Memory
- c) 1TB 7200 RPM Hard Drive
- d) NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
- e) Integrated DVD-RW
- f) Integrated 10/100/1000 Gigabit Ethernet
- g) HP USB Mouse
- h) HP USB Keyboard
- i) HP EliteDisplay E223 21.5-In LED Monitor (1920x1080, VGA / HDMI / DP / USB Hub)
- j) Network Adapters: Intel X550-T2 10GbE Dual Port NIC
- k) Microsoft Windows 10 Enterprise Edition 64-bit
- l) The Contractor shall setup and commission the instrument and ensure that the instrument is synchronised with the instrument software after installation.

3.3.18 Others necessary for installation and commissioning of the automated BOD system:

- a) The automated BOD system must be commissioned with the capability to analyse and measure the 5-day BOD value of glucose-glutamic acid standard provided by the laboratory in the range of 198 ± 30.5 mg/L.
- b) BOD bottles with stopper (Wheaton or Kimble 300ml BOD bottles) are NOT required as these will be provided by the laboratory. If other types of BOD bottle with stopper are proposed to be analysed by the automated BOD system, at least 100 BOD incubation glass bottles (with stopper) of ~300 mL capacity specially designed for BOD analyses are to be provided.
- c) Necessary accessories to install and commission the automated BOD system:
 - i) Cables and tubing
 - ii) connection assembly
 - iii) Pump assembly
 - iv) Any other parts or accessories required for the installation and commissioning of the system

3.4 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

3.4.1 The Contractor shall install, configure and commission the following software items with complete documentation:

- a) The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.

- b) Operating system and necessary system components
- c) Antivirus software (provided by the Board)
- d) Backup software

3.5 REQUIREMENT TO CONNECT TO STARLIMS

- 3.5.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 3.5.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 3.5.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

3.6 TRAINING

- 3.5.1 The Contractor shall provide **comprehensive hands-on training on-site at the PUB laboratory or at their local training centre at the Contractor's own cost.** The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the automated BOD system and accessories. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. **Details of the training programme and schedule** shall be submitted together with the tender.
- 3.5.2 The Contractor must be competent and able to perform trouble-shooting for unforeseen breakdown and repair for respective units. The Contractor shall provide all necessary personnel with adequate skills and required professional certification (where applicable) for the performance of the contract. Upon request by the Board, the Contractor shall provide evidence of certification and competency of the personnel assigned. The Service Engineer must be able to provide maintenance support, service and repair for the meters.

3.7 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply should be 230 V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the automated BOD system and accessories will be placed. External transformer is not acceptable.

3.8 WARRANTY

The system (inclusive of ALL hardware such as meter, probe, heater) supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of **twelve (12) months** from the date of commissioning of the system. Engineer support for software related services shall also be provided for a period of twelve (12) months after the instrument is commissioned. During the warranty period, the Contractor shall provide unlimited on-site breakdown services, supply and replacement of parts, attend unlimited times of phone calls and emails enquiries from the Board on issues concerning the instrument (inclusive of software issues). The Contractor shall respond to service calls within 1 working day and respond on-site (if necessary) within the next working day. All labour cost shall deem to be included in the tender sum.

3.9 HANDOVER

3.9.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following:

- a) Latest Microsoft security patches
- b) Latest anti-virus definition updates
- c) Hardening documentations
- d) Backup and recovery procedures and mechanisms (includes image)

3.9.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following:

- a) Issues resolution
- b) Backup and recovery procedures and mechanisms (includes image)

3.10 AFTER SALES SERVICES

The Tenderer shall provide full **details of after sales services** in his tender proposal, response time in the supply, replacement, repairing and servicing of the automated BOD system and accessories supplied. The Contractor shall respond to service calls within 1 working day and respond on-site (if necessary) within the next working day. **Tenderer without the proper licence, facility or experience to carry out the after sales services for the automated BOD system and accessories would not be considered under this tender.**

3.11 SCHEDULE OF DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the

Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Deviations.**

3.12 PLACE AND PERIOD OF DELIVERY

The Contractor shall deliver, install and commission the automated BOD system complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, #C2-19 WaterHub, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

4 SPECIFICATIONS FOR SCHEDULE IV

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF AUTOMATED CHEMICAL OXYGEN DEMAND (COD) SYSTEM

4.1 OVERVIEW OF THE AUTOMATED COD SYSTEM

The Automated COD system shall improve laboratory testing efficiency and productivity, and to provide quality and consistency of test results.

4.1.1 The supply of Automated Chemical Oxygen Demand (COD) system shall be able to perform analysis workflow as specified in Clause **4.1** and the scope of work specified in Clause **4.2**, and the system shall comply with the technical specifications specified in Clause **4.3**.

4.1.2 The automated COD system shall be able to analyse various water matrices, ranging from reservoir water, raw water, treated water, sludge and effluent water etc.

4.1.3 Process Overview is as follows. Procedure step marked with “#” is performed by the user; other steps are carried out entirely by the automated system.

- a) User place sample tubes (filled with sample) in the sample rack of system, and the COD reagent tubes (capped) in the reagent rack of system[#]
- b) User enter identities and dilutions (if necessary) in the software batch table, and allocate positions of COD reagent tube for each sample has to be dispensed into[#]
- c) User starts the system to begin analysis[#]
- d) The allocated COD reagent tube from a specified position is de-capped
- e) The water sample is stirred to homogenize the sample. A specified volume (2 mL or lesser if dilution is required) of sample is transferred into the allocated COD reagent tube from a specified position. No reagent or sample shall be spilled.
- f) The filled COD reagent tube is capped and inverted gently several times to mix.
- g) The system carry out rinsing of the sample dispensing needle and moves on to prepare the next sample. Steps (d) to (g) are repeated for the whole batch of samples. One blank (deionized water) shall be prepared and analysed for each batch of samples.
- h) The whole batch of filled COD reagent tubes are transported into the preheated (at 150°C) heater for 2 hours.
- i) After 2 hours of heating, each filled COD reagent tube is inverted several times (while still warm) and transported to the reagent rack (at allocated positions) for cooling down to room temperature.
- j) Each of the cooled COD reagent tubes (including blank containing deionized water) are transported to the spectrophotometer and COD is measured at a 420 nm wavelength (for low range COD) and 620 nm (high

range COD). The reagent tube containing blank (deionized water) should be read first to ZERO the spectrophotometer before measurement of other samples. Alternatively, the measured value for samples shall be corrected with the COD value of blank in the software.

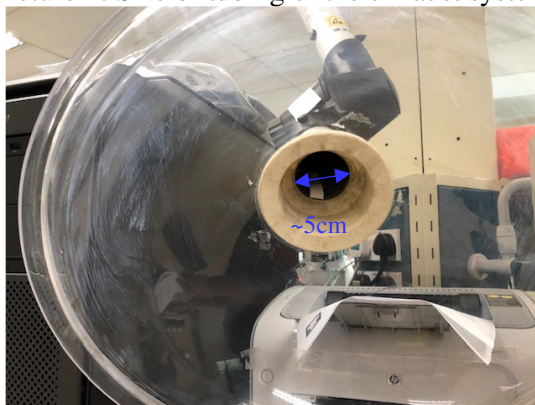
- k) In between samples and measurements, the stirrers, needles, dispensers are automatically rinsed thoroughly with deionized water to avoid cross contamination.
- l) The COD reagent tubes are transported back to the reagent racks and results (corrected with the COD value of blank) are displayed in the data system.

4.2 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 4.2.1 One (1) unit of automated COD system which can perform COD analysis in accordance with USEPA 410.4 method. It shall carry out the overview of sample processing and COD analysis are stated in Clause 4.1.3. Sample throughput of the system: at least 20 samples are analysed in 3 hours (including 2 hours heating) or better.
- 4.2.2 To include all lab renovation work needed such as removing existing lab furniture to install the automated COD system, extend piping (diameter of tubing: ~5 cm as shown in picture below) of existing exhaust system to remove hazardous vapours arising from the system, install piping to connect the automated COD system with the source of compressed air if compressed air is required for running of system. Any installation of piping shall meet safety standards.

Picture 1: Size of tubing of the exhaust system



- 4.2.3 One (1) unit of Hach DR3900 multi-wavelength Spectrophotometer (or equivalent)
- 4.2.4 One (1) unit of DRB 200 block heater (or equivalent) which can operate at $150^{\circ}\text{C} \pm 2^{\circ}\text{C}$ with wells to accommodate the COD reagent tubes (16mm in diameter, P/N: Hach 2125815 or equivalent)
- 4.2.5 Data software system

4.2.6 PC will be provided by PUB. The Contractor must ensure the instruments are synchronised with the instrument software after installation.

4.2.7 Others necessary for installation and commissioning of the automated COD system

4.3 TECHNICAL SPECIFICATIONS

Robotic system proposed shall comprise of the following and meet the following specifications:

4.3.1 Sample throughput: at least 20 samples are analysed in 3 hours (including 2 hours heating) or better.

4.3.2 Size dimension of the whole robotic system (excluding PC) should not be more than 150 cm (length) by 100 cm (depth) by 110 cm (height).

4.3.3 Moving mechanism shall have safety protection features in accordance to national guidelines, such as CE Mark Certification or equivalent (eg. enclosed system, locked protective covers, emergency stop button etc.)

4.3.4 Sample tube racks shall be removable for sample tubes loading and unloading, and compatible to accomodate at least 90 sample tubes.

4.3.5 COD reagent tube racks shall be removable for reagent tubes loading and unloading, and compatible to accomodate at least 90 COD reagent tubes of 16mm in diameter (P/N: Hach 2125815 or equivalent).

4.3.6 The whole automated COD system shall be able to carry out sample preparation, heating process and analyse COD reagent tubes of 16mm in diameter (P/N: Hach 2125815 or equivalent).

4.3.7 A stirrer to homogenize the sample in the sample tube. The mechanical stirring shall be user adjustable in terms of speed and interval for flexibility of methods.

4.3.8 A calibrated dispensing system to transfer specified amount of sample (2mL or less if dilution is required) from the sample tube into the COD reagent tube (decapped). Accuracy of the dispensing system: 1%. Calibration certificate of the dispensing system shall be provided upon commissioning.

4.3.9 A calibrated dispensing system to transfer specified amount of deionized water (according to the dilution ratio stated in the batch table) into the COD reagent tube (decapped). Accuracy of the dispensing system: 1%. Calibration certificate of the dispensing system shall be provided upon commissioning.

4.3.10 A rinsing system for the stirrer, tubings and dispenser needle(s) to ensure no sample carryover.

4.3.11 One (1) unit of digital reactor heater block (DRB 200 or equivalent) which can accomodate at least 45 COD reagent tubes (16mm vial wells) and placed in the

robotic analyser. Heating from ambient to 150°C ($\pm 2^\circ\text{C}$ fluctuation) should take less than 10 minutes. It should have a digital timer with automatic switch-off feature, audible signal and temperature feedback to the software to maintain set temperature. A calibration certificate of the heater block shall be provided.

4.3.12 A mixing system which can hold onto the COD reagent tubes and shake/ invert gently or vigorously. Force of shaking and length of shaking should be programmable.

4.3.13 Decapping device to cap or decap the COD reagent tubes.

4.3.14 One (1) unit of Hach DR3900 multi-wavelength Spectrophotometer (or equivalent) for COD measurement. It shall be placed within the robotic analyser. A calibration certificate of the spectrophotometer to be provided.

- a) Benchtop visible spectrum of at least 320 – 1100 nm, split beamspectrophotometer
- b) Operating mode: Transmittance (%), Absorbance and Concentration, Scanning
- c) Wavelength selection: Automatic, based on method selection
- d) Wavelength resolution: 1nm
- e) Compatible to Hach TNTplus™ chemistries vials, **Hach 16mm and Hach 13mm cells** (or equivalent)
- f) Perform more than 200 pre-programmed methods optimised for laboratory water analysis. An equivalent spectrophotometer shall be able to perform at least the same type and number of tests as a Hach DR3900 spectrophotometer.
- g) Sample analysis: automatic test recognition and expiration date check.
- h) Software allows elimination of lot to lot variation, and eliminates false readings/ outliers.
- i) Allows documentation of 2000 measured values (Result, Date, Time, Sample ID, User ID)
- j) Includes: Adapters, light shield, dust cover, power cords and any other necessary accessories for testing.
- k) Interfaces: USB type A, USB Type B, Ethernet
- l) Photometric Accuracy: 5mAbs @0.0 – 0.5 Abs, 1% at 0.50 – 2.0 Abs
- m) Photometric Measuring Range: $\pm 3/0$ Abs (wavelength range 340 – 900 nm)

4.3.15 Data software system that shall meet the minimum specifications listed below:

- a) Definable access levels and password protection
- b) Fast set-up of sample worklist in routine operation by dragging the racks to the analyzer and selecting the required application per sample
- c) User definable sample table and print report layout
- d) Customized or pre-defined application files
- e) Addition of tubes, trays and worklist extension during the run
- f) Display status of the sequence events of the automated system (eg.

- Remaining time for heating/ cooling, rinsing etc.)
- g) Extensive Quality Control criteria including CLP protocols
- h) Direct data transfer or data can be exported into LIMS readable format
- i) Possibility of exporting results during analysis
- j) Automatic back-up of raw and calculated data meeting GLP criteria
- k) Automatic flagging of “out-of-range” results applying pre-defined criteria
- l) Automatic pre-dilution with a pre-dilution factor
- m) Automatic pre- and post-dilution of over range samples with a pre-defined dilution factor
- n) Auto-calculation of results based on the dilution factor written in the sample batch table
- o) Automatic sample result averaging applying pre-defined criteria
- p) Automatic start-up and shut-down using an analyses scheduler
- q) Calculations compliant with US EPA 410.4 method
- r) Results shall be measured and calculated automatically with auto-correction of the blank’s COD value
- s) Software shall be compatible for use on Microsoft Windows 10 or higher operating environment

4.3.16 PC will be provided by PUB, with specifications listed below:

HP Z8 G4 Workstation

- a) Intel Xeon 4116 Processor (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
- b) 32GB (2x16GB) DDR4-2666 ECC Memory
- c) 1TB 7200 RPM Hard Drive
- d) NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
- e) Integrated DVD-RW
- f) Integrated 10/100/1000 Gigabit Ethernet
- g) HP USB Mouse
- h) HP USB Keyboard
- i) HP EliteDisplay E223 21.5-In LED Monitor (1920x1080, VGA / HDMI / DP / USB Hub)
- j) Network Adapters: Intel X550-T2 10GbE Dual Port NIC
- k) Microsoft Windows 10 Enterprise Edition 64-bit
- l) The Contractor shall setup and commission the instrument and ensure the instrument is synchronised with the instrument software after installation.

4.3.17 Others necessary for installation and commissioning of the automated COD system

- a) The automated COD system must be commissioned with the capability to analyse and detect the 100 ppm COD standard provided by the laboratory within 10% accuracy.
- b) COD reagent tube kits are NOT required as these will be provided by the laboratory.

- c) Necessary accessories to install and commission the automated COD system:
 - i) Sample tubes of plastic or glass material
 - ii) Racks for sample tubes and COD reagent tubes
 - iii) Cables and tubing
 - iv) Heater block connection assembly
 - v) Pump assembly
 - vi) Any other parts or accessories required for the installation and commissioning of the system

4.4 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

- 4.4.1 The Contractor shall install, configure and commission the following software items with complete documentation:
 - a) The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.
 - b) Operating system and necessary system components
 - c) Antivirus software (provided by the Board)
 - d) Backup software

4.5 REQUIREMENT TO CONNECT TO STARLIMS

- 4.5.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 4.5.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 4.5.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

4.6 TRAINING

- 4.6.1 The Contractor shall provide **comprehensive hands-on training on-site at the PUB laboratory or at their local training centre at the Contractor's own cost.** The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the automated COD system and accessories. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. **Details of the training programme and schedule** shall be submitted together with the tender.

- 4.6.2 The Contractor must be competent and able to perform trouble-shooting for unforeseen breakdown and repair for respective units. The Contractor shall provide all necessary personnel with adequate skills and required professional certification (where applicable) for the performance of the contract. Upon request by the Board, the Contractor shall provide evidence of certification and competency of the personnel assigned. The Service Engineer must be able to provide maintenance support, service and repair for the meters.

4.7 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply should be 230 V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the automated COD system and accessories will be placed. External transformer is not acceptable.

4.8 WARRANTY

The system (inclusive of ALL hardware such as meter, probe, heater) supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of **twelve (12) months** from the date of commissioning of the system. Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned. During the warranty period, the Contractor shall provide unlimited on-site breakdown services, supply and replacement of parts, attend unlimited times of phone calls and emails enquiries from the Board on issues concerning the instrument (inclusive of software issues). The Contractor shall respond to service calls within 1 working day and respond on-site (if necessary) within the next working day. All labour cost shall deem to be included in the tender sum.

4.9 HANDOVER

- 4.8.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following:
- a) Latest Microsoft security patches
 - b) Latest anti-virus definition updates
 - c) Hardening documentations
 - d) Backup and recovery procedures and mechanisms (includes image)
- 4.8.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following:
- a) Issues resolution
 - b) Backup and recovery procedures and mechanisms (includes image)

4.10 AFTER SALES SERVICES

The Tenderer shall provide full **details of after sales services** in his tender proposal, response time in the supply, replacement, repairing and servicing of the automated COD system and accessories supplied. The Contractor shall respond to service calls within 1 working day and respond on-site (if necessary) within the next working day. **Tenderer without the proper licence, facility or experience to carry out the after sales services for the automated COD system and accessories would not be considered under this tender.**

4.11 SCHEDULE OF DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Deviations.**

4.12 PLACE AND PERIOD OF DELIVERY

The Contractor shall deliver, install and commission the automated COD system complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, #C2-19 WaterHub, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

5 SPECIFICATIONS FOR SCHEDULE V

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF FLUORESCENCE MICROSCOPE

The fluorescence microscope and accessories supplied shall include the scope of work specified in Clause 5.1 and the microscope shall comply with the technical specifications specified in 5.2.

5.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 5.1.1 Supply, delivery, installation and commissioning of one units of fluorescence microscope as specified in 5.2.
- 5.1.2 Provision of all necessary accessories as specified in 5.2.2 and any other accessories required for the installation and commissioning of the fluorescence microscope;
- 5.1.3 Provision of comprehensive training on the operation of the fluorescence microscope at site by an authorized specialist from the manufacturer;
- 5.1.4 Carrying out all other work not specified herein for the successful commissioning of the one units of fluorescence microscope.

5.2 TECHNICAL SPECIFICATIONS

5.2.1 The Fluorescence Microscope

The fluorescence microscope should be suitable for both fluorescent and differential interference contract (DIC) microscopy.

The microscope shall consist of the following features:

5.2.1.1 Main Body of Microscope:

- a) Upright microscope stand
- b) High power LED lamp suitable for Brightfield and DIC microscopy
- c) Built in transmitted Koheler illumination for pre-centred LED illumination or equivalent
- d) Adjustable light intensity control
- e) Vertical stage movement for focusing

- f) Coarse and fine focus knob, with fine focus knob with adjustment graduations of at least 1µm or equivalent
- g) Trinocular widefield observation tube with
 - A Binocular and one camera port
 - 3-step light path selection for binocular, camera and binocular with camera
- h) Two Eyepieces
 - 10X magnification
 - Widefield
 - Focusable
- i) Revolving nosepiece with
 - At least 7 positions for objective lens
 - Slot and position for DIC components
- j) Mechanical stage with
 - Ceramic coated surface
 - Graduated
 - Right-hand low drive control, tension adjustment for X & Y movement

5.2.1.2 Objective Lens:

- a) 4X magnification objective
 - Plan Semi Apochromat objective or equivalent
 - Numerical Aperture (NA) at least 0.13
 - Working distance (WD) at least 17mm
 - Suitable for fluorescence microscopy
- b) 10X magnification objective

- Plan Extended Apochromat objective or equivalent
- NA at least 0.4
- WD at least 3.1 mm
- Chromatic aberration correction from 400nm to 1000nm or equivalent
- Suitable for fluorescence and DIC microscopy

c) 20X magnification objective

- Plan Extended Apochromat objective or equivalent
- NA at least 0.8
- WD at least 0.6mm
- Chromatic aberration correction from 400nm to 1000nm or equivalent
- Suitable for fluorescence and DIC microscopy

d) 40X magnification objective

- Plan Extended Apochromat objective or equivalent
- NA at least 0.95
- WD at least 0.18mm
- Chromatic aberration correction from 400nm to 1000nm or equivalent
- Suitable for fluorescence and DIC microscopy

e) 100X magnification objective

- Plan Extended Apochromat objective or equivalent
- NA at least 1.45
- WD at least 0.13mm
- Oil immersion
- Chromatic aberration correction from 400nm to 1000nm or equivalent
- Suitable for fluorescence and DIC microscopy

5.2.1.3 Optical Components:

a) Condenser with:

- Components suitable for Brightfield and DIC microscopy
- Rotatable turret with at least 8 positions
- Adjustable aperture iris diaphragm
- Optical element centring screws or equivalent
- Built in polariser and control or equivalent
- Swing-out, Achromat/Aplanet type dry top lens with NA 0.9 - 0.2, or equivalent

b) DIC Optical components

- DIC Prism insert for 20X, 40X and 100X objective or equivalent
- Mirror unit, slider, analyser, calibrate unit or other optical components for DIC microscopy shall be included

5.2.1.4 Fluorescence Components:

- a) Reflected light fluorescence illuminator with
 - Field stop
 - Mirror unit cassette with at least 8 positions
 - UV protection shield
- b) LED light source for fluorescence
 - Able to generate broad spectrum illumination that suitable for the following fluorophores
 - DAPI (4',6-diamidino-2-phenylindole)
 - FITC (Fluorescein isothiocyanate)
 - Texas Red
 - LED sources able to generate 3 different wavelengths of UV, blue and green light
 - Control pod to have:
 - Individual on and off control for 3 different LED wavelengths of UV, blue and green
 - Individual intensity control of 3 different LED wavelengths of UV, blue and green.
 - Unit shall have suitable adaptor to microscope
- c) Fluorescence Mirror Unit suitable for the following fluorophores
 - DAPI (4',6-diamidino-2-phenylindole)
 - FITC (Fluorescein isothiocyanate)
 - Texas Red

5.2.1.5 Microscope Digital Camera

- a) Camera with single chip color CMOS (pixel shifting) and Peltier cooling device, or equivalent
- b) Image sensor of at least 2.35 megapixel colour CMOS with global shutter or equivalent
- c) Effective image resolution up to 5760 X 3600 or equivalent
- d) Exposure time from 39 μ s to 60s and, live frame rate at least 60 fps or equivalent

- e) Have position navigation function with corresponding imaging software to enable users in keeping track of their location within the specimen from low to high magnification, without the need for a motorized or encoded stage.
- f) Suitable camera mount/adaptor for the microscope

5.2.1.6 Imaging and Analysis Software

- a) The software shall be fully compatible to the microscope camera and, support all the function of the camera
- b) The software shall have the following function
 - Overlay multiple images
 - Document groups for side-by-side image comparison
 - Movie playback
 - Tile view (multiple images in a single data set shown side by side)
 - Snap/movie acquisition
 - Time-lapse at specified interval
 - Geometry/combine/filter image processing
 - Regions and line measurement

5.2.1.7 Services and Support

- a) Shall include installation, commissioning and training
- b) Contractor shall provide demonstration units for evaluation of criteria points 5.2.1.1 – 5.2.1.6 upon request
- c) Twelve (12) months warranty for instrument upon successful installation and commissioning
- d) Strong local service support with good track record

5.2.2 Accessories

5.2.2.1 Dust Cover

5.2.2.2 Immersion Oil with low auto-fluorescence

5.2.3 PC

The PC will be provided by PUB, with the specifications listed below:

- a) Intel Xeon 4116 Processor (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
- b) 32GB (2x16GB) DDR4-2666 ECC Memory
- c) 1TB 7200 RPM Hard Drive
- d) NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
- e) Integrated DVD-RW
- f) Integrated 10/100/1000 Gigabit Ethernet
- g) HP USB Mouse
- h) HP USB Keyboard
- i) HP EliteDisplay E223 21.5-In LED Monitor (1920x1080, VGA / HDMI / DP / USB Hub)
- j) Network Adapters: Intel X550-T2 10GbE Dual Port NIC
- k) Microsoft Windows 10 Enterprise Edition 64-bit
- l) The Contractor shall setup and commission the instrument and ensure the instrument is synchronised with the instrument software after installation.

5.3 WARRANTY

- 5.3.1 The supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of twelve (12) months from the date of successful commissioning of the system.
- 5.3.2 During the warranty period, the Contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts (excluding consumable parts).
- 5.3.3 Engineer support for software related services shall also be provided for a period of twelve (12) months after the instrument is commissioned.
- 5.3.4 All labour costs shall deem to be included in the tender sum.

5.4 HANDOVER

- 5.4.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following:
 - a) Latest Microsoft security patches
 - b) Latest anti-virus definition updates
 - c) Hardening documentations
 - d) Backup and recovery procedures and mechanisms (includes image)
- 5.4.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following:
 - a) Issues resolution
 - b) Backup and recovery procedures and mechanisms (includes image)

5.5 POWER REQUIREMENTS

- 5.5.1 All cables, plugs and wires necessary for the equipment to function must be supplied.
- 5.5.2 Plugs shall fit Singapore's standard sockets.
- 5.5.3 The power supply should be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the fluorescence microscope will be placed.
- 5.5.4 External transformer is not acceptable.

5.6 AFTER SALES SERVICES

- 5.6.1 The Contractor shall provide full details of after sales services and response time in the supply, replacement, repairing and servicing of the fluorescence microscope supplied.
- 5.6.2 Contractor without the proper license, facility or experience to carry out the after sales services for the fluorescence microscope would not be considered under this tender.

5.7 SCHEDULE OF DEVIATIONS

- 5.7.1 The specifications shall be strictly complied with and any deviations shall be clearly stated by the Contractor in the Schedule of Deviations.
- 5.7.2 Absence of comment in the Contractor's submission shall be interpreted as acceptance and compliance with the requirements of the specifications.
- 5.7.3 Details of these deviations shall be furnished in the Deviations.

5.8 PLACE AND PERIOD OF DELIVERY

The Contractor shall deliver, install and commission the one unit of Fluorescence Microscope complete with accessories as specified under the Scope of Work and Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, WaterHub, Level 2, #C2-02, Singapore 608576, within 4 months from Date of Commencement as specified in the Letter of Acceptance.

5.9 USE OF VIRUS-FREE ELECTRONIC MEDIA

- 5.9.1 The Contractor shall warrant that all storage media and software capable of being stored on such media supplied as software or used in performance of the service shall not contain any unauthorised code.
- 5.9.2 The Contractor shall conduct a complete and thorough scan for unauthorised Code using anti-virus software packages on all software and materials provided under this Contract.
- 5.9.3 The Contractor shall indemnify the Board fully against all costs incurred in the course of or incidental to removing the unauthorised codes and recovering any lost or damaged data or software.

6 SPECIFICATIONS FOR SCHEDULE VI

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF AUTOMATED DIGESTION SYSTEM WITH ACCESSORIES

The supply of Automated Digestion System shall include scope of work specified in Clause 6.1 and the system shall comply with the technical specifications specified in Clause 6.2.

6.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 6.1.1 Supply, delivery and commissioning of one unit of Automated Digestion System complete with heating block, exhaust blower, multi-reagent dispensing module, reagent storage cabinet (with sliding rack arrangement), sample probe assembly and sample carrying cart.
- 6.1.2 Provision of starter and calibration kit, all necessary accessories and consumables for commissioning, calibration and performance check of the system.
- 6.1.3 Provision of comprehensive training for at least 4 laboratory staff on the use of the system.
- 6.1.4 Carrying out all other works not specified herein for the successful commissioning of the entire system.

6.2 TECHNICAL SPECIFICATIONS

6.2.1 Automated Digestion and Liquid Handling System

- 6.2.1.1 The system shall be a benchtop model and does not need use of an additional fume hood. Dimensions of system should be smaller than: (width x depth x height) 100 x 60 x 80 cm, with weight not more than 100 kg.
- 6.2.1.2 System shall have the ability to utilize heating blocks with heating power and sample vials for preparing aqueous samples for inductively coupled plasma – optical emission spectrometry (ICP-OES) and inductively coupled plasma-mass spectrometry (ICP-MS). There should be no contamination from the operation. The system shall have the possibility to use different size of vials by swapping heating blocks.
- 6.2.1.3 System shall consist of all-plastic digestion area with integral waste/ rinse station, acid scrubbing area and air purged electrically isolated electronics section. It shall be acid-resistant high-density polyethylene (HDPE) construction, eliminating metal contamination.
- 6.2.1.4 System shall have three isolated compartments: work/digestion area, air purged electronic cavity, and reagent section. Work/ digestion area serves as built-in

fume hood and accommodates continuous-flow multi-chamber wash station and dedicated reagent probe rinsing station to minimize contamination between vials.

- 6.2.1.5 System shall come with laminar flow-driven exhaust path, with automated vial cooling module, high efficiency vial ventilation module for evacuation of fumes and cooling.

6.2.2 Digestion Block

- 6.2.2.1 The digestion block shall be compliant to US EPA methods including 3005A, 3050B, 200.7 and 200.8. Teflon coated graphite designed for high temperature open vessel digestion with high digestion temperature uniformity (maximum 0.5 °C of the temperature variation throughout the block for digestion below 120 °C).
- 6.2.2.2 The digestion block shall have HDPE non-corrosive and acid resistant bases with 5-sided high-efficiency thermal shield design for heating at high temperature with a negligible temperature variation and high-power efficiency.
- 6.2.2.3 The digestion block shall have an overheat prevention feature to minimize the potential of safety hazards. Teflon-coated tray and tray holder will be included with each Block.
- 6.2.2.4 The digestion block shall be capable of heating up to 230°C, performing digestion methods for water containing solids/sediments with a heating power of 1500 W.
- 6.2.2.5 The digestion block shall be able to digest minimum 50 samples simultaneously in independent block.
- 6.2.2.6 The block shall be able to hold minimum 50 vials (50-ml, polypropylene, flat round bottom), with well internal diameter of 30 mm, well depth of at least 55 mm.

6.2.3 Liquid Handling

- 6.2.3.1 The system shall come with peristaltic pump system with one single channel pump per reagent, allowing precise and software-controlled reagent delivery.
- 6.2.3.2 The system shall have a minimum of 8 dedicated reagent lines.
- 6.2.3.3 The system shall be precise, accurate and automated pick-up and dispensing of reagents and eliminate need of reagent priming during batch.
- 6.2.3.4 The system shall simultaneously dispense multiple liquids into each vial with high accuracy.
- 6.2.3.5 The reagent dispensing accuracy shall be better than +/- 0.2 mL with a flow control between 0.5-1.5 mL/ sec.

- 6.2.3.6 The system shall have computer-controlled robotic arm capable of dispensing all reagents to each vial as per the Method in use.
- 6.2.3.7 The Robotic Arm (XY / left-right and back-front) shall be equipped with non-contact level sensor for volume make-up at the end of digestion with the reagent dispensing combination to each vial with auto levelling (bringing up to volume) accuracy of +/- 0.2 ml.
- 6.2.3.8 System shall come with Air Probe Assembly for sample mixing / homogenizing to ensure sample homogeneity. The air supply required shall be low flow rate as 1-2 L/min for 60-65 PSI.
- 6.2.3.9 System shall come with Sample Probe Assembly for sample transfer to autosampler rack, which includes transferring digested samples into Child Racks for subsequent analyses and dispensing reagents/ diluents in Child Racks.

6.2.4 Reagent Storage Cabinet

- 6.2.4.1 The system shall come with a reagent storage cabinet to provide a convenient and safe way of storing the reagent bottles that supply various reagents to the liquid handling manifold.
- 6.2.4.2 This cabinet shall be made from corrosion-resistant material and designed for spillage control.
- 6.2.4.3 The cabinet shall be able to store at least 6 bottles (2.5 L each) of reagents including acids.
- 6.2.4.4 The reagent cabinet shall be supplied with 6 Teflon reagent anchors and 6 reagent bottle caps with filter.
- 6.2.4.5 The cabinet shall come with entry port for reagent tubing and exhaust port (½" barb) for reagent fume removal.
- 6.2.4.6 The dimensions shall be easily fit under the benchtop digestion & handling system.

6.2.5 Sample Carrying Cart

- 6.2.5.1 The cart shall be of acid and corrosion free construction with heavy duty castor wheels.
- 6.2.5.2 The cart shall be capable of storing and transporting samples before and after digestion and to hold up to 20 trays loaded with samples.
- 6.2.5.3 The sample-loaded trays shall be distributed in 4 compartments accessible from both sides of the cart.
- 6.2.5.4 The dimensions shall be around (W x D x H): 71 x 71 x 127 cm. (+/- 5 cm)

6.2.6 Work Bench and Extraction System

- 6.2.6.1 Design and fabricate a workbench to accommodate the installation of digestion system and reagent cabinet. The work bench shall be able to accommodate the digestion system, reagent cabinet, operating PC and all accessories needed for operation.
- 6.2.6.2 The critical dimensions (W x D) shall not be more than 110 x 100 cm.
- 6.2.6.3 The vendor shall be responsible for connecting exhaust ducting from the Automated Digestion System to the existing exhaust ventilation system.

6.2.7 Instrument Software

- 6.2.7.1 The software shall come with intuitive user guidance by self-explanatory software, compatible with Microsoft Windows 10 operation systems.
- 6.2.7.2 The software shall be able to record data from an additional external temperature probe.
- 6.2.7.3 The software shall be capable of robotic arm integration for movement of racks to autosampler or filtration devices.
- 6.2.7.4 The software shall be capable of reagent management, prompting when reagent bottles needs replacement.
- 6.2.7.5 The software shall be capable to calculate the total time for digestion and sample work up time.
- 6.2.7.6 The software shall be capable for total automation, keeps record of each movement of robotics arm and generate detailed time stamped report.

6.2.8 Computer

- 6.2.8.1 The computer will be supplied by PUB, with the following specifications listed below. It will be used to run the instrument control software, process data, save files and generate reports. The Contractor shall setup and commission the instrument and ensure that the instrument is synchronised with the instrument software after installation.

HP ProDesk 600 G4 Desktop Mini Business PC or equivalent

- Intel Core i7-8700T Processor (2.4 Ghz, Up to 4.0GHz Max. Turbo Frequency, 12MB Cache, 6 Cores)
- 8GB (1x8GB) DDR4 SDRAM Memory
- 500GB 7200 RPM Hard Drive

- Integrated 10/100/1000 Gigabit Ethernet
- Integrated VGA, DisplayPort
- TPM chip for secure bitlocker implementation
- USB Keyboard
- USB Mouse
- Monitor
- Microsoft Windows 10 Professional 64-bit (OEM)
- Network Adapter provided

6.2.9 Gas Lines and Electric Points

- 6.2.9.1 Gas lines: The Contractor shall provide manpower and supply of all necessary fittings and materials to extend existing air or nitrogen supply line with pressure regulator (when necessary) and outlet shut-off valve, and connect it to the Automated Digestion System.
- 6.2.9.2 Electrical points and other power requirements: The Contractor shall provide manpower and supply of all necessary materials to install additional electrical points and other power requirements required by the Automated Digestion System.

6.2.10 Exhaust Blower

- 6.2.10.1 System shall come with one unit of exhaust blower to provide a sufficient air draw (160-170 L/s, i.e., 340-360 CFM)
- 6.2.10.2 The blower shall be small dimension, no more than (width x depth x height) 50 x 60 x 50 cm
- 6.2.10.3 Acid fume resistant, flexible hose shall be connected from the output port of the blower, the other end of which will discharge the exhaust contents into laboratory exhaust outlet point (such as a fume hood or another fume discharge port).

6.3 CONSUMABLES AND ACCESSORIES

The Contractor must provide at least the following extended spare parts and consumable sets, and any other necessary items needed for the complete commissioning of the system:

- 6.3.1 Teflon vial with cap, 50-ml, flat inner bottom, OD 28.5 mm, Height 110 mm, 60 pieces.
- 6.3.2 Peristaltic pump tubing for delivery of digestion reagents, 10 pieces /pack x 10 packs, or equivalent.

- 6.3.3 Sample tray: suitable for the heating block in the Automated Digestion system, plastic, acid resistant, to fill up the sampling handling cart's tray space.
- 6.3.4 Sample mixing/bubbling probes, additional 2 units (besides the units coming with the system).

6.4 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

The Contractor shall install, configure and commission the following software items with complete documentation:

- 6.4.1 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.
- 6.4.2 Operating system and necessary system components.
- 6.4.3 Antivirus software (provided by the Board).

6.5 REQUIREMENT TO CONNECT TO STARLIMS

- 6.5.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 6.5.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 6.5.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

6.6 TRAINING

Contractor shall provide **hands-on comprehensive training course at least one time for at least four (4) of the Board's laboratory staff either on-site at the PUB laboratory or at their local training centre at the Contractor's own cost.** The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the Automated Digestion System. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. Details of the training programme and schedule shall be submitted together with the tender.

6.7 WARRANTY

- 6.7.1 The system supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of at least **12 months** from the date of successful

commissioning of the system. During the warranty period, the contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts for repairs (excluding consumable parts). All labour costs shall be included in the tender sum.

- 6.7.2 Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned.
- 6.7.3 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 6.7.4 The Contractor shall re-install the software, when necessary, during the warranty period.

6.8 DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Schedule of Deviations.**

6.9 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply shall be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the system will be placed. External transformer is not acceptable.

6.10 HANDOVER

- 6.10.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following:
 - e) Latest Microsoft security patches
 - f) Latest anti-virus definition updates
 - g) Hardening documentations
 - h) Backup and recovery procedures and mechanisms (includes image)
- 6.10.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following:
 - c) Issues resolution
 - d) Backup and recovery procedures and mechanisms (includes image)

6.11 AFTER SALES SERVICES

The Tenderer shall provide full details in his covering letter of after sales services, response time and price quoted in the supply, replacement, repair and servicing of the system supplied. Tenderer without the proper facility or experience to carry out the after sales services for the Automated Digestion System would not be considered under this tender.

6.12 DELIVERY LOCATION AND LEAD TIME

The Contractor shall deliver, install and commission the Automated Digestion System complete with the requirements as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, WaterHub, Level 2, #C2-01, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

7 SPECIFICATIONS FOR SCHEDULE VII

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF TOTAL ORGANIC HALIDES ANALYZER SYSTEM WITH ACCESSORIES

The supply of Total Organic Halides (TOX) Analyzer system shall include scope of work specified in Clause 7.1 and the TOX Analyzer system shall comply with the technical specifications specified in Clause 7.2.

7.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 7.1.1 Supply, delivery and commissioning of one unit of TOX analyzer with sample preparation unit, autosampler, microcoulometry detector, software for instrument control and data analysis.
- 7.1.2 Provision of all necessary consumables, spare parts and accessories for commissioning, calibration and performance check of TOX system.
- 7.1.3 Provision of comprehensive training for the laboratory staff on the use of the system and the determination of TOX in compliance with standards methods, such as USEPA 1650C, APHA 5320B, ISO 9562 and DIN 38409-22.
- 7.1.4 Carrying out all other works not specified herein for the successful commissioning of the entire system.

7.2 TECHNICAL SPECIFICATIONS

7.2.1 General Requirement

- 7.2.1.1 The TOX analyser system supplied shall be capable of analysis of TOX or Absorbable Organic Halides (AOX), and of a laboratory bench-top system.
- 7.2.1.2 The analyser shall have a double furnace technology that enables vertical and horizontal combustion in one instrument.
- 7.2.1.3 The analyser shall comply with standards methods, USEPA 1650C, APHA 5320B, ISO 9562 and DIN 38409-22.
- 7.2.1.4 The analyser must be highly automated and enable high sample throughput.
- 7.2.1.5 The system shall have compact and space-saving design.
- 7.2.1.6 Vertical combustion mode shall come with maintenance-free gas lock to guarantee easy and trouble-free automation for AOX samples.
- 7.2.1.7 The analyser shall come with an integrated gasbox to ensure stable gas flows,

high operating safety and reliable analysis results without the need to check rotameter settings and stability visually.

- 7.2.1.8 The analyser shall come with a self-check system that has permanent control of relevant system parameters for operating safety.
- 7.2.1.9 Combustion temperature shall be up to 1100 °C.
- 7.2.1.10 The system must have functions for automatic gas shut-off, system stand-by and shut-off in case of failure.

7.2.2 Sample Preparation

- 7.2.2.1 The sample preparation unit shall be capable for adsorption according to the solid phase extraction (SPE) procedure without any manual intervention.
- 7.2.2.2 It shall be a fully automatic unit for SPE-AOX analysis according to the column method as per ISO 9562:2004, USEPA 1650C or DIN 38409-22.
- 7.2.2.3 All operation parameters including adsorb volume (10-100 mL), flow rate (3 ml/min), sample position, etc., shall be set and controlled.
- 7.2.2.4 It shall have XYZ design to avoid multi-port valve system.
- 7.2.2.5 Individually pre-selectable sample and washing volumes shall be possible.
- 7.2.2.6 The sample preparation procedure shall include sample adsorption, sample wash and tubing cleaning.
- 7.2.2.7 It shall be suitable for overnight operation without manual intervention.
- 7.2.2.8 It shall be a two-channel system which allows two samples be prepared at the same time.
- 7.2.2.9 At least 28 sample positions on the sample rack for quartz duplex column containers.
- 7.2.2.10 Built-in stirring function for every sample shall be provided.

7.2.3 Automatic Sample Introduction

- 7.2.3.1 The analyzer shall come with an autosampler for large sample throughput using the direct dosing of activated charcoal from a maximum of 112 columns for AOX determination using the column method.

7.2.4 Detector

- 7.2.4.1 The analyzer shall have a light protected coulometric cell with combination electrode based on modern ceramic technology.

- 7.2.4.2 The coulometer cell shall be compact and robust and equipped with self-cleaning for the silver anode.
- 7.2.4.3 The combination electrode shall combine indicator electrodes and generator cathode with no diaphragms or salt bridges required to guarantee minimum maintenance and provide fast readiness for operation.
- 7.2.4.4 The analyzer shall have a wide range coulometer suitable for the determination of chlorine from 1 µg to 100 µg chlorine absolute and upgradable to 1 mg Cl absolute (optional).
- 7.2.4.5 The analyzer shall have a wide dynamic measuring range with no sudden exhaustion of the electrolyte in case of unexpected high TOX concentrations in the sample.
- 7.2.4.6 The analyzer shall have an integrated cell cooling for highest sensitivity and long-term stability of analysis in case of big sample series.
- 7.2.4.7 The measurement time for TOX shall be no more than 10 min.
- 7.2.4.8 The analyzer shall have a detection limit of 1 ug Cl absolute and upgradable for 10 ng Cl absolute with high sensitive cell (optional).
- 7.2.4.9 The analyzer shall have the precision of <2% RSD at >5 ug Cl absolute, direct injection into the coulometer cell.

7.2.5 Instrument Software

- 7.2.5.1 The software shall come with intuitive user guidance by self-explanatory software, compatible with all Windows 10 operation systems.
- 7.2.5.2 The system components shall be automatically recognized and activated, methods are automatically loaded with high level of ease of use and operational safety.
- 7.2.5.3 The software shall enable comfortable data handling and clear presentation of the measurement results in individual analysis reports, as well as automated or manual data exports (LIMS, Excel etc.).
- 7.2.5.4 The software shall be able to permanently monitor the gas supply, furnace temperature, cell temperature detector signals and maintenance intervals.
- 7.2.5.5 The software shall have automatic gas shut-off to automatically shut off the carrier gas pump as the end of a sample sequence to save operating costs.
- 7.2.5.6 The software shall have automatic standby functions to save operating costs due to lower temperatures of the furnace and assure fast operating readiness.
- 7.2.5.7 The software shall have automatic system shut-off in case of failure to ensure highest operating safety.

7.2.6 Computer

- 7.2.6.1 The computer will be supplied by PUB, with the following specifications listed below. It will be used to run the instrument control software, process data, save files and generate reports. The Contractor shall setup and commission the instrument and ensure that the instrument is synchronised with the instrument software after installation.

HP ProDesk 600 G4 Desktop Mini Business PC or equivalent

- Intel Core i7-8700T Processor (2.4Ghz, Up to 4.0GHz Max. Turbo Frequency, 12MB Cache, 6 Cores)
- 8GB (1x8GB) DDR4 SDRAM Memory
- 500GB 7200 RPM Hard Drive
- Integrated 10/100/1000 Gigabit Ethernet
- Integrated VGA, DisplayPort
- TPM chip for secure bitlocker implementation
- USB Keyboard
- USB Mouse
- Monitor
- Microsoft Windows 10 Professional 64-bit (OEM)
- Network Adapter provided

7.3 GAS LINES AND ELECTRIC POINTS

- 7.3.1 Gas lines: The Contractor shall provide manpower and supply of all necessary fittings and materials to extend existing gas lines with pressure regulator (when necessary) and outlet shut-off valves for argon and oxygen, and connect the extended gas lines to the TOX Analyzer system.
- 7.3.2 Electrical points and other power requirements: The Contractor shall provide manpower and supply of all necessary materials to install additional electrical points and other power requirements required by the TOX Analyzer system.

7.4 CONSUMABLES AND ACCESSORIES

The Contractor must provide at least the following extended spare parts and consumable sets, and any other necessary items needed for the complete commissioning of the system:

- 7.4.1 Eight (8) units of combination electrodes.
- 7.4.2 Three (3) bottles of adsorbent (≥ 10 g/ bottle).

7.4.3 Ten (10) bottles (100pk/bottle) of disposable tube for TOX adsorption.

7.4.4 One connecting hose, drying vessel/coulometer cell.

7.4.5 Two (2) units of aspiration tube for sample needle.

7.5 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

The Contractor shall install, configure and commission the following software items with complete documentation:

7.4.1 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.

7.4.2 Operating system and necessary system components.

7.4.3 Antivirus software (provided by the Board).

7.6 REQUIREMENT TO CONNECT TO STARLIMS

7.6.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.

7.6.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.

7.6.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

7.7 TRAINING

Contractor shall provide **hands-on comprehensive training course at least one time for at least four (4) of the Board's laboratory staff either on-site at the PUB laboratory or at their local training centre at the Contractor's own cost.** The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the TOX analyzer system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. Details of the training programme and schedule shall be submitted together with the tender.

7.8 WARRANTY

7.8.1 The system supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of at least **12 months** from the date of successful

commissioning of the system. During the warranty period, the contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts for repairs (including all electronic boards). All labour costs shall be included in the tender sum.

- 7.8.2 Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned.
- 7.8.3 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 7.8.4 The Contractor shall re-install the software, when necessary, during the warranty period.

7.9 DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Deviations.**

7.10 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply shall be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the TOX analyser system will be placed. External transformer is not acceptable.

7.11 HANDOVER

- 7.11.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not be limited to the following:
 - a) Latest Microsoft security patches
 - b) Latest anti-virus definition updates
 - c) Hardening documentations
 - d) Backup and recovery procedures and mechanisms (includes image)
- 7.11.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not be limited to the following:
 - a) Issues resolution
 - b) Backup and recovery procedures and mechanisms (includes image)

7.12 AFTER SALES SERVICES

The Tenderer shall provide full details in his covering letter of after sales services, response time and price quoted in the supply, replacement, repair and servicing of the system supplied. Tenderer without the proper facility or experience to carry out the after sales services for the Alpha/Beta system would not be considered under this tender.

7.13 DELIVERY LOCATION AND LEAD TIME

The Contractor shall deliver, install and commission the TOX analyser system complete with the requirements as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, WaterHub, Level 2, #C2-20, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

8 SPECIFICATIONS FOR SCHEDULE VIII

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF MULTI-DETECTOR LOW BACKGROUND ALPHA/BETA COUNTING SYSTEM WITH ACCESSORIES

The Multi-Detector Low Background Alpha/Beta Counting System (Alpha/Beta system) supplied shall be a bench-top or stackable system complete with accessories and consumable materials as specified in Clause 8.3. The supply of the Alpha/Beta system shall include the scope of work specified in clause 8.1 and the Alpha/Beta system shall comply with the technical specifications specified in Clause 8.2.

8.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 8.1.1 Supply, delivery and commissioning of a low background Alpha/Beta Counting system complete with sample drawers, eight gas-flow proportional detectors, lead shield, gas line fitting and tubing, software and data handling system.
- 8.1.2 Provision of all necessary consumables, spare parts and accessories for commissioning, calibration, performance check and training of the Alpha/Beta system.
- 8.1.3 Provision of comprehensive training for at least 4 laboratory staff on the use of the system.
- 8.1.4 Carrying out all other works not specified herein for the successful commissioning of the Alpha/Beta system.

8.2 TECHNICAL SPECIFICATIONS

8.2.1 General Requirement

- 8.2.1.1 The Alpha/Beta system shall be a true multi-tasking, high performance counting system for low-level radioactivity in water and environmental samples.
- 8.2.1.2 Eight detectors integrated in the system shall be controlled individually or in group and each drawer be mechanically independent.
- 8.2.1.3 Routine use of a counting channel, including sample loading and unloading, calibration, counting and routine maintenance, shall be done without affecting other detectors in the system.
- 8.2.1.4 The electronic module shall be accessible from the front of the system without rear access required.

- 8.2.1.5 The design of the system and control software shall allow easy expansion in the field for addition of at least 4 detectors.
- 8.2.1.6 Heavy duty rack assembly or wheeled cart shall be provided to hold the Alpha/Beta system.

8.2.2 Detectors

- 8.2.2.1 All detectors shall be independent 2.25 inch diameter pancake style gas flow proportional sample detectors.
- 8.2.2.2 Each detector shall have a field replaceable (low cost) aluminized window with a nominal density of 80-100 $\mu\text{g}/\text{cm}^2$.
- 8.2.2.3 Each detector shall come with one sample carrier with inserts for 1/8 inch, 1/4 inch and 5/16 inch deep planchets.
- 8.2.2.4 Warranted background of each detector: Alpha ≤ 0.1 count per minute (cpm), Beta ≤ 0.9 cpm.
- 8.2.2.5 Efficiency of each detector (measured with a NIST-traceable standard point-source, using P-10 counting gas, 2 inch $\times$ 1/8 inch planchet in 1/8 inch insert):
Alpha (Po-210, Am-241) $\geq 38\%$;
Beta (Sr-90/Y-90) $\geq 45\%$.
- 8.2.2.6 Detector plateau:
Alpha (Po-210) slope $\leq 2.5\%$ /100 V, length $\geq 800\text{V}$;
Beta (Sr-90/Y-90) slope $\leq 2.5\%$ /100 V, length $\geq 200\text{V}$
- 8.2.2.7 Crosstalk (measured with Alpha/Beta sources):
 $\leq 1.5\%$ Po-210 Alpha into Beta channel;
 $\leq 0.1\%$ spillover of Sr-90/Y-90 Beta into Alpha channel
- 8.2.2.8 Detector uniformity: $\geq 90\%$ over active area.
- 8.2.2.9 Counting time preset: adjustable between 1 and 9999 minutes.
- 8.2.2.10 Count modes: at least two modes included, i.e., Alpha only, and simultaneous Alpha + Beta
- 8.2.2.11 Spectroscopy grade amplifiers shall be used to shape and filter the detector signals.
- 8.2.2.12 The detector shall be biased with a regulated high voltage supply and the high voltage and detector signals shall be routed through shielded cables.
- 8.2.2.13 Certificate (or report) of performance test of the detectors shall be provided.

8.2.3 Lead Shield

- 8.2.3.1 Four-inch thick newly mined (virgin) lead shield to minimize cosmic background.
- 8.2.3.2 Detectors and detector window shall be completely accessible from the system front without lifting part of the lead shield.
- 8.2.3.3 The system shall have improved inter detector shielding for zero adjacent detector crosstalk.

8.2.4 Software and Computer

- 8.2.4.1 The software controlling the Alpha/Beta system shall be Microsoft Windows-based application programmes and compatible for use with desktop PC supplied by PUB.
- 8.2.4.2 The computer will be supplied by PUB with the following specifications listed below. It will be used to run the instrument control software, process data, save files and generate reports. The Contractor shall setup and commission the instrument and ensure that the instrument is synchronised with the instrument software after installation.

Model: HP Z8 G4 Workstation

- Intel Xeon 4116 Processor
 - (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
 - 32GB (2x16GB) DDR4-2666 ECC Memory
 - 1TB 7200 RPM Hard Drive
 - NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
 - Integrated DVD-RW
 - Integrated 10/100/1000 Gigabit Ethernet
 - HP USB Mouse
 - HP USB Keyboard
 - Microsoft Windows 10 Professional 64-bit (OEM)
 - Network Adapter Card provided
- 8.2.4.3 All data for the system shall be contained in a Microsoft Access or equivalent database with a simple, reliable and intelligent design.
 - 8.2.4.4 Samples and their specific parameters shall be logged into the database as batches and linked to a pre-defined count method.
 - 8.2.4.5 Each detector shall have its own unique set of calibration records.
 - 8.2.4.6 The software shall support each sample to be counted to MDA.

- 8.2.4.7 The software shall contain comprehensive quality control (QC) functionality, e.g., Control Charts, and Trending Charts.
- 8.2.4.8 The software shall contain a set of standard reports written and designed to satisfy the majority of user application.
- 8.2.4.9 The system shall provide the connectivity option to Laboratory Information Management System (LIMS).

8.3 CONSUMABLES AND ACCESSORIES

- 8.3.1 Alpha check source: Am-241 or Th-230, immobilized on counting planchet, activity > 500 Bq.
- 8.3.2 Beta check source : Sr-90/Y-90 or Cs-137, immobilized on counting planchet, activity > 500 Bq.
- 8.3.3 Counting planchets: 2-inch stainless steel flat planchets, 1000 pieces.
- 8.3.4 A dual-stage gas regulator (stainless steel) and the tubing to connect the counter and gas supply port.
- 8.3.5 A low flow gas sensor shall be installed to monitor the system for any P-10 or equivalent gas fault and halt counting until it is corrected.
- 8.3.6 A quick disconnect, a particle filter, a critical flow orifice, a flow meter, and tubing should be supplied for the P-10 or equivalent gas flow.

8.4 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

The Contractor shall install, configure and commission the following software items with complete documentation:

- 8.4.1 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.
- 8.4.2 Operating system and necessary system components.
- 8.4.3 Antivirus software (provided by the Board).

8.5 REQUIREMENT TO CONNECT TO STARLIMS

- 8.5.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.

- 8.5.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 8.5.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

8.6 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply should be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the Alpha/Beta system will be place. External transformer is not acceptable.

8.7 TRAINING

Contractor shall provide **hands-on comprehensive training course at least one time for at least four (4) of the Board's laboratory staff either on-site at the PUB laboratory or at their local training centre at the Contractor's own cost.** The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the Alpha/Beta counting system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. Details of the training programme and schedule shall be submitted together with the tender.

8.8 HANDOVER

- 8.8.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following:
- a) Latest Microsoft security patches
 - b) Latest anti-virus definition updates
 - c) Hardening documentations
 - d) Backup and recovery procedures and mechanisms (includes image)
- 8.8.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following:
- a) Issues resolution
 - b) Backup and recovery procedures and mechanisms (includes image)

8.9 WARRANTY

- 8.9.1 The system supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of at least **12 months** from the date of successful commissioning of the system. During the warranty period, the contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts for repairs (excluding consumable parts). All labour costs shall be deemed to be included in the tender sum.
- 8.9.2 Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned.
- 8.9.3 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 8.9.4 The Contractor shall re-install the software, when necessary, during the warranty period.

8.10 AFTER SALES SERVICES

The Tenderer shall provide full details in his covering letter of after sales services, response time and price quoted in the supply, replacement, repair and servicing of the system supplied. Tenderer without the proper facility or experience to carry out the after sales services for the Alpha/Beta system would not be considered under this tender.

8.11 SCHEDULE OF DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Deviations.**

8.12 DELIVERY LOCATION AND LEAD TIME

The Contractor shall deliver, install and commission the Alpha/Beta system complete with the requirements as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, WaterHub, Level 1, #C1-23, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

9 SPECIFICATIONS FOR SCHEDULE IX

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF MICROPLATE READER SYSTEM

The supply of one (1) unit of microplate reader with accessories shall include the scope of work specified in Clause 9.1 and the system shall comply with the technical specifications specified in Clause 9.2.

9.1 SCOPE OF WORK

Supply, delivery, installation and commissioning of one (1) microplate reader with accessories. It includes the supply of labour, tools, equipment and materials to fabricate, adapt, integrate, assemble and accessories complete with on-site installation, testing and commissioning.

The scope of work shall include but not limited to the following:

- 9.1.1 Supply, delivery, installation and commission of one unit of microplate reader with accessories shall be carried out by the Tenderer.
- 9.1.2 One-time training on the operation of the multi-mode microplate reader system at site by authorized specialist from the manufacturer.
- 9.1.3 Carrying out all other work not specified herein for the successful commissioning of the entire system.

9.2 TECHNICAL SPECIFICATIONS

9.2.1 Microplate Reader System

9.2.1.1 General specifications:

- a) The Microplate Reader shall have the detection modes of UV-Vis Absorbance and Fluorescence Intensity and be compatible with various microplate formats.
- b) The Microplate Reader and related software must be compatible with Microsoft Windows 10 Operating System.

9.2.1.2 Base System Specifications:

- a) Temperature control: shall be able to control temperature from room temperature to at least 45 °C with +/- 1 °C at 37 °C.
- b) Microplate types: shall be compatible with 6- to 384-well plates (including commercial test kit plates such as the Abraxis ELISA test kit).
- c) Shaking mode shall be linear.
- d) Light source: Xenon flashlamp.

e) Detector: Photomultiplier tube (PMT).

9.2.1.3 Detection Modes:

This system shall be capable of performing UV-Vis Absorbance and Fluorescence Intensity modes.

a) Absorbance

- Wavelength range for absorbance detection shall be 200 -1000 nm (or equivalent) with 1 nm increment.
- Photometric range should be between 0 - 4.0 OD.
- Photometric accuracy should be $< \pm 0.006 \text{ OD} \pm 1\%$, 0 - 2 OD.
- Photometric precision should be $< \pm 0.003 \text{ OD} \pm 1\%$, 0 - 2 OD.

b) Fluorescence

- Dual monochromator with 1 nm increment selection.
- EX wavelength range for fluorescence shall be 250 nm – 850 nm, or equivalent
- EM wavelength range for fluorescence shall be 360 nm – 850 nm, or equivalent

9.2.2 Applications

Microplate Reader system shall be able to perform the following but not limited to ELISAs, protein assays and DNA/RNA quantitation.

9.2.3 Data Analysis Software

9.2.3.1 Data analysis shall have the full functions with easy operation.

9.2.3.2 Software must be compatible with Microsoft Windows 10 Professional Operating System.

9.2.4 Power Supplier

All cables, plugs and wires necessary for the system to work shall be supplied.

9.2.5 Computer Requirements

PC will be provided by PUB with the specifications listed below:

- HP ProDesk 600 G4 Desktop Mini Business PC or equivalent
- Intel Core i7-8700T Processor (2.4Ghz, Up to 4.0GHz Max. Turbo Frequency, 12MB Cache, 6 Cores)

- 8GB (1x8GB) DDR4 SDRAM Memory
- 500GB 7200 RPM Hard Drive
- Integrated 10/100/1000 Gigabit Ethernet
Integrated VGA, DisplayPort
- TPM chip for secure bitlocker implementation
- USB Keyboard
- USB Mouse
- Monitor
- Microsoft Windows 10 Professional 64-bit (OEM)

The Contractor shall setup and commission the instrument and ensure that the instrument is synchronized with the instrument software after installation.

9.2.6 Administrative Rights and Antivirus Software

The Tenderer shall install, configure and commission the following software items with complete documentation:

- 9.2.6.1 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.
- 9.2.6.2 Operating system and necessary system component.
- 9.2.6.3 Antivirus software (provided by the Board).

9.3 REQUIREMENT TO CONNECT TO STARLIMS

- 9.3.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 9.3.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 9.3.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

9.4 TRAINING

The Tenderer shall provide training for the users of the instruments on-site, after installation and commissioning. The Tenderer must demonstrate that it has a proven appropriate setup and capability to provide after-sales services efficiently and effectively.

The user manual and all training materials shall be provided. The Tenderer shall submit details on the training provided including expertise of the trainer. The Tenderer shall provide information relating to the limitations of the instruments for the user's laboratory.

9.5 WARRANTY

The system (both hardware and software) supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of at least 12 months from the date of commissioning of the system inclusive of parts and labour.

9.6 DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer. Absence of comment in the tender shall be interpreted as acceptance and compliance with the requirements of the specifications.

9.7 AFTER SALES SERVICES

- 9.7.1 The Tenderer shall provide full details in their tender of after sales services, response time and price quoted in the supply, replacement, repair and servicing of the microplate reader system and accessories supplied. The Tenderer without the proper facility or experience to carry out the after sales services for the microplate reader system will not be considered under this tender.
- 9.7.2 Engineer support for hardware- and software-related service shall be provided after installation, acceptance test and in cases when it is not covered by any warranty or instrument maintenance contract. This engineer support shall be for a period of 12 months, starting from the date of installation.

9.8 DELIVERY LOCATION AND LEAD TIME

The Tenderer shall deliver the specified Goods to Public Utilities Board, 82 Toh Guan Road East, #C2-21, WaterHub Building, Singapore 608576 within 4 months from the **Date of Commencement** as specified in the **Letter of Acceptance**.

10 SPECIFICATIONS FOR SCHEDULE X

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF GAS CHROMATOGRAPHY-TRIPLE QUADRUPOLE MASS SPECTROMETER (GC-MS/MS) SYSTEM

The Gas Chromatograph Triple Quadrupole Mass Spectrometer (GC-MS/MS) System supplied shall be capable of quantifying targeted organic contaminants at ultra-trace level in water samples. The supply of the GC-MS/MS system shall include scope of work specified in Clause 10.1 and the system shall comply with the technical specifications specified in Clause 10.2.

10.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 10.1.1 Supply, delivery and commissioning of one GC-MS/MS system complete with gas chromatography system with one unit of split/splitless inlet, liquid autosampler, Triple Quadrupole Mass Spectrometer with electron ionization mode and chemical ionization mode, software for instrument control, data acquisition, storage, processing and reporting, instrument installation relevant work including instrument configuration, gas line configuration and bench configuration, accessories and consumables.
- 10.1.2 Provision of starter and calibration kit, all necessary accessories and consumables for commissioning, calibration and performance check of the GC-MS/MS system.
- 10.1.3 Provision of hands-on comprehensive training for at least 8 laboratory officers at the PUB laboratory at the Contractor's own cost. The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the GC-MS/MS system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee in the beginning of the training. Details of the training programme and schedule shall be submitted together with the tender.
- 10.1.4 Carrying out all other work not specified herein for the successful commissioning of the entire system.

10.2 TECHNICAL SPECIFICATIONS

10.2.1 Gas Chromatograph

10.2.1.1 Split/splitless Inlet

- a) The GC should be supplied with one unit of split/splitless inlet.
- b) Must be suitable for all capillary columns.
- c) Split ratio set point up to 7500:1.
- d) Must support up to 2 operating modes: split, splitless.

- e) Maximum operating temperature up to 400°C.
- f) Electronic pneumatic controls, in which pressure has typical control of ± 0.001 psi for the range of 0 to 150 psi.
- g) Inlet sealing system is built in standard with each inlet for quick, easy, injector liner changes.
- h) Must be able to select carrier and makeup gas types: Helium, Hydrogen, Nitrogen or Argon.
- i) Built-in automatic carrier shutoff if the inlet pressure drops significantly, i.e. in the case of leakage.
- j) Total flow range should be settable with an upper limit of at least 500 mL/min for H₂ or He.

10.2.1.2 Oven

- a) Oven operating range can be from ambient temperature + 4°C to 450°C.
- b) Oven temperature set point resolution must be 0.1°C.
- c) Supports 20 oven ramps and negative ramps must be allowed.
- d) Oven cools down 450°C to 50°C in less than 4.0 min.
- e) Retention time repeatability < 0.008%.
- f) Area repeatability : < 1% RSD
- g) Temperature set point resolution: 0.1 °C
- h) Temperature stability for < 0.01°C for a 1°C ambient change
- i) Oven power must turn-off automatically when the lid/door is opened.

10.2.1.3 Liquid Autosampler:

- a) Must be able to house at least 150 2-mL sample vials.
- b) Must have the capability to rinse the syringe both pre and post injection with 2 separate solvents, A & B, for each solvent.
- c) Autoinjectors should be able to perform “sandwich” injection with the insertion of air gaps between multiple liquid suction.
- d) The carryover should be less than 10⁻⁴.

10.2.2 Triple Quadrupole Mass Spectrometer

10.2.2.1 Ionization Source

- a) The mass spectrometer must include sources capable of electron ionization, positive ion chemical ionization and negative ion chemical ionization.

- b) The ion sources include dual filaments, programmable from 150 to 350 °C.
- c) The MS detector should have unique technology to reduce neutral noise, ensuring a cleaner signal and lower detection limits.
- d) Should have quick vent feature to automated and rapid venting the MS.
- e) Mass Axis Stability should be $< \pm 0.1$ u over 24 hours.
- f) Both Autotune and manual tuning can be carried out.

10.2.2.2 Sensitivity

- a) EI MRM instrument detection limit (IDL) should be 0.5 fg or less octafluoronaphthalene (OFN), statistically derived at 99 % confidence level from the area precision of eight sequential splitless injections of 1 μ L, 2 fg/ μ L OFN standard (MS/MS transition of m/z 272 $\rightarrow$ 222, 100 msec dwell time).
- b) EI MRM Signal-to-noise (S/N) should be 600:1 or greater for 2 fg octafluoronaphthalene (OFN) for the transition of m/z 272 $\rightarrow$ 222.

10.2.2.3 Mass Range

The mass spectrometer must operate in the mass range of 10 - 1050 m/z.

10.2.2.4 Scan Rate

The mass spectrometer must operate at scan rate up to 20,000 u/s.

10.2.2.5 MRM Speed

MRM speed should be at least 800 transitions/sec.

10.2.2.6 Minimum MRM Dwell Time

Minimum MRM dwell time should be 0.5 msec.

10.2.2.7 Vacuum System

The mass spectrometer must have high capacity turbo molecular pump.

10.2.3 Data System and Computer

The system should incorporate Windows 10 operation system. The results generated from the GC-MS/MS system must be able to be captured by the lab's existing STARLIMS data management system seamlessly.

10.2.3.1 Data System

- a) The supplied software must have the capability of instrument control, data acquisition, data analysis, automation and customization.
- b) The software should be able to control autosampler, GC inlets, oven and detectors, etc.
- c) The software should be able to load and execute existing GCMS method, SIM and Scan directly in the GC-MS/MS system.
- d) The software should allow retention time locking or be able to identify target analyte correctly in the event where retention time has shifted from the originally supposed retention time.
- e) Data analysis functions should include integration, calibration, reporting, annotation and signal comparison.
- f) NIST 2017 mass spectral library and vendor environmental contaminants database like pesticides database, etc. MRM database (including MRM transitions, relative intensities and retention time) should be included.

10.2.3.2 Computer

PC will be provided by PUB, with specifications listed below:

HP Z8 G4 Workstation

- a) Intel Xeon 4116 Processor (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
- b) 32GB (2x16GB) DDR4-2666 ECC Memory
- c) 1TB 7200 RPM Hard Drive
- d) NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
- e) Integrated DVD-RW
- f) Integrated 10/100/1000 Gigabit Ethernet
- g) HP USB Mouse
- h) HP USB Keyboard
- i) HP EliteDisplay E223 21.5-In LED Monitor (1920x1080, VGA / HDMI / DP / USB Hub)
- j) Network Adapters: Intel X550-T2 10GbE Dual Port NIC

- k) Microsoft Windows 10 Enterprise Edition 64-bit

The Contractor shall setup and commission the instrument and ensure that the instrument is synchronised with the instrument software after installation.

10.2.4 Others

10.2.4.1 GC Mass Spectrometer must come with the following accessories:

- a) Kit for GCs gas purifiers, Includes leak detection fluid, swage-type fittings, copper tubing, syringes, screw-drivers and wrenches.
- b) Universal Helium trap.
- c) Oven exhaust deflector to deflects the oven hot-air exhaust in the back of the GC from a horizontal direction to an upward direction and allows connection to a venting system.

10.2.4.2 Chromatography Columns

- a) DB-5MS UI, Capillary Column (15.0 m x 0.25 mm x 0.25 μ m) or equivalent, 8 units
- b) DB-5MS UI, Capillary Column (60.0 m x 0.25 mm x 0.25 μ m) or equivalent, 4 units
- c) Evaluation results (such as sensitivity, accuracy of analytes) provided by vendors for tested samples will be taken into consideration.

10.2.4.3 Technical and Applications Support

The contractor must provide **local** technical and application support to minimize downtime of the GC-MS/MS system and ensure high productivity of the lab.

10.3 REQUIREMENT TO CONNECT TO STARLIMS

- 10.3.1 The results generated from the system shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 10.3.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.

- 10.3.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image).

10.4 WARRANTY

The system supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of **12 months** from the date of successful commissioning of the system. During the warranty period, the Contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts (excluding consumable parts). Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned. All labour costs shall be included in the tender sum.

10.5 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply should be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the GC-MS/MS system will be placed. External transformer is not acceptable.

10.6 AFTER SALES SERVICES

The Contractor shall provide full **details of after sales services** and response time in the supply, replacement, repairing and servicing of the GC-MS/MS system supplied. Tenderer without the proper license, facility or experience to carry out the after sales services for the GC-MS/MS system would not be considered under this tender.

10.7 TRAINING

The Contractor shall provide hands-on comprehensive training either at the PUB laboratory or at their local training centre at the Contractor's own cost. The training program shall at least include hands-on operation, trouble shooting and routine maintenance of the system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee in the beginning of the training. **Details of the training program and schedule** shall be submitted together with the tender.

10.8 SCHEDULE OF DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Contractor in **the Schedule of Deviations**. Absence of comment in the Contractor's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. Details of these deviations shall be furnished in the Deviations.

10.9 PLACE AND PERIOD OF DELIVERY

The Contractor shall deliver, install and commission the GC-MS/MS system complete with accessories as specified under the Scope of Work and Technical Specifications to Public Utilities Board, 82, Toh Guan Road East, WaterHub, Singapore 608576, within **4 months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

11 SPECIFICATIONS FOR SCHEDULE XI

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF TWO (2) UNITS OF ULTRA HIGH PERFORMANCE LIQUID CHROMATOGRAPHY-TRIPLE QUADRUPOLE MASS SPECTROMETERS (UHPLC-MS/MS)

The UHPLC-MS/MS systems should belong to an established brand in the market, with direct manufacturer's support locally. The system shall be capable of performing analysis of organic compounds at ultra-trace levels in water samples.

The supply of UHPLC-MS/MS shall include scope of work specified in clause 11.1 and the system shall comply with the technical specifications specified in clause 11.2.

11.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

11.1.1 Supply, delivery and commissioning of **two (2) units** of UHPLC-MS/MS systems complete with UHPLC pumps with built-in sample introduction systems, solvent delivery systems, column ovens, solvent degassers, triple quadrupole mass spectrometer systems, software for instrument control, N₂ gas generators, instrument installation relevant work including instrument configuration, gas line configuration and bench configuration, accessories and consumables.

11.1.2 Provision of starter and calibration kits, all necessary accessories and consumables for commissioning, calibration and performance check of the UHPLC/MS/MS systems.

11.1.3 Carrying out all other work not specified herein for the successful commissioning of the entire system.

11.2 TECHNICAL SPECIFICATIONS

11.2.1 High Performance Liquid Chromatography

11.2.1.1 Sample Introduction system

11.2.1.1.1 injection volume: 0.1 – 50 µL in 0.1 µL increment

11.2.1.1.2 Injection precision: < 0.25% RSD from 2- 20 µL

11.2.1.1.3 Injection accuracy: ±1% for 10 µL, n=10

11.2.1.1.4 Pressure range: up to 1200 bar

11.2.1.1.5 injection cycle time: < 25 s with need wash

11.2.1.1.6 Sample carryover: < 0.005%

11.2.1.1.7 Controlled sample environment over a range of 4 – 40 °C

11.2.1.1.8 Must have include the sample tray with at least 100 vial capacity for 1.5ml standard vials

11.2.1.2 Solvent Delivery System

11.2.1.2.1 Pump system: ultra high pressure binary pump

11.2.1.2.2 Settable flow range: 0.001 – 2 mL/min, in 0.001 mL/min increments

11.2.1.2.3 Flow precision: 0.07% RSD or 0.005 min SD, whatever is greater

11.2.1.2.4 Flow accuracy: $\pm 1\%$ or 10 μ L/min whatever is greater

11.2.1.2.5 Pressure pulsation: <1% amplitude or <5 bar whichever is greater

11.2.1.2.6 Compressibility compensation: automatic, pre-defined, based on mobile phase selection

11.2.1.2.7 pH range: 2.0-12.0

11.2.1.2.8 Composition range: settable range: 0.0 – 100.0%

11.2.1.2.9 Composition precision: < 0.15 % RSD or 0.01 min SD whatever is greater

11.2.1.2.10 Composition accuracy: $\pm 0.35\%$ absolute from 5-95%

11.2.1.2.11 Integrated Degassing Unit: 2 channels

11.2.1.2.12 Materials in contact with solvent: Teflon AF, FEP, PPS

11.2.1.2.13 Regular tray with 4 solvent bottles complete with fitting & automatic rinsing kit

11.2.1.2.14 Leak sensor as safety feature

11.2.1.3 Column Compartment

11.2.1.3.1 Temperature range: 10 °C above ambient to 80 °C in 0.1 °C steps

11.2.1.3.2 Temperature stability: +0.05 °C for flow rates between 0.2 and 2 ml/min

11.2.1.3.3 Temperature set point accuracy: + 0.5 °C

11.2.1.3.4 Heat-up rate: within 5 min from ambient to 40 °C

11.2.1.3.5 Can house up to 3 columns with built-in column switching valve

11.2.1.3.6 Should be able to handle column length from 10-250 mm

11.2.1.4 Solvent Degasser

11.2.1.4.1 On-line vacuum type

11.2.1.4.2 Maximum flow rate: 2 ml/min per channel

11.2.1.4.3 Internal volume per channel should not be more than 1.5 ml

11.2.1.4.4 Should have at least 2 independent channels

11.2.1.4.5 Error status should be fed back to system software

11.2.1.4.6 Leak sensor as a safety feature

11.2.2 Triple Quadrupole Mass Spectrometer System

- 11.2.2.1 Minimum mass range: 10-1800 amu
- 11.2.2.2 Scan speed at least 15,000 amu/sec
- 11.2.2.3 Mass stability: maximum ± 0.1 amu over 24 hrs
- 11.2.2.4 Mass resolution: minimum 0.7 Da with autotune
- 11.2.2.5 Nebuliser spray can be orientated perpendicular to the axis of the ion source or OFF-Axis ion source
- 11.2.2.6 Has an integrated divert valve to switch the LC flow to waste during void volume elution, gradient end-point and any other portion of analytical run
- 11.2.2.7 Source elements can be removed for cleaning without breaking vacuum
- 11.2.2.8 Fully automated optimization of ion optics and mass axis calibration
- 11.2.2.9 Positive/Negative polarity switching must be less than 30 ms, in continuous mode during LC/MS and LC/MS/MS runs
- 11.2.2.10 The ion source should be equipped with Atmospheric Pressure Ionisation (API) Probes, one set of Electrospray Ionisation (ESI) source and another set of APCI (Atmospheric Pressure Chemical Ionisation) interface
- 11.2.2.11 Electrospray Ionisation (ESI) Source
 - 11.2.2.11.1 Compatible with liquid flow rates of 1 μ L/min to 2 mL/min without splitting
 - 11.2.2.11.2 The ESI source must be equipped with heater assembly for achieving efficient desolvation and increased efficiency of ionization
 - 11.2.2.11.3 Source temperature: 400 °C or higher
 - 11.2.2.11.4 Full gradient capability from 100% aqueous to 100% organic
 - 11.2.2.11.5 Sensitivity: for positive ESI, at least S/N 150,000:1 for 1pg reserpine on-column, transition m/z 609 to 195; for negative ESI, at least S/N 150,000:1 for 1pg reserpine on-column, transition m/z 609 to 195 or at least 150,000:1 for 1pg chloramphenicol on-column, transition m/z 321 to 152
 - 11.2.2.11.6 Additional sensitivity requirements for negative ESI: (a) Instrument Detection Limit (IDL) of less than 25 fg (equivalent to 2.5 ppt with 10 μ L injection or 0.5 ppt

with 50 µL injection) for estrone injected on-column, MRM transition m/z 269 to 145; and (b) IDL of less than 25 fg (equivalent to 2.5 ppt with 10 µL injection or 0.5 ppt with 50 µL injection) for perfluorooctanoic acid (PFOA) injected on-column, MRM transition m/z 413 to 369.

11.2.2.12 APCI (Atmospheric Pressure Chemical Ionisation) source

11.2.2.12.1 Sensitivity: at least S/N: 100,000:1 for 1 pg reserpine, transition m/z 609 to 195 or at least 300:1 for 1pg 17 α -hydroxyprogesterone, transition m/z 321 to 152 for positive APCI.

11.2.2.12.2 Compatible with liquid flow rates of 50 µl/min to 2 ml/min without splitting

11.2.2.12.3 Source temperature: 400 °C or higher

11.2.2.12.4 Full gradient capability from 100% aqueous to 100% organic

11.2.2.13 Mass Analyzer

11.2.2.13.1 Allows the following data acquisition modes: Q1/ Q3 MS scan, precursor scan, product ion scan, neutral loss/gain scan, multiple reaction monitoring (MRM) and selected ion monitoring (SIM).

11.2.2.13.2 Maximum dwell time of 1ms

11.2.2.13.3 LCMS start-up kit should be supplied as standard

11.2.2.14 Mass detector

11.2.2.14.1 Has high energy conversion dynode and high-gain electron multiplier horn

11.2.2.14.2 Detector operates in both positive and negative ion modes

11.2.2.14.3 At least six orders of magnitude for linearity

11.2.2.15 Vacuum System

11.2.2.15.1 The high vacuum must be maintained by turbo-molecular pump. This pump should be backed by mechanical (rough) pump

11.2.2.15.2 Should be delivered with enclosure to reduce the noise level of the mechanical pump

11.2.3 Nitrogen Gas Generator

11.2.3.1 Max Flow rate up to 70 L/min

- 11.2.3.2 Max Pressure up to 116 psi
- 11.2.3.3 Purity 95-99.5%
- 11.2.3.4 Must have at least dual redundant built-in air compressors
- 11.2.3.5 Noise level: $\leq 59\text{dB}$
- 11.2.3.6 Phthalate & BHT Free
- 11.2.3.7 Particles $< 0.01\ \mu\text{m}$
- 11.2.3.8 Suspended liquid: none
- 11.2.3.9 Generator Dimensions: $H \leq 1000\text{mm}$; $W \leq 600\text{mm}$; $D \leq 750\ \text{mm}$

11.2.4 Data system and PC

- 11.2.4.1 Data system that shall meet the minimum specifications listed below:
 - 11.2.4.1.1 The system must include a Windows®-based data acquisition and editing software package that incorporates a graphical user interface utilizing multi-pane windows for easy data acquisition and analysis
 - 11.2.4.1.2 Must be able to provide fully integrated control for both the ultra high performance liquid chromatography (UHPLC) and the triple quadrupole mass spectrometer (MS/MS) system
 - 11.2.4.1.3 Has on-line help for instrument control programs as well as user manual in PDF file format
 - 11.2.4.1.4 It should cover digital instrument control, qualitative and quantitative processing, report creation, self-diagnosis and auto-tune.
 - 11.2.4.1.5 Auto tuning with sensitivity and resolution optimization for both positive ion and negative ion should be standard.
 - 11.2.4.1.6 Capable of tuning for electrospray (ESI) in positive and negative ion modes
 - 11.2.4.1.7 Software control of MS tuning parameters of all scan, SIM, MRM and linked, all tune files can be stored as part of a method. Positive and negative autotune modes, autotune can be customized
 - 11.2.4.1.8 The software must have “MRM triggered full scan MSMS” function in order to have additional information and confirmation of target compounds.
 - 11.2.4.1.9 Automatic mass calibration routines

- 11.2.4.1.10 Zoom scan capability for achieving higher mass resolution
- 11.2.4.1.11 The software must be able to perform Automatic determination of MRM transitions for easy method development
- 11.2.4.1.12 The software should have MRM optimizer for optimization of MRM transition using Flow injection mode, Manual optimization using syringe flow must be available as an option.
- 11.2.4.1.13 MRM ion table can associate name to ion and internal standard
- 11.2.4.1.14 Dynamic/Scheduled MRM function with automatic maximization of dwell time for multi-residues analysis
- 11.2.4.1.15 The self-diagnosis feature of the software should enable diagnosis of the mass spectrometer and all connected LC units.
- 11.2.4.1.16 Method file should be capable to save all analysis parameters, data processing parameters and report format.
- 11.2.4.1.17 The setting parameters of data acquisition and data analysis/ reporting for existing/remaining compounds should not be affected by the addition or deletion of compounds
- 11.2.4.1.18 Auto Start up and shutdown of the MS should be possible using a single key operation.
- 11.2.4.1.19 Sample schedule wizard function should be standard
- 11.2.4.1.20 The vendor should provide method packages that include ready-made methods for LC and MS parameters and mass spectrum for various applications at least including as follows: (i) Endocrine-disrupting compounds; (ii) Haloacetic acids; (iii) Perfluoroalkyl compounds; (iv) Environmental

11.2.4.2 PC

PC will be provided by PUB, with specifications listed below:

HP Z8 G4 Workstation

- a) Intel Xeon 4116 Processor (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
- b) 32GB (2x16GB) DDR4-2666 ECC Memory
- c) 1TB 7200 RPM Hard Drive

- d) NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
- e) Integrated DVD-RW
- f) Integrated 10/100/1000 Gigabit Ethernet
- g) HP USB Mouse
- h) HP USB Keyboard
- i) HP EliteDisplay E223 21.5-In LED Monitor (1920x1080, VGA / HDMI / DP / USB Hub)
- j) Network Adapters: Intel X550-T2 10GbE Dual Port NIC
- k) Microsoft Windows 10 Enterprise Edition 64-bit

The Contractor shall setup and commission the PC. The Contractor must ensure the instruments are synchronized with the instrument software after installation.

11.2.5 Consumables and Accessories

- 11.2.5.1 ESI tuning mix, 100ml
- 11.2.5.2 APCI calibration solution, 100ml
- 11.2.5.3 APCI low concentration tuning mix, 100ml (optional)
- 11.2.5.4 ESI/APCI positive ion performance standard, 5 X 1ml ampoules
- 11.2.5.5 Electrospray LC demo sample
- 11.2.5.6 ESI+APCI LC demo sample
- 11.2.5.7 ES negative ion standard performance standard, 5 x 1ml ampoules
- 11.2.5.8 LC/MS tool kit
- 11.2.5.9 Plastic tubing cutter
- 11.2.5.10 Different capillary tubing which is:
 - 11.2.5.10.1 from column to DAD cell (4 pieces)
 - 11.2.5.10.2 port valve to column (2 pieces)
- 11.2.5.11 Peek tubing:

11.2.5.11.1 ID 0.18mm, length 1.5m (4 pieces)

11.2.5.11.2 ID 0.13mm, length 1.5m (4 pieces)

11.2.5.12 Foreline pump oil, Inland 45, 1L for LC/MS/MS pump use, 4 bottle

11.2.5.13 Column guard cartridge for following HPLC column (4 units)

11.2.5.14 Chromatography Columns:

- a. InfiityLab Poroshell 120 HILIC (100 x 4.6 mm, particle size 2.7 µm) or equivalent (2 units)
- b. InfiityLab Poroshell 120, EC-C18 (100 x 2.1 mm, particle size 2.7 µm) or equivalent (1 unit)
- c. InfiityLab Poroshell 120 HILIC-Z (100 x 3 mm, particle size 2.7 µm) or equivalent (1 unit)
- d. ZoRBaX Eclipse Plus PAH (100 x 2.1 mm, particle size 1.8 µm) or equivalent (2 units)
- e. ZoRBaX Bonus-RP (100 x 2.1 mm, particle size 1.8 µm) or equivalent (2 units)
- f. ZoRBaX SB-aq (100 x 2.1 mm, particle size 1.8 µm) or equivalent (2 units)

11.2.5.15 The samples will be sent to suppliers for evaluation. Sensitivity and reproducibility will be taken into consideration.

11.2.5.16 System includes installation kit and maintenance kit

11.2.5.17 System shall have a ten-year value guarantee such that vendor shall have ten years' guaranteed parts and comprehensive service available or give residual value credit for replacement

11.3 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

11.3.1.1 The Contractor shall install, configure and commission the following software items with complete documentation:

11.3.1.2 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.

11.3.1.3 Operating system and necessary system components.

11.4 REQUIREMENT TO CONNECT TO STARLIMS

- 11.4.1 The results generated from the systems shall be able to be captured by the Board's existing Laboratory Information Management System (i.e. STARLIMS) seamlessly.
- 11.4.2 The instrument shall be connected to a workstation with software installed. The system operation software shall be able to generate a file with results and put (or saved) in a specific folder.
- 11.4.3 The result file shall be in Excel file or a text format (i.e. .txt or .csv or a non-proprietary file format that can be read via text readers such as Microsoft® Notepad) or text-based pdf format (not scanned pdf file which is an image)

11.5 TRAINING

The Contractor shall provide comprehensive hands-on training course for at least 4 laboratory staffs either on-site at the PUB laboratory or at their local training centre at the Contractor's own cost. The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the UHPLC-MS/MS system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. Details of the training programme and schedule shall be submitted together with the tender.

11.6 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply should be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the UHPLC/MS/MS systems will be placed. External transformer is not acceptable.

11.7 HANDOVER

- 11.7.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following
 - 11.7.1.1.1 latest Microsoft security patches
 - 11.7.1.1.2 latest anti-virus definition updates
 - 11.7.1.1.3 hardening documentations
 - 11.7.1.1.4 backup and recovery procedures and mechanisms (includes image)
- 11.7.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following
 - 11.7.2.1.1 Issues resolution

11.7.2.1.2 backup and recovery procedures and mechanisms (includes image)

11.8 WARRANTY

- 11.8.1 The systems supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of at least **12 months** from the date of successful commissioning of the systems. During the warranty period, the contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts for repairs (excluding consumable parts). All labour costs shall deem to be included in the tender sum.
- 11.8.2 Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned.
- 11.8.3 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 11.8.4 The Contractor shall re-install the software, when necessary, during the warranty period.

11.9 AFTER SALES SERVICES

The Tenderer shall provide full details in their tender proposal of after sales services and response time in the supply, replacement, repairing and servicing of the UHPLC-MS/MS system supplied. Tenderer without the proper license, facility or experience to carry out the after sales services for the UHPLC/MSMS system would not be considered under this tender.

11.10 SCHEDULE OF DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Deviations.**

11.11 PLACE AND PERIOD OF DELIVERY

The Contractor shall deliver, install and commission the UHPLC-MS/MS systems complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, WaterHub, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.

12 SPECIFICATIONS FOR SCHEDULE XII

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF AUTOMATED SOLID PHASE EXTRACTION (SPE) SYSTEM

The automated SPE system shall perform the full SPE extraction method with minimal user intervention. The system should automatically load sample, condition, rinse, and elute the cartridge.

The supply of automated SPE system shall include scope of work specified in Clause 12.1 and the system shall comply with the technical specifications specified in Clause 12.2.

12.1 SCOPE OF WORK

The scope of work shall include but not limited to the following:

- 12.1.1 Supply, delivery and commissioning of one (1) unit of automated SPE system, instrument installation relevant work including instrument configuration, accessories and consumables.
- 12.1.2 Provision of starter and calibration kit, all necessary accessories and consumables for commissioning, calibration and performance check of the automated SPE system.
- 12.1.3 Carrying out all other work not specified herein for the successful commissioning of the entire system.

12.2 TECHNICAL SPECIFICATIONS

12.2.1 Automated SPE System

- 12.2.1.1 Shall be a Teflon-reduced configuration that uses PEEK material in the sample and solvent flow paths for PFAS extraction.
- 12.2.1.2 The automated SPE system shall meet all requirements of U.S. EPA Method 537.1 with the recovery of all analytes within 70 – 130% and RSDs < 20% for replicate analysis. This Method performance shall be documented with a written proof statement that is produced and fully supported by the vendor.
- 12.2.1.3 Shall accommodate large volume samples ranging from 20 mL – 4 L.
- 12.2.1.4 Shall support up to five different solvents for the conditioning, rinsing, and elution steps.
- 12.2.1.5 The automated SPE system shall support polypropylene collection vials in 16 x 100 mm format to avoid PFAS analyte loss following the extraction.
- 12.2.1.6 The software for the automated SPE system shall provide the ability to create optional method steps which include rinsing of the sample container follow loading,

drying the flowpath with nitrogen, pausing operation, increasing absorption time during the elution step, and cleaning the sample path with rinse solvent to prevent cross-contamination.

12.2.1.7 Shall offer front panel control for easy access for up to 24 stored extraction methods and 7 diagnostic methods.

12.2.1.8 Shall separate organic and aqueous waste into separate containers using separate waste lines to simplify disposal.

12.2.1.9 Shall be enclosed to prevent analyst exposure to solvent vapors and offer an optional exhaust line to connect to a laboratory ventilation system. This system will not require operation in a fume hood.

12.2.1.10 Shall demonstrate the means of conformity for the following list of directives and standards:

- a. Low voltage/safety directive: 2014/35/EU
- b. EMC directive: 2014/30/EU
- c. Safety standards: EN 61010-1:2012, UL 61010-1 3rd edition, CAN/CSA-C22.2 No. 61010.1 3rd edition
- d. EMC standards: EN 61326-1:2013
- e. RoHS Directive: RoHS Standard EN 50581:2012
- f. REACH Directive: EC 1907/2006

12.2.1.11 Shall be manufactured in a factory that maintains ISO Certification according to the requirements of ISO 9001:2015.

12.2.2 Data system and PC

12.2.2.1 Data system that shall meet the minimum specifications listed below

- a. The system must include a Windows®-based software support to set operational parameters and write method steps. The software will allow creation and storage of up to 24 methods. Through setup parameters, the software will control the flow rates of solvent and sample in each solid phase extraction step of the method.
- b. The software shall provide the ability to create optional method steps which include rinsing of the sample container follow loading, drying the flowpath with nitrogen, pausing operation, increasing absorption time during the elution step, and cleaning the sample path with rinse solvent to prevent cross-contamination.

12.2.2.2 PC

PC will be provided by PUB, with specifications listed below:

HP Z8 G4 Workstation

- a) Intel Xeon 4116 Processor (2.1GHz, Up to 3.0GHz Max. Turbo Frequency, 16.5MB Cache, 12 Cores)
- b) 32GB (2x16GB) DDR4-2666 ECC Memory
- c) 1TB 7200 RPM Hard Drive
- d) NVIDIA Quadro P1000 4GB Graphics (4)mDP-DP
- e) Integrated DVD-RW
- f) Integrated 10/100/1000 Gigabit Ethernet
- g) HP USB Mouse
- h) HP USB Keyboard
- i) HP EliteDisplay E223 21.5-In LED Monitor (1920x1080, VGA / HDMI / DP / USB Hub)
- j) Network Adapters: Intel X550-T2 10GbE Dual Port NIC
- k) Microsoft Windows 10 Enterprise Edition 64-bit

The Contractor shall setup and commission the instrument and ensure that the instrument is synchronised with the instrument software after installation.

12.2.3 Consumables and Accessories

12.2.3.1 Consumables and accessories for PFAS system including PEEK Valves, tubing, collection vials and others:

- a. Valves: 3-way, PEEK for U.S. EPA Method 533 and 537.1
- b. Tubing: 1/16" ID, (6 total supplied), PEEK for U.S. EPA Method 533 and 537.1
- c. Collection vials: polypropylene in 16 x 100 mm format
- d. Other PEEK accessories in the sample and solvent flow paths for PFAS extraction not included in a, b and c.

12.2.3.2 System includes installation kit and maintenance kit

12.2.3.3 System shall be covered by a three-year parts warranty from the factory.

12.3 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

12.3.1 The Contractor shall install, configure and commission the following software items with complete documentation:

12.3.1.1 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.

12.3.1.2 Operating system and necessary system components

12.4 TRAINING

The Contractor shall provide comprehensive hands-on training course for at least 4 laboratory staffs either on-site at the PUB laboratory at the Contractor's own cost. The training programme shall at least include hands-on operation, trouble shooting and routine maintenance of the automated SPE system. One set of training materials (softcopy or hardcopy) shall be provided for each trainee at the beginning of the training. Details of the training programme and schedule shall be submitted together with the tender.

12.5 POWER REQUIREMENT

All cables, plugs and wires necessary for the equipment to function must be supplied. The power supply should be 230V and 50Hz AC, 13A electrical line directly or suitable to be connected to the existing power point of the laboratory where the automated SPE system will be placed. External transformer is not acceptable.

12.6 HANDOVER

12.6.1 The Contractor shall handover the hardware and software to the Board ONE (1) month after the start of the warranty period and validated by the Board. This shall include but not limited to the following

- a. latest Microsoft security patches
- b. latest anti-virus definition updates
- c. hardening documentations
- d. backup and recovery procedures and mechanisms (includes image)

12.6.2 The Contractor shall handover the following ONE (1) month before the end of the warranty period. This shall include but not limited to the following

- a. Issues resolution
- b. backup and recovery procedures and mechanisms (includes image)

12.7 WARRANTY

12.7.1 The system supplied shall be guaranteed against inaccuracy, poor performance and workmanship used for a period of at least **12 months** from the date of successful commissioning of the system. During the warranty period, the contractor shall provide unlimited on-site breakdown services, and supply and replacement of parts for repairs

(excluding consumable parts). All labour costs shall be included in the tender sum.

12.7.2 Engineer support for software related services shall also be provided for a period of 12 months after the instrument is commissioned.

12.7.3 The Contractor shall notify the Board of any version updates to their software during the warranty period.

12.7.4 The Contractor shall re-install the software, when necessary, during the warranty period.

12.8 AFTER SALES SERVICES

The Tenderer shall provide full details in their tender proposal of after sales services and response time in the supply, replacement, repairing and servicing of the automated SPE system supplied. Tenderer without the proper license, facility or experience to carry out the after sales services for the automated SPE system would not be considered under this tender.

12.9 SCHEDULE OF DEVIATIONS

The specifications shall be strictly complied with and any deviations shall be clearly stated by the Tenderer in the **Schedule of Deviations**. Absence of comment in the Tenderer's submission shall be interpreted as acceptance and compliance with the requirements of the specifications. **Details of these deviations shall be furnished in the Deviations.**

12.10 PLACE AND PERIOD OF DELIVERY

The Contractor shall deliver, install and commission the automated SPE system complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, WaterHub, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.