

**SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF FOUR (4)
LABORATORY ANALYTICAL INSTRUMENTS FOR WATER QUALITY
DEPARTMENT OF PUB**

	Page
1. Content Page	RS-1
2. General Specifications	RS-2 to RS-7
3. Technical Specifications	
a) Specifications for Schedule I	RS-8 to RS-13
b) Specifications for Schedule II	RS- 14 to RS- 20
c) Specifications for Schedule III	RS- 21 to RS- 30
d) Specifications for Schedule IV	RS- 31 to RS- 38

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF FOUR (4) LABORATORY ANALYTICAL INSTRUMENTS FOR WATER QUALITY DEPARTMENT OF PUB

GENERAL SPECIFICATIONS

1. GENERAL

- a. This tender consists of **four (4)** Schedules of supply. **Tenderers are invited to price for the Schedule they want to offer only. If no offer, the Tenderers shall indicate “No Quote” in 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 IV 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 four (4) laboratory analytical instruments to Water Quality Department at 82 Toh Guan Road East, WaterHub, Singapore 608576.

3. SCHEDULES OF SUPPLY

The four (4) Schedules of supply in this tender are as follows:

- | | |
|--------------|--|
| Schedule I | Supply, Delivery, Installation and Commissioning of One (1) Unit of Automated Flow Analyzer for Total Cyanide |
| Schedule II | Supply, Delivery, Installation and Commissioning of One (1) Unit of Ion Chromatography (IC) System |
| Schedule III | Supply, Delivery, Installation and Commissioning of One (1) Unit of Ion Chromatography-Mass Spectrometry (IC-MS) System |
| Schedule IV | Supply, Delivery, Installation and Commissioning of One (1) Unit of Ultra High Performance Liquid Chromatography-Triple Quadrupole Mass Spectrometer (UHPLC-MS/MS) |

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; and
 - ii. Work Injury Compensation Insurance
- b) In the event of any claims, the Contractor shall comply with the Claims Procedure for Contractors' All Risks and Work Injury Compensation Insurances included in Supplement 1

6. SECURITY-RELATED REQUIREMENTS

6.1 Security Training, Competency & Awareness

The Contractor shall ensure that his personnel are sufficiently trained in ICT security and are aware of the security implications of the work performed. The personnel shall be well versed in the security requirements of PUB and adhere to the security standards and procedures stipulated by the PUB.

6.2 Secure Erasure

- 6.2.1 PUB shall have the right to conduct a secure erasure by such means as PUB deems fit on any or all hard disks before they are removed from PUB premises for repair or replacement, if PUB deems this to be necessary for security reasons. Secure erasure may entail the physical destruction of the hard disks. PUB 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.
- 6.2.2 Without prejudice to the generality of any provisions on warranties, or to any other rights and remedies of PUB, 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:
 - a. 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
 - b. 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.

6.3 Setup, Hardening, Patching and Scanning

6.3.1 Setup

- 6.3.3.1 The Contractor shall setup the systems, computers and laptops according to the Board's requirements.

6.3.3.2 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.

6.3.3.4 The Contractor shall install the anti-virus software provided by the Board on the system.

6.3.3.5 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.

6.3.2 Hardening

The Contractor shall harden the systems, computers and laptops (such as hardening of operating systems and database) supplied in this contract according to the Board hardening guidelines. 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.

6.3.3 Patching

6.3.3.1 The Contractor shall ensure that the latest patch had been applied to the system prior to production environment.

6.3.3.3 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

6.3.3.4 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	

6.3.3.5 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.

6.4 Log Management

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

6.5 Authentications

6.5.1 Account lockout shall be implemented when the maximum number of 10 or less failed authentication attempts is reached.

6.5.2 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. Prohibit passwords from being the same as the account ID or user ID;
- g. Limit consecutive failed authentication attempts that can be made on a single account to 10 times or less

6.6 Account and Access Control

6.6.1 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.

6.6.2 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.

6.6.3 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:

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

6.6.5 Suspend the account when it is unused for at least 90 days.

6.6.6 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.]

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

6.7 Use of Virus-Free Electronic Media

6.7.1 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.

6.7.2 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.

6.7.3 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.

6.7.4 In this Clause 6.7.2: “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.

6.8 Backup and Recovery

The Contractor shall implement backup and recovery procedures and mechanisms to back up critical system files and PUB’s information stored in the project on a periodic basis.

6.9 Incident Handling and Response

All security incidents, such as viruses, security compromises, unauthorised access and modifications, and discovery of security vulnerability, shall be reported to PUB. The Contractor shall establish an incident handling and response capability. When a security incident occurs, the Contractor shall inform PUB and work closely with PUB’s personnel to handle and respond to the security incident. The Contractor shall keep PUB informed of corrective measures and implement these measures timely and also implement preventive measures to thwart the recurrence of security incidents.

6.10 Standards and Policy Compliance

6.10.1 The Contractor shall note the policies, standards and guidelines issued by PUB subsequently and shall comply unless better proposals are provided and accepted by PUB.

6.10.2 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.

6.11 Physical & Logical Access

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

6.12 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 PUB. If the Contractor is unable to effect the necessary repairs or remedial action, PUB 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.

TECHNICAL SPECIFICATIONS

1. SPECIFICATIONS FOR SCHEDULE I

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF AUTOMATED FLOW ANALYZER FOR TOTAL CYANIDE

The supply of Automated Flow Analyzer for Total Cyanide shall include scope of work specified in clause **1.1** and the system shall comply with the technical specifications specified in clause **1.2**.

1.1 SCOPE OF WORK

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

- 1.1.1 Supply, delivery, installation and commissioning of one (1) unit of Flow Analyzer for Total Cyanide as specified in clause **1.2**;
- 1.1.2 Provision of all necessary accessories as specified in clause **1.2** including desktop computer with analysis software and printer device, and any other accessories or chemicals required for the installation and commissioning of the system;
- 1.1.3 Provision of comprehensive training on the operation and maintenance of Flow Analyzer for Total Cyanide at site by an authorized specialist from the manufacturer;
- 1.1.4 Carrying out all other work not specified herein for the successful commissioning of one (1) unit of Flow Analyzer for Total Cyanide;
- 1.1.5 Warranty for a period of twelve (12) months from the date of commissioning completion of the system;
- 1.1.6 Provision of one preventive maintenance (PM) service by the Contractor not more than 2 months before the end of the warranty period, and one set of PM kit for the PM service.

1.2 TECHNICAL SPECIFICATIONS

1.2.1 General Requirements

- 1.2.1.1 The Cyanide Analyser shall comply to latest version of either APHA Standard Method 4500-CN- O/USEPA 335.3, or ISO 14403 for measurement of Total Cyanide in water samples.

The principles of the methods are as following:

APHA 4500-CN-O/USEPA 335.3: total cyanide consists of various metal-cyanide complex, which analysts break down (digest) by mixing a sample with heated acid and then irradiating it with UV light to produce a “donor stream” containing aqueous HCN. Analysts then pass the stream over a silicone-rubber gas-permeation membrane, which extracts gaseous HCN. They then trap the gaseous HCN in a parallel acceptor stream that consists of diluted NaOH. Analysts convert the cyanide in the acceptor stream to CNCl with reaction with chloramine-T at pH<8. Then add pyridine-barbituric acid reagent, which reacts with CNCl to form a red-blue dye, the absorbance of which is detected with an absorbance detector at 570 nm.

ISO 14403 is also acceptable if the detection limit meets the specification as stated below.

Tenderers shall indicate which standard method is followed and submit all details and specifications of the instrument method/set up/configuration. If ISO 14403 is followed, full copy of the standard method is to be submitted.

- 1.2.1.2 The detection limit shall be 7 µg/L or lower, as Cyanide.
- 1.2.1.3 This should be a fully automated procedure without any manual injection, digestion and distillation involved.
- 1.2.1.4 The Cyanide Analyzer shall be able to measure total cyanide (all free cyanides, all dissociable cyanides and various strong metal cyanides excluding thiocyanate) using automated UV digestion, automated distillation, and automated determination and recording processes.
- 1.2.1.5 The Cyanide Analyser shall be designed for automated dilution and preparation of calibration standards, automated run of QCs and samples, automated generation of reports and QC/calibration charts and exportation of data to LIMS.
- 1.2.1.6 The Cyanide Analyser shall be able to perform auto-dilution and auto-calibration from a single stock standard.
- 1.2.1.7 The analyzer shall require at most one type of carrier gas. The carrier gas can be 99.99% nitrogen gas or other purging gases.
- 1.2.1.8 Tenderers may be required to run QC and spiked samples provided by PUB during the tender evaluation period.
- 1.2.1.9 The cyanide manifold shall be able to operate in an unventilated location with safe procedure for collection of cyanide waste and prevention of leakage of gaseous or liquid chemical waste.
- 1.2.1.10 The Board may conduct site inspection at Tenderer's site for the proposed Cyanide Analyzer.
- 1.2.1.11 Multi speed pump function with standby / analyze / fast rinse positions
- 1.2.1.12 The Cyanide Analyzer shall be capable to run at least 12 samples per hour.
- 1.2.1.13 Tenderers shall provide supporting evidence for the operations of the Flow Analyzer for Total Cyanide, including calibration graph, calibration range, detection limit, precision, repeatability and spike recovery. All these shall be submitted as technical support together with the tender documents.
- 1.2.1.14 Tenderers shall provide the list of all chemicals, reagents, standard solutions etc, used, their compositions and preparation procedure for cyanide analysis. **This shall be submitted as technical support together with the tender documents.**

1.2.2 Flow Analyzer for Total Cyanide Manifold

- 1.2.2.1 The manifold shall include tubing heaters, in-line ultraviolet digestion fluidics, a gas-permeable silicone rubber membrane and its holder, and flow cell, or materials which are equivalent.
- 1.2.2.2 Manifold tubing shall be of an inert material.
- 1.2.2.3 The ultraviolet unit shall consist of TFE tubing irradiated by a mercury discharge ultraviolet lamp, or equivalent.

- 1.2.2.4 The system shall allow most of the samples containing particles (particle size ~0.45 mm) to be analyzed without clogging up the system. Such particles shall not affect the maintenance of the system. No filtration shall be required before sample injection for most of the samples including drinking water, reservoir water, surface water, ground water, etc.
- 1.2.2.5 **Sufficient glass wool** is to be provided and included in the tender price to remove larger and fibrous particles in samples during instrument commissioning period.
- 1.2.3 Automated stirrer at auto-sampler
 - 1.2.3.1 Must be supported with manufacturer's software which is capable to integrate the stirrer with the Cyanide Analyzer to allow automated stirring and homogenization of sample before test procedure.
- 1.2.4 Dilutor Station
 - 1.2.4.1 Must be supported with a dilutor unit for (i) automatic preparation of standard solutions to fit the measurement range during calibration and (ii) automatic dilution of over-range samples.
- 1.2.5 Auto-sampler
 - 1.2.5.1 Must be supported with manufacturer's software which is capable to integrate the auto-sampler with the Flow Analyzer for Total Cyanide to ensure cyanide data management.
 - 1.2.5.2 Must have the capacity to load **at least 60 vial positions**.
- 1.2.6 Data system, PC and printer
 - 1.2.6.1 Data system that shall meet the minimum specifications listed below
 - 1.2.6.1.1 Software shall be compatible for use on Microsoft Windows 10 or higher operating environment.
 - 1.2.6.1.2 It shall be user-friendly and provide fully automatic control of the process of analysing samples, including entering sample data and description, acquiring data, quantitation, and producing report.
 - 1.2.6.1.3 Calibration curves shall be generated using a variety of curve fitting functions as linear, quadratic, etc.
 - 1.2.6.1.4 Shall allow real time integration monitoring.
 - 1.2.6.2 PC that shall meet the minimum specifications listed below:
 - 1.2.6.2.1 Intel Core i7-8700 Processor (6 Cores/12MB/12T/up to 4.6GHz/65W) or equivalent
 - 1.2.6.2.2 Operating system: Microsoft Windows 10 Professional or equivalent with BitLocker Encryption
 - 1.2.6.2.3 Memory: 8 GB RAM
 - 1.2.6.2.4 Intel Integrated Graphics or equivalent
 - 1.2.6.2.5 Hard Drive: 500 GB 3.5" SATA (7,200 Rpm) Hard Drive
 - 1.2.6.2.6 8x DVD+/-RW 9.5mm Optical Disk Drive
 - 1.2.6.2.7 Minimum of 6 USB (2.0 & 3.0) Ports
 - 1.2.6.2.8 Minimum of 2 Integrated 10/100/1000 Gigabit Ethernet connections
 - 1.2.6.2.9 Monitor: 21-inch LCD flat panel display, resolution 1920×1080
 - 1.2.6.2.10 System documentation kit

- 1.2.6.2.11 USB Optical Scroll Mouse
- 1.2.6.2.12 USB Keyboard
- 1.2.6.2.13 One (1)-year on-site warranty for the PC, including labour, parts and accessories.

1.2.6.3 Printer that shall meet the minimum specifications listed below:

- 1.2.6.3.1 A printer with automated double-side printing function shall be provided.
- 1.2.6.3.2 Install with the latest firmware and wifi features disabled

1.2.7 Consumables and Accessories

The Contractor shall supply the following consumables and accessories of which the cost shall be included in the tender price:

- 1.2.7.1 Contractor shall provide all necessary chemicals and reagents for commissioning and method set-up. A full list of chemicals and reagents is to be submitted. (only NaOH/KCN solid for standard preparation and sulfuric acid will be provided by the Board.)
- 1.2.7.2 Contractor shall submit all necessary consumables and/or accessories, such as gas tubing from gas port to the instrument (if carrier gas is required for the instrument operation), **two** sets of sample trays/racks, **at least 500 vials** for auto-sampler, waste/drain tubing & container, and other materials required for commissioning, calibration, performance check and training of the cyanide analyser system.
- 1.2.7.3 One set of operation manual

1.3 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

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

1.4 REQUIREMENT TO CONNECT TO LABORATORY INFORMATION MANAGEMENT SYSTEM

- 1.4.1 The results generated from the instrument 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 save) in a specific folder.
- 1.4.3 The best location to store the instrument result files is in the server.
- 1.4.4 STARLIMS will then capture these files from the server and update to the system.
- 1.4.5 The result file shall be in 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 TRAINING

- 1.5.1 The Tenderer shall provide a one-time comprehensive training of the Flow Analyzer for Total Cyanide for the Board's laboratory officers on-site at the PUB laboratory after delivery and start-up commissioning of the analyzer at Contractor's own cost. One set of training materials (softcopy or hardcopy) shall be provided for each trainee in the beginning of the training. The training programme shall include hands-on operation, trouble shooting and routine maintenance of the cyanide analyser. Details of the training programme shall be decided by the Board.

1.6 POWER REQUIREMENT

- 1.6.1 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 Flow Analyzer for Total Cyanide will be placed.

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
 - 1.7.1.1 latest Microsoft security patches
 - 1.7.1.2 latest anti-virus definition updates
 - 1.7.1.3 hardening documentations
 - 1.7.1.4 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
 - 1.7.2.1 Issues resolution
 - 1.7.2.2 backup and recovery procedures and mechanisms (includes image)

1.8 WARRANTY

- 1.8.1 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 (excluding consumable parts). All labour costs shall deem to be included in the tender sum.
- 1.8.2 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 1.8.3 The Contractor shall re-install the software, when necessary, during the warranty period.

1.9 AFTER SALES SERVICES

- 1.9.1 The Tenderer shall provide full **details of after sales services** in his submission, including response time and price for the supply, replacement, repairing and servicing of the Flow Analyzer for Total Cyanide system supplied. The Tenderer must demonstrate that it has a proven appropriate setup and capability to provide after-sales service efficiently and effectively. Tenderer without the proper facility or experience to carry out the after sales services for the Flow Analyzer for Total Cyanide system would not be considered under this Tender.

1.10 SCHEDULE OF DEVIATIONS

- 1.10.1 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.**

1.11 PLACE AND PERIOD OF DELIVERY

- 1.11.1 The Contractor shall deliver, install and commission the Flow Analyzer for Total Cyanide complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, #C4-04 WaterHub, Singapore 608576 within **four (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 ION CHROMATOGRAPHY (IC) SYSTEM

The supply of Ion Chromatography (IC) System shall include scope of work specified in clause 2.1 and the system shall comply with the technical specifications specified in clause 2.2.

2.1 SCOPE OF WORK

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

- 2.1.1 Supply, delivery and commissioning of an integrated IC system complete with detectors, autosampler, suppressors, columns, eluent pumps and data handling system
- 2.1.2 Provision of all necessary consumables and accessories, such as eluent reservoirs, sample vials, peristaltic pump tubing, wire extension, adaptor and standard materials required for commissioning, calibration and performance check of the IC system
- 2.1.3 Provision of comprehensive training for at least five (5) lab staff on the use of IC system for all related analysis
- 2.1.4 Carrying out all other work not specified herein for the successful commissioning of the entire system

2.2 TECHNICAL SPECIFICATIONS

2.2.1 General requirements

- 2.2.1.1 The IC system shall be a robust, integrated and reliable system, complete with two sets of eluent pumps, separation columns, suppressors and UV-vis detectors (UVD) and one unit of conductivity detector.
- 2.2.1.2 It shall be able to run as two independent modules (Module I & Module II), for analysis of Iodide and Hexavalent Chromium in various water matrices.
- 2.2.1.3 Module I and Module II shall be configured as two separate systems with separation and detection functions, but can share autosampler, computer and data analysis system.
- 2.2.1.4 The two modules shall be able to operate simultaneously for two methods.
- 2.2.1.5 The system shall be ready to run high pressure gradient analysis when it is extended to other application of anion analysis, without the need of changing of eluent pump.
- 2.2.1.6 Flow pass should be metal free to reduce possibility of corrosion.
- 2.2.1.7 Module I shall be able to separate and detect Iodide in various water samples at a total running time (including sample equilibration, sample injection and separation on column) of not more than 30 min per sample, with a limit of quantitation for fresh water matrices at 5 µg/L or lower by UV-vis or conductivity detection.
- 2.2.1.8 Module II shall be able to separate and detect Hexavalent Chromium in various water samples with post column reaction UV-vis detection. by following USEPA method 218.7 or equivalent, with a limit of quantitation for fresh water matrices at 0.05 µg/L or lower.
- 2.2.1.9 The system shall be able to use carbonate or hydroxide as eluents.
- 2.2.1.10 For any of the analysis, no Ag-based cartridges shall be used in fresh water sample preparation.

- 2.2.1.11 Tenderers shall provide supporting evidence of the proposed separation modules, including chromatogram, calibration graph, calibration range, detection limit, precision, and spike recovery. All these shall be submitted as technical supports together with the tender documents.
- 2.2.1.12 Tenderers may be required to analyze quality control samples and water samples (including spiked samples) provided by PUB on the tenderer's proposed system and submit analytical report during the tender evaluation period.
- 2.2.1.13 Application supports shall be provided to set up the test methods. The commissioning shall include obtaining the calibration curves and limits of quantitation as required in above clause 2.2.1.7 and 2.2.1.8 from the IC system.
- 2.2.1.14 No gas shall be required for the operation of the IC system.
- 2.2.1.15 Leak sensor shall be included to allow fast response to system leaks.

2.2.2 Eluent pump system

- 2.2.2.1 Two high pressure eluent pumps, each pump for Module I and Module II
- 2.2.2.2 Able to perform gradients for both Modules
- 2.2.2.3 Flow rate: 0.001 - 10 mL/min
- 2.2.2.4 Maximum pressure: Able to routinely work at > 3000 psi
- 2.2.2.5 The pump housing shall be able to accommodate at least two independent pumping systems
- 2.2.2.6 Flow rate inaccuracy: <0.1%
- 2.2.2.7 Pulsation: <1%
- 2.2.2.8 Shall be of dual piston design
- 2.2.2.9 Pumps shall be made of non-metallic material to reduce possibility of corrosion
- 2.2.2.10 Pumps shall have user-settable pressure limits to automatically stop flow in the event of leaks or flow restrictions
- 2.2.2.11 A built-in vacuum degas assembly which provides in-line degassing of eluents, ensuring reproducibility and protection of eluents from contamination and decomposition. Control of the degas operation must be able to be automated to sense when degassing is required.

2.2.3 Suppressors

- 2.2.3.1 Two suppressors shall be provided, each for Module I and Module II.
- 2.2.3.2 Shall be based on membrane, column or gel replacement, to remove the counter cations
- 2.2.3.3 The suppressors shall operate in a continuous or sequential suppression mode to reduce background noise.
- 2.2.3.4 Suppressors shall be covered under warranty terms, and if their performance become deteriorated within warranty period of at least twelve (12) months, they shall be replaced with new units without extra cost to PUB.

2.2.4 Conductivity Detector

- 2.2.4.1 One conductivity detector for Module I
- 2.2.4.2 Measuring range: 0-15000 μ S
- 2.2.4.3 The detector shall be compatible with extreme eluents, i.e., eluents at pH 0-14
- 2.2.4.4 Working temperature: 20-50° C
- 2.2.4.5 Measuring frequency: 10Hz
- 2.2.4.6 Baseline noise: <0.2 nS/cm
- 2.2.4.7 Electronic noise: <0.1 nS/cm

2.2.5 UV-vis detector (VWD)

2.2.5.1 Two units shall be provided together with absorbance flow cells (light path length 10 mm)

2.2.5.2 Shall be a dual beam forward optics design and dual wavelength UV-Vis detector

2.2.5.3 Lamps: Each unit of VWD shall contain a Tungsten lamp and a Deuterium lamp

2.2.5.4 Pixel resolution: ≤ 0.7 nm

2.2.5.5 Operating humidity range: 5-80% relative humidity, no condensing

2.2.5.6 Wavelength accuracy shall be ± 1 nm, wavelength range 190-900 nm, settable in 1 nm or smaller increment

2.2.5.7 Noise: $< \pm 5$ μ AU at 254 nm and $< \pm 10$ μ AU at 520 nm under the condition: dry (dummy) flow cell, 1 second constant, one lamp on only, 60 min or less of warm-up time

2.2.6 Separation Column Set I

2.2.6.1 A separation column set shall include one guard column and one analytical column to be configured for analysis of Iodide.

2.2.6.2 It shall withstand at least 3000 psi pressure.

2.2.6.3 It shall be high capacity, with 2-mm or 4-mm analytical column of 150 mm or longer.

2.2.7 Separation Column Set II

2.2.7.1 A separation column set shall include one guard column and one analytical column, to be configured for analysis of Hexavalent Chromium.

2.2.7.2 It shall withstand at least 3000 psi pressure.

2.2.7.3 It shall be high capacity, with 2 mm or 4 mm analytical column of 150 mm or longer.

2.2.8 Autosampler

2.2.8.1 The autosampler can be shared by Module I and Module II, or separate unit of autosampler for Module I and Module II

2.2.8.2 Autosampler vials shall be composed of polymeric material

2.2.8.3 Shall be able to perform both full loop and partial loop injection

2.2.8.4 Shall be able to perform dilution function without additional hardware

2.2.8.5 Shall have at least 120 sample positions for 1.5-2.5 ml vials

2.2.8.6 Shall allow modifying a run sequence anywhere within the sampler during the run without interrupting analysis

2.2.8.7 Eluent reservoirs (4-5 L each, for two modules) shall be included.

2.2.8.8 Shall be controlled by the instrument software

2.2.8.9 Shall have injection volume of 20 μ L to 1.0 mL, based on different sample loops

2.2.8.10 At least two sets of sample loops of 20, 50, 200, 500, 1000 μ L shall be provided

2.2.9 Eluent Generator

2.2.9.1 No daily preparation shall be required for Module I. Concentrated eluent solution shall be automatically injected into the IC system with additional pump or eluent generator. Pump for gradient generation or eluent generator cartridge shall be included.

2.2.9.2 Concentration increments shall be as low as 0.01 mmol/L which is required to optimize chromatographic peak resolution and separation time.

2.2.10 Auxiliary pump

2.2.10.1 Shall be a single-piston, isocratic metering pump for the reagent delivery in post column reaction for hexavalent chromium analysis

- 2.2.10.2 Its material shall be PEEK, ceramic and /or inert polymer
- 2.2.10.3 Flow rate: adjustable in range of 0.01 – 9.99 ml/min
- 2.2.10.4 Pressure ripple: 2% peak-to-peak at 100 psi, 1ml/min with in-line pulse damper
- 2.2.10.5 Pressure range: able to reach 15 MPa
- 2.2.10.6 Control: to be interface with IC system software and PC via USB
- 2.2.10.7 Flow accuracy: 3% throughout flow range
- 2.2.10.8 Flow precision: 0.5%

2.2.11 Data system, PC and printer

2.2.11.1 Data system that shall meet the minimum specifications listed below

- a. The software license to the Board shall be provided without extra charge
- b. It shall provide fully automatic control of the process of analyzing samples, including acquiring data, quantitation, and producing report
- c. Calibration curves shall be generated using a variety of curve fitting functions as linear, quadratic, etc
- d. Shall allow real time integration monitoring
- e. Shall allow urgent or priority analysis after sequence starts
- f. Shall allow customization of report format and content
- g. It shall be able to compute statistical values, such as mean, standard deviation and relative standard deviation (coefficient of variation).
- h. It shall include online self-help function to troubleshoot any problems encountered during sample analysis.
- i. User menu/guide for the instrument software shall be provided.
- j. It shall provide feature to ensure no data is lost in the event when the computer breaks down or operating system hangs.
- k. It shall allow multiple applications windows to appear concurrently on the display for easy viewing.
- l. It shall have the function of auto-shut down, delay starting, smart start-up etc.
- m. Automatic shutdown function available upon reaching the pressure limit
- n. Other software included for proposed system to function fully if necessary
- o. Software shall be compatible for use on Microsoft Windows 10 or higher operating environment.

2.2.11.2 PC that shall meet the minimum specifications listed below:

- a. Intel Core™ i7-8700 Processor (6 Cores/12MB/12T/up to 4.6GHz/65W) or equivalent
- b. Operating system: Microsoft Windows 10 Professional or equivalent with BitLocker Encryption
- c. Memory: 8 GB RAM
- d. Intel Integrated Graphics or equivalent
- e. Hard Drive: 1000 GB 3.5" SATA (7,200 rpm)
- f. 8x DVD+/-RW 9.5mm Optical Disk Drive
- g. Minimum of 6 USB (2.0 & 3.0) Ports
- h. Minimum of 2 Integrated 10/100/1000 Gigabit Ethernet connections
- i. Monitor: 21-inch LCD flat panel display, resolution 1920×1080
- j. System documentation kit
- k. USB Optical Scroll Mouse
- l. USB Keyboard
- m. One (1)-year on-site warranty for the PC, including labour, parts and accessories

2.2.11.3 Printer that shall meet the minimum specifications listed below:

- a. A laser printer with double-side printing function shall be provided
- b. Install with the latest firmware and wifi features disabled

2.2.12 Consumables and Accessories

The Contractor shall supply the following consumables and accessories at his own cost:

2.2.12.1 One set of maintenance tools for the IC system

2.2.12.2 Provision of all necessary consumables and/or accessories, such as sample trays for autosampler, waste/drain tubing, and calibration standard materials required for commissioning, calibration, performance check and training of the IC system.

2.2.12.3 At least 2,000 sample vials (1.5-ml or other size suitable to autosampler) with caps shall be included in this tender.

2.2.12.4 One set of operation manual

2.3 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

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

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

2.3.1.2 Operating system and necessary system components

2.3.1.3 Antivirus software (provided by the Board)

2.4 REQUIREMENT TO CONNECT TO LABORATORY INFORMATION MANAGEMENT SYSTEM

2.4.1 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.

2.4.2 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 save) in a specific folder.

2.4.3 The best location to store the instrument result files in the server.

2.4.4 STARLIMS will then capture these files from the server and update to the system.

2.4.5 The result file shall be in 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)

2.5 TRAINING

- 2.5.1 The Contractor shall provide hands-on comprehensive training course for at least five (5) laboratory staffs either on-site 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 IC 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.

2.6 POWER REQUIREMENT

- 2.6.1 If necessary, the Contractor shall provide all the renovation work and material required for the installation and commissioning of the IC system in the laboratory (82 Toh Guan Road East, #C2-20, Singapore 608576). The renovation and installation work carried shall not affect the operation of equipment in the laboratory. The Contractor shall not generate any extra cost to PUB for fully installation and commissioning of the IC system.
- 2.6.2 All cables, plugs and wires necessary for the equipment to function shall be supplied.
- 2.6.3 Plugs shall be fit to Singapore's standard sockets.
- 2.6.4 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 IC system will be placed.
- 2.6.5 External transformer is not acceptable.

2.7 HANDOVER

- 2.7.1 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
- latest Microsoft security patches
 - latest anti-virus definition updates
 - hardening documentations
 - backup and recovery procedures and mechanisms (includes image)
- 2.7.2 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
- Issues resolution
 - backup and recovery procedures and mechanisms (includes image)

2.8 WARRANTY

- 2.8.1 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 (excluding consumable parts). All labour costs shall be included in the tender sum.
- 2.8.2 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 2.8.3 The Contractor shall re-install the software, when necessary, during the warranty period.

2.9 AFTER SALES SERVICES

- 2.9.1 The Tenderer shall provide full **details of after sales services** in his submission, including response time and price for the supply, replacement, repairing and servicing of the IC system supplied. The Tenderer must demonstrate that it has a proven appropriate setup and capability to provide after-sales service efficiently and effectively. Tenderer without the proper facility or experience to carry out the after sales services for the IC system would not be considered under this Tender.

2.10 SCHEDULE OF DEVIATIONS

- 2.10.1 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.**

2.11 PLACE AND PERIOD OF DELIVERY

- 2.11.1 The Contractor shall deliver, install and commission the IC system as specified in clause 2.2 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**.

3 SPECIFICATIONS FOR SCHEDULE III

SUPPLY, DELIVERY, INSTALLATION AND COMMISSIONING OF ONE (1) UNIT OF ION CHROMATOGRAPHY-MASS SPECTROMETRY (IC-MS) SYSTEM

The supply of Ion Chromatography-Mass Spectrometry (IC-MS) System shall include scope of work specified in clause 3.1 and the system shall comply with the technical specifications specified in clause 3.2.

3.1 SCOPE OF WORK

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

- 3.1.1 Supply, delivery and commissioning of one unit of Ion Chromatography-Mass Spectrometry (IC-MS) system complete with ion chromatograph autosampler, eluent pump, column compartment, column heater, suppressor, conductivity detector, degas assembly, mass spectrometer with electron ionization mode, data handling system, auxiliary pump and nitrogen generator
- 3.1.2 Provision of starter and calibration kit, all necessary accessories and consumables, such as IC separation columns, eluent reservoirs, sample vials, peristaltic pump tubing, wire extension, for commissioning, calibration and performance check of the IC-MS system
- 3.1.3 Provision of training for PUB staff at the PUB laboratory or at their local training centre at the Contractor's own cost.
- 3.1.4 Carrying out all other work not specified herein for the successful commissioning of the entire system

3.2 TECHNICAL SPECIFICATIONS

3.2.1 General Requirements

- 3.2.1.1 The IC-MS system shall be a robust and reliable system, integrated from one unit of High Performance Ion Chromatograph (HPIC) system and one unit of Triple Quadrupole Mass Spectrometer (MS) system, and advanced software for instrument control and data processing, auxiliary pump and nitrogen generator.
- 3.2.1.2 Shall be at high efficiency and high sensitivity for all the three analytical applications: (1) bromate, chlorite and perchlorate (by following USEPA method 332.0 & 557 or equivalent or modified); (2) herbicide glyphosate and its primary degradation product aminomethylphosphoric acid (AMPA); (3) nine haloacetic acids (HAA 9) by following USEPA method 557 or equivalent or modified. All the analytes are at levels of sub-µg/L to low µg/L in various water samples.
- 3.2.1.3 There shall be in place the suppressor(s), conductivity detector, auxiliary pumps (for makeup solvent and/or to supply pure water or reagent for suppressor), triple quadrupole mass spectrometer and accessories. Only IC column and software's instrument method need be changed to switch between the applications.
- 3.2.1.4 Tenderers shall provide supporting evidence of the proposed system or equivalent for the three applications, including chromatogram, calibration graph, calibration range, limit of quantitation, precision, and spike

recovery. All these shall be submitted as technical supports together with the tender documents.

- 3.2.1.5 Application support must be provided to set up the applications with the performance to be demonstrated to meet the limits of quantitation (LOQ) for fresh water matrix, as listed in Table 3.1. LOQ of perchlorate, glyphosate and AMPA in sea water matrix shall not exceed 1 µg/L.

Table 3.1 Limits of quantitation (LOQ) required for fresh water matrix

Parameter	LOQ (µg/L)	Parameter	LOQ (µg/L)
Bromate	0.05	Monochloroacetic acid	0.5
Perchlorate	0.1	Monobromoacetic acid	0.5
Chlorite	0.2	Dichloroacetic acid	0.5
Glyphosate	0.1	Bromochloroacetic acid	0.5
AMPA	0.1	Dibromoacetic acid	0.5
		Trichloroacetic acid	0.5
		Bromodichloroacetic acid	0.5
		Chlorodibromoacetic acid	0.5
		Tribromoacetic acid	0.5

3.2.2 Ion Chromatograph system

3.2.2.1 Eluent pump system

- 3.2.2.1.1 Two pumps, both able to perform high pressure binary gradient applications, shall be included
- 3.2.2.1.2 Flow rate: 0.001 - 10 mL/min
- 3.2.2.1.3 Maximum pressure: Able to routinely work at 5000 psi
- 3.2.2.1.4 The pump housing shall be able to accommodate at least two independent pumping systems
- 3.2.2.1.5 Flow rate inaccuracy: <0.1%
- 3.2.2.1.6 Pulsation: <1%
- 3.2.2.1.7 Shall be of dual serial piston design to reduce maintenance cost and ensure precision
- 3.2.2.1.8 Pumps and fluid flow path shall be made of non-metallic material to reduce possibility of corrosion and contamination of samples.
- 3.2.2.1.9 Pumps shall have user-settable pressure limits to automatically stop flow in the event of leaks or flow restrictions.
- 3.2.2.1.10 A built-in vacuum degas assembly which provides in-line degassing of eluents, ensuring reproducibility and protection of eluents from contamination and decomposition. Control of the degas operation must be able to be automated to sense when degassing is required.
- 3.2.2.1.11 Leak sensor shall be included to allow fast response to system leaks.

3.2.2.2 Eluent generation

- 3.2.2.2.1 Two units of eluent generator must be included.
- 3.2.2.2.2 The single channel eluent generator must be field upgradeable to dual and both channels must be contained in the same enclosure.
- 3.2.2.2.3 The eluent generator must be able to produce an unlimited number of linear, convex, concave, or negative eluent gradients.
- 3.2.2.2.4 Concentration increments must be as low as 0.01mM which is required to optimize chromatographic peak resolution and optimize separation time.

3.2.2.3 Thermal and detector compartments

- 3.2.2.3.1 Thermally controlled to minimize the effects of the environment
- 3.2.2.3.2 Shall house two independent valves in any of the following configurations: injection valve, 6 port, or 10 port valve for column switching.
- 3.2.2.3.3 Shall be able to house a minimum of 2 column sets (2-5 mm) up to a maximum of 250 mm in length with associated pre column (guard column) of 50 mm in length and two optional heat exchangers
- 3.2.2.3.4 Shall be able to house any combination of up to two conductivity detectors (with suppressors), and automatically detectable by the software
- 3.2.2.3.5 The detectors shall be able to operate in series or separately.

3.2.2.4 Conductivity detector

- 3.2.2.4.1 Measuring range: 0-15000 μ S
- 3.2.2.4.2 The detector shall be compatible with extreme eluents, i.e., eluents at pH 0-14
- 3.2.2.4.3 Working temperature: 20-50° C
- 3.2.2.4.4 Measuring frequency: 10Hz
- 3.2.2.4.5 Baseline noise: <0.2 nS/cm
- 3.2.2.4.6 Electronic noise: <0.1 nS/cm
- 3.2.2.4.7 Two units of conductivity detector shall be included

3.2.2.5 Suppressors

- 3.2.2.5.1 Two units of suppressors shall be included, either electrolytic or chemical suppression
- 3.2.2.5.2 Shall be based on membrane, column or gel replacement, to remove the counter cations, and be able to suppress carbonate or hydroxide as required by USEPA methods
- 3.2.2.5.3 The suppressors shall operate in a continuous or sequential suppression mode to reduce background noise.
- 3.2.2.5.4 Suppressors shall be covered under warranty terms, and if their performance become deteriorated within the IC-MS system warranty period, they shall be replaced with new units without extra cost to PUB.

3.2.2.6 Separation column set

- 3.2.2.6.1 One separation column set shall include one guard column and one analytical column.

- 3.2.2.6.2 Two separation column sets shall be provided to cover the three analytical applications.
- 3.2.2.6.3 It shall withstand at least 5000 psi pressure and have a pH stability of 0-14.
- 3.2.2.6.4 Each analytical column shall be high capacity, with 2-mm analytical column of 150 mm or longer.
- 3.2.2.6.5 Each guard column shall be of same column packing material as analytical column or a packing material that is a complementary polymeric resin.

3.2.2.7 Autosampler

- 3.2.2.7.1 The autosampler have at least 80 sample positions for 1.5-2.5 ml vials
- 3.2.2.7.2 Autosampler vials shall be composed of polymeric material
- 3.2.2.7.3 Autosampler shall be able to thermally control sample tray temperature at a temperature between 4-60 °C.
- 3.2.2.7.4 Shall be able to perform both full loop and partial loop injection
- 3.2.2.7.5 Shall be able to perform dilution function without additional hardware
- 3.2.2.7.6 Shall be capable of modifying a run sequence anywhere within the sampler during the run without interrupting analysis
- 3.2.2.7.7 Two eluent reservoirs (≥ 4 L each) shall be included.
- 3.2.2.7.8 Shall be controlled by the instrument software
- 3.2.2.7.9 Shall have a minimum injection volume of 10 μ L from a 300 μ L microvial or 20 μ L from a 500 μ L microvial
- 3.2.2.7.10 At least two sets of sample loops of 20, 50, 200, 500 μ L shall be provided.

3.2.3 Triple Quadrupole Mass Spectrometer (MS) System

3.2.3.1 MS system performance

- 3.2.3.1.1 Mass range m/z : 5-2000 amu
- 3.2.3.1.2 Mass stability: ± 0.1 Da over 24 hours when room temperature is maintained at 18 -27 °C.
- 3.2.3.1.3 Mass accuracy: 0.1 Da from 5-2000 m/z
- 3.2.3.1.4 Mass resolution: 3110 (or 0.2 Da FWHM) at m/z 622, and adjustable from 0.2 to 2.0 Da FWHM across the entire mass range achieved by automatic tune and calibration.
- 3.2.3.1.5 Scan speed: at least 15,000 amu/sec (in the case of 2 Da FWHM)
- 3.2.3.1.6 SRM transitions: ≥ 500 SRM/sec

3.2.3.2 Atmospheric Pressure Ionization (API) source

- 3.2.3.2.1 Shall have an electrodynamic ion funnel technology (EDIF) with mass-dependent potential for focusing ions in the free jet expansion region of the source
- 3.2.3.2.2 Shall have ion-optics that enables automated tuning
- 3.2.3.2.3 Shall have an automatic tuning programme that optimizes all ion focusing voltages
- 3.2.3.2.4 Shall incorporate a safety interlock switch to shut off voltages when source housing is opened or removed from the system

- 3.2.3.2.5 Shall include high-voltage dual-polarity power supply, sheath gas flow control, and auxiliary gas flow control
- 3.2.3.2.6 Must include an independently heated ion transfer tube, heated by an external heater to up to 400°C
- 3.2.3.2.7 The ion transfer tube shall be removable to provide vent-free maintenance.
- 3.2.3.2.8 All voltages for focusing the ion beam in the API source shall be controlled through the data system.
- 3.2.3.2.9 Shall include a removable ion sweep cone
- 3.2.3.3 Heated Electrospray Ionization (HESI) probe
 - 3.2.3.3.1 Must include a feedback-controlled heater capable of operation up to 550°C to vaporize the solvent and analyte
 - 3.2.3.3.2 Must operate at flow rates from 1 $\mu\text{L}/\text{min}$ to 2 mL/min when 100% water is used without splitting
 - 3.2.3.3.3 An electrically-isolated electrospray needle, shall be included and be capable of operation up to ± 6.0 kV at 100 μ amps discharge current.
 - 3.2.3.3.4 Must have an optional, interchangeable metal spray needle for stable flows down to 1 $\mu\text{L}/\text{min}$
 - 3.2.3.3.5 Shall be moveable relative to the sampling orifice for optimal tuning
- 3.2.3.4 Transfer ion optics
 - 3.2.3.4.1 Shall consist of RF only square quadrupole non-linear transfer ion optics
 - 3.2.3.4.2 Must be designed for high stability and ion transmission efficiency
 - 3.2.3.4.3 The square quadrupole must incorporate neutral blocking post to eliminate noise and provide effective ion transmission from the RF lens to the mass analyzer.
- 3.2.3.5 Inter quadrupole ion guide lens
 - 3.2.3.5.1 The mass spectrometer must include an inter-pole lens orifice optimized for ion transmission between the square quadrupole and Q1.
- 3.2.3.6 Triple stage quadrupole mass spectrometer
 - 3.2.3.6.1 The analyzers must be dual segmented hyperbolic quadrupole.
 - 3.2.3.6.2 The quadrupoles shall have a large field radius of ≥ 5.25 mm for high transmission and superior peak shape.
 - 3.2.3.6.3 The collision cell must have a 90-degree square profile quadrupole ion guide.
 - 3.2.3.6.4 The collision cell must have an axial DC field for acceleration of fragment ions enabling data acquisition rate of ≥ 500 SRM/second.
 - 3.2.3.6.5 Shall be software controlled and have the function of automated optimization of collision energy
 - 3.2.3.6.6 Shall have an automatic mass and resolution calibration “check”
 - 3.2.3.6.7 Shall have automatic system calibration and optimization
 - 3.2.3.6.8 Shall have ion polarity switching of 25 ms, including signal stabilization time.

- 3.2.3.6.9 Shall be capable of high resolution precursor ion selection (at 0.2 Da FWHM across the mass range)
- 3.2.3.7 Vacuum system
 - 3.2.3.7.1 High vacuum shall be maintained by turbo molecular pump, which shall be backed by mechanical (roughing) pump(s)
 - 3.2.3.7.2 Should be delivered with enclosure to reduce the noise level of the mechanical pump
- 3.2.3.8 MS detection system
 - 3.2.3.8.1 Shall have a high energy conversion dynode and high-gain electron multiplier horn
 - 3.2.3.8.2 Shall be capable of supporting linear dynamic range of at least 6 orders of magnitude
 - 3.2.3.8.3 Shall be capable of detecting both positive and negative ions
- 3.2.3.9 Divert valve
 - 3.2.3.9.1 The divert valve must be fully automated controlled by data system.
 - 3.2.3.9.2 Shall enable the user to switch the solvent front, gradient end point and any other portion of the IC effluent to waste
 - 3.2.3.9.3 Allow user to define the default state of the valve and change state in time segments
- 3.2.3.10 Syringe Pump
 - 3.2.3.10.1 Shall be controlled by data system to allow for automated infusion
 - 3.2.3.10.2 Shall be switched on and off in time segments by data system
- 3.2.3.11 Auxiliary pump
 - 3.2.3.11.1 Shall be a single-piston, isocratic metering pump for makeup solvent or supply external water or reagent for suppressor
 - 3.2.3.11.2 Its material shall be PEEK, ceramic and /or inert polymer
 - 3.2.3.11.3 Flow rate: adjustable in range of 0.01 – 9.99 ml/min
 - 3.2.3.11.4 Pressure ripple: 2% peak-to-peak at 100 psi, 1ml/min with in-line pulse damper
 - 3.2.3.11.5 Pressure range: able to reach 15 MPa
 - 3.2.3.11.6 Control: to be interface with IC-MS system software and PC via USB
 - 3.2.3.11.7 Flow accuracy: 3% throughout flow range
 - 3.2.3.11.8 Flow precision: 0.5%
- 3.2.4 Nitrogen Generator
 - 3.2.4.1 Shall be able to supply IC-MS required nitrogen gas at sufficient flow rate and gas pressure (32 L/min at 6.9 bar., i.e., 1.13 CFM at 100 psi)
 - 3.2.4.2 Operating temperature: 5-35 °C
 - 3.2.4.3 Maximum relative humidity: 80% non-condensing
 - 3.2.4.4 Particle: < 0.01 µm
 - 3.2.4.5 Noise Level ≤ 54 dB(A) at 1m distance
 - 3.2.4.6 Flexibility to position generator where required, the generator shall be supplied with caster wheels for easy mobility

3.2.4.7 Simple installation, generator designed as a plug & play system

3.2.5 Consumables and Accessories

The Contractor shall supply the following consumables and accessories at his own cost:

3.2.5.1 One set of maintenance tools for the IC-MS system

3.2.5.2 Provision of all necessary consumables and/or accessories, such as sample trays for autosampler, waste/drain tubing, and calibration standard materials required for commissioning, calibration, performance check and training of the IC-MS system.

3.2.5.3 At least 2,000 sample vials (1.5-2.5 ml) with caps shall be included in this tender

3.2.5.4 One set of operation manual

3.2.6 Data system, PC and printer

3.2.6.1 Data system that shall meet the minimum specifications listed below

- a. Shall include IC and MS instrument control and data processing software
- b. Shall be compatible for use on Microsoft Windows 10 or higher operating environment
- c. Shall incorporate a graphical user interface which utilize multi-panel windows for easy data acquisition and analysis.
- d. It shall provide feature to ensure no data is lost in the event when the computer breaks down or operating system hangs.
- e. It shall allow multiple applications windows to appear concurrently on the display for easy viewing.
- f. It shall have the function of auto-shut down, delay starting, smart start-up etc.
- g. Automatic shutdown function available upon reaching the pressure limit
- h. Other software included for proposed system to function fully if necessary
- i. The software licence to the Board shall be provided without extra charge.

3.2.6.2 PC that shall meet the minimum specifications listed below:

- a. Intel Core™ i7-8700 Processor (6 Cores/12MB/12T/up to 4.6GHz/65W) or equivalent
- b. Operating system: Microsoft Windows 10 Professional or equivalent with BitLocker Encryption
- c. Memory: 16 GB RAM
- d. Intel Integrated Graphics or equivalent
- e. Hard Drive: 1000 GB
- f. 8x DVD+/-RW 9.5mm Optical Disk Drive
- g. Minimum of 6 USB (2.0 & 3.0) Ports
- h. Minimum of 2 Integrated 10/100/1000 Gigabit Ethernet connections
- i. Monitor: 21-inch LCD flat panel display, resolution 1920×1080
- j. System documentation kit
- k. USB Optical Scroll Mouse

- l. USB Keyboard
- m. One (1)-year on-site warranty for the PC, including labour, parts and accessories

3.2.6.3 Printer that shall meet the minimum specifications listed below:

- a. Shall be a laser jet printer with double side print function
- b. Processor speed 800 MHz, memory 256 MB
- c. Fast Resolution 1200 (up to 1200 x 1200 dpi)
- d. Print speeds up to 40 A4-papers per minutes
- e. Hi-Speed USB 2.0
- f. Install with the latest firmware and wifi features disabled

3.3 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

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

3.4 REQUIREMENT TO CONNECT TO LABORATORY INFORMATION MANAGEMENT SYSTEM

- 3.4.1 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.
- 3.4.2 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 save) in a specific folder.
- 3.4.3 The best location to store the instrument result files is in the server.
- 3.4.4 STARLIMS will then capture these files from the server and update to the system.
- 3.4.5 The result file shall be in 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)

3.5 TRAINING

- 3.5.1 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 IC-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.

3.6 POWER, GAS SUPPLY AND EXHAUST SYS REQUIREMENT

- 3.6.1 The IC-MS system will be installed on a bench in the laboratory (82 Toh Guan Road East, #C2-20, WaterHub, Singapore 608576). The Contractor shall check the available electrical points, exhaust extraction system, gas lines with pressure regulators and outlet shut off valves, and make necessary alteration and addition without any extra cost to PUB for the installation and commissioning of the IC-MS system.

3.7 HANDOVER

- 3.7.1 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
- 3.7.1.1.1 latest Microsoft security patches
 - 3.7.1.1.2 latest anti-virus definition updates
 - 3.7.1.1.3 hardening documentations
 - 3.7.1.1.4 backup and recovery procedures and mechanisms (includes image)
- 3.7.2 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
- 3.7.2.1.1 Issues resolution
 - 3.7.2.1.2 backup and recovery procedures and mechanisms (includes image)

3.8 WARRANTY

- 3.8.1 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 (excluding consumable parts). All labour costs shall deem to be included in the tender sum.
- 3.8.2 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 3.8.3 The Contractor shall re-install the software, when necessary, during the warranty period.

3.9 AFTER SALES SERVICES

- 3.9.1 The Tenderer shall provide full **details of after sales services** in his submission, including response time and price for the supply, replacement, repairing and servicing of the IC-MS system supplied. The Tenderer must demonstrate that it has a proven appropriate setup and capability to provide after-sales service efficiently and effectively. Tenderer without the proper

facility or experience to carry out the after sales services for the IC-MS system would not be considered under this tender.

3.10 SCHEDULE OF DEVIATIONS

- 3.10.1 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.**

3.11 PLACE AND PERIOD OF DELIVERY

- 3.11.1 The Contractor shall deliver, install and commission the IC-MS system complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, #C2-20, WaterHub, Singapore 608576 within **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 ULTRA HIGH PERFORMANCE LIQUID CHROMATOGRAPHY-TRIPLE QUADRUPOLE MASS SPECTROMETER (UHPLC-MS/MS)

The UHPLC-MS/MS system 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 4.1 and the system shall comply with the technical specifications specified in clause 4.2.

4.1 SCOPE OF WORK

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

- 4.1.1 Supply, delivery and commissioning of a UHPLC-MS/MS system complete with UHPLC pump with built-in sample introduction system, solvent delivery system, column oven, solvent degasser, triple quadrupole mass spectrometer system, software for instrument control, one computer system for hardware control and data handling, printer, N₂ gas generator, instrument installation relevant work including instrument configuration, gas line configuration and bench configuration, accessories and consumables.
- 4.1.2 Provision of starter and calibration kit, all necessary accessories and consumables for commissioning, calibration and performance check of the UHPLC/MS/MS system.
- 4.1.3 Carrying out all other work not specified herein for the successful commissioning of the entire system.

4.2 TECHNICAL SPECIFICATIONS

4.2.1 High Performance Liquid Chromatography

4.2.1.1 Sample Introduction system

- 4.2.1.1.1 injection volume: 0.1 – 50 µL in 0.1 µL increment
- 4.2.1.1.2 Injection precision: < 0.25% RSD from 2- 20 µL
- 4.2.1.1.3 Injection accuracy: ±1% for 10 µL, n=10
- 4.2.1.1.4 Pressure range: up to 1200 bar
- 4.2.1.1.5 injection cycle time: < 25 s with need wash
- 4.2.1.1.6 Sample carryover: < 0.005%
- 4.2.1.1.7 Controlled sample environment over a range of 4 – 40 °C
- 4.2.1.1.8 Must have include the sample tray with at least 100 vial capacity for 1.5ml standard vials

4.2.1.2 Solvent Delivery System

- 4.2.1.2.1 Pump system: ultra high pressure binary pump
- 4.2.1.2.2 Settable flow range: 0.001 – 2 mL/min, in 0.001 mL/min increments
- 4.2.1.2.3 Flow precision: 0.07% RSD or 0.005 min SD, whatever is greater
- 4.2.1.2.4 Flow accuracy: ±1% or 10µL/min whatever is greater
- 4.2.1.2.5 Pressure pulsation: <1% amplitude or <5 bar whichever is greater

- 4.2.1.2.6 Compressibility compensation: automatic, pre-defined, based on mobile phase selection
- 4.2.1.2.7 pH range: 2.0-12.0
- 4.2.1.2.8 Composition range: settable range: 0.0 – 100.0%
- 4.2.1.2.9 Composition precision: < 0.15 % RSD or 0.01 min SD whatever is greater
- 4.2.1.2.10 Composition accuracy: $\pm 0.35\%$ absolute from 5-95%
- 4.2.1.2.11 Integrated Degassing Unit: 2 channels
- 4.2.1.2.12 Materials in contact with solvent: Teflon AF, FEP, PPS
- 4.2.1.2.13 Regular tray with 4 solvent bottles complete with fitting & automatic rinsing kit
- 4.2.1.2.14 Leak sensor as safety feature

4.2.1.3 Column Compartment

- 4.2.1.3.1 Temperature range: 10 °C above ambient to 80 °C in 0.1°C steps
- 4.2.1.3.2 Temperature stability: +0.05 °C for flow rates between 0.2 and 2 ml/min
- 4.2.1.3.3 Temperature set point accuracy: + 0.5 °C
- 4.2.1.3.4 Heat-up rate: within 5 min from ambient to 40 °C
- 4.2.1.3.5 Can house up to 3 columns with built-in column switching valve
- 4.2.1.3.6 Should be able to handle column length from 10-250 mm

4.2.1.4 Solvent Degasser

- 4.2.1.4.1 On-line vacuum type
- 4.2.1.4.2 Maximum flow rate: 2 ml/min per channel
- 4.2.1.4.3 Internal volume per channel should not be more than 1.5 ml
- 4.2.1.4.4 Should have at least 2 independent channels
- 4.2.1.4.5 Error status should be fed back to system software
- 4.2.1.4.6 Leak sensor as a safety feature

4.2.2 Triple Quadrupole Mass Spectrometer System

- 4.2.2.1 Minimum mass range: 10-1800 amu
- 4.2.2.2 Scan speed at least 15,000 amu/sec
- 4.2.2.3 Mass stability: maximum ± 0.1 amu over 24 hrs
- 4.2.2.4 Mass resolution: minimum 0.7 Da with autotune
- 4.2.2.5 Nebuliser spray can be orientated perpendicular to the axis of the ion source or OFF-Axis ion source
- 4.2.2.6 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
- 4.2.2.7 Source elements can be removed for cleaning without breaking vacuum
- 4.2.2.8 Fully automated optimization of ion optics and mass axis calibration
- 4.2.2.9 Positive/Negative polarity switching must be less than 30 ms, in continuous mode during LC/MS and LC/MS/MS runs
- 4.2.2.10 An Extra syringe pump must be available as an option for direct infusion of sample.
- 4.2.2.11 Delivered with necessary tubing, connectors and tools for enabling the above functions
- 4.2.2.12 The ion source should be equipped with Atmospheric Pressure Ionisation (API) Probes, one set of Elettrospray Ionisation (ESI) source

and another set of APCI (Atmospheric Pressure Chemical Ionisation) interface

4.2.2.13 Electrospray Ionisation (ESI) Source

- 4.2.2.13.1 Compatible with liquid flow rates of 1 μ L/min to 2 mL/min without splitting
- 4.2.2.13.2 The ESI source must be equipped with heater assembly for achieving efficient desolvation and increased efficiency of ionization
- 4.2.2.13.3 Source temperature: 400 °C or higher
- 4.2.2.13.4 Full gradient capability from 100% aqueous to 100% organic
- 4.2.2.13.5 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
- 4.2.2.13.6 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 μ L 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 μ L injection or 0.5 ppt with 50 μ L injection) for perfluorooctanoic acid (PFOA) injected on-column, MRM transition m/z 413 to 369.

4.2.2.14 APCI (Atmospheric Pressure Chemical Ionisation) source

- 4.2.2.14.1 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
- 4.2.2.14.2 Compatible with liquid flow rates of 50 μ L/min to 2 mL/min without splitting
- 4.2.2.14.3 Source temperature: 400 °C or higher
- 4.2.2.14.4 Full gradient capability from 100% aqueous to 100% organic

4.2.2.15 Mass Analyzer

- 4.2.2.15.1 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).
- 4.2.2.15.2 Maximum dwell time of 1ms
- 4.2.2.15.3 LCMS start-up kit should be supplied as standard

4.2.2.16 Mass detector

- 4.2.2.16.1 Has high energy conversion dynode and high-gain electron multiplier horn
- 4.2.2.16.2 Detector operates in both positive and negative ion modes
- 4.2.2.16.3 At least six orders of magnitude for linearity

4.2.2.17 Vacuum System

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

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

4.2.3 Nitrogen Gas Generator

- 4.2.3.1 Curtain gas (nitrogen): 12 L/min @ 80 psi
- 4.2.3.2 Source gas (dry air) 24 L/min @ 110 psi
- 4.2.3.3 Exhaust gas: (dry air): 8 L/min @ 60 psi
- 4.2.3.4 Must have dual redundant built-in air compressors
- 4.2.3.5 Noise level: $\leq 54\text{dB (A)}$
- 4.2.3.6 Phthalates: none
- 4.2.3.7 Particles $< 0.01\text{micron}$
- 4.2.3.8 Suspended liquid: none

4.2.4 Data system, PC and printer

4.2.4.1 Data system that shall meet the minimum specifications listed below

- 4.2.4.1.1 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
- 4.2.4.1.2 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
- 4.2.4.1.3 Has on-line help for instrument control programs as well as user manual in PDF file format
- 4.2.4.1.4 It should cover digital instrument control, qualitative and quantitative processing, report creation, self-diagnosis and auto-tune.
- 4.2.4.1.5 Auto tuning with sensitivity and resolution optimization for both positive ion and negative ion should be standard.
- 4.2.4.1.6 Capable of tuning for electrospray (ESI) in positive and negative ion modes
- 4.2.4.1.7 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
- 4.2.4.1.8 The software must have “MRM triggered full scan MSMS” function in order to have additional information and confirmation of target compounds.
- 4.2.4.1.9 Automatic mass calibration routines
- 4.2.4.1.10 Zoom scan capability for achieving higher mass resolution
- 4.2.4.1.11 The software must be able to perform Automatic determination of MRM transitions for easy method development
- 4.2.4.1.12 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.
- 4.2.4.1.13 MRM ion table can associate name to ion and internal standard
- 4.2.4.1.14 Dynamic/Scheduled MRM function with automatic maximization of dwell time for multi-residues analysis
- 4.2.4.1.15 The self-diagnosis feature of the software should enable diagnosis of the mass spectrometer and all connected LC units.

- 4.2.4.1.16 Method file should be capable to save all analysis parameters, data processing parameters and report format.
- 4.2.4.1.17 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
- 4.2.4.1.18 Auto Start up and shutdown of the MS should be possible using a single key operation.
- 4.2.4.1.19 Sample schedule wizard function should be standard
- 4.2.4.1.20 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

4.2.4.2 PC that shall meet the minimum specifications listed below:

- 4.2.4.2.1 Intel Core™ i7-8700 Processor (6 Cores/12MB/12T/up to 4.6GHz/65W) or equivalent
- 4.2.4.2.2 Memory: 16 GB RAM
- 4.2.4.2.3 Intel Integrated Graphics or equivalent
- 4.2.4.2.4 Hard Drive: 500 GB 3.5" SATA (7,200 Rpm) Hard Drive
- 4.2.4.2.5 8x DVD+/-RW 9.5mm Optical Disk Drive
- 4.2.4.2.6 Minimum of 6 USB (2.0 & 3.0) Ports
- 4.2.4.2.7 Minimum of 2 Integrated 10/100/1000 Gigabit Ethernet connections
- 4.2.4.2.8 Operating system: Microsoft Windows 10 Professional or equivalent with BitLocker Encryption
- 4.2.4.2.9 23" LCD monitor
- 4.2.4.2.10 System documentation kit
- 4.2.4.2.11 USB Optical Scroll Mouse
- 4.2.4.2.12 USB Keyboard
- 4.2.4.2.13 One (1)-year on-site warranty for the PC, including labour, parts and accessories

4.2.4.3 Printer that shall meet the minimum specifications listed below:

- 4.2.4.3.1 Laser printer
- 4.2.4.3.2 Print speeds up to 42 ppm (Letter) & 40 ppm (A4)
- 4.2.4.3.3 Fast Resolution 1200 (up to 1200 x 1200 dpi)
- 4.2.4.3.4 Processor speed 540 MHz, memory 128 MB
- 4.2.4.3.5 Hi-Speed USB 2.0. Std
- 4.2.4.3.6 Must have double side print function
- 4.2.4.3.7 Install with the latest firmware and wifi features disabled

4.2.5 Consumables and Accessories

- 4.2.5.1 ESI tuning mix, 100ml
- 4.2.5.2 APCI calibration solution, 100ml
- 4.2.5.3 APCI low concentration tuning mix, 100ml (optional)
- 4.2.5.4 ES/APCI positive ion performance standard, 5 X 1ml ampoules
- 4.2.5.5 Electrospray LC demo sample
- 4.2.5.6 ESI+APCI LC demo sample
- 4.2.5.7 ES negative ion standard performance standard, 5 x 1ml ampoules

- 4.2.5.8 LC/MS tool kit
- 4.2.5.9 Plastic tubing cutter
- 4.2.5.10 Different capillary tubing which is:
 - 4.2.5.10.1 from column to DAD cell (4 pieces)
 - 4.2.5.10.2 port valve to column (2 pieces)
- 4.2.5.11 Peek tubing:
 - 4.2.5.11.1 ID 0.18mm, length 1.5m (4 pieces)
 - 4.2.5.11.2 ID 0.13mm, length 1.5m (4 pieces)
- 4.2.5.12 Foreline pump oil, Inland 45, 1L for LC/MS/MS pump use, 4 bottle
- 4.2.5.13 Column guard cartridge for following HPLC column (4units)
- 4.2.5.14 Chromatography Columns:
 - 4.2.5.14.1 Biphenyl column, core-shell, 100 x 2.1 mm, particle size 2.6 μ m (2 units)
 - 4.2.5.14.2 XB C18 column, core-shell, 100 x 2.1 mm, particle size 2.6 μ m (2 units)
 - 4.2.5.14.3 PS C18 column, fully porous, 100 x 2.1 mm, particle size 1.7 μ m (2 units)
 - 4.2.5.14.4 C18 column, fully porous, 150 x 2.1 mm, particle size 1.7 μ m (2 units)
- 4.2.5.15 The samples will be sent to suppliers for evaluation. Sensitivity and reproducibility will be taken into consideration.
- 4.2.5.16 System includes installation kit and maintenance kit
- 4.2.5.17 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

4.3 ADMINISTRATIVE RIGHTS AND ANTIVIRUS SOFTWARE

- 4.3.1 The Contractor shall install, configure and commission the following software items with complete documentation:
 - 4.3.1.1 The software package and accompanying modules. The software shall be able to run normally and correctly on a user account without administrator rights.
 - 4.3.1.2 Operating system and necessary system components

4.4 REQUIREMENT TO CONNECT TO LABORATORY INFORMATION MANAGEMENT SYSTEM

- 4.4.1 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.
- 4.4.2 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 save) in a specific folder.
- 4.4.3 The best location to store the instrument result files is in the server.
- 4.4.4 STARLIMS will then capture these files from the server and update to the system.
- 4.4.5 The result file shall be in 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)

4.5 TRAINING

- 4.5.1 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.

4.6 POWER REQUIREMENT

- 4.6.1 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 system will be placed. External transformer is not acceptable.

4.7 HANDOVER

- 4.7.1 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
- 4.7.1.1.1 latest Microsoft security patches
 - 4.7.1.1.2 latest anti-virus definition updates
 - 4.7.1.1.3 hardening documentations
 - 4.7.1.1.4 backup and recovery procedures and mechanisms (includes image)
- 4.7.2 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
- 4.7.2.1.1 Issues resolution
 - 4.7.2.1.2 backup and recovery procedures and mechanisms (includes image)

4.8 WARRANTY

- 4.8.1 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 (excluding consumable parts). All labour costs shall deem to be included in the tender sum.
- 4.8.2 The Contractor shall notify the Board of any version updates to their software during the warranty period.
- 4.8.3 The Contractor shall re-install the software, when necessary, during the warranty period.

4.9 AFTER SALES SERVICES

- 4.9.1 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.

4.10 SCHEDULE OF DEVIATIONS

- 4.10.1 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.**

4.11 PLACE AND PERIOD OF DELIVERY

- 4.11.1 The Contractor shall deliver, install and commission the UHPLC-MS/MS system complete with accessories and consumable materials as specified under the Technical Specifications to Public Utilities Board, 82 Toh Guan Road East, #C4-04, WaterHub, Singapore 608576 within **four (4) months** from **Date of Commencement** as specified in the **Letter of Acceptance**.