**099000 - Technical Specification UV Disinfection System – Base Bid**

# GENERAL

## GENERAL:

The Contractor shall provide all labor, materials, tools, and equipment required to furnish and install a vertical format UV disinfection system including startup, commissioning and performance testing and shall be suitable for continuous service as shown on the plans and as specified herein.

### Work and Components to be provided by UV System Manufacturer (But Not Limited To):

1. Vertical UV disinfection modules.
2. Power distribution/data center (PDDC) and interconnecting power and data Cables to modules.
3. UV Intensity Monitoring System.
4. UV eye shields.
5. Personnel safety equipment.
6. Automatic dose/flow pacing energy conservation system (Row-By-Row).
7. Automatic fault compensation (Row-By-Row).
8. Effluent level control device (reuse existing)
9. Spare Parts.
10. Start-up, testing, and personnel training.
11. Module lifting frame.
12. Automatic module cleaning (wiping) system.
13. Stainless steel tank for cleaning station (reuse existing)
14. Cleaning plate exerciser.
15. Stepdown transformer (480/400).

### Work to be Provided by the Contractor (But Not Limited To):

1. Foundations, concrete channels, conduits, handrails and stairs.
2. Removal of existing equipment.
3. UV channel cleanup.
4. Installation of new equipment.
5. Main electrical power supply including a properly grounded neutral.
6. Control wiring and installation for remote signals.
7. Piping, channel drains and valves.
8. Walkway Grating.
9. Channel isolation gates and motorized gate actuators.
10. Lifting crane and hoist (1/2 ton minimum, reuse existing).
11. Interconnect conduits between the wireways and the PDDC.

### Manufacturer:

1. The process design and equipment layout specified and as shown on the contract drawings is based upon the Aquaray® 40 “HO” High Output Vertical Lamp System as manufactured by Veolia Water Technologies Treatment Solutions USA Inc. of Leonia, NJ. If an alternate UV system manufacturer is proposed, the Contractor is responsible for all costs associated with the system evaluation and redesign including all electrical, mechanical, structural and civil aspects of installation. No alternate shall be considered unless pre-approved by the owner/engineer 14 days prior to bid opening.
2. Any alternate “approved as equal” manufacturers shall only be reviewed following bid submittal if elected by the Engineer and Owner.
	1. To be considered, the manufacturer will be regularly engaged in the manufacture of UV systems with a proven track record of at least fifty (50) installations of 10 MGD or more in Continental United States
	2. The manufacturer will provide documentation of previous experience with at least 5 references – location, names and contacts - of municipal UV disinfection systems in wastewater applications with the same type and model of equipment proposed.
	3. Alternate submittals from manufacturers will include a complete and detailed proposal of equipment offered, including the number of lamps proposed and a detailed description of any exceptions taken to the specification.
	4. To be considered, the alternate manufacturer will submit a bioassay evaluation for the proposed UV system. This bioassay must follow protocols described in the NWRI (National Water Research Institute) Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, Third Edition (August 2012), for MS2 bioassays, without exception. The manufacturer’s bioassay report must demonstrate that the proposed UV system design and number of lamps will deliver the specified dose.
	5. Independent certification of fouling factor and lamp aging factor must be submitted if values other than the specified default values are being proposed.
	6. Documentation of UV manufacturer's service capabilities including location and experience.
	7. Sample disinfection performance guarantee including scope and duration of guarantee.

### UV System Requirements:

1. Provide a UV disinfection system complete with UV modules, Power Distribution Data Center(s), UV intensity sensor(s), module cleaning system, automatic level controls and eye shields as shown on the contract drawings and as herein specified.
2. The disinfection system shall be designed for maximum energy conservation and partial system shutdown by automatic flow pacing in increments not to exceed 10% in response to plant flow and UVT meter signals.
3. System sizing and dose calculations shall be based on a third-party bioassay. Dose calculations based on the Point Source Summation model, or any UV intensity model, will not be accepted.

### Lamp Array Configuration:

1. The lamp array configuration shall be vertical, with a uniform staggered array, with all lamps parallel to each other and 90o perpendicular to the flow. The lamps shall be spaced in vertical rows with centerline spacing which will ensure effective disinfection and low system head loss.
2. System with inclined or horizontal lamp array configurations that are not 90o perpendicular to the flow direction shall not be allowed.

## SUBMITTALS:

### The Contractor shall furnish the following information to insure a successful fast track completion of this project. Failure to comply with these requirements may result in the rejection of submittal.

1. UV system manufacturer references for a minimum of fifty (50) installations of 10 MGD or greater within the Continental United States using the same vertical lamp concept.
2. An Independent third party bioassay based on the 40 lamp vertical UV High Output Lamp arrangement and specific to the equipment being supplied shall be provided. This bioassay must follow protocols described in the NWRI (National Water Research Institute) Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse, Third Edition (August 2012), for MS2 bioassays.

### The manufacturer shall provide 5 copies of shop drawing submittals, these shall include interconnections and interface requirements, dimensions and locations of all major elements of the UV system and critical clearance requirements. Once approved no changes may be made without the written consent of the engineer and the UV equipment supplier. Information should include the following:

1. Complete description in sufficient detail to permit a thorough comparison with the appropriate specification section(s).
2. Major component dimensions and installation requirements.
3. Complete description in sufficient detail to permit a thorough comparison with the appropriate specification section(s)
4. Descriptive summary of the UV system provided.
5. Electrical and major component layouts.
6. Head loss calculations demonstrating compliance with the specified hydraulic characteristics.
7. UV dosage calculations. Dose calculations shall be based on bioassay third-party calculations.
8. Preliminary UV equipment O & M manuals prepared for this project.

### C. Project Specific Operation and Maintenance Manuals:

Final Operation and Maintenance (O&M) manuals for this specific project shall be submitted to the Engineer upon approval of shop drawings and delivery of the equipment. The O&M manuals shall include instructions on equipment storage, installation, start-up, and operation and maintenance, together with a thorough troubleshooting guide and recommended spare parts list.

## QUALITY ASSURANCE:

### The vertical UV disinfection system shall be capable of disinfecting the specified flows based on the minimum influent water quality specified in Section 1.04A.

### Acceptance Test. The UV manufacturer shall provide a test protocol for the UV system to be followed after initial start-up and following a minimum of 10 days of continuous plant operation. The installing contractor shall notify the Owner and UV manufacturer in writing, that he is prepared to begin the acceptance test. The Owner shall then provide written notification to the Contractor to proceed with the acceptance testing. Results of the test done by the contractor will be supplied for review to the UV manufacturer.

## DESIGN CRITERIA:

### Provide equipment which shall disinfect an effluent with the following characteristics:

Peak Flow : 8 MGD

 (4 MGD per channel)

Total Suspended Solids : <30 mg/L (30-day geometric mean)

 <45 mg/L (Single sample maximum)

Ultraviolet Transmittance

@ 253.7 nm: 65% (minimum)

Effluent Standards to be achieved:

Fecal Coliform : <200 MPN/100 mL (30-day geometric mean)

### The system shall be installed in an open channel having the following dimensions.

Length: Existing

Width : Existing

Depth : Existing

### The effluent depth in the channel shall be automatically maintained at a nominal 60 inches water depth (±1.5").

### A total of two (2) channels shall be provided. The two (2) existing UV channels shall be retrofitted with new UV equipment. The UV system shall deliver a minimum UV dose of 30 mJ/cm2 at peak flow of 8 MGD and minimum UV transmittance of 65% with all UV modules in service.

### The system supplied shall, as a minimum, include:

Number of Channels: 2

Number of UV Modules/Channel : 2

Module Layout: 1 Across by 2 Banks in Series

UV Modules, Total: 4

Number of Lamps in Each Module : 40

UV Lamps, Total: 160

Number of Power Distribution

And Data Centers (PDDC): 1

Number of UV Intensity Sensors : 4

Number of Low/High Level Switches : 2 sets

Number of air hose assemblies: 5

Level Controllers: Fixed weirs (reuse existing)

## PERFORMANCE REQUIREMENTS:

### System Performance

1. The end of lamp life third-party bioassay UV dose produced by the system shall not be less than 30.0 mJ/cm2 with all UV modules in service, in an effluent with 65% UV transmission at 253.7 nm. Lamp output must be at least 90% of initial level after 13,000 hours of operation and with no fouling on the lamp sleeves.
2. The system design shall be based on third-party bioassay dose calculations taking into consideration the criteria listed below. Dose calculations based on the Point Source Summation model, or any UV intensity model, will not be accepted.
	1. UV transmission (T10) 65%.
	2. UV lamp end of life derating factor (fP) = 0.90.
	3. Sleeve fouling derating factor (fP) = 0.90 (in addition to 10% quartz sleeve loss).
3. Total head loss for each channel shall not exceed 1.10 inches, this being confirmed by measurements in the field after start-up.

### Energy and Lamp Conservation (Automatic Flow Pacing)

1. The UV control system shall automatically turn on and off appropriate rows in relation to variations in plant flow and UV transmittance. The signals, provided by others, shall be 4-20 ma or numerical via Ethernet Modbus TCP/IP.
2. For this project, the UV system shall be capable of responding in minimum 10% increments within each channel for maximum flow pacing flexibility and economy.
3. The UV system design shall allow the operator an option to operate the UV system in either manual or automatic modes.
4. To reduce energy consumption the UV system shall be capable of automatically adjusting the number of lamps in service by eight lamp increments within each UV module.

### Automatic Fault Compensation

1. Flow pacing shall be proactive and compensate for failed lamps by automatically turning on additional rows of lamps.
2. The UV system controls shall ignore the dose contribution of a row when 2 or more lamps out of 8 lamps are reported failed.

# PRODUCTS

## MATERIALS:

### General:

1. All metal components in contact with effluent shall be Type 316L stainless steel.
2. All material exposed to UV light shall be Type 304L or Type 316L stainless steel, Type 214 quartz, Teflon, or other suitably UV resistant material.

### Ultraviolet Lamps:

Lamps shall meet the following requirements:

1. Low pressure High Output UV lamps. Each lamp shall produce UV light with at least 90% of the UV emission at 253.7 nanometer wave length.
2. Low pressure mercury of the hot cathode instant start design in which the coiled filament cathodes are heated by the arc current.
3. The filament of the lamps shall be the clamped design, significantly rugged to withstand shock and vibration.
4. The electrical connections of the UV lamps at one end shall be through a non-proprietary pigtail with molded 2-wire connector.
5. The rated UVC lamp output shall be approximately 52.0 UVC watts.
6. The UV lamp intensity at a distance of 1 meter in air shall be 370 microwatts/square centimeter.
7. Minimum UV lamp arc length shall be 58 inches.
8. Lamps shall not produce any ozone.
9. The lamp bases shall be of a durable construction resistant to UV.
10. The lamp design shall prevent electrical arcing between electrical connections in moist conditions.
11. The power consumption of the system, on a per lamp basis, should not exceed 172 watts.

### Ultraviolet Lamps Guarantees:

1. The UV supplier shall warrant that after 13,000 hours of operation the average UV lamp output will be no less than 90% of a new lamp (after 100 hours initial burn-in).
2. The number of UV lamps required shall be as determined sufficient by the UV manufacturer to meet the required disinfection standard and the minimum UV dosage specified.
3. The UV lamps will be warranted for 13,000 hours of useful life and the warranty is to be pro-rated against actual lamp use.

### UV Lamp Sleeve.

1. The UV lamps are to be protected from contact with the effluent by a 99.9% silicon dioxide quartz sleeve with a minimum of 90% transmission of UV radiation at the 253.7 nanometer wave length and have OD of 24.5 mm and a nominal wall thickness of 1.25 mm.
2. One end of the quartz jacket shall be a closed test tube end and the other open with smooth radius edges.

### Electronic Lamp Controllers (ELC)

1. Each module will include one high performance electronic lamp controller, or ballast for each pair of UV lamps such that the failure of one lamp does not impact operation of the peer lamp. The ELC shall be designed for use with the specified UV lamps. The ELC shall turn on and off lamps upon request and provide analog feedback to the UV system controls such as lamp current and internal ELC temperature. The ELC will automatically shut down lamps upon detection of a ground fault or ELC over-temperature.
2. The ELC shall comply with the following requirements:
	1. Specifically designed to power two (2) UV germicidal low pressure high output lamps, each lamp, with a UVC output of not less than 52 watts.
	2. Powers each UV lamp to produce lamp-output of370 microwatts/cm2UV at a distance of one meter in air.
	3. With two (2) lamps in operation, the electrical power draw shall not 172 watts per lamp.
	4. Electronics shall be housed inside an aluminum casing.
	5. Housed inside the top enclosure of the UV module and attached to heat sinks for optimum cooling.
3. Separate enclosures for the ELCs, if used, must meet UL/NEMA 4X specifications. Force ventilated enclosures which permit introduction of outside air shall not be acceptable unless equipped with an active air filtration system or an automatic signal to advise operators when replacement of filter is required.

### Data Control Assembly (DCA)

1. Each module shall include a Data Control Assembly (DCA), which will provide coordinated command, control and communications between all internal module systems and the UV system PLC via a dedicated Modbus TCP/IP communication link.
2. The DCA card will command:
3. Rows of lamps to turn on and off.
4. Cleaning plate to move up and down.
5. UV module cooling fans to run, or not.
6. The DCA card will gather the following information for the UV system PLC:
7. Lamp on/off status, current, hours and cycles.
8. Cleaning plate end travel (bottom / top).
9. Ballast temperature.
10. UV sensor intensity readings (mW/cm2).
11. Various faults including the ELC GFI failure (ground fault) and ELC over-temperature shutdown (OTSD).
12. Each DCA must include rotary dip switch to customize the last three digits of the DCA card IP address for Modus communication link:
13. Each DCA must include a 10-position rotary dip switch to select a proper restart mode following loss of power or loss of communication with the PLC:
14. Each DCA must include on board LED indicators, which will simplify diagnosis and repairs:

### UV Module:

* 1. Each vertical UV module shall be precision fabricated in type 316L stainless steel. The top enclosure meet the NEMA-4X standards. Six individual compression latches are used to clamp the module lid tight against a foam in place gasket. Four support legs shall connect the module enclosure to a bottom pan.
	2. Each module shall be completely serviceable in the field while located in the channel and shall be fitted with water resistant UL & CE rated multi-pin connectors for power and an RJ-45 connection port for data.
	3. All electrical connections shall be above maximum operating water elevations to protect against electrical hazard.
	4. Ultraviolet lamps, electronic controls and individual ELCs shall be arranged so that they may be easily tested in place. When necessary, any malfunctioning device or unit shall be capable of being replaced without removal of the entire module from the channel.
	5. To maintain proper operating temperatures each module shall be equipped with a stainless steel shroud and high efficiency-cooling fans. The fans and shroud will automatically direct cooling air across the exterior surfaces of the module. In addition to the cooling fan, each module must be fitted with passive aluminum heat sink material to maintain proper operating temperatures inside the module with ambient air temperature from 320F to 1300F.
	6. Each module will be equipped with lifting lugs to allow for the attachment of a lifting spreader so that the modules or banks of modules can be easily lifted with a standard hoist or similar lifting device specified elsewhere.
	7. Automatic interlock protection will be incorporated into each module enclosure such that with the opening of the module enclosure lid power to the lamps will be automatically shut off.
1. Each module shall be identified by the electronic serial number from its DCA card.
2. To minimize chemical cleaning frequency each module shall be equipped with a sleeve cleaning plate fitted with wipers. The wiper cleaning plate must be motor driven and can be operated in either manual or automatic mode from the UV system controls. In automatic, entire channel cleaning cycles are triggered at regular time intervals which are adjustable within the range of once per day to once per week. The wiping system shall be equipped with a current overload detection feature that stops the motor before a mechanical torque tender disengages.
3. Wipers
4. Wipers are designed to clean the sleeve external surface by friction without the need to inject any chemical or detergent in-situ.
5. Wipers shall be fabricated of UV resistant material and installed in a manner which accommodates any irregularities associated with the quartz sleeves and precludes any binding during operation.
6. The wipers shall be replaceable without having to dismantle the wiper drive system, complete removal of the quartz sleeves, or disassembly of the module structure.
7. To further extend the life of the wipers, the wipers shall be normally parked above the water level elevation when not in use. This will also prevent disturbance to the flow hydrodynamics of the module during normal disinfection operation.
8. The wiper system shall be mechanically driven with a single drive assembly. The drive shall incorporate a centrally located means of supporting and aligning the wipers properly throughout the travel.
9. The wipers shall travel the full length of the UV lamp sleeves. Designs with the wipers traveling only part way along the sleeves will not be considered acceptable.
10. Module cleaning systems which rely on a centralized method (such as a compressor or hydraulic pump) for driving the wiper where the failure of that component would result in a loss of wiping capability in the whole system, shall be equipped with a back-up compressor or pump and associated automated valves to insure adequate cleaning of the quartz sleeves.
11. Each UV module housing 40 low pressure high output UV lamps shall be equipped with protruding flow dispersion baffles to improve hydraulic mixing and to create a uniform UV intensity field within the reactor.
12. The baffles shall be an integral part of the UV module.
13. The baffle material shall be 316L stainless steel.

### Electrical:

1. Power requirement of 400V, 3-phase, Wye, 3 wires + neutral + ground, 50/60 Hz, per channel shall be provided. If necessary the UV system supplier shall be responsible in providing one (1) 480V Delta – 400V Wye + neutral + ground /3Phase/50/60Hz/40KVA stepdown transformer per channel.
2. Maximum power consumption per UV module housing 40 low pressure high output lamps shall be 6.88 kW and shall not be greater than 13.76 kW per channel.
3. Each module shall be completely serviceable while located in the channel and shall be fitted with water resistant UL rated multi-pin connectors for power and data. Combined power and data shall not be acceptable.
4. Power interconnect cables and data cables provided in between the UV modules and PDDC shall be field terminated and interconnections be made by the Contractor.

5. Power cable interconnecting conduits between the wireways and the PDDC shall be provided by the Contractor.

## INSTRUMENTATION AND CONTROLS

### Power and Data Distribution Center (PDDC):

* 1. The wall/floor mounted PDDC shall be NEMA 4X rated for indoor/outdoor use, and will be conveniently located as shown on the drawings. The minimum size of the PDDC shall be 48 inches in height, 36 inches width, and 12 inches depth. The maximum size of the PDDC shall be 60 inches in height, 36 inches width, and 12 inches depth. NEMA-3R with forced ventilated enclosures, which allow introduction of outside air shall not be acceptable unless equipped with an active air filtration system or automatic signal to advise operators when replacement of filter is required.
1. Mains power supply will enter the PDDC from below and terminate into an MCB. From the MCB power supply will be split between circuit breakers dedicated to provide power to each module and peripheral equipment.
2. Each UV module shall be protected by a panel mounted thermal magnetic circuit breaker device per NEC Code. These circuit breakers shall be mounted inside the PDDC. Each circuit breaker shall provide visual trip indication, be capable of regular testing. To ensure safe operation, ground fault circuit detection systems, which permit remote reset, shall not be used.
3. The PDDC will include a Local Operator Interface (LOI) as described below. All equipment for the local control and monitoring of the UV system shall be mounted on or in the PDDC.

### Local Operator Interface (LOI) Description

* 1. The LOI shall be PLC based. The Programmable Logic Controller (PLC) shall be an Allen Bradley CompactLogix. The Operator Interface Terminal (OIT) shall be a programmable NEMA 4X rated Panelview Plus 7 standard 10” color touch screen display which shall be mounted on the PDDC panel door. The PLC will communicate with each UV module DCA card using an Ethernet Modbus TCP/IP communication protocol.
	2. System operating information will be displayed on the OIT in both color graphic and text format. The information must be continuously updated. As a minimum the following information shall be displayed in the main screen simultaneously: Number of channels/rows/banks/modules in service, channel actual vs. target dose, UV intensity, communication link status and UV lamp status.
	3. System command, control and status shall be accomplished through the OIT. In the event of a fault the alarm blinks white on a red background until the alarm has been manually or automatically cleared.
	4. Alarms shall, as a minimum, include:
1. Channel low & high level switch.
2. Channel UV dose low and low-low.
3. Module (DCA) comms failure.
4. Module DCA-Ballast com link failure.
5. Module (DCA) over-temperature.
6. Module (DCA) fault.
7. Module lamp fault.
8. Module multi-lamp failure.
9. Module adjacent lamp failure.
10. Module ELC over-temperature shutdown (OTSD).
11. Module ELC GFI.
12. UV intensity sensor out of range.
13. UV intensity sensor low and low-low
14. Cleaning fault
	* 1. Limit switches
		2. Motor overload
		3. Motor timeout
	1. The alarm display will identify the affected module and then the actual component.
	2. Information, such as individual lamp hours and cycles, normally stored in the DCA shall be accessed using the OIT. Lamp cycles and hours shall be reset via a password protected screen.
	3. The Automatic Module Wiper Cleaning system shall be controlled and monitored by the DCA card. Automatic control of each module wiper plate shall be based on time and controlled from the UV system PLC whereby the operator shall be able to alter the interval between cleaning cycles. Manual control of the module wiper cleaning system shall be provided as well (up, down, cleaning cycle, stop).

## AUTOMATIC LEVEL CONTROL

### The existing fixed weirs shall be reused and are placed at the discharge end of the UV disinfection channel(s) to ensure that the UV lamps are properly submerged regardless of the plant flows.

### The level of the water shall be maintained between 57.5” and 62” inches at all design flow conditions.

##  MODULE CLEANING STATION:

### The existing stainless steel liner with drain stub and cover shall be reused. The module cleaning station accommodates one (1) module with 40 lamps immersed in citric or phosphoric acid (5-10% concentration with pH between 2.0-3.0).

## SPARE PARTS AND SAFETY EQUIPMENT

### The UV supplier shall furnish as part of the system the following spare parts and safety equipment:

1. 10% of Installed UV Lamps.
2. 10% of Installed Quartz Sleeves.
3. 10% of Installed Cleaning Wipers.
4. 5% of Installed ELCs.
5. One (1) UV Intensity Sensor.
6. Two (2) pairs of personnel goggles for protection against UV energy between 200 - 400 nanometers wave length.
7. Two (2) UV area warning signs.
8. One (1) 50 lb. bag of citric acid.
9. One (1) Cleaning System Exerciser.
10. One (1) Lifting Frame
11. Gloves

### All spare parts and safety equipment are to be separately packaged. All packages are to have with quantity, item description and part number.

# EXECUTION

## INSTALLATION

### The Contractor shall construct the disinfection channels for the Ultraviolet Disinfection system as shown on the drawings and as recommended by the UV manufacturer.

### Equipment shall be installed in accordance with the manufacturer's shop drawings and written installation instructions.

## ELECTRICAL CONNECTIONS AND WIRING

### The UV manufacturer shall furnish power and data cabling between the UV modules and the PDDC. The incoming power supply, conduit, and field terminations will be the responsibility of the contractor.

### If needed, the contractor shall furnish power, motor starter, and control wiring as required for the air blower.

### Equipment shall be delivered to site requiring minimal on-site labor for installation. Systems requiring extensive on-site wiring of the modules, and systems with more than one power and one data connection per module shall not be allowed.

## MANUFACTURER'S FIELD SERVICES

### Installation and Start-Up Services shall include a minimum of five (5) eight hour days in two (2) trips. Training for Plant Operators and maintenance staff will be coordinated between the Owner, Contractor and UV supplier to ensure maximum effectiveness.

### Service personnel shall be fully qualified and full-time employees of the UV system manufacturer.

### Performance testing of the UV system, if required, will be the Contractor's responsibility.

### The UV supplier shall provide for engineer's approval a formal test protocol for use during performance tests.

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