SECTION 3.0
UV INFLUENT PUMPING DESIGN AND OPERATING DESCRIPTION

3.1 INTRODUCTION

.1 Pumps and related electrical systems are City supplied. The Contractor shall be responsible for supplying, installing, and Commissioning of the pump control systems.

.2 Secondary Effluent (SE) leaves the clarifiers via a pair of rectangular conduits. Up to 400 ML/d of the flow is diverted to one conduit only at the Primary Effluent Bypass Junction structure. The flow is conveyed in this single conduit for approximately 150 m to the existing Effluent Gate Chamber (EGC).

.3 SE enters a new channel connected to the future outfall connection of the EGC. The new channel terminates in a deep section which serves as a pump intake sump. Five (5) laterals convey flow to five (5) vertically mounted axial flow propeller pumps mounted in individual "cans". The pumps discharge into individual boxes set higher than the receiving channel water level, providing a passive backflow protection, with no need for valves or flapgates.

.4 The SE flows down a channel and is distributed into the three (3) UV Reactor Channels.

3.2 DESIGN

3.2.1 Description

.1 SE flows through a channel to a structure where five (5) submersible axial flow propeller pumps are installed in vertical draft tubes. The pumps are removable with an overhead crane for repair, maintenance, and replacement.

.2 Because flows vary throughout the day, the pumps are equipped with variable frequency drives (VFDs). The pump(s) speed modulates to maintain a relatively constant level in the intake sump between the minimum submergence and overflow levels.

.3 There are five (5) pumps, each sized to pump one-fifth ($^1/_5$) of the maximum flow. No standby pump is installed; a sixth unit will be available on the shelf. Because the pumps are relatively easy to remove and install, this reduces the size of the pump intake and discharge structure by approximately 20%.

.4 Each pump will pump between 42 ML/d and 86 ML/d at a static head of 6 to 6.5 m

.5 The pumps will be restricted to a maximum combined flow of approximately 410 ML/d. Flow in excess of this amount will be allowed to back up into the Primary Effluent (PE) Channel and spill over the PE bypass weirs directly into the outfall conduit.

3.2.2 Design Criteria

.1 Five (5) pumps will be installed at this stage, each sized to accommodate 100% of the minimum flow to 20% of the maximum flow (approximately). Each pump will be variable speed. The level in the wetwell (SE channel) will control the speed of the pumps between their minimum and maximum pumping rates. Signals from level sensor(s) in the intake control the pump speed to maintain the set level.

.2 The water depth will be maintained at between 226.12 m ASL (above sea level) (4.3 m above plant datum) to provide at least 1,800 mm above the centre line of the pump intake lateral, and a maximum water level of 226.62 m ASL (4.8 m above plant datum).

.1 Main Inlet Channel Invert: 225.478 m ASL / 3.658 m APD (above plant datum)

.2 Pump Intake Channel and Pipe Invert: 223.72 m ASL / 1.900 m APD

.3 Pump Intake Pipe Centre Line: 224.32 m ASL / 2.5 m APD

.4 Normal LWL (low water level): 226.12 m ASL / 4.3 m APD

.5 Normal Operating Water Level: 226.37 / 4.55 m APD

.6 Normal HWL (high water level): 226.62 ASL / 4.8 m APD

.7 Pump Shut-off Level: 225.82 / 4.0 m APD

.8 Overflow Level: 227.12 m ASL / 5.3 m APD

.3 As the influent flow increases and the water level in the channel rises, the pumps' speeds will increase to prevent SE from rising above HWL (26.62 m), and spilling over the UV bypass weir (227.12 m). At flows less than or equal to 430 ML/d, the pumps turn on and off or speed up and slow down to maintain the water level between the minimum submergence level and the maximum water level.

.4 Flow into the secondary treatment system will be restricted to 380 ML/d at the inlet to the existing High Purity Oxygen (HPO) reactors. Excess flow will overflow at the PE bypass structure. The influent control at the HPO reactors is not precise, and allowance is made for the pumps and UV structure to hydraulically accommodate up to 430 ML/d. Under normal circumstances, the flow into the pump intake will not exceed 380 ML/d.

.5 Each pump is mounted in a 1,000 mm diameter vertical tube, which discharges vertically into individual discharge boxes set approximately 500 mm above HWL in the receiving channel, preventing backflow when a pump is not operating.

3.2.3 Design Data

Description	Units	Design Value
Duty		5
Standby		1 (on shelf)
Capacity (maximum, each)	L/s	995
Capacity (minimum, each)	L/s	486
Discharge tube diameter	mm	1,000 maximum
TDH	m	6-0 - 6.5
Power, each	kW	127 maximum
Firm capacity total	ML/d	410 – 430 (APPROX)
Minimum Submergence	m	1.800
Wetwell (SE channel) floor invert	m	223.42
Pump Intake Pipe Centre Line	m	224.32
Minimum water level at pump intake	m	226.12
Bypass weir elevation	m	227.12
Maximum water level	m	226.62
High High alarm level (bypass occurring)	m	227.12
High alarm (bypass imminent)	m	226.82
Minimum water level (pump stop)	m	225.82

3.2.4 Arrangement

.1 The pump inlet channel abuts the eastern side of the EGC structure. The PE enters a deeper section of channel, and is withdrawn to the pumps by five (5) 1,200 mm diameter laterals [one (1) per pump].

.2 The five (5) pumps are mounted in individual "cans" and discharge tubes which discharge to a channel upstream of the UV reactors.

.3 The UV system is sized for a peak flow of 380 ML/d (disinfection capacity) and approximately 430 ML/d (hydraulic capacity). The pumps installed at this stage will be sized to convey approximately 410 - 430 ML/d.

3.2.5 Other Disciplines

.1 Structural/Building Services

.1 The floor of the pump intake area must be at an elevation to provide an overall minimum submergences.

.2 The length and width of the pump intake area must meet the minimum requirements to optimize flow conditions through each pump.

.3 The enclosure over the pump structure must provide adequate access to allow the pumps to be removed by crane or hoist.

.4 Each pump weighs approximately 1,700 kg; the can and discharge tube assembly is estimated to weigh 11,000 kg.

.2 Mechanical

.1 The pump structure is an enclosed underground structure and does not require general ventilation.

.3 Electrical

.1 The electrical room and electrical service must be sized for the major items of equipment installed summarized in the following table.

Description	**Tag**	**Full Load (kW)**
UV Influent Pump 1	U010-P1	100 – 130
UV Influent Pump 2	U020-P1	100 – 130
UV Influent Pump 3	U030-P1	100 – 130
UV Influent Pump 4	U040-P1	100 – 130
UV Influent Pump 5	U050-P1	100 – 130
TOTAL PUMP LOAD		
UV Lamps		
TOTAL UV LOAD		
Miscellaneous		

3.3 OPERATING DESCRIPTIONS

3.3.1 Control Devices

Description	Location	Number	Function
U010-VFD1	Central	1	Match pump 1 output to inflow, up to 995 L/s
U020-VFD2	Central	1	Match pump 2 output to inflow, up to 995 L/s
U030-VFD3	Central	1	Match pump 3 output to inflow, up to 995 L/s
U040-VFD4	Central	1	Match pump 4 output to inflow, up to 995 L/s
U050-VFD5	Central	1	Match pump 5 output to inflow, up to 995 L/s
U005-LE U005-LIT U005-LT	Local	1	Controls pump VFDs to maintain wetwell water level
U060-LE U060-LIT U060-FT	Local	1	Measure flow by depth over inlet weirs
U170-LE U170-LIT U170-LT	Local	1	Water Depth at UV Channel 1 outlet
U270-LE U270-LIT U270-LT	Local	1	Water Depth at UV Channel 2 outlet
U370-LE U370-LIT U370-LT	Local	1	Water Depth at UV Channel 3 outlet
U102-ZSB			UV outlet weir gate closed
U102-ZSD			UV outlet weir gate open
U102-ZIT			UV outlet weir gate position
U102-HS1/HS2/HS3			UV outlet weir gate HOA
U202-ZSB			UV outlet weir gate closed
U202-ZSD			UV outlet weir gate open
U202-ZIT			UV outlet weir gate position
U202-HS1/HS2/HS3			UV outlet weir gate HOA
U302-ZSB			UV outlet weir gate closed
U302-ZSD			UV outlet weir gate open
U302-ZIT			UV outlet weir gate position
U302-HS1/HS2/HS3			UV outlet weir gate HOA
Off/On Switch	Central	5	Turn pumps on and off from central control
HOA Switch	Local	5	Turn pumps control from central (AUTO) to OFF to local (HAND)
Start/Stop	Local	5	Start and stop pumps in local control mode

3.3.2 Normal

.1 Automatic (local HOA selector switch in AUTO)

.1 The pumps maintain a relatively constant liquid level in the wetwell and generally pump the SE at the same rate as it arrives from the secondary clarifiers.

.2 During normal operation all five (5) pumps will be available for operation, and will run, depending on the flow. The lead and lag pump roles will alternate according to the defined duty assignments.

.3 All five (5) pumps are placed in AUTO mode at the local panel and ON at the central control system.

.4 The speed of the pumps and the number of pumps in operation is controlled by the level in the inlet. One (1) to five (5) pumps normally run continuously, unless the water level falls below the minimum operating level and approaches the level corresponding to the minimum submergence requirement. If this occurs while the pump(s) is/are running at minimum speed, it/they will shut down.

.1 Water levels used for pump control are as follows:

.1 225.82 m (4.0 m): minimum pump submergence level; all pumps shut off.

.2 226.12 m (4.3 m): approximate normal operating level with operating pump(s) running at minimum speed (operating pumps will adjust speed to maintain this level).

.3 226.62 m (4.8 m): Operating pump(s) will speed up if they are running at less than maximum speed if this level cannot be maintained.

.4 226.82 m (5.0 m): Normal HWL at which next duty pump will start. If all duty pumps are operating at maximum speed (> 380 ML/d combined) the water level will be allowed to rise to overflow 227.12 m (5.3 m).

.5 227.12 m (5.3 m): Overflow weir level.

.2 At effluent flows between 85 and 170 ML/d, two (2) pumps will run; water level should be maintained at about 226.37 m. If influent flow drops below the minimum pumping rate of 42 ML/d per pump while the two (2) pumps are at minimum speed, the water level will drop. One (1) pump will shut off in this event. If the inflow is less than 42 ML/d, the last operating pump will shut off when the water level drops to the shutoff level.

.3 As flows increase, the increase in water level will cause additional pumps to start. All operating pumps will be controlled to run at the same speed.

.5 High alarm level is 226.82 m (bypass to outfall is imminent). There are three (3) possible responses to this condition:

.1 If five (5) pumps are running at maximum speed: Normally, as it is permissible to bypass the UV process when flows exceed 380 ML/d, this high level alarm is an “information alarm” only, indicating that bypass of the UV influent pumps is about to occur; the pumps will not speed up past their combined imposed limit of 410 to 430 ML/d. The flow into the pump intakes should not exceed this under normal conditions as the flow is restricted to 380 ML/d at a remote point upstream.

.2 All running pumps should be running at maximum speed if the water rises to this level. If, however, the pumps are not running at maximum speed, the pumps will speed up, and the next duty pump [if four (4) or fewer pumps are operating] will start to prevent overflow into the bypass, up to their combined imposed limit of 410 ML/d.

.3 If High level alarm occurs in conjunction with another alarm that indicates failure or malfunction of a pump, another pump will be started.

.6 High High alarm 227.12 m (bypass to outfall is occurring). There are three (3) possible responses to this condition:

.1 If five (5) pumps are running at maximum speed: Normally, as it is permissible to bypass the UV process when flows exceed 380 ML/d, this alarm is an "information alarm" only, indicating that bypass of the UV is occurring; the pumps will not speed up past their combined imposed limit of 410 ML/d.

.2 All running pumps should be running at maximum speed if the water rises to this level. If, however, the pumps are not running at maximum speed, the pumps will speed up, and the next duty pump [if four (4) or fewer pumps are operating) will start in an attempt to prevent overflow into the bypass, up to their combined imposed limit of 410 – 430 ML/d.

.3 If High level alarm occurs in conjunction with another alarm that indicates failure or malfunction of a pump (at flows less than 330 ML/d), another pump will be started.

.7 Low level alarm is 225.82 m (approximately 300 mm above minimum required pump submergence, indicating pump shutdown is imminent). The pumps will continue to run, but will slow down to try to maintain the water level at this elevation. If the water level drops with all running pumps at minimum speed, they will shut down one by one, until no pumps are in operation.

.8 The lead pump will restart first when the influent level to rises above 226.37 m after all pumps have been shut down

.9 The number of pumps running, and the speed at which they are running, is controlled to maintain a relatively constant level in the wetwell (SE channel) at about 226.37 m.

.10 An ultrasonic level transmitter measures the water level in the wetwell. The signal is sent to the control system, which uses the setpoints for start, stop, speed control, and alarms for the pumps.

.11 A second submersible hydrostatic level transmitter measures the water level in the wetwell. The signal is sent to the control system, which uses the setpoints for start, stop, speed control, and alarms for the pumps.

.12 The operator has the option to select which level signal (or the average of the two) is used for control.

.13 Motor status and HOA status of each pump are output to the Computer Control System.

.2 Manual (Local HOA selector switch in HAND, and start/stop button on START)

.1 Each pump that is in MANUAL will run continuously, regardless of the level in the wetwell (PE channel) or signal from the flow meter, until it is shut off (start/stop button on STOP or HOA placed in OFF or AUTO).

.2 The pump will run at the speed set at the VFD

.3 Start-up

.1 To start the pumps, place the HOA on AUTO and ensure that all control inputs (wetwell levels, flow signals, speed controllers etc) are functional. Ensure the suction and discharge structures are unobstructed. The pumps will start at minimum speed and gradually ramp up to match the controller output and vary their speed automatically in response to the level in the wetwell.

.2 Normally, two (2) pumps will operate in tandem until flow exceeds 170 ML/d. When this occurs, a third pump will start, and the lead pumps will slow down, and the pumps will run at the same speed. Above 250 ML/d, a fourth pump starts. All running pumps ramp down and match speed to pump the incoming wastewater. If the inflow exceeds 330 ML/d, the fifth pump starts. Again, all operating pumps ramp down to match each other's speed. All four (4) pumps then ramp up to match inflow if it increases beyond this point. At 410 ML/d, all five (5) pumps should be running at maximum speed. Higher flows should not occur as the flow into the upstream process is limited to 380 ML/d.

.3 The pumps alternate lead/lag/standby roles according to the defined duty assignments.

.4 Shutdown

.1 From the central control system, any pump can be stopped by the operator by placing it in an OFF status.

.2 From the local panel, placing any pump local HOA selector switch in OFF stops the pump from operating regardless of other conditions.

.3 In AUTO, the pumps automatically shut down in sequence; the LEAD pump continues to run while the LAG pumps shut down in sequence. When inflow falls below 100 ML/d, only the lead pump should remain in operation.

3.3.3 Adverse Conditions

.1 Low Flows: When the minimum capacity of a single pump exceeds the SE flow, water level in the intake structure will fall. The pump will stop if the interval of low flow is sufficient to decrease the water level to the shut off level of 225.82 m (4.0 m). The pump will restart when the water level rises to 226.37 m (4.55 m).

.2 High flows: When flow exceeds the capacity of each individual pump, water level in the intake structure will rise, and the pumps will start/stop or speed up/slow down in response, as described above.

.3 Extreme flows: When the influent to the Works exceeds the design capacity of the five (5) duty pumps (410 – 430 ML/d), the five (5) pumps will run continuously at the speed required to convey their maximum capacity, and excess flows will be allowed to spill over the PE bypass weir (approximately 150 m upstream of the EGC) directly to the outfall.

.4 One (1) unit out of service: The facility is not designed to allow a pump to be taken out of service at any one time. A shelf spare is provided and any out-of-service unit needs to be removed and the spare installed in its place.

3.3.4 Complete Pump System Failure

.1 The pumps are supplied with redundant power supplies. In the event of a *localized* catastrophic event that causes the pump station to shut down, *independently of the entire plant*, it will no longer be possible to disinfect. However, flow will still be entering the plant and the pump station and UV system will need to be bypassed.

.2 Due to hydraulic constraints, it is not possible to passively overflow the peak flow through the existing system. Without pumping, the capacity of the single Secondary Conduit falls from 400 ML/d to approximately 275 ML/d.

.3 If the flow is less than 250 ML/d, and the pumps fail, the condition will trigger a signal to restrict plant inflow at the Influent Pumps to 250 ML/d. The overflow weir at the pump intake will allow approximately 250 ML/d to overflow. The hydraulic gradeline in the SE conduit will increase approximately 500 mm, but at this flow and below, the secondary clarifier discharges should remain free.

.4 If the plant flow is greater than 250 ML/d, the Influent Pumps will also be slowed, but the effect on SE flows will not be immediate. The south secondary effluent conduit (SSECon) needs to be opened, and relatively quickly as there is minimal storage available in the SE Conduit system (approx 275,000 L under best conditions). An actuator (independent power source from the UV Pumps) will open the gate automatically (at lower flows the gate will not open automatically, but will open on active intervention of a human operator).

.5 In the event of a plant-wide power failure, the need to bypass is eliminated as no flow is entering the plant due to shut down of the influent pumps.