16900 – CONTROLS AND INSTRUMENTATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: This section covers work necessary for the design, documentation, assembly, installation, field testing, startup, training, and final documentation for Pump Station Controls, as described herein and as necessary to provide a complete operational system.

1.2 GENERAL REQUIREMENTS

A. Electrical: All wiring shall be in complete conformance with the National Electric Code, state, local and NEMA electrical standards. All incoming and outgoing wires shall be connected to numbered terminal blocks and all wiring neatly tied and fastened to chassis as required. For ease of servicing and maintenance, all wiring shall be color coded and uniquely numbered. The wire color code and number shall be clearly shown on the drawings, with each wire's color and number indicated.

1.3 QUALITY ASSURANCE

A. General: The system provider (hereafter referred to as Contractor) shall be responsible for and shall provide for the design, supply, delivery, installation, certification, calibration and adjustment, software configuration, testing and startup, owner training, warranty and routine future field services, of a complete coordinated system which shall perform the specified functions.

B. Standard Products: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, to the greatest extent practical, like items of equipment provided hereunder shall be the end products of the same manufacturer.

1.4 SUBMITTALS

A. Hardware Submittals: Before any components are fabricated, and/or integrated into assemblies or shipped to the job site, furnish to the Engineer for their review copies of submittal documents. Submittals shall include full details, shop drawings, catalog cuts, and such other descriptive matter and documentation as may be required to fully describe the equipment and to demonstrate its conformity to these specifications. Specifically, the Contractor shall submit the following materials:

1. Drawings of equipment to be supplied shall include, as a minimum: overall dimension details for each panel, console, etc., including internal and external arrangements and door mounted operator devices with nameplate designations. Wiring diagrams of equipment including field device connections shall be included and specific installation/wiring requirements identified.
2. Operational Description shall include the principal functions/capabilities of each personal PLC as provided and configured /programmed.
3. Provide a detailed Bill of Materials along with descriptive literature identifying component name, manufacturer, model number, and quantity supplied.

B. Scope of Engineer's Review: The Owner and the Engineer will review system technical information as submitted by the Contractor for software; operating system, database, control strategies and the graphical user interface, i.e. report and log formats, graphics, trends, alarming, etc. for compliance with these

specifications. Review of the submittal does not relieve the Contractor from the responsibility of providing a fully functional telemetry and control system which complies with the project documents.

1.5 OPERATION AND MAINTENANCE MANUALS AND SOFTWARE

A. General: The Contractor shall provide a digital O&M manuals for the controls. In addition to "as-built" system drawings, the manuals shall include internal wiring diagrams and operating and maintenance literature for all components provided under this section. Wiring diagrams shall be provided for all equipment panels and shall include colors and unique numbers for all panel wires.

The submitted literature shall be in sufficient detail to facilitate the operation, removal, installation, programming and configuration, adjustment, calibration, testing, and maintenance of each component and/or instrument.

Operation and Maintenance manuals shall include copies of all PLC programs written to accomplish the monitoring and control functions specified. Programs shall be updated after startup is complete, with the fully commented program(s) licensed to and provided to the Owner on USB storage device. Two (2) copies shall be provided. All custom programing shall be licensed to Owner for their use on existing facilities and as a base for future expansion of system.

The contents of the O&M manuals shall include the following sections:

1. System Hardware/Installation
2. Operation
3. Maintenance and Troubleshooting

1.6 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling: Deliver, store, and handle products using means and methods that will prevent damage, deterioration, and loss, including theft. Comply with manufacturer’s written instructions. Protect equipment and controls from dirt and damage.

B. Delivery: Schedule deliveries to minimize long-term storage at the Project site and to prevent overcrowding of construction spaces. Deliver products to Project site in an undamaged condition in Manufacturer's original sealed container or other packaging system, complete with labels and instructions for handling, storing, unpacking, protecting, and installing. Inspect products on delivery to ensure compliance with the Contract Documents and to ensure that products are undamaged and properly protected.

PART 2 - PRODUCTS

2.1 PUMP STATION CONTROL PANEL

A. General: The functions and features specified herewith are the minimum acceptable requirements for the pump station controls. The provided system shall equal or exceed each requirement. In some cases, the specifications may allow the accomplishing of certain functions by means of more than one hardware/firmware/software approach. Any approach that is proposed shall equal or exceed all functional, operational, convenience and maintenance aspects of the one described. Major equipment, component and software items are specified; however, the Contractor shall provide all appurtenant items necessary to achieve the required operation as hereinafter specified. Hand-Off-Auto selector switches shall be provided for each pump on the panel front. Indicator lights shall be provided on the panel front

for Pump Run, Overtemp, and Seal Warning of each pump as well as Low Level Alarm and High Level Alarm.

B. Functional Overview: The pump station controls shall be PLC based and shall provide level/flow paced control of the three station pumps through variable speed drives for each pump. Station operation shall be as follows:

1. A rise in the water level above the "Lead Pump On" level setting starts Lead Pump #1, #2, or #3 based on which pump has been idle the longest.
2. Pump speed is adjusted through the variable frequency drives proportional to the wetwell level as sensed by the level transducer. Full pump speed is equivalent to 0.5 feet below the Lag Pump On level setting or may defined as an additional setpoint. Minimum configured pump speed is equivalent to the "All Pump Off" level setting. As the wetwell level changes, the pump speed is continuously adjusted, allowing pump discharge to match influent rate if possible within the allowable pump discharge range.
3. If influent flow exceeds the maximum discharge capacity of a single pump and wetwell level rises to the "Lag Pump On" level setting, the next pump will be started. Both pumps will be at 100% speed initially. If the wetwell level drops, the speed of both pumps will decrease proportionally as previously described for single pump operation.
4. If influent flow exceeds the maximum discharge capacity of two pumps and the wetwell level rises to the "Third Pump On" level setting, the final pump will be started. All pumps will operate at be at 100% speed initially. If the wetwell level drops, the speed of all pumps will decrease proportionally as previously described for single pump operation.
5. A continued rise in the wet well level above the "High Level Alarm" elevation turns on the warning light, sounds the buzzer, and communicates the alarm to an external telemetry system.
6. A decline in the wet well water level below the "High Level Alarm" elevation turns off the alarm buzzer and light. The buzzer may also be silenced by a manual pushbutton.
7. Pumps continue to operate until the water level drops below the "All Pumps Off" elevation, which stops all pumps.
8. Continued decline in the wet well level below the "Low Level Alarm" elevation turns on the warning light, sounds the buzzer and communicates the alarm to the external telemetry system. This alarm is deactivated similar to the high level alarm described above.
9. PLC controls shall monitor analog flow rate signal and digital input totalizing flow pulse signal from discharge flow meter and relay signals to external telemetry system. HMI shall indicate flow rate and current day total flow. HMI shall also have detailed history screen to display total daily flow for current and each of the seven previous days.

C. External Telemetry System Integration: PLC shall include analog and digital outputs to communicate with an Owner supplied external telemetry and alarm system. The following signals shall be communicated:

1. Run Status of Each Pump
2. Overtemp Status of Each Pump
3. Seal Fail Warning Status of Each Pump
4. Wetwell Level
5. High Level Alarm
6. Low Level Alarm
7. Discharge Flow Rate
8. Discharge Flow Totalizing Pulse

D. HMI Screens: The control panel HMI shall include the following screens.

1. Main Screen
   a. Numerical and graphical display of current wetwell level

b. Status of each pump including Run/Off, overtemp Normal/Alarm, and seal fail Normal/ Alarm. Color code pump symbol according to status (green Run, grey Idle, red Alarm).

c. Selection mode of each pump as either Hand/Off/Auto

2. Level Screen

a. Graphical display of 24 hour historical levels

b. Total daily flow for current and each of the seven previous days

3. Configuration Screen (Password Protected):

1) High and low wetwell transducer level alarm setpoints

2) Transducer high level alarm enable/disable

3) Transducer low level alarm enable/disable

4) Transducer full range span (feet)

5) Transducer calibration offset (feet)

6) Low level float switch alarm enable/disable

7) High level float switch alarm enable/disable

E. Enclosure: The controls shall be housed in a corrosion resistant welded NEMA Type 4X UL Listed enclosure. Enclosure shall be fabricated from stainless steel. Units shall include a double gasketed front door with full height hinges and lever handle operated 3-point latches.

F. Power Supply: Equipment shall operate from an input source of either 480 volts, 3 phase, and 60 Hz (if VFDs are mounted and powered within panel) or 120 volts, 1 phase, and 60 Hz (if VFDs are mounted and powered external to panel). Panel shall include a 24 VDC power supply for internal control hardware. Circuit breakers shall be quick-make, quick-break, thermal-magnetic, trip indicating.

G. Battery Back Up System: Included with the control panel , and working in conjunction with the unit's DC power supply, shall be an intelligent battery backup system including battery health logic module, charger and sufficiently sized battery. Battery system shall provide full on-line protection, power conditioning, and a seamless switchover to battery upon detection of main DC power supply failure. Once main DC power is restored, the unit shall provide seamless switchback to normal DC power source and recharge the battery. Battery health logic module shall individually monitor main DC power supply, battery and converter voltages for low voltage conditions, and provide low voltage cutoff to protect battery from an unrecoverable depletion. An on board LED, or local Operator Interface (OI) if provided shall locally indicate detection of an alarm condition. The unit shall be capable of providing two hours of battery backed operation.

H. PLC Control System: Operations of the Control Panel shall be controlled through a programmable logic controller (PLC) consisting of a power supply, CPU, discrete input and output modules and analog input and output modules. The processor unit shall include built-in USB and two (2) Ethernet IP communication ports. All input and output points supplied (including unused) shall be wired to terminal blocks. Processor design characteristics shall include: minimum 1.0MB user memory size, real-time clock and calendar, battery backed RAM and an operating temperature range between 32 °F and 140°F. The PLC processor shall be an Allen-Bradley CompactLogix 1769 or approved equal. The PLC rack shall provide space for addition of a minimum (2) two future modules.

I. Local Inputs and Outputs: The PLC panel shall be capable of accepting and producing all analog inputs (AI), digital inputs (DI), analog outputs (AO), and digital outputs (DO) as require. Analog isolators/repeaters shall be provided at control panel for connection of analog inputs.

J. Condensation Protection: Enclosure shall have a heater and thermostat to prevent condensation build-up.

K. Wiring: All wiring shall be in complete conformance with the National Electric Code, state, local and NEMA electrical standards. All incoming and outgoing wires shall be connected to numbered terminal

blocks and all wiring neatly tied and fastened to chassis as required. For ease of servicing and maintenance, all wiring shall be color coded and uniquely numbered. The wire color code and number shall be clearly shown on the drawings, with each wire's color and number indicated. Short circuit rating of control enclosure shall be 5 kA RMS symmetrical @ 120VAC maximum. All control panel single conductor wire shall be 16 AWG multi-strand machine tool wire (MTW) minimum, with PVC insulation. Wire colors shall be as follows:

120 VAC control power:	Red
Neutral:	White
Ground:	Green
AC Power from remote source:	Yellow
Neutral from remote source:	White with Yellow Stripe
24 VDC (+):	Blue
24 VDC (-):	White with Blue Stripe
VDC (+) from remote source:	Orange
VDC (-) from remote source:	White with Orange Stripe
Intrinsically Safe:	Light Blue

1. All wires shall be clearly marked with an identification number consistent with the wiring schematic drawing. Wire markers shall be a thermal transfer printable type. The material shall be a self-laminating vinyl. Labels shall be Brady THT-9-427-10 or approved equal.
2. Wiring inside the control panel shall be run in PVC wiring duct rated for continuous temperatures up to 122° F (50°C). Devices mounted in the enclosure door shall have wires run in spiral wrap to avoid pinch points when opening and closing the door.
3. Control components mounted internal and external to the enclosure shall be mounted with stainless steel hardware and clearly labeled with a plastic identification nametag. The tag shall be white with black lettering.

L. Operator Interface Terminal: A graphical operator Human Machine Interface (HMI) unit shall be provided at each filter console. HMI shall be touchscreen type with a minimum diagonal display length of 9 inches and display resolution of 800 x 480 WVGA 18-bit color graphics. Interface shall be an Allen-Bradley PanelView Plus 7 Terminal, or approved equal.

M. Selector and Push Button Switches: Selector and push button switches shall be industrial miniature oiltight units with double break silver contacts rated to carry 5 amperes at 120 volts AC, to make 30 amperes and to break 3 amperes. Engraved nameplates with appropriate markings shall be provided with each switch. Units may be maintained contact, Hand-Off-Automatic or momentary contact similar to Square D, Class 9001.

N. Indicator Lights: Indicator lights shall be industrial oil-tight units with 1” lens, replaceable lights, and push-to-test feature. Indicator light lens color shall be green for run, red for failure, and yellow for warning.

O. Relays: Relays within PLC and I/O panels shall be solid state, plug in units, similar to Phoenix Contact PLC-INTERFACE series.

Non-PLC based panel relays shall be plug-in relays with contacts rated 5 amperes at 120 volts AC and clear polycarbonate covers. Relays shall be similar to square D RS14, Class 8501 general purpose relays with screw terminal sockets mounted in a NEMA 1 enclosure.

P. Fuses: Properly rated fuses and fuse holders shall be provided for protection of individual control devices (discrete and analog signals) mounted outside of the enclosure. Each fuse shall be housed in a hinged type fuse block to protect against contact with the fuse. Fuses shall be rated up to 250 VAC and be Littelfuse or approved equal. Fuse holders for discrete devices shall be rated to 600 VAC and 30 Amps.

Fuse holders for analog devices shall be rated to 300 VAC and 15 Amps. Fuse holders shall be Allen Bradley 1492 or approved equal.

Q. Surge Protection: Surge protection shall be installed to protect electrical components in accordance with minimum International Society of Automation (ISA) standards.

1. All field analog instruments shall be protected by surge suppression on the instrument.
2. Level velocity meter analog signal to control panel shall be protected with surge suppression in panel via analog isolator/repeater.
3. All digital input/output signals and instrumentation shall be protected by inline fuses.
4. Transient voltage surge suppression (TVSS) shall be installed at the filter control panel.
5. Insulation and grounding of suppressors shall be in conformance with manufacturers recommendations.

2.2 VARIABLE SPEED DRIVES

A. General: Furnish variable frequency drives to provide control of pumps indicated, as indicated. Drives may be provided internal to Pump Control Panel or mounted and powered externally with individual minimum Nema 3R Enclosures and lockable disconnect switches. Drives shall be as manufactured by Danfoss, Allen Bradley, or approved equal.

B. Converter: A converter stage shall change fixed voltage, fixed frequency, AC line power to a fixed DC voltage. The converter shall consist of six power diodes in a three phase, full wave bridge, configuration. The converter shall be insensitive to the phase rotation of the AC line and shall not cause displacement power factor of less than .95 lagging under any speed and load condition.

C. Inverter: An inverter stage shall change fixed DC voltage to variable frequency, variable voltage, AC for application to a standard NEMA design B squirrel cage motor. The inverter shall utilize gate turn off (GTO) devices switched in a manner to produce a sine coded pulse width modulated (PWM) output waveform.

D. Temperature Rating: The controller shall be rated to operate in an ambient temperature 0 degrees C to 40 degrees C continuously. Installation at altitudes less than 3,300 feet above sea level shall not require derating.

E. Current Ratings: The controller shall be capable of supplying 150 percent of rated full load current for one minute at maximum ambient temperature. The controller shall be designed to operate from a 460V + 10 percent, - 5 percent three phase, 50/60 Hz supply and control a motor with a corresponding voltage rating. Acceleration and deceleration time shall be independently adjustable from 1 second to 60 seconds.

F. Current Limiting: Adjustable full-time current limiting shall limit the current to a preset value which shall not exceed 150 percent of the controller rated current. The current limiting action shall maintain the V/Hz ratio constant so that constant torque can be maintained. Short time starting override shall allow starting current to reach 175 percent of controller rated current to maximize starting torque.

G. Output Frequency: The controller shall be capable of producing an output frequency over the range of 3 Hz to 60 Hz (20 to 1 speed range), 3 Hz to 90 Hz (30 to 1 speed range) or 3 Hz to 120 Hz (40 to 1 speed range) without low speed cogging. Over frequency protection shall be included such that a failure in the controller electronic circuitry shall not cause frequency to exceed 110 percent of the maximum controller output frequency selected (60, 90, or 120 Hz). Minimum and maximum output frequency shall be adjustable over the following ranges:

1. Minimum frequency 3 Hz to 50 percent of maximum selected frequency

2. Maximum frequency 40Hz to 60, 90 or 120 Hz

H. Restarting: The controller shall be capable of being restarted into a motor coasting in either the forward or reverse direction without tripping.

I. Protection: Protection of power semiconductor components shall be accomplished without the use of fast acting semiconductor output fuses. Subjecting the controller to any of the following conditions shall not result in component failure or the need for fuse replacement:

1. Short circuit at controller output
2. Ground fault at controller output
3. Open circuit at controller output
4. Input undervoltage
5. Input overvoltage
6. Loss of input phase
7. AC line switching transients
8. Instantaneous overload
9. Sustained overload exceeding 115 percent of controller rated current

J. Overload Protection: Solid state motor overload protection shall be included such that current exceeding an adjustable threshold shall activate a 60 second timing circuit.

Should current remain above the threshold continuously for the timing period, the controller will automatically shut down. The timing circuit shall include a memory such that current exceeding the threshold for less than 60 seconds and dropping back below the threshold momentarily shall not cause the timer to reset to zero but shall cause the timing circuit to pick up at a point dependent upon the length of time the current was below the threshold.

K. Slip Compensation: A slip compensation circuit shall be included which will sense changing motor load conditions and adjust output frequency to provide speed regulation of NEMA B motors to within +-0.5 percent of maximum speed without the necessity of a tachometer generator.

L. Reversing: the controller shall include static reversing which shall change the output phase rotation by changing the order of firing signals to the inverter switching devices. All logic necessary to accept a direction select contract shall be included.

M. Display: The controller electronics shall contain light emitting diodes (LEDs) or a digital diagnostic display to monitor and indicate the following conditions:

1. Drive Lockout
2. Undervoltage
3. Overvoltage
4. Overtemperature
5. Instantaneous Overcurrent
6. Ground Fault
7. Shoot Through
8. Overload Threshold Exceeded
9. Overload Shutdown
10. Power Up Delay
11. +10V supply 0K112.10V Supply OK112.-10V Supply OK
12. Controller Enabled
13. Motor Regenerating

14. Current Limit Operating (Motor Mode)
15. Current Limit Operating (Regen. Mode)

N. Inputs and Outputs: The controller shall include the following input and output signal connections.
1. Digital Run Command Input
2. Digital Run Confirmation Output
3. Digital Fail Indication Output
4. Analog (4-20mA) Speed Command Input
5. Analog (4-20mA) Operating Speed Output

2.3 LEVEL SENSORS

A. Transducer: The level of the clearwell well shall be measured by a submersible level transducer with a minimum bottom diaphragm of 2-5/8" providing a 4-20 mA instrumentation signal. The transducer shall be of the solid state head pressure sensing type mounted using a removable cable suspension mounting kit utilizing all stainless steel hardware and cable attached to a 25# plastisol coated cast iron weight. The transducer housing shall be fabricated of type 316 stainless steel. A hydraulic fill liquid behind the diaphragm shall transmit the sensed pressure to a solid state variable capacitance transducer element to convert the sensed pressure to a corresponding electrical value. The sensed media shall exert its pressure against the diaphragm that flexes minutely so as to vary the proximity between an internal ceramic diaphragm and a ceramic substrate to vary the capacitance of an electrical signal created between the two surfaces. A stable, hybrid operational amplifier assembly shall be incorporated in the transducer to excite and demodulate the sensing mechanism.

B. Float Switches: Float switches shall be a 5-1/2" diameter type 316 stainless steel device with a 4 amp mercury free switch at 250 VAC and #14 AWG fine stranded copper conductors. The switch assembly shall be installed in the neck of the float switch and held in place by a dual circular crimp. The float shall have a minimum net positive buoyancy of two pounds. The float switch shall be attached to the transducer suspension mounting cable and shall activate the automatic telephone dialer. High level float shall provide normally open contact, and low level float shall provide normally closed contact.

PART 3 - EXECUTION

3.1 SERVICE

A. Field Service: The Contractor shall provide experienced personnel to for installation, adjustment, testing, and startup of the system. All elements of the system shall be tested to demonstrate that the total system satisfies all of the requirements of the Contract Documents. The Contractor shall provide all special testing materials and equipment required. The Contractor shall coordinate and schedule all testing and startup work with the Owner. As a minimum, the testing shall include both a factory test and a field test.

B. Training: The training program shall educate operators, maintenance, engineering, and management personnel with the required levels of system familiarity to provide a common working knowledge concerning all significant aspects of the system being supplied. The training program shall include a minimum of one trips with a minimum of 8 hours on-site instruction. The supplier shall provide all instructional course material, equipment and manuals to conduct the training program.

END OF SECTION