Procurement Documents – Volume II

DESIGN CRITERIA PACKAGE

FOR THE

EXPANSION OF THE ARBENNIE PRITCHETT WATER RECLAMATION FACILITY

OKALOOSA COUNTY WATER AND SEWER DEPARTMENT

March 30, 2015

PROPOSALS DUE:

May 29, 2015
4:00 pm CST

Okaloosa County Water and Sewer
Suite 300
Lewis Turner Boulevard
Fort Walton Beach, FL 32547

TABLE OF CONTENTS

LIST OF APPENDICES

LIST OF TABLES

TABLE NO. **PAGE NO.**

1.0 INTRODUCTION

1.1 General Project Description

The Okaloosa County Board of County Commissioners is using the Design-Build (D-B) delivery method to construct a 5 million gallon per day (mgd) expansion to the 10 mgd Arbennie Pritchett Water Reclamation Facility (APWRF) (Project) to serve a portion of its service area in Fort Walton Beach, Florida. This Design Criteria Package (DCP) presents specific minimum requirements related to the features to be provided by the Design-Builder selected for the Project. This DCP is an appendix to the Request for Proposal (RFP) document issued by the Okaloosa County Water and Sewer Department (OCWS) for this Project.

1.1.1 Overview

This DCP presents the minimum requirements for design and construction of the APWRF expansion. The DCP contains Project-specific requirements including minimum design criteria for individual unit operations and processes; general technical requirements for engineering disciplines and architectural requirements; and start-up, training, and commission requirements. Although minimum requirements are established in this DCP, the Design-Builder shall be fully responsible for final design and construction of the Project, and for seamlessly incorporating the operation of the new facilities with the existing facilities.

The APWRF serves the County's Garniers Service Area, unincorporated areas of the OCWS service area, the City of Fort Walton Beach, Eglin Air Force Base, and several outlying military cantonments and fields. Design criteria are specified for biological treatment, secondary clarifier, return activated sludge (RAS) pumping, ultraviolet (UV) disinfection, sludge management facilities, and effluent pumping. The APWRF expansion shall be constructed on the existing parcel located on Eglin Air Force Base (Eglin AFB) property. Figure 1-1 shows the approximate location of the WRF. A CD containing electronic files on the contract documents is included with the RFP.

1.2 Overall System Requirements

The APWRF receives influent wastewater from a single 36-inch diameter force main entering the site along Roberts Road from the south and discharges into the Headworks facility. Treated wastewater is discharged to rapid infiltration basins (RIBs) located adjacent to the plant site and a portion is treated to reuse quality standards and conveyed by gravity to the City of Fort Walton Beach Golf Course and used for irrigation. The Design-Builder will be responsible for maintaining undisrupted flow into and out of the existing facility, and for minimizing disruptions to current operations.

The Design-Builder shall develop the site layout for all new unit operations, unit processes, buildings, and required support facilities as described in this document to provide an expanded, fully functional water reclamation facility. The intent of this project is to provide a fully integrated treatment facility that operates as one treatment plant, and not as two separate treatment plants. This section summarizes critical information for influent characteristics, effluent requirements, treatment processes to be included, and a discussion of redundancy requirements. Each of these items is described in the following subsections.

1.2.1 Wastewater Treatment Plant Influent Characteristics

Projected influent flow rates and characteristics developed for the original APWRF project were based upon existing and assumed influent information generated and maintained by plant personnel. Table 1-1 presents the design criteria for the influent waste loading to the WRF. Existing influent data is presented in the Electronic Data included with the RFP.

Table 1-1
Raw Wastewater Characteristics

Parameter	Concentration (mg/L)
Influent CBOD	250 mg/L
Influent TSS	250 mg/L
Influent TKN	50 mg/L
Influent Ammonia	35 mg/l
Influent Total Phosphorus	8 mg/l
Influent Alkalinity	125 mg/L
pH	6.5 – 8 SU

The APWRF shall also be designed to meet treated effluent criteria assuming that up to an additional 2,000 gallons per day (gpd) of septage will be discharged at the plant directly by third-party haulers.

1.2.2 Effluent Criteria

The APWRF shall be designed to meet the treated effluent criteria listed in Table 1-2.

Table 1-2
Effluent Characteristics

Effluent $CBOD_5$	Less than 20 mg/L, monthly average
Effluent TSS	Less than 20 mg/L, monthly average
Effluent NO_3 (as N)	Less than 8 mg/L, monthly average
Effluent pH	6.5 to 8.5 standard units
Disinfection	Less than 200 CFU/100 mL

The effluent characteristics shall also comply with requirements in Florida Statue 62.610 for Rapid Rate Land Application (RIBs).

1.2.3 Redundancy

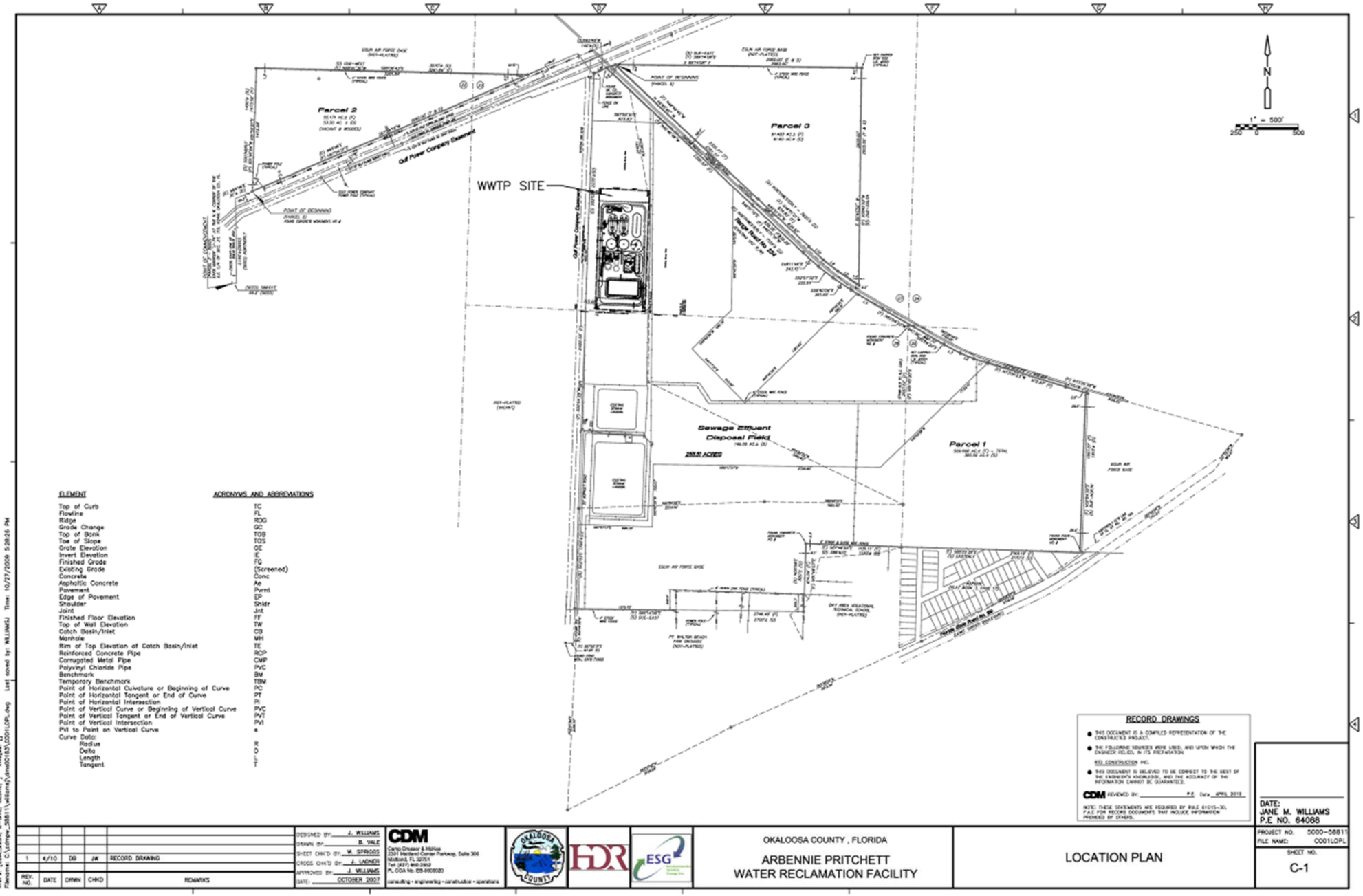
The APWRF shall be designed and constructed to allow the entire facility to meet the following redundancy criteria, unless otherwise specifically noted:

- Hydraulic Criteria – Process facilities shall be capable of hydraulically passing the peak hourly design flow of 37.5 mgd with the largest unit out of service.
- Treatment Criteria – Process facilities shall be capable of treating the maximum monthly average daily flow of 15 mgd to meet the specified effluent criteria and to meet the Florida Department of Environmental Protection (FDEP) Class I reliability, except where noted.

1.2.4 Treatment Processes

While several processes offer the ability to meet the pollutant limits stated above, the process that should be considered for the 5.0 mgd expansion should be similar to the existing WRF with a 4-stage Bardenpho process with pre-anoxic, aeration, post-anoxic, and post-aeration zones to include nitrogen removal.

Figure 1-1
Location and Site Map



The major treatment process additions for the expanded APWRF shall include:

- Biological Treatment with a new 5-mgd oxidation ditch with the reaction zones associated with a 4-stage Bardenpho process
- Additional secondary clarifier, and mixed liquor suspended solids (MLSS) splitter box and interconnection with existing MLSS splitter box
- Additional RAS pumping (waste activated sludge (WAS) pumping will be from the existing system)
- Additional UV disinfection modules within the existing UV basin
- Effluent management and pumping improvements
- New electrical service to the expanded treatment process
- Additional Standby power
- Site work, yard piping, and plant utilities
- Plant monitoring and control system (PCMS) additions and improvements

These existing unit operations and processes were selected to meet the regulatory criteria for effluent discharge and biosolids management of the expanded15 mgd WRF that will be required to meet the same regulatory criteria. In addition to the major treatment processes listed above, supporting processes, systems, and facilities shall be provided by the Design-Builder as more fully described in this DCP. The hydraulic profile from the record construction documents for the existing facility is shown in Figure 1-2. A modified hydraulic profile will be developed by the Design-Builder after the final site layout is developed and equipment systems are selected to identify any changes to the calculated water surface elevations. The Design-Builder will be fully responsible for the overall hydraulic capacity of the expanded facility, and it will be the Design-Builder's responsibility to identify any areas where there will be hydraulic constraints and to modify existing structures and piping to alleviate these constraints.

1.2.5 Miscellaneous Improvements and Modifications

In addition to the major treatment processes listed above, OCWS has identified other miscellaneous improvements and modifications that it is considering for inclusion in this expansion project to address certain operational or maintenance concerns, reliability or redundancy concerns, or improvements to facilitate their current and future operating strategy. Design-Build Teams are encouraged to develop alternative improvements or modifications projects that would address the issues of concern identified below. These should be presented as discrete projects in the technical and cost proposals separate from the Major Treatment Improvements associated with the expansion of the WRF. A detailed description of each is presented below.

1.2.5.1 Site Work and Miscellaneous Utilities

1.2.5.1.1 ***Replace aboveground black iron plant reuse (W3) piping with galvanized pipe.*** *The existing aboveground reuse water piping is painted black iron pipe that has begun to rust and has contributed to rust stains at the basins. OCWS is requesting alternatives to remove the existing aboveground black iron pipe and replace it with galvanized pipe. The cost for painting should be presented as a separate item. Existing valves and appurtenances that are not deteriorated can be reused.*

1.2.5.1.2 ***Install improvements to increase the pressure for the for the W3 system.*** *Plant staff would like to increase the pressure in the existing reuse system by about 25 psi to enhance the wash*

water pressure at both the headworks and the rotary drum thickener (RTD). OCWS is requesting alternatives to increase the pressure in the reuse system by about 25 psi.

1.2.5.1.3 ***Evaluate the capacity of the on-site lift station.*** *Future additional processes at the WRF could increase the flow to the existing on-site lift station, including an additional centrifuge and additional effluent filters. OCWS is requesting the Design-Build Team to evaluate the capacity of the existing on-site lift station and offer alternatives for increasing the capacity of the station if the evaluation determines additional capacity is necessary.*

1.2.5.1.4 ***Install improvements for additional chemical storage.***

1.2.5.2 Headworks

1.2.5.2.1 ***Replace the existing 36-inch diameter influent, strap-on Doppler flow meter, with new magnetic flow meter.*** *The existing 36-inch diameter influent strap-on Doppler flow meter is inconsistent and does not represent the influent flows to the WRF accurately. OCWS is requesting alternatives to install a new magnetic flow meter of appropriate size to measure the full range of influent flow to the WRF. The need for bypass piping and valves should be evaluated and included as necessary to facilitate future service of the meter.*

1.2.5.2.2 ***Install improvements to increase the velocity in the influent channels to eliminate scum and grit build up in channels.*** *Operators report that there is a buildup of scum and grit in the influent channels downstream of the influent screens and upstream of the grit handling equipment. OCWS is requesting alternative solutions to eliminate or reduce the buildup of scum and grit in this section of the influent channels.*

1.2.5.2.3 ***Install flush ports at the grit pump suction lines to enhancing cleaning.*** *The existing grit pump suction lines are not provided with reuse water flushing ports to help clear grit that may have clogged the suction piping. OCWS is requesting alternative solutions to provide and install the flushing ports and reuse piping and appurtenances.*

1.2.5.3 Digesters and Solids Handling Systems

1.2.5.3.1 ***Install modifications to reduce ragging at centrifuge.*** *Presently, thickened WAS from the WRF and WAS from OCWS's satellite WRF's is discharged into the two existing aerobic digesters. The digested sludge is pumped to the centrifuge using progressive cavity pumps (NETZSCH). Operators report that rags in the digested sludge have clogged the influent 2-inch diameter centrifuge feed piping. It is believed that the source of the rags may be material that escapes the influent screens at the WRF or is from the WAS that is supplied to the digesters from one of the satellite WRFs. OCWS is requesting alternatives to eliminate the clogging at the centrifuge that may include modifications to reduce the accumulation of rags and materials in the digesters from on- and off-site sources; or installation of a grinder/macerator upstream of the centrifuge.*

1.2.5.3.2 ***Install a second centrifuge for redundancy and increased dewatering capacity.*** *The existing WRF is provided with a single centrifuge for dewatering. While the existing unit has provided good service for the facility, OCWS is considering adding a second unit for increased capacity and redundancy. The existing dewatering structure, as well as the site/civil, electrical, and mechanical components, are not design to accommodate a second centrifuge and additional modifications would be necessary. OCWS is requesting alternatives to install a second centrifuge at the WRF.*

1.2.5.3.3 Install a third aerobic digester for additional capacity. *The existing WRF is provided with two aerobic digesters and a single rotary drum thickener for WAS thickening and digestion. While the existing equipment has provided good service for the facility, OCWS is considering adding a third digester for increased capacity and redundancy. OCWS is requesting alternatives to implement improvements and modifications to install a new aerobic digester that would address the WAS thickening, digester air supply, civil/site, structural, electrical, and mechanical system improvements required at the WRF.*

1.2.5.3.4 Install a second Rotary Drum Thickener for additional WAS thickening capacity. *The existing WRF is provided with a single rotary drum thickener for WAS thickening. While the existing unit has provided good service for the facility, OCWS is considering adding a second unit for increased capacity and redundancy. The existing thickening structure, as well as the site/civil, electrical, and mechanical components, are not design to accommodate a second rotary drum thickener and additional modifications would be necessary. OCWS is requesting alternatives to install a second thickener at the WRF.*

1.2.5.3.5 Modify the drains at the centrifuge loading bay to improve solids capture and conveyance. *The existing drain at the dewatered sludge loading bay is inefficient. OCWS is requesting alternatives to install improvements to the existing drain, that might include a trench drain, to enhance collection and conveyance of drainage at this structure.*

1.2.5.4 Clarifiers

1.2.5.4.1 Re-route the Clarifier scum lines to the on-site lift station. *OCWS is requesting alternatives to convey scum from the clarifiers directly to the existing on-site lift station rather than to the scum pump station that is currently provided at the WRF. These modifications could include new piping to convey the scum directly from the clarifiers to the lift station or to the gravity collection system.*

1.2.5.4.2 Modifications to screening algae from clarifier effluent upstream of UV system. *Presently, algae that grows in the clarifiers is periodically released in the clarifier effluent and conveyed to the effluent UV Disinfection system. In the past, the accumulation of large quantities of algae have adversely impacted the effectiveness of the UV Disinfection system and have actually caused significant damage on one occasion. In response, OCWS has installed a manual screen upstream of the UV Disinfection system to remove large particles of algae. OCWS is requesting alternatives to install an automatic screen to remove or significantly reduce the amount of algae in the clarifier effluent upstream of the UV Disinfection system.*

1.2.5.5 General Site Issues and Miscellaneous

1.2.5.5.1 Alternatives for additional chemical storage. *Presently, the WRF uses liquid polymer and sodium hypochlorite in their treatment process. These chemicals are supplied in tote containers that are stored in a metal shed on site. OCWS is requesting alternatives to increase the amount of chemical storage that may be needed to meet the chemical demand at the design plant flow of 15 mgd. Design-Build teams should consider the current method of storing chemicals, using totes, as well as other methods of storage including bulk containers or even on-site generation.*

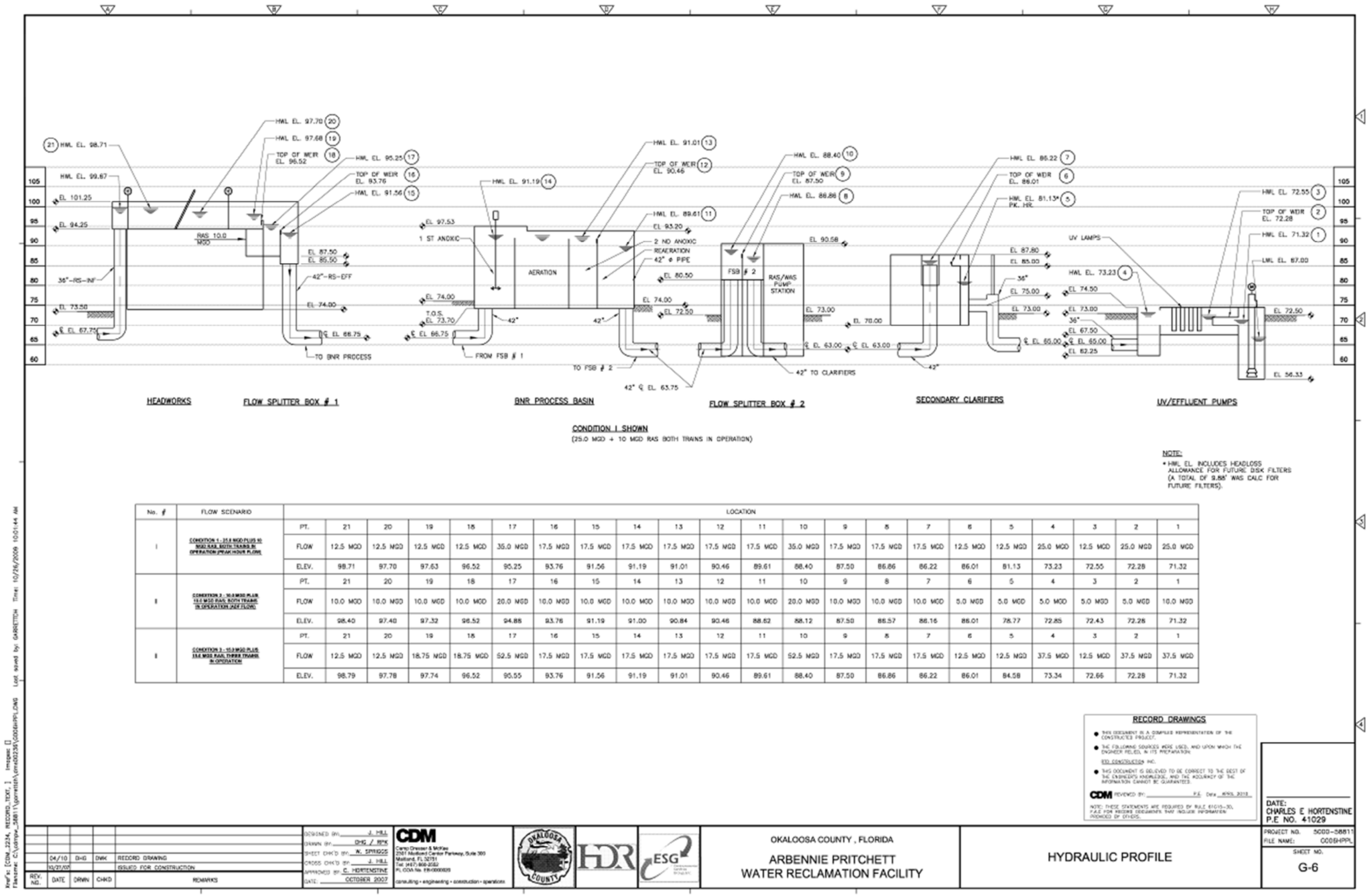
1.2.5.6 Energy/O&M Optimization

1.2.5.6.1 Modifications to reduce operating costs, enhance and optimize energy consumption at the WRF. *OCWS is requesting alternative modifications to optimize energy consumption at the WRF. These could include improvements or modifications to the aeration system in the biological process, the diffused aeration system in digesters, or digester blowers as examples. Other opportunities for energy or O&M optimization will be considered and should include an evaluation of the present worth value of the capital and annual costs of operation.*

1.2.5.7 Electrical Modifications to Accommodate Future Expansion

1.2.5.7.1 Modifications to accommodate future expansion of the WRF to include additional reuse filtration, disinfection, and pumping, and additional solids drying processes. *OCWS is developing conceptual plans for future expansion of the effluent management system to provide a total of 8 mgd of reuse capacity at the WRF. The unit processes and equipment required to implement this additional capacity would include new disk membrane filters, chlorine disinfection, chlorine contact basin, and effluent pumping system. The total connected load for the unit processes and equipment conceived for this modification is about 450 kVA. Furthermore, OCWS is developing conceptual plans for a sludge dryer to further process the dewatered sludge. The facility that would house the dryer equipment might also include the two centrifuges. The total connected load for the unit processes and equipment conceived for this modification is about 650 kVA. Conceptually, these additional processes would be located south of the existing digesters and the existing UV Disinfection system. OCWS is requesting alternatives that might consider modifications that could be implemented as part of this project to accommodate the re-allocation of the current electrical loads and future electrical loads to minimize the total number of new electrical services and standby generators, while cost-effectively implementing the expansion of the WRF.*

Figure 1-2
Existing Hydraulic Profile



No. #	FLOW SCENARIO		LOCATION																				
I	CONDITION 1 - 25.0 MGD PLUS 10 MGD RAS, BOTH TRAINS IN OPERATION (PEAK HOUR FLOW)	PT.	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		FLOW	12.5 MGD	12.5 MGD	12.5 MGD	12.5 MGD	35.0 MGD	17.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	35.0 MGD	17.5 MGD	17.5 MGD	17.5 MGD	12.5 MGD	12.5 MGD	25.0 MGD	12.5 MGD	25.0 MGD	25.0 MGD
		ELEV.	98.71	97.70	97.63	96.52	95.25	93.76	91.56	91.19	91.01	90.46	89.61	88.40	87.50	86.86	86.22	86.01	81.13	73.23	72.55	72.28	71.32
II	CONDITION 2 - 10.0 MGD PLUS 10.0 MGD RAS, BOTH TRAINS IN OPERATION (AAF FLOW)	PT.	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		FLOW	10.0 MGD	10.0 MGD	10.0 MGD	10.0 MGD	20.0 MGD	10.0 MGD	10.0 MGD	10.0 MGD	10.0 MGD	10.0 MGD	10.0 MGD	20.0 MGD	10.0 MGD	10.0 MGD	10.0 MGD	5.0 MGD	5.0 MGD	5.0 MGD	5.0 MGD	5.0 MGD	10.0 MGD
		ELEV.	98.40	97.40	97.32	96.52	94.88	93.76	91.19	91.00	90.84	90.46	88.62	88.12	87.50	86.57	86.16	86.01	78.77	72.85	72.43	72.28	71.32
II	CONDITION 3 - 10.0 MGD PLUS 15.0 MGD RAS, THREE TRAINS IN OPERATION	PT.	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
		FLOW	12.5 MGD	12.5 MGD	18.75 MGD	18.75 MGD	52.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	52.5 MGD	17.5 MGD	17.5 MGD	17.5 MGD	12.5 MGD	12.5 MGD	37.5 MGD	12.5 MGD	37.5 MGD	37.5 MGD
		ELEV.	98.79	97.78	97.74	96.52	95.55	93.76	91.56	91.19	91.01	90.46	89.61	88.40	87.50	86.86	86.22	86.01	84.58	73.34	72.66	72.28	71.32

2.0 WATER RECLAMATION FACILITY DESIGN CRITERIA

This section summarizes the minimum design criteria for the major components of the treatment processes for the APWRF expansion. An overview of the processes is given, followed by specific design criteria for the Design-Builder.

2.1 General Overview

The APWRF expansion will consist of the following major process areas and associated support facilities:

- Biological treatment process – Section 2.1
- Effluent management – Section 2.2
- Support facilities – Section 2.3

The following table provides a list of acceptable manufacturers for the equipment associated with the treatment process and support facilities.

Table 2-1
Approved Manufacturers

UNIT PROCESS	MANUFACTURER
Activated Sludge Biological Treatment	Ovivo/Eimco Process Equipment Co
	WesTech
Diffuser Systems	Xylem/Sanitaire Water Pollution Corp. (Diffuser)
	US Filter Envirex Dual Air Fine Bubble System
	EDI (diffuser system)
Blowers	Roots (PD Blower)
	Sutorbilt (Blower)
Mixers	Ovivo/Eimco Process Equipment Co
	WesTech
Secondary Clarification	Envirex - US Filter
	Ovivo/Eimco Process Equipment Co
	Walker Process
	WesTech
UV Disinfection	Infilco Degremont, Inc.
	Sunlight
	WEDECO
Centrifugal Pumps	Morris
	Chicago
	Flow Serve
	Gorman Rupp
	Hayward Gordon
	Fairbanks Morse
Centrifugal Pumps	Peerless
	Turbine
	Goulds
	Wayne
	Flow Serve

UNIT PROCESS	MANUFACTURER
Turbine Pumps	Pearless
	Goulds
	Layne
	Flow Serve
Chopper Pumps	Vaughn (Eshelman Co.)
Grinder Pumps	JWC

2.2 Biological Treatment Processes

The biological treatment process is intended to remove or reduce organic constituents, nutrients, and suspended solids from the wastewater. Treatment includes bioreactors, secondary clarification, and return activated sludge and waste activated sludge (RAS/WAS) pumping. Secondary effluent management includes ultraviolet disinfection and additional pumping for process operations.

The existing biological treatment process includes an activated sludge system consisting of two parallel 4-stage Bardenpho process trains utilizing mechanical aeration, two secondary clarifiers with RAS and WAS systems with associated instrumentation and controls. A third activated sludge train shall be furnished to provide additional biological treatment capacity for the treatment plant effluent to meet permit conditions. The activated sludge system shall be designed to reduce carbonaceous biochemical oxygen demand (CBOD), ammonia, nitrite, and nitrate to the levels listed in Section 1.2 – Overall System Requirements, for plant effluent criteria, when this process is followed by secondary clarification.

The third biological treatment train shall be configured with influent from the existing pretreatment splitter box entering an anoxic zone to serve as both an anoxic selector and a denitrification zone when combined with an internal mixed liquor suspended solids (MLSS) followed by an aerobic zone. The MLSS from the biological treatment basin shall flow to a new MLSS splitter box that will include interconnecting piping and isolation/weir gates to allow MLSS to be transferred between the existing and the new MLSS splitter boxes. MLSS will be proportioned to the new secondary clarifier from the new MLSS splitter box. The design of secondary clarifier shall take into account the solids loading from the biological processes that precedes it and the RAS and WAS requirements.

A RAS metering/control/pumping system shall be provided to return mixed liquor solids settled in the third secondary clarifier to the activated sludge biological treatment basin. The RAS shall be pumped back to the headworks, and combined with the RAS from the existing two trains prior to the pretreatment splitter box so that the RAS and influent flow will combine and be split proportionally to the three process trains. The existing WAS pumping system shall remove the portion of activated sludge solids from the secondary clarifiers to be wasted from the process, so therefore, additional WAS facilities will not be required for the facility expansion. This section describes the design criteria for the biological treatment processes.

2.2.1 Activated Sludge System

The activated sludge system includes concrete basins, mechanical mixers, an oxygen delivery system, an internal recycle system as may be needed to meet effluent limits. Design criteria for these elements are described in the following subsections. The activated sludge system shall conform to Section 92 of the RSWF 2004 (10 States Standards) unless otherwise noted.

2.2.1.1 Basins

One activated sludge basin shall be provided at least equal in size and design as the two existing basins and shall be provided and constructed of cast-in-place or pre-stressed concrete. The activated sludge basins shall provide biological CBOD and nitrogen removal. Biological treatment in the basins, followed by secondary clarification, shall result in an effluent meeting the water quality criteria for BOD, TSS, and nitrate listed in Section 1.2. Basin sizing criteria shall comply with the following minimum requirements:

- Treatment system shall include four zones, including anoxic zone 1, aerobic zone 1, anoxic zone 2, and aerobic zone 2. The individual zone sizes shall be optimized to remove nitrates.
- Solids Retention Time (SRT) based on maximum month flow conditions, shall be a minimum of 8 days in the aeration basin with all basins in service.
- Design MLSS shall be such that compliance with RSWF 2004 (10 States Standards) is met to comply with the stated specific requirements for different operating modes.
- Oxygen Requirements – Either a minimum of 1.5 pounds of oxygen per pound of CBOD removed and 4.7 pounds of oxygen per pound of ammonia oxidized to nitrate shall be provided or lower oxygen requirements shall be demonstrated through the application of a calibrated appropriate International Water Association Activated Sludge Model (ASM). The model shall be calibrated in accordance with the Water Environment Research Foundation procedures. Air transfer calculations shall be provided in accordance with the American Society of Civil Engineers guidance document on aeration systems.
- Wastewater temperature to be used for design purposes shall be 30^{o}C maximum and 20^{o}C minimum.
- Nitrate rich internal mixed liquor recycle (IMLR) from the downstream end of the aerobic zone will also be combined with the preliminary effluent (PE) and RAS stream in a volume appropriate for rapid mixing. The motive force generated by the mechanical aerators is the preferred method for accomplishing the internal recycle.
- Air supply to the aeration basins shall be adjustable for the range of operating conditions from initial minimum condition to the design flow peak day, worst case air transfer conditions.
- Adequate mixing shall be provided in all zones of the basins to maintain the mixed liquor in suspension, either by the aeration equipment in the aerobic zones or by mixers in the anoxic zones.
- Basins shall be provided with inlet and outlet isolation slide gates or gate valves and drain system to allow each basin to be taken out of service and to be emptied. Tank drains shall be provided to allow removal of liquid by gravity within a 72-hour period.
- The effluent weir for a horizontally mixed aeration tank system must be easily adjustable by mechanical means and shall be sized based on the design peak instantaneous flow plus the maximum return sludge flow. The hydraulic properties of the system shall permit the design peak instantaneous flow to be carried with any single aeration tank unit out of service.
- Channels and pipes carrying liquid with solids in suspension shall be designed to maintain self-cleaning velocities or shall be agitated to keep such solids in suspension at all rates of flow within the design limits.
- Equipment and washdown access walkways shall be provided for continuous access along basins; sufficiently high enough to minimize splashing of MLSS onto the stairway. These

walkways shall be provided at the basins and at equipment such as mixers, mixed liquor recycle pumps, gates, valves, and instruments for maintenance access. In addition, aluminum elevated walkways shall be provided as follows:

- from the existing biological treatment basins to the new biological treatment basin.
- from the new biological treatment basin to the new RAS pumping station and the new secondary clarifier.
- Stairway access shall be provided to the east side of the biological treatment basin.

- Dedicated anoxic zones or anoxic selectors shall be provided with a means of positive mixing to ensure all solids remain in suspension and complete mix conditions prevail.
- Aerobic zone dissolved oxygen (DO) monitoring shall be provided for the basins using dissolved oxygen probes. The DO probes shall be provided in accordance with Section 3.6 – General Instrumentation and Controls Design Criteria section.
- All aeration tanks shall have a freeboard of no less than 18 inches (460 mm).

2.2.1.2 Oxygen Delivery System

The main oxygen delivery system shall consist of mechanical surface aerators, and the post-aeration system shall consist of a submerged air diffuser system with associated air blowers. This section describes the design criteria for the options for the oxygen delivery systems.

Slow-Speed Mechanical Surface Aerators:
The mechanical surface aerators shall be evaluated using the following table.

DESIGN POINT	PLANT AIRFLOW (SCFM)	NO. OF OPERATING UNITS	HP	OXYGEN TRANSFER EFFICIENCY (LB O_2 /HP HR)	TOTAL GUARANTEED POWER CONSUMPTION (KW)	EVALUATED FACTOR	FACTORED POWER (KW)
1	Max.					0.05	
2	Avg. High					0.40	
3	Avg.					0.45	
4	Min.					0.10	
A					Guaranteed Total Factored Power Draw (kW) = (1+2+3+4)		
B					Hours of Operation per Year		8,760
C					Average Cost of Power ($/kWh)		$0.10
D					Years of Operation		20
E					20-Year Energy Costs = (A x B x C x D)		
F					Equipment Capital Costs		
G					Total 20-year Life Cycle Costs = (E+F)		

The slow-speed mechanical surface aeration system shall comply with the following design criteria:

- The aeration equipment shall be designed to operate satisfactorily over a wide range of power draw conditions to accommodate the expected load variations to the aeration system. The

aeration equipment shall be capable of maintaining an average water velocity near the basin floor of at least:

- 1.0 fps with the aerators operating at full design speed and immersion drawing 100% of nameplate horsepower.
- 0.8 to 0.9 fps with the aerators operating at reduced immersion at a power level of no more than 60% of full nameplate horsepower.
- 0.7 fps with the aerators operating at reduced immersion and speed at a power level of no more than 25% of full nameplate horsepower.

- The complete slow-speed surface aerator assembly shall be capable of delivering an oxygen transfer efficiency of no less than 3.5-pound O_2/HP-hr based on motor output power at standard transfer conditions. The manufacturer must provide oxygen transfer efficiency test reports before equipment is shipped from the manufacturer.
- Aeration equipment shall be capable of maintaining a minimum of 2.0 mg/l of dissolved oxygen in the mixed liquor at all times throughout the tank or basin.
- Each aerator shall be driven by totally enclosed fan-cooled, constant torque, premium efficiency motor wired for 460 volt, 60 cycle, 3 phase current and suitable for a 2:1 speed turndown. The motors shall be rated at 40°C ambient with Class F insulation and shall have a Class B temperature rise at full load. The motor shall have a service factor of 1.15 on sine wave power and a 1.0 service factor on VFD supplied power and shall comply with the applicable provision of the Standards of NEMA. The minimum AFBMA B10 bearing life shall be 100,000 hours. The nominal motor speed shall be 1800 rpm.
- The motors shall be cast iron construction and furnished with a canopy cap (drip cover) and suitable lifting lugs. The motor to gear reducer connection shall be accomplished by the use of a flexible coupling.
- Motors shall be suitable for operation in a moisture-laden atmosphere. The conduit boxes shall be gasketed with neoprene or equivalent material, so as to prevent moisture from entering the stator through the conduit box. Stainless steel condensation drains shall be suitably positioned in the lower external surface, so that any accumulation of moisture can drain from the complete motor housing. Ball bearings shall be supplied and shall be grease-lubricated. Grease reservoirs shall be ample and provisions shall be made for re-greasing with a lubrication system where grease is flushed through the bearings. The winding end turns shall be dipped and baked with a non-hygroscopic varnish; the stator bores and rotor cores shall be coated with epoxy paint. The entire enclosure shall be finish painted by the motor manufacturer at the factory with a corrosion-resistant paint to provide additional protection against moisture and contaminants. The nameplates shall be stainless steel.
- Each motor shall be equipped with a suitably sized space heater to keep condensation from forming when the motor is not running.
- Each motor shall be equipped with a normally closed thermostatic heat protection device to protect the motor from overheating during operation. The unit shall immediately stop the aerator drive motor in the event of excessive heat build-up.
- Each gear reducer shall be of the helical gear type and shall be sized with a minimum service factor of 2.5 times the motor nameplate horsepower rating in accordance with applicable American Gear Manufacturers' Association (AGMA), when each unit is operating at full load motor horsepower, 24 hours a day continuous running under moderate shock loads. The efficiency shall not be less than 94 percent based on the gear reducer input horsepower. The

gear reducer shall be specifically designed for the loading associated with aerators and/or mixers and shall have an independent lower bearing (if required).

- The gear reducers shall be designed for vertical input and output shaft operation and the housing shall be cast iron construction with provisions for the attachment of suitable lifting devices. Each reduction unit shall have gearing of the helical gear type. Worm gearing will not be acceptable. The units shall be designed to AGMA Service Classification III minimum. All shafts shall be supported on tapered roller or double spherical roller bearings. Gears and pinions shall be made of alloy steels. Shafting shall be made out of medium carbon steel. The gear teeth shall be through-hardened or carburized. Flame hardened gears will not be acceptable. All gears shall be made from alloy steels with sufficient hardenability to obtain case and core properties meeting the requirements for grade 2 material in accordance with ANSI/AGMA 2001-C95. The steel alloy shall be selected, and the heat treatment shall be controlled, to obtain a microstructure that meets all the requirements for grade 2 material in accordance with ANSI/AGMA 2001-C95.
- All gears shall meet the accuracy requirements for AGMA quality No. Q12 in accordance with ANSI/AGMA 2001-B88. Pitting resistance and bending fatigue resistance shall be rated in accordance with ANSI/AGMA 2001-B88.
- All bearings incorporated within the gear reduction unit shall have a rating-life expectancy (B10) of 100,000 hours, except those bearings attached directly to the output shaft, which shall have a rating-life expectancy (B_{10}) of 250,000 hours. All bearings shall be of the anti-friction type. Bearing life shall be rated in accordance with ANSI/AFBMA Std. 11-1990 based on operating continuously at the rated full load horsepower and speed.
- The lubrication of the speed reducer shall conform to AGMA 9005-E02. A reliable lubrication system shall be provided for the gears and bearings. Lubrication systems which rely wholly or in part upon oil circulating pump or internal splash lubrication shall incorporate a proven reliable pressure or level switch device which will immediately stop the driving motor and transmit an alarm signal to the motor control center in the event of insufficient lubrication. Each electrical switch shall be wired to its respective aerator motor control center. External oil cooling will not be permitted. The unit shall be provided with a dipstick or sight glass to observe oil levels. Oil fill and drain lines shall be sufficient size to permit efficient functioning and shall be located on the gear unit in a position which is easily accessible from the bridge platform. The oil drain piping shall be installed so that a container may be placed under the drain discharge. The Design-Builder shall supply the first charge of run in oil for the reducers and, if necessary due to run time, the change of oil. The Design-Builder shall purchase the oil from a local firm selected by the Owner, in accordance with the information in the Operation & Maintenance manual, to assure lubricant compatibility.
- All grease lubricated bearings shall have seals to retain the grease. The low-speed shaft shall have grease lubricated bearings and shall have a dry well to prevent oil leakage. The dry well shall be 100% maintenance free with no wearing parts. The dry well shall be sealed by a non-contact double labyrinth seal with a return drain above. Additionally, the output end of the well shall include the upper and lower bearing seals and separate oil seal. All grease lubrication pressure lines shall be fed from fittings accessibly located above the platform supporting the mechanism.
- The housing shall be constructed of high tensile strength gray cast-iron conforming to ASTM A48 class 30 minimum with integral dry well construction to eliminate oil leakage at the output shaft and prevent loss of lubrication in the event of a seal failure. The housing shall be stress-relieved prior to machining. The housing shall be tested to preclude casting porosity or weld defects that could result in oil leakage. Lifting lugs shall be provided on the housing

suitably located to enable safe removal of the combined electric motor and gear unit from the supporting platform. Removable inspection cover(s) or inspection port(s) shall be provided.

- Each gear reducer shall be mounted on a support with hot dipped galvanized steel bolts. The support shall be mounted on four galvanized steel jack studs inserted in the platform structure and designed to withstand all normal operating loads. The jack studs shall have the capability to provide a total vertical adjustment of six (6) inches.
- The surface impeller shall provide oxygenation and propulsion of the mixed liquor in the activated sludge basin. The surface impeller shall present a minimum amount of edge perpendicular to the flow to prevent any attachment of solid materials.
- The aerator shaft shall be attached to the gear reducer by a rigid, cast iron flange-type coupling. A retainer plate shall be provided for mounting to the end of the gear reducer output shaft to provide protection against disengagement of the coupling from the gear reducer output shaft. The flanges and flange-type coupling shall be assembled with A325 high strength bolts only. Stainless steel fasteners are not acceptable.
- All structural steel used in the fabrication of the aerator shall conform to the requirements of "Standard Specifications for Structural Steel" ASTM Specification A-36. All shop welding shall conform to the latest standards of the American Welding Society (AWS). Fabricated assemblies shall be shipped in convenient sections as permitted by carrier installations.
- Supports shall be fabricated from Type 304 stainless steel, ASTM A240. Welded parts shall be Type 316L stainless steel. Air manifold and air distribution system supports shall include all the required supports, guides, clamps, anchor bolts, and hold-down mechanisms required to support and anchor the system in place.
- An integral sump, drain and purge system shall be provided for each air manifold system. The purge system valve shall be accessible from the walkway level of the aeration basins.
- Diffuser systems shall be capable of providing for 200 percent of the designed average day oxygen demand. The air diffusion piping and diffuser system shall be capable of delivering normal air requirements with minimal friction losses.

Positive Displacement Blowers:

Positive displacement blowers shall comply with the following design criteria:

- Blowers shall be provided with provisions made for noise control using sound dampening wall panels. Maximum noise level from the blowers at a distance of 1 meter shall not exceed 88 dBA.
- The intake and discharge silencers shall be made of welded carbon steel, the packing shall be combination chamber-absorptive, the retainer shall be 14 ga steel minimum, and the flanges shall be ANSI125 lb.
- The following materials shall be used: ductile iron, ASTM A536 for impellers; cast iron ASTM A278 for blower casing; steel for base; heat treated alloy steel, AISI 1045 or4140 for shaft; cast iron, ASTM A278 for bearing housing; alloy steel or type 316 steel for timing gears.
- The inlet filters shall have a cast iron or carbon steel body; the filter element shall be dry type polyester, washable and removable with minimum 99% efficiency for removal of 10 micron particles; the disc shall be ductile iron and the shaft material shall be stainless steel; bolt holes shall match 125# ANSI flange; and vacuum breaker shall be provided.

- Butterfly valves shall be wafer type, with discharge isolation, manual handwheel operator and 125/150 # ANSI flanges.
- Flexible connectors shall have wire reinforced Dacron body with EPDM tube and cover; shall be fit with control unit to limit axial movement; and shall be flanged on both ends with split galvanized retaining rings.
- Relief valves shall be high capacity, with full nozzle, spring type, constructed of cast iron with bronze trim, capable of discharging total blower output with 10 percent pressure accumulation; springs of various operating ranges shall be supplied after installation for adjustment after installation.
- Check valves shall be heavy duty, cast iron body, aluminum plates, stainless steel spring, Buna L seal; shall have low pressure drop, wafer type, with maximum service pressure of 125 psig; flange shall be flat face, 125# ANSI.
- Pressure/vacuum gauges shall be installed at each blower discharge.

2.2.1.3 Internal Process Recycle System

The nitrate rich internal process recycle shall be accomplished by the motive force generated by the mechanical aerators. The system shall consist of a diversion gate that can be set to achieve an internal recycle equal to at least 4.5 times the influent flow rate on an average daily flow basis.

2.2.1.4 Anoxic Zone Mixers

Anoxic zone mixing shall be provided by mechanical mixers which have motors located above the maximum water surface of the basins or submersible mixers. Adequate mixing capacity shall be provided to maintain solids in suspension. Mechanical mixers shall be Philadelphia Mixing Equipment Co., Series 4000 or Lightnin Mixers, Series 10. The following criteria shall be met:

- Speed Reducers: Each mixer shall be furnished with a heavy-duty speed reducer of the right-angle type, with spiral bevel or helical gears, or combinations of helical and spiral gearing, specifically designed for mixer service. The speed reducer used for the mixer shall be suitable for direct connection through a flexible coupling to the electric motor drive. General maintenance including, but not limited to, motor changes, gear changes, replacement of all anti-friction bearings (except the bearings supporting the output shaft), and the lubrication system maintenance shall not require the removal of the speed reducer housing from its foundation. Speed reducer shall be provided with eyebolts and lifting lugs.
- All shaft support bearings shall be the anti-friction roller or ball bearing type. Output shafts shall be supported by tapered roller bearings. All mixer bearings shall be designed for a rated B-10 life of 100,000 hours. Bearings located outside the reducer oil supply shall be grease lubricated and shall be equipped with grease fittings and seals. Other bearings and gears shall be lubricated by a constant flow of oil by splash lubrication, an oil slinger, or an oil pump. The reducer shall include provisions to prevent leakage of oil down the output shaft via a dry well. An oil dipstick or sight gauge shall be provided.
- Impeller shaft shall be Type 316 stainless steel. Where welding is used for fabrication, the shaft seal shall be annealed after fabrication or made from a low carbon stainless steel. The shaft shall be of overhung design. Use of bottom steady bearings is not permitted. The shaft supporting the impellers shall be removable from the speed reducer without disturbing the internal gearing of the speed reducer. The lower mixer shaft shall be connected to the upper or drive output shaft with rigid, stainless steel flanged coupling of either the welded or

interference fit hub type.

- The shaft-impeller design shall limit operating speed to a maximum of 65 percent of the first lateral harmonic vibration frequency (critical speed).
- Mixing impellers shall be constructed of Type 304 stainless steel and shall be bolted or cast construction.

2.2.2 Secondary Clarification

The clarifier shall conform to Sections 72 and 73 of the RSWF 2004(10 States Standards) unless otherwise noted. Secondary clarification equipment components shall include but not be limited to:

- Reinforced or pre-stressed concrete clarifier basin.
- Influent and effluent piping.
- Center drive unit and torque control.
- Walkway and platform with handrail.
- Center influent column.
- Inlet well and inlet baffle.
- Perimeter effluent weirs.
- Scum baffles.
- Effluent launder.
- Extended beach scum skimming system.

2.2.2.1 Secondary Clarifier Basin

One clarifier shall be provided equal in size as the two existing clarifiers. The circular secondary clarifier shall be provided and constructed of cast-in-place or pre-stressed concrete with perimeter V-notch weir and launder. The maximum surface overflow rate of the secondary clarification process with one unit out of service (two operational) during the peak hourly flow of 37.5 mgd shall not exceed 1,200 gpd/sq. ft.

At least 16 feet of sidewater depth shall be provided. Walls of settling tanks shall extend at least 6 inches (150 mm) above the surrounding ground surface and shall provide not less than 12 inches (300 mm) freeboard. Additional free board or use of wind screen is recommended where tanks are subject to high wind velocity.

A Crosby-type baffle shall be provided at the clarifier perimeter. The baffle shall be sloped to prevent solids from settling on top with equally spaced gas relief holes at a minimum 10-foot spacing. An integral V-notch weir and scum baffle system shall be provided. V-notch weirs and scum baffles shall be constructed of fiberglass reinforced plastic (FRP) and shall be fabricated to prevent damage from prolonged exposure to ultraviolet light. Overflow weirs shall be readily adjustable over the life of the structure to correct for differential settlement, located to optimize actual hydraulic detention time, and minimize short circuiting. Weir troughs shall be design to prevent submergence at design peak hourly flow, and maintain a velocity of at least 1 foot per second (0.3 m/s) at one-half design average flow.

2.2.2.2 Clarifier Mechanism

The clarifier mechanism shall convey the settled activated sludge solids to the center outlet. Clarifier mechanisms shall remove sludge uniformly from the bottom of the clarifier through the sludge

withdrawal system. The clarifier mechanism shall be of the Tow-Bro type as manufactured by Envirex (Evoqua), WesTech Engineer, Eimco Process Equipment Co. (Ovivo), or Walker Process. Spiral scrapers shall not be acceptable.

Clarifier drive mechanism should meet the following criteria:

Design Running Torque:	21,200 foot-pounds minimum
Alarm Torque:	28,620 foot-pounds minimum
Cutout Torque:	33,900 foot-pounds minimum
Ultimate Torque:	42,400 foot-pounds minimum
Minimum Bearing Race Diameter:	45 inches
Secondary Reducer (worm):	21.5 inches minimum pitch diameter

The torque cage shall be designed such that calculated stresses do not exceed AISC Allowable Stress at 110,000 ft-lbs load.

The collector mechanism shall be of the center pier-supported, center drive type. The mechanism shall be furnished complete, including drive motor, gearing, influent column, walkway, walkway support system, rotating scum skimmer, scum trough, overload devices, sludge withdrawal manifold, return activated sludge piping seal at the center column, and all other necessary parts, including anchor bolts.

The mechanism shall consist of the center pier that supports a center drive mechanism, which rotates a center cage. Epoxy-coated carbon steel or galvanized steel shall be provided for the clarifier mechanism.

The sludge withdrawal headers shall be parallel to the tank floor bottom, and shall have a series of inlet orifices located so that the header removes sludge from the entire tank bottom. The tank shall be constructed in a cylindrical configuration, with minimum floor slope only, to ease in washdown if the clarifier is removed from service. The headers must be able to remove sludge proportional to the area. The longitudinal cross-sectional axis of the headers shall be mounted at an angle of 45 degrees with the tank bottom to provide a peaked top. The leading edge of the header shall extend downward 2 inches to provide a fluidizing vane as an integral part of the headers and to direct the sludge into the area of influent of the orifices.

Inlet orifices varying in size from a minimum near the tank center to a maximum at the outer end shall be located at regular intervals in the sludge headers.

The mechanism shall operate continuously at a speed no greater than one revolution in 40 minutes. The drive mechanism shall consist of a primary gear reduction unit, an intermediate reduction unit, and an enclosed final reduction unit consisting of a pinion and internal gear enclosed in a turntable base. All gearing shall be enclosed in fabricated steel or gray iron Class 40B or 40C housings when cast units are selected. The bearings shall be designed for a B-10 life of 100 years.

At the ultimate torque, no parts of the mechanism shall be stressed to more than 90 percent of the material yield strength, except the drive assembly parts shall not be stressed more than 60 percent of the material yield strength. Stresses shall include surface stresses of gears and shall be as calculated by AGMA accepted design methods.

The primary speed reduction unit shall be a worm, helical or cycloidal gear, heavy-duty, speed reducer. All bearings shall be anti-friction type, running in oil in cast iron housing for a cast drive, or in a sealed

bearing for manufactured housing. The primary reduction unit shall drive the intermediate reduction unit through a chain and sprocket arrangement.

The intermediate reduction unit shall be a heavy-duty, cycloidal or worm gear speed reducer, mounted in a gray iron housing secured to the turntable base, with oil or grease lubricated anti-friction type bearings. The internal final gear shall be driven by a heat-treated steel pinion from the slow speed shaft of the intermediate gear reduction unit. The turntable shall have a forged steel precision gear/bearing set with fully contoured raceway or an annular raceway containing balls upon which the internal gear rotates. The balls shall be alloy steel and shall bear vertically and horizontally on renewable hardened strips, force fitted into the turntable base and internal gear. The internal gear, pinion and ball race shall run in an oil bath or be grease lubricated and be protected by a seal and dust shield.

The turntable base shall be bolted to the center column and shall support the internal gear with the rotating mechanism. All gears, bearings, chains and sprockets shall be above the water surface. All steel parts of the mechanism shall have a minimum thickness of 1/4 inch.

A collector overload device shall be provided and shall be a mechanical or hydraulic device which will actuate integral contacts to indicate an impending overload (high torque) and shut off the motor at a predetermined load (high-high torque). The overload device shall be a high torque contact which closes on impending overload at 120 percent of running torque for alarm and a high-high torque contact which opens for motor shutdown at 140 percent of the running torque. In addition, a mechanical linkage or shear pin shall be provided to protect the drive at a load determined by the supplier/manufacturer in case of a control system failure. The manufacturer's proposed torque testing procedures for the clarifier mechanism shall be submitted for review by OCWS.

The access platform and half bridge shall be constructed of aluminum. The minimum clear walkway width between rails shall be 36 inches.

2.2.2.3 Influent Column and Feed Well

Ports shall be cut in the top of the influent column to permit the escape of entrapped scum. Equally spaced openings shall be provided, with an adequate number of openings provided to allow the scum to flow out from the influent column area.

The clarifier inlet wells can include both an inlet well and conventional feed well configuration at the recommendation of the manufacturer, but shall include a conventional feedwell spaced at roughly 30 percent of the clarifier diameter and roughly 30 percent of the clarifier depth. A “scooped feedwell” or “energy dissipating feedwell” shall not be acceptable.

Suitable openings in the inner well shall be provided to allow floating material to be removed. A water spray system shall be provided to direct the scum out through the openings of the inner well.

2.2.2.4 Scum Skimming System

The clarifier mechanism shall be furnished with two scum collector arms. Each skimming device shall be arranged to sweep the surface of the sedimentation compartment, automatically removing scum and floating material to an extended beach scum box at the periphery of the clarifier. The extended beach shall collect scum from a minimum of 7 feet at the clarifier periphery. The rotating scum skimmer shall include a vertical steel plate supported by vertical steel members extending up from the rake arms. The blade shall extend tangentially from the influent feedwell to the hinged scum skimmer assembly at the tank periphery.

A hinged scum skimmer assembly shall be mounted on the outer end of the skimmer device. The hinged scum skimmer assembly shall be designed to form a pocket for trapping the scum. The hinged arrangement shall ensure continual contact and proper alignment between wiper blade, scum baffle, and ramp as the blade travels up the ramp. The wiper blade shall have a wearing strip on its outer end, which contacts the scum baffle and a neoprene strip on its lower and inner edge. Scum shall be trapped as the wiper blade meets the ramp and shall be raised up the ramp to be dumped into the scum trough for disposal.

Scum shall flow from the scum trough through a pipe to the plant drainage system which flows to the plant lift station.

2.2.3 RAS Pumping

The RAS pumps shall be centrifugal type as described in Section 3.4 – Mechanical Design Criteria. The number of RAS pumps shall be supplied such that one RAS pump withdraws sludge from the secondary clarifier, with one backup RAS pump being provided. Each RAS pump capacity shall be 100 percent of the maximum month treatment facility design flow of 3,500 gpm.

The RAS flow from the new secondary clarifier shall be measured with a magnetic flow meter. After flow measurement, the RAS shall be pumped to the pretreatment structure and combined with the RAS from the two existing trains. The RAS shall tie-into the existing piping if sufficient capacity is available or discharge into the grit chamber/RAS collection channel and shall mix with the preliminary effluent (PE) prior to being split proportionally to the operating aeration basins.

The RAS pump casings shall be ASTM A48, Class 30 cast iron. Suction liner shall be ASTM A532, Class III, Type A. Impeller shall be ASTM A nodular iron. A stuffing box seal shall be provided, holding four rows minimum of Teflon-impregnated Kevlar or acrylic yam, packing, and a lantern ring. W3 water shall be used to lubricate the packing.

2.2.4 Operation and Control

2.2.4.1 Major Field Instrumentation

Activated Sludge System:

- Return activated sludge flow meter
- DO probes – two per basin
- Ultrasonic level measurement, aeration train effluent measurement.

Clarifiers:

- Secondary clarifier torque switches (High and High-High)

RAS Pumping:

- RAS flow measurement

2.2.4.2 Local Monitoring and Control

Activated Sludge System:

- Post aeration blower, local control panel
- Post aeration blower, isolation valves
- Mixer or blower status/HOA

- Anoxic zone mixers local On/Off/Remote handswitch
- Water level
- pH, temperature

Clarifiers:

- Start/Stop pushbuttons
- On status light
- High High Level light
- Low Low Level light
- Various Fail conditions

RAS Pumping:

- RAS pumps – Manual/Auto control

2.2.4.3 Remote Monitoring and Controls

Activated Sludge System:

- Open/Closed status, bypass valve, each blower
- Mechanical Aerator On status
- Aeration blower multiple alarms, each blower
- Anoxic zone mixers On/Off status for each mixer

Clarifiers:

- Clarifier On status, one per clarifier
- Clarifier high torque alarm, one per clarifier
- Secondary clarifier High and High-High torque alarm

RAS Pumping:

- Provide Start/Stop and speed control of each RAS pump
- Provide indication of the status of the flow control system

2.3 Effluent Management

The effluent management includes disinfection and effluent pumping.

2.3.1 UV Disinfection

Ultraviolet (UV) light disinfection equipment shall be provided to accomplish disinfection of the clarifier effluent. The UV system shall use low pressure high intensity lamps arranged in open channels where the water shall flow by gravity continuously. Lamp arrangements within the channel shall be vertical and not horizontal. The existing UV disinfection structure consists of three channels. Two of the channels have been outfitted with UV lamp modules. The third channel shall be utilized for this expansion. It shall be the responsibility of the Design-Builder to integrate any new equipment with and into the existing equipment and to provide overall responsibility for the treatment performance of the complete UV system at the permitted flows.

2.3.1.1 Performance Requirements and Design Criteria

The performance requirements and design criteria for the UV disinfection equipment is specified below.

Performance Requirements:

Peak Disinfection Flow	37.5 mgd
Max Month Average Daily Flow	15 mgd
Total Suspended Solids	20 mg/l
$CBOD_5$	20 mg/l
Effluent Fecal Coliform Standard:	
CFU/100 ml (30-day geometric mean)	200
CFU/100 ml (7-day geometric mean)	400

- The UV system will be designed to deliver a minimum UV dose of 30 mJ/cm^2 at peak flow, in effluent with a UV transmission of 65 percent after reductions for quartz sleeve absorption, sleeve fouling, and at end of lamp life (EOLL). The basis for evaluating the UV dose delivered by the UV system will be the manufacturer's bioassay as carried out by an independent third party. The UV dose is not based on the dose response testing. Using existing information regarding influent quality, the design transmittance was assumed to be 65%. Bioassay validation methodology to follow protocols described in the US EPA Design Manual – Municipal Wastewater Disinfection (EPA/625/1-86/021), without exception.
- The UV dose will be adjusted using an EOLL factor of 0.5 to compensate for diminishing lamp output over one year of lamp operation. The use of a higher lamp aging factor will be considered only upon review and approval of independent third-party verified data that has been collected and analyzed in accordance with protocols described in NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2003).
- The UV dose will be adjusted using a quartz sleeve fouling factor of 0.8 when sizing the UV system in order to compensate for attenuation of the minimum dose due to sleeve fouling during operation. The use of a higher quartz sleeve fouling factor will be considered only upon review and approval of independently verified data that has been collected and analyzed in accordance with protocols described in NWRI Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2003).
- The UV disinfection system shall be designed to operate in either "flow-pacing" or "dose-pacing" mode, as selected by an operator using the plant control system. In flow-pacing mode, lamp output or number of lamps in a service for a vertical system shall be adjusted based on the measured flow rate. In dose-pacing mode, lamp output shall be adjusted based on measured flow rate, and trimmed using the measured UV intensity and UV transmittance as measured by an on-line UV transmittance monitor or simply the measured UV transmittance. The transmittance is based on dose response testing.

Design Criteria:

- The system shall consist of a minimum of three banks of two modules to be installed in the one channel that is not in use in accordance with the manufacturer's recommendations. Two channels are currently in operation.
- The lamp array configuration shall be a uniform array with all lamps parallel to each other perpendicular to the flow. The lamps shall have equal centerline spacing along the horizontal and vertical axes. The single array pattern shall be continuous and symmetrical throughout the reactor.

- The system shall be designed for complete immersion in the effluent of the UV lamps within their protective quartz sleeve. Both electrodes and the full arc length of the lamp shall be below the water surface. Both lamp electrodes shall operate at the same temperature and be cooled by the effluent.

2.3.1.2 System Manufacture and Construction

A general description of the UV system manufacture and construction and UV system components is presented in this section.

- All metal components in contact with effluent or directly above the effluent shall be type 304 or 316 stainless steel or anodized aluminum, as a minimum. All materials exposed to UV light shall be Type 316 stainless steel, Type 214 quartz, Teflon or other UV resistant material such as polyurethane. All wiring exposed to UV light shall be Teflon™ coated.
- Electrical enclosures that house electrical components above the effluent shall have a NEMA 4X rating and made of 304 or 316 stainless steel or anodized aluminum. If necessary, a climate-controlled building adjacent to the UV channels will be supplied by the Design-Builder for electrical and control components and shall be sized and designed to accommodate all components. Electrical and control enclosures located in the controlled building shall be NEMA 12 painted steel.
- Lamps shall be low-pressure, high intensity type.
- Lamps shall be rated to produce zero levels of ozone. Lamps bases shall be metal and ceramic construction resistant to UV and ozone. Electrical connections shall be at one end. 90 percent of the UV output shall be written within the wavelengths of 233.7 to 273.7nm.
- Lamp sleeves shall be rated for UV transmission of at least 92 percent and shall not be subject to solarization over the length of their life.
- The rack shall be stainless steel and suspended above the effluent allowing adjustment to the precise height of the channel and requiring no fastening of the individual UV lamp modules.
- The UV lamp module shall be made of stainless steel and shall be designed so that no ultraviolet light radiates above the channel when the UV lamp modules are energized and fully immersed in the effluent.
- Two face shields shall be provided which block UV light wavelengths between 200 and 400 nm.
- Each UV lamp assembly shall consist of a UV lamp, enclosed in an individual quartz sleeve, and with the ends appropriately sealed using an O-ring sealed quartz end plug.
- The quartz sleeve shall be fixed to the module frame using stainless steel clips onto the end plugs of the sleeve. The quartz sleeves shall not come in contact with the stainless steel of the module frame.
- The UV lamp sleeve shall be a single piece of clear fused quartz circular tubing, open at both ends.
- Each UV module shall consist of a dual (side-by-side) row configuration of UV lamp assemblies.
- The module frame shall be constructed of heavy gauge, 316 stainless steel with stainless steel spring tension clips for holding the lamp assemblies in place. The top of the frame shall also serve as a UV reflector shield to prevent UV light from exiting the UV bank area.

- The ends of the lamp sleeve shall not protrude beyond the stainless steel frame of the UV module.
- The UV modules shall be designed such that operating personnel at the plant can change the lamps and quartz sleeves without requiring special tools.
- Each UV module shall be equipped with an interlock switch, which will automatically disconnect power to its associated UV bank if the module is raised from the UV channel or the quick disconnect plug is removed.
- Each UV module shall be equipped with an automatic wiping system with selectable wiping frequency and number of strokes.
- Wiper systems that require the maintenance of an integral chemical reservoir in order to function are not acceptable.
- The automatic wiping system shall be pneumatically or hydraulically powered and shall use Teflon wipers to clean the quartz sleeves. Wiping frequency shall have an adjustable number of strokes and an adjustable timer interval.
- The wiping system shall be PLC controlled and provide a fully automatic, unattended operation.
- The number of wiping strokes per interval shall be factory preset for optimum effect and shall be easily reset by the owner from 1 to 5 strokes per interval.
- The useful life of the wiper brush or cleaning device in contact with the quartz sleeve shall be in excess of two years based on factory stroke and interval settings.
- The cleaning system shall maintain uniform wiping tension and cleaning over complete wiping length of the quartz sleeve and the UV sensors full efficiency throughout its life, with no deterioration in quality of cleaning.
- The wiper blade brush or other cleaning device in contact with the quartz sleeve shall be non-metallic and shall not damage or scratch the quartz sleeve or sensor in any way.
- To offset cleaning mechanism wear and to maintain positive contact and wiping efficiency with the quartz sleeve, the wiper blade brush or other cleaning device shall be self adjusting and shall automatically adjust to account for wear over its useful life.
- A submersible UV sensor shall continuously sense the UV intensity produced in each bank of UV lamp modules.
- The sensor shall measure only the germicidal portion of the light emitted by the UV lamps as measured at 254 nm. It shall have sensitivity at 254 nm of greater than 95 percent. Sensors whose sensitivity to other wavelengths amounts to more than 5 percent of the total sensitivity shall not be allowed.
- The UV intensity monitoring system shall be field calibrated.
- The measured intensity shall be displayed on the operator interface as an absolute value in mW/cm2 or percentage of original reading.
- The sensor shall be automatically cleaned at the same frequency as the lamp sleeves to prevent fouling of the sensor and hence spurious false alarms for low intensity.
- Control of the water level in the UV channel shall be provided by the existing finger weir system currently employed by the operating UV system.

- Covers for prevention of UV light dissipation out of the channel shall be provided by the UV system manufacturer and placed in every channel between each bank of modules, at the upstream side of the first bank and at the downstream side of the last bank.
- Covers shall be aluminum and designed to support the anticipated surface loads.
- Influent distribution channel and effluent collection channel shall not be covered.

2.3.1.3 Electrical

- The electrical system shall be designed to provide maximum reliability of the UV disinfection system.
- Segregation of plant services and supplies into sensible groups to allow for safe and simple maintenance or servicing whist ensuring maximum possible disinfection capability is maintained.
- Plug and socket quick disconnect facilities enabling non-technical personnel to carry out lamp replacement, wiper insert replacement, etc. without the need for any tools or specialist isolation procedures.
- The location of sensitive electronic components, e.g., electronic ballasts, shall be chosen to ensure that a long service life can be guaranteed.
- All heat sensitive components shall be adequately cooled with dry air utilizing forced or natural ventilation or an integral closed loop cooling system which uses the effluent to dissipate the heat.
- Systems or designs that subject sensitive electrical or electronic components to excess humidity or poor air quality for cooling are not acceptable.
- Systems that lack positive mechanical heat transfer such as fans (or air conditioning) for the sensitive electronic components are not acceptable.
- Harmonic distortion correction equipment shall be provided by the UV manufacturers as required to meet IEEE519 of The Institute of Electrical and Electronic Engineers.
- The enclosures for the UV system shall be NEMA 12 painted steel and shall be installed within a climate-controlled structure. The ambient temperature within the building shall not exceed 86 degrees F. Any UV system components installed outdoors shall be located in NEMA 4X SS enclosures and the enclosures shall be provided with conditioning equipment as required to keep the components within their manufacturer required operational temperature ranges.
- Facilities for fully automated control and manual control independent of the PLC shall be provided.

Power:
The new UV channel equipment shall be powered by new distribution equipment to prevent interference with the existing equipment. The new power equipment shall be comprised of a the following components (as shown on the plans):

- ***480Vac distribution breaker in a Motor Control Center (MCC) cubicle to match existing MCC cubicles and fit in the existing MCC.***
- ***Stepdown transformer.***
- ***UV power distribution panel housed in a NEMA 4X SS enclosure with 3 point latch.***

- ***All power components and ancillary equipment as required by the UV equipment manufacturer for a fully functional UV process channel.***

Controls:
An existing freestanding control system comprised of a PLC, operator interface, control and instrumentation equipment, and plant interface points currently provides monitoring and control access to the existing UV channels. The new UV channel equipment shall be integrated into the existing control system by a control system representative of the manufacturer of the UV equipment. In addition to the incorporation of the new channel the manufacturer's representative shall also replace the existing programmable logic controller (PLC) with one capable of running Allen Bradley's Firmware version 21. The manufacturer's representative shall be responsible for any additional modifications (such as I/O) that are required as a result of the PLC/firmware upgrade. Additionally the manufacturer's representative shall verify that once the PLC has been replaced and the firmware has been upgraded all of the original functionality of the UV channels remains intact. Once complete the UV equipment manufacturer's representative shall work with the owner's representative to facilitate the integration of the new equipment into the PMCS as well as verify the existing equipment status in the PMCS.

2.3.2 Effluent Pump Station

An effluent utilities pump station has been provided and sized appropriately to pump the current treated wastewater effluent to the RIBs. The Design-Builder shall provide and install the fourth effluent pump and associated piping, valves and electrical components to increase the capacity to the specified peak hourly flow rate. Materials of construction for all equipment and piping shall conform to the discipline-specific criteria given in Section 3.4 – Mechanical Design Criteria. Programming and integration of the new effluent pump into the PMCS shall be performed by an owner's representative.

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3.0 DESIGN CRITERIA

3.1 General Site/Civil Design Criteria

3.1.1 Detailed Field Surveys

Field surveying and existing topography will be supplied to the Design-Builder. If any additional information is required, the Design-Builder shall be responsible for obtaining it.

The Design-Builder shall follow these guidelines:

- All new field survey data shall be entered in the survey and mapping electronic database.
- Each new survey shall be assigned a separate file designation so new data can be attached to original electronic files.
- All final record drawings of utilities and facilities shall be provided after construction has been completed.

3.1.2 Horizontal and Vertical Coordinate System

All new construction on the OCWS facilities shall be tied to the Florida State Plane Coordinates System, North Zone (NAD 83 - 90). Vertical controls shall be referenced to NAVD 1988. Permanent horizontal and vertical controls shall be identified and used in the construction phase.

3.1.3 Design Documentation

3.1.3.1 Site Drawing Organization

The site plans shall be organized as follows:

- Drawings shall be parallel or perpendicular to the grid system.
- Unless otherwise specified, the drawing scale for site plans shall be 1″=50′ (or larger) with common match lines as required, with 1″=20″ for individual sheets to short grade lines.

Site drawings for individual projects shall be organized as follows:

- Existing topography.
- Demolition plans.
- Horizontal control/geometry plans:
  - Existing facilities.
  - New structures and facilities with coordinates and dimensions.
  - Pavement types and limits.
  - Concrete joint types and dimensions.
- Finished grading/vertical control plans:
  - Existing contours.
  - Finished grade contours and spot elevations.
  - Road profiles.
  - Roadway intersection grading details at a larger scale.

- Storm drainage system, profiles and details.

- Maintenance of traffic plans (if required).
- Traffic signing plans.
- Erosion and sediment control plans.
- Temporary facilities during construction:
  - Permanent facilities.
- Landscaping plans.

3.1.3.2 Typical Construction Details

Typical construction details shall be developed for the site improvements.

3.1.3.3 Existing and New Geotechnical Data, Soil Borings, and Explorations

The Design-Builder shall be responsible for interpreting all geotechnical data and performing any additional studies to satisfy their requirements.

3.1.3.4 Site Utilization and Construction Staging Plan

The Design-Builder prepares the site utilization plan. This drawing indicates authorized staging and laydown areas for each project. Examples of construction support activities shown on this drawing include access roads to the construction sites; utilities such as power, water, sanitary, and telephone hookups; transportation logistics; and other common services required to support the construction activity.

A final site survey of the proposed APWRF site will be provided to the Design-Build Team with coordinates. The site is approximately 20 acres. Design-Builder will work with Owner to identify areas that can be used for construction staging and APWRF construction. At this time, the Owner has identified the vacant property adjacent to, and located north and south of, the existing APWRF site. If additional area is needed for staging, the Design-Build firm shall identify how much additional area shall be needed. There may be other areas available adjacent to the APWRF site; however, additional area may be provided at the discretion of OCWS. The security fence shall be maintained around the perimeter of the APWRF. Temporary modifications can be made to accommodate construction, provided that the permanent security fence is restored in like condition prior to final completion of the project.

3.1.3.5 Civil Legend, Abbreviations, Schedules, and Notes

All submittals shall include a drawing. Drawings must include the following:

- A civil legend.
- List of acronyms and abbreviations.
- An outside piping schedule.
- Notes providing direction for the Design-Builder regarding critical areas not adequately defined in the drawings.

The drawing shall be sufficiently detailed to identify and clarify symbols, line work, and abbreviations used throughout the drawings. The following acronyms and abbreviations shall be used for all site development documents:

Element	Acronyms and Abbreviations
Top of Curb	TC
Flowline	FL
Ridge	RDG

Element	Acronyms and Abbreviations
Grade Change	GC
Top of Bank	TOB
Toe of Slope	TOS
Grate Elevation	GE
Invert Elevation	IE
Finished Grade	FG

Element	Acronyms and Abbreviations
Existing Grade	(Screened)
Concrete	Conc
Asphaltic Concrete	AC
Pavement	Pvmt
Edge of Pavement	EP
Shoulder	Shldr
Joint	Jnt
Finished Floor Elevation	FF
Top of Wall Elevation	TW
Catch Basin/Inlet	CB
Manhole	MH
Rim of Top Elevation of Catch Basin/Inlet	TE
Reinforced Concrete Pipe	RCP
Corrugated Metal Pipe	CMP

Element	Acronyms and Abbreviations
Polyvinyl Chloride Pipe	PVC
Benchmark	BM
Temporary Benchmark	TBM
Point of Horizontal Curvature or Beginning of Curve	PC
Point of Horizontal Tangent or End of Curve	PT
Point of Horizontal Intersection	PI
Point of Vertical Curve or Beginning of Vertical Curve	PVC
Point of Vertical Tangent or End of Vertical Curve	PVT
Point of Vertical Intersection	PVI
PVI to Point on Vertical Curve	e
Curve Data:	
Radius	R
Delta	D
Length	L
Tangent	T

3.1.4 Demolition Plans

The drawing scale for demolition plans shall be 1:100 or smaller. Demolition of facilities and improvements shall address the following:

- Verify existing facility information. Confirm that layout is correct, complete, and up to date.
- Determine allowable methods of demolition.
- Identify the limits of demolition requirements, and delineate areas of demolition (e.g., buildings, pavement, and utilities). A separate drawing is required for delineating buried structures and utilities located below surface structure or utilities.
- Identify the disposition of salvageable materials and equipment.
- Evaluate the condition of structure, site, and equipment remaining after demolition. The Design-Builder shall delineate areas for disposal or clearly define which materials are to be disposed of, those that shall be removed from the site and disposed of elsewhere, and those that shall be retained by OCWS, if applicable.
- Identify buried structures and utilities that will be abandoned in place or plugged and filled.
- Indicate the extent of facilities that will be removed or remain, and the facilities that will be protected to maintain continued plant operations.
- Determine environmental safety issues.

3.1.4.1 Limits of Demolition

Prior to demolition, the Design-Builder shall remove unused facilities only where required to remove obstacles for the new construction, unless noted otherwise. If removing only part of the unused existing facilities will not interfere with new construction, the Design-Builder shall demolish and remove facilities only as necessary. Thus, in roadways, parking areas, planting areas, and other areas outside the limits of major structure construction, the unused facilities must be removed to a set elevation of 1 to 5 feet below finished grade. The Design-Builder shall also:

- Cut holes in the base slabs so the water table can move freely through the remainder of the structure.
- Compact granular backfill inside and over the remaining structure to the finished grade.
- Backfill with bank-run gravel or other granular materials.

Future construction in the areas where facilities have been partially removed and buried may require additional demolition work.

3.1.4.2 Salvage

The Design-Builder shall obtain OCWS approval for the disposal or reuse of salvageable materials and equipment, and clearly indicate the following:

- Ownership of salvageable materials.
- Delivery of salvageable materials and equipment for reuse identifying whether they are to be stored by OCWS or the Design-Builder.

3.1.5 Roadway/Street Systems

The Design-Builder shall construct new roads with either reinforced concrete or hot plant-mix bituminous pavement. Critical areas that use heavy-duty reinforced or un-reinforced concrete paving and heavy truck traffic areas require special consideration.

For road plans, the Design-Builder shall follow these guidelines:

- Show all data required for constructing the travelway.
- Include curve geometry, pavement widths, stationing and offsets, elevations, contours, utilities, and drainage structures.
- Use roadway centerline profiles corresponding to the plan view shown at the top of the sheet.
- Show roadway profiles even when vertical controls can be shown clearly on the finished grading plans.
- These road plans and profiles shall clearly show the following:
  - All changes in grade:
    - Horizontal curve stationing and data.
    - Central angles.
    - Radius (R).
    - Arc length (A).
    - Tangent length (T).
    - Points of horizontal curvature (PC).
    - Points of horizontal intersection, include coordinates (PI).
    - Points of horizontal tangency (PT).
  - Vertical curve stationing and data:
    - Points of vertical curve (PVC).
    - Points of vertical intersection (PVI).
    - Points of vertical tangency (PVC).
    - Length of vertical curve (L).
    - Middle ordinate offset distance from the PVI elevation to the crest/sag roadway curve elevation (e).
    - Centerline elevation at every 100-foot station along roadway tangents and vertical curves.
    - Stationing and elevations for low points.
    - Stations identifying locations on the roadway.

3.1.5.1 Widths

Roadway widths (measured face-to-face of curbs) shall be 24 feet wide for two-way traffic roadways; 14 feet wide for one-way traffic roadways. This limitation is based on using the roadways for fire trucks and emergency vehicles.

3.1.5.2 Grades

Longitudinal grades on curbed roadways shall not be less than 0.5 percent. To improve gutter drainage along curved sections of curbed roadways and along curb radii at intersections, the Design-Builder shall use a minimum gutter slope of 0.7 percent. Uncurbed roadways with open ditches for drainage shall have a 0.5 percent longitudinal grade if ditch drainage can be maintained.

3.1.5.3 Transverse Slopes

The Design-Builder shall use crowned sections with 2.00 percent minimum transverse slopes along paved roadways and 4.00 percent along unpaved roadways on all streets. Special care shall be taken in grading intersections so drainage from the intersection area to the gutters and catch basins or the ditches is adequate. Sheet drainage from beyond the roadway corridor across the entire roadway width or intersection area is not permitted.

Drainage, roadway intersections, parking areas, and other warped vehicular traffic areas shall have a minimum slope (combined longitudinal and transverse slope) of not less than 1.0 percent for paved areas and 1.5 percent for unpaved areas.

Roadway drainage must be directed away from areas where pedestrians walk unless raised curbs and sidewalks are provided for pedestrian traffic.

3.1.5.4 Facilities for the Handicapped

The Design-Builder shall provide a means of access for persons with functional limitations. Site work facilities shall include special parking spaces, curb ramps, building access ramps, and handrails. Vehicle and pedestrian ramps, except for ramps for handicapped persons, may have a maximum slope of 8 horizontal to 1 vertical (12.5 percent). Handicap ramps can have a maximum slope of 12 horizontal to 1 vertical (8.3 percent) with 5-foot long transitional platforms at 30-foot intervals, or at locations where ramps must change direction. The Design-Builder shall comply with Federal ADA Guidelines and Florida Accessibility Code, whichever is more stringent.

3.1.5.5 Pavements

The Design-Builder shall use the FDOT guidelines for Design of Pavement Structures (latest edition).

The Design-Builder must provide separate pavement designs for:

- Heavy truck traffic areas.
- Medium truck and auto traffic areas.
- Auto traffic areas, including parking lots.

Rigid or flexible roadway and parking area pavement designs shall be based on:

- Type of Traffic Use – Truck and automobile.
- Estimated Traffic Volume – Truck and automobile.
- Design Life – Minimum 20 years.
- Subgrade strength developed from soil testing at the site.

For truck traffic, the following pavement design is the minimum allowed by the County code criteria. Actual pavement design will be based on recommendations provided by the Design-Builder's Registered Geotechnical Engineer:

- Minimum Pavement Design:

Asphalt	2 inches
Base	8 inches
Stabilized Subbase	12 inches

Alternative base material may be acceptable depending on seasonal high groundwater elevations at the site and the quantity of fill required for the site.

- Maximum Concrete Joint Spacing (all joint types):

Walkways and Sidewalks	Per FDOT Standard Index 305
Curbs and Gutters	Per FDOT Standard Index 300
Unreinforced Pavements	15 feet
Reinforced Pavements	20 feet

Concrete pavement that cannot be placed by machine shall conform to the need for special joint spacing and design. Shrinkage reinforcement shall be required and minimum thicknesses will need to be increased.

3.1.5.6 Sidewalks

The Design-Builder shall follow these guidelines:

- Construct sidewalks 4 feet wide minimum.
- Include smooth, greased dowels to control vertical displacements at all construction and expansion joints.
- Do not use steel or welded-wire mesh reinforcing as a substitute for proper water-cement ratios and an appropriate flexural concrete design mix. Metal reinforcing shall be used for all new sidewalks.

3.1.5.7 Pavements Joints

The Design-Builder shall abide by these guidelines:

- Show, dimension, and detail concrete pavement joints carefully.
- Slope individual concrete panels uniformly, in all directions, between construction joints.
- Place grade changes or "breaklines" at construction joints.

3.1.5.8 Butt-Type Joints

The Design-Builder shall follow these procedures:

- Use butt-type construction joints with bond breaker or preformed joint filler; joint sealant; and smooth, lubricated, steel dowels instead of formed shear keys.
- Avoid joint intersections with angles of less than 90 degrees, or "T intersections," without load and stress transfer separation.
- Remove existing concrete paving to joints and do not sawcut through the middle of existing panels.
- Avoid stress transfer across joints separating new and existing pavements.

3.1.5.9 Truck-Turning Movements

Heavy-truck roadways and traffic areas must be designed to account for truck-turning movements without encroaching into opposing traffic lanes. Developing a truck traffic pattern with counter-clockwise forward

movements and clockwise backing movements will make maneuvering the truck easier for the driver, and the movement will require less pavement area.

3.1.5.10 Truck Size and Weight

The Design-Builder shall observe the following guidelines:

- Standard design vehicle: WB-67 with a maximum length of 70 feet Maximum trailer length of 50 feet per the Surface Transportation Assistance Act (STAA).
- Maximum width: 8.5 feet.
- Maximum height: 14 feet.

3.1.5.11 Truck Loading Docks

In general, truck docks should be 4 to 4.5 feet high. Permanent dock boards usually have a maximum height adjustment range of approximately 1 foot.

3.1.5.12 Dock Boards

Portable or permanent dock boards can be used to adjust to height differences between the dock and truck bed. Dock board lengths depend on the type and clearance (at the longitudinal centerline between the front and rear wheels) of the loading equipment. Avoid bottom drag on loading equipment to be operated over dock boards.

3.1.5.13 Grading

Grading for docking area pavement shall drain toward the main roadway to avoid low points at building side. Maximum recommended grades for various types of loading equipment are the following:

Table 3-2
Grading for Docking Area Pavement

Power-operated hand trucks	3 percent
Powered platform trucks	7 percent
Low-lift pallet or skid trucks	10 percent
Electric forklift trucks	10 percent
Gasoline forklift trucks	15 percent

3.1.5.14 Horizontal Control/Geometry Plans

The drawing scale shall be 1″=20″, except an overall site plan of 1″=50″ shall be acceptable. All horizontal control geometric data, notes, and other information shall be placed on the drawings. In preparing the plans, the Design-Builder shall:

- Verify that the grid coordinate system is correct.
- Verify that any existing information (e.g., on buildings and roads) shown is accurate and complete.
- Locate all proposed structures by using coordinates.

- Show distances between all structures.
- Indicate coordinates to establish the location of all buildings and structures on the site plan with the Project north coordinate written above the Project east coordinate. Building locations should be tied to property boundaries.
- Indicate the area that defines the contract package limits of work (where applicable).
- Show a structure corner column line intersection and provide a coordinate to locate the intersecting column lines for new buildings or structures.

3.1.5.15 Vertical Controls/Finished Grades

Site finished grades define the finished ground and pavement configuration at the site area between the buildings or structures. The Design-Builder shall follow these guidelines:

- Make the drawing scale for grading plans 1″=20″.
- Make finished grades at structures, slabs, and buildings 6 inches below the finished floor or slab elevation, unless vehicular access is required.
- Make finished grades around open-water-retaining structures at least 3.5 feet below the top of the wall; otherwise, handrails shall be installed on top of the wall for safety.
- Incorporate contours with control points and grade changes, and establish "breaklines" to provide for intersecting planes in grading design.
- Locate control points for staking during construction by coordinates, or dimensions from permanent structures. Spot elevations and control lines without contours are not adequate.
- Direct sheet flow and flow lines away from areas of frequent pedestrian traffic (walkways) and yard activities.
- Provide culverts where collected drainage must cross walkways.
- Direct drainage away from structures and buildings and away from the top of cut-and-fill slopes.
- Design inlet structures so ponding does not occur and hinder the operation of the facility if drainage is collected into an underground system.
- Design surface-water overflow protection into any drainage area served by an under-ground pipe (storm drain). When the drain system is out of service, drainage will flow over berms and landscaped areas, which protect buildings and other water-sensitive structures from flooding.
- Set the overflow elevation at a minimum 6 inches below the floor elevations of the buildings.
- Isolate areas where treatment plant spills or overflows could occur onto adjacent off-site areas during emergency circumstances.
- Use finished grade contours at 18-inch intervals to define drainage patterns in areas where roadway plans and profiles do not define the finished grades. In some warped areas, such as street intersections, 1-foot contours shall be necessary to properly define finished grading patterns. All finished grade contours shall be straight, parallel lines that reflect precise uniform slopes between grade changes or "breaklines."
- Show spot elevations at all grade changes, such as the beginning and ends of curves, ridges, and flowlines.

- Define the finished paved surfaces to an accuracy of 0.01 foot and unpaved areas, such as landscaping, lawns, and groundcover, to an accuracy of 0.1 foot.
- Define all pavement XYZ controls to an accuracy of 0.01 foot either by showing a specific spot XYZ control point or by showing vertical control elevations at defined horizontal control lines, such as roadway centerlines, curb lines, and back of sidewalk.
- Construct slopes as follows:
  - Uniform asphaltic concrete surfaces: 1.00% minimum (perpendicular to finished contours)
  - Asphaltic concrete flowlines 0.75% minimum
  - Uniform concrete surfaces 0.80% minimum (perpendicular to finished contours
  - Unpaved slopes such as lawns 2.00% minimum
  - Concrete flowlines 0.50% minimum
  - Grass slopes 4:1 desirable, 3:1 (Horizontal: Vertical) maximum

3.1.6 Outside Piping Plans, Profiles, and Sections

The drawing scale for outside piping (site utilities) plans shall be 1″=20′. The Design-Builder must not show contours on this sheet. If additional detail is necessary, the Design-Builder shall use a scale of 1:10. Show the proposed storm drainage system on the grading plans only. The storm drainage system may be depicted in a shaded/ghosted manner to aid in the avoidance of utility conflicts, if applicable.

The outside piping (site utilities) plans, profiles, and sections shall clearly show the following:

- All grade changes.
- Coordinates for all manholes, stubs, branches, fittings and interfaces.
- Invert elevations of all gravity lines and centerline elevations of all non-gravity lines.
- Elevations of gravity and non-gravity lines at buildings, structures, and interfaces.
- Each line size, material type, system designation and direction of flow, where applicable.
- Buried piping and conduits to the outside face of the building or structure.
- Pipe interfaces with existing utilities.

Provide cross-sections of both gravity and non-gravity lines in congested piping areas, or elsewhere as requested by OCWS.

If the number of manholes, stubs, branches, and interfaces shown on the same sheet makes it difficult to indicate Project grid coordinates and elevations for each item, an XYZ table shall be prepared on a separate drawing. This table will display the location or interface number, north and east coordinates, invert and centerline elevations, and instructions.

If multiple pipe crossings or corridors cannot be shown clearly on a profile, sections shall be used in lieu of profiles. Multiple pipes may be shown on sections.

Piping must be laid out in corridors to provide space for future piping as well as access for repair without affecting adjacent pipes.

Pipe bedding shall be shown on the drawings to suit soil conditions, pipe materials, and depth of cover.

The drain system for collecting process return and washdowns for return to the treatment system must be combined as much as possible to minimize yard piping. If drains are combined, hydraulic structures with higher water elevations shall not backflow into structures with lower elevations. The manholes for the drain system shall be pressure manholes with bolted down covers if the system is likely to surcharge or use pressure cleanouts. Gravity systems for floor drains, sanitary service, etc. shall be kept separate from the previously noted system.

Piping at structures shall conform to the following criteria:

- Piping shall be encased in concrete whenever under the structure and to a distance outside the structure determined by a 45-degree downward angle from the outside of the footing to the pipe.
- Immediately outside the structure or encasement, two flexible joints shall be provided on pipes leaving the structure to allow for differential settlement, including pipes connecting to structures. For pressure lines, the flexible joints shall have a mechanical restraint to prevent the joint from separating because of lateral thrust. For gravity lines, the flexible joints shall be the normal push-on joints. The first flexible joints shall be 2 feet from the structure, manhole, or end of the concrete encasement. The second flexible joint shall be approximately 5 feet from the first.
- If gravity lines with flexible push-on gasket joints connect to structures, the connection must be made with an adapter cast set into the structure to receive the pipe with the rubber-gasketed joint.

3.1.6.1 Storm Drainage Design and Analysis

Design Storm Runoff Determination. The Design-Builder shall comply with the County Department of Growth Management and applicable County Land Development Regulations. Stormwater runoff "Qs" shall be determined by using the Rational Method. The Design-Builder shall follow FDOT Design Manual (latest edition) for runoff coefficients.

3.1.6.2 Rainfall Duration/Intensities

Design storm rainfall intensities shall be determined from the Rainfall Intensity-Duration- Frequency Curves for Florida (US Weather Bureau, latest edition). Times of concentration (T_c) shall be considered for both overland and pipe flow in determining intensities for calculating design Qs.

3.1.6.3 Design Storm Events

The Design-Builder shall follow the County Department of Growth Management.

Location	Frequency of Occurrence
Mainline pipes	25 years
Catch basins/curb inlets	25 years
Catch basin/curb inlet pipe connections	25 years
Roof-drain pipe connections	10 years
External areas draining through the site	100 years
Stormwater pumping systems	50 years
Areas subject to flooding without overland flow relief	100 years

3.1.6.4 Pipe Capacity Design

The Design-Builder shall use the Manning formula for determining pipe capacities and hydraulic and energy gradelines.

Minimum velocities for storm drains shall be 3.0 feet per second (fps) to promote self-cleaning. Minimum slopes, from a constructability standpoint, shall be 0.001 or 0.1 percent. Manning "n" of 0.013 for all sizes of reinforced concrete, concrete, ductile iron, and cast-iron pipe for determining pipe friction losses shall be used. Use "n" of 0.011 for PVC pipes. Grass and other flexible lined channels shall be designed according to Federal Highway Administration Design of Roadside Channels with Flexible Linings (HEC-15). Design procedures for flexible lined channels shall be based on the concept of maximum permissible tractive force. For culvert design, the Design-Builder shall use FDOT hydraulic design requirements for culverts (latest edition). All culverts shall have energy dissipaters at the outlet.

Minimum pipe diameters shall be 18 inches. Yard piping connections to roof drains shall be a minimum of 6 inches for normal situations. Increases to larger-diameter pipe, with in-line cleanouts, may be prudent if the length of the pipe run to the trunk storm drains exceeds 75 feet. Pipe connections as small as 4 inches in diameter will be permitted for short runs and where multiple connections are made to a larger diameter collector.

Minor Head Losses:
Minor head losses shall be taken into consideration in the hydraulic design. Pipes shall be designed to flow full without having the hydraulic gradeline penetrate the finished grade. Surcharging catch basins and manholes are permissible if surcharging is limited to be at least 1 foot below the top of the structure under design flow.

Manholes:
Manholes shall be at:

- All grade changes.
- All alignment changes.
- All pipe size changes.
- Intervals not exceeding:
  - For 36-inch diameter pipes or less 300 feet
  - Pipes larger than 36-inch but less than 60-inch 450 feet
  - For pipes larger than 60-inch 600 feet
- Sewer dead ends for cleaning and flushing ease

Pipe Materials:
The following pipe materials shall be used in storm sewers:

- Reinforced concrete pipe.
- Corrugated metal pipe (temporary installations only).
- Polyvinyl chloride (PVC) pipe, as approved by the engineer of record.

Pipe Joints:
All pipe joints shall be watertight to exclude infiltration or exfiltration.

Pipe Trenches
Trench excavation shall be classified as common excavation—all material not classified as rock excavation. Pipe bedding shall be 3/4 inch minus coarse aggregate (AASHTO No. 7) for all pipes

except PVC pipes, which shall be sand or selected sandy soil, all of which passes a 0.9 cm sieve and not more than 10 percent of which passes a No. 200 sieve and conforms to FDOT standard specifications, latest edition.

Trench backfill above the pipe zone for all pipeline construction within highway rights-of-way or other paved areas shall be select granular base materials as defined by FDOT standard specifications, latest edition.

For pipelines located in unpaved areas, backfill above pipe zone shall consist of soil, loam, or other excavated material suitable for use as backfill, free from roots or organic matter, refuse, boulders and material larger than 1/2-cubic foot, or other deleterious materials. Compact to minimum 85 percent relative compaction. Should settlement occur, place additional earth backfill and restore final grade.

Pipe Strength:
Pipe strength requirements and pipe materials shall be shown on the storm sewer profiles. The design procedure for selecting rigid pipe strength requires:

- Determination of earth load.
- Determination of live load.
- Selection of bedding class.
- Determination of load factor.
- Application of safety factor.

Controlling trench width at the top of the storm sewer pipe shall be used to reduce pipe strength requirements. To calculate pipe strength (D-load) requirements for rigid pipes, American Concrete Pipe Association methods shall be used.

Seismic stresses, water hammer loads, and thermal stresses should be combined appropriately with the stresses and loads due to overburden, earth pressure, and hydraulic flow. The calculation of seismic stresses should be based on propagation of ground motions along the pipeline and should account for stress concentrations at pipe bends and other pipe supports and constraints. Standard methods available in the literature should be used to calculate these stresses. Similar calculations should be performed for water hammer loads and thermal stresses. Joints at building foundations and where pipes traverse from soil to concrete fill should be designed for the combined movements of settlement, heave, seismic shaking, and seismically induced settlement. These calculations should be consistent with all applicable code requirements, the geotechnical evaluation for seismic considerations, the applicable design earthquake and design seismic ground motions, and the consequences of failure of a given pipeline.

3.1.6.5 Sanitary Sewers Design and Analysis

Sanitary sewers shall be designed in accordance with the RSWF 2004 10 States Standards, FDEP/Florida Administrative Code (F.A.C.) criteria, and constructed of material that is resistant to hydrogen sulfide corrosion. Appropriate linings or coatings shall be applied to structures, such as manholes and wetwells, likely to be in contact with hydrogen sulfide gas and/or subject to high turbulence.

The drains and washdown from new process facilities on the APWRF site as applicable, shall be discharged by gravity into the APWRF site pump station where the flow shall be pumped to the plant headworks. The capacity of the existing site pump station shall be verified to accommodate any additional sanitary sewer flows added by this facility expansion.

All gravity pipelines shall be at least 8 inches in diameter and have manholes to grade. Manholes shall be located at all changes in direction. In straight stretches of pipe, the distance between manholes shall be no more than 250 feet. Smaller pressure lines shall have pressure cleanouts at grade. These cleanouts shall be spaced at appropriate intervals to allow access.

Gravity sewers shall be designed for steady flow conditions to carry the design flow without surcharge when flowing full. The factors to consider in determining gravity system hydraulics include the design formula, roughness coefficient, velocity, and slope.

If sewers are designed at minimum grades for long distances that end in a manhole drop connection, the slopes shall be adjusted to make it steeper to avoid flat grade and drop connection. This will apply unless there are other design criteria involved.

Sanitary Sewer System Pipeline Design:
Sanitary sewers shall be designed using Manning's equation, to flow partially full or full. Surcharging of manholes or structures shall not be permitted. The value of "n" in the Manning formula is assumed to be constant for partially flowing or completely full pipes. An "n" value of 0.013 shall be used as an average coefficient for all sizes and types of sanitary sewer pipe. Minimum velocity under full-flow conditions is 2 fps to ensure an adequate cleansing velocity.

Manhole Losses:
Headloss within a manhole is caused by change of direction, size, and slope.

When a sewer pipe joins another pipe with a larger diameter, the Design-Builder shall sufficiently lower the invert of the larger pipe to maintain the same energy gradient (no headloss). The Design-Builder can also match crowns when the downstream pipe size is greater than the upstream pipe size.

Change in Direction:
Where sanitary sewers of the same size, designed at a minimum gradient, have an angle of divergence greater than 30 degrees at manholes, a minimum drop of 3 inches shall be included for the downstream sewer. Wherever the velocity exceeds 4 fps, the drop shall be determined by the following formulae:

Degrees	Loss
90	$1.0\ v^2/2g$
45	$0.3\ v^2/\ 2g$
30	$0.2\ v^2/\ 2g$

Where v = the downstream velocity.

Change in Slope:
$0.3\ (A\ v^2/2g)$

Where (A v2/2g) = difference between upstream and downstream velocity heads. This difference cannot be less than zero.

Materials:
Ductile iron should be used for all sanitary sewer lines and shall be coated on the inside with a special hydrogen sulfide-resistant material, as provided by the manufacturer. Joints should be designed to minimize leakage and root damage. Maximum allowable infiltration shall not exceed 200 gallons per inch of pipe diameter per mile of sewer per 24 hours.

Sanitary Sewer Manholes:
When designing and constructing manholes, the Design-Builder shall:

- Install manholes at all connection points and where the sewer changes horizontal alignment, slope, or pipe size.
- Space manholes no more than 250 feet apart.
- Construct manholes of precast or cast-in-place concrete. If buried deeper than 10 feet, precast sections shall be joined with flexible gasket joints for watertight installation.
- Include watertight gaskets in pipe/manhole connections.
- Core drill pipe connections to existing manholes. A synthetic-rubber link seal should be installed to maintain water tightness.
- Check and design manholes for possible structure flotation.
- Do not construct manholes of brick or masonry.
- Size the interior of standard manhole barrels at 48-inch minimum, but size will depend on the number of pipes and largest pipe diameter connecting to the manhole.
- Design manhole frames and covers for applicable wheel loadings.
- Design other manhole features as follows:
  - Manhole Bases – Cast-in-place or precast.
  - Cone Sections – Eccentric, with the vertical side oriented to provide the best access for steps or ladders.
  - Flat Slab Manhole Tops – Use only where necessary, such as extremely shallow manholes.
  - Manhole Landings – Use grated platforms for all manholes over 20 feet deep. Space equally between rim and invert. Maximum distance between platforms is 20 feet and should conform to current OSHA Standards.
  - Manhole Steps – Location and spacing shall conform to current OSHA standards. Manholes deeper than 4.5 feet shall have steps. Aluminum steps will not be permitted. Steps shall be copolymer polypropylene plastic with steel reinforcement.
  - Pipe connections to manholes shall only be via a boot system.

Outside Drop Manholes:
Drop connections shall be used for connections if the invert elevation of the entering sewer is 24 inches or more above the spring line of the outgoing sewer.

3.1.6.6 Site Pressure Pipe Systems

General Information:
Pressure mains shall be designed in coordination with the pumping system design. The capacity of the pipe shall be calculated in conjunction with the plant hydraulic profile to ensure that reasonable headloss allowances have been made in determining the capacity. The major factors to consider in analyzing pressure system hydraulics include the design formula, roughness coefficient, velocity, pressure surges, and maintenance.

Domestic and Plant Utility Water:
A potable water distribution system is provided to ensure its delivery to applicable areas of the APWRF site. A separate non-potable water system also is provided and shall be provided to supply water needed for plant processes and housekeeping where potable water is not required. The non-potable water shall be disinfected treatment plant effluent.

The Design-Builder shall construct the water system as a loop to minimize dead ends, increase reliability, and reduce the size of piping. Isolation valves shall be provided at all tee fittings (one on each downstream pipe).

Potable water lines and sewer or process lines shall be separated at least 10 feet horizontally. When water and sewer lines cross, then minimum vertical clearance shall be 18 inches vertically with the sewer lines preferably lower than water lines. If 10 feet of horizontal separation cannot be provided, special piping and encasement requirements shall conform to the applicable FDEP requirements.

Fire Protection Water System:
Plant fire protection shall be connected to a piping loop provided around the perimeter of the plant. The system shall be able to provide a minimum of either 250 gallons per minute (gpm) at a residual pressure of 30 psi throughout the system, or the fire consumption rate established in the latest edition of the NFPA code, whichever is more stringent. Off-site pump stations may require less flow. Actual flow requirements shall be confirmed with the local fire department. This system shall meet the following minimum criteria:

- Design velocities should not exceed 8 fps.
- Fire hydrants shall conform to Ft. Walton Beach and Eglin AFB Fire Departments standards.
- Fire hydrant spacing shall conform to the rules and ordinances of the local fire department. As a general rule, a fire hydrant provides a 250-foot radius coverage for structures.
- Fire hydrants shall be placed near cross streets and roads with fire truck access. Hydrants should be readily visible to fire department personnel.
- All fire hydrants shall have an isolation valve between the loop/main tee and the hydrant.

Use the Hazen-Williams formula for design. The roughness coefficient varies with the pipe material, size, and age. The following Hazen-Williams pipe roughness coefficients (C-factors) shall be used in the design of pressure piping systems:

Table 3-3
Hazen-Williams Formula for Design

MATERIAL	C FACTOR
Cement-lined cast iron or ductile iron	120
PVC	120
Concrete cylinder pipe	100

The minimum velocity shall be 3 fps. Dual-pressure mains may be needed to obtain the required velocities for both initial and ultimate design flow conditions. Dual-pressure mains often can be installed in two stages.

Unbalanced forces in pressure mains require that some form of physical restraint be applied to the piping system. The methods generally used to achieve adequate restraint are the following:

- Thrust blocks.
- Restrained joints.
- Tie rods.

- Combined systems and structural connections.

Within plant sites, only restrained joints are permitted. All pumped lines shall be restrained. All other piping shall be evaluated and restrained as necessary. Pipe manufacturers' design data also include the recommended practice for all types of anchorage systems.

Drains shall be installed at low points in the pipe. Air-release/vacuum valves shall be installed at high points (e.g., automatic valves for clean water and manual and automatic valves for raw wastewater and sludge).

Conduit to be installed by open-cut construction shall be designed both for the normal trench width and for unlimited trench conditions where applicable. The pipe section and trench width shall be shown on the plans.

All conduit designs shall consider loads imposed on pipe by the weight of the earth (dead loads) and any superimposed static and moving loads.

Method of Analysis:
The method of structural analysis used shall be consistent with the allowable construction procedures for each project. The three most common conditions to be considered are trenches in natural ground, embankment conditions, and tunnels. Marston's theory is recommended to calculate vertical load on buried conduits from gravity. The Boussinesq formula is recommended for computing live loads on conduits.

Dead Loads:
Dead loads for conduits to be constructed in open cuts shall be computed by using the normal trench width at the top of the pipe, or by the positive projecting conduit formula, whichever gives the least load on the pipe.

Pipe Bedding:
Pipe bedding shall be 3/4-inch minus coarse aggregate (AASHTO No. 7) for all pipes except PVC pipes which shall be sand or selected sandy soil, all of which conforms to FDOT standard specifications, latest edition.

Allowable Loads on Rigid Conduit:
Rigid conduits are selected on the basis of the actual loads that will be applied and the safe supporting strength of a particular type of rigid conduit.

Safe supporting strength is expressed as:

[three-edge bearing strength (ultimate) x load factor] / [factor of safety]

Three-edge bearing strength (ultimate) is a laboratory test strength described in American Society for Testing and Materials specifications.

Load Factor:
Load factor is the strength ratio of a pipe under field loading and bedding conditions to its strength, as measured by the three-edge bearing test. Bedding is a primary design parameter.

Primary classes of pipe bedding load factors vary from 1.5 to 5.0. The general classes of bedding installations are described and illustrated in Chapter 9 of American Society of Civil Engineers Manual No. 37. Load factors for each of the basic classes are as follows:

Table 3-4
Pipe Bedding Load Factors

BEDDING CLASSIFICATION	LOAD FACTOR
Concrete envelope or arch	3.5 to 5.0
Concrete cradle	2.2 to 3.4
Shaped bottom with granular bedding	1.9
Ordinary bedding	1.5
Flat bottom	Not permitted

Safety Factor
A factor of safety of at least 1.5 based on ultimate strength shall be used for all rigid conduit.

3.1.7 Traffic Maintenance and Signing Plans

The Design-Builder shall follow FDOT requirements in the preparation of the traffic maintenance and traffic signing plans.

3.1.8 Erosion and Sediment Control Plans

The Design-Builder shall fulfill all requirements for soil erosion and sediment control according to FDEP rule criteria and FDOT Specifications. All soil erosion and sediment control measures used in the Project shall be detailed in a separate drawing.

3.2 General Architectural Design Criteria

3.2.1 Codes and Standards

All architectural design must conform to all state, county, and local codes, laws, ordinances, and zoning regulations and design guidelines as provided for by the County of Okaloosa, Florida, and as mentioned herein.

The pertinent codes for building design are:

- 2010 Florida Building Code
- 2010 Florida Mechanical Code, Second Edition
- 2010 Florida Plumbing Code, Second Edition
- 2007 Florida Fuel Gas Code, Second Edition
- 2012 Florida Chapter 11, Accessibility Provisions
- International Fire Code, latest edition
- National Electric Code

The code data shall be located on the drawing with the first floor plan. The code data may be located elsewhere, provided a note is given on the first floor plan stating the location of the code data by drawing number.

3.2.1.1 Code Data

A code search shall be conducted for this Project, and the building code data shall be provided on the drawings. The code data shall be located on the drawing with the first floor plan. The code data may be located elsewhere, provided a note is given on the first floor plan stating the location of the code data by drawing number. The code data shall be as follows:

Building Code Data (Electrical Building Only):
The buildings shall be designed to meet the requirements of the Florida Building Code (latest edition), including Chapter 11, Florida Accessibility Code for Building Construction, and the following additional criteria:

Occupancy Group Classification:	List as appropriate, list each separate occupancy group required by the program
Type of Construction:	List as appropriate
Building Height:	List as appropriate
Height Limitation:	
Total Floor Area:	As calculated, list floor area for each identified occupancy
Largest Floor Area:	As calculated
Area Limitation:	List as appropriate
Occupant Load:	List number of total calculated occupants. Also list actual occupants as determined by program if appropriate
Fire Suppression System:	
Fire Alarm System:	

3.3 Plant Architectural Requirements

3.3.1 Design Standards

All Design Standards provided by the County will be evaluated for applicability and incorporated into the building design as appropriate.

3.3.1.1 Visual Image Policies and Guidelines

Architectural Elements:
The architectural design standards shall provide design unity throughout the facilities. The individuality of each facility shall be expressed in form or mass, with continuity achieved through the use of scale, color, texture, material, and detail. The following design standards apply to all structures:

- Design architectural elements with crisp, clean lines and reflect the scale proportions and contextural quality of existing buildings and structures.

3.3.2 Railings and Guards

3.3.2.1 Height

On stairways or ramps, handrails shall be 34 inches high, measured vertically above the nosing of the stair treads or from the ramp. All stairways of more than three risers shall have handrails. Railings shall extend at least 12 inches beyond the top riser and 12 inches plus one tread width at the bottom risers. Open sides of stairways, landings, and ramps shall have a guardrail, designed to be 42 inches high.

On level walking surfaces, railing guards at different elevation shall be designed 42 inches high and shall be constructed to prevent passage of a sphere with a diameter of 21 inches. In areas intended for public access, the railing shall be constructed to prevent passage of a sphere with a diameter of 4 inches.

Toe boards at least 4 inches high shall be used along exposed edges of all elevated platforms, walks, balconies, mezzanines, and ramps to prevent materials from falling.

Railing construction shall be aluminum.

3.3.2.2 Application

Type 1 handrails shall be used in all areas.

3.4 General Structural Design Criteria

3.4.1 Purpose and Content

This document describes the structural engineering design criteria for the Arbennie Pritchett APWRF. Included in the criteria are required design loads for buildings, tankage, miscellaneous structures, and components. Also included are analysis and design methodologies for various materials of construction including concrete (cast-in-place and precast), steel, masonry, aluminum, fiberglass, and stainless steel.

For prestressed concrete tank design refer to the following section.

In case of this document's overlap and conflict with governing codes and standards, the Design-Builder will follow the more strict interpretation or directive. Similarly, where multiple reference standards are cited, the most stringent requirements shall govern.

3.4.2 Prestressed Concrete Tanks

A. The design shall be in conformance with applicable portions of American Concrete Institute (ACI) 372R-03 Design and Construction of Circular Wire- and Strand-Wrapped Prestressed Concrete Structures, AWWA D110-04 Wire- and Strand-Wound, Circular, Prestressed Concrete Water Tanks, and currently accepted engineering principles and practices for the design of such structures.

B. Earthquake Design: Fixed percentage method as specified in AWWA D110, Section 4.1.

C. The thickness of the core wall shall be calculated so as to accept the initial compressive forces applied by prestressing, hydrostatic stresses induced by contents, and other applicable loads such as soil backfill and wind.

D. Backfill loads shall not be used in the design of the core wall to counteract hydraulic loads or provide residual compression in the wall.

E. Qualifications and Experience:

- Tank Construction Company: Shall be a firm with ten years of experience in the design and construction of wire-wound, circular prestressed composite tanks with satisfactory evidence that it has the skill, reliability, and financial stability to build and guarantee the tank in accordance with the quality required by these specifications. The company constructing the tank shall have built completely in its own name in the past five years, and be presently responsible for, a minimum of ten (10) prestressed composite tanks of equal or greater size than that required for this project which meet these specifications and are now providing satisfactory service.

- Construction: The entire tank, including all portions of the floor and wall shall be built by the tank construction company, using its own trained personnel and equipment.

- Design: All design work for the tank shall be performed by a professional engineer with no less than five years of experience in the design and construction of circular prestressed composite tanks. The professional engineer shall be a full-time staff member of the tank construction company and shall be licensed to work in the state where the project is located.

3.4.3 Standard Definitions and Abbreviations

- **Allowable Stress Design (ASD or Working Stress Design)** – A method of structural design that applies actual service loads to structural elements, and limits the stress on elements to a code-prescribed allowable fraction of the strength of the section or component.
- **CMU** – Concrete masonry unit (concrete block).
- **CIP** – Cast-in-place (refers to concrete construction).
- **FRP** – Fiber-reinforced plastic.
- **Strength Method (or Ultimate Strength Method or LRFD)** – A method of structural design that applies factored design loads to structural elements, and strength reduction factors to the yield or ultimate strength of the material(s) being designed.

3.4.4 Codes and Standards

Structural designs fall under the jurisdiction of the Florida Building Code 2010) with any local amendments (hereafter called “Building Code” or “Code”).

All codes, standards, and specifications referenced in the Building Code are applicable. In addition, the following shall also be used:

- “Aluminum Design Manual” by the Aluminum Association, 2010 edition.
- “Environmental Engineering Concrete Structures,” ACI-350-06 by the American Concrete Institute.

ACI 350 applies to all water containment structures which shall be classified as “normal” environmental exposure, per section 10.6.4 thereof.

3.4.5 Guidelines and Procedures

All structural engineering shall be done in accordance with this DCP and applicable codes, specifications, and standards, as well as to reflect the judgment and experience of the responsible professional engineer. Designers will use the guidelines contained herein unless there is an overriding reason not to use them for particular components of the Project. In that event, documentation must be provided in the calculations or by separate memorandum.

3.4.5.1 Calculations

Structural design may be performed either manually, with use of spreadsheets (such as Microsoft Excel), or using computer programs. Computer software must be appropriate industry-standard programs. Samples of specific industry-standard software that may be used on the Project include:

- "STAAD" structural analysis and design program from Research Engineers, or similar nationally recognized finite element software.
- "PCA Column," "MATS," "PCA Bear," and "ADOSS" from the Portland Cement Association (PCA).
- RISA 2D from the RISA Technologies.
- ENERCALC Structural Engineering Library.
- L-Pile by Ensoft.

All calculations must be submitted to OCWS for review.

3.4.5.2 Structural Design Checklist

A Structural Design Checklist will be completed for each of the individual structures designed for the Project. This checklist will be included at the front of each structural calculation along with the sketches and layouts of the facility components when the design is submitted for quality review. A copy of this checklist is included in Appendix S-1, which is attached to this DCP.

3.4.5.3 Design Method (unless otherwise noted)

For concrete design: Strength Method, including ACI-350 provisions for durability in environmental structures.

All other designs: Either allowable stress design or LRFD, to the extent permitted by governing design standards.

3.4.6 Loads

3.4.6.1 General

Loads used for design shall be obtained using the sources listed on the Structural Design Checklist included in Appendix S-1. Loads to be considered shall include both lateral and vertical loads. Lateral loads are imposed by wind, seismic, soil and liquid pressures, and surcharge loads adjacent to walls. Vertical loads include dead loads, live loads, snow load, suction and uplift loads imposed by wind, and uplift loads imposed by flood or groundwater including soil and liquid weights. Equipment, large piping, and pipe thrust loads shall be accurately determined and incorporated into the structural design.

The following loads will be used for structural analysis of floor and roof systems:

- Roof live loads.
- Roof snow loads.
- Roof dead loads.
- Erection and construction loads.
- Future loads, if known.
- Hoist and laydown loads.

- Roof wind (uplift loads).
- Floor and platform live loads.
- Floor and platform dead loads.
- Ceiling/collateral loads.
- Interior wall loads.
- Exterior wall loads, including horizontal loads.
- Equipment loads.
- Piping[1] and electrical loads.
- Phantom[1] gravity loads (if used).
- Seismic loads (if required).
- Any other appropriate loads, as determined by the structural engineer.

3.4.6.2 Dead and Live Loads

For dead load, include all permanent or semi-permanent loads. This includes equipment, piping, banks of conduit, electrical trays, floors, supporting members, walls, partitions, chemicals in bins or on storage floors, and liquid contents of piping, containers, and equipment. Dead load also includes weight of soil on soil-covered roofs, if applicable.

Storage area loads for bagged chemicals shall be in accordance with ACI 350. Assume material stacked to two-thirds of clear ceiling height over entire available area.

Roofing dead loads shall be assumed to be 10 psf (non-ballasted) or 20 psf (ballasted), unless actual loads are known.

Live loads include all loads not defined as dead loads including people, tools, and equipment that may be placed on floors temporarily. Live loads need not be applied to floor areas permanently covered by equipment, unless the live load is higher than the equipment load. Reduction of live loads may be considered only as permitted in the Building Code.

Several common design dead and live loads are summarized in Appendix S-2 of this DCP; additional data shall be obtained from recognized references. Design uniform live loads shall be indicated on drawings, as required by the Building Code.

3.4.6.3 Liquid-Containing Structures

Structural design shall be performed for "maximum" liquid levels indicated by process requirements. Applicable load factors and durability coefficients from the Building Code ACI 318 and 350 shall be applied to these loads. Conservatively, the assumption will be that no soil exists outside of the structure when it is loaded internally with liquid, and, conversely, no liquid is present inside the structure when it is externally loaded with lateral pressures. Furthermore, structures must be designed for any combination of empty and full compartments that will produce worst-case loading.

The worst-case or overtopping condition shall be checked unless an absolutely fail-safe overflow is located below the overtopping level. The worst-case loading level must be indicated in the calculations; a temporary overstress of 25 percent will be allowed for this load case only, and cracking serviceability shall not be required for this scenario.

[1] Phantom gravity loads are used in conjunction with piping loads when the location of miscellaneous piping is undetermined. Phantom loads will be one kip on secondary beams and two kips on primary beams, placed at the point of maximum moment for bending calculations and at the ends for shear and connection design. Phantom loads shall not be used for large piping loads. Each of the large piping loads shall be calculated separately, and their locations determined. Large pipes are designated as 12 inch or greater in diameter.

The following densities shall be used for design:

- Water 62.4 pcf
- Raw Sewage 63 pcf
- Digested sludge 70 pcf
- Thickened or dewatered sludge 85 pcf

3.4.6.4 Groundwater/Flood Stability

Unless otherwise specified, structures shall be designed to resist forces due to both groundwater and flood conditions. In resisting groundwater or flood loadings, only dead loads shall be considered; resisting loads shall not include the weights of pumps, piping, or other appurtenances, nor any of the liquid contents of the structure. Resisting loads may consider the appropriately submerged weight of any soil above the extended footing, using a zero-degree angle from the vertical plane located at the footing perimeter. In the event the structure self-weight plus soil restraint proves insufficient or uneconomical to resist flotation, the use of soil/rock anchors, or concrete tension piles may be considered.

A minimum factor of safety of 1.25 for flood stability shall be ensured for structures located in non-coastal "A" flood zones. Structures located in "V" zones or coastal "A" flood zones shall maintain a 2.5 minimum factor of safety against flood load stability.

The minimum groundwater level to be used in uplift calculations for flotation due to groundwater shall be the 100-year flood elevation or grade elevation, whichever is higher. The minimum factor of safety against flotation due to groundwater shall be 1.25.

3.4.6.5 Structural Stability

Structural stability shall be checked for all appropriate structures and will include the following:

- Wind loads.
- Hydrostatic loads
- Seismic loads.
- Piping/equipment thrust loads.
- Column stability loads (as applicable).

Loads required to ensure column stability shall be applied where normal structural framing provides the minimum lateral support required for the columns. With braced steel construction, bracing will be designed to include these stability loads, the magnitude of which will be not less than 1 percent of the vertical load on the relevant columns. In steel moment frame systems where sidesway is permitted, bracing stability shall be addressed by use of the "summation of P" theory, or by modification of column K-factors to include the effect of "lean-on" columns. In addition, steel moment frame analysis and design shall include secondary, or P-delta effects. Column stability will be addressed in CIP concrete systems through use of the moment magnifier approach given in ACI 318, or through appropriate implementation of P-delta analyses.

3.4.6.6 Impact and Vibration

The following allowances shall be made to account for impact:

Table 3-7
Impact Loads

Elevators	100% of the lifted load
Cab operated traveling cranes and hoists	25% of the lifted load
Pendant operated traveling cranes and hoists	10% of the lifted load
Rotating equipment	20% of the total machine weight
Reciprocating equipment	50% of the total machine weight
Railroads and forklifts	25% of the wheel loads

Consideration shall be given to the deflection of beams supporting reciprocating and rotating machines. To help dampen vibration, equipment shall be supported on concrete foundation having a weight at least three times the total weight of the equipment or 15 times the rotating weight, whichever is greater. A natural frequency analysis may be required to investigate potential vibration problems of system in operation. Impact loads for rotating or reciprocating equipment may be considered as dead loads.

For heavy equipment on ground-supported slabs, consideration shall be given to separate isolated equipment foundations. In this case, expansion joint material shall be provided between the machine foundation and the remainder of the slab.

3.4.6.7 Wind Loads

Refer to the Florida Building Code (Latest Edition) for complete derivation of wind loads. A summary of wind design information shall be clearly presented on the structural drawings, including basic wind speed, wind importance factor and building risk category, wind exposure category, building enclosure classification and internal pressure coefficient, and a summary of design component/cladding wind pressures. No deviation from wind load requirements will be considered.

3.4.6.8 Earth Loads

Lateral earth pressures and coefficients along with allowable soil bearing pressures shall be obtained from the Project's geotechnical report. Geotechnical investigations shall be completed and information provided to the Design-Builder. The Design-Builder can perform additional geotechnical investigation at its discretion at no additional cost to OCWS.

3.4.6.9 Loads on Vendor-Designed Items

Specifications commonly designate certain structural components as vendor designed (e.g., precast, prestressed concrete, hollow-core planks and double tee sections, aluminum domes, specialty FRP components, etc.). To guide the design of vendor-designed items, all required loads shall be indicated on drawings or in related specification sections. Load information shall include uniform dead and live loads, and point loads from piping, hoists, line loads from walls, future loads, etc. Vendor-designed items shall be required to be certified for structural adequacy by a Professional Engineer licensed in the state of Florida. Standard manufactured items such as platform grating and componentized guardrail systems may be certified through a letter provided by the manufacturer, to the extent permitted by the Building Code.

3.4.6.10 Future Loads

Consideration shall be given to loads from future expansions and equipment to the extent directed by OCWS.

3.4.7 Foundations

3.4.7.1 General

The D/B Team may elect to utilize the provided geotechnical report or commission a separate investigation to determine the geotechnical design criteria required for all structural foundation design.

Shallow footings, except for those bearing on rock or hard shale, shall be proportioned to limit total and differential settlements as required by facility operation and structural serviceability.

3.4.7.2 Foundation Stability

A stability safety factor of 1.5 or greater shall be provided for both sliding and overturning; the sliding coefficient of friction is provided in the geotechnical report. For structures founded on yielding subgrade, the resultant of all forces shall fall within the middle one-third of the base, unless specific approval is granted for eccentric foundations, and the design of eccentric foundations is performed appropriately. All foundation subgrades, with the exception of hard shale and solid rock, shall be considered yielding soils.

For structures founded on rock, hard shale, piling, or piers, the structure shall be designed for a factor of safety against overturning of not less than 2.0.

Buoyancy and uplift forces shall be included in calculating the position of the resultant force and the factor of safety against overturning.

3.4.8 Deflections

CIP concrete framing members meeting the minimum depth criteria listed in the reinforced concrete design procedure will generally not need to be checked for deflection. Spot-checks for deflection will be performed where the Design-Builder deems necessary, or where required by facility operation Deflections will be calculated for concrete members not meeting the ACI 318, Table 9.5(a) depth criteria. Where deflections are calculated for CIP framing members, calculations shall comply with ACI 318, Section 9.5. Prestressed concrete members will meet the limitations of ACI 318, Paragraph 9.5.4.

CIP and steel framing members shall not exceed the maximum deflections given below.

3.4.8.1 Cast-In-Place Concrete Framing

Table 3-8
Cast-in-Place Concrete Framing

MEMBER	ALLOWABLE LIVE LOAD DEFLECTION*
Flat roof slabs	L/180
Roof beam	L/240**
Roof beam supporting ceiling below	L/360**
Floor beam	L/360
Floor beam supporting rigid ceiling below	L/480
Floor beam supporting masonry wall	L/480

* See ACI 318, Section 9.5 for limitations affecting deflection calculations.
** Beam may be cambered for dead load and partial live load deflection. Ponding shall be investigated.

3.4.8.2 Structural Steel Framing

Table 3-9
Structural Steel Framing

MEMBER	ALLOWABLE LIVE LOAD DEFLECTION
Roof beam	L/240*
Roof beam support ceiling below	L/360*
Floor beam	L/360
Floor beam supporting rigid ceiling below	L/480
Floor beam supporting masonry wall	1/8 inch for L $\leq$ 60 inches L/480 for L > 60 inches
Crane support beam and monorails	L/800 (not including impact)
Monorails for underslung hoists	L/450
Girt (horizontal)	L/360
Girt (vertical)	L/240
Girt supporting window (vertical)	1/8 inch for L < 100 inches L/480 for L > 100 inches
Pre-engineered Building sway due to lateral load	H/100 with NO masonry veneers (H/180 with masonry veneer)

* Beam may be cambered for dead load and partial live load deflection. Ponding shall be investigated. The span length L is in inches.

3.4.9 Materials of Construction

3.4.9.1 Materials

New tankage and below-grade structures exposed to soil or liquids shall be made of reinforced CIP concrete. Use of prestressed concrete tankage shall be reviewed and approved by OCWS on a case-by-case basis. The main structural roof system of enclosed buildings will generally be steel framing, utilization of a precast concrete roof system will be considered.

Where above- or below-grade structures are subject to wet or corrosive atmosphere, floors, walls, and ceilings shall be made of concrete. Materials for other structures or components in corrosive areas are described below. Structures not in wet or corrosive environments shall be designed as standard industrial-type structures. The structural engineer shall consider economics, speed of construction, serviceability, and sequencing by various building trades, as well as any OCWS-dictated material requirements, when selecting and specifying all materials.

Material specifications are summarized in Appendix S-3.

3.4.9.2 Corrosion

For corrosive conditions, consideration shall be given to the usage of inherently corrosion-resistant materials or conventional materials with high performance and low maintenance corrosion-resistant coatings. The Owner will be consulted to determine which material to specify. The structural engineer will participate in the decision to the extent of providing relative cost comparisons for OCWS' consideration. The standard material for grating and guardrail/handrail systems shall be aluminum, unless

otherwise required by OCWS. The standard for platform and walkway supports in corrosive and highly corrosive areas shall be either aluminum or FRP.

Concrete for tankage containing sulfites shall be specified to contain approximately 20 percent fly ash in the mix. The Design-Builder shall also consider specifying extra cover over the reinforcing steel on the faces exposed to this, and other corrosive atmospheres. For cast-in-place nonprestressed elements add 1" of concrete cover to the ACI 318 cover requirements for structures having "severe" exposure as defined by ACI 350. Concrete liners (whether spray-applied or mechanically fastened) will be considered where appropriate.

For all non-corrosion areas aluminum or Type 316 stainless steel shall be used. In corrosive areas, Type 316L stainless shall be used. All expansion or epoxy adhesive drilled anchors (into concrete) shall be specified as 316L stainless steel.

3.4.10 Concrete

3.4.10.1 Standard Details

Standard Structural Detail Sheets shall be included in this Project by the structural engineer.

- **Minimum Dimensions** – All members shall be sized using the minimum concrete cover and clear spacing between bars for reinforcement as given in ACI 318, and as modified by ACI 350, Section 7.7.

- **Slabs** – Except for joist top slabs and slabs supporting members that could be damaged by deflection, such as partitions, minimum thickness of slabs shall be in accordance with Table 9.5(a) or Table 9.5(c) of ACI 318, ACI 350 or as modified by the Building Code. If higher reinforcing ratios (values of ρ) than recommended in this DCP are required, then long- and short-term deflections shall be calculated and the thickness increased as required.

  Beam Minimum depth shall be in accordance with Table 9.5(a) of ACI 318 or ACI350, or as modified by the Building Code. The deflection of beams shall be further restricted by increasing the depth for those cases where deflections exceed allowable limits, or where required serviceability or facility operation.

  The Design-Builder shall consider the location of construction joints at the tops of walls, and the advisability of using beams with constant depth for a given floor or roof system. Walls shall be blocked out to provide space for monolithically placed beam cross-sections, extending across the entire wall thickness.

  Beams shall have a minimum width of 12 inches. For economy, consideration shall be given to including concrete slabs as part of the beam geometry.

- **Concrete Walls** – Liquid containment structures shall have two mats of steel in walls 12 inches or thicker. An exception may be made for 10-inch thick walls with a height 10 feet or less, and with reinforcing bars less than 3/4 inches in diameter; these walls may be furnished with two mats of reinforcing. Bearing walls shall have a minimum thickness of 1/25 of the supported height or length (whichever is shorter). The Design-Builder shall also consider whether the structure is likely to be backfilled before the top of the wall is supported or braced, and design the wall accordingly.

- **Footings** – Footings shall have a minimum depth above the bottom reinforcement of 6 inches for footings on soil or rock and 12 inches for pile footings, or as stipulated in the provided

geotechnical report. Building Code requirements shall be followed, including frost protection requirements for depth of cover.

3.4.11 Joints

All required construction and control (contraction) joints shall be indicated on the design drawings, and are required for any structure with a dimension of 40 feet or more in any direction. The joint spacing shall also be used to determine the amount of shrinkage and temperature reinforcement required, in accordance with ACI 350, section 7.12.2. Horizontal spacing of construction and control joints should generally not exceed 50 feet for non-liquid containing structures and 40 feet for liquid-containing structures. Further guidelines for spacing of joints in liquid containment structures are listed in ACI 350. Individual jointing requirements shall be evaluated on an individual basis, in accordance with ACI 350. With proper reinforcement, the 40' maximum joint spacing may be reconsidered. However, the tendency of joints to create pathways for leakage in liquid-containing concrete structures should be carefully evaluated and joints eliminated as much as possible, to the extent permitted by ACI 350 and sound engineering practices. In general, construction joints should be located at points of minimal flexural stress. Control joints should be similarly located where flexural continuity is not required.

Expansion joints shall also be located on the plans when they are required. Special attention shall be paid to anticipated joint movement, waterstop details, and protecting smooth bar dowels from corrosion. Structures over 120 feet in plan length and with exterior exposure shall have expansion joints or may be evaluated on an individual basis, in accordance with ACI 350. The greatest possible elimination of expansion joints in structural or liquid containment elements, while complying with ACI 350, is recommended. Expansion joints may also be required in the form of complete isolation joints between walls and sidewalks, around rotating machinery foundations, at internal flumes, and in similar applications where non-structural elements are not intended to perform as horizontal supports.

3.4.12 Waterstops

Construction and control joints shall have waterstops at the following locations:

- All walls and bottom slabs of dry pits or rooms below finished grade and in contact with fluid or backfill material.
- All walls and slabs in contact with liquid (with the exception of baffle walls that are not required to be water-tight).
- All other locations shown on the drawings or specified.

PVC, metal, or adhesive (hydrophilic, non-bentonite type) waterstops shall be used in construction or contraction joints, and PVC waterstops will be used in expansion joints. The specifications for waterstops shall be performance based. Waterstops in joints at the bases of walls (and similar applications) shall be so specified to assure they remain in their intended position during the construction process. Where more than one type or style of waterstop is specified in a structure, consideration and guidance shall be given regarding how the different waterstops are joined together or overlapped.

Waterstop details shall be shown on the Standard Detail Sheets. The Design-Builder shall consider the embedded length of waterstops to avoid interference with the reinforcement.

3.4.13 Splices, Connections, and Development of Reinforcement

Development lengths and splice lengths shall be in accordance with ACI 318, ACI 350, and the Building Code, and shall be shown on the Standard Detail Sheets. Welded splices shall not be used, unless

specifically allowed by the Contract Documents. Mechanical connectors shall be as indicated in the Specifications. Mechanical connectors and lap splices shall be staggered except for couplers used at the face of a construction joint, and comply with the requirements of the specifications.

Hooked dowels for compressive reinforcement will meet compression development length requirements of ACI 318 and ACI 350 and as shown on the Standard Detail Sheets.

Splices in members subject to direct tension shall be avoided wherever possible. Where splices in tension members cannot be avoided, mechanical connectors shall be used. The drawings shall indicate the location of all splices.

Horizontal bars in walls in direct tension shall be spliced as shown on the Standard Detail Sheets, staggered both horizontally and vertically.

3.4.14 Arrangement of Reinforcement

Beam and column joints, wall corners, and extra reinforcement at openings are places that shall be considered when selecting member sizes and reinforcement size and spacing. Reinforcement shall be spaced according to the following:

3.4.14.1 Slabs and Footings

The center-to-center spacing of flexural and shrinkage and temperature reinforcement shall be at least 4 inches for No. 6 and larger, and at least 3 inches for No. 5 and smaller. The maximum spacing for all reinforcing shall be 12 inches for structures designed in accordance with ACI 350 to be watertight. For other structures, the maximum bar spacing shall be 18 inches. Bars smaller than No. 4 shall not be used except in pavements, roof slabs, beam stirrups, or column ties.

Reinforcement in one-way or square two-way footings shall be spaced uniformly across the entire width or area of the footing. Reinforcement in rectangular two-way footings shall be spaced uniformly across the long direction and distributed across the short direction as outlined in Paragraph 15.4 of ACI 318.

3.4.14.2 Beams

Generally, the clear distance between parallel flexural reinforcement in the same plane shall be at least 1 inch, and center-to-center spacing will not be less than two times the bar diameter. Bars smaller than No. 5 shall not be used for flexural reinforcement. Bars larger than No. 4 will not be used for stirrups.

Where beams intersect at columns, the designer shall decide which beam shall have depressed top bars and the steel area will be calculated based on the reduced “d” dimension. The drawings shall show which beams have depressed top steel. The structural design shall also comply with any specific seismic detailing requirements dictated by the relevant design standards.

Where stirrups are required, but the capacity of the concrete cross-section is greater than or equal to the applied shear (in other words, only “nominal” shear reinforcing is required), the stirrups shall be a single size and spaced equally across the length of the beam. When greater than “nominal” shear reinforcement is required, stirrups shall be of a single size with a maximum of two different spacing across the length of the beam. In all cases, maximum stirrup spacing shall not exceed the limits required by both ACI 318 and ACI 350. In addition, where stirrups are required for strength, an upper bound stirrup spacing of 12 inches shall be maintained.

3.4.14.3 Walls

All walls 10 inches thick or less shall have one layer of reinforcement in both vertical and horizontal directions (see also section 3.4.9.1 for exception). Walls greater than 10 inches thick shall have reinforcement in each face in both vertical and horizontal directions. The spacing of vertical or horizontal reinforcement shall preferably be at least 6 inches but not more than 12 inches for liquid-containing structures. Bars smaller than No. 4 shall not be used except in non-load-bearing walls and as temperature and shrinkage steel.

3.4.14.4 Circular Walls

Smaller bars spaced more closely will control cracking more effectively than larger bars spaced farther apart in designing circular concrete walls under ring tension. In addition, higher levels of horizontal reinforcement may decrease the stress in the steel, but increases concrete tensile stress in the wall due to shrinkage restraint. Horizontal reinforcement in circular tanks, together with the wall thickness, shall be proportioned such that tension in the concrete does not exceed 10 percent of the concrete compressive strength, while the rebar supports the full factored ring tension (including serviceability) in accordance with ACI 350. Bars shall be at least No. 5 bars with a minimum spacing of 4 inches and a maximum spacing of 12 inches. Splice locations will be staggered both horizontally and vertically per Standard Detail Sheets and ACI 350.

3.4.14.5 Compression Members

The clear distance between longitudinal reinforcement in compression members including splices shall be in accordance with Paragraph 7.6 of ACI 318 and 350. Interaction of column bars and beam bars will be considered in order to avoid congestion.

Tie spacing will be as outlined in Paragraph 7.10 of ACI 318 and 350.

3.4.15 Shrinkage and Temperature Reinforcement

Control of shrinkage and temperature cracking is essential, particularly in liquid containment structures. The percentages of this reinforcement will vary with the spacing of construction and control joints as detailed and/or specified and shall be sized as follows for reinforcing bars where Fy=60,000 psi:

Table 3-10
Minimum Percent of Gross Concrete Section

SPACING OF CONTROL/ CONSTRUCTION JOINTS	LIQUID CONTAINMENT STRUCTURES	OTHER STRUCTURES
30 feet or less	0.3 (0.003)	0.18 (0.0018)
31 to 40 feet	0.4 (0.004)	0.24 (0.0024)
41 feet or more	0.5 (0.005)	0.3 (0.003)

Concrete sections 24 inches or thicker shall have minimum shrinkage and temperature reinforcement based on a 24-inch thickness. The minimum size of shrinkage and temperature reinforcement will be No. 4, except in roof slabs and pavements, which may be No. 3 or welded-wire fabric.

Shrinkage and temperature reinforcement shall be divided equally between the two surfaces of the concrete section. Vertical faces of deep beams shall be reinforced to prevent longitudinal shrinkage cracking. The non-flexural shrinkage and temperature reinforcement in the bottom of slabs reinforced top and bottom, in contact with the subgrade, may be reduced to one-half the values calculated.

Synthetic fibers blended in the concrete mix perform well in reducing the potential for shrinkage cracks and should be specified for all liquid containing structures. No reduction of steel reinforcement shall be taken for this mix addition.

3.4.16 Analysis and Design

3.4.16.1 Design Methods

Reinforced members shall be proportioned using the methods and factors that follow:

- Slab panels with a ratio of length-to-width of 1.5 or greater shall be analyzed as one-way slabs.
- Two-way flat plate and flat slabs may be analyzed by the direct-design method outline in Chapter 13 of ACI 318 and 350 providing the limitations of Paragraph 13.6 are met. Two-way and flat slabs that do not meet these limitations may alternately be analyzed by the equivalent frame method. Two-way, edge-supported slabs may also be analyzed by use of the coefficients tabulated in the PCA Publication "Rectangular Concrete Tanks."
- Beams shall be analyzed as rectangular beams unless depth limitations require the use of T-beams. Minimum shear reinforcement shall be provided when the factored force Vu exceeds one-half the shear strength provided by the concrete, ØVc, except as provided by Paragraph 11.5 of the ACI. Reinforcing provisions of ACI 318, chapter 21, shall also be satisfied where appropriate.
- Wall panels supported on three or four sides, and having an aspect ratio of less than or equal to 2, may be analyzed using the moment coefficients tabulated in "Moments and Reactions for Rectangular Plates," U.S. Bureau of Reclamation Engineering Monograph No. 27 or PCS Publication "Rectangular Concrete Tanks." Supporting walls and slabs shall be designed to adequately resist the moments calculated by this method.
- Walls supported top and bottom will be analyzed according to the degree of stiffness provided by the foundation as outlined by the three cases that follow:

  Case I – The base slab or footing is placed on yielding subgrade. In this case, the wall shall be analyzed as follows:

  (a) Pinned at the top and at the bottom for positive moment.

  (b) Pinned at the top and fixed at the bottom for negative moment. The wall/base joint design negative moment will be one-half the calculated fixed end moment.

  Case II – The base slab or footing is placed on nonyielding subgrade (rock). In this case, the wall shall be analyzed as pinned at the top and fixed at the bottom.

  Case III – The base slab or footing has a high degree of stiffness, which induces or resists wall moments. In this case, the wall/base joint negative moment shall be determined using approximate or rigid analysis as required for the degree of stiffness assumed.

- The designer will ensure by notes on Drawings that members (such as walls that are to support backfill) will not be loaded until all supporting members are constructed and cured. The Design-Builder may have to allow for the above cantilevered condition in the structural design of the walls, if support cannot be assured, or if constructability concerns dictate that the walls must be backfilled before support or bracing can be constructed.

- Walls and footings where the walls are fixed at the bottom shall be designed to accommodate the required fixed end moments.
- Circular walls in direct tension shall be analyzed using the coefficients tabulated in PCA publication "Circular Concrete Tanks Without Prestressing." Reinforcement shall be sized to develop the full factored/modified tensile load. Tensile stresses in the concrete shall be calculated by Equation 1 in Section 4 of the above publication, with "T" being the unfactored ring tension. Tank walls shall be analyzed as having both a hinged base and a fixed base and reinforced accordingly (see Cases I, II and III, above). Details shall be coordinated with design assumptions. As an alternate to the PCA approach, finite-element analysis may be used to analyze and design circular tanks under ring tension. Design with finite-element analysis shall take concrete tension stresses into account, in the same manner as described in the PCA document.
- Walls may be designed for axial loads, with or without flexure, by either Chapter 10 or Chapter 14 of the ACI Codes. Walls exceeding the limits of Paragraph 14.5.1 of the ACI Codes shall be designed by the requirements of Chapter 10. The horizontal length of wall considered as effective for each concentrated load shall not exceed either the width of the loaded area plus four times the wall thickness or the center-to-center distance between the concentrated loads. Pilasters shall be used for concentrated loads when the load Pu exceeds Ø (0.85) f'cA1 where A1 equals the loaded area, and Ø=0.65 or per governing version of ACI 318. For determining A1, the effective horizontal length of wall will be at least the width of the load area.
- Columns shall be analyzed with the following limitations:
  - The longitudinal reinforcement shall be at least 1 percent but not more than 5 percent of the gross concrete section. If column longitudinal bars are lap spliced, reinforcement percentage shall be limited to 4 percent.
  - Unless the moment magnification procedure outlined in Chapter 10 of the ACI Codes is used, unbraced columns (where sidesway is permitted) shall have a klu/r equal to or less than 22 such that slenderness effects can be neglected, and braced columns shall have a klu/r equal to or less than [34-12(M1/M2)]. The k factor for unbraced columns shall be calculated from the traditional nomograph, taking into account end restraint stiffnesses. The k factor for braced columns shall be taken as 1.0.
- Columns with kl_u/r greater than 100 shall not be permitted.

3.4.16.2 Frame Analysis Factors

When loading conditions meet the limitations listed in Chapter 8 of the ACI Codes, the moment and shear factors given in ACI may be used for analysis of continuous one-way slabs and beams.

Load Factors:
Load factors for all structures shall comply with ACI 318, ACI 350, and the Building Code.

For liquid-containing structures, lateral liquid (F) and earth pressure loads (H) shall be treated as live loads with a factor of Per ASCE 7-10 as follows:

- A factor of 1.6 where the effect of the loads add to the primary variable load effect and
- A factor of 0.9 when they resist the primary variable load effect if the load (F) or (H) is permanent or 0.0 for all other conditions.
- Impact loads will be included in the factor for live loads.

Durability for Liquid Containment Structures:
Durability factors for liquid containment structures will be in addition to the above factors as follows:

- In calculations for reinforcement in flexure, the required strength will be U1c=1.3U.
- In calculations for reinforcement in direct tension, the required strength will be U1c=1.65U.
- In calculations for reinforcement in diagonal tension (shear), the required strength will be 1.3 times the excess of factored shear, Vu, less shear carried by the concrete ØVc. [ØVs>1.3 (Vu-ØVc)] where Vs is the design capacity of the shear reinforcement.
- In calculations for the compressive region of flexure and compressive axial loads, and for all loads carried by concrete, the required strength will be 1.0U.
- Beams, one-way slabs, and one-way walls shall be subject to the requirements of ACI 350, section 10.6, with flexural reinforcing distributed appropriately to limit the cracking "z-factor" as required. Two-way structural elements may also be proportioned to satisfy the "z-factor" requirements, but in all cases shall satisfy ACI 350, section 13.3.

Strength Factors:
Strength factors shall be as tabulated in Chapter 9 of ACI 318 and ACI 350, and as required by the Building Code

Reinforcement Factors:
Reinforcement factors for singly reinforced flexural members of f'_c = 4,000 psi and F_y = 60,000 psi are:

ρ_{min} = 0.0033

$\rho_{max.}$ = 0.021

The reinforcement factor ρ_{min} may be reduced as provided in Chapter 10 of the ACI. In no case shall flexural reinforcement be less than that provided for shrinkage and temperature reinforcement.

Shear and Torsion:
Shear strength shall be calculated in accordance with Chapter 11 of the ACI. For members subject to shear and flexure only, use $V_c = 2\sqrt{f'_c}\,bd$. For members subject to axial compression, use equation 11 –4 of ACI 318.

High torsional moments usually occur in structures with undesirable framing arrangements. Reframing the structure to avoid the high torsion may be preferred to designing for the torsion. When torsion cannot be avoided, the members shall be designed in accordance with Section 11.6 of ACI 318.

3.4.17 Steel

Steel design shall be performed in accordance with the requirements of the American Institute of Steel Construction "Manual of Steel Construction" and "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings."

No special requirements are applicable to design of steel in wastewater treatment facilities. Members shall be designed with due consideration for maximizing durability and minimizing corrosion potential. Primary support members shall be selected that have a minimum of 1/4-inch thickness.

3.4.18 Masonry

CMU design may be by the working stress method or strength design method in accordance with ACI 530/ASCE 5/TMS 402 "Building Code Requirements for Masonry Structures" and the Building Code. Special inspection requirements will consistent with the Building Code.

3.4.19 Aluminum

Aluminum design shall be done in accordance with the Aluminum Association's "Aluminum Design Manual." Deflection is of special concern in aluminum design due to the lower modulus of elasticity, so deflection checks shall be performed for all aluminum framing members. Proper consideration shall be given to weld capacity and the required strength reductions in proximity to welds.

3.4.20 Fiberglass

Specifications will generally call for fiberglass structural design to be performed by the vendor. Where necessary to arrive at accurate preliminary sizes, engineering data from manufacturers will be used in preliminary calculations. Fiberglass grating shall be sized by the grating manufacturer. All frp structural components shall be certified by a registered Professional Engineer licensed in the state of Florida.

3.4.21 Stainless Steel

Stainless steel design for thin sections will follow the requirements of ANSI/ASCE-8, "Specification for the Design of Cold-Formed Stainless Steel Structural Members." Type 316L stainless will be utilized in all corrosive and immersion environments.

3.4.22 References

A partial list of structural engineering reference material for the Project follows:

- ACI-318-08 Building Code Requirements for Structural Concrete, and Commentary.
- ACI-350-06 Code Requirement for Environmental Engineering Concrete Structure.
- ACI 350.3-06 Seismic Design of Liquid Containing Concrete Structure.
- ACI 530-08/ASCE 5-08/TMS 402-08 Building Code Requirements for Masonry Structures, and Commentary.
- AISC "Manual of Steel Construction-Allowable Stress Design" (2005), Thirteenth Edition.
- AISC "Load and Resistance Factor Design," 3rd Edition.
- Aluminum Association, Aluminum Design Manual, 2005.
- Aluminum Association, Specifications for Aluminum Structures, 2000.
- Aluminum Association, Specifications for Aluminum Structures (Commentary).
- ASCE 7-10, Minimum Design Loads for Buildings and other Structures (with errant dated January 11, 2011).
- ANSI/ASCE-8-02, "Specification for the Design of Cold-Formed Stainless Steel Structural Members."
- J. McCormac "Design of Reinforced Concrete, 1998.
- CRSI, "CRSI Handbook."

- D. Barkan “Dynamics of Bases and Foundations,” 1962.
- F. Merrit “Standard Handbook for Civil Engineers.”
- J. Bowles “Foundation Analysis and Design.”
- M. Fintel, “Handbook of Concrete Engineering,” 1974.
- NCMA “Nonreinforced Concrete Masonry Design Tables,” 1971.
- NCMA “Reinforced Concrete Masonry Design Tables,” 1971.
- O. Blodgett “Design of Welded Structures,” 1966.
- PCA, “Circular Concrete Tanks Without Prestressing,” 1993.
- PCA, “Rectangular Concrete Tanks,” 1994 and 1998.
- PCI, “PCI Design Handbook, Precast & Prestressed Concrete,” 7th Ed, 2010.
- PCI, “Notes” on ACI 318.
- R. Means & J. Parcher “Physical Properties of Soils,” 1963.
- R. Schneider & W. Dickey “Reinforced Masonry Design,” 3rd Ed., 1987.
- Research Engineers, “STAADPro 2004 User’s Manual.”
- U.S Dept. of the Interior “Moments and Reactions for Rectangular Plates,” 1983.
- U.S. Grout, “Grouting Handbook.”
- U.S.A.C.E. User’s Guide: Computer Program for Design and Analysis of Sheet Pile Walls by Classical Methods, 1985.
- W. Young, “Roark’s Formulas for Stress and Strain,” 1989.
- “Design of Concrete Structures,” 10th Ed., Winter and Nilson.
- The Design of Water-Retaining Structures, Batty & Westbrook.
- PCA, Design of Concrete Buildings for Earthquake and Wind Forces, 2nd Ed.
- Earthquake Design of Concrete Masonry Buildings, Vol. 2, Englekirk and Hurt.
- ACI/ASCE/TMS, Masonry Designers Guide.
- PCA, Concrete Masonry Handbook, 6th Ed.
- Steel Structures, 4th Ed., Salmon & Johnson

3.4.23 Examples and Attachments

The following attachments are located in Appendix A

Appendix S-1	Structural Design Checklist
Appendix S-2	Structural Design Loads
Appendix S-3	Structural Material Specifications

3.5 General Mechanical Design Criteria

3.5.1 Overview

The general mechanical design criteria are presented herein as a guideline for the minimum criteria to be followed during the design and construction of this Project. The criteria where applicable; (pumps, motors and control panels) shall conform to the requirements specified in the RSWF 2004 10 States Standards. These criteria, in conjunction with the Project specific design criteria, shall provide the basis of design for this Project

The Design-Builder shall be responsible for providing a thorough design and installing working systems that meet all prevailing codes and good construction practices. It is the responsibility of the Design-Builder to be knowledgeable of appropriate codes and to follow them accordingly. Where multiple codes and regulations are referenced, the most stringent guideline shall apply.

All similar pieces of equipment for this Project, including but not limited to pumps, valves, and gates, shall be furnished by the same manufacturer to maintain uniformity.

3.5.2 General Access and Layout Requirements

The design and construction of all facilities under the scope of this Project shall incorporate equipment layout guidelines as given herein and shall meet federal codes such that adequate access and support facilities are provided for operation and maintenance. Specific requirements for equipment layout follow:

- The minimum clear space around equipment and pipe shall be as required by Applicable Law, Good Engineering and Construction Practice, or 3 feet, whichever is greater. Maintenance and operational access requirements, especially for large equipment, shall be taken into account when establishing the layout. The minimum clear space around the equipment and pipe shall also allow the equipment and pipe to be completely removed and replaced without dismantling portions of the building or adjacent equipment, piping, etc.
- Arrange equipment and piping to prevent any tripping hazards.
- Maintain a minimum of 10 feet clear on centerline off the floor for piping that may impact equipment access. Piping that would limit personnel access shall be a minimum of 7′-6″ clear above the floor.
- Locate all equipment and panels on reinforced concrete pads. The pads shall be a minimum of 6 inches high and extend 3 inches outside the equipment and panels.
- Indicate and identify all space required for removing, replacing, and maintaining equipment on the drawings.
- Provide stairs and hatches for accessing and removing equipment; ladders are not allowed.
- Provide hoists and monorails, or cranes for disassembling or removing equipment.
- Provide lifting eyes for single pieces of equipment weighing 100 pounds or more.
- Leave room for installing future equipment where future needs are defined in the plant specific criteria.
- Provide adequate headroom for removing all equipment in a single stroke or specify that the equipment be in sections that are easily disassembled for removal.

- Install permanent, physical measures as required to protect all large or critical equipment motors from a 100-year flood.
- Install large (>10 hp) or critical equipment motors above grade, or design motors to operate continuously in a submerged condition.
- Follow these general guidelines for the layout of all piping and valves.
- Include operators (chain wheels) or access (platforms) for easy operation of all valves in elevated piping.
- Locate washdown drains and secondary drains for proper maintenance of equipment and the building. Design-Builder shall refer to the general building design criteria for plumbing requirements.
- Locate piping so that it is not a safety hazard, or a barrier to accessing equipment.
- Lay out the piping within 4 feet of the walls so it can be supported easily, particularly in spaces with high ceilings.
- Leave at least 2 feet of clearance between the outermost pipe flange and the wall to facilitate disassembly if piping must be run close to a wall, but is not supported by the wall.
- Install a manual vent valve on the highest point of every pipeline that shall be filled with liquid or that shall be tested hydrostatically so air can be purged from the pipeline while it is being filled with water.
- Install a manual drain valve on the lowest point of every pipeline to drain water. Air-and gas-system piping may require automatic drip traps for removing water from the system. Per 10 State Standards, no automatic drip traps shall be allowed on the digester gas system.
- Provide pipe supports of appropriate material for the application and show their locations on the drawings. The pipe supports shall allow thermal pipe expansion and contraction and vibration.
- Provide flexible connections for easily assembling and disassembling piping and for connections to equipment. Ensure that adequate thrust restraint is provided at each flexible coupling.
- Determine and locate the placement of anchor and expansion joints on the drawings.
- Indicate piping reducers on the drawings.
- Where piping reducers are required on the suction side of pumps, they shall be eccentric reducers that are flat on top.
- Allow ample space for diaphragm-, cylinder-, and motor-operated valve and gate actuators. Allow adequate space to serve actuators.
- Provide adequate clearances for rising stem valves and gates in all positions.
- Service-air and instrument-air mains shall be pitched downward in the direction of flow so both flow and gravity shall carry moisture to traps or water legs, which shall be placed at frequent intervals.
- Gas piping shall not be concealed or located under building slabs or in crawl spaces.
- Water lines or ductwork shall not be run over electrical rooms or electrical equipment.

The above listed criteria are minimum requirements and do not exempt the Design-Builder from meeting all federal, state, and other applicable local laws, codes, and regulations.

3.5.3 Pipe Design Criteria

3.5.3.1 General Piping Standards

The following design standards shall be followed to ensure that the system is adequate for the intended service and sufficiently sized for future conditions:

- The following standards shall be applied to the design and construction of the pipelines:
  - No thrust blocks shall be allowed for achieving thrust restraints within the treatment plant confines.
  - Depth of cover shall be a minimum of 3 feet.
  - A 10-foot horizontal separation and an 18-inch positive vertical separation between water and wastewater pipelines shall be maintained throughout. Water pipelines shall be installed at a higher elevation than wastewater pipelines.
  - Tie-ins to existing lines shall be made only after a minimum of 48 hours of prior notification to OCWS, DEP, or other appointed agency.
  - Any necessary system shutdowns shall be strictly coordinated with OCWS or other appointed agency. It is possible that tie-in work may have to occur during off-hours.
  - Provide adequate flushing locations and sample taps to allow adequate disinfection and bacteriological sampling.
  - Disinfect, sample, and test potable water lines in accordance with AWWA standards.
- The sanitary system shall be capable of adequately handling all flows generated within the facility.
- The non-potable water system shall be capable of adequately providing water to all required locations within the facility. Additional requirements are as follows:
  - Any tap on a water main for non-potable water supply shall be a minimum of 2 inches, with a gate valve immediately following the tap and shall be provided with a reduced pressure backflow preventer in accordance with AWWA standards. The valve shall be clearly identified and easily operated.
  - Primary runs (>30 feet) of non-potable water piping shall be a minimum of 6-inch diameter pipe. Short feeder lines shall be no smaller than 2-inch diameter pipe. All taps (or tees) made for individual supply lines shall be immediately followed by a gate valve.
  - Non-potable water supply provided to buildings shall be a minimum of 4-inch diameter pipe, and brought inside the building prior to the first tap. Whenever possible, non-potable water piping shall enter the building above grade through the wall instead of up through the floor slab.
  - Sufficient valves shall be supplied to allow isolation of potential problem areas while minimizing the effect on other services.
  - Clean and flush all yard piping and new raw/finished transmission mains prior to start-up. These activities shall be coordinated with all parties, shown on the project schedule, and included in the start-up procedure.
  - Backflow prevention shall be provided by reduced pressure backflow preventers. The non-potable water shall be isolated from the potable water. Also provide backflow preventer at each building.
- Use materials compatible to the service, considering, but not limited to the following factors: corrosion, erosion, dynamic and static pressure loads, and temperature.

- Ensure conformity of piping, labeling, and pipe location to applicable codes for all hazardous chemicals.
- Use a design velocity in the range of 6 to 8 fps for pumped pipelines. Design velocities shall be in the range of 3 to 5 fps for gravity pipelines. Minimum velocities of 2 fps shall be maintained for all pipelines. Absolute minimum line velocities shall not be less than 1/2 fps. Maximum velocities for control valves and similar components shall be less than 15 fps.
- Determine the expansion stress range for piping subjected to thermal expansion in accordance with the requirements of the appropriate codes.
- Support piping connected to equipment with a pipe support and not with the equipment. Pipe supports shall withstand the dead loads imposed by the weight of the pipes filled with water and shall have a minimum safety factor of 5.
- Provide dual hose bibs around the plant site. Dual hose bibs shall be located so that a maximum of 75 feet of hose per hose bib is needed for washdown requirements. All unit processes shall be provided with washdown facilities, and each tank shall be capable of being drained to a plant site drainage pump station within 24 hours unless otherwise specified in the plant specific process criteria.

3.5.3.2 Gas-Handling Guidelines

Observe the following guidelines for all gas piping:

- Slope all gas pipelines downward in the direction of flow or equip with drip legs or drip traps at appropriate intervals. Slopes shall be 1 percent or more, if possible.
- Place drip legs with manual blowoff at low points in the piping system for drawing off moisture. The drip legs shall be shown piped to a floor or equipment drain.
- Tee branch lines off the main line vertically or at a 45-degree angle.
- Size piping carefully and conservatively to ensure that the supply pressure requirements of connected equipment are met.
- Ensure velocity of air piping is between 15 to 50 fps and is sized with the consideration of energy losses, noise, and sonic velocity.

3.5.3.3 Piping Expansion and Flexibility

In addition to fulfilling the requirements of the construction contract, the Design-Builder shall be responsible for locating and sizing pipe anchors. Anchors shall resist hydraulic thrust and thermal forces and also direct and control thermal expansion. Anchors shall be shown and detailed on the drawings.

Double joints shall be provided where pipes enter concrete or otherwise rigid structures to account for differential settling. The first joint shall be located within 2 feet of the structure and the second joint within 5 feet of the first joint, as a minimum requirement.

Minimum hydraulic thrust requirements shall be computed in accordance with the Handbook of Ductile Iron Pipe, latest edition.

3.5.3.4 Pipe Support and Anchorage

All pumped discharge lines shall be restrained. All other pressure piping shall be evaluated and restrained as necessary. Acceptable types of supports include guides, saddles, penetrations, and structural

attachments for general pipe support. Piping shall be vertically supported by anchor brackets, guides, saddles, or hangers. Each run at each change of direction shall be supported. Existing pipes and supports shall not be used to support new piping.

All nonmetallic pipe 3 inches in diameter and smaller shall be continuously supported with structural channel or other appropriate means.

3.5.3.5 Pipe Testing

Test Piping Systems as Follows:

- Isolate equipment which may be damaged by the specified pressure test conditions.
- Perform pressure test using calibrated pressure gages and calibrated volumetric measuring equipment to determine leakage rates.
- Correct leakage greater than allowable, and retest as specified.

Testing Medium: Utilize the Following Test Media:

- Process and plant air system:

Table 3-11
Testing Media for Process and Plant Air Systems

Pipe Line Size	Specified Test Pressure	Testing Medium
2-inch and smaller	75 psi or less	Air or water
2-inch and smaller	Greater than 75 psi	Water
Greater than 2-inch	3 psi or less	Air or water
Greater than 2-inch	Greater than 3 psi	Water

- Laboratory gases and natural gas systems: Cylinder nitrogen.
- Liquid systems:

Pipe Line Size (Dia)	Gravity Or Pumped	Specified Test Pressure	Testing Medium
Up to and including 48-inch	Gravity	25 psig or less	Air or water
Above 48-inch	Gravity	25 psig or less	Water
All sizes	Pumped	250 psig or less	Water

Test Pressure and Duration:

Pressure testing shall be performed on all piping at the test pressures established in the Pipe Schedule in this section or at pump or blower shut-off pressures, whichever is greater. Maintain the test pressure for a minimum of 6 hours and for such additional time as necessary to conduct examinations for leakage.

Allowable Leakage Rates:

- Hazardous gas systems, all exposed piping systems, all pressure piping systems, and all buried insulated piping systems which are hydrostatically pressure tested shall have zero leakage at the specified test pressure throughout the duration of the test.
- Hydrostatic exfiltration and infiltration for sanitary and storm water sewers (groundwater level is below the top of pipe):

- Leakage Rate: 200 gallons per inch diameter per mile of pipe per day at average head on test section of 3 feet.
- Average head is defined from groundwater elevation to average pipe crown.
- Acceptable test head leakage rate for heads greater than 3 feet: Acceptable leakage rate (gallons per inch diameter per mile per day) = 115 x (actual test head to the 1/2 power).

- Hydrostatic infiltration test for sanitary and storm water sewers (groundwater level is above the top of pipe):
  - Allowable leakage rate: 200 gallons per inch diameter per mile of pipe per day when depth of groundwater over top of pipe is 2 to 6 feet.
  - Leakage rate at heads greater than 6 feet: Allowable leakage rate (gallons per inch diameter per mile of pipe per day) = 82 x (actual head to the 1/2 power).
- Large diameter (above 48-inch) gravity plant piping systems shall have a maximum exfiltration of 25 gpd per inch-mile.
- Non-hazardous gas and air systems which are tested with air shall have a maximum pressure drop of 5 percent of the specified test pressure throughout the duration of the test.
- For low pressure (less than 25 psig) air testing, the acceptable time for loss of 1 psig of air pressure shall be:

Table 3-12
Low Pressure Air Testing

PIPE SIZE (IN DIA)	TIME, MINUTES/100 FT
4	0.3
6	0.7
8	1.2
10	1.5
12	1.8
15	2.1
18	2.4
21	3.0
24	3.6
27	4.2
30	4.8
33	5.4
36	6.0
42	7.3
48	7.6

Hydrostatic Pressure Testing Methodology:

- General:
  - All joints, including welds, are to be left exposed for examination during the test.
  - Provide additional temporary supports for piping systems designed for vapor or gas to support the weight of the test water.
  - Provide temporary restraints for expansion joints for additional pressure load under test.

- Isolate equipment in piping system with rated pressure lower than pipe test pressure.
- Do not paint or insulate exposed piping until successful performance of pressure test.

- Soil, waste, drain and vent systems:
  - Test at completion of installation of each stack or section of piping by filling system with water and checking joints and fittings for leaks.
  - Eliminate leaks before proceeding with work or concealing piping.
  - Minimum test heights shall be 10 feet above highest stack inlet.
- Larger diameter (above 36-inch) gravity plant piping:
  - Plug downstream end of segment to be tested. Provide bracing as required.
  - Fill segment and upstream structure to normal operating level as per hydraulic profile.
  - Allow 24 hours for absorption losses. Refill to original level.
  - Provide reservoir to maintain constant head over duration of test.
- Record reservoir water volume at beginning and end of test.

Air Testing Methodology:

- General:
  - Assure air is ambient temperature.
- Low pressure air testing:
  - Place plugs in line and inflate to 25 psig.
  - Check pneumatic plugs for proper sealing.
  - Introduce low pressure air into sealed line segment until air pressure reaches 4 psig greater than groundwater that may be over the pipe.
  - Use test gage conforming to ANSI B40.1 with 0 to 15 psi scale and accuracy of 1 percent of full range.
  - Allow 2 minutes for air pressure to stabilize.
  - After stabilization period (3.5 psig minimum pressure in pipe) discontinue air supply to line segment.
  - Record pressure at beginning and end of test**.**

3.5.3.6 Pipe Schedule

Pipes shall be color coded according to service and shall be labeled with the appropriate flowstream identification. Pipe designations and colors are defined in Table 3-13 on the following page.

3.5.4 Valve Selection Criteria

These design standards shall be followed to ensure that the system is adequate for the intended service and sufficiently sized for future conditions.

- Use all valves that conform to AWWA standards which are constructed of the appropriate materials for the application
- Use self-contained valves with resettleable set points which are in the mid-range of the valves operating capability.
- All valves in lines 1 inch or greater requiring automatic actuators shall be electrically operated unless the service demands otherwise. Solenoid valves shall be used for service in lines 1 inch and smaller.

- Provide all valve operators that are accessible from the ground or from adequate platforms.
- Provide chain actuators for valves 6 feet or higher from the finish floor to valve centerline. The chain actuator shall be cadmium-plate and chain looped to within 3 feet of the finished floor. Equipment chain wheel with chain guides to permit rapid operation with reasonable side pull without "gagging" the wheel.
- Provide valves for safe isolation of all equipment and to facilitate removal for maintenance.
- Valves smaller than 24 inches shall be direct buried with valve box. Valves 24 inch and larger shall be buried inside a valve vault, a minimum of 3 feet under cover.
- The selection criteria for valve type that shall be used are shown in Table 3-14.

Table 3-14
Valve Section Criteria

SERVICE	SIZE	ISOLATION	THROTTLING
Wastewater and Solids	6" and larger	Eccentric plug	V-Port Ball Valve or notched Knife Gate Valve (RAS Control Only)
Potable and Non potable Water	2" and smaller	Gate	Globe
	2-1/2" — 8"	Gate	Globe
	10" and larger	Gate	Globe
Filtered Effluent	6" and larger	Gate	Butterfly
Filtered Effluent	6" and smaller	Gate	Globe
Air	All	Butterfly	Butterfly
Hot water	2" and smaller	Gate	Globe type plug
Fuel Oils and Gaseous Fuels	2" and smaller	Lubricated plug	Globe
	2 1/2" and larger	Lubricated plug	Globe type plug
Chemical Service	2" and smaller	Ball/Diaphragm	Diaphragm
	2 1/2" and larger	Diaphragm	Diaphragm

Table 3-13
Pipe Schedule

SYMBOL	SERVICE	CONSTRUCTION	SIZE (IN)	PIPE MATERIAL	TEST PRESSURE	PIPE COLOR	BAND COLOR
BD	Basin Drain	Exposed & Buried	3-48	Ductile	25	Brown	11WH-White
DWV	Drain	Exposed & Buried	All	PVC–S 40	25	32GR-Grat	11SF-Safety Blue
IW	Irrigation Water	Exposed & Buried	1-3	PVC - 80	125	Blue	Black
		Exposed & Buried	3-24	PVC - 80	125	Blue	Black
LPA	Low Pressure Air	Exposed	2-24	SS - 304L	20	Green	
		Buried	2-24	SS - 304L	20		
		Submerged	2- 24	SS - 304L	20		
NPW	Non Potable Water	Exposed & Buried	< 1	Stainless Steel Tubing	125	Blue	Black
		Exposed & Buried	1-3	Galvanized, Schedule 40	125		
		Exposed & Buried	3-24	Ductile	125		
PW	Potable Water	Exposed & Buried	< 3	Copper Tubing	125	08SF-Safety Green	35GR/07SF-Black/Red
		Exposed & Buried	3-24	Ductile	125		
RAS	Return Activated Sludge	Exposed & Buried	3-24	Ductile	125	YB24-Brown	32GR/07SF-Gray/Red
RS	Raw Sewage	Buried	3-48	Ductile	125	32Gr-Gray	35GR-Black
SCM	Scum	Exposed & Buried	3-24	Ductile	125	YB23-Dk. Brown	32GR-Gray
SE	Secondary Effluent	Exposed & Buried	3-24	Ductile	125	32GR-Gray	05SF/YB24-International Orange/Brown
SG	Sludge	Exposed & Buried	3-24	Ductile	125	YB24-Brown	11SF/35GR-Safety Blue/Black
SMP	Sample	Exposed & Buried	< 12	PVC	100	08SF-Safety Green	02SF-Safety Yellow
STW	Storm water	Buried	>4	Concrete or Ductile	See Section 3.4.3.5		

- The following selection criteria for end connections shall be used:

Table 3-15
End Connections

TYPE	SIZE	END CONNECTION
Gate	2″ and Smaller	Screwed
	2-1/2″ – 12″	Flanged
Butterfly	12″ and larger	Flanged
Plug or Ball	2″ and smaller	Screwed
	2-1/2″ and larger	Flanged
Check	2″ and smaller	Screwed
	2-1/2″ and larger	Flanged
Diaphragm	3″ and larger	Flanged

- All actuators for automatic valves and gates shall be electric. Electric actuators shall meet the requirements of AWWA C540. The following accessories shall be included for all control valves:
  - Position Indicators: The position of the control shall be indicated by mechanical attachment or linkage to either the valve stem or the valve actuator.
  - Solenoid Pilot Valves: All solenoid pilot valves that are specified as a part of the control loop shall have a main control valve. Solenoid valves shall be the same diameter as the line.
  - Valve Bypass: If a flow stream can be shut down long enough to replace the control valve without upsetting a critical process, no bypass shall be required. If the process is critical and can be controlled by manual throttling, a bypass shall be installed. If a process is critical but cannot be controlled by manual throttling, a redundant control valve shall be installed. Manually operated isolation valves shall be required on either one side or both sides of the control valve to facilitate its removal and replacement.
  - Electric actuators shall be equipped with side mounted handwheels for manual operation
- Each valve operator shall be tagged with a 1 to 2-inch diameter heavy brass or stainless steel tag, bearing the valve tag number depicted on the Design-Builder drawings.
- All valves shall be provided with actuators that are easily accessible.
- Three phase motors for the valve actuators shall be suitable for 600 starts per hour minimum.
- One phase motors for the valve actuators shall be suitable for 100 starts per hour minimum.
- For mud valves, frame, cover, yoke, and stem extension connection shall be cast iron. Stems shall be stainless steel and lift nuts bronze.
- Sealing faces shall be flat and bronze. Frame flange drilling shall be suitable for mounting on the drainage pipework flange.
- Valve shall operate via a stainless steel extension shaft complete with suitable stem guides terminating in a standard AWWA 2-inch valve nut 18 inches above design peak flow top water level.

3.5.5 Sluice and Slide Gate Selection Criteria

3.5.5.1 General Sluice and Slide Gate Guidelines

Sluice and slide gates shall be selected in accordance with the guidelines described below.

- Comply with AWWA C501, Cast-Iron Sluice Gates and AWWA C513, Open-Channel, Fabricated-Metal Slide Gates.
- Complete an equipment-specific sluice and slide gate information sheet for each gate that shall be used. Data sheets are required for both power-operated and manually operated gates.
- Use slide gates only to change flow, alter the water surface elevation, or provide isolation where a leak at the gate does not create safety, housekeeping, or other process problems.
- Use slide gates for holding liquids with hydraulic grade lines not greater than 10 feet above the invert of the gate opening. Sluice gates (or other relatively non-leaking gates) shall be used in all other places.
- Use wall thimbles for all sluice gates.
- Directly bolting the gates to concrete shall not be permitted on new construction. Slide plates shall not be allowed.
- Use fabricated stoplogs only for infrequent major rehabilitation or future construction. Stoplog grooves shall be installed as a minimum at locations required for maintenance of future expansions.
- Design-Builder shall provide means of isolating gate for maintenance and replacement.

3.5.5.2 Sluice Gate Components

Sluice gates shall comply with the following criteria:

- Gates and operators shall be the rising-stem type so the position of the gate can be determined visually.
- Gates that are 24 inches by 24 inches or smaller, or larger gates operating with only a few feet of unbalanced head, shall have bench-stand or floor-stand hand crank operators.
- All other sluice gates shall have enclosed, geared-type bench-stand or floor-stand operators.
- Use bench stands only if they can be installed at convenient operating heights.
- Use nonrising-stem operators only when headroom precludes using rising-stem operators.
- Requirements for operators shall be as follows:
  - Manual operators shall be operated by hand crank. The maximum manual pull or crank effort required to operate the gate shall not exceed 40 pounds. Because all crank operators shall be operable by a portable electric drill after the hand crank is removed, a 120-volt plug-in receptacle shall be located near the gate.
  - Sluice gates shall be equipped with permanently installed electric operators when any one of the following criteria is met
    - Required vertical movement is 72 inches or greater.
    - The gate cross-sectional area is greater than 6 square feet.
    - The gate is anticipated to be operated more frequently than once per month.

- Operating the gate operator with a portable electric drill would be inconvenient (e.g., operator would have to carry the drill up a ladder).
- Sluice gate may require rapid or instantaneous operation in response to some condition.

Motorized gate operators shall be equipped with side-mounted handwheels for manual operation. The handwheel shall have an adapter on the shaft, so the gate can be operated manually with a portable electric drill.

3.5.5.3 Slide Gate Components

Slide gates shall comply with the following criteria:

- Slide gates shall be constructed of cast iron, aluminum or stainless steel depending on the application.
- Slides shall have a frame and be reinforced as required so they shall not deflect more than 1/360 of the gate span.
- Slide gates having a width greater than 60 inches shall have dual or multiple stems.
- Downward-opening weir-type gates shall have stems near the outside edges of gate.

Maximum leakage rate: Not to exceed 0.1 gpm per foot of seat perimeter with water at top of gate slide and operating in seating position.

3.5.6 Pump Selection Criteria

3.5.6.1 Pump Types and Application

General:
The allowable pumps for the each application are provided in the Pump Schedule below.

Table 3-16
Pump Schedule

APPLICATION	TYPE OF PUMPS
Scum	Vaughn or approved equal chopper pumps
Return Activated Sludge	Centrifugal Submersible Recessed Impeller
Plant Effluent	Vertical Turbine
Plant Water System	Vertical Turbine
Digested Sludge	Progressive Cavity

Vertical Turbine:
Where vertical turbine pumps are utilized, the manufacturer shall be Goulds, Peerless, Fairbanks Morse, Johnston, Flowserve or Floway. All vertical turbine pumps provided for this Project shall by the same manufacturer. Unless otherwise indicated, pump material for all vertical turbine pumps shall be:

- Lineshaft: Open type. ASTM A276, Type 416 stainless steel

- Lineshaft bearings: Fluted cutless rubber
- Head Shaft: ASTM A276, Type 416 stainless steel
- Impeller Shaft: ASTM A276, Type 416 stainless steel
- Impeller: Bronze, ASTM B584
- Impeller Wear Rings: Bronze, ASTM B584, Alloy 836
- Bowl and Suction Case Bearings: Bronze, ASTM B585, Alloy 932. Enamel coat bowls.
- Lubrication: Pumped liquid
- Discharge Head: Fabricated steel or cast iron
- Shaft Seal: Mechanical
- Column: Steel, ASTM A53, Grade A, 3/8-inch minimum wall thickness with threaded section joints.
- Motor Shaft: Solid.
- Anchor Bolts: Type 316 stainless steel

Horizontal or Vertical End Suction Centrifugal Pumps:
Where horizontal end suction centrifugal pumps are utilized, the manufacturer shall be Goulds, Peerless, or Flowserve. All horizontal end suction centrifugal pumps provided for this Project shall by the same manufacturer. Unless otherwise indicated, pump material for all horizontal end suction pumps shall be:

- Impeller: Bronze, ASTM B584, Type 836
- Impeller Shaft Material: Solid stainless steel, Type 416, ASTM A276
- Pump Casing: Cast Iron, ASTM A48, Class 30 minimum
- Lubrication: Grease
- Shaft Seal: Mechanical
- Bearing: Ball with L10 life of 100,000 at the best efficiency point
- Baseplate: Fabricated Steel or Cast Iron
- Anchor Bolts: Type 316 stainless steel

Non-Clog Centrifugal Pumps:
Where non-clog centrifugal pumps are utilized, the manufacturer shall be Fairbanks-Morse, Morris or Worthington. All non-clog centrifugal pumps provided for this project shall by the same manufacturer. Unless otherwise indicated, pump material for all non-clog centrifugal pumps shall be:

- Impeller: Cast Iron A48, Class 30 minimum
- Impeller Shaft Material: Solid stainless steel, Type 416, ASTM A276
- Impeller Wear Rings: Stainless steel, Type 416, 400 BHN minimum
- Casing Wear Rings: Stainless Steel, Type 416, 450 BHN minimum

- Stuffing Box, gland bolts and nuts: Stainless Steel Type 316
- Pump Casing: Cast Iron, ASTM A48, Class 30 minimum
- Shaft Seal: Double Mechanical
- Baseplate: Fabricated steel or cast iron
- Anchor Bolts: Type 316 stainless steel

Pumping System Design:
Pumps shall be selected and sequenced so they normally operate within their Allowable Operating Region in accordance with the Hydraulic Institute Pump Standards, latest edition.

Pump NPSH margins shall be based on suction energy level and wastewater application as recommended in the Hydraulic Institute Pump Standards, latest edition.

The pump intakes shall be designed in accordance with the requirements of the Hydraulic Institute Pump Standards, latest edition. The Design-Builder shall provide a Computation Fluid Dynamics analysis or a physical model study to comply with the Hydraulic Institute Pump Standards, latest edition.

Pump Components:
The following criteria shall pertain to the internal components of all pumps:

- Furnish pumps with mechanical seals except packing type seals will be considered for effluent pumps.
- Provide seal water for all seals used except chemical metering pumps.
- Use single seals for most applications except where solids are present in the pumped fluid.
- Provide seal water pressure for mechanical seals of approximately 3 to 5 psig higher than the stuffing box pressure at shut-off head.
- Use non-potable water for seal lubrication (no plant effluent)
- In abrasive services, bowl or line shaft bearings on vertical turbine pumps shall be flushed by a screened or protected clean water supply from an external source.
- The minimum bearing rating life for 24-hour continuous duty and maximum reliability shall be 100,000 hours at best efficiency point.
- Specify grease lubrication for ball and roller bearings, both guide and thrust. Oil lubrication shall be standard on American Voluntary Standard chemical service pumps. Specify oil lubrication for high-temperature or high-thrust services where bearing temperatures could exceed 200°F.
- Where grease-lubricated bearings are provided, they shall be fitted with grease and relief fittings except where permanently lubricated bearings are provided by the manufacturer.
- Where oil-lubricated bearings are used, they shall be fitted with a sight window.
- Use exposed pump shafts and couplings protected by OSHA-approved guards supplied by the pump manufacturer.

3.5.7 Motors

Motors shall be rated as dictated in the electrical design criteria.

3.5.8 Plant Drain Systems

The Design-Builder shall determine the number, size, and location of internal lift stations required at the plant site. A wastewater lift station shall be used for non-hazardous plant drains (e.g., floor drains) and shall be located outside of any building.

The following design criteria shall be followed:

- Route all wastewater or potential wastewater wastes to a sanitary lift station located outside of any buildings.
- Monitor containments for liquid level detection, and alarm the plant control system upon indication of either high level or presence.
- Lift station.
- Provide a minimum duplex pump system provided with guide rails or lifting cables, vertical, single-stage, submersible grinder (less than 3-inch solids) pumping units and controls.
- Size pumps based on maximum estimated source inflows to avoid any overflows.
- Include a discharge base, an access hatch cover, and a duplex pump control panel.
- Provide complete automatic operation from level in the wet well.
- Provide signals to the duplex pump panel concerning pump common general fail, high/low water level, and running status.

3.5.9 Noise and Vibration Considerations

As a minimum, the noise produced shall be evaluated to comply with OSHA regulations and local codes. The design shall isolate vibration in accordance with Noise and Vibration Control, by L. L. Beranek, 1971 edition, and Handbook of Noise Control, by C. M. Haris, 1979 edition.

3.5.10 Design Standards

As a minimum, the following standards shall apply:

- American Society of Testing Materials (ASTM)
- American Water Works Association (AWWA)
- American National Standards Institute (ANSI)
- Recommended Standards for Wastewater Facilities, 1990, Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers
- Recommended Standards for Water Facilities, 1997, Great Lakes-Upper Mississippi River Board of State Public Health and Environmental Managers

As a minimum, the following Codes shall apply:

- Florida Building Code
- The National Electrical Code
- National Fire Protection Association (NFPA) Standards
- Occupational Safety & Health Administration Regulations

- Other Requirements
- EPA 430-99-74-001 Design Criteria for Mechanical Electrical and Fluid System and Components Reliability
- EPA Rules and Regulations - 40 CFR Part 33 Rev. (Last Revision)

3.5.11 Design Procedures

3.5.11.1 Process Equipment and Instrument Identification

All process equipment and instrumentation (e.g., piping, valves, and gates) shall be shown and identified with appropriate tags on the process and mechanical drawings. All devices shall be tagged in accordance with the process and instrumentation diagrams (P&IDs).

3.5.11.2 Equipment Data Sheets

An equipment data sheet shall be filled out completely for each piece of equipment selected. Data sheets are required for all process equipment, such as pumps, motorized gates and valves, and process devices. Refer to the attached sample equipment data sheet for required information.

3.5.11.3 Calculations and Support Data

The list below shows calculations or support data that shall be required as part of the process or mechanical work. This list shall not limit the Design-Builder from performing other calculations that are required for specific facilities or systems. Calculations for the following items are required for process and mechanical work:

- Pipe sizing.
- Pressure-piping thrust, described under "Plant Piping."
- Thermal expansion of piping systems operating above 150°F.
- Hydraulics that support the selection of pumps, which shall be accompanied by completed copies of equipment data sheets, including pump curves.
- Control-valve sizing, accompanied by completed copies of equipment data sheets for each control valve.
- Wet-well design; pump selections shall be accompanied by completed copies of equipment data sheets for each pump.
- Compressed-air system that supports compressor and receiver selections, accompanied by complete copies of equipment data sheets for each compressor.
- Heat-exchanger sizing, accompanied by complete copies of equipment data sheets for heat exchangers.

Calculations supporting the selection of all process mechanical equipment and basin sizing (selections shall be based on factors such as detention time, overflow rate, and solids loading), accompanied by complete copies of equipment data sheets.

3.6 General Building Services Design Criteria

3.6.1 General

All design must conform to the local building codes, including the 1997 edition of the Unified Building Code and all other codes and standards as contained therein.

3.6.2 HVAC

3.6.2.1 HVAC System Functions

The HVAC system shall perform the following functions:

- Maintain the concentration of combustible and hazardous gases within safe limits.
- Maintain a low relative humidity in the administration and maintenance buildings and process areas to minimize or eliminate condensation and corrosion.
- Process incoming outside air by filtering.
- Provide uninterruptible operation of odor containment and processing in critical process areas through an adequately redundant system.
- Odor control, where required, shall be designed as described in the project-specific design requirement document.

3.6.2.2 General HVAC Drawing Criteria

In addition to the HVAC design criteria, the following requirements shall apply to HVAC drawings:

- Ensure the minimum scale for ductwork and piping plans is 1/8 inch = 1 foot for congested areas and equipment rooms; the part plans shall have a scale of 1-1/4 inch = 1 foot.
- Provide sections and elevations for all major equipment and multiple layers of piping or ductwork. Sections and elevations shall have a scale of 1-1/4 inch = 1 foot.
- Indicate the airflow through the various rooms and duct systems on an air-balance diagram as part of the construction documents.

The air-balance diagrams shall, as a minimum, show the following:

- Ventilated spaces with space identification.
- Ventilation air flow in cubic feet per minute (cfm).
- Ventilation rate in air changes per hour and design basis.
- Infiltration or exfiltration rate in cfm.

Pressurization Criteria:

- All ductwork, fans and air handlers.
- Fan and air handler identification numbers (IDs).
- Fan and air handler capacities in cfm.
- Duct air flows in cfm.
- Pressure relief dampers.

- Control dampers.
- Fire-rated and smoke control dampers.
- In addition, the following shall be provided where applicable:
  - Standard construction detail sheets.
  - Demolition drawings of all existing equipment to be removed.
  - Automatic temperature-control systems.

The following information used by construction field personnel in the construction of the Project shall be on the drawings:

- Piping details.
- Air handling units and fans installation details.

Fire damper locations:

- Ductwork layout

3.6.2.3 HVAC Design Procedures

Codes and Standards:
The latest editions of the following codes and standards shall apply:

- Florida Building Code.
- Florida Mechanical Code (FMC).
- Florida Plumbing Code (FPC).
- Florida Fire Prevention Code.
- Florida Accessibility Code for Building Construction.
- Florida Energy Efficiency Code for Building Construction.
- The National Electrical Code (NEC).
- Occupational Safety & Health Administration Regulations.

The HVAC design shall comply with the applicable standards and recommended practices of the following organizations:

- American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE).
- Sheet Metal and Air Conditioning Contractors National Association (SMACNA).
- Air Moving and Conditioning Association (AMCA).
- Associated Air Balance Council (AABC).
- National Environmental Balancing Bureau (NEBB).
- American Conference of Governmental Industrial Hygienists (ACGIH).

In cases where existing facilities are included in the scope of work and the existing HVAC systems do not meet current code requirements, the HVAC systems shall be modified to meet these requirements.

Calculations:
Calculations must follow the methodology outlined in the applicable energy codes, the latest edition of ASHRAE's Handbook of Fundamentals, and referenced ASHRAE handbooks and publications.

At a minimum, calculations shall be performed for the following:

- Heat transmission coefficients.
- Space heat gain.
- Space ventilation rates.
- Exhaust ventilation capture velocity.
- Ductwork pressure loss.
- Fan motor sizing.
- Condensation control.
- Ventilation rates shall be calculated for all applicable criteria, and the highest ventilation rate shall be used for design.

Evaluations:
As part of the design, the following items shall be evaluated:

- Ventilation rates versus electrical area classification.
- Degree of interface between HVAC controls and main plant control system.
- Refrigeration type: degree of environmental impact.

In areas where other criteria do not require a higher ventilation rate, the selected ventilation rate shall be based on an evaluation of the potential occupancy of the space. Electric valves and dampers shall be provided. Balancing dampers will be manual with locking quadrants.

Design and Layout:
In making layouts, the following requirements shall be observed:

- Position air-handling units so filters and coils can be pulled and removed from the building without demolishing permanent walls or structures.
- Mount equipment and panels on pads to protect them from washdown.
- Provide the recommended clearance (no less than 3 feet) between the outermost extremities of adjacent pieces of equipment or between a wall and a piece of equipment. Clearances will be required on sides of equipment in accordance with manufactures recommendations. Exceptions shall be identified by the Design-Builder and approval must be obtained from OCWS.
- When equipment is not mounted on the floor, provide service platforms with suitable access.
- Provide ladders, catwalks, and hatches for accessing and removing equipment.
- Provide lifting lugs for removing equipment.
- Locate piping so it does not create a hazard to workers or prevent access to equipment. Allow a minimum clearance of 7 feet (8 feet is preferred) for a walkway.
- Lay out piping close to walls for better support, particularly in areas with high ceilings.

- Verify that equipment can be replaced. Clearance for the largest component is acceptable if removing the assembled unit is not feasible. Where a standby unit is required, replacing one unit should not require shutting down the standby unit for access or removal.
- Check alternate supplies when determining space requirements. Consider the need for removing the fan shaft if using externally isolated units.
- Pipe supports generally are not shown on the layout drawings. Locations for anchoring rigid pipe should be shown. Acceptable types of supports and anchorage details are shown on the standard details.
- Provide flexible connections so piping can be easily assembled and disassembled.
- Locate electrical equipment in washdown areas at least 3 feet from the floor.
- Allow ample space for diaphragm-, cylinder-, and motor-operated valve and gate actuators.
- Provide adequate clearance for rising-stem valves and gates.
- Leave room for installing equipment where future needs are established in the plant-specific criteria.
- Provide ducted air supply into open pits requiring regular maintenance.
- Connect ductwork to liquid-filled tanks with overflow device to prevent flooding of the ductwork if the tank overflows.
- Provide conditioned cool air (direct expansion type) to electrical room.
- Provide adequate clearance for equipment installation, operation, and maintainability.

In addition to the layout information listed above, the following requirements shall be observed on piping drawings:

- Provide for draining gravity lines.
- Provide unions where required for disassembling piping and equipment.
- Piping should be at least 3/4 inch to provide rigidity. This does not apply to refrigerant lines whose size will be provided per manufacturer's recommendations.
- Design sufficient flexibility into piping systems to allow for thermal expansion and contraction without using expansion joints.
- Provide shut-off valves so the systems can be serviced without major shutdowns.

HVAC System Types:

The following are basic requirements for the different HVAC systems.

- **Ventilation Systems.** Ventilation systems shall provide ventilation to space with supply and exhaust fans. Ductwork shall be installed to increase air movement and to eliminate dead spots.
- **Air Conditioned Systems.** Air-conditioned systems shall provide space temperature and/or humidity control utilizing direct expansion refrigeration systems with air handling and ducted air distribution. Electrical and/or instrumentation rooms shall be air-conditioned.

- **Wind Load on HVAC Systems.** HVAC equipment located outside buildings shall be designed and installed for the code-prescribed winds loads. HVAC equipment located outside shall be designed according to the manufacturer's design criteria
- **Indoor Design Conditions.** Design conditions shall be selected based upon occupancy and equipment requirements. Proper dehumidification and cooling shall be provided in air-conditioned spaces. Unless otherwise specified, occupied spaces shall be air conditioned to maintain a minimum of 72°F. Electrical and Instrumentation rooms shall be designed to maintain a minimum of 77°F with equipment operating.
- **Building Envelope Heat-Transmission Coefficients.** Buildings, spaces, or rooms that have air-conditioning systems for cooling shall be enclosed in building envelopes that meet the local building codes.
- **Ventilation Air-Rates.** ASHRAE Standard 62-2001, "Ventilation for Acceptable Indoor Air Quality," lists the required ventilation air rates for MAC systems for occupied areas.

  The minimum ventilation air rates in the process areas shall be determined on the basis of the following: NFPA 820, "Recommended Practices for Wastewater Facilities;" least restrictive electrical criteria; survey of similar facilities.
- **Location of Ventilation Air Intake, Air Distribution, and Exhaust Air.** Filtered outdoor air, and/or filtered and cooled outdoor air, shall be drawn in by supply air fans and distributed into the buildings. The supply shall then be distributed to work areas and low-odor areas of each building. Additional requirements follow.
  - Provide outdoor air intakes to prevent intaking odorous air and vehicle exhaust emissions.
  - Locate exhaust discharge points away from outdoor air intakes. With the exception of clean ventilation exhaust air, exhaust discharges shall not be located where they shall discharge onto people. Louvers shall not be used over doors for chemical exhaust. Exhaust containing hazardous materials shall be located so the discharge point is inaccessible to people and the exhaust plume shall discharge in a safe location. Vertical upblast discharge from roofs is preferred.
  - Collect odor-control exhaust air systems in high-odor areas as defined in the plant specific criteria. Exhaust air fans shall then deliver contaminated air to the odor-control systems for purification, with the purified air discharged directly outdoors.
  - Design intake louvers and hoods for low face velocity. Hoods shall capture odors being generated. Shut-off dampers for intakes and exhausts shall be located at the intake or discharge opening and not at the fan suction or discharge.
- **Outdoor Air Filtration.** For offices, electrical equipment rooms and laboratory spaces in areas with odorous outdoor air, replaceable impregnated carbon filters with post filters shall be used for removing odors.

  Use drainable blade intake louvers to minimize water penetration. Filters for administration areas should have a 35 to 60 percent dust spot efficiency, with the remaining areas having a 25 to 30 percent dust spot efficiency.
- **Building Pressure Control.** Clean spaces shall have a positive pressure, and odorous spaces shall have a negative pressure.
  - When adjacent spaces are odorous, the more odorous space shall have a negative pressure relative to the less odorous space.

- Evaluate spaces on the basis of the air tightness of the space to maintain the required pressure difference between supply and exhaust. In addition, the system shall be balanced after construction to the required pressure differential.
- Consider the potential for air leaks at the openings in odorous areas and access ports that shall be open during normal operation of the plant.
- Provide emergency inlet relief to prevent structural overloading of cover systems in closed areas.
- Install pressure differential alarms in critical areas.

System specifications shall define balancing procedures for both air flow and pressure control.

- **Volume Control for Ventilation Air in Process Facilities.** All ventilation systems shall operate continuously, not intermittently. Redundant ventilation capacity or the need for emergency power for the ventilation systems shall be provided where the plant specific criteria dictates.

  If required by NFPA 820, flow sensors and alarms shall be provided for supply and exhaust systems. The control loops shall be independent of all other controls and shall activate at low flow regardless of the cause. Flow alarms shall be transmitted to the plant control system.

- **Indoor Relative Humidity and Temperature Control in Process Facilities.** RH control shall be provided in areas with a high potential for indoor moisture evaporation. Exhaust air pick-up points shall be located in areas of high sewage agitation to reduce the effects of indoor moisture evaporation.

- **Noise Control.** HVAC systems serving occupied areas shall be designed to meet the average noise criteria (ANC) levels recommended by ASHRAE.

  Noise produced outside of the buildings shall be evaluated to comply with local codes and ordinances. The evaluations shall also consider the sound emission criteria for all other sources.

- **Duct Construction Materials.** The following duct materials shall be provided:

  - Use aluminum sheet metal for all supply air ducts.
  - Use aluminum sheet metal for return ducts in clean dry areas.
  - Use welded 316 stainless sheet metal, fiberglass, or PVC for all exhaust and ductwork conveying gases to odor control facilities and for lab exhaust ductwork and equipment. 316 stainless steel shall not be used in areas with chlorine, nor outside the building. Fiberglass or PVC ductwork shall be used outside. No PVC pipe, nor PVC duct, shall be installed in ventilation plenums.
  - Use fiberglass ductwork with appropriate resins for exhaust in areas with chlorine and downstream of the odor-control scrubber system.
  - Do not use reinforced polyester or vinyl ester duct or aluminum duct to convey flammable vapors.
  - Fire protection systems may be required inside of the ductwork because of the materials of construction, the material handled, or the potential for the building up of combustibles. Duct systems requiring sprinklers shall not be allowed.
  - Metallic ductwork shall conform to the latest SMACNA standards. Exhaust ductwork shall comply with SMACNA industrial ductwork standards. Nonmetallic ductwork shall comply with Underwriters Laboratories (UL) and SMACNA standards.
  - Use round ductwork wherever possible for exhaust system. If rectangular ductwork is required, the aspect ratio shall not exceed 4 to 1, except where necessary. Ductwork shall

be designed for a maximum pressure drop of 0.10 inch water gauge per 100 feet of duct. Maximum duct velocities shall be as follows:
  - Offices and administration: 1,500 fpm
  - General process areas: 1,800 fpm
  - Odor-control systems: 2,000 fpm
- Access doors shall be installed to clean out dust- and dirt-laden duct systems. Doors shall be 24 inches x 24 inches or the largest door that shall fit into the duct. If there is the potential for moisture carryover or condensation, drains with traps shall be provided at low points in the ductwork.
- Ductwork shall run inside of buildings whenever possible.
- Insulate ductwork as required by the Energy Conservation Code and where necessary to prevent condensation.
- If any of the preceding standards conflict, the most stringent requirements shall govern.

- **Equipment, Ratings, and Materials.** All HVAC equipment shall meet space efficiency requirements imposed by the Energy Code. Additional requirements follow:
  - Name at least two manufacturers wherever possible (OCWS must approve any exceptions). Model numbers shall also be stated for the alternate manufacturer, if stated for the design basis manufacturers. If no alternate manufacturer can be determined, the Design-Builder shall write a performance specification, omitting any mention of a specific manufacturer.
  - In general, locate all HVAC equipment indoors. Roof-mounted equipment, such as roof exhaust fans and or air handling units, shall be used only with permission of OCWS. Suitable access is required for all roof-mounted equipment.
  - Provide full-height access doors in air-handling units.
  - Construct all exhaust-air fans handling odorous air of fiber-reinforced plastic, resin-bonded fiberglass, or 316 stainless steel. Non-sparking blades and explosion-proof motor construction shall be provided where the plant-specific criteria dictate their use.
  - Use all other fans and air-handling units made of materials suitable for the air stream and surrounding conditions. For all major fan systems, the designer should prepare a fan curve of the selected fan with the calculated system curve, at design and both plus and minus 10 percent of flow, to prove stable fan selection.
  - Provide fans with a 70 percent or greater efficiency, if possible.
  - In general, use equipment in process areas able to withstand wet conditions.
  - Use a margin of safety for heat gains of 10 percent.
  - The following margins of safety for static pressure of fans as recommended by the Associated Air Balance Council shall be provided:
    - Low number of zones and balancing dampers: 20 percent
    - Medium number of zones and balancing dampers: 30 percent
    - High number of zones and balancing dampers: 40 percent
  - HVAC designers shall use their own discretion in applying a margin of safety to static pressure calculations.
  - Use AMCA Publication 201, Fans and Systems reference for non-ideal fan installations. Provisions shall be made for the effects of fan inlet and outlet configuration on static pressure losses, including poor fan inlet and outlet conditions and air acceleration in exhaust fans.

- **Corrosion Control.** Corrosion control is required to improve the performance, reduce maintenance, and extend operating life of the HVAC systems. Refer to the corrosion control criteria for more specific requirements.

- **Redundancy and Reliability.** The Design-Builder must consider the need for redundant equipment and emergency electrical service. For large systems, consider using two air handling units sized at 50 percent capacity each.
- **Control System.** The control system for HVAC equipment shall interface with the plant control system for alarms and data gathering. Additional HVAC requirements follow:
  - The HVAC control system shall include local control panels for equipment, either provided with packaged equipment or free-standing to serve one or more air handling units. HVAC controls shall provide complete control of the system.
  - Economizer cycles, temperature reset, and other energy-saving features shall be specified where practical and where those features do not interfere with other design criteria. However, the Energy Code's control requirements shall always be met.
- **Coordination with Other Disciplines.** The following steps provide guidance for coordination:
  - If required in the plant-specific criteria, interlocks with the odor-control fans and supply-air systems shall be provided within the HVAC controls.
  - Flow alarms in the odor-control ductwork as required by NFPA 820 shall be provided.
  - HVAC designers shall interface with control system designers to define the number and types of points and the required types of signals.
  - Ventilation systems shall be coordinated with fire-detection systems so fans can be shut down and duct-mounted smoke sensors can signal the plant's fire alarm system.

3.6.3 Plumbing

3.6.3.1 Plumbing System Functions

The plumbing system shall perform the following functions:

- Provide comfortable and odorless condition in buildings and areas intended for human occupancy.
- Provide sewer and potable water service for non-process sanitary and laboratory fixtures.
- Provide potable water services for emergency and eye showers.

General Plumbing Drawings Criteria:
In addition to the plumbing design procedures, the following requirements shall apply to the plumbing drawings:

- Use 1/8″ = 1′ as the minimum scale for plumbing plans. For enlargement view, the part plans shall have a scale of 1/4″ =1′.

Drawings shall include the following plumbing details if required for the building or facility as described in the plant specific criteria:

- Nonprocess sanitary-fixture drains.
- Plumbing-fixture water supplies (hot and cold).
- Vent piping.
- Roof drains and piping.
- Isometric for sewer system.

- Extend the drawing of the building drain and water service for each building or facility 5 feet outside the building line. The drawing of the utility services, beyond 5 feet of the building, shall be shown on the civil site drawings.

Plumbing Design Procedures:

- **Codes and Standards.** The latest editions of the following codes and standards shall apply:
  - AAA Rules and Regulations for Design Standards 1984.
  - Florida Building Code.
  - Florida Mechanical Code (FMC).
  - Florida Plumbing Code (FPC).
  - Florida Fire Prevention Code.
  - Florida Accessibility Code for Building Construction.
  - Florida Energy Efficiency Code for Building Construction.
  - The National Electrical Code.
  - Occupational Safety & Health Administration Regulations.

  Plumbing design shall comply with the applicable standards and recommended practices of the following organizations:

  - American Society of Plumbing Engineers (ASPE).
  - American Society of Testing Materials (ASTM).
  - American Water Works Associations (AWWA).
  - American National Standards Institute (ANSI).

  In cases where existing facilities are included in the scope of work and the existing plumbing systems do not meet current code requirements, the plumbing systems shall be modified to meet these requirements.

- **Plumbing Calculations.** Calculations of the following items are required for plumbing:
  - Cold- and hot-water-network pipe sizing and sewer pipe sizing in accordance with the Florida Building Code and the National Standard Plumbing Codes
  - Water heaters, in accordance with the guidelines recommended by the American Society of Plumbing Engineers (ASPE); for procedure see ASPE Data Book 1989, Volume I - Fundamentals of Plumbing Design, Chapter 4.
  - Pipe sizing for other building services such as propane, fire sprinkler networks, and irrigation networks.

  Other calculations not listed also may be needed for specific facilities or systems.

- **Plumbing Layout.** The plumbing drawings shall follow the requirements listed below:
  - Locate sumps at depths sufficient for properly draining gravity lines. Inform the structural designer of sump requirements.
  - Piping embedded in slabs shall be positioned to avoid interfering with reinforcing bars. Always inform the structural designer if pipes shall be embedded. Pipe joints shall occur at slab joints for embedded pipe.
  - Provide unions at joints so piping and equipment can be disassembled.
  - Branch connections shall be taken off the top of service-air and instrument-air lines to minimize moisture carryover.
  - Insulate branch connections for hot-water-system piping to minimize sediment carryover.
  - Maintain water mains to a minimum of 3/4-inch diameter in long horizontal runs.
  - Locate cleanout in accessible areas for services and no less than 18 inches from any wall.

- Provide a higher invert elevation of any plumbing branch of 18 inches minimum from finish floor elevation.
- Locate hot and cold piping to minimize safety hazards.
- Provide adequate space to install pipe supports.
- Provide adequate clearances for shut-off valves.
- Do not run water lines over electrical rooms.
- Coordinate underground piping with structural, electrical, and HVAC elements.
- Unless otherwise indicated, all drainage piping 3-inch and smaller shall be sloped 1/4 inch per foot. Larger pipes of 4-inch nominal shall be sloped 1/9-inch per foot.

- **Pipe Support and Anchorage.** All pressure piping shall be restrained. All pipe, gravity, and pressure shall be positively restrained at wall and slab penetrations.

  Locations for anchoring rigid pipe shall be shown on the drawings. Acceptable types of supports—guides, saddles, penetrations, and structural attachments for general pipe support, as well as anchorage details—shall be shown on the standard details. Piping shall be vertically supported by anchor brackets, guides, saddles, or hangers. Each run at each change of direction shall be supported. In general, existing pipes and supports cannot be used to support new piping.

  All nonmetallic pipe 3 inches in diameter and smaller shall be continuously supported with structural channel or other appropriate means.

- **Pipe Protection.** All polyvinyl chloride pipelines shall be evaluated to determine if mechanical protection is required to prevent catastrophic failure, such as a tank inadvertently emptying. No PVC piping shall be installed in ventilation plenum.

3.7 General Instrumentation and Controls Design Criteria

3.7.1 Introduction and Overview

The ICS is an inclusive term covering both field and panel mounted instrumentation, the Plant Monitoring and Control System (PMCS), the Information Management Systems (IMS), and telemetry.

The Design-Builder shall provide an I&C system designed to operate the wastewater treatment plant automatically, to continuously monitor and record all required operational data, and to immediately annunciate and log any alarm condition, event, or operator action.

The I&C system shall:

- Provide a plant PMCS system which consists of a PLC in the main plant control room that provides monitoring and control for treatment process. Remote control or automation of all VFDs and modulating valves shall be provided through the plant PMCS system in the main control room. All other unit operations shall provide monitoring to the plant PMCS system with local control or automation.
- Maintain personnel safety and equipment protection.
- Provide continuous closed-loop control of analog loops.
- Provide sequential/logical control of discrete equipment.
- Provide historical data trending (collection, storage, retrieval, and display).
- Log important events and all operator actions.
- Alarm and log anomalies and take corrective action.

- Provide operations reporting functions including data warehousing, data archiving, relational database management, manual data entry and processing, data verification and validation, and report design, scheduling, and processing. Coordinate with OCWS to aquire database structure and tag naming convention.
- Coordinate with OCWS regarding populating the existing computerized maintenance management system functions including asset management, preventive and corrective maintenance management and tracking, and inventory – iSeries THE Work Order/Facility Maintenance application. OCWS will provide the Design Builder with THE work station.
- Provide a web-based facility information management system with access to electronic versions of operations and maintenance information including equipment operations and maintenance manuals, plant drawings, standard operating procedures, and other items.

3.7.2 References

3.7.2.1 Terminology

Terminology and acronyms used in this section are shown in Table 3-17.

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Table 3-17
Terminology and Acronyms

Term or Acronym	Meaning
Application Software	Software to provide functions unique to this Project and that are not provided by standard software alone. Configuring databases, tables, displays, reports, parameter lists, ladder logic, and control strategies required to implement functions unique to this Project.
Standard Software	Commercial software packages that are independent of the project on which they are used. Standard software includes system software and process monitoring and control software.
System Software	Application independent software developed by digital equipment manufacturers and software companies. Includes but is not limited to operating systems, programming languages such as C++, assemblers, file management utilities, text editors, debugging aids, and diagnostics.
CMMS	Computerized Maintenance and Management Systems.
CPU	Central Processing Unit.
FIM	Facility Information Manager for Data Management and Report Automation.
FDT	Factory Demonstration Test.
HTML	Hypertext Markup Language.
IMS	Information Management System.
I&C	Instrumentation and Control System.
ICS	The overall information and control system. I&C system is an umbrella term covering instrumentation, PMCS, telemetry system, and Information Management Systems.
LAN	Local Area Network.
ODBC	Open Database Connectivity.
OWS	Operator Workstation—generally personal computers and ancillary equipment.
ORT	Operational Readiness Test.
PAT	Performance Acceptance Test.
PLC	Programmable Logic Controller.
PMCS	Plant Monitoring and Control System—generally used in reference to plant monitoring and control.
RDMS	Relational Database Management System.
RMON	Remote Monitoring.
RTU	Remote Terminal Unit.
PMCS	Supervisory Control and Data Acquisition.

PMCS SOFTWARE	Standard software packages, independent of the specific process control project on which they are used, which provide real-time process monitoring, control and historical data collection, and processing and viewing capability.
SCSI.	Small Computer Standard Interface.
Server	A computer or processor that holds applications, files, or memory shared by users on a network.
SDT	Staging Site Demonstration Test.
SNMP	Simple Network Management Protocol.
Telemetry	Communication modes—UHF, VHF, and spread spectrum radio, leased telephone lines, autodialers, etc.—used for communication between the plant, the Operations Center, and off-site equipment such as remote storage tanks and pump stations.

3.7.2.2 Codes and Standards

The I&C System shall comply with codes and standards applicable to the wastewater industry. The codes, standards, and recommended practices listed in Table 3-18 are issued by the following organizations:

ITA	Instrument Testing Association
NFPA	National Fire Protection Association
UL	Underwriters Laboratories, Inc.
ANSI	American National Standards Institute
IEEE	Institute of Electrical and Electronics Engineers
NEMA	National Electrical Manufacturers Associations
ISA	Instrumentation, Systems and Automation Society
DIN	Deutsche Industrie-Norm
AWWA	American Waterworks Association
OSHA	Occupational Safety and Health Administration
SAMA	Scientific Apparatus Manufacturers Association
NEC	National Electrical Code (ANSI/ NFPA-70)
API	American Petroleum Institute RP550 Manual on Installation of Refinery Instruments and Control Systems (API RP550)

Table 3-18
I&C Codes and Standards

References	Title
API RP550	Manual on Installation of Refinery Instruments and Control Systems
IEEE 100	Standard Dictionary of Electrical and Electronics Terms
IEEE 472	Guide to Surge Withstand Capability Tests Instrumentation Symbols and Identification
ISA S5.3	Graphic Symbols for Distributed Control/Shared Display Instrumentation, Logic, and Computer Systems
ISA S5.4	Instrument Loop Diagrams
ISA RP7.3	Quality Standards for Instrument Air
ISA RP12.6	Installation of Intrinsically Safe Instrument Systems in Class 1 Hazardous Locations Annunciator Sequences and Specification
ISA S18.1	Specification Forms for Process Measurement
ISA S20	Control Instruments, Primary Element and Control Valves
ISA S51.1	Process Instrumentation Terminology
NEMA 250	Enclosures for Industrial Controls and Systems
NEMA ICS	Industrial Control
NFPA 70	National Electrical Code
NFPA 820	Standard for Fire Protection in Wastewater Treatment and Collection Facilities
EPA-430-99-74-001	Design Criteria for Mechanical, Electrical, and Fluid System and Component Reliability
ISA S50.1	Compatibility of Analog Signals for Electronic Industrial Process Instruments Hardware Testing of Digital Process Computers, Recommended Practice
SDIN VDE 0611	Specification for Modular Terminal Blocks for Connection of Copper Conductors up to 1,000 V AC and up to 1,200 V DC

3.7.3 System Architecture

3.7.3.1 Connection to Main Plant PMCS

3.7.3.2 Vendor-Supplied Package Controls

Unless otherwise noted in the specific Project design criteria, the criteria for vendor-supplied package controls is:

- Provide non-redundant PLCs as part of vendor-supplied package control systems for various process equipment.
- Vendor-supplied package control PLCs must be furnished with all required interfaces (e.g., ethernet ports, as dictated by the specific Project design criteria).

- For each vendor-supplied package PLC, provide an Operator Interface Unit (OIU), which uses the PLC manufacturer's proprietary operating system and configuration software, and ports directly into the main plant PLC. OIU shall have a color display, touch screen interface with at least 640 x 480 pixels, and display nominal size of 14.58 inches wide x 11.11 inches high. OIU shall be Allen Bradley PanelView 1000 or approved equal.
- For simple packages, vendor may elect to use relay-based package control systems rather than PLCs. However, if relay based packages are used, they must support all required monitoring and control functions as required by the PMCS system.
- Vendor-supplied package control PLCs shall be of the same manufacturer as those provided for the main plant PLC. Communication between the PLCs must use the same protocol.
- Within each package control panel, provide a surge suppressor on the incoming power, and any signal which extends outside a protected building.

Acceptable Manufacturers:

The following manufacturers are considered acceptable suppliers of PLCs:

- Allen Bradley

3.7.4 Project Deliverables

Project deliverables include the following

3.7.4.1 Drawings

Drawings must be prepared in accordance with the standards contained in the Submittals Section. Drawings must be presented logically, following the process train. The following deliverables are required.

Instrumentation and Control Legends:
An I&C legend sheet must be provided based on ISA standard symbology. The Design Builder shall coordinate with TESCO on specific standards and naming convention created for Okaloosa County. All symbols and abbreviations shown on the drawings must appear on the legend.

Control System Block Diagram:
A control system block diagram must be provided to schematically depict the following:

- Locations, interconnection and physical topology of all PLCs including packaged equipment PLCs, servers, workstations, and their in-plant communications networks.
- Data communications cabling. Show type of cable (data highway, coaxial, fiber optic, etc.) and connections.
- Individual PLC configuration including number of racks, power supplies, I/O cards, etc.
- Remote sites, communication links, and Remote Terminal Units (RTUs).

Tagging and Numbering System:
The Design Builder shall coordinate with OCWS on specific standards and naming convention created for Okaloosa County. The tagging and numbering system used shall be provided in accordance with Section 3.6.15.

Process and Instrumentation Diagrams (P&IDs).
P&IDs must be produced for all unit processes. The process flow on all P&IDs must be left to right. Equipment may be shown in either plan or elevation, whichever provides the clearer presentation of the process flow. All process equipment must be shown. The use of "typical" units is acceptable if corresponding equipment and loop numbers are given in tabular form. At a minimum, P&IDs must depict the following information:

- Process equipment.
- Major process piping.
- Auxiliary process piping.
- Instrumentation field elements.
- Final control elements.
- Loop designations.
- Connections and references to other processes and drawing sheets.

Loop Diagrams:
Detailed loop diagrams shall be provided for all control loops. Typical diagrams may be used if loop and equipment numbers are shown in tabular form. At a minimum, loop diagrams shall include content required by ANSI/ISA S5.4. In addition to the minimum standards set by ANSI/ISA S5.4, the following information must be included on the loop diagrams:

- Specific location of each device, such as area, panel location, rack number, etc.
- Instrumentation, equipment, and component descriptions, manufacturers, and model numbers.
- Signal ranges and calibration information, including set point values for switches, alarms, and shutdown devices.
- PLC related items such as input/output (I/O) type and address, PLC rack number, PLC slot number, PLC point number, PLC number, and PLC equipment manufacturer and part numbers.

Elementary Wiring Diagrams and Interconnection Wiring Diagrams:
Elementary wiring and interconnection wiring diagrams for control panels and PLC enclosures shall be provided. These diagrams shall show PLC panel internal wiring and the associated interconnections with field elements and equipment.

Interconnection Wiring Diagrams:
At a minimum, the interconnection wiring diagrams shall show the following:

- Tag numbers of connected field instrumentation and panel components.
- Internal terminal strip number and terminal number assignments.
- External wire number assignments.
- General location of devices such as field or panel.
- All point-to-point interconnections with identifying numbers of electrical cable or wire.
- Show all pullboxes, handholes, and junction boxes for all point-to-point interconnections.

- Field element tag number, description, terminals, location (e.g., "FIELD", enclosure, MCC number), and signal range and calibration information (such as setpoints).
- Circuit name or field wire numbers for wires entering or leaving a panel.
- Energy sources for field, panel, or other devices such as electrical power. Identify voltage and other applicable requirements. For electrical sources, identify circuit or disconnect numbers.

Elementary Wiring Diagrams.
At a minimum, the elementary wiring diagrams shall show the following and be in the following format:

- Overall panel power wiring showing the primary source of panel power, voltages, branch circuits, and power connections to panel and field devices.
- Ladder diagram format with a unique rung number shown on the left side of each rung.
- All devices related to discrete function and requiring electrical connections.
- Each circuit and rung individually. No "typical" diagrams or "typical" wire lists shall be provided.
- Internal wire numbers.
- Terminal strip and block number.

Panel Layouts and Schedules:
Provide detailed drawings of the construction and layout of all control panels and PLC enclosures. The drawings shall show the following.

- Scale Drawings: Show dimensions and location of panel mounted devices, doors, louvers, and subpanels, internal and external.
- Construction Details: Show panel NEMA rating, enclosure dimensions, panel configuration (e.g., type of mounting), panel material, internal backplane dimensions, detailed cable configuration and protocol configuration, and other construction details.
- Instrumentation and Control Components Schedule: Include item number, tag designations, nameplate inscriptions, instrument scale, and any other special information and remarks required for clarity.
- Bill of Materials: Indicate item identifier, tag number, description, manufacturer, model number, and quantity.
- Construction Notes: Include panel wire color schemes, wire and terminal block numbering, and labeling scheme.

If possible, the components schedule and bill of materials should appear on the same drawing as the panel layout.

Control Room and Control Closet Layout Drawings:
A layout must be provided of all control rooms, control closets, electrical equipment rooms, and other areas where I&C panels, workstations, network devices, and related equipment shall be installed. Ample space must be shown for equipment and future requirements. These drawings must be coordinated with other design disciplines, including electrical, HVAC, structural, and architectural.

3.7.4.2 Standard Mounting and Installation Details

Typical mounting and installation details shall be developed for all instrument and control system components. To maintain quality and consistency, these details shall be used whenever possible. Details must define enough information to avoid confusion and to prevent field instruments and panels from being improperly mounted, installed, and used.

In general, details shall conform to standard industry practices as shown in American Petroleum Institute Recommended Practice 550 (API RP 550), "Manual on Installation of Refinery Instruments and Control Systems," and other standard references such as the "Instrument Engineers Handbook" (B. Liptak, Chilton Book Co) and "Instrumentation Handbook for Water and Wastewater Treatment Plants" (R. Skretner, Lewis Publishers). Provided I&C details shall be grouped as follows:

- Analytical instruments
- Flow instrument
- Level instruments
- Pressure instruments
- Temperature instruments
- Miscellaneous I&C components
- Sizing and Selection Calculations.

Provide the following:

- Provide complete calculations plus process data used to size and select all primary elements. For example, for flow tubes, provide minimum and maximum flow, differential pressure at minimum and maximum flows, permanent headloss at maximum flow, and assumptions made.
- Controller, computing, and function generating modules: Provide actual scaling factors used with units and show how they were computed.

3.7.4.3 I/O Lists

An I/O list must be provided, using either Microsoft Access database or Microsoft Excel file format. The database must contain a list of all analog and discrete points connected to the control system. The Design Builder shall coordinate tags and field naming with OCWS.

The PLC I/O list shall include as a minimum the following data fields.

Field Name	Field Description
TAG	The ISA or TESCO tag number for the data point. Tag numbers must follow tagging standards described elsewhere in this document.
DESCRIPTION	A brief description of the function and location of the point
SIGNAL TYPE	Input or output signal type. Signal types include: AI = Analog Input AO = Analog Output DI = Discrete Input

	DO = Discrete Output
I/O ADDRESS	The particular input or output address in the PLC.
RACK NUM	The rack number or address where the I/O point is located.
SLOT NUM	The slot number in the rack where the I/O point is located.
POINT NUM	The point number in the slot where the I/O point is located.
PLC NUM	The PLC number (or station number) that owns the I/O address.
PLC ADDRESS	Internal PLC address for I/O mapping and communication between PLC and PMCS system.
LO RANGE	For analog point: The lowest value of the data point in engineering units. This typically corresponds to a 4 mA DC signal.
For discrete point:	This field shall be left blank.
HI RANGE	For analog point: The highest value of the data point in engineering units. This typically corresponds to a 20 mA DC signal.
For discrete point:	This field shall be left blank.
LO ALARM	The value in engineering units of the point at which a low value alarm is initiated. For discrete points, this field shall be left blank.
LOLO ALARM	The value in engineering units of the point at which a low low value alarm is initiated. For discrete points, this field shall be left blank.
HI ALARM	The value in engineering units of the point at which a high value alarm is initiated. For discrete points, this field shall be left blank.

Field Name	**Field Description**
HIHI ALARM	The value in engineering units of the point at which a high high value alarm is initiated. For discrete points, this field shall be left blank.
EU	The engineering units that the ranges and alarms are specified in. For discrete points, this field shall be blank.
STATUS	For discrete points: A word to describe what the status of the point is when the data point is set high (true). STATUS words include:

ON	
OFF	
STRT	(Start)
STOP	(Stop)
OPND	(Opened)
CLSD	(Closed)
FWD	(Forward)

REV	(Reverse)
AUTO	(Automatic)
MAN	(Manual)
CASC	(Cascade)
REM	(Remote)
LOC	(Local)
HI	(High)
HIHI	(High-High)
LO	(Low)
LOLO	(Low-Low)
FAIL	(Fail)
TRBL	(Trouble)
ALM	(Alarm)

For analog points, this field shall be left blank.

3.7.4.4 Instrument Data Sheets

Instrumentation data sheets shall be provided for all instrumentation and secondary components. Data sheets provided are to be similar to ISA data sheets, ISA standard ISA-S20 Specification Forms for Process Measurement and Control Instruments, and Primary Elements and Control Valves. Data sheets for instrumentation and control components shall include the following information, as applicable:

- Instrument tag number.
- Instrument type.
- Instrument location or service.
- Manufacturer and complete model number.
- Size and scale range.
- Setpoints.
- Materials of construction.
- Power requirements.
- Mounting type.
- Options included.

3.7.4.5 Sequence of Operation and Process Loop Descriptions

Narrative descriptions of each process and control loop must be provided. The narrative must be a concise, easy-to-follow description of the control sequence, algorithm, and interfaces with other loops and equipment.

3.7.4.6 Field Cable and Wire

All field wire, cables, and circuits shall be documented either on schedules or drawings. A field cable and wire schedule must include at a minimum the following information:

- Field cable and wire tag/number:
  - Quantity, type, and size of wire or cable (as applicable)/
  - Origination of circuit/
  - Destination of circuit/

3.7.5 ICS Design Criteria

This section defines the design criteria for Information and control systems for the plant process equipment. It does not address instrumentation and controls for other systems such as lighting, HVAC, or power distribution.

3.7.5.1 Reliability and Redundancy

The ability of wastewater facilities to continue to operate and maintain water quality limits under atypical or adverse conditions is an important design consideration. Plants also must be able to continue treatment during necessary maintenance and scheduled downtimes. EPA Technical Bulletin EPA-430-99-74-001, Design Criteria for Mechanical, Electrical, and Fluid System and Component Reliability, is the basis for designing reliable wastewater facilities.

The Instrumentation and Control system shall be designed so that no single component failure can result in a plant outage or loss of control. The plant must also be able to continue treatment during necessary maintenance and scheduled downtimes. This does not mean that all control and equipment must be provided with redundant units. Redundancy is only required for critical components, including:

- The main plant PMCS system.
- The network communications.
- Workstations in the main plant control room.

Redundant components must be powered from separate uninterruptible power supplies (UPSs). Backup Hi and Low alarms shall be provided for analog monitoring systems. Provide backup float switches in case ultrasonic level transmitter malfunctions. Where practical, redundant process elements shall be served by separate I/O racks and/or modules. For example, if there are four high service pumps, the Design-Builder shall terminate digital inputs for two pumps onto one I/O module, and digital inputs for the other two pumps on a separate I/O module.

3.7.5.2 Network Design

Network Protocols:
Provide network components including PLCs, servers, workstations, switches and other components using the following protocols:

- IEEE 802.3 CSMA/ CD (ISO/IEC 8802-3).
- IEEE 802.3i 10BASE-T (ISO/IEE 8802.3).
- IEEE 802.3u 10BASE-T (ISO/IEE 8802-3).
- IEEE 802.1D MAC Bridges (ISO/IEC 10038).

Use Transmission Control Protocol/Internet Protocol (TCP/IP) for communication among servers, workstations, and PLCs. Proprietary protocols are acceptable for communications: 1) between redundant PLC pairs and I/O bases, and 2) where asynchronous serial communication links are used between PLCs and remote PLCs or RTUs.

Ethernet Switches:
As a minimum standard, the type of network switches required shall be 3COM SuperStack 3 4950 Switch(s) (3COM Item#:3C17706-US) for the "backbone" of the plant with additional 3COM SuperStack 3 4924 Switch(s) (3COM Item# 3C17701-US) for network connections.

Network Communication Media:
Use fiber optic media for all on-site and off-site network communication links (Ethernet and other) that are over 30 meters in length or extend outside any lightening protected building. Radio communications are not acceptable.

3.7.5.3 Spares and Future Capacity

Installed Spare Capacity:
Provide a minimum of 20 percent installed spare capacity for all components and assemblies. The following is a list of some components requiring spare capacity:

- Programmable Logic Controllers (PLC) memory.
- PLC I/O points.
- PLC rack slots.
- PLC OIUs.
- Terminal blocks.
- Power supplies.
- Control panel space.
- Computer disk drives.
- Process monitoring and control database.
- Graphic displays.
- Spare conductors, fibers and cables (see Spare Conductors and Cables section).
- Future Capacity. For projects without routers, the PMCS must be designed to allow future connections with other systems (see related project specific requirements).

Shelf (Non-Installed) Spares:
Provide a minimum of 20 percent shelf spares for components and assemblies listed below. Provide a minimum of at least one shelf spare for each listed component. The following is a list of I&C components requiring shelf spares. If noted in this list, provide spares as noted rather than 20 percent.

- Surge suppressors.
- Major network devices.
- Media converters.
- Ethernet switches.
- Light interface units (patch panels).
- Patch panels.

- Major PLC components.
- Optical communication modules.
- Operator interface units (one of each type).
- Remote I/O modules.
- Chassis power supplies.
- PLC CPUs (one of each type).
- Serial communication modules.
- Uninterruptible power supplies (UPS).

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3.7.6 Control Hierarchy

3.7.6.1 Control Hierarchy Levels

Provide a LOCAL/REMOTE (and START/STOP, OPEN/STOP/CLOSE, etc.) or HAND/OFF/REMOTE selectors at each piece of equipment. These selectors shall provide the only local manual control for each device.

Use the following switch position and actuation definitions:

- REMOTE Position. The PLC has control. Operator Workstations provide AUTO/MAN selectors for each piece of equipment for selection between remote manual control from Operator Workstations or PLC control.
- LOCAL. Control is transferred to manual control device at the driven equipment. The equipment can be started, stopped, open, closed, etc. with local controls.
- HAND. The equipment runs. Only hardwired equipment protection and personnel safety interlocks are active. Equipment automatically restarts after a power failure.
- OFF. As an actuation, equipment shall not run when the control switch (hardwired or software) is in this position. As an indication, indicates that the equipment is not operating.
- ON. As an indication status, indicates that the equipment is operating.
- START. The equipment starts. Only hardwired equipment protection and personnel safety interlocks are active. Equipment requires manual restart after a power failure.
- STOP. The equipment or valve stops and remains stopped or off.
- OPEN. As an actuation, the valve begins to open and continues to open until the STOP pushbutton is pressed or the end of travel is reached. As an indication, indicates that the valve is fully open.
- CLOSE. As an actuation, the valve begins to close and continues to close until the STOP pushbutton is pressed or the end of travel is reached. As an indication, indicates that the valve is fully closed.

3.7.6.2 Local Control

Local manual control overrides PLC control, but not hardwired interlocks. Local control is intended to be used primarily for maintenance functions and not for normal operation.

3.7.6.3 Maintained Versus Momentary Controls

In general, provide PLC discrete outputs that are maintained closed as long as the equipment is required in run.

3.7.6.4 PLC Monitoring and Control of Constant Speed Motor Driven Drive

As a minimum, each equipment controller and control station shall provide isolated, maintained contacts, which shall be input to the PLC to monitor each of the following:

- Motor Running
- Motor in Remote and ready to operate
- Motor Fail [only required when hardwired interlocks or drive fail conditions exist.]

3.7.6.5 PLC Monitoring and Control of Variable Speed Drives

In addition to requirements for motor driven equipment, provide the following for each variable speed drive:

- Hardwired manual speed control and indication, at drive itself, not locally at the equipment.
- Equipment shall be started and stopped locally at the driven equipment and not the variable speed drive.
- An isolated 4-20 mA signal of speed indication to the PLC system. Each VFD shall: Run (by accepting a maintained RUN signal from the PLC) and accept from the PLC a 4-20 ma speed setpoint.

3.7.6.6 PLC Monitoring and Control of Valve and Gates (if applicable)

Modulating Valves and Gates:
Valve or gate positioning control can either be provided by electronic controllers integral to the valve or gate as shown, or PLC based positioning control. For valves and gates with integral electronic controllers, the PLC shall provide 4 to 20 mA DC analog position control outputs. For valves and gates using PLC based positioning control, the PLC shall provide OPEN and CLOSE contact outputs and accept a 4 to 20 ma DC analog position feedback signal. For either control scenario, the PLC shall receive OPEN and CLOSED valve position discrete inputs.

Open/Close Valves and Gates:
For electrically actuated OPEN/CLOSE valves and gates, the PLC shall:

- Provide OPEN and CLOSE valve control outputs.
- Accept OPEN and CLOSED valve position discrete inputs.
- Solenoid Valves. In general, position switches are not available for solenoid valves. Provide interposing relays and control schemes as required.

- Where position switches are available, provide full open and full closed valve position valve position inputs.
- For solenoid valves without position switch contacts, use the current state of the command signal and feedback of the OPEN/CLOSE/REMOTE hand switch position to infer a valve position.
- Valve Fail Positions. Unless otherwise noted in the Project specific design criteria, provide the following valve fail positions:
  - Modulating Valves and Gates, with Integral Electronic Controllers: Upon loss of analog position control signal from PLC, the valve/gate shall remain at last position. Upon loss of actuator power, the valve/gate shall remain at last position.
  - Modulating Valves and Gates, without Integral Electronic Controllers: Upon the PLC losing the 4-20 mA DC analog position transmitter input, the valve/gate shall remain at last position. Upon loss of actuator power, the valve/gate shall remain at last position.
  - Open/Close Valves and Gates: Upon loss of actuator power, the valve shall remain at last position.

Solenoid Valves:
Seal water valves shall be Fail Open, and thus shall open upon loss of power. Unless otherwise noted, all other solenoid valves shall be Fail Closed, and thus shall close upon loss of power.

3.7.7 Control System Practices

3.7.7.1 Equipment Protection and Personnel Safety

Except for devices required for protection, logic shall be accomplished by the PLC and not by devices hardwired into the equipment starters. Most interlocks shall be provided through the plant control system and not hardwired to individual starters.

In general, only those protective devices which are required for equipment protection or personnel safety shall be hardwired directly into the sensing device, individual equipment controller or starter, and not rely on the plant control system. There shall be no duplication of hardwired interlocks through the plant control system.

Where hardwired interlocks are necessary:

- The interlocks must be operational in all control modes including local (including Local Manual) and Remote, unless specifically agreed to by OCWS in writing.
- Provide contact outputs directly from the sensing device without interposing relays where feasible.
- The actual protective instruments shall be of the automatic reset type, but the interlock should be latched until reset manually.
- Provide a manual reset at the interlocked equipment.
- Provide individual indicating lights on the equipment controller indicating specifically what caused the failure.
- Provide a secured key lock for interlock override. Keys for all interlock overrides shall be identical.
- Provide an alarm generation and contact input to the PLC when in override.

3.7.7.2 Discrete Signals

Discrete inputs shall be 24 VDC.

Discrete outputs, including spares, shall be 24 VDC driving interposing relays within the control panels wired to the field termination terminal blocks. Wire out spare discrete outputs including the interposing relays and terminal blocks. Contact outputs shall be arranged such that on loss of PLC power the controlled equipment shall de-energize.

3.7.7.3 Analog Signals

General Requirements:
All analog inputs shall be isolated 4-20 mA DC. Wherever possible, analog input devices should be 2-wire loop powered from the control panel. All current loops must have an easily accessible point where a signal simulator can be temporarily connected for testing purposes.

Where required to convert to voltage, 4-20 mA DC signals must be converted to voltage at panel terminal blocks, and signals within the panel must be parallel-wired to the various receivers. This scheme prevents current loop-loading problems and permits lifting signal leads from individual instruments during maintenance and troubleshooting without interrupting the current loop. Resistors for converting 4 to 20 mA DC to voltage must have a minimum precision of 0.1 percent.

Signal Conditioning:
Analog process-signal conditioning and conversion functions (such as square-root extraction and linearization) shall be performed in the field instrument transmitter, if possible. In general, signals shall be converted in the field, particularly if local indication or backup hardware is required.

3.7.7.4 Corrosion Protection

The Design-Builder shall provide corrosion protection for components of the I&C system in accordance with Section 3.8, General Corrosion Control Requirements. In addition, the Design-Builder shall provide corrosion protection as required by the Section Control Panels/Enclosures.

3.7.7.5 Control Panels

Installation:
The clearance behind major free-standing panels must comply with code requirements and, in general, shall be at least 3 feet. The viewing clearance in front of panel shall be no less than one-half the panel width, with a minimum clearance of 5 feet. The viewing clearance need not exceed 10 feet, even for large panels.

Freestanding panels not requiring rear access may be located with their rear flush to the room's wall. However, panel design must ensure that ventilation is adequate to maintain panel component operation within a suitable temperature.

"Local" control panels should be installed only when required for proper system operation. Area control panels and local "backup" control panels generally are not desired or required.

Enclosures:
Enclosures must be suitable for the specific application. If possible, panels shall be designed in accordance with manufacturers' standard configurations and sizes. Panels must not be installed in areas that are likely to flood. Control panel enclosures shall be rated as follows:

- Panels in control rooms or other conditioned spaces must be rated NEMA 12 as a minimum.

- Panels not in conditioned spaces must be rated NEMA 12 (industrial dust tight) as a minimum.
- Panels in process areas, or other damp or wet locations, shall be NEMA 4X 316 stainless steel. Materials used must match the specific chemical environmental compatibility requirements.
- Outdoor Panels shall be 316 stainless steel NEMA 4X with a drip shield and solar screen.
- Provide air conditioners suitably sized to dissipate heat within the enclosure and maintain equipment within equipment temperature ratings as required. Louvers or force ventilation system shall not be allowed.
- Wall-mounted panels in wet locations must be installed at least 3 feet above the floor.
- All panels must contain an internal, door activated panel light, a 120 VAC power receptacle and a drawing storage pocket.
- Corrosion-inhibitor vapor capsules and vent-drains must be furnished in all NEMA 4X control panels as well as in other control panels as required by process conditions

DC Panel Power and Loop Powering Practices:

Where required, 24-volt DC control power must be provided from multiple redundant, regulated power-supply units with automatic fold-back in case of overload. To permit designated signal circuits as Class 2, the maximum capacity of 24-volt DC supplies must not exceed 4 amperes. The negative terminal of 24-volt DC power supplies must be grounded. Power supplies shall be diode isolated. All power supplies installed in panels must be supplied with a NEMA 1 enclosure.

Individual fuses shall be provided for each 4-20 mA signal loop.

Individual fuses shall be provided for each group of discrete inputs for a common piece of equipment.

Wiring Terminations:

All PLC I/O wiring shall be terminated on removable terminal strips on the individual PLC modules that permit removing I/O modules without disconnecting the wiring. Tag and mark all terminal blocks and individual wiring.

All wiring from the field shall terminate on separate numbered terminal blocks. Separate groups of terminal blocks shall be provided for the following:

- Discrete inputs.
- Discrete outputs.
- Analog inputs.
- Analog outputs.

Each different voltage level shall also be on separate tracks at least 6 inches apart. All outside voltage sources of a like voltage level should be grouped together, and shall also be labeled and provided with individual disconnects.

3.7.8 Field Instrumentation

3.7.8.1 General

Provide instruments that reset automatically and immediately to accurate measurement upon restoration of power after a power failure, except where specifically noted.

Use single source manufacturer for each instrument type. Use the same manufacturer for different instrument types whenever possible.

Provide instrumentation of rugged construction designed for site conditions. Provide only new, standard, first-grade materials throughout, conforming to standards established by Underwriter's Laboratories (UL), Inc., and so marked or labeled, together with manufacturer's brand or trademark.

Instrument enclosures shall be NEMA rated for the environment. In hazardous areas, meet the NEC Class, Group, and Division as shown or specified. Submergence rated enclosures shall be provided in areas subject to flooding.

Provide instrument transmitters that produce isolated 4-20 mA DC analog signals. Follow ISA-S50.1.

Use linear, direct reading indicators unless otherwise specified. The table below presents the minimum instrumentation required for each unit process. Additional instrumentation may be required depending on the specific processes and equipment selected.

The Design-Builder is responsible for installing any additional instrumentation for proper operation maintenance control and operation of all equipment.

DESCRIPTION	SERVICE	LOCATION	MANUFACTURER	REMARKS
Activated Sludge System				
Dissolved Oxygen Probes (2 per basin)	Dissolved Oxygen Concentrations	Activated Sludge System	Great Lakes	
Ultrasonic Level Transmitter	Aeration Train Effluent Measurement	Aeration Basin	Miltronics, STI, or Pulsar	
Pressure Gage	Blower Discharge Pressure	Blower Discharge (1 per blower)	Ashcroft or approved equal	Liquid Filled, minimum 4-1/2" dial,
Pressure Switch (High)	High Pressure for Blower Discharge	Blower Discharge (1 per blower)	Ashcroft, or United Electric	Applies only if blowers are utilized
Motor Current Transmitter	Blower Motors	Aeration Blowers		Applies only if blowers are utilized
Local Control Panel	Blowers/Surface Aerators	Aeration Basin		
Local Control Panel	Mechanical Mixers	Aeration Basin		Applies only if mechanical mixer utilized
Secondary Clarifier Basins				
Torque Switches (High and High High)	Clarifier Mechanism Torque	Clarifier Mechanism		
Ultrasonic Continuous Level	Scum Pit Level	Clarifier	Miltronics, STI, or Pulsar	

DESCRIPTION	SERVICE	LOCATION	MANUFACTURER	REMARKS
RAS Pumping				
Electromagnetic Flow Meter	Return Activated Sludge Flow Measurement	Downstream of RAS Pumps	Foxboro, Rosemount, ABB/Fischer&Porter	
Pressure Gage	RAS Pump Discharge Pressure	RAS Pump Discharge (1 per pump)	Ashcroft	Liquid Filled, Minimum 4-1/2" face
Pressure Switch (High)	High Pressure for RAS Pumps	RAS Pump Discharge (1 per pump)	Ashcroft, or United Electric	Diaphragm seals
Local Control Panel	RAS Pumps	RAS Pump Station		
UV Disinfection				
Electromagnetic Flow Meter	UV Influent Flow	Influent to UV (1 per channel)	Foxboro, Rosemount, ABB/Fischer&Porter	
Ultrasonic Level Transmitter	UV Channel Level	UV Channel	Miltronics, STI, or Pulsar	
Local Control Panel	UV Disinfection	UV Channel (1 per Channel)		
Effluent Pump Station				
Pressure Gage	Effluent Pump Discharge Pressure	Effluent Pump Discharge (1 per pump)	Ashcroft	Liquid Filled, Minimum 4-1/2" face
Pressure Switch (High)	High Pressure for Effluent Pumps	Effluent Pump Discharge (1 per pump)	Ashcroft, or United Electric	Diaphragm seals

3.7.8.2 Maintenance and Troubleshooting

The continued, useful operation of a control system depends on effective maintenance and calibration. The availability of complete system documentation and the installation of proper test connections greatly assist in maintenance and calibration. During the design of the I&C system, every effort must be made to make the system as easy to maintain and troubleshoot as possible.

The following guidelines shall be applied when selecting instrument locations:

- Install control equipment in easily accessible locations. Equipment or piping should not have to be removed to access controls.
- Locate instruments so the instrument is protected from adverse conditions and not exposed to corrosion. Wherever possible, mount all controls within 5 feet of finished floor.
- Avoid installing instruments where they could be accidentally submerged, damaged by passing vehicles, or dripped upon.
- Install instruments in areas adjacent to where operators walk so local indicators can be checked easily to confirm proper operation.
- Use intrinsically safe instruments in explosion-proof environments wherever possible.
- When performing routine maintenance, personnel should not need to break any permanent piping or electrical connections.
- Locate instruments so routine maintenance does not require using ladders or placing personnel outside of protective handrails.

- As much as possible, locate transmitters inside buildings to ease calibration.
- Install all equipment and instrument tubing rigidly. It is intended that after installation a slight to moderate pressure on the installed device shall not move it and in no circumstance should it sway back and forth if pressure is suddenly removed.
- Pressure transmitters must have suitable fittings and valves so a test gage can be easily installed without shutting down the process or interrupting the measurement and its transmission to other process instruments. When performing routine maintenance, personnel should not need to break any permanent piping or electrical connections.

3.7.8.3 Level Measurement

Required Type for Intended Service:
Unless otherwise noted in the process specific section or in the table, use the following types of level measuring devices:

- For clean water wetwells, use ultrasonic level elements and transmitters, level electrodes and level electrode relays, and level float switches.
- For wetwells holding scum or sludge-bearing waters, use ultrasonic level elements and transmitters.
- For backup point monitoring, use a device suitable for the intended service. For example, consider a wetwell in which the primary device is an ultrasonic device. Permissible backup devices are electrodes, floats, or other ultrasonic devices.
- Devices containing mercury (such as floats with mercury switches) shall not be used in potable water applications. Mercury free floats may be used for potable water applications.

Backup Level Point Monitoring:
Unless otherwise noted in the process specific design criteria for all wetwells, provide backup level point monitoring to the primary level element. For instance, if an ultrasonic level transmitter is the wetwell's primary element, provide backup High High and Low Low alarms, using Floats as the backup level element.

Ultrasonic Level Transmitters:
All ultrasonic level transmitters shall be microprocessor-based devices with external keypads, LCD display, and shall be programmable without the use of potentiometers. Transmitter enclosures shall be NEMA 4X rated. Provide at least one calibration per lot of transmitters. Acceptable manufacturers include Milltronics, STI, or Pulsar.

- Provide solar shields on both the sensor and transmitter for each unit located outdoors.
- Install units so that the sensor's sound wave cone of influence does not reflect off a side wall within the measuring range.
- For units located outside, install sensor/transmitter cable in grounded PVC metallic conduit to prevent possible radio interference.
- For adjacent transmitter, provide synchronization interconnection cable to prevent sonic wave interference.

Resistance Tape Level Transmitters:
Units shall consist of resistance tape (element), transmitter, and miscellaneous parts such as filters and desiccant. Actuator depth shall be 5 inches, nominal. Welted materials shall be polyester epoxy, Type 303 stainless steel, and glass-filled polypropylene. Transmitter shall be loop powered. Desiccant shall have a 12- to 48-month life. Acceptable manufacturers include Consilium Metritape Type AGS.

Level Conductance Electrodes:
Units shall have 316 stainless steel electrodes and electrode holders, unless otherwise required by the process fluid. Unless otherwise noted, rod type electrodes shall be used in wetwells and sumps; suspended type shall be used in ground storage tanks. Relays shall be of the solid state type and shall have a NEMA 4X enclosure. Acceptable manufacturers are B/W controls or Charles F. Warrick Company.

Level Float Switches:
Floats shall be watertight and shall have a diameter of at least 4 inches. Exterior float material shall be polyethylene. Unless otherwise noted, floats shall be provided with ancillaries suitable for pipe mounting. Floats containing mercury shall not be used for potable water service. Acceptable manufacturers are Consolidated Electric, Pulsar, or Anchor Scientific.

3.7.8.4 Flow Measurement

Required Type for Intended Service:
Unless otherwise noted in the process specific section or the instrument table above, use the following types of flow measuring devices for various applications. Design flowmeter pipe runs to provide upstream and downstream clearances required by the selected flowmeter. In cases where several types are permissible for a given service, the type used shall: 1) be suitable for use with the available upstream and downstream clearances, and 2) posses adequate turndown for the design flow range. Apply flowmeters as follows:

- For chemical feeds, use electromagnetic flow meters. For pH neutral feedstreams, use polyurethane liners with 316 stainless steel liners. For non-neutral pH feedstreams, use Teflon liners with electrodes of suitable material (Tantalum, Hastelloy C, Platinum, or Titanium).
- For pH neutral sludges such as RAS, WAS, and digested sludge, use electromagnetic flowmeters with polyurethane liners and 316 stainless steel electrodes.
- For pH non-neutral sludges, use electromagnetic flow meters with Teflon liner with suitable electrode material.
- For abrasive sludges such as grit, use electromagnetic flowmeters with either ceramic or polyurethane liners.
- For process air service, use insert flow tubes or thermal mass flow meters.

Venturis:
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Venturi turndown shall be such that the venturi can accurately measure the design flow range. If turndown for a single venturi is insufficient, make provisions to measure the entire flow range. Possible alternatives include:

- Parallel venturis, of different sizes if necessary.
- A single venturi with multiple transmitters of overlapping calibrated ranges and PLC or RTU signal processing to produce a single combined flow signal.
- A different style flowmeter with inherently greater turndown, such as an electromagnetic flowmeter where adequate upstream and downstream clearances are available.

Electromagnetic Flow Element and Transmitter (Magmeters):

Unless otherwise noted, magmeters shall have a 304 stainless steel tube. Liner and electrodes shall be suitable for the intended service. Magmeters shall be provided with grounding rings or electrodes. Magmeter elements shall be rated for accidental submergence. Magmeter transmitters shall be remote (nonintegral) from the meter, and shall be NEMA 4X rated. Transmitter shall include local (LCD) display of both instantaneous flow rate and totalized flow. Provide one calibration unit per lot of magmeters provided. Do not use magmeters where acceptable upstream and downstream piping clearances cannot be assured.

Acceptable manufacturers are Foxboro, ABB/Fischer and Porter, or Rosemount.

Size magmeter so its turndown can accurately measure the entire process flow range. For sludges, size magmeters such that process flow is at least 3 feet per second (fps) under average process conditions.

Flow Element and Transmitter, Flume/ Weir, Ultrasonic:
Unit shall be nonintrusive and shall be of the ultrasonic type. Unit electronics shall be configured to match the characteristics of the associated primary element (flume or weir). Provide one calibrator for each lot of transmitters provided. Acceptable manufacturers include Milltronics, STI, or Pulsar.

3.7.8.5 Pressure Measurement

General:
These devices include pressure instruments used for directly measuring pressure, inferred level from pressure, inferred flow from differential pressure, pressure switches, and pressure gauges.

Installation Practices:
Provide the following accessories to meet the following requirements, as applicable.

- Instrument tubing shall be 316 stainless steel unless otherwise required by the process fluid. All instrument tubing shall be sloped at a 1:12 slope and shall be rigidly mounted. Provide blowoff lines with isolation valves to remove sediment and air.
- Provide pressure snubbers or pulsation dampeners for all pressure measurement devices where pressure fluctuations could provide inaccurate readings or damage instruments.
- Provide diaphragm seals where isolation from the process is required such as for all chemical feed applications.
- Provide isolation valves for all instruments.
- Provide two-way valve manifolds on all pressure transmitters to facilitate calibration without removing instrument.
- Provide three-way valve manifolds on all differential pressure transmitters to facilitate calibration without removing instrument.
- All transmitters shall be provided with local direct reading indicators.
- Provide heat tracing for all outdoor pressure lines.
- Provide solar shields for all pressure and pressure differential transmitters located outdoors.

Pressure and Differential Pressure Transmitters:
Acceptable pressure and differential pressure transmitter manufacturers are Foxboro, Rosemount, ABB/Fischer&Porter, or Honeywell. Differential pressure transmitters used for flow measurement shall be provided with integral square root extraction.

Pressure Annular Seals:
Units shall be an annular fluid-filled device that measures pressure around the full circumference of the pipe. Units shall have buna-n liner, carbon steel body and flange, and 50:50 glycol:water fluid, unless otherwise noted. Acceptable manufacturers are Red Valve or Ronningen-Petter.

Annular seal site and installation shall be a function of process pipe size as follows:

- For process pipe 4 inches and below, the annular seal shall be mounted in-line with the process pipe.
- For process pipe above 4 inches, the annular seal can be mounted off-line of the main process. For these applications, use 2-inch seals.

Pressure Diaphragm Seals:
Units shall have 316 stainless steel lower housings and diaphragms; unless otherwise required by process fluid. Unit shall have flush connections in lower housings, and bleed connections in upper housing. Acceptable manufacturers are Ashcroft or Ametek Mansfield and Green.

Pressure Indicators:
Units shall be Bourdon tube actuated for ranges above 10 psig and direct reading bellows for ranges below 10 psig. Dial size shall be 4-1/2 inches minimum. Acceptable manufacturers are Ashcroft.

Pressure Switches:
Units shall be the diaphragm sealed piston actuator type with automatic reset and snap action switch. Acceptable manufacturers are Ashcroft B Series, United Electric Series 400 or Static-O-Ring.

3.7.8.6 Temperature Measurement

Installation Practices:
Provide thermowells on all temperature elements. Thermowells shall be 304 stainless steel; unless otherwise required by process fluid.

Temperature Transmitters:
Units shall be three or four wire RTDs with integral two wire transmitters. Elements shall be 100-ohm platinum conforming to SAMA Standard RC 21-4 accuracy specifications. Acceptable manufacturers are Foxboro, ABB/Fischer&Porter, or Rosemount.

Temperature Switches:
Units shall have vapor pressure bulb sensing elements, automatic reset, and snap action switch. Acceptable manufacturers are Ashcroft B Series or Barksdale.

Temperature Indicators:
Units shall have liquid or gas filled element. Dial size shall be 4-1/2 inch minimum. Acceptable manufacturers are Ashcroft or Ametek US. Gauge Division.

3.7.8.7 Analytical Instrumentation

Turbidity Analyzer and Transmitter, Low Range:
The unit shall measure turbidity of high quality treated water. Principle of operation shall be light scatter detection measurement. Range shall be 0-100 NTU with a resolution of 0.001 NTU. Unit shall include a bubble trap and vent. Provide a complete unit consisting of the following:

- Element.
- Analyzer/transmitter.
- Cable.
- Mounting hardware.
- Lamp units.
- Calibration kit. (2 year supply)
- Expendables. (2 year supply)

Transmitter enclosure shall be NEMA 4X. Acceptable manufacturers are Hach, HF Scientific, Great Lakes, and ABB Taylor.

Dissolved Oxygen Sensor and Transmitter:
The unit shall measure dissolved oxygen of wastewater. Sensor shall be temperature and pressure compensated with an accuracy of 0.2 ppm. The response time shall be 90 percent in 20 seconds with an operating temperature of 32 to 104 Deg F. The transmitter shall be 2-1/2 digit local LED display with 0.1 ppm resolution. Provide a complete unit consisting of the following:

- Element.
- Transmitter.
- Cable.
- Junction box.
- Expendables. (2 year supply)

Acceptable manufactures are Rosemont, or Great Lakes with Zulligprobe.

Mixed Liquor Suspended Solids Sensor:
The unit shall measure mixed liquor suspended solids of wastewater, both raw and treated. The system shall be capable of measuring suspended solids concentration from 500 – 5,000 ppm and complete with single light source and minimum of two sensors. Seal the complete unit against moisture. The resolution and sensitivity shall be 10 ppm. Provide a complete unit consisting of the following:

- Element.
- Transmitter.
- Cable.
- Junction box.
- Expendables. (2 year supply)

pH Analyzer and Transmitter:
Unit shall electromechanically measure pH without requiring electrolyte flow. Provide a complete unit consisting of the following:

- Element.
- Transmitter.
- Cable.
- Junction box.
- Expendables. (2 year supply)

Unit shall have integral temperature compensation. Accuracy shall be better than 0.05 pH units with 24-hour zero stability of 0.01 pH units. Indicator shall be LCD or LED. Transmitter enclosure shall be NEMA 4X. Acceptable manufacturers are Rosemount or Foxboro.

3.7.9 Conductors and Cabling for Instrumentation and Communication

3.7.9.1 Installation Practices

All cabling shall be installed in conduit or cable tray. Cable tray is preferred but not required. Individual conduit runs shall be kept to a minimum and control cabling may be combined in common conduits and routed to centralized terminal boxes to the greatest extent possible. Wherever combined control cables are split out of a common conduit, a terminal box shall be provided. Note that different control voltages shall not be combined.

Exposed aerial cable and wiring methods outdoors are not acceptable.

To minimize effects of lightning and surges, underground control and communication cabling routed outside the building confines shall meet the following requirements:

- Underground or outdoor communication media on site shall use fiber optic cable to communicate between PLC components.
- For off-site facilities (such as pump stations and storage tanks), use radio communications media between PLC components.
- Where individual control or monitoring signals must be routed outside, minimize the routing lengths. Evaluate cost-effectiveness of installing a separate remote I/O cabinet near the monitored equipment.

3.7.9.2 Grounding

Proper grounding of equipment is essential for reliable and safe operation of the complete I&C system. See Section on Grounding for minimum requirements.

3.7.9.3 Conductor Labeling

Wire labels shall be provided for each individual conductor and multiconductor assemblies at all termination points including termination/junction boxes. Labeling of "through" wiring at pull boxes will not be required.

3.7.9.4 Fiber Optic Cable

Provide 62.5/125 micron, multimode fiber optic cable.

All fiber optic cable (including spares) shall be terminated or spliced in fiber optic patch panels. All patch panels indoors shall be provided with NEMA 12 enclosures. All panels outdoors shall be located in NEMA 4X enclosures. Provide patch panels at every structure boundary and in every panel enclosure.

3.7.9.5 Shielded Twisted Cabling

Shielded twisted pair or triad cabling shall be used for all analog signal loops.

3.7.9.6 Telephone Cabling

Category 5e twisted pair telephone cabling shall be used for all 10/100BASET wiring.

3.7.9.7 Conductors and Cables

Conductor Installation:
Signal circuits must be separated physically from power and control circuitry by no less than 24 inches in non-metallic raceway systems and 12 inches in metallic raceway systems. Spacing may be reduced only for short sections at crossovers and where signal cables enter control cabinets.

Cable Installation:
Network cables must be installed in rigid conduit. Fiber optic network cables shall be used when practical. Analog wiring installed underground must be in steel conduit. For more information, see electrical spare conductor section.

Spare Conductors and Cables (Fibers):
Spare conductors and fibers must be provided in all I&C system conduits. All spare wires and fibers entering local control panels or terminal junction boxes must be terminated. Wires and fibers shall not be coiled in the bottom of a cabinet. All spare conductors and fibers must be labeled as spare, and shall be numbered.

Provide at least 20 percent spare wires and 50 percent spare fibers per circuit with a minimum of two spare conductors/fibers per circuit. Round required amount of spares to the nearest whole number.

3.7.9.8 Multiconductor Control Cable

Multiconductor control cabling shall be used for all discrete signal wiring.

Multiconductor control cable shall be used instead of single conductor control cable due to ease of identifying individual conductors by color as well as individual conductor labeling.

Each multiconductor control cable must provide at least 25 percent spare conductors.

3.7.10 Instrument Air System and Miscellaneous Mechanical Components

3.7.10.1 Instrument Air System

Where pneumatically operated valves are being provided to be consistent with existing equipment, provide an instrument air system. Because it is critical to valve operation, the instrument air system shall meet the redundancy and reliability requirements specified previously in this Design Criteria Package.

The instrument air system shall be designed to meet the requirements of ISA Standard S7.3, Quality Standards for Instrument Air including requirements for minimum dew point, maximum particle size, and maximum total hydrocarbon (oil-free) content.

3.7.10.2 Miscellaneous Mechanical Components

Miscellaneous mechanical components shall be fabricated with 316 stainless steel wetted parts unless otherwise indicated or required by process fluid.

Pressure Gauge:
Other than for process variable measurement, pressure gauges shall have a 4-inch dial size. Accuracy shall be 2 percent of span. Scale range shall be such that normal operating pressure lies between 50 and 80 percent of scale range.

Acceptable manufacturers are:

- Ashcroft Utility.
- Gauge Series 1000, Marsh.
- Standard Gauge Series, Ametek U.S.
- Gauge Series P500, or Acculite; Series 2000.

Needle Valves:
Needle valves shall have a 0.020-inch orifice. Acceptable manufacturers are Whitney; Model 21RF2 or Hoke.

ON/OFF Valves:
ON/OFF Valves shall be ball valves. Acceptable manufacturers are Whitney or Hoke.

Regulating Valves:
Regulating valves shall be needle valves, with regulating stems and screwed bonnets. Acceptable manufacturers are Whitney or Hoke.

Four-Way Valves:
Four-way valves shall be two-position ball valves. Ball and stem shall be one piece assembly. Handle stops and directional nameplates shall be machined. Acceptable manufacturers are Whitney or Hoke.

Two-Way Solenoid Valves:
Two-way solenoid valves shall be globe valves directly actuated by solenoid and not requiring minimum pressure differential for operation. Solenoid enclosure shall be NEMA 4. An acceptable manufacturer is ASCO.

Air Pressure Regulator:
Air pressure regulator shall provide air at reduced pressures, constant to within plus or minus 10 percent for flows from 0 to 300 scfh with 100 psi supply pressure. Outlet pressure adjustment shall be via a set screw. Integral filter and relief valve shall be provided. Acceptable manufacturers and products are Masoneilan; Series 77-4 or Fisher; Series 67FR.

Stainless Steel Tubing:
Stainless steel tubing shall ASTM A312, Type 316, seamless, soft annealed 0.065-inch wall.

Stainless Steel Fittings:
Stainless steel fittings shall be compression type with ASTM A182 forged bodies or ASTM A276 barstock bodies, Type 316, flareless. Acceptable manufacturers and products are Swagelok tube fittings or Parker CPI tube fittings.

Air Sets:
Air Sets shall consist of a shutoff valve, pressure regulator, discharge pressure gauge, and interconnecting tubing.

Tubing Raceways:
Tubing raceways shall be cable tray systems complete with tees, elbows, reducers, and covers; and shall be sized in accordance with manufacturer's recommendations for the intended service.

3.7.11 Tagging and Numbering Systems

3.7.11.1 Instrumentation and Control Loop Tagging System

Instrument tags shall be used for unique instrumentation and control loop identification. The tagging scheme shall be based on ANSI/ISA S5.1 Instrumentation Symbols and Identification system.

The convention for instrumentation and control loop tags shall be as follows: **TAG – D-W-X-Y-Z**

D Instrument Tag/Descriptor: Defines function of instrument or component. Based on ANSI/ISA S5.1.

W Area Process Designator: Identifies an area or a process. Below is an example Area Process Designation for this Project.

00	**Supply**	**40**	**Auxiliary Systems**
02	Effluent Pumps	42	Yard Utilities
		45	Plant Drains
10	**Treatment**		
15	Activated Sludge System	**50**	**Electric Power**
16	Secondary Clarifier	51	12 kV Primary
17	RAS/WAS Pumping	52	4160 V
18	UV Disinfection	53	480 V
22	Plant Water System	54	120 V and Lighting
		55	UPS
		60	**Instrumentation and Control**
		61	PLC
		62	Computers
		63	Communication
		64	Process Analyzers and Transmitters

3.7.11.2 Equipment Tagging System

The equipment tagging system shall be used for all process, mechanical, and electrical equipment. The equipment tag designates the facility code, type of equipment, equipment process area location, loop number, and its number. Equipment tag number shall be used in all Information Management System software packages and operation reports.

The convention for equipment tags shall be as follows:

D-W-X-Y-Z

D **Equipment type designator shall be alphanumeric letter codes with a maximum of four characters; some examples are:**

AC	=	Air Compressor
AD	=	Air Dryer
ARV	=	Air Release Valve
ASV	=	Automatic Switchover Valve Assembly
AV	=	Ambient Vaporizer
AVRV	=	Air and Vacuum Release Valve
BL	=	Blower
DM	=	Demister
EJ	=	Ejector
FCV	=	Flow Control Valve
G	=	Gate
LCV	=	Level Control Valve
ME	=	Mechanical Equipment
OGB	=	Off Gas Blowers
PU	=	Pump
PCV	=	Pressure Control Valve
PRA	=	Pressure Regulator Assembly
PSE	=	Rupture Disk
PRV	=	Pressure Relief Valve
TH	=	Trim Heater
TK	=	Tank
TCV	=	Temperature Control Valve
TSV	=	Low Temperature Shutoff Assembly
Uv	=	UV Disinfection
VFD	=	Variable Frequency Drive

For equipment enclosures, control panels, or PLC enclosures:

FP	=	Field Panel (control panel or PLC enclosure)
MCC	=	Motor Control Center

W Area Process Designator. As defined under Area Process Designator under "Instrumentation and Control Loop

X Loop Number

Y Equipment (Unit) Number (Used when there are multiple units with the same W-X designations)

Z Set Number (Used when there are multiple sets with the same W-X-Y designations)

Note: All present equipment and pump numbers must be retained.
For example, High Service Pump 1 shall remain as High Service Pump 1 in the new system

Field panels that do not belong to a specific area process will not be assigned an area process designator or loop number. In this case, the field panel shall be assigned sequential numbers. A field panel that may not have a unique area process can be assigned an area process number most closely related to the panel. Examples of field panel tags (shown without facility designator) are FP-1-1 and FP-1-2.

Motor control centers shall be numbered with the facility code, equipment type, and its number (no area process or loop number required).

3.7.12 Testing Procedures and Test Documentation

3.7.12.1 General

Factory Demonstration Tests, Operational Readiness Tests, and Performance Acceptance Tests are required for all Information and control systems and subsystems.

All tests performed may be witnessed by the County or its representatives. The tests and their respective documentation requirements are outlined below.

3.7.12.2 Factory Demonstration Test (FDT)

Test fabricated panels, enclosures, or systems at their assembly location (referred to herein as "factory"). FDT shall include testing and verification of panel power wiring, panel internal point-to-point wiring, and panel functions such as indicating lights, switch operation, and indicator operation. Simulate inputs and outputs for field primary elements, field final control elements, and all other equipment excluded from the test to demonstrate that the panel or system is interconnected and operational. Include PLCs in the test.

Submission of proposed Factory Demonstration Test procedures, forms, and checklists is required.

Correct any deficiencies found prior to shipment of equipment and panels to site. Failed Factory Demonstration Test must be repeated and may be witnessed by OCWS or designee. Copy of signed-off test procedures when tests are completed shall be furnished to OCWS.

3.7.12.3 Operational Readiness Test (ORT)

General:

Prior to startup, Operational Readiness Test (ORT) shall be performed to inspect, test, and document that the entire system is ready for operation.

Test and check entire information and control system for proper installation, wiring, calibration, and adjustment on a component-by-component and loop-by-loop basis. All loop, power, and interconnection wiring shall be checked and tested for proper termination and functionality.

As part of the ORT, loop status reports and component calibration sheets shall be completed.

Loop status reports shall be provided to organize and track inspection, adjustment, and calibration of each loop and shall include the following:

- Project name.
- Loop number.
- Loop description.
- Tag number for each component.
- Check-offs/sign-offs for each component: Tag/identification, installation, termination wiring, termination tubing, calibration/adjustment.
- Check-offs/sign-offs for the loop: Panel interface terminations, I/O interface terminations with PLCs.
- I/O Signals for PLCs are operational: received/sent, processed, adjusted.
- Total loop operational.
- Space for comments.

Component Calibration Sheets (CCS) (forms used as part of the ORT):
Component calibration sheet shall be provided for each active instrument and panel component (except simple hand switches, lights, gauges, and similar items). Each PLC I/O module shall include the following:

- Project name.
- Loop number.
- Component tag number or I/O module number.
- Manufacturer.
- Model number/ serial number.
- Summary of Operational Readiness requirements, for example:
  - Indicators and Recorders: Scale and chart ranges.
  - Transmitters/Converters: Input and output ranges.
  - Computing elements' function.
  - Controllers: Action (direct/reverse) and control modes (PID).
  - Switching elements: Unit range, differential (fixed/adjustable), reset (auto/manual).
  - I/O Modules: Input or output.
- Calibrations, for example, but not limited to:
  - Analog Devices: Actual inputs and outputs at 0, 10, 50, and 100 percent of span, rising and falling.
  - Discrete Devices: Actual trip points and reset points.
  - Controllers: Mode settings (PID).
  - I/O Modules: Actual inputs or outputs of 0, 10, 50, and 100 percent of span, rising and falling.
- Space for comments.

Correct any deficiencies encountered during the ORT. Upon test completion, copy of completed ORT forms shall be provided to Okaloosa County.

3.7.12.4 Performance Acceptance Tests (PAT)

Once ORT has been completed and the facility has been started up, perform a Performance Acceptance Test (PAT) on complete Plant Instrumentation and Control System to demonstrate that the entire system is operating as required. Each required function shall be demonstrated on a loop-by-loop and site-by-site basis.

Perform local and manual tests for each loop before proceeding to remote and automatic modes. Where possible, verify test results using visual confirmation of process equipment and actual process variables. Exercise and observe new and existing devices as needed to verify correct signals to and from such devices and to confirm overall system functionality. Test verification by means of disconnecting wires, measuring signal levels, or simulation is acceptable only where direct operation of plant equipment is not possible.

PAT forms shall be completed for each control loop. The PAT forms shall include:

- Project name.
- Loop number.
- Loop functional requirements.

- Brief description of the demonstration test.
- Cite required test results which will verify proper performance.
- Space for signoff by witness.

Submission of Performance Acceptance Tests proposed test procedures, forms, and checklists to OCWS is required. Upon test completion, copy of signed-off test procedures shall be provided to OCWS.

3.7.13 Software Component Registration

Register all software products in the County's name. Coordinate contact name, phone number, and address information with OCWS.

3.7.14 Operations and Maintenance (O&M) Manuals

Operations and Maintenance Manuals (O&M) shall be provided for the plant I&C system. The O&M manuals shall include the following:

- As-built versions of all submittal material including both drawings and catalog data.
- Paper copies and electronic files of both drawings and catalog data.
- As-built versions of all submitted material including both drawings and catalog cut information in an electronic form, suitable for integration into the FIM system.
- Original O&M Manuals available for components furnished.
- Available electronic media O&M information for components.
- Available two-year upgrade and support agreements for software components furnished.
- Original license agreements, serial numbers, and original documentation and boxes for software components.
- Signed-off copies of all test documentation.

3.7.15 Post Acceptance Support

Unless otherwise noted in the specific Project design criteria, in addition to warranty provisions, provide the following post acceptance support services for a period of one year after acceptance:

- On-site support for two days each month by a qualified engineer or technician familiar with the Project to perform routine software and hardware maintenance including software and hardware upgrades and patches, minor configuration changes requested, and to spot check and troubleshoot instrumentation problems.
- On-call support during normal business hours to address problems with the PMCS identified by OCWS.
- Phone support as required.

3.8 General Electrical Design Criteria

The electrical system is intended to continuously and reliably provide power to all equipment. The major functions of the electrical system are as follows:

- Provide power to all process equipment, instrumentation, and facilities services.

- Standby power generation to service vital loads.
- Equipment and personnel protection.
- Sequential/logic control (discrete equipment control).

3.8.1 Electrical Design Standards

3.8.1.1 Drawings

General:
The following drawings will be prepared in accordance with the instructions prepared for this Project:

Legend Sheet:
The standard legend sheet of electrical symbols provided in the section will be used without exception on all design drawings. The legend sheet is a general electrical symbol list and may be edited for individual contract drawing sets. The legend may also include electrical abbreviations if there is no separate, comprehensive abbreviation list. If abbreviations are shown on the electrical legend, the list must be complete and accurate. If special symbols are required, they must be shown on the legend sheet and used throughout the entire Project.

Site and Area Plans:
The electrical site plan will show the location of all buildings, facilities, major equipment, outdoor site lighting, electrical power distribution poles, duct bank routes, hand hole and manhole locations, outdoor switchgear locations, and points at which duct bank sections are taken. If space on the sheet permits, site electrical plans will include electrical facility designs for facilities which do not require a separate drawing such as a guardhouse floor plan. Gulf Power point(s) of connection shall be shown.

Area plans will show interferences with existing buried pipes, ducts, and other such equipment. In special cases, site and area plans may be needed for plant-wide special systems, such as fire alarms, security, and communications. Electrical site and area plans will be overlays to civil site backgrounds (base sheets).

Process and Facility Plans:
Process and facility plans will show the location of, and connection to, all equipment and instrumentation that requires raceways or conductors. A separate connection point shall be shown for each of the devices located within an area even if they are all supplied as part of the same package, unless the specifications clearly require that all of the devices are to be wired to a single panel or terminal junction box (TJB) by the supplier of the equipment. Spare raceways for future equipment will also be shown and clearly labeled, where appropriate.

For each area, there shall be a separate plan created for process electrical and for facility electrical.

Process drawings will show all process and instrumentation equipment locations, connections and circuits. Final connection to all I&C supplied equipment will be shown on the drawings as being made by the electrical subcontractor. The description of the legend symbol to be used, a circle with a filled triangle, will indicate that the electrician is to install the conductors and terminate them with final connection being made under the direct supervision of the supplier of the equipment.

On the process drawings, the environmental classifications of each area (e.g., wet, corrosive, or hazardous) will be indicated so the proper type of material and enclosure will be provided.

Process plan drawings will be overlays of the mechanical process plan sheets and shall be at 1/4″ = 1′ minimum scale. If the mechanical process plan is shown at a scale smaller than the required minimum for electrical work, a separate electrical plan sheet will be created.

On the facility plan, show locations of receptacles, lights, lighting panels and lighting transformers, water heaters, HVAC equipment, motorized doors, fire alarm systems, security systems, telephone systems, public address systems and other non-process loads. Facility plans will show lighting fixtures (for normal and emergency lighting), illuminated exit signage, outdoor building-mounted lighting, switch controls, lighting panelboards, and connection assignments for branch circuits. Home runs may be used to indicate the destination of branch circuits to the local lighting panels or to emergency power supplies.

Connection configuration for building systems (e.g., fire alarm, security, and public address systems) will be shown on separate riser diagrams. A separate riser diagram will be provided for each system.

Enlarged plans will be provided for electrical rooms, laboratory spaces, and other similar spaces where the plan scale and the number of devices located in a small area make it impractical to show the required information.

Single-Line Diagrams:

- **General Requirements.** The single-line diagrams will show how the new system will connect to the existing system. The diagrams will also show the new electrical distribution system associated with the facility expansion and shall include any electrical service entrance equipment, all distribution switchgear, distribution circuits, and other components down to 460-volt utilization devices and 208V/120-volt panelboards. Circuiting from 208V/120-volt panelboards to their loads will be shown on the panel schedules and on the plans. Circuiting of 480-volt panelboard loads should be shown on the panel schedules and on the plans where possible. For panelboards which are powered from MCC buses through a transfer switch, the interconnection with the two sources should be shown on the single-line diagram.

  Subfeeds from panelboards to transfer switches, both manual and automatic, or to locally mounted motor starters are another special case that should be shown on the single-line diagram down to the final panel or device.

  Information on single-line diagrams will include bus capacity, short circuit ratings, overcurrent device types and ratings, surge protection devices, protective relay types and ratings, instrument transformer connections and ratings, motor starters and their types and ratings, power transformer connections and ratings, motors, metering and load ratings (horsepower or kilowatt) and other major electrical loads.

- **Medium Voltage Distribution.** The single-line diagram for medium voltage distribution, if used, (e.g., 4160 V) will show the entire medium voltage electrical distribution system within the facility to the primary side of the transformers for 480-volt substations. The information to be included on these single-line diagrams will be bus capacity, short circuit ratings, type of overcurrent device or motor starter, protective relays types and quantities, surge protection devices metering instruments, instrument transformers and their ratings, interconnections and switching arrangements for all distribution equipment.

- **480-Volt Equipment.** A separate single-line diagram will be provided for each 480-volt unit substation and switchgear. The single-line diagrams will generally be shown on separate drawings. The single-line diagrams for 480-volt equipment will show the primary disconnecting means, primary fuse rating and type, transformer identification, voltages, impedance and kVA ratings, transformer surge protection, 480-volt switchgear arrangements including number and rating of circuit breakers, ampere and short circuit ratings of the bus,

metering and metering instruments. This diagram shall also show interconnection circuits within the 480-volt power distribution system along with identification and ratings of equipment powered from the switchgear.

- **Motor Control Center (MCC).** A separate single-line diagram shall be provided for each MCC. The single-line diagrams will generally be shown on separate drawings. Single-line diagrams for MCCs include the ratings of all circuit breakers, ampere and short circuit ratings for all bus within the MCC, motor starters sizes and types, power contactors, motor loads and horsepower rating, and all other loads connected to the MCC bus.

Elevations:
Front elevations for switchgear, unit substations, MCCs, and low-voltage switchboards will be provided. The elevations need not be drawn to scale but must show the relative locations of MCC compartments, overcurrent devices, metering, conductor entrances, and depth of assemblies. The size of MCC buckets must allow space for extra relays, and other equipment, as required. The manufacturer of switchboards and switchgears should review the elevations of this equipment to ensure proper placement of equipment and check the accuracy of the depicted equipment arrangements. The depths of assemblies should be noted on elevations.

Motor-Control Schematic Diagrams:
Motor-control schematic diagrams shall be grouped together and shown on separate drawings. Motor-control schematic diagrams shall be presented in a standard format. A separate diagram shall be provided for each starter or group of starters with identical controls. The control schematics in the contract documents shall indicate terminals and equipment in which terminations will be made. The schematics shall show all control circuit devices supplied as part of the MCC equipment, existing devices (where applicable), field-mounted devices, and devices in panels or equipment furnished under other divisions of the specifications. Control diagrams shall indicate the terminals in I&C panels and other equipment panels to which a terminal connection must be made. Single controls in an I&C panel or equipment panel (for instance, on-off switch and start-stop pushbutton) may be shown in special cases. Complex control in an I&C or equipment panel is to be shown as two terminals in a dashed rectangle with a reference to the I&C panel. If smart controllers are used instead of standard type MCC controllers, the ladder logic programmed into the unit and the custom software program block numbers shall be shown on the same drawing as the connection diagram for that controller.

The following control devices, not shown on the P&IDs, shall be shown on the motor control schematic diagrams, where necessary:

- ON/OFF/REMOTE switch (where required and not shown).
- ON/OFF/CP switches (where required).
- Elapsed time meters (will be provided if the motor falls into the criteria described hereinafter).
- Ground fault relays.
- Metering.
- Motor heaters.
- Motor thermal devices.
- ON/OFF status lights.
- Blower motor CTs.

- Ground fault CTs.
- Capacitors.
- Surge arresters.

Motor control schematic diagrams shall be developed for the equipment located in each MCC in each facility. A sample of the standard format for these diagrams is included with the standard details.

Schedules:
Schedules will generally be shown on the drawings except in the rare case where a separate bound volume of 8-1/2 x 11 inch sheets depicts the segments more easily. The luminaire schedule will show the symbol or alpha-numeric designator for the fixture, power rating, voltage, brand name, catalog number, and a brief description of fixture type and use. Fixture mounting method (e.g., wall pendant, pole, etc) and heights may be listed on the fixture schedule or as noted on plan drawings. The luminaire schedule will be available to all designers at the early stages of design and the same luminaire will be used for all similar applications throughout the facility.

Panel schedules shall be prepared using a computer spreadsheet program, which allows the final product to be imported into a CADD file and placed electronically onto the drawing. Panel schedule shall include estimated circuit loads in volt amperes. The computer spreadsheet shall automatically calculate total loads in amperes and volt-amperes.

A separate panel will be provided within the facility for the power supply to process related instruments and control equipment. This panel shall be powered from a shielded transformer and transfer switch that is separated from the building facility power supply for reliability.

The panel schedules shall be included on the drawings with the buildings or facilities where they are located or with the one-line diagrams or equipment elevation of the related equipment.

Grounding Plans and Details:
The grounding system shall be shown on the drawings. Grounding shall be shown on the site plans, the process facilities plans, or a separate plan. The grounding plans shall show the grounding electrodes, grounding conductors, equipment busses, and grounding requirements for separately derived systems. The size and ratings of the driven electrodes and conductors shall be shown. Grounding plans shall be supplemented by grounding details. A minimum of one test well per facility shall be provided. Lightning protection system connections to the grounding system shall also be shown.

Duct Bank Sections:
Sectional drawings of the duct banks shall be provided for underground conduit systems. Conduits shall be listed in the conduit and wire schedules. The sections shall indicate the ducts at the point where the section is taken, the configuration of the duct bank, conduit numbers if used, duct section number if used, and concrete encasement and reinforcing. The sectional drawings shall call out the drawing on which the section appears. An electrically continuous 250 KCMIL bare copper grounding conductor shall be longitudinally embedded within the concrete encasement of all duct banks. This ground conductor shall be located at the bottom of the duct banks with 2 inches of concrete between raceways and conductor, and 2 inches of concrete between conductor and bottom of duct bank bonded to any reinforcing steel in the ductbank. This grounding conductor will be brought into facilities and manholes where it will be exothermically welded to the building's grounding system. When the duct bank intercepts a manhole, the grounding conductor shall be continued through the manhole and connected to a ground rod installed in each manhole.

System Riser Diagrams:
Separate riser diagrams shall be provided for the fire alarm, public address, security, telephone, and communication systems. Riser diagrams shall show all components for each system. The riser shall be arranged to show the relative location of each device or component with respect to the other system devices and components. The name and number of the room or space where the device or component is located shall be noted on the riser diagram. Interconnecting conduits and wiring also shall be shown on the diagrams.

Details:
Standard details have been provided to supplement the master specifications/standard details. Changes to the standard details must be approved before the modified details shall be used. Create unique details as required. Installation details will be grouped together and shown on separate drawings.

3.8.1.2 Calculations

All calculations are to be prepared on 8½ x 11 inch sheets and submitted to OCWS for review. Calculations shall include loads as well as future loads and include all necessary safety factors. Calculations may be done manually or by computer. Each sheet must show the date the calculations were performed, the Project number, and the signature of the person performing the calculations.

At a minimum, the following calculations will be prepared:

- Load summaries for each switchgear, substation, MCC, transformer, and panelboard.
- System short circuit analyses.
- Preliminary system coordination analyses.
- Voltage-drop calculations for feeder and branch circuits that are heavily loaded or over 500 feet long.
- Lighting calculations.

3.8.2 Design Criteria and Guidelines

3.8.2.1 General Requirements

An electrical engineer registered in Florida will be responsible for overseeing the preparation of the electrical design documents. The design will be in accordance with the best professional practices. The final electrical design drawings will be signed and sealed by an electrical engineer licensed in Florida.

The design of each task must conform to the requirements of these guidelines. The guidelines describe the minimum requirements. Deviations from the guidelines that are in the best interest of OCWS and demonstrate a better design will be allowed as long as OCWS approves the deviation in advance. Documentation, including calculations and cost estimates, must be developed in enough detail so the Design Builder and OCWS can evaluate the proposed deviations.

3.8.2.2 Standards and Codes

Electrical design shall conform to the latest editions of the following applicable standards and codes:

- National Electrical Code (NEC) (NFPA 70).
- National Electrical Safety Code (NESC).

- Life Safety Code (NFPA-101-HB).

Standards and codes of the following organizations shall also govern where applicable:

- American National Standards Institute (ANSI).
- Illuminating Engineers Society (IES).
- Recommended Practices for Wastewater Facilities.
- Instrument Society of America (ISA).
- National Electrical Manufacturers Association (NEMA).
- Institute of Electrical and Electronic Engineers (IEEE).
- Insulated Cable Engineers Association (ICEA).
- Occupational Safety and Health Act (OSHA).
- American Society for Testing and Materials (ASTM).
- Underwriters Laboratory (UL).
- Environmental Protection Agency Technical Bulletin (EPA-430-99-74-001).
- All applicable regulations of the Ft. Walton Beach and Eglin AFB Fire Departments.

Local codes and ADA standards shall be applied as appropriate. Where the requirements of more than one code or standard are applicable, the more restrictive shall govern. Requirements of applicable codes and standards are not repeated in this section.

Applicable Federal and local codes and UL listing requirements shall be followed for electrical inspection. Exit signs, emergency egress lighting, and emergency lighting power supply shall conform to requirements of the local code authority.

NFPA (70 and 820), EPA-430-99-74-001, and "Recommended Practices for Wastewater Facilities" should be used to determine if areas should be classified as "explosive hazardous." The Design Builder shall determine the types and quantities of vapor that could be present in the air in each space, and shall determine which "hazardous" classification, if any, applies.

3.8.2.3 Inspection Authorities

The design will comply fully with the rules and regulations of all authorities having jurisdiction over the electrical work.

If the Design Builders contact any of these agencies during the course of the design, they must document these communications. The topics listed below must be resolved at the beginning of the design work:

- Gulf Power:
  - Point(s) of connection.
  - Revisions and expansions to the distribution system.
  - Additional connected and demand electrical energy loads.
  - Cost to bring power to point(s) of connection.
- Eglin AFB Inspector.
- Electrical Inspector:

- Applicable local codes.
- Third-party listing requirements (UL, CSA, ETL, factory manual).
- Requirements for reviewing plans.

♦ Building Inspector:

- Exit signage.
- Emergency egress lighting.
- Emergency-lighting power supply.

♦ Fire Marshall:

- Hazardous area determination.
- Fire alarm requirements.

♦ Insurance Carrier:

- Fire alarm requirements.

3.8.2.4 Load Analysis

At the beginning of the Project, a preliminary load survey shall be prepared to help plan the power distribution system. Essential and nonessential loads, as defined by the redundancy requirement, will be kept separate. Major loads, including connected load values, estimated peak demand, and average demand for each building or process area, will be identified on a general layout drawing to establish load center location and size. Because detailed load data will not be available during the early part of the design, preliminary load values will be based on square foot averages and preliminary motor lists compiled by the process and mechanical engineering groups. Redundant and standby units will be excluded from the total connected load to establish the critical load requirements. The load requirement will be tabulated for the following categories:

Table 3-19
Load Requirements

	CONNECTED LOAD kVA	DEMAND FACTOR	Avg kVA	PEAK kVA	SOURCE
Lighting		1.0			Sq ft
HVAC		0.8			Mechanical information
Process		0.8			Process information
General Bldg.		0.4			Sq. ft.
Special					Estimated

At the end of the design phase, the final load will be analyzed using DAPPER, EDSA, or another previously approved computer program using the same breakdown and detail given for the preliminary analysis. Final computations will be based on the actual loads shown on the drawings, HVAC load on actual motor horsepower, process load on actual motor horsepower, general building load on number of receptacles, the connected lighting load, and the actual connected load of special appliances. Provisions will be made for future expansion. All computer output will be incorporated into the Project support document.

3.8.2.5 Harmonic Analysis

Since variable-frequency drives are being used for most variable-speed applications and a significant UV disinfection system is being proposed, a harmonic analysis on the power distribution system shall be performed to determine the total harmonic distortion at the points of common coupling. All new and existing nonlinear loads will be analyzed. The Design-Builder shall perform a harmonic analysis when the specific design involves the use of nonlinear loads. The point of common coupling will be taken at both the primary and secondary terminals of each substation transformer, and at the plant's main service switchgear. The harmonic analysis report will present the results in a format similar to the tables in IEEE 519. The harmonics analysis report shall verify that all harmonics at the point of common coupling are below the guidelines as specified in IEEE 519.

The analysis should examine the effects that harmonics developed by nonlinear loads have on power factor correction capacitors. *Do not add power factor correction capacitors to busses directly connected to adjustable frequency drives.* Power factor correction should be incorporated in the design of the adjustable-frequency, drive-input filter.

3.8.2.6 Power Distribution Planning

General:

The design of the power distribution system for the APWRF will follow the guidelines in IEEE Standard 141-1986, "Recommended Practice for Electric Power Distribution for Industrial Plants" (the Red Book), and the requirements in "Recommended Practices for Wastewater Facilities."

Reliability and Redundancy Requirements:

The guidelines for reliability of the power distribution system are given in EPA Bulletin 430-99-74-001 and "Recommended Practices for Wastewater Facilities." The distribution system will be designed to provide sufficient redundancy so no single fault or loss of power (caused, for instance, by plant equipment or PLC power failures) will disrupt more than one MCC or bus on a double-ended MCC that serves loads common to a critical unit.

Loads to critical units are to be supplied from at least two separate MCCs or a double-ended MCC. Each MCC will be served by a power supply circuit that is connected to an independent bus. Medium voltage MCCs will be powered from separate buses in the main medium voltage distribution switchgear or directly from a transformer. Low voltage MCCs will be powered from separate buses in the 480-volt substation serving the building or area. If feasible, 480-volt MCCs serving common loads will be powered from separate buses at different substations.

Each feeder will have enough capacity to serve all vital components connected to the MCC bus, except the redundant/standby unit.

Non-critical unit loads must be supplied from at least two MCCs or one double-ended MCC. The MCCs should be configured the same as those for the critical unit loads, except that each power substation, MCC, and feeder must have the capacity to power the components necessary to pass, treat, or process in accordance with the average design conditions (provided their combined capacity is enough to handle the peak design condition).

Hazardous Areas:

The various areas of the plant that may contain concentrations of hazardous gases shall be reviewed against the requirements of NFPA 820. The areas that will be affected include enclosed areas open to raw sewage or secondary influent (i.e., up to the aeration basin) that shall be considered Hazardous Class I Division I, due to the presence of methane and gasoline unless

adequate ventilation is provided. Other areas may be classified hazardous as required by NFPA 820. Devices that contain contacts located in hazardous areas should generally be wired intrinsically safe, except Class I Division II areas where hermetically sealed contacts may be installed.

Miscellaneous - Provide Local Disconnects Per NEC:
Provide disconnects where required at process equipment, especially at motor-operated valves. Work with the equipment specified to see if integral disconnects are a standard option. Do not require that they be specified unless they are a standard option. Provide disconnect switches for all HVAC equipment that has any integral controls (i.e., unit heaters, compressors, duct heaters, air handlers, etc.). Provide a local disconnect for all hoisting equipment. For drives fed from MCCs, the lockable disconnect at the starter is adequate unless directed otherwise by client preference.

Distribution Voltage Selection:
Standard grounded systems for plant voltages shall be used. The Design-Builder shall select one of the following voltages, depending on load characteristics and location:

- 460 volts, solidly grounded wye, 3-phase.
- 208/120 volts, solidly grounded wye, 3-phase.
- 120 volts, solidly grounded, uninterrupted power supply (UPS).
- 12 or 120 volts DC, emergency lighting.

Utilization Voltages:
Designers shall select from the following equipment voltages:

♦ Fluorescent lighting	120 volts, single-phase
♦ Emergency lighting	12 or 120 volts DC
♦ High-pressure sodium lighting	120 or 208 volts, single-phase
♦ Incandescent lighting	120 volts, single-phase
♦ Convenience outlets	120 volts, single-phase
♦ UPS	120 volts, single-phase
♦ Motor control	120 volts, single-phase
♦ Motors, less than 1/2 hp	120 volts, single-phase
♦ Motors, 1/2 to 300 hp	460 volts, three-phase
♦ Motors, greater than 300 hp	4,000 volts, three-phase

Voltage Drop:
Steady-state voltage drop shall be calculated for all heavily loaded or long circuits of 500 feet or more from source to load. Calculations for motor circuits shall be developed on the basis of an 80 percent power factor. Designers must not exceed the following total voltage drops from the 480-volt source bus (excluding site distribution) to the feeder, branch circuit, and transformer:

♦ Interior lighting	3 percent
♦ Exterior/gallery lighting	5 percent

- Motors 5 percent (running)
- Receptacles 3 percent
- Electrical heaters 4 percent

The voltage drop shall be calculated for starting the motor if a motor exceeds 20 percent of the serving transformer capacity. The drop in voltage (flicker) shall meet the following limits:

Table 3-20
Voltage Drop Limits

STARTS/HR	PROCESS AREA SECONDARY (%)	PRIMARY SYSTEM (%)	UTILITY SYSTEM (%)
1 or less	15	5	1
2 to 10	10	4	1
Over 10	8	3	1

Demand Factors:
The Design-Builder must consider the following demand factors for sizing switchgear, panelboards, feeder breakers, feeder conductors, and transformers:

Service	Demand Factor
Lighting	1.0 x connected load
Emergency lighting	1.0 x connected load
Air conditioning equipment	0.8 x connected load
Ventilation equipment	0.8 x connected load
Drainage pumps and ejectors	0.5 x connected load
Convenience receptacles	1.5 ampere, each
Process loads	0.8 x connected load

The connected load shall be used for sizing all branch circuits.

Branch Circuits:
Connected load and NEC requirements must be used for sizing branch circuit breakers and conductors, except for motor loads.

Designers shall follow these guidelines:

- A minimum wire size of No.12 American Wire Gage (AWG) copper must be used for lighting and receptacle branch circuits. No.10 AWG or larger shall be used if a larger conductor is required because of voltage drop.
- Lighting and receptacle loads must not be combined on the same branch circuit.
- The number of convenience receptacles on any one branch circuit shall be limited to five duplex in process areas and six duplex in other areas.
- Critical process instrumentation loads shall be connected to a UPS.

Utilization Equipment Identification:
These numbers fall into two classifications: interim and permanent.

- Interim. Until I&C tag numbers become available, utilization equipment will be identified by the FF-SS format, where FF is the facility number in or near which the equipment is located and SS is a sequence number. Sequence numbers will be assigned in order by the facility designer. Sequence numbers for deleted equipment will not be reused.
- Permanent: Utilization equipment will be identified by I&C tag numbers as those numbers become available. Utilization equipment which does not appear on the P&IDs, such as HVAC equipment, will be identified by the Design-Builder in a manner similar to that used for electrical distribution equipment (see below) using an appropriate equipment type; for example, UH for unit heater.

Electrical Distribution Equipment Identification:
Electrical distribution equipment will be identified in the TIT-FF-SS format, where TIT is the equipment type, FF is the facility number with which the equipment is associated, SS is the sequence number. For electrical equipment not associated with any particular facility, use the load center number from which power originates. Equipment type designations are as follows:

CMS = Combination motor starter
JB = Junction box
MCC = Motor control center, medium, or low voltage
MSR = Grouped motor control, not part of a manufactured assembly
PNL = Panelboard
DPNL = Distribution panelboards
SWBD = Switchboard, low voltage
SWGR = Switchgear, medium voltage
TJB = Terminal junction box
TX = Transformer
USB = Unit substation

Other equipment-type designations may be used.

Sequence numbers are required even if only one of a particular type of equipment is in a particular facility. For TJBs only, the sequence number will be followed by "A" for analog/electronic, "D" for discrete control, or "P" for power.

The following equipment will be identified:

- Motor control centers.
- Panelboards.
- Distribution panelboards.
- Switchboard.
- Switchgear.
- Terminal junction boxes.
- Transformers.
- Unit substations.

Other equipment may be identified if identification is required for other purposes; for example, junction boxes may need to be identified in order to route homerun circuits through them.

Major electrical equipment, i.e., MCCs, SWBDs, SWGRs etc., will be located on the site plan and the area plans in addition to the facility and process electrical plans.

Unit Substations:
The layout design of the unit substations will follow the guidelines in IEEE's Red Book.

Plant power supply redundancy requirements shall be met by providing two independent sources from the serving electric utility or by providing one utility source and an engine-generator system on-site.

All plant distribution switchgear and MCC units will be constructed in the "double ended" concept. This means that each switchgear line or MCC will have two main protective devices, one associated with each of two incoming main power supply circuits, and one bus tie switching device that allows the two halves of the main bus to be powered independently. Under normal operating conditions, the bus tie switch is open and each half of the bus is powered by one of the incoming power supply circuits.

The two main and bus tie circuit breakers will be key-interlocked to prevent more than two of the three circuit breakers or switches being closed at any time. Electrical loads will be distributed evenly between the two buses.

Each main circuit breaker or protective device will have solid-state, three-phase metering for volts, amps, kilowatts, power factor, and I-square-t data. The metering system will be capable of recording peak demand, fault data, and other data.

The metering equipment will provide a 4-20 MA output signal, which is field selectable for remote monitoring of any of the metering parameters recorded.

Transformers will be fully redundant and sized to carry all essential and non-critical loads connected to both sides of the bus. Transformers will have line surge protection, cooling fans, automatic fan controls, and temperature-sensitive alarms.

Distribution System Equipment Preferences:
The following types of equipment shall be used for the medium- and low-voltage distribution systems:

- **Power Transformers:** Indoor type shall be silicone filled or cast coil dry type. Outdoor type shall be liquid-filled pad-mounted or substation class. Cooling fans or provision for fans will be included on all power distribution transformers. Transformers with secondary voltages of 480 volt 3-phase shall be limited in size to 1,500 kVA, where possible, and specified with 5.75 percent impedances to limit fault currents. Transformers that supply 208V/120-volt lighting requirements and indoor transformers that supply 480-volt power distribution requirements shall be dry type and suitable for the area in which they are to be located. Transformers that include a small panelboard in the same enclosure (mini-power center) shall not be used indoors; a small transformer with a separate panelboard shall be used in these cases.
- **Medium Voltage Switchgear:** 5 or 15 kV class, indoor or outdoor non-walk-in, metalclad switchgear, 2-high construction with vacuum circuit breakers and copper bus will be used. Switchgear will be fitted with transducer modules to provide remote status indication and control of circuit breakers.
- **Medium Voltage Motor Control:** Draw-out type vacuum contactors with current limiting fuses in NEMA one gasketed enclosure for indoor application, two-high construction.
- **Low Voltage Switchgear:** 600-volt, indoor or outdoor non-walk-in, metalclad switchgear, 2-high construction with vacuum circuit breakers and copper bus will be used. Switchgear will be fitted with transducer modules to indicate remote status and control of circuit breakers.

- **Low Voltage Switchboard:** 100 percent rated, insulated case, individually mounted circuit breakers with solid-state trip for mains and feeders 600 amperes and larger. Smaller feeder breakers shall be molded case with solid state trips. See the manufacturer's data for additional information. Depending on the size and rating of the switchboard, back access may be required.
- **Low Voltage Motor Control Center:** Indoor, class II, type B wiring motor control center (MCC) shall be used. Supply circuit to MCCs shall be 480 volts, three-phase, 3-wire (no neutral bus is required since there will be no line-to-neutral 277-volt loads). MCCs shall have copper phase buses and a 400-ampere copper ground bus. MCCs shall be similar to General Electric model 8000. Overloads shall be nonambient-compensated unless such compensation is needed; for instance, at submerged pumps. MCCs shall be 20 inches deep. All solenoid valves, thermal devices, etc. that need to be operated when the motor is on shall be powered from the motor starter control power transformer (CPT). Where this is done, call out the need for additional CPT capacity on the control diagrams. Some spares and spaces should be allowed (on the order of 5 percent spares and 10 percent spaces) in addition to the identifiable spares required for known future equipment. Allow space for at least one future vertical section at each MCC.
- **Low Voltage Motor Control Center Main Circuit Breakers:** 100 percent rated molded case with solid state trips.
- **Low Voltage Motor Control Center Branch Circuit Breakers (other than combination motor starters):** Molded-case thermal magnetic.
- **Low Voltage Feeder Circuit Breakers in MCCs and Power Distribution Panelboards, 400-ampere and Larger:** Molded case solid-state trip, 100 percent rated. Smaller circuit breakers shall be molded case thermal magnetic.

Equipment shall have adequate momentary and interrupting capacity to withstand fault currents that may occur where equipment is applied. Each circuit breaker located immediately downstream from the secondary main on a 480-volt secondary transformer shall be equipped with ground fault protection unless that circuit breaker is rated 200 amps or less. Each circuit breaker protecting a motor of 100 horsepower or more shall be equipped with ground fault protection. Ground fault protection on motors shall be instantaneous and ground fault protection on main breakers and feeder breakers shall be equipped with time delay setting and restraint systems.

Motor Protection and Control:

Magnetic-only circuit breakers shall be provided as a branch circuit protection in motor starters for all motors 50 hp and smaller. Branch circuit protection for larger motors shall be provided by thermal magnetic breakers with adjustable magnetic trips.

Motor control center type construction shall be used where multiple three-phase motors are located in the same general area.

Each motor shall be provided with thermal overload protection in all ungrounded phases. Controller-mounted relays shall have external manual reset.

Internal temperature detectors embedded in motor windings shall be specified for motors of 100 hp and larger and all motors 10 hp and larger that are powered by an adjustable frequency drive. Temperature detectors in motors smaller than 100 hp shall be thermostat type, 480 volt motors 100 hp and larger shall have thermistors, and RTDs shall be provided in all medium voltage motors. Multi-function protective relays for overload, phase protection, and ground fault protection shall also be provided on large motors.

For motors with motor starters as part of an integral package, the overload protection will be in the motor starter. For fractional hp equipment not normally requiring motor starters, manual motor starters with overload protection will be added. Some small equipment such as ceiling fans will have overload protection integral with the motors.

All motor control circuits shall operate at 120 volts and shall be supplied by individual control power transformers fused both in the primary and secondary sides.

Electrical motor starter control shall normally consist of indicating lights, pushbuttons, or switches. Devices connected with process controls, such as timers and auxiliary relays, shall be provided in instrumentation and control panels or operated by a programmable logic controller as part of its internal control logic.

All motors 25 hp and larger that are installed outside shall contain motor space heaters to minimize condensation. The space heaters shall operate on 120V and shall be energized when the associated motor is not in operation.

Panelboards:

Distribution panelboards shall be 480-volt, three-phase, three-wire type with the main circuit breaker sized to match the supply transformer capacity.

Lighting panelboards shall be 208V/120-volt, three-phase, four-wire type with the main circuit breaker sized to match the lighting transformer capacity. To prepare and install panelboards, follow these steps:

- Surface mount panelboards in process areas and flush mounted in office or other finished areas.
- Provide separate panelboards to supply power to instruments and control panels where the equipment to be supplied requires a conditioned power supply. Where two 480-volt power supplies are available, an automatic transfer switch shall be provided to supply power to the lighting panelboard transformers from either 480-volt source. If feeder breakers are not local (near the transfer switch) provide disconnect switches in the same area to facilitate maintenance.
- Equip each panelboard with a minimum of 20 percent spare breakers with spaces, bus work, and terminations to complete the standard size panelboard.
- Show the circuit description, protective device trip rating, number of poles, rating of main lugs or main circuit breaker, neutral bus size, ground bus size, and interrupting rating of breakers on panelboard descriptions. Computer-generated panelboard schedules shall be included in the design.
- Prepare panelboard schedules using the standard format which indicates circuit description, protective device trip rating, number of poles, load in voltamps by phase, rating of main lugs or main circuit breaker, neutral bus size, ground bus size, and interrupting rating of breakers.
- Provide a separate circuit breaker for instruments that perform the same function on parallel flow streams, such as generator controls, fuel control instruments, etc. Instruments of different types that are all associated with the same flow stream may be connected to the same branch circuit to simplify the design.
- Identify all branch circuits or feeders on the drawings with the panelboard and device protecting the individual circuit or feeder.

Motor Starter Selection:
Unless required otherwise by the local utility, across-the-line starters shall be used for all motors smaller than 100 hp. Reduced-voltage starters shall be used for all motors 100 hp and larger. Adjustable frequency drives will be used when required to vary the speed of the motor as determined by the particular process. When possible, the associated motor starter shall be installed in a motor control center located in an electrical room. Adjustable frequency drives, when used, must be located within 200 feet of the motor. No starter smaller than NEMA Size 1 shall be used.

3.8.2.7 Adjustable Frequency Drive (AFD) Selection

Where it is necessary to vary the speed of an AC induction motor, an AFD must be selected to provide adequate electrical power of adjustable frequency and suitable quality to power the motor. The AFD must convert three-phase, 60 Hz AC input power to adjustable frequency output power using the pulse-width-modulation (PWM) technique. The system must be rated for continuous industrial duty and include any devices or methods necessary to limit the propagation of voltage and current harmonics in the power distribution system to which it is connected. The magnitude of these harmonics shall be maintained within the allowable limits described in IEEE standard 519. Any specification for AFDs must contain information such as that shown on the sample Simplified Plant One-line Diagram attached. In order to verify compliance with IEEE 519, a supplier must know the Point of Common Coupling (PCC) and the available fault current at that point. The AFD system which includes the AFD and motor should be supplied by one vendor or source so that the responsibility for compatibility of components rests with one company. After installation per manufacturer recommendations, it is important to test the operation of the AFD system under load and measure the quality of the power and the magnitude of harmonics generated in the actual operational environment.

Standby Power Generation:
Generators shall be provided to power the vital loads at the facility. The vital loads to be powered are the:

- New Biological processes.

The generators shall provide either 480V three-phase power depending on the loads at the facility.

The generator shall operate on diesel fuel oil and shall be housed in a sound attenuating enclosure. The enclosure shall contain internal and external lights. The sound rating of the enclosure shall be 70 db at 20 feet when the generator is operating at full load. The engine generator shall include jacket water heaters, a voltage regulator, automatic starting batteries, battery charger, vibration isolators, automatic louvers, ventilation fans, an engine control panel, space heaters, and an integral fuel storage “day” tank.

The batteries shall be capable of starting the engine a minimum of three times without recharging. The battery charger shall have the capability of remotely indicating a failure to the plant Programmable Logic Controller (PLC). The fuel storage tank shall be double-wall carbon steel. Leak detection shall be provided with the fuel tank. The fuel tank shall be sized to contain a minimum of 24 hours of fuel at 100 percent full load. Fuel piping and storage shall be designed and installed in accordance with local codes.

The generator shall be sized to run all the vital loads at the facility. The maximum acceptable voltage drop upon starting any of the vital loads shall be 20 percent.

All medium voltage generators shall include a neutral grounding resistor and a grounding pad. The grounding pads shall be non-corrosive stainless steel welded to the alternator.

Convenience Receptacles:
Convenience receptacles for general service shall be spaced not more than 40 feet apart inside all process buildings and 75 feet apart in outside process areas, and shall be located on the surface of walls or columns. Receptacles shall be located as needed in commercial areas. In addition, provide receptacles at all air conditioning units and air handling units as required by NEC.

Where washdown is expected, outlets shall be located 48 inches above the floor so that weatherproof receptacles will not be required. All receptacles located outdoors shall be twist lock type and shall be ground fault protected.

Ground Fault:
Ground fault systems will be zero sequence type. Facilities will be provided for testing the ground fault circuit by secondary current injection, with or without tripping and for indicating a ground fault. Current and time trip levels shall be adjustable. In general, this means that ground fault will have to be supplied external to the circuit breaker. Motor ground fault shall be an instantaneous trip.

Power Factor:
Power factor correction capacitors shall be applied to correct power factor to 95 percent at all motor starters for motors rated 30 hp and larger. Capacitor banks shall generally be located on top of motor control centers. Calculate conductor sizes in accordance with NEC 460, which requires conductor ampacity to be the larger of 135 percent of capacitor FLA, or 1/3 of motor branch circuit ampacity. Show capacitors connected between the motor starter contactor and the overload heaters on the one-lines and control diagrams. Do not apply capacitors where they will be connected to a bus that also supplies adjustable frequency drives.

Raceways:
Specific types of raceway shall be chosen for use in various locations in the facility based on moisture, temperature, exposure to damage, corrosion, voltage, and cost. An underground duct bank consisting of concrete-encased, polyvinyl chloride (PVC) conduits with galvanized steel "elbows" shall be provided for all circuits that are routed outside of buildings on the site. All junction boxes shall be installed above ground. The following systems shall be grouped in separate ductbanks:

- Power wiring above 600 volts.
- Power and discrete control wiring below 600 volts.
- Process instrumentation analog and communication wiring, including 24-volt discrete signals, intrinsically safe circuits, and LAN/Data Highway computer circuits shall be routed in steel conduit. Intrinsically safe circuits and computer circuits shall be carried through handholes and manholes in conduit.
- Fiber optic cable.

Duct banks shall include a minimum of two spare conduits. Underground raceways that are not installed in a duct bank shall be direct buried, schedule 40 PVC conduit with galvanized steel "elbows." The following general guidelines shall be used for raceway sizing, selection, and installation:

- Conduit shall be sized based on THWN insulation for sizes below No. 6 AWG, and THW insulation for all other wiring 600 volts and below.

- The minimum diameter of exposed conduit in all areas shall be 3/4 inch. Exceptions may be made for short distances from a junction box to a device which has a 1/2-inch knock-out provided by the manufacturer of the device.
- Concealed conduits shall not be smaller than 1 inch.
- Raceways in duct banks shall not be smaller than 2 inches.
- Exposed raceways shall be installed in process areas.
- Raceways in walls and ceilings of control rooms, offices, and all areas with finished interiors shall be concealed.
- Embedded and buried nonmetallic conduits shall be converted to metallic conduit before exiting from masonry or earth and galvanized steel shall be used at all bends of 30 degrees or greater.
- The number of conduit bends shall be limited to an equivalent of 270 degrees on long runs.
- Exterior, exposed conduit shall be PVC-coated rigid galvanized steel (PVC/RGS).
- Exterior, underground, direct buried conduit shall be schedule 40 PVC.
- Exterior, underground, concrete-encased conduit shall be schedule 40 PVC.
- Interior, concealed conduit shall be electrical metallic tubing (EMT) in frame construction and finished ceiling spaces.

Wire and Cable:
For medium voltage power conductors, or cables, use stranded copper, 15 kV insulated, shielded, XLPE or EPR insulated conductor for all medium voltage circuits up to 13.8 kV.

For all lighting and power wiring of 600 volts and below, use stranded copper conductors. Solid conductors shall be used for No.10 AWG and smaller where required by wiring devices. Stranded conductors shall be used for other applications.

The current carrying capacity of conductors shall be based on 75°C insulation ratings. Conductors No. 6 AWG and smaller shall have THHN/THWN insulation, larger conductors shall have XHHW insulation.

Individual No.14 AWG conductors shall be used for discrete control circuits, unless it is practical to use multi-conductor cables to group control circuits.

Twisted-shielded pair control cable with 16 AWG individual stranded copper conductors and an aluminum mylar tape shield around the pair shall be used for analog signals. Multi-pair cables shall be used where grouping of circuits is practical.

Grounding:
Load centers shall be bonded to a grounding electrode, which may consist of a building steel column that is bonded to the underground rebar, or an electrode system (triad or connection to ground loop around the building). In addition, a ground loop system shall be installed around all concrete structures including buildings, pads, and tanks buildings to supplement the ground electrode.

Grounding electrodes of ground mats or embedded rods and cables will be specified to have a maximum resistance to ground of 3 ohms. Use 4/0 AWG copper conductor, minimum, for interconnecting ground rods and connection to transformers and switchgear.

The parts of all electrical equipment, devices, panelboards, and metallic raceways that do not carry current shall be connected to the ground conductors. The transformer neutrals of wye-connected transformers shall be solidly grounded through a grounding conductor connected to the grounding system.

A ground wire shall be installed in all raceways that contain power conductors of any voltage. The single exception is the medium voltage circuits that use shielded conductors or cable. These circuits will not have a separate ground conductor in the conduit.

Grounded requirements for instrument and control cable shields shall be in accordance with control system equipment manufacturer recommendations. Generally, instrument and control cable shields shall be grounded at only one end of the circuit, preferably at the circuit power source end.

Noise and transient occurrence is often caused by faulty grounds. Appropriate safeguards must be included to ensure grounding equipment is located at the proper places and not located where there should be none. Basic code requirements are referenced in the specifications. Grounding requirements should be included in the electrical drawings; field testing and inspection should be emphasized.

Lightning Protection:
A lightning protection system shall be provided on all high profile structures and equipment, in accordance with NFPA 780. The lightning protection system "downcomers" shall be grounded separately and bonded to the grounding system of the building or equipment being protected.

Lighting:
Lighting levels in all areas of the facility shall be calculated following the procedures recommended in the Illumination Engineering Society (IES) handbook. For larger areas, use the "Zonal Cavity Calculations" method. The foot-candle level resulting from the actual fixtures to be installed shall be documented. The following minimum foot-candle levels shall be provided:

AREA	FOOT CANDLE
Process, inside	30
Process, outside	5
Storage, inside	10
Walkway	5
General site	1

The following general types of light source shall be used to provide the proposed foot-candle levels:

Area	Light Source
Process, inside to 14 feet mounting height	Fluorescent
Process, above 14 feet mounting height	High Intensity Discharge
Storage, inside	Fluorescent
Walkway, inside	Fluorescent
Walkway, outside	High Intensity Discharge
General site	High Intensity Discharge

Where fluorescent lights are indicated, fixtures with energy saver ballasts and lamps shall be used.

Buildings with outdoor lighting will use luminaires with individual photocells. All luminaires will have individually fused ballasts. Site lighting must take into consideration operator's visibility at all gates and doors.

High bay lighting fixtures that are not easily accessible (such as over turbines) shall be equipped with lowering devices to facilitate re-tamping.

Miscellaneous Systems:
Fire alarm systems shall be included in the building as required by applicable codes. Telephone jacks shall be provided in all offices, work areas, and near exits throughout the facility.

Data highway computer circuits and fiber optic instrumentation circuits shall be defined by the I&C design and shown on the electrical drawings.

3.9 General Corrosion Control Requirements

3.9.1 General

This section addresses general corrosion control, protective coatings, and architectural coating requirements for inclusion in design and construction. Specific requirements identified in other sections of this DCP shall take precedence.

The corrosive environments typically present in water and wastewater treatment facilities can cause rapid deterioration and premature failure of structures and equipment. Corrosion in water and wastewater treatment plants is typically caused by several conditions (singly or in combination) that accelerate deterioration of common materials used in construction. These conditions include:

- Complete or partial immersion in water or wastewater.
- Acid environments resulting from hydrogen sulfide (H2S) condensation or from biological byproducts.
- Confined areas with high humidity.
- Presence of H2S in the headworks area (the severity of this exposure depends on the extent of H2S confinement in a particular area).
- Salty atmospheres.

The Design-Builder shall incorporate corrosion control methods during the facility's design and construction in accordance with the requirements of this section.

Definition of acceptable protective coating systems is included in Table 3.21.

Table 3-21
Minimum Protective Coatings

SYSTEM NUMBER	APPLICATION	SURFACE PREPARATION	PAINT MATERIAL	MINIMUM COATS/COVER
No. 1	Submerged Metal-Potable Water	Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Polyamide Epoxy NSF compliant Prime in accordance with manufacturer's recommendations	3 coats, 3 MDFTPC

SYSTEM NUMBER	APPLICATION	SURFACE PREPARATION	PAINT MATERIAL	MINIMUM COATS/COVER
No. 2	Submerged Metal-Domestic Sewage	Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Coal-Tar Epoxy -OR- Polyamide Epoxy	2 coats, 16 MDFT
No. 5	Exposed Metal-Mildly Corrosive	Abrasive Blast, or Centrifugal Wheel Blast (SP 10)	Polyamide, Anticorrosive Epoxy Primer Polyurethane Enamel	1 coat, 2.5 MDFT 1 coat, 3 MDFT
No. 6	Exposed Metal-Atmospheric	Abrasive Blast, or Centrifugal Wheel Blast (SP 6)	Rust-Inhibitive Primer Alkyd Enamel	1 coat, 2 MDFT 2 coats, 4 MDFT
No. 8	Buried Metal-General	Abrasive Blast or Centrifugal Wheel Blast (SP 10)	Standard Hot Coal-Tar, Enamel -OR- Coal-Tar Epoxy -OR- Tape Coat System -OR- High Build Polyamide Epoxy For Acidic Soil, Brackish Water High Bacteria: Hot Coal-Tar, Double Felt For Highly Abrasive Soil Brackish Water: Hot Coal-Tar, Fibrous Glass -OR- Tape Coat System	AWWA C203 AVWVA C210 AVWVA C214 AVVWA C203 App. A, Sec. A1.5 AVVWA C203 App. A Sec. A1.5 AVWVA C214 with Double Outer Wrap
No. 10	Galvanized Metal Conditioning	Solvent Clean (SP 1) Followed by Hand Tool (SP 2) or Power Tool (SP 3)	Wash Primer or Coating Manufacturer's Recommendation	1 coat, 0.4 MDFT Remaining coats as required for exposure.
No. 11	Galvanized Metal Repair	Solvent Clean (SP 1) Followed by Hand Tool (SP 2), Power Tool (SP 3), or Brush-off Blast (SP 7)	Organic Zinc Rich Primer	1 coat, 3 MDFT

SYSTEM NUMBER	APPLICATION	SURFACE PREPARATION	PAINT MATERIAL	MINIMUM COATS/COVER
No. 12	Skid-Resistant-Steel	Abrasive Blast, or Centrifugal Wheel Blast (SP 10)	Polyamide Epoxy Primer Epoxy Nonskid (Aggregated)	1 coat, 2.5 MDFT 1 coat, 16 MDFT
No. 13	Skid-Resistant-Aluminum and FRP	Brush-off Blast (SP 7) or Plastic Surface Preparation	Epoxy Nonskid (Aggregated)	1 coat, 16 MDFT
No. 14	High Heat-Resistant-700 Degrees F Maximum	Abrasive Blast, or Centrifugal Wheel Blast (SP 6)	Inorganic Zinc Primer Silicone	1 coat, 2.5 MDFT 1 coat, 2 MDFT
No. 15	Heat-Resistant-425 Degrees F Maximum	Abrasive Blast, or Centrifugal Wheel Blast (SP 6)	Inorganic Zinc Primer Silicone Acrylic (limited colors)	1 coat, 2.5 MDFT 2 coats, 2 MDFT
No. 16	Elastomeric Coating	Concrete (see 5.8.5.2) or Masonry (see 5.8.5.4) OR Steel: Abrasive Blast, or Centrifugal Wheel Blast (SP 5)	Prime in accordance with manufacturer's recommendations Elastomeric Polyurethane	1 coat, 32 SFPG
No. 18	Concrete Tank Lining-Potable Water	Concrete (see 5.8.5.2)	Polyamide Epoxy NSF compliant	3 coats, 250 SFPGPC
No. 19	Concrete Tank Lining-Domestic Sewage	Concrete (see 5.8.5.2)	Prime in accordance with manufacturer's recommendations Coal-Tar Epoxy -OR- High Build Polyamide Epoxy	2 coats, 140 SFPGPC
No. 21	Skid-Resistant-Concrete	Concrete (see 5.8.5.2)	Epoxy Nonskid (Aggregated)	I coat, 160 SFPG
No. 22	Chemical-Resistant Wall, Heavy-Duty-Concrete Masonry	Concrete Masonry (see 5.8.5.4)	Block Filler Polyamide Epoxy High Build Polyamide Epoxy High Build, Gloss	1 coat, As Req'd. to Fill Voids 1 coat, 160 SFPG 1 coat, 160 SFPG
No. 23	Chemical-Resistant Wall-Concrete Masonry	Concrete Masonry (see 5.8.5.4)	Block Filler Polyamide Epoxy High Build, Gloss	1 coat, As Req'd. to Fill Voids 1 coat, 160 SFPG
No. 24	Exterior and Interior Fiberglass, PVC	Plastic (see 5.8.5.3)	Polyamide Epoxy Primer Polyurethane Enamel	1 coat, 2.5 MDFT 1 coat, 320 SFPGPC

SYSTEM NUMBER	APPLICATION	SURFACE PREPARATION	PAINT MATERIAL	MINIMUM COATS/COVER
No. 26	Canvas Jacketed Pipe	Remove All Oil and Grease	Canvas Sealer Acrylic Latex	1 coat, 200 SFPG 2 coats, 240 SFPGPC
No. 27	Aluminum and Dissimilar Metal Insulation	Solvent Clean (SP 1)	Wash Primer Bituminous Paint	1 coat, 0.4 MDFT 1 coat, 10 MDFT
No. 29	Fusion Bonded Coating Steel Dowel	Abrasive Blast, or Centrifugal Wheel Blast(SP 10) or Acid Pickling (SP 8	Fusion Bonded 100 percent Solids Epoxy or Polyurethane	1 or 2 coats, 7 MDFT
No. 29A	Fusion Bonded, Coating	Abrasive Blast, or Centrifugal Wheel Blast (SP 10) or Acid Pickling (SP 8) TFE Lube, Shop Applied; Grease Lube Alternative, Field Applied Just Prior to Installation	Fusion Bonded100 percent Solids Epoxy TFE Lube or Grease Lube	1 or 2 coats, 7 MDFT 1 coat, as Required

3.9.2 Carbon Steel and Ductile Iron

3.9.2.1 Atmospheric Exposure

Carbon steel must have an adequate protective coating system. In open areas and dry non-process areas of the plant, structural steel shall be protected with System No. 6. In more aggressive environments, such as salt atmospheres, areas above basins and in buildings with high humidity (including most plant process areas), structural steel shall be painted with System No. 5.

3.9.2.2 Immersion Exposure

For most immersion applications of carbon steel in wastewater, System No. 2 is suitable. For immersion applications in potable water, System No.1 must be used. Coatings provided for this system must be certified in accordance with NSF Standard 61.

3.9.2.3 Buried

The Design-Builder must abide by the following standards:

- Provide corrosion protection in the form of coatings supplemented by cathodic protection for all ferrous and non-ferrous metals in underground applications. Underground pipelines shall be protected with System No. 8. Tape coat systems (American Water Works Association standard C214) are considered suitable for most applications. In addition, coal-tar epoxy, hot-applied coal-tar enamels, fusion-bonded epoxy, and extruded polyethylene are acceptable.

- Supplement the protective coating system that is applied to carbon steel pipelines with cathodic protection. Galvanic anode cathodic protection systems shall be always be used. All piping must be electrically isolated using suitable electrical insulating devices.
- The use of galvanic protection systems is recommended for use with the buried pipe segments. Galvanic anodes in soil <1000 ohm-cm require Zinc material and those > 1000 ohm shall use magnesium anodes. Each galvanic installation shall be installed in a test station facility to the pipe or structure at the test station or in anode junction boxes. The anodes shall be connected to the protected piping using a shunt of known resistance so that the DC current output of each anode may be monitored.
- Protect buried carbon steel structures (other than driven piling) with an appropriate coating system and supplement with cathodic protection. In most cases, System No. 2 is suitable for buried steel structures.
- If drives steel piling are included, they should be reviewed and determine on a case by case basis if they need coating and/or cathodic protection.

3.9.3 Aluminum

The Design-Builder must abide by the following standards:

- Use aluminum for cable trays, stair treads, grating, and handrails, except in chemical storage areas. Cast aluminum is suitable for electrical boxes and fittings.
- Do not use aluminum alloys for ductwork where it will be exposed to chemical environments.
- Use aluminum embedded in or attached directly to concrete to protect against corrosion from the high alkalinity of the concrete. In these applications, the aluminum shall be protected by applying Bitumastic 300M coatings, such as those specified in System No. 27.

3.9.3.1 Stainless Steel

Stainless steel may be used to minimize corrosion and coating requirements. Unless otherwise specified, Type 304 stainless steel may be used for atmospheric exposures. Stainless steel may be used for embedments in concrete. For non-immersion service, Type 316 stainless steel is acceptable. Salt atmospheres, chemical atmospheres, and immersion applications require Type 316 stainless steel.

3.9.3.2 Fasteners

Use Type 316 stainless steel fasteners for all submerged, splash, and spillage exposures. In wet, humid exposures (no contact with chloride-containing water or wastewater), Type 316 stainless steel is acceptable. In dry, conditioned environments, galvanized steel fasteners are acceptable.

3.9.3.3 Copper

Because copper is affected rapidly when it is exposed to the H_2S prevalent in a APWRF, copper use will only be allowed in processes other than wastewater and where approved by OCWS County. Painting copper is not acceptable to minimize the effects of H_2S exposure. Polyvinyl chloride-(PVC-) jacketed copper tubing may be suitable in certain applications approved by OCWS.

3.9.3.4 Grating

Unless otherwise specified, grating and covers in process areas shall be aluminum.

3.9.3.5 Handrails

Aluminum or stainless steel shall be used for handrails in all outdoor and indoor areas within the process units.

3.9.4 Architectural Elements and Structures

3.9.4.1 Flashing and Roof Accessories

Type 304 stainless steel shall be used for all sheet metal used in flashing and other roofing accessories.

3.9.4.2 Doors

The Design-Builder must abide by the following standards:

- Use aluminum, FRP, or stainless steel doors (including frames and hardware) in process buildings with high humidity or where H_2S is present.
- Use properly coated galvanized doors for locations where fire-rated doors are required, and FRP or stainless steel doors are not allowed. Doors shall have a high-quality coating appropriate for the exposure conditions (see System No. 4 and System No. 10).
- Use steel doors if coated with System No. 6 in dry, non-aggressive areas.

3.9.4.3 Window Frames

Annodized aluminum shall be used for window frames.

3.9.4.4 Finish Hardware

All finish hardware shall be Type 304 stainless steel.

3.9.4.5 Painting and Protective Coatings

The Design-Builder shall be responsible for proper application of all paint and protective coatings. The minimum acceptable protective coating systems are identified in Table 3.7-1. Acceptable architectural coatings for non-process, interior spaces are identified in the General Architectural Design Criteria of this document.

The Design-Builder must abide by the following standards:

- Apply paint in manufacturer's recommended maximum or minimum allowable temperatures.
- Do not apply paint in dust- or smoke-laden atmosphere, or in damp or humid weather.
- Do not perform abrasive blast cleaning whenever relative humidity exceeds 85 percent or whenever surface temperature is less than 5°F above dew point of ambient air. If humidity is above 85% should use (DH) dehumidification system. Coating shall always be done separate of other work, or at minimum coordinate with the other trades.
- Epoxy primer is not recommended for contact with potable water. All coatings in contact with potable water should be NSF 61 approved.

3.9.5 Surface Preparation

3.9.5.1 Metal Surfaces

Metal surfaces shall be prepared in accordance with the following Steel Structures Painting Council (SSPC) Specifications:

- Solvent Cleaning: SP 1
- Hand Tool Cleaning: SP 2
- Power Tool Cleaning: SP 3
- White Metal Blast Cleaning: SP 5
- Commercial Blast Cleaning: SP 6
- Brush-Off Blast Cleaning: SP 7
- Pickling: SP 8
- Near-White Blast Cleaning: SP 10
- Power Tool Cleaning to Bare Metal: SP 11

To prepare metal surface, silica abrasives shall not be used anywhere in the facilities. The Design-Builder shall verify current regulations regarding the use of volatile organic compounds (VOCs). VOCs may only be used in accordance with regulations in effect at the time of use**.**

3.9.5.2 Concrete

Poured/New Concrete:
This concrete must be prepared as follows:

- Cure poured concrete surfaces for a minimum of 30 days before painting begins.
- Remove grease, oil, dirt, salts, form-release agents, loose materials, or other foreign matter with solvents, detergents, or other cleaning agents.
- Use brush-off blasting on new concrete. If brush-off blasting is impractical, the surface may be etched with muriatic acid.
- Check that moisture content does not exceed manufacturer's recommendations.

Damaged Concrete:
To paint damaged concrete, follow these steps:

- Fill and smooth cavities, cracks, and abrupt depressions before a coating system is applied to the cleaned concrete.
- Plug water leaks with hydraulic cements.
- Restore the surface in a manner compatible with the coating system selected.

3.9.5.3 Plastics

The Design-Builder must abide by the following standards:

- Plastic surfaces should be hand-sanded with a medium-grit sandpaper to provide sufficient "tooth" for the specified coating system.
- If a specific color is required for FRP equipment, the FRP manufacturer shall use a pigmented gel coat on the exterior of the FRP where available.
- PVC and FRP pipe shall be color coded with labels and color bands.

3.9.5.4 Masonry

The Design-Builder must follow these standards:

- Cure masonry construction a minimum of 14 days.
- Remove oil, grease, dirt, salts, or other chemicals, loose materials, or other foreign matter by solvent, detergent washing, or other suitable methods.
- Clean masonry surfaces of mortar and grout spillage.

3.9.6 Piping

3.9.6.1 Atmospheric Exposure

The Design-Builder must abide by the following standards:

- Coat metallic piping (carbon steel and ductile iron) exposed to the various atmospheres in the APWRF with a protective coating system. Carbon steel and ductile iron pipe shall be painted according to Table 3-21 or approved equal.
- Remove foundry-applied asphaltic varnish on ductile iron pipe before other coatings are applied. If high performance coatings such as epoxies are required, the pipe manufacturer shall prepare the pipe for coating and apply the coating in cooperation with the coating manufacturer.
- Use pipe color coding as specified in the General Mechanical Design Criteria, unless otherwise specified.

3.9.6.2 Submerged Pipe

The Design-Builder must abide by the following standards:

- Use stainless steel and nonmetallic pipe in immersion service (potable water or wastewater) unless otherwise approved by OCWS.
- Use Type 316 stainless steel, FRP, PVC, and chlorinated polyvinyl chloride (CPVC) pipe (where applicable within their temperature and pressure limits) for immersion applications.
- Use alternative piping materials for immersion service only where approved by OCWS.

3.9.6.3 Buried Pipe

The methods required to mitigate buried pipe corrosion shall be determined by the Design-Builder based on the aggressiveness of the soil at the site and the pipe material. The Design-Builder shall incorporate appropriate mitigation methods for the specific soil conditions. Table 3.7-2 provides critical criteria to assess the soil and to determine a mitigation method. The Design-Builder must abide by the following standards:

All buried carbon steel piping shall be protected with appropriate for the installation applications coatings.

3.9.6.4 Pipe Hangers and Supports

Type 304 stainless steel shall be used for pipe hangers. For dry, conditioned air exposures, hot-dipped galvanized steel may be used.

3.9.7 Pumps

The Design-Builder must abide by the following standards:

- The columns of vertical turbine pumps for potable service shall be coated on the interior and exterior with System No.1. For non-potable applications, System No. 2 shall be used.
- Normal immersion coatings shall not be used in high-velocity areas, such as pump bowls and impellers. Provide alloy construction for these components.

In abrasive applications, impellers and pump bowls shall be NilHard.

3.9.8 Electrical

3.9.8.1 Electrical Raceways

The Design-Builder must abide by the following standards:

- Use hot-dipped galvanized steel for interior applications with low humidity and low exposure to hydrogen sulfide.
- Use PVC-coated galvanized steel for exterior exposure and in high-humidity areas.
- Cable trays may be aluminum or FRP throughout the plant, with galvanized steel only for indoor, low-humidity, conditioned air environments.

3.9.8.2 Outdoor Electrical Equipment

Lighting, instruments, and electrical enclosures shall be Type 304 stainless steel, conforming to the applicable National Electrical Manufacturers Association standards for the conditions of service.

3.9.9 Motor Control Centers

Motor control centers located in areas of potential hydrogen sulfide shall be housed in rooms equipped with activated-carbon filters to remove any trace of hydrogen sulfide in the incoming air. Additional cooling shall be provided as required by the equipment. Vapor phase inhibitors (VPI) shall be provided for electrical enclosures that are not installed in conditioned rooms.

3.9.10 Special Corrosion Mitigation

3.9.10.1 Pretreatment Structures

The concrete surfaces in wastewater flow-diversion structures and in open channels where flow is turbulent shall be coated to a point of 1 foot below the minimum water level. Table 3-22 identifies minimum concrete coating requirements for use in wastewater pretreatment structures.

Table 3-22
Coating Alternatives for Concrete Surfaces

CONDITION OF CONCRETE	COATING SYSTEM
New concrete, normal bug-holes, and pockets	Squeegee surface for bug-holes; elastomeric urethane, flake-filled polyester, or reinforced epoxy.

3.9.11 Corrosion Control During Construction

The Design-Builder must abide by the following standards:

- During construction, all materials delivered to the Project sites shall be protected against corrosion during storage and after installation.
- Electrical and I&C equipment shall be packaged and protected with desiccant and vapor-phase inhibitors.
- Mechanical, structural, process, and architectural equipment shall be coated before being shipped to the sites.
- Once on the site, equipment shall be stored properly and protected from the elements.
- Wire VFD MCC heaters during construction to reduce condensation.

3.9.12 Abrasive Applications

Equipment in abrasive applications shall incorporate wear-resistant materials, such as applying hard-facing to wear surfaces, use of abrasion-resistant alloys for the particular component, heat treating to make the alloy harder, and use of sheet-rubber linings.

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4.0 COORDINATION

4.1 Utilities

The Design-Builder shall coordinate work with various utilities within Project limits. The Design-Builder shall notify applicable utilities prior to commencing work, if damage occurs, or if conflicts or emergencies arise during work.

4.1.1 Project Meetings

The OCWS Representative should schedule physical arrangements for meetings throughout progress of work, prepare meeting agenda with OCWS and Design-Builder input, and distribute with written notice of each meeting, preside at meetings, record minutes to include significant proceedings and decisions, and reproduce and distribute copies of minutes within five days after each meeting to participants and parties affected by meeting decisions. Representatives of OCWS, Design-Builder and any subconsultants shall attend meetings, as needed.

4.1.2 Progress Meetings and Coordination Meeting(s):

The OCWS Representative shall schedule regular progress meetings at site, conducted weekly to review work progress, progress schedule, Shop Drawing and Sample submissions schedule, and Application for Payment. Progress meetings shall include OCWS Representative, Design-Builder, subcontractors, suppliers, and others as appropriate.

4.1.3 Quality Control

The Design Builder shall schedule quality control and coordination meetings on regular basis and as necessary to review test and inspection reports, and other matters relating to quality control of work and work of subcontractors. Attendees shall include Design-Builder, Design-Builder's designated quality control representative, selected subcontractors and suppliers, and the OCWS Representative.

4.1.4 Sequence of Work

This section describes the general sequence of work.

- The construction schedule and operation shall be coordinated with OCWS.
- Power outages shall be scheduled with OCWS within 48 hours of the planned shutdown. A written request for the power outage shall be submitted to OCWS describing the reason for the outage, anticipated length, and areas of existing plant affected by the outage. OCWS shall respond within 24 hours of receipt of the written notice whether the timing is acceptable.
- The work shall be performed continuously 24 hours per day, 7 days per week during critical connections and changeovers, and as required to prevent interruption of OCWS' operations.
- Schedule work with OCWS and facility operations personnel before effecting unit shutdowns. Under no circumstances work shall cease at the end of a normal working day if such actions may inadvertently or otherwise cause a cessation of any facility operating process, in which case, remain on-site until necessary repairs are complete.
- No lines shall be closed or valves shall be open, or action shall be taken which would affect the operation of existing systems. Such actions shall be considered by OCWS and the

OCWS Representative upon 48 hours written notice to OCWS. Any such actions required for construction of the work shall be performed by OCWS only.

4.1.5 Construction Photographs

- The Design-Builder shall provide photographs showing the preconstruction site, construction progress, and the post-construction site. All photographs shall be taken electronically and have the date, job title, and brief description of the photographs and location where the photograph was taken indicated on. The Design-Builder shall deliver the photographs to OCWS electronically or hard prints if requested.
- The Design-Builder shall take minimum of 36 exposures of the preconstruction site and the property adjacent to the perimeter of the construction site. Particular emphasis shall be directed to structures both inside and outside the site, or as directed by OCWS or the OCWS Representative.
- The Design-Builder shall take 24 exposures monthly showing the progress of construction.
- The Design-Builder shall take minimum of 36 exposures of the post-construction site and the property adjacent to the perimeter of the site. Particular emphasis shall be directed to structures both inside and outside the plant boundary, or as indicated by OCWS or the OCWS Representative.

4.1.6 Reference Points and Surveys

The location and elevation of benchmarks shall be displayed on the Drawings. Any existing survey points or other control markers destroyed without proper authorization shall be replaced by the Design-Builder to the satisfaction of OCWS Owner.

The Design-Builder shall have the following responsibilities:

- Provide survey and layout required.
- Establish and protect reference points prior to starting site preparation.
- Preserve and leave undisturbed control staking until the OCWS Representative has completed checks it deems necessary.
- Re-establish reference points resulting from destruction by Design-Builder's operations.
- Retain professional land surveyor or civil engineer registered in Florida who shall perform or supervise engineering surveying necessary for construction staking and layout.
- Prepare horizontal coordinate values for control monuments as NAD 83 and prepare a supplemental table with coordinate values in both NAD 83 and NAD 27. Base all elevation on NGVD 29.
- Maintain complete accurate log of survey work as it progresses as a Record Document.
- On request of OCWS, submit documentation.
- Provide competent employee(s), tools, stakes, and other equipment and materials as OCWS County may require to check layout, survey, or measurement work.
- Measure quantities for payment purposes.
- Cooperate with the OCWS or OCWS Representative so that checking and measuring may be accomplished with least interference to Design-Builder's operations.

4.1.7 Cutting, Fitting, and Patching

The Design-Builder shall:

- Cut, fit, adjust, or patch work and work of others, including excavation and backfill as required, to make work complete.
- Obtain prior written authorization of OCWS or the OCWS Representative before commencing work to cut or otherwise alter:
  - Structural or reinforcing steel, structural columns or beams, elevated slabs, trusses, or any other structural member.
  - Weather- or moisture-resistant elements.
  - Efficiency, maintenance, or safety of element.
  - Work of others.
  - Refinish surfaces to provide an even finish.
  - Refinish continuous surfaces to nearest intersection.
  - Refinish entire assemblies.
  - Finish restored surfaces to such planes, shapes, and textures that no transition between existing work and work is evident in finished surfaces.
- Restore existing work, underground facilities, and surfaces that are to remain in completed work including concrete-embedded piping, conduit, and other utilities as specified and as shown.
- Make restorations with new materials and appropriate methods as specified for new work of similar nature; if not specified, use best recommended practice of manufacturer or appropriate trade association.
- Fit work airtight to pipes, sleeves, ducts, conduit, and other penetrations through surfaces and fill voids.
- Remove specimens of installed work for testing when requested by the OCWS Representative.

4.2 Submittals

4.2.1 General

- Documentation that describes the work to be performed under the Contract shall be prepared and submitted by the Design-Builder as required in this section. The documentation furnished by the Design-Builder must allow OCWS to verify the Design-Builder's performance and compliance with Contract requirements.
- Submittal of documents for OCWS' review shall be for the purpose of keeping OCWS informed of the Design-Builder's progress and to demonstrate Design-Builder's compliance with the Contract Documents. It shall in no way relieve the Design-Builder of full responsibility for providing a complete, safe, reliable, operating Project that is in compliance with the Contract Documents.
- Design-Builder shall prepare documentation and submittals required by this section, other sections of the Contract Documents, and as otherwise required to demonstrate compliance with the Contract Documents. The format of all submittals shall conform to the requirements of this section.

- All inquiries regarding procedure, purpose, or extent of submittal shall be made direct to OCWS or the OCWS Representative.
- All submittals shall be scheduled and submitted in accordance with requirements of the Contract Documents and in such sequence as to cause no delay in work.
- Identification of Submittals:
  - All submittals shall be complete and signed, and transmitted with each submittal package shall be one Transmittal of Design-Builder's Submittal Form (attached at the end of this section).
  - Each submittal shall be identified with the following numbering and tracking system:
    - Sequential number
  - Resubmission of a submittal shall have original number with sequential alphabetic suffix
  - Format shall be orderly, indexed with labeled tab dividers.
  - Date of submission shall be identified.
  - Each submittal shall show Project title and the OCWS' contract identification and contract number.
  - Each submittal shall show names of Design-Builder, subcontractor or supplier, and manufacturer as appropriate.
  - Each submittal shall identify subject by Design-Builder Drawing, Design-Builder Specification, Project Definition, or other Contract Document reference to which submittal applies.
  - Each submittal shall have identification of product by description, model number, or style number, if applicable.
  - Each submittal shall identify submittal type; submit only one type in each submittal package.
  - Each submittal shall identify and indicate each deviation or variation from Contract Documents.
- When resubmitting, submittals shall clearly identify each correction or change made.
- Incomplete Submittal Submissions:
  - The OCWS Representative shall return the entire submittal for Design-Builder's revision/correction and resubmission.
  - Submittals which do not clearly bear Design-Builder's specific written indication of Design-Builder review and approval of submittal or which are transmitted with an unsigned or uncertified submission form or as may otherwise be required shall be returned to Design-Builder not reviewed.
- OCWS or the OCWS Representative shall act upon Design-Builder's submittal and transmit response to Design-Builder not later than 20 days after receipt, unless otherwise specified. Resubmittals shall be subject to the same review time.

4.2.2 Drawing Formats and Requirements

Drawings shall be prepared using the following standards:

- All Drawings shall be prepared on 22-inch by 34-inch paper. OCWS shall provide the Design-Builder with a standard title block that shall be used for all Drawings.
- Digital drawing files shall be submitted at the completion of design in the latest AutoCAD Release version in 2014 unless specifically agreed upon prior to construction. A unique

filename shall be assigned to each Drawing. A consistent file naming format shall be used throughout the Project.

- Signature blocks shall be included to show the name of primary individual producing Drawing, the primary designer, the primary reviewer, and the Engineer approving the Drawing. All names in the signature block should be the first initial and the complete last name.
- Standard legends and abbreviations shall be used throughout the Project. Standard legend sheets shall be prepared containing all symbols and abbreviations used on the Drawings.
- Drawings shall include a sequential revision number to allow tracking of the Drawings. Title block shall note Drawings issued for procurement or construction and any subsequent changes including final.
- All Design Submittals required under Applicable Laws to be sealed and signed shall be signed and sealed by the Design-Builder's Designer, who shall be a professional engineer or architect currently licensed in Florida under Applicable Laws.
- Design submittals shall be delivered in bound sets, indexed, and clearly marked to indicate the date of issuance and stage of development.
- Specification Requirements: All Specifications shall be consistent with Construction Specifications Institute (CSI) and comply with the MasterFormat 1995 of 16 Divisions.
- Design Submittals:
  - Ten (10) copies of Drawings, Specifications, and other design submittals shall be provided.
  - Design-Builder shall submit documents during the design phase that shall be sufficiently complete to:
    - Communicate to the OCWS Representative the design intent.
    - Demonstrate compliance with all requirements of the Contract Documents.
    - Clearly define the Design-Builder's requirements for procurement and construction.
- As a minimum, the Design-Builder shall prepare and submit the following:
  - Final plans, sections, and details for all structures.
  - Final building plans, sections, elevations, and details.
  - Final pipeline plan and profile sheets.
  - Pipeline details.
  - Site/Civil plans including finished grading.
  - Mechanical plans, sections, and details.
  - Electrical plans.
  - Instrumentation plans and details.
  - Control diagrams.
  - Specifications.
  - Test procedures for equipment and system testing.
  - Electronic files of Drawings, Specifications, and test procedures. Each electronic file shall include an index of its contents.
- In addition to the above submittals, Design-Builder shall submit updates to any documents submitted as part of its Proposal and incorporated into the Contract including the Process Design Report.

- As part of each design submittal, review comments from previous Design Submittal shall be submitted with actions taken to address comments clearly indicated.
- If requested by the OCWS Representative, Design-Builder shall submit an additional design submittal after submittal of Preliminary Design documents and prior to submittal of Final Design Documents. Such submittal would consist of the latest version of Drawings and Specifications available at the time of request.

4.2.3 Shop Drawings and Samples

The Design-Builder shall submit six (6) copies of Shop Drawings and Product data and two (2) samples when applicable.

The Design-Builder, who prepares the necessary Design Drawings and Specifications for completion of the work, shall be solely responsible for reviewing and approving all shop drawings and other submittals required to confirm that the work is in conformance with the Contract Documents. The OCWS Representative shall audit the review process to make sure that all required reviews by the Design-Builder's designers are occurring and to confirm Design-Builder's conformance to the Contract Documents.

In addition, after completion of design, the OCWS Representative shall identify specific shop drawings and other submittals that it shall review concurrently with the Design-Builder's designer's review. After the Design-Builder's designer's review, the final disposition of the shop drawing based on the Design-Builder's designer's review, shall also be forwarded to the OCWS Representative for informational purposes only. The submittals to and review by the OCWS Representative shall be included in the Design-Builder's Progress Schedule.

The Shop Drawings shall be identified in the following manner:

- Pertinent Drawing sheet(s) and detail number(s), products, units and assemblies, and system or equipment identification or tag numbers.
- Critical field dimensions and relationships to other critical features of Work.
- Samples: Source, location, date taken, and by whom.
- Each deviation or variation from Contract Documents and/or the Design.

Shop Drawings shall be prepared as follows:

- Whenever possible, shop drawings and samples required for submission in each Specification section or division shall be combined into a single submittal package. Product data for like items shall be combined into a single submittal package.
- Shop Drawings shall be presented in a clear and thorough manner and of sufficient detail to show kind, size, arrangement, and function of components, materials, and devices and compliance with Contract Documents and the Design.
- Reproducible Copy:
  - Preferred Minimum Sheet Size: 8-1/2 by 11-inch and 11 by 17-inch pages, suitable for photocopying.
  - Larger than 11 by 17-inch Sheets: 22-inch by 34-inch preferred.
- Piping systems shall be drawn to scale.

- Each copy shall be clearly marked to identify pertinent products or models and show performance characteristics and capacities, dimensions and clearances required, wiring or piping diagrams and controls, and external connections, anchorages, and supports required.
- Equipment and Component Titles shall be identical to title shown on Design Drawings.
- Manufacturer's standard schematic drawings and diagrams shall be as follows:
  - Information that is not applicable to work shall be deleted.
  - Standard information shall be supplemented to provide information specifically applicable to work.
- Shop Drawing Disposition: Submittal of shop drawings and samples to the OCWS Representative shall be for informational purposes only, unless the Design-Builder is requesting a substitution of materials or equipment in place of those specified in the Contract Documents. Any submittal requesting a substitution shall be in accordance with the General Conditions. If a shop drawing is submitted with a request for substitution, the OCWS Representative shall review, mark, and distribute the marked-up copies as noted:
  - Conditionally Accepted as Submitted: Two copies shall be retained in the OCWS Representative's file. Remaining copies returned to Design-Builder appropriately annotated. Subject to approval by the Design-Builder's designer, Design-Builder may begin to implement activities to incorporate specific product(s) or work covered by submittal.
  - Conditionally Accepted as Noted: Two copies shall be retained in the OCWS Representative's file. Remaining copies returned to Design-Builder appropriately annotated. Subject to approval by the Design-Builder's designer, Design-Builder may begin to implement activities to incorporate product(s) or work covered by submittal, in accordance with the OCWS Representative's notations.
  - Not Acceptable: One copy shall be retained in the OCWS Representative's file. Remaining copies returned to Design-Builder appropriately annotated. Design-Builder shall make corrections or develop replacement and resubmit (in same manner and quantity as specified for original submission). Submittal is not acceptable.
  - Incomplete: One copy shall be retained in the OCWS Representative's file. Remaining copies returned to Design-Builder appropriately annotated. Design-Builder shall complete and resubmit or submit missing portions. Submittal shall not be considered acceptable.
  - Not Reviewed: One copy shall be retained in the OCWS Representative's office. Remaining copies returned to Design-Builder. Subject to approval by the Design-Builder's designer, Design-Builder may begin to implement activities to incorporate specific product(s) or work covered by submittal.
- Sample Disposition shall be the same as shop drawing disposition; samples shall not be returned.

4.2.4 Administrative Submittals

Four (4) copies of Administrative submittals shall be submitted.

Submittals that are not shop drawings or samples, or that do not reflect quality of product or method of construction. Administrative submittals may include, but not limited to those submittals identified below.

- Applications for Payment (and Cash Allowance Data and Values): Meet requirements of the General Conditions.

- Construction Photographs and Videotapes shall be submitted to OCWS.
- As a noted exception for photographs, there shall be 1 digital copy and 2 hard copies for pre- and post-construction and progress photos.
- Progress Reports and Quantity Charts shall be submitted as required in the General Conditions.
- Progress Schedule(s) shall meet requirements of the General Conditions.
- Schedule of Submittal Submissions:
  - Prepare and submit preliminary list of submissions with identification, numbering, and tracking system as specified under Paragraph Identification of Submittals and as approved by the OCWS Representative.
  - Include only the following required submissions:
    - Shop drawings and samples.
    - Training plans.
    - Test procedures.
    - Operation and Maintenance Manuals.
    - Record documents.
    - Specifically required certificates, warranties, and service agreements.
  - Each Submittal shall be coordinated with progress schedule to show at a minimum, the following:
    - Estimated submission date to OCWS.
    - Specifically requested and clearly identified the OCWS review time if shorter than that set forth herein, with justification for such request and critical dates submittals shall be needed from the OCWS Representative.
    - For first 6-month period from the Notice to Proceed or following any update or adjustment of the submissions, the estimated submission date shall be week, month, and year; for submissions beyond 6-month time period, the closest month and year shall be shown.
    - A monthly updated list shall be submitted to OCWS if changes have occurred; otherwise a written communication confirming existing list and adjusted submissions reflecting submission activity planned for forthcoming 6-month time period and beyond shall be submitted. All submittals shall be coordinated with progress schedule updates.
- Training Materials shall meet the requirements of Manufacturer's Services section.
- Submittals Required by Laws, Regulations, and Governing Agencies shall comply with the following:
  - Notifications, reports, certifications, payrolls, and otherwise as may be required shall be submitted directly to the applicable federal, state, or local governing agency or their representative.
  - One copy of correspondence and transmittals (to include enclosures and attachments) between Design-Builder and governing agency shall be transmitted to OCWS.

OCWS or the OCWS Representative shall review and indicate requirements for resubmission or acceptance on submittal as follows:

- ***Conditionally Accepted***: Design-Builder may proceed to perform submittal related work. One copy shall be furnished to OCWS. One copy shall be retained in the OCWS

Representative's file. Remaining copies shall be returned to Design-Builder appropriately annotated.

- ***Not Acceptable as Noted:*** One copy shall be retained in the OCWS Representative's file. Remaining copies shall be returned to Design-Builder appropriately annotated. Design-Builder shall revise/correct or develop replacement and resubmit.

4.2.5 Quality Control Submittals

The following quality control documents shall be submitted.

- Certificates required shall include the following as specified in the Manufacturer's Services section:
  - Manufacturer's Certificate of Compliance.
  - Certificates of Successful Testing or Inspection when testing or inspection is required by laws and regulations or governing agencies.
  - Manufacturer's Certificate of Proper Installation.
- An Operation and Maintenance Manual shall be prepared and submitted for OCWS review and approval providing all Operation and Maintenance Data.
- Statements of Qualification including evidence of qualification, certification, or registration shall be prepared and submitted as required in the Contract Documents to verify qualifications of professional land surveyors, engineers, materials testing laboratories, specialty subcontractors, trades, specialists, consultants, installers, and other professionals.
- Field samples shall be provided as required by the Contract Documents and as may be required by OCWS during progress of work.
- Written test reports of each test and inspection shall be provided and as a minimum shall include the following:
  - Date of test and date issued, Project title and number, testing laboratory name, address, and telephone number, and name and signature of laboratory inspector.
  - Date and time of sampling or inspection and record of temperature and weather conditions.
  - Identification of product and Specification section, location of sample, test or inspection in the Project, type of inspection or test with referenced standard or code, certified results of test.
  - Compliance with Contract Documents and the design, and identifying corrective action necessary to bring materials and equipment into compliance.
  - Interpretation of test results, when requested by OCWS.
- OCWS or the OCWS Representative shall review, stamp, and indicate requirements for resubmission or acceptance on submittal as follows:
  - ***Conditionally Accepted***: Subject to approval by the Design-Builder, Design-Builder may proceed to perform submittal related work. Two copies shall be retained in the OCWS Representative's file. Remaining copies returned to Design-Builder appropriately annotated.
  - ***Not Acceptable as Noted***: One copy shall be retained in the OCWS Representative's file. Remaining copies shall be returned to Design-Builder appropriately annotated. Design-Builder shall revise/correct or develop replacement and resubmit.

4.2.6 Contract Closeout Submittals

The Contract Closeout Submittals shall be in accordance with the General Conditions. One set of all approved shop drawings shall be submitted indicating Design-Builder.

OCWS or the OCWS Representative shall review, stamp, and indicate requirements for resubmission or acceptance on submittal as follows:

- ***Conditionally Accepted***: One copy shall be furnished to OCWS. One copy shall be retained in the OCWS or the OCWS Representative's file. The remaining copies shall be returned to Design-Builder appropriately annotated.
- ***Not Acceptable as Noted***: One copy shall be retained in the OCWS Representative's file. Remaining copies shall be returned to Design-Builder appropriately annotated. Design-Builder shall revise/correct or develop replacement and resubmit.

4.3 QUALITY CONTROL

4.3.1 Requirements and Standards

The Design-Builder shall schedule and administer a Quality Control program to ensure an acceptable level of quality for all products and services provided, as evidenced by:

- Design resulting in a facility that can be efficiently operated and maintained.
- Continuous monitoring of engineering design and documentation preparation.
- Firm procurement and performance specifications.
- Firm procedures for transmission of data and information to OCWS and subcontractors, and ensuring the subcontractors' compliance therewith.
- Adequate testing and verification to ensure uniform product or services conforming to the design requirements.
- Total program surveillance and verification of physical conformance and configuration accountability.

The Quality Control program shall apply to all work provided under this Contract, including design, components, equipment, systems, services, software, and construction.

Design-Builder and its subcontractors shall conform to reference standards current on bid opening date including:

- ASTM D3740 – Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
- ASTM E329 – Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction.

Design-Builder and its subcontractors shall indicate any instance where specified reference standards conflict with Contract Documents and request clarification from the OCWS Representative before proceeding.

4.3.2 Quality Assurance/Control of Work

The Design-Builder is responsible for controlling the quality of work including work of its subcontractors, sub-subcontractors, and suppliers and for assuring that the specified quality is achieved. The Design-Builder and its subcontractors, sub-subcontractors, and suppliers shall be responsible for developing and maintaining a quality control program which is responsive to the requirements of this section including the attached QC Program elements and which includes implementing procedures necessary to assure compliance with the requirements of the Contract. An outline of the Quality Control (QC) program shall be submitted within 20 days after receipt of Notice to Proceed. The QC program and implementing procedures for quality control of work scheduled to be performed within 180 days after receipt of the Notice to Proceed together with a schedule of Design-Builder procedures for later work activities shall be submitted to OCWS and the OCWS Representative for approval prior to commencement of the work but no later than 60 days following receipt of the Notice to Proceed, whichever occurs first. The QC program shall explain the Design-Builder's and its subcontractors' approach to design quality control, on-site quality control, off-site quality control, the QC organization, and documentation of quality control activities, and provide all other information necessary to demonstrate to OCWS and the OCWS Representative that the Design-Builder and its subcontractors, sub-subcontractors, and suppliers will provide quality control services that ensure compliance of the work with the Contract Documents. The QC program shall identify the Design-Builder's individuals responsible for the execution of the program, and identify those subcontractors/sub-subcontractors/suppliers working to the QC program and those working to their own Quality Control (SQC) program. The Quality Control programs shall apply to the control of quality throughout all areas of contract performance including, as appropriate, all design phases; procurement, identification, stocking, and issue of material; the entire process of construction; the installation and testing of equipment; the training of operations and maintenance personnel; and the start-up and acceptance testing of the Project.

Overall administration of the QC program shall be vested in a responsible, authoritative element of the Design-Builder's organization, hereinafter referred to as the QC Organization, under a qualified QC Manager acceptable to OCWS and the OCWS Representative, who has clear access to top level management and to subcontractors' officers responsible for the execution of the SQC Program. The QC Manager's sole duty is to manage and administer the QC program unless otherwise authorized in writing by the OCWS Representative. Such authorization can be withdrawn at any time. The QC Manager shall be assigned for the duration of the Contract, and any change is subject to the OCWS Representative's approval. The Design-Builder shall perform the work covered by this Section with a QC Manager having at least five (5) years of experience in quality control management of construction inspection personnel performing quality control inspection on construction projects and with construction inspection personnel having at least three (3) years of experience in quality control inspection on construction projects.

As part of the QC Organization, the Design-Builder shall include specialized personnel to assist the QC Manager in the areas of civil, electrical, instrumentation and control, mechanical, process/environmental, structural, and materials testing. These individuals shall be employed by the Design-Builder, be responsible to the QC Manager; be physically present during the execution of work on their areas of responsibility, and have the necessary education and/or experience in accordance with the experience matrix listed herein. These individuals may perform other non-conflicting duties but must be allowed sufficient time to perform their assigned quality control duties as described in the QC Plan. Except for materials testing, each of these individuals shall have a 4-year college degree from an accredited program in their respective disciplines, and 5 years of experience in their respective disciplines. The materials testing technician shall have a minimum of 2 years of experience. Educational requirements may be waived by OCWS in lieu of relevant experience and additional relevant certifications.

As part of the QC Organization, the Design-Builder shall include a Design QC Manager who shall be responsible for Quality Control for all Design Professional Services performed as part of the Project. The Design QC Manager shall be employed by the Design-Builder's designer who is responsible for design of the Project. Minimum requirements for the Design QC Manager shall include a Civil Engineering degree, professional registration in Florida, a minimum of ten (10) years experience in water or wastewater engineering, and a minimum of five (5) years experience with managing design QC programs.

Resumes of all QC Organization personnel shall be submitted and must be evaluated by the OCWS Representative to be so qualified prior to the commencement of work. If OCWS or the OCWS Representative has reasonable objection to the qualifications of the Design-Builder's nominated quality control personnel, the Design-Builder shall, at no additional cost to OCWS, employ qualified personnel or subcontractors, subject to the review of their qualifications by the OCWS Representative. Employment by the Design-Builder of quality control subcontractors shall not in any way alter or reduce the Design-Builder's obligations under this Section.

The QC Organization shall be staffed by technically competent personnel with freedom to make decisions without pressure or bias. It shall have sufficient authority to ensure that quality requirements are consistently maintained and shall be independent from that portion of the Design-Builder's organization responsible for production.

Written implementing quality control, test, and inspection procedures shall be used for all pertinent operations. These procedures shall contain instructions for performing the required review, test, or inspection, contain the accept/reject criteria for each review or inspection activity listed on the checklist (i.e., applicable design criteria, drawing, specification section, industry code or standard), and shall establish the schedule and/or frequency for performing the review, test, or inspection. These procedures shall be kept current and shall be available at all locations where they will be used.

The Design-Builder shall maintain control over procurement sources to ensure that materials, equipment, and services conform to specified requirements. The Design-Builder's procurement documents shall require subcontractors and suppliers to implement their own (SQC) program, as required by this Section or implement the QC Program. Copies of procurement documents shall be provided to the OCWS Representative upon request. When required by the Contract Documents, procurement documents shall be submitted to OCWS or the OCWS Representative at the time of award/purchase. The Design-Builder and its subcontractors shall comply fully with manufacturers' instructions, including completing each step in sequence. Should manufacturers' instructions conflict with Contract Documents, the Design-Builder is to notify the OCWS Representative before proceeding and shall resolve the conflict in a manner that is acceptable to the OCW Representative. Work to be done away from the site is subject to inspection on behalf of OCWS during its fabrication, manufacture, or testing, or before shipment. The Design-Builder shall give notice to OCWS or the OCWS Representative of the place and time where such fabrication, manufacture, testing, or shipping is to be done at least thirty (30) days in advance so that the necessary arrangements for inspections and witnessing of shop tests can be made.

OCWS and the OCWS Representative may audit and inspect the Design-Builder's and subcontractor's Quality Control programs at any times. Such audits may be conducted on a random or routine basis and may include an audit of the Design-Builder's review and inspection records and data. Additionally, OCWS and the OCWS Representative shall have the right to witness any quality control tests or inspections and shall have access to all test data, including test procedures, test specifications, and test results. Further, OCWS and the OCWS Representative shall have the right to conduct independent tests or inspections of any part of the work. OCWS and the OCWS Representative shall not be obligated to perform such audits, inspections, or tests and the performance or non-performance of such audits, inspections, or tests by OCWS or the OCWS Representative shall not relieve the Design-Builder of any of its obligations under the Contract.

Means and methods shall be established for controlling the identification, handling, and storage of raw and fabricated material and inspection status of the material. These controls shall be maintained from the time of receipt of the material until its incorporation in the work or delivery to OCWS or the OCWS Representative, in order to protect the material from damage, deterioration, loss, or substitution.

The Design-Builder shall maintain control over construction and installation processes to assure compliance with specified requirements. In-process and final inspection and testing of construction shall be performed in accordance with written implementing quality control, test, and inspection procedures to assure that contract requirements have been met. The results of in-process and final inspections shall be recorded on inspection checklists developed by the Design-Builder and approved by the OCWS Representative.

Means and methods shall be established to assure conformance with requirements for special process specifications such as welding, heat treating, and nondestructive testing of materials. Certifications for personnel, procedures, and equipment shall be maintained as required to meet the requirements of the Contract Documents and all applicable codes.

Procedures shall provide for the identification and control of unsatisfactory or nonconforming work and for the prompt notification to the OCWS Representative with recommendations for corrective action. Procedures for performing corrective work shall also be defined.

The QC and SQC programs are subject to periodic audit by OCWS or the OCWS Representative to assure compliance with the Contract Documents.

The Design-Builder shall issue monthly quality control reports to the OCWS Representative. These reports shall address: status of the Design-Builder Quality Control program for design and construction including procedure development, status of subcontractor/supplier quality control program/procedures, number of reviews/inspections/tests performed during the month, any quality problems experienced, and corrective actions taken.

4.3.3 Quality Assurance/Control of Subcontractors/Suppliers

The Design-Builder is responsible for controlling the quality of work performed by its subcontractors, subcontractor, and suppliers. Subcontractors and suppliers may implement their own quality control program if the Design-Builder and the OCWS Representative approve the program. Otherwise, the Design-Builder will instruct the subcontractor or supplier to implement the QC program on all work performed and will perform the QC inspections of the subcontractor's or supplier's work and activities. The OCWS Representative's approval of supplier QC Programs may be waived at the discretion of the OCWS Representative. Such waivers can be withdrawn at any time.

Overall administration of the QC Program shall be vested in a responsible, authoritative element of the subcontractor's organization under a qualified QC Manager in residence at the work location. The QC Manager shall meet the same experience requirements as specified for the Design-Builder QC Manager, be acceptable to the Design-Builder and the OCWS Representative, and have clear access to top level management. The resume of the QC Manager shall be submitted and be evaluated by the Design-Builder and the OCWS Representative prior to the commencement of work. Any subcontractors providing Design Professional Services shall implement a design QC program under a Design QC Manager and meet the same requirements outlined in this section.

4.3.4 Design-Builder's On-Site Quality Control Testing and Inspection

The Design-Builder and its subcontractors shall perform reviews, inspections, tests, and other services as required by the Contract Documents and their approved QC programs, in accordance with laws, codes,

rules, and regulations, and as required to assure the quality of the work. The results of all reviews, inspections, tests, and other services shall be documented on checklists as described herein.

Design-Builder shall provide reasonable notice to the OCWS Representative so that the OCWS Representative may witness Design-Builder and/or subcontractors on site tests. The OCWS Representative's witnessing of tests does not relieve the Design-Builder and/or subcontractors of their obligation to comply with the requirements of the Contract Documents.

The Design-Builder and its subcontractors shall develop a review, inspection, and test index identifying all required reviews, inspections, and tests as indicated in the Contract Documents and their approved QC program. The Design-Builder shall provide one copy of review, test, and inspection results to the OCWS Representative witnessing the test and retain and file the original review, inspection, and test results in an orderly manner so that Design-Builder can readily turn over such records to the OCWS Representative and demonstrate to the OCWS Representative at Substantial Completion that the work has been satisfactorily performed and tested.

4.3.5 Quality Control Action Items

Unless otherwise directed in writing by OCWS or the OCWS Representative, the Design-Builder shall promptly undertake appropriate action at no additional cost to OCWS to respond and correct any unsatisfactory, nonconforming, or otherwise deficient conditions reported to the Design-Builder by the OCWS Representative. These conditions may be identified as a result of OCWS or the OCWS Representative inspections, audits, or surveillance.

The Design-Builder’s refusal, failure, or neglect to take appropriate action or to submit a written response within the time period requested shall constitute reasonable evidence that the Design-Builder is not prosecuting the work or separable part with the diligence that will ensure its acceptable quality within the applicable Contract requirements and shall constitute sufficient basis for the OCWS Representative to recommend in accordance with the General Conditions to withhold any payment otherwise due, or identify and order alternate actions on the basis of the information in the Contract.

4.3.6 Independent Testing Laboratory

Design-Builder shall employ the services of an independent testing laboratory to perform routine testing of earthwork and concrete, i.e., soil density; concrete strength, slump, and air content; and perform random tests of other areas previously completed and inspected by Design-Builder. The Design-Builder shall submit the qualifications of the independent testing laboratory to the OCWS Representative for review and approval. All tests required by the Contract Documents, referenced codes and standards, or local laws or regulations are the responsibility of the Design-Builder.

Laboratories utilized for testing soils, concrete, asphalt, and steel shall meet criteria detailed in ASTM D3740 and ASTM E329.

Reports will be submitted by the independent testing firm to the Design-Builder with copies to the OCWS Representative indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents.

Design-Builder and subcontractors shall cooperate with the independent testing laboratory and shall furnish samples of materials and provide assistance as requested in accordance with procedures and requirements established and/or approved by the independent testing laboratory.

The Design-Builder shall provide reasonable notice (at least 24 hours) to the OCWS Representative prior to expected time for operations requiring independent testing.

If testing by the independent testing laboratory indicates that Design-Builder's and/or subcontractors work fails to conform to the specified requirements, Design-Builder and/or subcontractors shall correct the defective work, develop suitable procedures to ensure that any new work will be in conformance with specifications, and perform testing to verify that the corrected work and new procedures are in compliance with the specifications, all at no additional cost to OCWS.

4.3.7 Manufacturers' Field Installation Services and Reports

Manufacturer's field installation services and reports shall be in accordance with the Manufacturer Services section.

When specified in the Contract Documents or necessary for completion of the work, the Design-Builder and its subcontractors shall require material or product suppliers or manufacturers to provide qualified staff personnel to observe site conditions, conditions of surfaces and installation, quality of workmanship, start-up of equipment (test, adjust, and balance of equipment), and to provide instructions when necessary.

Design-Builder shall report to OCWS or the OCWS Representative in writing any observations and site decisions or instructions given by the manufacturers' representative to the Design-Builder that are supplemental or contrary to manufacturers' written instructions.

The Design-Builder shall submit manufacturer's representative's reports (in duplicate) within 10 days of each field visit, to the OCWS Representative for review. If the durations of field visits are greater that one week, the Design-Builder shall submit weekly reports. Final report shall include Manufacturer's Certificate of Proper Installation.

4.3.8 Quality Control Program Maintenance

The QC program shall define all quality records that are to be developed and turned over to OCWS or the OCWS Representative as a result of implementing the quality program and procedures. The list shall be submitted to OCWS for approval.

The Design-Builder and subcontractors shall maintain QC programs, procedures, and records at the site where the work is being performed. All quality records shall be legible and identifiable as to the design document, material, equipment, or other element of the work involved. Quality records shall be stored and maintained in such a manner that they are readily retrievable in facilities that provide a suitable environment to minimize deterioration or damage to prevent loss. Retention times of quality records shall be established and recorded. Quality records shall be made available, at all times, for evaluation and review by OCWS or the OCWS Representative.

4.3.9 Quality Control Program Implementation

OCWS reserves the right to have the OCWS Representative either prepare or assist the Design-Builder or its subcontractors and suppliers in the preparation of a quality control program and implementing procedures submittals which are overdue by more than fifteen (15) days, and the Design-Builder shall reimburse OCWS for all associated direct, indirect, or consequential costs. In the event the Design-Builder fails to pay those costs within thirty (30) days after receipt of an invoice from OCWS, OCWS shall be entitled to a decrease in Contract Sum or to withhold a set-off against any amounts recommended for payment. The OCWS Representative's assistance with quality control program and implementing procedure preparation shall not relieve the Design-Builder of its responsibilities for determination of the methods, techniques, and sequences for the performance of the work.

After acceptance of the Design-Builder's QC program, the Design-Builder shall notify OCWS in writing of any proposed change. Proposed changes are subject to acceptance by the OCWS Representative.

The Design-Builder shall maintain its QC organization at full strength at all times. When it is necessary to make changes to the QC staff, the Design-Builder shall revise the QC program to reflect the changes and submit the changes to OCWS for acceptance.

The QC program shall be reviewed and documented, not less frequently than on a semi-annual basis, by the Design-Builder's management to ensure its continued suitability and effectiveness. The Design-Builder's review of the QC program shall be conducted to ensure that (i) QC program requirements are adequately defined and understood by personnel involved in implementing the Work; (ii) any requirements differing from those in the Contract Documents are resolved; and (iii) the Design-Builder and all subcontractors are satisfying all Contract requirements with respect to quality control. Records of such reviews shall be maintained at the site.

Pursuant to the General Conditions, the OCWS Representative may refuse to recommend the whole or part of any payment if, in the OCWS Representative's opinion, the Design-Builder's or its subcontractors' failure, refusals or neglect to provide the required quality control program and implementation precludes a proper evaluation of either quality control activities or the quality of work. OCWS may refuse to make payment of the full amount recommended by the OCWS Representative, and OCWS may withhold from any payment a set-off if, in OCWS' opinion, the Design-Builder's or its subcontractors' failure, refusal, or neglect to provide the required quality control program and implementation precludes a proper evaluation of whether or not the Design-Builder or its subcontractor is prosecuting the quality control program and controlling the quality of the work with diligence that will ensure its completion within the Contract requirements.

These remedies for the Design-Builder's failure, neglect, or refusal to comply with the requirements of this Section are in addition to, and not in limitation of, those provided under the OCWS/Design-Builder Agreement and the General Conditions.

Inspections and tests shall be made by the Design-Builder and its subcontractors and the appropriate documentation produced as each element of work is executed. The OCWS Representative may require completion of all required QA/QC documentation as a condition of payment for a particular item. The OCWS Representative will require that all documentation be complete as a condition precedent to release of retainage.

4.4 OPERATION AND MAINTENANCE DATA

Manuals for equipment and systems shall be prepared by equipment manufacturer or system supplier. Manuals for system operation and maintenance shall be prepared by the Design-Builder.

4.4.1 Sequencing and Scheduling

Preliminary and final manuals shall be submitted through the following procedure:

- Preliminary Manuals: Submit prior to shipment date for equipment, system, subsystem, or component. Include copy of warranties, Bonds, and service agreements if specified.
- Final Manuals: Submit not less than 30 days prior to equipment or system field testing or startup.

Manuals for Materials and Finishes shall be submitted through the following procedure:

- Preliminary Manuals: Submit at least 15 days prior to request for final inspection.

- Final Manuals: Submit within 10 days after final inspection.

System Operation and Maintenance Manuals shall be submitted through the following procedure:

- Preliminary Manuals: Submit not less than 60 days prior to facility startup.
- Final Manuals: Submit not less than 30 days prior to facility startup.

4.4.2 General Requirements for Equipment and Treatment Plants

4.4.2.1 Major Equipment O&M Manuals

This section describes the equipment operation and maintenance manuals and the treatment plant operation and maintenance manual.

For each item of equipment or system included in the Project, a list of proposed manuals shall be submitted to OCWS. The manuals shall follow the following format.

- Size: 8-1/2 by 11 inches.
- Manufacturer's printed data, or neatly typewritten.
- Three-hole punch data for binding and composition; arrange printing so that punched holes do not cover data.
- Provide separator for each product or piece of equipment with typed description of product and major component parts.
- Cover: Identify each volume with typed or printed title "OPERATION AND MAINTENANCE MANUAL, VOLUME NO. _ OF _," if applicable, and list:
  - Project title.
  - Designate the system or equipment for which it is intended.
  - Identity of separate structure as applicable.
  - Identity of general subject matter covered in manual.
- Material shall be suitable for reproduction, with quality equal to original. Photocopying of material will be acceptable, except for material containing photographs.
- Table of contents neatly typewritten, arranged in a systematic order:
  - Design-Builder, name of responsible principal, address, and telephone number.
  - List of each product required to be included, indexed to content of each volume.
  - List with each product: name, address, and telephone number of subcontractor, supplier, installer, and maintenance contractor, as appropriate.
  - Identify area of responsibility of each.
- Provide local source of supply for parts and replacement. Identify each product by product name and other identifying numbers or symbols as set forth in Contract Documents.
- Include only those sheets that are pertinent to specific product.
- Clearly annotate each sheet to identify specific product or part installed, and to identify data applicable to installation.
- Delete references to inapplicable information.
- Drawings: Supplement product data with Drawings as necessary to clearly illustrate:

- Relations of component parts of equipment and systems.
- Control and flow diagrams.
- Coordinate drawings with Project record documents to assure correct illustration of completed installation.
- Do not use Project record documents as maintenance manual drawings.
- Provide reinforced punched binder tab, bind in with text.
- Reduced to 8-1/2 by 11 inches, or 11 by 17 inches folded to 8-1/2 by 11 inches.

♦ Instructions and Procedures: Within text, as required to supplement product data.

- Handling, storage, maintenance during storage, assembly, erection, installation, adjusting, testing, operating, shutdown in emergency, troubleshooting, maintenance, interface, and as may otherwise be required.
- Organize in a consistent format under separate heading for each different procedure.
- Provide a logical sequence of instructions for each procedure.
- Provide information sheet for the OCWS personnel, including:
  - Proper procedures in the event of failure.
  - Instances that might affect the validity of warranties or Bonds.

♦ Warranties, Bonds, and Service Agreements: In accordance with the General Conditions.

♦ Electronic Format: Microsoft Word, most current version.

4.4.2.2 Treatment Plant O&M Manual Update

The format for the treatment plant O&M manual update shall follow the general requirements of the individual major equipment O&M manuals specified in Section 4.4.2.1. The manual update shall include:

♦ Description and operation of all new treatment plant components, including process and non-process systems such as communications systems (telephone, intercom, alarm), potable water system, fuel system, electrical distribution system, the HVAC system, and emergency power system, as applicable. A clear discussion of how the new components have been integrated into the existing facility shall be provided.

♦ Each process subsystem (unit operation) shall be covered in separate chapters and include the following information:

- Subsystem design intent; what equipment the subsystem consists of and is designed to accomplish. Descriptions of any controls and instrumentation that are part of the subsystem shall be included. Actual design and expected values and ranges of parameters (e.g., flow, temperature, pressure, concentrations) shall be tabulated. Equipment and instrumentation lists shall be included.
- Startup, operating, and shutdown procedures and strategies for the system and system components. This shall include abnormal, alternate, and emergency operating procedures.
- Standard Operating Procedures (SOP's) that shall outline the steps and procedures for starting, operating, and shutting down all individual unit processes and equipment items. The SOP's shall be in an easy to read format that will allow them to be posted near the equipment they refer to.
- Comprehensive system troubleshooting and corrective procedures; operating indicators and alarms that will alert the operator to a situation that requires troubleshooting.
- System controls and instrumentation; use of instrumentation for monitoring and control (Note: Any plant instrumentation and control systems that allow for the monitoring and/or

operation of equipment from remote locations shall be considered as a subsystem and shall have a dedicated chapter of the manual.

The Design-Builder shall conform to EPA guidance on treatment plant operation and maintenance requirements. Information to be followed is included, but not limited to EPA's *Considerations for Preparation of Operation Maintenance Manuals* (EPA 430/9-74-001, 1978).

4.4.3 Submittal Procedure

The submittal procedure for the preliminary manuals shall be the following:

- Submit three copies for the OCWS Representative review.
- If accepted:
  - One copy will be returned to Design-Builder.
  - One copy will be retained in the OCWS Representative's file.
  - Submit five copies of final manual.
- If rejected:
  - Two copies will be returned to Design-Builder with the OCWS Representative's comments for revision.
  - One copy will be retained in the OCWS Representative's file.
  - Resubmit three copies revised preliminary copies for the OCWS Representative review.

The submittal procedure for the final manuals shall be the following:

- If different than accepted preliminary manuals, submit:
  - Two copies of any necessary supplemental material, including revised table of contents.
  - Instructions for insertion of supplemental material in unreturned sets.
- If final manuals are acceptable, Design-Builder will be so notified.
- If rejected, and at the OCWS Representative's option:
  - All copies will be returned to Design-Builder for revision, or;
  - All copies will be retained by the OCWS Representative, and the necessary revision data will be requested from Design-Builder.

4.5 CONSTRUCTION FACILITIES AND TEMPORARY CONTROLS

4.5.1 Shop Drawings

Administrative submittals consisting of copies of permits and approvals for construction shall be submitted as required by laws and regulations and governing agencies.

Shop Drawings of temporary utility submittals shall include:

- Electric power supply and distribution plans.
- Water supply and distribution plans.
- Sanitary facilities.
- Drainage plans.

Shop Drawings of temporary construction submittals shall include:

- Access Roads: Routes, cross-sections, and drainage facilities.
- Parking area plans.
- Design-Builder's field office, storage yard, and storage building plans including gravel surfaced area.
- Fencing and protective barrier locations and details.
- The OCWS Representative field office plans.
- Staging area location plan.
- Traffic Control and Routing Plans: As specified herein, and proposed revisions thereto.
- Plan for maintenance of existing plant operations.

Shop Drawings of temporary control submittals shall include:

- Noise control plan.
- Plan for disposal of waste materials and intended haul routes.

4.5.2 Mobilization

Mobilization shall include, but not be limited to, these principal items:

- Obtaining required permits.
- Moving Design-Builder's field office and equipment required for first month operations onto site.
- Installing temporary construction power, wiring, and lighting facilities.
- Providing on-site communication facilities, including telephones.
- Providing on-site sanitary facilities and potable water facilities as specified and as required by laws and regulations and governing agencies.
- Arranging for and erection of Design-Builder's work and storage yard.
- Posting OSHA required notices and establishing safety programs and procedures.

4.5.3 Design-Builder’s Use of Premises

Lands owned by which Design-Builder shall perform the work are as shown on the Drawings.

4.5.4 Permits

Permits, Licenses, or Approvals: Obtain in accordance with the General Conditions and as otherwise may be provided in the Special Conditions and retain on site.

4.5.5 Protection of Work and Property

Comply with OCWS' safety rules while on OCWS property. Keep OCWS County informed of serious accidents on the site and related claims.

4.5.6 Project Sign

Provide and maintain one 8-foot wide by 4-foot high sign constructed of 3/4-inch exterior high density overlaid plywood. Paint shall be exterior type enamel. Information to be included will be provided by OCWS.

4.5.7 Temporary Utilities

4.5.7.1 Power

- The Design-Builder shall be responsible for obtaining temporary electric power service for its offices and facilities. Owner shall pay all costs for the electric power used during the Contract period.
- Cost of electric power used in performance and acceptance testing will be borne by the Owner.

4.5.7.2 Lighting

- Design-Builder shall provide temporary lighting at least to meet all applicable safety requirements to allow erection, application, or installation of materials and equipment, and observation or inspection of the work.

4.5.7.3 Cooling and Ventilating

- Design-Builder shall provide as required to maintain adequate environmental conditions to facilitate progress of the work, to meet specified minimum conditions for the installation of materials, and to protect materials, equipment, and finishes from damage due to temperature or humidity.
- Design-Builder to provide adequate forced air ventilation of enclosed areas to cure installed materials, to dispense humidity, and to prevent hazardous accumulations of dust, fumes, vapors, or gases.
- Design-Builder to pay all costs of installation, maintenance, operation, removal, and fuel consumed.

4.5.7.4 Water

- Design-Builder shall be responsible for obtaining construction water at the site, including any temporary facilities and piping required to bring water to the point of use; as well as removal when no longer needed.
- Owner shall pay the costs for any potable water required for testing equipment, tanks or basins, and piping where treated effluent cannot be used.
- OCWS shall locate utilities on plans but the Design-Builder shall be responsible for all associated costs.

4.5.7.5 Sanitary and Personnel Facilities

- Facilities for the OCWS Representative, Design-Builder's employees, subcontractors, and all other on-site Non-Owner employees shall be provided and maintained by Design-Builder. Design-Builder may install temporary piping to allow sanitary sewers to discharge in the existing sanitary sewer system at Design-Builder's sole cost.
- Owner shall pay the operating cost for the gravity conveyance and treatment of sanitary waste from non-Owner personnel at APWRF site.

4.5.7.6 Telephone Service

On-site telephone service for Design-Builder and non-Owner employees use during construction shall be provided and maintained by the Design-Builder. All costs of installation and monthly bills shall be paid by the Design-Builder.

4.5.7.7 Protection

- Adequate firefighting equipment capable of extinguishing incipient fires shall be provided and maintained on site. All fire protection equipment shall be in accordance with National Fire Prevention Standard for Safeguarding Building Construction Operations (NFPA No. 241).

4.5.8 Protection of Work and Property

- The Design-Builder shall maintain continuous service of all existing oil and gas pipelines, underground power, telephone or communication cable, water mains, irrigation lines, sewers, poles and overhead power, and all other utilities encountered along the line of work, unless other arrangements satisfactory to owners of said utilities have been made.
- Where completion of Work requires temporary or permanent removal and/or relocation of an existing utility, the Design-Builder shall coordinate all activities with owner of said utility and perform all work to their satisfaction.
- The Design-Builder shall protect, shore, brace, support, and maintain underground pipes, conduits, drains, and other underground utility construction uncovered or otherwise affected by construction operations.
- The Design-Builder shall keep fire hydrants and water control valves free from obstruction and available for use at all times.
- The Design-Builder shall provide and maintain temporary security fences to protect the work and products not yet installed.

4.5.10.1 Barricades and Lights

- The Design-Builder shall provide barricades and lights as required in sufficient quantity to safeguard public and work.
- The Design-Builder shall provide barricades and lights as necessary to prevent unauthorized entry to construction areas and affected roads, streets, and alleyways, inside and outside of fenced area, and as required to ensure public safety and the safety of Design-Builder's employees, other employer's employees, and others who may be affected by the work.

- The Design-Builder shall provide barricades and lights to protect existing facilities and adjacent properties from potential damage.
- The Design-Builder shall locate barricades and lights to enable access by facility operators and property owners.
- The Design-Builder shall provide barricades and lights to protect streets, roads, highways, and other public thoroughfares that are closed to traffic by effective barricades with acceptable warning signs.

4.5.10.2 Trees and Plantings

- The Design-Builder shall protect from damage and preserve trees, shrubs, and other plants outside the limits of the work and within the limits of the work which are designated to remain undisturbed.
- The Design-Builder shall employ hand excavation as necessary to prevent tree injury.
- The Design-Builder shall not stockpile materials or permit traffic within drip lines of trees.
- The Design-Builder shall provide and maintain temporary barricades around trees.
- The Design-Builder shall water vegetation as necessary to maintain health.
- The Design-Builder shall cover temporarily exposed roots with wet burlap, and keep the burlap moist until soil is replaced around the roots.
- The Design-Builder shall dispose of removed trees in a legal manner off the site, unless approved by OCWS.
- In the event of damage to bark, trunks, limbs, or roots of plants that are not designated for removal, the Design-Builder shall treat damage by corrective pruning, bark tracing, application of a heavy coating of tree paint, and other accepted horticultural and tree surgery practices.
- The Design-Builder shall replace each plant that dies as a result of construction activities.

4.5.10.3 Finished Construction

- The Design-Builder shall protect finished floors and concrete floors exposed as well as those covered with composition tile or other applied surfacing.

4.5.10.4 Waterways

- The Design-Builder shall keep ditches, culverts, and natural drainages continuously free of construction materials and debris.

4.5.10.5 Dewatering

- The Design-Builder shall construct, maintain, and operate cofferdams, channels, flume drains, sumps, pumps, or other temporary diversion and protection works.
- The Design-Builder shall furnish materials required, install, maintain, and operate necessary pumping and other equipment for the environmentally safe removal and disposal of water from the various parts of the work. Maintain the foundations and parts of the work free from water. Construction dewatering shall be performed and maintained to provide stable subgrades, excavation slopes, and protection of existing structures and utilities and all

ongoing new construction. Dewatering systems shall have adequate backup capacity and power to prevent loss of dewatering critical to the protection and stability of the above listed items.

4.5.9 Temporary Controls

4.5.9.1 Air Pollution Control

- Air pollution from construction operations shall be minimized.
- Burning of waste materials, rubbish, or other debris shall not be permitted on or adjacent to the site unless approved by OCWS.
- Operations of dumping rock and of carrying rock away in trucks to cause a minimum of dust shall be conducted. Give unpaved streets, roads, detours, or haul roads used in the construction area a dust-preventive treatment or periodically water to prevent dust. Strictly adhere to applicable environmental regulations for dust prevention.
- Provide and maintain temporary dust-tight partitions, bulkheads, or other protective devices during construction to permit normal operation of existing facilities. Construct partitions of plywood, insulating board, plastic sheets, or similar material. Construct partitions in such a manner that dust and dirt from demolition and cutting will not enter other parts of existing building or facilities. Remove temporary partitions as soon as the need no longer exists.

4.5.9.2 Noise Control

- Acoustical barriers shall be provided as required so noise emanating from tools or equipment will not exceed legal noise levels.

4.5.9.3 Water Pollution Control

- Sanitary sewage and non-storm waste flow interfering with construction and requiring diversion to sanitary sewers shall be diverted. Necessary actions shall be taken to prevent overflow to an existing waterway.
- Prior to commencing excavation and construction, the Design-Builder shall obtain the OCWS Representative's agreement with detailed plans showing procedures intended to handle and dispose of sewage, groundwater, and stormwater flow, including dewatering pump discharges.
- Volatile wastes such as mineral spirits, oil, chemicals, or paint thinner in storm or sanitary drains shall not be disposed. Disposal of wastes into streams or waterways shall be prohibited. Acceptable containers for collection and disposal of waste materials, debris, and rubbish shall be provided.

4.5.9.4 Erosion, Sediment, and Flood Control

- The Design-Builder shall provide, maintain, and operate temporary facilities to control erosion and sediment releases, and to protect work and existing facilities from flooding during construction period.
- Erosion and sediment controls shall be designed to handle peak runoff resulting from 25-year, 24-hour storm event.

- Temporary stormwater conveyances shall be sized based on procedures presented in U.S. Department of Agriculture "Urban Hydrology for Small Watersheds," Soil Conservation Service Engineering Technical Release No. 55, 1986.

4.5.10 Storage Yards and Buildings

4.5.10.1 Temporary Storage Yards

- Temporary storage yards shall be constructed for storage of products that are not subject to damage by weather conditions.

4.5.10.2 Temporary Storage Buildings

- Environmental control systems that meet recommendations of manufacturers of equipment and materials stored shall be provided.
- Arrange or partition to provide security of contents and ready access for inspection and inventory.
- Store combustible materials (paints, solvents, fuels, etc.) in a well ventilated and remote building meeting safety standards.

4.5.11 Access Roads and Detours

- Access roads shall be constructed, as required, within Project limits and as shown on the Drawings. Alignments for new routes must be approved by OCWS.
- All existing roads and access routes shall be maintained during construction.
- Drainage ways shall be maintained. Culverts shall be constructed to allow water to flow beneath access roads. Corrosion-resistant culvert pipe of adequate strength to resist construction loads shall be provided.
- Gravel, crushed rock, or other stabilization material shall be provided to permit access by all motor vehicles at all times.
- Road grade and crown shall be maintained to eliminate potholes, rutting, and other irregularities that restrict access.
- Detours and other operations affecting traffic and access shall be coordinated with OCWS. At least 72-hour notice of operations that will alter access to the site shall be given to OCWS.
- Where access roads cross existing fences, gates shall be installed and maintained.
- Upon completion of construction, ground surface disturbed by access road construction shall be restored to original grade. Damaged or broken culverts shall be replaced with new culvert pipe of same diameter and material.

4.5.12 Parking Areas

Vehicular parking shall be controlled to preclude interference with public traffic or parking, access by emergency vehicles, or construction operations. Parking facilities for personnel working on the Project shall be provided. No employee or equipment parking shall be permitted on existing roads.

4.5.13 Vehicular Traffic

The Design-Builder shall comply with laws and regulations regarding closing or restricting the use of public streets or highways. No public or private road shall be closed, except by written permission of the proper authority. The least possible obstruction to traffic and normal commercial pursuits shall be provided. Prepare traffic control plans in accordance with the requirements of the FDOT. Where required, the plans shall be completed by the licensed design professional.

Road Closures: Maintain satisfactory means of exit for persons residing or having occasion to transact business along the route of the work. If it is necessary to close off roadway or alley providing sole vehicular access to property for periods greater than 2 hours, provide written notice to each owner so affected 3 days prior to such closure. In such cases, closings of up to 4 hours may be allowed. Closures of up to 10 hours may be allowed if a week's written notice is given and undue hardship does not result.

Top of backfilled trenches shall be filled before they are paved, to allow normal vehicular traffic to pass over.

When flaggers and guards are required by regulation or when deemed necessary for safety, they shall be furnished with approved orange wearing apparel and other regulation traffic control devices.

Traffic routing shall be coordinated with that of others working in the same or adjacent areas.

4.5.14 Cleaning During Construction

All floors (basins, tunnels, platforms, walkways, roof surfaces) shall be swept weekly and debris shall be disposed.

Approved containers for collection and disposal of waste materials, debris, and rubbish shall be provided. At least at weekly intervals, such waste materials, debris, and rubbish shall be disposed off site.

At least weekly, the entry drive and roadways shall be brush swept, and all other streets and walkways affected by work and where adjacent to work.

4.6 MATERIAL AND EQUIPMENT

Material and equipment shall be identified as new items for incorporation in the work, whether purchased by Design-Builder or OCWS for the Project, or taken from previously purchased stock, and may also include existing materials or components required for reuse.

Material and equipment can also include equipment, machinery, components, subsystem, system, hardware, software, and terms of similar intent and is not intended to change the meaning of such other terms used in the Contract Documents, as those terms are self-explanatory and have well recognized meanings in the construction industry.

Material and equipment can also be identified by manufacturer's product name, including make or model designation, indicated in the manufacturer's published product literature, that is current as of the date of the Contract Documents.

4.6.1 Submittals

4.6.1.1 Administrative Submittals

- List of all proposed substitute or "or-equal" items/methods shall be provided.

- Schedule of factory tests required by Contract Documents and/or the design shall be provided.

4.6.1.2 Quality Control Submittals

- Factory tests shall be as specified in the Contract Documents and/or the design.
- Procedures shall be submitted prior to start of factory testing.
- Test documentation with results of successful testing, including certification of procedures and results, shall be provided.

4.6.2 Preparation for Shipment

When practical, products shall be factory assembled. Separate parts and assemblies shall be matched and marked to facilitate field assembly. Machined and unpainted parts that may be damaged by the elements shall be covered with a strippable protective coating.

Products shall be packed to facilitate handling and protect from damage during shipping, handling, and storage. Outside of each package or crate shall be marked and matched to indicate its purchase order number, bill of lading number, contents by name, name of Project and Design-Builder, equipment number, and approximate weight. Complete packing lists and bills of materials shall be included with each shipment.

Spare parts, special tools, test equipment, expendables, and maintenance materials shall comply with the following requirements:

- Shall be furnished prior to (i) starting functional testing as set forth in Section 7.0, Facility Start-up, (ii) operation of the equipment by OCWS, or (iii) 75 percent Project completion, whichever occurs first.
- Shall be properly packaged to avoid damage, in original cartons insofar as possible. Damaged parts shall be replaced or otherwise inoperable.
- On each package there shall be affixed a minimum 3-inch by 6-inch manila shipping tag with the following information printed clearly:
  - Manufacturer's part description and number.
  - Applicable equipment description.
  - Quantity of parts in package.
  - Equipment manufacturer.
  - Applicable Specification section.
  - Name of Design-Builder.
  - Project name.
- Materials shall be delivered to the site.
- OCWS or OCWS' Representative shall be notified upon arrival.

Equipment shall be protected from exposure to the elements and kept thoroughly dry and dust free at all times. Painted surfaces shall be protected against impact, abrasion, discoloration, or other damage. All bearings and similar items shall be greased or oiled.

Factory test results shall be reviewed and accepted by licensed design professional before product shipment.

4.6.3 Delivery and Inspection

Products shall be delivered in accordance with the accepted current progress schedule and coordinated to avoid conflict with work and conditions at the site. Anchor bolts and templates shall be delivered sufficiently early to permit setting prior to placement of structural concrete.

Products shall be delivered in undamaged condition, in manufacturer's original container or packaging, with identifying labels intact and legible. Date of manufacture and shelf life shall be included on the label, where applicable. UL labels shall be included on products so specified.

Products shall be unloaded in accordance with manufacturer's instructions for unloading, or as specified. The receipt of products shall be delivered at the site. All shipments shall be inspected for completeness and evidence of damage during shipment.

Damaged products shall be removed from the site and delivery of identical new undamaged products and remedy incomplete or lost products shall be expedited, so as not to delay the progress of the work.

4.6.4 4.6.4 Handling, Storage and Protection

Products shall be handled in accordance with the manufacturer's written instructions, and in a manner to prevent damage. Products shall be stored upon delivery, in accordance with manufacturer's instructions, with labels intact and legible, in approved storage yards or sheds provided. Manufacturer's recommended maintenance shall be provided during storage, installation, and until products are accepted for use by OCWS.

Storage shall be arranged in a manner to provide easy access for inspection. Periodic inspections of stored products shall be made to assure that products are maintained under specified conditions, and free from damage or deterioration. There shall be a running account of products in storage to facilitate inspection and to estimate progress payments for products delivered but not installed in the work.

Electrical, instrumentation, and control products and equipment with bearings shall be stored in weather-tight structures maintained above 60 degrees F. Electrical, instrumentation, and control products, and insulation shall be protected against moisture, water, and dust damage. All space heaters furnished in electrical equipment shall be connected and operated continuously.

Fabricated products shall be stored aboveground, on blocking or skids, over a gravel base, to prevent soiling or staining. Loose granular materials shall be stored in a well-drained area on solid surfaces to prevent mixing with foreign matter. Products that are subject to deterioration shall be covered with impervious sheet coverings; adequate ventilation shall be provided to avoid condensation.

Finished products that are ready for installation shall be stored in dry and well-ventilated areas. Finished products shall not be subjected to extreme changes in temperature or humidity.

Contamination of personnel, the storage building, and the site with hazardous materials shall be prevented. The Design-Builder shall comply with the requirements of the product specifications, codes, and manufacturer's instructions.

4.6.5 Substitute and "Or-Equal" Products

The Design-Builder shall meet the requirements of the General Conditions and as set forth herein.

If the Design-Builder proposes to replace a product specified in the Contract Documents and/or design with a substitute product, or, where allowed in the Contract Documents and/or design, proposes an "or-

equal" product, the Design-Builder shall submit the request to OCWS for acceptance. The Design-Builder shall include licensed design professional's approval of the proposed substitute or "or-equal" product.

With consideration of the additional evaluation time necessary for OCWS' review of such items, for each item the review status (either substitute or "or-equal") and estimated submission date shall be indicated.

OCWS may return unreviewed those submissions (i) not shown on the current accepted schedule, (ii) for which the review status differs from that indicated on the accepted list unless previously approved in writing by the OCWS Representative, (iii) not as specified herein, (iv) which are incomplete, or (v) which are uncertified, in which case the Design-Builder shall provide the specified product.

Six copies of proposed substitute or "or-equal" item/method shall be submitted, to include all supporting data to allow the OCWS Representative's review. Complete, sign, and transmit with each proposed substitute or "or-equal" item/method submission.

- **Accepted**: The OCWS Representative shall evidence such acceptance by recommendation of a Change Order for Design-Builder and OCWS execution. Such Change Order will accompany the OCWS evaluation and acceptance of Design-Builder's proposed substitute.
- **Rejected:**
  - One copy shall be retained by the OCWS Representative.
  - One copy shall be returned to Design-Builder with a commentary by the OCWS Representative.
  - Remaining copies shall be destroyed.
- Design-Builder shall provide item specified in Contract Documents.

4.6.6 Materials

Manufacturer's standard materials suitable for service conditions shall be provided unless otherwise specified in the individual Specifications.

"Or-Equal" Items shall be handled in accordance with Shop Drawings and Samples, or as follows:

- Where product specifications include a named manufacturer, with or without model number, and also include performance requirements, named manufacturer's products must meet the performance specifications.
- Like items of products furnished and installed in the work shall be end products of one manufacturer and of the same series or family of models to achieve standardization for appearance, operation and maintenance, spare parts and replacement, and manufacturer's services and implement same or similar process instrumentation and control functions in same or similar manner.
- Materials and equipment removed from existing premises shall not be used, except as specifically permitted by the Contract Documents.
- Interchangeable components of the same manufacturer shall be provided for similar components, unless otherwise specified.
- Equipment, components, systems, subsystems shall be designed and manufactured with due regard for health and safety of operation, maintenance, and accessibility, durability of parts, and shall comply with applicable OSHA and local health and safety regulations.

- Coating materials shall meet federal and local requirements and shall limit the emission of volatile organic compounds and for worker exposure.
- Care shall be provided for all belt or chain drives, fan blades, couplings, or other moving or rotary parts. Rotating part shall be covered on all sides and shall be designed for easy installation and removal. 16-gauge or heavier galvanized steel, aluminum coated steel, or galvanized or aluminum coated 1/2-inch mesh expanded steel shall be used. Galvanized steel accessories and supports, including bolts, shall be provided. For outdoors application, entrance of rain and dripping water shall be prevented.
- Materials and equipment listed by UL shall be provided wherever standards have been established by that agency.
- Upon acceptance of equipment, all accessories required to place each item of equipment in full operation shall be furnished. These accessory items include, but are not limited to, adequate oil and grease (as required for first lubrication of equipment after field testing), light bulbs, fuses, hydrant wrenches, valve keys, handwheels, chain operators, special tools, and other spare parts as required for maintenance.
- Provide written certification from manufacturers that spare parts provided are in accordance with the manufacturer's recommendations. Supply spare parts for each piece of process equipment named in the Specifications. Spare parts shall consist of the following:
  - All materials, including filters, seals, bearings, and other wearing parts that are recommended by the manufacturer to be changed during the first year of service or may reasonably be expected to need replacing during the first year of service.
  - In addition to spare parts, which may be required during the first year of service of the following spare parts for process equipment shall be supplied for each piece of equipment:
    - A complete set of bearings.
    - A complete set of seals.
    - Two complete sets of belts for belt-driven equipment.
    - A dozen shear pins if appropriate for the equipment.
    - A dozen air or oil filters if appropriate for the equipment.
  - Spare parts furnished for each ventilating and cooling equipment unit shall include a year's supply of air filters and two complete sets of belts for belt-driven equipment.
  - One dozen fuses of each size and type for all equipment, including electrical, ventilating and cooling, and process equipment.
  - One dozen replacement lamps of each size and type for all equipment, including electrical, ventilating and cooling, process equipment, and lighting fixtures. One half dozen ballasts for each type of fluorescent lighting equipment.
- Lubricant: Provide initial lubricant recommended by equipment manufacturer in sufficient quantity to fill lubricant reservoirs and to replace consumption during testing, startup, and operation until final acceptance by OCWS. Supply one year’s supply of lubricant of the manufacturer's recommended type and grade for all process equipment. If shipping lubricant is different than operating lubricant, drain shipping lubricant and fill with operating lubricant just prior to startup. Supply complete lubricant specifications for each lubricant supplied.

4.6.7 Fabrication and Manufacture

- Parts shall be manufactured to U.S.A. standard sizes and gauges.

- Two or more items of the same type shall be identical, by the same manufacturer, and interchangeable.
- Structural members shall be designed for anticipated shock and vibratory loads. 1/4-inch minimum thickness shall be used for steel that will be submerged, wholly or partially, during normal operation.
- Standard products shall be modified as necessary to meet performance Specifications.
- Lubrication system shall comply with the following requirements:
  - Lubrication system shall require no more than weekly attention during continuous operation.
  - Lubrication system shall be convenient and accessible. Oil drains with bronze or stainless steel valves and fill plugs easily accessible from the normal operating area or platform. Drains shall be located to allow convenient collection of oil during oil changes without removing equipment from its installed position.
  - Constant-level oilers or oil level indicators shall be provided for oil lubrication systems.
  - For grease type bearings, which are not easily accessible, stainless steel tubing shall be provided and installed; protect and extend tubing to convenient location with suitable grease fitting.

4.6.8 Source Quality Control

- Calibration instruments shall bear the seal of a reputable laboratory certifying that instrument has been calibrated within the previous 12 months to a standard endorsed by the National Institute of Standards and Technology (NIST).
- Factory tests shall be performed in accordance with accepted test procedures and document successful completion.
- Materials and equipment shall be inspected for signs of pitting, rust decay, or other deleterious effects of storage. No material or equipment showing such effects shall be installed. Damaged material or equipment shall be removed from the site and delivery of identical new material or equipment shall be arranged. Delays to the work resulting from material or equipment damage that necessitates procurement of new products shall be considered delays within Design-Builder’s control.
- No shimming between machined surfaces shall be allowed.
- Work shall be installed in accordance with NECA Standard of Installation, unless otherwise specified.
- Painted surfaces that are damaged prior to equipment acceptance shall be repainted.
- Products shall be handled, installed, connected, cleaned, conditioned, and adjusted in accordance with manufacturer's instructions and as may be specified. A copy of manufacturers' instruction shall be retained at site and shall be available for review at all times.
- Unless indicated otherwise, manufacturer's recommended factory-finish for the specific application shall be provided.
- Field finishes shall be in accordance with the Contract Documents and design.
- Required adjustments, tests, operation checks, and other startup activities shall be performed.

- Lubricant reservoirs shall be filled and replaced consumption during testing, startup, and operation prior to acceptance of equipment by OCWS.

4.7 MANUFACTURER'S SERVICES

The manufacturer shall provide the following submittals:

- Training schedule shall be submitted not less than 21 days prior to start of equipment installation and shall be revised as necessary for acceptance.
- Lesson plan shall be submitted with proposed lesson plan not less than 21 days prior to scheduled training and shall be revised as necessary for acceptance.
- Training session tapes shall be furnished to OCWS with two complete sets of tapes fully indexed and cataloged with printed label stating session and date taped.

4.7.1 Qualifications of Manufacturer's Representative

Authorized representative of the manufacturer shall be factory trained and experienced in the technical applications, installation, operation, and maintenance of respective equipment, subsystem, or system. Additional qualifications may be specified elsewhere.

Representative(s) shall be subject to acceptance by the OCWS Representative. No substitute representatives shall be allowed unless prior written approval by such has been given.

4.7.2 Fulfillment of Specified Minimum Services

Manufacturer's services shall be provided as required in the Contract Documents and to meet the requirements of this section.

- Manufacturer's services shall be scheduled to avoid conflicting with other on-site testing or other manufacturer's on-site services.
- Prior to the service, all conditions necessary to allow successful testing shall be met before scheduling services.
- Only those days of service approved by OCWS Representative will be credited to fulfill the specified minimum services.
- As required, manufacturer's on-site services shall include:
  - Assistance during product (system, subsystem, or component) installation to include observation, guidance, instruction of Design-Builder's assembly, erection, installation or application procedures.
  - Inspection, checking, and adjustment as required for product (system, subsystem, or component) to function as warranted by manufacturer and necessary to furnish Manufacturer's Certificate of Proper Installation.
  - Revisiting the site as required to correct problems until installation and operation are acceptable to the OCWS Representative.
  - Resolution of assembly or installation problems attributable to or associated with respective manufacturer's products and systems.
  - Assistance during functional and performance testing, and facility startup and evaluation.
  - Training of operations and maintenance personnel in the operation and maintenance of respective product as required.
  - Additional requirements as may be specified.

4.7.3 Manufacturer's Certificate of Compliance

Manufacturer's Certificate of Compliance shall be issued where products are specified to a recognized standard or code, and shall be submitted prior to shipment of product or material to the site. OCWS may permit use of certain materials or assemblies prior to sampling and testing if accompanied by accepted certification of compliance, and approved by licensed design professional.

The Manufacturer's Certificate of Compliance shall be signed by product manufacturer certifying that materials, manufacture, and product specified conforms to or exceeds specified requirements and intent for which product will be used. All supporting reference data, affidavits, and certifications shall be provided.

Manufacturer's Certificate of Compliance may reflect recent or previous test results on material or product, but must be acceptable to OCWS and approved by licensed design professional.

4.7.4 Manufacturer's Certificate of Proper Installation

Manufacturer's Certificate of Proper Installation form shall be completed and signed by the equipment manufacturer's representative for all equipment and systems with a cost exceeding $10,000. Such form shall certify that the signing party is a duly authorized representative of the manufacturer, is empowered by the manufacturer to inspect, approve, and operate their equipment, and is authorized to make recommendations required to assure that the equipment is complete and operational.

4.7.5 Training

Manufacturers' representatives shall have access to a classroom and hands-on training to OCWS' personnel on operation and maintenance of specified product (system, subsystem, or component). Training shall be provided for all products with a cost exceeding $10,000 unless otherwise specified in the Contract Documents.

Trained, articulate personnel shall be provided to coordinate and expedite training, to be present during training coordination meetings with OCWS, and familiar with operation and maintenance manual information. Manufacturer's representative shall be familiar with facility operation and maintenance requirements as well as with specified equipment. The number of training hours shall depend on the manufacturers' requirements. Complete training materials, to include operation and maintenance data, shall be provided to be retained by each trainee.

4.7.5.1 Training Schedule

Training schedule shall be provided and shall contain the following information.

- List of specified equipment and systems that require training services and respective manufacturer.
- Estimated dates for installation completion.
- Estimated training dates.
- Allowance for multiple sessions when several shifts are involved. A minimum of two sessions shall be provided.
- Schedule shall be adjusted to ensure training of appropriate personnel as deemed necessary by OCWS and to allow full participation by manufacturers' representatives. Schedule shall be adjusted for interruptions in operability of equipment.

4.7.5.2 Lesson Plan

For each required training session, a lesson plan shall be prepared containing the following minimum information:

- Title and objectives.
- Recommended attendees (e.g., managers, engineers, operators, maintenance).
- Training session description and outline of content.
- Format (e.g., lecture, self-study, demonstration, hands-on).
- Instruction materials and equipment requirements. Resumes of instructor(s) providing the training.

4.7.5.3 Pre-Startup Training

Training sessions shall be coordinated with OCWS operating personnel and manufacturers' representatives, and with submission of operation and maintenance manuals. The pre-startup training shall be completed at least 14 days prior to beginning of facility startup.

If necessary and if required by the Contract Documents, training of OCWS operating personnel shall be coordinated by respective manufacturer's representatives.

4.7.5.4 Taping of Training Sessions

Audio and color video taping of pre-startup and post-startup instruction sessions, including manufacturers' representatives' hands-on equipment instruction and classroom sessions shall be provided. Video training tapes shall be produced by a qualified, professional video production company. VHS format, suitable for playback on standard equipment shall be used. Include only one training session on each tape, or on a single track of a tape. DVD can be used as an alternative to VHS.

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5.0 FACILITY STARTUP

This section includes procedures and actions required of the Design-Builder, which are necessary to achieve and demonstrate Substantial Completion.

5.1 Facility Startup Tests

Facility startup tests include functional testing and performance testing on the overall process, or a portion thereof, that performs a specific function. A description of each type of test is presented below.

- **Functional Test**: A test or tests in the presence of OCWS or the OCWS Representative to demonstrate that the installed equipment or system meets manufacturer's installation and adjustment requirements and other requirements specified including, but not limited to, noise, vibration, alignment, speed, proper electrical and mechanical connections, thrust restraint, proper rotation, and initial servicing.
- **Performance Test**: A test performed in the presence of the OCWS Representative and after any required functional test specified, to demonstrate and confirm that the equipment and/or system meet the specified performance requirements.

5.2 Submittals

Functional and performance test schedules and plan for equipment, units, and systems shall be submitted at least 30 days prior to start of related testing. Test plan, procedures, and log format shall be included.

Facility startup activities shall be scheduled and planned at least 21 days prior to commencement.

The following Quality Control Submittals shall be prepared and submitted to OCWS:

- Manufacturer's Certificate of Proper Installation as required.
- Test Reports: Functional and performance testing, in format acceptable to OCWS and certification of functional and performance test for each piece of equipment or system specified.
- Certifications of Calibration including testing equipment.

5.3 Design-Builder Facility Startup Responsibilities

The Design-Builder shall demonstrate proper installation, adjustment, function, performance, and operation of equipment, systems, control devices, and required interfaces individually and in conjunction with process instrumentation and control system. The Design-Builder shall operate process units and devices.

The Design-Builder shall provide sampling, labor, and materials as required and provide laboratory analyses to confirm that facility meets performance, requirements specified in the Contract Documents.

The Design-Builder shall provide chemicals, and other consumables as required for testing, unless otherwise indicated. OCWS should pay for water and power used during the facility start up.

5.4 OCWS' Facility Startup Responsibilities

OCWS shall review the test plan and schedule; shall witness each functional or performance test; and shall coordinate other operations, if necessary, to facilitate the tests. OCWS will provide RAS and treated effluent for seeding the new facility as agreed upon during startup meetings. Delivery of process water or

RAS will be provided using existing and new facilities, however, the Design-Builder shall provide temporary pumping and piping if needed to accelerate any schedule requirements.

During the startup test, OCWS shall observe facility operations performed by the Design-Builder.

5.5 Testing Preparation

All work associated with the unit and related processes shall be completed before testing, including related manufacturer's representative services. Qualified manufacturer's representatives shall be available when required to assist in testing. Functional and performance procedures, results, problems, and conclusions shall be documented.

Schedule and attend pretest (functional and performance) meetings related to test schedule, plan of test, materials, chemicals, and liquids required, facilities' operations interface, and OCWS involvement.

One or more persons shall be available and responsible for coordinating and expediting the Design-Builder's facility startup duties. The person or persons shall be present during facility startup meetings and shall be available at all times during the facility startup period.

Temporary valves, gauges, and equipment required to conduct testing shall be provided.

Prior to starting functional testing:

- Testing equipment shall be calibrated for accurate results.
- Equipment, devices, connected piping, and structures shall be inspected and cleaned so they are free of foreign material.
- Equipment shall be lubricated in accordance with manufacturer's instructions.
- Rotating equipment shall be turned by hand and motor-driven equipment shall be checked for correct rotation.
- Valves shall be opened and closed by hand and other devices shall be operated to check for binding, interference, or improper functioning.
- Power supply to electric-powered equipment shall be checked for correct voltage.
- Clearances and torques shall be adjusted.
- Pipes shall be checked for leaks.
- HVAC systems shall be balanced, measuring airflow (cfm) static pressure, and component pressure losses. Typed report documenting results of balancing shall be presented to OCWS.

Ready-to-test determination will be by OCWS based at least on the following:

- Notification by Design-Builder of equipment and system readiness for testing, including certification by licensed design professional.
- Acceptable testing plan.
- Acceptable Operation and Maintenance Manuals.
- Receipt of Manufacturer's Certificate of Proper Installation.
- Adequate completion of work adjacent to, or interfacing with, equipment to be tested.

- Availability and acceptability of manufacturer's representative, when specified, to assist in testing of respective equipment.
- Equipment and electrical tagging complete.
- All spare parts and special tools delivered to the site.

5.6 Functional Testing

- The testing shall begin at a time mutually agreed upon by OCWS and the Design-Builder
- OCWS or the OCWS will be present during test. OCWS and manufacturer's representative(s) shall be notified in writing at least 10 days prior to scheduled date of functional tests.
- Separate items of equipment demonstrated to function properly during subsystem testing may require no further functional test if documentation of subsystem testing is acceptable to licensed design professional and OCWS.
- Functional tests shall be conducted for each equipment item or system.
- All operational features and instrumentation and control functions shall be demonstrated while in automatic mode.
- If, in OCWS' opinion, functional test results do not meet requirements specified, the systems will be considered as nonconforming.
- Performance testing shall not commence until the equipment or system meets the specified functional tests.

5.7 Performance Testing

- The testing shall begin at a time mutually agreed upon by OCWS and the Design-Builder.
- OCWS or the OCWS Representative will be present during test. OCWS and manufacturer's representative(s) shall be notified in writing at least 14 days prior to scheduled date of functional tests.
- Performance tests shall be conducted for each equipment item or system.
- Performance test report shall be prepared summarizing test method. The report shall include test logs and pertinent calculations, including the licensed design professional's written certification that the equipment or system performs as specified.

5.8 Startup Test Period

The Design-Builder shall attend planning meetings and arrange for attendance by key major equipment manufacturer representatives. In addition, the Design-Builder shall designate one or more persons on their staff, other than the field superintendent, to be responsible for coordinating and expediting facilities startup duties.

When facility startup has commenced, the remaining work shall be scheduled so as not to interfere with or delay the completion of facility startup.

There shall be sufficient staff to prevent delays during the facility startup activities. Such staff shall include, but not be limited to, major equipment and system manufacturer's representatives, electricians, instrumentation and control personnel, millwrights, pipe fitters, and plumbers.

The Design-Builder shall furnish and coordinate specified manufacturer's facility startup services.

After the facility is operating, the Design-Builder shall complete the testing of those items of equipment, systems, and subsystems which could not or were not successfully tested prior to the startup test period.

5.9 Startup Testing Protocol

- Startup of the new facilities or any portion thereof shall require the coordinated operation of the facilities by the Design-Builder, subcontractors, and manufacturer's representatives.
- Startup test period shall occur after all required functional tests have been completed and those performance tests deemed necessary for the safe operation of the entire facility have been completed.
- Startup of the new facilities or any portion thereof shall be considered complete when, in the opinion of OCWS, the facility or designated portion has operated in the manner intended for 60 continuous days without significant interruption. This period is in addition to any training, functional, or performance test periods specified elsewhere.
- Significant interruption may include any of the following events:
  - Failure of the Design-Builder to maintain qualified on-site startup personnel as scheduled.
  - Failure to meet specified performance for more than two consecutive hours.
  - Failure of any critical equipment unit, system, or subsystem that is not satisfactorily corrected within five hours after failure.
  - Failure of any non-critical unit, system, or subsystem that is not satisfactorily corrected within eight hours after failure.
- A significant interruption will require the startup then in progress to be stopped and restarted after corrections are made.
- Startup Test Reports: As applicable to the equipment furnished, certify in writing that:
  - Hydraulic structures, piping systems, and valves have been successfully-tested.
  - Equipment systems and subsystems have been checked for proper installation, started, and successfully tested to indicate that they are operational.
  - Systems and subsystems are capable of performing their intended functions, including fully-automatic.

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