CHAPTER 500

LIFT STATIONS AND
LOW PRESSURE SYSTEMS

SECTION 501
Requirements Common to both Lift Stations and Low Pressure Systems

501.01 Introduction	This Section provides the planning, design, and submittal requirements common to both lift stations and low pressure sewer systems. For requirements specific to lift stations refer to Section 502 and 503. For requirements specific to low pressure sewer systems refer to Section 504.
501.02 General	When possible, gravity sewers shall be extended to the proposed development. Lift Stations will be allowed if ALL the following conditions are met: 1. The proposed lift station or low pressure system is justified per Section 501.03; 2. The force main is designed per Section 502.15; and 3. Existing Service Area boundaries are not crossed. Sanitary Sewer Service Area boundaries shall not be crossed to avoid extending gravity sanitary sewers. When an existing lift station requires a capacity upgrade for a proposed development, the entire lift station system will be evaluated to determine the necessary upgrades. The requirements shall be determined on a case-by-case basis and shall be at the discretion of the Department. The intent is to upgrade the existing lift station to the Standards set forth in this Manual.
501.03 Justification	Lift stations and low pressure systems shall be justified and will only be approved if the installation of a gravity sanitary sewer alternative exceeds the 50-year life cycle cost for the proposed system AND the criteria in Section 501.02 are met. An accurate cost estimate to construct a gravity sanitary sewer alternative and a 50-year life cycle cost estimate for the proposed lift station shall be submitted prior to Approval. The Department, at its sole discretion, may choose to estimate the 50-year life cycle cost for the proposed lift station.

SECTION 502
Lift Station Design

502.01 Introduction

This Section provides the planning, design, and submittal requirements for lift stations with pumping capacities of 1,000 gpm or less.

Requirements for lift stations with capacities greater than 1,000 gpm will be determined by the Department on a case-by-case basis.

502.02 General

Due to the variability of site conditions, each site and proposed lift station will be evaluated on a case-by-case basis. If deemed necessary, the Department may make additional requirements not covered in this Manual.

To avoid unnecessary delays in the Permitting process, a pre-submittal meeting with the Division and Department during the planning stages of the project is recommended.

502.03 Submittal Requirements for Approval and Construction Permit

When submitting for an Approval and a Construction Permit, the following are required:

1. Lift Station Service Area – Per Section 502.04.
2. Lift Station Justification – Per Section 501.03.
   a. 50-year life cycle analysis.
   b. Gravity sewer alternative cost estimate.
3. Lift Station Calculations
   a. Pumping Capacity – Per Section 502.07.
   b. Total Dynamic Head (TDH) Calculations – Per Section 502.09.
   c. Pump and System Head Curves – Per Section 502.10.
4. Standard Lift Station Details

   The most recent version of the Standard Lift Station Detail Sheets, as furnished by the Department, shall be submitted for lift stations.
5. Pre-Construction Submittal Requirements - Per Section 503.04.
6. Any other information the Division and/or Department deems necessary to review and evaluate the proposed pumping system.

502.04 Lift Station Service Area

The Applicant shall prepare a Lift Station Service Area Study in accordance with all the requirements in Section 202.03.

In addition to the requirements of Section 202.03, if it determined an existing lift station can be abandoned and connected to the proposed sanitary sewer system, the area served by the existing lift station shall be included in the proposed Lift Station Service Area.

502.05 Lift Station Location

Lift station locations will be evaluated by the Department on a case-by-case basis. At a minimum, the lift station shall be located to assure the following:

1. SCADA Connectivity.

   The lift station shall be located within the proposed development to assure connectivity to the ISD's SCADA wireless monitoring and control network.

Connectivity shall be verified prior to Approval.

To verify connectivity, the location of the lift station shall staked by the Engineer. Connectivity will be verified by a radio path test done by the Department, or a representative of the Department, and paid for by the Applicant. If the location does not provide adequate connectivity, an alternate location shall be chosen.

To assure future connectivity, the development shall be configured in such a way to provide for a thirty (30) feet wide by seven hundred (700) feet long "clear zone" between the antenna at the lift station and the designated receiving radio tower. The clear zone is not required to be extended onto adjacent properties. However, if site conditions allow, the Department may require an alternate location for the proposed lift station to have the entire clear zone, or as much as practical, located within the project boundaries.

If possible, the clear zone shall be located in obstruction-free areas that cannot be built upon such as, but not limited to, right-of-ways, easements, common areas, flood hazard areas, or detention areas.

If any of the above conditions cannot be met, the Department will evaluate alternatives, including building height restrictions, on a case-by-case basis.

The clear zone shall be shown on the plans.

2. Adequate Access

The lift station shall be located to assure adequate access is available for operation and maintenance activities. Clearance requirements are as follows:

a. Concrete Pad

i. To adjacent property lines – twenty (20) feet minimum;

ii. To public right-of-way – thirty (30) feet maximum;

iii. To private paved streets or paved areas – twenty (20) feet minimum and thirty (30) feet maximum; and

iv. To structures or buildings – thirty (30) feet minimum.

b. Access Drive

To adjacent property lines – ten (10) feet minimum.

Lift stations shall not be located in areas the Department determines to be inaccessible such as, but not limited to, rear yards.

502.06
Lift Station Type

Only submersible duplex lift stations will be allowed.

The configuration shall be per the Department's most recent version of the Standard Lift Station Detail Sheets.

502.07
Pumping Capacity

The pumping capacity shall be calculated as follows:

$$Q = \text{Design Flow} / 1440$$

where:

Q = Pumping rate, gpm

Design Flow = Flow as determined per Section 202.04, gpd

1440 = Conversion from gpd to gpm

Each pump in a duplex station shall have a pumping capacity of Q. The second pump shall act as a backup in the event one (1) pump is out-of-service.

Q shall be rounded up in increments of 10 gpm (i.e. 233 gpm shall be rounded up to 240 gpm).

The Department may require the pumping capacity to be increased or decreased, if deemed necessary.

The minimum pumping capacity shall be 100 gpm.

502.08
Initial Pumping Capacity

Because proposed developments may only be a portion of the overall Lift Station Service Area, the Department may allow or require the pumping capacity to be reduced for the proposed development if the following conditions are met:

1. The area of the proposed development is less than 50% of the Lift Station Service Area.
2. The required Pumping Capacity for the proposed development is less than 50% of the required Pumping Capacity for the Lift Station Service Area.

At a minimum, each pump shall be sized to accommodate the Design Flow of the proposed development plus 20%.

Meeting the above criteria does not guarantee a reduction will be allowed.

The specific equipment requirements and allowable reductions will be at the discretion of the Department and will be evaluated on a case-by-case basis. Only the pumps, motors, and relevant control panel equipment will be considered for allowable reductions. The wet well, valve and meter vaults, piping, valves, and force main shall be sized for the overall Lift Station Service Area.

502.09
Total Dynamic Head Calculations

The Total Dynamic Head (TDH) shall be calculated for the pumping capacity of the lift station.

The TDH is the sum of the static head and friction losses for a given pumping rate in a defined pumping system. TDH shall be calculated as follows:

$$TDH = \text{Static Head} + h_f + h_m$$

where:

TDH = Total Dynamic Head, feet

Static Head = Elevation difference between the force main discharge elevation and the pump off elevation, feet

h_f = Piping friction losses, feet

h_m = Minor losses, feet

The above variables shall be calculated as follows:

1. Static Head, feet

Static Head = Force Main Discharge Elevation – Pump Off Elevation

When the high point in a force main is not at the discharge elevation, the elevation of the high point shall be evaluated to determine if the pump performance characteristics are adversely affected.

2. h_f = Piping friction losses, feet

Piping friction losses shall be calculated as follows:

$$h_f = 10.44\ L \frac{Q^{1.85}}{C^{1.85}\ D^{4.8655}}$$

where:

D = pipe diameter, inches

Q = pumping rate, gpm

C = pipe roughness coefficient (100, 120, & 140)*

L = force main length, feet

* A roughness coefficient of C = 120 shall be use to determine the Operating Point. However, due to changing force main conditions over time, the TDH shall also be calculated using C = 100 at the Pump Off elevation and C = 140 at the Pump On elevation. See Section 502.10 for Pump Selection Criteria and further explanation.

3. h_m = Minor losses, feet

Minor losses are due to pipe fittings and shall be calculated as follows:

$$h_m = \frac{KV^2}{2g}$$

where:

K = proportionality constant**

V = velocity, ft/sec

g = gravitation constant = 32.2 ft/sec^2

** The proportionality constant, K, is dependent on the type of fitting. Unless justified, K, shall be as follows:

Fitting	K
Check Valve	2.5
Plug Valve	1.5
Tee	0.9
90° Elbow	0.3
45° Elbow	0.2

Alternate methods to determine minor losses, such as using Equivalent Lengths, may be allowed on a case-by-case basis with prior approval from the Department.

502.10
Pump Selection

The Pumping Capacity and TDH, as calculated in Sections 502.07 and 502.09, shall be used as the Operating Point when selecting the pump make and model.

Per Section 502.09, a roughness coefficient of C = 120 was used to determine the Operating Point. However, each pump shall be within the pumps operating range when C = 100 at the Pump Off elevation and C = 140 at the Pump On elevation. The pump, motor, and impeller shall be non-overloading throughout the entire operating range for all roughness coefficients.

The system head curves for each roughness coefficient shall be plotted on the pump performance curve to determine the operating characteristics.

Engineering judgment may be used when evaluating pump alternatives. If justified, the Department may require a different operating point or an alternate pump to be used.

502.11
Variable Speed
Pumping Systems

The need for variable speed pumping systems will be evaluated on a case-by-case basis and shall be at the discretion of the Department.

Variable Speed Pumping systems may be required if <u>ANY</u> of the following conditions are met:

1. Horsepower – Greater than sixty (60) hp;
2. TDH – Greater than fifty (50) feet;
3. Pump Capacity – Greater than 500 gpm;
4. Hydraulic Transients (water hammer) – When the potential for damaging transients exist;
5. Buildout conditions – If the design flow as determined in Section 202.03 justifies; and
6. Others – If pump system conditions justify.

Lift stations with constant speed pumping systems shall be designated as “Level 3” Lift Stations and those with variable speed pumping systems shall be designated as a “Level 2” Lift Stations.

Constant speed control system requirements for Level 3 Lift Stations shall be per Section 503.08.

Variable speed control system requirements for Level 2 Lift Stations shall be per Section 503.09.

502.12
Wet Well Sizing

The wet well shall be sized for the entire Lift Station Service Area.

The minimum size of the wet well shall be as follows:

1. Diameter of Wet Well

   The minimum wet well diameter shall be six (6) feet.

2. Depth of Wet Well, below the invert of the incoming sewer

   The minimum required depth of the wet well below the invert of the incoming sewer shall be calculated as follows:

   Depth = 1.5 feet + Operating Depth + Height of pump

   where:

   1.5 feet = Difference between the lowest incoming gravity sewer invert and the lead pump on elevation.

   Height of Pump = Distance from the bottom of the wet well to the top of the pump, feet.

   Operating Depth = Depth between the lead pump on and pump off elevations, feet.

   The operating depth is a function of the volume and diameter.

   The volume shall be based on four (4) starts per hour and shall be calculated as follows:

$$V = \frac{t\,Q}{4}$$

   where:

   V = Volume, gallons

   t = 15 minutes (15 minute station cycle time)

   Q = Pumping rate per 502.07, gpm.

   The minimum Operating Depth shall be 2.5 feet.

   Only one (1) incoming sewer connection is allowed per Section 502.17.

   When Variable Speed Pumps are required per Section 502.11, the Department may consider or require a reduction of the volume.

   Both pumps shall remain fully submerged at all times during the full pumping cycle.

3. Detention Time

   The maximum detention time (pump off time) shall be thirty (30) minutes based on the average daily flow.

There may be some situations when one or more of the above wet well sizing criteria cannot be met. The Department will evaluate those instances on a case-by-case basis.

Note: If noticeable odors are being generated at any time before the Maintenance Bond expires, the Applicant shall determine the cause and construct an odor control facility at either the wet well or the discharge end of the force main. The method used for odor control will be approved by the Department on a case-by-case basis.

502.13 Operating Set Points

The elevation of the set points for the operation of the lift station shall be as follows:

1. Primary level sensor - Pressure Transducer (Per Section 503.08 or 503.09).
   a. Alarm Level = 0.5 feet below the lowest incoming invert;
   b. Lag Pump On = 1.0 feet below the lowest incoming invert;
   c. Lead Pump On = 1.5 feet below the lowest incoming invert;
   d. Pump Off = (Lead Pump On Elev. – Operating Depth per Section 502.12.)
2. Backup (Alarm) level sensors - Ball Floats (Per Section 503.08 or 503.09)
   a. Pump On = (Lowest incoming pipe invert + 1/2 diameter of pipe.)
   b. Pump Off = 0.5 feet below the lowest incoming pipe invert.

502.14 Valve and Meter Vaults

The minimum vault dimensions for Level 2 and Level 3 lift stations shall be per the most recent version of the Standard Lift Station Detail Sheets.

502.15 Force Main Design

The force main shall be designed as follows:

1. Lift stations shall not pump downhill.

   Prior to discharging into the receiving manhole, the force main shall not flow downhill. When possible, the receiving gravity sewer shall be extended a sufficient distance to avoid downhill pumping.

   The discharge elevation of the force main at the discharge location shall not be below the elevation in the valve vault and greater than two (2) feet above the invert of the incoming sewer.

2. The size, depth, slope, and location shall be as follows:
   a. Size

      The diameter shall be sized using the Pumping Capacity as determined in Section 502.07 with the following velocities:

      i. Minimum Velocity – 2.5 ft/sec
      ii. Maximum Velocity – 6.0 ft/sec

         Higher velocities will be considered and evaluated on a case-by-case basis.

         If the Pumping Capacity is reduced per Section 502.08, the minimum velocity may be reduced to 2.0 ft/sec when using the Initial Pumping Capacity.

      The minimum diameter force main shall be 4 inches.

   b. Depth

      The minimum depth to the top of the pipe shall be 4.5 feet.

      The depth may be required to be increased if air release valves can be avoided or the minimum slope cannot be achieved.

c. Slope

The minimum slope for force mains is determined by the installation method and shall be as follows:

i. Open Cut Installation – Greater than 0%

The force main shall not be designed on a flat slope (0%).

ii. Horizontal Directional Drilling (HDD) – Minimum 1.5%

The Division or Department may limit the length installed with HDD or require open cut installation if the number of air release valves can be reduced.

d. Location

Existing and proposed force mains shall be located per Section 202.07.1 & 2.

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3. Air Release / Vacuum Relief Valves

When possible, force mains shall be designed to avoid the need for air release or vacuum relief valves.

When high points cannot be avoided, A.R.I. D-020, stainless steel air release valves shall be installed per the most recent version of the Standard Lift Station Detail Sheets and at each high point where air could become trapped.

4. Force Main Anchorage

Force mains shall be anchored to resist thrusts at all bends, angles, tees, etc. in the force main pipe. The required anchorage shall be achieved by installing restrained pipe joints and concrete thrust blocks or anchor blocks as designed by the Engineer, and shown on the plans.

Restrained joints shall be per Section 304.

The Engineer shall determine the number of joints and/or length of pipe to be restrained on each side of all bends. The number of restrained joints or length of pipe shall be shown on the plans.

5. Connections to force mains are prohibited, except for connections to common force mains in Low Pressure Systems.

502.16 Buoyancy

The wet well shall be designed to prevent “floating” by assuring:

Opposing Forces > Buoyancy Forces

where:

Opposing Forces = Weight resisting buoyancy forces (lbs).

Buoyancy Forces = Uplifting forces due to groundwater (lbs).

The groundwater elevation shall be assumed to be at the surface elevation immediately adjacent the base slab.

502.17 Connections to the Wet Well

For proposed lift stations, only one (1) incoming connection to the wet well will be allowed. The connection shall be of sufficient depth to provide service to the entire Lift Station Service Area.

SECTION 503
Lift Station Equipment and Operating Requirements

503.01 Introduction	This Section provides the equipment and operating requirements for lift stations.
503.02 General	Lift station equipment meeting or exceeding the requirements set herein will be approved. However, the Department may modify any of the requirements in this Section, if justified. All components of the lift station exposed to weather shall be constructed of material that is resistant to corrosion and will not require surface protection throughout the expected life of the lift station. In general, these materials are stainless steel, aluminum, fiberglass reinforced polyester (FRP), and ultraviolet stabilized PVC.
503.03 Equipment Vendors	All equipment shall be an integral package supplied by the pump manufacturer with local representation so as to provide undivided responsibility.
503.04 Submittal Requirements: Pre-Construction	Prior to construction, the Contractor shall submit the following: 1. A cover letter from the Engineer and Contractor indicating all proposed equipment and components meet the requirements of this Manual and the approved Plans. 2. Four (4) sets of shop drawings, detailed specifications, pump warranty, and performance characteristics for all equipment and components to be furnished and installed.
503.05 Power Requirements	Only electric-utility-delivered 3-phase, 60 Hz, 4-wire wye, or delta power will be allowed. **The use of phase converters to derive 3-phase power from 1-phase power is prohibited.**
503.06 Pump Equipment	Pumps shall be either Hydromatic or Flygt pumps. Pump Equipment shall be as follows: 1. Pumps Pumps shall be of the submersible type for handling raw unscreened sewage. Pump volute, motor, and seal housing shall be high quality gray cast iron. Impeller shall be either cast iron or cast bronze of a non-clog design capable of handling minimum three (3) inch sphere solids, fibrous material, heavy sludge, and other matter found in normal sewage applications. Impeller shall have pump out vanes on the back shroud of the impeller to keep pumped material away from the seal area and increase operating life. Impeller shall be either slip fit or taper fit with key to securely lock the impeller to the driving shaft. The pump volute shall be fit with a replaceable bronze wear ring to minimize wear on the impeller and help achieve longer balance operating life. All fasteners shall be of stainless steel. 2. Mating Surfaces All mating surfaces where watertight sealing is required shall be machined and fitted with nitrile rubber O-rings. Sealing shall be accomplished when metal-to-metal contact is made, resulting in controlled compression of the rubber O-rings without requirement of a specific torque limit.

3. Seal System

The pump shall be provided with a mechanical rotating shaft seal system running in an oil reservoir having separate, constantly lubricated lapped seal faces. The lower seal unit between the pump and oil chamber shall consist of one (1) stationary seat and one (1) rotating ring held in place by its own spring. The lower seal shall be removable without disassembling the seal chamber. The upper seal between the motor and the seal chamber shall be of the same design with its own separate spring system. The seals shall require neither maintenance nor adjustment, but shall be easily inspected and replaceable. Shaft seals with conventional double seal utilizing a single spring between the two (2) seals and requiring a pressure differential to offset external pressure shall not be considered acceptable nor equal to the dual independent seal system specified. The shaft sealing system shall be capable of operating submerged to pressures equivalent to two hundred (200) feet. No seal damage shall result from operating the pump unit out of its liquid environment. The seal system shall not rely upon the pumped media for lubrication.

The seal chamber shall also be equipped with a seal failure sensor probe which will sense water intrusion through the lower seal. This sensor shall be connected to an alarm in the control panel to indicate lower seal failure.

4. Housing

The stator winding, rotor and bearings shall be mounted in sealed submersible type housing. Insulation utilized in the stator windings shall be Class H with maximum temperature capability of 180° C. Motor housing shall be filled with a high dielectric oil to give superior heat transfer and allow the bearing to run in a clean, well lubricated environment; or the housing shall be air filled with grease lubricated bearings. The pump and motor are to be specifically designed so that they may be operated partially or completely submerged in the liquid being pumped. The pump shall not require cooling water jackets. Stator shall be securely held in place with a removable end ring and threaded fasteners so that it may be easily removed in the field without use of heat or press. Shaft shall be stainless steel and supported by ball bearings. Motor shall be provided with heat sensing units attached to the motor windings which shall be connected to the control panel to shut down pump if overheating occurs.

5. Cables

Pump motor cable and heat sensor/seal failure sensor cable shall be suitable for submersible pump applications and this shall be indicated by a code or legend permanently embossed on the cable. Cable sizing shall conform to NEC specifications for pump motors and shall be of adequate size to allow motor voltage conversion without replacing the cable. Cable of the proper length shall be provided to eliminate need for splices or junction boxes between pump and “control center.” The cable shall enter the motor through a cord cap assembly which is double sealed allowing disassembly and disconnect of the wires and the motor and still not damage the sealed characteristics of the motor housing. Each individual conductor shall be color coded in accordance with generally accepted industry standards. The color coding shall designate the application of the conductor.

6. Mounting Base

The pump mounting base shall include adjustable guide rail supports and a discharge connection with a one hundred twenty-five (125) pound standard flange. The base and the discharge piping shall be permanently mounted in place. The base plates shall be anchored in place utilizing epoxy type anchors with stainless steel studs and nuts as manufactured by HILTI Fasteners, Inc. or equal.

7. Guide Rails

A rail system shall be provided for easy removal of the pump and motor assembly for inspection and service. The system shall not require a man to enter the wet well to remove the pump and motor assembly. Two (2) rails of two (2) inch stainless steel pipe for Flygt pumps or one rail of fiberglass reinforced plastic (FRP) I-Beam for Hydromatic pumps shall be provided for each pump unless the size of the pump dictates otherwise. The guide rails shall be positioned and supported by the pump mounting base. The guide rails shall be aligned vertically and supported at the top by attachment to the access hatch frame. One (1) intermediate guide rail support shall be required for each nine (9) feet of guide rail length for FRP and fifteen (15) feet for stainless steel pipe. All mounting equipment shall be stainless steel.

8. Rail Guide and Lifting Chain

The pumps shall be equipped with sliding brackets or rail guides. To insure easy removal of the pumps, the rail guides attached to each pump shall not encircle the rails. A stainless steel lifting chain of adequate length for the basin depth shall be provided for each pump. Each pump shall be equipped with a permanent, stationary lifting handle with a minimum clearance of twelve (12) inches between the top of the pump and bottom of the handle.

The rails and the rail guide shall function to allow the complete weight of the pumping unit to be lifted on dead center without binding and stressing the pump housing. The rail system shall function to automatically align the pumping unit to the discharge connection by a simple downward movement of the pump. No twisting or angle approach will be considered acceptable. The actual sealing of the discharge interface may be of the hydraulically sealing diaphragm type assembly with removable Buna-N diaphragm as supplied by Hydromatic Pump or may be of the metal-to-metal contact as provided by Flygt Pump.

9. Warranty

Pump warranty shall be provided by the pump manufacturer and shall warrant the units being supplied to the Owner and City against defects in workmanship and materials for a period of five (5) years under normal use, operation and service. The warranty shall be in printed form and apply to all similar units. A copy of the warranty statement shall be submitted with the approval drawings.

503.07
Lift Station
Components

The lift station shall be configured and shall include all components shown on the most recent version of the Standard Details Lift Station Details Sheets and the following:

1. Wet Well, Valve and Meter Pits, Flat Top, and Base Slab

   a. Material

   The wet well, valve and meter vaults, flat tops and base slabs shall be constructed of precast concrete meeting the requirements of ASTM C 478. Cast-in-place monolithic structures may be substituted with the prior written approval from the Department.

   b. Joints

   All joints between precast sections shall be per Section 305.02.

   c. Waterproofing

   The outside wall below grade shall be coated with bituminous waterproofing material.

2. Concrete Pad

   The wet well and valve and meter vaults shall be enclosed at grade level with a minimum eight (8) inch thick reinforced concrete pad rectangular in shape.

3. Access Drive

   The Lift Station shall be provided with a minimum eight (8) inch thick by fifteen (15) feet wide reinforced concrete access drive conforming to the latest DOT Standards for Design of Driveways.

4. Access Hatches and Frames

   a. An aluminum two (2) door access hatch frame and door assembly shall be installed in the concrete top for the wet well. This door assembly shall provide access for removal of the pumps and shall support the guide rails. The doors shall be provided with a lifting handle, safety latch to hold the door in the open position, and a hasp suitable for a padlock. The doors shall have a non-skid finish and be designed with a minimum 300 psi, live loading.

   b. Valve and Meter Vaults

      An aluminum single door access hatch frame and door assembly similar to the one described above for the wet well shall be installed in the concrete top for the valve and meter vaults. Minimum opening shall be thirty-six (36) inches by thirty-six (36) inches.

5. Check and Shutoff Valves

   A swing check valve with a weight operated external swing arm and an eccentric plug valve shall be installed in the valve vault on each pump's discharge piping. A minimum clearance of twelve (12) inches shall be allowed from the bottom of the valves to the invert of the vault.

   A drain pipe and check valve shall be installed to drain the valve vault back to the wet well but not allow the wet well liquid to enter the valve vault. In addition, a tee or cross with bleedable blind flange shall be provided in the valve vault.

6. Magnetic Flow Meter and Shutoff Valves

   When variable speed pumping systems are required, a magnetic flow meter and an eccentric plug valve shall be installed on the discharge piping per Section 503.09. A minimum clearance of twelve (12) inches shall be allowed between the bottom of the valves to the invert of the vault.

   Straight sections of pipe upstream and downstream of the magnetic flow meter shall be per manufacture's recommendation.

7. Drop Pipes

   Drop pipes shall be installed in all incoming pipes four (4) feet or greater above the pump-on elevation or as directed by the Department.

503.08 Control System Requirements – Level 3 Lift Stations

The Control System Requirements for Level 3 lift stations with constant speed pumps shall be per the current Department specifications or as follows:

1. Overall Lift Station Control System Enclosure Requirements

   a. General Requirements:

      i. Control and electrical components shall be individually equipment rack mounted as shown on schematics and as follows:

- Pump Control Panel. NEMA 4X stainless steel with dead front and internal swing out panel door. Include pump controls, operator interface, telemetry equipment, and uninterruptible power supply.
- Power distribution panel. NEMA 4X stainless steel. Include phase monitor, surge protection devices, branch circuit breakers, and motor starters.
- Utility approved meter socket.
- Service entrance rated NEMA 3R double throw fused main disconnect switch for utility power and portable emergency generator connection. Include exterior mounted weather proof generator receptacle mounted to disconnect enclosure. Disconnect and receptacle shall be suitable for outdoor use.
- NEMA 3R control power transformer, suitable for outdoor use.

  Note to specifier: Covert alarm system required on interim basis until SCADA System is operational

- NEMA 4X rated "Covert" alarm system.

ii. Enclosures shall be mounted on lift station concrete pad. Concrete pad shall be a minimum three inches higher than the adjacent ground. Concrete pad shall be a minimum of one foot larger in dimension than enclosure plus radius of door swings. Orientate panel placement so that panel doors do not open over or near wet well opening.

iii. Provide enclosures with following additional accessories:

- Drip shield.
- Padlock hasp.
- Stainless steel 3-point latch to allow panel opening without tools.
- In addition to above, Pump Control Panel shall be provided with:
  - Fluorescent door switch activated light.
  - GFI 120 VAC receptacle.
  - Thermostatically controlled heaters sized to maintain panel internal temperature at 50°F with outdoor temperature of -20°F.

2. Electrical Requirements

a. The lift station shall have electric-utility-delivered 3-phase, 60Hz, 4-wire wye, or delta power. All stations powered by 3-phase primary voltage shall have a minimum 2.0 KVA single-phase, 480/240 to 120/240 VAC transformer. **Use of phase converters to derive 3-phase power from 1-phase power source is prohibited**.

b. Include provision for connection of OWNER provided portable emergency generator. Receptacle shall be rated for 200 amps, 600 volts. Coordinate receptacle type and manufacturer with OWNER to assure capability with OWNER'S generator plug.

c. Motor starters shall be **NEMA**-rated magnetic type with a 120 volt control coil, and three thermal overload relays with a minimum size of NEMA-1.

3. Wiring, Termination, and Labeling Requirements

a. Wiring:

i. In addition to NEC and NEMA requirements, wiring shall conform to following:

- Power: 12 AWG stranded minimum, type MTW, 600 V.

- Control: 16 AWG stranded minimum, type MTW, 300 V.
- Analog Signal: Twisted pair, 18 AWG, Beldon 8760 or equal.

ii. Wire color code:

- AC neutral conductor: White.
- AC hot conductor: Black.
- Grounding conductor: Green.
- AC control conductor, powered from within panel: Color coded and numbered.
- AC control conductor, powered from remote source: Yellow.
- DC (+) power conductor: Blue.
- DC (-) power conductor: Blue.
- DC control conductor: Blue.
- Twisted pair cable (-) signal conductor: White.
- Twisted pair cable (+) signal conductor: Black.
- Intrinsically safe conductors – light blue.

iii. Design control panels to keep 3-phase power, 120-vac power and discrete signals, and analog and other low voltage signals separated.

- Do not run 3-phase power, 120-vac power and discrete signals, and analog or other low voltage signals in the same conduit or wire-duct.
- Where 3-phase power, 120-vac power and discrete signals, and analog or other low voltage signals must cross, they shall do so at right angles.

iv. Internal Panel Wiring Within Wire Duct:

- Wherever feasible plastic wire duct with cover shall be used for routing of wire within control panel.
- Size wire duct to be no more than 50% full.
- Maintain 2” clearance between wire duct and terminals.

v. Internal Panel Wiring outside of wire duct.

- Wiring outside of ducts shall be restrained by use of plastic wire-ties.
- Restrain wiring a minimum of every six inches.
- Provide abrasion protection for wires passing through holes or across abrasive metal edges.
- Adhesive type wire fasteners shall not be used. Hard screw type shall be employed.

b. Terminations:

i. Wiring within control panel shall be continuous and terminated only at terminal blocks or equipment terminals. Splices or butt connectors shall not be used within panel.
ii. Other than terminal to terminal bussing as described below, no more than one wire shall be terminated at any one terminal.
iii. Make external connections by way of numbered terminal blocks on numbered terminal strips.
iv. When signals are powered from remote location, switched terminal blocks shall be used where conductors enter or leave panel.
v. When signals are powered from within panel, fused terminal blocks shall be used where conductors enter or leave panel.
vi. Provide integral bussing system on terminal block array where more than two terminations require common source or drain connection. Jumpered terminations shall not be acceptable.
vii. Include provisions for grounding of shields on shielded twisted pair cables entering or leaving panel. Cable shields shall be grounded at terminal block end only.

viii. Provide separate locations on terminal strips for each of the following types of signals.

- 480 or 240-vac power circuits.
- 120-vac power circuits.
- 120-vac discrete signals.
- 24 or 48 Vdc discrete signals.
- Analog signals.
- Serial or parallel digital communication signals.

ix. Provide separate terminal strip for intrinsically safe circuits. Intrinsically safe wiring shall be separated by non-conducting or grounded barrier within panel, and not combined with any other wiring within conduit or wire duct.

c. Power Distribution:

i. Panels having 3-phase power supply:

- Service entrance rated NEMA 3R double throw fused main disconnect switch to isolate utility power to panel and allow connection of portable emergency generator. Mount generator receptacle to disconnect enclosure. Disconnect and generator receptacle shall be rated for 200 A.
- Provide circuit breakers for all motor starters provided.
- Provide phase monitor relay (PMR).
- If panel includes separate 120 vac control power supply, provide auxiliary contact to isolate control power when main circuit breaker is opened.
- 480(240, 208) / 120 control power transformer requirements:
  - Both primary leads shall be fused.
  - First secondary lead shall be fused.
  - Second secondary lead shall be grounded.

ii. Panels having 120 vac power supply:

- Provide circuit breaker on power supply entering panel.

iii. Provide separately fused power supply to each major panel component.

iv. Panels using modular or solid state I/O devices.

- Provide separately fused power circuit for panel powered I/O signals entering panel from field devices. Provide separate circuit for each module.
- Include digital transient surge suppressor/varistor installed in parallel with output contact at terminal strip for each output signal driving an inductive load including:
  - Relays.
  - Solenoids.
  - Motor starters.
  - Motors.

4. UPS Requirements

Note to specifier: Covert alarm system replaces radio on interim basis until SCADA System is operational. Delete radio and Ethernet switch in item b below if Covert alarm system is to be included in lift station specification.

a. Provide true on-line non switching uninterruptible power supply (UPS).

b. UPS shall supply power to PLC, OIU, radio, Ethernet switch, field instruments, and other low voltage control devices.

c. UPS shall have enough capacity to power these devices for a period of 2 hours after the utility power has failed. Provide with extended battery module to meet this requirement.

d. UPS shall provide dry contacts to PLC for utility fail and low battery power alarms.

e. Minimum UPS size shall be 700 VA.

f. Double power conversion on-line operation including rectifier and inverter, constantly conditioned AC output.

g. Provide make before break manually operated bypass switch or other means to bypass UPS to allow operation of system controls in event of UPS failure.

h. Eaton Powerware Model 9125.

Note to specifier: Covert alarm system replaces radio and antenna on interim basis until SCADA System is operational. Delete item 5 below if Covert alarm system is to be included in lift station specification.

5. Ethernet Switch, Radio, Antenna, and Antenna Mounting Requirements

a. Provide Ethernet switch, radio, antenna, antenna cable, and antenna mounting pole.

b. Radio, antenna cable, antenna, and lightning and surge protection devices shall be purchased from the City's approved radio equipment supplier to ensure compatibility with City's radio based SCADA communication network used for lift station monitoring.

c. Ethernet switch and radio shall be mounted within Pump Control Panel.

d. Contractor shall determine signal strength available at lift station location using both 900 MHz and 5.7 GHz radio test unit supplied by the City. Available signal strength shall be tested at elevations of 20' and 15' above ground level and signal strength test results shall be supplied to the City.

e. Contractor shall determine the most suitable location for the antenna based on the results of signal strength testing. Antenna pole shall be affixed to lift station concrete pad.

f. Based on the results of signal strength testing, the Contractor shall purchase either the 900 MHz or 5.7 GHz radio, as selected by the City, from the City's approved radio equipment supplier.

g. Contractor shall mount the antenna in the selected location, and provide antenna cable in conduit.

h. Where lift station structure does not exist or is unsuitable for antenna mounting, antenna mounting pole shall be up to 20' tall, 4" in diameter, aluminum, and set within concrete or firmly affixed to pump station.

i. Where lift station structure is suitable for antenna mounting, antenna mounting pole shall be 2" in diameter, aluminum, and firmly affixed to pump station.

j. Provide grounding of antenna pole in accordance with NEC requirements.

k. Programming of radio shall by City.

6. Field Instrument Requirements

a. Provide submersible level transmitter to sense level in wet well and control pump on/off operation.

i. Hydrostatic pressure measurement.
ii. Loop powered.
iii. 4 – 20 mAdc output signal.
iv. 316 stainless steel submersible housing and diaphragm, Viton grommet and o-ring. Provide with stainless steel braided support cable to prevent transmitter from being supported by signal cable.
v. Accuracy +/- 0.25% of span including linearity, hysteresis, and repeatability.
vi. Provide with lightning and surge protector to be mounted in Pump Control Panel.
vii. CSA approved intrinsically safe when used with appropriate barrier.
viii. Ametek model 575.

b. Provide wet well float switches to sense high and low level in wet well and control standby pump on/off operation. Standby pump operation shall be independent of PLC.

i. SPDT contacts, rated 1 amp at 150 VAC/VDC inductive, mechanical life 10 million operations.
ii. 316 stainless steel mounting hardware. Mounting shall be via weight and chain/cable not requiring entry to wet well for cleaning or replacement.
iii. Connery Model 2900 pear shaped neoprene covered mercury switch ball float of standard size, supported by stainless steel cable.

c. For lift stations containing a dry well, or areas prone to flooding due to pump seal or piping failure, provide dry well float switch to sense dry well flooding.

i. SPDT contacts, rated 1 amp at 150 VAC/VDC inductive, mechanical life 10 million operations.
ii. Connery Model 2900 pear shaped neoprene covered mercury switch ball float of standard size.

d. Provide intrusion detection switches.

i. When control and electrical components are mounted outdoors, provide intrusion detection switches for electrical and control equipment enclosure.
ii. When control and electrical components are mounted indoors provide intrusion detection switches for all entrances into pump station.
iii. Reed switch enclosed in ABS plastic case, normally closed contact.
iv. Sentrol 1045 series or approved equal.

7. Pump Control Panel Requirements

Note to specifier: Covert alarm system replaces radio and Ethernet switch on interim basis until SCADA System is operational. Delete radio and Ethernet switch in item a below if Covert alarm system is to be included in lift station specification.

a. A Pump Control Panel shall be provided to house the Programmable Logic Controller (PLC), Operator Interface Unit (OIU), Ethernet switch, radio, lightning and surge protection devices, and pump monitoring equipment.

b. When Pump Control Panel is mounted outdoors, provide with a low temperature switch, set at 40 °F, mounted within the enclosure to alarm failure of heater.

c. The automatic pump operation, automatic pump lead-lag alteration, and all control logic commands shall be performed by the PLC. The PLC shall be Allen Bradley Micrologix 1200, with no substitutions allowed, and shall meet the following requirements:

   i. Minimum 24 Discrete Inputs
   ii. Minimum 12 Discrete Outputs
   iii. Minimum 4 Analog Inputs
   iv. Minimum 2 Analog Output
   v. 6 K-word memory minimum, 2 K data storage, 4 K program.
   vi. Real time clock
   vii. Floating point math
   viii. PID control
   ix. Ethernet interface

d. The OIU shall be Allen Bradley Panelview Plus 400 meeting the following requirements:

   i. 3.7” monochrome display
   ii. 320 X 240, 32 level greyscale resolution
   iii. Keypad
   iv. NEMA 12/4X
   v. DC Powered

e. The Ethernet switch shall be Phoenix Contact meeting the following requirements:

   i. 4 RJ45 ports ports
   ii. 10/100 Mbits/s
   iii. 0 to 55 °C operating temperature
   iv. DC Powered

f. Provide the following front of panel mounted devices to be labeled as indicated. For outdoor locations, devices shall be mounted to swing out panel door.

   i. “Hand-Off-Automatic” selector switch for each pump, with the hand mode wired for manual operation independent of the PLC.
   ii. Operator interface.

g. PLC I/O signals:

   i. Discrete Inputs:

      - Pump 1 running
      - Pump 2 running
      - Pump 1 “Auto” (from panel mounted HOA switch)
      - Pump 2 “Auto” (from panel mounted HOA switch)
      - Pump 1 seal fail (submersible pump applications only, alarm display only – no pump interlock)
      - Pump 2 seal fail (submersible pump applications only, alarm display only – no pump interlock)
      - Pump 1 motor high motor temperature (submersible pump applications only), motor breaker trip, and motor starter overload combined into common alarm and used to interlock pump operation.
      - Pump 2 motor high motor temperature (submersible pump applications only), motor breaker trip, and motor starter overload combined into common alarm and used to interlock pump operation.

- Alarm test (from pushbutton)
- Alarm silence (from pushbutton)
- High wet well level
- Low wet well level
- Dry well flood
- Lift station intrusion
- Low temperature
- Low battery power
- Utility power fail
- Phase fail

ii. Discrete Outputs:

- Pump 1 required
- Pump 2 required
- Pump 1 seal test (submersible pump applications only)
- Pump 2 seal test (submersible pump applications only)
- Common alarm to horn and light

Note to specifier: Covert alarm outputs required on interim basis until SCADA System is operational

- Covert Alarm 1
- Covert Alarm 3
- Covert Alarm 4
- Covert Alarm 5

iii. Analog Inputs:

- Wet well level

h. OIU shall be configured to allow:

i. Display pump run, fail, automatic mode, overload, seal fail, motor over-temperature, accumulated pump run time, and accumulated pump number of starts for each pump. Display all discrete and analog signals input to PLC, and calculated or derived parameters including communication fail, crew on site, intrusion, and float control mode.
ii. Wetwell level, high and low level alarms.
iii. “Lead Pump 1 / Lead Pump 2 / Lead Pump Alternate” selection.
iv. Calculated lift station flow rate and accumulated flow total.
v. Display communication fail (to SCADA central).
vi. Display status of all input signals to PLC.
vii. Capability to place pump “Out of Service”. Display “Out of Service” status at OIU.
viii. Configure to allow “Crew on Site” input. Allow entry of operator’s 4 digit identification number after “Crew on Site” has been entered. This function is to work in conjunction with the Intrusion switch. Once an intrusion has been detected the crew will have a set amount of time to enter a valid code before the intrusion alarm is activated.
ix. Operator data entry for adjustable set points, including pump on/off levels, time delays, etc. Allow for operator entry of 4 digit password prior to accepting parameter changes.

i. System programming guidelines:

i. Provide program documentation for all OIU and PLC program files developed for the system. PLC program documentation shall include comments for all registers used and sufficient rung comments to describe operation of logic used within program. Provide four copies of program documentation on CD.
ii. Automatic pump control shall start and stop pumps in a lead and lag fashion based on wet well level input.

iii. Provide lead pump alternation on each successive lead pump shutdown when automatic alternation is selected.
iv. Provide pump fault logic to sense discrepancy between pump-required output being turned on and no pump run signal being received. Configure system to generate fault on any condition including motor overload, motor over temperature, seal failure or power disconnect.
v. Provide time delay on pump required outputs, initially set at 10 seconds and 20 seconds, to prevent simultaneous pump restart on restoration of control power.
vi. "Out of Service" entry shall remove pump from operating sequence, and prevent alarms from being generated for pump.
vii. All alarms shall automatically reset when the alarm condition has cleared. An adjustable 0-15 minute time delay relay shall be activated and timed-out prior to transmitting the high or low wet well level condition.
viii. Pump accumulated run time shall be calculated for each pump.
ix. Pump accumulated number of starts shall be calculated for each pump.
x. Provide routine to calculate lift station draw down time. Draw down time data shall be time stamped, and indicate which pump(s) running during draw down event.
xi. Program to ensure that regardless of configuration of backup hardware, (re: back up ball floats when primary level control device is pressure transducer) primary level control device automatically takes over when level of wet well returns to desired operating level.
xii. Provide routine to calculate lift station flow rate and accumulated lift station accumulated flow total. Calculation shall be based on following:

- Wet well dimensions, include adjustable offset for equipment, piping, or other items affecting wet well volume and account for cross-sectional changes between minimum and maximum levels. Calculation shall be made such that changes to pump on and off level set-points shall not require change to flow calculation routine.
- Wet well level rate of rise shall be used to calculate inflow rate when pump are not operating.
- During pump run events, inflow rate shall be calculated as the average inflow rate occurring immediately before and after pump run event.

xiii. PLC shall be configured to periodically transfer information to SCADA Central HMI. Transfer of information shall occur periodically based on information request from SCADA Central HMI, and be initiated by lift station PLC on occurrence of alarm condition. Periodic data transfer of information to SCADA Central HMI shall include:

- Lift station accumulated flow total.
- 10 minute averaged flow rate data. Time stamped average flow rate data values shall be logged internally to PLC memory. Logged data shall be retained until data successfully transferred to HMI, at which point it shall be deleted.
- Pump draw down data. Time stamped data values shall be logged internally to PLC memory. Logged data shall be retained until data successfully transferred to HMI, at which point it shall be deleted.
- Pump elapsed run time data
- Accumulated number of starts for each pump
- Coordinate programming requirements with City

- Data transfer shall be configured to allow SCADA Central HMI to emulate all data input and display functions present at OIU, including display all discrete and analog signals input to PLC, and calculated or derived parameters including communication fail, crew on site, intrusion, and float control mode.
- Data transfer to and from SCADA Central HMI shall take place using contiguous PLC register locations to maximize efficiency of data transfer. Register usage and addressing shall be coordinated with City.
- Include provision for periodic receipt of current time and date SCADA Central HMI.

j. Required modifications to the Lift Station Central SCADA system monitoring software at the Waste Water Treatment Plant will be performed by the City.

503.09
Control System Requirements – Level 2 Lift Stations

The Control System Requirements for Level 2 Lift Stations with variable speed pumps shall be per the current Department specifications or as follows:

1. Overall Lift Station Control System Enclosure Requirements

Note to specifier: Select item a or b below as appropriate

a. Outdoor Location Requirements:

i. Control and electrical components shall be individually equipment rack mounted as shown on schematics and as follows:

- Pump Control Panel. NEMA 4X stainless steel with dead front and internal swing out panel door. Include pump controls, operator interface, flow meter transmitter, telemetry equipment, and uninterruptible power supply.
- Power distribution panel. NEMA 4X stainless steel. Include phase monitor, surge protection devices, and branch circuit breakers.
- Utility approved meter socket.
- Service entrance rated NEMA 3R double throw fused main disconnect switch for utility power and portable emergency generator connection. Include exterior mounted weather proof generator receptacle mounted to disconnect enclosure. Disconnect and receptacle shall be suitable for outdoor use.
- NEMA 3R control power transformer, suitable for outdoor use.

  Note to specifier: Covert alarm system required on interim basis until SCADA System is operational

- NEMA 4X stainless steel rated “Covert” alarm system.

ii. Provide NEMA 4X rated variable speed drives suitable for outdoor use. Drive enclosure shall be end product of drive manufacturer. Drive may be mounted to equipment rack or freestanding as shown on schematics.

iii. Enclosures shall be mounted on lift station concrete pad. Concrete pad shall be a minimum three inches higher than the adjacent ground. Concrete pad shall be a minimum of one foot larger in dimension than enclosure plus radius of door swings. Orientate panel placement so that panel doors do not open over or near wet well opening.

iv. Provide enclosures with following additional accessories:

- Drip shield.
- Padlock hasp.
- Stainless steel 3-point latch to allow panel opening without tools.
- In addition to above, Pump Control Panel shall be provided with:
  - Fluorescent door switch activated light.
  - GFI 120 VAC receptacle.
  - Thermostatically controlled heaters sized to maintain panel internal temperature at 50°F with outdoor temperature of -20°F.

b. Indoor Location Requirements:

i. Control and electrical components shall be individually wall mounted in NEMA 12 rated enclosures as follows:

- Pump Control Panel. Include GFI 120 VAC receptacle within panel.
- Service rated fused disconnect switch for utility power connection
- Power distribution panel, including surge protection devices, branch circuit breakers, and motor starters.
- Uninterruptible power supply.
- Flow meter transmitter.
- Control power transformer.
- Variable speed drives.
- Double throw transfer switch for use with portable emergency generator.
- "Covert" alarm system.

Note to specifier: Covert alarm system required on interim basis until SCADA System is operational

ii. Size enclosures to adequately dissipate heat generated by equipment mounted in or on panel.

iii. Include exterior mounted weather proof generator connection.

2. Electrical Requirements

a. The lift station shall have electric-utility-delivered 3-phase, 60Hz, 4-wire wye, or delta power. All stations powered by 3-phase primary voltage shall have a minimum 2.0 KVA single-phase, 480/240 to 120/240 VAC transformer. **Use of phase converters to derive 3-phase power from 1-phase power source is prohibited**.

b. Include provision for connection of OWNER provided portable emergency generator. Receptacle shall be rated for 200 amps, 600 volts. Coordinate receptacle type and manufacturer with OWNER to assure capability with OWNER'S generator plug.

3. Wiring, Termination, and Labeling Requirements

a. Wiring:

i. In addition to NEC and NEMA requirements, wiring shall conform to following:

- Power: 12 AWG stranded minimum, type MTW, 600 V.
- Control: 16 AWG stranded minimum, type MTW, 300 V.
- Analog Signal: Twisted pair, 18 AWG, Beldon 8760 or equal.

ii. Wire color code:

- AC neutral conductor: White.
- AC hot conductor: Black.
- Grounding conductor: Green.
- AC control conductor, powered from within panel: Color coded and numbered.
- AC control conductor, powered from remote source: Yellow.
- DC (+) power conductor: Blue.
- DC (-) power conductor: Blue.
- DC control conductor: Blue.
- Twisted pair cable (-) signal conductor: White.
- Twisted pair cable (+) signal conductor: Black.
- Intrinsically safe conductors – light blue.

iii. Design control panels to keep 3-phase power, 120-vac power and discrete signals, and analog and other low voltage signals separated.

- Do not run 3-phase vac power, 120-vac power and discrete signals, and analog or other low voltage signals in the same conduit or wire-duct.
- Where 3-phase vac power, 120-vac power and discrete signals, and analog or other low voltage signals must cross, they shall do so at right angles.

iv. Internal Panel Wiring Within Wire Duct:

- Wherever feasible plastic wire duct with cover shall be used for routing of wire within control panel.
- Size wire duct to be no more than 50% full.
- Maintain 2” clearance between wire duct and terminals.

v. Internal Panel Wiring outside of wire duct.

- Wiring outside of ducts shall be restrained by use of plastic wire-ties.
- Restrain wiring a minimum of every six inches.
- Provide abrasion protection for wires passing through holes or across abrasive metal edges.
- Adhesive type wire fasteners shall not be used. Hard screw type shall be employed.

b. Terminations:

i. Wiring within control panel shall be continuous and terminated only at terminal blocks or equipment terminals. Splices or butt connectors shall not be used within panel.
ii. Other than terminal to terminal bussing as described below, no more than one wire shall be terminated at any one terminal.
iii. Make external connections by way of numbered terminal blocks on numbered terminal strips.
iv. When signals are powered from remote location, switched terminal blocks shall be used where conductors enter or leave panel.

v. When signals are powered from within panel, fused terminal blocks shall be used where conductors enter or leave panel.
vi. Provide integral bussing system on terminal block array where more than two terminations require common source or drain connection. Jumpered terminations shall not be acceptable.
vii. Include provisions for grounding of shields on shielded twisted pair cables entering or leaving panel. Cable shields shall be grounded at terminal block end only.
viii. Provide separate locations on terminal strips for each of the following types of signals.

- 480 or 240-vac power circuits.
- 120-vac power circuits.
- 120-vac discrete signals.
- 24 or 48 Vdc discrete signals.
- Analog signals.
- Serial or parallel digital communication signals.

ix. Provide separate terminal strip for intrinsically safe circuits. Intrinsically safe wiring shall be separated by non-conducting or grounded barrier within panel, and not combined with any other wiring within conduit or wire duct.

c. Power Distribution:

i. Panels having 3-phase power supply:

- Service entrance rated NEMA 3R double throw fused main disconnect switch to isolate utility power to panel and allow connection of portable emergency generator. Mount generator receptacle to disconnect enclosure. Disconnect and generator receptacle shall be rated for 200 A.
- Provide circuit breakers for all variable frequency drives provided.
- Provide phase monitor relay (PMR).
- If panel includes separate 120 vac control power supply, provide auxiliary contact to isolate control power when main circuit breaker is opened.
- 480(240, 208) / 120 control power transformer requirements:
  - Both primary leads shall be fused.
  - First secondary lead shall be fused.
  - Second secondary lead shall be grounded.

ii. Panels having 120 vac power supply:

- Provide circuit breaker on power supply entering panel.

iii. Provide separately fused power supply to each major panel component.

iv. Panels using modular or solid state I/O devices.

- Provide separately fused power circuit for panel powered I/O signals entering panel from field devices. Provide separate circuit for each module.

- Include digital transcient surge suppressor/varistor installed in parallel with output contact at terminal strip for each output signal driving an inductive load including:
  - Relays.
  - Solenoids.
  - Motor starters.
  - Motors.

4. VFD Requirements

a. Drive enclosure shall be end product of drive manufacturer.

b. Provide pulse width modulated variable speed drives (VFDs).

c. Provide with bypass contactor to allow across the line operation.

d. Suitable for outdoor mounting, with maximum ambient temperature of 105°F.

e. Mount in pad-lockable NEMA 4X stainless steel rated dead-front enclosure. Drive enclosure shall be end product of VFD manufacturer.

f. Include thermostatically controlled heaters sized to maintain drive panel internal temperature at 50°F with outdoor temperature of -20°F.

g. Use of air conditioning or heat exchangers to allow operation of VFD in elevated ambient temperatures is prohibited. Include externally mounted heat sinks (one per VFD) sized to maintain drive panel internal temperature at 100°F with outdoor temperature of 105°F. If required to meet specified ambient temperature requirements, derate drive capacity to meet temperature requirements. Provide with a high temperature switch, set at 110°F, mounted within the enclosure to alarm high drive temperature.

h. Capable of withstanding line voltage transients up to 3000 V in accordance wit ANSI 37.90.1.

i. IGBT switching.

j. Match output power to motor, 0.5% speed regulation, 110% overload capacity for 60 seconds, 100% rated torque from 60 Hz to required turndown.

k. 3% input line reactors.

l. Instantaneous over-current trip shutdown, under-voltage protection with automatic restart.

m. Include keypad/display mounted within enclosure, accessible when enclosure is opened.

n. Manufacturers

   i. Allen Bradley.
   ii. Eaton/Cutler Hammer.
   iii. Saftronics.
   iv. Toshiba.
   v. No substitutions allowed.

5. UPS Requirements

Note to specifier: Covert alarm system replaces radio on interim basis until SCADA System is operational. Delete radio and Ethernet Switch in item b below if Covert alarm system is to be included in lift station specification.

a. Provide true on-line non switching uninterruptible power supply (UPS).

b. UPS shall supply power to PLC, OIU, radio, Ethernet switch, field instruments, and other low voltage control devices.

c. UPS shall have enough capacity to power these devices for a period of 2 hours after the utility power has failed. Provide with extended battery module to meet this requirement.

d. UPS shall provide dry contacts to PLC for utility fail and low battery power alarms.

e. Minimum UPS size shall be 700 VA.

f. Double power conversion on-line operation including rectifier and inverter, constantly conditioned AC output.

g. Provide make before break manually operated bypass switch or other means to bypass UPS to allow operation of system controls in event of UPS failure.

h. Eaton Powerware Model 9125.

Note to specifier: Covert alarm system replaces radio and antenna on interim basis until SCADA System is operational. Delete item 6 below if Covert alarm system is to be included in lift station specification.

6. Ethernet Switch, Radio, Antenna, and Antenna Mounting Requirements

a. Provide Ethernet switch, radio, antenna, antenna cable, and antenna mounting pole.

b. Radio, antenna cable, antenna, and lightning and surge protection devices shall be purchased from the City's approved radio equipment supplier to ensure compatibility with City's radio based SCADA communication network used for lift station monitoring.

c. Ethernet switch and radio shall be mounted within Pump Control Panel.

d. Contractor shall determine signal strength available at lift station location using both 900 MHz and 5.7 GHz radio test unit supplied by the City. Available signal strength shall be tested at elevations of 20' and 15' above ground level and signal strength test results shall be supplied to the City.

e. Contractor shall determine the most suitable location for the antenna based on the results of signal strength testing. Antenna pole shall be affixed to lift station concrete pad.

f. Based on the results of signal strength testing, the Contractor shall purchase either the 900 MHz or 5.7 GHz radio, as selected by the City, from the City's approved radio equipment supplier.

g. Contractor shall mount the antenna in the selected location, and provide antenna cable in conduit.

h. Where lift station structure does not exist or is unsuitable for antenna mounting, antenna mounting pole shall be up to 20' tall, 4" in diameter, aluminum, and set within concrete or firmly affixed to pump station.

i. Where lift station structure is suitable for antenna mounting, antenna mounting pole shall be 2" in diameter, aluminum, and firmly affixed to pump station.

j. Provide grounding of antenna pole in accordance with NEC requirements.

k. Programming of radio shall by City.

7. Field Instrument Requirements

a. Provide submersible level transmitter to sense level in wet well and control pump on/off operation.

i. Hydrostatic pressure measurement.
ii. Loop powered.
iii. 4 – 20 mAdc output signal.
iv. 316 stainless steel submersible housing and diaphragm, Viton grommet and o-ring. Provide with stainless steel braided support cable to prevent transmitter from being supported by signal cable.
v. Accuracy +/- 0.25% of span including linearity, hysteresis, and repeatability.
vi. Provide with lightning and surge protector to be mounted in Pump Control Panel.

vii. Suitable for use in Class 1, Division 1, Group D hazardous classified location when used with appropriate barrier.
viii. Ametek model 575.

b. In high grease or other applications, ultrasonic level sensor may be used with approval from OWNER.

i. Ultrasonic level measurement.
ii. 120 VAC powered.
iii. 4 – 20 mAdc output signal.
iv. Accuracy +/- 0.1 % of span including linearity, hysteresis, and repeatability.
v. Provide with lightning and surge protector to be mounted in Pump Control Panel.
vi. Suitable for use in Class 1, Division 1, Group D hazardous classified location.
vii. Manufacturers:

- Milltronics MINI-Ranger
- Endress and Hauser Prosonic M
- No substitutions allowed.

c. Provide wet well float switches to sense high and low level in wet well and control standby pump on/off operation. Standby pump operation shall be independent of PLC.

i. SPDT contacts, rated 1 amp at 150 VAC/VDC inductive, mechanical life 10 million operations.
ii. Connery Model 2900 pear shaped neoprene covered mercury switch ball float of standard size , supported by stainless steel cable.

d. For lift stations containing a dry well, or areas prone to flooding due to pump seal or piping failure, provide dry well float switch to sense dry well flooding.

i. SPDT contacts, rated 1 amp at 150 VAC/VDC inductive, mechanical life 10 million operations.
ii. Connery Model 2900 pear shaped neoprene covered mercury switch ball float of standard size.

e. Provide intrusion detection switches.

i. When control and electrical components are mounted outdoors, provide intrusion detection switches for electrical and control equipment enclosure.
ii. When control and electrical components are mounted indoors provide intrusion detection switches for all entrances into pump station.
iii. Reed switch enclosed in ABS plastic case, normally closed contact.
iv. Sentrol 1045 series or approved equal.

f. Provide magnetic flow meter.

i. Size meter to maintain average velocity of 3 ft/sec.
ii. System accuracy of +/- 25% of flow rate with 10:1 turndown.
iii. Meter body:

- Utilize low frequency dc pulse.
- Accidental submergence rating of 30 ft. water for 48 hours.
- Polyurethane or hard rubber liner, 316 stainless steel electrodes.
- Provide with 316 stainless steel grounding rings, use of grounding probes not acceptable.
- Suitable for Class 1, Division II, Hazardous classified location.
- Include isolating plug valves before and after meter body to facilitate meter removal. Include spool piece of same dimensions as meter body.

- Maintain minimum of 5 upstream and 3 downstream unobstructed pipe diameters before and after meter body. Provide separate meter vault if required to meet dimensional requirement. Meter vault shall be provided with sump and flood alarm float switch.

iv. Transmitter:

- 120 VAC, 60 Hz power.
- For outdoor locations, mount on Pump Control Panel internal swing out panel as shown.
- Provide pulsed DC voltage to meter body magnet coils.
- Integral keypad/display.
- Automatic empty pipe detection.

v. Manufacturers:

- Rosemount
- Krohne
- ABB
- Foxboro
- Sparling
- No substitutions allowed.

8. Pump Control Panel Requirements

Note to specifier: Covert alarm system replaces radio and Ethernet switch on interim basis until SCADA System is operational. Delete radio and Ethernet switch in item a below if Covert alarm system is to be included in lift station specification.

a. A Pump Control Panel shall be provided to house the Programmable Logic Controller (PLC), Operator Interface Unit (OIU), Ethernet switch, radio, lightning and surge protection devices, and pump monitoring equipment.

b. When Pump Control Panel is mounted outdoors, provide with a low temperature switch, set at 40 °F, mounted within the enclosure to alarm failure of heater.

c. The automatic pump operation, automatic pump lead-lag alteration, and all control logic commands shall be performed by the PLC. The PLC shall be Allen Bradley Micrologix 1200, with no substitutions allowed, and shall meet the following requirements:

i. Minimum 32 Discrete Inputs
ii. Minimum 12 Discrete Outputs
iii. Minimum 8 Analog Inputs
iv. Minimum 4 Analog Output
v. 6 K-word memory minimum, 2 K data storage, 4 K program.
vi. Real time clock
vii. Floating point math
viii. PID control
ix. Ethernet interface
x. DC Powered

d. The OIU shall be Allen Bradley Panelview Plus 400 meeting the following requirements:

i. 3.7” monochrome display
ii. 320 X 240, 32 level greyscale resolution
iii. Keypad
iv. NEMA 12/4X
v. Ethernet Interface

vi. DC Powered

e. The Ethernet switch shall be Phoenix Contact meeting the following requirements:

i. 4 RJ45 ports ports
ii. 10/100 Mbits/s
iii. 0 to 55 °C operating temperature
iv. DC Powered

f. Provide the following front of panel mounted devices to be labeled as indicated. For outdoor locations, devices shall be mounted to swing out panel door.

i. “Hand-Off-Automatic” selector switch for each pump, with the hand mode wired for manual operation independent of the PLC.
ii. “Constant Speed (CS)/Variable Speed (VS)” selector switch for each pump. Selector switch active in the “Hand” mode of operation.
iii. “Speed Control” potentiometer for each pump. Potentiometer shall be wired for manual mode operation independent of the PLC when “Hand” mode, “Variable Speed” operation has been selected via front of panel mounted hand switches.
iv. Operator interface.

g. PLC I/O signals:

i. Discrete Inputs:

- Pump 1 running
- Pump 2 running
- Pump 1 “Auto” (from panel mounted hand switch)
- Pump 2 “Auto” (from panel mounted hand switch)
- Pump 1 seal fail (submersible pump applications only, alarm display only – no pump interlock)
- Pump 2 seal fail (submersible pump applications only, alarm display only – no pump interlock)
- Pump 1 motor high motor temperature (submersible pump applications only), motor breaker trip, and motor starter overload combined into common alarm and used to interlock pump operation.
- Pump 2 motor high motor temperature (submersible pump applications only), motor breaker trip, and motor starter overload combined into common alarm and used to interlock pump operation.
- VFD 1 fault
- VFD 2 fault
- VFD 1 high temperature
- VFD 2 high temperature
- VFD 1 low temperature
- VFD 2 low temperature
- High wet well level
- Low wet well level
- Dry well flood
- Meter vault flood
- Lift station intrusion
- Low temperature
- Low battery power
- Utility power fail
- Phase fail

ii. Discrete Outputs:

- Pump 1 required – variable speed

- Pump 2 required – variable speed
- Pump 1 required – constant speed
- Pump 2 required – constant speed
- Pump 1 seal test (submersible pump applications only)
- Pump 2 seal test (submersible pump applications only)
- Common alarm to horn and light

Note to specifier: Covert alarm outputs required on interim basis until SCADA System is operational

- Covert Alarm 1
- Covert Alarm 3
- Covert Alarm 4
- Covert Alarm 5

ii. Analog Inputs:

- Pump 1 speed
- Pump 2 speed
- Pump 1 current
- Pump 2 current
- Wet well level
- Flow

iii. Analog Outputs:

- Pump 1 speed control
- Pump 2 speed control

h. OIU shall be configured to allow:

i. Display pump run, pump fail, VFD fail, pump speed, automatic mode, overload, seal fail, motor over-temperature, accumulated pump run time, and accumulated pump number of starts for each pump. Display all discrete and analog signals input to PLC, and calculated or derived parameters including communication fail, crew on site, intrusion, and float control mode.
ii. Wetwell level, high and low level alarms.
iii. “Lead Pump 1 / Lead Pump 2 / Lead Pump Alternate” selection.
iv. “Pump Manual/Automatic” mode selection for each pump.
v. “Pump Start”, “Pump Stop”, and “Manual Speed Control” entry for each pump, active when in the manual mode of control.
vi. Capability to place pump “Out of Service”. Display “Out of Service” status at OIU.
vii. Lift station flow rate and integrated flow total.
viii. Display communication fail (to SCADA central).
ix. Display status of all input signals to PLC.
x. Configure to allow “Crew on Site” input. Allow entry of operator’s 4 digit identification number after “Crew on Site” has been entered. This function is to work in conjunction with the Intrusion switch. Once an intrusion has been detected the crew will have a set amount of time to enter a valid code before the intrusion alarm is activated.
xi. Operator data entry for adjustable set points, including pump on/off levels, time delays, etc. Allow for operator entry of 4 digit password prior to accepting parameter changes.

i. System programming guidelines:

i. Provide program documentation for all OIU and PLC program files developed for the system. PLC program documentation shall include comments for all registers used and sufficient rung comments to describe operation of logic used within program. Provide four copies of program documentation on CD.

ii. Automatic pump control shall start and stop pumps in a lead and lag fashion and control pump speed based on wet well level input.

iii. Configure controls to maintain operator entered wet well level set point using PID control. Pump start request shall be initiated when:

- Wet well level rises operator adjustable amount above wet well level set point
- Lead pump, if operating, speed control output is at 100%
- The wet well is not falling

Pump immediate start command shall be issued if wet well level rises to adjustable high level "Immediate Start" level.

iv. Pump stop request shall be initiated when:

- Wet well level falls operator adjustable amount below wet well level set point.
- Speed control output is at minimum speed setting for currently operating number of pumps. Provide separate adjustable minimum speed setting for one pump running and two pumps operating scenarios.
- The wet well is not rising.

Pump immediate stop command shall be issued if wet well level falls to adjustable low level "Immediate Stop" level.

v. Provide weekly lead pump alternation based on operator entered time of day and day of week.

vi. Provide pump fault logic to sense discrepancy between pump-required output being turned on and no pump run signal being received. Configure system to generate fault on any condition including motor overload, motor over temperature, seal failure or power disconnect.

vii. Provide time delay on pump required outputs, initially set at 10 seconds and 20 seconds, to prevent simultaneous pump restart on restoration of control power.

viii. "Out of Service" entry shall remove pump from operating sequence, and prevent alarms from being generated for pump.

ix. All alarms shall automatically reset when the alarm condition has cleared. An adjustable 0-15 minute time delay relay shall be activated and timed-out prior to transmitting the high or low wet well level condition.

x. Pump accumulated run time shall be calculated for each pump.

xi. Pump accumulated number of starts shall be calculated for each pump.

xii. Program to ensure that regardless of configuration of backup hardware, (re: back up ball floats when primary level control device is pressure transducer) primary level control device automatically takes over when level of wet well returns to desired operating level.

xiii. Provide integration routine to calculate accumulated lift station accumulated flow total based on flow rate input signal.

xiv. Periodic data transfer of information to SCADA Central HMI shall include:

- Lift station accumulated flow total.
- 10 minute averaged flow rate data. Time stamped average flow rate data values shall be logged internally to PLC memory. Logged data shall be retained until data successfully transferred to HMI, at which point it shall be deleted.
- Pump elapsed run time data
- Accumulated number of starts for each pump
- Coordinate programming requirements with City

- Data transfer shall be configured to allow SCADA Central HMI to emulate all data input and display functions present at OIU, including display all discrete and analog signals input to PLC, and calculated or derived parameters including communication fail, crew on site, intrusion, and float control mode.
- Data transfer to and from SCADA Central HMI shall take place using contiguous PLC register locations to maximize efficiency of data transfer. Register usage and addressing shall be coordinated with City.
- Include provision for periodic receipt of current time and date SCADA Central HMI.

j. Required modifications to the Lift Station Central SCADA system monitoring software at the Waste Water Treatment Plant will be performed by the City.

503.10 Operation & Maintenance Manuals	Four (4) Operation and Maintenance Manuals shall be submitted to the Department in both hard copy and .pdf format. Manuals shall include, at a minimum, the following: 1. Warranty Statement; 2. Pump down test from the initial start-up test; 3. Operation instructions; 4. Maintenance instructions; 5. Recommended spare parts list; 6. Lubrication schedules; 7. Structural diagrams; 8. As-built wiring diagrams; 9. Piping and Instrumentation Drawings (P&ID); and 10. Bill of materials.
503.11 Spare Parts	At the discretion of the Department, the Contractor may be required to supply one set of spare parts for each station, including, at a minimum, the following: 1. Impeller; 2. Upper seal assembly; 3. Lower seal assembly; 4. Upper bearing assembly; 5. Lower bearing assembly; 6. Wear rings; and 7. O-Rings and gaskets - two (2) sets.
503.12 Station Warranty	Warranties for the lift station and all equipment, except for the pumps, shall be three (3) years from the date of acceptance per City Maintenance Bond requirements. Warranty for the pumps shall be five (5) years from the date of acceptance and per Section 503.06.

SECTION 504
Low Pressure Pump Stations and Appurtenances

504.01 Introduction	This Section describes, in general terms, the guidelines and requirements for the planning, design, and submittal requirements for low pressure sewer systems.
504.02 General	Low-pressure systems will only be considered in areas where sanitary sewers currently serve the surrounding areas and where conventional sanitary sewer facilities cannot be constructed.
504.03 Submittal Requirements for Approval and Construction Permit	Approval of low-pressure sewer systems will be evaluated on a case-by-case basis and will only be allowed with prior written approval from the Department. At the discretion of the Department, a lift station may be required in lieu of a low pressure system. When submitting for an Approval and Construction Permit, the following are required: 1. Written approval from the Department; 2. Low pressure system service area – Per Section 504.04; 3. Low pressure system justification – Per Section 501.03; a. 50-year life cycle analysis; and b. Gravity sewer alternative cost estimate. 4. Low pressure system calculations – Per manufacturer's recommendations and at a minimum the following: a. Calculation worksheet – Per manufacturer; b. Individual pump curves; and c. Make and model number of pumps. 5. Standard Low Pressure System Detail Sheet; 6. Identification of the person/entity responsible for the maintenance of the pumps and other components of the system that are not the responsibility of the City; 7. Homeowners Association Covenants and Restrictions, if applicable; and 8. Any other information the Division and/or Department deems relevant to review and evaluate the proposed low-pressure system.
504.04 Low Pressure System Service Area	The Applicant shall prepare a Low Pressure System Service Area Study in accordance with all the requirements in Section 202.03.
504.05 Responsibility	The City will only be responsible for the operation and maintenance of the common force main and the portion of the lateral from the common force main to, and including, the shutoff valve. The homeowner shall be responsible for all piping, pumping equipment, and appurtenances between the building and the shutoff valve.

For low-pressure systems with multiple units, the City of Indianapolis is NOT responsible for assuring replacement equipment is compatible with the existing equipment in the system.

504.06
System Design and Layout

Due to the variability of each site, the design of low-pressure systems shall rely on sound engineering judgment and manufacturer's recommendations. The Division or Department may, if reasonably justified, make any requirement deemed necessary to assure the system performs as intended.

The minimum requirements for the design and layout of low-pressure systems shall be per the most recent version of the Standard Detail Sheets, the manufacturers' recommendations, and as follows:

1. Pipe Size

   Pipe size shall be per pump manufacturer's recommendations with a minimum size of two (2) inches for the common force main and one and one-quarter (1-1/4) inches between the grinder pump and the common force main. The Engineer shall assure adequate cleansing velocities in the common force main.

2. Overall System Design/Layout

   The design shall be as follows:

   a. Sufficient to achieve a cleansing velocity of two (2) feet per second in the common force main; and

   b. Without any "loops" or parallel pumping segments in the system.

3. Cleanouts

   Cleanouts shall be per pump manufacturers recommendations but at a minimum the following locations:

   a. At the terminal end of each common force main;

   b. When two (2) or more force mains are connected; and

   c. Every 1,000 feet.

4. Flushing Stations

   Flushing stations shall be incorporated into the system.

5. Air Relief Valves

   Air relief valves shall be installed at the following locations:

   a. All high points in the system; and

   b. At intervals of 2,000 feet on all horizontal runs lacking a clearly defined high point.

6. Lateral Assembly Installation

   A lateral assembly installation shall be installed on each service line.

7. Other requirements as deemed necessary.

504.07 Maximum Connections to Grinder Pump Units

No more than one (1) building will be permitted to connect to a Grinder Pump Unit.

Common Grinder Pumps for one (1) building with multiple residential units are also prohibited, except for the following:

1. Apartment buildings (only one apartment building per grinder pump unit); and
2. Condominiums where different floors have different owners (only one building per grinder pump unit).

The intent is to have individual residential units be served by individual Grinder Pump Units.

Industrial facilities will be handled on a case-by-case basis.

504.08 Grinder Pump Types

To assure all the Grinder Pump Units are compatible, all units shall be the same Make, Model Number, and have the same pump performance characteristics, unless justified.

Replacement units shall be the same make and model as was originally approved by the Division.

Pump specifications and pump replacement requirements shall be part of the Homeowners Association (HOA) Covenants and Restrictions if a HOA is planned.

The type of pumps and allowable applications are as follows:

1. Positive Displacement Pumps

   May be used in all low pressure system applications.

2. Semi-Positive Displacement Pumps

   May be used in all low pressure system applications.

3. Centrifugal Pumps

   May only be used if the number of units is ten (10) or less and the Total Dynamic Head is less than forty (40) feet.

The Engineer and manufacturer are responsible for assuring the system will operate as intended.

504.09 Grinder Pump Equipment

Simplex or duplex grinder pumps may be used for single dwelling units. For uses other than single dwelling units, the Engineer shall determine which is appropriate.

General equipment requirements are as follows:

1. Grinder Pump Station

   The grinder pump stations shall be a complete package consisting of all equipment and appurtenances required for a fully operable pumping system. Pump level controls, starter, alarm, piping, fittings, valves, and all accessories shall be part of a factory fabricated package so that after burying the wet well, the field connection of the gravity lateral, discharge line and electrical service line to the control box will complete the installation.

2. Manufacturer

   Each grinder pump station shall be manufactured and assembled by a single manufacturer.

3. Pumps

   The pumps shall be capable of macerating all material in normal domestic and commercial sewage, including reasonable amounts of foreign objects such a wood, plastic, glass, rubber, disposable diapers and the like to a fine slurry that will pass freely through the pump and one and one-quarter (1-1/4) inch discharge pipe.

4. Electrical Motor and Level Controls

   Electrical and level controls shall be provided by the pump manufacturer. All controls shall be mounted so they can be cleaned or replaced without disturbing the pump or piping.

5. Control Panels

   The control panels and all associated components on each standard unit shall be U.L. Approved and installed per manufacturer's recommendations. All equipment associated with each unit shall meet the current requirements of all applicable Federal, State, and Local electrical codes.

   An Electrical Permit issued by DMD is required for each grinder pump unit.

The Engineer and manufacturer are responsible for assuring the equipment is designed properly and will operate in a safe manner.