

## **DESIGN AND CONSTRUCTION STANDARDS**

### **SECTION 5 – WASTEWATER PUMP STATIONS**

#### **5.1 General Requirements**

These general criteria are to be used as the minimum standards for the design of wastewater pump stations. Each pumping station is to be designed for the site-specific conditions and restraints and shall consider current as well as future development in the service area. A detailed Preliminary Engineering Report or technical memorandum shall be submitted by the Design Engineer to the City for approval prior to design.

Wastewater pump stations are to be provided solely for the conveyance of sanitary wastes. Under no circumstances shall any form of storm water be allowed to pass through the proposed facility.

In addition to the Standards herein, the design must comply with all applicable federal, state, and local regulations and standards. These regulations and standards include, but may not be limited to:

Virginia Department of Environmental Quality (DEQ), Sewage Collection and Treatment (SCAT) Regulations

<http://lis.virginia.gov/000/reg/TOC09025.HTM#C0790>

Virginia DEQ, Erosion and Sediment Control Law, Regulations, and Certification Regulations

<http://www.deq.virginia.gov/Programs/Water/StormwaterManagement/ErosionandSedimentControl.aspx>

Hampton Roads Planning District Commission (HRPDC), Regional Construction Standards, 6<sup>th</sup> Edition

<https://www.hrrcs.com/ras/category/6/current-standards>

Hampton Roads Sanitation District (HRSD), Regional Technical Standards (RTS)

<https://www.deq.virginia.gov/Portals/0/DEQ/Enforcement/FinalOrders/HRSDandLocality-RTS-Sept262007.pdf>

Virginia Uniform Statewide Building Code (USBC)

<https://dhcd.virginia.gov/virginia-uniform-statewide-building-code-usbc>

Virginia Occupational Safety and Health (VOSH), 1926 Construction Industry Standards

<https://www.osha.gov/laws-regulations/standardnumber/1926>

Hydraulic Institute - Engineering Data Book Standards

[http://pumps.org/Standards\\_and\\_Guidebooks.aspx](http://pumps.org/Standards_and_Guidebooks.aspx)

National Fire Protection Agency (NFPA) 820: Standard for Fire Protection in Wastewater Treatment and Collection Facilities

<http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=820>

All applicable federal, state, and local permits and approvals must be obtained prior to plan approval. At the start of the preliminary design phase, the Design Engineer shall begin coordination with other City of Norfolk Departments including the Department of Public Works and the Department of Recreation, Parks and Open Space.

Before the plans are considered complete, they must undergo the City's site plan review process, initiated by the Department of Planning and distributed to all City Departments for input. The plans must receive site plan approval from each of the Departments as well as from the City's Architectural Review Board and Planning Commission. All wastewater pump station designs shall include an Erosion and Sediment Control Plan and adhere to the requirements set forth in the City Right of Way Excavation and Restoration Manual.

## **5.2 Technical Design**

### **A. System Layout**

1. Wastewater pump stations should be located as far as practicable from present or proposed built-up residential areas. A buffer zone of at least 100 feet shall be provided when possible. If it is not possible, the buffer zone may be 50 feet provided an artificial buffer is constructed. An artificial buffer can be landscaping, security fence, or another buffer as approved by the Department.
2. A concrete driveway shall be provided for easy access to the pump station by Department maintenance vehicles, vacuum trucks, and lifting equipment sized to remove and replace the largest piece of equipment in the station. The Design Engineer shall consult with the Department for information on the vehicles and equipment in the Department fleet.
3. All mechanical and electrical equipment which could be damaged or inactivated by contact with or submergence in water (motors, control equipment, transformers, blowers, switch gear, bearings, etc.) shall be physically located three feet above the 100-year flood elevation as determined by the latest version of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM), or 4 feet above finished grade whichever is higher, measured from the bottom of the cabinet. The finished floor of the wastewater pump station, the concrete pads for the emergency standby bypass pump and the odor control unit shall also be located at the elevation stated above.
4. Each new station site shall include provisions and adequate area for future pump station replacement or expansion, while allowing for the station to remain in service.

5. The pump station influent pipe invert shall not exceed 15 feet in depth.
6. The slope of the last two sections of pipe after the splitter box shall be twice that required by the SCAT Regulations.

## **B. Hydraulic Analysis & Pump Design**

1. The average and peak hourly station inflows shall be determined in accordance with Section 4, Wastewater Collection Systems.
2. Calculations must include detailed pump station plans that clearly depict the proposed pump station, inlet sanitary sewer(s), number of services discharging to the pump station, minimum, average and peak flow rates from the pump station service area, and the discharge force main up to its discharge point. Static head, lengths of pipe, and approximate type and number of pipe fittings must be clearly marked.
3. The station shall meet Class I Reliability as defined in the SCAT Regulations.
4. At least two pumps shall be provided. Where two pumps are provided, each pump shall be capable of handling flows in excess of the expected peak flow as defined in Section 4, Wastewater Collection Systems. Where three or more units are provided, they shall be designed to have such capacity that, with the largest unit out of service, the remaining units will have capacity to handle the peak flow. The capacity of the pump station with the largest pump out of service or on standby is also known as firm pumping capacity. When the station is expected to operate at a flow rate less than one-half times the average design flow for an extended time, the design shall address measures taken to prevent septicity due to long holding times of untreated sewage in the wet well.
5. The Department prefers to achieve firm station pumping capacity with two pumps installed in the station, whenever feasible. However, it may be more cost effective and beneficial to equip a station with three or more pumps. In general, two pumps should be used if the size of the pump motors is less than 50 hp. If over 50 hp, the Design Engineer shall perform a cost benefit analysis of three or more pumps to determine the most economical option for consideration by the Department.
6. The pump sizing shall be determined from a system pipe friction loss analysis of the pumping station piping and force main to its discharge point, plus the static head. Appropriate industry standard engineering methods, subject to approval by the Department, may be used to calculate pipe friction loss. All formulas, constants and assumptions must be clearly explained in the calculation. If using the Hazen-Williams formula, the C value for existing pipe shall be 100; for new pipe the C value shall be 110.
7. The system curve shall be determined and transposed to a manufacturer's pump performance curve. The assumed operating point shall be indicated, along with the

appropriate motor size, impeller size, Net Positive Suction Head (NPSH) capability and motor speed. The maximum one pump operation capacity, minimum operation head, maximum NPSH requirements and maximum motor loading shall also be indicated on the pump curves. The system curve shall be included in the Operations and Maintenance Manual turned over to the Department at the completion of the project.

8. Submit NPSH calculations for all pumping units for the maximum flow condition. The NPSH required by the pump under the maximum flow condition should not exceed 85% of the available NPSH.
9. Pumps handling raw sewage should be preceded by readily accessible, removable, bar racks with clear openings not exceeding 2-1/2 inches. Where screens are located below ground, convenient facilities must be provided for handling screenings. For the larger and/or deeper stations, duplicate protection units of proper capacity are preferred. Interceptor or separation basins may be necessary prior to pumps handling raw sewage.
10. Pumps in which the solids pass through the impeller(s) shall be capable of passing spheres of at least three inches in diameter.
11. Suitable shut-off valves shall be placed on each suction and each discharge line of each pump for normal pump isolation. A check valve is to be placed on each discharge line, between the shut-off valve and the pump. Periodic exercising of valves should be specified within the Operation and Maintenance Manual for the station.
12. Operating Sequence for Constant Speed Pumps. At a preset point during a rise in wet well level, the first pump (the lead pump) shall be started, and it shall run as long as necessary to pump out the wet well to a low-level pump cut off point. If the level continues to rise, the second pump (the lag pump) shall be started, and the two pumps shall operate in parallel as long as necessary to pump out the wet well to the cutoff point. This procedure continues for stations with three or more pumps. The automatic alternating control circuitry shall switch the operating sequence of the pumps (i.e. pumps alternate as lead pump) at each instance when all pumps are stopped. Provide a manual selector switch which shall allow manual selection of pump sequence or automatic alteration.
13. The station shall be equipped with a permanently mounted standby bypass pump. The standby pump shall be designed to handle the same flow and head conditions as the firm capacity of the station. Controls shall be included for the standby pump to override and lockout pump station pumps when operating. Where readily available and feasible, natural gas-powered equipment shall be used. Where natural gas is not feasible, diesel-powered equipment shall be used. Gasoline powered engines will not be accepted.

## **C. Wet Well Requirements**

1. The effective capacity of the wet well should be such that one pump will run continuously for at least five (5) minutes during a thirty (30) minute period of minimum flow at design flow conditions and there will be no more than five (5) pump starts per pump in one hour.
2. Provisions shall be made to prevent solids deposition. Where used, wet well fillets shall have a minimum slope of one-to-one. The horizontal area of the hopper bottom shall be no greater than necessary for proper installation and function of the inlets.
3. The wet well shall be designed to minimize the introduction of air. Influent wastewater shall not free-fall into the wet well under normal operating conditions. The use of a sloped bench to mount the bar screen is required. Reinforced concrete and other material alternatives shall be considered during design of the sloped bench. Do not install base elbows on the influent pipe in the wet well.
4. A corrosion resistant coating shall be installed on the interior of the wet well. Refer to the Department's Approved Products List for suitable wet well coatings.
5. A splitter box (deep vault) shall be provided at the last access location before the wet well. The vault shall contain an isolation valve for isolating the wet well.
6. All interior metal work shall be Type 316L stainless steel.
7. A suitable and safe means of access shall be provided to the wet well. Wet well hatches shall be flush with floor and have a keyed recessed locking mechanism. All hatch hardware shall be of Type 316L stainless steel material. The access must be designed to facilitate personnel hoist equipment. There shall be no obstructions in the hatch opening that would impede the hoisting equipment.

## **D. Structural Design**

1. The station shall be designed to meet all applicable building codes. The building shall be structurally sound and designed for existing geotechnical conditions.
2. The station shall be designed with a lifting system (bridge cranes, overhead rails with hoists, etc.) that enables the heaviest equipment (typically the pump and motor assembly) to be lifted and removed from the building and loaded onto a vehicle. The lifting system should be designed such that the heaviest equipment to be lifted does not exceed 75% of the system lifting capability. Electric hoists with manual trolleys shall be used instead of manual hoists. The Design Engineer shall consult with the Department to determine the most appropriate lifting and removal system for the existing site conditions and the available Department equipment. Lifting instructions and calculations shall be included in the final Operations and Maintenance Manual.

- a. Beam shall be centered over the pump access hatches and shall extend to the door of the pump station.
  - b. Davit arm cranes or portable gantry cranes shall be provided for all submersible pump stations without a dry well.
3. The effect of hydraulic thrust must be calculated by the Design Engineer and countered using joint restraints, pipe anchorage, or other suitable means to prevent movement of pumping equipment and pipelines within the station. Submit calculations to the Department.
4. The use of flat station roofs is not acceptable. A standing seam metal roof shall be provided for all pump station buildings.
5. Structural access hatches and manholes shall be designed for ease of operation. Consideration shall be given to spring-assisted covers for all hatches, but are required for all covers weighing 150 pounds or more.
  - a. The open position of hatches shall not conflict with fixed equipment and maintenance operations. The release arm for the open hatch shall be in an accessible location that does not require leaning over the open hatch to close it. A single leaf hatch is preferred. The lifting weight is limited to 150 pounds per leaf.
  - b. Access hatches shall be provided with an integral fall protection safety grate.
6. Ladders mounted in vaults and wet wells shall have an integral telescoping grab bar extension rod. Consideration shall be given to providing two telescoping grab bars, one on each side of the ladder rather than just one in the middle.
7. The suction piping penetrations between the wet well and dry well shall be a cast wall sleeve with a link-seal on both the wet well and dry well sides.
8. Railing sections around the landing outside of pump station doors shall be removable to facilitate removal of equipment and loading onto trucks. Removal of equipment shall not require lifting over railings or moving down stairs. Removeable railing sections shall be face mounted on the platform and not embedded.

## **E. Pump Station Interior**

1. The pump room shall be sized for ease of maintenance. A minimum of three (3) feet shall be provided from major pieces of equipment to the next piece of equipment, pipe or structure element.
2. Access and handling facilities shall be designed to facilitate removal and reinstallation of pumps.
  - a. An individual access opening in the floor shall be provided for and centered over each pump. The opening size shall allow the entire pump assembly to be

removed in one piece. Removable grates shall be provided at each pump access opening.

- b. For wet well/dry well stations, safety railings shall be installed around each of the pump access openings.

3. The below grade portion of the pump room shall conform with the following:

- a. Sump pump: The pump discharge is to be located above the wet well high-water elevation and discharge into the wet well.
- b. Pumps shall be installed on raised pads. Provide a means for water to drain from the top of the pump pad by filling the recess with grout to prevent water from pooling on the pump pad.
- c. Electrical outlets are to be installed three (3) feet or higher above the floor slab elevation. Installation shall include National Electrical Manufacturers Association (NEMA) Type "4 X" enclosures.
- d. All lights are to be accessible from both the bottom slab and/or the stairs.
- e. Emergency stops for pumps shall be located at the bottom of the stairwell with sufficient space between the E-stops and the pumps.

4. A dry well submersible pump installation shall be used for all dry well type pumping stations.

5. Wet well, submersible type stations shall be considered during design with Operations and Engineering input. The considerations should include station capacity, size and weight of equipment and Operations ability to remove and maintain the equipment. Submersible well type stations without an above grade superstructure shall be provided with an outdoor control panel and stainless-steel enclosures.

6. Suction-lift type, wet well pump stations are not acceptable.

7. All valve operators shall be accessible from the pump room floor or stair landing.

8. The pump discharge piping shall include a chain wheel operated knife valve located on the vertically aligned discharge piping before connecting to the header force main.

9. Provide all pump stations with station bypass piping and valves including 8" bypass pump suction piping from the wet well and 8" bypass connection from the force main complete with valve and cap.

- a. Bypass pump pipe connections shall be extended above grade for ease of connection, when site conditions allow. Quick disconnect camlock style fittings are required on the end of the suction and discharge bypass pipes. The emergency bypass suction line shall be located on the wet well top slab with a gate valve. The size of the bypass connections shall be compatible with Operations' existing bypass equipment.

10. The pump station shall also contain restroom facilities and a washdown hose bib for Department personnel. Appropriate backflow prevention devices shall be installed on potable water supply lines per applicable City codes. The sink in the pump station shall be a deep utility sink.
11. Stairways shall be installed with rest landings at vertical intervals that do not exceed ten (10) feet. Stair treads shall be of a non-slip type and a minimum width of thirty-six (36) inches.
12. A spiral stairway shall have a 7.5-inch (191 mm) minimum clear tread depth at a point 12 inches (305 mm) from the narrow edge. The risers shall be sufficient to provide a headroom of 78 inches (1981 mm) minimum, but riser height shall not be more than 9.5 inches (241 mm). The minimum stairway clear width at and below the handrail shall be 26 inches (660 mm).

## **F. HVAC**

1. Ventilation shall be provided for the building and the wet well in accordance with National Fire Protection Agency (NFPA) Code 820, SCAT Regulations, and VOSH requirements and shall comply with this section for enclosed spaces within pump stations during all periods when the station is manned. Where the pumps are permanently mounted below the ground, mechanical ventilation is required and shall be arranged so as to independently ventilate the dry well. The vent pipe shall terminate 18" above the floor of the dry well, and 2' above the intermediate platform in the wet well.
2. The building shall be provided with adequate outside air ventilation to maintain a maximum internal station temperature of 40° C (104° F) based on an outside air temperature of 35° C (95° F).
3. Ventilation using outside air is generally acceptable to dissipate motor heat. In stations with Variable Frequency Drives (VFD's) where heat buildup may be a problem, calculations shall be performed for the outside air ventilation system to dissipate the maximum heat load (all pumps and VFD's operating) while maintaining a maximum air temperature of 40°C (104°F) based on an outside air temperature of 35°C (95°F).
4. At a minimum, ventilation of the wet well shall be accomplished by the provision of a fresh air penetration with gooseneck piping, and a properly screened exhaust vent with the end terminating above the roof line of the pump station. The vent shall be at least four inches in diameter.
5. There shall be no interconnection between the wet well exhaust flow and the dry well ventilation systems. In pits over 15 feet deep, multiple duct inlets shall be provided. Dampers shall not be used on exhaust or fresh air ducts, and fine screens or other obstructions in air ducts shall be avoided to prevent clogging. Automatic heating equipment shall be provided in all stations.

6. Switches for operation of ventilation equipment shall be marked and conveniently located above grade, outside the wet well and near the pumping station entrance. Consideration should be given also to automatic controls where intermittent operation is used. The fan drive shall be fabricated from non-sparking material in accordance with applicable codes and standards.
7. Ventilation shall be provided in accordance with NFPA 820 standards. Such ventilation shall be accomplished by mechanical means.
8. All ventilating equipment shall be corrosion resistant and non-sparking construction.
9. The station controls system shall include a control feature that shuts off all ventilation equipment when there is a high water alarm in the wet well or in the dry well. This feature is to prevent wastewater from entering the ventilation intake.
10. Wet well exhaust HVAC shall not be routed through the control room or other spaces with electrical components. Wet well exhaust shall be installed in a separate chimney structure outside of the control room or outside of the pump station. The wet well exhaust equipment and ductwork shall not be accessible from inside the control room.
11. Permanent multi-gas detectors are prohibited.

## **G. Odor Control**

1. The station shall be designed such that no adjacent residents experience objectionable H<sub>2</sub>S odors while occupying their properties. To achieve this, every effort shall be made to keep H<sub>2</sub>S odor generations below 1.5 parts per million (ppm) at the pump station property line, without the use of an odor control unit. The design engineer shall consider submerging the influent line, venting the sewer upstream, minimizing the wet well size, minimizing turbulence at the wet well inlet, and any other design elements that can be incorporated to keep odor generations to a minimum.
2. If it is determined that an odor control unit will be necessary to satisfy the requirement above, an appropriate technology shall be recommended by the consultant after performing an odor control assessment on the pump station. The consultant may choose to follow the Department's Odor Control Assessment Guidelines (<https://www.norfolk.gov/DocumentCenter/View/46742/AF5---Appendix-F5---Wastewater-Pump-Stations-Odor-Control-Assessment-Guidelines-052019?bidId=>), or establish their own study procedures in determining the most appropriate odor control technology.
3. Odor testing shall be conducted on all new pump stations once the station has been placed into service. Testing shall be performed on a quarterly basis for no less than

one year after pump station startup. The testing period shall be at least one week in duration.

## **H. Controls and Alarms**

1. Pump Control and SCADA Telemetry shall be through a Programmable Logic Controller as specified by the Department. Telemetry shall be to the Department's SCADA Control Center with equipment compatible with existing hardware and software. Reference AH1 - Appendix H1 - Standard Instrumentation, SCADA, and VFD Specification 1.2021 (DRAFT)
2. For the purpose of designating liquid levels for alarm requirements, high liquid level in the wet well is defined as a level of sewage in the wet well above normal operating levels such that either: (i) a backup of sewage in the incoming sewer may occur, or (ii) an overflow may occur, or (iii) standby pump(s) may be required to be activated. In the case of a duplex pumping station with limited wet well volume, the alarm design should include activation at the time of simultaneous operation of both pumps, initiating when the second alternating pump starts (referred to as the lag pump). A low water level alarm shall also be included for all stations. The low water level alarm indicates a condition where the pumps do not shut off at the designated level.
3. The pump station alarm system shall be designed to be compatible with the Department's standard alarm and station monitoring functions and standards. At a minimum, the alarm system at each station must monitor each pump failure, power failures, and high-water level. The alarm system at each station shall be equipped with a test function and a back-up power supply, an on-site audio/visual alarm and must be integrated with the City's SCADA system, which will transmit to a 24-hour manned location. The design engineer shall coordinate with the Department for the latest acceptable pumping station alarm hardware and equipment.

## **I. Electrical Design**

1. Motors shall be three (3) phase sixty (60) cycle (220, 240 or 480 voltage). Stations that use three (3) phase motors shall be provided with one spare pumping unit (pump and motor) for each size provided. Where three (3) phase power is not available, single-phase power may be used with a three (3) phase motor with the provision of a Variable Frequency Drive (VFD).
2. Station electrical and control wiring must meet City code and National Electric Code. Each station shall contain a main disconnect. All electrical equipment and components shall be UL listed unless otherwise specified.
3. The Design Engineer shall determine the availability of electrical service and coordinate the available electrical service with that required for the facility. The

Design Engineer shall also determine the need for primary service extension and advise the City if an extension is necessary.

4. Electrical equipment and wiring shall be insulated and properly grounded. Switches and control shall be of the non-sparking type.
5. Electric pump motors shall be designed and provided with reduced voltage motor starters.
6. Adequate lighting shall be provided in all locations including outside, motor control room, dry well, and any other area deemed necessary. The interior lighting shall be shielded. Outdoor lighting shall illuminate all the doors, the emergency bypass pump connection, the permanent standby bypass pump and the temporary or permanent generator or bypass pump location(s).
7. Electrical equipment in enclosed places where gas may accumulate shall comply with the NEMA Class I, Div. 1, Group D specifications for hazardous conditions.
8. Pumping stations shall be equipped with a secure external disconnect switch located above grade.
9. Incoming station power supply shall be protected with appropriately sized transient voltage surge suppressors (TVSS).
10. The designer shall provide a lightning protection system on all new pump stations or upgrades. Lightning protection system components shall be designed, manufactured and tested in accordance with the latest UL 96 standard and meet the requirements of NFPA 780, Lightning Protection Institute (LPI) and NEC.
11. Control panels at submersible station shall be located such that opening the wet well hatch does not prevent the operator's ability to safely access the control panel.
12. Provide one emergency stop switch for all pumps in the dry well near the base of the stairs. The switches shall have a visual indication as to its ON/OFF position.

## **J. Other Requirements**

1. There shall be no cross connection between any potable water supply and a wastewater pump station which under any conditions might cause contamination of the potable water supply. Potable water supply brought to the station shall comply with conditions stipulated in Section 3, Drinking Water System(s), including the installation of an approved reduced pressure zone backflow prevention device on the water supply line to the pumping stations.

2. All pumping stations shall have reliable flow-measuring (mag meter or substitute approved by the Department) and pressure recording devices which are connected to the SCADA system. The flowmeter shall be installed in a vault outside of the dry well.
3. Pressure-transducers shall be used to determine the liquid level in the wet well.
4. Station security systems shall include door switches, wet well hatch switches, card reader systems, hardened station access systems, or other security systems as required and approved by the Department.
5. When discharging into the HRSD force main system, both minimum and maximum HRSD pressures shall be considered in the pump selection. The pumps shall operate efficiently without cavitation, under existing and proposed future head conditions. The installed pumps shall be capable, at a minimum, of conveying the peak daily flow entering the station (at build-out) against future HRSD maximum head conditions. The pumps shall be provided with variable speed drives that allow the station to be operated over the full range of HRSD pressure conditions.
6. Operating Sequence for Variable Speed Pumps. A Proportional-Integral-Derivative (PID) level controller shall be configured in the Programmable Logic Controller (PLC) to control the sewage level in the wet well. The level controller shall vary the speed of the pumps as required to match the pump discharge flow rate to the wet well influent rate. The desired level to be maintained in the wet well will be programmed in the PLC as the setpoint for the level controller. The level controller will compare the actual wet well level to the setpoint level and output a 4-20mA speed reference signal to the VFD for the operating sewage pumps to increase or decrease the speed of the pump or pumps as required to maintain the setpoint level.
7. Pumping station sites shall be landscaped as required by the Norfolk Department of Recreation, Parks and Open Space. The aesthetics of the station shall match the adjacent areas and are subject to review by the City's Architectural Review Board and Planning Commission.
8. The City of Norfolk standard “seal” shall be placed on all dry-pit type pumping stations at the primary station access door. The “seal” shall be installed on the outdoor control panel on all wet pit, submersible pump pumping stations.
9. For existing pumping stations undergoing rehabilitation, the designer shall consider the sequence of construction required to maintain operations or to shut down and bypass the pumping station during construction. This proposed sequence of construction shall be included in the construction contract documents with the requirement that the contractor submit a detailed work plan with a sequence of construction for approval. The designer shall also include in the contract documents a requirement for the Contractor to protect and maintain existing equipment in the pumping station.

10. For existing pumping stations undergoing rehabilitation, the designer shall consider the check out and testing required to bring the station back into full operation. This includes newly installed equipment as well as existing equipment. At the discretion of the City, a startup checklist specific to the pumping station may be required to facilitate a smooth startup of the pumping station. The designer shall clearly define in the contract documents the requirements for station acceptance and turnover to the Department.