City of Aurora

STORMWATER AND WASTEWATER LIFT STATION DESIGN AND ENGINEERING GUIDELINES

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List of Abbreviations

AASAS	Aluminum Association Specification for Aluminum Structures
ACI	American Concrete Institute
A/C	Air Conditioning
AISC	American Institute for Steel Construction
AITC	American Institute of Timber Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating Refrigerating and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ATS	Automatic Transfer Switch
AWS	American Welding Society
BHP	Brake Horsepower
BIA	Brick Institute of America
CAD	Computer-aided design
CDPHE	Colorado Department of Health and Environment
CDR	Conceptual Design Report
CFR	Code of Federal Regulation
COA	City of Aurora
CRSI	Concrete Reinforcing Steel Institute
DC	Direct Current
DEG	Design Engineering Guidelines
DIP	Ductile Iron Pipe
DRCOG	Denver Regional Council of Governments
FAT	Factory Acceptance Testing
FCC	Flow Control Center
FDR	Final Design Report
FPM	Feet per Minute
FPS	Feet per Second
GIS	Geographic information system
GPM	Gallons per Minute
HGL	Hydraulic Grade Line
HIS	Hydraulic Institute Standards
HMI	Human Machine Interface
HP	Horsepower
HVAC	Heating Ventilation and Air Conditioning
Hz	Hertz
IBC	International Building Code
IEC	International Electrotechnical Commission
I&C	Instrumentation and Control
I/C	Integrated Circuit
I/O	Input-Output
IEEE	Institute of Electrical and Electronics Engineers
IMC	International Mechanical Code
IP	Internet Protocol
IPC	International Plumbing Code

ISA	Instrument Society of America
LCP	Local Control Panel
MCC	Motor Control Center
MGD	Million Gallons per Day
MPR	Motor Protection Relay
MWRD	Metro Wastewater Reclamation District
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
NPSH	Net Positive Suction Head
NSF	National Sanitation Foundation
OIT	Operator Interface Terminal
OSHA	Occupational Safety and Health Act
PAR	Pressed Aluminum Reflection
PDR	Preliminary Design Report
PE	Professional Engineer
PLC	Programmable Logic Controller
PID	Process and Instrumentation Diagram
PPM	Parts per Million
PRV	Pressure Relief Valve
PSIG	Per Square Inch Gauge
PVC	Polyvinyl Chloride
RPM	Revolutions per Minute
RTD	Resistance Temperature Detector
RTP	Remote Terminal Panel
RTU	Remote Terminal Unit
SAT	Site Acceptance Testing
SCADA	Supervisory Control and Data Acquisition
TCP	Transmission Control Protocol
UL	Underwriters Laboratories
UPS	Uninterruptible Power Supply
USBR	United States Bureau of Reclamation
kV	Kilovolt
kW	Kilowatt
V	Volt
VFD	Variable Frequency Drive
WUP	Wastewater Utility Plan
X/R	Reactance to Resistance Ratio

1.0 Introduction

Design Consultants and Developers (Consultants) shall comply with these design guidelines for stormwater and wastewater lift station designs for the City of Aurora (City). Lift stations are used to move wastewater from lower to higher elevation, particularly where the elevation of the source is not sufficient for gravity flow and/or when the use of gravity conveyance will result in excessive excavation depths and high sewer construction costs. In general, the installation of wastewater lift stations is discouraged due to the additional complexity and cost they bring to the City's collection system; however, in certain instances, the City may choose to construct either interim or permanent lift stations that are consistent with the City's Master Wastewater Utility Plan (WUP) and in compliance with an approved Master Utility Study. Infrastructure determined to be regional facilities by the City shall require pre-qualification of the design consultants and contractors.

These guidelines provide standards for the design of wastewater lift stations ranging in size from approximately 700 GPM to 35,000 GPM (1 MGD to 50 MGD). Requirements for lift stations with smaller or larger capacities are handled on a case-by-case. Package lift stations to be owned and maintained by the City, with a pumping capacity of 1 MGD or less, are subject to review and approval by the City. Package lift stations require easy accessibility of the wet well and panels and are required to meet these design guidelines in addition to the City's Electrical Design and Engineering Guidelines (E-DEGS) and SCADA DEGS, latest edition.

1.1 General Design Requirements

The goal for a proper and cost-effective lift station design include matching pump capacity, type, and configuration with wastewater quantity and quality and providing reliable and uninterrupted operation. Lift Stations shall be designed with standby and duty pumps capable of handling peak flows along with dual force mains (primary and secondary backup) and interconnects spaced at an interval as specified by the City. Appendix A provides a complete list of applicable standards and specifications. All lift station designs shall be design in accordance with the following items:

1. Comply with the City's Electrical DEGs, the City's Water, Sanitary, and Storm Drainage Infrastructure Standards and Specifications, and the City's WUP (latest editions).
2. Be compatible with the City's existing SCADA system and associated standards designated in the SCADA DEGs (latest edition).
3. Allow for ease of operation and maintenance of the installed equipment.
4. Avoid septic conditions and excessive release of odors in the collection system and at the lift station.
5. Minimize environmental and landscape impacts, such as noise and odor on the surrounding residential and commercial developments.
6. Avoid flooding of the lift station and the surrounding areas by providing redundancy as necessary.
7. Any produced or manufactured spare parts provided to/by the contractor at the time of installation shall be retained by the City.
8. Build-out flows need to be accommodated with initial certificate of occupancy. All equipment needed at build-out will be required at start-up.

1.2 Regulatory Permit and Code Conformance

The Consultant shall attend meetings with the appropriate agencies, along with the City, to initiate formal discussions and determine special permitting requirements. The Consultant will be responsible for completing the application or notification packages and submitting them to the City for final review and then to the agencies for final processing. The efforts of the Consultant will include providing all technical assistance and background studies necessary to meet the requirements of the permitting agencies. The Consultant shall assist the City in follow-up actions with the permitting agencies and will provide responses to questions directed to the City. All discussions and correspondence with the various agencies shall be coordinated through the City.

Original permits will be kept by the City, and copies will be retained by the Consultant. The Consultant shall be responsible for incorporating all requirements of the various permits and approvals into the construction contract documents and provide supplementary information to the Contractor in support of securing building permits, as directed by the City.

1.3 Design Documentation and Submittals

Initially, the Consultant shall work directly with Aurora Water through a process of workshops and meetings. To set-up an initial consultation meeting, the Consultant shall email the Water Engineering group, waterengineering@auroragov.org.

The Consultant shall provide all submittals to the City including, design calculations, plans, specifications, construction submittals, and support documents, in hard copy and a tabbed electronic format (PDF or other approved). See Section 14.0 for Project Completion submittal requirements.

For all lift stations, design plans and engineering design reports shall be signed and sealed by a Colorado licensed PE. The design reports shall include all necessary calculations and background information to support and document the design. Support documents shall be developed to provide a complete design that is constructible and biddable. It is important to note, the SCADA DEGs and Electrical DEGs outlines additional design calculations and reports that are required to be submitted through this review process.

The Consultant shall coordinate with the City project manager and review staff for design input and comments on 30%, 60%, 90% and 100% final design submittals. See sections 1.3.1 to 1.3.4 for more detailed requirements for each design submittal. The Consultant shall provide Aurora a copy of the approved Site Application from CDPHE.

A Stormwater Management Plan and Report using the City's latest template shall be prepared as part of the Civil Design of the Lift Station. See the latest revision of the City of Aurora Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities Manual (SWMP Manual) for more detailed requirements. The site shall provide water quality and stormwater detention according to City of Aurora criteria shall be provided on the site.

The City of Aurora has developed a CAD Data Submittal Standard for internal and external use to streamline the process of importing AutoCAD information into the City's Enterprise GIS. All construction plans prepared for City Lift Station sites, including those that are privately funded, must comply with the most current version of the City of Aurora CAD Data Submittal Standards. Details of the CAD Data Submittal Standard can be found on the CAD Standards web page. Table 1 provides a summarized view of the various submittals and their anticipated review timelines.

Table 1: Review Timelines

CDR - 30% Design Point	
CDR	15 working days
PDR - 60% Design Point	
PDR	15 working days
Plans	
Development Application	See Development Review for review timelines
FDR - 90% Design Point	
FDR	15 working days
Plans and Specifications	
Civil Plan Application and Drainage Report	See Civil Plans Review for review timelines
100% Design Point - Plans and Specifications	
Civil Plans	See Civil Plans Review for review timelines
Specifications	15 working days
Building Department Review	See Building Department for review timelines

1.3.1 30% Conceptual Design

A Conceptual Design Report (CDR) report shall be submitted to the City and include the project's background information such as location (quarter section, major cross streets, etc.), service area, zoning and land use, population, water demand data, and basis of design. Appendix C outlines a submittal checklist for items which should be addressed, at a minimum. The Consultant shall also submit the preliminary site plan. The Consultant should consult with Aurora Planning for a complete list of requirements for their submittals.

In addition, the report shall provide an anticipated list of plans (by discipline) and project specifications sections that will be developed for the project. All assumptions shall be clearly identified and listed. Once completed, the CDR must be signed and sealed by a registered professional engineer in the State of Colorado and submitted to the City for review and approval prior to progressing to the 60% Design.

1.3.1.1 Phasing and Expandability

The CDR shall address whether it is expected the lift station may be expanded in the future and the Consultant shall ensure adequate space is provided to accommodate installation of future equipment and structures and ease of operation access and maintenance. The expanded facility layout will be shown in the CDR. The force main, wet well, and all yard piping shall be designed for the ultimate build-out capacity of the lift station unless otherwise approved by the City. Planned phased expansions shall be incorporated into the ultimate design where applicable.

The lift station design must take into account initial flows, as well as, future build-out flows and attempt to optimize for both. Major elements such as the wet well, electrical service, power supply, panels, odor control, etc. shall be sized for the ultimate condition. The Consultant should provide design consideration needs to the expandability of all lift station site components in order to increase the capacity as tributary flows increase. Approval of the phasing plan is a required element to obtain final signatures from the City. Design of the project will not move forward until the City approves the phasing approach. The following design features should be incorporated to facilitate future expansion:

- The suction and discharge piping manifold shall be sized for future peak flows as identified by the City's WUP or direction given by City.
- Pumps, their supports, piping, and electrical facilities should be selected to allow easy replacement and/or expansion to meet future needs.
- If required by anticipated future conditions, the wet well should be designed for larger pumps, possibly with temporary fillets to accommodate the smaller or lesser number of initial pumps.
- Generally, pumps should not be selected with the largest possible impeller, but should be sized to accommodate the largest impeller in the future; this includes sizing of electrical conduit and wires, motor starters, etc.
- If required by anticipated future conditions, the SCADA system and associated controls shall be sized (panel and associated hardware) to accommodate potential expansion.
- If it appears to be impractical or uneconomical to construct the lift station building to house the future equipment, the Consultant shall present to the City a comparative evaluation of cost, operability, and constructability issues. The evaluation shall address alternative means of providing the desired capacity to meet future capacity requirements.

1.3.2 60% Preliminary Design

The Preliminary Design Report (PDR) plans and specifications are submitted to the City for review after the conceptual design report is approved. Consultants shall respond to the City's comments from the CDR review via a submittal log and the CDR comments shall be incorporated into the PDR. Once completed, the PDR, construction plans, and specifications must be signed and sealed by a registered professional engineer in the State of Colorado and submitted to the City for review and approval prior to progressing to the 90% Pre-Final Design. Formal submittal of a development application to the City's planning department and Public Works is required. See Appendix C for a submittal checklist for items which should be addressed in the PDR report, construction plans, and construction specifications, at a minimum. The construction plans should represent approximately a 60% percent completion level of detail in all disciplines.

1.3.3 90% Pre-Final Design

The Final Design Report (FDR) and 90% pre-final construction plans and specifications are submitted to the City for review after the PDR is approved. FDR must be signed and sealed by a registered engineer in the State of Colorado and submitted to the City at the time of 90% pre-final plan submittal. Consultants shall respond to the City's comments from the PDR review via a submittal log and the PDR comments shall be incorporated into the FDR. The plans and specifications shall be complete including all required site, civil, process/mechanical, electrical, instrumentation and control, architectural, structural, and landscaping plans and details. Formal submittal of a civil plan application is required with the 90% set.

Key design criteria from the FDR should be included on the General Notes sheet of the Final plan set. These criteria include wet well dimensions and volume, pump capacity and horsepower, dual force main length and diameter, odor control type and capacity, generator size, etc. This information must be provided for all phases shown on the plans. The content of this General Note sheet, as well as the entire plan set, must be discussed at length with the City and is subject to its review and approval.

1.3.4 100% Final Design

The 100% plans and specifications can be completed and submitted for final City approval and required signatures once all previous review comments have been resolved. These plans and specifications must be signed and sealed by a registered engineer in the State of Colorado and hard copies (as specified by

City PM) submitted to the City. In addition, a tabbed electronic copy of the plans, specifications, and FDR in PDF format shall be submitted to the City. Once the plans are signed and approved by the City, the City will issue the approval to bid and construct the project. However, construction cannot begin until all applicable permits have been obtained. Formal submittal to the City's building division is required with 100% drawings. See Appendix C for a submittal checklist for items which should be addressed, at a minimum.

All wastewater lift stations require approval by CDPHE and the City including the Planning, Parks, Public Works, and Building Divisions. The Consultant shall be responsible for preparing the Application for Site Approval for Construction or Expansion of Lift Stations and Interceptor Sewers for submittal to CDPHE. A pre-construction workshop with, but not limited to the City's Engineering, Operations, and SCADA staff, Contractor, and Consultant shall be held prior to construction.

2.0 Hydraulics

2.1 Design Flows and Design Criteria

The basis of design reports (CDR, PDR, and FDR) shall quantify and identify the estimated flow from the area ultimately contributing to the lift station by the corresponding sanitary sewer system. Lift station design flows shall be based on Section 5 of the latest edition of the City's Water, Sanitary and Storm Drainage Infrastructure Standards and Specifications or other design criteria as approved by the City and consistent with approved WUPs.

The Consultant shall develop system hydraulic profiles and shall define levels needed for system controls such as wet well high-high, high, normal operating band, and low-low water levels. The Consultant shall also include elevations needed for all alarm conditions that will be programmed into the system during startup. In the event the alarm conditions are to be provided by suppliers of the equipment, those shall be clearly defined in the Contract Documents and defined as the responsibility of the Contractor.

The following design criteria should be considered for hydraulic design:

1. Hazen-Williams C-values should be used, ranging from 100 for old pipe to 150 for new pipe, depending on the pipe material and age.
2. Hydraulic Institute Engineering Data Book, or other recognized reference for hydraulic data, should be used for fitting and valve velocity head K-factors.
3. Pipe pressure class ratings
4. The velocity of the pump suction line (where provided) shall not exceed 5 FPS and must be within the pump manufacturer's recommendations.
5. The pump discharge and force mains velocities shall not exceed 7 FPS and be within the manufacturer's recommendations.
6. NPSH calculations must be provided.
7. To minimize vortexing, submergence of the inlet shall be in accordance with the requirements of the Hydraulic Institute Standards.
8. Surcharging of receiving sewers is not allowed. The receiving sewer must have sufficient capacity to accept the peak discharge rate from the proposed force main while not surcharging (i.e., the HGL in the receiving sewer must be beneath the pipe's crown) and meet the City's Water, Sanitary and Storm Drainage Infrastructure Standards and Specifications.

2.2 Surge Analysis and Control

Pressure surge control devices may be required to reduce pipeline pressure below a safe operating pressure during lift station start-up and shutdown. Typically, automatically operated valves are used to control pressure surges at the pump discharge. Surge (water hammer) is not typically a problem when force mains are relatively flat and do not have significant static head requirements. However, down-surge resulting in a full vacuum condition (-14.7 PSIG) can have a significant impact on force main design. Therefore, all lift station and force main designs should include a surge evaluation to maintain system pressure within the rated pressure criteria.

The Consultant shall be responsible for completing a surge analysis of the lift station and force main system and shall make recommendations for surge protection equipment. The surge analysis and the surge protection equipment recommendation shall be submitted to the City for approval. In some instances, the City may perform a preliminary surge analysis as part of other preliminary design work. In this case, the City shall provide a copy to the Consultant for their review of the surge analysis and verify the type and size of the recommended equipment.

Because other project elements, such as pre-purchased pipe, may be dependent on surge, the Consultant is responsible for coordinating the overall system design pressures. Where a new lift station connects to an existing pipeline, the surge analysis shall include both the new and existing pipelines to ensure that surge pressures do not exceed the pressure rating of either the new or the existing pipeline.
A computer model capable of performing transient analysis shall be used to provide a detailed assessment of surge potential. The model should also provide insight into potential problems such as minimum and negative pressures, as well as potential cavitation locations within a pipeline. An accurate analysis may allow the Consultant to specify less costly materials while still maintaining an appropriate safety factor. The computer model to be used must be pre-approved by the City.

2.3 Pumps

The Consultant should prepare a set of pump curves to represent the operation of the selected pumps and force main under a wide range of scenarios. Variable speed pumping shall be used. The Consultant shall analyze pump performance at the following conditions:

1. Wet well level at pump turn-on, discharging to the lowest possible elevation, and a C value of 150.
2. Wet well level at pump shut-off, discharging to highest possible elevation, and a C value of 100.
3. At a minimum, individual pump performance requirements (flow, head, and brake horsepower (BHP)) should be specified for the following conditions:
    a. Maximum shut-off head.
    b. Design flow condition (low wet well level and C=100).
    c. Maximum flow condition (high wet well level and C=100).

A dry well/wet well flooded suction station configuration should be utilized. Pumps will be either vertical, close-coupled, vacuum primed, non-clog pumps installed directly above the wet well, or centrifugal pumps of an acceptable design installed in a dry well adjacent to the wet well. The latter arrangement should have extended shafts so that the motors can be located on the floor above where the pumps are so that they are out of flooding range.

Submersible pumps will not be allowed for any sites with a peak flow rates over 1 MGD at buildout as determined by the basis of design report. Submersible pumps will be considered for any sites under 1 MGD at buildout but are subject to City review and approval. Any submersible pumps shall have a 316 stainless-steel guide rail system installed to allow for pump removal and installation for ongoing maintenance. All pumps will be manufactured and supplied by the same company. Pumps should be capable of passing spheres of at least 3-inches in diameter. Pump suction and discharge openings shall be at least 4 inches in diameter. All pumps shall be equipped with soft starts and amperage rings.

Lift stations with dual wet wells shall be designed utilizing a minimum of four pumps. Single wet well lift stations shall have a minimum of three pumps (operations, back-up, and out of service).

Pump sizing and selection shall consider that the peak design pumping capacity must be achieved with the largest pump out of service - this is termed the “firm pumping capacity.” For example, a four-lift station configuration with two smaller pumps and two larger pumps will have a design firm station capacity equal to the two smaller and one of the larger pumps operating together.

A larger number of small pumps are preferred over a fewer number of large pumps because this limits the unit size of the pumps and thus reduces the cost of repairs. In addition, smaller motors have a lower electrical demand charge associated with starting the pumps. Also, several smaller pumps can cover a greater number of flow points than fewer large pumps. However, these arguments need to be balanced with the increase in building footprint that will be required by a larger number of small pumps. Using standard pump sizes permits more efficient stocking of spare parts and interchangeability between facilities. Prior to pump size selection, the Consultant shall coordinate with the City regarding standard pump sizes utilized in the existing system. Pump selection is subject to review and approval by the City’s Operations staff. See Appendix B for a complete list of required spare parts.

2.3.1 Pump Capacity

The number of wastewater pumps and associated capacity should be selected to provide head-capacity characteristics that correspond as nearly as possible to wastewater quantity fluctuations. This can be accomplished by preparing pump/pipeline system head-capacity curves showing all conditions of head and capacity under which the pumps will be required to operate.

2.3.2 Pump Speed

Lower rotational speed pumps are more desirable, since they reduce pump wear. Generally, pump speed for units 1,000 HP and greater shall not exceed 900 RPM, but for smaller pumps, higher rotational speeds may be used at the discretion of the Consultant with approval by the City.

2.3.3 NPSH Requirements

The pump should be located so that under normal operating conditions, it will operate under a positive suction head. The NPSH and suction lift requirements of the pumps shall be considered.

2.3.4 Pump Efficiency

Pumps should be selected for best efficiency (80% or greater) at average daily flow conditions. The Consultant shall select pumps that meet or exceed the high efficiency pump rating per the latest IEC standards. After selecting the pumps that best meet the design criteria, the Consultant shall request the pump manufacturer provide a system natural frequency analysis report for the selected pump and design configuration. The system natural frequency must be at least 25% higher than the largest impeller excitation frequency.

2.3.5 Pump Motors

To assure greater efficiency, synchronous motors shall be used in all pump drives exceeding 1,000 HP, except for variable speed drives where motors shall be of the induction type. Motor size shall be such that the nominal horsepower rating is not exceeded over the full operating range of the pump (i.e. motors shall be non-overloading at all points on the pump curve, exclusive of the service factor). Where directed by the City, variable speed drives should be utilized to achieve the following goals:

- Optimize pump performance by allowing pumps to be operated at maximum efficiency under a variety of flow conditions.
- Minimize power use.
- Minimize the number of pump starts and stops.
- Reduce the size and cost of the wet well.

3.0 Wet wells

Lift stations shall be of the dry well/wet well combination configuration. The wet well will consist of a cast-in-place reinforced concrete structure. Stations shall have wet wells that are divided into two compartments to facilitate maintenance. An in-line diversion vault to direct flows into either wet well should be included for dual wet well configurations. Compartments shall be capable of being isolated from each other with sluice gates or other watertight gates, operable from above the wet well. The dual compartments will allow the draining of one compartment for cleaning or maintenance without affecting the operation of the lift station. A flow splitting structure, with permanently mounted sluice gates or other watertight gates, will be provided upstream of the wet well to allow the lift station flow to be directed into either or both of the wet well compartments. Slide gates are not considered acceptable due to their propensity to leak. The dividing wall between wet well compartments shall extend to the top of the wet well, so that when the gates are closed the wet well that is being dewatered, and potentially accessed, is maintained dry and not subjected to gases from the adjacent wet well. This will serve to protect workers entering the dewatered wet well.

At a minimum, wet wells in the unoccupied mode should be designed for passive gravity ventilation with a gooseneck vent pipe and equipped with non-corroding insect screens. Vent rates should not create more than 1 inch of static pressure or vacuum to be applied to the structure at peak pump output. Vent opening (bottom of gooseneck) should be at least 1-foot above 100-year flood elevation.

The wet well hydraulic entrance should be designed to minimize turbulence and potential hydrogen sulfide gas release. Hydraulic Institute Standards and pump manufacturer's recommendations are to be followed for all wet well designs. <u>The Consultant shall obtain from the pump manufacturer a statement, in writing, indicating that the proposed arrangement is acceptable to them for the full range of flows that the pumping system will be handling.</u> The statement should be submitted with the 90% pre-final design as outlined in Section 1.3.3. Wet wells shall be either circular or rectangular to suit the available site. The Consultant shall select the most economical geometry and height.

There should not be direct access connection between wet wells and dry wells. Any common wall between a wet well and dry well should be gas-tight to prevent the migration of hydrogen sulfide, foul air, or other substances, which could otherwise cause safety concerns, as well as possible degradation to equipment. Wet wells should be accessed directly and only from outside atmospheric areas.

3.1 Volume

Wet wells should be large enough to prevent rapid pump cycling, but small enough to prevent a long detention time and associated odor release. Wet well volume sizing should consider the following factors:

- The effective capacity of the wet well should provide a holding period not to exceed 30 minutes for the design minimum flow.
- Wet wells should always hold some level of sewage to minimize odor release.
- Adequate volume should be provided to prevent short-cycling of the pumps (i.e., frequent starting and stopping of the pumps.
- Adequate submergence of the pump inlet should be provided to prevent vortexing and preclude turbulence that could carry entrained air into the pump.
- The wet well proportions and dimensions should preclude the formation of hydraulic eddies that could produce submerged vortices; submerged vortices can cause separation that results in pump cavitation.

3.2 Cleaning and Corrosion Protection

Provisions shall be provided for draining of wet wells. It is typically desirable to drain structures within eight hours for maintenance, but that requirement may vary depending upon demands, redundant features, and other factors.

Self-cleaning wet wells are preferred provided that no detrimental effects are incurred on the downstream collection system as a result of passing materials through the lift station. Lift Stations designed for peak flows greater than 4 MGD, should be designed with a fill and draw configuration and be self-cleaning. The City reserves the right to require self-cleaning wet wells for any size station, utilizing long narrow wet wells and pump operational schemes that allow the wet well to be scoured.

Floor bottoms should be sloped toward pump inlets to minimize grit accumulation. The minimum recommended wet well bottom slope is 2:1 to allow self-cleaning and minimum deposit of debris. The horizontal area of the hopper bottom should be no greater than necessary for proper installation and function of the pump inlet. For the protection of the wet well against corrosion, all wet wells shall be at a minimum "T-lock" coated or an acceptable alternative, or as specified by Owner.

Corrosion protection shall be provided for all interior surfaces of the wet well from the base slab to and including any overhead ceiling or roof. Concrete protective coatings shall be in accordance the Standards and Specifications for Water, Sanitary Sewer and Storm Drainage Infrastructure, latest edition. All piping, guide rails, chains, anchor bolts, and other fasteners and hardware within the wet well and dry well shall be Type 316 stainless steel.

If cathodic protection is required, the Consultant shall follow Cathodic Protection Section (11.11) of the Standards and Specifications for Water, Sanitary Sewer and Storm Drainage Infrastructure, latest edition and its Appendix B for preapproved materials. If metallic pipe is used, all external piping should be isolated from internal piping when it enters and exists the station.

3.3 Grinding

Depending on the wastewater characteristics, in-line grinders are required for raw wastewater entering the wet well to minimize pump clogging problems. For larger facilities, duplicate units of proper capacity are required. Direct access for maintenance shall be provided to each grinder.

3.4 Confined Space Entry

Designs must address confined space entry conditions and requirements for wet wells and for valve vaults. Designs shall consider the provisions stipulated within OSHA and other regulatory agency requirements to protect operational and maintenance personnel from potential hazards in all lift stations.

3.5 Access

Wet wells shall be designed to provide two access hatches for personnel access. Access hatches shall be located on top and at opposite ends of the wet well. The minimum distance between hatch openings is 12 inches. Non-slip manhole rungs shall be provided for wet well access. All access manholes shall include a Davit Crane and Base with a safety-up post. All instruments shall be accessible from a standing position without the need of extension ladders, platforms, scaffoldings, or mechanical lifts. In areas where instrumentation may be installed outside the normal standing areas of the station, secure catwalk access shall be provided. Wet wells shall have adequate clearance to provide a straight suction piping connection between the wet well and the lift station.

3.6 Level Control

The Lift Station shall have a back-up float system. Wet wells shall be designed to include all necessary level controls. The primary device for lift station level measurement shall be non-contact sonic level measuring systems. Tipping float level switches shall be the secondary control method for backup of the primary measurement system. Each pump shall have its own float system. The float system should be attached to a Type 316 stainless steel chain and weight in a configuration that is capable of being lifted out of the wet well for replacement and level adjustments, without the need for personnel to enter the wet well. Any level transmitters should also be accessible from the top of the wet well on the outside to allow for safer and easier maintenance. All ferrous materials inside the wet well shall be Type 316 stainless steel. All bolts, nuts, and washers shall be Type 316 stainless steel.

Since float switches are discrete devices, they shall be used to indicate “Low”, “High:, and “High-High” levels. Each pump shall have a minimum of two floats: Low (pump enable) and High (pump on). There shall be one “High-High” float per wet-well. As such, the level set points for the float switches shall be set 6-inches outside of the normal operating range associated with the primary level set points. The float system shall run independent of the transducer and PLC. See the SCADA DEGs Section 13 for specifics. The floats shall consist of the following:

- The floats shall be 316 stainless steel encapsulated floats with mercury wetted form C contacts.
- The float system shall have a support system for wall mounting that allows for vertical adjustment of the floats.
- The floats system shall be as manufactured by Consolidated Electric of St. Paul MN USA or approved equal.
- The wet well float system shall also incorporate an intrinsic safe barrier between the wet well and the pump station drywell.
- The intrinsic safe barrier will be a GEM-SAFE PAC as manufactured by Gem Equipment Co.

- Floats should be wired directly to the pump motor starters / VFDs and be able to operate independent of transducer and PLC.

The peak wet well elevation should be maintained at 2-feet below the lowest inlet pipe invert discharging into the wet well. Therefore, this maximum elevation should be used to determine the LEAD PUMP ON elevation for a two-lift station, or the LAG PUMP ON elevation for a three-lift station. The wet well high-level alarm shall be maintained at 1-foot below the lowest inlet pipe invert discharging into the wet well. The PUMP OFF elevation may be determined using the following equation:

$$E_{OFF} = E_{ON} - \frac{V_e}{A_w}$$

V_e is the effective pumping volume in cubic feet
A_w is the wet well cross sectional area in square feet

The effective pumping volume may be estimated as follows:

$$V_e = \frac{Q \times t_{min}}{7.481 \times 4}$$

Q is the pumping rate in GPM
V_e is the effective pumping volume in cubic feet
t_{min} is the minimum time interval in minutes allowed in one pumping cycle

Minimum cycle time (t_{min}) can be calculated as follows:

$$t_{min} = \frac{60 \text{ min}}{\text{No. Cycles/hour}}$$

The time within one pumping cycle should be limited in order to prevent motor insulation failure due to overheating. When a motor starts, the in-rush current may be significantly higher than normal operating current, resulting in significant heat generation. Hence frequent motor starts do not give the motor adequate time to “cool down” between starts. The Consultant shall also refer to NEMA standards.
Pump cycle times shall be limited as follows:

- 10 minutes or longer for motors of 10 HP or less.
- 12 minutes or longer for motors of 10 to 40 HP.
- 15 minutes or longer for motors of 40 HP or greater.

The operating depth for LEAD PUMP ON level controls for a three-pump lift stations should be based on the same minimum cycle times between pump starts, accounting for the incrementally reduced pumping capacities.

4.0 Odor Control Systems

Odor control systems are required at all lift station facilities. The Consultant shall evaluate the most suitable type of odor control system on a site-by-site basis and present such findings to the City for their consideration and approval. Odor control systems shall consist of minimizing wet well turbulence, addition of odor control chemicals (i.e. nitrate solution - Bioxide), and the collection of odors generated in the lift station and their treatment via activated carbon filtration. Biofilter beds are not allowed.

The design should take into consideration space for storing onsite, any necessary chemicals for odor control. Storage volume and location will depend on the dosage and the pump cycles along with any chemicals freeze point. Double wall containment may be necessary, depending on the chemicals.

Additional odor control systems, such as a passive drum air scrubber, shall be used to remove odorous air discharged from air release valves installed on force mains. Air release valves shall be housed in a vault with a vent pipe that is located in areas that minimize adverse impacts to the surrounding community. Any liquid collected in the vault must be drained to a contained sump and emptied by the City/Owner. It is intended that all foul air be collected and treated to produce a peak H_2S concentration at point of removal of 10 PPM, and an average H_2S concentration at point of removal of 5 PPM.

Design should include multiple gas (O2, H2S, CO, LEL) air monitoring devices pre-approved by the City in wet wells and dry wells that are hardwired to the Programmable Logic Controller (PLC).

5.0 Chemical Feed Systems

Chemical addition may be desirable for corrosion control, as well as odor control. The Consultant shall evaluate the need for chemical feed systems on a site-by-site basis and present such findings to the City for their consideration. Design of chemical feed facilities is not currently a part of this design standard but may consist of adding chlorine or ferrous salts to the wastewater to prevent excessive corrosion.

6.0 Civil Requirements

The following sections discuss the various civil requirements for the Lift Station design.

6.1 Site Selection

The lift station site shall be approved by the City’s Planning and Utility Departments and shall be located in accordance with the latest version of the City of Aurora’s WUP. The site shall be on City-owned land and shall be adjacent to a City maintained right-of-way. The site provided for the lift station facility shall be dedicated fee simple to the City of Aurora by plat or separate document. Site selection is critical in producing a satisfactory permanent facility with attractive life-cycle costs. Site evaluation shall include assessment of the following:

<u>Visual impact on the neighborhood</u>: the lift station should be sufficiently set back from the property line to the fence line to accommodate a xeriscape landscape buffer zone; to the greatest extent, features should be located below grade. The architecture of the lift station should blend with the local surroundings.

<u>Topography:</u> the lift station should be located to take advantage of topography so as to maximize the reach of the proposed system. Lift stations shall not be damaged by flooding.

<u>Access/drainage:</u> the selected site should have access and maintain necessary clearances for construction and maintenance. The site should have adequate drainage and should consider site security and fencing. The site should be large enough to provide necessary access for operation and maintenance of the lift station. Lift stations should not be located on the following:

- Road and street rights-of-way.
- Easements.
- Excessively small parcels.
- Areas where future maintenance access, security, or odor mitigation could be problematic.

- A site with topography that prevents the top of the station from being located above the 100-year flood elevation, or where the site may not be accessible during a 25-year flood event.

See Section 6.6 for additional details for site drainage capacity.

Elevation of site structures: the site structure(s) depth and its potential impact on adjacent areas should be considered. The top of lift station structures, top of valve vaults, and concrete pads for pump control panels/electrical rooms shall all be at the same elevation; this common elevation shall be a minimum of one foot above the highest of the following:

- Base flood.
- Record inundation.
- Center line of adjacent street.
- Nearest controlling sanitary sewer manhole.

Access for pump removal equipment: the site should include sufficient pavement area and clearance to accommodate full movement and operation of the City vehicles utilized for pump removal work; this includes being able to safely navigate around overhead interferences, such as electrical lines. Facilities containing pumps too large for removal with City-owned equipment shall be designed with permanent pump removal systems.

Entrance gate: the site should accommodate an entrance gate with sufficient setback to allow entrance without blocking the main roadway. Consultant shall follow all applicable roadway standards including Aurora's Roadway Design and Construction Specifications (latest edition).

Odor potential and impact on neighborhood: to the extent possible, lift stations should be oriented according to the prevailing wind direction so as to minimize potential hydrogen sulfide odors in adjacent areas, and to minimize gases entering electrical panels or control building intake grills. The Consultant will work with the City in development of neighborhood public participation planning during initial site selection and design development. The City will coordinate site acquisitions.

6.2 Site Plan

Planning and design must specifically address the visual impact on the neighborhood, access to the site for normal service trucks, clearance/separation from property lines and adjacent facilities, potential odor impacts, and site security. A development application must be submitted to the City of Aurora Planning Department for review and approval. The lift station should be oriented according to prevailing wind direction to minimize hydrogen sulfide gases entering control building intake grills or electrical panels, whenever possible. If main electrical and control panels must be installed outside the station, they should be out of direct sunlight and located in weather-proof enclosures.

For single-lot sites, the lift station should be positioned centrally on the lot or to maximize separation between neighboring structures, within the clearance guidelines. The Consultant shall prepare a conceptual site layout plan. The site plan shall be submitted for review and approval at the 30% design. See Section 1.3.1 for Conceptual Design Requirements.

6.3 Clearances

The site design should include the following clearances:

- Setback distances from all property lines as governed by City ordinances.

- A minimum of at least 30 feet from all sides of structure to the property lines.
- A minimum of at least 20 feet from structure to property lines on at least two sides when available land is limited.
- Sufficient pavement area and clearance within secure site area to permit full movement and operation of the maximum number of City-owned trucks as may be required to remove the pumps selected at a specific site.
- Wet well tops extending a maximum of 12-inches above the finished grade without berming up to top slab elevation.

6.4 Intrusion Protection/Fencing/Security

Site security should be provided by a full-perimeter fence, including one 16-foot wide, double-leaf, inward-opening swing gate secured with chain and keyed padlock. The padlock shall be provided by Aurora Operations. For lift station buildings, Primus locks shall be provided by the Consultant or Contractor along with 60 copies of the keys.

The site shall also be equipped with intrusion alarms for all hatches, doors, and skylights. The site shall also be equipped with motion detection. Please see the SCADA DEGs for specific design requirements. Other security measures will be considered on a case-by-case basis, if special conditions or requirements dictate. Depending on the lift station location, one of the following fencing systems will be required:

1. A fence system consisting of wooden pickets supported by galvanized steel posts, with the posts located on the interior of the fence.
2. A fence system that is approved by Aurora Operations and Planning.

6.5 Maintenance and Access Requirements

The site layout should address access and setting location for Vactor trucks and vehicles that will lift out pumps or other equipment if permanent pump removal systems are not provided. Site size, facilities locations, clearance areas, overhead utilities, and orientation of hatches should be coordinated with the setting position and lifting capacity of a maintenance crane.

Paving into and around the inside of the site should be low maintenance. Low maintenance paving is defined as Portland cement concrete of sufficient design and thickness for anticipated loads. The pavement should have drainage slopes away from the lift station, valve vault, and control panels. The pavement should be wide enough for proper mobility of the appropriate vehicle, but not less than 12 feet. In areas that are not accessible to vehicular traffic, concrete shall extend a minimum of four feet from all structures and control panel bases. The use of guard posts shall be considered to protect pavement from being driven on when paved areas are not designed for vehicular traffic.

The site security fence and entrance gate should be placed far enough from the street to allow a Vactor truck to be off the main roadway when the operator stops to unlock the gate. Entry to the site must be reliable and convenient during a 25-year storm event. The turnout radius (inside) should be at least 50 feet, or long enough to prevent truck or crane wheel overrun from the pavement. Curbs on access roads shall not be required. The lift station shall have 360-degree access and should be provided with a card reader compatible with the City’s used cards for security purposes.

6.6 Site Drainage Capacity

The site should have adequate drainage and should provide water quality and detention for stormwater run-off either on-site or tributary to a communal detention. The site should be graded with slopes not greater than 1-foot vertical to 6-feet horizontal. The impact of the new project on existing drainage patterns should be evaluated and mitigated if necessary. Stormwater shall be collected in pipes or swales for discharge and conveyance to an on-site detention pond or communal detention area in accordance with local requirements. Water quality is a requirement for the site development. The Consultant is responsible for investigating all local stormwater issues and coordinating specific drainage requirements into the project design.

6.7 On-site Emergency Wastewater Retention

On-site retention for emergency storage of the sanitary flows shall be provided at all lift stations per CDPHE guidelines. Lift station size, location of the lift station site, and CDPHE requirements will determine the size and capacity of the on-site retention. If an onsite pond will be used, a PVC liner with a minimum thickness of 30 mil per CDPHE requirements shall be used. On-site emergency storage should take into consideration the ease of the long maintenance.

6.8 Landscaping

Lift station site landscaping designs need to be safe and simple with emphasis on native xeriscape types of plantings. Aesthetically, they should blend into the surrounding landscape and included with the site plan application. Upon completion of the lift station construction, all disturbed areas within the site shall be fertilized, planted, and mulched.

7.0 Architectural Requirements

The Consultant, in close cooperation with the City, shall develop an architectural style that is cost-effective, functional, and blends with the surrounding existing, or future architecture to the extent possible. The Consultant shall take the lead in investigating zoning constraints, applicable building codes, and anticipated governmental review procedures that will be required during the course of the design. The City will participate in all public and agency meetings associated with architectural design.

The Consultant shall comply with the following guidelines:

- The lift station will be an above ground structure sized to accommodate all of the pumps, electrical equipment, and controls required to operate the facility.
- The facility shall be kept as low in profile as is functionally possible.
- Highly reflective materials and surface finishes should be avoided on the exterior of the building.
- The station shall be lighted, heated, cooled, and well-ventilated, and will be designed for easy expansion if required.
- If non-City personnel are to be allowed into the facility (e.g. guided tours) then regulations governing handicap access, public versus private facilities, and large group assemblies must be met.
- Security and safety should be considered in the selection of materials and in the design features of the building.
- Materials of construction should be durable and easily maintained.
- Lift station hardware shall be stainless.
- The type, availability, and location of utility services should be evaluated and integrated into the design.

- Energy efficiency should be enhanced through sufficient insulation in the walls and roofs.
- Exterior lighting should meet the requirements of Electrical DEGs.
- All mechanical and electrical equipment as well as service yards and areas shall be screened from public view; this includes rooftop mounted equipment.
- Electrical and control equipment shall be elevated from ground level and housed in a separate MCC/Control Room.
- All floors should slope ¼ inch per foot to floor drains.
- Dry well designs should include a full-perimeter drainage system along the base of the walls at the lowest floor level; slope of bottom towards drainage sump should be at least ¼ inch per foot.
- Provisions should be made to mitigate pump noise, if necessary, at both the project site boundary as well as within the lift station.
- Roofs shall be designed for positive drainage; the selection of roofing shall be consistent with the aesthetic and functional requirements of the building; elastomeric sheet roofing shall not be used.
- Roof penetrations should be minimized or eliminated, where possible.
- Over dry wells, roof hatches for pump removal are generally discouraged; lifting equipment should be included within the building itself. A powered crane for pump removal and loading onto vehicle should be provided.
- Doors and frames should be of fiberglass construction with Type 316 stainless steel hardware; security concerns may dictate selection of door/frame material, such as steel stiffened type construction.
- A rolling service door shall be considered for access to the lift station to facilitate removal of equipment.
- Regular stairway access must be provided for dry well type lift stations; straight ladders or ship ladders shall not be used.

8.0 Structural Requirements

Structural design requirements are provided in this section. The following general guidelines apply as well:

- Geotechnical Coordination - At least one boring shall be located below the foundation of the lift station and extended at least 20-feet below the planned foundation base; actual depth to be determined by the Consultant and their Geotechnical Engineer.
- Unless indicated by special site considerations, evaluation of soil corrosivity is not required.
- Construction Type - The type of material for wet well construction shall be concrete.
- Corrosion Control - See Section 3.2 for corrosion protection requirements.

8.1 Design Loads

The following criteria define the minimum design loads to be used for structural design of lift stations. Without limiting the generality of other requirements, all design loads and detailing shall conform to or exceed the latest requirements of the IBC, and the applicable requirements of the aforementioned documents.

8.1.1 Dead Loads

Dead loads shall be defined as the weight of the structure and all material permanently attached to or supported by the structure. In addition to the dead load of the basic structural elements, the following items shall be included:

- All equipment and piping permanently attached to and considered part of the structure including future equipment and piping.

- Structural steel platform framing and floor plates (use an estimate of 20 PSF); heavy beams or girders, other than platform beam supports, shall be considered separately.
- Piping 12-inch diameter and smaller, shall be treated as uniformly distributed loads; typical values are 20 PSF for extensive piping and 10 PSF for light to moderate piping.
- Piping larger than 12 inches in diameter shall be treated as concentrated loads.
- Pipeline thrust under maximum pressure conditions.
- Fireproofing used on structural steel, vessel skirts, and equipment.

8.1.2 Live Loads

Live loads given in Table 1607.1 of the IBC shall be considered as minimum values to be used in design. In addition, the following live loads shall apply:

- General walkways, platforms, and stairs shall have a minimum (unreduced) live load of 100 PSF.
- Equipment area loads can vary from 100 PSF to 300 PSF and additional consideration shall be given for the type, size, and weight of specific equipment, and maintenance of equipment, in determining the actual design live loads and concentrated loads.
- Where the roof may be subjected to vehicle wheel loads, H-20 live loads shall be included.
- Office floor live loads shall be 50 PSF.
- Electrical equipment areas shall be designed for a minimum of 100 PSF live load.
- Mechanical areas shall be designed for a minimum 100 PSF live load.

8.1.3 Seismic Loads

When selecting ground motions for the seismic design of concrete structures, the economic life and requirements for uninterrupted operation after a major earthquake shall be considered. The following are basic guidelines for determining the design ground acceleration and seismic forces:

- Seismic design shall be in accordance with the requirements of the IBC, ASCE 7, and ACI 350 and 350.3.
- The seismic induced forces of architectural, mechanical, electrical, and non-structural systems, components, and elements permanently attached to structures shall be designed in accordance with the requirements of Section 1621 of the IBC.
- Load factors and load combinations shall be in accordance with the requirements of ACI 350.
- The environmental durability factors shall be applied to all parts of structures below grade in accordance with the requirements of Section 9.2.8 of ACI 350, except that the environmental durability factor need not be applied to load combinations that include seismic load.
- Seismic soil pressure shall be determined in accordance with the recommendations given in the geotechnical report for each specific project site.

8.1.4 Hydrostatic Loads

Buried concrete structures shall be designed for hydrostatic forces imposed by external groundwater. The Consultant shall provide buoyance calculations with the 60% Preliminary Design Report per Section 1.3.2.

8.1.5 Lateral Soil Loading

All below grade structures or parts of structures shall be designed for the following soil pressures:

- Active soil pressure for all yielding walls (i.e., cantilever walls).
- At-rest soil pressure for all non-yielding walls (i.e., restrained or supported walls).
- Passive soil pressure.

- Surcharge pressure equal to a minimum of 2 feet, or equal to the actual height of earth blanket above the roof.
- Seismic soil pressure per ACI 350.3.
- The values for lateral soil pressures shall be in accordance with the geotechnical report.

8.1.6 Wind Loads and Snow Loads

Wind loads shall be considered in the design in accordance with the IBC and local governing codes. The minimum wind velocity shall be 105 mph (3-second gust). Snow loads shall be per the IBC and the local codes but shall not be less than 30 PSF for roofs and 34 PSF for ground snow. Design for snow loads shall be per the IBC.

8.1.7 Impact and Vibration Loads

Crane rails and supports shall be designed for impact loading per the IBC. All forces produced by equipment or machinery having a tendency to vibrate shall be considered in the design of supporting structures. The magnitude of the forces shall be obtained from the equipment supplier for use in the design. Impact forces due to process operations such as surging fluid shall be considered in the design.

8.1.8 Load Combinations

Lift stations shall be designed for loading combinations per ACI 350 and the IBC.

8.2 Structural Design Criteria

This section defines the general structural design criteria for lift stations.

8.2.1 Concrete Design

Structural design of reinforced concrete shall be in accordance with the general requirements of the following:

- ACI 318
- ACI 350
- ACI 350.3
- IBC
- ASCE 7

Lift stations shall be designed for both strength and serviceability. The strength design method shall be used for design of concrete. The following guidelines shall be followed for hydraulic concrete structures:

- The load factors shall be in accordance with ACI 350.
- Serviceability requirements shall be in accordance with the provisions of ACI 350.
- Environmental durability factor ‘S’ shall conform to the requirements of ACI 350.

Expansion and construction joints shall be provided in accordance with ACI 350 to allow flexibility and to adequately tolerate differential movements and shrinkage stress. All types of joints in reinforced concrete structures where water tightness is required shall be provided with waterstops and sealant. All joint detailing, type, and location criteria shall be in accordance with Section 4.8 of ACI 350. Locations of all joints shall be shown on the plans.

Expansion joints shall be provided only for partially buried structures to release stress resulting from thermal expansion and at abrupt changes in the structural configuration. The maximum spacing of expansion joints shall be 120 feet.

Construction joints shall be located so as to least impair the strength of the structure, to provide logical separation between segments of the structure, and to facilitate construction.

8.2.2 Equipment Footings

The following shall be included in the design loading of equipment footings:

1. Equipment dead weight plus contents.
2. Portion of piping and the contents attached to the equipment.
3. Operating live load.
4. Dead load and live load of attached platforms, ladders, and stairs.
5. Equipment impact, vibration, and torque.
6. Seismic and wind load.

Equipment footings shall be designed for the maximum load under operating or testing conditions. Test and seismic loading need not be combined in footing design. Only 50% of the platform live load needs to be combined with the test loading case. The most unfavorable effects from wind and seismic loads shall be considered in the design.

Factor of safety against wind and seismic overturning and sliding shall not be less than 1.5. Piping connecting to the equipment shall not be used as a means to resist the wind or seismic loading. Equipment footings of vibrating and rotating equipment may need to be isolated from the surrounding slab to minimize the effect of vibration on the adjacent structure.

Horizontal vessels should be supported by pedestal(s). In addition to the loading above, friction forces due to thermal movement should be taken into consideration in the design. Sliding bearing should be provided at one end to reduce the friction loading.

Movement and shear acting on footings caused by removing some internal components from equipment should be considered in the design. The horizontal force should be assumed at two times the weight removed. Equipment footing should be five times the weight of vibrating and rotating equipment per HIS recommendation.

8.2.3 Roof

The following guidelines shall be used when designing below grade or exposed reinforced concrete roof systems:

- The effect of relative rigidity shall be considered when the concrete roof is rigidly connected to the walls.
- The effect of daily temperature fluctuation on exposed concrete roof slabs shall be considered for partially buried structures.
- For large exposed roof structures where expansion joints are required, ductile moment resisting frames, or the combination of shear walls and ductile moment frames shall be provided to resist seismic forces;. See Section 8.2.1 for the maximum spacing if expansion joints.

8.2.4 Footings and Floor Slabs

Lift station floors shall slope for drainage at minimum of 1% along the longest distance, sloped to the sump or drains.

9.0 Mechanical Requirements

Mechanical design requirements for lift stations are provided in this section.

9.1 Piping and Appurtenances

The following piping design guidelines shall be followed:

9.1.1 General

a) The Consultant shall select piping materials that are appropriate for the type of fluid being conveyed and shall prepare a piping schedule presenting materials and test requirements.
b) All exposed raw wastewater piping in lift stations shall be ductile iron pipe rated appropriately for the intended pressure class.
c) All exposed piping should be hard flanged without thrust-rod tie elements.
d) Use fabricated hot-dip galvanized steel pipe saddle assemblies for support and thrust restraint of exposed pipes and valves that are not in the wet well. For support and thrust restraints in the wet well, Type 316 stainless steel shall be used.

9.1.2 Valves and Couplings

a) Isolation valves in pump suction lines of dry well/wet well type stations should be of the flanged type, connected to the piping flanges. Valves shall be at least 12-inches from the walls.
b) Flanged adapters, sleeve-type compression couplings or grooved-end couplings should be provided with a suitable harness to provide longitudinal restraint; for bolted flanges, make sure that flanges of different materials are compatible.
c) Flexible pipe couplings for installation on pump inlet and discharge piping shall be sleeve-type flexible couplings.
d) Flexible couplings shall be located between the inlet isolating valve and the pump and between the pump and the discharge control valve; these couplings shall be spaced at least 18-inches apart on piping that is 14 inches in diameter and smaller.
e) Valves shall be installed within proximity to the pump room floor. Valves shall not be located at or near the ceiling.
f) No obstructions shall impair removal of check valve bonnets.
g) Flexible sleeve-type couplings shall be provided at both the pump inlet and discharge connections; since these couplings do not provide any longitudinal restraint, the pipes and the pump must be suitably and separately anchored against significant longitudinal movement; all couplings should be harnessed to achieve this objective; rubber bellows-type flexible couplings shall not be acceptable.

9.1.3 Joints

a) Mechanical joints, flanged coupling adapters, grooved-end couplings, or other non-continuous flexible pipe joining methods should not be incorporated between the wet well wall and isolation valve.
b) The selection of pipe joints or couplings and the care with which they are installed are important considerations for the Consultant; sleeve couplings, bell and spigot rubber-gasketed joints, field-

weld joints, grooved and shouldered couplings, and flanges are commonly used with steel water pipe.

c) Screw joints shall be used on threaded small steel, cast-iron, bronze, stainless, etc.
d) Patented joints may be considered if the application fits the recommended use and design data from the joint manufacturer.

9.1.4 Pumps

a) Pumps with discharge connections greater than 16 inches in diameter shall have flexible couplings at the suction connection.
b) Lift stations shall be designed so that each pump takes suction from the wet well using individual and separate suction piping.
c) Suction header pipe serving multiple pumps may be used when there is adequate suction and pressure to satisfy the pumps net positive suction head.
d) The suction manifold shall be carefully designed to preclude turbulence that may cause cavitation of the pumps.
e) Suction piping shall be designed for a velocity not to exceed 5 FPS.
f) Pump branch connections to discharge manifolds shall enter the manifold at an approximately 45-degree angle to the centerline.
    i) 90-degree fittings and Tee's shall not be used without City approval.
    ii) If wyes are used to connect the pump discharge to the manifold the wyes shall be the same diameter as the manifold. However, depending on the site and its constraints, the use of reducing/increasing wyes or other reducing/increasing fittings may be necessary; the use of these fittings shall be reviewed on a case-by-case basis by the City during design.
g) The pump inlet shall be designed in accordance with HIS to preclude turbulence, vortexing, and jet velocities, and to provide adequate NPSH to prevent cavitation of the pumps. A scaled hydraulic model test may be required to ensure proper design of pump inlet configuration on larger lift stations.
h) Pumps shall be arranged to provide convenient access for operation and maintenance personnel, equipment installation, maintenance, and equipment removal.

9.1.5 Spacing

a) The minimum acceptable vertical distance from any walking surface to the bottom of any pipe, slab, beam, or other overhead obstruction is 6 feet, 8 inches.
b) Open-air vaults with grating must have enough depth for air release valve(s) to fit on top of the discharge header and beneath the grating with at least six inches of clearance beneath the grating and its supports.
c) The minimum acceptable spacing between the outside of piping joints and walls is 24 inches measured from the outside of the widest pipe fitting or valve, typically a check valve.
d) The minimum acceptable spacing between a floor and the deepest pipe fitting or valve is 12 inches.
e) The minimum acceptable spacing between discharge pipes is typically determined by the required spacing between the pumps or the pump hatches.
f) Dry well type designs should provide not less than 5 feet or 1½ times volute diameter, whichever is larger, clearance between pumps and not less than 3 feet clearance between pumps, walls, handrails, other equipment, and major components. Trench style drains should be provided in dry wells.

g) All pump spacing and related clearances must be in accordance with manufacturer's recommendations and HIS for proper pump operation.

9.1.6 Bypass

a) The lift station discharge header should be installed with an isolation valve and blind flange for connection of temporary piping to accommodate a lift station bypass.
b) A vertical standpipe compatible with Bauer connections shall be included in the wet well design to be used for bypass pumping.
c) Rails shall be sized and incorporated into the design of the wet well to allow for lowering and removal of a bypass pump.

9.2 Force Mains

Unless otherwise approved, force mains shall be DIP and lined with an approved lining that conforms to the City Standard Specifications. The Consultant must determine the necessity and extent of cathodic protection. See Section 3.2 for corrosion protection requirements. Force mains should be designed and constructed to maintain a positive slope. High points in the force main should be avoided. If it is not possible to do so, combination sewage air and vacuum valve shall be installed at high points to prevent air locking and relieve negative pressures. Combination sewage air and vacuum valves shall be made with corrosion resistant pipeline materials. The dual force main barrel diameters may vary to account for phasing of the lift station. A minimum barrel-to-barrel clearance of 5 feet, outside to outside, shall be maintained unless specifically approved otherwise by the City.

Force mains pressure rating shall be at least 1.333 times greater than the pressure generated by instantaneous pump stoppage due to a power failure under maximum pumping conditions as determined by dynamic pressure analysis, but in no case shall be rated less than specified pressure class in City's Standards and Specifications for Water, Sanitary Sewer and Storm Drainage Infrastructure, latest edition. Design engineer must include an analysis showing the maximum surge pressure for such conditions in the PDR and FDR design reports and provide a solution to prevent a force main break. See Sections 1.3.2 and Section 1.3.3 for additional details on the PDR and FDR requirements.

Force mains shall not discharge directly into a gravity sewer system without the use of a splitter box or a manhole. Force mains shall enter the gravity sewer system such that the invert of the force main is within 1 foot of the crown of the highest influent sewer. If possible, the discharge shall be oriented to discharge into the flow line of the sewer in the downstream direction in order to reduce turbulence. In addition, the following design criteria for force mains shall be followed:

2) Minimum pipe diameter size shall be 4 inches.
3) Velocity at design flow design point should be between 4 FPS and 5 FPS.
4) Minimum velocity of 3 FPS and maximum velocity of 7 FPS under all operating conditions.
5) Pipe cover shall be a minimum of 4.5 feet and higher than the gravity inlet line elevation.
6) Provide isolation and plug valves (at a minimum every 2000 feet) for maintenance and testing.
7) All valving shall be pressure and leak tested in the presence of the Owner, to the same standards list for force main pressure testing below.
8) Force main shall be pressure and leak tested in the presence of the Owner.
   a) Force mains must be tested by filling with water and pressurizing to 50 psi above force main nominal rated pressure or 50% greater than maximum operating pressures, whichever is greater shall govern. Force main must hold the test pressure for 2 hours.

b) A leak test must be also performed per Section 11.14 of the Standards and Specifications for Water, Sanitary Sewer and Storm Drainage Infrastructure, latest edition.

9) A force main average flush time analysis must be performed and submitted with the PDR and FDR. Average flush time shall not exceed 180 minutes. See Sections 1.3.2 and Section 1.3.3 for additional details on the PDR and FDR requirements.
10) The forcemains shall be locatable and meet the minimum requirements in Section 21 of the Standards and Specifications for Water, Sanitary Sewer and Storm Drainage Infrastructure, latest edition.
11) Marking tape shall also be placed in the trench, above and parallel to the force main. The tape must bear the label "PRESSURIZED WASTEWATER" continuously repeated in at least 1.5-inch letters.
12) The severity of all direction changes should be minimized and shall be no greater than 45 degrees without City approval.
13) No valves shall be installed on the discharge end of the force main barrels.
14) Drain back lines from force main lines shall be provided.

9.2.1 Force Main Cleaning

Force main cleaning includes running a manufactured "pigging" device through the line. Long force mains are typically equipped with "pig" insertion and retrieval stations. In most cases, insertion facilities are located within the lift station. The Consultant shall coordinate with the City to determine force main cleaning provisions required at the lift station. The Consultant shall verify the forcemains have adequate flushing velocities and frequencies.

9.3 Pump and Piping Removal Systems

Pump and piping removal systems, such as floor hatches above the pump room, overhead monorail beam, bridge crane, or portable hoists, shall be provided, as appropriate, for the installation, disassembly, maintenance, and removal of piping, motors, pumps, valves, flow meters, and other major components in the lift station.

For dry well designs with motors installed inside an enclosing superstructure, permanently installed hoisting facilities shall be provided for pump, motor, and other equipment servicing and removal. Station equipment openings and loading areas shall permit direct access and drops without intermediate "picks" or maneuvers. Monorail beam hoist systems should be avoided because of their limited mobility. A bridge crane with an electric hoist and manual chains for trolley and bridge movement is the preferred material handling system. Single-speed hoist lifting speed should not exceed 8 FPM. Two-speed operation at 16 FPM and 1.6 FPM is preferable.

9.4 Emergency Bypass Pumping

An emergency pump bypass connection assembly shall be provided on the lift station's discharge header complete with an isolation plug valve and a camlock fitting with an approved cover and is easily accessible on-site. The discharge lines shall connect to the discharge manifold in such a way to allow a portable pump to be connected to the manifold and pump into the force main as if it were a normal station pump. An additional bypass assembly shall be installed on the redundant force main that allows the manifold to be bypassed. The isolation valves, check valves, and/or hydraulic/air operated plug valves located on the discharge lines shall prevent any backflow to the permanent lift station pumps. Other following bypasses must be provided where feasible:

- Camlock quick-connect connections to the discharge force main to permit connection of a dewatering pump discharge during wet well maintenance.
- An immediate upstream manhole on the influent sewer within 30 feet of the wet well to serve as dewatering pump suction well.
- Tee with blind flange on the header pipe.

9.5 Flow Metering

All lift stations shall have suitable devices for measuring, recording, and totaling sewage flow. Accurate measurement of flow discharged from a wastewater lift station is critical to the overall operation of the station. Consequently, a flow meter must be installed in the common discharge header of all wastewater lift stations to indicate and record the quantity of flow being pumped. The City requires the flow meter be an in-line magnetic flow meter. Restrained flexible couplings or equipment dismantling joints shall be installed adjacent to the meter to allow for easy removal and replacement. The meter must be protected from direct exposure to the sun.

For new sites, the Consultant shall provide no less than the minimum number of straight-run pipe diameters required by the flow meter manufacturer both upstream and downstream of the flow meter to ensure accurate flow measurement. Minimum velocities recommended by the meter manufacturer must be maintained through the meter at the lowest anticipated pumping rate. If this requires installation of reducers, they shall be eccentric reducers, installed flat-on-top. The piping must be configured so that the meter is always filled with wastewater.

Flow meters shall be installed to meet the manufacturer's recommendations and configured such that alternative metering methods are available to field verify the accuracy of the installed meters. The design of the flow measurement system shall consider the type of flow meter, its final layout configuration, and required controls based on available land, the station layout, the flow meter manufacturer, and City input. Additional City flow meter requirements are listed below:

- The flow meter transmitter shall be located in an air-conditioned space if possible. A shade screen shall be constructed to shield the meter if the transmitter cannot be routed remotely.
- All discharge piping and fittings, including the metering segment, must be epoxy lined.
- See Section 11.4 for additional flow meter requirements.

9.6 Valves

The Consultant shall select valve types and materials that are compatible with the fluid being conveyed so that the number of valve types within the facility is minimized. The following valve design guidelines shall be followed:

Check valves shall be heavy-duty swing type check valves of the outside spring and lever type. Check valves 8-inches in diameter and larger shall be independently supported at each flange or valve body. Check valves shall have replaceable seats. Check valves, if required, shall be installed on horizontal piping runs.

In general, all isolation valves for sewage service shall be plug valves. Isolation valves shall be installed at the suction and discharge of each pump. Isolation valves should be bolted directly to the flange connections on headers.

Eccentric plug valves (non-lubricated) with elastomeric-coated plug and geared handwheel operators are acceptable. Lubricated plug valves with metal seats are not allowed. Eccentric plug shaft should be installed horizontally with plug stored in the top position when valve is OPEN, to minimize potential for grit accumulation in valve seat or shaft bearing. Electric operators shall be used where the valve has to respond to a process control such as flow or pressure. A hydraulic valve should be used in lieu of electric when the valve is required to operate during power outages.

Air release, air vacuum release, or combination air release and vacuum valves, specifically designed for wastewater service, shall be provided at critical locations in the lift station. These valves will serve to prevent air from being captured inside the piping system, or to prevent the collapse of the piping system because of vacuum conditions. A combination air valve shall be installed on the vertical leg of a T-fitting on the discharge piping prior to any other valve. Additionally, an air release valve shall be installed downstream of the check valves and upstream of the flow meter, again on the vertical leg of a T-fitting. The valves should be equipped with stainless hardware and spill monitoring in manhole(s) should be included, as applicable. Air-vacs and gauges must have stainless steel isolation valves and associated parts.

The air release outlet shall be piped back to the wet well for discharge. Air release valve outlet piping shall include an air compressor type quick-release coupling. Each valve shall be sized with the proper orifice size suitable for the volume of air to be admitted or released, and each shall be provided with an eccentric plug isolation valve. The entire valve assembly shall be rated for the same service rating as the main piping where the valve is installed. To allow for periodic maintenance on each valve, an additional isolation valve (¼-turn, resilient, rubber seated ball valve) and back-flushing connection is required for each air valve. These valve assemblies, including the isolation ball valve and associated piping, shall be rated for the maximum design pressure of the system piping. All valves installed underground shall be installed in a manhole or valve structure with adequate drainage and protected from freezing.

Double-disk gate valves, knife gates, and “coplastic” gates are not acceptable. Chain wheel operators should be provided for all valves mounted with centerlines more than 6 feet, 9 inches above the operating floor.

9.7 Air System

Where compressed air is required for operations or maintenance activities, the Consultant shall size and evaluate the air demand for each individual lift station. The air system shall consist of lubricated motor-driven compressors, air or liquid-cooled aftercooler, coalescing filter, refrigerated air dryer, air receiver, pressure switches, relief valves, pressure reducing valves with bypasses, condensate removal system with traps, and all associated piping systems. Air tools may require filters, pressure regulators, and lubricators. Where air usage is considered critical, a redundant compressor unit should be installed to operate on an automatic alternating “lead-lag” mode. The compressors shall be reciprocating type, with ASME-approved receivers. Air piping shall be designed to provide a separate piping header to each type of service to ensure that priority equipment will have a continuous, uninterrupted supply of compressed air.

9.8 Water System

The potable water supply system shall be protected by a reduced pressure principle backflow preventer, in accordance with local code requirements. Water systems shall be designed to avoid possibility of contamination. A backflow preventer for the water supply source should be located within a controlled environment in the structure adjacent to the control building with a hose bib on the exterior. If the backflow preventer must be located on the water supply immediately as the line arrives on-site, then it should be mounted above grade. The area should be appropriately landscaped. Note that backflow preventers have a drain that operates periodically - this must be taken into account in the design.

The Consultant shall verify that adequate potable water pressure exists at the site, and that the need for potable water booster pumps is not required. There shall be no physical connection between any potable water supply and a sewage lift station which under any conditions may cause contamination of the potable water supply. If a potable water supply is brought to the station, it shall comply with CDPHE and City requirements. Service water (plant water or utility water) shall be obtained from the potable water supply. If required by local code, a backflow preventer or air gap tank shall be provided. Service water will be used for general housekeeping purposes and for chemical dilution systems. A minimum one- and one-half inch potable water service according to Aurora Water Rules and Regulations shall be provided to the facility or as determined by Aurora Water. In addition, a one- and one-half inch cam-lock located near the wet wells for wash down is required. Applicable water connection fees do apply.

9.9 Sanitary System

Lift stations should be equipped with an eye wash station, hand wash sink, mop sink, toilet, emergency shower, and lavatory facilities. All sanitary drains shall be designed in conformance with all applicable plumbing codes.

9.10 Floor Drain System

The drainage system shall consist of a floor drain, hub drain, floor sink, cast iron drain pipe, grease interceptor, holding sump, and sump pumps. The drainage system shall be designed to handle drainage from the pump seals, housekeeping, HVAC units, and evaporative coolers. It is the Consultant's responsibility to consult the local governing authority to design the drainage system to meet all applicable codes. The holding sump shall be designed with adequate volume to prevent the pump from cycling in excess of the number of starts per hour recommended by the motor manufacturer. The sump may be covered with aluminum grating.

Sump pumps shall be duplex-type submersible pumps complete with lifting chain, discharge valve, check valve, piping, starter, level controls, and automatic alternator. High water level alarms shall be connected to the main lift station PLC and retransmitted to the station RTP. All floor and walkway surfaces should have an adequate slope to the point of drainage.

The station shall be equipped with a moisture detector/sensor. The unit shall be installed 6-inches above the floor in the lower pump room to detect the presence of water and consist of a float type switch with sealed contacts. The detector will send a flood alarm to the RTP, Gems Inc. model LS-270, with normally open contacts #43765 or equal.

9.11 Heating, Ventilation, and Air Conditioning (HVAC) Requirements

HVAC systems should be designed in accordance with the Uniform Building Code, International Mechanical Code, and NFPA 820. All HVAC equipment shall be designed to provide adequate space for installation, removal, operation, and maintenance. Heating and cooling loads should be calculated using ASHRAE methods. For wet wells and valve vaults, the capability to provide temporary venting (when they are to be entered) shall be provided in the design. The HVAC and SCADA Systems shall be completely individual and separate systems that do not touch, control or communicate with one another other than to transmit required status and alarms.

Adequate ventilation shall be provided for all lift stations that mechanically ventilate the dry well. If screens or mechanical equipment requiring maintenance or inspection are located in the wet well, it shall be mechanically ventilated. The vent shall be made from or coated in a corrosion resistant material. There shall be no interconnection between the wet well and dry well ventilating systems. In pits over 15-feet deep, multiple inlets and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts, and fine screens or other obstructions in the air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment should be marked and conveniently located. Consideration should be given to automatic controls where intermittent operation is practiced. In climates where excessive moisture or low temperatures are a problem, consideration should be given to installation of heating and/or dehumidification equipment.

The following HVAC design criteria shall be utilized:

- Wet wells: Where mechanical wet well ventilation is required, it should be continuous and provide at least 12 complete air changes per hour. For intermittent operation, at least 30 complete air changes per hour should be provided.
- Dry Wells: Ventilation may be either continuous or intermittent. For continuous operation, at least six complete air changes per hour should be provided. For intermittent operation, at least 30 complete air changes per hour should be provided.
- MCC/Control Room: The MCC/Control Room should have a ventilation system adequate to provide six air changes per hour and should be heated and air conditioned to 55 to 85 degrees F
- Chemical Storage: If chemicals are stored, minimum temperature should be 55 degrees F and per the manufacture's recommendations.

9.11.1 HVAC Area Classifications

Wet wells, dry wells, above grade spaces, and below grade spaces should be classified based on configuration and ventilation rate (Class I, Division I, Class I, Division 2, or unclassified) per NFPA 820. The preferred design should be wet wells classified as Class I, Division 1 and may be upgraded to Class I, Division 2, should certain provisions be met. Dry wells are classified as Class I, Division 2 and are allowed to be upgraded to unclassified, should certain provisions be met. Electrical and control buildings and valve spaces are designed as unclassified, should certain provisions be met. See the Electrical DEGs for additional design parameters and requirements.

9.11.2 Ventilation

Specific ventilation requirements are as follows:

- Permanently installed ventilation fans for valve vault or dry wells should be both supply and exhaust fans; the intake duct should draw from the bottom of the structure within 18-inches of floor and ceiling levels. Valve vault fans should be interlocked to operate when the light switch is ON, with the switch located at the entrance. Ventilation through panels should be avoided because of resulting corrosion problems; exterior panels should be stainless steel instead of aluminum.
- All ventilation fans should be made of explosion-proof and corrosion resistant materials in classified areas.
- The Consultant should investigate both active and passive ventilation systems.
- Pressure drop through louvers should not exceed 0.1 inch at an airflow velocity of 750 fpm.
- Ductwork in passive ventilation systems should be designed for velocities less than 600-fpm.

9.11.3 Heating and Air Conditioning

The Consultant shall design a cooling system for the pump rooms, local exhaust systems for rest rooms, janitor rooms, storage rooms, and electric heat pump system for the control rooms. The Consultant shall recommend the most appropriate type, subject to approval by the City. Electric heat pumps shall also be designed for other areas where personnel comfort is of prime importance. Outside air supply to the lift station shall be provided with roll-up filters rated for average synthetic dust weight arrestance of 83%. Filters shall be an electrically operated roll-up blanket type. Filters installed in front of heat pumps shall be 75% efficiency, disposable cartridge-type filters. Local exhaust systems shall provide 10 air changes per hour or 100 cfm, whichever is greater, by means of ceiling fans with wall or roof discharge.

Heating loads should be calculated based on an ambient temperature of 0 degrees F and an interior temperature of 65 degrees F. Air conditioning loads should be based on an ambient dry-bulb temperature of 100 degrees F, ambient wet-bulb temperature of 78 degrees F, and a maximum interior temperature of 80 degrees F.

Control rooms should be equipped with moisture and condensation control. Because most A/C units are oversized and do not cycle frequently enough to control moisture, the preferred design is a properly sized unit that runs continuously to keep the air moving and to function as a dehumidifier. Window A/C units are not acceptable. Portions of the A/C unit that contact high humidity and potentially corrosive atmospheres shall be coated with corrosion-resistant material. The protective coating shall be factory applied and provided by the A/C unit manufacturer.

The Consultant should address the following issues during the design phase:

- Building insulation requirements.
- Noise and vibration control mitigation measures.
- Any equipment and piping containing liquids which may be subject to freezing must be provided with heat tracing located under the insulation and controlled by a thermostat.
- Design temperature and humidity in lift station structures shall conform to ASHRAE requirements.
- Equipment selection shall include high efficiency units that minimize electrical energy usage and water consumption.
- Equipment, accessory, and ductwork materials of construction shall be selected to resist the corrosive elements of the environment in which they are installed.

10.0 Electrical System Requirements

The lift station electrical system shall be designed in accordance the City of Aurora's Electrical DEGs, latest edition. For purposes of delineating electrical enclosure and installation requirements, certain areas should be classified as "hazardous areas," "corrosive areas," "outdoor areas," "damp and splash areas," and "general purpose areas."

11.0 SCADA (I&C) System

This section includes guidelines for I&C system design for pumping stations. The City of Aurora has developed a computer-based SCADA system to monitor and control the operation of the City's water and wastewater systems. The lift station shall have an automated SCADA control and alarm system that are hardwired and programmed per City Standards.

All SCADA System equipment and design shall be in compliance with the latest edition of City's SCADA DEGs. The summary of the primary requirements during the design process for COA SCADA are:

1. Inclusion / review / comments on the 30%, 60%, 90% and 100% final design submittals
2. Mandatory PLC / OIT / HMI programming workshop
3. Mandatory Factory Acceptance Testing (FAT)
4. Mandatory Site Acceptance Testing (SAT)

For successful completion of the FAT and SAT, the City project manager, Consultant(s) and other applicable designers/vendors shall be present.

11.1 Instrument Summary

The Consultant shall compile a preliminary listing of all required instruments on an Excel spreadsheet. The instrument summaries will list each instrument's tag and loop number, specification number, associated instrument panel name / number, I/O list (including tag and loop number, process description, and PID drawing reference), installation detail number, instrument range, instrument set points, trip points, NEMA rating, material requirements, and all other data needed to precisely define the instrument requirements. This data will be submitted in hard copy and electronic to the City for review, comments, and or approval prior to ordering said instruments.

The Consultant shall obtain all the necessary data and information on valves, pumps, pump control valves, flow meters, and other control devices which the control system must interconnect. The Consultant shall correlate this information into project specifications to ensure that elements furnished are completely compatible with every control device including Owner-furnished materials and equipment. All interconnections shall be shown on the wiring diagrams.

11.2 Control Strategies

As determined to be necessary by the City, a control strategy will be prepared for each instrument loop that controls equipment. In addition, overall process control strategies, which interlock numerous individual control strategies to provide an efficient operator interface, will also be prepared. Control and process strategies will list all applicable inputs and outputs, provide a general description of what the strategy is supposed to do, and provide an explicit description of how each element in the control loop functions.

Each strategy will describe monitoring, alarm, and control functions associated with both local (HAND, OFF, AUTOMATIC) and remote (MANUAL, AUTOMATIC) control. Each strategy will describe in detail the sequence of operations required to start or stop a device under normal and abnormal conditions. All process trip points, set points, and timers will be quantified in each strategy. Strategies will be annotated using the instrument and equipment tag numbers shown on the P&IDs, and a P&ID reference will be provided. Each strategy will describe the required functions needed in process graphic screens used to monitor and control a specific process. Each strategy will also describe what should happen under abnormal conditions such as an I&C system failure, transmitter failures, abnormal process values, and communication losses between SCADA and PLC.

These control strategies will be submitted in hard copy and electronic format to the City for appropriate Customer / Site Owner for review and approval. PLC programming will initiate only after the Customer /

Site Owner has approved the control strategies. See the SCADA DEGs Section 2.0 Control Narratives for additional details and requirements.

11.3 Lift Station Controls

Lift stations will generally be operated automatically, based on level in the wet well at its location. Under normal conditions, the system will be locally controlled manually or automatically. Lift station controller will consist of a main LCP or RTP with the lift station PLC, UPS and the SCADA communications equipment. The City's SCADA system will receive signals from the LCP or RTP at each lift station to monitor the number of pumping units to match the incoming wastewater flow demands. The automatic control will be programmed in the lift station PLC (per COA SCADA Standard programming requirements) and will start and stop the pumping units at the respective lift station in accordance with the on-site wet well level.

Equipment supplied to control the operation of the Lift Station shall be from City pre-approved manufacturer(s). The Consultant is responsible to verify that equipment provided for any part of an operation be compatible with other parts. Small piping parts, connection devices, auxiliary switches, or any other equipment required due to differences in manufactured equipment shall be supplied as a part of the system at no extra cost.

Taking into consideration the duty and standby pumps pumping capacity, the standby pump should be activated while a duty pump is out of service. The pumps will change lead at the completion of a determined pump pumping cycle, or on a maximum time as determined by the City. Each of the duty pumps shall be controlled by the amount of flow through the metering vaults.

11.4 Flow Measurement

11.4.1 Influent Flow Measurements

If required, an ultrasonic flow transmitter will monitor the flow through the flume or other flow metering device. A 4-20ma signal proportional to flow through each flume will be individually transmitted via UHF/FM leased radio signal and/or a leased telephone bridge-circuit line to the lift station RTP. The total flow shall be sent via radio to the City of Aurora every 24 hours for archiving purposes and to verify amount pumped equals the amount of flow through influent flumes. The minimum and maximum flow through the lift pumps shall be determined when final pump submittals are received. See SCADA DEGs Section 13 for specific SCADA requirements and Section 9.5 of this Guidance Document.

11.4.2 Discharge Flow Measurement

A magnetic flow meter mounted in each discharge meter vault will continuously monitor the discharge flow from the lift station. Only one of the discharge flow meter vaults will be used at a time unless an emergency requires both meter vaults to be in operation. See SCADA DEGs Section 13 for specific SCADA requirements and Section 9.5 of this Guidance Document.

11.5 Station Pressure

A pressure transmitter shall continuously monitor the pressure in each discharge header from the lift station. See SCADA DEGs for specific SCADA requirements.

12.0 Shutdowns and Interlocks at Lift stations

Hardwired and software shutdown functions will be generated at each of the lift stations, which will cause operational pumps to stop. There will also be an "emergency shut-down" program in the main PLC and via a local push-button hardwired directly to the pumps to facilitate an instantaneous shut-down of all pumps at any lift station. Typical hardwired shutdown functions will be a low-low level and a high-high level in the wet well or tank being pumped to, a not fully open gate/valve to the lift station wet well, or a control cabinet power failure alarm.

Lift stations with pumps larger than 1,000 HP will be powered by two main transformers. These transformers should be provided with sensors that indicate the transformer condition. Less serious conditions such as high temperature and low oil level should be alarmed to the master control at the water treatment facility. More serious conditions such as sudden pressure or pressure relief should be provided with lockout relays, which will trip appropriate functions within the lift station. Where two full-size transformers are provided, it shall not be necessary to trip the entire station, only those pumps served from the faulted transformer. Other electrical problems such as under voltage, overcurrent, and under frequency can be sensed by either motor or feeder protection relays. The protection relays should be programmed to protect their specific pieces of equipment.

13.0 Communications

The Consultant shall refer to the SCADA DEGs, Section 10 Communication Criteria for communication requirements.

14.0 Construction and Project Completion

14.1 Submittals

The Developer/Applicant shall obtain bids from contractors that have been pre-qualified by the Aurora Water Department. The Developer/Applicant should recommend the contractor for approval by contacting Aurora Water staff during the selection process. Furthermore, a Critical Infrastructure Permit is required to be executed by the Developer/Applicant and the pre-qualified contractor prior to commencement of work.

Once a Contractor has been selected, the Consultant shall include the City in the pre-construction meeting and provide an overall construction schedule with the following milestones identified:

- Submittal Reviews (for the main components: pumps and motors, valves, PLC, I&C components, etc.)
- Programming Workshop
- Procurement
- Mobilization
- Factory Acceptance Testing (FAT)
- Site Acceptance Testing (SAT)

During the construction phase, the Consultant shall provide the City of copies of all Requests for Information (RFIs), Field Orders, and Work Change Directives, etc. pertaining to the lift station. See Appendix C for a checklist of necessary submittals.

14.2 Operation and Maintenance Manual

Consultant to provide the City with electronic and three hard copies of the compiled Operation and Maintenance Manual including system operating descriptions, as-built plans, catalog cuts, installation instructions, maintenance instructions, and replacement part(s) list for all control systems and equipment. Provide address and telephone number of local sources for parts and maintenance. See Appendix C for a checklist of necessary submittals.

14.3 Spare Parts

The Consultant shall coordinate with the contractor to provide the City with the necessary spare parts. Appendix B has a complete list of required spare parts. A draft spare parts list shall be supplied to the City for review and approval.

14.4 Record Documents

The final version of all shop plans, including O&M Manuals, PLC schematics, Network layout (where applicable), PIDs, instrumentation wiring diagrams and panel layout, shall be submitted to the City in hard copy and electronic format. PLC, OIT, and HMI documentation shall include programming and graphics in accordance with City of Aurora SCADA DEGs, latest edition. See City of Aurora SCADA DEGs for specific requirements regarding control system design documents.

In addition to Lift Station construction record plans, the contractor shall be required to maintain a complete set of Record Electrical Plans at the site with all changes, etc., marked neatly thereon in a contrasting color. This set shall not be used for any other purpose. The plans shall always be kept current and present them to the Engineer upon completion of work. Record electrical plans should provide the following information:

1. Correct plan location of equipment installed.
2. One-line diagram and panelboard corrections.
3. Detail wiring diagram of all electrical equipment installed. Diagrams shall show the size and color of the wire, wire number (if used), and terminal block number (if used).
4. The manufacturer's catalog number or part numbers shall be included for all equipment installed.

This information shall be incorporated in a neatly drafted and legible format as part of the operating and maintenance manual. Record documents shall be submitted to waterengineering@auroragov.org along with the checklist found in Appendix C.

14.5 Asset Intake Form

The purpose of the vertical asset intake form is to ensure that all new qualifying assets are added to Aurora Water's Computerized Maintenance Management System (CMMS). This process also ensures that all removed, rehabilitated, replaced or abandoned assets are updated in the CMMS system appropriately after work is performed. Once the nameplate information is complete, the Consultant shall email waterengineering@auroragov.org for a link to the online asset intake form.

The form shall be filled in for each pump, isolation valve, VFD, ATS, etc. Please note, before the form can be completed a picture of the installed asset will need to be uploaded as well.

15.0 References

1. Sanks, R. L., Tchobanoglous, G., Bosserman, B. E., & Jones, G. M. (1998). Pumping Station Design (2nd Ed.). Boston: Butterworths.
2. United States, City of Phoenix Water Services Department. (2012). Wastewater Lift Station Design Guidance Manual (pp. 2-5). Phoenix, AZ.
3. United States, San Antonio Water System (SAWS), Operations & Maintenance Engineering Lift Station Maintenance Instrumentation and Controls. (2012). Lift Station Design & Construction Guidelines (pp. 18-19). San Antonio, TX: SAWS.
4. CDPHE, Design Criteria for Domestic Wastewater Treatment Works also known as Policy WPC-DR-1

APPENDIX A – Applicable Design Standards and Codes

Specific regulatory requirements associated with wastewater lift station design include the following list. All referenced standards and codes shall be the latest edition.

1) CDPHE
   a) Application for Site Approval for Construction or Expansion of Lift Stations and Interceptor Sewers
   b) Permit Guidelines

2) MWRD
   a) Rules and Regulations

3) City of Aurora
   a) Standards and Specifications for Water, Sanitary Sewer and Storm Drainage Infrastructure
   b) City of Aurora Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities Manual
   c) Roadway Design and Construction Specifications
   d) SCADA Design and Engineering Guidelines
   e) Electrical Design and Engineering Guidelines

4) Other relevant codes and standards for the design of wastewater lift stations include:
   a) AASAS
   b) ACI 318, Building Code Requirements for Reinforced Concrete
   c) ACI 350, Code Requirements for Environmental Engineering Concrete Structures
   d) ACI 350.3 Seismic Design of Liquid Containing Concrete Structures
   e) ACI 531, Building Code Requirements for Concrete Masonry Structures
   f) ACI 531.1 Specifications for Masonry Structures
   g) AISC, Steel Construction Manual
      i) AISC-S-326 American Institute of Steel Construction, Specifications for the Design, Fabrication, and Erection of Structural Steel for Buildings
   h) AITC Timber Construction Manual
   i) ANSI
   j) ASCE 7 Minimum Design Loads for Buildings and Other Structures
   k) ASHRAE
   l) ASME
   m) AWS
   n) Applicable requirements of the BIA
   o) CRSI Handbook
   p) Design of Wastewater and Stormwater Lift Stations, Manual of Practice FD-4, Water Environment Federation
   q) HIS
   r) IBC International Building Code.
   s) ISA
   t) IEEE
   u) IMC
   v) IPC

w) Local Building and Applicable Design Codes
x) NEMA
y) NEC
z) NFPA, 101, Life Safety Code
aa) NFPA 70E, Standard for Electrical Safety in the Workplace (Arc Flash)
bb) NFPA 820, Recommended Practice for Fire Protection in Wastewater Treatment and Collection Facilities
cc) NSF Standard 61 Drinking Water System Components and Materials
dd) OSHA
ee) Roark's Formulas for McGraw-Hill Professional; 7th edition (Sept. 13, 2001)
ff) Standard Building Code by the Southern Building Code Congress
gg) Stress and Strain by Warren Young, Richard Budyras
hh) USBR Engineering Monograph #27, Moments and Reactions for Rectangular Plates
ii) USBR Concrete Manual

APPENDIX B – Required Spare Part List

Please see Section 14.3 for spare parts requirements.

Pumps

Example – If 4 pumps are in the project then 4 of each item will be in the spare parts list. A complete rotating assembly can be substituted in leu of individual parts; impeller, wear plate/ring, all bearings, but gaskets will need to be included.

- Impeller; 1 per each pump supplied
- Wear plate/ring; 1 per each pump supplied
- All Bearings; 1 per each pump supplied
- Any gaskets, if gaskets are used as clearance shims, then any sizes available need to be included
- If applicable, flappers, pressure blow-off valve, assorted O-rings for assembly, oil reservoir and associated pipe/hoses, belts, air compressor (GR)
- Spare shafts and/or rotating assemblies; 1 per each pump supplied
- Mechanical seals/packing; 1 per each pump supplied
- Replacement springs for check valves; 1 per each check valve supplied
- Replacement check valve seats and installation hardware; 1 per each valve supplied
- 1 bearing housing per 2 pumps supplied, depending on the type of pump supplied
- 1 volute per 2 pumps supplied, depending on the type of pump supplied

If the site has ***submersible pumps***, 1 complete pump including installation hardware and electrical components will need to be included in the spare parts. If the site has 4 or more pumps, then 2 spare complete pumps and hardware/electrical components will be needed.

Motors

If the site has only 2 pumps, then 1 spare motor will need to be included in addition to the appropriate pump parts.

Air Vacs

- Complete spare units; ex. If there are 6 units on the force main, then 3 complete units are required. Provide half of the total amount of air vacs.
- Rebuild kits supplied should be half of the total amount of units located on the force main.

APPENDIX C – Submittal Checklists

Conceptual Design Report (CDR) – 30% Design Point

- CDR
    - Operation Plan
    - Address operation access and maintenance
    - Design calculations,
        - Pump sizing
        - Forcemain sizing
    - Preliminary control narrative and descriptions,
    - Preliminary equipment sizing,
    - Project phasing plan,
    - Identification of all required easements, licenses, rights-of-way, etc.
    - Anticipated list of plans and specifications (by discipline)
- Conceptual site layout,
    - Dimensions between structures.
    - Distances from structures to property lines.
    - Building elevations
    - Location of all underground piping and utilities, existing and proposed.
    - Location of overhead obstructions, such as power lines or trees.
    - Limits of paving.
    - Existing ground elevations.
    - Location of fencing and gates.
    - North arrow.
    - Direction of prevailing winds.
    - 25-year and 100-year flood elevations.
    - Landscape and irrigation plan
    - Force main alignment,

Preliminary Design Report (PDR) – 60% Design Point

- Response log addressing comments from CDR
- PDR
    - Discuss safety and maintenance provisions
    - Design parameters calculated in the hydraulic analysis
    - Preliminary pump flow rates (initial and build-out flows)
    - Preliminary system curve
    - Preliminary manufacturer's pump curves for initial and future flows
    - Minimum and maximum flow velocities through the system piping
    - Maximum allowable pump shutoff head
    - Hydraulic grade line (see Section 2.1)
    - Pipe class rating (see Section 2.1)
    - Frictional head loss calculations (see Section 2.1)
    - Surge analysis report (see Section 2.2)
    - Buoyance Calculations (see Section 8.1.4)
    - Force main average flush time analysis (see Section 9.2)
    - SCADA and Electrical (see SCADA DEGs and Electrical DEGs)

        - Instrumentation and Controls, SCADA compatibility, PLS/OIT program specifics
        - Findings from a Short Circuit and Arc Flash study for each lift station
        - Radio Path Communication Study
        - Cathodic Protection Study
    - Specifications (list by disciple)
    - Other pertinent engineering data developed for the design

- Plans
    - Site plans
    - Landscaping plans
    - Civil and electrical site plans
    - Civil, structural, mechanical, and electrical details
    - Grading and drainage plan
    - Force main alignment plan and profile
    - Completed wet well plan and sections
    - Odor control layout and preliminary details
    - Preliminary single line diagram
    - Preliminary control schematics
    - Completed pipe and instrumentation diagrams
    - Preliminary terminal strip plans
    - Preliminary Stormwater Management Plan
    - Preliminary Hydraulic Gradeline profile
- Specifications

Final Design Report (FDR) – 90% Design Point

- Response log addressing comments from PDR
- FDR (stamped by PE)
- 90% pre-final construction plans
    - General Notes (include the following at a minimum):
        - wet well dimensions and volume,
        - pump capacity and horsepower,
        - dual force main length and diameter,
        - force main pressure testing parameters (test pressure, duration, allowable drop, etc)
        - odor control type and capacity,
        - generator size
    - Site
    - Civil
    - Process/Mechanical
    - Electrical
    - Instrumentation and control,
    - Architectural,
    - Structural,
    - Landscaping plans, and
    - Details
- Pump manufacturer's written statement indicating the proposed arrangement is acceptable to them for the full range of flows that the pumping system will be handling.

- Specifications
- Formally submitted to the City for a Civil Plans Review

100% plans and specifications

- Plans (stamped by PE)
- Specifications (stamped by PE)
- Approved CDPHE Site Application Submittal
- Documentation showing City of Aurora building department submittal
- Formally submitted to the City Building Department

Construction Submittals

- Construction Submittals
- Construction RFIs, Field Orders, and Work Change Directives, etc.
- As-Built drawings (3 hard copies and 1 electronic copy) including the following
    - Site Plans
    - PLC schematics,
    - Network layout (where applicable),
    - PIDs
    - Instrumentation wiring diagrams and panel layout documentation
    - PLC documentation
    - OIT documentation
    - HMI documentation
- Spare Parts List
- Spare Parts
- O&M Manuals
- Asset Intake Form