Preliminary Design Report

Lift Station 66 Refurbishment

Phoenix, Arizona

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Engineer's Certification

I hereby certify that this Preliminary Design Report for the rehabilitation of Lift Station 66 was prepared by Garver under my direct supervision for the City of Phoenix.

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List of Acronyms

APS	Arizona Public Service (Electricity Provider)
ARV	Air Release Valve
CCWRP	Cave Creek Water Reclamation Plan
HVAC	Heating, Ventilation, and Air Conditioning
LS66	Lift Station 66
MGD	Million Gallons per Day
MOPO	Maintenance of Plant Operations
OPCC	Opinion of Probable Construction Cost
PLC	Programmable Logic Controller
PSV	Pressure Sustaining Valves
SCADA	Supervisory Control and Data Acquisition
TVSS	Transient Voltage Surge Suppressants
VFD	Variable Frequency Drive

1.0 Introduction

The City of Phoenix has partnered with Garver to design refurbishments to Lift Station 66 (LS66). LS66 Refurbishment Project (Project) site is stationed south of the Anthem development in the City of Phoenix, Arizona at 30101 N. Black Canyon Highway and east of Interstate 17 (I-17). The purpose of this report is to present recommended improvements for the LS66 Refurbishment Project.

LS66 was initially designed to convey collected wastewater from the northern region of the City to Cave Creek Water Reclamation Plant (CCWRP), however, operation of the CCWRP has been limited due to reduced flows in the service area. As such, the majority of the sewer load intended for CCWRP is bypassed around LS66 and directed to the 91st Avenue Wastewater Treatment Plant instead. LS66 currently only receives flow from the adjacent City of Phoenix Waste Transfer Facility. The practice of bypassing LS66 is a necessary optional decision but contributes to high hydraulic retention times (HRTs) in the lift station wet well and increased odors.

LS66 is equipped with a split wet well, designed for two submersible pumps on each side. Three submersible pumps are installed in three of four available pump bays and are currently in good working order. The pumping capacity is 8.0 million gallons per day (MGD) per pump with a firm pumping capacity of 16 MGD, which exceeds current capacity needs. Historical flow data provided by the City of Phoenix, the existing flows are minimal and average approximately 0.1 MGD. There are plans to construct the West Anthem Lift Station (LS76) that will discharge to LS66. Phase 1 flows are 0.50 MGD per a report provided to Garver, “Lift Station No. 76 Design Report” by Stanley Consultants, dated January 2019. Depending on the timing of this project, the expected average flows are 0.1 MGD to 0.5 MGD. The LS66 Refurbishment will provide a firm capacity of 16 MGD.

The City of Phoenix will begin sending additional flow to LS66 soon and has decided to keep the existing pumps in place because they are in adequate operating condition, but the existing forcemains may be in poor condition. Per the City’s request, discharge piping improvements will be expedited and completed prior to the pump replacement. Replacing these elements sooner than the pumps allows the City to have the operational flexibility that this project will provide in place once LS66 begins receiving additional flow from the Anthem LS.

1.1 Objectives

The City of Phoenix contracted with Garver to design improvements to the entire facility, including the replacement of the existing pumps, discharge lines, valves, fittings, odor control system, and improvements to the electrical building to mitigate water infiltration. The City’s objective for the LS 66 Refurbishment Project are as follows:

1. Provide site improvements including erosion control surrounding the electrical building, pavement improvements, and additional lights in the facility.
2. Demolition of existing submersible pumps, piping, supports, and valves.
3. New submersible pumps.

4. Upgrade discharge piping to provide operational flexibility of the dual forcemains as well as provide surge mitigation.
5. Incorporate a bypass connection between the two discharge headers.
6. Demolition of a portion of the existing chemical odor control facilities.
7. Provide a new buried biofilter.
8. Concrete slab rehabilitation.
9. Electrical building improvements including wall sealings for HVAC ducts, door sealing replacements to mitigate water infiltration, and demolition of the fire sprinkler system.

The existing conditions, proposed equipment, hydraulic analysis, proposed improvements as well as opinion of probable construction cost (OPCC) are presented in this pre-design report (PDR).

2.0 Existing Site Conditions

The LS66 site consists of the lift station, chemical odor control facility, electrical building, and emergency generator. The dual-chambered wet well contains three submersible pumps and space for a fourth pump. All pumps discharge into a common 24-inch diameter header, which subsequently splits between two 24-inch diameter force mains (with space available for a future third force main). The odor control facility currently has an aboveground chemical odor control system installed along with bulk storage for sodium hypochlorite, sodium hydroxide, and calcium nitrate.

2.1 Site Layout

Minor site improvements are proposed with this project, including grading around the electrical building, pavement and lighting improvements, and discharge piping improvements. Figure 2-1 shows the proposed site plan.

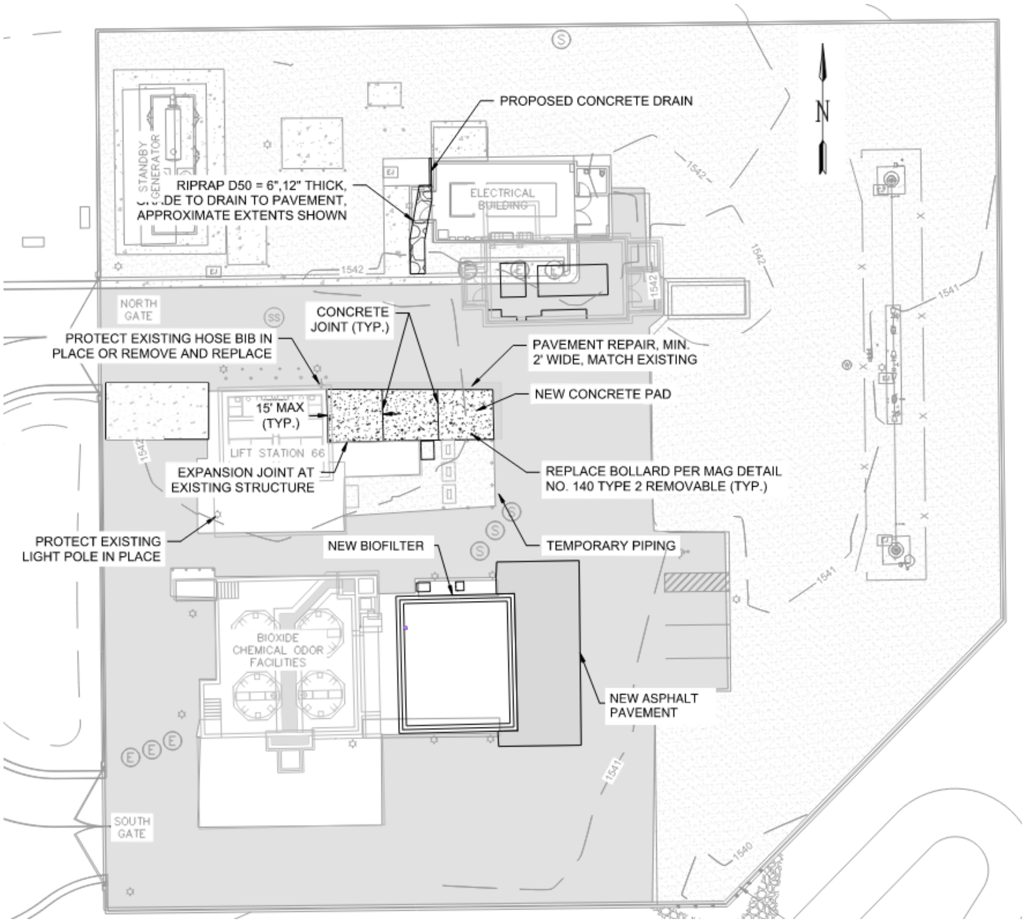


Figure 2-1: LS66 Proposed Site Improvements Plan

3.0 Hydraulic Analysis

A hydraulic analysis was conducted to evaluate performance of the current pumps at LS66, assess system curves under a variety of scenarios, and provide guidance for sizing of the replacement pumps. The hydraulic analysis included the development of a steady-state model and evaluation of pump curves against model output and City of Phoenix design criteria.

3.1 Hydraulic Model

The hydraulic model was created in WaterGEMS and was developed from record drawings of LS66 and force mains. The pipe profile developed from the record drawings and used in the model is shown in Figure 3-1. This figure also includes locations of air release valves (ARVs). The high point of the dual force mains occurs approximately 42,000 feet downstream of the pumps and is at an elevation of 1,600 feet.

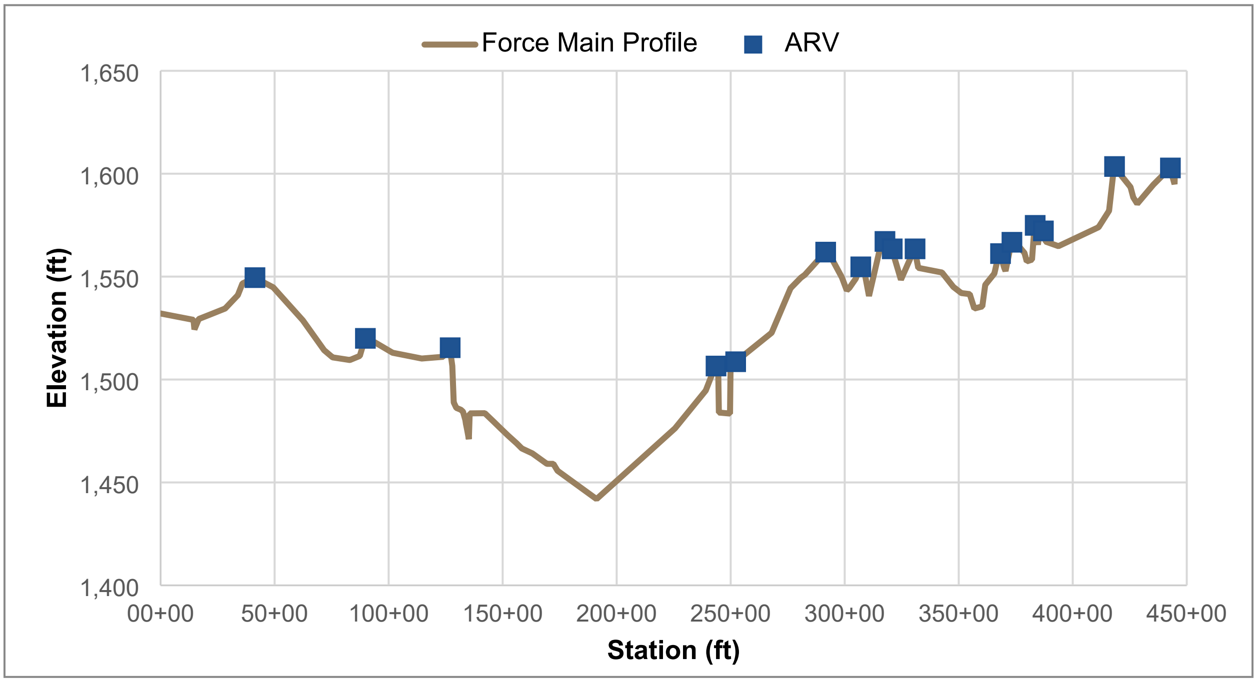


Figure 3-1: Lift Station 66 Force Main Profile

In the model, ARVs are represented as Pressure Sustaining Valves with a pressure setting of 1 psi. This ensures that the modeled force mains will not experience negative pressure in the length of pipe upstream of the force main high point during steady-state conditions. However, given the profile of the LS66 force main, which has the highest elevations towards the end of the force main, full pipe flow conditions should exist up to the last ARV during normal operations.

The initial model set up includes a tank with the water level set to the "all pumps off" set point (representing the LS66 wet well), three lift station pumps downstream of the tank, two 24-inch force mains, ARVs at force main local high points, and a reservoir representing the force main outfall. A schematic of this configuration is shown in Figure 3-2.

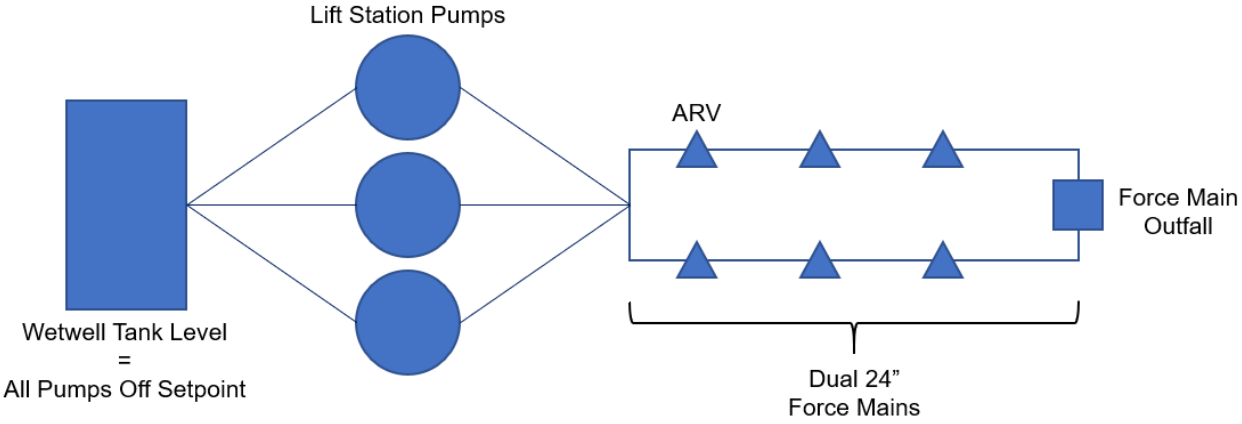


Figure 3-2: Model Configuration

The lift station pump curves were taken from the existing pumps, which are Flygt model 3312.875 pumps. The existing pump curve and best efficiency point (BEP) data from pump testing conducted in 2004 is shown in Figure 3-3.

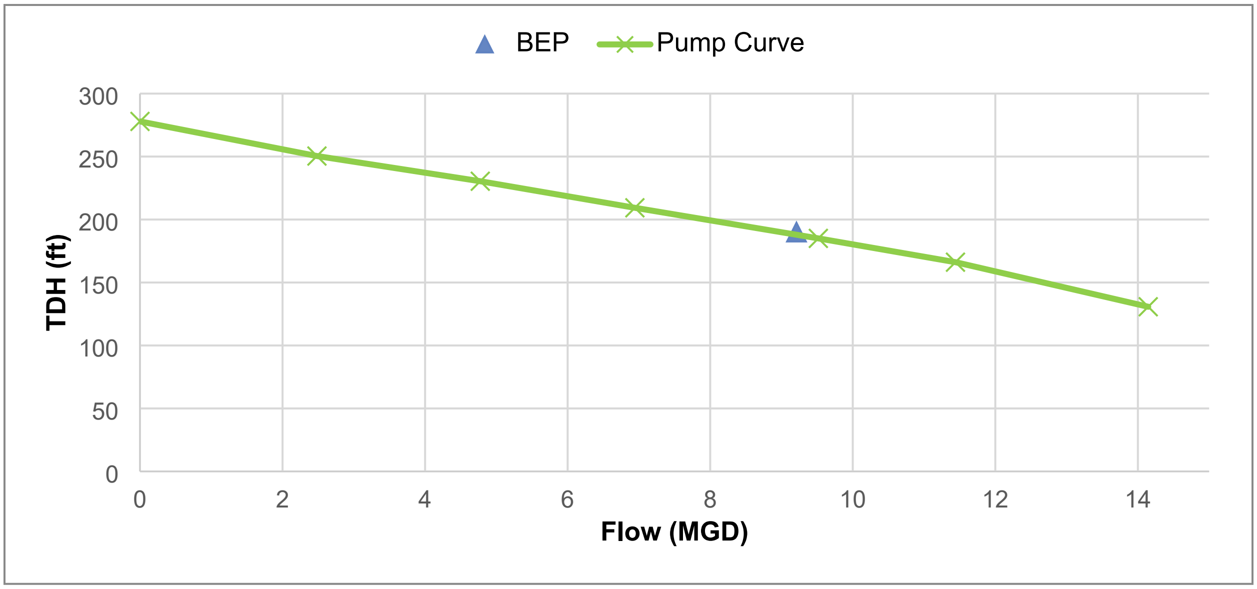


Figure 3-3: Existing Pump Curve

Steady state simulations were completed on this model for a variety of scenarios, which are summarized in Table 3-1. The modeling scenarios evaluate the system (1) with a single existing force main operating and (2) with both existing force mains operating. For each of these force main infrastructure alternatives, the model was also run with the force main having a Hazen-Williams Coefficient (C-Factor) of 110 and 130. This was intended to encompass the range of friction losses that could be occurring in the force mains. The force mains are primarily cement-lined ductile iron, with a small section of glass-fiber-reinforced plastic pipe. The typical C-Factor for a cement lined ductile iron pipe is 120. In the absence of actual flow and pressure data to calibrate the model, generating system curves for a range of C-Factors provides a viable method to assess pumping alternatives and characterize potential uncertainty in the system.

Table 3-1: Model Scenarios

Scenario	Infrastructure Alternative	Friction Factor Alternative
A	1 Force Main	C-Factor 110
B	1 Force Main	C-Factor 130
C	2 Force Mains	C-Factor 110
D	2 Force Mains	C-Factor 130

The model was run for wet well water level at the “All Pumps Off” set point. However, during results analysis, system curves were scaled up to represent conditions for a variety of wet well operating ranges. These wet well levels are summarized in Table 3-2.

Table 3-2: Evaluated Wet Well Operated Levels

Description	Water Level (ft)
All Pumps Off	1520.0
Lead Pump On	1525.0
Lag Pump 1 On	1528.6
Lag Pump 2 On	1532.0

3.2 Surge Analysis

Garver completed a surge analysis using Bentley HAMMER hydraulic modeling software. The surge model was constructed based on wet well, pump, and force main elevations and configurations from as-builts and the proposed plans. An instantaneously closing check valve was included in the model downstream of each pump.

Pipe wave speeds were assigned to pipe segments based on their known diameter and material. Assumptions were made about the pressure class used for the materials to produce conservative surge model results. Pipe wave speeds for ductile iron with an assumed pressure class of 250 psi were assigned to the first 27,500 LF of the force main, while pipe wave speeds for fiberglass reinforced plastic pipe with an assumed pressure class of 200 psi and stiffness class of 72 psi were assigned to approximately 14,000 LF of the remaining force main. The force mains were modeled throughout their entire extent. Existing air valves were assumed to be combination air valves without surge suppression features. Vacuum relief valves were not modeled at the lift station.

During normal operations, up to two pumps will discharge into one of the 24-inch force mains. Thus, the surge model was used to evaluate the effects of rapid pump shutdown within a single 24-inch force main during two-pump shutdown.

Figure 3-4 presents the maximum air/vapor volume and hydraulic grade line (HGL) results along the force main during rapid two-pump shutdown. The maximum air/vapor volume is shown as a red line in the top portion of Figure 3-4, and the HGL results are in the lower portion of Figure 3-4 with the following lines:

- Maximum HGL – red line
- Initial HGL before system change resulting in the transient condition – black line
- Minimum HGL – blue line
- Top of pipe elevation of the force main – green line

The following conclusions can be drawn based on the surge model results:

- The system is anticipated to experience minimal surge responses during emergency two-pump shutdown. This is indicated by the minimal increase in hydraulic grade from the initial HGL to the maximum HGL.
- Negative gauge pressure conditions are likely to occur at the lift station during emergency two-pump shutdown, as indicated by the minimum HGL being below the top of the pipe.
- There is a potential for vacuum conditions to occur in the farthest downstream extents of the force main near the gravity discharge point as indicated by the minimum HGL being below the top of the pipe resulting in minimum pressures at or below vacuum conditions for water. These conditions are not anticipated to be sustained for extended periods of time based on surge model

results. Figure 3-5 represents the HGL (blue line), flow (red line), and air/vapor volume (green line) near the gravity discharge point over time following the two-pump shutdown. From this figure, the HGL is below the top of the pipe (1,605 ft) for momentary periods.

- Figure 3-6 presents the HGL in the discharge lines at the lift station over time following the two-pump shutdown. At a simulation time of approximately 160 seconds, it appears the surge wave reached the lift station and did not exceed operating pressures in the force main during normal two-pump operations.
- There is a potential for air valve slam to occur at the first intermediate high point located approximately 4,200 LF downstream of the lift station. The surge model predicts a minor valve slam occurring at this location during emergency two-pump shutdown. Based on maximum HGL results in Figure 3-4, this predicted air valve slam does not lead to excessive pressures throughout the system.
- The maximum operating pressure in a single force main while two pumps are operating are approximately 110 psi in the section of pipe that is ductile iron and approximately 49 psi through the section pipe that is fiberglass reinforced plastic. The pressure classes of both materials should be confirmed to ensure that the force main is able to operate under these maximum operating conditions. If the pressure classes are adequate for the operating pressures, it is not anticipated that maximum surge pressures will exceed surge allowances based on typical surge allowances for these materials.

Based on the conclusions from surge model results summarized above, the following improvements are recommended to mitigate surge effects throughout this system:

- Combination air valves sized for normal operation be installed on both discharge headers. Following an iterative evaluation of air valve sizes at the lift station and the results with no air valves at the lift station, the air valves do not need to be oversized for significant vacuum relief to mitigate surge effects following a power failure.
- Surge relief valves be provided on both discharge headers to mitigate the risk of surge effects from rapid pump shutdown in the event of a power outage. It is recommended to that pressure relief valves sized to convey a maximum surge flow of at least the rated capacity of one of the force mains, which is 9.5 MGD. It is not likely these valves will be activated following a power failure because the surge wave during two-pump shutdown did not result in pressure spikes higher than operating pressures in the hydraulic model. These valves will provide additional protection for the lift station and force main in case of abnormal operations, such as one of the automated valves closing while the pumps are operating.
    - Surge anticipator valves were investigated using the surge model and did not provide significant benefit to reducing the surge response resulting from two-pump emergency shutdown. Based on surge model results, the first intermediate high point appeared to dampen most of the reverse wave returning to the lift station from the end of the force main. Furthermore, the first immediate high point appeared to cause the lift station to be hydraulically isolated from the majority of the surge response following emergency two-pump shutdown.

- Garver recommends installing a surge-suppression air valve at the first intermediate high point located approximately 4,200 LF downstream of the lift station or retrofit the existing valve with a surge-suppression device to mitigate the risk of potential air valve slam at this location.

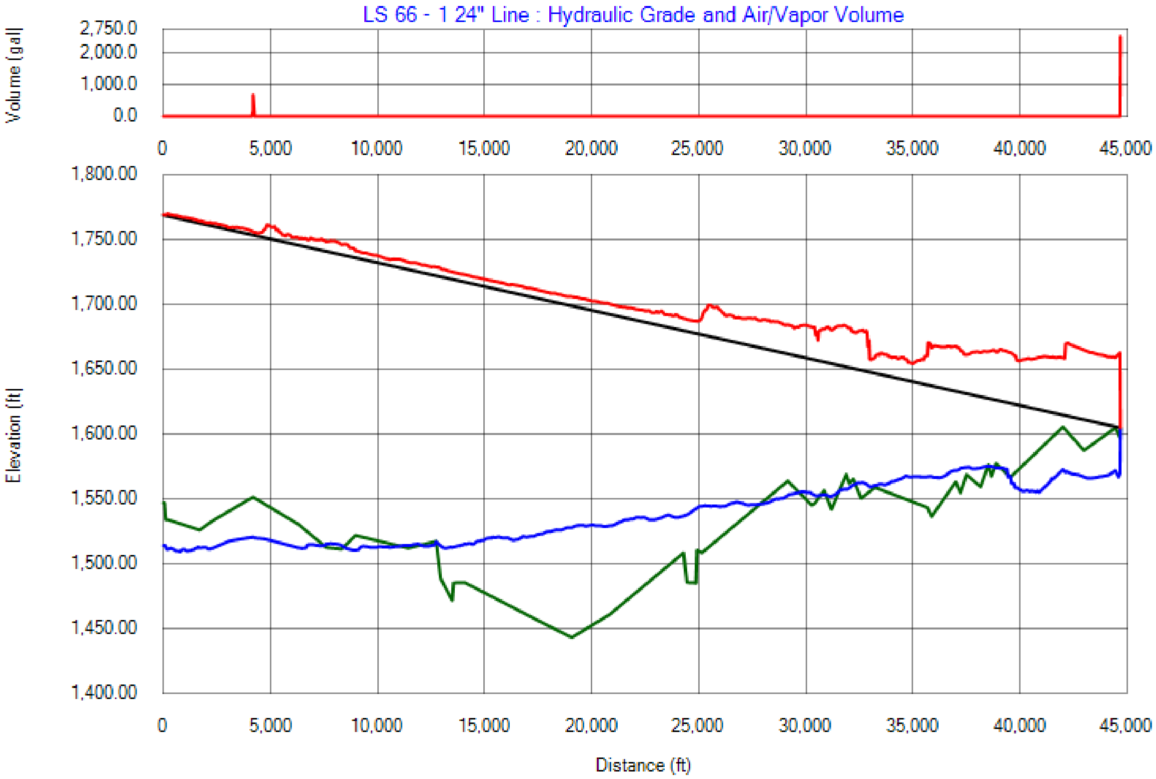


Figure 3-4: Surge Model Results for Emergency Two-pump Shutdown – Minimum and Maximum HGL and Air/Vapor Volume Profile

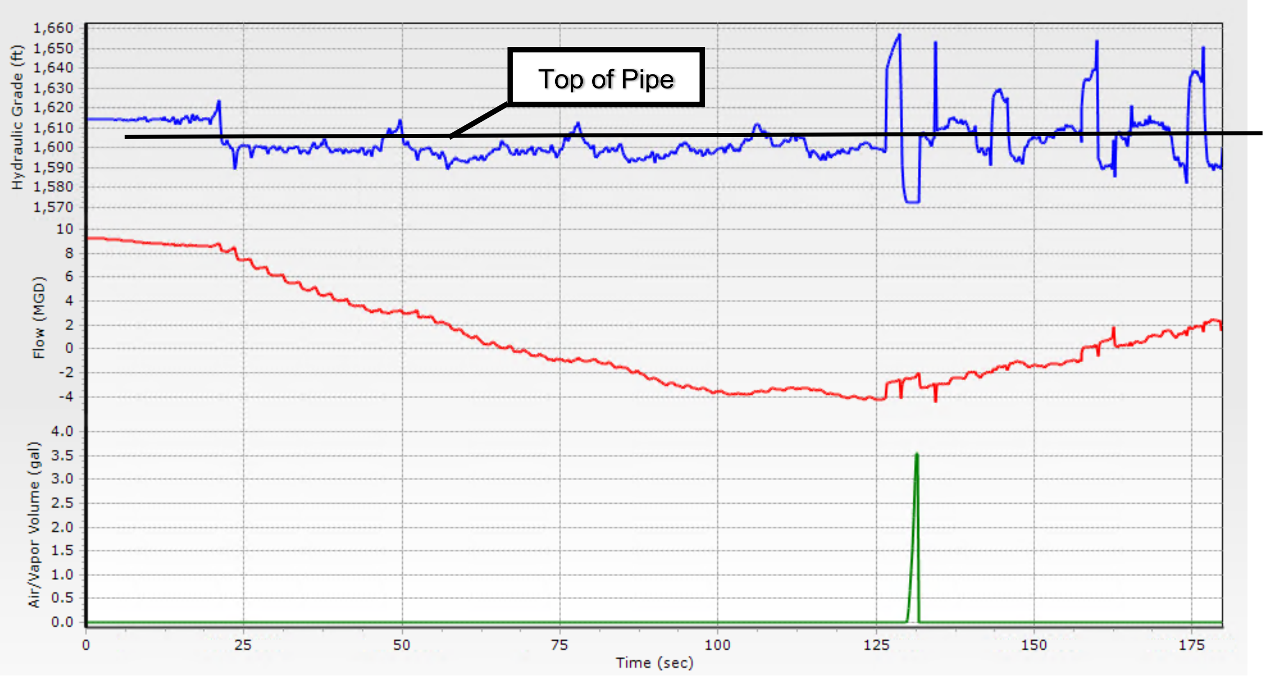


Figure 3-5: Surge Model Results for Emergency Two-pump Shutdown – HGL, Flow, and Air/Vapor Volume Time Series for Lines near the Gravity Discharge Point

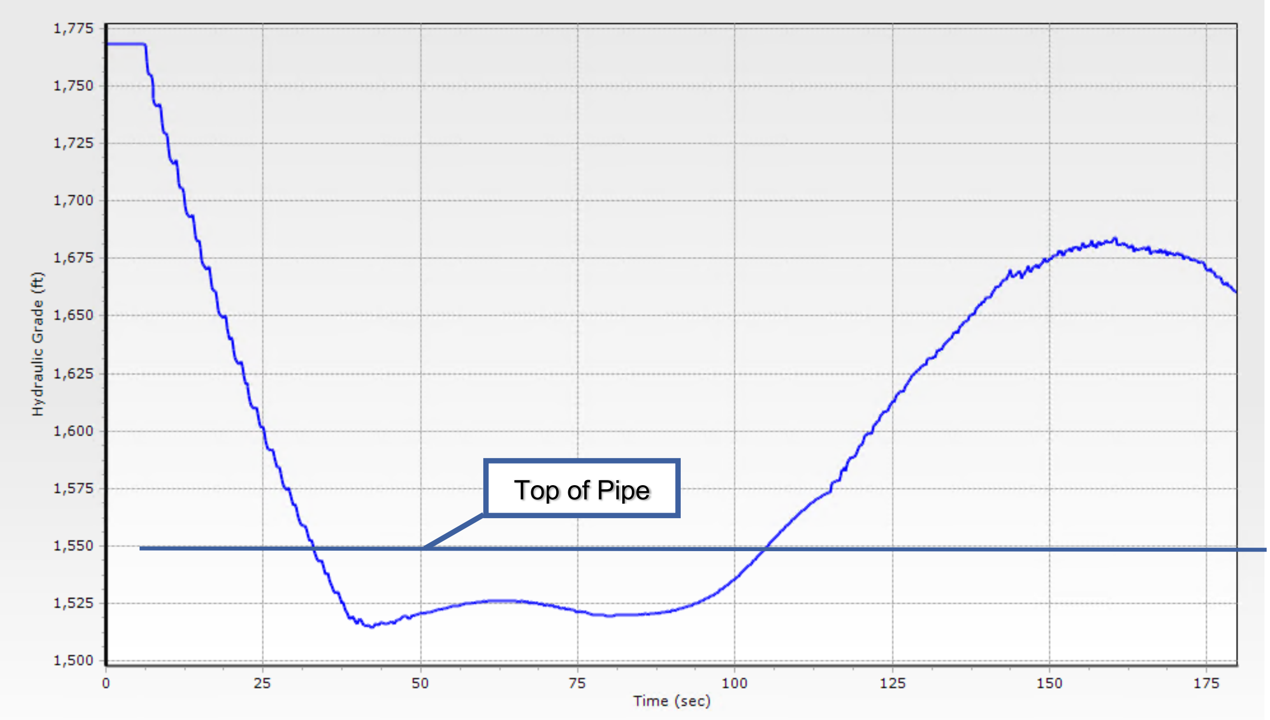


Figure 3-6: Surge Model Results for Emergency Two-pump Shutdown – HGL Time Series for Discharge Piping at the Lift Station

4.0 Hydraulic Design

4.1 Design Criteria

A minimum velocity of 3-fps is to be maintained in the force mains in order to minimize solid deposition, per the City of Phoenix design standards. The minimum flow to maintain 3-fps is 6.1-MGD for a single force main and 12.2 MGD for both force mains while the design firm capacity for the lift station is 16 MGD. A total of four pumps are proposed to provide the design firm capacity of 16 MGD. VFDs will be provided for each pump to provide operational range and flexibility. The design criteria are presented in Table 4-1.

Table 4-1: Pump Design Criteria

Criteria	Design Value
Head Range @ 6.1 MGD	230 to 250 feet
Head Range @ 12.2 MGD	145 to 170 feet
Minimum Turndown	5.5 MGD
Single Pump Design Flow	8.5 MGD
Minimum Efficiency	75%

4.2 Pump Selection and Analysis

The hydraulic model was used to develop system curves for the scenarios displayed previously in Table 3-1. Scenario A (single force main with a lower C-Factor) is the system condition with the highest head for a given flow, whereas Scenario D (both force mains operating with a higher C-Factor) produces the system conditions with the lowest head for a given flow. Several pump manufacturers approved by the City were considered for the replacement pumps. These included Flygt, Ebara, and Fairbanks.

4.2.1 Flygt Pump Selection

The Flygt model NP 3312.866 pump was identified as the best-fit pump offered by Flygt. Figure 4-1 shows the pump curve with the Scenario A and Scenario D system curves to cover the expected range of operations.

During Scenario A (one pump and one force main), this pump could provide 6.5 to 8.0 MGD in the preferred operating region (POR) of the pump. It could be possible to reduce to 4.1 MGD and remain within in the allowable operating region (AOR) of the pump. This pump would provide very good coverage for running one pump through both force mains. It is rated for 470 hp.

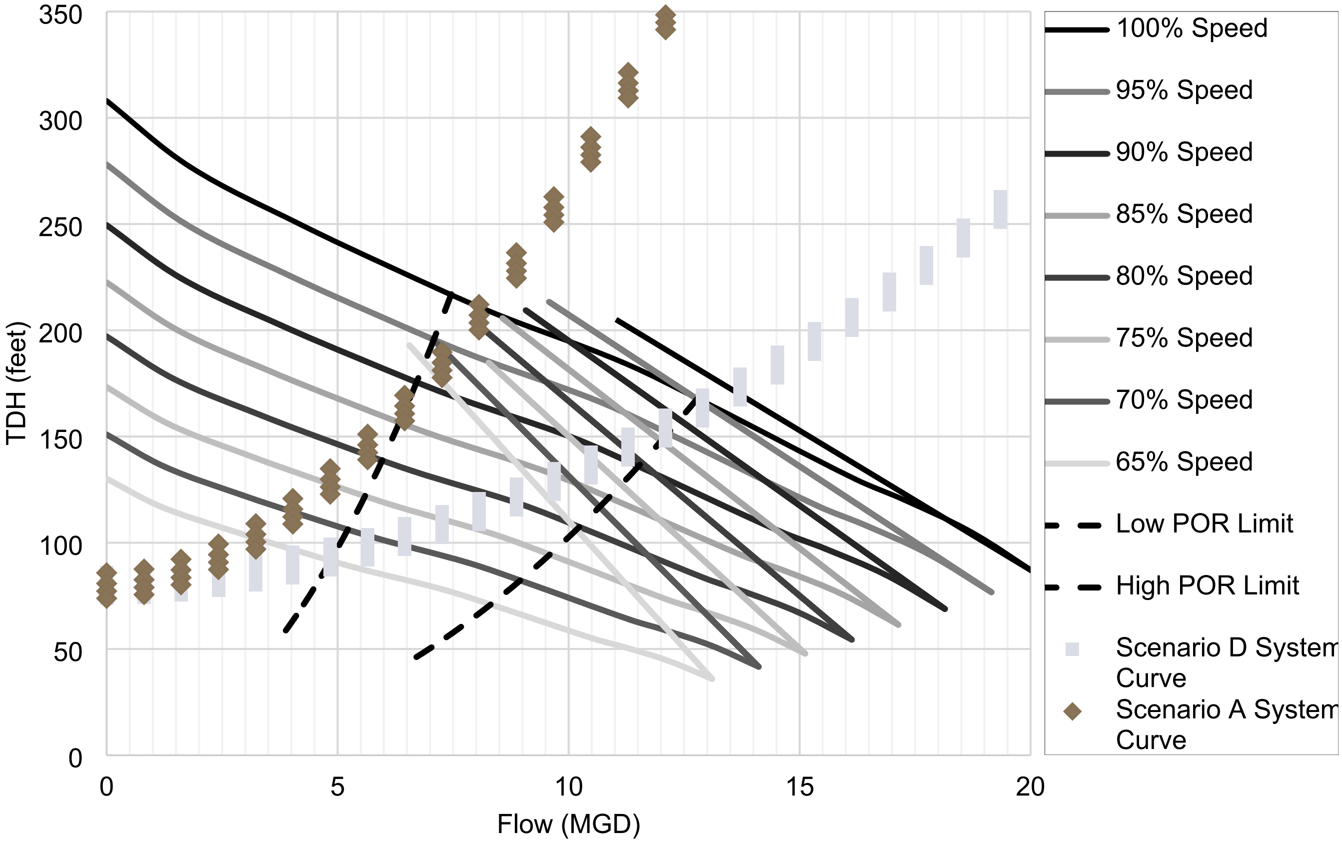


Figure 4-1: Flygt Pump Curve and System Curve with Expected Range of Operations

4.2.2 Ebara Pump Selection

The Ebara model 250DSC3 F1302-1780 pump was identified as the best fit Ebara pump available. Figure 4-2 below shows the pump curve with the Scenario A and Scenario D system curves to cover the expected range of operations.

This pump would allow operations between 4.5 and 8.5 MGD with one pump and one force main. It will also allow 9 to 17 MGD with two pumps running and two force mains. This pump does not provide good coverage for one pump through both force mains. This pump has a minimum recommended motor rating of 422 hp.

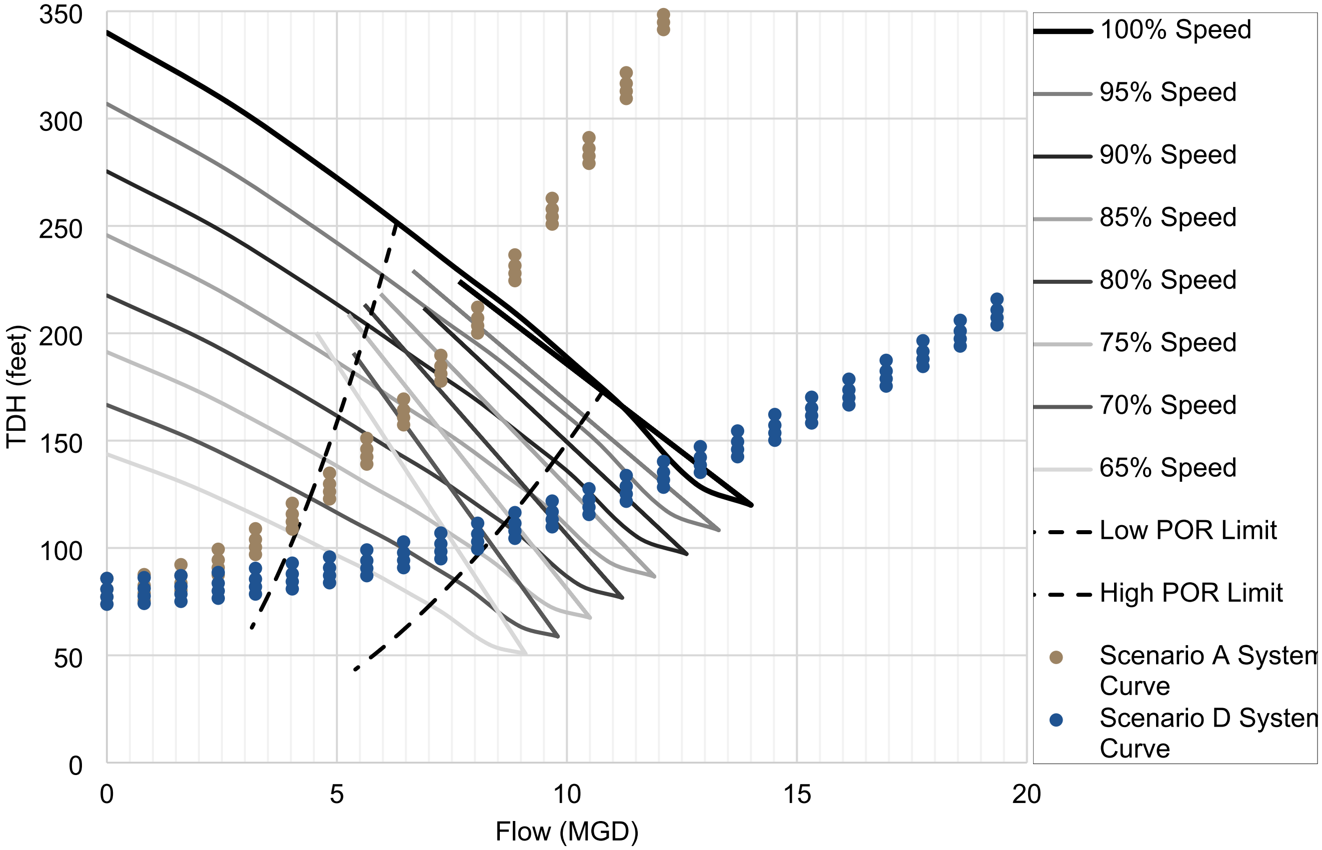


Figure 4-2: Ebara Pump Curve and System Curve with Expected Range of Operations

4.2.3 Fairbanks Pump Selection

Fairbanks does not have a standard pump and motor combination that will cover the design point. There is a possibility that a combination could work but this would not be standard and will require additional coordination with the manufacturer.

4.2.4 Pump Selection Recommendation

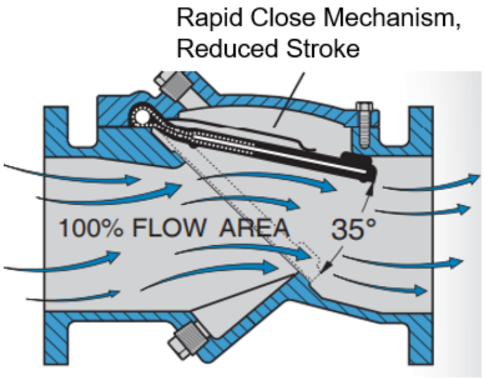
Both the Flygt and Ebara options are a good fit for LS66. The selected Flygt pump is not as efficient at lower flows but provides efficient options running one pump through both force mains. The Ebara pump is more efficient for lower flows and is very efficient at full speed while providing the design flow of 16 MGD with two pumps and both force mains.

During discussions with the City, it was noted that the City must have a contract with a vendor that can perform maintenance on the pumps that are selected. Currently the City has a vendor for Flygt pumps support. Therefore, the pump selection, specifications and drawings will be based on the Flygt pump.

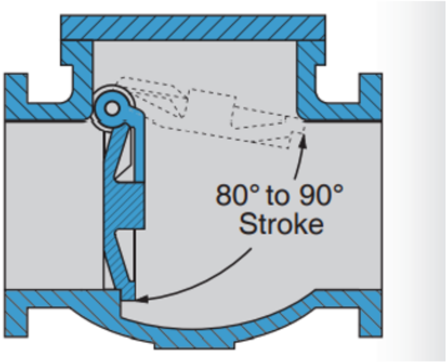
4.3 Check Valve Selection

Check valve options for wastewater service typically entail swing check valves equipped with counterweight, spring and lever, which are capable of passing large solids. A swing check valve operates from opening to closing with a 80-to-90-degree stroke. A common issue with swing check valves is valve slam due to a reverse velocity catching the valve disc and resulting sudden stop of the disc, lever and counterweight. The impact from check valve slam causes excess noise and vibration.

The latest type of swing check valve incorporates non-slam features. These features include flexible action in an increased slope angle of the disc coupled with a shorter stroke of 30 to 35 degrees as well as an elastomer coated disc. The net result is faster closing time. A comparison of a traditional swing check valve with a non-slam type swing check valve is presented in Figure 4-3.



Improved Non-Slam Check Valve Features



Conventional swing Check Valve

Figure 4-3: Comparison of Traditional Swing Check Valve with Non-Slam Type

The deceleration of forward flow is a known parameter that can cause check valve slam. A comparison of the deceleration as well as associated severity of check valve slam from one manufacturer is presented in Figure 4-4.

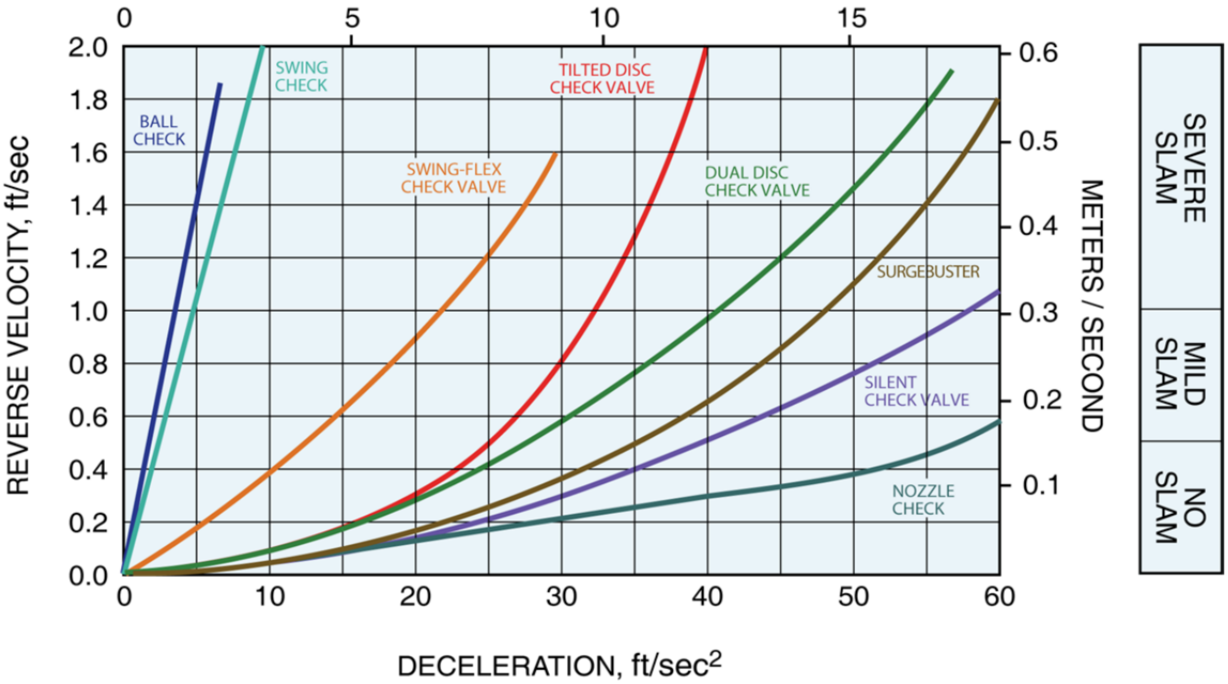


Figure 4-4: Comparison of Check Valve Deceleration and Associated Slam Severity (Courtesy of ValMatic)

It is noted that Figure 4-4 indicates that the lowest potential for check valve slam is associated with the non-slam ‘Swing-Flex’, ‘Silent Check’ and ‘Surgebuster’ models.

Due to the known issues with check valve slam at LS66 as well as potential for surge along the force main described in Section 3.2, it is recommended that non-slam type swing check valves be incorporated into the new facilities.

4.4 Pump Control Strategy

The proposed control strategy for LS66 is shown below.

1. The four pumps will be designated as lead, lag 1, lag 2, and standby.
2. The operator can designate the lead, lag 1, lag 2 and standby status for each pump manually or automatically rotate based on adjustable time interval.
3. Operational controls will be based on wet well levels.
    a. Pumps will turn off at a minimum wet well level.
    b. The lead pump will be turned on at the minimum speed at wet well level 1.
    c. If, after the lead pump is turned on, the wet well level continues to rise, the speed for the lead pump will increase until the wet well level starts decreasing. Once the wet well level stabilizes, the VFD speed will remain constant. If the wet well level starts to reduce, the speed will be reduced until the minimum speed is reached.
    d. If, after the lead pump reaches maximum speed, the wet well level continues to rise, lag 1 pump will be turned on at its minimum speed (and the lead pump will be reduced to minimum speed). Subsequently the speed of all pumps in operation will be increased or decreased similar to the scheme for the lead pump.
    e. If, after the lead pump reaches maximum speed, the wet well level continues to rise, lag 2 pump will be turned on at its minimum speed (and the lead pump and lag 1 pump will be reduced to minimum speed). Subsequently the speed of all pumps in operation will be increased or decreased similar to the scheme for the lead pump.
    f. If any of the lead, lag 1, or lag 2 pumps experiences an alarm or shutdown during operation and the wet well level continues to rise then the standby pump will be turned on at its minimum speed. Subsequently the speed of all pumps in operation will be increased or decreased similar to the scheme for the lead pump.
4. The automated valve between the two discharge headers will be utilized as an open/close arrangement depending on whether the operational conditions dictate the use of a single force main or both force mains. The typical configuration will be for the force mains to operate independently, except the valve will open when both pumps from Wet Well #1 are used as the lead and lag pumps and both pumps are operating.

5.0 Odor Control System Design Criteria

The existing odor control system being used at LS66 is past its useful life and will be replaced. The City of Phoenix has requested the use of a biological odor control system (biofilter) to manage the odor produced by the facility.

Biofilters are structures composed of organic or inorganic media designed to treat foul air by using a blower to move the air through the media. Compared to chemical scrubbers, biofilters typically have lower life cycle costs and can be more aesthetically pleasing, which makes them an attractive alternative. Figure 5-1 shows an example of a typical buried biofilter.

Figure 5-1: Buried Biofilter Example

5.1 Design Criteria

Biofilters are sized based on the desired removal of odors such as hydrogen sulfide. To determine the hydrogen sulfide concentration of constituents of foul air in the wet well, several odor sensors (Detection Instruments Corp. Model Odalog RTx) were deployed in the collection system. Of the Odalogs installed, two were installed at or near LS66.

Figure 5-2 shows the location of the two Odalogs as well as the existing odor control system.

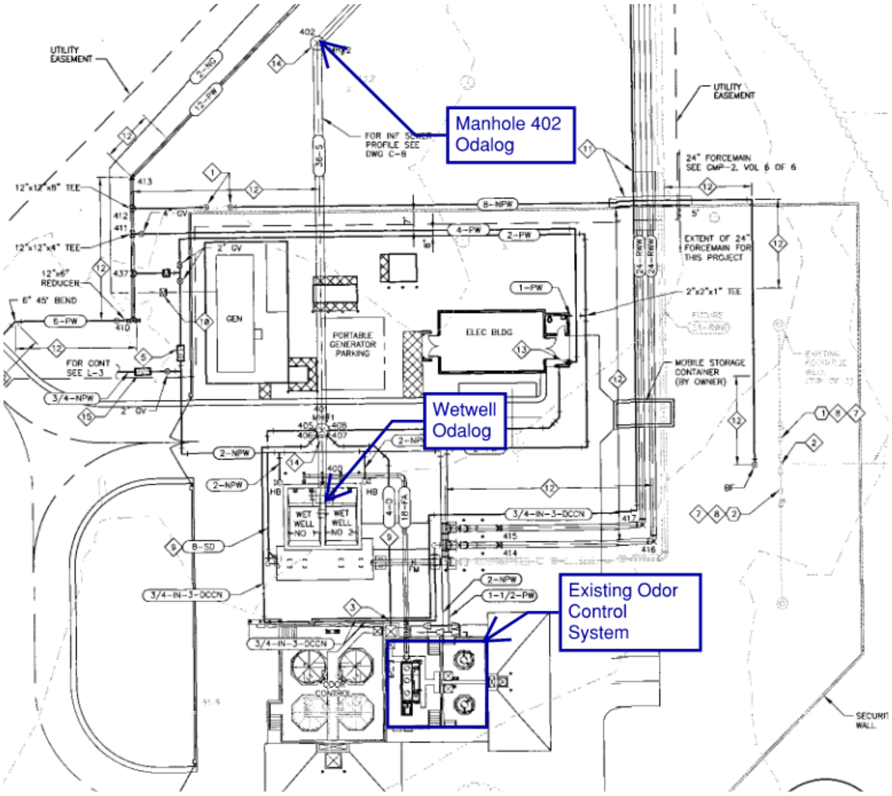


Figure 5-2: Odor Control and Odalog Installation Site Plan

The highest hydrogen sulfide concentrations near the lift station were seen at Manhole 402 instead of at the wet well Odalog. The reason this may be the case is if the existing odor control system was operating at the time of the Odalog installation. Based on the proximity of the manhole to LS66, the concentrations detected at the manhole are the recommended design points. Table 5-1 shows the Odalog concentration data.

Table 5-1: Odalog H_2S Concentration Data

	Wet well	Manhole 402
Minimum, PPM	0.00	0.60
Average, PPM	2.69	23.4
Maximum, PPM	11.0	81.2

A buried biofilter system is proposed which will require demolition of a portion of the existing chemical odor control facilities and containment. The new biofilter will require a nominal 30ft x 35ft footprint with new concrete slab and containment walls. The design criteria used to size the biofilter are shown in Table 5-2.

Table 5-2: Design Criteria for the Biofilter

Parameter	Units	Value
Wet-Well Volume	ft^3	13,500 ft^3
Wet Well Air Changes	Air Changes/Hr	12
Collection Pipe Foul Air Flow	CFM	500
Required Wetwell Airflow	CFM	3,000
Total Foul Airflow	CFM	3,500
Foul Air Temperature	Deg F	50 - 120
Nominal Foul Air Fan Motor Size	HP	7.5
Hydrogen Sulfide Concentration	ppm	10 - 200
% Removal of Hydrogen Sulfide	%	99
Nominal Biofilter Media Depth	in	55
Nominal Biofilter Area	ft^2	924
Nominal Biofilter Footprint	L, ft x W, ft	28 x 33

5.2 Summary of Manufacturers

Currently Garver is considering two manufacturers for the proposed biofilter system: BIOREM and Bohn Biofilter. Both of these manufacturers were recommended by the City of Phoenix and have been installed at other lift stations owned by the City. Each of the manufacturers have proposed buried biofilter systems. A comparison of the two manufacturers is shown in Table 5-3.

Table 5-3: Summary of Biofilter Manufacturers

Description	BIOREM	Bohn Biofilter
Geometry of Biofilter	Rectangular	Rectangular
Nominal Dimensions of Proposed System	Length = 20-ft Width = 20-ft Depth = 10-ft	Length = 30-ft Width = 35ft Depth = 5-ft
Media	1. Engineered biofilter media, provided in skidded bags 2. Plenum zone material	1. Bohn soil media – the filter medium: a blend of sand, soils, and top-soils.
Scope of Supply	1. Grease filter with removable pad 2. Lot media support flooring and air distribution system 3. Rectangular flexible transition piece on fan outlet, flange material of construction to be 304 stainless steel	1. Foul air fan: FRP, with motor, flex-couplers, and discharge transition 2. PE containment liner 3. HDPE biofilter air pipe and fittings

Description	BIOREM	Bohn Biofilter
	4. 5 HP centrifugal FRP exhaust fan rated for 1,350 CFM at 8 inWC with a TEXP motor 5. Schedule 80 PVC manifold with spiral spray nozzles for optimized in-duct humidification 6. Schedule 80 PVC manifold with matched precipitation rate nozzles for optimized coverage of biofilter media 7. Control panel 8. Waterbox 9. Instrumentation and fluid control valves external to waterbox 10. Furnished spares	4. Gravel, air distribution and pipe-bedding material 5. Automated irrigation system: sprinkler type 6. A ten (10) year life-span guarantee of the soil media
Manufacturer Installation	1. Engineering submittal packages 2. Operation and maintenance manuals 3. Two (2) consecutive days (1 trip) for system installation assistance, inspection, and commissioning. 4. One (1) consecutive days (1 trip) for operator training and performance testing. Includes taking four (4) odor samples to be analyzed by a third-party laboratory.	1. On-site construction consultation and start-up assistance 2. Operator training and operation and maintenance manuals 3. Performance test

5.3 Recommendations

Garver recommends a buried biological odor control system be installed at LS66 where the existing chemical odor control system is located. The design will be based on Bohn Biofilter and the odor sampling data collected for LS66.

6.0 Proposed Improvements

Improvements included with this project are outlined in the following sections. Generally, the lift station will be rehabilitated with new pumps, valves, and piping, a second discharge header, and a connection between the headers to provide flexibility. Other improvements include a new biological odor control system, electrical building improvements, and paving and lighting improvements.

6.1 Mechanical Considerations

6.1.1 Lift Station Improvements

The existing lift station has two wet wells with a total of three submersible pumps and space for a fourth pump in the future. The existing pumps currently pump into a common discharge header equipped with a surge protection valve and piping that flows back to the wet well influent manhole. The discharge header can be routed to one or both of two forcemains. South of the common discharge header and lift station there are several electrical panels.

The proposed improvements include:

- Two discharge headers that provide operational flexibility and redundancy.
- A connection between the two headers with an actuated plug valve to provide operational flexibility and enable flow velocity to remain within the recommend range.
- New submersible pumps that will be controlled with individual VFDs.
- Pressure transmitters on each pump discharge line.
- Resilient seated, anti-slam swing check valves on each pump discharge line.
- Actuated plug valves on each pump discharge line.
- Pumped pressure surge protection for each discharge header that is routed back to the wet well influent manhole.
- Removable handrails around the wet well hatch to provide additional safety.
- One flow meter on each discharge header.

Figure 6-1 shows the plan and Figure 6-2 shows the section of the proposed lift station.

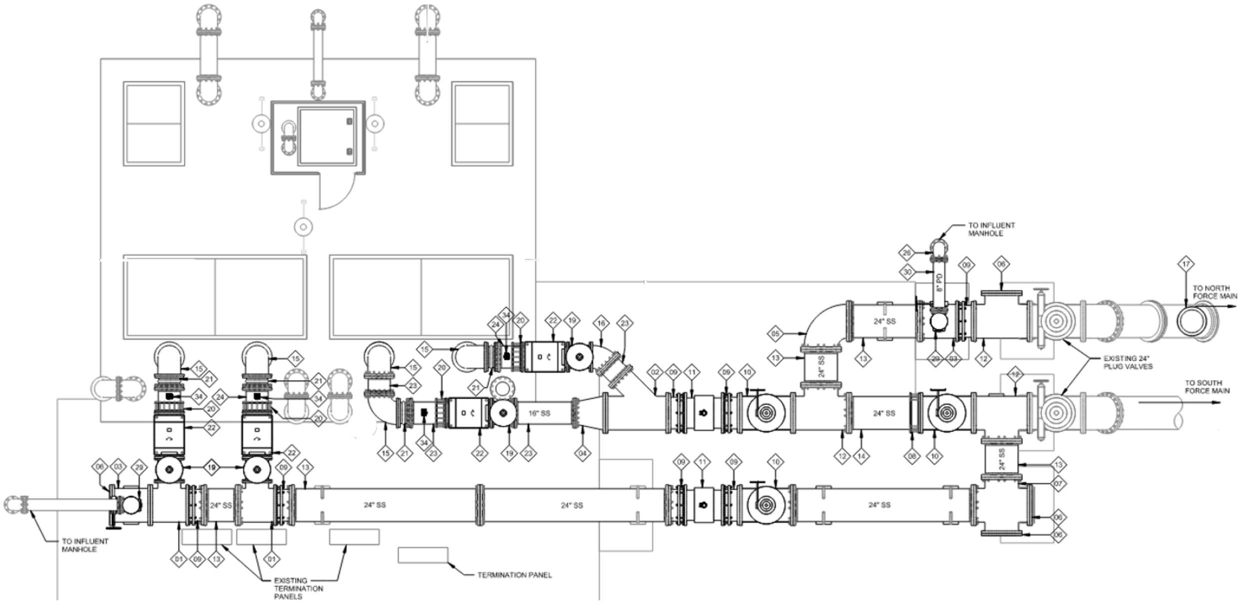


Figure 6-1: Proposed Lift Station 66 Improvements Plan

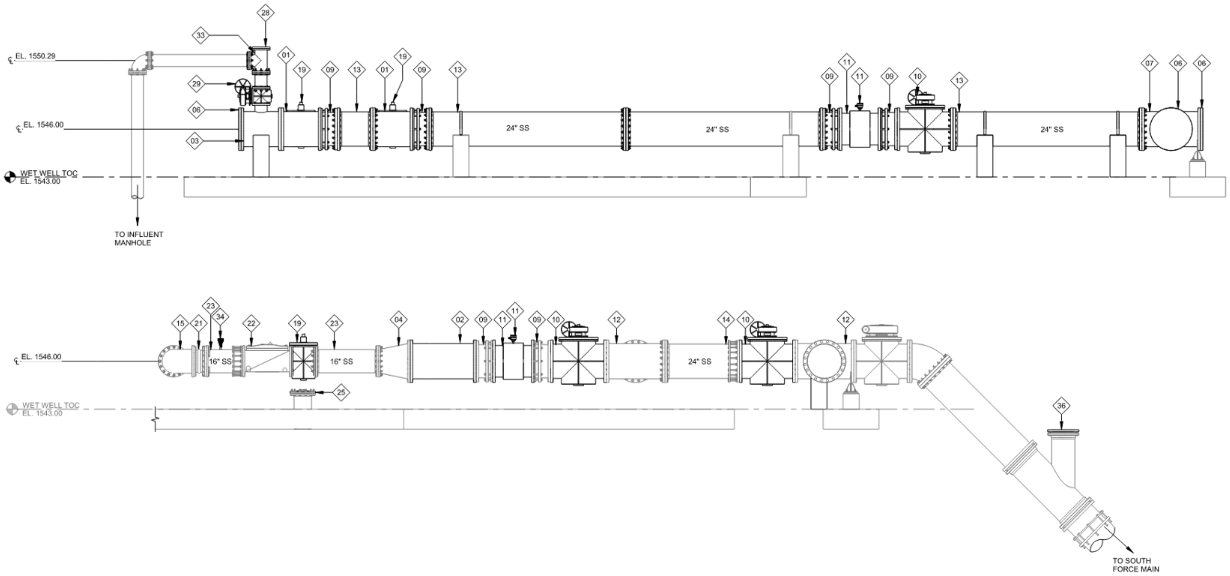


Figure 6-2: Proposed Lift Station 66 Improvements Sections

6.1.2 Odor Control System Improvements

The existing odor control system utilizes sodium hypochlorite and sodium hydroxide to remove foul odors. Both of those chemicals along with calcium nitrate are stored in bulk storage tanks with concrete containment. Calcium nitrate is directly injected into the discharge header prior to the force mains to mitigate H_2S downstream. Figure 6-3 shows the existing odor control and chemical storage facility.

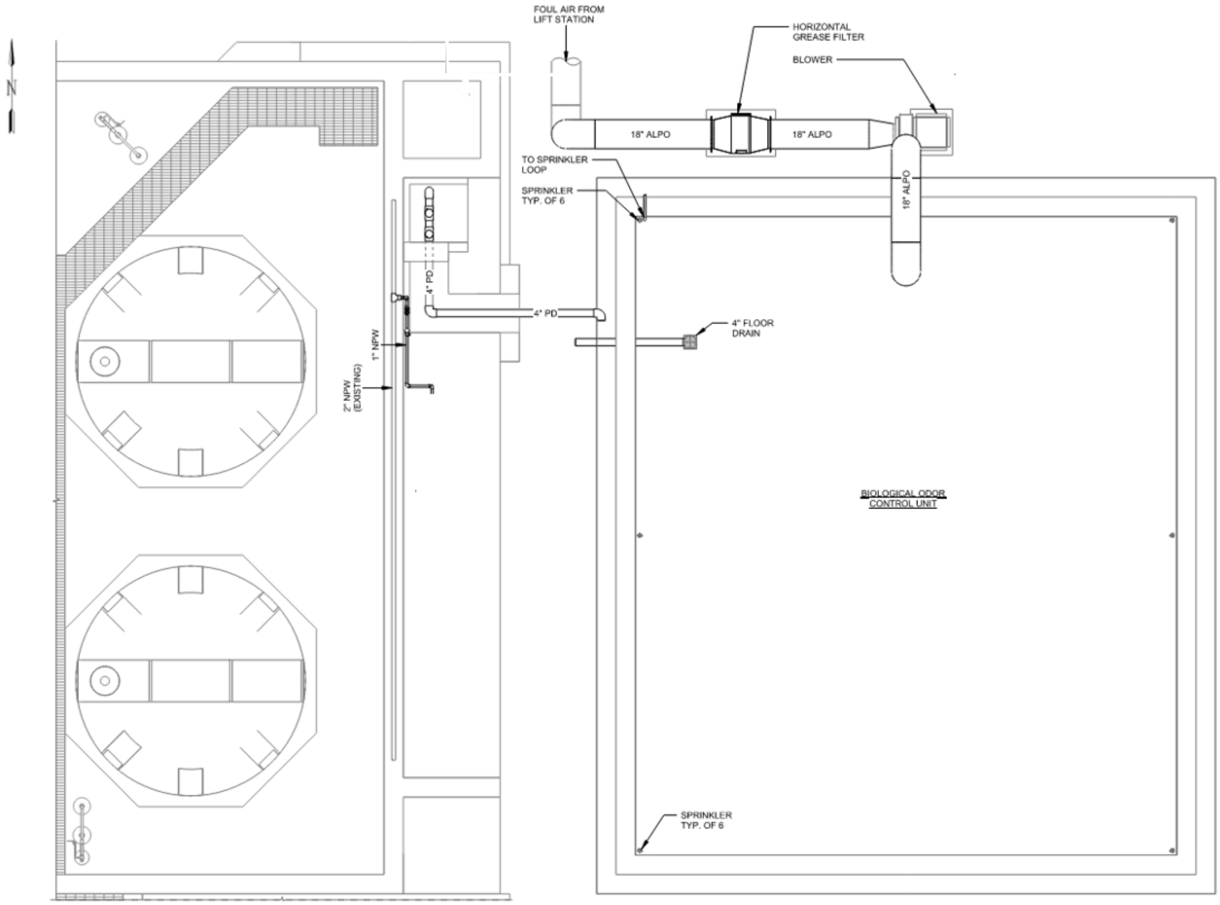


Figure 6-3: Proposed LS66 Buried Biofilter Facility

The chemical odor control system, including the sodium hypochlorite and sodium hydroxide bulk storage tanks, are proposed to be removed. The space where the existing odor control system is located will be used for a similarly sized biological odor control system. The calcium nitrate storage will continue being utilized and an additional injection location will be provided for both discharge headers to be injected prior to the force mains.

6.2 Civil Considerations

As part of the improvements to LS66, a new concrete pad will be added on the northeast side of the wet well and an additional concrete pad directly west of the lift station. The concrete pad will be designed for heavy trucks, maintenance vehicles or boom trucks that can be used to remove and maintain the submersible pumps and associated header valves and piping. The pavement in this area is currently failing. There are also two light poles that will be relocated due to conflicts. Existing safety posts that are in conflict will be removed, these and additional bollards will be added to protect upgrades.

An issue has also been observed at the door to the electrical building. It has been determined that water may leak under the door when the entrance to the electrical building is cleaned with a hose. A small trench drain will be added in front of the door that will drain away from the door to the south. It is also recommended to replace the seals on the door to the electrical building to add waterproofing protection.

6.3 Structural Considerations

Structural improvements proposed for LS66 include:

- Provide new cast-in-place concrete containment tank for the new buried biofilter.
- Provide four (4) sets of concrete pipe supports for two 24" discharge headers.
- Repair the concrete slab to improve drain of existing electrical building flooring by adding drainage grooves.
- Reseal HVAC wall penetrations and duct flange connections in existing electrical building.
- Replace door sweep gaskets and sealant beds at thresholds.
- Repair/replace metal door hardware for East and West entrances.
- Repair sealant for metal flashing at roof to CMU wall connections at restroom area.
- Repair/replace ill-seated flashing, repair/replace penetration boots, and repair gutters.

6.4 Electrical Considerations

6.4.1 Utility Power

The electrical power utility for Lift Station 66 is being provided by Arizona Public Service (APS). A new service is being installed at Lift Station 66 under a separate project. The utility transformer's primary voltage will be 12,470 Volts with the secondary voltage of 480 Volts. APS transformer will be 2,000kVA.

6.4.2 Service Entrance Section

The Service Entrance Section (SES-LS66) is being installed under a separate project. This Service Entrance Section is rated for 3,000 Amps, 480 Volts, 3-phase. The Service Entrance Section is equipped with Transient Voltage Surge Suppressants (TVSS), also known as Surge Protection Device.

6.4.3 Generator and Automatic Transfer Switches

A 1,750 KW, 277/480 Volts, 3-phase standby diesel generator with a sub-base fuel storage tank has recently been installed (year 2020) and will provide standby power to the entire lift station. The sub-base fuel storage tank is sized for 24 hours of continuous full load operation. The generator is enclosed in a sound attenuating enclosure.

The generator is equipped with two transfer switches:

- Automatic Transfer Switch: A new Automatic Transfer Switch, rated for 3000 Amps, 277/480 Volts, 3-phase is being installed under a separate project. This automatic transfer switch will connect the generator (through the Manual Transfer Switch) to the Main Switchgear.
- Manual Transfer Switch: The existing Manual Transfer Switch will remain in place. This Manual Transfer Switch will provide the flexibility of providing a portable generator in case the existing generator is not operational.

6.4.4 Electrical Power Distribution

The existing main switchgear (3,600 Amps, 480 Volts, 3-phase) is equipped with multiple draw out circuit breakers feeding the following equipment:

- New Pump No. 1 VFD
- New Pump No. 2 VFD
- New Pump No. 3 VFD
- New Pump No. 4 VFD
- Existing Power Distribution Panel PP-A
- Existing Panelboard LP-A through a 112.5 KVA transformer (480V to 120/208V). Panel LP-A is a 120/208V, 3-phase, 4-wire panel.
- Existing Odor Control System's Control Panel

6.4.5 Variable Frequency Drives (VFD)

Each of the existing pump motors are currently fed through individual existing VFDs. The existing VFDs will be replaced with new VFDs. These VFDs will be Active Front End (AFE) drives because of the high pump horsepower required.

Active Front End VFDs offer mitigation by reducing both voltage and current harmonics in the power distribution system. These VFDs will also be equipped with filters on the load side in order to reduce the damaging effects of reflective waves at the pump motors.

6.4.6 Local Disconnects Switches and Junction Boxes

The existing power feed from each VFD to its pump motor is fed through an 800 Amp, 480 Volt, 3-phase disconnect switch (total of three disconnect switches). These disconnect switches will be replaced with new fused disconnect switches as required by The City of Phoenix electrical inspections group based on the results of software-generated arc flash calculations.

The existing power feed from each disconnect switch to its pump motor is also fed through a junction box in which the feeder conductors are spliced to the pump's submersible cables. These junction boxes will be replaced with new. Conduit seal offs will be installed on each of the conduits (total of three conduits per junction box) entering each of the new junction boxes from the new fused disconnect switches. These seal offs will separate the wet well's hazardous gases away from the ignitable conditions inside the electrical building.

6.4.7 Lighting

A couple of outdoor pole lights will be removed in order to provide better access to the pumps for maintenance and replacement. All other lights will remain as is.

6.4.8 Corrosive Areas

The wet well and its surrounding areas will be considered corrosive areas. Also, the equipment located outside of the electrical building or air-tight enclosures will be rated for corrosive environments.

Panels and enclosures located outside will be made from 316 stainless steel and rated for corrosive environments.

6.4.9 Hazardous Areas

Hazardous area will be determined in accordance with NFPA 820. Equipment inside the hazardous areas will be rated for hazardous environments (Class-1, Division-1 or Class-1, Division-2). Some of these hazardous areas include:

- Inside the wet well and limited areas around the wet well
- Odor control system and limited areas around the odor control system

6.4.10 Conduits

Existing conduits will be re-used for new conductors.

New underground conduits will be PVC and encased in concrete. Where ductbanks are exposed to heavy traffic, the ductbanks will be encased in concrete and reinforced with rebar.

New exposed conduits inside the electrical building will be galvanized rigid steel.

New exposed conduits outside of the electrical building will be PVC-coated galvanized rigid steel.

6.4.11 Arc Flash Hazard

A power system short circuit study, protective device coordination study, and arc flash analysis study will be performed on the rehabilitated lift station’s electrical system after construction and prior to project close-out.

6.5 Instrumentation and Controls

6.5.1 PLC Control and Monitoring System

The existing PLC control and monitoring system is equipped with dual redundant PLCs and their associated devices. The existing PLC control and monitoring system will be kept in place, but the majority of its devices will be replaced.

Refer to Section 4.3 for the control strategy. Pump speeds will be controlled using the variable frequency drives as required to reach and maintain a set wet well level. The pump control system is primarily controlled by wet well level transmitters. Each wet well shall include two ultrasonic level transmitters; a primary and a backup.

6.5.2 PLC Cabinet

The lift station is equipped with an existing PLC Cabinet (PCP-PS-NG). Proposed improvements to PCP-PS-NG include:

- Existing Quantum PLC input and output modules will be replaced with new Modicon X80 input and output modules for most signals except for VFDs. VFDs will communicate to the PLCs via an Ethernet CAT6e communication cable using Modbus TCP communication protocol.

- Existing analog isolators will be replaced with modern equivalents.
- Existing analog signal splitters will be replaced with modern equivalents.
- Existing fuse blocks will be replaced with modern equivalents.
- Existing relays will be replaced with modern equivalents.
- Existing light switch and receptacle will be replaced with new.
- Power supplies will be replaced, which will be fed from a UPS-fed panelboard.
- Terminal strips and their associated wiring will be kept in place.
- The existing Quantum PLC program will be downloaded and converted into a M580 PLC program by the contractor's System Integrator.

6.5.3 Communication Cabinet

The lift station is equipped with an existing Communication Cabinet (LCP-FO-NG). Proposed improvements to LCP-FO-NG include:

- Replace redundant existing Modicon Quantum PLC system with new Modicon M580 PLC system.
- Existing Cisco fiber optic switch will be replaced with modern equivalent.
- Existing breakers will be replaced with modern equivalents.
- Existing radio equipment will remain in place.
- Existing fiber optic patch panel will remain in place.
- Existing light switch and receptacle will be replaced with new.
- Power supplies will be replaced, which will be fed from a UPS-fed panelboard.
- Modbus coax splitters, coax termination boxes, and coax cables will be removed.

6.5.4 Autodialer

The existing alarm signals to the autodialer are transmitted to the autodialer via the existing PLC such that if the PLC malfunctions, no signals will go to the autodialer. These specific alarm signals will be intercepted prior to going to the PLC, split into two separate sets of signals with one set going directly to the PLC and another set going directly to the autodialer.

6.5.5 Level

The existing wet well is split into two wet wells, separated by slide gates.

Each wet well is equipped with two level transmitters. In each wet well, one level transmitter is the primary level instrument, and the other is a backup level instrument. Existing level transmitters will be replaced with new level transmitters. The associated level transducers will be replaced and relocated for ease of maintenance access. Liquid level is relayed from the level sensors inside the wet well to the level transmitters just outside the wet well. Consequently, the level signals are conveyed from the level transmitters to the PLC for monitoring and control purposes.

6.5.6 Pressure

The existing pressure transmitter is installed at the discharge header. Currently there is one pressure transmitter for all pumps on the existing single discharge header.

Each pump is proposed to be equipped with its own pressure transmitter and pressure gauge. The pressure transmitters will be equipped with Block & Bleed valve and manifold. Pressure transmitters will relay the pressure signals to the PLC.

6.5.7 H_2S (Hydrogen Sulfite) Gas Detection and Transmitters

The existing H_2S sensor and transmitter are neither functioning nor required. The existing H_2S sensor and transmitter will be removed.

6.5.8 Temperature and Leak Sensors

Each pump will be equipped with temperature and leak sensors. The temperature and leak sensors are part of the MiniCAS relay system (or a similar device) and provide pump/motor protection. Alarm signals will be transmitted to the PLC.

6.5.9 Valve Operators

The existing valves and operators located on each pump discharge will be replaced with swing check valves. There will be a new actuated valve on the discharge header connection that will allow the City to use either forcemain or both forcemains.

6.5.10 Standby Generator and Automatic Transfer switch

Signals from the Generator and Automatic Transfer switch are already brought back to the PLC and Autodialer and will remain the same.

6.5.11 Instrumentation and I/O Signal Standards

All instrumentation and I/O signals will follow the City's latest specification standards. Currently, the instrumentation and I/O signal standards are 4-20 mADC for analog signals, 24 VDC for discrete signals, and isolated relay contacts or interposing relays will be used where equipment application requires 120 VAC. For pump VFDs, network communication (Ethernet) will be used.

7.0 Maintenance of Plant Operations

The maintenance of plant operations (MOPO) is intended to provide a plan regarding maintenance of operations at LS66 during construction. Prior to construction of improvements at the lift station, a temporary “construction-phase” piping arrangement will be necessary to bypass the lift station.

The sizing and complexity of the bypass pumping and piping is heavily dependent upon the expected flows to be conveyed. Table 7-1 summarizes Garver’s current understanding of timelines, triggers, LS66 anticipated flows, and references. Garver requests the City of Phoenix staff to review and comment on the table below to ensure up-to-date assumptions are documented correctly.

Table 7-1: Bypass Pumping Timeline and Anticipated LS66 Flows

Timeline	Trigger	Anticipated LS66 Flow	Information Source / Reference
December 2020	Existing Conditions	0.1 MGD	City of Phoenix verbal information
Early 2021	West Anthem Lift Station (LS76) Start-up	0.5 MGD	"Lift Station No. 76 Design Report" by Stanley Consultants, dated January 2019
Mid-year 2021	North Valley Parkway Interceptor flow increase	1.45 MGD (avg) 3.5 MGD (peak)	City of Phoenix verbal information
Spring or Summer 2022	Expected additional growth and flow	16.0 MGD	City of Phoenix verbal information

In summary, the expected bypass flows are 0.5 MGD – 3.5 MGD if the LS66 Refurbishment project is constructed in 2021 and is expected to increase to 16.0 MGD during the year 2022. Therefore, City of Phoenix staff requested that the temporary piping project be constructed in 2021 to provide the following two functions:

1. Connect discharge from pump (whether submersible or temporary trailer-mounted) into both force mains.
2. Connect both force mains to an influent manhole or wet well to drain the forcemains if needed.

Construction of the temporary piping project was completed in October 2021, which is illustrated in Figure 7-1.

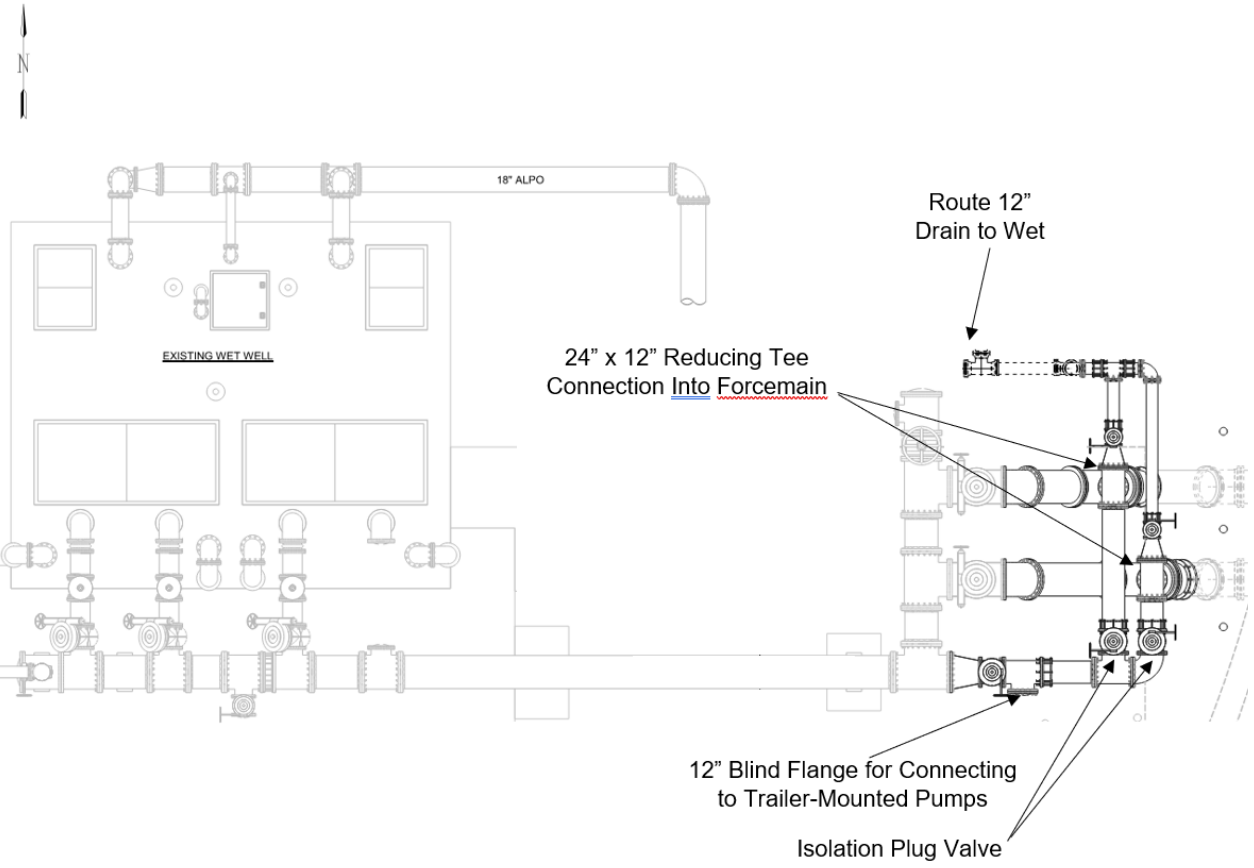


Figure 7-1: LS66 Temporary Piping Improvements

As shown in Figure 7-1, smaller diameter piping is recommended for the interim piping. This helps to reduce weight, cost, complexity, and temporary footprint. Smaller diameter piping of 12-inch has been provided, which can accommodate peak flows up to 3.5 MGD. Also, Class 250 epoxy-lined, epoxy-coated ductile iron pipe material has been provided for all of the temporary piping.

8.0 Opinion of Probable Construction Cost

This section presents the Opinion of Probable Construction Cost (OPCC) for the proposed LS66 improvements. In addition, the assumptions and methodologies adopted to develop the OPCC are detailed herein. It is noted that costs for the temporary piping project described in Section 7.0 are not included.

8.1 Base Assumptions for Cost Estimate

The OPCC has been developed based on conceptual building and equipment sizing, site layouts, record drawings, and other similar information. Table 8-1 details some key estimating criteria adopted to develop costs for the different facilities.

Table 8-1: Preliminary Design OPCC Estimate Assumptions

Consideration	Assumption
Contractor Mobilization	5%
Contractor's Overhead and Profit	20%
Contingency	30%

8.2 Cost Estimate

Table 8-2 shows the cost estimate for the recommended improvements to LS66. Contingencies outlined in Table 8-1 are included in each line item.

Table 8-2: Cost Estimate Summary Table

ID	Line Item	OPCC
1	Site Civil	$212,000
2	Electrical Building Modifications	$87,000
3	Lift Station 66 Improvements	$2,800,000
4	Biofilter Odor Control	$1,040,000
5	Electrical, Instrumentation and Control	$1,580,000
	EQUIPMENT AND INSTALLATION SUBTOTAL	**$5,720,000**
	3.5% Escalation to Midpoint of Construction (1-Year)	$200,000
	TOTAL ESTIMATED CONSTRUCTION COST	**$5,920,000**

9.0 Conclusions and Recommendations

It is recommended that the City of Phoenix rehabilitate LS66 with the improvements as described within this preliminary design report. Upon completion of the project, the City can expect to have an optimized lift station that better meet the needs of their staff and customers. The Opinion of Probable Construction Cost for Lift Station 66 is $5,920,000.