*Final Report*

# WISE Binney Connection Pump Station Study

Prepared for

## South Metro WISE Authority

November 5, 2018

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CH2M Engineers, Inc.
9191 S. Jamaica Street
Englewood, CO 80112

# Acknowledgements

The following project team was instrumental in a collaborative approach to develop the preferred alternative for the WISE Binney Connection Pump Station that will serve as guidance for the design of the selected alternative.

**South Metro WISE Authority**

• Chris Muller —Project Manager
• Kara Scheel — Project Engineer
• Lisa Darling— Executive Director
• Mikal Martinez—Project Support

**Aurora Water**

• Elizabeth Carter—Project Manager

**Denver Water**

• Nathan Elder—Project Manager

**CH2M**

• Liv Haugen—Project Manager
• Patrick Murphy— Project Engineer
• Klint Reedy—Senior Technical Consultant
• Bill Carter— Senior Technical Consultant
• Scott Champlin – Senior Mechanical Engineer

**TRS, Inc.**

• Richard Pittenridge—Land Acquisition Manager

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This Technical Memorandum (TM) documents the results of the WISE Binney Connection Pump Station alternative study. Three pump station alternatives were evaluated based on cost and non-cost criteria in a structured decision framework process. The alternatives evaluation process followed a series of steps that identified the preferred pump station configuration alternative.

# 1.0 Project Background

The proposed WISE pump station will allow for the transfer of water from the Binney Water Purification Facility (BWPF), Aurora Reservoir Train (AR) and the South Platte Train (SP) or a blend of any increment of the two trains to the WISE conveyance system. The current WISE connection to the Aurora Water System has a maximum capacity of approximately 15 million gallons per day (MGD). By June 2021, the contract terms that allow for the use of the Aurora Water distribution system to convey WISE water to SMWA will expire and a dedicated pumping and conveyance system with a capacity of at least 25 MGD and as much as 30 MGD is required. This TM will focus on evaluating pump station alternatives. The new pipeline alignment alternatives that will allow water to be conveyed from the new pump station to the existing WISE system are described in TM *WISE Binney Connection Pipeline Study*, CH2M, 2018.

## 1.1. Summary

This TM presents information developed to support selection of the preferred alignment for the WISE Binney Connection Pump Station. The following are key components of the alternative selection process:

- Development of pump station alternative configurations. The proposed pump station layouts were developed in a collaborate process with South Metro WISE Authority (SMWA) and other project stakeholders. The three pump station layout alternatives were developed utilizing existing aerial photography, and as-built information for the BWPF and Smoky Hill Tank.
- Comparison of pump station alternatives. The cost and non-cost characteristics of the alternatives were evaluated. The cost-based criteria include conceptual level estimated construction cost. The non-cost criteria included land space requirements, operations and maintenance (O&M) considerations, permitting requirements, constructability, reliability, and public acceptance. A methodology for combining the cost and non-cost evaluations was developed and utilized for comparison of alternatives.

# 2.0 Alternative Evaluation Process

A structured decision framework process was utilized for selection of the preferred alternative that followed a series of steps to identify the alternative with the highest cost per benefit. The alternative evaluation decision framework process is shown schematically in Figure 2.1 and described in detail in the following sections.

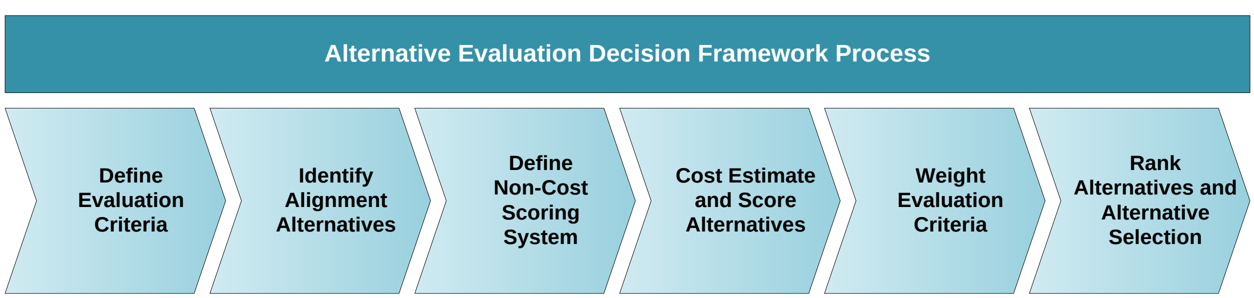



*Figure 2.1: Alternative Evaluation Decision Framework Process*

The alternative evaluation process included the following steps:

**Define Evaluation Criteria** – This step of the evaluation process was completed in a collaborative setting at the initial alternative review meeting. This step included selection of cost based and non-cost based alternative evaluation criteria. The cost-based criteria included conceptual level construction costs and estimated annual power and chemical costs. The non-cost criteria included land requirements, O&M considerations, permitting requirements, constructability, reliability, and public acceptance.

**Identify Alternatives** – This step of the evaluation process was also completed in a collaborate setting at the initial alternative review meeting. Three alternatives were identified: single pump station; two pump stations; and two pump stations with deferred capital (interim use of Wemlinger Blending Pump Station), which are described in detail in subsequent sections of this TM.

**Define Non-Cost Scoring System** – This step of the evaluation process included defining the ratings that were assigned to each alternative for the non-cost criteria. More specifically, a performance scale was defined to systematically score each alternative against the identified non-cost criteria. For this evaluation, the alternatives are assigned one of the following scores for each of the non-cost criteria: More Favorable “M”, Neutral “N”, Less Favorable “L”, or Negative “O.” The non-cost criteria and scoring performance scales are described in detail in subsequent sections of the TM.

**Cost Estimate and Score Alternatives** – This step of the evaluation process included development of conceptual level construction costs for each alternative. Estimated annual power and chemical costs were also compiled. In addition, non-cost criteria were assigned to each alternative.

**Weight Evaluation Criteria** – The non-cost evaluation criteria were weighted based on the relative importance of addressing stakeholder priorities. The criteria weights were used to define tradeoffs between goals and to build a defensible foundation for ranking alternatives. The non-cost criteria were weighted by surveying project stakeholders. The result of this approach is that the criterion with the most “more favorable” ratings has the highest weighting. The criteria were weighted in the second pump station alternative review meeting.

**Rank Alternatives and Alternative Selection –** The alternatives were then ranked based on a combination of the cost and non-cost weighting and scoring. Each alternative was assigned a relative benefit based on how each alternative scored against each criterion and the weight of the criterion. The benefit is the sum of the products of the non-cost criteria weight and the performance score – the higher the score, the better the benefits. A cost per benefit was then calculated by dividing the project cost by the benefit score. The lower the weighted cost, the more benefit per dollar.

**Consider Potential Adverse Consequences of Selecting Alternative with Best Score –** Before selecting the alternative with the best analytical score, the Project Team considered if there were reasons to believe that the structured decision-making process did not produce the best alternative. This is a final intuitive check of the structured decision process.

# 3.0 BWPF Site Overview

An overall site plan of the BWPF is shown on Figure 4.1. Source waters from Aurora Reservoir (AR) and the South Platte (SP) are treated in separate trains and not blended until upstream of the disinfection contact basin. Aurora Reservoir water is treated with a conventional process and enters the filter building from the AR floc/sed basins. South Platte water is treated through softening and UV advanced oxidation before filtration and GAC adsorption. The SP filters are in the western portion of the filter building, and the AR filters are in the eastern portion of the filter building. The GAC adsorbers are immediately south of the filter building. Flow from the AR and SP trains meet in a blending box located on the east end of the filter and adsorber building. The blended flow is piped to the disinfection contact basin and from this location is pumped to the Robertsdale Tank.

As described in detail in the following sections, all three of the WISE pump station alternatives will require modifications to the blending box to allow for SMWA to access non-blended water. Also, all three of the alternatives require different types and configurations of new facilities to be located on the BWPF site.

# 4.0 Pump Station Alternatives

The three pump station alternatives considered in this evaluation were identified during the Alternatives Conceptual Design Review Meeting on May 9, 2018. The alternatives include single pump station, two pump stations, and two pump stations with deferred capital (interim use of Wemlinger Blending Pump Station). Figure 4.2 provides a high-level overview of the three alternatives. The proposed alternatives are described in more detail in the following sections.

## 4.1 Alternative 1 – Single Pump Station

### *4.1.1 Overview*

The Alternative 1 configuration includes directly pumping from the BWPF to the Smoky Hill Tank without an intermediate pumping facility. Figure 4.3 shows an overview of this configuration. This configuration includes a flow control valve vault that delineates ownership from Aurora Water and SMWA. Downstream of the SMWA flow control valve is a Chlorine Contact Basin (CCB), a High-Pressure Pump Station, and chemical storage and feed facilities.

To provide the capability of delivering blended water to SMWA (which is a contractual requirement through June 2030), a pipeline from the finished water pipeline, downstream of the BWPF Finished Water Pumps, to a SMWA blending flow control valve vault to the WISE pump station wetwell is also required.


*Figure 4.1 – BWPF Site Overview*

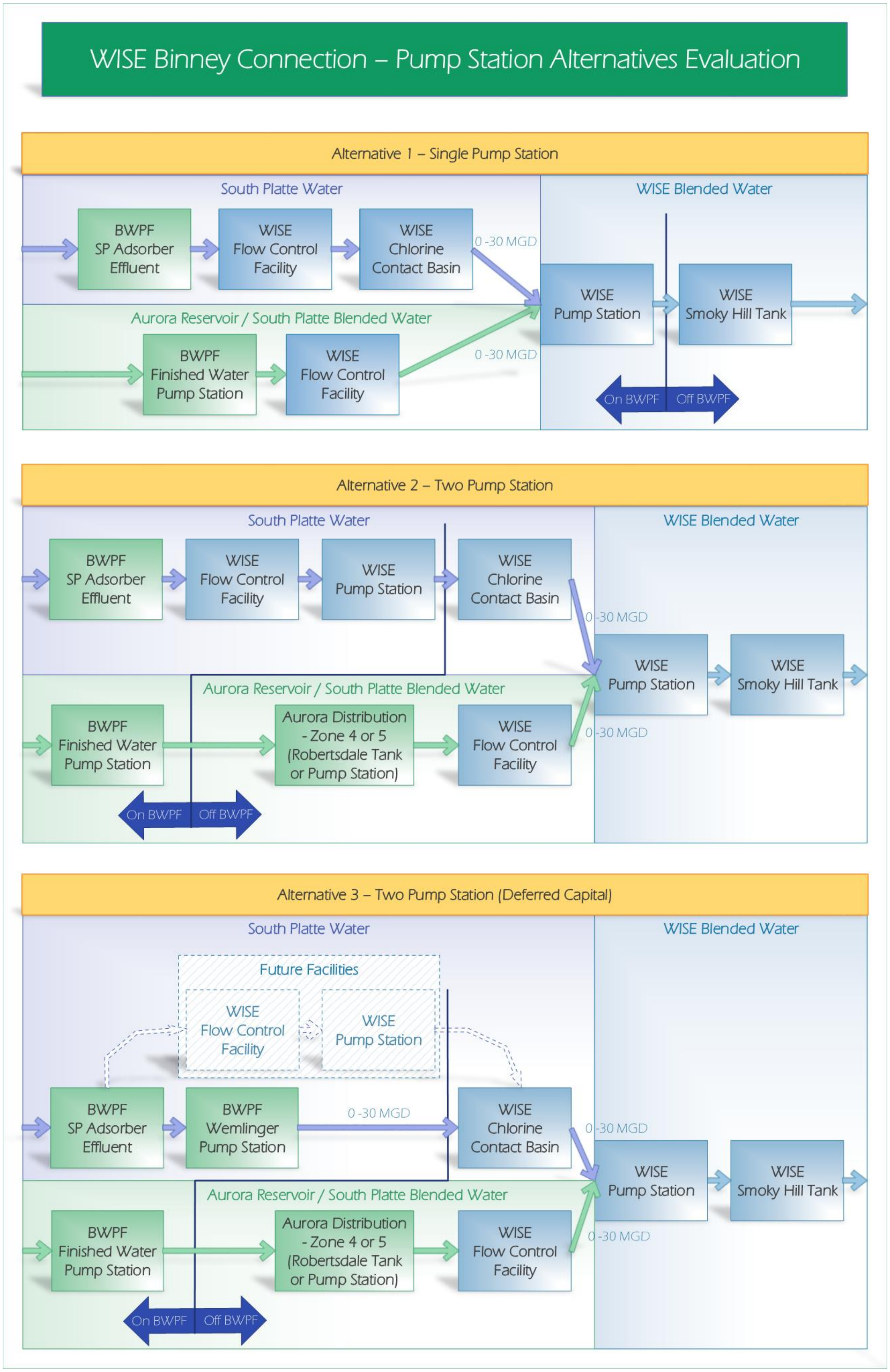



*Figure 4.2 – Schematic Summary of Pump Station Alternatives*

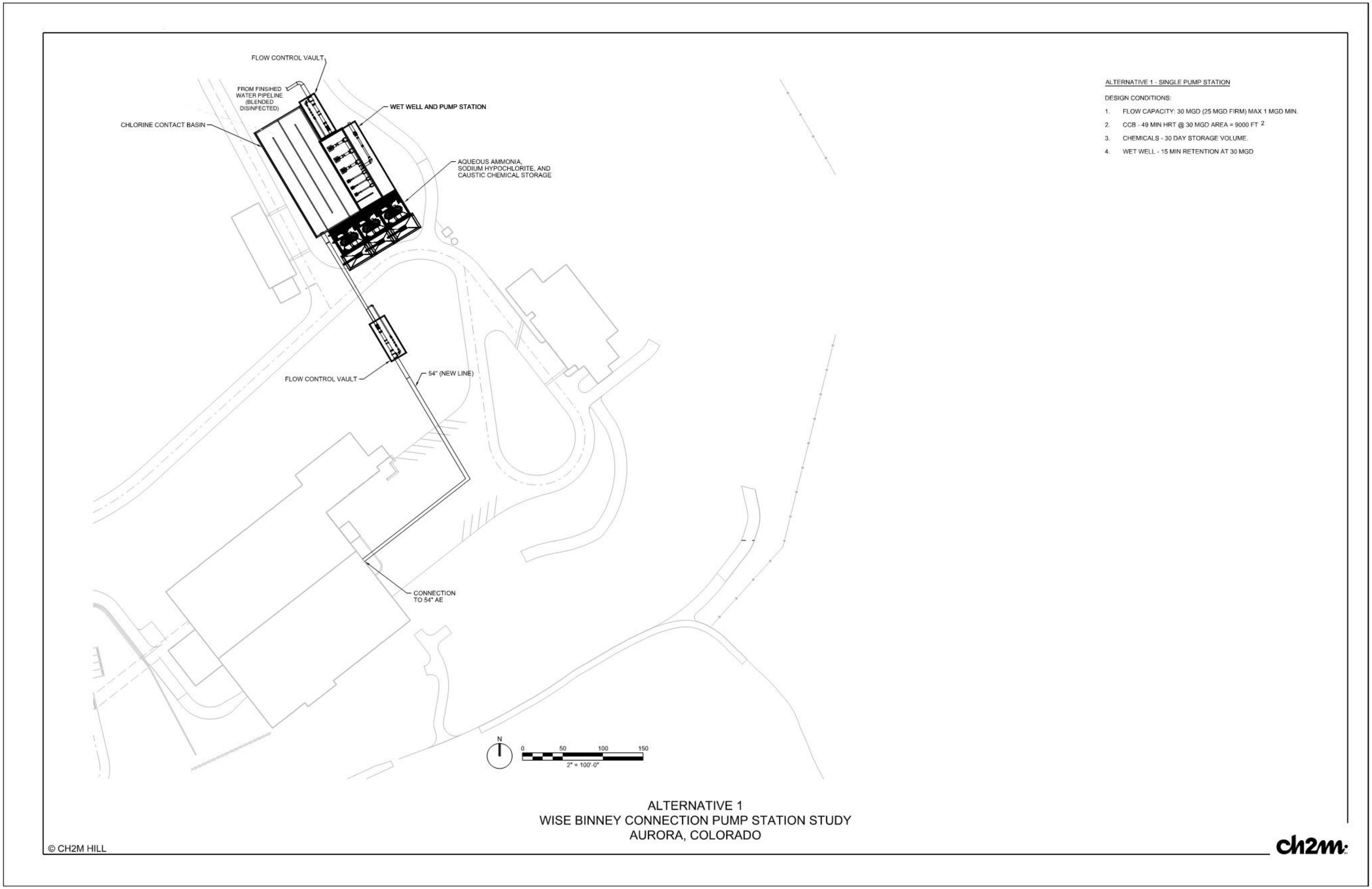



*Figure 4.3 – Alternative 1 - Single Pump Station Layout*

### *4.1.2 Connection to South Platte Train*

The SMWA connection to the existing BWPF will occur on an existing pipeline leaving the SP train adsorbers just upstream of the existing blending box on the northeast side of the Filtration Facility (Facility 32). The blending box as shown in Figure 4.4 collects waters from the AR and SP trains prior to being conveyed to the BWPF disinfection contact basin (DCB) and finished water pumping station. Currently, the blending box allows the AR and SP waters to blend in the southern portion of the box. The blended water spills over a weir inside the box before being conveyed to the disinfection contact basin. If Aurora Water and SMWA do not want to rely solely on set points of the SMWA flow control valves to ensure proper isolation of the two waters, and to confirm SMWA is only getting SP water under the non-blend operating condition, a dividing wall will need to be installed in the blending box. Figure 4.4 shows the conceptual location of the dividing wall in the blending box

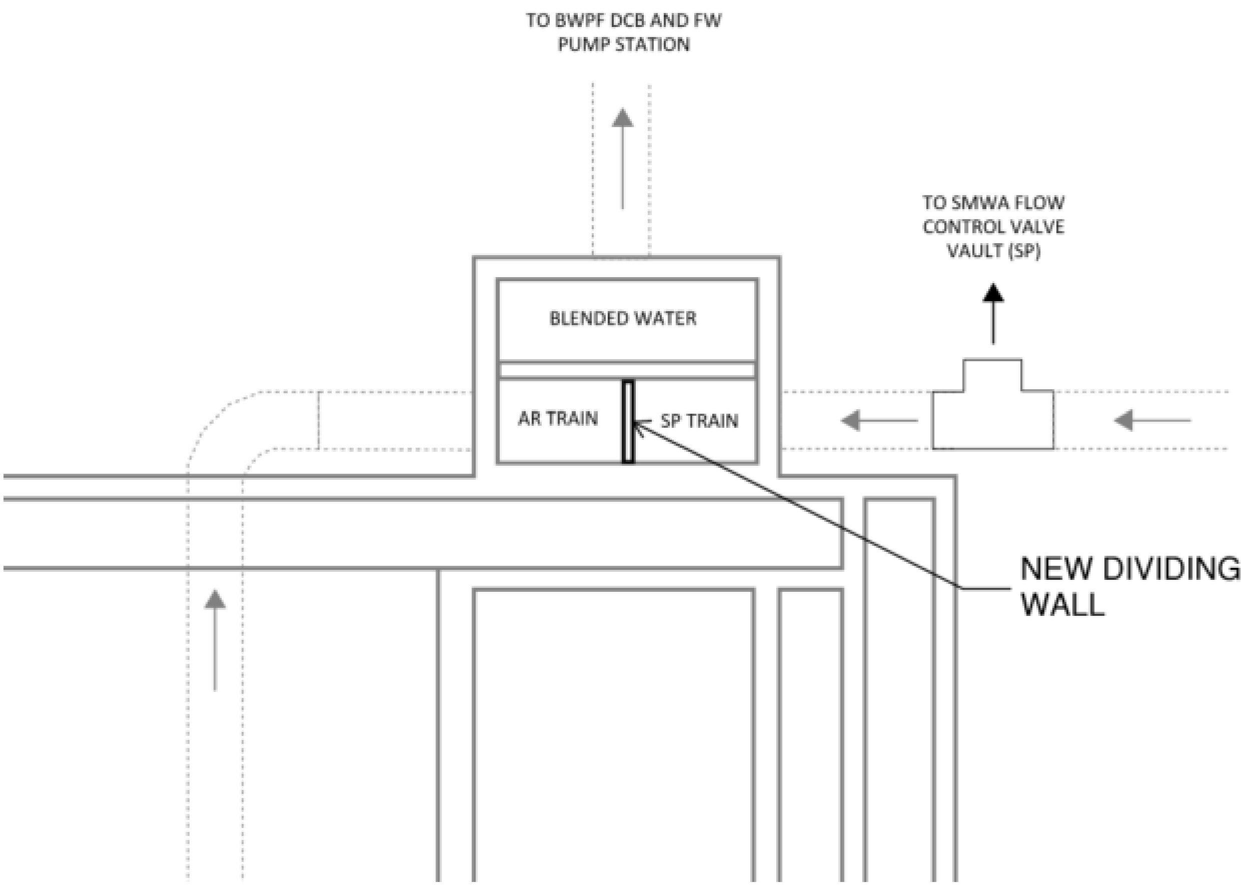



*Figure 4.4: Blending Box modification for WISE connection on SP train.*

### *4.1.3 Flow Control Valve Vault and Blending Flow Control Valve Vault*

The flow control valve vault and blending flow control valve vault will be comprised of a below grade vault with two control valves each. The flow control vault will be located northwest of the Filter Facility and the blending flow control valve vault will be located north of the SMWA wetwell. To provide the capability of delivering disinfected blended water to SMWA (which is a contractual requirement through June 2030), a connection from the finished water pipeline will be provided and routed to the blending flow control valve vault.

To achieve a flow range of 1-30 mgd, two control valves are required for each vault. One control valve will be able to control flows between 1-10 mgd while the other will control flows from 10 to 30 mgd. Each control valve will have a dedicated flow meter for control. The vault will have an access stairway for entry and egress and hatches over each valve to facilitate removal. The vaults will be ventilated and designed such that it will not be classified as a confined space per Aurora requirements. Table 4.1 lists the design criteria for the proposed facility.

Figure 4.5 shows one half of the vault, the purposed layout of the Flow Control Valve Vault. The blending flow control valve vault would have an identical layout.

**Table 4.1: WISE SP Water Flow Control Vault and WISE Blend Flow Control Vault Design Criteria**

| Item | Values | Units |
|---|---|---|
| Number of vaults | 2 | # |
| Maximum Flow Rate | 30 | mgd |
| Minimum Flow Rate | 1 | mgd |
| Overall Vault Length | 53 | Ft |
| Overall Vault Width | 20.5 | Ft |
| Control Valve Size – small / large | 12 / 36 | inch |
| Control Valve max CV – small / large | 5730 / 53200 | # |
| Control Valve – Small flow range | 1-10 | mgd |
| Control Valve – Large flow range | 10-30 | mgd |

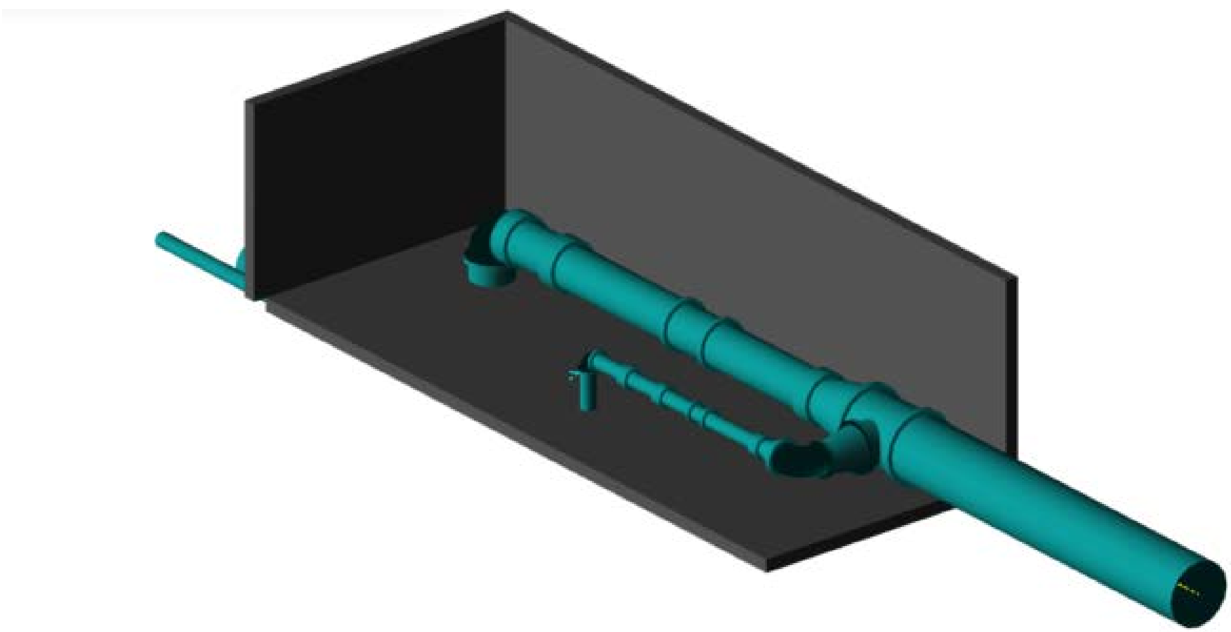


*Figure 4.5: Proposed Layout for half of the WISE SP Water Flow Control Valve Vault.*

### 4.1.4 Chlorine Contact Basin

United States Environmental Protection Agency (USEPA) regulations grant log removal credits based on compliance with treatment techniques. Table 4.2 presents a summary of the disinfection requirements based on the requirements of the USEPA's Surface Water Treatment Rule (SWTR) and Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR). The chlorine contact basin includes sufficient water volume to provide 0.5-log

*Giardia* inactivation and 2-log virus inactivation under the following most demanding disinfection conditions as detailed in Table 4.3.

**Table 4.2: Enhanced Surface Water Treatment Rule Disinfection Requirements**

| | Virus | *Giardia* | Cryptosporidium[1] |
|---|---|---|---|
| Total Requirement (log removal/inactivation) | 4.0 | 3.0 | 3.0 |
| Credit for Conventional Filtration (log removal credit) | 2.0 | 2.5 | 3.0 |
| Additional Disinfection Needed (log inactivation requirement) | 2.0 | 0.5 | 0[2] |

[1] The LT2ESWTR converted the Bin 1 Cryptosporidium oocyst inactivation requirement achieved by a well-operated (i.e., individual filter effluent <0.15 Nephelometric Turbidity Unit (NTU), 95% of the time) filtration water treatment plant to 3-log.

[2] No additional Cryptosporidium oocyst inactivation is required for Bin 1 and up to an additional 2.5-log Cryptosporidium oocyst inactivation would be necessary if the source water was to degrade to a Bin 4.

**Table 4.3: Chlorine Contact Design Criteria**

| **Item** | **Values** | **Units** |
|---|---|---|
| Maximum Flow Rate | 30 | mgd |
| *Giardia* Log Inactivation | 0.5 | #log |
| CT @ 5 deg C, 1.5 mg/L, 8 pH | 39 | Mg-min/L |
| T10 required @ 5-deg C, 1.5 mg/L, 8-pH | 26 | min |
| Chlorine Contactor Water Path L:W Ratio | 40:1 | - |
| CCB Baffling Factor | 0.7 | # |
| CCB Hydraulic Retention Time @ Max Flow | 48.5 | Min |
| Number of Contactors | 1 | # |
| Free Board | 3 | Ft |
| Contactor Water Volume | 1,009,800 | Gal |
| Number of Passes | 4 | # |
| Contactor Sidewater Depth | 15 | Ft |
| Contactor Pass Width | 15 | Ft |
| Contactor Total Water Length | 600 | Ft |
| Contactor Water Pass Length | 150 | Ft |
| Overall Contactor Width | 65 | Ft |
| Overall Contactor Length | 152 | Ft |
| Overall Contractor Depth Less Top Slab | 18 | Ft |

The CCB includes four, serpentine, concrete baffled, passes providing a 40:1 pass length to width ratio targeting a basin baffling factor of 0.7. The 54-inch pipe from the flow control valve will enter the CCB such that it will dissipate inlet velocity head to distribute flow through the cross-sectional area of the first pass for disinfection contact. At the inlet of the CCB, a sodium hypochlorite addition will be added and a mixer will be installed to ensure a constant chemical distribution throughout the water column. A ported baffle wall will be provided to provide even flow distribution in the channel. An effluent weir is located at the exit of the CCB to maintain the disinfection water volume under all flow conditions. The addition of ammonium sulfate after disinfection will create chloramine residual. Disinfected water will overflow the CCB effluent weir into a wet well serving the vertical turbine pumping system. Figure 4.6 shows the proposed layout for the CCB.

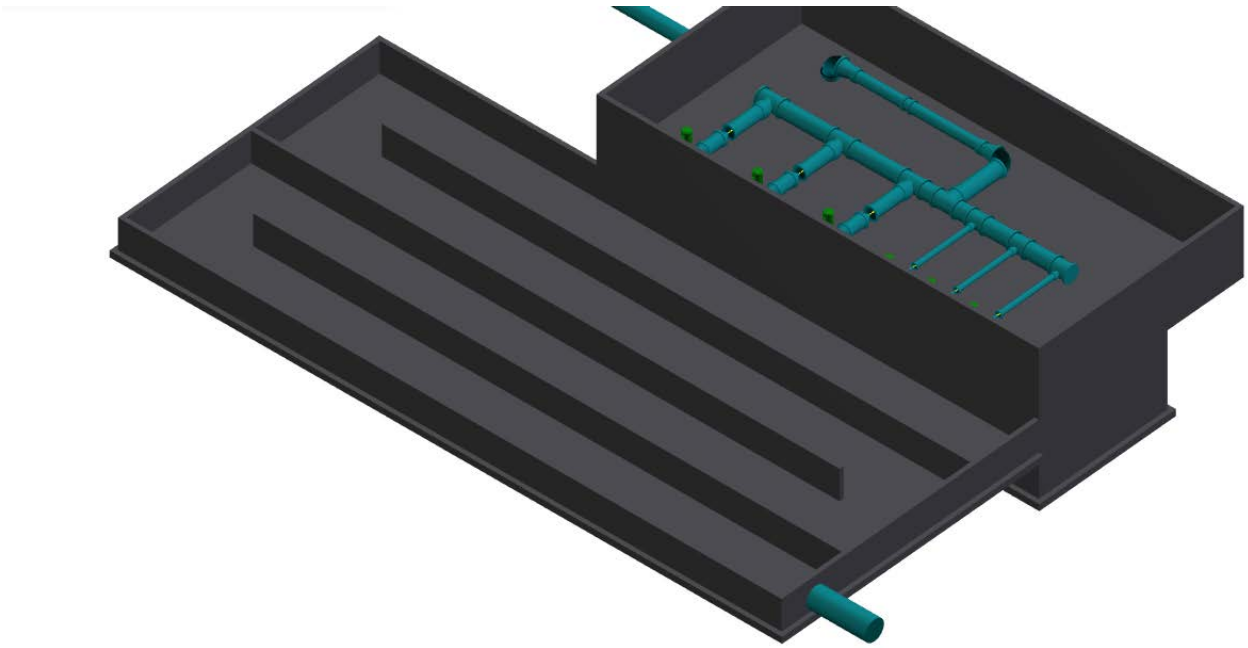


*Figure 4.6: Proposed Layout for the CCB.*

### 4.1.5 High Pressure Pump Station and Wet Well

To service the entire flow range, the Pump Station will be equipped with a total of six vertical turbine pumps operating in parallel. The six pumps will be configured as follows:

Three small pumps (0.5-3 mgd), equipped with variable frequency drives (VFD)

Three large pumps (5-15 mgd), equipped with VFDs

The connecting discharge piping, and related appurtenances, will be sized for the facility's design flow range from a minimum of 1 million gallons per day (mgd) to the maximum rated flow capacity of 30 mgd. The maximum design capacity requires two large pumps operating in parallel. The minimum flow requires one small pump operating at a reduced speed. Between 5 mgd and 6 mgd, there will be transition between two small pumps and one large pump in operation. The third large and small pumps provide redundancy.

The pump station wet well is separated from the CCB by an effluent weir. A baffle wall is added downstream of the effluent weir to promote even distribution and to reduce cross flow velocities in the wet well. Submergence requirements for the pumps are satisfied by maintaining a minimum water level inside the wet well. The wet well volume is sized such that there is a 15-minute retention time in the event of a sudden and unplanned reduction in flow from BWPF treatment trains. In the event of a sudden and unplanned pump outage, water will overflow to Solids Handling Lagoon No. 2. This will occur either by connecting an additional overflow from the pump station to the existing 60-inch Plant Drain (PD) or by utilizing the existing overflow in the BWPF finished water pump station. All pipes and equipment are sized such that velocities and dimensions meet Hydraulic Institute (HI) 9.8 standards.

The vertical turbine pumps will boost water from the wet well, through 12-inch and 30-inch discharge lines for the small and large pumps respectively, into a 36-inch combined discharge header. A check valve and isolation valve is provided on each pump discharge. A 24-inch magnetic flow meter is installed downstream of the 36-inch combined header as shown in Figure 4.7. The flow meter will be the primary measured variable for controlling the pump station. From there, the piping is routed underground and connected to the WISE Binney Connection Pipeline. For more information regarding the Connection Pipeline refer to TM *WISE Binney Pump Station Study, CH2M, 2018.*

It should be noted that if the southern pipeline alignment is selected for this alternative, consideration should be given on the portion of the profile that slopes down to the Smoky Hill Tank, as the high point in the line will be above any water surface level in the tank lower than 6125-ft. If the water surface level in the Smoky Hill tank is below 6125 and at low flows, there is insufficient frictional loss within the system to keep the HGL above the high point in the line. Therefore, a deeper than assumed pipeline or a pressure sustaining valve would be needed just before the inlet of the tank for this alignment. Note that the pressure sustaining valve option would not allow water to back flow from the Smoky Hill Tank to Rangeview. If this alignment is chosen, further analysis is required to ensure that hydraulic scenarios have been addressed. For the complete hydraulic analysis refer to Appendix B – Hydraulic Analysis.

The pump station footprint is approximately 100-ft x 50-ft. A minimum of 5-ft is maintained around all major equipment items. The option detailed within this section is just one of the potential pump station layouts. This option can be optimized and valued engineered during detailed design to ensure that the best equipment is provided to meet the needs of SMWA.

**Table 4.4: Single Pump Station Design Criteria**

| Item | Values | Units |
|---|---|---|
| Maximum Pump Station Flow Rate | 30 | mgd |
| Minimum Pump Station Flow Rate | 1 | mgd |
| Pumps Required | 2 Sets of 3 | - |
| Small Pump Quantity | 2 Duty / 1 Standby | - |
| Large Pump Quantity | 2 Duty / 1 Standby | - |
| Small Pump Flow Range, ea. | 0.5 – 3 | mgd |
| Large Pump Flow Range, ea. | 5 – 15 | mgd |
| Small Pumps Motor Horsepower | 200 | HP |
| Large Pumps Motor Horsepower | 1,500 | HP |
| Large Pumps Motor Voltage (1) | 4160 | Volts |

NOTES:

(1) Advantages of Medium Voltage VFD’s & Motors:

- The medium voltage system will have a lower incident energy thus reduce the arc-flash hazard.
- Medium voltage feeder conductors will be smaller and thus reduce the amount of copper conductor and quantity of conduits required.
- Fewer medium voltage motors & drives required to move the same amount of water.
- Medium voltage circuit breakers and protective relays can be configured to operate significantly faster (thus reducing incident energy & arc-flash hazard) than low-voltage

Disadvantages of Medium Voltage VFD’s & Motors:

- Work on medium voltage equipment would need to be contracted out if the Owner’s electricians are not trained for medium voltage.
- Code required clearances for medium voltage equipment is greater than low-voltage which could result in a larger electrical room.
- Medium voltage equipment often has a longer lead time than low-voltage.

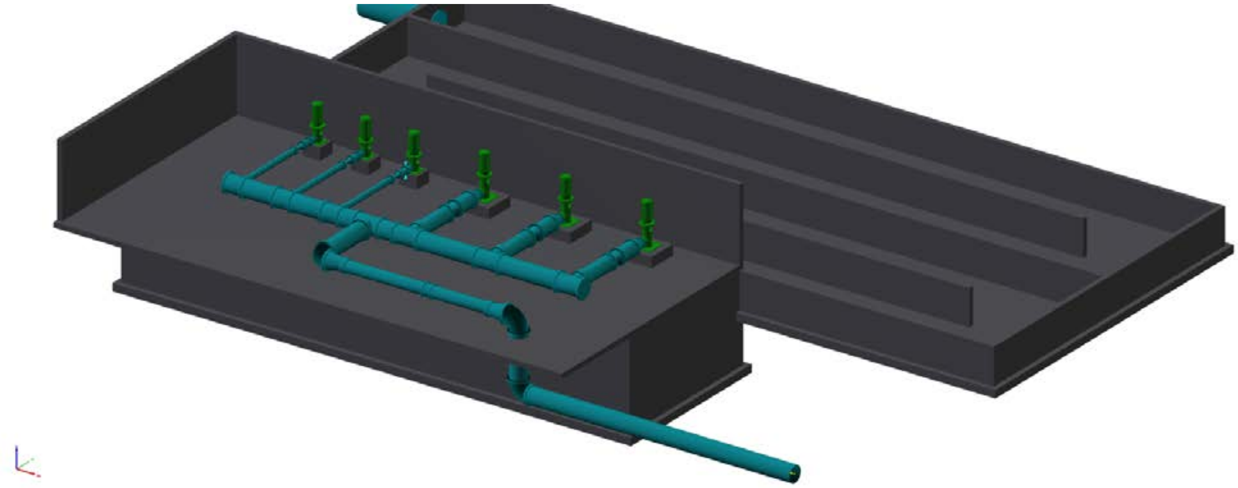


*Figure 4.7 Proposed Layout for the High-Pressure Pump Station.*

### 4.1.6 Chemical Storage

A chemical storage facility will be provided for bulk storage of sodium hypochlorite (primary disinfection), liquid ammonia sulfate (secondary disinfection), and sodium hydroxide (pH adjustment). The facility will be enclosed and each chemical area will have its own containment. Each containment area will be designed to capture the largest tank volume in the event of tank or nozzle failure. Figure 4.8 shows the layout of the chemical storage facility. Fire flow volume will be accounted for in the total containment volume required. Design temperatures within the facility will be maintained to prevent degrading of sodium hypochlorite.

The International Plumbing code and American National Standards Institute Z358.1 require safety showers and emergency eyewashes to be located near the hazard. Current codes define the distance as within 10 seconds of a hazard (about 55 feet) and on the same level as the hazard. The travel path to the shower must be free of obstructions. Therefore, a combination safety shower and eyewash will be provided in each containment area.

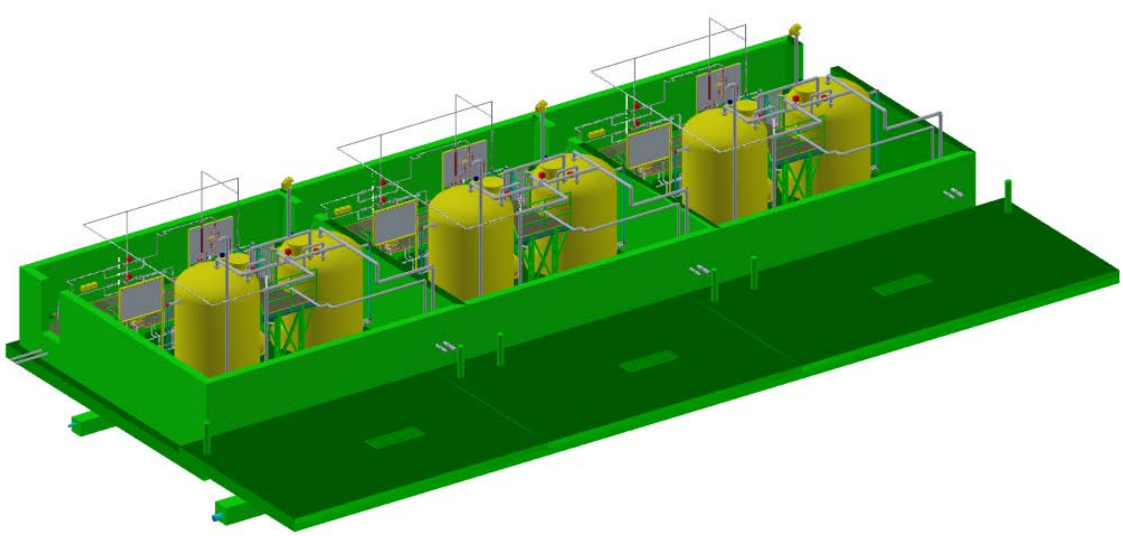


*Figure 4.8: Proposed layout for the Chemical Storage Facility.*

#### *4.1.6.1 Sodium Hypochlorite*

A 12.5 percent sodium hypochlorite (SHC) solution will be used for disinfection. SHC will be added at the influent of the chlorine contact basin where it will achieve sufficient contact time for *Giardia* and virus inactivation.

The SHC storage and delivery system will be installed in a separate room with independent ventilation.

Bulk SHC will be delivered into the polyethylene storage tank from the chemical unloading panel located outside. A beacon and horn will be mounted to alarm a high level in the storage tank. The tank will be equipped with a drain, overflow, vent, fill connection, outlet connection, level element and pressure instrumentation.

A skid package containing two peristaltic metering pumps (one duty and one standby) will pump SHC from the bulk storage tank to the application point. A secondary application point will be provided at the end of the CCB which allows for fine tuning of residual prior to water leaving the facility. The skid package will also include a calibration column, pressure control valve and pressure relief valves. Residual boosting pumps will also be provided.

The SHC chemical storage area will have 1 CFM/square foot of constant ventilation to remove off-gassing of chlorine vapors from the hypochlorite. This constant exhaust will be made up by transferred make-up air from the adjacent pump and chemical area to ensure that the room is negative relative to the other spaces, and will not allow chlorine vapors to migrate and damage other equipment. Make-up air for this room will be transferred from the pump room/chemical area.

The SHC chemical room should remain cool, therefore; this room will be required to be air conditioned.

**Table 4.5 Sodium Hypochlorite System Design Criteria**

| Criteria | Value | Unit |
|---|---|---|
| **Sodium Hypochlorite** | | |
| % Active | 12.5 | wt/wt (trade concentration) |
| Specific gravity | 1.2 | |
| Active chemical concentration | 1 | lb/gal |
| Average dose | 2 | mg/L as Cl |
| Maximum dose | 4 | mg/L as Cl |
| Target free chlorine residual | 1.5 | mg/L as Cl |
| **Chemical Metering Pumps** | | |
| Minimum feed pump flow | 0.7 | gph |
| Average feed pump flow | 6.2 | gph |
| Maximum feed pump flow | 41.7 | gph |
| Pump Turndown Required | 60:1 | |
| **Chemical Usage** | | |
| Minimum | 16.7 | gallons/day |
| Average | 148.5 | gallons/day |
| Maximum | 1001 | gallons/day |
| **15 Day Storage Volumes** | | |
| Minimum | 250.2 | gallons |
| Average | 2,226.8 | gallons |
| Maximum | 15,000 | gallons |
| **Chlorine Storage Tank** | | |
| Diameter | 10 | feet |
| Straight Shell Height | 15 | feet |

Notes:
gph: gallons per hour
lb: pound

#### *4.1.6.2 Liquid Ammonium Sulfate*

A 39 percent Liquid Ammonium Sulfate (LAS) solution will be used to establish a chloramine residual. LAS will be added to the disinfected water at the overflow weir into the pump well. The ammonia combines with the chlorine in the water to form chloramines. The mass ratio of chlorine to ammonia-N for optimal chloramine formation can vary between approximately 3.5:1 to 5:1. Chloramines will maintain a secondary disinfectant residual in the WISE conveyance system while reducing the potential to form disinfection by-products.

The LAS storage and delivery system will be installed in a common building with the sodium hydroxide and sodium hypochlorite systems, but in separate rooms per fire code. Bulk LAS will be stored in two 4,000 gal tanks. LAS will be delivered into the storage tank from the chemical unloading panel located outside. A beacon and horn will be mounted to alarm a high level in the storage tank. The tanks will be equipped with a drain, overflow, vent, fill connection, outlet connection, level element and differential pressure gage.

A skid package containing two peristaltic metering pumps (one duty and one standby) skid will pump LAS from the bulk storage to the application point. The skid package will also include a calibration column, pressure control valve and pressure relief valves. Residual boosting pumps will also be provided.

Table 4.6 shows the LAS system design criteria.

**Table 4.6 Liquid Ammonium Sulfate System Design Criteria**

| Criteria | Value | Unit |
|---|---|---|
| **Ammonium Sulfate - $(NH_4)_2SO_4$** | | |
| % Active | 39% | |
| Specific Gravity | 1.22 | |
| Active Chemical Concentration | 0.84 | Lb-N/gal |
| **Chemical Feed Pump Sizing** | | |
| Min Feed Pump Flow | 0.14 | gph |
| Average Feed Pump Flow | 1.55 | gph |
| Max Feed Pump Flow | 11.9 | gph |
| Pump Turndown Required | 80:1 | |
| **Chemical Usage** | | |
| Minimum | 3.3 | gallons/day |
| Average | 37.1 | gallons/day |
| Maximum | 285.9 | gallons/day |
| **30 Day Storage Volumes** | | |
| Minimum | 100 | gallons |
| Average | 1113.4 | gallons |
| Maximum | 8578.3 | gallons |
| **Ammonia Storage** | | |
| Diameter | 10 | feet |
| Straight Shell Height | 10 | feet |

### *4.1.6.3 Sodium Hydroxide*

A 50 percent sodium hydroxide solution (caustic) will be used for pH adjustment. Sodium hydroxide will be added at the effluent of the chlorine contact basin if final pH adjustment is required.

The sodium hydroxide storage and delivery system will be installed in a separate room with independent ventilation.

Bulk caustic will be delivered into the storage tanks from the chemical unloading panel located outside. A beacon and horn will be mounted to alarm a high level in the storage tank. The tank will be equipped with a drain, overflow, vent, fill connection, outlet connection, level element and differential pressure gage.

A skid package containing two peristaltic metering pumps (one duty and one standby) will pump sodium hydroxide from the bulk storage tank to the application point. The skid package will also include a calibration column, pressure control valve and pressure relief valves.

**Table 4.7 Sodium Hydroxide System Design Criteria**

| Criteria | Value | Unit |
|---|---|---|
| **Sodium Hypochlorite** | | |
| % Active | 50 | |
| Specific gravity | 1.5 | |
| Active chemical concentration | 6.4 | lb/gal |
| Maximum dose | 20 | mg/L |
| **Chemical Metering Pumps** | | |
| Minimum feed pump flow | 1.1 | gph |
| Average feed pump flow | 9.6 | gph |
| Maximum feed pump flow | 32.5 | gph |
| Pump Turndown Required | 30:1 | |
| **Chemical Usage** | | |
| Minimum | 26.4 | gallons/day |
| Average | 230.4 | gallons/day |
| Maximum | 780.0 | gallons/day |
| **15 Day Storage Volumes** | | |
| Minimum | 389.6 | gallons |
| Average | 3467.5 | gallons |
| Maximum | 11,688.3 | gallons |
| **Chlorine Storage Tank** | | |
| Diameter | 10 | feet |
| Straight Shell Height | 10 | feet |

Notes:
gph: gallons per hour
lb: pound

## 4.2 Alternative 2 – Two Pump Stations

The Alternative 2 configuration includes pumping from the BWPF to the Smoky Hill Tank with an intermediate pumping facility located generally north of the Aurora Water Robertsdale Tank. A major difference between Alternative 2 and Alternative 1 is that blended water is provided to SMWA by making a connection to the Aurora Water distribution system near the Robertsdale Tank. Water from this connection will be directed to the high-pressure pump station wet well for blending with disinfected, unblended SP water transferred from the low-pressure pump station. Figures 4.9 and 4.10 show an overview of the facilities at the BWPF and the facilities near the Robertsdale Tank, respectively. At the Binney WPF this configuration includes the SP WISE flow control valve vault shown in Alternative 1. However, under this alternative, the water will flow directly into a wet well for a low-pressure pump station. The low-pressure pump station will transfer unblended and undisinfected SP water to a location near the Robertsdale Tank site where disinfection will take place followed by final pumping by a high-pressure pump station to the Smoky Hill Tank.

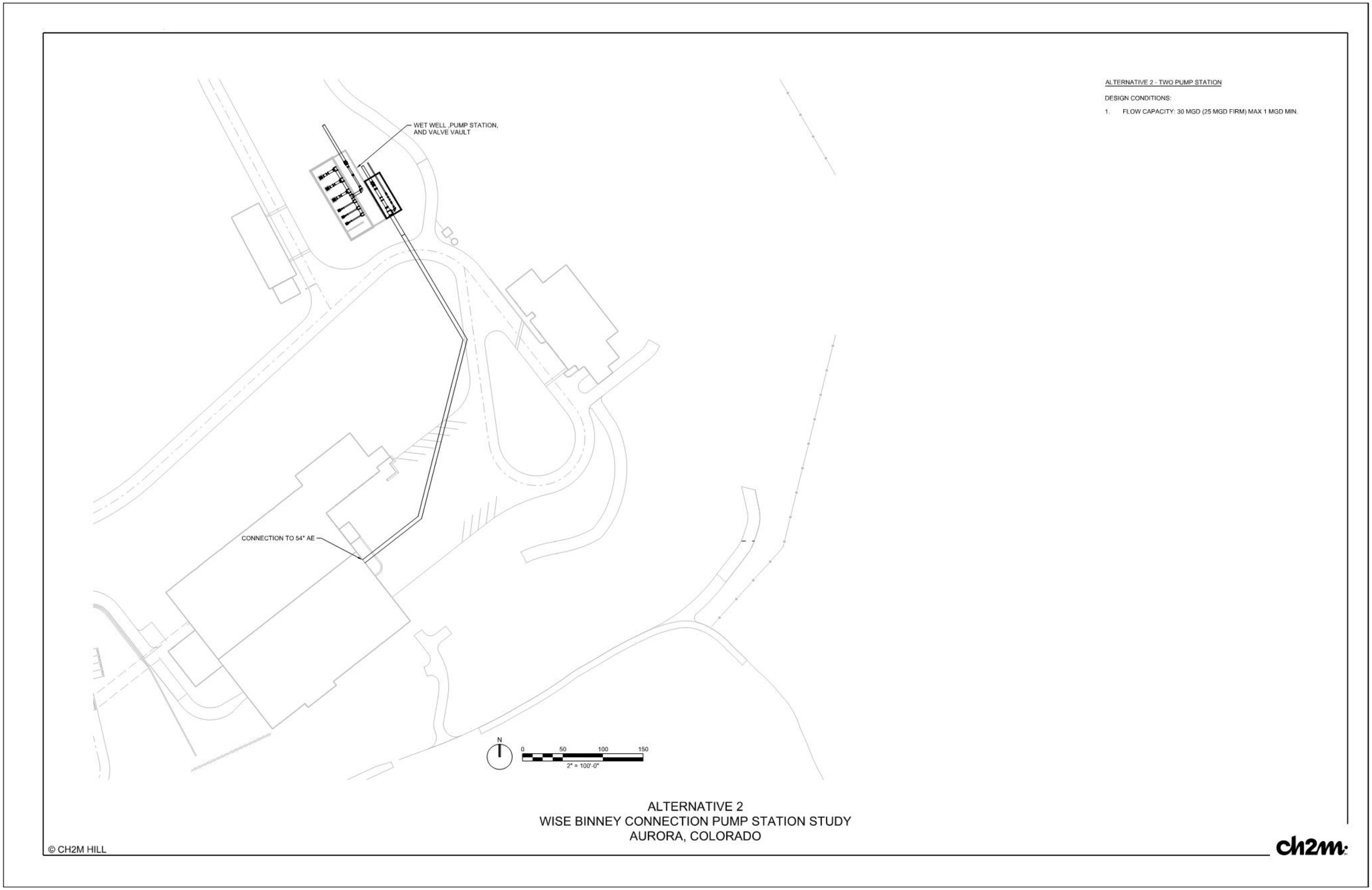
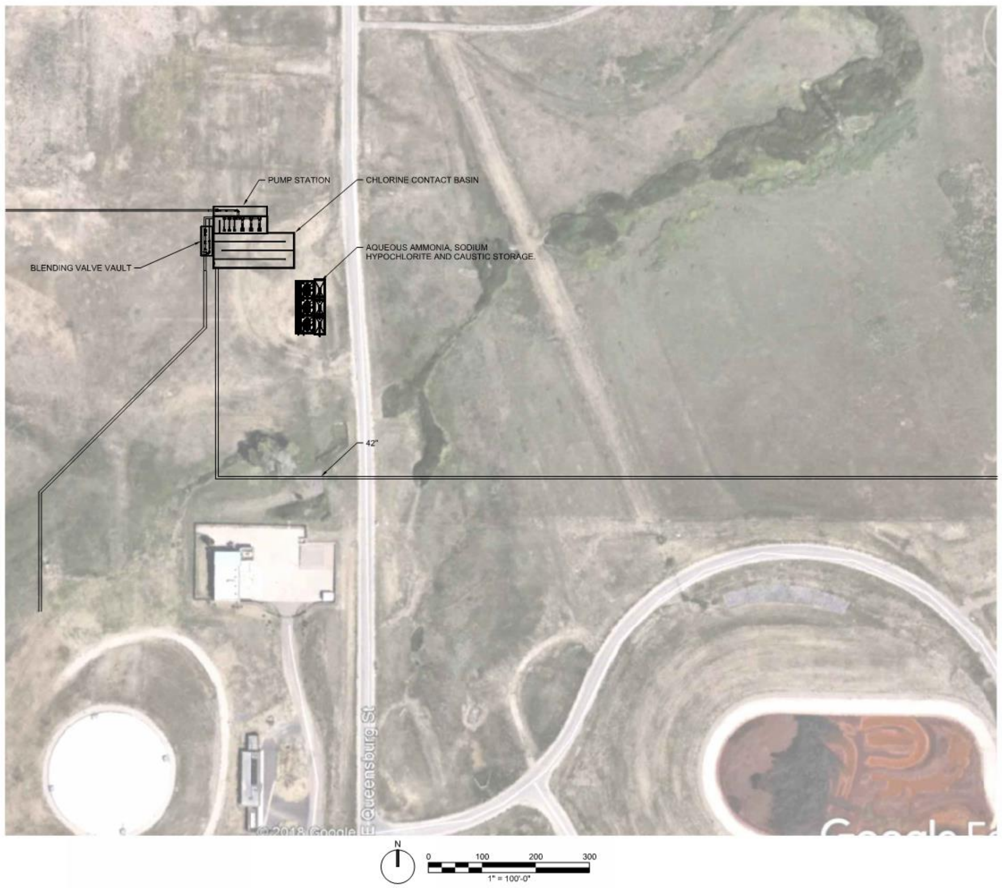



*Figure 4.9 – Alternative 2 – SMWA Low-Pressure Pump Station at BWPF*




ALTERNATIVE 2 AND 3 - TWO PUMP STATION

DESIGN CONDITIONS:

1. FLOW CAPACITY: 30 MGD (25 MGD FIRM) MAX 1 MGD MIN.

ALTERNATIVE 2 AND 3
WISE BINNEY CONNECTION PUMP STATION STUDY
AURORA, COLORADO



ch2m

*Figure 4.10 – Alternative 2 – SMWA Chlorine Contact Basin and High-Pressure Pump Station Near Robertsdale Tank*

### *4.2.1 Low Pressure Pump Station and Wet Well*

The pump station will be of similar design to that shown for Alternative 1. The only major difference will be the discharge pressure will be significantly lower and therefore the motor horsepower will also be significantly lower since the pumps are only required to lift the water to the nearby facilities located near Robertsdale Tank. Figure 4.11 shows the layout of the flow control valve vault and low-pressure pump station.

Consideration should be given to the connection pipeline between the low-pressure and high-pressure pump stations as there is an intermediate high point. Further analysis will be required to ensure appropriate equipment (pressure sustaining valve, etc.) is placed downstream of the highpoint to prevent the line from draining every time the pump station shuts off.

As described for Alternative 1, consideration should also be given on the southern pipeline alignment, specifically the portion of the profile that slopes down to the Smoky Hill Tank since the high point in the line for any water surface is lower than 6125-ft in the tank. If this alignment is chosen, further analysis is required to ensure that hydraulic scenarios have been addressed. For the complete hydraulic analysis refer to Appendix B – Hydraulic Analysis.

The low-pressure pump station footprint is approximately 100-ft x 50-ft. A minimum of 5-ft is maintained around all major equipment. A summary of the low-pressure pump station is shown in Table 4.8.

**Table 4.8: Low-Pressure Pump Station Design Criteria**

| Item | Values | Units |
|---|---|---|
| Maximum Flow Rate | 30 | mgd |
| Minimum Flow Rate | 1 | mgd |
| Pumps Required | 2 Sets of 3 | - |
| Small Pump Quantity | 2 Duty / 1 Standby | - |
| Large Pump Quantity | 2 Duty / 1 Standby | - |
| Small Pump Flow Range, ea. | 0.5– 3 | mgd |
| Large Pump Flow Range, ea. | 5 – 15 | mgd |
| Small Pumps Motor Horsepower | 50 | HP |
| Large Pumps Motor Horsepower | 200 | HP |
| Wet Well Volume (Working) | 312,500 | gal |

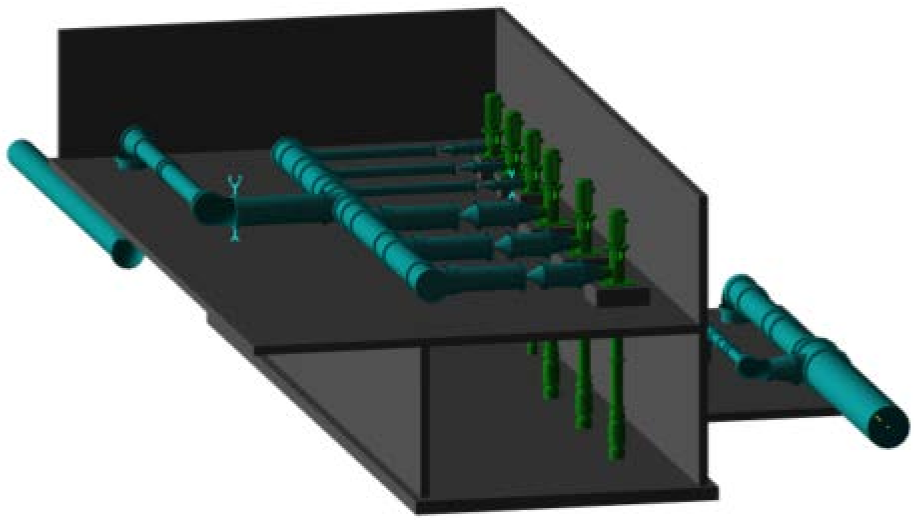


*Figure 4.11: Proposed Layout of the Flow Control Valve Vault and Low-Pressure Pump Station.*

### *4.2.2 Other Alternative 2 Facilities*

As shown on Figure 4.10, the remaining facilities are located near the Robertsdale Tank. These facilities are essentially identical to those shown for Alternative 1, except the facilities are located off the BWPF site, near the Robertsdale Tank.

The only significant difference between these alternatives is the blended water valve vault, shown on the northwest corner of the wet well. This vault allows water to by-pass the contact basin and blend with the SP water in the high-pressure pump station wet well.

## 4.3 Alternative 3 – Two Pump Station (Deferred Capital)

Alternative 3 has an identical configuration to Alternative 2 but for an interim period uses the Wemlinger Blending Pump Station as the low-lift pump station that will pump (treated but not disinfected) SP water off the BWPF site. The Wemlinger Blending Pump Station structure is located on the west end of the BWPF filtration facility. The Wemlinger Blending Pump station structure was built at the time that the filtration facility was constructed, because it would have been difficult to add the pump station structure at a later date. However, because Aurora Water does not currently have a need to transfer water from the SP Train to the Wemlinger Water Treatment Plant (WTP), the Wemlinger Pump Station structure is currently not outfitted with any mechanical equipment. Therefore, SMWA would need to procure and install the pumps, motors, valves, VFDs, and all associated equipment that would be required to make the Wemlinger Pump Station operational. Additionally, the pipeline from the Wemlinger Pump Station to Robertsdale Road has been partially constructed, so SMWA would need to extend the existing pipeline to at least the SMWA proposed site near the Robertsdale Tank.

Therefore, the deferred capital is effectively limited to the cost of the pump station structure.

### *4.3.1 Wemlinger Pump Station*

The Pump Station will be retrofitted with a total of four vertical turbine pumps operating in parallel. The four pumps will be configured as follows:

Two small pumps (0.5-3 mgd), equipped with variable frequency drives (VFD)

Two large pumps (5-15 mgd), equipped with VFD’s

This existing space does not allow for redundant pumps, so some flow rates will require both the small or both the large pumps to be operational.

The connecting discharge piping, and related appurtenances, will be sized for the facility's design flow range from a minimum of 1 mgd to the maximum rated flow capacity of 30 mgd.

Due to the configuration of the Wemlinger Blending Pump Station it is not possible to place a flow control structure between the SP train and the pump station. Therefore, the pump station will act as the flow control facility from Aurora to SMWA. All pipes and equipment are sized such that velocities and dimensions meet Hydraulic Institute (HI) 9.8 standards.

The vertical turbine pumps will boost water from the wet well, through 12-inch and 30-inch discharge lines for the small and large pumps respectively, into a 36-inch combined discharge header. A check valve and an isolation valve is provided on each pump discharge. A 24-inch magnetic flow meter is installed downstream of the 36-inch combined header. The flow meter will be the primary instrument used for controlling the pump station. A combination of existing and new pipe will convey the SP Train water to the CCB located at the Robertsdale Tank area. Figure 4.12 shows the layout of the Wemlinger Pump Station.

Consideration should be given to the connection pipeline between the low-pressure and high-pressure pump stations as there is an intermediate high point. Further analysis will be required to ensure appropriate equipment (pressure sustaining valve, etc.) is placed downstream of the highpoint to prevent the line from draining every time the pump station turns off.

As described for Alternatives 1 and 2, consideration should also be given on the southern pipeline alignment, specifically the portion of the profile that slopes down to the Smoky Hill Tank since the high point in the line for any water surface is lower than 6125-ft in the tank. If this alignment is chosen, further analysis is required to ensure that hydraulic scenarios have been addressed. For the complete hydraulic analysis refer to Appendix B – Hydraulic Analysis.

**Table 4.9: Wemlinger Pump Station Design Criteria**

| Item | Values | Units |
|---|---|---|
| Maximum Plant Flow Rate | 30 | mgd |
| Minimum Plant Flow Rate | 1 | mgd |
| Pumps Required | 2 Sets of 2 | - |
| Small Pump Quantity | 2 Duty | - |
| Large Pump Quantity | 2 Duty | - |
| Small Pump Flow Range, ea. | 0.5 – 3 | mgd |
| Large Pump Flow Range, ea. | 5 – 15 | mgd |
| Small Pumps Motor Horsepower | 50 | HP |
| Large Pumps Motor Horsepower | 200 | HP |

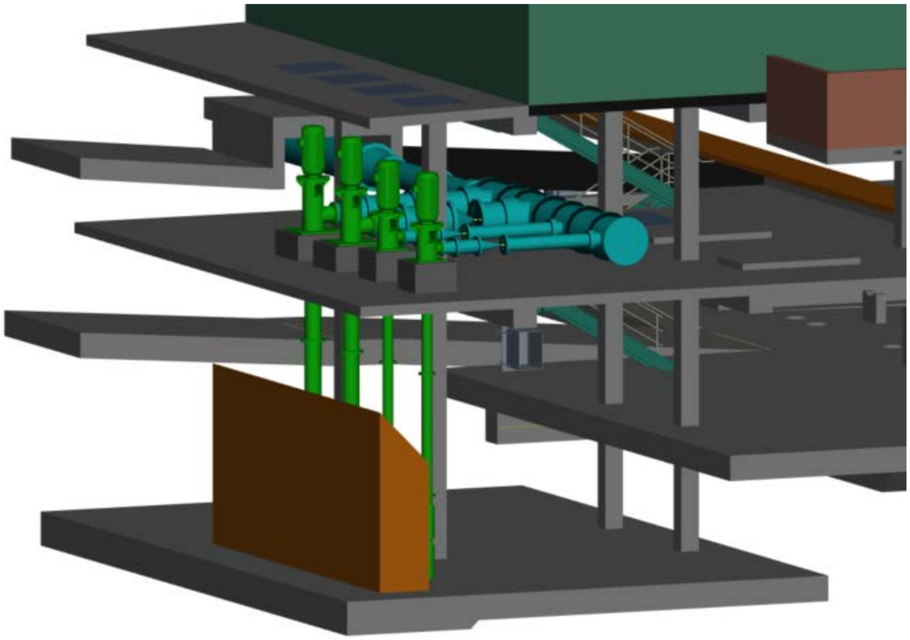


*Figure 4.12: Proposed Layout of the Wemlinger Pump Station.*

# 5.0 Capital Cost Calculation

Conceptual level construction cost estimates were developed for each alternative. The cost estimates developed for this study are considered to be Class 4 - Planning Level Estimates as defined by the American Association of Cost Engineering (AACE) and as designated in ASTM E2516-06 Standard Classification for Cost Estimate Classification System. Class 4 costs are considered accurate from -30 to +50 percent (%) based on a 1% to 15% complete project definition. This range of accuracy is on the final estimate, including any applicable markups for contingency or other project costs.

Standard markups were applied for the following items:

- Allowance for Unscoped Items – 5 percent of the initial estimated construction cost to account for items not identified at the level of this study.
- Contractor Overhead & Profit – 17 percent of the estimated construction cost.
- Contractor Mobilization, Bonds, and Insurance – 5 percent of the estimated construction cost.
- Contingency – 30 percent of the estimated construction cost.

The total estimated construction cost for each alternative is presented in Table 5.1. The detailed cost estimate can be found in Appendix E – Cost Estimate.

**TABLE 5.1 Total Estimated Construction Cost**

| Alternative | Estimated Construction Cost WITHOUT Contingency | Estimated Construction Cost WITH 30% Contingency |
|---|---|---|
| Single Pump Station | $ 15,832,400 | $ 20,581,900 |
| Two Pump Station without Wemlinger | $ 21,253,400 | $ 27,629,200 |
| Two Pump Station with Wemlinger | $ 23,029,600 | $ 29,938,200 |

# 6.0 Non-Cost Criteria

Non-cost criteria were also considered in the evaluation of alternatives. Criteria weights are a measure of the relative importance of each criterion to addressing stakeholder priorities. As described earlier in this TM, the criteria weights are based on a survey of project stakeholders and were used to define tradeoffs between competing goals and to build a defensible foundation for ranking the alternatives based on their anticipated benefits. The selected non-cost criteria and respective weightings are shown in Table 6.1 below.

**Table 6.1 Non-Cost Evaluation Criteria and Weighting**

| Criteria | Description | Relative Weighting |
|---|---|---|
| Land Requirements | This category is a quantitative assessment of the actual square footage required for the new infrastructure (not including the pipeline). | 16% |
| Operations and Maintenance | This category includes quantitative assessment of the anticipated operations and maintenance requirements for the pump station facilities and the pipeline. | 26% |
| Permitting | This category is a qualitative assessment of potentially difficult permitting issues associated with a particular alternative. Also, any unique permits or permits with extensive review periods or documentation would reduce the relative rating in this category. | 11% |
| Constructability | This category is a preliminary assessment of known construction challenges such as limited space available for construction, construction access constraints, and power supply availability challenges. | 21% |
| Reliability | This category addresses the reliability of the alternative from an operations perspective including opportunity for SMWA to receive water when BWPF is off-line and the number of power supplies (drops) that could subject the system to temporary service interruptions. | 21% |
| Public Acceptance | This category covers the full range of potential issues that might make a pump station alternative difficult to implement. Consideration of the potential risk to implementing the project due to any unfavorable situation should be captured by the ratings used for this category. | 5% |

Performance scales were constructed to provide a scoring system in which each alternative can be evaluated. The scoring system for each non-cost criterion is “M” = More Favorable, “N” = Neutral, “L” = Less Favorable, and “O” = Negative. The numerical values assigned to each of these scores are identified in Table 6.2.

**Table 6.2 Non-Cost Criterion Performance Scale and Numerical Values**

| Performance Scale | Numerical Value |
|---|---|
| “M” = More Favorable | 1.0 |
| “N” = Neutral | 0.7 |
| “L” = Less Favorable | 0.4 |
| “O” = Negative | 0.1 |

## 6.1 Land Requirements

This category is a quantitative assessment of the square footage required for the new infrastructure (not including the pipeline). The land requirements scores and descriptive reasoning are identified in Table 6.3.

**Table 6.3 Land Requirements Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 1 – Single Pump Station | "N"<br>Neutral | Alternative 1 – Single Pump Station requires:<br>- Approximately 28,000 square feet at BWPF. |
| Alternative 2 – Two Pump Station | "L"<br>Less Favorable | Alternative 2 – Two Pump Station requires:<br>- Approximately 7,000 square feet at BWPF.<br>- Approximately 36,000 square feet off BWPF property. |
| Alternative 3 – Two Pump Station (Deferred Capital) | "L"<br>Less Favorable | Alternative 3 – Two Pump Station requires:<br>- Approximately 7,000 square feet at BWPF. (1)<br>- Approximately 36,000 square feet off BWPF property. |

Note 1. This land requirement will be deferred until Aurora utilizes Wemlinger PS.

## 6.2 Operations and Maintenance

This category includes quantitative assessment of the anticipated operations and maintenance requirements for the pump station facilities and the pipeline. The scores and descriptive reasoning are identified in Table 6.4.

**Table 6.4 Operations and Maintenance Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 1 – Single Pump Station | "M"<br>More Favorable | Alternative 1 – Single Pump Station includes:<br>- 8.9 MGD required 4.0M kWh of electricity for pump station operation per year.<br>- 16 Total Assets:<br>o 3, 0.5-3 mgd pumps<br>o 3, 5-9 mgd pumps<br>o 1, CCB and pump station wet well<br>o 1, SP Water Flow control valve vault<br>o 1, Blended water flow control valve vault<br>o 6, chemical storage tanks (2 of each chemical – LAS, Hypo, Caustic)<br>o 1, surge tank<br>- No room for additional future operational (equipment) storage |
| Alternative 2 – Two Pump Station | "N"<br>Neutral | Alternative 2 – Two Pump Station includes:<br>- 8.9 MGD required 4.4M kWh of electricity for pump station operation per year.<br>- 25 Total Assets:<br>o 3, 0.5-3 mgd pumps – high pressure<br>o 3, 5-9 mgd pumps – high pressure<br>o 3, 0.5-3 mgd pumps – low pressure<br>o 3, 5-9 mgd pumps – low pressure<br>o 2, pump station wet wells<br>o 1, CCB<br>o 1, SP Water Flow control valve vault<br>o 1, Blended water flow control valve vault<br>o 6, chemical storage tanks (2 of each chemical – LAS, Hypo, Caustic)<br>o 2, surge tanks<br>- Room for additional (future) operational (equipment) storage at high-pressure pump station location |

**Table 6.4 Operations and Maintenance Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 3 – Two Pump Station (Deferred Capital) | "L"<br>Less Favorable | Alternative 3 – Two Pump Station includes:<br>- 8.9 MGD required 4.4M kWh of electricity for pump station operation per year.<br>- 29 Total Assets:<br>o 3, 0.5-3 mgd pumps – high pressure<br>o 3, 5-9 mgd pumps – high pressure<br>o 3, 0.5-3 mgd pumps – low pressure (future)<br>o 3, 5-9 mgd pumps – low pressure (future)<br>o 2, 0.5-3 mgd pumps – low pressure (Wemlinger PS)<br>o 2, 5-15 mgd pumps – low pressure (Wemlinger PS)<br>o 2, pump station wet wells (1 future)<br>o 1, CCB<br>o 1, SP Water Flow control valve vault (future)<br>o 1, Blended flow control valve vault<br>o 6, chemical storage tanks (2 of each chemical – LAS, Hypo, Caustic)<br>o 2, surge tanks (1 future)<br>- Room for additional (future) operational (equipment) storage at high-pressure pump station location |

## 6.3 Permit Requirements

This category is related to a qualitative assessment of potentially difficult permitting issues associated with a particular alternative. Also, any unique permits or permits with extensive review periods or documentation reduces the relative rating in this category. The permit requirements scores and descriptive reasoning are identified in Table 6.5. A comprehensive list of potentially applicable permits and stakeholders is included in Appendix A – WISE Infrastructure Project Regulatory Analysis.

**Table 6.5 Permit Requirements Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 1 – Single Pump Station | "N"<br>Neutral | Alternative 1 – Single Pump Station requires:<br>- CDPHE approval for Binney modifications and new disinfection (treatment) facility. |
| Alternative 2 – Two Pump Station | "L"<br>Less Favorable | Alternative 2 – Two Pump Station requires:<br>- CDPHE approval for Binney modifications and new disinfection (treatment) facilities and building department review for new bathroom associated with remote chemical facility.<br>- Potential permit challenges for hydraulic considerations associated with pumping downhill between the two pump stations. |
| Alternative 3 – Two Pump Station (Deferred Capital) | "L"<br>Less Favorable | Alternative 3 – Two Pump Station requires:<br>- Same as alternative 2. |

## 6.4 Constructability

This category is a preliminary assessment of known construction challenges such as space available for construction, construction access constraints, and power supply availability and location. The constructability scores and descriptive reasoning are identified in Table 6.6.

**Table 6.6 Constructability Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 1 – Single Pump Station | "O"<br>Negative | Alternative 1 – Single Pump Station requires:<br>- 80% of the available space at the BWPF site is required (28,000 of 35,000 sq ft)<br>- May be possible to use other lands on the BWPF site for laydown, if allowable<br>- Sub meter from BWPF electrical system<br>o Tie into 13.2 kV plant loop, reduce to 4160V. Utilize medium voltage equipment for pump station. |
| Alternative 2 – Two Pump Station | "L"<br>Less Favorable | Alternative 2 – Two Pump Station requires:<br>- 20% of the available space at the BWPF site is required (7,000 of 35,000 sq ft)<br>- 36,000 sq ft is also required at the offsite (near Robertsdale Tank) location.<br>o Not space limited at off site location.<br>- For low-pressure pump station at BWPF, sub electrical meter from BWPF electrical system<br>o Tie into 13.2 kV plant loop, reduce to 480V. Utilize low voltage equipment for pump station.<br>- For high-pressure off-site pump station, sub meter from power line in Robertsdale Road that feeds BWPF site<br>o Offsite location utilizes medium voltage equipment for pump station.<br>- Hydraulic consideration for potentially having negative pressures in the pipeline between the two pump stations. |
| Alternative 3 – Two Pump Station (Deferred Capital) | "L"<br>Less Favorable | Alternative 3 – Two Pump Station requires:<br>- Same as Alternative 2. |

Note: Available space is open space that could be used for construction, laydown, facilities, etc.

## 6.5 Reliability

This category addresses the reliability of the alternative from an operations perspective including flexibility to deliver water to SMWA when BWPF is off-line and the reliability of power supplies (drops) that could subject the system to temporary service interruptions. The reliability scores and descriptive reasoning are identified in Table 6.7.

**Table 6.7 Reliability Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 1 – Single Pump Station | "N"<br>Neutral | Alternative 1 – Single Pump Station includes:<br>- Temporary connection can be used as alternate supply when BWPF is off-line<br>- No secondary alternate supply connection is feasible<br>- System is dependent on one electrical system working and one electrical supply for the single facility |

**Table 6.7 Reliability Assigned Scores**

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 2 – Two Pump Station | "L"<br>Less Favorable | Alternative 2 – Two Pump Station requires:<br>- Temporary connection can be used as alternate supply when BWPF is off-line<br>- A second alternate supply connection can be made to the distribution system near Robertsdale Tank<br>- System is dependent on two electrical systems and electrical supplies working for both facilities<br>- Hydraulic considerations for pumping between the two pump stations (intermediate high point which will require additional equipment to keep the line full) |
| Alternative 3 – Two Pump Station (Deferred Capital) | "L"<br>Less Favorable | Alternative 3 – Two Pump Station requires:<br>- Same as Alternative 2. |

## 6.6 Public Acceptance

This category covers the full range of potential issues that might make a pump station alternative difficult to implement. Consideration of the potential risk to implementing the project due to any unfavorable situation should be captured by the ratings used for this category. Public Acceptance non-cost scores and descriptive reasoning are identified in Table 6.8.

**Table 6.8 Public Acceptance Assigned Scores**

Public Acceptance Assigned Scores

| Alternative | Assigned Score | Description |
|---|---|---|
| Alternative 1 – Single Pump Station | "N"<br>Neutral | Alternative 1 – Single Pump Station includes:<br>- Chemical storage on existing plant site |
| Alternative 2 – Two Pump Station | "L"<br>Less Favorable | Alternative 2 – Two Pump Station requires:<br>- Offsite Chemical Storage (LAS/Hypo/Caustic)<br>- Offsite Pump Station Building |
| Alternative 3 – Two Pump Station (Deferred Capital) | "L"<br>Less Favorable | Alternative 3 – Two Pump Station requires:<br>- Offsite Chemical Storage (LAS/Hypo/Caustic)<br>- Offsite Pump Station Building |

# 7.0 Alternative Ranking and Selection

The alternatives were ranked based on a combination of the cost and non-cost weighting and scoring. Each alternative was assigned a relative benefit score based on the sum of the products of the non-cost criteria weight and scoring. The higher the benefit score, the better the benefits. A cost per benefit was then calculated by dividing the project cost by the benefit score. The lower the weighted cost, the more benefit per dollar. The total estimated construction cost, non-cost criteria scoring, benefit, and cost per benefit are identified in Table 7.1 and shown graphically on Figure 7.1.

Table 7.1: Alternative Ranking Score

| Alternative | Estimated Construction Cost | Annual Cost (Power and Chemicals) | Land Requirements 16% | Operations & Maintenance 26% | Permitting 11% | Constructability 21% | Reliability 21% | Public Acceptance 5% | Net Present Value Cost 10 year at 2% (net of inflation) | Benefit | Cost per Benefit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 - Single Pump Station | $ 21,000,000 | $ 557,000 | N | M | N | O | N | N | $ 26,000,000 | 0.65 | $ 39,709,000 |
| 2 - Two Pump Station | $ 28,000,000 | $ 606,000 | L | N | L | L | L | L | $ 33,400,000 | 0.48 | $ 69,791,000 |
| 3 - Two Pump Station (Deferred Capital) | $ 30,000,000 | $ 585,000 | L | L | L | L | L | L | $ 33,700,000 | 0.40 | $ 84,250,000 |

The alternative with the lowest cost per benefit or highest cost per benefit ratio is Alternative 1 – Single Pump Station and represents the preferred alternative for the WISE Binney Connection Pump Station.

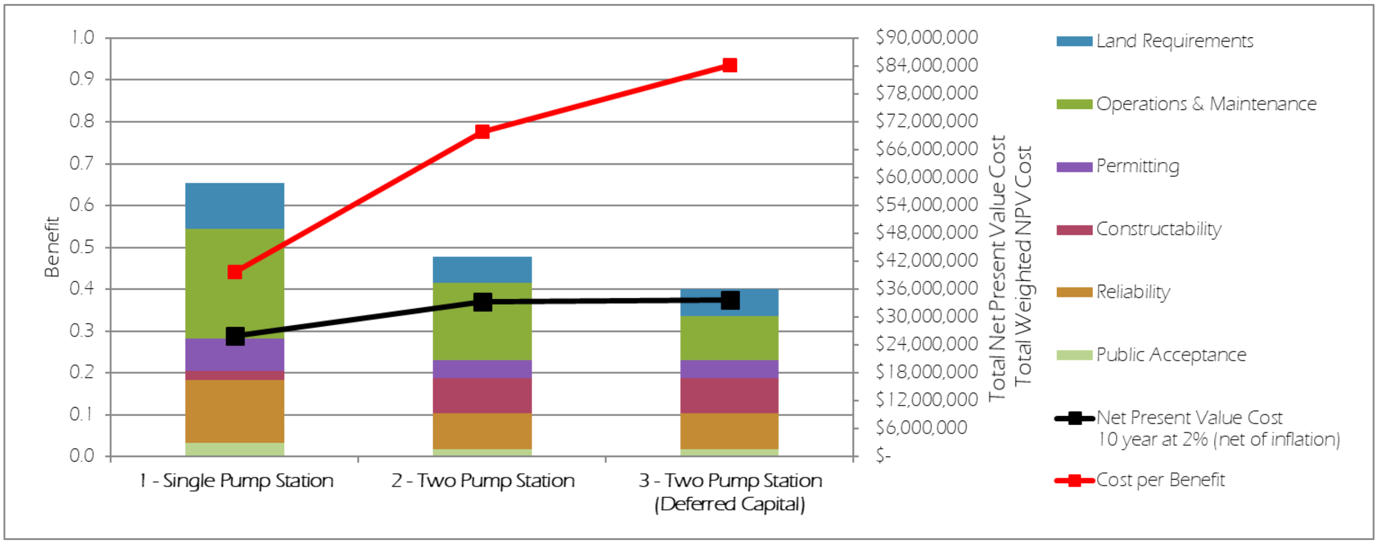



*Figure 7.1: Graphical representation of the total estimated construction cost, non-cost criteria scoring, benefit, and cost per benefit.*

## 8.0 Consider Potential Adverse Consequences of Selecting the Highest Scoring Alternative

Before advancing the single pump station alternative into final design, there are several key items to consider that could change the selected alternative in size and configuration. The items include:

- Coordinate with SMWA Operations Staff to determine if a 480-volt pump station is desired instead of a 4160-volt facility. It is important to note that 480-volt is significantly larger facility will not fit on the limited space available on the BWPF (refer to the Enhancements Section for preliminary evaluation).
- Confirm that SMWA Operations Staff can access the proposed SMWA facilities to be located on the BWPF site as assumed in this evaluation (develop an IGA as appropriate).
- Confirm that chemical deliveries for the SMWA facility can be delivered through the BWPF front gate as assumed in this evaluation (develop an IGA as appropriate).
- Confirm that 13-kV looped power supply at BWPF has sufficient capacity for over 3,000 HP of pump capacity. Note that this has been preliminarily confirmed based on the BWPF electrical model from the original facility design and the proposed new loading.
- Further investigate the enhancements outlined in the following section.

# 9.0 Enhancements

There are several potential enhancements that could be made to the selected alternative (Alternative 1 – Single Pump Station). Some of these are discussed below.

## 9.1 Locate Single Pump Station Off BWPF Site

It may be possible to relocate the Single Pump Station (Alternative 1) off the BWPF property. One option is to locate the pump station near Robertsdale Tank. This option would likely require a tunnel or deep pipe to allow water to flow from the BWPF to this site without intermediate pumping. Another option is to locate the pump station just north of the currently shown location, on the City of Aurora Parks, Recreation, and Open Space parcel to the north. Locating a single pump station facility off BWPF site will require a hydraulic analysis to ensure it is viable to convey water from the SP train to the new location via gravity. It is recommended that survey of the proposed area be conducted to confirm site elevations.

It is important to note that locating the pump station in a location that is not currently defined in the Aurora Reservoir Master Plan as an Aurora Water facility area will require an amendment to the Master Plan including approval by the Aurora Parks, Recreation, and Open Space board and the City of Aurora Planning Commission.

## 9.2 Design for Maximum of 480 Volt Equipment

Limiting the maximum voltage of equipment to 480V would increase the size and cost of the pump station but would be easier to maintain. The following figure and tables provide a perspective on the potential size and cost of a high-pressure pump station with equipment limited to 480V. To limit the motor size to 480V it would require three smaller pumps at 0.5 to 3 mgd to reach the low end of the flow range and seven larger pumps at 3-5 mgd. The maximum horsepower is approximated at 450 HP. Note, that this quick analysis does not take into account is the size of the electrical room to accommodate the increased number of pumps. It should be noted that the 480V pump station is more expensive (approximately $2 million) than the 4160V pump station. The option detailed below is just one option for a potential 480V pump station layout. This option can be optimized and value engineered during detailed design to ensure that the best equipment is provided to meet the needs of SMWA. Refer to Appendix E – Cost Estimate for detailed costing on the 480V pump station option. The estimated annual operations and maintenance cost for this alternative would be similar to Alternative 1, shown above.

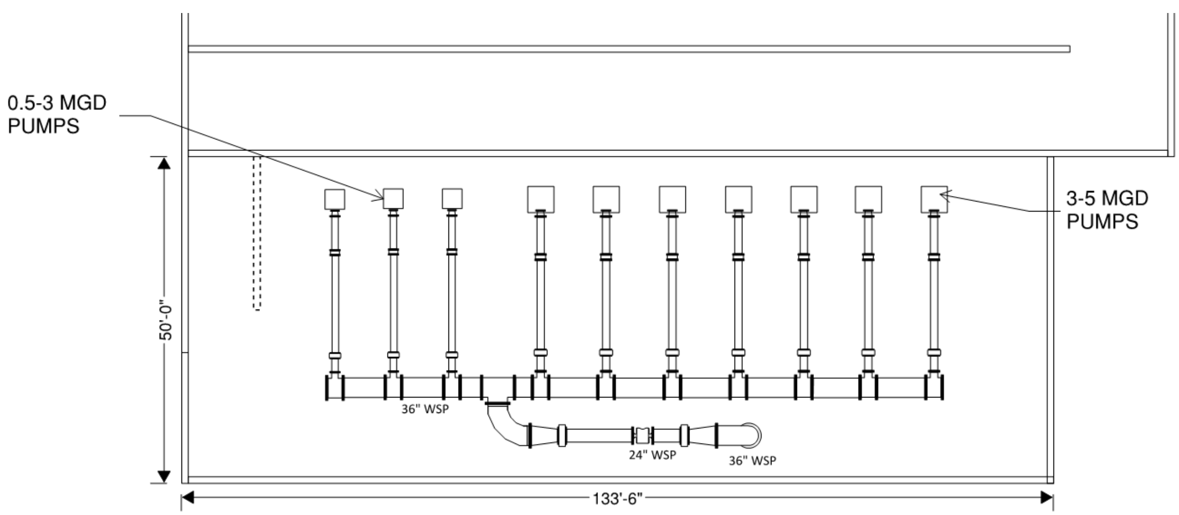



*Figure 9.1: Possible layout for a 480 Volt Pump Station alternative.*

## 9.3 Utilize UV for Disinfection

It may be feasible to utilize UV disinfection technology instead of the chlorine contact basin. A UV reactor, which emits UV-C light, is able to penetrate the cells of microorganisms and render the microorganisms inactive. Based on preliminary vendor information two duty and one standby reactors with 2 medium pressure 10kW lamps per reactor would be required to achieve 0.5 log *Giardia* reduction. The UV reactors would be placed downstream of the flow control valve vault and upstream of the CCB. Utilizing UV would require additional equipment which may require more Operator interaction than strictly a CCB.

# 10.0 Construction Schedule and Next Steps

Refer to appendix F for the proposed construction schedule. Key next steps are summarized below:

| | |
|---|---|
| Begin Detailed Design: | October 2018 |
| Bid Project: | October 2019 |
| Begin Construction: | February 2020 |
| Begin Start-up and Testing: | April 2021 |
| Begin Normal Operations: | June 2021 |

# Appendix A - WISE Infrastructure Project Regulatory Analysis

# 1.0 Overview

The proposed WISE Binney Connection Pipeline will convey flows from the Robertsdale Tank near Binney Water Purification Facility (BWPF) to the existing Smoky Hill Tank. The pipeline alignments range from approximately 4.6 miles to 5.3 miles of 42-inch pressurized steel pipeline. The focus of the WISE Binney Connection Pump Station Study is to evaluate alternatives for siting disinfection, blending, and pumping facilities that would transfer water from the BWPF to the WISE conveyance system.

This project will likely require federal, state, and local regulatory agency reviews, which will impact the project from both a cost and schedule perspective. The permitting requirements for both the pipeline and pump station projects are summarized in Table A.1. It is anticipated the project will require permitting approval from the following agencies:

- U.S. Army Corps of Engineers (USACE)
- U.S. Fish and Wildlife Service (USFWS)
- Colorado State Office of Archaeology and Historic Preservation (SHPO)
- Colorado Parks and Wildlife Division (CPW)
- Colorado Department of Public Health and Environment (CDPHE)
- City of Aurora
- E-470 Public Highway Authority

TABLE A.1

Binney WISE Connection Pump Station and Pipeline Permit Requirements

| Section Reference | Agency | Permit | Applicability | Permittee | Responsibility for preparing permit application | Estimated Time to Submit Application | Total Estimate Time to Obtain Approval | Design | Construction | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| **Federal** | | | | | | | | | | |
| 2.1 | United States Army Corps of Engineers (USACE) | 404 Nationwide Permit 12 Authorization (Utility crossing) | Required - Pipeline | SMWA | SMWA/Designer | 10 days | 45 days | X | | A nationwide 404 permit is a straightforward permit for crossing waters of the United States as compared to an Individual 404 permit. It is highly likely that a nationwide permit can be acquired for this project if waters of the U.S. are tunneled, wetlands are avoided, and a reasonable effort is made to minimize impacts to cultural resources. Specifically, this project will apply for a NWP 12 – Utility Line Activities. This permit applies for activities that do not result in the loss of greater than ½ acre of waters of the United States. The requirement to tunnel Waters of the US will require further investigation to determine if there is a federal nexus for this project that would not allow open-cut under a nationwide permit. That nexus could reside in agreement related to WISE specifically.<br>A Pre-Construction Notice (PCN) and a delineation is required if this project uses mechanized land clearing in wetlands (likely), pipeline exceeds 500 linear feet in the waters of the U.S. (unlikely), or runs parallel to a stream bed within the jurisdictional area (unlikely). The designer will provide exhibits once utility crossing design is completed. PCN exhibits include location map, plan view sketch, and cross-section sketch of the utility crossing. |
| 2.2 | U.S. Department of the Interior – U.S. Fish and Wildlife Service (USFWS) | Section 7 Consultation | Required - Pipeline | SMWA | Designer | 10 days | 40 days | X | | As part of the 404 nationwide permit process and/or as part of City of Aurora Permitting Process, a consultation with the U.S. Fish and Wildlife Service is required if it is found that the project has adverse effects on any federally listed species or its habitat.<br>The designer will need to provide a natural resources assessment identifying potential wetlands, potential federally threatened and endangered species habitat, and natural resources that may affect the project's alignment. A biological assessment may identify the following, but not limited to, federally-endangered species: Preble's Meadow Jumping Mouse Habitat, Raptor Nesting Corridors, Songbird Nesting Corridors, Burrowing Owls Habitat. If any of these areas are identified, it can impact the season that construction is required and my required some habitat mitigation. |
| 2.3 | Federal Emergency Management Agency (FEMA) | Conditional Letter of Map Revision (CLOMR) / Letter of Map Revision (LOMR) | Not Likely - Pipeline | SMWA | SMWA/Designer | 2 months | CLOMR: 3-5 months<br>LOMR: 6 months | X | | FEMA permitting would only be required if the pipeline results in modifications to the 100-year floodplain. It is expected that the design can avoid impacts to the 100-year floodplain and this permit is not likely. |
| **State** | | | | | | | | | | |
| 3.1 | Colorado Office of Archaeology and Historic Preservation | Class I/III Cultural Resource Survey (Section 106 of the National Historic Preservation Act (NHPA) Review | Likely Required - Pipeline, Pump Station | SMWA | SMWA | 2 months | 2 months | X | | As part of the 404 nationwide permit process and/or as part of City of Aurora Permitting Process, a Class I cultural survey may be required. A class I survey can take about 2 months. If a Class I survey identifies construction is proposed in an area with cultural interests, a Class III survey may be required. A Class III survey can take at least 3 months and possibly as long as 8 months. The Class III survey can identify areas where monitoring is required during construction and possibly a revised alignment could be required to avoid cultural or historic resources. |
| 3.2 | Colorado Department of Public Health and Environment (CDPHE) | Site Location & Design Approval | Required – Pump Station/Disinfection | SMWA | Designer | 1 month | 3 months | X | | Required for new or expanding lift/pump stations. Section 22.7 Site Location Application along with an engineering report is required. |
| 3.3 | CDPHE | Drinking Water Design Submittal | Required – Pump Station/Disinfection | SMWA | Designer | 1 month | 3 months | X | | Required for in-plant improvements of the Binney Water Purification Facility (BWPF) or any drinking water facility, which include siting new disinfection, blending, and pumping facilities. A Drinking Water Construction Completion Certification Form will need to be submitted upon the completion of construction and prior to commencing operations. |
| 3.4 | CDPHE | APEN and Construction Permit | Required – Pipeline, Pump Station | Contractor | Contractor | 2 weeks | 90 days | | X | Required as authorization for air emissions associated with construction activities for projects that are greater than 25 acres of earthmoving operations AND lasting longer than 6 months in duration. This will be required for all pipeline alternative alignments and likely not required for the pump station since disturbance is less than 25 acres. |
| 3.5 | CDPHE | Construction Stormwater Discharge Permit | Required - Pipeline | Contractor | Contractor | 1 month | 30 days | | X | Required to obtain permit certification authorizing the discharge of stormwater runoff from construction sites greater than 1 acre. The development and implementation of a Stormwater Management Plan (SWMP) is required prior to submission of the application. The SWMP should be developed along with the Grading Permits as the same information is required. This permit is required for the pipeline project and likely the pump station project too. |
| 3.6 | CDPHE | Construction Dewatering Discharge Permit | Required – Pipeline, Pump Station | Contractor | Contractor | 2 weeks | 30 days | | X | Required for authorization of groundwater discharge and stormwater from excavation sites into state waters. Timeframe assumes that water quality samples have already been obtained. |

TABLE A.1

Binney WISE Connection Pump Station and Pipeline Permit Requirements

| Section Reference | Agency | Permit | Applicability | Permittee | Responsibility for preparing permit application | Estimated Time to Submit Application | Total Estimate Time to Obtain Approval | Design | Construction | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| 3.7 | CDPHE | Hydrostatic Testing of Pipelines, Tanks, and Similar Vessels Discharge Permit | Required – Pipeline, Pump Station | Contractor | Contractor | 2 weeks | 30 days | | X | Required for authorization of the discharge of hydrostatic testing process generated wastewater effluent to ground and/or surface waters of the State of Colorado. |
| 3.8 | Colorado Division of Water Resources | Dewatering Well – Notice of Intent | Required – Pipeline, Pump Station | Contractor | Contractor | 1 day | 3 days | | X | As defined in Section 37-91-102(4.5), C.R.S., a Dewatering Well is any excavation or other ground penetration for dewatering purposes exclusively related to construction projects. Dewatering Wells may be constructed only after proper Notice of Intent and must be plugged and abandoned within one year of being constructed. Upon written request for variance and as warranted by project considerations, the one-year abandonment requirement may be extended. |
| 3.9 | Colorado Department of Local Affairs (CDLA) | 1041 Regulation | Unlikely – Pipeline | N/A | N/A | | | | | May be required if the pipeline crosses the City of Aurora boundaries into Arapahoe County, that has 1041 in effect for large water supply projects.<br>1041 powers allow local governments to identify, designate, and regulate areas and activities of state interest through a local permitting process. The general intention of these powers is to allow for local governments to maintain their control over particular development projects even where the development project has statewide impacts. |
| **City – Aurora** | | | | | | | | | | |
| 4.1 | Aurora | Planning – Development Application (Use by Special Review, Location and Extent) | Required – Pipeline, Pump Station | SMWA | Designer | 1 week | 3 to 4 months | X | | If siting is in municipal city limits, then comply with applicable zoning and subdivision requirements. |
| 4.2 | Aurora | Civil Construction Plan | Required – Pipeline, Pump Station | SMWA | Designer | 1 week | 2 months | X | | Required to obtain Public Improvement Permit and Stormwater Management Permit. |
| 4.3 | Aurora | Public Improvement Permit: Include Right-of-Way Use | Required – Pipeline, Tentative - Pump Station | Contractor | Contractor | 1 week | 2 weeks | | X | These permits are issued for any work performed within the City's right of way related to street cuts for water, sanitary, and storm sewer tie-ins. Permits are also required for paving, curb and gutter, and sidewalk construction, etc. Permits are required for retaining wall installations as well. Construction within the right of way (curb/gutter/sidewalks) and on city-owned and maintained facilities require special licensing and bonding for contractors. Required for the construction of the pipeline within public right-of-way. Any work in the right of way restricting access to ROW will require an approved traffic control plan prior to permit issuance. |
| 4.4 | Aurora | Temporary Use Permit | Required – Pipeline, Pump Station | Contractor | Contractor | 1 week | 2 weeks | | X | Required for construction access and staging. |
| 4.5 | Aurora | COA Stormwater Quality Discharge Permit for Construction Activities | Required – Pipeline, Tentative - Pump Station | SMWA | Designer | 1 week | 2 weeks | X | | Covers stormwater discharges associated with small and large construction sites. Required for projects greater than 1 acre. The Permittee is responsible for and is subject to any liability for drainage, erosion, and sediment control for the permitted site. |
| 4.6 | Aurora | Grading, Erosion and Sediment Control Permit (GESC) | Required – Pipeline, Pump Station | SMWA | Designer | 1 week | 2 weeks | X | | GESC report and plans are required for sediment and erosion control measures. The pipeline will have less stringent GESC requirements compared to plant development. GESC report and drawings will be encompassed in the City of Aurora SWMP plan. |
| 4.7 | Aurora | Floodplain Development Permit | Required – Pipeline, Tentative - Pump Station | SMWA | Designer | 1 month | 1 month | X | | Required if pipeline crosses a drainage or if pump station development occurs within a designated floodplain. Regulates new development, minor improvements, or substantial improvements that occur within a designated floodplain. |
| 4.8 | Aurora | Building Permit | Required – Pipeline, Pump Station | Contractor | Contractor | 1 week | 2 months | | X | Building permit may be required for disinfection, blending, and pumping facilities based on alternative selected. This permit demonstrates that a building project is being constructed under processes for insuring code compliance and public safety. City of Aurora Building permits cannot be issued until all other Development Review processes have been completed. |
| 4.9 | Aurora | Certificate of Occupancy or Temporary Certificate of Occupancy | Required – Pipeline, Pump Station | Contractor | Contractor | 1 day | 24-hour notice prior to occupancy | | X | The Certificate of Occupancy (CO), either temporary or final, is issued prior to occupancy of any structure. No CO may be issued until the requirements of all inspection agencies involved are satisfied, which include stormwater management plan inspections, building inspections, and public improvement inspections. |
| **Other** | | | | | | | | | | |
| 3.10 | E-470 Public Highway Authority | Construction Permit/Permit to Occupy | Required (Pending Design) - Pipeline | SMWA | Contractor (Designer to start, Contractor to complete) | 1 month | 2 months | X | X | Required to allow shoulder survey work, construction, operation, and maintenance of the trenchless crossing through E-470 right-of-way. |

# 2.0 Federal Agencies

USACE typically requires a month to initiate its review process before notifying the USFWS for biological assessment review. After the USFWS review and approval is complete, the USACE typically issues a permit within one month, though the process could require up to 45 days to finalize. The USFWS is given 135 days (4.5 months) to review and issue an opinion, however the current backlog is stretching the process to nearly six months. It is recommended that the project schedule include one year to clear federal review and approval.

## 2.1 Section 404 Permit – United States Army Corp of Engineers

Under Section 404 of the Clean Water Act, the USACE regulates the discharge of dredge and fill material in jurisdictional waters and associated wetlands of the United States. Pipelines fall under NWP 12, which applies to the construction, repair, maintenance and removal of utility lines, provided the area impacted by the project does not result in the loss of greater than 0.5 acres of waters of the United States. For this project, most of the impacts to jurisdictional waters will be temporary during construction and the affected area will be restored to pre-construction grade and conditions. Based on the selected alignment, around 0.046 to 0.172 acres of jurisdictional waters (stream crossings) will be temporarily impacted via open cut. If the project surpasses the half-acre disturbance requirement, trenchless technology will be used instead of open cut to avoid the need for an individual 404 permit. Trenchless technology will not disturb any wetlands or its ordinary floodway compared to open cut.

It will also be important to review any jurisdictional related documentation associated with this project to confirm if previous direction was provided by a Federal Agency that would restrict the options for open-cut of a Waters of the U.S. If those provisions are in place, then the waters of the US will be crossing with trenchless construction to mitigate potential impacts.

If the pipeline alignment encounters wetlands, a Pre-Construction Notification (PCN) and a wetlands delineation will be required to the District Engineer before commencing construction, since there will be mechanized land clearing for the right-of-way. Additionally, if it is determined that the site will adversely impact an endangered species, habitat or wetlands, it is recommended that the PCN mentions mitigation strategies indicating that the pipeline will avoid impacting this area to the maximum extent practicable.

## 2.2 Section 7 Consultation - U.S. Department of the Interior – U.S. Fish and Wildlife Service (USFWS)

Section 7 of the Endangered Species Act requires federal agencies to coordinate with the USFWS whenever a project has the potential to adversely impact any federally listed species or its habitat. To determine if the alignment disturbs any of these areas, a biological assessment is required to identify potential wetlands, potential federally threatened and endangered species habitat, and natural resources that may affect the selected project's alignment. If the assessment determines the alignment impacts wetlands, species or habitat, coordination with Colorado Fish and Wildlife Conservation Office is recommended.

Common federally-listed species that may be near the project site include:

- Preble's Meadow Jumping Mouse
- Raptor Nesting Corridors – require a concurrent Colorado Parks and Wildlife review and a Letter of Conformance if the project is anticipated to impact raptor habitat during the breeding season.
- Songbird Nesting Corridors
- Burrowing Owls
- Additional species of concern may be identified at project site.

The USFWS is then notified by the USACE through consultation to review the potential impacts on critical habitat in the project location.

### 2.3 Conditional Letter of Map Revision (CLOMR) / Letter of Map Revision (LOMR) - Federal Emergency Management Agency (FEMA)

FEMA permitting would only be required if the pipeline or pump station results in modifications to the 100-year floodplain. It is expected that the design can avoid impacts to the 100-year floodplain and this permit is not likely to be required.

If required this permit may impact the project schedule and cost. FEMA requires a Conditional Letter of Map Revision (CLOMR) review prior to construction and a Letter of Map Revision (LOMR) at project completion with demonstration the action will not cause a rise in the 100-year water surface elevation. This process can be executed while other permitting processes are underway. LOMR and CLOMR requirements are moderately complex.

To avoid FEMA permitting, the designer will need to avoid impacting the floodway in the design of the pipeline.

## 3.0 State Agencies

### 3.1 Class I Cultural Resource Survey (Section 106 of the National Historic Preservation Act (NHPA) Review – Colorado Office of Archaeology and Historic Preservation (SHPO)

Section 106 of the National Historic Preservation Act requires federal permitting agencies to ensure cultural and archaeological resources are identified and protected as part of their application review. In Colorado, the SHPO agency is responsible for review of a cultural survey if USACE identifies there is a potential for cultural resources to be found in the project area. It is unclear at this stage whether USACE will require SHPO consultation. However, it is important to consider SHPO review has the potential to significantly impact schedule, if required. Cultural survey reviews could take at least six months and possibly as much as one year to complete.

Based on the available cultural resource mapping provided for this project by SHPO, the only pipeline alignment that has cultural resource impacts except is the Southern Alignment. This alignment passes the Smoky Hill Trail, which is classified as cultural land.

*Compliance during Construction:*

If a cultural sensitive artifact is discovered at the project site during construction, the contractor must stop work in that area and report the findings to the owner, who will make the necessary notifications and determine follow up action. The Contractor will not be allowed to work in the area until it has been cleared by SHPO.

### 3.2 Site Location Approval – CDPHE

New and expanding pump stations require CDPHE Site Location Approval under Regulation 22.7 before construction can begin. This section requires a basis of design report, an engineering report and signage (public notification) for all new pump stations. Signs are to be posted for 15 continuous days prior to the time the site application is submitted to the Division. A photograph of the sign or other documentation certifying that this posting requirement has been met must be included in the application. CDPHE is experiencing significant application backlog now with review and approvals requiring up to four months to complete. For planning purposes, even though the process could potentially take longer, eight to ten months should be assumed for Site Location Approval document preparation, agency review and approval.

### 3.3 Drinking Water Design Submittal – CDPHE

Drinking Water Design Submittal application is required for in-facility modifications to the BWPF. This application requires a site plan, design report of modifications, stamped drawings and specifications. It is estimated that CDPHE review and approval will take up to four months to complete. Future backlogs and review and approval schedules are difficult to predict.

### 3.4 APEN and Construction Permit – CDPHE

For all alignments, the pipeline will likely require APEN authorization if construction of the pipeline is over 25 contiguous acres and exceeds six months in duration. It is expected that the pump station will be APEN-exempt since the disturbance will be less than 25 acres.

If APEN permit is required, it is anticipated that the selected construction contractor could request coverage under the Land Development General Permit (GP03).

### 3.5 Construction Stormwater Discharge Permit – CDPHE

The pipeline will require certification under CDPHE's Colorado Discharge Permit System Stormwater Discharge Permit since this project will disturb greater than one acre of land. This permit requires the development of a Stormwater Management Plan (SWMP). The SWMP developed must include the required elements of the Grading, Erosion and Sediment Control Permit (GESC Grading permits) developed for the City of Aurora. The Construction Contractor, while not obtaining these permits, will be expected to comply with the requirements.

The pump station project is expected to disturb about 0.8 acres and will not require this permit unless the area of disturbance is increased during the design process.

### 3.6 Construction Dewatering Discharge Permit – CDPHE

It is anticipated that the construction of both projects could require dewatering. Consequently, the contractor is required to obtain permit coverage under the Construction Dewatering General Permit. Given the nature of the surrounding development in the area, it is unlikely for CDPHE to require a Groundwater Remediation Discharge Permit. To minimize risks associated with unknown regulatory requirements with the construction dewatering, the client could apply for the Construction Dewatering Discharge Permit prior to selecting a construction contractor and providing a Notice to Proceed.

### 3.7 Hydrostatic Testing of Pipelines, Tanks, and Similar Vessels Discharge Permit – CDPHE

The construction of both projects will require the contractor to obtain a Hydrostatic Testing of Pipelines, Tanks and Similar Vessels Discharge Permit. This applies to hydrostatic testing of equipment and discharge of water after testing.

### 3.8 Dewatering Well – Notice of Intent – Colorado Division of Water Resources

If dewatering is required for pipeline or pump station construction, then the selected construction contractor will need to submit a Notice of Intent to the Colorado Division of Water Resources prior to exposing groundwater.

For the purposes of determining well permitting and notification requirements, the Colorado Division of Water Resources provides the following information on their website, "As defined in Section 37-91-102(4.5), C.R.S., a Dewatering Well is any excavation or other ground penetration for dewatering purposes exclusively related to construction projects. Dewatering Wells may be constructed only after proper Notice of Intent and must be plugged and abandoned within one year of being constructed. Upon written request for variance and as warranted by project considerations, the one-year abandonment requirement may be extended."

In accordance with Rule 6.3 of the Water Well Construction Rules (2 CCR 402-2) (Rules) and the requirement of the State Engineer, Notice of Intent (Notice) must be provided before drilling any Test Hole that penetrates a confining layer and any Monitoring and Observation Hole or Dewatering Well. Notice is accomplished by submitting Form GWS-51(Monitoring and Observation Holes), or Form GWS-62 (Dewatering Wells), to the Division of Water Resources at least three (3) days and no more than ninety (90) days prior to construction. Faxed notices are acceptable.

All Monitoring and Observation Holes and Dewatering Wells must be constructed within 90 days of the receipt of the Notice by the State Engineer's office. Multiple Notices may be filed for projects that require the installation of wells over more than one 90-day period.

### 3.9 1041 Regulations – Colorado Department of Local Affairs (CDLA)

The Colorado General Assembly empowers local agencies with permit review authority over projects of statewide interest through 1041 regulations. Arapahoe County has 1041 regulations in effect for large water supply projects. The 1041 process can be used as a method to control development by local agencies. The regulations have the potential to adversely impact projects with costly remediation requirements or long public and agency review schedules. To avoid lengthy and costly 1041 processes, a proactive approach is recommended that includes project proponents conducting outreach to county and local agencies prior to project site selection. This allows project owners to explore how their project would be perceived in each county, to help county leaders understand the benefits of locating the project in their jurisdiction, and to define the project to meet the least local resistance. The 1041 process can be highly complex because of the extended length of time required and potentially challenging political atmosphere.

This project is not expected to require the 1041 process as the entire limits are within the City of Aurora limits. If during the design process the construction limits are extending into unincorporated Arapahoe County, then this permit process could be required.

### 3.10 Construction Permit/Permit to Occupy – E-470 Public Highway Authority

E-470 Public Highway Authority will become involved if the pipeline alignment is within E-470 Authority Property. The E-470 Public Highway Authority requires construction permits for occupancy, access, and construction. E-470 may be willing to enter into a Common Use Agreement with negotiated fees associated with permits. Occupancy and access permits will be pursued early in the design phase, but construction permit applications cannot be submitted until after the Common Use Agreement is finalized.

## 4.0 City of Aurora

City of Aurora land use laws apply to sites located within their boundaries. Potential permitting submittals include the Development Application (DA), Civil Construction Documents (Civil CDs), and Building Construction Documents (Building CDs). Checklists of the minimum information needed in the plan submittals can be found on City of Aurora's website.

A pre-application meeting is recommended to determine the exact permits required for and issues that may affect the pipeline and pump station project. Additionally, the City of Aurora's development process includes pre-submittal meetings with the planning, engineering, and building departments. At the pre-submittal meeting, all plan sets will be reviewed prior to submittal to ensure the plans are complete and ready for the City of Aurora's review.

### 4.1 Planning – Development Application (Use by Special Review, Location and Extent)

This application will be submitted to the Planning and Development Services Department. The typical submittal includes a site plan, preliminary drainage study, landscape plan, and building elevations. A typical review time is a 12.5-week schedule.

## 4.2 Engineering - Civil Construction Documents

These documents will be submitted to the Public Works Department's Engineering Services Division. The typical submittal includes erosion control plans, grading plan, street construction plans and utility plans. The review timeframe varies based on the number of sheets in the plan set submitted, but is typically an 8-week schedule.

## 4.3 Public Improvement Permit: Right-of-Way Use

These permits are issued for any work performed within the City's right of way related to utility tie-ins. This permit also covers wall installation as well as paving, curb and gutter, and sidewalk construction. Note, the construction within the right of way and on city-owned and maintained facilities require special licensing and bonding for contractors.

## 4.4 Temporary Use Permit

The Temporary Use permit process is intended to allow uses of a temporary nature to exist for a specified length of time in a manner which will not adversely impact the general welfare of persons residing in the community. The pipeline will require this permit, since construction will interfere with pedestrian or vehicular traffic occurring on city streets or right of ways. Depending on the alignment selected and advanced through final design, approximately 200 to 5,400 feet of pipeline is within the roadway.

Additionally, this permit is required for construction staging.

## 4.5 Stormwater Quality Discharge Permit for Construction Activities

This permit is required for the pipeline and is issued prior to grading or other earth disturbance activities and allows the discharge of stormwater from a construction site within City of Aurora limits. According to the "*Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities*" handbook, any of the following conditions for utility construction trigger the need for this permit:

- Disturb one acre or more
- Utility installation site is less than one acre, but is part of a larger project
- Installing underground utilities in excess of 1000 linear feet using open cut installation
- Utilizing trenchless technology for utility boring that has one acre or more of attributable construction disturbance area. BMPs are required to limit discharge into the public right of wat at bore pit locations.
- Installing utilities for a development, prior to the start of overlot clearing and grading.
- Within 100 feet of a watercourse

Projects within the Cherry Creek Watershed must also comply with Cherry Creek Reservoir Control Regulation No. 72, which identifies specific requirements for erosion and sediment control (GESC) best management practices (BMPs) on construction sites and limits the area of land that can be disturbed at a time.

Before the permit can be issued a Stormwater Management Plan (SWMP) must be developed by the applicant and approved by the City of Aurora. During the construction phase, routine inspections by the City of Aurora Water Department Erosion Control Program Staff will be conducted to ensure that the site complies with the permit.

## 4.6 Grading and Erosion Control Plans

A Stormwater Management Plan (SWMP) detailed drawings and report, which include the grading and erosion control plans, must be submitted and approved to receive the Stormwater Quality Discharge

Permit. The design of this report and drawing criteria can be referred in the City of Aurora's "*Rules and Regulations Regarding Stormwater Discharges Associated with Construction Activities*" handbook.

*Compliance during Construction:*

The Designer will identify this permit requirement in the design documents. SWMP must be approved prior to the issuance of the Stormwater Quality Discharge Permit for construction activities. The erosion control BMPs identified in the SWMP report and plans are the minimum required. The contractor is required to comply with the permit. The permit requirements should be included as elements in the Contractors SWMP for coverage under the CDPHE General Permit for Stormwater at Construction Sites.

### 4.7 Floodplain Development Permit

The Floodplain Development Permit is required for the pipeline since portions of the alignment will be constructed within the floodplain and will require temporary modifications (typically fill) to the floodplain itself. The process requires demonstration of no impact on the water surface level. This permit will be applicable to the pump station project if any construction occurs within the floodplain.

*Compliance during Construction:*

The contractor is responsible for verifying that there is zero net fill or cut within the floodplain and that no materials will be stockpiled within the floodplain.

### 4.8 Building Construction Documents

These documents will be submitted to the Public Works Department's Building Division. The typical submittal contains plans and calculations for structural, electrical, plumbing, mechanical, fire and life safety items. The review process can take up to 8 weeks.

### 4.9 Certificate of Occupancy (CO) or Temporary Certificate of Occupancy

All temporary or final buildings and facilities require to have a Certificate of Occupancy that describes the approved uses for the building. Before receiving this Certificate of Occupancy (CO), inspections that include Storm Water Management Plan Inspections, Building Inspections, Public Improvement Inspections, and Zoning Inspections must be completed and passed to proceed. Prior to the start of construction, a pre-construction meeting is recommended to provide additional information on how the City of Aurora will interact with the contractors working on the projects.

## 5.0 Permit Acquisition Strategy

The schedule displaying permitting activities and durations will be developed when a project timeline is set. This schedule will include the acquisition of permits that will be obtained by the Designer, responsible parties for each step in the permitting process, and key milestones associated with the design and construction procurement processes.

# Appendix B – Hydraulic Analysis

# Hydraulic Analysis

The flow requirements for the Binney WISE Connection Pump Station alternatives is a range of 1 to 30 mgd. This flow range can be accomplished either from purely the South Platte (SP) train or a blend of the two (Aurora Reservoir and South Platte) trains. For the hydraulic analysis performed below, the minimum flow is defined as 1 mgd, average flow is defined as 8.9 mgd, and maximum flow is defined as 30 mgd. Note that 8.9 mgd equals 10,000 acre-feet per year, which is the average delivery of WISE water at the maximum subscription level. Table B.1 defines the design flow range and the associated pipeline velocity.

**Table B.1: Design Flow Range and Associated Pipeline Velocities**

| | Flow Range (mgd) | | | Pipeline Velocities (ft/s) | | |
|---|---|---|---|---|---|---|
| | Min | Avg | Max | Min | Avg | Max |
| Alternative 1 | 1 | 8.9 | 30 | 0.16 | 1.45 | 4.9 |
| Alternative 2 | 1 | 8.9 | 30 | 0.16 | 1.45 | 4.9 |
| Alternative 3 | 1 | 8.9 | 30 | 0.16 | 1.45 | 4.9 |

CH2M's proprietary software Replica™ was utilized for the preliminary hydraulic analysis for this study. Replica is a suite of models and intelligent object libraries developed in ExtendSIM™ for dynamic simulation and optimization of process systems. Replica models are assembled from libraries of intelligent objects and can be used to simulate numerous aspects of a system simultaneously, including:

- Fluid Dynamics – including pressurized hydraulics (pipes, pumps, valves, etc.) gravity hydraulics (tanks, channels, weirs, etc.) and compressible gas flow (blowers, pressurized tanks, valves, etc.).
- Operations and Controls – including instrumentation, PLC control logic, and operator simulation.
- Process and Water Quality – including water chemistry, biological process and empirical relationships.

## Alternative 1 – Single Pump Station Hydraulics

The hydraulic model for Alternative 1 included hydraulic elements for the Blending Box, Flow Control Valve Vault, Chlorine Contact Basin (CCB), High Pressure Pump Station, Connection Pipeline and Smoky Hill Tank. The hydraulic model space is shown in Figure B.1. The boundary conditions were set at the Blending Box and the Smoky Hill Tank. The source boundary condition is dictated by flow through both trains at the BWPF. The discharge boundary condition is dictated by the level in the Smoky Hill Tank which has a minimum and maximum water surface elevation of 6105 to 6136 ft, respectively.

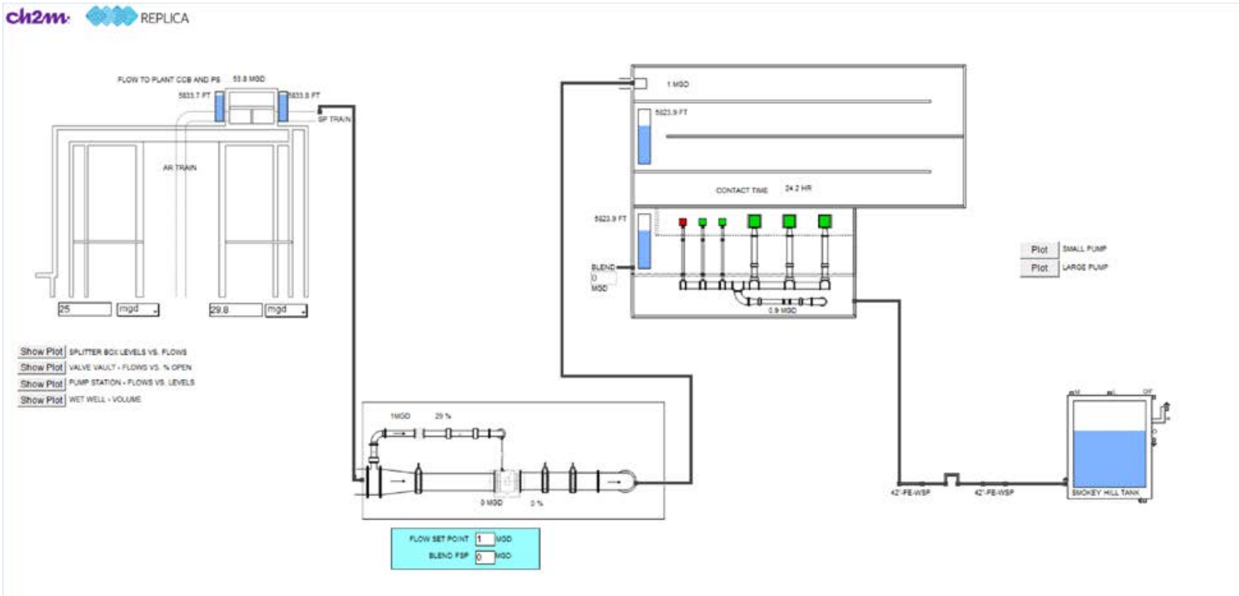



*Figure B.1: Alternative 1 model space from Replica™.*

Within the Flow Control Valve Vault, consideration was given to provide flow control without affecting the hydraulic profile within the existing plant. To accomplish flow control for the full design range of flow rates of 1 to 30 mgd, two flow control valves are required. This allows the control valves to control the flow within their preferred operating range of approximately 20-80% open and this also allows the head loss across each valve to be minimized on the extreme end of the flow range as appropriate CV valves can be selected for each valve.

For preliminary pump selection each Connection Pipeline Alignment, as defined within TM *Binney Wise Connection Pipeline, CH2M, 2018,* was considered for pump selection. Each elevational profile is located in Figures B.2, B.3, and B.4 for the Southern, Northern, and Central alignment profiles respectively. System curves were developed based on the maximum and minimum suction head conditions at the PS, the maximum and minimum hydraulic grade line elevations at Smoky Hill Tank, and the estimated pipe friction conditions. On the basis of the connecting boundary conditions, system curve development was conducted to determine the envelope of expected hydraulic conditions from the highest to lowest total dynamic head requirements for the PS over the full range of flows. System head curves represent the conditions described below:

- The maximum system head curve defines the maximum operating total head conditions at any given flow. This condition is estimated by combining the maximum static head (minimum suction hydraulic grade line versus maximum discharge free water surface level).
- The lower system head curve defines the minimum total dynamic head conditions at any given flow. This condition is estimated by combining the minimum static head (maximum suction HGL versus minimum discharge free water surface level).
- The pumping equipment selected for the PS will be capable of continuous operation within the pump equipment manufacturer's acceptable performance limits over the full envelope, for the full range of design flows and corresponding operating speeds.

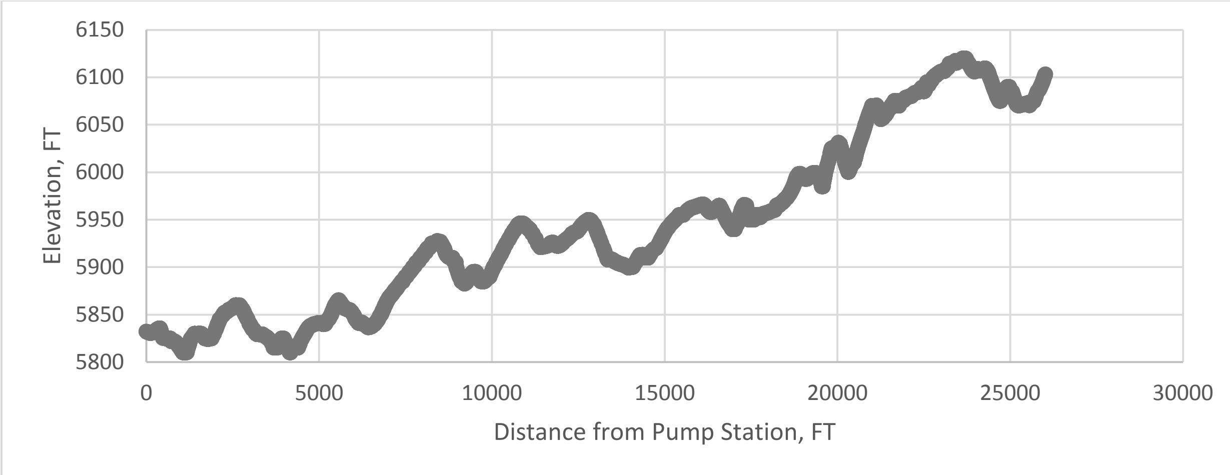



*Figure B.2: South Connection Pipeline Alignment Profile.*

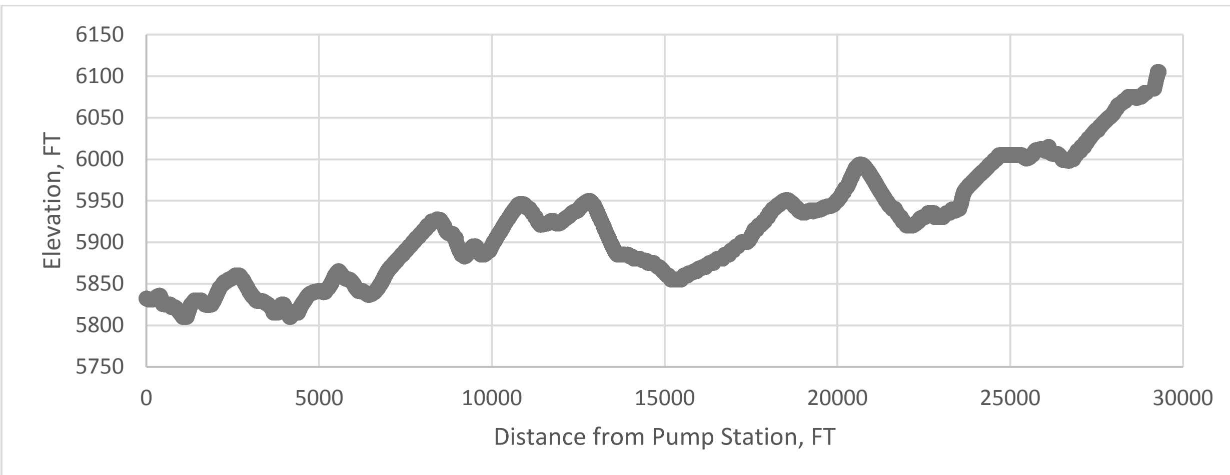



*Figure B.3: North Connection Pipeline Alignment Profile.*

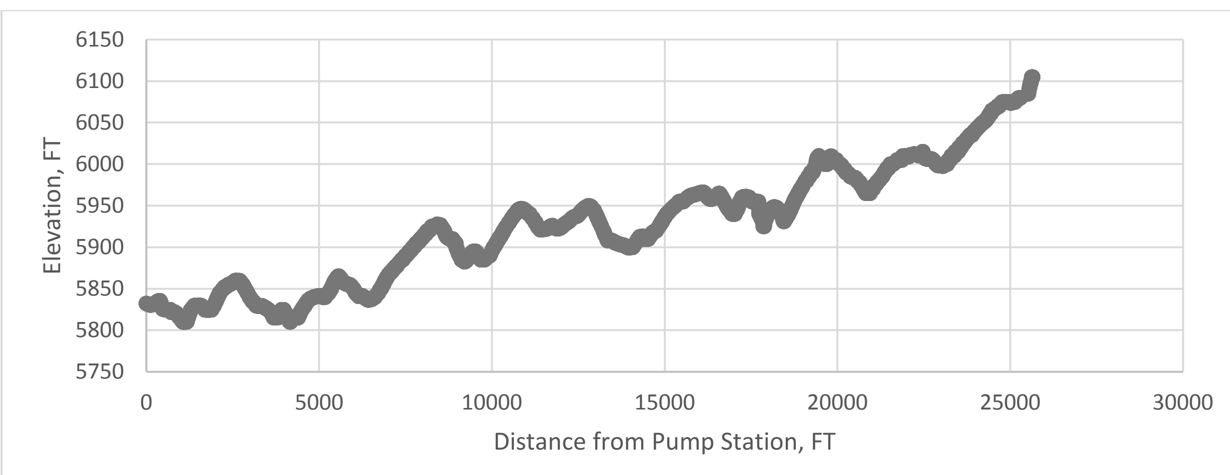



*Figure B.4: Central Connection Pipeline Alignment Profile.*

Consideration should be given on the southern alignment on the portion of the profile that slopes down to the Smoky Hill Tank as the high point in the line will be above any water surface level in the tank lower than 6125 ft. If the water surface level in the Smoky Hill tank is below 6125 and at low flows, there is insufficient frictional loss within the system to keep the HGL above the high point in the line. Therefore, a deeper than assumed pipeline or a pressure sustaining valve would be needed just before the inlet of the tank for this alignment. Note that the pressure sustaining valve option would not allow water to back flow from the Smoky Hill Tank to Rangeview. If this alignment is chosen, further analysis is required to ensure that hydraulic scenarios have been addressed.

Based on the above design conditions the head requirements for the pumps for each alignment are as detailed in Table B.2.

Table B.2: Pump Requirements for Pump Station Alternative 1 and Each Pipeline Alignment

| | Southern Alignment | | | Central Alignment | | | North Alignment | | |
|---|---|---|---|---|---|---|---|---|---|
| | Required Pump TDH, FT | | | | | | | | |
| | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max |
| Alternative 1 | 297.7 | 307.7 | 347.3 | 282.7 | 303.4 | 345.7 | 282.7 | 303.4 | 349.7 |

As shown in Table B.2 each alignment is similar in pump requirements. Therefore, the minimum and maximum head conditions were chosen to allow for the use of the same pump throughout all alignments. The pump selection criteria are shown in Figures B.6 and B.7. Minimum submergence requirements per Hydraulic Institute (HI) Section 9.8, American National Standard for Rotodynamic Pumps for Pump Intake Design, is shown in Figures B.8 and B.9 for the small and large pumps respectively. Due to the large flow requirements for the large pumps, baffle walls will be required per HI Section 9.8. Baffle wall sections for the large pumps shall be with the clearances defined in Figure B.5 and with the values listed in Figure B.9.

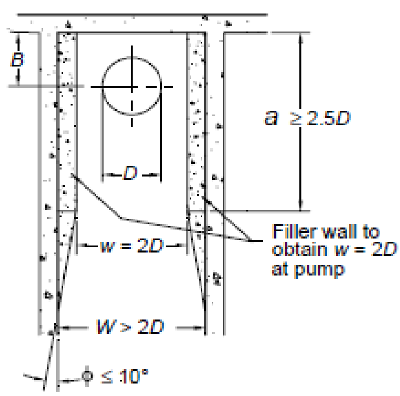



*Figure B.5: HI wetwell design requirements for baffle walls.*

As shown in Figure B.9, the minimum water elevation required for minimum submergence is 42.6 inches and 84.1 inches for the small and large pumps respectively. Therefore, the floor of the wet well is located approximately 22 ft below existing grade.

| ch2m | | | | | | | |
|---|---|---|---|---|---|---|---|
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| | **By:** | PMM | **Chk'd:** | | **Appr'd:** | | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

High Pressure - Large Pumps

**Operating Data**

| | | |
|---|---|---|
| Minimum Flow Rate | 3472.2 | GPM |
| Normal Flow Rate | 6180.6 | GPM |
| Maximum Flow Rate | 10416.7 | GPM |
| Rated Flow Rate | 10416.7 | GPM |
| Required Head | 349.7 | ft |

**Curve Data**

| | | | |
|---|---|---|---|
| Best Efficiency Point, Flow | 9232 | GPM | @ Maximum Impeller |
| Best Efficiency Point, Flow | 8979.2 | GPM | @ Rated Point |
| Shut Off Head | 921 | ft | |
| Motor Sizing, HP | 1500 | HP | |
| Rated Speed | 1180 | RPM | |
| Rated Impeller Size | 13.47 | inch | |

**3.1 Stable Head Rise**

| | | | | | | |
|---|---|---|---|---|---|---|
| Normal Operating Head | 349.7 | ft | Head Rise Ratio | 163.37% | ≥ | 10% |
| Shut Off Head | 921 | ft | | | | |

**3.2 Impeller Diameter**

| | | | | | | |
|---|---|---|---|---|---|---|
| Maximum Impeller Allowable | 13.85 | in | Ratio Rate/Maximum | 97.26% | ≤ | 98% |
| Rated Impeller Diameter | 13.47 | in | | | | |

**3.3 Operating Points, BEP and Suction Specific Speed - Single Speed Suction Impellers**

**3.3.1.1 Suction Specific Speed @ BEP (Maximum Impeller)**

$$Specific\ Suction\ Speed\ Nss = \frac{(nQ^{0.5})}{NPSHR^{0.75}}$$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rotational Speed (RPM), n | 1180 | | | | | | |
| BEP Flow Rate (GPM), Q | 9232 | | | | | | |
| Net Positive Suction Head Required (ft), NPSHR | | | 22.7 | | | | |
| Specific Suction Speed, NSS | 10902 | ≤ | 11000 | | | | |
| Normal Flow as % of Supplied Impeller BEP | | | 80% | ≤ | 68.8% | ≤ | 110% |
| Maximum Specified Flow as % of Supplied Impeller | | | | 116% | ≤ | 120% | |

**3.3.3 Minimum Continuous Stable Flow is less than minimum operating flow?** YES

Minimum Continuous Stable Flow 2284.7 GPM

**3.4 NPSH Margin/Ratio**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NPSHA | 47.1 | ft | @ Normal Flow | NPSHA | 46.2 | ft | @ Maximum Flow |
| NPSHR | 10 | ft | @ Normal Flow | NPSHR | 22.7 | ft | @ Maximum Flow |

3.4.1 For motor ratings 200 HP or less

| | | | | | | |
|---|---|---|---|---|---|---|
| Margin | NA | ft | ≥ | 5 | ft | @ Normal Flow |
| Margin | NA | ft | ≥ | 3 | ft | @ Maximum Flow |

**Process or Utility**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | NA | ≥ | 1.2 |
| Maximum Flow NPSHA/NPSHR Ratio | NA | ≥ | 1.1 |

**Cooling Water**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | NA | ≥ | 1.3 |
| Maximum Flow NPSHA/NPSHR Ratio | NA | ≥ | 1.2 |

→ 3.4.2 For motor rating greater than 200 HP

| | | |
|---|---|---|
| Impeller Eye Diameter, DE | 12.123 | inch |
| Rotational Speed (RPM), n | 1180 | RPM |
| Specific Gravity, SG | 1 | |

(Impeller Eye Diameter is typical 90% of suction nozzle for horizontal end suction pumps)

*Continued on next page*

*Figure B.6: Pump design and selection criteria for the large high-pressure pumps in Alternative 1.*

| | | | |
|---|---|---|---|
| **Project No.:** | 651952 | **Revision:** A | **Date:** 5/12/15 |
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| **By:** | **Chk'd:** | **Appr'd:** | |

| | | | |
|---|---|---|---|
| **Client:** | SMWA | **Subject:** | Binney WISE Connection Pump Station Study |
| **Project:** | Binney WISE Connection PS Study | **Ref. P&ID(s):** | NA |
| **Site:** | Aurora, CO | | |

**Notes**

High Pressure - Large Pumps

3.4.2 *Continued*

Specific Energy 155,956,193 @ Maximum Speed $Specific\ Energy\ SE = DE * N * NSS * SG$

**Normal Flow**

| | | | | | |
|---|---|---|---|---|---|
| → | **Process or Utility SE<160,000,000** | | | | |
| | Margin | 37.1 ft | ≥ | 5 ft | |
| | Normal Flow NPSHA/NPSHR Ratio | 4.71 | ≥ | 1.2 | |
| → | **Cooling Water SE<160,000,000** | | | | |
| | Margin | 37.1 ft | ≥ | 5 ft | |
| | Normal Flow NPSHA/NPSHR Ratio | 4.71 | ≥ | 1.3 | |
| | **All 160,000,000 to 240,000,000** | | | | |
| | Margin | NA ft | ≥ | 5 ft | |
| | Normal Flow NPSHA/NPSHR Ratio | NA | ≥ | 1.26 | *Between 1.3 to 2* |
| | **All >240,000,000** | | | | |
| | Margin | NA ft | ≥ | 5 ft | |
| | Normal Flow NPSHA/NPSHR Ratio | NA | ≥ | 2.5 | |

**Maximum Flow**

| | | | | | |
|---|---|---|---|---|---|
| → | **Process or Utility SE<160,000,000** | | | | |
| | Margin | 23.5 ft | ≥ | 5 ft | |
| | Maximum Flow NPSHA/NPSHR Ratio | 2.04 | ≥ | 1.1 | |
| → | **Cooling Water SE<160,000,000** | | | | |
| | Margin | 23.5 ft | ≥ | 5 ft | |
| | Maximum Flow NPSHA/NPSHR Ratio | 2.04 | ≥ | 1.2 | |
| | **All 160,000,000 to 240,000,000** | | | | |
| | Margin | NA ft | ≥ | 5 ft | |
| | Maximum Flow NPSHA/NPSHR Ratio | NA | ≥ | 1.26 | *Between 1.2 and 1.7* |
| | **All >240,000,000** | | | | |
| | Margin | NA ft | ≥ | 5 ft | |
| | Maximum Flow NPSHA/NPSHR Ratio | NA | ≥ | 2.50 | |

**4.2 Motor Drivers**

4.2.1 Electric motor sizing, excluding service factor with the supplied impeller at maximum specific gravity and viscosity, shall be the greater of the sizing per the following table or the power required to be non-overloading (i.e. nameplate rating not exceeded at any point of the performance curve nor at the end of curve application)

| | | |
|---|---|---|
| Pump Power at Normal Operating Flow | 561 | HP |
| Non-Overloading Power | 1370 | HP |

| | | | |
|---|---|---|---|
| Percentage of Pump Power at Normal Operating Flow | 617.10 | ≤ | 1500 |
| Non-Overloading Check | 1370 | ≤ | 1500 |

*Figure B.6: Pump design and selection criteria for the large high-pressure pumps in Alternative 1, continued.*

| ch2m | Project No.: 702800 | Revision: A | Date: 4/25/18 |
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**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

High Pressure - Small Pumps

| **Operating Data** | | | **Curve Data** | | | |
|---|---|---|---|---|---|---|
| Minimum Flow Rate | 694.4 | GPM | Best Efficiency Point, Flow | 1972.2 | GPM | @ Maximum Impeller |
| Normal Flow Rate | 1388.9 | GPM | Best Efficiency Point, Flow | 1972.2 | GPM | @ Rated Point |
| Maximum Flow Rate | 2083.3 | GPM | Shut Off Head | 463.1 | ft | |
| Rated Flow Rate | 2083.3 | GPM | Motor Sizing, HP | 200 | HP | |
| Required Head | 311 | ft | Rated Speed | 688 | RPM | |
| | | | Rated Impeller Size | 12.25 | inch | |

**3.1 Stable Head Rise**

| | | | | | | |
|---|---|---|---|---|---|---|
| Normal Operating Head | 311 | ft | Head Rise Ratio | 196.14% | ≥ | 10% |
| Shut Off Head | 921 | ft | | | | |

**3.2 Impeller Diameter**

| | | | | | | |
|---|---|---|---|---|---|---|
| Maximum Impeller Allowable | 12.25 | in | Ratio Rate/Maximum | 100.00% | ≤ | 98% |
| Rated Impeller Diameter | 12.25 | in | | | | |

**3.3 Operating Points, BEP and Suction Specific Speed - Single Speed Suction Impellers**

**3.3.1.1 Suction Specific Speed @ BEP (Maximum Impeller)**

$$Specific\ Suction\ Speed\ Nss = \frac{(nQ^{0.5})}{NPSHR^{0.75}}$$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rotational Speed (RPM), n | 688 | | | | | | |
| BEP Flow Rate (GPM), Q | 1972.2222 | | | | | | |
| Net Positive Suction Head Required (ft), NPSHR | | | 5.2 | | | | |
| Specific Suction Speed, NSS | 8873 | ≤ | 11000 | | | | |
| Normal Flow as % of Supplied Impeller BEP | | | 70% | ≤ | 70.4% | ≤ | 110% |
| Maximum Specified Flow as % of Supplied Impeller | | | | 106% | ≤ | 120% | |

**3.3.3 Minimum Continuous Stable Flow is less than minimum operating flow?** NO

Minimum Continuous Stable Flow 0.74e6/24/60 GPM

**3.4 NPSH Margin/Ratio**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NPSHA | 46.8 | ft | @ Normal Flow | NPSHA | 39.8 | ft | @ Maximum Flow |
| NPSHR | 1.7 | ft | @ Normal Flow | NPSHR | 5.29 | ft | @ Maximum Flow |

→ 3.4.1 For motor ratings 200 HP or less

| | | | | | | |
|---|---|---|---|---|---|---|
| Margin | 45.1 | ft | ≥ | 5 | ft | @ Normal Flow |
| Margin | 34.51 | ft | ≥ | 3 | ft | @ Maximum Flow |

**Process or Utility**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | 27.53 | ≥ | 1.2 |
| Maximum Flow NPSHA/NPSHR Ratio | 7.52 | ≥ | 1.1 |

**Cooling Water**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | 27.53 | ≥ | 1.3 |
| Maximum Flow NPSHA/NPSHR Ratio | 7.52 | ≥ | 1.2 |

3.4.2 For motor rating greater than 200 HP

| | | |
|---|---|---|
| Impeller Eye Diameter, DE | | inch |
| Rotational Speed (RPM), n | 688 | RPM |
| Specific Gravity, SG | 1 | |

(Impeller Eye Diameter is typical 90% of suction nozzle for horizontal end suction pumps)

*Continued on next page*

*Figure B.7: Pump design and selection criteria for the small high-pressure pumps in Alternative 1.*

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| | By: | Chk'd: | Appr'd: | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study
**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA
**Site:** Aurora, CO
**Notes**
High Pressure - Small Pumps

3.4.2 *Continued*

Specific Energy - @ Maximum Speed $Specific\ Energy\ SE = DE * N * NSS * SG$

**Normal Flow**

**Process or Utility SE<160,000,000**

Margin NA ft ≥ 5 ft
Normal Flow NPSHA/NPSHR Ratio NA ≥ 1.2

**Cooling Water SE<160,000,000**

Margin NA ft ≥ 5 ft
Normal Flow NPSHA/NPSHR Ratio NA ≥ 1.3

**All 160,000,000 to 240,000,000**

Margin NA ft ≥ 5 ft
Normal Flow NPSHA/NPSHR Ratio NA ≥ -0.10 *Between 1.3 to 2*

**All >240,000,000**

Margin NA ft ≥ 5 ft
Normal Flow NPSHA/NPSHR Ratio NA ≥ 2.5

**Maximum Flow**

**Process or Utility SE<160,000,000**

Margin NA ft ≥ 5 ft
Maximum Flow NPSHA/NPSHR Ratio NA ≥ 1.1

**Cooling Water SE<160,000,000**

Margin NA ft ≥ 5 ft
Maximum Flow NPSHA/NPSHR Ratio NA ≥ 1.2

**All 160,000,000 to 240,000,000**

Margin NA ft ≥ 5 ft
Maximum Flow NPSHA/NPSHR Ratio NA ≥ -0.10 *Between 1.2 and 1.7*

**All >240,000,000**

Margin NA ft ≥ 5 ft
Maximum Flow NPSHA/NPSHR Ratio NA ≥ 2.50

**4.2 Motor Drivers**

4.2.1 Electric motor sizing, excluding service factor with the supplied impeller at maximum specific gravity and viscosity, shall be the greater of the sizing per the following table or the power required to be non-overloading (i.e. nameplate rating not exceeded at any point of the performance curve nor at the end of curve application)

Pump Power at Normal Operating Flow 155 HP
Non-Overloading Power 186 HP

Percentage of Pump Power at Normal Operating Flow 170.50 ≤ 200
Non-Overloading Check 186 ≤ 200

*Figure B.7: Pump design and selection criteria for the small high-pressure pumps in Alternative 1, continued.*

ch2m:

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| **By:** PMM | **Chk'd:** | | **Appr'd:** | | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

HIS 2012 Standard

Alternative 1 - Small Pumps

**Hydraulic Institute Standards - Section 9.8 - Rotodyanmic Pumps - Intake Design**

1) Liquid Depth at entrance to intake structure

$$H_1 \geq 0.7\left(\frac{Q}{W_1}\right)^{0.667}$$

Where:

$W_1$ Is the width at the entrance of the intake structure, in ft

$H_1$ Is the liquid depth at the entrance to the intake structure, in m (ft)

Q Is the total flow at $W_1$, in L/s ($ft^3/s$)

2) Minimum Submergence

$$S = D + \left(\frac{0.574Q}{D^{1.5}}\right)$$

Where:

S Minimum submergence in inches

D Inlet diameter (outside dimensions), inches

Q Flow in GPM

| Input | | |
|---|---|---|
| **Variable** | **Value** | **Unit** |
| $W_1$ | | ft |
| $Q_{entrance}$ | | $ft^3/s$ |
| $Q_{pump}$ | 2083.3333 | GPM |
| D | 17.38 | inch |

3) Distance between Inlet and floor

$$C = 0.5D$$

4) Total Submergence Required

$$H = S + C$$

5) Distance between back wall to pump centerline

$$B = 0.75D$$

6) Distance between pump centerlines

$$W = 2.5D$$ Minimum

7) Recommended Inlet Diameter (outside dimensions)

$$D = (0.0744Q)^{0.5}$$

| | | |
|---|---|---|
| *Recommended D* | *12.4* | *inches* |

*Based on Inlet Bell Design Velocity of 5.5 fps*

8) Distance from pump inlet bell centerline to the downstream face of through-flow traveling screen

$$Y = 4D$$ Minimum, dual flow screens require a physical model study.

9) Distance from pump inlet bell centerline to diverging walls

$$Z_1 = 5D$$ Minimum, assuming no significant cross-flow at entrance to intake structure.

10) Distance from pump inlet bell centerline to sloping floor

$$Z_2 = 5D$$ Minimum

| Output | | |
|---|---|---|
| **Variable** | **Value** | **Unit** |
| $H_1$ | Not Provided | ft |
| S | 33.9 | inch |
| C | 8.69 | inch |
| H | 42.6 | inch |
| B | 13.035 | inch |
| W | 43.45 | inch |
| Y | 69.52 | inch |
| $Z_1$ | 86.9 | inch |
| $Z_2$ | 86.9 | inch |

*Figure B.8: HIS minimum submergence check and dimensional requirements; Alternative 1, Small Pumps.*

| | | | | | |
|---|---|---|---|---|---|
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**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

HIS 2012 Standard

Alternative 1 - Large Pumps

**Hydraulic Institute Standards - Section 9.8 - Rotodyanmic Pumps - Intake Design**

1) Liquid Depth at entrance to intake structure

$$H_1 \geq 0.7\left(\frac{Q}{W_1}\right)^{0.667}$$

Where:

$W_1$ Is the width at the entrance of the intake structure, in ft

$H_1$ Is the liquid depth at the entrance to the intake structure, in m (ft)

Q Is the total flow at $W_1$, in L/s ($ft^3/s$)

2) Minimum Submergence

$$S = D + \left(\frac{0.574Q}{D^{1.5}}\right)$$

Where:

S Minimum submergence in inches

D Inlet diameter (outside dimensions), inches

Q Flow in GPM

| Input | | |
|---|---|---|
| **Variable** | **Value** | **Unit** |
| $W_1$ | | ft |
| $Q_{entrance}$ | | $ft^3/s$ |
| $Q_{pump}$ | 10416.667 | GPM |
| D | 26 | inch |

3) Distance between Inlet and floor

$$C = 0.5D$$

4) Total Submergence Required

$$H = S + C$$

5) Distance between back wall to pump centerline

$$B = 0.75D$$

6) Distance between pump centerlines

$$W = 2.5D$$ Minimum

7) Recommended Inlet Diameter (outside dimensions)

$$D = (0.0744Q)^{0.5}$$

| | | |
|---|---|---|
| *Recommended D* | *27.8* | *inches* |

*Based on Inlet Bell Design Velocity of 5.5 fps*

8) Distance from pump inlet bell centerline to the downstream face of through-flow traveling screen

$$Y = 4D$$ Minimum, dual flow screens require a physical model study.

9) Distance from pump inlet bell centerline to diverging walls

$$Z_1 = 5D$$ Minimum, assuming no significant cross-flow at entrance to intake structure.

10) Distance from pump inlet bell centerline to sloping floor

$$Z_2 = 5D$$ Minimum

| Output | | |
|---|---|---|
| **Variable** | **Value** | **Unit** |
| $H_1$ | Not Provided | ft |
| S | 71.1 | inch |
| C | 13 | inch |
| H | 84.1 | inch |
| B | 19.5 | inch |
| W | 65 | inch |
| Y | 104 | inch |
| $Z_1$ | 130 | inch |
| $Z_2$ | 130 | inch |

*Figure B.9: HIS minimum submergence check and dimensional requirements; Alternative 1, Large Pumps.*

# Alternative 2 and 3 – Two Pump Station

The hydraulic model for Alternative 2 includes hydraulic elements for the Blending Box, Flow Control Valve Vault, CCB, High Pressure Pump Station, Low Pressure Pump Station, Connection Pipeline and Smoky Hill Tank. The hydraulic model space can be found in Figure B.10 and Figure B.11 for Alternative 2 and Alternative 3 respectively.

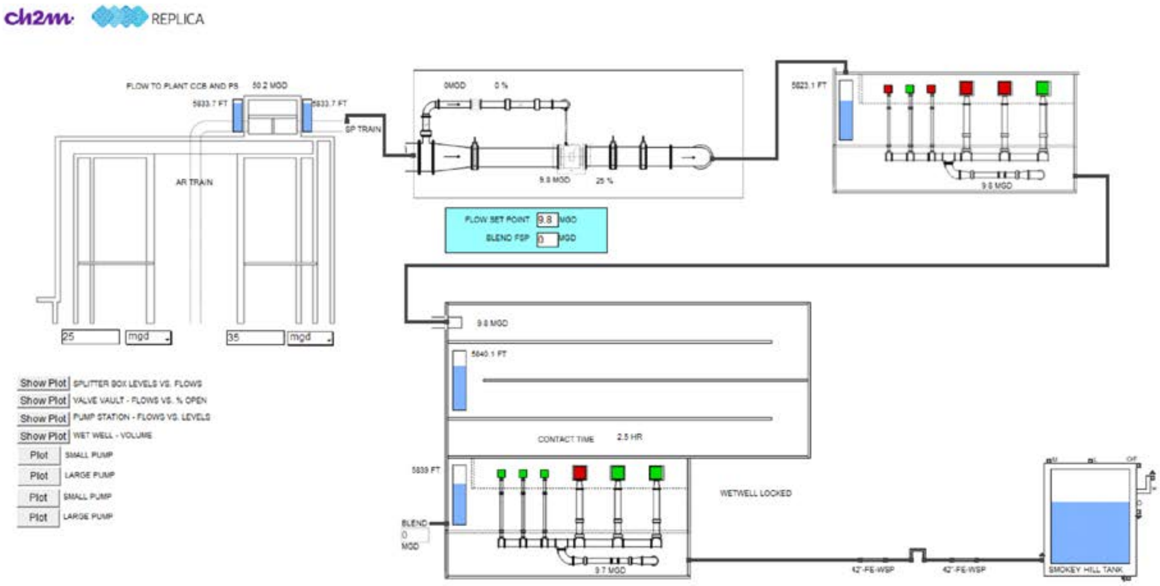


*Figure B.10: Model space for Alternative 2.*

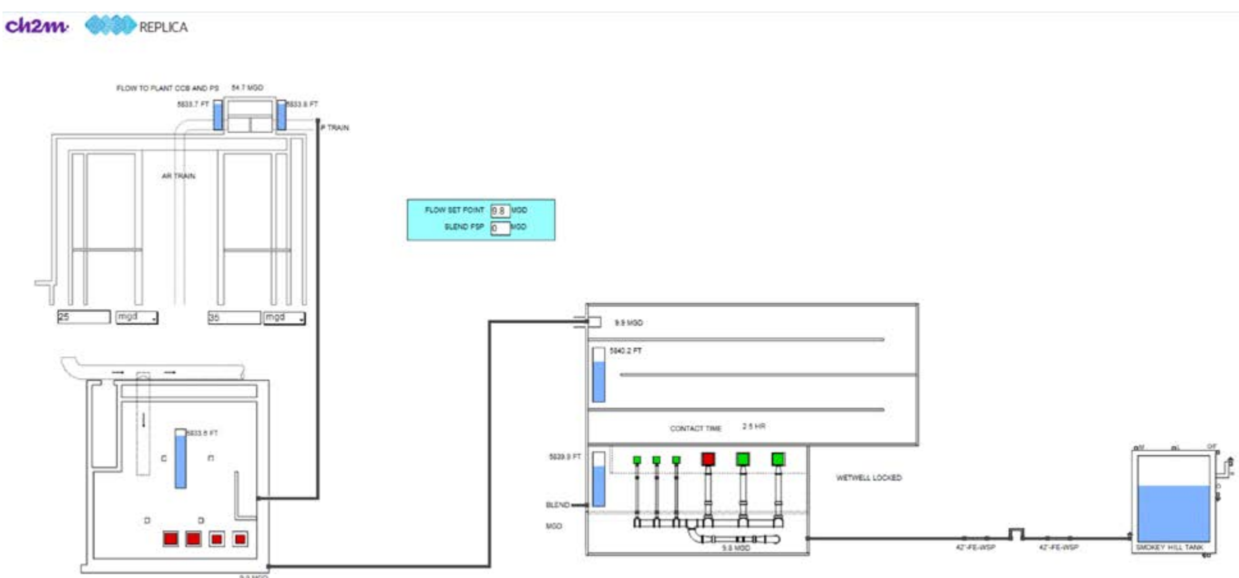


*Figure B.11: Model space for Alternative 3.*

Consideration should be given to the connection pipeline between the low-pressure and high-pressure pump stations as there is an intermediate high point. If Alternative 2 or 3 is selected, further analysis will be required to ensure appropriate equipment (pressure sustaining valve, etc.) is placed downstream of the highpoint to prevent the line from draining every time the pump station turns off.

As described for Alternative 1, consideration should also be given on the southern alignment on the portion of the profile that slopes down to the Smoky Hill Tank as the high point in the line for any water surface lower than 6125 ft in the tank. If this alignment is chosen, further analysis is required to ensure that hydraulic scenarios have been addressed.

Based on the above design conditions the head requirements for the pumps for each alignment are as detailed in Table B.3.

**Table B.3: Pump Requirements for Pump Station Alternatives 2 and 3 for Each Alignment**

| | **Southern Alignment** | | | **Central Alignment** | | | **North Alignment** | | | **Low Pressure Line** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Required Pump TDH, FT** | | | | | | | | | | | |
| | **Min** | **Avg** | **Max** | **Min** | **Avg** | **Max** | **Min** | **Avg** | **Max** | **Min** | **Avg** | **Max** |
| **Alternative 2 & 3** | 281.7 | 288.7 | 335.3 | 266.6 | 282.3 | 323.0 | 266.7 | 282.8 | 327.2 | 35.7 | 41.8 | 52.9 |

As shown in Table B.3, each alignment has similar pump requirements. Therefore, the minimum and maximum head conditions were chosen to allow for the use of the same pump throughout all alignments. The pump selection criteria are shown in Figures B.12 and B.13. Minimum submergence requirements per Hydraulic Institute (HI) Section 9.8, American National Standard for Rotodynamic Pumps for Pump Intake Design, is shown in Figures B.14 and B.15 for the small and large pumps respectively. Due to the large flow requirements for the large pumps, baffle walls will be required per HI Section 9.8.

| | | | |
|---|---|---|---|
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| **By:** PMM | **Chk'd:** | **Appr'd:** | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

High Pressure - Large Pumps - ALT 2 & 3

**Operating Data**

| | | |
|---|---|---|
| Minimum Flow Rate | 3472.2 | GPM |
| Normal Flow Rate | 6180.6 | GPM |
| Maximum Flow Rate | 10416.7 | GPM |
| Rated Flow Rate | 10416.7 | GPM |
| Required Head | 52.9 | ft |

**Curve Data**

| | | | |
|---|---|---|---|
| Best Efficiency Point, Flow | 13392.6 | GPM | @ Maximum Impeller |
| Best Efficiency Point, Flow | 11437.5 | GPM | @ Rated Point |
| Shut Off Head | 86.82 | ft | |
| Motor Sizing, HP | 200 | HP | |
| Rated Speed | 705 | RPM | |
| Rated Impeller Size | 20.66 | inch | |

**3.1 Stable Head Rise**

Normal Operating Head 52.9 ft — Head Rise Ratio 64.12% ≥ 10%

Shut Off Head 86.82 ft

**3.2 Impeller Diameter**

Maximum Impeller Allowable 23.63 in — Ratio Rate/Maximum 87.43% ≤ 98%

Rated Impeller Diameter 20.66 in

**3.3 Operating Points, BEP and Suction Specific Speed - Single Speed Suction Impellers**

**3.3.1.1 Suction Specific Speed @ BEP (Maximum Impeller)**

$$Specific\ Suction\ Speed\ Nss = \frac{(nQ^{0.5})}{NPSHR^{0.75}}$$

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Rotational Speed (RPM), n | 705 | | | | | | |
| BEP Flow Rate (GPM), Q | 13392.6 | | | | | | |
| Net Positive Suction Head Required (ft), NPSHR | 20.93 | | | | | | |
| Specific Suction Speed, NSS | 8338 | ≤ | 11000 | | | | |
| Normal Flow as % of Supplied Impeller BEP | 70% | ≤ | 54.0% | ≤ | 110% | | |
| Maximum Specified Flow as % of Supplied Impeller | 91% | ≤ | 120% | | | | |

**3.3.3 Minimum Continuous Stable Flow is less than minimum operating flow?** YES

Minimum Continuous Stable Flow 3348.8 GPM

**3.4 NPSH Margin/Ratio**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NPSHA | 49 | ft | @ Normal Flow | NPSHA | 39.8 | ft | @ Maximum Flow |
| NPSHR | 8 | ft | @ Normal Flow | NPSHR | 16.25 | ft | @ Maximum Flow |

→ 3.4.1 For motor ratings 200 HP or less

| | | | | | | |
|---|---|---|---|---|---|---|
| Margin | 41 | ft | ≥ | 5 | ft | @ Normal Flow |
| Margin | 23.55 | ft | ≥ | 3 | ft | @ Maximum Flow |

**Process or Utility**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | 6.13 | ≥ | 1.2 |
| Maximum Flow NPSHA/NPSHR Ratio | 2.45 | ≥ | 1.1 |

**Cooling Water**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | 6.13 | ≥ | 1.3 |
| Maximum Flow NPSHA/NPSHR Ratio | 2.45 | ≥ | 1.2 |

3.4.2 For motor rating greater than 200 HP

| | | |
|---|---|---|
| Impeller Eye Diameter, DE | 18.594 | inch |
| Rotational Speed (RPM), n | 705 | RPM |
| Specific Gravity, SG | 1 | |

(Impeller Eye Diameter is typical 90% of suction nozzle for horizontal end suction pumps)

*Continued on next page*

*Figure B.12: Pump design and selection criteria for the large low-pressure pumps in Alternative 2 and 3.*

ch2m:

| | | | | | |
|---|---|---|---|---|---|
| **Project No.:** | 651952 | **Revision:** A | **Date:** 4/25/18 | | |
| **Area/Unit:** | Binney WISE Connection P.S. | **Page** 2 | of 2 | | |
| **By:** | | **Chk'd:** | | **Appr'd:** | |

| | | | |
|---|---|---|---|
| **Client:** SMWA | | **Subject:** | Binney WISE Connection Pump Station Study |
| **Project:** Binney WISE Connection PS Study | | **Ref. P&ID(s):** | NA |
| **Site:** Aurora, CO | | | |

**Notes**

High Pressure - Large Pumps - ALT 2 & 3

3.4.2 *Continued*

Specific Energy 109,296,584 @ Maximum Speed $Specific\ Energy\ SE = DE * N * NSS * SG$

**Normal Flow**

**Process or Utility SE<160,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 1.2

**Cooling Water SE<160,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 1.3

**All 160,000,000 to 240,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 0.86 *Between 1.3 to 2*

**All >240,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 2.5

**Maximum Flow**

**Process or Utility SE<160,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 1.1

**Cooling Water SE<160,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 1.2

**All 160,000,000 to 240,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 0.86 *Between 1.2 and 1.7*

**All >240,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 2.50

**4.2 Motor Drivers**

4.2.1 Electric motor sizing, excluding service factor with the supplied impeller at maximum specific gravity and viscosity, shall be the greater of the sizing per the following table or the power required to be non-overloading (i.e. nameplate rating not exceeded at any point of the performance curve nor at the end of curve application)

Pump Power at Normal Operating Flow 105 HP

Non-Overloading Power 170 HP

Percentage of Pump Power at Normal Operating Flow 115.50 ≤ 200

Non-Overloading Check 170 ≤ 200

*Figure B.12: Pump design and selection criteria for the large low-pressure pumps in Alternative 2 and 3, continued.*

| ch2m | | | | |
|---|---|---|---|---|
| **Project No.:** 702800 | **Revision:** A | **Date:** 4/25/18 | | |
| **Area/Unit:** Binney WISE Connection P.S. | **Page** 1 | of 2 | | |
| **By:** PMM | **Chk'd:** | **Appr'd:** | | |

| | | | |
|---|---|---|---|
| **Client:** | SMWA | **Subject:** | Binney WISE Connection Pump Station Study |
| **Project:** | Binney WISE Connection PS Study | **Ref. P&ID(s):** | NA |
| **Site:** | Aurora, CO | | |

**Notes**

Low Pressure - Small Pumps - Alt 2 & 3

| **Operating Data** | | | **Curve Data** | | | |
|---|---|---|---|---|---|---|
| Minimum Flow Rate | 694.4 | GPM | Best Efficiency Point, Flow | 2140.3 | GPM | @ Maximum Impeller |
| Normal Flow Rate | 694.4 | GPM | Best Efficiency Point, Flow | 2083.3 | GPM | @ Rated Point |
| Maximum Flow Rate | 2083.3 | GPM | Shut Off Head | 89.85 | ft | |
| Rated Flow Rate | 2083.3 | GPM | Motor Sizing, HP | 40 | HP | |
| Required Head | 52.9 | ft | Rated Speed | 875 | RPM | |
| | | | Rated Impeller Size | 11.91 | inch | |

**3.1 Stable Head Rise**

| | | | | | | |
|---|---|---|---|---|---|---|
| Normal Operating Head | 52.9 | ft | Head Rise Ratio | 69.85% | ≥ | 10% |
| Shut Off Head | 89.85 | ft | | | | |

**3.2 Impeller Diameter**

| | | | | | | |
|---|---|---|---|---|---|---|
| Maximum Impeller Allowable | 12.25 | in | Ratio Rate/Maximum | 97.22% | ≤ | 98% |
| Rated Impeller Diameter | 11.91 | in | | | | |

**3.3 Operating Points, BEP and Suction Specific Speed - Single Speed Suction Impellers**

**3.3.1.1 Suction Specific Speed @ BEP (Maximum Impeller)**

$$Specific\ Suction\ Speed\ Nss = \frac{(nQ^{0.5})}{NPSHR^{0.75}}$$

| | | | | | | |
|---|---|---|---|---|---|---|
| Rotational Speed (RPM), n | 688 | | | | | |
| BEP Flow Rate (GPM), Q | 2140.3 | | | | | |
| Net Positive Suction Head Required (ft), NPSHR | 10.57 | | | | | |
| Specific Suction Speed, NSS | 5430 | ≤ | 12000 | | | |
| Normal Flow as % of Supplied Impeller BEP | 50% | ≤ | 33.3% | ≤ | 110% | |
| Maximum Specified Flow as % of Supplied Impeller | 100% | ≤ | 120% | | | |

**3.3.3 Minimum Continuous Stable Flow is less than minimum operating flow?** YES

Minimum Continuous Stable Flow 603.4 GPM

**3.4 NPSH Margin/Ratio**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NPSHA | 49 | ft | @ Normal Flow | NPSHA | 42.8 | ft | @ Maximum Flow |
| NPSHR | 3.08 | ft | @ Normal Flow | NPSHR | 10.01 | ft | @ Maximum Flow |

→ 3.4.1 For motor ratings 200 HP or less

| | | | | | | |
|---|---|---|---|---|---|---|
| Margin | 45.92 | ft | ≥ | 5 | ft | @ Normal Flow |
| Margin | 32.79 | ft | ≥ | 3 | ft | @ Maximum Flow |

**Process or Utility**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | 15.91 | ≥ | 1.2 |
| Maximum Flow NPSHA/NPSHR Ratio | 4.28 | ≥ | 1.1 |

**Cooling Water**

| | | | |
|---|---|---|---|
| Normal Flow NPSHA/NPSHR Ratio | 15.91 | ≥ | 1.3 |
| Maximum Flow NPSHA/NPSHR Ratio | 4.28 | ≥ | 1.2 |

3.4.2 For motor rating greater than 200 HP

| | | |
|---|---|---|
| Impeller Eye Diameter, DE | | inch |
| Rotational Speed (RPM), n | 875 | RPM |
| Specific Gravity, SG | 1 | |

(Impeller Eye Diameter is typical 90% of suction nozzle for horizontal end suction pumps)

*Continued on next page*

*Figure B.13: Pump design and selection criteria for the small low-pressure pumps in Alternative 2 and 3.*

| ch2m | Project No.: | 651952 | Revision: A | Date: 4/25/18 |
|---|---|---|---|---|
| | Area/Unit: | Binney WISE Connection P.S. | Page 2 | of 2 |
| | By: | Chk'd: | Appr'd: | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

Low Pressure - Small Pumps - Alt 2 & 3

3.4.2 *Continued*

Specific Energy - @ Maximum Speed $Specific\ Energy\ SE = DE * N * NSS * SG$

**Normal Flow**

**Process or Utility SE<160,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 1.2

**Cooling Water SE<160,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 1.3

**All 160,000,000 to 240,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ -0.10 *Between 1.3 to 2*

**All >240,000,000**

Margin NA ft ≥ 5 ft

Normal Flow NPSHA/NPSHR Ratio NA ≥ 2.5

**Maximum Flow**

**Process or Utility SE<160,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 1.1

**Cooling Water SE<160,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 1.2

**All 160,000,000 to 240,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ -0.10 *Between 1.2 and 1.7*

**All >240,000,000**

Margin NA ft ≥ 5 ft

Maximum Flow NPSHA/NPSHR Ratio NA ≥ 2.50

**4.2 Motor Drivers**

4.2.1 Electric motor sizing, excluding service factor with the supplied impeller at maximum specific gravity and viscosity, shall be the greater of the sizing per the following table or the power required to be non-overloading (i.e. nameplate rating not exceeded at any point of the performance curve nor at the end of curve application)

Pump Power at Normal Operating Flow 10.68 HP

Non-Overloading Power 36.7 HP

Percentage of Pump Power at Normal Operating Flow 12.28 ≤ 40

Non-Overloading Check 36.7 ≤ 40

*Figure B.13: Pump design and selection criteria for the small low-pressure pumps in Alternative 2 and 3, continued.*

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|---|---|---|---|---|---|
| Area/Unit: | Binney WISE Connection P.S. | | Page 1 | of 3 | |
| By: PMM | Chk'd: | | Appr'd: | | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study
**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA
**Site:** Aurora, CO

**Notes**

HIS 2012 Standard
Alternative 1 - Small Pumps

**Hydraulic Institute Standards - Section 9.8 - Rotodyanmic Pumps - Intake Design**

1) Liquid Depth at entrance to intake structure

$$H_1 \geq 0.7\left(\frac{Q}{W_1}\right)^{0.667}$$

Where:
$W_1$ Is the width at the entrance of the intake structure, in ft
$H_1$ Is the liquid depth at the entrance to the intake structure, in m (ft)
Q Is the total flow at $W_1$, in L/s ($ft^3/s$)

2) Minimum Submergence

$$S = D + \left(\frac{0.574Q}{D^{1.5}}\right)$$

Where:
S Minimum submergence in inches
D Inlet diameter (outside dimensions), inches
Q Flow in GPM

3) Distance between Inlet and floor

$$C = 0.5D$$

4) Total Submergence Required

$$H = S + C$$

5) Distance between back wall to pump centerline

$$B = 0.75D$$

6) Distance between pump centerlines

$W = 2.5D$ Minimum

7) Recommended Inlet Diameter (outside dimensions)

$D = (0.0744Q)^{0.5}$ | *Recommended D* | *12.4* | *inches*

*Based on Inlet Bell Design Velocity of 5.5 fps*

8) Distance from pump inlet bell centerline to the downstream face of through-flow traveling screen

$Y = 4D$ Minimum, dual flow screens require a physical model study.

9) Distance from pump inlet bell centerline to diverging walls

$Z_1 = 5D$ Minimum, assuming no significant cross-flow at entrance to intake structure.

10) Distance from pump inlet bell centerline to sloping floor

$Z_2 = 5D$ Minimum

**Input**

| Variable | Value | Unit |
|---|---|---|
| $W_1$ | | ft |
| $Q_{entrance}$ | | $ft^3/s$ |
| $Q_{pump}$ | 2083.3333 | GPM |
| D | 17.38 | inch |

**Output**

| Variable | Value | Unit |
|---|---|---|
| $H_1$ | Not Provided | ft |
| S | 33.9 | inch |
| C | 8.69 | inch |
| H | 42.6 | inch |
| B | 13.035 | inch |
| W | 43.45 | inch |
| Y | 69.52 | inch |
| $Z_1$ | 86.9 | inch |
| $Z_2$ | 86.9 | inch |

*Figure B.14: HIS minimum submergence check and dimensional requirements; Alternative 2 and 3, Small Pumps.*

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| Project No.: | 702800 | Revision: | | Date: | 4/15/18 |
|---|---|---|---|---|---|
| Area/Unit: | Binney WISE Connection P.S. | Page | 1 | of | 3 |
| By: PMM | | Chk'd: | | Appr'd: | |

**Client:** SMWA **Subject:** Binney WISE Connection Pump Station Study

**Project:** Binney WISE Connection PS Study **Ref. P&ID(s):** NA

**Site:** Aurora, CO

**Notes**

HIS 2012 Standard
Alternative 1 - Large Pumps

**Hydraulic Institute Standards - Section 9.8 - Rotodyanmic Pumps - Intake Design**

1) Liquid Depth at entrance to intake structure

$$H_1 \geq 0.7\left(\frac{Q}{W_1}\right)^{0.667}$$

Where:
$W_1$ Is the width at the entrance of the intake structure, in ft
$H_1$ Is the liquid depth at the entrance to the intake structure, in m (ft)
Q Is the total flow at $W_1$, in L/s ($ft^3/s$)

2) Minimum Submergence

$$S = D + \left(\frac{0.574Q}{D^{1.5}}\right)$$

Where:
S Minimum submergence in inches
D Inlet diameter (outside dimensions), inches
Q Flow in GPM

| Input | | |
|---|---|---|
| Variable | Value | Unit |
| $W_1$ | | ft |
| $Q_{entrance}$ | | $ft^3/s$ |
| $Q_{pump}$ | 10416.667 | GPM |
| D | 26 | inch |

3) Distance between Inlet and floor

$$C = 0.5D$$

4) Total Submergence Required

$$H = S + C$$

5) Distance between back wall to pump centerline

$$B = 0.75D$$

6) Distance between pump centerlines

$$W = 2.5D$$ Minimum

7) Recommended Inlet Diameter (outside dimensions)

$$D = (0.0744Q)^{0.5}$$

| | | |
|---|---|---|
| *Recommended D* | *27.8* | *inches* |

*Based on Inlet Bell Design Velocity of 5.5 fps*

8) Distance from pump inlet bell centerline to the downstream face of through-flow traveling screen

$$Y = 4D$$ Minimum, dual flow screens require a physical model study.

9) Distance from pump inlet bell centerline to diverging walls

$$Z_1 = 5D$$ Minimum, assuming no significant cross-flow at entrance to intake structure.

10) Distance from pump inlet bell centerline to sloping floor

$$Z_2 = 5D$$ Minimum

| Output | | |
|---|---|---|
| Variable | Value | Unit |
| $H_1$ | Not Provided | ft |
| S | 71.1 | inch |
| C | 13 | inch |
| H | 84.1 | inch |
| B | 19.5 | inch |
| W | 65 | inch |
| Y | 104 | inch |
| $Z_1$ | 130 | inch |
| $Z_2$ | 130 | inch |

*Figure B.15: HIS minimum submergence check and dimensional requirements; Alternative 2 and 3, Large Pumps.*

# Appendix C – Water Age Considerations

# Water Age

Water age for the new system configuration should be evaluated as prolonged time within the system can contribute to increased water quality problems. Table C.1 highlights potential water quality problems with increased water age as noted by the United States Environmental Protection Agency (USEPA). The water age between the discharge of the Chlorine Contact Basin (CCB) to the Smoky Hill Tank for each of the pipeline alignment and pump station alternative combinations was evaluated. Water age downstream of the Smoky Hill Tank was not evaluated. Table C.2 details the expected water age when the water arrives at the Smoky Hill Tank for the minimum, average, and maximum design flow rates within the system. As shown, the water age for the average and maximum design flow rates is less than eight hours for Alternative 1 and less than 12 hours for Alternatives 2 and 3. At the minimum flow rate of 1 MGD, the water age is approximately 2.5 days for Alternative 1 and 4 days for Alternatives 2 and 3.

**Table C.1: Summary of Water Quality Problems Associated with Water Age**

| **Chemical Issues** | **Biological Issues** | **Physical Issues** |
|---|---|---|
| Disinfection by-product formation | Disinfection by-product biodegradation | Temperature increases |
| Disinfectant decay | Nitrification | Sediment Deposition |
| Corrosion Control Effectiveness | Microbial regrowth, recovery, shielding | Color |
| Taste and Odor | Taste and Odor | |

**Table C.2: Water Age at the Smoky Hill Tank**

| | **Southern Alignment** | | | **Central Alignment** | | | **Northern Alignment** | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Water Age (days)** | | | **Water Age (days)** | | | **Water Age (days)** | | |
| | **Min Flow** | **Avg Flow** | **Max Flow** | **Min Flow** | **Avg Flow** | **Max Flow** | **Min Flow** | **Avg Flow** | **Max Flow** |
| **Alternative 1** | 2.2 | 0.2 | 0.1 | 2.2 | 0.2 | 0.1 | 2.4 | 0.3 | 0.1 |
| **Alternative 2** | 3.9 | 0.4 | 0.2 | 3.8 | 0.4 | 0.1 | 4.1 | 0.5 | 0.1 |
| **Alternative 3** | 3.9 | 0.4 | 0.2 | 3.8 | 0.4 | 0.1 | 4.1 | 0.5 | 0.1 |

Note: The Northern Power Alignment Alternative is similar to the Central Alignment.

# Appendix D – Surge Analysis

# Surge Analysis

The following analysis studied the impact of power failure on the planned Pump Stations (PS). The analysis provided an estimate of transient surge pressures during a power outage and proposed solutions to mitigate possible extreme pressure transients by utilizing surge chambers and air valves.

The evaluation resulted in the following conclusions and recommendations:

- Adding a surge chamber at each pump station would mitigate the pressure transients caused by the power failure to within acceptable limits. Under Alternative 1 scenario, one surge chamber can be used for the central and northern alignment profiles. Under Alternative 2 scenario, each pump station has a surge chamber and the design recommendation is suitable for any of the three pipe profiles.
- Of the three potential pipe profiles, the Southern profile requires the surge chamber/s as described above with the addition of air valves and a pressure sustaining valve to prevent cavitation in the case of power outage. This is due to a high point unique to this specific profile.

## Overview

The hydraulic transient analysis was conducted using the Bentley HAMMER computer program. HAMMER uses the method of characteristics described by Benjamin E. Wylie and Victor L. Streeter[1].

## Analysis Objectives

The objectives of the present analysis were to evaluate if any unacceptable pressures, extreme high or low, resulted from a power failure causing an abrupt pump station shutdown and to determine, if needed, the measures required to manage extreme pressure transients within acceptable limits. A safety factor of 2 on vapor pressure was used for the minimum pressure. Column separation is expected to occur at -11.8 psi at EL 6,100 feet. Therefore, the evaluation criteria used to design and size surge mitigation methods was to keep minimum pressure above -5.9 psi.

## Model Summary

The pipe section connecting the upstream PS and Smoky Hill Tank is 42 inches in diameter. Two pipe wall thickness were considered, 1/2" and 3/8". Of the two, the design with 3/8" wall thickness pipe resulted in a slightly higher uncontrolled maximum velocity (Southern Alternative 1 average flow 30.35 mgd and 30.31 mgd for ½" and 3/8" respectively). To be conservative, the pipe wall thickness of 3/8" was assumed throughout the analysis. The wave speed of the selected pipe was calculated to be 3,538 ft/sec. The friction factor of all pipe was set to a Hazen Williams C factor of 140.

## Analyses

Three potential pipe routes and two PS alternatives were considered. The Northern Power pipeline alignment alternative was not evaluated, but is similar to the Central Alignment. Alternative 1 involved a single PS with three 30" high pressure pumps and three 12" high pressure pumps. In the enclosed figures, this PS is labeled as PS Wet Well. Alternative 2 involved two PSs, a low-pressure PS at the upstream end and a high-pressure PS approximately 4,500 feet downstream of the first PS. The low-

[1] Wylie, Benjamin E. and Victor L. Streeter, ***Fluid Transients in Systems***, Prentice Hall, 1993

pressure PS pumped to the top of a small hill then flowed by gravity to a new wet well at the high-pressure PS. The gravity section was not modeled.

In each scenario the system was evaluated assuming power failure after 10 seconds of steady state operations. The PSs were assumed to have two active 30” pumps, one standby 30” pump and three 12” low flow pump that were inactive. The pump performance curves are shown in Figure D.1.

# Alternative 1

Under alternative 1, of the three pipeline alignment options, the southern alignment required air valves at a peak prior to the Smoky Hill Tank and a pressure sustaining valve just upstream of the Smoky Hill Tank to maintain positive pressure over the peak. The central and northern alignments do not have a point higher than the Smoky Hill Tank at any point of the route, hence such measures were not necessary. A surge chamber must be installed at the PS located at the BWPF. The recommended surge chamber and valve specs are shown in Table D.1 and Table D.2.

**Table D.1: Alternative 1 Recommended Surge Chamber**

| Total vol. (gal) | Initial air vol. (gal) | Initial water vol. (gal) | Min P estimate (psi) | $D_{in}$ (in) | $D_{out}$ (in) |
|---|---|---|---|---|---|
| 17000 | 7000 | 10000 | Northern, -5.03 | 18 | 36 |
| 17000 | 7000 | 10000 | Central, -4.15 | 18 | 36 |
| 17000 | 7000 | 10000 | Southern, -5.82 | 18 | 36 |

gal=gallon
psi=pounds per square inch
in=inch

Table D.2:. Alternative 1 Recommended Valve Specifications

| | Elevation (ft) | $D_{in}$ (in) | $D_{out}$ (in) | Distance from low pressure PS (ft) |
|---|---|---|---|---|
| AV1 | 6120 | 12 | 0.3 | 6112.50 |
| AV2 | 6116.35 | 12 | 0.3 | 6119.70 |
| PSV at 35 psi | 6098.78 | 42 | 42 | 6095.00 |

Applies to southern profile only

Figure D.5 through Figure D.13 summarize simulated pressure and hydraulic grade line (HGL) envelope plots and pressure time series plots recorded at PS Wet Well for the three profiles. These pressure envelope and HGL plots show the maximum, minimum, and steady state pressure experienced at a location throughout the simulated time. The pressure time series plot signifies the occurrence of pressure transient event caused by the power outage and the pressure damping function served by the surge chamber. The maximum and minimum pressures are within acceptable limits.

# Alternative 2 and 3

For all three pipeline profiles, the low-pressure PS pumps water over a 30-foot hill to the next PS. The interval between this hill and the second pump station was assumed to be a gravity fed section and was not modeled. The configuration of Alternative 2 allowed the first pump station to have a smaller surge chamber than Alternative 1. The high-pressure PS required larger surge chambers. Their specifications are shown in D.7 and Table D.8. The simulation result indicated that the same surge chamber design could be applied to all three potential profiles. The maximum and minimum pressures are within acceptable limits. The results are shown in Figures Figure D.14 through Figure D.25.

Table D.7: Alternative 2 Recommended Surge Chambers for the Low-Pressure PS

| Total vol. (gal) | Initial air vol. (gal) | Initial water vol. (gal) | Min P estimate (psi) | $D_{in}$ (in) | $D_{out}$ (in) |
|---|---|---|---|---|---|
| 12500 | 5000 | 7500 | Northern, -5.57 | 18 | 36 |
| 12500 | 5000 | 7500 | Central, -3.97 | 18 | 36 |
| 12500 | 5000 | 7500 | Southern, -5.27 | 18 | 36 |

Table D.8: Alternative 2 Recommended Surge Chambers for the High-Pressure PS

| Total vol. (gal) | Initial air vol. (gal) | Initial water vol. (gal) | Min P estimate (psi) | $D_{in}$ (in) | $D_{out}$ (in) |
|---|---|---|---|---|---|
| 16000 | 7000 | 9000 | Northern, -5.18 | 18 | 36 |
| 16000 | 7000 | 9000 | Central, -5.97 | 18 | 36 |
| 16000 | 7000 | 9000 | Southern, -3.68 | 18 | 36 |

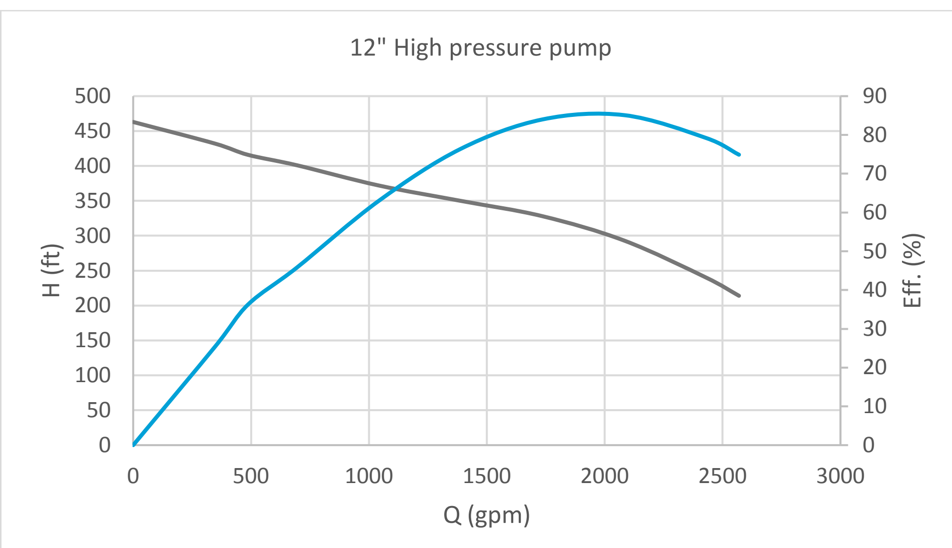
# Conclusion and Recommendation

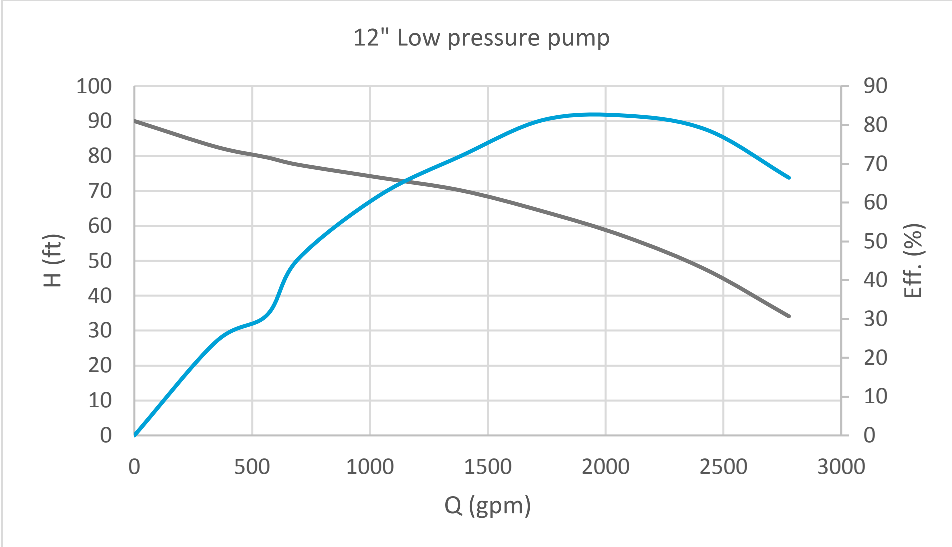
The installation of surge chambers as a protection against extreme surging was found to be necessary. For each alternative, one surge chamber design could be used for all three potential profiles. For the southern alignment profile only, air valves and a pressure sustaining valve must also be installed.

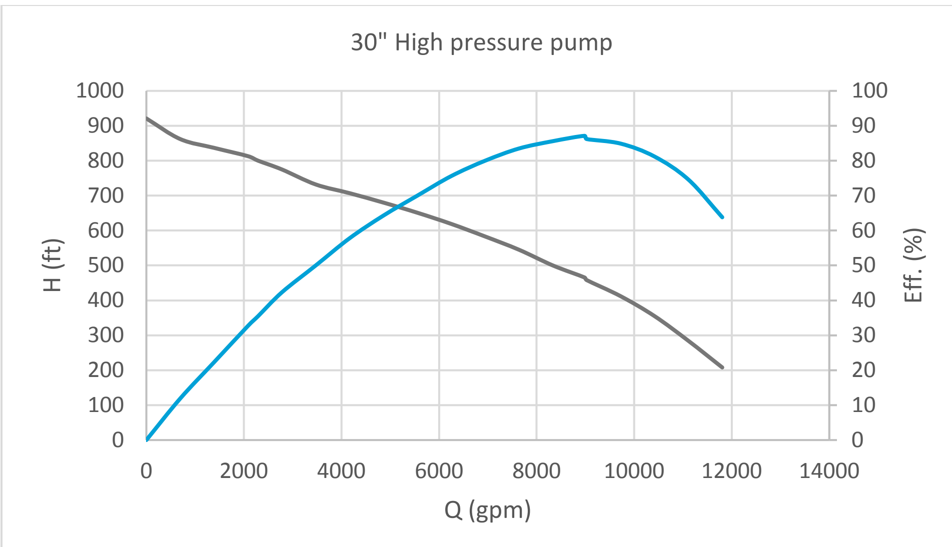
Air valves are prone to malfunction. The valves can stick from infrequent use and valve vaults can fill with water making them non-effective. Therefore, they must be properly installed and maintained to provide reliable system protection. In addition, they let large amounts of air into the system which needs to be accounted for during start up procedures. It is important for the owner to accept this responsibility for the protection of the system when air valves are part of the selected mitigation alternative.

Surge chambers are the most reliable transient control device. Surge chambers require air compressors and controls to ensure they are properly set when needed. Surge chambers act as an energy source following power failure and as a shock absorber during pressure upsurges. They tend to remove sharp pressure spikes and create smooth, controlled pressure oscillations until friction dampens out transient pressure waves.

*Figure D.1: Assumed Pump Curves*




12" Low pressure pump
H (ft)
Eff. (%)
Q (gpm)
100
90
80
70
60
50
40
30
20
10
0
0
500
1000
1500
2000
2500
3000


30" High pressure pump
H (ft)
Eff. (%)
Q (gpm)
1000
900
800
700
600
500
400
300
200
100
0
0
2000
4000
6000
8000
10000
12000
14000

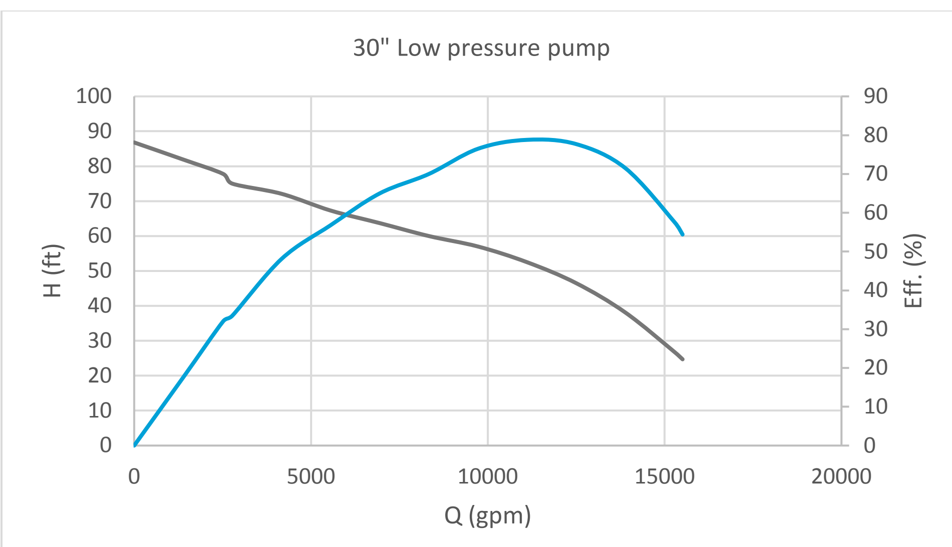
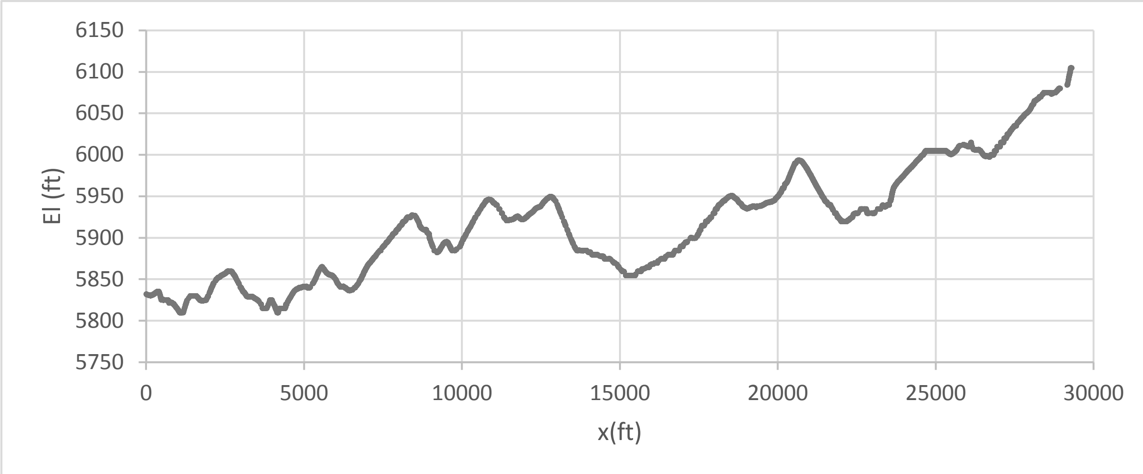
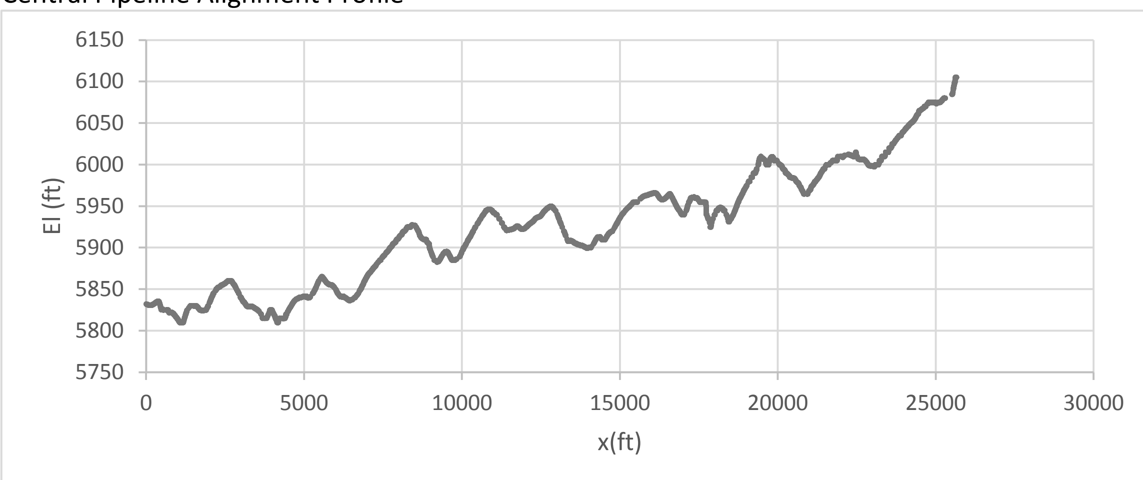

30" Low pressure pump
H (ft)
Eff. (%)
Q (gpm)
100
90
80
70
60
50
40
30
20
10
0
0
5000
10000
15000
20000

*Figure D.2: Assumed Northern, Central and Southern Profiles*

Northern Pipeline Alignment Profile




Central Pipeline Alignment Profile




Southern Pipeline Alignment Profile

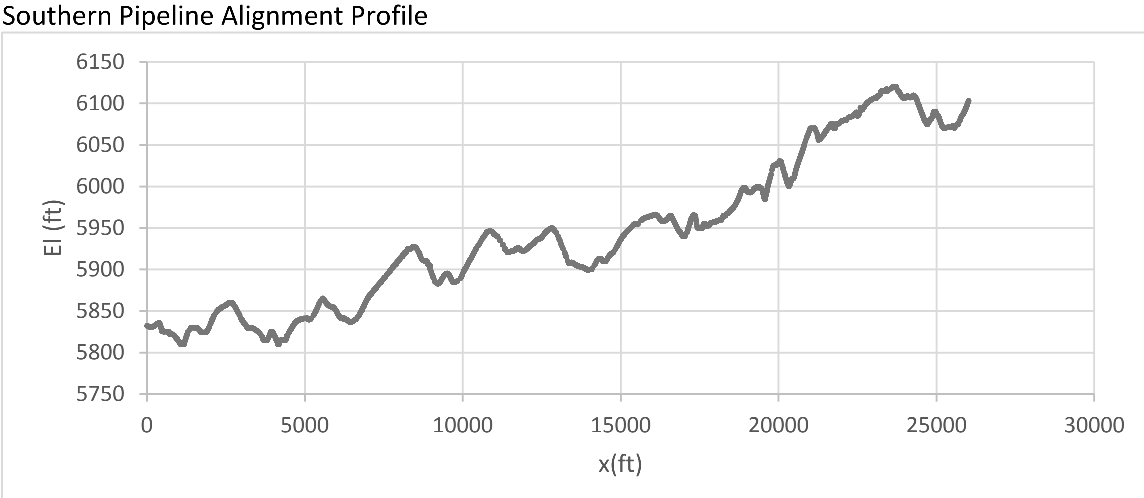
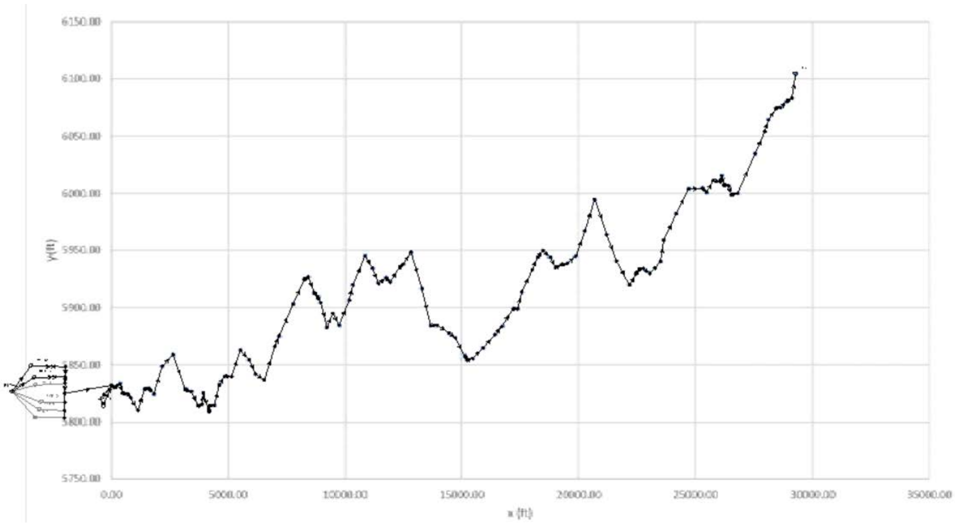
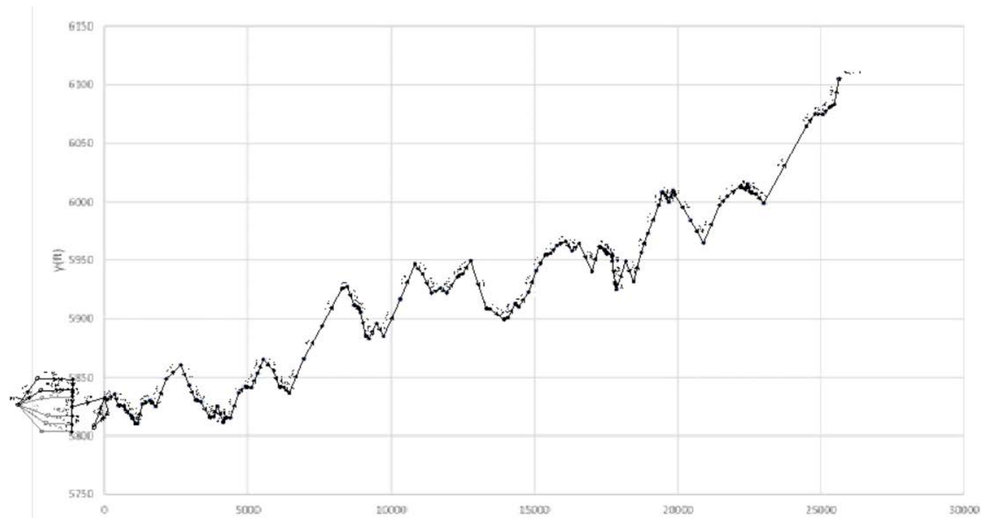


*Figure D.1: Alternative 1 Layout*

*Northern*




*Central*




*Southern*

*Figure D.4: Northern Profile, Alternative 1, Pressure Envelope Plot*

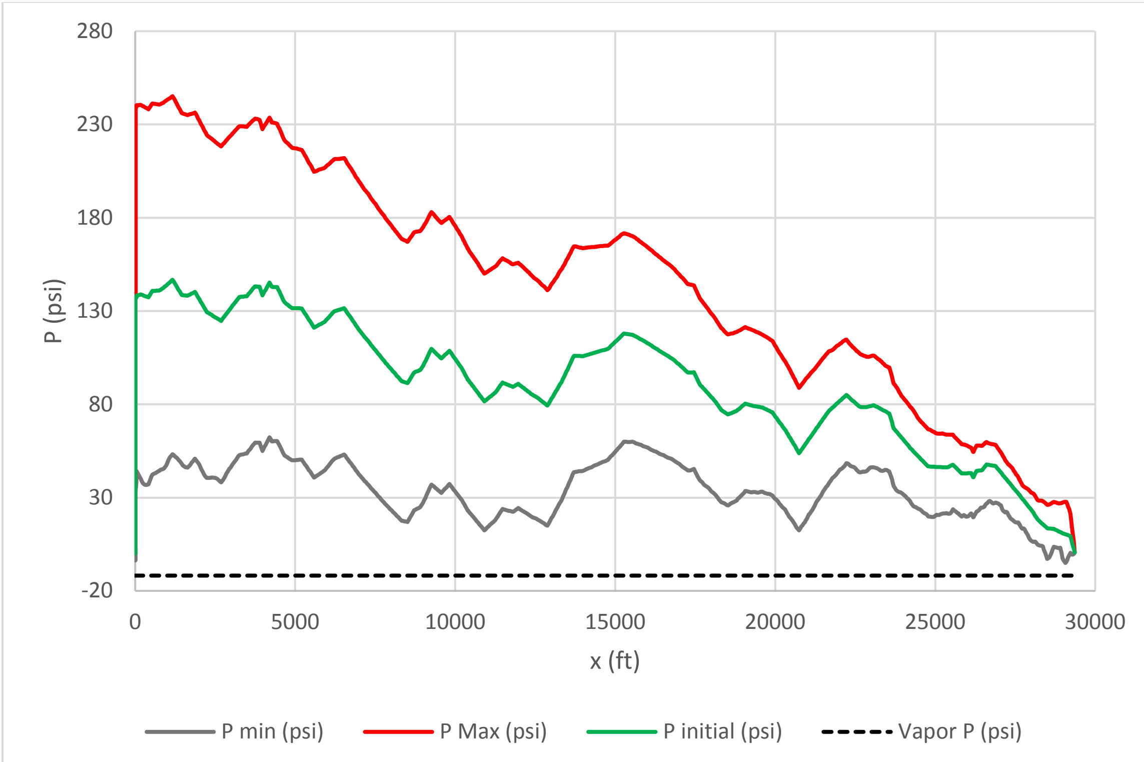



*Figure D.5: Northern Profile, Alternative 1, HGL Envelope Plot*

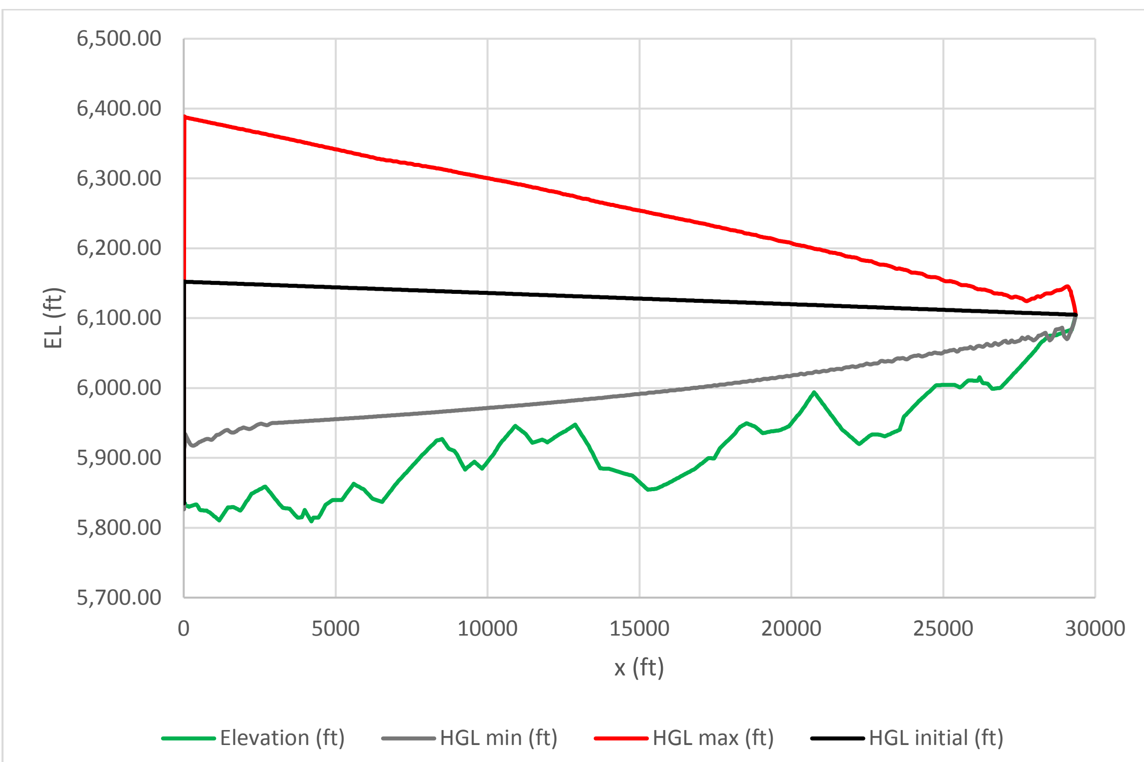


*Figure D.6: Northern Profile, Alternative 1, Pressure Time Series at PS Wet Well*

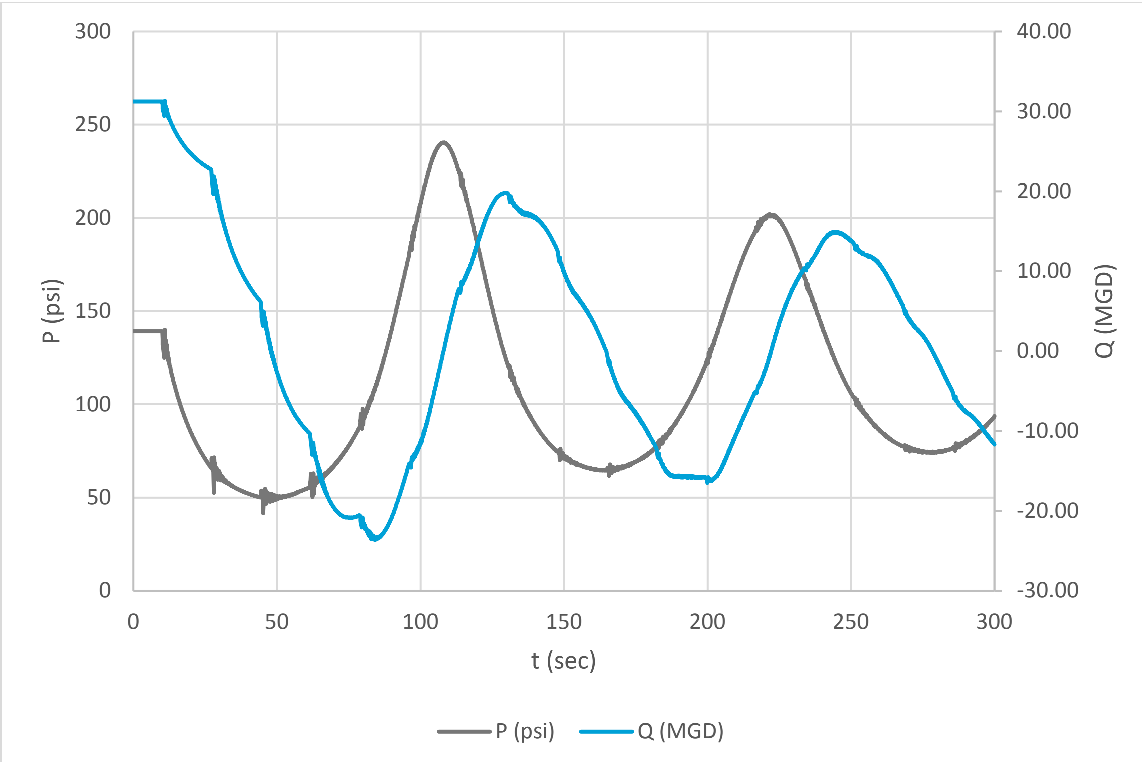



*Figure D.7: Central Profile, Alternative 1, Pressure Envelope Plot*

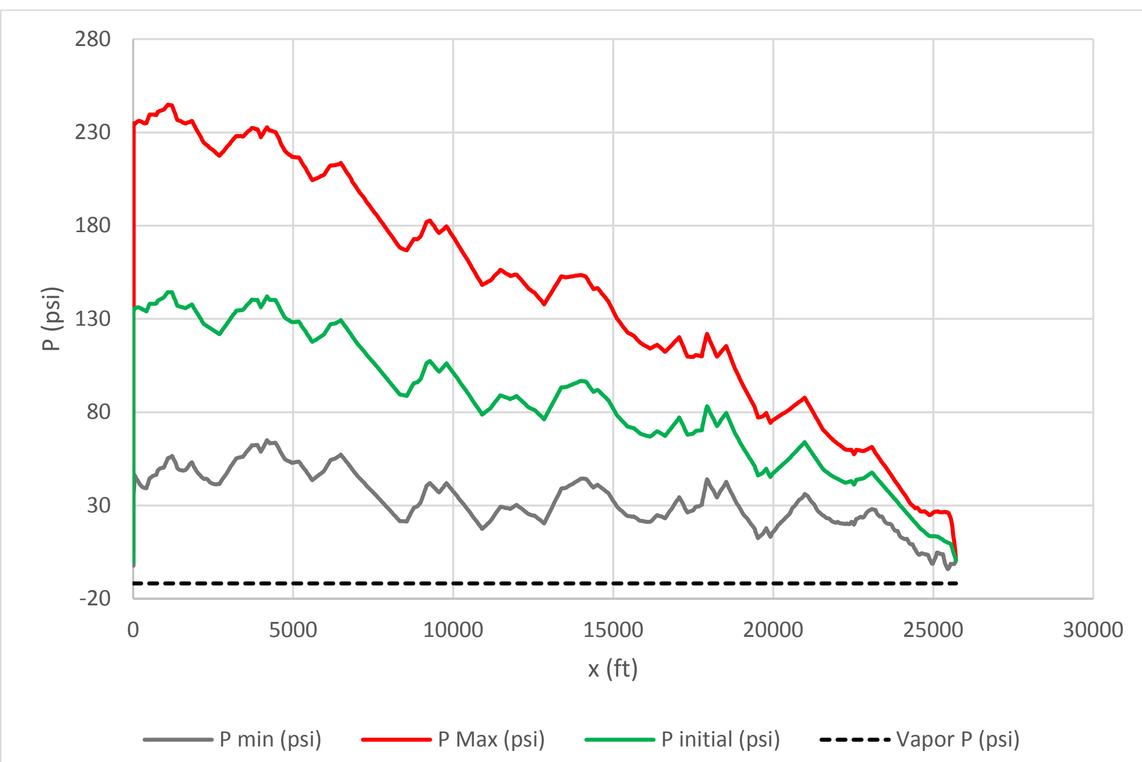


*Figure D.8: Central Profile, Alternative 1, HGL envelope plot*

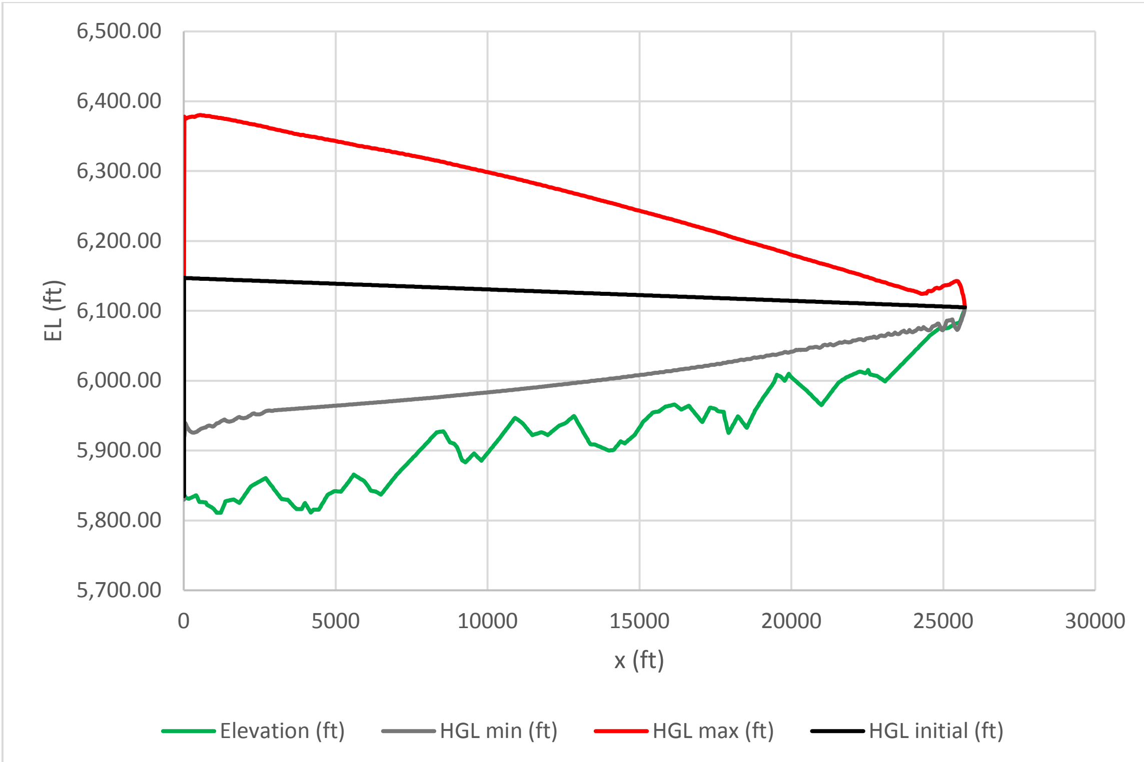



*Figure D.9: Central Profile, Alternative 1, Pressure time series at PS Wet well*

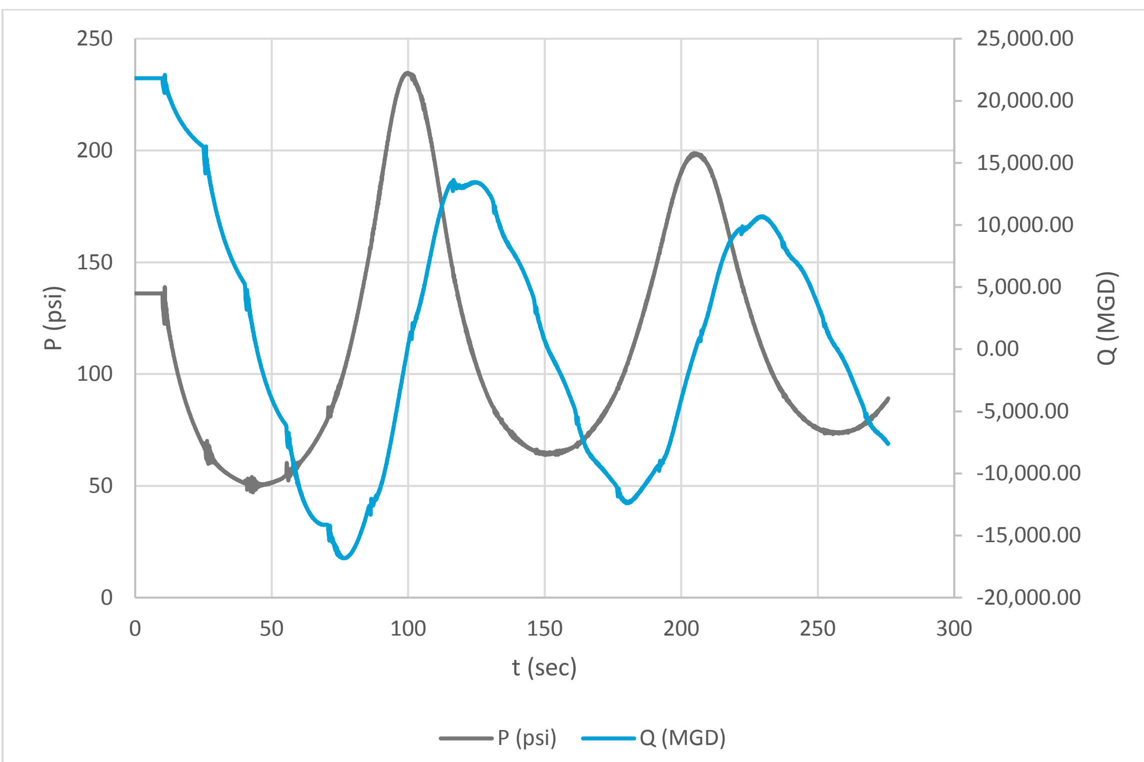


*Figure D.10: South Profile, Alternative 1, Pressure envelope plot*

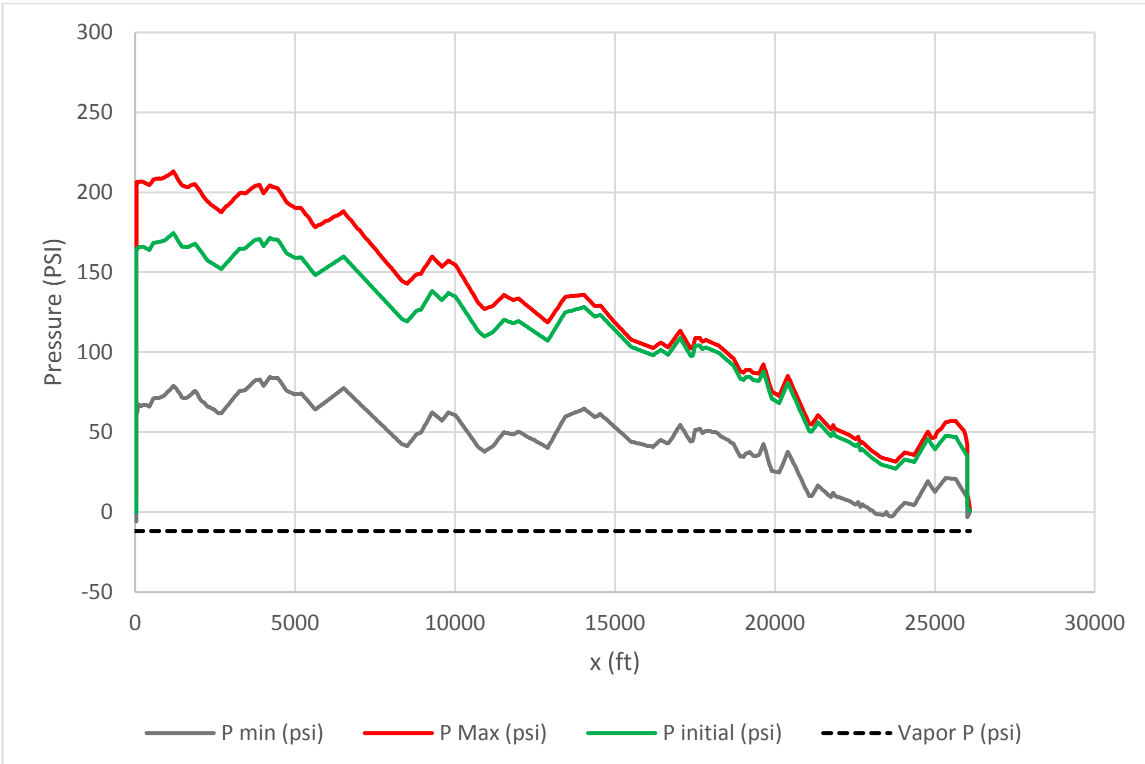



*Figure D.11: South Profile, Alternative 1, HGL envelope plot*

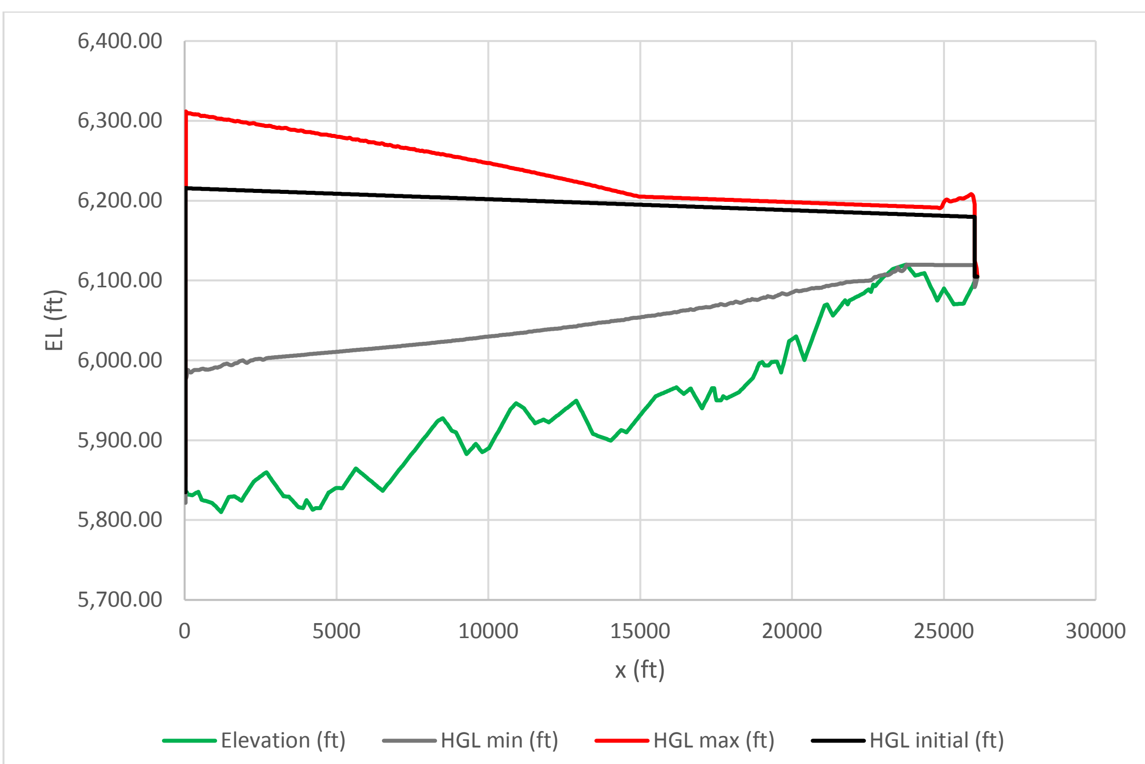


*Figure D.12: South Profile, Alternative 1, Pressure time series at PS Wet well*

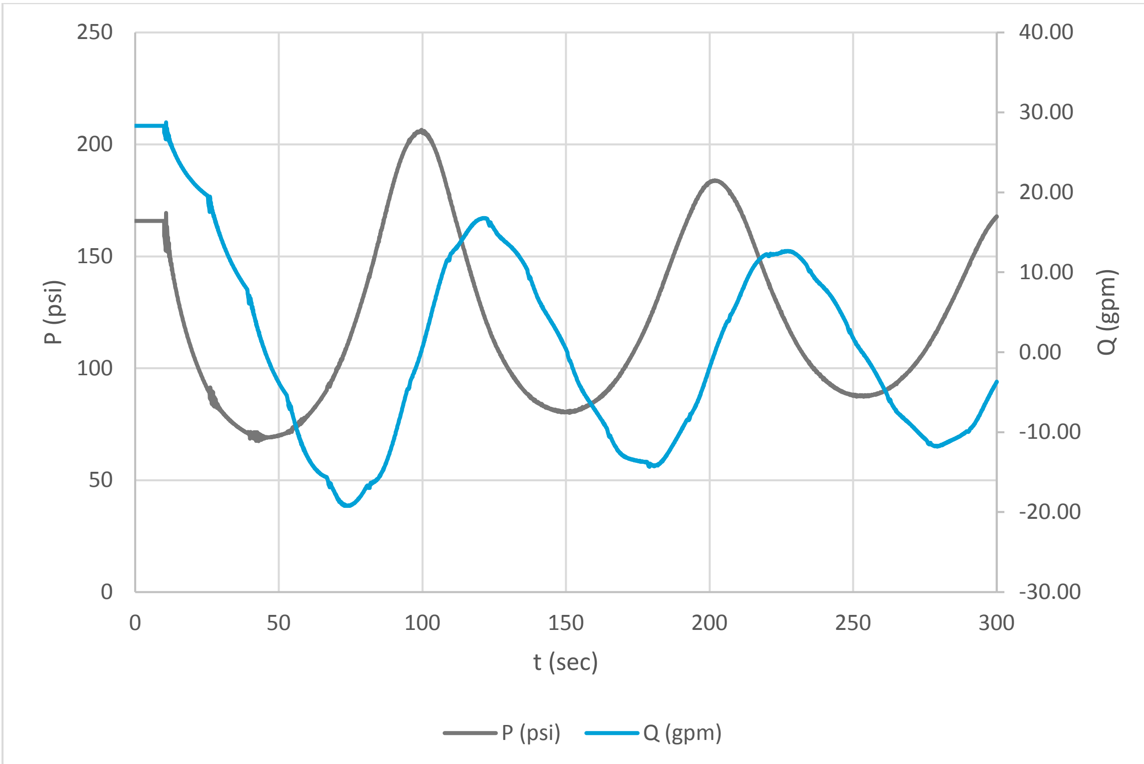
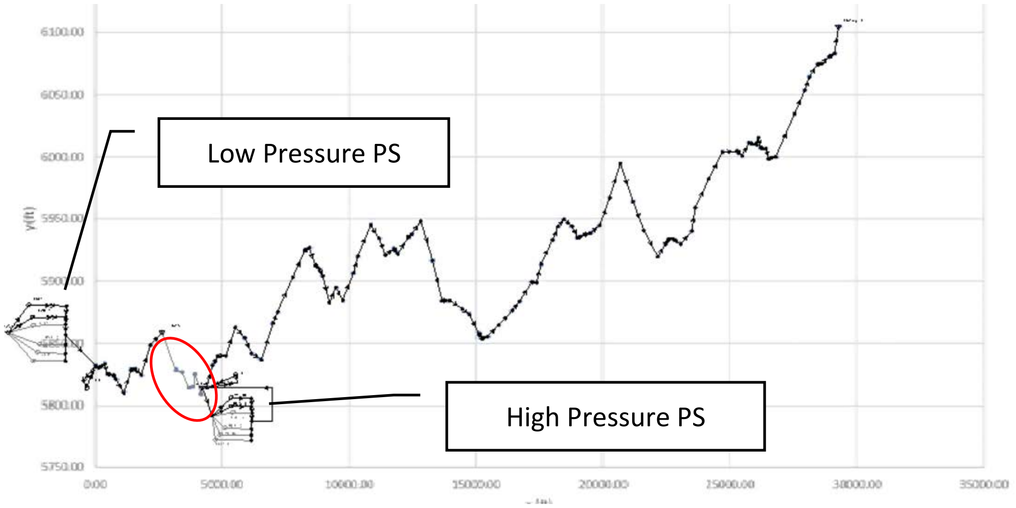


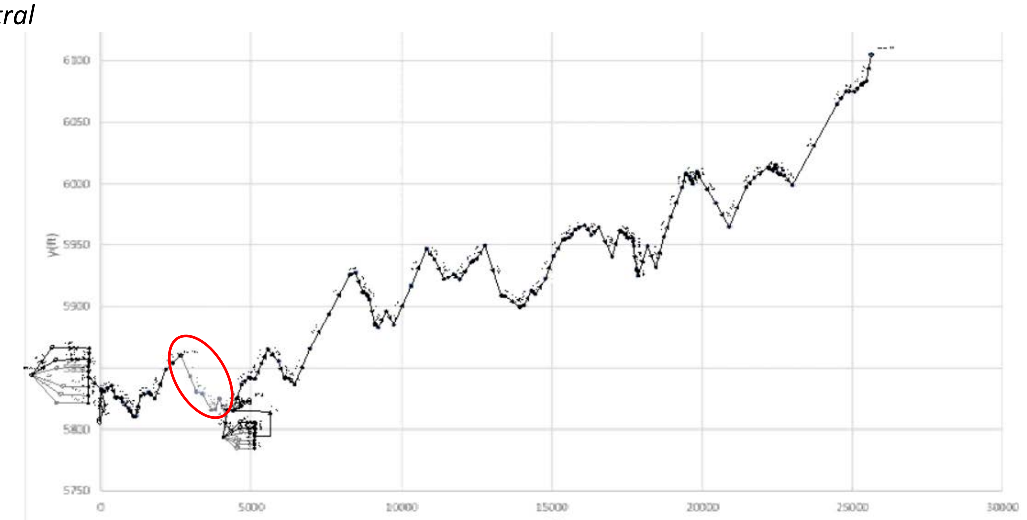

Figure D.12

*Figure D.13: Alternative 1 layout with the gravity fed section to the high pressure PS noted*

*Northern*




*Central*




*Southern*

*Figure D.14: Northern Profile, Alternative 2, Pressure envelope plot*

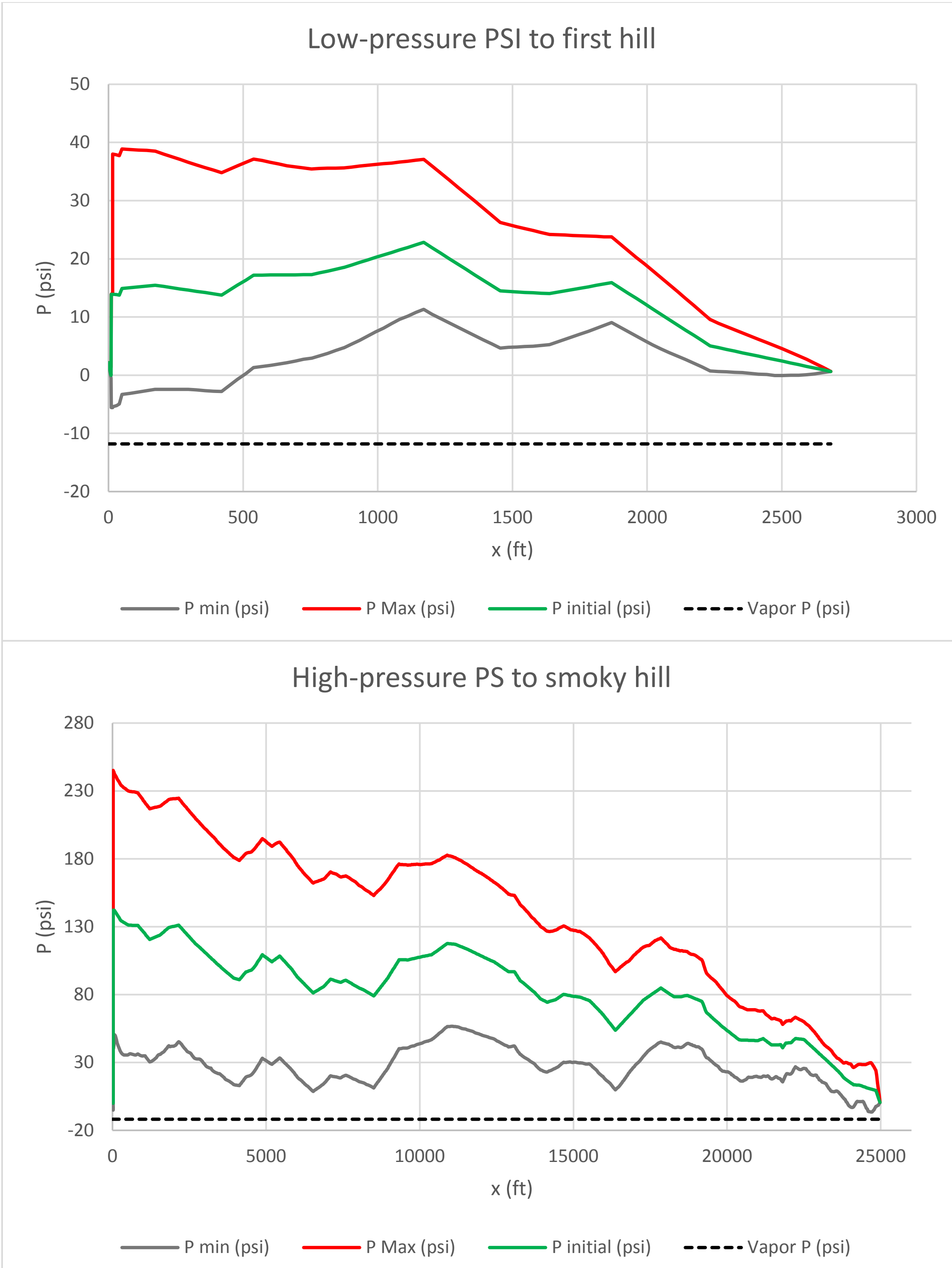



Figure D.2
Northern Profile, Alterative 2, Pressure envelope plot

*Figure D.15: Northern Profile, Alternative 2, HGL envelope plot*


Figure D.3
Northern Profile, alterative 2, HGL envelope plot

*Figure D.16: Northern Profile, Alternative 2, Pressure time series at Low Pressure PS*

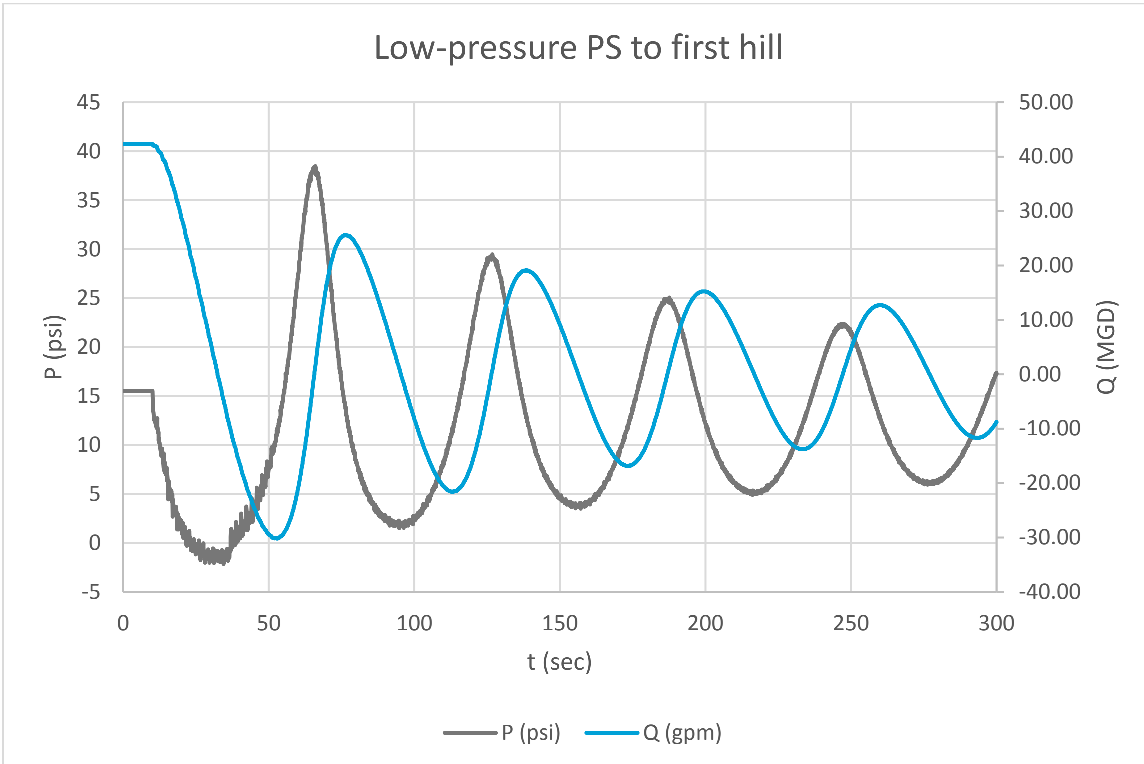



Figure D.4
Northern Profile, alterative 2, Pressure time series at Low Pressure PS

*Figure D.17: Northern Profile, Alternative 2, Pressure time series at High Pressure PS*

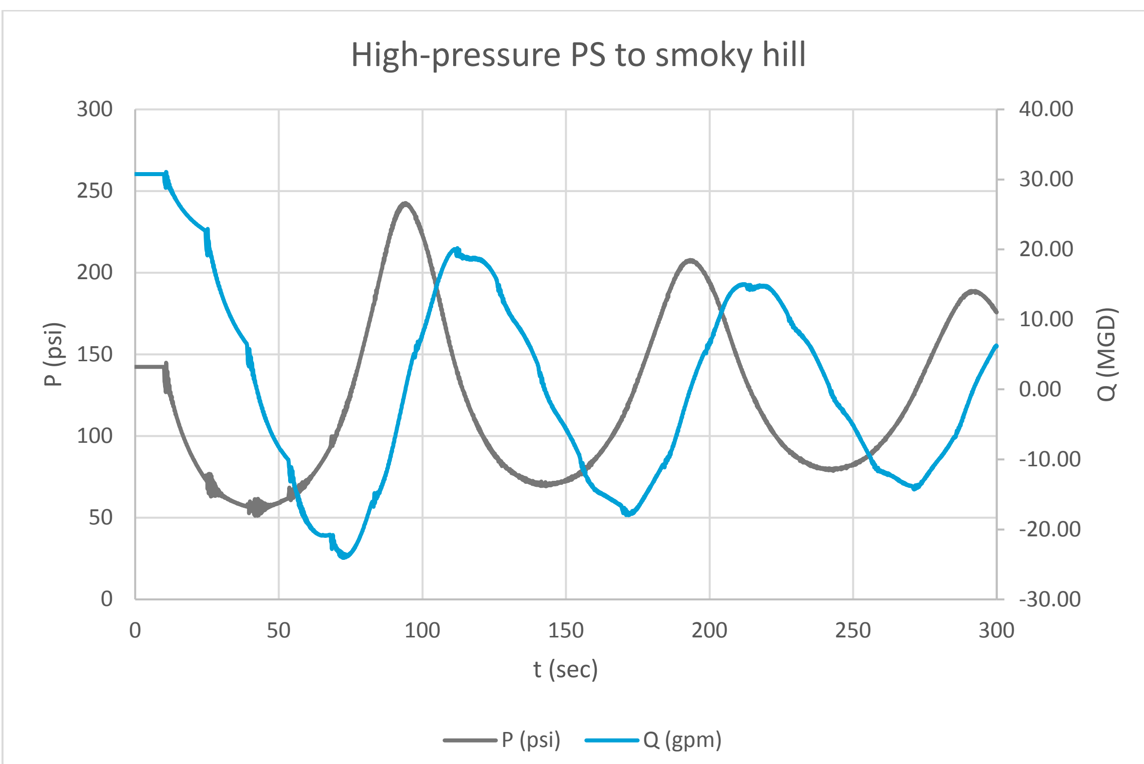



Figure D.5
Northern Profile, alterative 2, Pressure time series at High Pressure PS

*Figure D.18: Central Profile, Alternative 2, Pressure envelope plot*

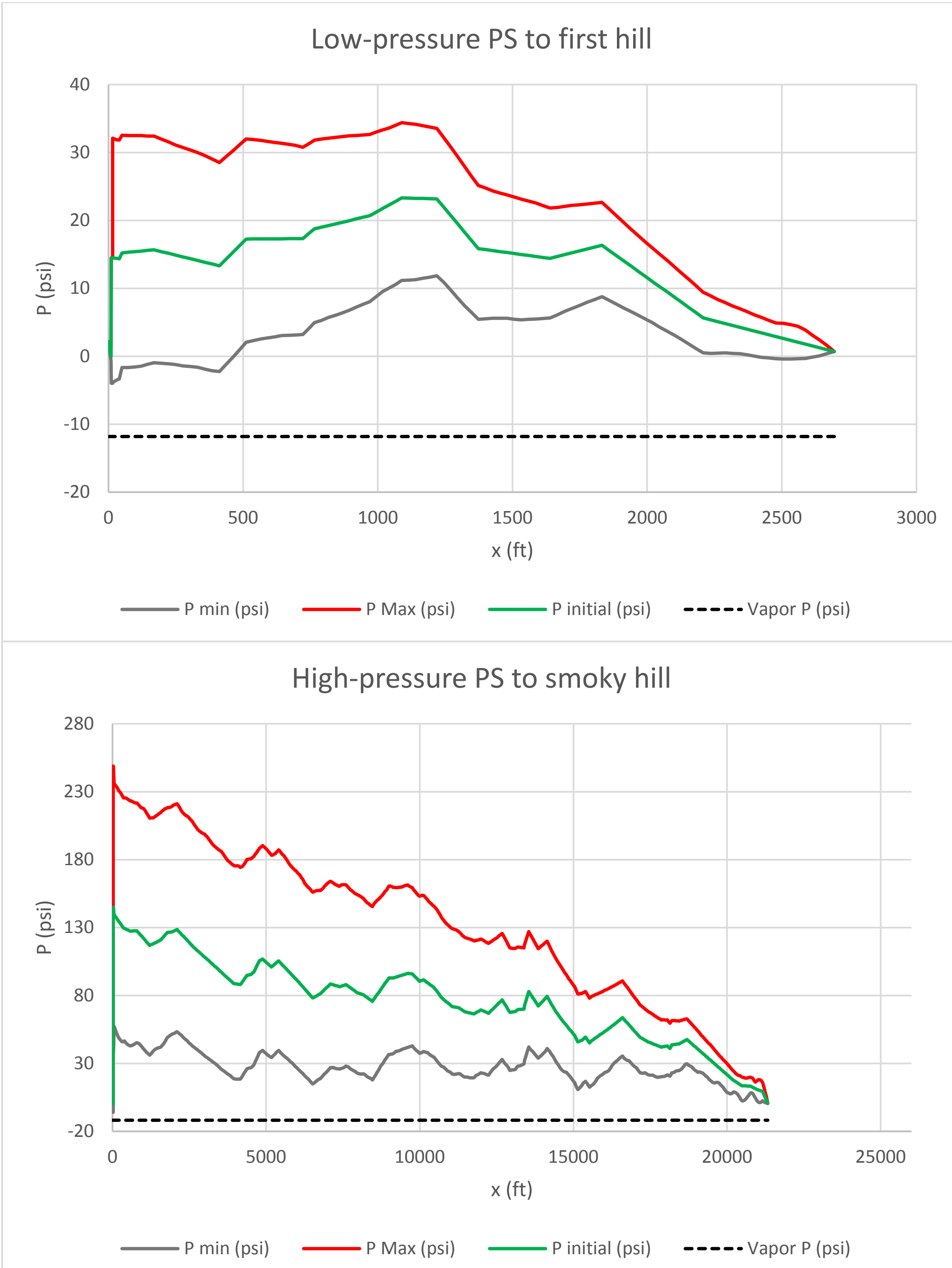



Figure D.6
Central Profile, alterative 2, Pressure envelope plot

*Figure D.19: Central Profile, Alternative 2, HGL envelope plot*

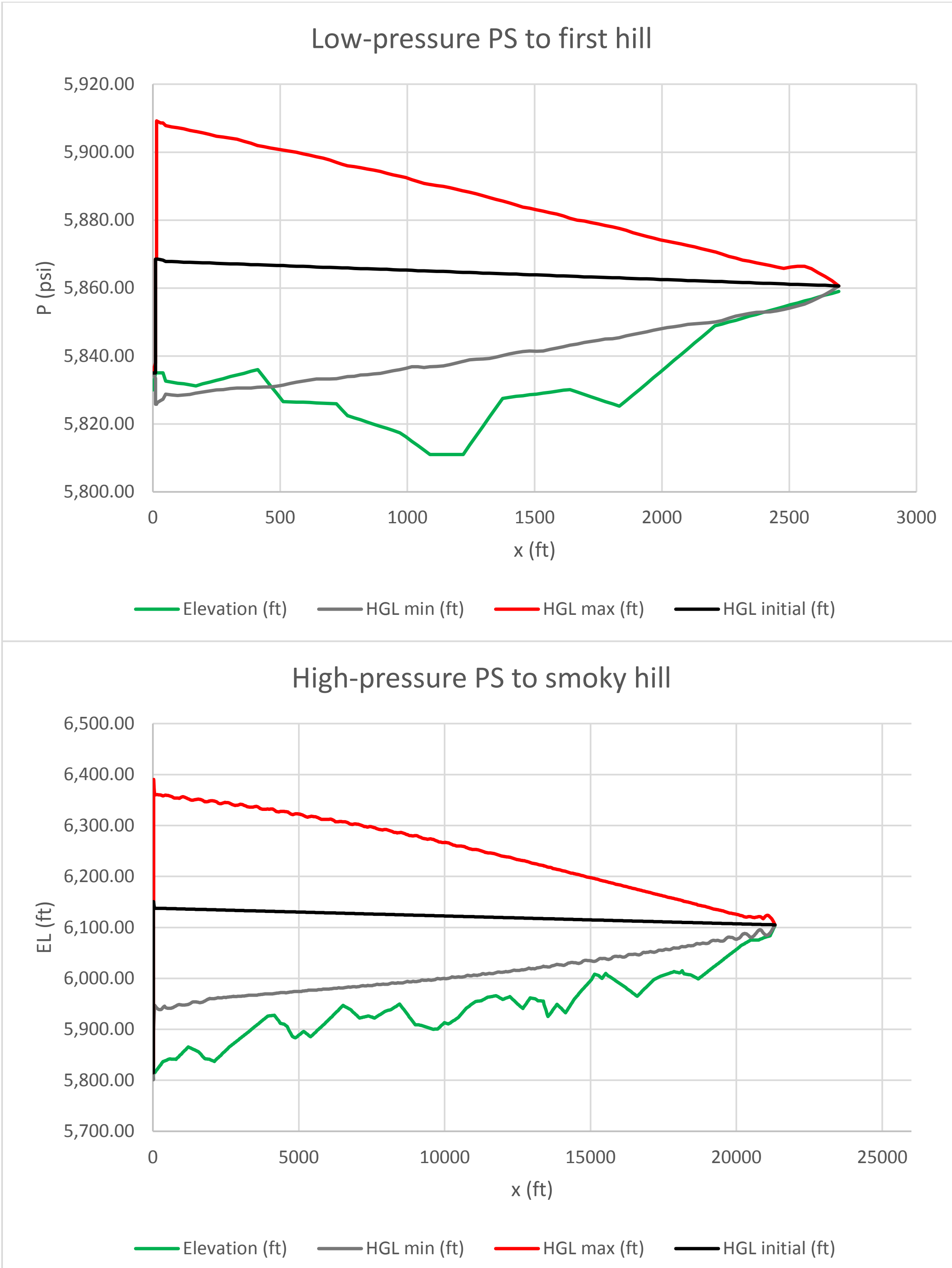



Figure D.7
Central Profile, alterative 2, HGL envelope plot

*Figure D.20: Central Profile, Alternative 2, Pressure time series at Low Pressure PS*

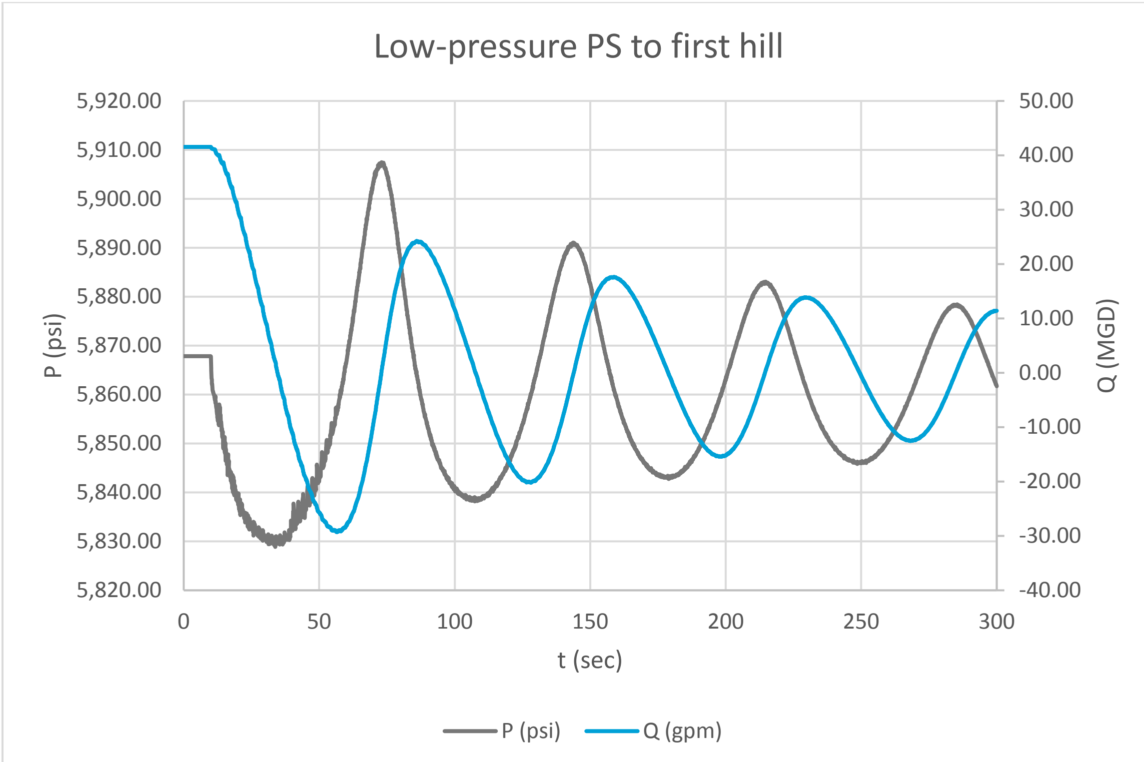



Figure D.8
Central Profile, alterative 2, Pressure time series at Low Pressure PS

*Figure D.21: Central Profile, Alternative 2, Pressure time series at High Pressure PS*

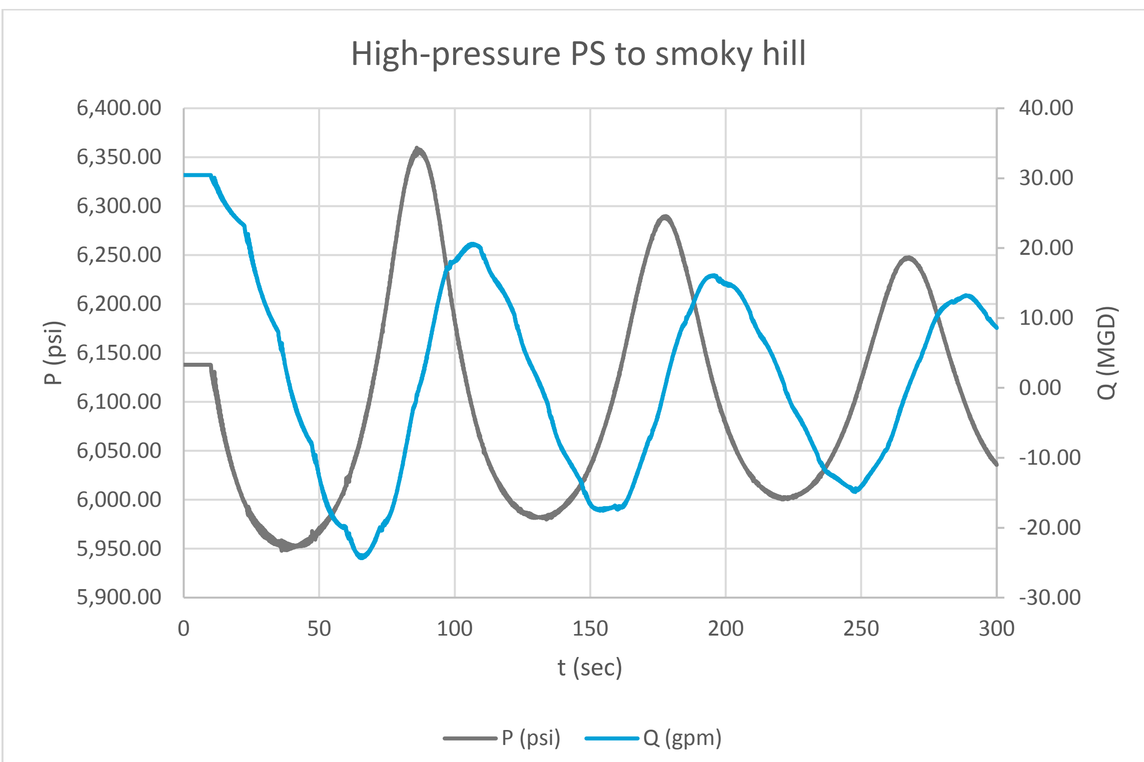
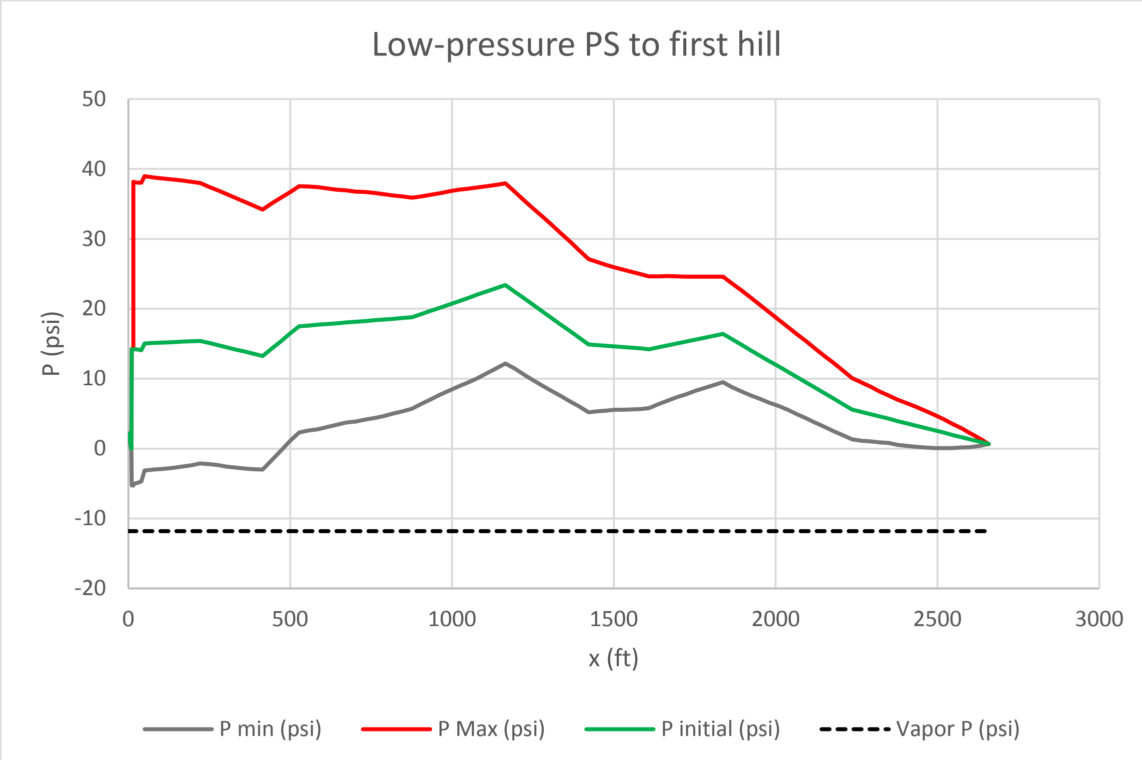



Figure D.9
Central Profile, alterative 2, Pressure time series at High Pressure PS

*Figure D.22: Southern Profile, Alternative 2, Pressure envelope plot*



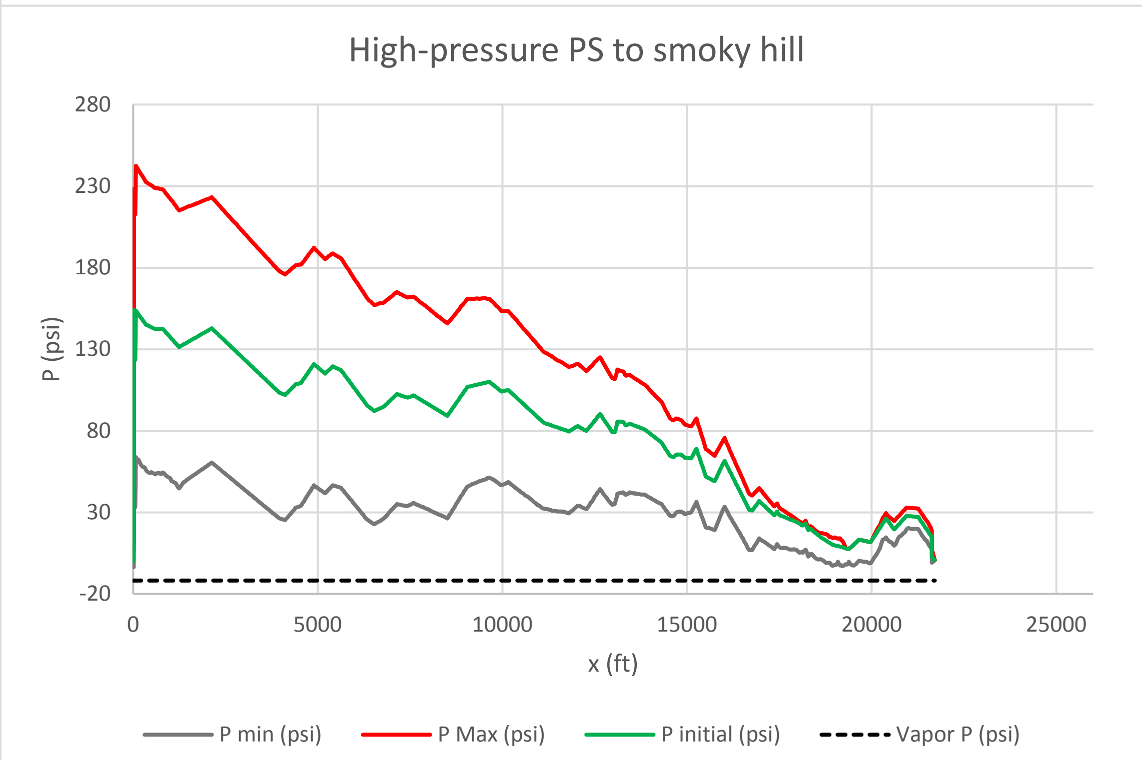
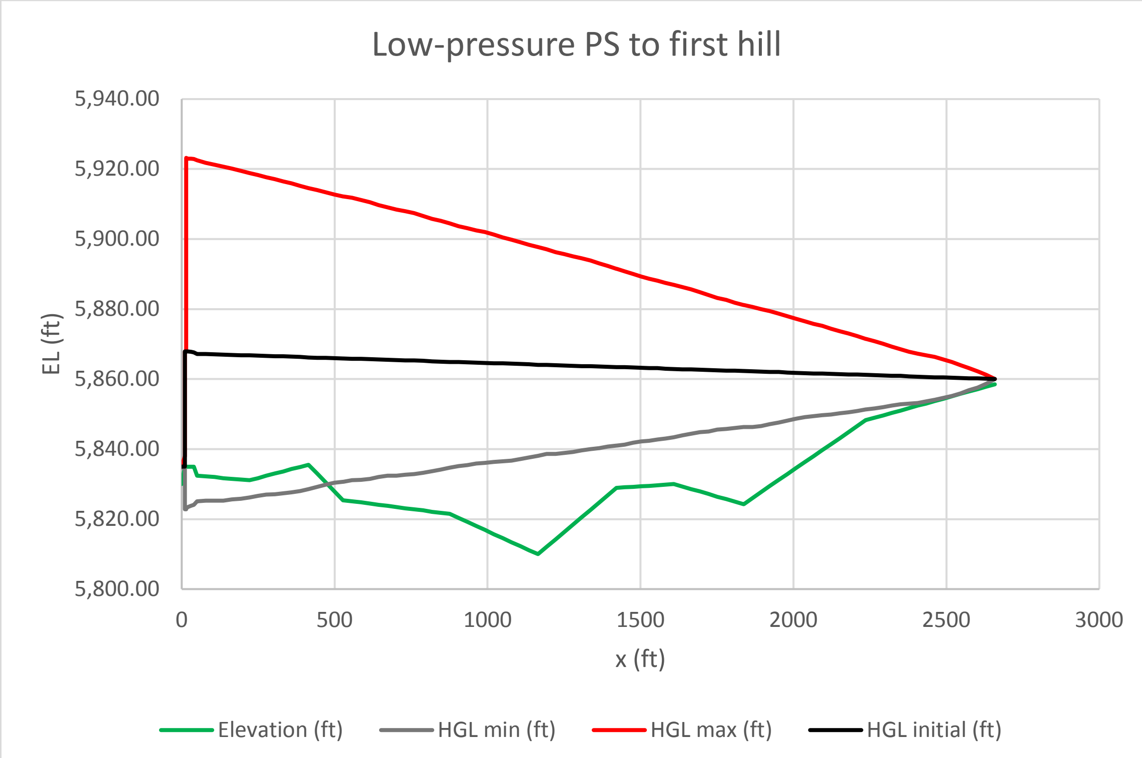



*Figure D.23: Southern Profile, Alternative 2, HGL envelope plot*



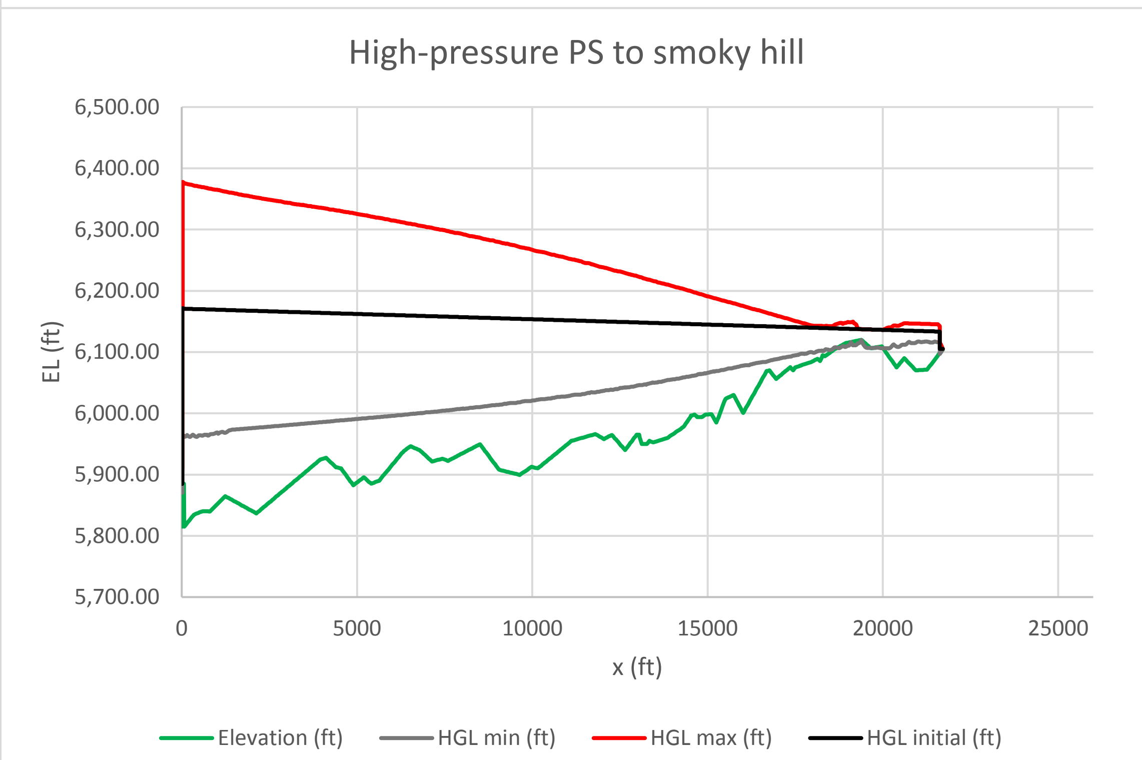




Figure D.10
Southern Profile, alterative 2, HGL envelope plot

*Figure D.24: Southern Profile, Alternative 2, Pressure time series at Low Pressure PS*

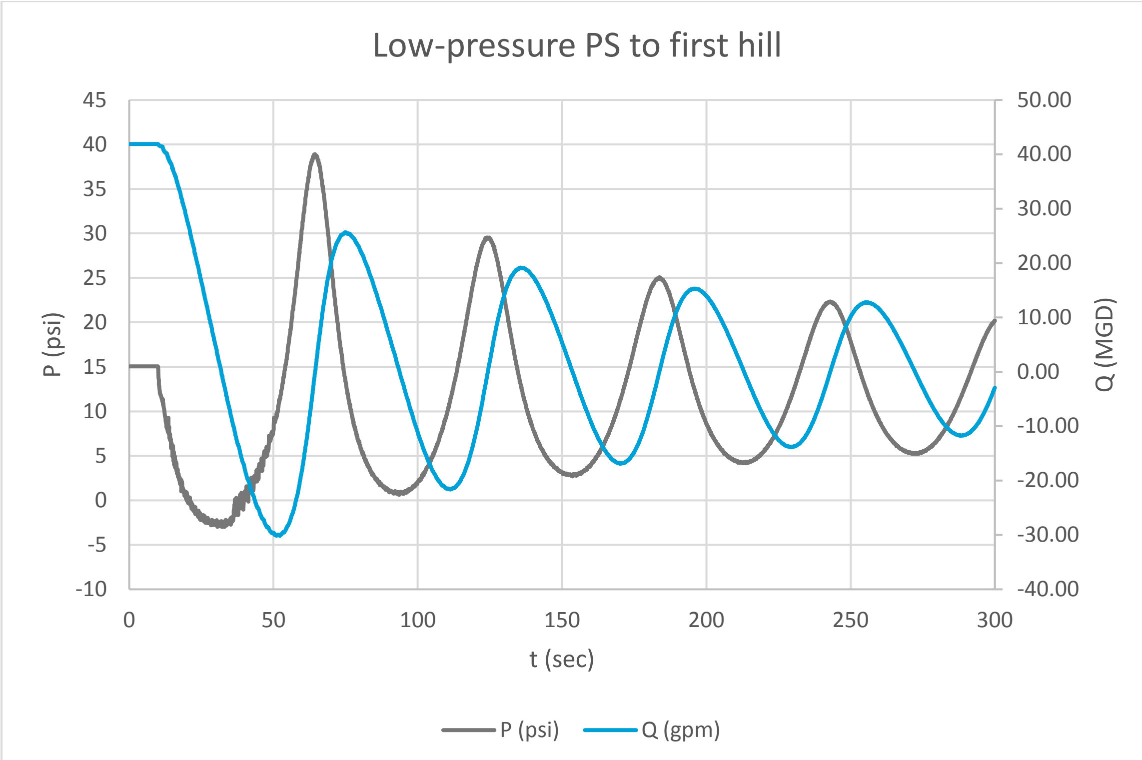
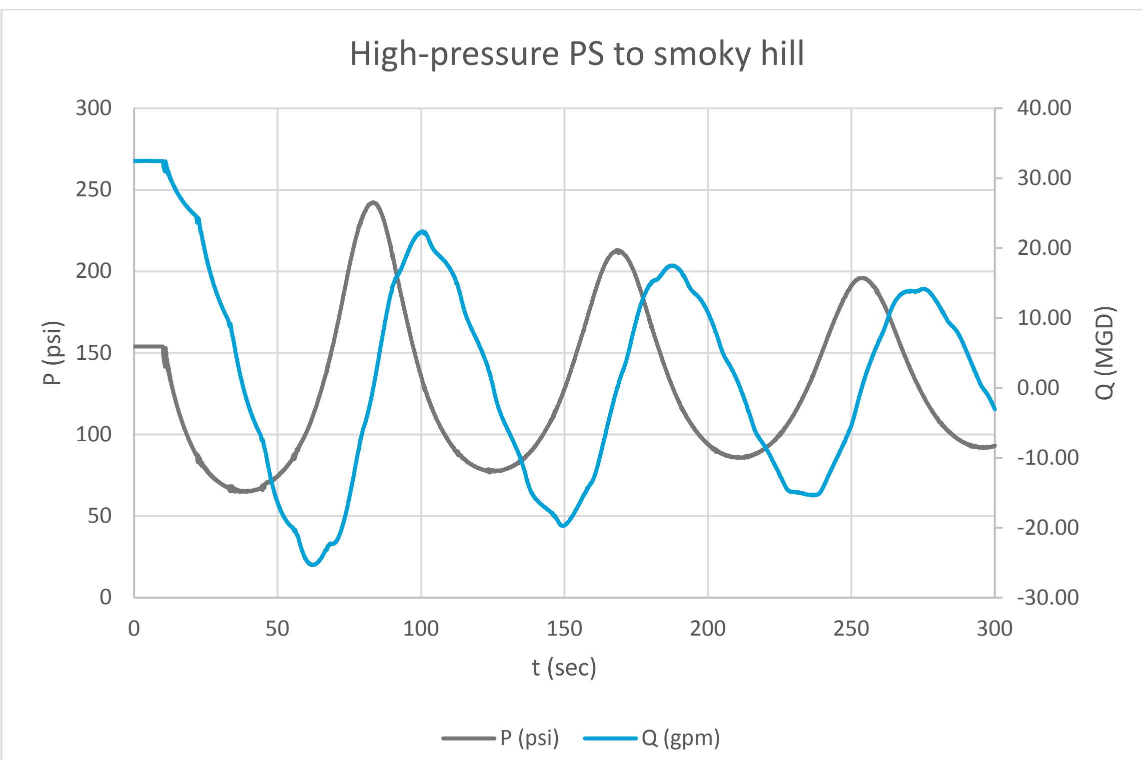



Figure D.11
Southern Profile, Alterative 2, Pressure time series at Low Pressure PS

*Figure D.25: Southern Profile, Alternative 2, Pressure time series at High Pressure PS*



# Appendix E – Cost Estimate

7/10/2018 Summary

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

**WISE Binney Connection Pump Station Study**
**COST SUMMARY**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION (ALT 1) - Single Pump Station | INCLUDED IN ESTIMATE? | TOTAL COST *(in 2018 dollars)* |
|---|---|---|
| 1. 2 Flow Control Valve Vaults and Conveyance Piping | Yes | $3,884,300 |
| 2. Chlorine Contact Basin | Yes | $3,132,600 |
| 3. Finished Water Pump Station (Final) | Yes | $9,169,000 |
| 5. Chemical Building - LAS | Yes | $1,526,000 |
| 6. Chemical Building - Sodium Hypochlorite | Yes | $1,435,000 |
| 7. Chemical Building - Caustic | Yes | $1,435,000 |
| **TOTAL COST** | | **$20,581,900** |

| DESCRIPTION (ALT 2) - Two Pump Station | INCLUDED IN ESTIMATE? | TOTAL COST *(in 2018 dollars)* |
|---|---|---|
| 1. 2 Flow Control Valve Vaults and Conveyance Piping | Yes | $3,884,300 |
| 2. Chlorine Contact Basin | Yes | $3,132,600 |
| 3. Finished Water Pump Station (Final) | Yes | $9,169,000 |
| 4. Intermediate Finished Water Pump Station | Yes | $7,047,300 |
| 5. Chemical Building - LAS | Yes | $1,526,000 |
| 6. Chemical Building - Sodium Hypochlorite | Yes | $1,435,000 |
| 7. Chemical Building - Caustic | Yes | $1,435,000 |
| **TOTAL COST** | | **$27,629,200** |

| DESCRIPTION (ALT 3) - Two Pump Station (Deferred Capital) | INCLUDED IN ESTIMATE? | TOTAL COST *(in 2018 dollars)* |
|---|---|---|
| 1. 2 Flow Control Valve Vaults and Conveyance Piping | Yes | $3,884,300 |
| 2. Chlorine Contact Basin | Yes | $3,132,600 |
| 3. Finished Water Pump Station (Final) | Yes | $9,169,000 |
| 4. Intermediate Finished Water Pump Station | Yes | $7,047,300 |
| 5. Chemical Building - LAS | Yes | $1,526,000 |
| 6. Chemical Building - Sodium Hypochlorite | Yes | $1,435,000 |
| 7. Chemical Building - Caustic | Yes | $1,435,000 |
| 8. Reuse of Wemlinger Pump Station | Yes | $2,309,000 |
| **TOTAL COST** | | **$29,938,200** |

7/10/2018 Item 1

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| ***1. 2 Flow Control Valve Vaults and Conveyance Piping*** | | | | | |
| *Number of Vaults* | **2** | EA | | | |
| *Wall Length* | **53.00** | FT | | | |
| *Wall Width* | **21.00** | FT | | | |
| *Wall Height* | **9.00** | FT | | | |
| *Wall Thickness* | **1.00** | FT | | | |
| *Slab Thickness* | **1.50** | FT | | | |
| *Elevated Slab Thickness* | **1.00** | FT | | | |
| *Excavation Side Slope Ratio* | **1.00** | :1 | | | |
| *Burial Depth of Structure* | **3.00** | LF | | | |
| *Volume of Structure* | 538.8 | CY | | | |
| *Slab Length* | 57.00 | FT | | | |
| *Slab Width* | 25.00 | FT | | | |
| *Excavation Length* | 61.00 | FT | | | |
| *Excavation Width* | 29.00 | FT | | | |
| *Excavation Depth* | 14.00 | FT | Includes structure burial depth | | |
| *Sitework:* | | | | | |
| Site Prep | 1 | LS | $500.00 | $500 | |
| Excavation | 1,759 | CY | $10.00 | $17,591 | |
| Imported Fill Under Slab | 26 | CY | ***$51.57*** | $1,361 | |
| Native Backfill | 1,220 | CY | ***$8.37*** | $10,211 | |
| Haul Excess | 539 | CY | ***$8.37*** | $4,508 | |
| Surface Restoration | 413 | SY | $20.00 | $8,251 | |
| *Conveyance Pipe:* | | | | | |
| Pipe Trench Excavation, Bedding, Backfill and Surface Resoration | 500 | LF | $110.00 | $55,000 | |
| 54" Pipe (Welded Steel Cement Mortar Lined) | 500 | LF | $738.79 | $369,394 | Based on 2018 RSM 15107-620-2220 |
| Allowance for Fitting and Valves | 15% | | $369,393.75 | $55,409 | |
| *Concrete:* | | | | | |
| Slab on Grade (1.5 feet thick) | 79 | CY | ***$442.91*** | $35,064 | |
| Concrete Walls (9 feet high,1 feet thick) | 32 | CY | ***$750.50*** | $24,266 | |
| Elevated Slab (1 feet thick) | 47 | CY | ***$1,161.94*** | $54,439 | |
| Hatch Curb (8" wide, 12" high) | 0.79 | CY | $450.00 | $356 | |
| *Enclosure:* | | | | | |
| Dog House | 100 | SF | $100.00 | $10,000 | |
| *Metals:* | | | | | |
| Stairs | 14 | RISERS | ***$502.06*** | $7,029 | |
| Handrail | 25.4 | LF | ***$92.04*** | $2,336 | 2018 RSM 05500-500-0020 |
| Aluminum Grating Over Sump | 4.0 | SF | ***$92.04*** | $368 | |
| Guard Posts | 6 | EA | $507.68 | $3,046 | 2018 RSM 05120-260-0890 |
| *Moisture Protection:* | | | | | |
| Aluminum Access Hatch (4' x 4' with lock) | 1 | EA | $2,988.00 | $2,988 | Based on 2018 RSM 08310-350-0300 |
| Aluminum Access Hatch (6' x 6' with lock) | 1 | EA | $6,473.00 | $6,473 | Based on 2018 RSM 08310-350-0300 |
| *Equipment:* | | | | | |
| Sump Pump | 1 | EA | $1,200.00 | $1,200 | |
| *I&C:* | | | | | |
| 36" Electromagnetic Flowmeter | 1 | EA | $43,200.00 | $43,200 | |
| 12" Electromagnetic Flowmeter | 1 | EA | $18,000.00 | $18,000 | |
| *Mechanical:* | | | | | |
| 54" Wall Pipe | 1 | EA | $4,432.73 | $4,433 | Based on 2018 RSM 15107-620-2220 |
| 54" Pipe (Welded Steel Cement Mortar Lined) | 10 | LF | $738.79 | $7,388 | Based on 2018 RSM 15107-620-2220 |
| 54" Insulated Flange | 1 | EA | $540.00 | $540 | |
| 54 x 12" Tee | 1 | EA | $18,952.50 | $18,953 | Based on 2018 RSM 15107-660-3490 |
| 54" x 36" Reducer | 1 | EA | $15,000.00 | $15,000 | |
| 36" Pipe (Welded Steel Cement Mortar Lined) | 40 | LF | $492.53 | $19,701 | Based on 2018 RSM 15107-620-2220 |
| 36" Bend | 2 | EA | $6,230.00 | $12,460 | 2018 RSM 15107-660-3349 |
| 36" Dismantling Joints | 1 | EA | $720.00 | $720 | |
| 36" BFV with Electric Operator | 3 | EA | $19,468.25 | $58,405 | Based on 2018 RSM 02080-500-3500 |
| 12" Pipe (Welded Steel Cement Mortar Lined) | 30 | LF | $328.35 | $9,851 | Based on 2018 RSM 15107-620-2220 |
| 12" Bend | 3 | EA | $908.50 | $2,726 | 2018 RSM 15107-660-3330 |
| 12" Insulating Flange | 1 | EA | $120.00 | $120 | |
| 12' Dismantling Joint | 1 | EA | $720.00 | $720 | |
| 12" Restrained Dismantling Joint | 1 | EA | $1,200.00 | $1,200 | |
| 12" BFV Valve with Electric Operator | 3 | EA | $2,755.50 | $8,267 | Based on 2018 RSM 02080-500-3340 |
| 2" Pipe (PVC Sch 80) [Sump pump piping] | 30 | LF | $34.73 | $1,042 | Based on 2018 RSM 15107-520-1120 |

7/10/2018 Item 1

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| ***DESCRIPTION*** | **QUANTITY** | **UNIT** | **$/UNIT** ***(includes Material & Installation)*** | **TOTAL COST** | **REFERENCE** |
|---|---|---|---|---|---|
| *Electrical:* | | | | | |
| Distribution Panel Board | 1 | EA | $1,000.00 | $1,000 | |
| Mini Power Center | 1 | EA | $5,000.00 | $5,000 | |
| Local Control Panel | 1 | EA | $1,000.00 | $1,000 | |
| General Purpose Box | 1 | EA | $1,000.00 | $1,000 | |
| Enclosed Circuit Breaker (480v, 60A, 3P) | 1 | EA | $2,500.00 | $2,500 | |
| *Subtotal* | | | | $903,013 | |
| *Allowance for Misc Items* | 5% | | $903,012.71 | $45,151 | |
| *Subtotal* | | | | $948,163 | |
| *ALLOWANCES:* | | | | | |
| *Finishes Allowance* | 3.00% | | $948,163.34 | $28,445 | |
| *I & C Allowance* | 3.00% | | $948,163.34 | $28,445 | |
| *Mechanical Allowance* | 5.00% | | $948,163.34 | $47,408 | |
| *Electrical Allowance* | 5.00% | | $948,163.34 | $47,408 | |
| ***Subtotal*** | | | | **$1,099,869** | |
| *CONTRACTOR MARKUPS:* | | | | | |
| *Overhead* | 12% | | $1,099,869.48 | $131,984 | |
| *Subtotal* | | | | $1,231,854 | |
| *Profit* | 5% | | $1,231,853.81 | $61,593 | |
| *Subtotal* | | | | $1,293,447 | |
| *Mob/Bonds/Insurance* | 5% | | $1,293,446.51 | $64,672 | |
| *Subtotal* | | | | $1,358,119 | |
| *Contingency* | 30% | | $1,358,118.83 | $407,436 | |
| *SUBTOTAL with Markups* | | | | $1,765,554 | |
| *Escalation* | 0.0% | | $1,765,554.48 | $0 | |
| ***SUBTOTAL Construction Cost with Escalation*** | | | | **$1,765,554** | |
| *Tax* | 0% | | $1,059,332.69 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax*** | | | | **$1,765,554** | |
| ***Market Adjustment Factor*** | 10% | | $1,765,554.48 | **$176,555** | |
| ***TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor*** | | | | **$1,942,110** | |
| Permitting Allowance | 0% | | $1,942,109.93 | $0 | |
| Engineering | 0% | | $1,942,109.93 | $0 | |
| SDC | 0% | | $1,942,109.93 | $0 | |
| Commissioning & Startup | 0% | | $1,942,109.93 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance*** | **1** | **EA** | | **$1,942,110** | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance*** | **2** | **EA** | **$1,942,109.93** | **$3,884,220** | |

7/10/2018 Item 2

JACOBS
WISE Binney Connection Pump Station Study
PROJECT NO: 702800.03.31.06
PREPARED BY: E.R.MEYER

To: Summary Sheet

WISE Binney Connection Pump Station Study
(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| **2. CHLORINE CONTACT BASIN** | | | | | |
| Wall Length | 150.00 | FT | | | |
| Wall Width | 63.00 | FT | | | |
| Wall Height | 18.00 | FT | | | |
| Wall Thickness | 2.50 | FT | | | |
| Slab Thickness | 2.50 | FT | | | |
| Elevated Slab Thickness | 1.00 | FT | | | |
| Excavation Side Slope Ratio | 1.00 | :1 | | | |
| Burial Depth of Structure | 3.00 | LF | | | |
| Volume of Structure | 8,393.0 | CY | | | |
| Slab Length | 157.00 | FT | | | |
| Slab Width | 70.00 | FT | | | |
| Excavation Length | 161.00 | FT | | | |
| Excavation Width | 74.00 | FT | | | |
| Excavation Depth | 24.00 | FT | Includes structure burial depth | | |
| Sitework: | | | | | |
| Site Prep | 1 | LS | $500.00 | $500 | |
| Excavation | 17,476 | CY | $10.00 | $174,760 | |
| Imported Fill Under Slab | 204 | CY | $51.57 | $10,496 | |
| Imported Backfill | 9,083 | CY | $51.57 | $468,436 | |
| Haul Excess | 8,393 | CY | $8.37 | $70,230 | |
| Surface Restoration | 2,408 | SY | $20.00 | $48,156 | |
| Concrete: | | | | | |
| Slab on Grade (2.5 feet thick) | 1,018 | CY | $442.91 | $450,702 | |
| Concrete Walls (18 feet high,2.5 feet thick) | 9 | CY | $750.50 | $6,995 | |
| Elevated Slab (1 feet thick) | 6 | CY | $1,161.94 | $6,503 | |
| Internal Baffle Walls | 270.00 | CY | $750.50 | $202,635 | |
| Hatch Curb (8" wide, 12" high) | 0.79 | CY | $450.00 | $356 | |
| Metals: | | | | | |
| Aluminum Access Ladder | 36.0 | VLF | $92.95 | $3,346 | 2018 RSM 05500-500-0020 |
| Guard Posts | 6 | EA | $507.68 | $3,046 | 2018 RSM 05120-260-0890 |
| Moisture Protection: | | | | | |
| Aluminum Access Hatch (4' x 4' with lock) | 4 | EA | $2,988.00 | $11,952 | Based on 2018 RSM 08310-350-0300 |
| I&C: | | | | | |
| Level Indicator Transmitter | 3 | EA | $2,500.00 | $7,500 | |
| Mechanical: | | | | | |
| 54" Wall Pipe | 1 | EA | $4,432.73 | $4,433 | Based on 2018 RSM 15107-620-2220 |
| 54" BFV with Valve Box | 1 | EA | $26,202.38 | $26,202 | Based on 2018 RSM 02080-500-3500 |
| 54" Insulating Flange | 1 | EA | $540.00 | $540 | |
| 12" Vent | 2 | EA | $4,000.00 | $8,000 | |
| Electrical: | | | | | |
| Distribution Panel Board | 1 | EA | $1,000.00 | $1,000 | |
| Mini Power Center | 1 | EA | $5,000.00 | $5,000 | |
| Local Control Panel | 1 | EA | $1,000.00 | $1,000 | |
| General Purpose Box | 1 | EA | $1,000.00 | $1,000 | |
| Enclosed Circuit Breaker (480v, 60A, 3P) | 1 | EA | $2,500.00 | $2,500 | |
| Subtotal | | | | $1,515,286 | |
| Allowance for Misc Items | 5% | | $1,515,285.96 | $75,764 | |
| Subtotal | | | | $1,591,050 | |
| ALLOWANCES: | | | | | |
| Finishes Allowance | 0.50% | | $1,591,050.26 | $7,955 | |
| I & C Allowance | 3.00% | | $1,591,050.26 | $47,732 | |
| Mechanical Allowance | 3.00% | | $1,591,050.26 | $47,732 | |
| Electrical Allowance | 5.00% | | $1,591,050.26 | $79,553 | |

7/10/2018 Item 2

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| **Subtotal** | | | | $1,774,021 | |
| | | | | | |
| CONTRACTOR MARKUPS: | | | | | |
| Overhead | 12% | | $1,774,021.04 | $212,883 | |
| Subtotal | | | | $1,986,904 | |
| Profit | 5% | | $1,986,903.56 | $99,345 | |
| Subtotal | | | | $2,086,249 | |
| Mob/Bonds/Insurance | 5% | | $2,086,248.74 | $104,312 | |
| Subtotal | | | | $2,190,561 | |
| Contingency | 30% | | $2,190,561.18 | $657,168 | |
| SUBTOTAL with Markups | | | | $2,847,730 | |
| | | | | | |
| Escalation | 0.0% | | $2,847,729.53 | $0 | |
| **SUBTOTAL Construction Cost with Escalation** | | | | $2,847,730 | |
| | | | | | |
| Tax | 0% | | $1,708,637.72 | $0 | |
| **TOTAL Construction Cost with Escalation & Tax** | | | | $2,847,730 | |
| **TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor** | 100.00 | | | $2,847,730 | |
| **Market Adjustment Factor** | 10% | | $2,847,729.53 | $284,773 | |
| **TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor** | | | | $3,132,502 | |
| Permitting Allowance | 0% | | $3,132,502.48 | $0 | |
| Engineering | 0% | | $3,132,502.48 | $0 | |
| SDC | 0% | | $3,132,502.48 | $0 | |
| Commissioning & Startup | 0% | | $3,132,502.48 | $0 | |
| **TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance** | | | | $3,132,502 | |

7/10/2018 Item 3

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| ***3. FINISHED WATER PUMP STATION (Final)*** | | | | | |
| *Wall Length* | 100.00 | FT | | | |
| *Wall Width* | 30.00 | FT | | | |
| *Wall Height* | 29.00 | FT | | | |
| *Wall Thickness* | 2.50 | FT | | | |
| *Slab Thickness* | 2.50 | FT | | | |
| *Elevated Slab Thickness* | 1.00 | FT | | | |
| *Excavation Side Slope Ratio* | 1.00 | :1 | | | |
| *Burial Depth of Structure* | 0.00 | LF | | | |
| *Volume of Structure* | 4,423.6 | CY | | | |
| *Slab Length* | 107.00 | FT | | | |
| *Slab Width* | 37.00 | FT | | | |
| *Excavation Length* | 111.00 | FT | | | |
| *Excavation Width* | 41.00 | FT | | | |
| *Excavation Depth* | 32.00 | FT | Includes structure burial depth | | |
| *Sitework:* | | | | | |
| Site Prep | 1 | LS | $500.00 | $500 | |
| Excavation | 12,498 | CY | $10.00 | $124,975 | |
| Imported Fill Under Slab | 73 | CY | ***$51.57*** | $3,781 | |
| Imported Backfill | 8,074 | CY | ***$51.57*** | $416,394 | |
| Haul Excess | 4,424 | CY | ***$8.37*** | $37,015 | |
| Surface Restoration | 1,859 | SY | $20.00 | $37,180 | |
| *Concrete:* | | | | | |
| Slab on Grade (2.5 feet thick) | 367 | CY | ***$442.91*** | $162,359 | |
| Concrete Walls (29 feet high,2.5 feet thick) | 9 | CY | ***$750.50*** | $6,995 | |
| Elevated Slab (1 feet thick) | 6 | CY | ***$1,161.94*** | $6,503 | |
| Hatch Curb (8" wide, 12" high) | 0.79 | CY | $450.00 | $356 | |
| *Building:* | | | | | |
| Building: | 5,000 | SF | $100.00 | $500,000 | |
| *I&C:* | | | | | |
| 24" Electromagnetic Flowmeter | 1 | EA | $30,000.00 | $30,000 | |
| Level Indicator Transmitter | 2 | EA | $2,500.00 | $5,000 | |
| *Equipment:* | | | | | |
| Pump - Small | 3 | EA | $156,814.20 | $470,443 | |
| Pump - Large | 3 | EA | $315,953.52 | $947,861 | |
| Surge Tank | 1 | EA | $180,000.00 | $180,000 | |
| *Mechanical:* | | | | | |
| 36" Piping (Welded Steel Cement Mortar Lined) | 80 | LF | $492.53 | $39,402 | Based on 2018 RSM 15107-620-2220 |
| 36" Bend | 2 | EA | $6,230.00 | $12,460 | 2018 RSM 15107-660-3349 |
| 36" x 24" Tee | 1 | EA | $12,635.00 | $12,635 | 2018 RSM 15107-660-3490 |
| 36" x 12" Tee | 2 | EA | $12,635.00 | $25,270 | 2018 RSM 15107-660-3490 |
| 36" x 30" Tee | 3 | EA | $12,635.00 | $37,905 | 2018 RSM 15107-660-3490 |
| 36" Blind Flange | 2 | EA | $4,599.00 | $9,198 | Based on 2018 RSM 15107-660-2518 |
| 30" Piping (Welded Steel Cement Mortar Lined) | 90 | LF | $410.44 | $36,939 | Based on 2018 RSM 15107-620-2220 |
| 30" Double Waffer Check Valve | 3 | EA | $69,806.88 | $209,421 | Based on 2018 RSM 02080-500-3730 |
| 30" BFV Electric Operated | 3 | EA | $16,556.88 | $49,671 | Based on 2018 RSM 02080-500-3500 |
| 24" Piping (Welded Steel Cement Mortar Lined) | 20 | LF | $328.35 | $6,567 | 2018 RSM 15107-620-2220 |
| 24" BFV Electric Operated | 2 | EA | $13,645.50 | $27,291 | Based on 2018 RSM 02080-500-3500 |
| 12" Piping (Welded Steel Cement Mortar Lined) | 60 | LF | $328.35 | $19,701 | Based on 2018 RSM 15107-620-2220 |
| 12" BFV Electric Operated | 2 | EA | $2,755.50 | $5,511 | Based on 2018 RSM 02080-500-3340 |
| 12" Double Waffer Check Valve | 2 | EA | $5,980.50 | $11,961 | 2018 RSM 02080-500-3720 |
| *Electrical:* | | | | | |
| VFD - Low Voltage | 3 | EA | $37,743.75 | $113,231 | Based on 2018 RSM 16220-900-0250 |
| VFD - Medium Voltage | 3 | EA | $105,682.50 | $317,048 | Based on 2018 RSM 16220-900-0250 |
| *Subtotal* | | | | $3,863,572 | |
| *Allowance for Misc Items* | 5% | | $3,863,571.84 | $193,179 | |

7/10/2018 Item 4

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| ***4. INTERMEDIATE FINISHED WATER PUMP STATION (ALT 2&3)*** | | | | | |
| *Wall Length* | **150.00** | FT | | | |
| *Wall Width* | **75.00** | FT | | | |
| *Wall Height* | **18.00** | FT | | | |
| *Wall Thickness* | **2.50** | FT | | | |
| *Slab Thickness* | **2.50** | FT | | | |
| *Elevated Slab Thickness* | **1.00** | FT | | | |
| *Excavation Side Slope Ratio* | **1.00** | :1 | | | |
| *Burial Depth of Structure* | **0.00** | LF | | | |
| *Volume of Structure* | 9,874.1 | CY | | | |
| *Slab Length* | 157.00 | FT | | | |
| *Slab Width* | 82.00 | FT | | | |
| *Excavation Length* | 161.00 | FT | | | |
| *Excavation Width* | 86.00 | FT | | | |
| *Excavation Depth* | 21.00 | FT | Includes structure burial depth | | |
| *Sitework:* | | | | | |
| Site Prep | 1 | LS | $500.00 | $500 | |
| Excavation | 16,580 | CY | $10.00 | $165,799 | |
| Imported Fill Under Slab | 238 | CY | ***$51.57*** | $12,295 | |
| Imported Backfill | 6,706 | CY | ***$51.57*** | $345,835 | |
| Haul Excess | 9,874 | CY | ***$8.37*** | $82,623 | |
| Surface Restoration | 2,670 | SY | $20.00 | $53,409 | |
| *Concrete:* | | | | | |
| Slab on Grade (2.5 feet thick) | 1,192 | CY | ***$442.91*** | $527,965 | |
| Concrete Walls (18 feet high,2.5 feet thick) | 9 | CY | ***$750.50*** | $6,995 | |
| Elevated Slab (1 feet thick) | 6 | CY | ***$1,161.94*** | $6,503 | |
| Hatch Curb (8" wide, 12" high) | 0.79 | CY | $450.00 | $356 | |
| *Building:* | | | | | |
| Building: | 5,000 | SF | $80.00 | $400,000 | |
| *I&C:* | | | | | |
| 24" Electromagnetic Flowmeter | 1 | EA | $30,000.00 | $30,000 | |
| *Equipment:* | | | | | |
| Pump - Small | 3 | EA | $60,000.00 | $180,000 | |
| Pump - Large | 3 | EA | $180,000.00 | $540,000 | |
| Surge Tank | 1 | EA | $180,000.00 | $180,000 | |
| *Mechanical:* | | | | | |
| 36" Piping (Welded Steel Cement Mortar Lined) | 80 | LF | $492.53 | $39,402 | Based on 2018 RSM 15107-620-2220 |
| 36" Bend | 2 | EA | $6,230.00 | $12,460 | 2018 RSM 15107-660-3349 |
| 36" x 24" Tee | 1 | EA | $12,635.00 | $12,635 | 2018 RSM 15107-660-3490 |
| 36" x 12" Tee | 2 | EA | $12,635.00 | $25,270 | 2018 RSM 15107-660-3490 |
| 36" x 30" Tee | 3 | EA | $12,635.00 | $37,905 | 2018 RSM 15107-660-3490 |
| 30" Piping (Welded Steel Cement Mortar Lined) | 90 | LF | $410.44 | $36,939 | Based on 2018 RSM 15107-620-2220 |
| 30" BFV Electric Operated | 3 | EA | $16,556.88 | $49,671 | Based on 2018 RSM 02080-500-3500 |
| 30" Double Wafer Check Valve | 3 | EA | $69,806.88 | $209,421 | Based on 2018 RSM 02080-500-3730 |
| 24" Piping (Welded Steel Cement Mortar Lined) | 20 | LF | $328.35 | $6,567 | 2018 RSM 15107-620-2220 |
| 24" BFV Electric Operated | 2 | EA | $13,645.50 | $27,291 | Based on 2018 RSM 02080-500-3500 |
| 12" Piping (Welded Steel Cement Mortar Lined) | 60 | LF | $328.35 | $19,701 | Based on 2018 RSM 15107-620-2220 |
| 12" BFV Electric Operated | 2 | EA | $2,755.50 | $5,511 | Based on 2018 RSM 02080-500-3340 |
| 12" Double Wafer Check Valve | 2 | EA | $5,980.50 | $11,961 | 2018 RSM 02080-500-3720 |
| *Electrical:* | | | | | |
| VFD Small - Low Voltage | 3 | EA | $11,700.00 | $35,100 | 2018 RSM 16220-900-0190 |
| VFD Large - Low Voltage | 3 | EA | $26,407.00 | $79,221 | 2018 RSM 16220-900-0240 |
| *Subtotal* | | | | $3,141,334 | |
| *Allowance for Misc Items* | 5% | | $3,141,333.81 | $157,067 | |

7/10/2018 Item 5

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| **5. CHEMICAL BUILDING - LAS** | | | | | |
| *Sitework:* | | | | | |
| Overall Sitework | 1 | LS | $20,000.00 | $20,000 | |
| Excavation | 529 | CY | ***$4.18*** | $2,215 | |
| Imported Fill Under Slab | 32 | CY | ***$51.57*** | $1,645 | |
| Native Backfill | 154 | CY | ***$8.37*** | $1,286 | |
| Haul Excess | 376 | CY | ***$8.37*** | $3,143 | |
| Asphalt Concrete Pavement | 924 | SY | $55.00 | $50,838 | |
| *Concrete:* | | | | | |
| Slab on Grade | 70 | CY | ***$442.91*** | $31,004 | |
| Containment Walls | 41 | CY | ***$750.50*** | $30,715 | |
| Containment Pedestals | 5 | CY | ***$750.50*** | $3,954 | |
| Concrete Equipment Pad | 36 | CY | ***$400.43*** | $14,325 | |
| Chemical Delivery Pad | 31 | CY | ***$400.43*** | $12,458 | |
| Precast Concrete Vault (10' x 10, PVC lined) | 1 | EA | $25,622.22 | $25,622 | |
| HVAC Pad | 1 | CY | ***$400.43*** | $544 | |
| Concrete Pads | 0 | CY | ***$400.43*** | $177 | |
| Precast Chemical Pull Box (5' x 4') | 1 | EA | $3,500.00 | $3,500 | |
| *Building:* | | | | | |
| Building: | 1,122 | SF | $80.00 | $89,760 | |
| *Metals:* | | | | | |
| FRP Grating/Platform | 298 | SF | $150.00 | $44,700.00 | |
| FRP Stairs | 12 | RISERS | ***$502.06*** | $5,491.90 | |
| FRP Ladder | 10 | VLF | $120.00 | $1,200.00 | |
| Handrail | 70 | LF | ***$92.04*** | $5,873.28 | |
| Bollards | 9 | EA | $507.68 | $4,569 | 2018 RSM 05120-260-0890 |
| *Moisture Protection:* | | | | | |
| Aluminum Access Hatches for Precast Containment Vault (3' x 3') | 2 | EA | $1,500.00 | $3,000 | |
| *Doors and Windows:* | | | | | |
| Single Man Door | 1 | EA | $900.00 | $900 | |
| Double Man Door | 1 | EA | $1,200.00 | $1,200 | |
| *Equipment:* | | | | | |
| Aqueous Ammonia Storage Tanks | 2 | EA | $66,000.00 | $132,000 | |
| Aqueous Ammonia Scrubber | 1 | EA | $21,600.00 | $21,600 | |
| Aqueous Ammonia Feed Pumps | 2 | EA | $14,400.00 | $28,800 | |
| Trench Drain | 12 | SF | $100.00 | $1,200 | |
| Sump Pump | 1 | EA | $3,000.00 | $3,000 | |
| *Mechanical:* | | | | | |
| MAU-1 (2500 cfm, 460 v, 107 MBU cooling, 60 kw electric heating) | 1 | EA | $24,000.00 | $24,000.00 | |
| Exhaust Fan (2650 cfm) | 1 | EA | $5,000.00 | $5,000.00 | |
| Ductwork | 1 | LS | $15,000.00 | $15,000.00 | |
| Tankless Water Heater | 2 | EA | $1,500.00 | $3,000.00 | |
| Safety Shower | 2 | EA | $2,000.00 | $4,000.00 | |
| *Electrical:* | | | | | |
| *Lighting:* | | | | | |
| High Bay LED (112w) | 9 | EA | $1,500.00 | $13,500 | |
| Exist Signs | 2 | EA | $500.00 | $1,000 | |
| Wall Mounted CFL (42w) | 2 | EA | $1,000.00 | $2,000 | |
| Emergency Lights | 2 | EA | $1,000.00 | $2,000 | |
| *Subtotal* | | | | $614,219 | |
| *Allowance for Misc Items* | 5% | | $614,218.77 | $30,711 | |
| *Subtotal* | | | | $644,930 | |
| *ALLOWANCES:* | | | | | |
| *Finishes Allowance* | 3.00% | | $644,929.70 | $19,348 | |
| *I & C Allowance* | 10.00% | | $644,929.70 | $64,493 | |
| *Mechanical Allowance* | 15.00% | | $644,929.70 | $96,739 | Includes HVAC |
| *Electrical Allowance* | 6.00% | | $644,929.70 | $38,696 | |

7/10/2018 Item 5

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| **Subtotal** | | | | $864,206 | |
| CONTRACTOR MARKUPS: | | | | | |
| Overhead | 12% | | $864,205.80 | $103,705 | |
| Subtotal | | | | $967,910 | |
| Profit | 5% | | $967,910.50 | $48,396 | |
| Subtotal | | | | $1,016,306 | |
| Mob/Bonds/Insurance | 5% | | $1,016,306.02 | $50,815 | |
| Subtotal | | | | $1,067,121 | |
| Contingency | 30% | | $1,067,121.33 | $320,136 | |
| SUBTOTAL with Markups | | | | $1,387,258 | |
| Escalation | 0.0% | | $1,387,257.72 | $0 | |
| **SUBTOTAL Construction Cost with Escalation** | | | | $1,387,258 | |
| Tax | 0% | | $832,354.63 | $0 | |
| **TOTAL Construction Cost with Escalation & Tax** | | | | $1,387,258 | |
| **TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor** | 100.00 | | | $1,387,258 | |
| **Market Adjustment Factor** | 10% | | $1,387,257.72 | $138,726 | |
| **TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor** | | | | $1,525,983 | |
| Permitting Allowance | 0% | | $1,525,983.50 | $0 | |
| Engineering | 0% | | $1,525,983.50 | $0 | |
| SDC | 0% | | $1,525,983.50 | $0 | |
| Commissioning & Startup | 0% | | $1,525,983.50 | $0 | |
| **TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance** | | | | $1,525,983 | |

7/10/2018 Item 6

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| **6. CHEMICAL BUILDING - SODIUM HYPOCHLORITE** | | | | | |
| *Sitework:* | | | | | |
| Overall Sitework | 1 | LS | $20,000.00 | $20,000 | |
| Excavation | 529 | CY | $4.18 | $2,215 | |
| Imported Fill Under Slab | 32 | CY | $51.57 | $1,645 | |
| Native Backfill | 154 | CY | $8.37 | $1,286 | |
| Haul Excess | 376 | CY | $8.37 | $3,143 | |
| Asphalt Concrete Pavement | 924 | SY | $55.00 | $50,820 | |
| *Concrete:* | | | | | |
| Slab on Grade | 70 | CY | $442.91 | $31,004 | |
| Containment Walls | 41 | CY | $750.50 | $30,715 | |
| Containment Pedestals | 5 | CY | $750.50 | $3,954 | |
| Concrete Equipment Pad | 36 | CY | $400.43 | $14,325 | |
| Chemical Delivery Pad | 31 | CY | $400.43 | $12,458 | |
| Concrete Vault (10' x 10', PVC Lined - Precast) | 1 | EA | $27,000.00 | $27,000 | |
| *Building:* | | | | | |
| Building: | 1,122 | SF | $80.00 | $89,760 | |
| *Metals:* | | | | | |
| FRP Grating / Platform | 300 | SF | $120.00 | $36,000 | |
| FRP Stairs | 12 | RISERS | $502.06 | $6,025 | |
| FRP Ladder | 10 | VLF | $120.00 | $1,200.00 | |
| Handrail | 70.0 | LF | $92.04 | $6,443 | |
| *Moisture Protection:* | | | | | |
| Aluminum Access Hatches for Precast Containment Vault (3' x 3') | 2 | EA | $1,500.00 | $3,000 | |
| *Doors and Windows:* | | | | | |
| Single Man Door | 1 | EA | $900.00 | $900 | |
| Double Man Door | 1 | EA | $1,200.00 | $1,200 | |
| *Equipment:* | | | | | |
| Sodium Hypochlorite Storage Tanks | 2 | EA | $66,000.00 | $132,000 | |
| Sodium Hypochlorite Feed Pumps | 2 | EA | $14,400.00 | $28,800 | |
| Trench Drain | 12 | SF | $100.00 | $1,200 | |
| Sump Pump | 1 | EA | $3,000.00 | $3,000 | |
| *Mechanical:* | | | | | |
| MAU-1 (2500 cfm, 460 v, 107 MBU cooling, 60 kw electric heating) | 1 | EA | $24,000.00 | $24,000.00 | |
| Exhaust Fan (2650 cfm) | 1 | EA | $5,000.00 | $5,000.00 | |
| Ductwork | 1 | LS | $15,000.00 | $15,000.00 | |
| Tankless Water Heater | 2 | EA | $1,500.00 | $3,000.00 | |
| Safety Shower | 2 | EA | $2,000.00 | $4,000.00 | |
| *Electrical:* | | | | | |
| *Lighting:* | | | | | |
| High Bay LED (112w) | 9 | EA | $1,500.00 | $13,500 | |
| Exist Signs | 2 | EA | $500.00 | $1,000 | |
| Wall Mounted CFL (42w) | 2 | EA | $1,000.00 | $2,000 | |
| Emergency Lights | 2 | EA | $1,000.00 | $2,000 | |
| *Subtotal* | | | | $577,591 | |
| *Allowance for Misc Items* | 5% | | $577,590.65 | $28,880 | |
| *Subtotal* | | | | $606,470 | |
| *ALLOWANCES:* | | | | | |
| *Finishes Allowance* | 3.00% | | $606,470.18 | $18,194 | |
| *I & C Allowance* | 10.00% | | $606,470.18 | $60,647 | |
| *Mechanical Allowance* | 15.00% | | $606,470.18 | $90,971 | |
| *Electrical Allowance* | 6.00% | | $606,470.18 | $36,388 | |
| ***Subtotal*** | | | | **$812,670** | |
| *CONTRACTOR MARKUPS:* | | | | | |
| *Overhead* | 12% | | $812,670.05 | $97,520 | |

7/10/2018 Item 6

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| *DESCRIPTION* | QUANTITY | UNIT | $/UNIT *(includes Material & Installation)* | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| *Subtotal* | | | | $910,190 | |
| *Profit* | 5% | | $910,190.45 | $45,510 | |
| *Subtotal* | | | | $955,700 | |
| *Mob/Bonds/Insurance* | 5% | | $955,699.97 | $47,785 | |
| *Subtotal* | | | | $1,003,485 | |
| *Contingency* | 30% | | $1,003,484.97 | $301,045 | |
| *SUBTOTAL with Markups* | | | | $1,304,530 | |
| *Escalation* | 0.0% | | $1,304,530.47 | $0 | |
| ***SUBTOTAL Construction Cost with Escalation*** | | | | **$1,304,530** | |
| *Tax* | 0% | | $782,718.28 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax*** | | | | **$1,304,530** | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor*** | 100.00 | | | **$1,304,530** | |
| ***Market Adjustment Factor*** | 10% | | $1,304,530.47 | **$130,453** | |
| ***TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor*** | | | | **$1,434,984** | |
| Permitting Allowance | 0% | | $1,434,983.51 | $0 | |
| Engineering | 0% | | $1,434,983.51 | $0 | |
| SDC | 0% | | $1,434,983.51 | $0 | |
| Commissioning & Startup | 0% | | $1,434,983.51 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance*** | | | | **$1,434,984** | |

7/10/2018 Item 7

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| **7. CHEMICAL BUILDING - CAUSTIC** | | | | | |
| *Sitework:* | | | | | |
| Overall Sitework | 1 | LS | $20,000.00 | $20,000 | |
| Excavation | 529 | CY | ***$4.18*** | $2,215 | |
| Imported Fill Under Slab | 32 | CY | ***$51.57*** | $1,645 | |
| Native Backfill | 154 | CY | ***$8.37*** | $1,286 | |
| Haul Excess | 376 | CY | ***$8.37*** | $3,143 | |
| Asphalt Concrete Pavement | 924 | SY | $55.00 | $50,820 | |
| *Concrete:* | | | | | |
| Slab on Grade | 70 | CY | ***$442.91*** | $31,004 | |
| Containment Walls | 41 | CY | ***$750.50*** | $30,715 | |
| Containment Pedestals | 5 | CY | ***$750.50*** | $3,954 | |
| Concrete Equipment Pad | 36 | CY | ***$400.43*** | $14,325 | |
| Chemical Delivery Pad | 31 | CY | ***$400.43*** | $12,458 | |
| Concrete Vault (10' x 10', PVC Lined - Precast) | 1 | EA | $27,000.00 | $27,000 | |
| *Building:* | | | | | |
| Building: | 1,122 | SF | $80.00 | $89,760 | |
| *Metals:* | | | | | |
| FRP Grating / Platform | 300 | SF | $120.00 | $36,000 | |
| FRP Stairs | 12 | RISERS | ***$502.06*** | $6,025 | |
| FRP Ladder | 10 | VLF | $120.00 | $1,200.00 | |
| Handrail | 70.0 | LF | ***$92.04*** | $6,443 | |
| *Moisture Protection:* | | | | | |
| Aluminum Access Hatches for Precast Containment Vault (3' x 3') | 2 | EA | $1,500.00 | $3,000 | |
| *Doors and Windows:* | | | | | |
| Single Man Door | 1 | EA | $900.00 | $900 | |
| Double Man Door | 1 | EA | $1,200.00 | $1,200 | |
| *Equipment:* | | | | | |
| Caustic Storage Tanks | 2 | EA | $66,000.00 | $132,000 | |
| Caustic Feed Pumps | 2 | EA | $14,400.00 | $28,800 | |
| Trench Drain | 12.0 | SF | $100.00 | $1,200 | |
| Sump Pump | 1.0 | EA | $3,000.00 | $3,000 | |
| *Mechanical:* | | | | | |
| MAU-1 (2500 cfm, 460 v, 107 MBU cooling, 60 kw electric heating) | 1 | EA | $24,000.00 | $24,000.00 | |
| Exhaust Fan (2650 cfm) | 1 | EA | $5,000.00 | $5,000.00 | |
| Ductwork | 1 | LS | $15,000.00 | $15,000.00 | |
| Tankless Water Heater | 2 | EA | $1,500.00 | $3,000.00 | |
| Safety Shower | 2 | EA | $2,000.00 | $4,000.00 | |
| *Electrical:* | | | | | |
| *Lighting:* | | | | | |
| High Bay LED (112w) | 9 | EA | $1,500.00 | $13,500 | |
| Exist Signs | 2 | EA | $500.00 | $1,000 | |
| Wall Mounted CFL (42w) | 2 | EA | $1,000.00 | $2,000 | |
| Emergency Lights | 2 | EA | $1,000.00 | $2,000 | |
| *Subtotal* | | | | $577,591 | |
| *Allowance for Misc Items* | 5% | | $577,590.65 | $28,880 | |
| *Subtotal* | | | | $606,470 | |
| *ALLOWANCES:* | | | | | |
| *Finishes Allowance* | 3.00% | | $606,470.18 | $18,194 | |
| *I & C Allowance* | 10.00% | | $606,470.18 | $60,647 | |
| *Mechanical Allowance* | 15.00% | | $606,470.18 | $90,971 | |
| *Electrical Allowance* | 6.00% | | $606,470.18 | $36,388 | |
| ***Subtotal*** | | | | **$812,670** | |
| *CONTRACTOR MARKUPS:* | | | | | |
| *Overhead* | 12% | | $812,670.05 | $97,520 | |
| *Subtotal* | | | | $910,190 | |

7/10/2018 Item 7

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| *Profit* | 5% | | $910,190.45 | $45,510 | |
| *Subtotal* | | | | $955,700 | |
| *Mob/Bonds/Insurance* | 5% | | $955,699.97 | $47,785 | |
| *Subtotal* | | | | $1,003,485 | |
| *Contingency* | 30% | | $1,003,484.97 | $301,045 | |
| *SUBTOTAL with Markups* | | | | $1,304,530 | |
| | | | | | |
| *Escalation* | 0.0% | | $1,304,530.47 | $0 | |
| ***SUBTOTAL Construction Cost with Escalation*** | | | | **$1,304,530** | |
| | | | | | |
| *Tax* | 0% | | $782,718.28 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax*** | | | | **$1,304,530** | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor*** | 100.00 | | | **$1,304,530** | |
| ***Market Adjustment Factor*** | 10% | | $1,304,530.47 | **$130,453** | |
| ***TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor*** | | | | **$1,434,984** | |
| Permitting Allowance | 0% | | $1,434,983.51 | $0 | |
| Engineering | 0% | | $1,434,983.51 | $0 | |
| SDC | 0% | | $1,434,983.51 | $0 | |
| Commissioning & Startup | 0% | | $1,434,983.51 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance*** | | | | **$1,434,984** | |

7/10/2018 Item 8

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| ***DESCRIPTION*** | **QUANTITY** | **UNIT** | **$/UNIT** *(includes Material & Installation)* | **TOTAL COST** | **REFERENCE** |
|---|---|---|---|---|---|
| ***8. Reuse of Wemlinger Pump Station (ALT 3)*** | | | | | |
| *Sitework:* | | | | | |
| Pipe Trench Excavation, Bedding, Backfill, and Surface Restoration | 1 | LS | $7,500.00 | $7,500 | |
| Surface Restoration | 1 | LS | $3,333.33 | $3,333 | |
| | | | | | |
| *Concrete:* | | | | | |
| Pump Pedestal | 4 | EA | $1,000.00 | $4,000 | |
| Core Drill 18" Opening in exisiting wetwell | 4 | EA | $1,000.00 | $4,000 | |
| | | | | | |
| *I&C:* | | | | | |
| 24" Electromagnetic Flowmeter | 1 | EA | $30,000.00 | $30,000 | |
| | | | | | |
| *Equipment:* | | | | | |
| Pump - Small | 2 | EA | $60,000.00 | $120,000 | |
| Pump - Large | 2 | EA | $180,000.00 | $360,000 | |
| Surge Tank | 1 | EA | $180,000.00 | $180,000 | |
| | | | | | |
| *Mechanical:* | | | | | |
| 36" Piping (Welded Steel Cement Mortar Lined) | 30 | LF | $492.53 | $14,776 | Based on 2018 RSM 15107-620-2220 |
| 36" Bend | 2 | EA | $6,230.00 | $12,460 | 2018 RSM 15107-660-3349 |
| 36" x 12" Tee | 2 | EA | $12,635.00 | $25,270 | 2018 RSM 15107-660-3490 |
| 36" x 30" Tee | 2 | EA | $12,635.00 | $25,270 | 2018 RSM 15107-660-3490 |
| 30" Piping (Welded Steel Cement Mortar Lined) | 25 | LF | $410.44 | $10,261 | Based on 2018 RSM 15107-620-2220 |
| 30" BFV Electric Operated | 2 | EA | $16,556.88 | $33,114 | Based on 2018 RSM 02080-500-3500 |
| 30" Double Wafer Check Valve | 2 | EA | $69,806.88 | $139,614 | Based on 2018 RSM 02080-500-3730 |
| 24" Piping (Welded Steel Cement Mortar Lined) | 25 | LF | $328.35 | $8,209 | 2018 RSM 15107-620-2220 |
| 24" BFV Electric Operated | 2 | EA | $13,645.50 | $27,291 | Based on 2018 RSM 02080-500-3500 |
| 12" Piping (Welded Steel Cement Mortar Lined) | 25 | LF | $328.35 | $8,209 | Based on 2018 RSM 15107-620-2220 |
| 12" BFV Electric Operated | 2 | EA | $2,755.50 | $5,511 | Based on 2018 RSM 02080-500-3340 |
| 12" Double Wafer Check Valve | 2 | EA | $5,980.50 | $11,961 | 2018 RSM 02080-500-3720 |
| | | | | | |
| *Electrical:* | | | | | |
| VFD - Small | 2 | EA | $11,700.00 | $23,400 | 2018 RSM 16220-900-0190 |
| VFD - Large | 2 | EA | $26,407.00 | $52,814 | 2018 RSM 16220-900-0240 |
| | | | | | |
| *Subtotal* | | | | $1,106,992 | |
| *Allowance for Misc Items* | 5% | | $1,106,992.02 | $55,350 | |

# Cost Estimate for 480V Pump Station

7/10/2018 Item 3

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| ***3. FINISHED WATER PUMP STATION (Final)*** | | | | | |
| *Wall Length* | 133.50 | FT | | | |
| *Wall Width* | 50.00 | FT | | | |
| *Wall Height* | 29.00 | FT | | | |
| *Wall Thickness* | 2.50 | FT | | | |
| *Slab Thickness* | 2.50 | FT | | | |
| *Elevated Slab Thickness* | 1.00 | FT | | | |
| *Excavation Side Slope Ratio* | 1.00 | :1 | | | |
| *Burial Depth of Structure* | 0.00 | LF | | | |
| *Volume of Structure* | 9,169.2 | CY | | | |
| *Slab Length* | 140.50 | FT | | | |
| *Slab Width* | 57.00 | FT | | | |
| *Excavation Length* | 144.50 | FT | | | |
| *Excavation Width* | 61.00 | FT | | | |
| *Excavation Depth* | 32.00 | FT | Includes structure burial depth | | |
| *Sitework:* | | | | | |
| Site Prep | 1 | LS | $500.00 | $500 | |
| Excavation | 20,429 | CY | $10.00 | $204,295 | |
| Imported Fill Under Slab | 148 | CY | ***$51.57*** | $7,649 | |
| Imported Backfill | 11,260 | CY | ***$51.57*** | $580,722 | |
| Haul Excess | 9,169 | CY | ***$8.37*** | $76,725 | |
| Surface Restoration | 2,678 | SY | $20.00 | $53,550 | |
| *Concrete:* | | | | | |
| Slab on Grade (2.5 feet thick) | 742 | CY | ***$442.91*** | $328,430 | |
| Concrete Walls (29 feet high,2.5 feet thick) | 9 | CY | ***$750.50*** | $6,995 | |
| Elevated Slab (1 feet thick) | 6 | CY | ***$1,161.94*** | $6,503 | |
| Hatch Curb (8" wide, 12" high) | 0.79 | CY | $450.00 | $356 | |
| *Building:* | | | | | |
| Building: | 5,000 | SF | $100.00 | $500,000 | |
| *I&C:* | | | | | |
| 24" Electromagnetic Flowmeter | 1 | EA | $30,000.00 | $30,000 | |
| Level Indicator Transmitter | 2 | EA | $2,500.00 | $5,000 | |
| *Equipment:* | | | | | |
| Pump - Small | 3 | EA | $104,542.80 | $313,628 | |
| Pump - Large | 7 | EA | $189,000.00 | $1,323,000 | |
| Surge Tank | 1 | EA | $180,000.00 | $180,000 | |
| *Mechanical:* | | | | | |
| 36" Piping (Welded Steel Cement Mortar Lined) | 80 | LF | $492.53 | $39,402 | Based on 2018 RSM 15107-620-2220 |
| 36" Bend | 2 | EA | $6,230.00 | $12,460 | 2018 RSM 15107-660-3349 |
| 36" x 24" Tee | 1 | EA | $12,635.00 | $12,635 | 2018 RSM 15107-660-3490 |
| 36" x 12" Tee | 2 | EA | $12,635.00 | $25,270 | 2018 RSM 15107-660-3490 |
| 36" x 30" Tee | 3 | EA | $12,635.00 | $37,905 | 2018 RSM 15107-660-3490 |
| 36" Blind Flange | 2 | EA | $4,599.00 | $9,198 | Based on 2018 RSM 15107-660-2518 |
| 30" Piping (Welded Steel Cement Mortar Lined) | 90 | LF | $410.44 | $36,939 | Based on 2018 RSM 15107-620-2220 |
| 30" Double Waffer Check Valve | 3 | EA | $69,806.88 | $209,421 | Based on 2018 RSM 02080-500-3730 |
| 30" BFV Electric Operated | 3 | EA | $16,556.88 | $49,671 | Based on 2018 RSM 02080-500-3500 |
| 24" Piping (Welded Steel Cement Mortar Lined) | 20 | LF | $328.35 | $6,567 | 2018 RSM 15107-620-2220 |
| 24" BFV Electric Operated | 2 | EA | $13,645.50 | $27,291 | Based on 2018 RSM 02080-500-3500 |
| 12" Piping (Welded Steel Cement Mortar Lined) | 60 | LF | $328.35 | $19,701 | Based on 2018 RSM 15107-620-2220 |
| 12" BFV Electric Operated | 2 | EA | $2,755.50 | $5,511 | Based on 2018 RSM 02080-500-3340 |
| 12" Double Waffer Check Valve | 2 | EA | $5,980.50 | $11,961 | 2018 RSM 02080-500-3720 |
| *Electrical:* | | | | | |
| VFD - Low Voltage | 3 | EA | $37,743.75 | $113,231 | Based on 2018 RSM 16220-900-0250 |
| VFD - Low Voltage | 7 | EA | $67,938.75 | $475,571 | Based on 2018 RSM 16220-900-0250 |
| *Subtotal* | | | | $4,710,085 | |
| *Allowance for Misc Items* | 5% | | $4,710,085.13 | $235,504 | |
| *Subtotal* | | | | $4,945,589 | |
| *ALLOWANCES:* | | | | | |

*WISE - COST ESTIMATE 5.29.2018 - Copy* 1 of 2

7/10/2018 Item 3

**JACOBS**
**WISE Binney Connection Pump Station Study**
**PROJECT NO: 702800.03.31.06**
**PREPARED BY: E.R.MEYER**

To: Summary Sheet

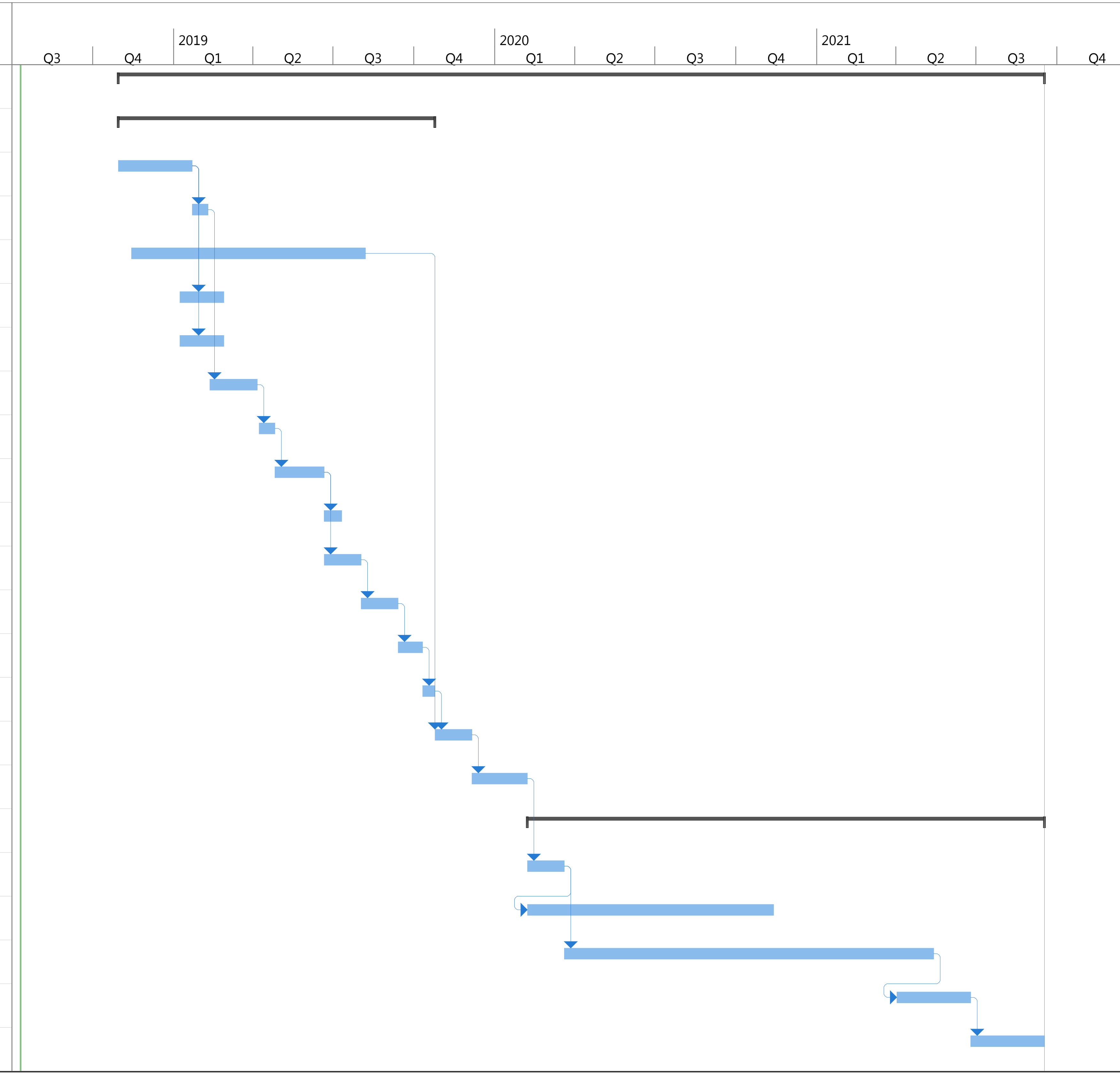
**WISE Binney Connection Pump Station Study**
**(This estimate was prepared in May 2018, ENR CCI 20 City Average = 11012.77)**

| DESCRIPTION | QUANTITY | UNIT | $/UNIT (includes Material & Installation) | TOTAL COST | REFERENCE |
|---|---|---|---|---|---|
| *Finishes Allowance* | 3.00% | | $4,945,589.39 | $148,368 | |
| *I & C Allowance* | 5.00% | | $4,945,589.39 | $247,279 | |
| *Mechanical Allowance* | 5.00% | | $4,945,589.39 | $247,279 | |
| *Electrical Allowance* | 15.00% | | $4,945,589.39 | $741,838 | |
| | | | | | |
| ***Subtotal*** | | | | **$6,330,354** | |
| | | | | | |
| *CONTRACTOR MARKUPS:* | | | | | |
| *Overhead* | 12% | | $6,330,354.42 | $759,643 | |
| *Subtotal* | | | | $7,089,997 | |
| *Profit* | 5% | | $7,089,996.95 | $354,500 | |
| *Subtotal* | | | | $7,444,497 | |
| *Mob/Bonds/Insurance* | 5% | | $7,444,496.80 | $372,225 | |
| *Subtotal* | | | | $7,816,722 | |
| *Contingency* | 30% | | $7,816,721.64 | $2,345,016 | |
| *SUBTOTAL with Markups* | | | | $10,161,738 | |
| | | | | | |
| *Escalation* | 0.0% | | $10,161,738.13 | $0 | |
| ***SUBTOTAL Construction Cost with Escalation*** | | | | **$10,161,738** | |
| | | | | | |
| *Tax* | 0% | | $6,097,042.88 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax*** | | | | **$10,161,738** | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor*** | 100.00 | | | **$10,161,738** | |
| ***Market Adjustment Factor*** | 10% | | $10,161,738.13 | **$1,016,174** | |
| ***TOTAL Construction Cost with Escalation & Tax, Location Adjustment Factor and Market Adjustment Factor*** | | | | **$11,177,912** | |
| Permitting Allowance | 0% | | $11,177,911.94 | $0 | |
| Engineering | 0% | | $11,177,911.94 | $0 | |
| SDC | 0% | | $11,177,911.94 | $0 | |
| Commissioning & Startup | 0% | | $11,177,911.94 | $0 | |
| ***TOTAL Construction Cost with Escalation & Tax, and Location Adjustment Factor, and Permitting Allowance*** | | | | **$11,177,912** | |

*WISE - COST ESTIMATE 5.29.2018 - Copy* 2 of 2

# Appendix F – Construction Schedule

| ID | Tasl Mo | Task Name | Duration | Start | Finish |
|---|---|---|---|---|---|
| 1 | | **WISE Binney Connection Pump Station Project** | **753 days** | **Tue 10/30/1** | **Thu 9/16/21** |
| 2 | | **Final Design Activities** | **258 days** | **Tue 10/30/1** | **Thu 10/24/19** |
| 3 | | Preliminary Design | 60 days | Tue 10/30/1 | Mon 1/21/19 |
| 4 | | Preliminary Design - Review | 14 days | Tue 1/22/19 | Fri 2/8/19 |
| 5 | | Permit Applications and Approvals | 190 days | Wed 11/14/1 | Tue 8/6/19 |
| 6 | | Utility Documentation and Location | 36 days | Tue 1/8/19 | Tue 2/26/19 |
| 7 | | Survey and Geotechnical Exploration | 36 days | Tue 1/8/19 | Tue 2/26/19 |
| 8 | | 60% Design | 40 days | Mon 2/11/19 | Fri 4/5/19 |
| 9 | | 60% Design Review | 14 days | Mon 4/8/19 | Thu 4/25/19 |
| 10 | | 90% Design | 40 days | Fri 4/26/19 | Thu 6/20/19 |
| 11 | | 90% Design Review | 14 days | Fri 6/21/19 | Wed 7/10/19 |
| 12 | | Public Works Plan Review #1 | 30 days | Fri 6/21/19 | Thu 8/1/19 |
| 13 | | Public Works Plan Review #2 | 30 days | Fri 8/2/19 | Thu 9/12/19 |
| 14 | | Public Works Plan Review #3 | 20 days | Fri 9/13/19 | Thu 10/10/19 |
| 15 | | Bid Documents | 10 days | Fri 10/11/19 | Thu 10/24/19 |
| 16 | | Bid Phase | 30 days | Fri 10/25/19 | Thu 12/5/19 |
| 17 | | Contract Award | 45 days | Fri 12/6/19 | Thu 2/6/20 |
| 18 | | **Construction** | **420 days** | **Fri 2/7/20** | **Thu 9/16/21** |
| 19 | | Mobilization/Material Delivery | 30 days | Fri 2/7/20 | Thu 3/19/20 |
| 20 | | Submittal Review - Long Lead Item Delivery | 200 days | Fri 2/7/20 | Thu 11/12/20 |
| 21 | | Active Construction | 300 days | Fri 3/20/20 | Thu 5/13/21 |
| 22 | | Startup and Testing | 60 days | Fri 4/2/21 | Thu 6/24/21 |
| 23 | | Project Closeout | 60 days | Fri 6/25/21 | Thu 9/16/21 |




Project: SMWA-Binney_PumpSt
Date: Wed 7/11/18

Task | Project Summary | Manual Task | Start-only | Deadline
Split | Inactive Task | Duration-only | Finish-only | Progress
Milestone | Inactive Milestone | Manual Summary Rollup | External Tasks | Manual Progress
Summary | Inactive Summary | Manual Summary | External Milestone