GOVERNMENT CANAL PUMP STATION ALTERNATIVES ANALYSIS REPORT

King County

Department of Natural Resources and Parks
Water and Land Resources Division

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Prepared for

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Water and Land Resources Division
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INTRODUCTION

This Alternatives Analysis Report presents five pump station alternatives for flood control generated for the Government Canal (Canal) and compares them in an alternatives analysis. A brief project background is provided below, followed by a description of the purpose of this report.

BACKGROUND

The Canal runs through the City of Pacific (City) on its way to the White River. In the past, the segment of canal near Butte Avenue has experienced flooding during large storm events. Recent examples include flooding in 2009 and 2015 which impacted the White River Estates neighborhood and is depicted in Figure 1 below. During these flood events water levels in the White River impeded drainage in the Canal which caused water to overtop its banks just upstream of Butte Avenue. Canal flood flows inundated Butte Ave, flooded White River Estates, and flowed South down Butte Avenue where they returned to the White River at a low point upstream of Stuart Street Bridge.

Figure 1. 2009 Flooding of White Rivers Estates

In response to these events, the City installed a packaged pump system and plywood panels to isolate the Canal. During large storm events, City personnel install the plywood panels in the Canal and turn on the pump. However, this solution is temporary and the pump is undersized for the flows in the Canal.

King County (County) has examined the possibility of buying out properties and building a levee up the left bank of the Canal in lieu of building a pump station in a Potential Project Concept's Analysis (Herrera 2019). However, when the Canal floods, water overtops its banks upstream of Butte Avenue and impacts areas beyond the White River Estates. This includes properties in Pierce County. Ultimately buying out properties and levees on the left bank of the Canal were screened out of the list of options for further analysis because it did not meet the project purpose and need of improving flooding and environmental conditions. In addition, buyouts would require the County to purchase properties in the White River Estates and along Butte Avenue all the way to Stewart Road. The cost associated with these buyouts is expected to be more than the cost of the pump station.

In 2019 Stantec Consulting Services, Inc. (Stantec) prepared a report titled "Government Canal Stormwater Pump Station" for the City of Pacific that provided a preliminary analysis of a flood control pumping system. The system included a pump station and associated control structures such as fish screens and flow control gates that could be built in conjunction with King County's Pacific Right Bank project. Earlier this year Herrera Environmental Consultants, retained by King County, contracted with HDR Engineering, Inc. (HDR) to build on Stantec's report and, as part of this work, HDR has:

- Conducted a detailed review of Stantec's report to identify design recommendations to move forward with
- Prepared a scoring matrix that was used to evaluate different pump station components and options
- Developed five pump station alternatives that will be used in the Environmental Impact Study for the Pacific Right Bank project

Design recommendations in Stantec's report were based on hydraulic and hydrologic modeling results developed by Clear Creek Solutions in 2018 and presented in a report titled "Storm Water Analysis of Government Canal Report." Herrera Environmental Consultants also contracted with Watershed Science & Engineering (WSE) to evaluate the Clear Creek Solutions stormwater analysis. Based on its review, WSE determined that Clear Creek Solutions' stormwater analysis was insufficient and developed a new H&H study, which is summarized in Section 2 of this report.

PURPOSE

The purpose of this report is as follows:

- Summarize the results and recommended design criteria from WSE's H&H modeling.
- Summarize the results from the scoring matrix.
- Describe the five pump station alternatives that have been developed. This includes preliminary site plans, operational criteria, and cost estimates.

HYDRAULIC AND HYDROLOGIC MODELING SUMMARY

This section presents a summary of the H&H modeling conducted for the Canal and White River Estates, followed by a gate closure analysis.

GOVERNMENT CANAL AND WHITE RIVER ESTATES

WSE developed H&H models of the Canal to determine the required capacity of the proposed pump station. The hydrologic analysis simulated runoff for existing conditions in the Canal drainage basin. The hydraulic model simulated hydraulic conditions in the Canal and was used to evaluate stormwater flows during a 100-year storm event. A summary of the hydraulic design criteria for the proposed pump station based on the modeling results is provided below in Table 1.

Table 1. Summary of Pump Station Hydraulic Design Criteria

Criterion	Value
Pump station firm capacity*	38,600 gpm (86 cfs)
Stormwater runoff from White River Estates	1,800 gpm (4 cfs)
Canal water surface elevation when flow control gates close	74.0 ft
Maximum allowable water surface elevation in the Canal downstream of Butte Ave.	74.6 ft
*Firm Capacity is the capacity of the pump station with the largest pump out of service.	

The following observations should be noted:

- WSE's hydraulic model assumed four pumps each with a capacity of 9,650 gallons per minute (gpm) (21.5 cubic feet per second [cfs]). The model required all four pumps operating at full capacity to maintain a water surface elevation (EL) of 74.60 feet (ft) in the Canal downstream of Butte Avenue. This is the basis for the pump station's firm capacity of 38,600 gpm (86 cfs).
- The peak 100-year runoff from White River Estates is approximately 1,800 gpm (4 cfs) but the peak is not timed coincidentally with the peak flows in the Canal. Therefore,

diverting these stormwater flows from the Canal would not significantly reduce the firm pumping capacity for the Canal pump station.

- The maximum allowable water surface elevation of 74.6 feet does not provide any freeboard in the canal.

- WSE made a preliminary evaluation of the potential effects of climate change on canal flows and pump station capacity based on data from the University of Washington Climate Impacts Group. The results from WSE's analysis predict that flows into the Government Canal might increase by 30.5% towards the end of the 21st century. This means that the firm capacity of the pump station would need to increase to 49,370 gpm (110 cfs). In order to account for this increase, space for a future pump will be included in all of the pump station alternatives. This will provide King County the flexibility to add additional capacity to the pump station should it be needed.

Additional details for the H&H analyses can be found in the *Proposed Government Canal Pump Station Hydraulic Analysis* technical memorandum dated September 11, 2020, by WSE, which is located in Appendix A of this report.

Gate Closure Analysis

King County recognizes that operation of a pump station will restrict salmonid access to Government Canal when flow control gates are closed. To characterize passage impacts, WSE analyzed the frequency and duration the flow control gates would be closed when the water surface elevation in the White River exceeds 74.0 feet. Its analysis determined that the flow control gates would be closed for 4.8 % of the modeled flood season (October 1 through April 30) and 2.8 percent of the spring rearing period for salmonids (February 1 to July 31). The pump station is assumed to be fully passable when flow control gates are open. Based on the limited average duration of gate closure, the gates will meet the 90% passage criteria described in the 2013 Washington Department of Fish and Wildlife (WDFW) Water Crossing Design Guidelines. Given this determination, King County decided that a fishway would not be included in the pump station design and directed HDR to evaluate fish passage considerations as part of the flow control gate evaluation.

SCORING MATRIX SUMMARY

Earlier this year HDR and King County collaborated to evaluate pump station components such as location, fish screening, intake structure configurations, pump types, culvert/flow control gates, and stormwater treatment and conveyance for runoff from White River Estates. A series of meetings was held between May 19th and July 22nd 2020 in which the evaluation criteria and scored rankings were discussed and finalized. These meetings resulted in spreadsheet-based decision matrixes that were developed for each component and evaluation criteria that were used to score different options. A low score signaled that the option compared favorably to the evaluation criteria. Conversely, a high score indicated that the option did not compare favorably to the evaluation criteria. The following sections summarize the scoring matrix results for the pump station components that were evaluated.

Pump Station Location

The north and south banks of the Canal were evaluated to determine a favorable location for the pump station. The criteria used to assess and compare the relative feasibility of locating the pump station on either the north or south bank of the Canal included:

- **Real estate:** This criterion is based on property ownership data from the King County Assessor website and it evaluates if King County would have to acquire additional property for each option. A rating of 1 indicates that the property is owned by King County and no constraints would complicate the layout and sizing of the pump station. A rating of 2 indicates that the property is not owned by King County but no constraints would complicate the layout and sizing of the pump station. A rating of 3 indicates that the property is not owned by King County and constraints would complicate the layout and sizing of the pump station.

- **Community impacts:** This criterion is based on the proximity of the future pump station to residential homes. A rating of 1 is given if there is enough room to keep the pump station more than 200 feet away from residential homes. A rating of 2 is given to locations where the pump station could be kept between 100 and 200 feet away from residential homes. A rating of 3 is given to locations where the pump station would be within 100 feet of residential homes.

- **Stormwater routing:** This criterion evaluates if stormwater piping from White River Estates would have to cross the Canal to discharge into the pump station's wetwell. A rating of 1 indicates that crossing the Canal would not be required. A rating of 3 indicates that stormwater piping would have to cross under the Canal.

- **Accessibility:** This criterion evaluates the ease of access associated with each location. A rating of 1 indicates that access is available. A rating of 2 indicates limited access (space is available but access to the site might impact private property). A rating of 3 indicates restricted access (site is available for the pump station but there is not space for an access road).

- **Wetland areas:** This criterion evaluates if the locations would impact existing wetlands. A rating of 1 indicates no impact to existing wetlands. A rating of 2 indicates potential impacts to existing wetland boundaries. A rating of 3 indicates that existing wetlands at the location would be impacted.

The overall results of the pump station location scoring matrix are shown in Table 2.

Table 2. Pump Station Location Scoring Matrix Results						
Location	**Real Estate**	**Community Impacts**	**Stormwater Routing**	**Accessibility**	**Wetland Areas**	**Total Score**
North bank	1	2	1	1	1	6
South bank	2	2	3	1	2	10

The Canal's north bank was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report.

Fish Screening

Four fish screening options were evaluated. The criteria used to assess and compare the relative feasibility of each fish screen option included:

- **Cleaning systems:** This criterion evaluates the effectiveness of the fish screen cleaning system. Cleaning systems that are very effective (require minimal manual cleaning) were given a rating of 1. Cleaning systems that are somewhat effective (require a moderate amount of manual cleaning) were given a rating of 2.

- **Operation and maintenance (O&M):** This criterion evaluates the ease of accessing the screens for maintenance. Screen types that can be lifted out in sections so that screened flow can be maintained were given a rating of 1. Screen types that can be easily lifted out but the whole screening system has to be removed, thus allowing unscreened water to reach the pumps, were given a rating of 2. Screens that are not easily removed were given a rating of 3.

- **Shallow depth operation:** This criterion evaluates the depth requirements for the different screen types. Screens that accommodate a shallow operating depth were given a rating of 1. Screens that permit a moderate operating depth were given a rating of 2. Screens that permit a deep operating depth were given a rating of 3.

- **Capital cost:** This criterion evaluates the anticipated capital costs associated with each screen type. Screen types that typically cost less were given a rating of 1. Screen types that are neither the cheapest nor the most expensive option were given a rating of 2. Screen types that typically cost the most were given a rating of 3.

- **Facility footprint:** This criterion evaluates the anticipated footprint associated with each screen type. Screens that typically have smaller footprints were given a rating of 1. Screens that usually require neither the smallest nor largest footprint were given a rating of 2. Screens that typically require a larger footprint were given a rating of 3.

- **Power required:** This criterion evaluates the power requirements associated with each screen type. Screens that normally require minimal power for water surface control and/or cleaning systems were given a rating of 1. Systems that usually require more power for water surface control and/or cleaning systems were given a rating of 3.

The overall results of the fish screening scoring matrix are shown in Table 3.

Table 3. Fish Screening Scoring Matrix Results

Option	Cleaning System	O&M	Shallow Depth Operation	Capital Cost	Facility Footprint	Power Req'd	Total Score
T-screen (fixed)	1	1	3	2	1	1	9
Cone screen	1	3	2	1	2	1	10
Flat plate (incline or vertical with air burst cleaning)	2	2	1	3	3	3	14
Flat plate (incline or vertical with brush cleaning)	2	2	1	3	3	3	14

Fixed T-screen was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report. It should be noted that the Canal does not have sufficient depth to provide one diameter of water above the T-Screens. For this reason it was given a score of 3 for the shallow depth operation criteria. However, this is not a fatal flaw and obtaining depth variances are common. In this case it would require proposing to reduce the water height requirements above and below the screen to the lead agency. Obtaining this variance shouldn't be an issue since the screens will be used infrequently.

INTAKE STRUCTURE CONFIGURATION

Six intake structures were evaluated. The criteria used to assess and compare the relative feasibility of each intake structure configuration included:

- **Footprint:** This criterion is based on the area required for each intake structure type. Intake structures with footprints estimated to be 500 square feet (ft^2) or less were given a rating of 1. Intake structures with footprints estimated to be between 500 and 1,000 ft^2 were given a rating of 2. Intake structures with footprints estimated to be more than 1,000 ft^2 were given a rating of 3.

- **Capital cost:** This criterion is based on historical costs data for each intake structure type. Intake structures with capital costs that are historically less than $350/gpm were given a rating of 1. Intake structures with capital costs that are historically between $350/gpm and $450/gpm were given a rating of 2. Intake structures with capital costs that are historically more than $450/gpm were given a rating of 3.

- **Applicability:** This criterion evaluates if the intake structure type is normally used for stormwater applications. Intake structures that are considered ideal for stormwater applications were given a rating of 1. Intake structures with potential for stormwater applications were given a rating of 2. Intake structures that are not recommended for stormwater applications are given a rating of 3.

- **Maintenance:** This criterion evaluates how easy or difficult the various intake structures are to maintain. Intake structures where the pumps would be easily removed and it would be easy for the structure to be cleaned manually or by vacuum truck were given a rating of 1. Intake structures where removal of the pumps would be more difficult but it would be easy for the structure to be cleaned manually or by vacuum truck were given a rating of 2. Intake structures where removal of the pumps would be difficult and it would be difficult for the structure to be cleaned manually or by vacuum track were given a rating of 3.

The overall results of the intake structure scoring matrix are shown in Table 4.

Table 4. Intake Structure Scoring Matrix Results

Type	Footprint	Capital Cost	Applicability	Maintenance	Total Score
Self-cleaning trench	2	2	3	2	9
Standard trench	2	2	2	2	8
Dry pit	3	3	1	1	8
Rectangular wet pit	2	2	1	1	6
Open-bottom can	1	1	2	3	7
Closed-bottom can	1	1	3	3	8

The rectangular wet pit intake structure was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report.

PUMP TYPE

Six pump types were evaluated. The criteria used to assess and compare the relative feasibility of each pump type included:

- **Pump efficiency:** This criterion is based on the pump efficiencies included with the pump selections provided by various vendors. Selections with efficiencies of 80 percent or greater were given a rating of 1. Selections with efficiencies of 70 percent and 80 percent were given a rating of 2. Selections with efficiencies below 70 percent were given a rating of 3.

- **Capital cost:** This criterion is based on the estimated cost of each pump type as provided by the various vendors. Pump types that cost less than $100,000 were given a rating of 1. Pump types that cost between $100,000 and $200,000 were given a rating of 2. Pump types that cost more than $200,000 were given a rating of 3.

- **Life-cycle cost:** this criterion is based on the estimated annual cost to operate, maintain, and replace each pump. Pump types with life-cycle costs estimated to be less than $200,000 per pump were given a rating of 1. Pump types with life-cycle costs estimated to be between $200,000 and $400,000 per pump were given a rating of 2. Pump types with life-cycle costs estimated to be more than $400,000 per pump were given a rating of 3.

- **System requirements:** This criterion is based on external items that the different pump types might require, such as protective structures for motors, larger underground structures for dry side system components, seal water systems, isolation valves, and cooling systems. A rating of 1 indicates that no protective structures, suction isolation valves, or supplemental external cooling systems would be required. A rating of 2 indicates that some type of above-grade structure would be required to protect pump motors or a larger underground structure would be required to house the dry side of the pump system. A rating of 3 indicates that, in addition to an above-grade structure or larger underground structure, suction isolation valves would be required and a supplemental external cooling system would be required.

The overall results of the pump type scoring matrix are shown below in Table 5.

Table 5. Pump Type Scoring Matrix Results

Type	Pump Efficiency	Capital Cost	Life-cycle Cost	System Requirements	Total Score
Vertical submersible axial flow	1	1	1	1	4
Vertical-turbine solids handling	1	3	3	2	9
Submersible solids handling	1	2	2	1	6
Dry pit submersible	1	2	2	3	8
Dry pit pump with frame-mounted bearing and extended shaft	1	2	3	3	9
Vertical axial flow line-shaft pump	1	1	1	2	5

The vertical submersible axial flow pump was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report.

CULVERT/FLOW CONTROL GATE

Six flow control gates were evaluated. The criteria used to assess and compare the relative feasibility of each flow control gate type included:

- **Operation and Maintenance:** This criterion evaluates the level of routine maintenance that would be required for each gate type. Gates that open and close based on differential head and have minimal mechanical components were given a rating of 1. Gates that use an electric actuator or a mechanical device such as a muted tidal regulator to open and close would require routine preventive maintenance and were given a rating of 2. Gates that open and close using an air compressor and have multiple electrical and mechanical components that would need routine preventive maintenance were given a rating of 3.

- **Debris:** This criterion evaluates how the gate types deal with debris. Gates that do not typically collect floating debris were given a rating of 1. Gates that have a history of collecting floating debris but the debris is easily removed with regular inspections were given a rating of 2. Gates that have a history of collecting floating debris and, even with regular inspections, the debris is difficult remove and has the potential to damage the gate were given a rating of 3.

- **Capital cost:** This criterion is based on vendor-supplied cost data. Gates with a capital cost less than $50,000 per gate were given a rating of 1. Gates with a capital cost between $50,000 and $120,000 per gate were given a rating of 2. Gates with a capital cost greater than $120,000 were given a rating of 3.

- **Life-cycle cost:** This criterion is based on a combination of the replacement cost for each gate, electrical cost associated with operating the gate, and labor cost associated with maintaining the gate over a 20-year period. Gates with a life-cycle cost less than $100,000 were given a rating of 1. Gates with a life-cycle cost between $100,000 and $200,000 were given a rating of 2. Gates with a life-cycle cost greater than $200,000 were given a rating of 3.

- **Culvert options:** This criterion evaluates the flexibility of the gate type to be installed on a circular or rectangular culvert. Gates that can be installed on either circular or rectangular culverts were given a rating of 1. Gates that can be installed only in rectangular culverts were given a rating of 3.

- **Fish passage:** This criterion evaluates the ability of each gate to pass fish. Under normal operating conditions all of the gates would be open to allow for fish passage. Gates that are able to open wide with little to no outflow are considered to be conducive to fish passage and were given a rating of 1. Gates that are not able to open wide and thus will be difficult for fish to pass through were given a rating of 3. Additional operational procedures for the gates are further discussed under the Pump Station Alternatives Section of this Report.

The overall results of the culvert/flow control gate scoring matrix are shown below in **Error! Reference source not found.**.

Table 6. Culvert/Flow Control Gate Scoring Matrix Results							
Options	**O&M**	**Debris**	**Capital Cost**	**Lifecycle Cost**	**Culvert Options**	**Fish Passage**	**Total Score**
Top Hinged Flap Gate	1	3	1	1	1	3	10
Side Hinged Flap Gate with Muted Tidal Regulator	2	1	2	2	1	1	9
Tideflex Valve	1	3	1	1	3	3	12
Sluice Gate	2	2	1	1	1	1	8
Obermeyer Gate	3	1	3	3	3	1	14
Radial Gate	2	1	2	2	3	1	11

The sluice gate was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report.

STORMWATER CONVEYANCE

Two stormwater conveyance options for runoff from White River Estates were evaluated. The first would route stormwater from White River Estates to the proposed Canal pump station and then pump to the Canal using a "low flow" jockey pump. The second option would install a packaged lift station downstream of catch basin 27 and pump stormwater from White River Estates directly to the White River. The criteria used to assess and compare the relative feasibility of each flow control gate type included:

- **Length:** This criterion evaluates the length of new stormwater conveyance piping associated with each option. Options that would require 300 feet or less of new stormwater conveyance piping were given a rating of 1. Options that would require between 300 and 600 feet of new stormwater conveyance piping were given a rating of 2. Options that would require more than 600 feet of new stormwater conveyance piping were given a rating of 3.

- **Operation and Maintenance:** This criterion evaluates the ease of operating and maintaining the facilities associated with each stormwater conveyance option. Options that would require minimal maintenance from staff were given a rating of 1. Options that would require routine maintenance for additional mechanical equipment and structures at one location were given a rating of 2. Options that would require routine maintenance for additional mechanical equipment and structures at multiple locations as well as maintenance of an outfall in the White River were given a rating of 3.

- **Capital cost:** This criterion evaluates the anticipated capital costs associated with each stormwater conveyance option. Options that are estimated to cost less than $2 million were given a rating of 1. Options that are estimated to cost between $2 million and $3 million were given a rating of 2. Options that are estimated to cost more than $3 million were given a rating of 3.

- **Real estate constraints:** This criterion evaluates existing space constraints associated with each stormwater conveyance option. Options with no space constraints that would not potentially impact the location of the levee were given a rating of 1. Options with space constraints that would potentially impact the location of the levee were given a rating of 2. Options with space constraints that would require the relocation of the levee were given a rating of 3.

The overall results of the stormwater conveyance scoring matrix are shown below in Table 7.

Table 7. Stormwater Conveyance Scoring Matrix Results

Option	Length	Maintenance	Capital Cost	Real Estate Constraints	Total Score
Wetwell discharge	3	2	3	1	9
White River discharge	1	3	2	2	8

The White River discharge was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report.

STORMWATER TREATMENT

Four stormwater treatment options for runoff from White River Estates were evaluated. The criteria used to assess and compare the relative feasibility of each stormwater treatment option included:

- **Treatment performance:** This criterion evaluates how effective the option is at treating stormwater. Options that are consistent in providing high-quality treatment were given a rating of 1. Options that provide good treatment if adequately maintained were given a rating of 2. Options that provide highly variable treatment from storm to storm were given a rating of 3.

- **Flexibility:** This criterion evaluates the ability to expand the treatment option in the future for additional flows if needed. Options that are easy to expand in the future are given a rating of 1. Options where future expansion is possible but would require some work and may temporarily disrupt the stormwater system were given a rating of 2. Options where future expansion would be very difficult if not impossible were given a rating of 3.

- **Footprint:** This criterion evaluates the footprint associated with each stormwater treatment option. Options with footprints that would impact less than 1,000 ft^2 were given a rating of 1. Options with footprints that would impact between 1,000 and 2,000 ft^2 were given a rating of 2. Option with footprints that would impact more than 2,000 ft^2 were given a rating of 3.

- **Maintenance:** This criterion evaluates the level of routine maintenance that is anticipated for each option. Options with no mechanical components and that are assumed to need minimal routine maintenance were given a rating of 1. Options that would require mechanical components but do not use proprietary technology were given a rating of 2. Options with mechanical components and proprietary technology are assumed to require routine maintenance on a regular basis and were given a rating of 3.

- **Capital cost:** This criterion evaluates the estimated capital cost of building each stormwater treatment option. Estimated capital costs were based on a combination of historical data and vendor quotes. Options that were estimated to cost less $2 million were given a rating of 1. Options that were estimated to cost between $2 million and $3 million were given a rating of 2. Options that were estimated to cost more than $3 million were given a rating of 3.

- **Life-cycle costs:** This criterion evaluates the life-cycle costs associated with maintaining and replacing each stormwater treatment option. Options with life-cycle costs that were estimated to be less $2 million were given a rating of 1. Options with life-cycle costs that were estimated to be between $2 million and $3 million were given a rating of 2. Options with life-cycle costs that were estimated to be more than $3 million were given a rating of 3.

The overall results of the stormwater conveyance scoring matrix are shown below in Table 8.

Table 8. Stormwater Treatment Scoring Matrix Results

Option	Treatment Performance	Flexibility	Footprint	O&M	Capital Cost	Life-cycle Cost	Total Score
Biofiltration swale	3	3	2	2	1	2	13
Wet pond	1	3	3	1	3	3	14
Wet vault	2	3	3	3	3	3	17
StormFilter	2	2	1	3	1	2	11

The StormFilter was found to be the preferred option based on the criteria evaluated. Additional information regarding the pros and cons associated with each option is provided in Appendix B of this report.

PUMP STATION ALTERNATIVES

Five pump station alternatives were developed based on the results of the scoring matrixes for the different pump station components. The alternatives were developed based on considerations such as score, cost, maintenance requirements, and location. Table 9 summarizes the different components associated with each pump station alternative. It should be noted that the number of alternatives required to comprehensively evaluate the number of possible configuration combinations is prohibitive. These alternatives should be interpreted in a manner that allows various design features to be mixed and matched between alternatives for the final configuration.

Table 9. Summary of Pump Station Alternatives

Alt	Location	Fish Screen	Intake Structure	Pump Type	Culvert/ Flow Control Gate	Stormwater Conveyance	Stormwater Treatment
1	No action						
2	North bank	T-screen	Rectangular wet pit	Vertical submersible axial flow	Side-hinged gate	White River discharge	StormFilter
3	North bank	Cone screen	Open-bottom can	Vertical submersible axial flow	Sluice gate	White River discharge	StormFilter
4	North bank	T-screen	Rectangular wet pit	Submersible solids handling	Top hinged flap gate	Wetwell discharge	StormFilter
5	South bank	Cone screen	Standard trench	Vertical axial flowline shaft	Sluice gate	White River discharge	StormFilter

The following sections describe each alternative, explain their proposed operational procedures, and summarize the Association for the Advancement of Cost Engineering (AACE) Class 5 cost estimates that were prepared.

ALTERNATIVE DESCRIPTIONS

The following sections provide detailed descriptions of each pump station alternative. Figures that provide process flow schematics, site plans, and layouts for each pump station alternative are provided in Appendix C of this report.

Alternative 1

Alternative 1 assumes that no action is taken and that the existing Canal pumping and White River Estates stormwater systems currently in place are maintained. The existing pumping system consists of a single Godwin Dri-Prime solids-handling pump capable of pumping approximately 10,000 gpm. During a storm event City of Pacific personnel use plywood panels to isolate the Canal from the White River and then pump water from the Canal to a discharge point near the confluence with the White River. The existing stormwater system consists of conveyance pipes that route stormwater runoff to a stormwater pond that has an outfall to the White River.

Alternative 2

Alternative 2 includes a selection of some of the best scoring components from the scoring matrix. Fixed T-screens with either brush or airburst cleaning systems would be installed in the Canal upstream of the culvert and flow control gates. Twenty-four-inch-diameter pipes would route stormwater from the screens to a below-grade rectangular wetwell, which would have a footprint that is approximately 26 feet wide and 31 feet long. These dimensions are based on the requirements given in Appendix E of Hydraulic Institute (HI) Standard 9.8. The wetwell would have space for three vertical submersible axial flow pumps (two duty and one standby) and each pump would have a capacity of 19,300 gpm. Each vertical submersible axial flow pump would use separate 30-inch diameter discharge pipes that would be routed over the top of the levee. Combination air valves would be installed at the high point of each pipe on top of the levee to allow air to be exhausted when the pumps turn on and admitted when the pumps turn off. On the other side of the levee the individual discharge pipes would then connect with a 48-inch diameter pipe that discharges into the Canal downstream of the levee. Using separate discharge pipes for each pump eliminates the need for check and isolation valves on the pump discharge pipelines. This lowers capital and maintenance costs by reducing the size of the building footprint and reducing the number of valves in the pump station. It also creates the opportunity for siphonic recovery which could reduce energy consumption.

A pump building would sit on top of the wetwell and would include a pump room, electrical room, and generator room. The pump building's footprint would be approximately 31 feet wide and 60 feet long. These dimensions are based on the following factors:

- The pump station would need a 750 kW backup electrical generator located inside the building to secure it from potential vandalism and minimize noise impacts in the neighborhood.
- The generator room would also have space for instrument panels for the generator, and an air compressor.
- The electrical room would hold equipment such as Motor Control Centers (MCCs), an Automatic Transfer Switch (ATS), a service entrance disconnect, a Main Control Panel (MCP), an Uninterruptible Power Supply (UPS), a dry type transformer, panelboards, and Variable Frequency Drives (VFDs) for the three pumps.
- The pump room would need to provide sufficient space for maintenance access to the pumps and below grade wetwell.

- The pump room would provide space for the installation of a future pump should the capacity of the pump station need to increase.

Stormwater flow from White River Estates would be intercepted in a flow splitter manhole near existing catch basin 27. A StormFilter vault would be used to provide basic treatment. A small packaged lift station would then be used to discharge stormwater from White River Estates directly into the White River.

Alternative 3

Alternative 3 includes a selection of some of the lower-cost components from the scoring matrix. Cone screens with either brush or airburst cleaning systems would be installed in the Canal upstream of the culvert and flow control gates. Thirty-six-inch-diameter pipes would route stormwater from the screens to a 54-inch-diameter suction header located underneath the pump building. The 54-inch-diameter suction header would have a length of approximately 45 feet and would serve as an open-bottom can intake for three vertical submersible axial flow pumps (two duty and one standby). The size of the 54-inch-diameter suction header is based on the requirements given in Section 9.8.3.6.4 of HI Standard 9.8. Each pump would have a capacity of 19,300 gpm. Similar to Alternative 2, each vertical submersible axial flow pump would use separate 30-inch diameter discharge pipes that would be routed over the top of the levee. Combination air valves would be installed at the high point of each pipe on top of the levee to allow air to be exhausted when the pumps turn on and admitted when the pumps turn off. On the other side of the levee the individual discharge pipes would connect with a 48-inch diameter pipe that discharges into the Canal downstream of the levee.

A pump building would sit on top of the 54-inch-diameter suction header and would include a pump room, electrical room, and generator room. The pump building's footprint would be approximately 35 feet wide and 54 feet long. These dimensions are based on the following factors:

- The pump station would need a 750 kW backup electrical generator located inside the building to secure it from potential vandalism and minimize noise impacts in the neighborhood.
- The generator room would also have space for instrument panels for the generator, and an air compressor.
- The electrical room would hold equipment such as Motor Control Centers (MCCs), an Automatic Transfer Switch (ATS), a service entrance disconnect, a Main Control Panel (MCP), an Uninterruptible Power Supply (UPS), a dry type transformer, panelboards, and Variable Frequency Drives (VFDs) for the three pumps.
- The pump room would need to provide sufficient space for maintenance access to the pumps.

- The pump room would provide space for the installation of a future pump should the capacity of the pump station need to increase.

Stormwater flow from White River Estates would be intercepted in a flow splitter manhole near existing catch basin 27. A StormFilter vault would be used to provide basic treatment. A small packaged lift station would then be used to discharge stormwater from White River Estates directly into the White River.

Alternative 4

Alternative 4 includes a selection of some of the components from the scoring matrix that would have minimal maintenance requirements. Fixed T-screens with either brush or airburst cleaning systems would be installed in the Canal upstream of the culvert and flow control gates. Twenty-four-inch-diameter pipes would route stormwater from the screens to a below-grade rectangular wetwell, which would have a footprint that is approximately 30 feet wide and 36 feet long. These dimensions are based on the requirements given in Appendix E of HI Standard 9.8. The wetwell would have space for four submersible solids-handling pumps (three duty and one standby) and each pump would have a capacity of 12,867 gpm.

The pump station would also include a small wetwell dedicated to stormwater runoff from White River Estates that would be approximately 8 feet wide and 16 feet long. These dimensions are based on the requirements given in Appendix E of HI Standard 9.8. The small wetwell would have space for two submersible solids-handling pumps (one duty and one standby) and each pump would have a capacity of 1,800 gpm. Stormwater flows from White River Estates would be intercepted at existing catch basin 27 and routed to the Canal pump station site. A flow splitter manhole would be used to divert flows to a StormFilter vault, which would provide basic stormwater treatment. Stormwater from White River Estates would then flow by gravity into the smaller wetwell.

Similar to Alternatives 2 and 3, each submersible solids-handling pump would use separate 24-inch and 12-inch diameter discharge pipes that would be routed over the top of the levee. Combination air valves would be installed at the high point of each pipe on top of the levee to allow air to be exhausted when the pumps turn on and admitted when the pumps turn off. On the other side of the levee the individual discharge pipes would connect with a 48-inch diameter pipe that discharges into the Canal downstream of the levee.

A pump building would sit on top of the below grade wetwells and would include a pump room, electrical room, and generator room. The pump building's footprint would be approximately 35 feet wide and 54 feet long. These dimensions are based on the following factors:

- The pump station would need a 750 kW backup electrical generator located inside the building to secure it from potential vandalism and minimize noise impacts in the neighborhood.

- The generator room would also have space for instrument panels for the generator, and an air compressor.
- The electrical room would hold equipment such as Motor Control Centers (MCCs), an Automatic Transfer Switch (ATS), a service entrance disconnect, a Main Control Panel (MCP), an Uninterruptible Power Supply (UPS), a dry type transformer, panelboards, and Variable Frequency Drives (VFDs) for the five pumps.
- The pump room would need to provide sufficient space for maintenance access to the pumps and below grade wetwells.
- The pump room would provide space for the installation of a future pump should the capacity of the pump station need to increase.

The 12- and 48-inch-diameter discharge pipes from the pump station would be routed so that stormwater is discharged into the Canal downstream of the flow control gates near the confluence of the White River.

Alternative 5

Alternative 5 focuses on installing the pump station on the Canal's south bank. The parcel where the pump station would be built is owned by the City of Pacific. Cone screens with either brush or airburst cleaning systems would be installed in the Canal upstream of the culvert and flow control gates. Thirty-six-inch-diameter pipes would route stormwater from the screens to a 54-inch-diameter pipe that discharges into a standard trench wetwell, which would have a footprint that is approximately 12 feet wide and 26 feet long. These dimensions are based on the requirements given in Section 9.8.3.4.1 of HI Standard 9.8. The wetwell would have space for three engine driven vertical axial flow-line shaft pumps (two duty and one standby) and each pump would have a capacity of 19,300 gpm. The vertical axial flowline shaft pumps would pump stormwater from the wetwell into a 48-inch-diameter discharge header located in an above-grade pump building. The pump building would have a pump room, electrical room, and generator room. The pump building's footprint would be approximately 37 feet wide and 66 feet long. These dimensions are based on the following factors:

- The pump station would need a 100 kW backup electrical generator located inside the building to secure it from potential vandalism and minimize noise impacts in the neighborhood.
- The generator room would also have space for instrument panels for the generator, and an air compressor.
- The electrical room would hold equipment such as an MCC, an ATS, a service entrance disconnect, an MCP, an UPS, a dry type transformer, and panelboards.

- The pump room would need to provide sufficient space for maintenance access to the pumps, engines, check and isolation valves, and access to the below grade trench.
- The pump room would provide space for the installation of a future pump should the capacity of the pump station need to increase.

The 48-inch-diameter discharge pipe from the pump station would be routed so that stormwater is discharged back into the Canal downstream of the flow control gates near the confluence of the White River.

Stormwater flow from White River Estates would be intercepted in a flow splitter manhole near existing catch basin 27. A StormFilter vault would be used to provide basic treatment. A small packaged lift station would then be used to discharge stormwater from White River Estates directly into the White River.

Operational Procedures

Operational procedures for the various pump station alternatives are provided below.

Alternative 1 Operational Procedures

During a large storm event personnel from the City of Pacific must drive out to the existing pumping system to install the plywood panels in the Canal and turn on the pump. The pump then runs until City of Pacific personnel remove the plywood panels and turn it off. Currently there is only one pump with no backup and the pump is undersized and not capable of handling the full flow in the Canal.

The White River Estates pond no longer operates as designed because of siltation in the White River’s floodway, which has caused the pond’s outfall to become clogged. Stormwater from the pond now overflows south to property owned by Pierce County, where it then flows into a wetland before ultimately entering the White River.

Alternatives 2 and 4 Operational Procedures

For Alternatives 2 and 4, the water surface elevation of the Canal would be controlled with either a side-hinged gate or a top hinged flap gate on the culvert and a weir at the entrance of the pump station’s wetwell. During a large storm event water levels in the White River would rise. Water would start backing up into the Canal once water levels at the confluence of the Canal and White River reach an elevation of 74 feet. This would trigger the gates on the culvert to close and water in the Canal would then start flowing over the top of the weir into the pump station’s wet well. Figure 2 depicts the relationship between the fish screen and the weir.

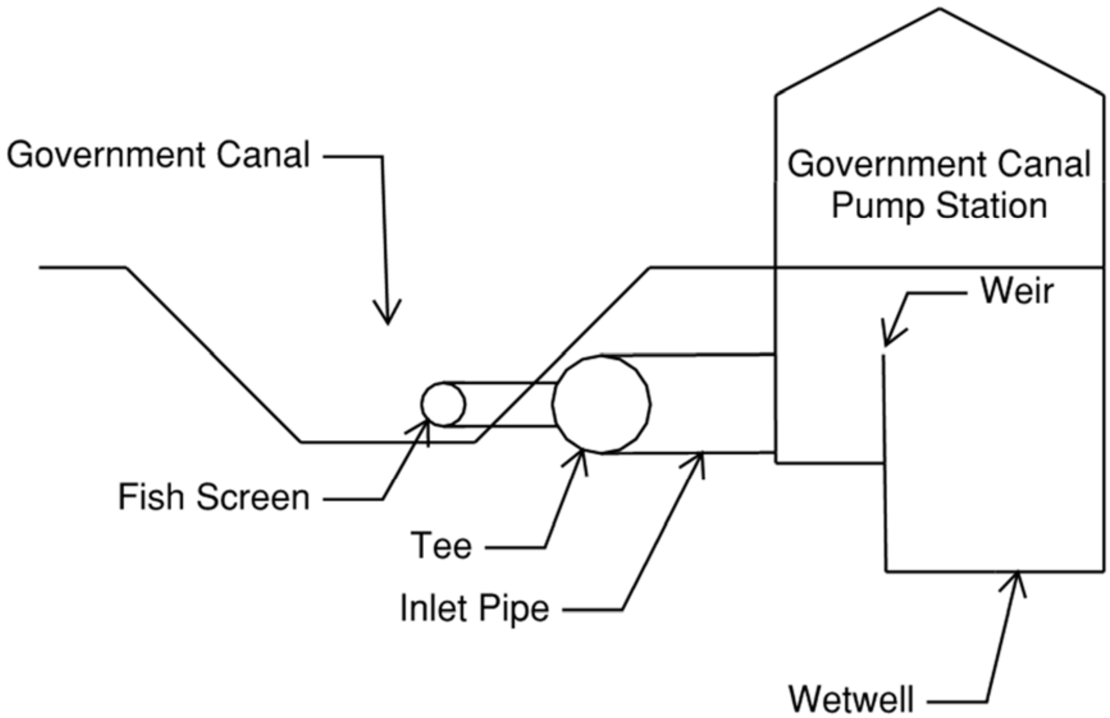

Figure 2. Fish Screen and Weir

The purpose of the weir is to prevent water in the Canal from entering the wetwell except during storm events. It will also keep the water surface elevation in the canal below the maximum elevation of 74.6 feet without requiring the pumps to ramp up and down in an effort to chase a water surface elevation in the Canal. Dimensions and elevations for Alternatives 2 and 4 are provided below in Table 10.

Table 10. Weir Summary for Alternatives 2 and 4

Alt	Length (ft)	Top of Weir Elevation (ft)	Flow (gpm)	Max Weir WSE (ft)
2	32	73.50	38,600	74.37
4	34.5	73.50	38,600	74.33

The water surface elevation in the wetwell would be monitored with an ultrasonic level sensor, which would be used to control pump operation. Backup level float switches would be installed to provide secondary pump start and/or stop and alarm indication. Wetwell level monitoring and float indication data would be communicated with the supervisory control and data acquisition (SCADA) system via on-site programmable logic controller (PLC). The ultrasonic level sensor and transmitter would communicate water levels to the PLC which would be programmed to operate the pumps at the following set points:

- Wetwell operating depth

- Wetwell low-water pump shutoff
- Pump 1 start
- Pump 2 start
- Standby pump start

Depending on the instrumentation installed, a separate alarm indication set point can be defined in the transmitter for additional system communication. A set of backup level floats would be installed to provide an analog indication of specific wetwell conditions. It is anticipated that the following set points would be provided:

- Wetwell low-water alarm and pump stop
- Wetwell high-high-water alarm

Operation of the pumps would be controlled via wetwell level indication and variable-frequency drives (VFDs). The system would modulate pump flow to maintain the level in the wetwell between the established low water level (LWL) and high water level (HWL) set points. As the water level in the canal increases the side hinged gates on the culvert will close and water from the canal will start to flow over the weir and fill the wetwell. When the water surface elevation in the wetwell reaches 74 feet then a pump run indication will be initiated at the pump station. At pump start initiation, Pumps 1 and 2 will be called to run at full speed to begin draw down of the wetwell. If the water level in the wetwell continuous to rise then the standby pump will be initiated.

As the water surface is drawn down and the weir is permitted to freely discharge then pump operating speeds would be modulated to maintain a water surface elevation of 73.0 feet in the wetwell. The number of pumps in operation would be adjusted to maintain this wet well water surface elevation. If a single pump is operating at full speed and the wet well water surface begins to rise, a second pump would be initiated and ramp up to match the speed of the operating pump. As the wet well water surface decreases, the pump speeds would be reduced until a point where the second pump can be shut down and a single pump speed would be modulated to maintain wet well water surface.

In the event that both pumps are not able to maintain a non-rising wet well water surface then the standby pump will initiate operation. Typically this pump would be started at full speed to attempt to recover wet well level. As the canal water surface reduces to the point at which the canal discharge gates are opened then the pump station will initiate a shutdown process in which the wet well will be drawn down to a point that the pumps can be shut down.

Alternatives 3 and 5 Operational Procedures

For Alternatives 3 and 5, the water surface elevation of the Canal would be controlled using motor-operated sluice gates and either vertical submersible axial flow pumps or vertical axial flow line-shaft pumps. During a large storm event water levels in the White River would rise. Water would start backing up into the Canal once water levels at the confluence of the Canal and White River reach an elevation of 74 feet. This would trigger the motor-operated sluice gates on the culvert to close and water levels in the Canal upstream of the gates to rise.

The water surface elevation in the Canal upstream of the gates would be monitored with an ultrasonic level sensor, which would be used to control pump operation. Backup level float switches would also be installed to provide secondary pump start and/or stop and alarm indication. Level monitoring and float indication data would be communicated with the SCADA system via on-site PLC. The ultrasonic level sensor and transmitter would communicate water levels to the PLC which would be programmed to operate the pumps at the following set points:

- Canal operating depth
- Canal low-water pump shutoff
- Pump 1 start
- Pump 2 start
- Standby pump start

Depending on the instrumentation installed, a separate alarm indication set point can be defined in the transmitter for additional system communication. A set of backup level floats would be installed to provide an analog indication of specific wetwell conditions. It is anticipated that the following set points would be provided:

- Canal low-water alarm and pump stop
- Canal high-high-water alarm

Operation of the pumps would be controlled via level indication and VFDs. The system would modulate pump flow to maintain the level in the Canal between the established LWL and HWL set points. When the Canal water surface reaches the defined Pump 1 start set point, Pump 1 would start at a defined operating speed. This speed is typically slower than pump full operating speed. As the water surface elevation increases, the pump operating speed would incrementally increase to maintain a non-rising water surface. If Pump 1 is operating at full speed and the Canal water surface continues to rise, the Pump 2 start set point would be triggered and Pump 2 would start and ramp up to match the speed of Pump 1. As the wetwell water surface decreases, the pump speeds would be reduced until a point where Pump 2 can be shut down and Pump 1 speed would be modulated to maintain the Canal water surface elevation. In the event that both pumps are not able to maintain a non-rising wetwell water surface, the standby pump start set point would initiate operation of the third pump. Typically this pump would be started at full speed to attempt to recover wetwell level.

For Alternative 3 it is recommended that the Pump 1 start elevation be set at 74.0 feet, Pump 2 start elevation be set at 74.4 feet, and the high-high water elevation be set at be set at EL 74.55 feet.

White River Estates Operational Procedures

For Alternatives 2, 3 and 5 a small packaged lift station will be used to deal with stormwater runoff from White River Estates. Operation of the packaged lift station would be controlled via level sensors and an onsite PLC. A level sensor and transmitter would be programmed to communicate the following data:

- Wetwell depth
- Wetwell low-water pump shutoff
- Pump 1 start
- Standby pump start

Depending on the instrumentation installed, a separate alarm indication set point can be defined in the transmitter for additional system communication. A set of backup level floats would be installed to provide an analog indication of specific wetwell conditions. It is anticipated that the following set points would be provided:

- Wetwell low-water alarm and pump stop
- Wetwell high-high-water alarm

Pump 1 in the packaged lift station would turn on when stormwater flows from the White River Estates filled the wetwell to the Pump 1 start level. Pump 1 would start at full speed and draw the water level in the wet well down to the low water level at which point the pump would shut off. If the water level in the wetwell continued to rise then the standby pump would turn on at full speed.

For alternative 4 a small wetwell for stormwater runoff from White River Estates will be located adjacent to the larger wetwell for flows from the Canal. The submersible pumps in the smaller wetwell will operate similar to what is described above for alternatives 2, 3, and 5.

Economic Analysis

An economic analysis was prepared to evaluate and compare construction and life-cycle costs for the alternatives described above.

Construction Cost Estimates

Conceptual level construction cost estimates were developed for each alternative. The following parameters apply to each estimate:

- All prices are presented in 2020 dollars.
- Each estimate is American Association of Cost Engineers (AACE) Class 5.
- Costs were developed using RS Means, vendor quotes, historic HDR cost data, and Engineering News Record (ENR) Construction Cost Indexes (CCI).

    The following assumptions apply to each construction cost estimate:

- Construction Costs
    - Sitework covers items such as dust control, construction survey staking, temporary fencing, clearing and grubbing, finish grading, erosion control, traffic control, and landscaping.
    - Fish screens covers the material, labor, and equipment costs associated with installing the fish screens. The material costs are based on vendor quotes. Labor and equipment costs were assumed to be 29% and 21% of the material costs, respectively.
    - Intake structure covers the excavation, hauling, shoring, dewatering, backfilling, and concrete costs associated with building the intake structure.
    - Pump building covers items such as structural materials, HVAC, plumbing, electrical and instrumentation associated with building the pump building.
    - Pumps covers the material, labor, and equipment costs associated with installing the pumps. The material costs are based on vendor quotes. Labor and equipment costs were assumed to be 29% and 21% of the material costs, respectively.
    - Culvert and flow control gate covers the pre-cast concrete culvert and flow control gates. RS Means was used to develop a cost for the culvert. Vendor quotes were used to develop material, labor, and equipment costs associated with installing the flow control gates. Labor and equipment costs associated with the flow control gates were assumed to be 29% and 21% of the material costs, respectively.
    - Yard piping covers items such as pipe material, trench excavation, hauling, trench safety, dewatering, and trench backfill.
- Direct Construction Cost Markups

- General Conditions are 10% of the construction costs and this covers items such as project management supervision, per diem, field offices, etc…
- Mobilization/Demobilization are 10% of the construction costs and covers getting equipment to and from the project site.
- Contractor overhead and profit is 8% of the construction costs.
- Insurance is 1.5% of the construction cost.
- Bonding is 1% of the construction cost.

- Indirect Costs
  - A contingency of 30% was applied to the subtotal of direct construction costs.
  - A sales tax of 10% was applied to the subtotal of direct construction costs.

  The following assumptions apply to alternatives 2, 3, and 5.

- Construction Costs
  - White River Estates stormwater covers items such as manholes, storm filter vault, packaged lift station, stormwater piping, excavation and backfill associated with installing a separate stormwater lift station.

A summary of each alternatives construction cost estimate is presented in Table 11 below. Detailed estimates for each alternative can be found in Appendix D.

Table 11. Construction Cost Summary

Alternative	Total Cost
1	NA
2	$15,102,000
3	$14,227,000
4	$21,065,000
5	$17,373,000

Lifecycle Cost Estimates

Conceptual level lifecycle cost estimates were developed to highlight the difference in cost of ownership of different alternatives. This analysis focused specifically on the initial construction cost, energy and fuel costs, operations costs, and equipment replacement costs. The following assumptions apply to each lifecycle cost estimate:

- The lifecycle period is for this analysis is 50 years.

- Cost inputs for construction are based on the estimates that were developed in Section 4.3.1.
- Costs are assumed to escalate at a rate of 3 percent per year.
- An interest rate of 6 percent was used to account for the value of future sums of money in current year dollars.
- The pump station will run when the gates are closed, which based on WSE's analysis will be approximately 468 hours between October 1 and April 30.
- The pump station will not run outside of the October 1 through April 30th window.
- Energy rates are based on average industrial electricity rates for Seattle.
- Labor costs are based on hourly prevailing wage rates for electricians in King County.
- Replacement costs for equipment will include pumps, fish screens, and gates.
- One pump, fish screen, gate and the generator will be replaced per year starting 25 years after installation until all of the pumps, fish screens and gates have been replaced.
- The intake structure, building, and culvert will be designed for a 50-year life and are not included in the replacement costs.

The following assumptions apply to alternatives 2 and 3:

- When the pump station is running it will have a demand load of approximately 400 kVA. This is based on two 150 hp pumps running and loads from HVAC and electrical equipment.
- When the packaged lift station is running it will have a demand load of approximately 50 kVA. This is based on one 35 hp pump running and loads from electrical equipment.
- The packaged lift station will operate more frequently than the Government Canal Pump Station.

The following assumptions apply to alternative 4:

- When the pump station is running it will have a demand load of approximately 600 kVA. This is based on three 140 hp pumps running, one 35 hp pump running and loads from HVAC and electrical equipment.
- The 35 hp pumps will operate more frequently than the larger 140 hp pumps.

The following assumptions apply to alternative 5:

- When the pump station is running it will have a demand load of approximately 100 kVA. This is based on loads from HVAC and electrical equipment.
- The engine driven pumps will run on diesel and have a thermal efficiency of 30%.
- Cost of diesel fuel is $2.65 per gallon.
- When the packaged lift station is running it will have a demand load of approximately 50 kVA. This is based on one 35 hp pump running and loads from electrical equipment.
- The packaged lift station will more frequently than the Government Canal Pump Station.

A summary of each alternatives lifecycle cost estimate is presented in Table 12 below. Detailed estimates for each alternative can be found in Appendix D.

Table 12. Summary of Lifecycle Costs

Parameter	Alternative 1	Alternative 2	Alternative 3	Alternative 4	Alternative 5
Construction Cost	NA	$15,102,000	$14,227,000	$21,065,000	$17,373,000
Energy Cost		$453,900	$453,900	$567,300	$227,000
Fuel Cost		NA	NA	NA	$1,233,600
Operations Cost		$469,400	$469,400	$352,100	$704,100
Replacement Cost		$2,549,300	$2,705,500	$2,730,100	$3,072,000
50 Year Lifecycle Cost (Present Worth)		$18,574,600	$17,855,800	$24,714,500	$22,609,700

References

Herrera, 2019. Potential Project Concepts Analysis to Inform Development of EIS Alternatives for the White River Pacific Bank Flood Protection Project Technical Memorandum. Prepared by Herrera Environmental Consultants, Inc., for King County Department of Natural Resources and Parks, Water and Land Resources Division. Seattle, Washington.

APPENDIX A

Government Canal Hydrologic and Hydraulic Modeling Memorandum

Memorandum

To: Mary Strazer, King County Water and Land Resources Division

From: Larry Karpack, PE, Chris Meder, EIT

Date: December 21, 2020

Re: Hydraulic Analysis of Proposed Government Canal Pump Station

INTRODUCTION

This memorandum summarizes results from hydrologic and hydraulic modeling completed by Watershed Science and Engineering (WSE) to investigate the required capacity of a proposed pump station and flood control structure designed to mitigate surface water flooding of properties along Government Canal (Canal). The proposed pump station alternatives will be included in the Environmental Impact Statement (EIS) for the King County (the County) Department of Natural Resources and Parks, Water and Land Resources Division (WLRD) Pacific Right Bank Project. Government Canal is located in the City of Pacific (City) and drains to the White River approximately 1 mile downstream of A Street. This memo documents data sources, model development, key assumptions, analysis, and results related to the following tasks:

1) Development and application of a Hydrologic Simulation Program – Fortran (HSPF) hydrologic model to simulate local runoff for existing conditions in the Canal drainage basin.
2) Development and application of a HEC-RAS 1D model to simulate hydraulic conditions in the Canal with the proposed pump station and flood control structure.
3) Analysis of model results to determine required pump capacity, water surface elevation and freeboard in the Canal during a 100-year flood event.
4) Estimation of gate closure frequency and duration under existing and proposed conditions to evaluate fish passage impacts.
5) Evaluation of the potential effects of climate change on hydrologic conditions and required pump capacity

HYDROLOGIC MODELING AND ANALYSIS

HYDROLOGIC MODEL DEVELOPMENT

The Hydrologic Simulation Program – Fortran (HSPF) was used for this study. HSPF is a continuous simulation hydrologic model that uses long-term precipitation and evaporation time series to simulate runoff based on user input sub-basin, land use, and soils information. The modeling for this study considered all area draining to the Canal. The area was subdivided into 14 sub-basins based on information shown on drainage maps available from the City of Pacific and the City of Auburn. Figure 1 presents the modeled sub-basin delineation. Figure 1 includes three sub-basins (15, 16 and 17) which drain to the White River and were included in the HSPF model but not routed to Government Canal.

Soils
Soils data for the study area were obtained from the Natural Resources Conservation Service (NRCS) Soil Survey Geographic Database (SSURGO). SSURGO soil maps indicate that the predominant soil groups in the study area are Renton, Oridia, Briscot, Seattle Muck, and Shalcar Muck, which are all SCS Hydrologic Soil Group D. The King County Surface Water Design Manual generally recommends classifying these soils as "till" for hydrologic modeling (King County, 2016). The City of Auburn Comprehensive Storm Drainage Plan indicates that the predominant soil type in the modeled area is alluvium (Brown and Caldwell, 2015). WSE's previous modeling experience in the White and Green River valleys suggests that the valley soils act differently from typical till soils, and as such are better modeled as alluvium (i.e., Custer-Norma). For purposes of the current modeling soils were therefore classified into two categories: Custer-Norma (alluvium), and saturated (wetland) for use in HSPF. The distribution of these soils used in the HSPF model is shown in Figure 1. All soil classifications used in this study were assigned a "moderate" slope.

Land Use
The hydrologic modeling considered existing land use in the basin. Future land use conditions were not modeled, as there is little area available for future development in the basin with the exception of a few small grassland areas. Thus, future changes to land use would be limited, and considering current stormwater management regulations future flood flow increases, if any, would be minimal. The modeled area includes a large industrial area in the north, residential areas in the south, and undeveloped wetlands in the west-central portion of the basin. Land use was delineated using 2019 aerial imagery from King County (King County, 2019). The percentage effective impervious area for each land use classification was estimated based on WSE's past hydrologic modeling experience (Snohomish County, 2002), engineering judgement, and field reconnaissance of existing development in Pacific. Effective impervious area (EIA) percentages used in this study range from 3% EIA for low density residential areas to 85.5% EIA for commercial/industrial/road areas. The soil type and land use distributions (shown in Figure 1) were overlain in GIS to determine the area of each combination within each sub-basin as required for input to HSPF. These are summarized in Table 1.

Precipitation and Evaporation
Precipitation input to HSPF was developed using a King County precipitation gage at the Lakeland Hills Pump Station (LHPS, 10/1/2000 to 5/1/2020), near the project site. The Lakeland Hills Pump Station gage record was extended back in time using the long-term precipitation record at SeaTac (beginning 10/1/1948). Mean annual precipitation at the Lakeland Hills Pump Station gage was compared to the SeaTac gage during the period of overlap to develop a scale factor of 1.06 to be applied to the SeaTac record for the period 10/1/1948 to 9/30/2000.

Evaporation data from the Natural Resources Conservation Service's Puyallup 2 W Experimental Station was used in this study. These data were available from the Western Washington Hydrology Model (WWHM) for the period 10/1/1948 to 10/1/2012. This evaporation record was extended through 5/1/2020 using the monthly averages of the observed data from 1997 to 2012 (the period for which continuous recording of evaporation data was conducted).

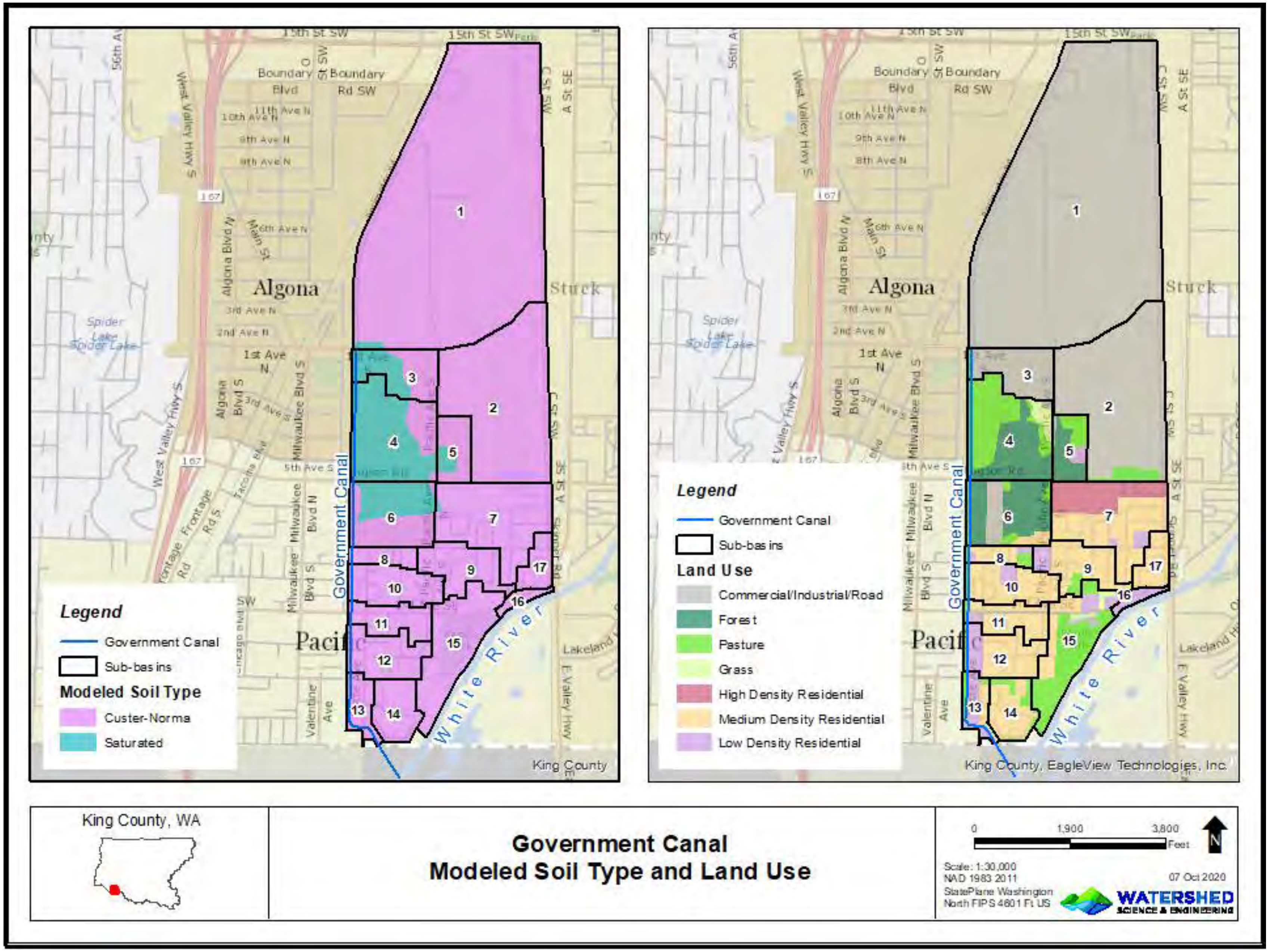

Figure 1 – Modeled soil type and land use

Table 1. Soil type and land cover by sub-basin

Soil Type and Land Cover									
Sub-basin	Custer-Norma (acres)			Saturated (acres)			Impervious (acres)	Total Area (acres)	Percent Impervious
	Forest	Pasture	Lawn	Forest	Pasture	Lawn			
1	0.00	0.00	59.91	0.00	0.00	0.36	355.41	415.68	85.5%
2	0.00	5.52	18.98	0.00	0.00	0.00	111.91	136.41	82.0%
3	0.00	0.00	2.35	0.00	1.19	2.23	27.01	32.78	82.4%
4	3.91	3.08	5.00	26.10	30.83	0.23	2.07	71.22	2.9%
5	6.67	7.90	0.70	3.33	0.53	0.17	1.73	21.01	8.2%
6	14.41	3.94	4.55	16.24	1.17	0.90	10.02	51.22	19.6%
7	0.02	2.38	56.52	0.01	0.00	0.39	13.16	72.48	18.2%
8	0.00	3.52	6.76	0.00	0.00	0.00	0.89	11.17	8.0%
9	0.00	5.72	23.20	0.00	0.00	0.00	2.61	31.53	8.3%
10	0.00	3.58	25.07	0.00	0.00	0.00	3.09	31.73	9.7%
11	0.00	1.75	17.28	0.00	0.00	0.00	3.67	22.70	16.2%
12	0.00	6.80	22.10	0.00	0.00	0.00	2.84	31.74	9.0%
13	0.00	8.83	5.55	0.00	0.00	0.00	1.05	15.43	6.8%
14	0.00	5.57	16.59	0.00	0.00	0.00	1.84	23.99	7.7%
15[1]	0.00	36.95	14.07	0.00	0.00	0.00	3.41	54.44	6.3%
16[1]	0.00	4.33	1.08	0.00	0.00	0.00	0.17	5.59	3.0%
17[1]	0.00	0.00	12.40	0.00	0.00	0.00	1.38	13.78	10.0%
Total [2]	25.00	58.58	264.55	45.67	33.73	4.27	537.30	969.10	55.4%

Notes:

1. Basins 15, 16 and 17 are included in the HSPF model, though these basins drain to the White River. Flows are not routed to Government Canal in the model and thus not included in the simulated runoff into the pump station.
2. Total areas do not include basins 15, 16 and 17. See Note 1.

Flow Routing

The configuration of the HSPF model showing the flow routing in the Government Canal basin is provided in Figure 2.

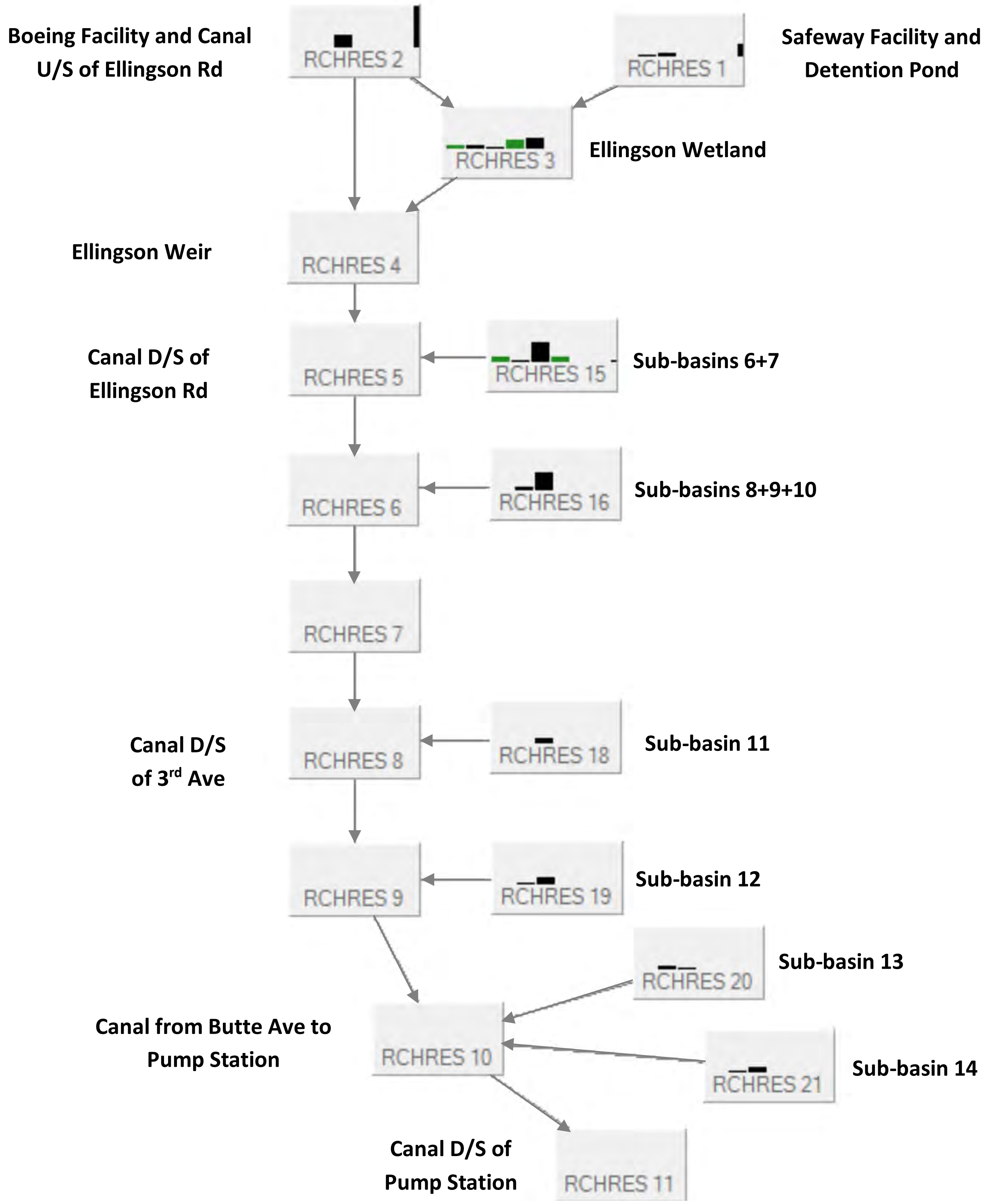

Figure 2 – Schematic of HSPF model

Model Configuration

Flow data measured at King County gage GovCan_1, at the V-notch weir located on Government Canal just upstream of Ellingson Road (active 10/31/2010 to 12/18/2019, with missing data from 1/2/2018 to 8/28/2018) were compared with simulated flow from HSPF at the gage location. Refinements were made to the model configuration as necessary, to match annual volumes, peak flows, and rising and falling limb characteristics in the observed data. Figure 3 presents simulated and observed flows at the Ellingson Road weir for the months of October and November 2017. This period includes the largest event in the observed record, 10/21/2017. This event is under-simulated by about 9.5%. Figure 4 presents simulated and observed flows at the Ellingson Road weir for February and March 2014. This period includes the largest event in the simulated record for which gage data is available (2/17/2014). The February event is over-simulated by about 16.5%.

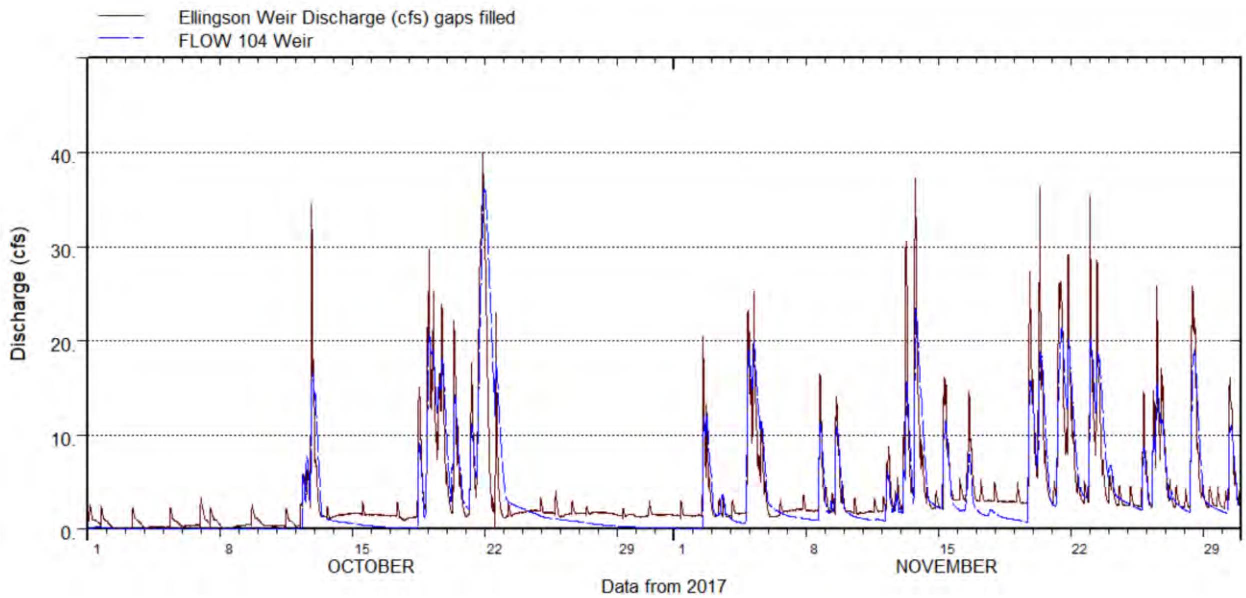

Figure 3 – Simulated (blue) and observed (brown) flow at the Ellingson Road weir for October - November 2017

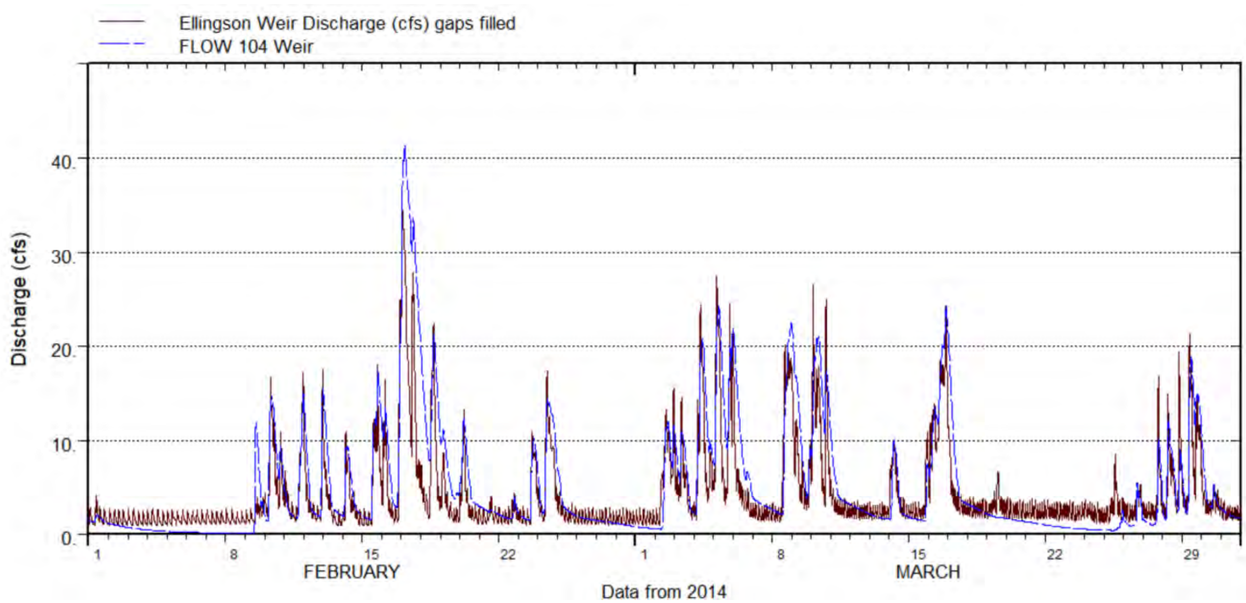

Figure 4 – Simulated (blue) and observed (brown) flow at the Ellingson Road weir for February - March 2014

HYDROLOGIC MODEL RESULTS

HSPF was run to produce a continuous simulation from 10/1/1948 to 5/1/2020 for existing conditions in sub-basins 1 through 14. The simulated flow data at the Ellingson Road weir and at the location of the proposed pump station in Government Canal were subject to flow frequency analysis, using a Log Pearson Type III distribution and the methods of USGS Bulletin 17B. Table 2 below reports the instantaneous peak flow quantiles from this analysis, in cubic feet per second (cfs).

Table 2: Flow frequency analysis results of the HSPF model simulation

Return Period (years)	Flow at Ellingson Road Weir (cfs)	Inflow to Proposed Pump Station (cfs)
2	36	52
10	49	74
25	55	85
100	65	101

Flows at the 1-hour, 3-hour, 6-hour, and 24-hour durations at the proposed pump station were similarly subject to frequency analysis and used to create inflow hydrographs for the hydraulic model. Review of the simulated flows showed that the storm events on 11/24/1990 and 1/8/2009 matched the flow frequency quantiles reasonably well across durations from 15-minutes to 24 hours. Simulated flow hydrographs from both of these “pattern storms” were therefore used to develop hydraulic model inflows. The pattern hydrographs were scaled by the ratio of the 100-year, 3-hour flow quantile to the 3-hour duration flow in the respective pattern event. Using this same multiplier, scaled inflow hydrographs were created for the Ellingson Road weir (routed flow for sub-basins 1 through 5) and for sub-basins 6 through 14 (unrouted, discharge to the Canal). These were then used as inputs to the hydraulic model.

HYDRAULIC MODELING AND ANALYSIS

HYDRAULIC MODEL DEVELOPMENT

A HEC-RAS one-dimensional (1D) hydraulic model was developed to simulate the hydraulics of Government Canal. Simulations were made for the 100-year flood using the two sets of scaled input hydrographs described above. Channel survey data, acquired for the project in May 2020, were integrated with LiDAR topographic data from 2016 and 2012 (south of 3rd Ave) to develop model cross sections. The hydraulic model domain extends from the Ellingson Road V-notch weir (upstream) to a cross section 400 feet upstream of the Canal outlet to the White River (300 feet downstream of the proposed pump station). The model was run in an unsteady configuration, routing the scaled hydrographs for each sub-basin (discussed in the Hydrologic Model Results section) into Government Canal at the Ellingson Road V-notch weir and appropriate locations adjacent to sub-basins 6 through 14, based on storm drainage network maps available from the City of Pacific’s online GIS.

The downstream boundary condition of the hydraulic model was a stage hydrograph at the Canal outlet to the White River. The stage hydrograph was developed using a combined flow record for the White River from USGS gages 12100496 and 12100490, and a flow versus stage rating from recent 2D hydraulic modeling of the White River, provided to WSE by Herrera Environmental Consultants (Herrera). This approach was used due to the lack of observed stage data for any location near the outlet of the Canal.

Hydraulic design criteria for the pump station were established by the project team, as follows:

- Prevent any flooding of properties along the Canal upstream of the proposed flood control structure. This requires the facility to maintain water surface elevations in the Canal downstream of Butte Ave at or below 74.6 feet NAVD88.
- For conservatism in the analysis, White River Estates stormwater runoff is assumed to discharge to the pump station and be included in pump capacity analysis. White River Estates is a residential neighborhood located just to the north of the proposed pump station.
- The Canal will be connected to the pump station wet-well via a control section weir that is sized large enough to minimize any upstream (Canal side) hydraulic effects.
- The flood control structure will include a gate closure system to prevent backflow from the White River when the downstream water level reaches 74.0 feet NAVD88 at the flood control structure.
- The first pump turns on when the Canal water surface elevation at the pump station is greater than 74 feet NAVD88 and subsequent pumps turn on sequentially with rising water level in the Canal upstream of the structure.

The proposed pump station and flood control structure in Government Canal were included in the model approximately 700 feet upstream of the Canal's outlet to the White River. The pump station simulation assumes four pumps, each with a capacity of 21.5 cfs. The modeled pumps were assumed to turn on sequentially (#1, #2, #3, #4) when Canal water surface elevations at the pump station reach 74.01, 74.2, 74.4 and 74.55 feet NAVD88, respectively. The pumps shut off sequentially in reverse order (#4, #3, #2, #1) when modeled Canal water surface elevations reach 74.03, 74.02, 74.01, and 74.0 feet NAVD88, respectively. The flood control structure was modeled in HEC-RAS as an inline structure with a box culvert fitted with a sluice gate. The inline structure spanned the Canal and had a top elevation of 80 feet NAVD88, and a top width of 20 feet. The sluice gates were set to close when the tailwater downstream of the box culvert rose above 74 feet NAVD88, and open when tailwater dropped below 74 feet NAVD88. The box culvert tailwater was assumed to be equal to the stage in the White River reflecting the anticipated flat water surface profile in the canal downstream of the structure.

HYDRAULIC MODEL RESULTS

The hydraulic model was run, modifying pump capacities and operating settings until the hydraulic design criteria discussed above were satisfied. The required pump capacity was determined to be 86 cfs. Together with the available flood storage, this pump capacity allows water surface elevations in the Canal to be maintained below 74.6 feet NAVD88 during the simulated 100-year storm runoff event in Government Canal. It may be possible to reduce the pump capacity by 2-3 cfs without flooding by using a slightly smaller fourth pump, but it was decided to keep all four pumps the same size (21.5 cfs) for simplicity and to maximize operational flexibility.

Figure 5 shows the maximum water surface elevation profile and Figure 6 shows the maximum water surface elevation and inundation extent simulated in the lower Canal for the 100-year event, with the 86 cfs pump station. All elevations are in NAVD88. As shown in Figure 6, there is no flooding of properties along the canal with the proposed pump station in place.

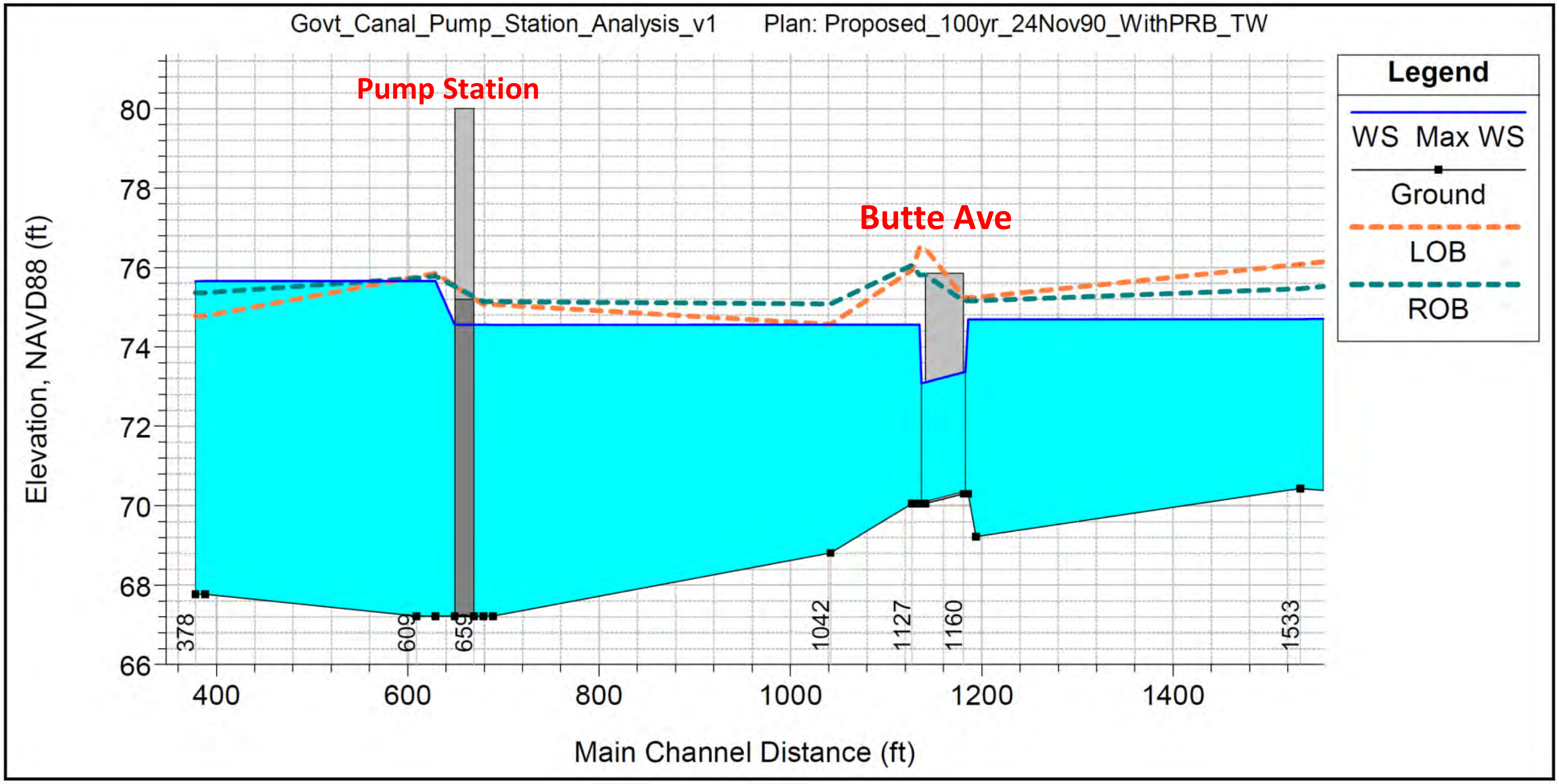

Figure 5 – Modeled water surface elevation profile (feet, NAVD88) in lower Government Canal during a 100-year event, with the pump station

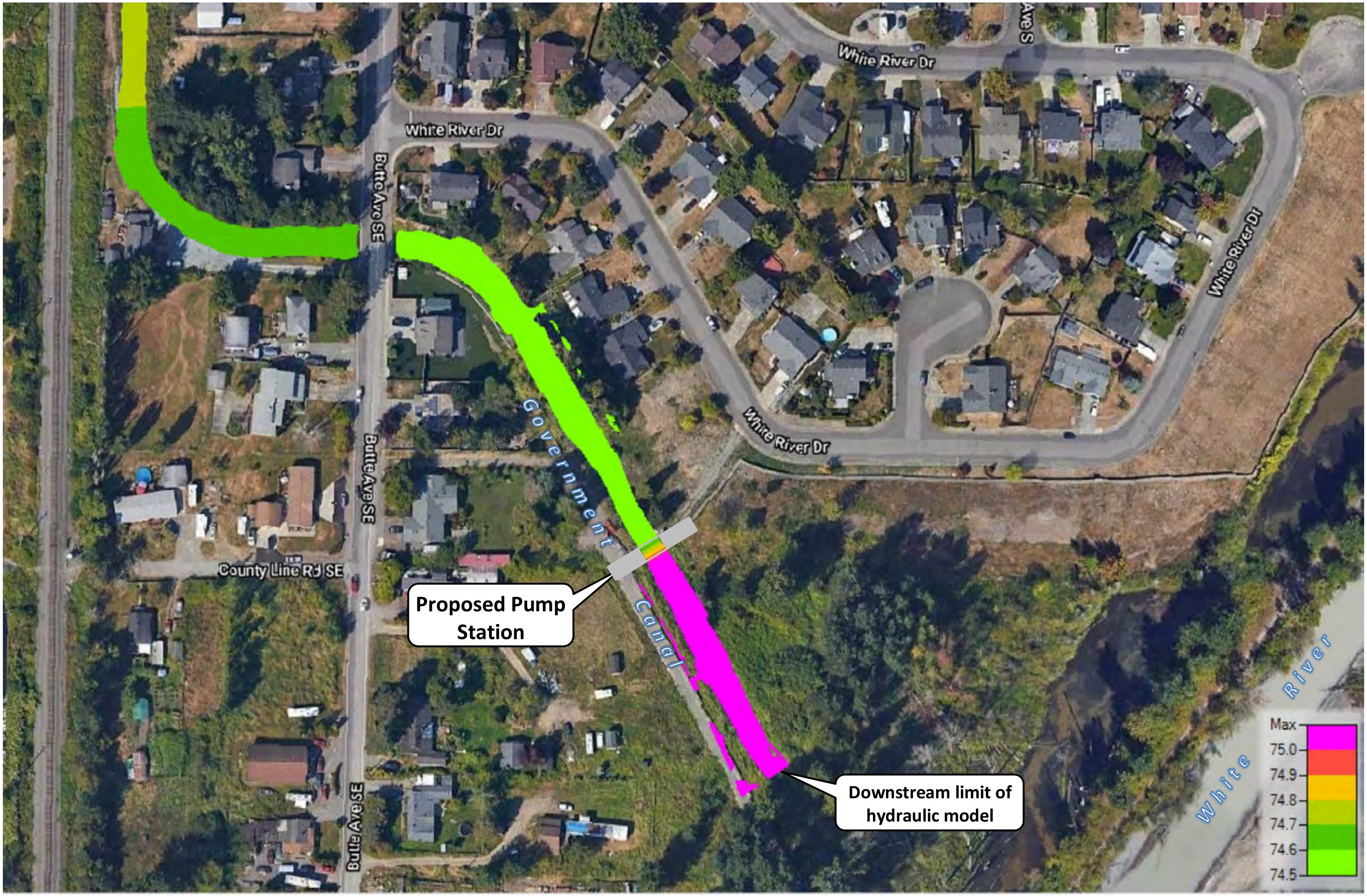

Figure 6 – Simulated water surface elevation (feet, NAVD88) and extent of flooding along Government Canal during a 100-year event, with the pump station

GATE CLOSURE ANALYSIS

Using the White River stage data at the outlet of Government Canal, developed as described above, an additional analysis was undertaken to estimate how often and for how long the slide gate at the proposed pump station would be closed during two seasons of interest. The two seasons, specified by the County, represented the flood season (October 1 to April 30), and a salmonid spring rearing period (February 1 through July 31). These two time periods were selected to evaluate the impacts of gate closures on fish passage; fish may use Government Canal for high flow refuge during the flood season and also for rearing, and gate closures would temporarily block access to off-channel habitat in the canal.

Stage records were developed for baseline (2019 conditions with no Pacific Right Bank project) and for proposed Project conditions (flood facility setback). Using the stage data between 2010-2020, all events requiring closure of the gates (i.e. White River water surface elevation of 74.0 feet or higher) were identified. For purposes of this analysis, it was assumed that if water levels rose above 74 feet, then temporarily fell below 74 feet for less than 12 hours before rising above 74 feet again, it was considered a single event and the gate was considered to be "closed" throughout the event in recognition of the fact that brief openings may not allow fish sufficient time to move into or out of the canal. Given that this approach may overestimate the duration of actual closures, the analysis is conservative. Summary statistics for the gate closure events for baseline and proposed project conditions are shown in Table 3.

Table 3. Summary statistics for Government Canal Gate Closures, based on analysis of available USGS data for White River gages near Auburn (gage 12100496) and at R Street (gage 12100490) for Water Years 2010-2020.

Baseline Conditions		
	October 1 to April 30	**February 1 to July 31**
Total No. of Events (from 2010-2020)	4	1
Average Events / Year	0.36	0.08
Total Time Closed (from 2010-2020)	79.45 hrs or 3.3 days	16 hrs or 0.7 days
Percent of Time Closed (from 2010-2020)	0.1%	0.03%
Average Event Duration	19.9 hrs or 0.8 days	16 hrs or 0.7 days
Average duration/year	7.2 hrs or 0.3 days	1.3 hrs or 0.1 days
Maximum Event Duration	40.2 hrs or 1.7 days	16 hrs or 0.7 days
Minimum Event Duration	0.3 hrs or 0 days	16 hrs or 0.7 days
With Pacific Right Bank Project Conditions		
	October 1 to April 30	**February 1 to July 31**
Total No. of Events (from 2010-2020)	34	13
Average Events / Year	3.09	1.18
Total Time Closed (from 2010-2020)	2659.5 hrs or 110.8 days	1321.9 hrs or 55.1 days
Percent of Time Closed (from 2010-2020)	4.8%	2.8%
Average Event Duration	78.2 hrs or 3.3 days	101.7 hrs or 4.2 days
Average duration/year	241.8 hrs or 10.1 days	110.2 hrs or 4.6 days
Maximum Event Duration	468 hrs or 19.5 days	463 hrs or 19.3 days
Minimum Event Duration	0.5 hrs or 0 days	1.3 hrs or 0.1 days

Importantly, gate closure results for baseline conditions do not reflect actual past gate closures implemented by the City of Pacific, as the current analysis evaluates data prior to 2017 when the City first began temporary pump station operations. Even in recent years the modeled results may not reflect actual closures since the City uses visual observations to determine when to begin and stop operating the pump station. Furthermore, the analysis summarized in Table 3 relies on stages calculated from 2D hydraulic modeling of the White River that used a 2019 terrain surface, which does not accurately represent conditions at other points in time. Instead, results from the baseline analysis can be interpreted as a representation of current conditions without implementation of the Pacific Right Bank project, to be compared to current conditions with project implementation. Conditions in the aggrading White River will likely continue changing in the future, and results of this analysis do not incorporate future changes to stage-discharge relationships.

Additionally, this analysis uses gage data for the period corresponding to reduced outflows from Mud Mountain Dam, as the dam has operated under a temporary deviation from authorized outflows since 2009. Therefore, this analysis assumes that dam operations will continue under the current reduced maximum outflow of 6,000 cfs, and duration of gate closures may be overestimated if outflows from Mud Mountain Dam are increased in the future; again, this makes the analysis conservative.

With the modeled 2019 terrain conditions without the proposed project, gate closures would have been relatively short and infrequent; the slide gate would have closed only four times during the flood season (Oct 1 – Apr 30) from 2010-2020 and just once during the spring rearing period (Feb 1 – July 31). This corresponds to just 0.1% and 0.03% of the time considered, respectively, during the 11 years included in the analysis (Table 3). Modeled conditions with the proposed project increase the duration and frequency of gate closure during both the flood season and spring rearing period, to an average of about 3 closures per year during the flood season and 1 closure per year during spring rearing period. This corresponds to 4.8% of the modeled flood season period and 2.8% of the spring rearing period (Table 3). While the project may increase gate closures, results from this analysis suggest that the Canal would remain open to passage more than 95% of the flood season and 97% of the spring rearing period, which meet the passage criteria of 90% of the time described in the 2013 WDFW Water Crossing Design Guidelines. Flow velocities in Government Canal would be low and are not expected to create a passage barrier through the box culvert, so the crossing is assumed to be fully passable when the gate is open.

CAVEATS

There are several caveats that should be understood with respect to this hydraulic modeling and analysis. First, for purposes of this analysis it was assumed that all runoff generated by the White River Estates development would be routed to the proposed pump station. In actuality this runoff may be handled by a separate pump station, and the Government Canal pump station would therefore be able to maintain target flood elevations in the canal with a lower pump capacity. The runoff from White River Estates in the modeled 100-year event is approximately 4 cfs and thus the pump station capacity may be able to be reduced by this amount. Including this runoff in the pump station analysis provides a level of conservatism in the current design.

It should also be noted that the simulated 100-year flood reached a water level of 74.6 feet in Government Canal, which is the same elevation as the low point on the left bank upstream of the proposed pump station. Thus, the current design does not provide any freeboard or factor of safety with respect to upstream water levels. The modeled operating range of the pump station is 74.0 feet to 74.6 feet (i.e., a total range of 0.6 feet) and thus the design is not amenable to providing significant freeboard.

Finally, the analysis and design of the pump station did not consider additional development or higher density redevelopment in the basin. The basin is already almost completely developed and thus it is unlikely that significant new development will occur. Furthermore, any infill or redevelopment would be required to mitigate flows to predeveloped conditions and thus should not result in increases in storm runoff to the pump station.

POTENTIAL EFFECTS OF CLIMATE CHANGE ON PUMP STATION CAPACITY

Climate change projections generally predict increased stormwater runoff in the future. While it is unclear precisely how climate change will affect Government Canal, a preliminary evaluation of its effect on canal flows and required pump capacity was made. The University of Washington Climate Impacts Group (UW CIG) recently completed an evaluation of climate change effects on King County Rivers (Mauger and Won, 2020). As part of that work, increases in flow frequencies due to climate change between historical (1970 - 1999) and future (2070 - 2099) conditions at 17 sites in the County were evaluated. Results of the CIG analysis for 100-year flows are summarized in their Table 3 copied below as Table 4:

Table 4: ***(Mauger and Won, Table 3)*** **Percent change in the 100-year extreme in 3-hour streamflow for the 2080s** (2070-2099) relative to the 1980s (1970-1999). WRF results are shown in the first two columns for the dynamically downscaled (WRF) models: ACCESS 1.0 RCP 4.5 and GFDL CM3 RCP 8.5. The next column shows the results (median, minimum, and maximum) for the ensemble of 12 RCP 8.5 WRF projections, including GFDL. The final two columns also show the Phase 1 results, in this case for the statistically downscaled bcMACA projections showing the median, minimum, and maximum among all 10 GCM projections, for each scenario.

	Dynamical Downscaling (WRF)			Statistical Downscaling (bcMACA)	
	RCP 4.5	RCP 8.5		RCP 4.5	RCP 8.5
Site Name	ACCESS 1.0	GFDL-CM3	ENSEMBLE		
SF Skykomish R Nr Index	-51%	40%	44% (-10%, 125%)	26% (-10%, 104%)	41% (-10%, 87%)
Skykomish R Nr Gold Bar	-52%	38%	40% (0%, 118%)	23% (-12%, 94%)	43% (-10%, 95%)
MF Snoqualmie R Nr Tanner	-49%	66%	52% (-12%, 108%)	14% (-7%, 67%)	47% (-8%, 114%)
NF Snoqualmie R Nr Snoq. Falls	-54%	58%	39% (-14%, 135%)	23% (-5%, 94%)	62% (-9%, 126%)
SF Snoqualmie R Abv Alice Cr	-49%	61%	48% (-20%, 90%)	38% (-9%, 90%)	73% (27%, 160%)
Snoqualmie R Nr Snoqualmie	-51%	75%	43% (-17%, 100%)	14% (-3%, 73%)	58% (-7%, 129%)
Raging R Nr Fall City	-25%	98%	25% (-22%, 98%)	25% (-27%, 77%)	61% (-9%, 132%)
NF Tolt R Nr Carnation	-41%	58%	47% (-9%, 125%)	19% (-2%, 125%)	73% (2%, 148%)
SF Tolt R Nr Carnation	-48%	55%	40% (-11%, 142%)	29% (-1%, 123%)	86% (5%, 159%)
Tolt R Nr Carnation	-41%	63%	46% (-10%, 121%)	18% (-3%, 122%)	71% (1%, 147%)
Snoqualmie R Nr Carnation	-48%	84%	39% (-17%, 107%)	17% (2%, 82%)	68% (-6%, 141%)
Green R Nr Lester	-37%	3%	29% (-40%, 117%)	137% (117%, 198%)	190% (112%, 288%)
Green R Blw HHD	-41%	15%	22% (-43%, 113%)	77% (39%, 159%)	133% (89%, 201%)
Green R nr Palmer	-41%	18%	23% (-42%, 111%)	75% (35%, 156%)	129% (85%, 200%)
Newaukum Cr Nr Black Diam.	-0%	128%	23% (-18%, 128%)	17% (-18%, 72%)	50% (18%, 129%)
Big Soos Cr Abv Hatchery	60%	83%	82% (-18%, 248%)	-8% (-32%, 59%)	11% (-15%, 128%)
Green R Nr Auburn	-31%	38%	31% (-36%, 98%)	65% (19%, 130%)	114% (73%, 200%)

WATERSHED SCIENCE & ENGINEERING

While none of the sites evaluated by the CIG are identical to Government Canal, the closest sites CIG evaluated in terms of proximity and basin size were Big Soos Creek and Newaukum Creek. Considering the bcMACA (statistically downscaled) data for the RCP 8.5 scenario (high end emissions) the median projected increase in 100-year flow on Newaukum Creek was 50% and the median projected increase in the 100-year flow on Big Soos Creek was 11%. As there is no way of knowing which of these sites (if either) is representative of conditions on Government Canal, it was assumed for this preliminary analysis that flows in Government Canal might increase by the average of these two locations, or 30.5%, by late century (2070 - 2099).

Using the HEC-RAS model of Government Canal with all inflows scaled up by 30.5% it was determined that the total pump capacity would need to be increased to approximately 110 cfs under the late century (2070–2099) climate conditions to maintain water levels in the canal below elevation 74.6 feet. This represents a 28% increase over the previously estimated required pump capacity for existing basin runoff conditions (86 cfs).

CONCLUSION

An HSPF hydrologic model of the drainage basin tributary to Government Canal was developed and used to estimate 100-year storm event discharges into the Canal. The resulting flows were used as input to a HEC-RAS 1D hydraulic model of the Canal, extending from Ellingson Road to just upstream of the White River. The HEC-RAS geometry was configured using May 2020 channel survey and recent LiDAR terrain data. Pump station alternatives to prevent surface flooding along Government Canal during events up to and including the 100-year flood on Government Canal are currently being designed. The total pump capacity required to keep water surface elevations in the Canal downstream of Butte Avenue below 74.6 feet was determined to be 86 cfs. Pump station alternatives will be described in the *King County Government Canal Pump Station Alternatives Analysis Report* and included in the Pacific Right Bank Project Environmental Impact Statement.

In addition to hydraulic design of the pumps, an analysis was undertaken to determine how often and for how long the flood gates at the pump station would be closed under baseline (2019) White River conditions, as well as with the proposed Pacific Right Bank project. The proposed project will increase the duration and frequency of gate closures compared to the baseline condition, though the gate is expected to be open more than 95% of the time during the flood season and more than 97% of the time during the salmonid spring rearing period (Table 3).

A preliminary analysis of climate change impacts on storm flows and pump capacity was also undertaken. Based on previous hydrologic analyses for nearby basins it was projected that storm flows in Government Canal could increase by 30.5% by the end of the century (2070-2099). Under this assumption the pump station capacity would need to be increased by 28% to 110 cfs to achieve the same level of flood protection as in the current proposed condition. This preliminary climate change analysis should be revisited and refined during the detailed design phase of the pump station.

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APPENDIX B

Information Packets

Pump Station Location Evaluation

The north and south banks of the government canal, as shown below, were evaluated to determine a favorable location for the pump station.

Pump Station Location

The criteria used to assess and compare the relative feasibility of location the pump station on either the north or south bank of the Government Canal include:

- Real Estate – This criterion is based on property ownership data from the King County Assessor Website and it evaluates if King County would have to acquire additional property for each option. A score of 1 indicates that the property is owned by King County and there are no constraints that will complicate the layout and sizing of the pump station. A score of 2 indicates that the property is not owned by King County but there are no constraints that will complicate the layout and sizing of the pump station. A score of 3 indicates that the property is not owned by King County and there are constraints that will complicate the layout and sizing of the pump station.
- Community Impacts – This criterion is based on the proximity of the future pump station to residential homes. A score of 1 is given if there is enough room to keep the pump station over 200 feet away from residential homes. A score of 2 is given to locations where the pump station can be kept between 100 and 200 feet away from residential homes. A score of 3 is given to locations where the pump station will be within 100 feet of residential homes.
- Stormwater Routing – This criterion evaluates if stormwater piping from the White River Estates would have to cross the Government Canal in order to discharge into the pump station's

wetwell. A score of 1 indicates that crossing the government canal is not required. A score of 3 indicates that stormwater piping would have to cross under the canal

- Accessibility - This criterion evaluates the ease of access associated with each location. A score of 1 indicates that access is available. A score of 2 indicates limited access (space is available but access to the site might impact private property). A score of 3 indicates restricted access (site is available for the pump station but there is not space for an access road).
- Wetland Areas – This criterion evaluates if the locations will impact existing wetlands. A score of 1 indicates no impact to existing wetlands. A score of 2 indicates potential impacts to existing wetland boundaries. A score of 3 indicates that there are existing wetlands at the location that would be impacted.

The overall results of the pump type scoring matrix are shown in the Table below.

Pump Station Location Scoring Matrix						
Location	**Real Estate**	**Community Impacts**	**Stormwater Routing**	**Accessibility**	**Wetland Areas**	**Total Score**
North Bank	1	2	1	1	1	**6**
South Bank	2	2	3	1	2	**10**

The North Bank is considered the most favorable option.

North Bank Pro/Con Table	
Pro	**Con**
Property Owned by King County.	Pump station will be located between 100 and 200 feet of residential homes.
Stormwater piping from the White River Estates will not have to cross under the Government Canal.	
This location is easily accessible from White River Drive.	
No impacts to wetland areas.	

The South Bank is considered the least favorable option.

South Bank Pro/Con Table	
Pro	**Con**
This location is easily accessible from Butte Avenue	Property is owned by the City of Pacific
	Pump Station will be located between 100 and 200 feet of residential homes.
	Stormwater piping from the White River Estates will have to cross under the Government Canal.
	Potential impacts to wetlands.

Fish Screen Evaluation

The following fish screening options were evaluated. Images of each fish screen option are provided at the end of this section.

- T Screen Fixed (Brush Cleaning)
- Cone Screens (Brush Cleaning)
- Flat Plate (Incline or Vertical with Air Burst Cleaning)
- Flat Plate (Incline or Vertical with Brush Cleaning)

The criteria used to assess and compare the relative feasibility of each fish screen option includes:

- Cleaning Systems – This criterion evaluates the effectiveness of the fish screen cleaning system. Cleaning systems that are very effective (require minimal manual cleaning) were given a rating of 1. Cleaning systems that are somewhat effective (require a moderate amount of manual cleaning) were given a rating of 2.
- Operation & Maintenance (O&M) – This criterion evaluates the ease of accessing the screens for maintenance. Screen types that can be lifted out in sections so that screened flow can be maintained were given a rating of 1. Screen types that can be easily lifted out but the whole screening system has to be removed thus allowing unscreened water to the pumps were given a rating of 2. Screens that are not easily removed were given a rating of 3.
- Shallow Depth Operation – This criterion evaluates the depth requirements for the different screen types. Screens that require a shallow operating depth were given a rating of 1. Screens that require a moderate operating depth were given a rating of 2. Screens that require a deep operating depth were given a rating of 3.
- Capital Cost – This criterion evaluates the anticipated capital costs associated with each screen type. Screen types that typically cost less were given a rating of 1. Screen types that are neither the cheapest nor the most expensive option were given a rating of 2. Screen types that typically cost the most were given a rating of 3.
- Facility Footprint – This criterion evaluates the anticipated footprint associated with each screen type. Screens that typically have smaller footprints were given a ranking of 1. Screens that usually require neither the smallest nor largest footprint were given a ranking of 2. Screens that typically require a larger footprint were given a ranking of 3.
- Power Required – This criterion evaluates the power requirements associated with each screen type. Screens that normally require minimal power for water surface control and or cleaning systems were given a ranking of 1. Systems that usually require more power for water surface control and or cleaning systems were given a ranking of 3.

The overall results of the fish screening scoring matrix are shown in the Table below.

Fish Screening Scoring Matrix							
Fish Screening Options	Cleaning System	O&M	Shallow Depth Operation	Capitol Cost	Facility Footprint	Power Req'd	**Total Score**
T-Screen Fixed	1	1	3	2	1	1	**9**
Cone Screens	1	3	2	1	2	1	**10**
Flat Plate (Incline or Vertical with Air Burst Cleaning)	2	2	1	3	3	3	**14**
Flat Plate (Incline or Vertical with Brush Cleaning)	2	2	1	3	3	3	**14**

The T-Screen Fixed (Brush Cleaning) is considered the most favorable option.

T-Screen Fixed (Brush Cleaning) Pro/Con Table	
Pro	**Con**
The brush or airburst cleaning systems are very effective at self-cleaning.	The shallow canal depth is not ideal for these screens but accommodations/exemptions can be made. It is not uncommon to obtain a variance.
Screens can be removed in sections for maintenance and still provide screened flow.	This screen will not have the lowest capital cost.
This screen is expected to have a small footprint.	
This screen is a low power alternative.	

The Cone Screen (Brush Cleaning) is considered the second most favorable option.

Cone Screen Pro/Con Table	
Pro	**Con**
The brush or airburst cleaning systems on the cone screen provide very effective self-cleaning.	The screens are difficult to remove for maintenance. When removed unscreened flow would be going to the pump station wetwell.
This screen is expected to have the lowest capital cost.	The shallow canal depth is not ideal for these screens but accommodations/exemptions can be made.
This screen is a low power alternative.	This screen is expected to have neither the smallest nor the largest footprint.

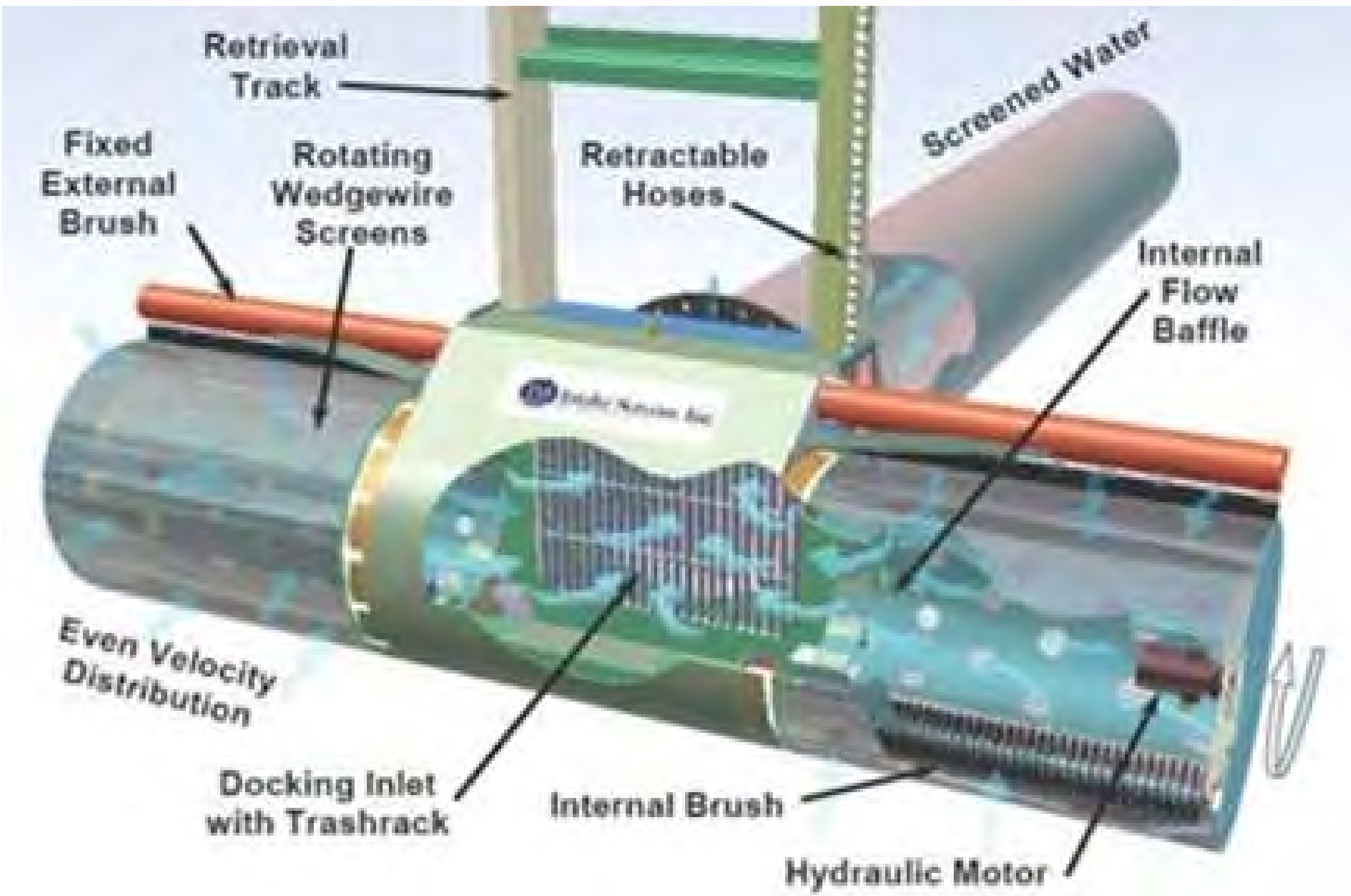
The Flat Plate Screen (Incline or Vertical with Air Burst Cleaning) is tied for the third most favorable option.

Flat Plate Screen (Incline or Vertical with Air Burst Cleaning) Pro/Con Table	
Pro	**Con**
Screens can be easily lifted for maintenance.	When the screen is removed for maintenance the whole screen has to be removed. This allows unscreened flow to the pump station wetwell.
This screen is can operate in shallow water depths.	The air burst cleaning system for this screen type is moderately effective. Manual cleaning will be required on a routine basis to supplement the self-cleaning system.
	This screen is a higher capital cost alternative.
	This screen will have one of the larger footprints
	This screen will have higher power requirements

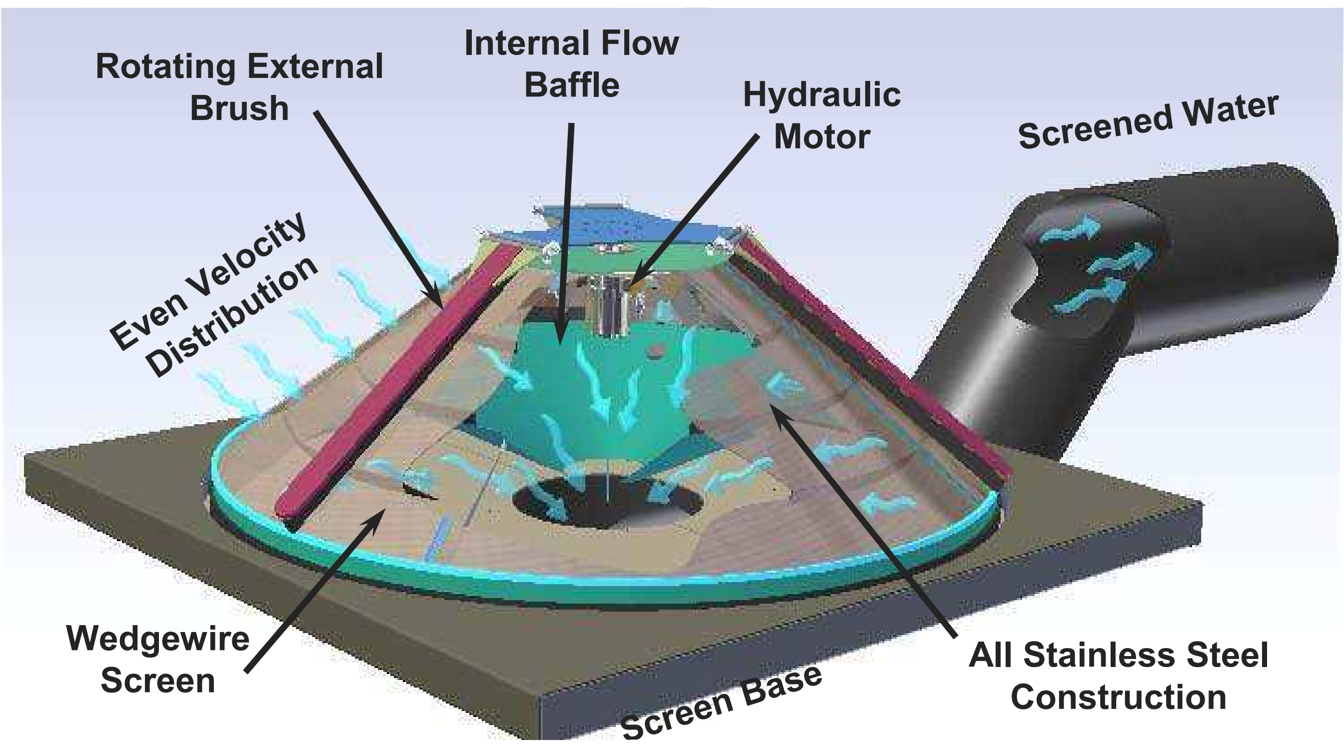
The Flat Plate Screen (Incline or Vertical with Brush Cleaning) is tied for the third most favorable option.

Obermeyer Gate Pro/Con Table	
Pro	**Con**
Screens can be easily lifted for maintenance.	When the screen is removed for maintenance the whole screen has to be removed. This allows unscreened flow to the pump station wetwell.
This screen is can operate in shallow water depths.	The air burst cleaning system for this screen type is moderately effective. Manual cleaning will be required on a routine basis to supplement the self-cleaning system.
	This screen is a higher capital cost alternative.
	This screen will have one of the larger footprints
	This screen will have higher power requirements

T-Screen Fixed (Brush Cleaning)


Retrieval Track
Screened Water
Fixed External Brush
Rotating Wedgewire Screens
Retractable Hoses
Internal Flow Baffle
Even Velocity Distribution
Docking Inlet with Trashrack
Internal Brush
Hydraulic Motor

Cone Screen (Brush Cleaning)



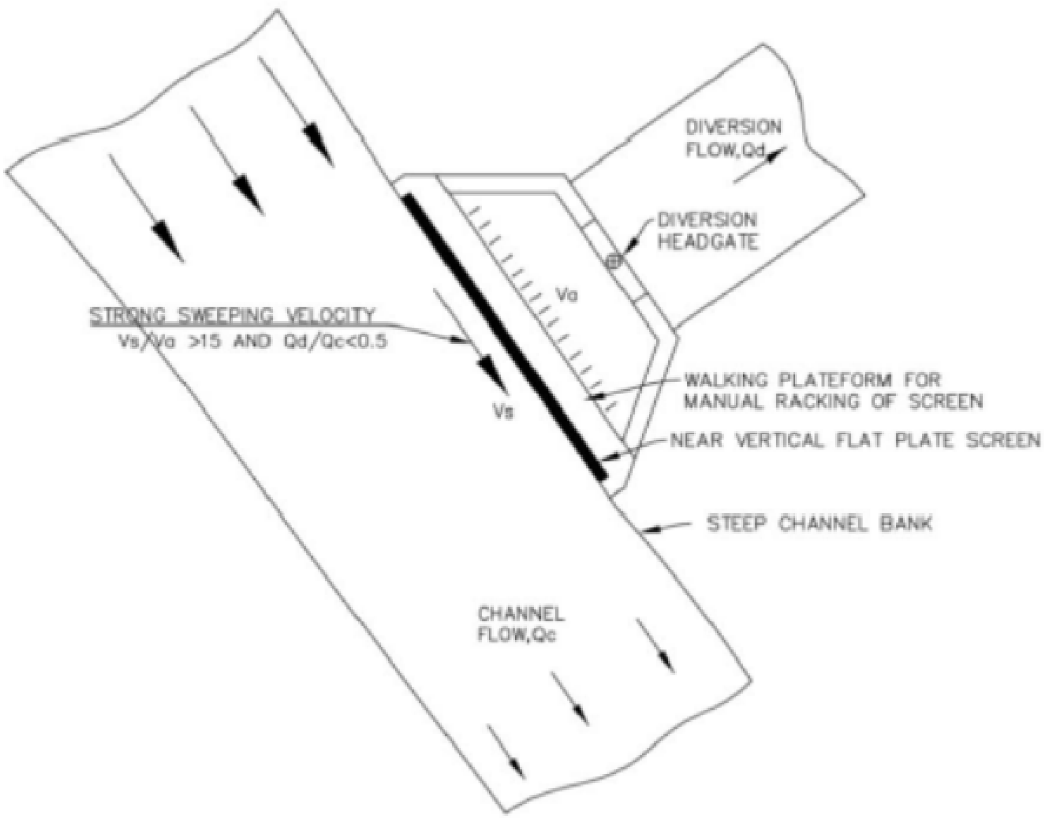
Rotating External Brush
Internal Flow Baffle
Hydraulic Motor
Screened Water
Even Velocity Distribution
Wedgewire Screen
Screen Base
All Stainless Steel Construction

Flat Plate (Incline or Vertical with Air Burst Cleaning)

Horizontal Flat Plate Screen

Air Burst Cleaning

Flat Plat (Incline or Vertical with Brush Cleaning)



Vertical Flat Plate Screen

Intake Structure Evaluation

The following six intake structures were evaluated. Images of each intake structure type are provided at the end of this section.

- Self-Cleaning Trench
- Standard Trench
- Dry Pit
- Rectangular Wet Pit
- Open Bottom Can
- Closed Bottom Can

The criteria used to assess and compare the relative feasibility of each intake structure type include:

- Footprint – This criterion is based on the area required for each intake structure type. Intake Structures with footprints estimated to be 500 square feet or less were given a rating of 1. Intake structures with footprints estimated to be between 500 and 1,000 square feet were given a rating of 2. Intake structures with footprints estimated to be over 1,000 square feet were given a rating of 3.
- Capital Cost – This criterion is based on historic costs data for each intake structure type. Intake structures with capital costs that are historically less than $350/gpm were given a rating of 1. Intake structures with capital costs that are historically between $350/gpm and $450/gpm were given a rating of 2. Intake structures with capital costs that are historically above $450/gpm were given a rating of 3.
- Applicability – This criterion evaluates if the intake structure type is normally used for stormwater applications. Intake structures that are considered ideal for stormwater applications were given ratings of 1. Intake structures with potential for stormwater applications were given ratings of 2. Intake structures that are not recommended for stormwater applications are given ratings of 3.
- Maintenance – This criterion evaluates how easy or difficult the various intake structures are to maintain. Intake structures where the pumps are easily removed and it is easy for the structure to be cleaned manually or by vacuum truck were given a rating of 1. Intake structures where removal of the pumps will be more difficult but it is easy for the structure to be cleaned manually or by vacuum truck were given a rating of 2. Intake structures where removal of the pumps will be difficult and it will be difficult for the structure to be cleaned manually or by vacuum track were a rating of 3.

The overall results of the intake structure scoring matrix are shown in the Table below.

Intake Structure Type Scoring Matrix					
Intake Types	**Footprint**	**Capital Cost**	**Applicability**	**Maintenance**	**Total Score**
Self-Cleaning Trench	2	2	3	2	**9**
Standard Trench	2	2	2	2	**8**
Dry Pit	3	3	1	1	**8**
Rectangular Wet Pit	2	2	1	1	**6**
Open Bottom Can	1	1	2	3	**7**

Intake Structure Type Scoring Matrix					
Intake Types	**Footprint**	**Capital Cost**	**Applicability**	**Maintenance**	**Total Score**
Closed Bottom Can	1	1	3	3	**8**

The rectangular wet pit intake structure is the most favorable option.

Rectangular Wet Pit Pro/Con Table	
Pro	**Con**
This intake structure configuration is commonly used for storm water applications.	This configuration will typically cost more than an open or closed bottom can but less than a dry pit.
The intake structure is easy to maintain. Submersible pumps on guiderails are typically used with this intake structure. These pumps allow for convenient maintenance of the wetwell because they are easily removed.	
If the wetwell is designed in accordance with the recommendations given in appendix E of H.I. 9.8 then it is possible for to have a moderately sized footprint (between 500 and 1,000 square feet)	

The open bottom can is the second favorable option.

Open Bottom Can Pro/Con Table	
Pro	**Con**
It has one of the smallest footprints (less than 500 square feet).	It is typically used for clean water applications.
This configuration will typically cost less than, self-cleaning trench, standard trench, dry pit, and rectangular wet pit style intake structures.	A crane would have to be brought onsite to remove pumps. This will make maintaining the intake structure more difficult. Furthermore, after the pumps are removed there are portions of the intake header that would be difficult to access for cleaning.

The standard trench is tied as one of third most favorable options.

Standard Trench Pro/Con Table	
Pro	**Con**
It will have a moderately sized footprint (between 500 and 1,000 square feet).	This configuration will typically cost more than an open or closed bottom can but less than a dry pit.

The dry pit intake structure is tied as one of the third most favorable options.

Dry Pit Pro/Con Table	
Pro	**Con**
This intake structure configuration is commonly used for storm water applications.	This configuration will typically cost more than the other intake types.
The intake structure is easy to maintain. The pumps are located in a dypit outside of the wetwell. This allows for easy access to the pumps and maintenance of the wetwell without removing the pumps.	This configuration will have a large footprint (over 1,000 square feet)

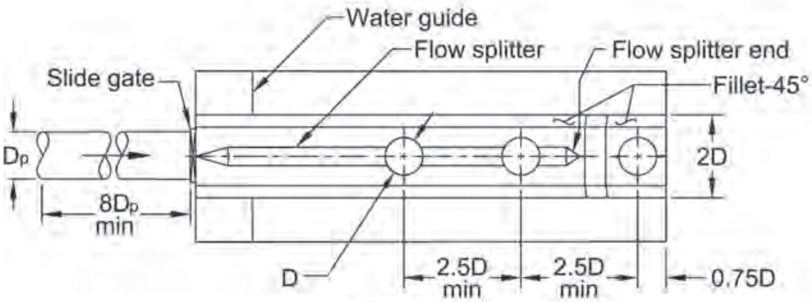
The closed bottom can is tied as one of the third most favorable options

Closed Bottom Can Pro/Con Table	
Pro	**Con**
It has one of the smallest footprints (less than 500 square feet).	It is typically used for clean water applications.
This configuration will typically cost less than, self-cleaning trench, standard trench, dry pit, and rectangular wet pit style intake structures.	A crane would have to be brought onsite to remove pumps. This will make maintaining the intake structure more difficult.

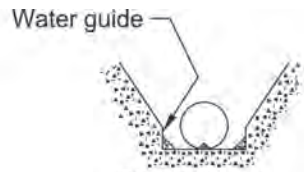
The self-cleaning trench was the least favorable option

Self-Cleaning Trench Pro/Con Table	
Pro	**Con**
It has a moderately sized footprint (between 500 and 1,000 square feet).	This configuration has the highest cost (approximately $520 / gpm).
	Although described as a self-cleaning trench it is expected that the trench will need to be cleaned manually or with vacuum truck because flows into the trench will be intermittent.
	The self-cleaning trench style wetwell is more commonly used with wastewater applications.

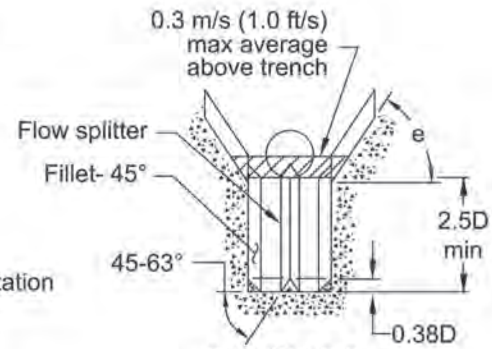
Self-Cleaning Trench



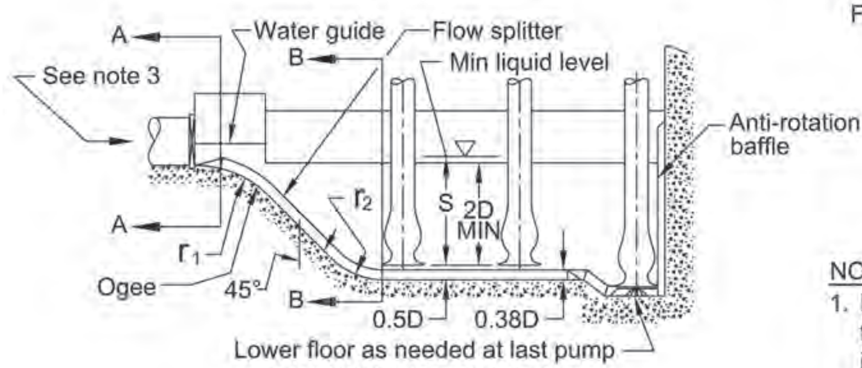
PLAN



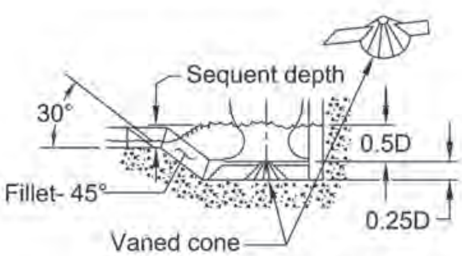
SECTION A-A



SECTION B-B



LONGITUDINAL SECTION

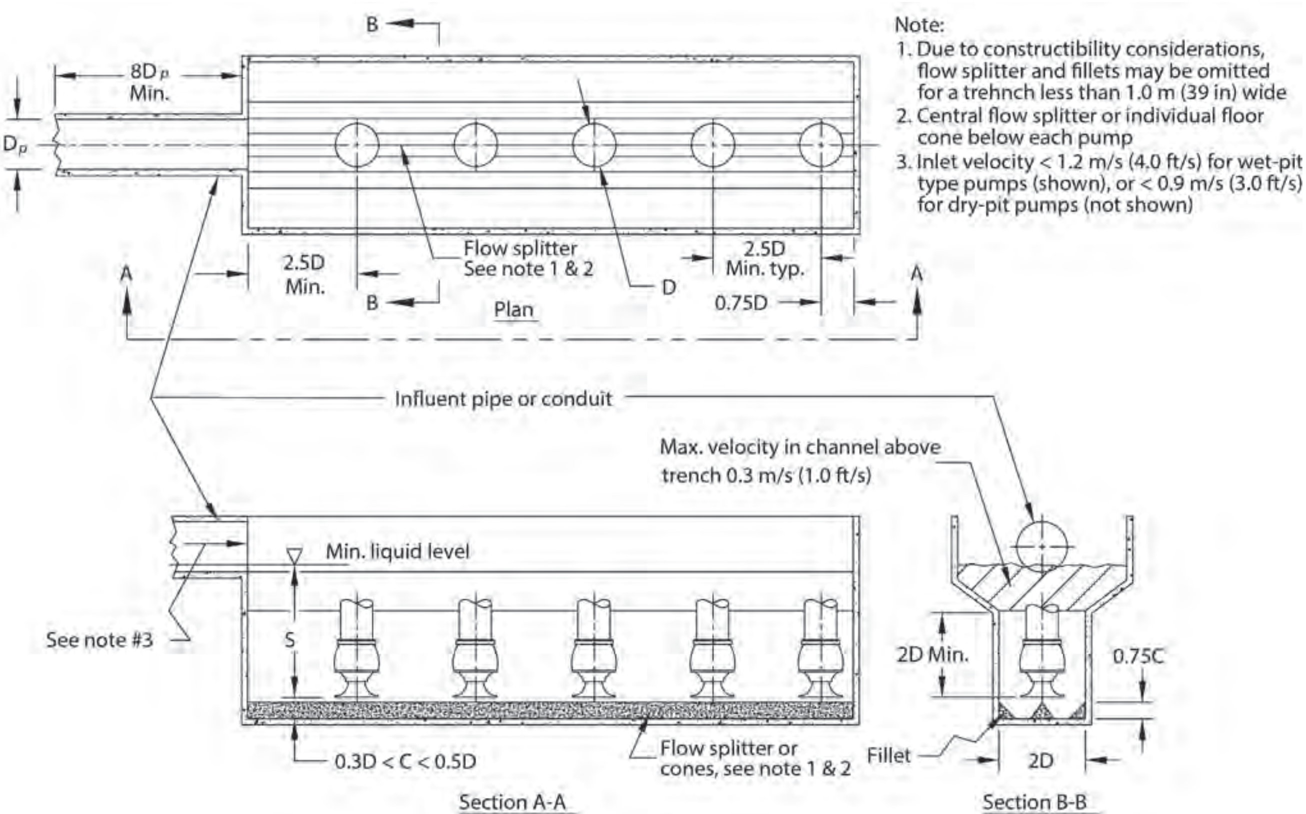


DETAIL AT LAST PUMP

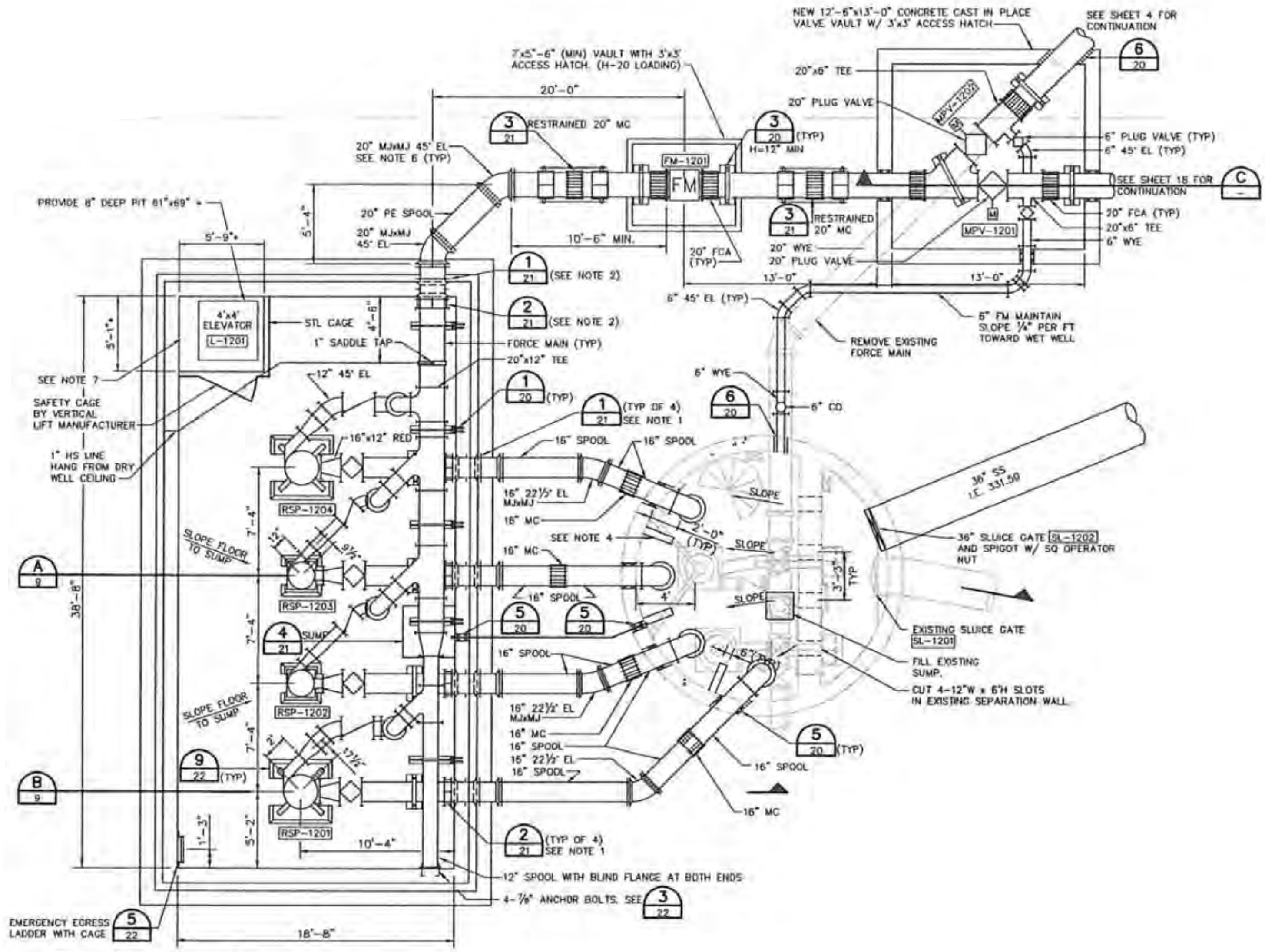
NOTES

1. Due to constructibility considerations, flow splitter and fillets may be omitted in a trench less than 1.0 m (39 in.) wide.
2. $r_1 \geq 2.33 \times v^2/2g$ where v = velocity at top of ramp (2D min), $r_2 \geq 1.25D$, 45° tangent between r_1 and r_2.
3. 1.2 m/s (4 ft/s) max wet pit pumps, 0.9 m/s (3 ft/s) max dry pit pumps
4. $e \geq 45°$ smooth surface (plastic lining)
5. $e \geq 60°$ concrete surface
6. $S \geq (1+2.3F_D)D$
7. See Appendix D for details and tutorials

Standard Trench

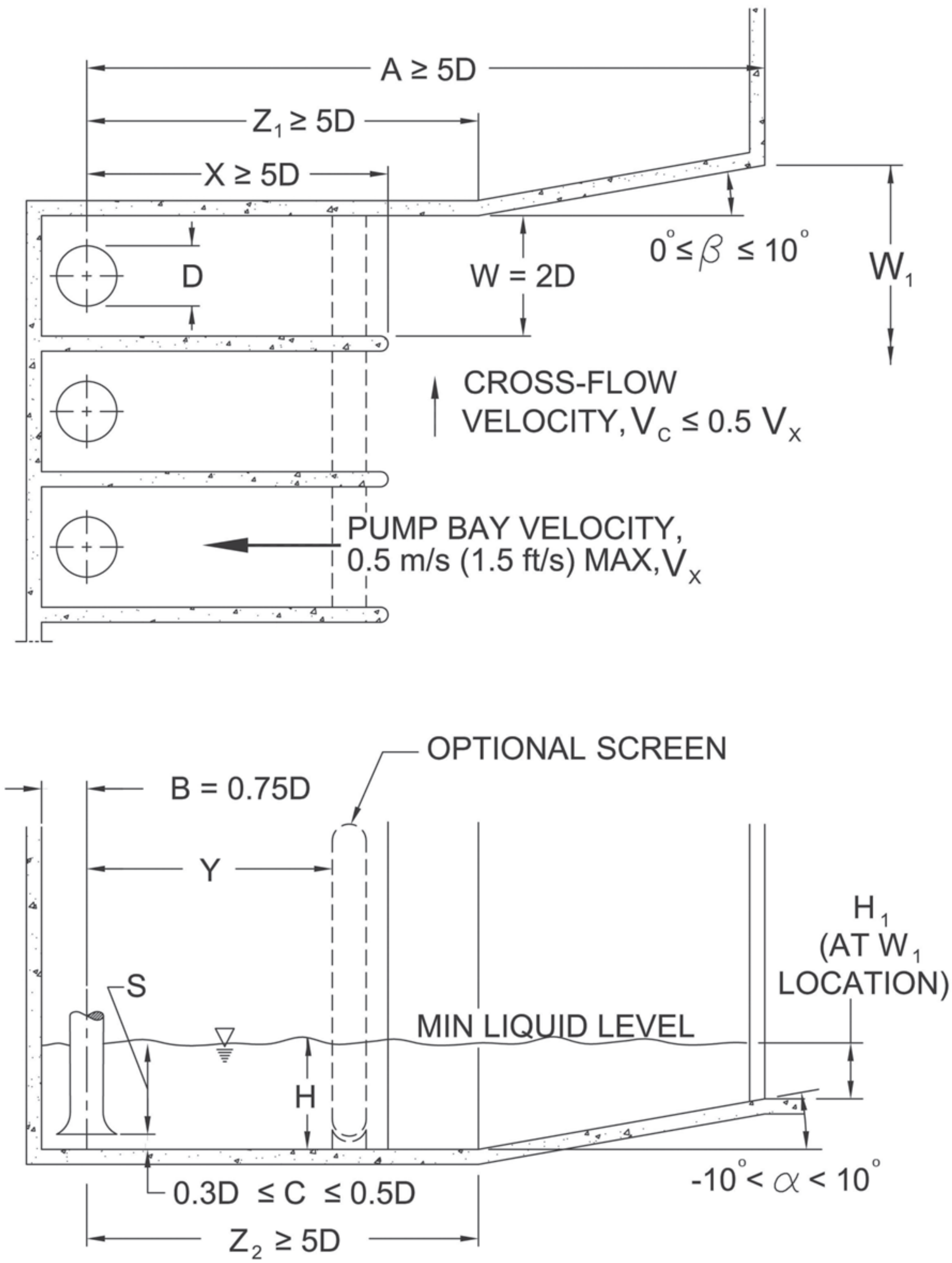

Note:
1. Due to constructibility considerations, flow splitter and fillets may be omitted for a trehnch less than 1.0 m (39 in) wide
2. Central flow splitter or individual floor cone below each pump
3. Inlet velocity < 1.2 m/s (4.0 ft/s) for wet-pit type pumps (shown), or < 0.9 m/s (3.0 ft/s) for dry-pit pumps (not shown)
B
8Dp Min.
Dp
2.5D Min.
Flow splitter See note 1 & 2
D
2.5D Min. typ.
0.75D
A
A
B
Plan
Influent pipe or conduit
Max. velocity in channel above trench 0.3 m/s (1.0 ft/s)
Min. liquid level
S
See note #3
0.3D < C < 0.5D
Flow splitter or cones, see note 1 & 2
Section A-A
2D Min.
0.75C
Fillet
2D
Section B-B

Circular Dry Pit

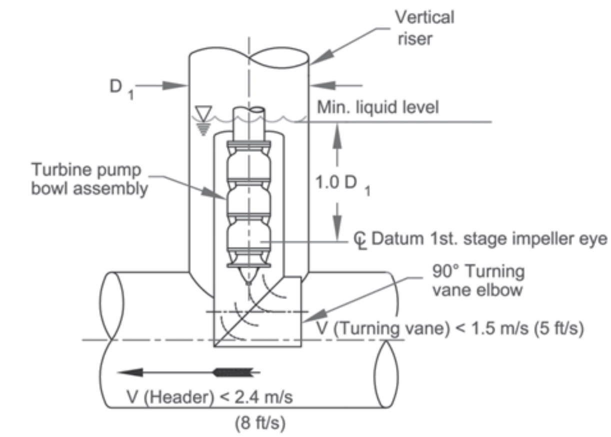


NEW 12'-6"x13'-0" CONCRETE CAST IN PLACE VALVE VAULT W/ 3'x3' ACCESS HATCH
SEE SHEET 4 FOR CONTINUATION
7'x5'-6" (MIN) VAULT WITH 3'x3' ACCESS HATCH. (H-20 LOADING)
20'-0"
20"x6" TEE
20" PLUG VALVE
RESTRAINED 20" MC
20" MJxMJ 45° EL SEE NOTE 6 (TYP)
FM-1201
FM
(TYP) H=12" MIN
6" PLUG VALVE (TYP)
6" 45° EL (TYP)
SEE SHEET 18 FOR CONTINUATION
PROVIDE 8" DEEP PIT 61"x69" ±
5'-4"
20" PE SPOOL
RESTRAINED 20" MC
MPV-1201
20" FCA (TYP)
20"x6" TEE
6" WYE
5'-9"±
20" MJxMJ 45° EL
10'-6" MIN.
20" FCA (TYP)
20" WYE
20" PLUG VALVE
(SEE NOTE 2)
13'-0"
13'-0"
6" 45° EL (TYP)
6" FM MAINTAIN SLOPE 1/4" PER FT TOWARD WET WELL
4'x4' ELEVATOR
L-1201
STL CAGE
(SEE NOTE 2)
5'-1"±
4'-6"
1" SADDLE TAP
FORCE MAIN (TYP)
REMOVE EXISTING FORCE MAIN
20"x12" TEE
SEE NOTE 7
12" 45° EL
6" WYE
(TYP)
SAFETY CAGE BY VERTICAL LIFT MANUFACTURER
(TYP OF 4) SEE NOTE 1
6" CO
1" HS LINE HANG FROM DRY WELL CEILING
16"x12" RED
16" SPOOL
16" SPOOL
RSP-1204
16" 22½° EL MJxMJ
SLOPE
36" SS I.E. 331.50
16" MC
7'-4"
SLOPE FLOOR TO SUMP
SEE NOTE 4
2'-0" (TYP)
SLOPE
36" SLUICE GATE SL-1202 AND SPIGOT W/ SQ OPERATOR NUT
38'-8"
16" MC
RSP-1203
16" SPOOL
4'
3'-3" TYP
SLOPE
7'-4"
SUMP
EXISTING SLUICE GATE SL-1201
16" SPOOL
FILL EXISTING SUMP.
RSP-1202
CUT 4-12"W x 6"H SLOTS IN EXISTING SEPARATION WALL.
SLOPE FLOOR TO SUMP
16" 22½° EL MJxMJ
16" MC
7'-4"
16" SPOOL
16" 22½° EL
(TYP)
16" SPOOL
(TYP)
16" SPOOL
16" MC
RSP-1201
5'-2"
1'-3"
10'-4"
(TYP OF 4) SEE NOTE 1
12" SPOOL WITH BLIND FLANGE AT BOTH ENDS
4-7/8" ANCHOR BOLTS. SEE
EMERGENCY EGRESS LADDER WITH CAGE
18'-8"

Rectangular Wet Pit

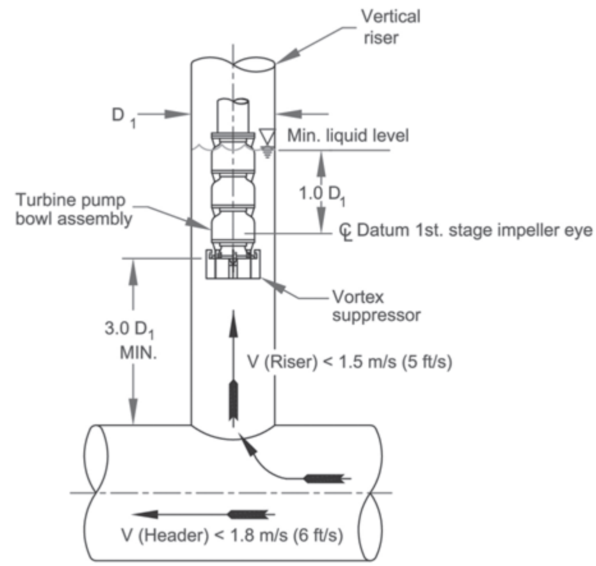

A ≥ 5D
Z1 ≥ 5D
X ≥ 5D
D
W = 2D
0° ≤ β ≤ 10°
W1
CROSS-FLOW
VELOCITY, VC ≤ 0.5 VX
PUMP BAY VELOCITY,
0.5 m/s (1.5 ft/s) MAX, VX
OPTIONAL SCREEN
B = 0.75D
Y
H1
(AT W1
LOCATION)
S
MIN LIQUID LEVEL
H
0.3D ≤ C ≤ 0.5D
-10° < α < 10°
Z2 ≥ 5D

Open Bottom Can



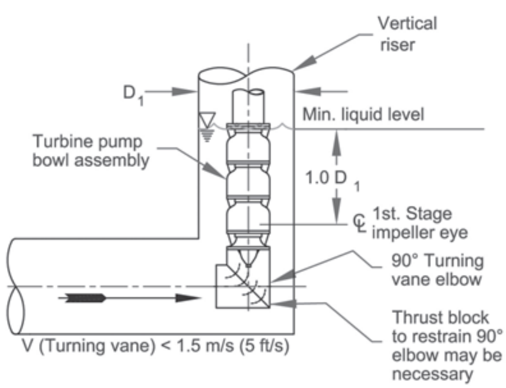
Horizontal header

Example - 1



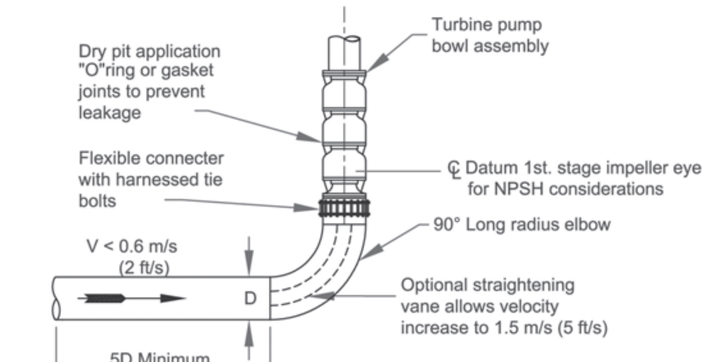
Horizontal header

Example - 2



Suction headed end

Example - 3



Dry pit

Example - 4

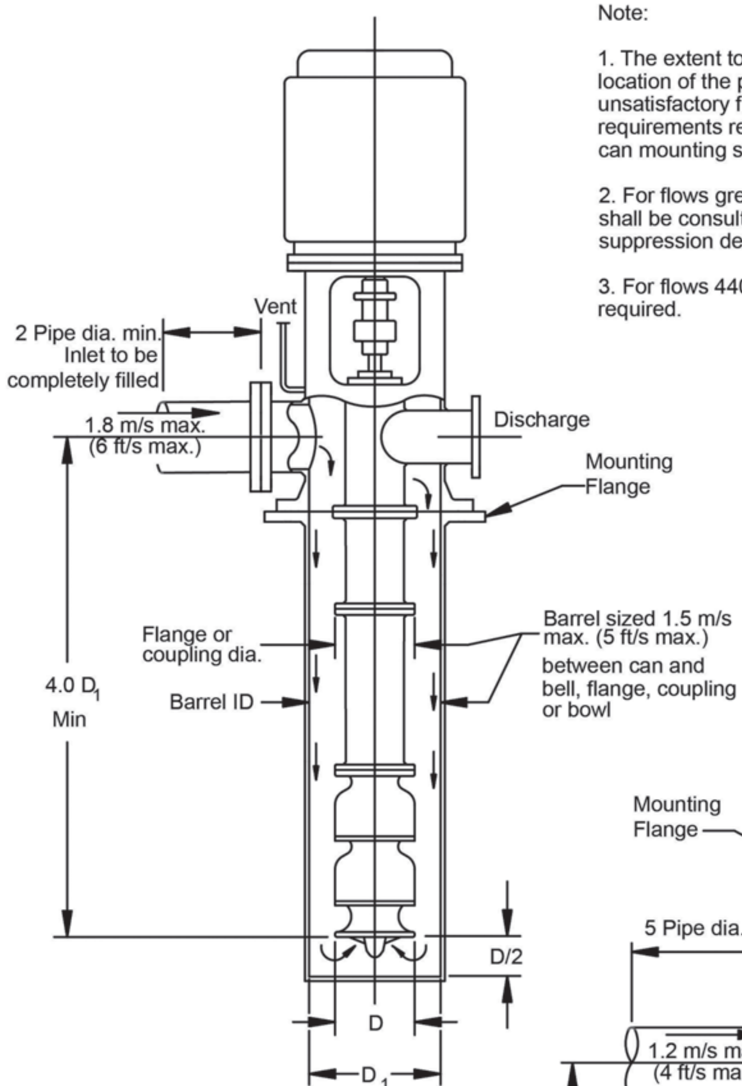
Closed Bottom Can

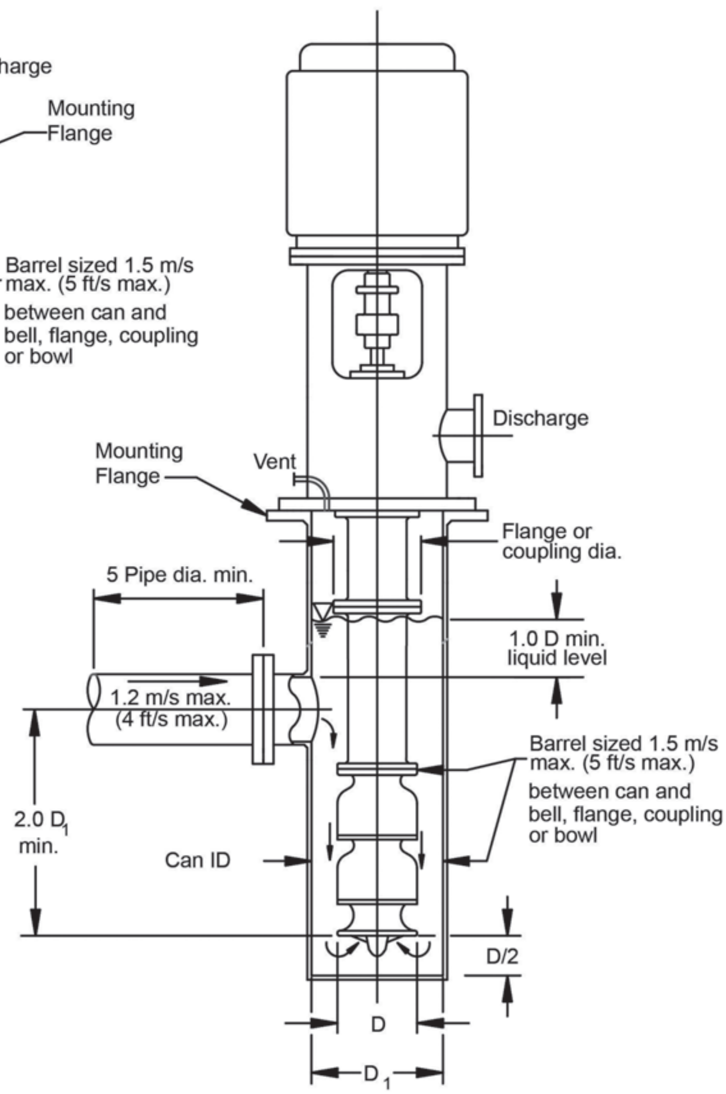
Note:

1. The extent to which the can is not plumb and level affects the location of the pump suction bell in the can and can result in unsatisfactory flow conditions into the pump. Refer to text for requirements regarding the can plumb criteria and for leveling the can mounting surface.

2. For flows greater than 189 L/S (3000 GPM) the manufacturer shall be consulted for applicability of flow straightening or vortex suppression devices inside the cans and associated details.

3. For flows 440 L/S (7000 GPM) and above a model study is required.





D = Pump suction bell dia.

D_1= Barrel inside dia.

Pump Type Evaluation

The following six pump types were evaluated. Images of each pump type are provided at the end of this section.

- Vertical Submersible Axial Flow Pump
- Vertical Turbine Solids Handling Pump
- Submersible Solids Handling Pump
- Dry Pit Submersible Pump
- Dry Pit Pump with Frame Mounted Bearing and Extended Shaft
- Vertical Axial Flowline Shaft Pumps

The criteria used to assess and compare the relative feasibility of each pump type include:

- Pump Efficiency – This criterion is based on the pump efficiencies included with the pump selections provided by various vendors. Selections with efficiencies 80% were given a score of 1. Selections with efficiencies 70% and 80% were given a score of 2. Selections with efficiencies below 70% were given a score of 3.
- Capital Cost – This criterion is based on the estimated cost of each pump type as provided by the various vendors. Pump types that will cost less than $100,000 were given a score of 1. Pump types that will score between $100,000 and $200,000 were given a score of 2. Pump type that will score over $200,000 were given a score of 3.
- Lifecycle Cost – this criterion is based on the estimated annual cost to operate, maintain, and replace each pump. Pump types with lifecycle costs estimated to be less than $200,000 per pump were given a rating of 1. Pump types with lifecycle costs estimated to be between $200,000 and $400,000 per pump were given a rating of 2. Pump types with lifecycle costs estimated to be over $400,000 per pump were given a rating of 3.
- System requirements – This criterion is based on external items that the different pump types might require such as protective structures for motors, larger underground structures for dry side system components, isolation valves and cooling systems. A rating of 1 indicates that no protective structures, suction isolation valves, or supplemental external cooling systems are required. A rating of 2 indicates that some type of above grade structure will be required to protect pump motors or a larger underground structure will be required to house the dry side of the pump system. A rating of 3 indicates that, in addition to an above grade structure or larger underground structure, suction isolation valves are required and a supplemental external cooling system is required.

The overall results of the pump type scoring matrix are shown in Table 3-1 below.

Pump Type Scoring Matrix					
Pump Types	Pump Efficiency	Capital Cost	Lifecycle Cost	System Requirements	**Total Score**
Vertical Submersible Axial Flow Pump	1	1	1	1	**4**
Vertical Turbine Solids Handling Pump	1	3	3	2	**9**
Submersible Solids Handling Pump	1	2	2	1	**6**
Dry Pit Submersible Pump	1	2	2	3	**8**

Pump Types	Pump Efficiency	Capital Cost	Lifecycle Cost	System Requirements	**Total Score**
Dry Pit Pumps with Frame Mounted Bearing and Extended Shaft	1	2	3	3	**9**
Vertical Axial Flowline Shaft Pumps	1	1	1	2	**5**

The vertical submersible axial flow pump is considered the most favorable option.

Vertical Submersible Axial Flow Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	
Capital costs provided by vendors were typically between $60,000 and $100,000 per pump.	
One of the lower lifecycle costs due to a low cost of replacement, smaller motor horsepower requirements and no maintenance costs associated with an external cooling system.	
Will not require suction isolation valves or a supplemental external cooling system.	
No drywell or above grade structure needed to for pump motor. Pump motor not susceptible to flooding.	

The vertical axial flowline shaft pump is tied as the second most favorable option.

Vertical Axial Flowline Shaft Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Motors will most likely need some type of above grade structure for protection and the motor will be susceptible to flooding.
Capital costs provided by vendors were typically between $80,000 and $100,000 per pump.	
One of the lower lifecycle costs due to a low cost of replacement, smaller motor horsepower requirements and no maintenance costs associated with an external cooling system.	
Will not require suction isolation valves or a supplemental external cooling system.	

The submersible solids handling pump is tied as the second most favorable option.

Submersible Solids Handling Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Somewhat higher lifecycle costs due to higher motor horsepower requirements which translates to higher electrical costs.
Will not require suction isolation valves or a supplemental external cooling system	Capital costs provided by vendors were typically between $120,000 and $170,000 per pump.
No drywell or above grade structure needed to for pump motor. Pump motor not susceptible to flooding.	

The vertical turbine solids handling pump is tied as the fourth most favorable option.

Vertical Turbine Solids Handling Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Capital costs provided by vendors were typically between $150,000 and $250,000 per pump.
Will not require suction isolation valves or a supplemental external cooling system	One of the highest lifecycle costs due to a high cost of replacement.
	Motors will most likely need some type of above grade structure for protection and the motor will be susceptible to flooding.

The drypit submersible pump is tied as the fourth most favorable option.

Drypit Submersible Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Capital costs provided by vendors were typically between $115,000 and $200,000 per pump.
	Somewhat higher lifecycle costs due to higher motor horsepower requirements which translates to higher electrical costs.
	Will require suction isolation valves and a supplemental external cooling system
	Will require a larger underground structure to house the dry side of the pump system

The drypit pump with a frame mounted bearing and extended shaft was the least favorable option

Drypit Submersible Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Capital costs provided by vendors were typically between $150,000 and $200,000 per pump.
	One of the highest lifecycle costs due to a high cost of replacement and higher motor horsepower requirements which translates to higher electrical costs..
	Will require suction isolation valves or a supplemental external cooling system
	Motors will most likely need some type of above grade structure for protection and the motor will be susceptible to flooding.

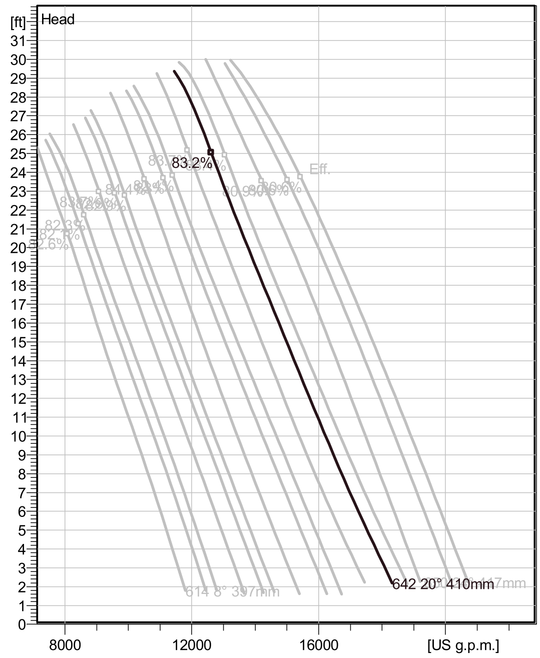
Vertical Submersible Axial Flow Pump

PL 7040 ** 3~ 642

Axial flow propeller pumps with fixed or adjustable pitch blades for high capacity low head pumping of clean or slightly contaminated liquids. Cast iron design optimized for high-flow efficiency.

Technical specification

Curves according to: Water, pure [100%],39.2 °F,62.43 lb/ft³,1.6888E-5 ft²/s



Curve: ISO 9906

Configuration

Motor number P7040.090 35-29-6AA-W 100hp	**Installation type** L - Column pipe Semi permanent, Wet
Impeller diameter 410 mm	**Discharge diameter** 23 5/8 inch

Pump information

Impeller diameter
410 mm

Discharge diameter
23 5/8 inch

Inlet diameter

Maximum operating speed
1180 rpm

Number of blades
3

Max. fluid temperature
40 °C

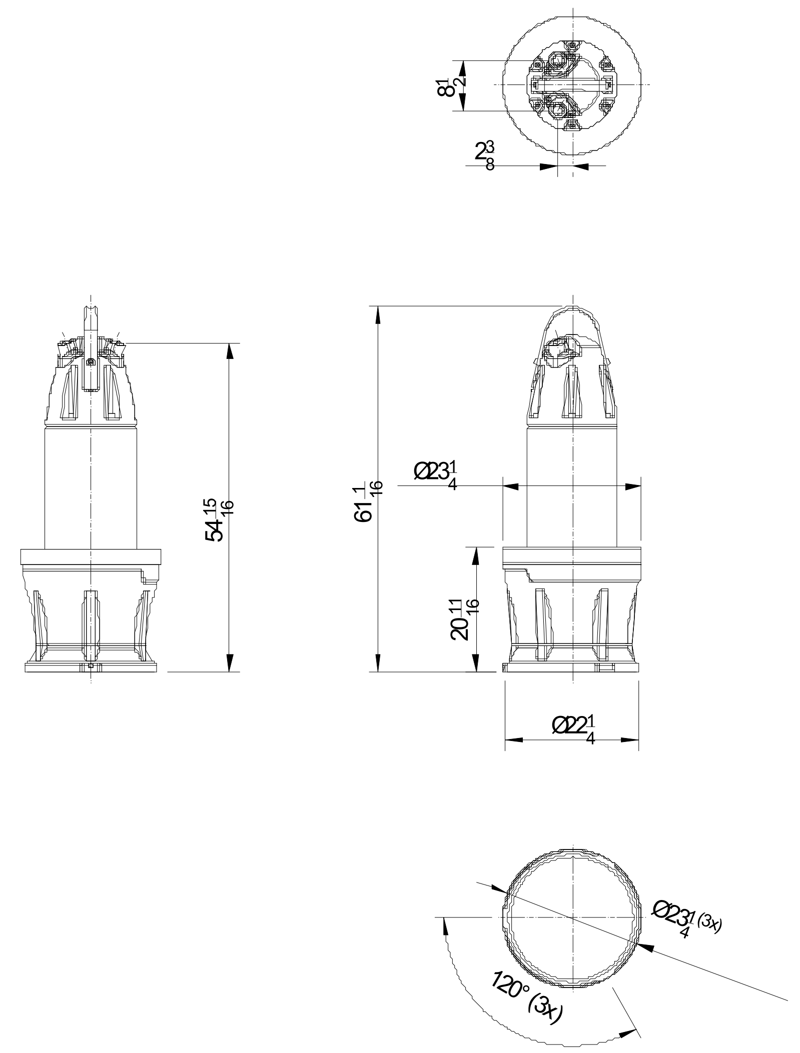
Materials

Impeller
Stainless steel

Project		**Created by**		**Last update**
Block	0	**Created on**	7/7/2020	

PL 7040 ** 3~ 642

Dimensional drawing



Weight (lbs)					
Pump					
1765					
PL	7040		Scale 1:20	Date 190911	
090, 180			Drawing number 7738900	Revision 8	

Project		**Created by**	**Last update**
Block	0	**Created on** 7/7/2020	

Vertical Turbine Solids Handling Pump

PENTAIR

Customer :
Project name : Default

Pump Performance Datasheet

Encompass 2.0 - 20.2.3

Item number	: 001	Size	: 24 VTSH-A
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 24 VTSH-A V24A1A 705RPM Rev 2
Quote number	: 256297	Date last saved	: 02 Jul 2020 11:42 AM

Operating Conditions

Flow, rated	: 12,867.0 USgpm
Differential head / pressure, rated (requested)	: 23.00 ft
Differential head / pressure, rated (actual)	: 23.02 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Site Supply Frequency	: 60 Hz

Performance

Speed criteria	: Synchronous
Speed, rated	: 504 rpm
Impeller diameter, rated	: 24.36 in
Impeller diameter, maximum	: 25.38 in
Impeller diameter, minimum	: 21.06 in
Efficiency (bowl / pump)	: 83.06 / - %
NPSH required / margin required	: 14.78 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 79 / 159 Metric units
Minimum Continuous Stable Flow	: 5,549.5 USgpm
Head, maximum, rated diameter	: 50.77 ft
Head rise to shutoff (bowl / pump)	: 120.72 / - %
Flow, best eff. point (bowl / pump)	: 10,893.1 / - USgpm
Flow ratio, rated / BEP (bowl / pump)	: 118.12 / - %
Diameter ratio (rated / max)	: 95.98 %
Head ratio (rated dia / max dia)	: 85.07 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids diameter limit	: 6.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

Material selected	: Standard Material

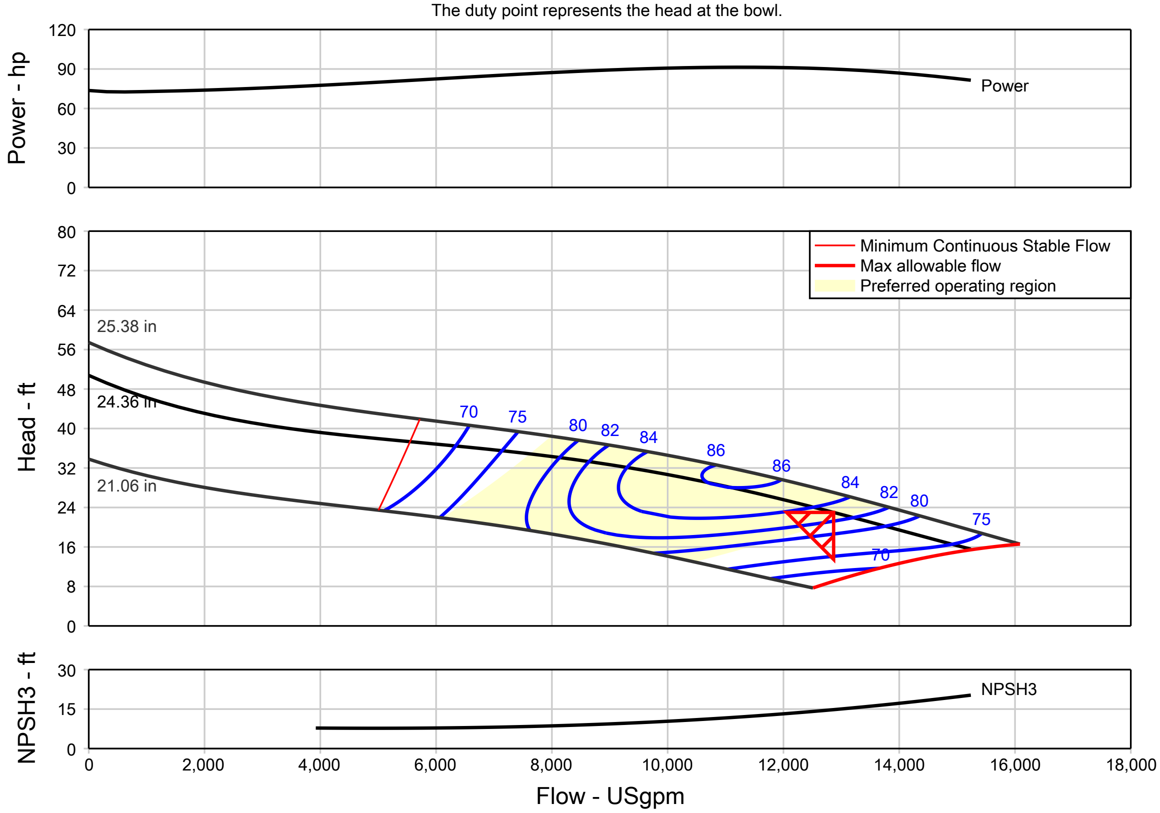
Pressure Data

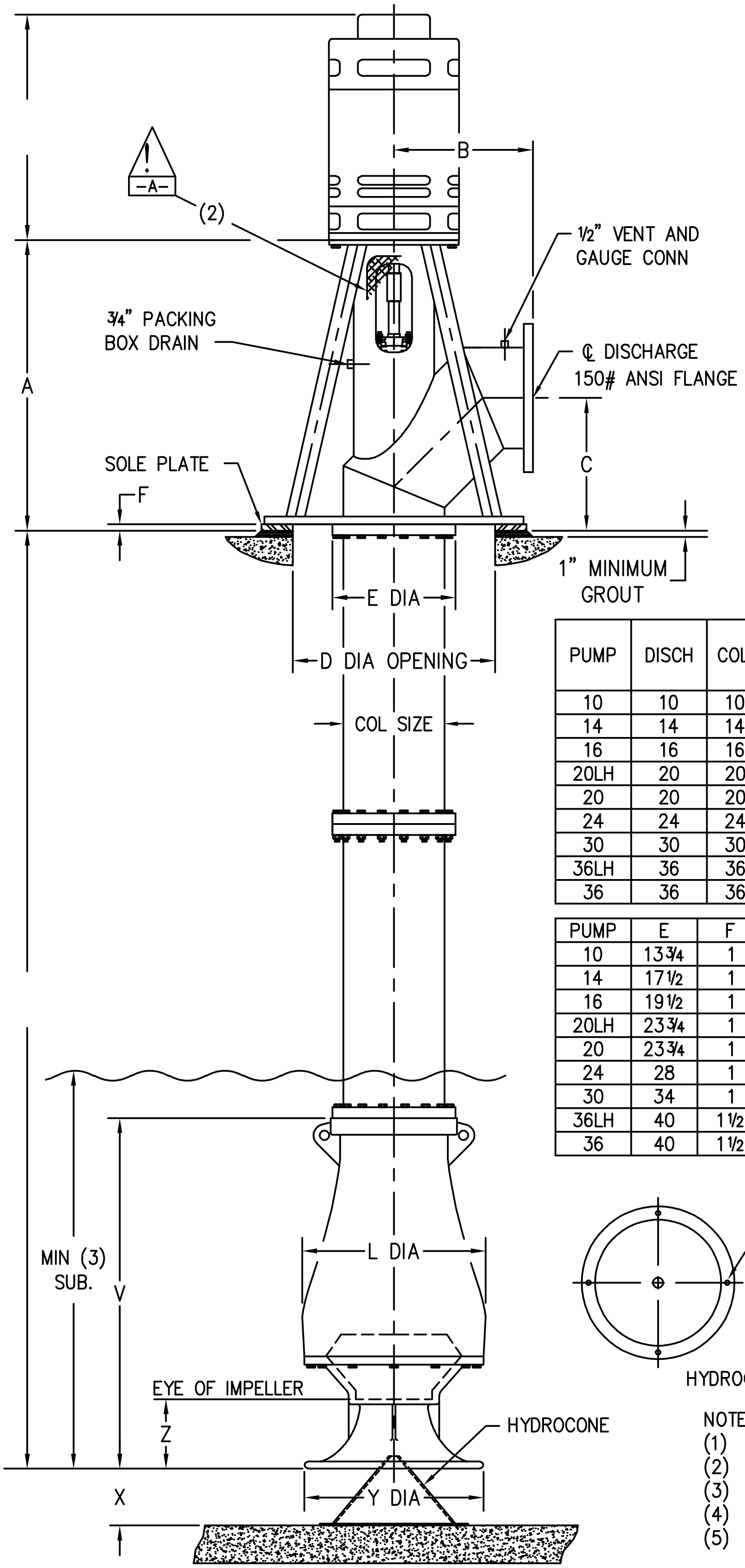
Maximum working pressure	: See the Additional Data page
Maximum allowable working pressure	: See the Additional Data page
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: See the Additional Data page

Driver & Power Data (@Max density)

Driver sizing specification	: Maximum Power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 74.72 hp
Power (bowl / pump)	: 89.95 / - hp
Power, maximum, rated diameter	: 91.38 hp
Minimum recommended motor rating	: 100 hp / 74.57 kW

Bowl performance. Adjusted for construction and viscosity.
The duty point represents the head at the bowl.

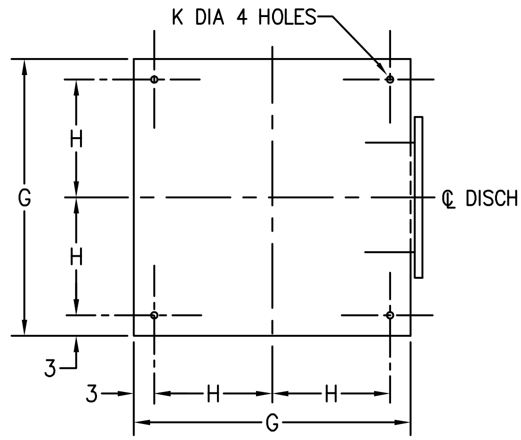




WARNING

DO NOT OPERATE THIS MACHINE WITHOUT PROTECTIVE GUARD IN PLACE. ANY OPERATION OF THIS MACHINE WITHOUT PROTECTIVE GUARD CAN RESULT IN SEVERE BODILY INJURY.

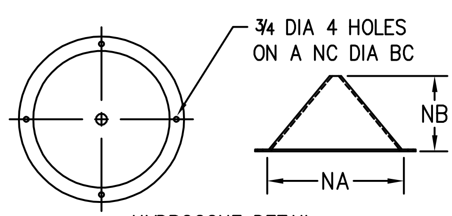
—A— SUPPLIED BY FMPC —B— SUPPLIED BY OTHERS



SOLE PLATE ANCHORING DIMENSIONS

PUMP	DISCH	COL.	A					B	C	D
			MOTOR BASE DIAMETER							
			10–12	16 1/2	20	24 1/2	30 1/2			
10	10	10	36 1/2	36 1/2	– –	– –	– –	17 1/2	16	23
14	14	14	41	43	46	– –	– –	21	22	30
16	16	16	44	45 1/2	49 1/2	– –	– –	22 1/2	25	33
20LH	20	20	– –	51	56	57	– –	27	31	32
20	20	20	– –	51	56	57	– –	27	31	42
24	24	24	– –	56 1/2	61 1/2	62 1/2	70 1/2	32	37	52
30	30	30	– –	– –	69 1/2	70 1/2	78 1/2	39	46	62
36LH	36	36	– –	– –	– –	80 1/2	89 1/2	45	55	64
36	36	36	– –	– –	– –	80 1/2	89 1/2	45	55	74

PUMP	E	F	G	H	K	L	V	X	Y	Z
10	13 3/4	1	33	13 1/2	1	19 1/8	37	6 1/2	19	7 3/8
14	17 1/2	1	40	17	1	25 7/8	50 1/2	8 1/4	25 7/8	10
16	19 1/2	1	43	18 1/2	1	29 3/8	55 1/2	9	28 3/8	11 1/4
20LH	23 3/4	1	52	23	1	28 3/8	49 3/8	9	28 1/4	10 1/2
20	23 3/4	1	52	23	1	37 3/4	73 5/8	12	37 5/8	14 1/2
24	28	1	62	28	1 1/4	47 5/8	83 1/4	15 1/4	48	14 3/8
30	34	1	72	33	1 1/4	57	100 1/2	19	58	17 3/8
36LH	40	1 1/2	84	39	1 3/8	57 5/8	109 1/2	19 1/2	60	25 7/8
36	40	1 1/2	84	39	1 3/8	68 3/8	120 9/16	23	69 9/16	21 1/2



HYDROCONE DETAIL

PUMP	NA	NB	NC
10	14	7	16
14	18 1/2	8 1/4	20 1/2
16	20	11	22
20LH	20	11	22
20	28	15	30
24	34	18	36
30	42	23	44
36LH	57	27	59
36	50 1/2	27 1/2	52 1/2

NOTES:
(1) ALL DIMENSIONS ARE IN INCHES UNLESS NOTED.
(2) GUARD FURNISHED WHEN FLANGED COUPLING IS USED.
(3) REFER TO SUBMERGENCE CHART FOR MIN. SUBMERGENCE.
(4) SOLEPLATE TO HAVE FULL CONTACT WITH GROUT.
(5) NOT FOR CONSTRUCTION, INSTALLATION, OR APPLICATION PURPOSES UNLESS CERTIFIED. DIMENSIONS SHOWN MAY VARY DUE TO NORMAL MANUFACTURING TOLERANCES.

CUSTOMER | P.O. NO.
JOB NAME | TAG NAME
PUMP SIZE AND MODEL | GPM | TDH | RPM | ROTATION
MOTOR | HP | FRAME | PHASE | HERTZ | VOLTS | ENCLOSURE
CERTIFIED FOR | CERTIFIED BY | DATE

Fairbanks Morse®
Pentair Water

SETTING PLAN
VERTICAL TURBINE
SOLIDS HANDLING
ABOVE GROUND DISCH

DWG NO VTSHS001 REV NO 5

Submersible Solids Handling Pump

Customer :
Project name : Default

Pump Performance Datasheet

Encompass 2.0 - 20.2.3

Item number	: 001	Size	: 24" 5731 (L24A1L) (W, WD)
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 24-57x1-600-L24A1L
Quote number	: 256297	Date last saved	: 02 Jul 2020 5:21 PM

Operating Conditions

Flow, rated	: 12,867.0 USgpm
Differential head / pressure, rated (requested)	: 23.00 ft
Differential head / pressure, rated (actual)	: 23.71 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Site Supply Frequency	: 60 Hz

Performance

Speed criteria	: Synchronous
Speed, rated	: 390 rpm
Impeller diameter, rated	: 27.75 in
Impeller diameter, maximum	: 27.75 in
Impeller diameter, minimum	: 24.75 in
Efficiency	: 85.92 %
NPSH required / margin required	: 8.68 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 77 / 169 Metric units
Minimum Continuous Stable Flow	: 4,095.0 USgpm
Head, maximum, rated diameter	: 33.06 ft
Head rise to shutoff	: 43.74 %
Flow, best eff. point	: 12,144.5 USgpm
Flow ratio, rated / BEP	: 105.95 %
Diameter ratio (rated / max)	: 100.00 %
Head ratio (rated dia / max dia)	: 97.00 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids diameter limit	: 9.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

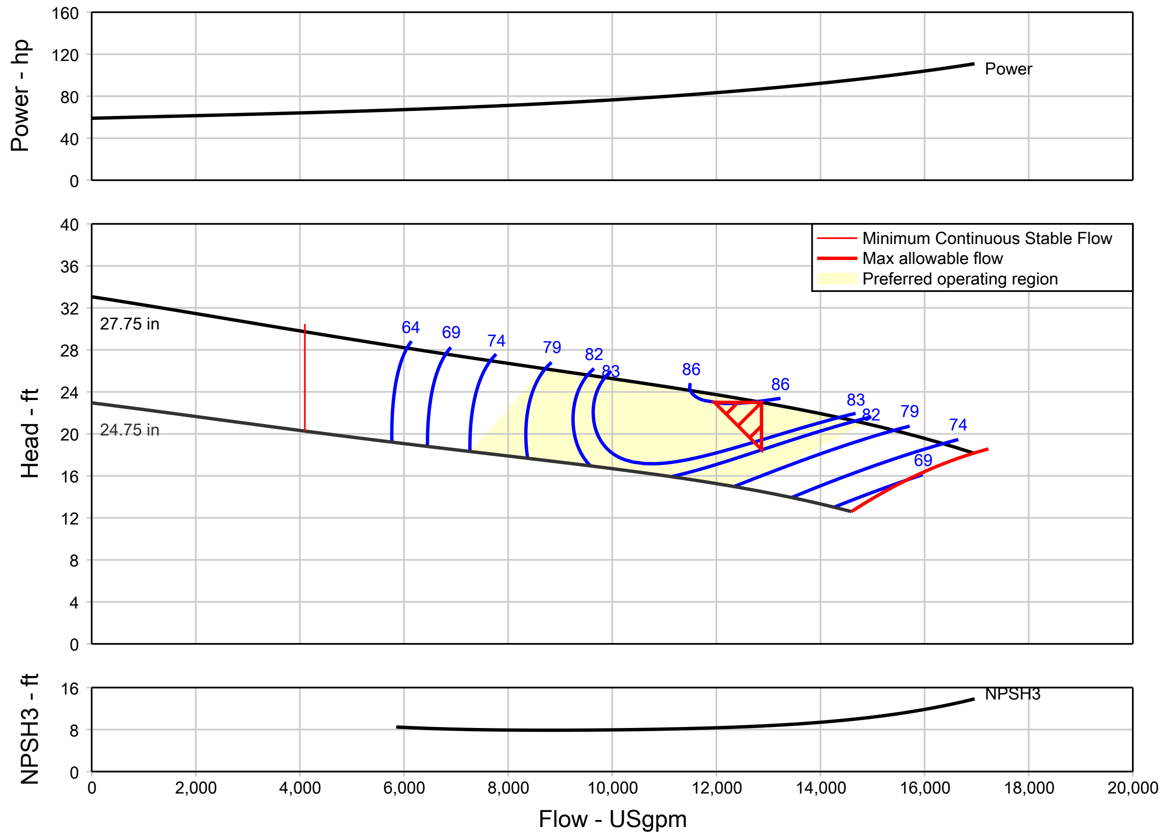
Material selected	: Cast Iron

Pressure Data

Maximum working pressure	: 14.31 psi.g
Maximum allowable working pressure	: 50.00 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: 75.00 psi.g

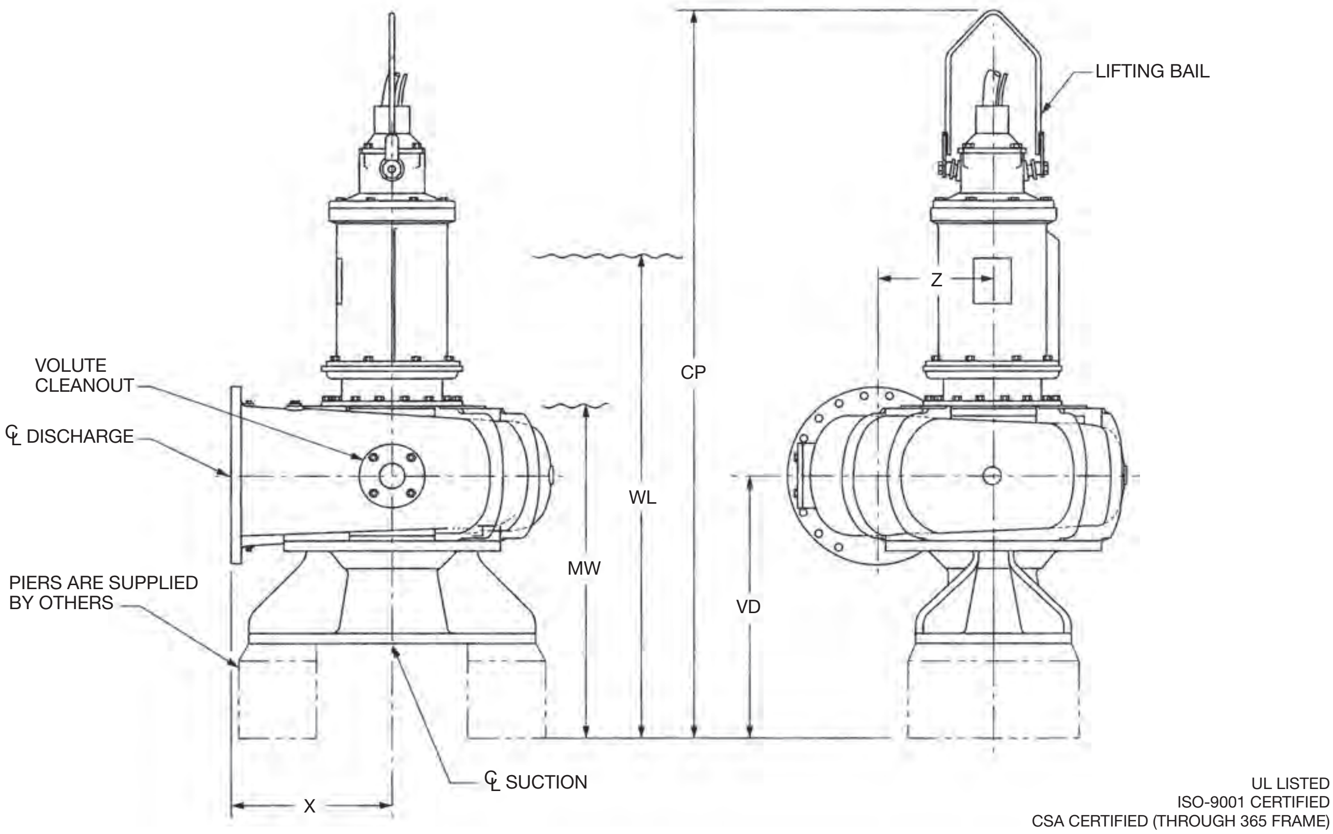
Driver & Power Data (@Max density)

Driver sizing specification	: Max Power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 74.71 hp
Power, rated	: 86.95 hp
Power, maximum, rated diameter	: 111 hp
Minimum recommended motor rating	: N/A



GRANICH ENGINEERED PRODUCTS INC
1313 SOUTH 96TH STREET · SEATTLE, WA 98108
PHONE: · FAX:

Dimensional Data – 12" THRU 24" D5731W SUBMERSIBLE



UL LISTED
ISO-9001 CERTIFIED
CSA CERTIFIED (THROUGH 365 FRAME)

PUMP	MOTOR FRAME	DISCH	X	Z	CP	MW	VD	WL
12" D5731W	250T	12	15	10-3/4	82-3/8	35-1/2	27-1/2	61
12" D5731W	320T	12	15	10-3/4	90-7/8	35-1/2	27-1/2	67
12" D5731W	360T	12	15	10-3/4	91-3/8	35-1/2	27-1/2	69
14" D5731W	320T	14	17-1/2	12-3/4	94	38-5/8	30-5/8	70
14" D5731W	360T	14	17-1/2	12-3/4	94-1/2	38-5/8	30-5/8	72
14" D5731W	440T	14	17-1/2	12-3/4	126-1/8	38-5/8	30-5/8	85-1/8
16" D5731W	320T	16	20	14-1/2	98-3/8	43	35	74
16" D5731W	360T	16	20	14-1/2	98-7/8	43	35	76
16" D5731W	440T	16	20	14-1/2	130-1/2	43	35	89-1/2
18" D5731W	360T	18	22-1/2	16-3/8	102	46-1/4	37-5/8	79
18" D5731W	440T	18	22-1/2	16-3/8	133-3/4	46-1/4	37-5/8	92-3/4
20" D5731SW	440T	20	25	18	137-3/4	50-1/4	41	96-3/4
20" D5731LW	440T	20	25	18	137-3/4	50-1/4	41	96-3/4
20" D5731SW	490T	20	25	18	157-5/8	50-1/2	41-1/4	101-3/8
20" D5731LW	490T	20	25	18	157-5/8	50-1/2	41-1/4	101-3/8
24" D5731W	490T	24	30	20-5/8	165-3/4	58-5/8	48	109-1/2

Piers are supplied by others.

NOTES:

All flanges are 125# ANSI drilling unless noted.

All dimensions are in inches unless noted.

Recommended low water level for continuous operation. 210 frame and water jacketed 250 through 440 frame units can operate continuously at "MW" water level.

Not for construction, installation or application purposes unless certified. Dimensions shown may vary due to normal manufacturing tolerances.

Water level may be drawn down to this level for short time duty in air motor ratings. Draw down can occur over a period of 15 minutes.

Dry Pit Submersible Pump

Customer :
Project name : Default

Pump Performance Datasheet

Encompass 2.0 - 20.2.3

Item number	: 001	Size	: 24" 5731 (L24A1L) (W, WD)
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 24-57x1-600-L24A1L
Quote number	: 256297	Date last saved	: 02 Jul 2020 5:21 PM

Operating Conditions

Flow, rated	: 12,867.0 USgpm
Differential head / pressure, rated (requested)	: 23.00 ft
Differential head / pressure, rated (actual)	: 23.71 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Site Supply Frequency	: 60 Hz

Performance

Speed criteria	: Synchronous
Speed, rated	: 390 rpm
Impeller diameter, rated	: 27.75 in
Impeller diameter, maximum	: 27.75 in
Impeller diameter, minimum	: 24.75 in
Efficiency	: 85.92 %
NPSH required / margin required	: 8.68 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 77 / 169 Metric units
Minimum Continuous Stable Flow	: 4,095.0 USgpm
Head, maximum, rated diameter	: 33.06 ft
Head rise to shutoff	: 43.74 %
Flow, best eff. point	: 12,144.5 USgpm
Flow ratio, rated / BEP	: 105.95 %
Diameter ratio (rated / max)	: 100.00 %
Head ratio (rated dia / max dia)	: 97.00 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids diameter limit	: 9.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

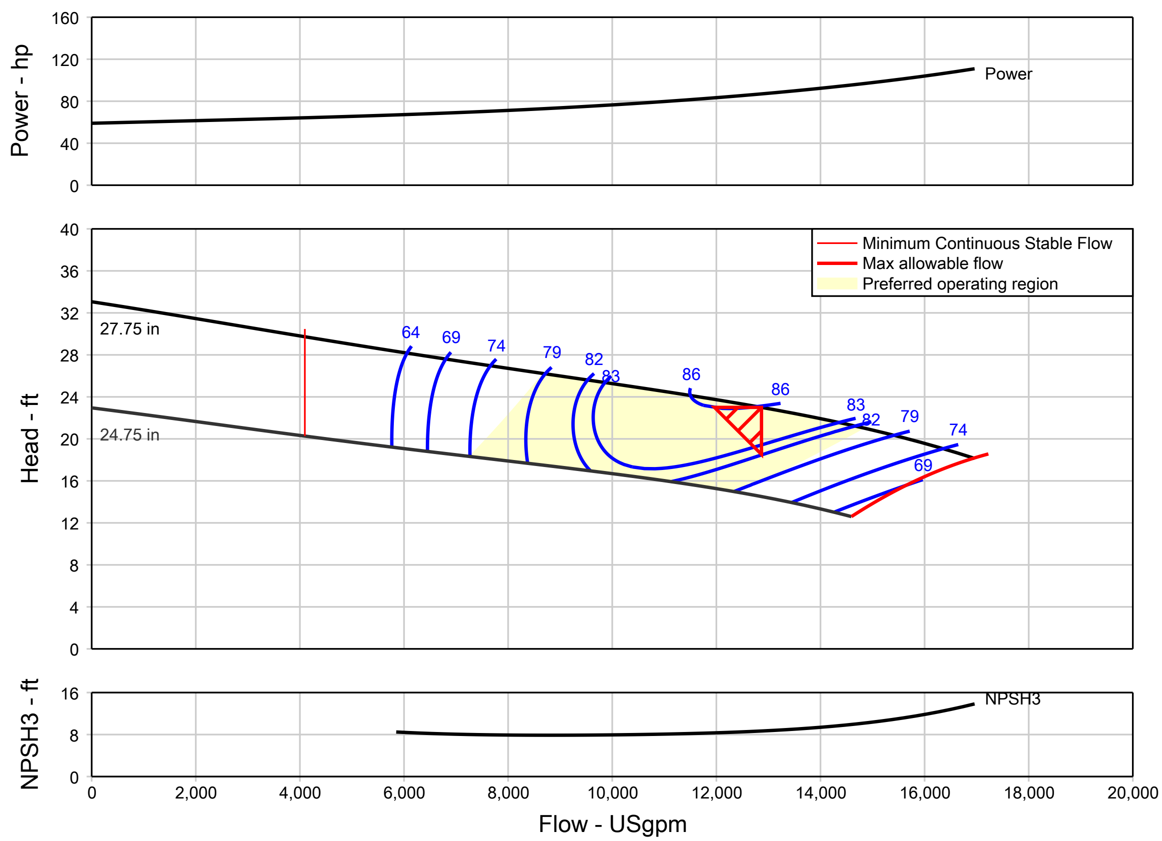
Material selected	: Cast Iron

Pressure Data

Maximum working pressure	: 14.31 psi.g
Maximum allowable working pressure	: 50.00 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: 75.00 psi.g

Driver & Power Data (@Max density)

Driver sizing specification	: Max Power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 74.71 hp
Power, rated	: 86.95 hp
Power, maximum, rated diameter	: 111 hp
Minimum recommended motor rating	: N/A

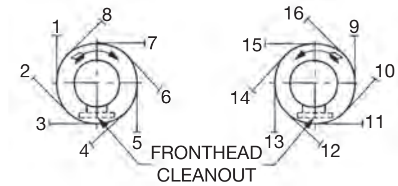


GRANICH ENGINEERED PRODUCTS INC
1313 SOUTH 96TH STREET · SEATTLE, WA 98108
PHONE: · FAX:

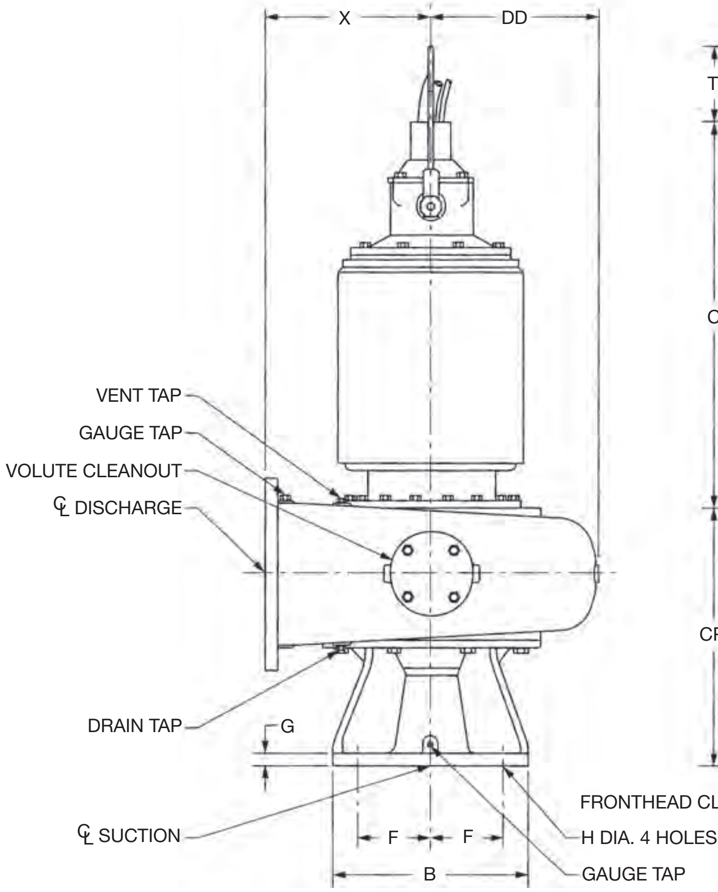
MOTOR DIMENSIONS		
FRAME	C	T
250T	34	N/A
320T	42-1/2	N/A
360T	48	N/A
365T	50	N/A
400T	RTF	RTF
440T	72-1/2	15
490T	92-1/8	15

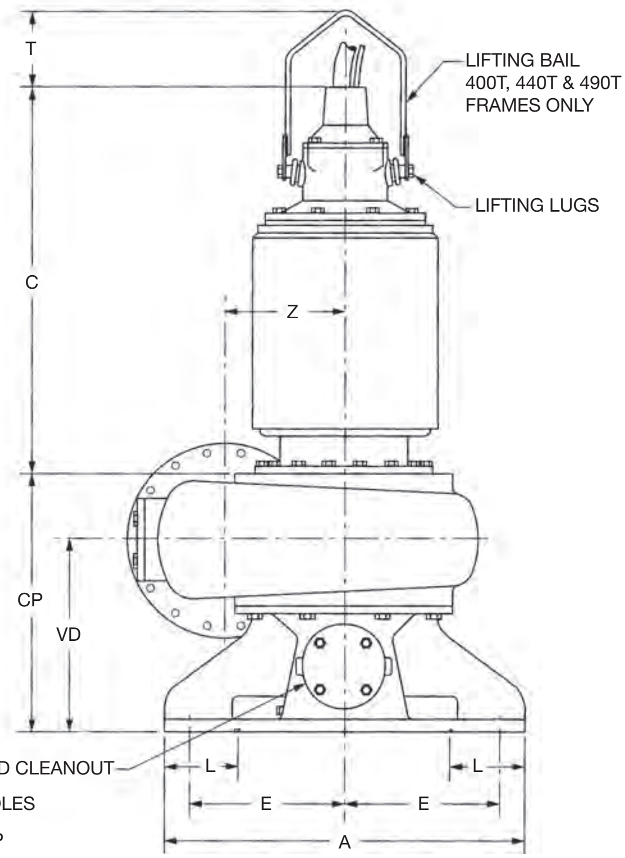
AVAILABLE DISCHARGE POSITIONS

CLOCKWISE COUNTERCLOCKWISE



POSITIONS #1 OR #9 ARE STANDARD WHEN VIEWED FROM THE DRIVER END UNLESS OTHERWISE SPECIFIED. CLOCKWISE ROTATION DISCHARGE POSITION #1 SHOWN.





UL LISTED
ISO-9001 CERTIFIED
CSA CERTIFIED (THROUGH 365 FRAME)

PUMP	MOTOR FRAME	SUCT	DISCH	A	B	E	F	G	H	L	X	Z	CP	DD	VD
12" D5731WD	250T – 320T – 360T	12	12	34	20	15-1/4	7-1/4	1-1/4	1-1/4	7	15	10-3/4	26-1/2	14-15/16	18-1/2
14" D5731WD	320T – 440T	14	14	38	21	16-1/2	7-1/2	1-3/8	1-1/4	8	17-1/2	12-3/4	28-1/8	17-3/4	20-1/8
16" D5731WD	320T – 440T	16	16	43-1/2	23-1/2	18-3/4	8-3/4	1-1/2	1-3/8	9	20	14-1/2	31	20-1/8	23
18" D5731WD	360T – 440T	18	18	46	25	21	9-1/2	1-9/16	1-3/8	9	22-1/2	16-3/8	32-5/8	22-3/4	24
20" D5731SWD	440T – 490T	20	20	42	27-1/2	19-1/4	10-1/2	1-11/16	1-3/8	6-1/2	25	18	35-1/4	24-3/4	26
20" D5731LWD	440T – 490T	20	20	46	46	20	20	1-1/4	1-1/2	N/A	25	18	35-1/4	24-3/4	26
24" D5731WD	490T	24	24	54	32	22	12-1/2	1-3/4	1-3/8	N/A	30	20-5/8	40-5/8	31-7/8	30

NOTES:

All flanges are 125# ANSI drilling unless noted.

All dimensions are in inches unless noted.

Bases are designed to have full contact with grout or a sole plate grouted in place.

Not for construction, installation or application purposes unless certified. Dimensions shown may vary due to normal manufacturing tolerances.

Lifting bail supplied as standard with 400, 440 and 490 frame units.

Dry Pit Pump with Frame Mounted Bearing and Extended Shaft

Customer :
Project name : Default

Pump Performance Datasheet

Encompass 2.0 - 20.2.3

Item number	: 005	Size	: 24" 57X1 (L24A1L)
Service	:	Stages	: 1
Quantity	: 1	Based on curve number	: 24-57x1-600-L24A1L
Quote number	: 256297	Date last saved	: 02 Jul 2020 12:04 PM

Operating Conditions

Flow, rated	: 12,867.0 USgpm
Differential head / pressure, rated (requested)	: 23.00 ft
Differential head / pressure, rated (actual)	: 23.66 ft
Suction pressure, rated / max	: 0.00 / 0.00 psi.g
NPSH available, rated	: Ample
Site Supply Frequency	: 60 Hz

Performance

Speed criteria	: Synchronous
Speed, rated	: 390 rpm
Impeller diameter, rated	: 27.75 in
Impeller diameter, maximum	: 27.75 in
Impeller diameter, minimum	: 24.75 in
Efficiency	: 85.45 %
NPSH required / margin required	: 8.68 / 0.00 ft
nq (imp. eye flow) / S (imp. eye flow)	: 77 / 169 Metric units
Minimum Continuous Stable Flow	: 4,095.0 USgpm
Head, maximum, rated diameter	: 33.04 ft
Head rise to shutoff	: 43.67 %
Flow, best eff. point	: 12,158.6 USgpm
Flow ratio, rated / BEP	: 105.83 %
Diameter ratio (rated / max)	: 100.00 %
Head ratio (rated dia / max dia)	: 97.20 %
Cq/Ch/Ce/Cn [ANSI/HI 9.6.7-2010]	: 1.00 / 1.00 / 1.00 / 1.00
Selection status	: Acceptable

Liquid

Liquid type	: Water
Additional liquid description	:
Solids diameter, max	: 0.00 in
Solids diameter limit	: 9.00 in
Solids concentration, by volume	: 0.00 %
Temperature, max	: 68.00 deg F
Fluid density, rated / max	: 1.000 / 1.000 SG
Viscosity, rated	: 1.00 cP
Vapor pressure, rated	: 0.34 psi.a

Material

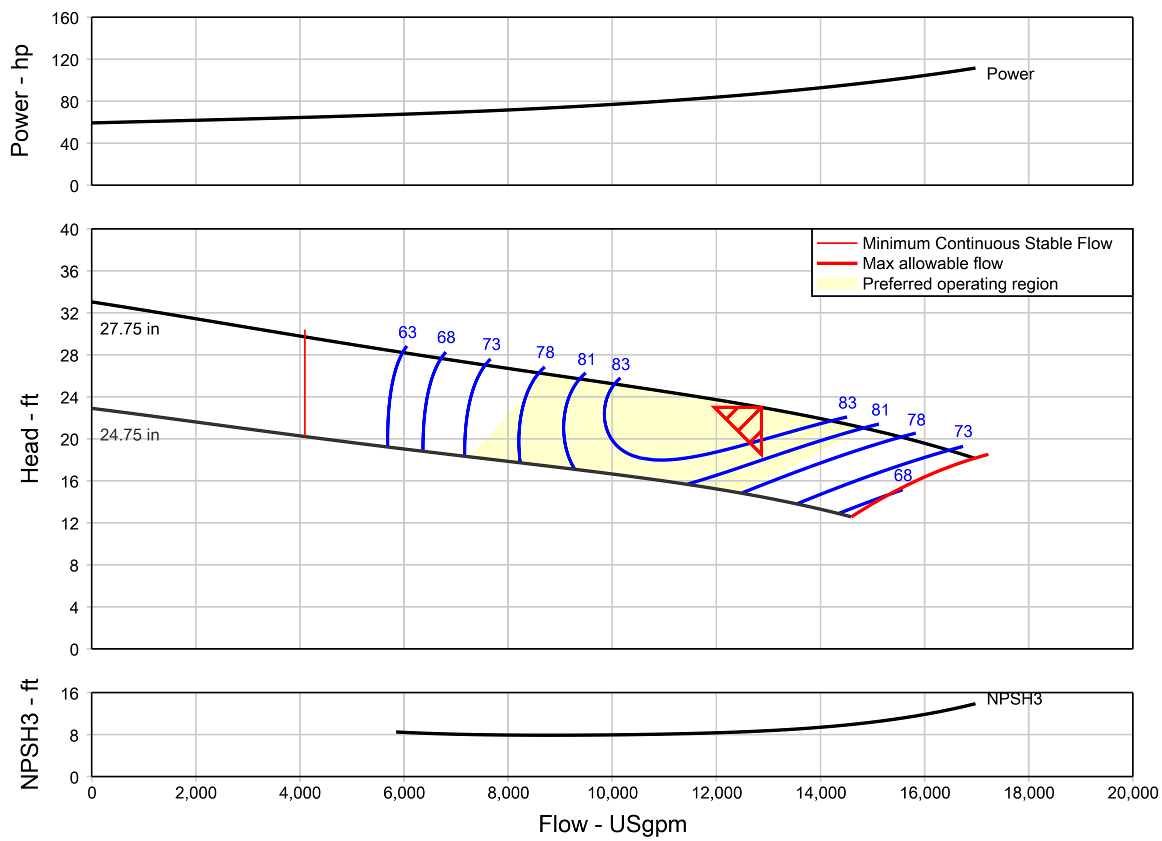
Material selected	: Cast Iron

Pressure Data

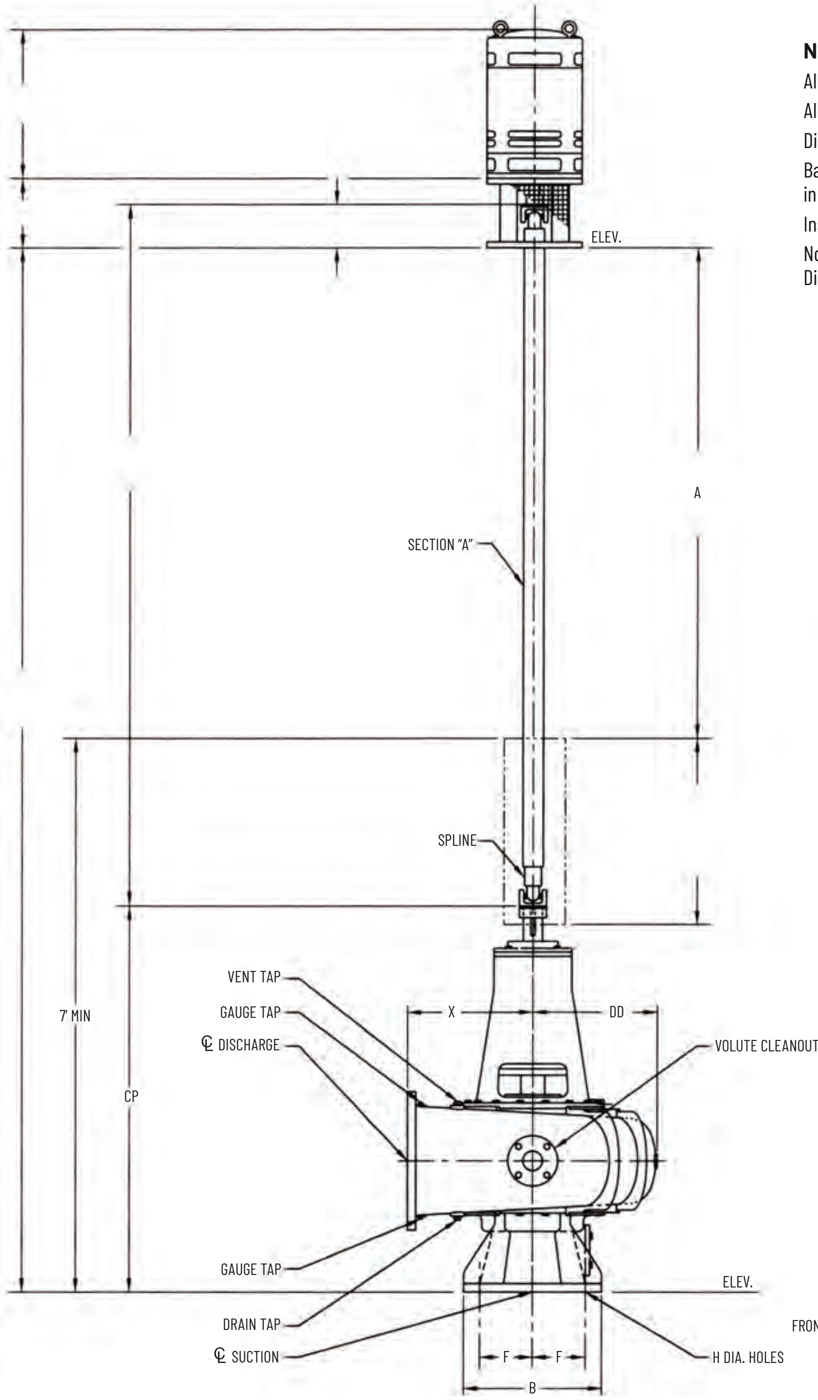
Maximum working pressure	: 14.30 psi.g
Maximum allowable working pressure	: 50.00 psi.g
Maximum allowable suction pressure	: N/A
Hydrostatic test pressure	: 75.00 psi.g

Driver & Power Data (@Max density)

Driver sizing specification	: Max Power
Margin over specification	: 0.00 %
Service factor	: 1.00
Power, hydraulic	: 74.71 hp
Power, rated	: 87.43 hp
Power, maximum, rated diameter	: 112 hp
Minimum recommended motor rating	: 125 hp / 93.21 kW



Dimensional Data – SETTING PLAN 8", 20" THRU 36" C5711 ONE-SECTION INTERMEDIATE SHAFT



NOTES:

All flanges are 125# ANSI drilling unless noted.

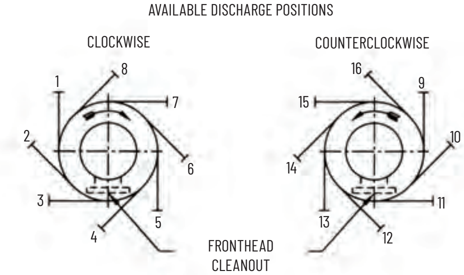
All dimensions are in inches unless noted.

Dimensions reflect usable shaft length.

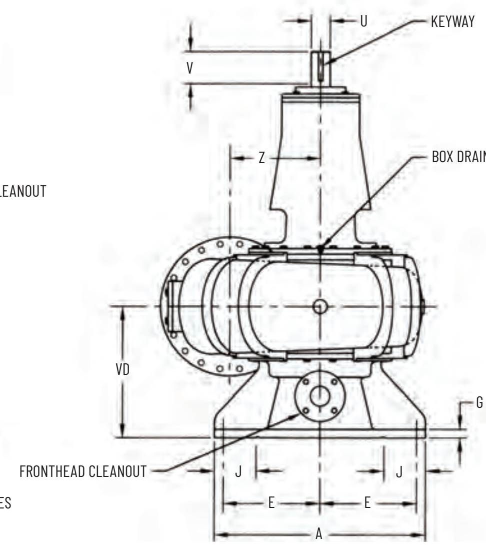
Bases are designed to have full contact with grout or a sole plate grouted in place.

Install drive shaft per manufacturer's recommendation.

Not for construction, installation, or application purposes unless certified. Dimensions shown may vary due to normal manufacturing tolerances.



POSITIONS #1 OR #9 ARE STANDARD WHEN VIEWED FROM THE DRIVER END UNLESS OTHERWISE SPECIFIED. CLOCKWISE ROTATION DISCHARGE POSITION #1 SHOWN.



PUMP	SUCT	DISCH	A	B	E	F	G	H	J	U	V	X	Z	CP	DD	VD	KEYWAY
8" C5711	8	8	23-1/2	16	10-3/4	5-3/4	1-1/8	1-1/8	4	1-7/8	3-13/16	10	7-1/4	40-5/8	10-3/8	14	1/2 X 1/4 X 3
20" C5711L	20	20	46	46	20	20	1-1/4	1-1/2	NA	3-3/4	7	25	18	76-5/8	24-3/4	26	7/8 X 7/16 X 5-9/16
20" C5711S	20	20	42	27-1/2	19-1/4	10-1/2	1-11/16	1-3/8	6-1/2	3-3/4	7	25	18	76-5/8	24-3/4	26	7/8 X 7/16 X 5-9/16
24" C5711	24	24	54	32	22	12-1/2	1-3/4	1-3/8	10	4-1/2	7	30	20-5/8	92	31-7/8	30	1 X 1/2 X 6
30" C5711	30	30	61	42	25-1/2	16	2-1/8	1-3/8	10	4-9/16	9-1/2	37-1/2	27-1/4	109-3/4	40-1/8	36	1-1/4 X 5/8 X 7-3/8
36" C5711	36	36	78	52	36	20	2-1/2	1-5/8	NA	5	8-7/8	39	33-3/4	133	49	46	1-1/4 X 5/8 X 8

The drypit submersible pump is tied as the fourth most favorable option.

Drypit Submersible Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Capital costs provided by vendors were typically between $115,000 and $200,000 per pump.
	Somewhat higher lifecycle costs due to higher motor horsepower requirements which translates to higher electrical costs.
	Will require suction isolation valves and a supplemental external cooling system

The drypit pump with a frame mounted bearing and extended shaft was the least favorable option

Drypit Submersible Pump Pro/Con Table	
Pro	**Con**
Pump selections had pump efficiencies above 80%.	Capital costs provided by vendors were typically between $150,000 and $200,000 per pump.
	One of the highest lifecycle costs due to a high cost of replacement and higher motor horsepower requirements which translates to higher electrical costs..
	Will require suction isolation valves or a supplemental external cooling system

Vertical Axial Flowline Shaft Pumps

CASCADE PUMP COMPANY
10107 South Norwalk Boulevard • PO Box 2767
Santa Fe Springs, California 90670-0767

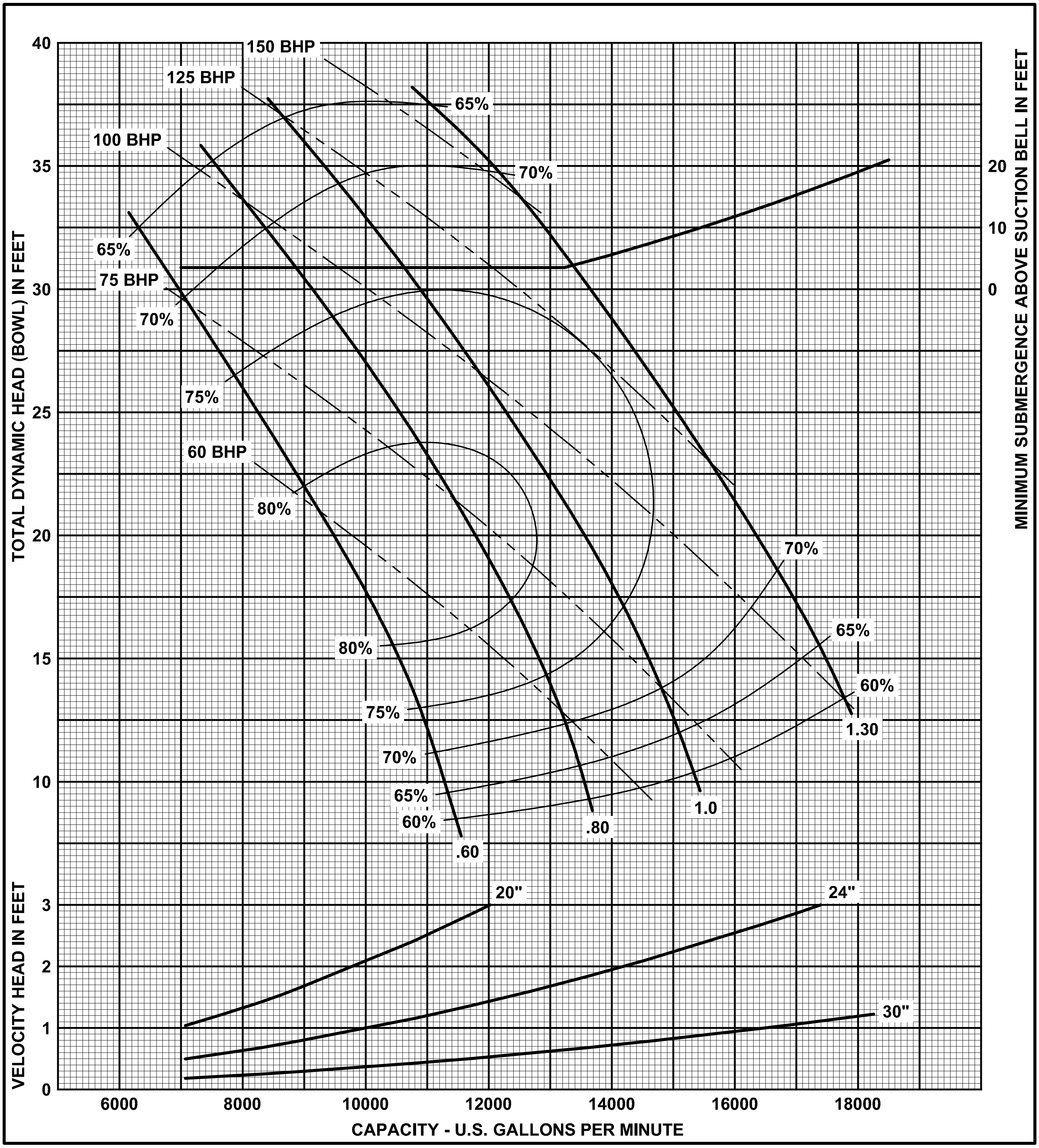
CURVE NUMBER	AP2006
DATE	06-03
SUPERCEDES	03-88

20

AP

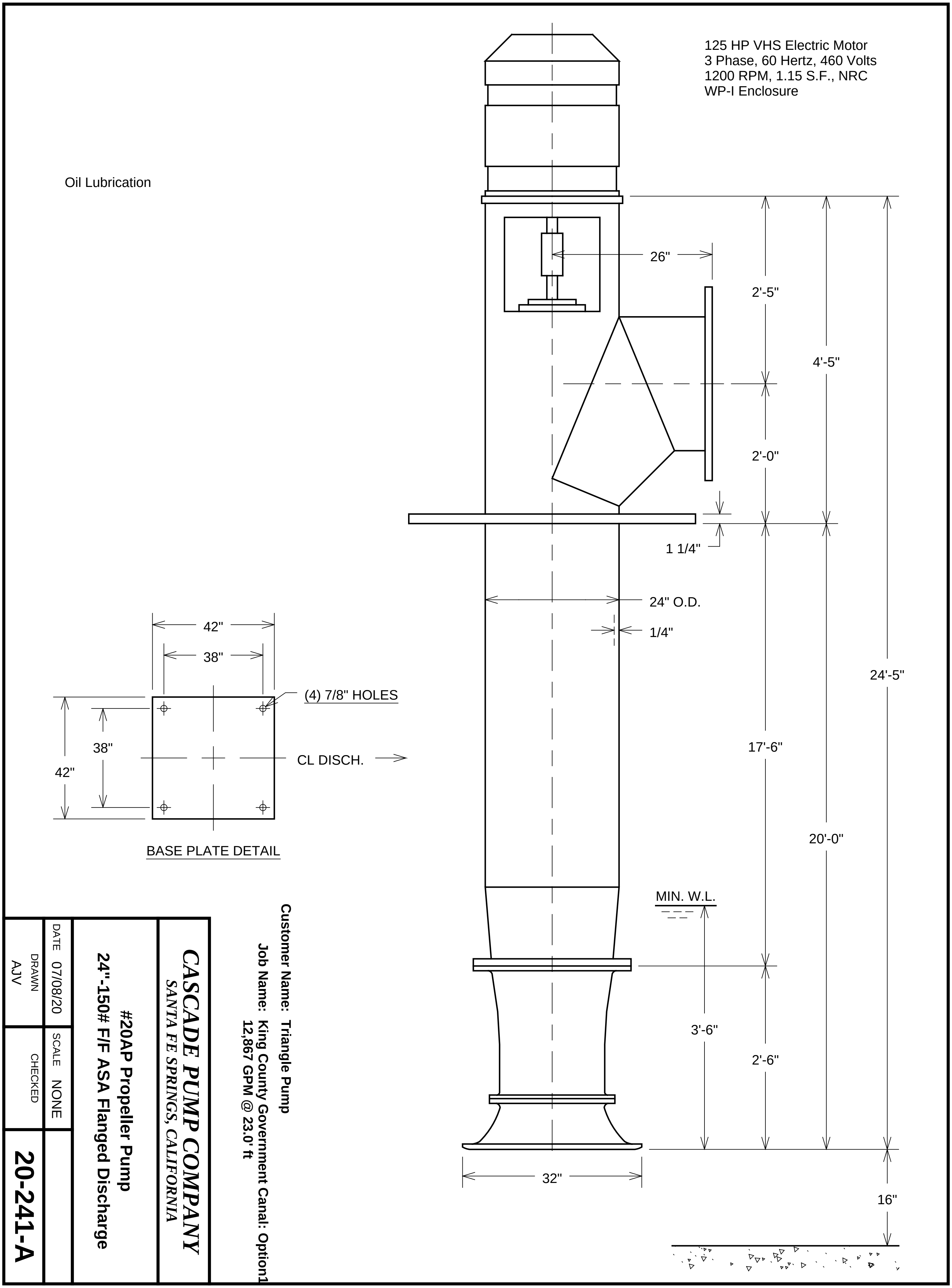
1175 RPM

CASCADE AXIAL FLOW PUMP



CURVE CHARACTERISTICS BASED ON PUMP PERFORMANCE WITH SPECIFIED AMOUNT OF CLEAR, NON-AERATED, FRESH COLD WATER.

THIS PERFORMANCE CURVE IS FOR ESTIMATING ONLY. CURVE SHOWS SINGLE STAGE PERFORMANCE. FOR MULTIPLE, VARIABLE AND OTHER SPEED APPLICATIONS, CONSULT FACTORY.



125 HP VHS Electric Motor
3 Phase, 60 Hertz, 460 Volts
1200 RPM, 1.15 S.F., NRC
WP-I Enclosure
Oil Lubrication
26"
2'-5"
4'-5"
2'-0"
1 1/4"
24" O.D.
1/4"
24'-5"
17'-6"
20'-0"
MIN. W.L.
3'-6"
2'-6"
32"
16"
42"
38"
(4) 7/8" HOLES
38"
42"
CL DISCH.
BASE PLATE DETAIL
Customer Name: Triangle Pump
Job Name: King County Government Canal: Option1
12,867 GPM @ 23.0' ft
CASCADE PUMP COMPANY
SANTA FE SPRINGS, CALIFORNIA
#20AP Propeller Pump
24"-150# F/F ASA Flanged Discharge
DATE 07/08/20
DRAWN AJV
SCALE NONE
CHECKED
20-241-A

Culvert/Flow Control Gate Evaluation

The following six flow control gates were evaluated. Images of each gate type are provided at the end of this section.

- Top Hinged Flap Gate
- Side Hinged Gate with Muted Tidal Regulator
- Tidflex Valve
- Sluice Gate
- Obermeyer Gate
- Radial Gate

The criteria used to assess and compare the relative feasibility of each gate type include:

- Operation and Maintenance (O&M) – This criterion evaluates the level of routine maintenance that will be required for each gate type. Gates that open and close based on differential head and have minimal mechanical components were given a rating of 1. Gates that use an electric actuator or mechanical device such as a muted tidal regulator to open and close would require routine preventive maintenance and were given a rating of 2. Gates that open and close using an air compressor and have multiple electrical and mechanical components that would need routine preventive maintenance were given a rating of 3.
- Debris – This criterion evaluates how the gate types deal with debris. Gates that do not typically collect floating debris were given a rating of 1. Gates that have a history of collecting floating debris but the debris is easily removed with regular inspections were given a rating of 2. Gates that have a history of collecting floating debris and, even with regular inspections, the debris is difficult remove and has the potential to damage the gate were given a rating of 3.
- Capital Cost – This criterion is based on vendor supplied cost data. Gates with a capital cost less than $50,000 per gate were given a rating of 1. Gates with a capital cost between $50,000 and $120,000 per gate were given a rating of 2. Gates with a capital cost greater than $120,000 were given a rating of 3.
- Lifecycle Cost – This criterion is based on a combination of the replacement cost for each gate, the electrical cost associated with operating the gate, and the labor cost associated with maintaining the gate over a 20 year period. Gates with a lifecycle cost less than $100,000 were given a rating of 1. Gates with a lifecycle cost between $100,000 and $200,000 were given a rating of 2. Gates with a lifecycle cost greater than $200,000 were given a rating of 3.
- Culvert Options – This criterion evaluates the flexibility of the gate type to be installed on a circular or rectangular culvert. Gates that can be installed on either circular or rectangular culverts were given a rating of 1. Gates that can only be installed in rectangular culverts were given a rating of 3.
- Fish Passage – This criterion evaluates the ability of each gate to pass fish. Gates that are able to open wide with little to no outflow and allow fish to pass are considered to be conducive to fish passage and were given a rating of 1. Gates that are not able to open wide will be difficult for fish to pass through and were given a rating of 3.

The overall results of the intake structure scoring matrix are shown in the Table below.

Culvert/Flow Control Gate Scoring Matrix							
Options	**O&M**	**Debris**	**Capital Cost**	**Lifecycle Cost**	**Culvert Options**	**Fish Passage**	**Total Score**
Top Hinged Flap Gate	1	3	1	1	1	3	10
Side Hinged Gate with Muted Tidal Regulator.	2	1	2	2	1	1	9
Tideflex Valve	1	3	1	1	3	3	12
Sluice Gate	2	2	1	1	1	1	8
Obermeyer Gate	3	1	3	3	3	1	14
Radial Gate	2	1	2	2	3	1	11

The sluice gate is considered the most favorable option.

Sluice Gate Pro/Con Table	
Pro	**Con**
This gate type will work on both circular and rectangular culverts	An electric actuator will be required to open and close this gate type. This will require regular routine maintenance.
This gate type is conducive to fish passage because it provides a wide clear waterway opening but it is either only open or closed.	Fish cannot pass during transition periods when water levels are rising or falling.
This gate type has one of the lower capital costs.	Debris can get caught on the stem. Regular inspections of the gate for debris will be required.
This gate type has one of the lower lifecycle costs.	

The side hinged gate with a muted tidal regulator is considered the second most favorable option

Side Hinged Gate with Muted Tidal Regulator Pro/Con Table	
Pro	**Con**
With a muted tidal regulator the gate open wide and provide a wide clear waterway opening. There shouldn't be issues with debris entrapment.	A muted tidal regulator will be used to open and close the gate based on upstream water elevations. This adds additional mechanical components that will require routine maintenance.
This gate type will work on both circular and rectangular culverts.	The muted tidal regulator will double the capital cost of the gate.
This gate type is conducive to fish passage because it provides a wide clear opening and will be either only open or closed when paired with a muted tidal regulator.	The gate with a muted tidal regulator will have higher lifecycle costs.

The top hinged flap gate scored as the third most favorable option.

Flap Gate Pro/Con Table	
Pro	**Con**
This gate will open and close based on differential head across the gate. No electric actuator or air compressor is required.	Large heavy gates don't open very wide and can trap debris in the gate opening or in the pinned hinges. Trapping floating debris is a known problem for top hinged flap gates that alternate between free and submerged flow, which is how these gates will operate. Regular inspections of the gate for debris will be required.
This gate type has one of the lower capital costs.	Large heavy gates don't open very wide and will have higher velocities of flow through their openings. These gates can be difficult for fish to pass through.
This gate type has one of the lower lifecycle costs.	
This gate type will work on both circular and rectangular culverts.	

The Radial gate is the fourth most favorable option.

Radial Gate Pro/Con Table	
Pro	**Con**
This gate provides a wide clear waterway opening and if the gate is installed in the standard raise to open style then there shouldn't be issues with debris entrapment.	This gate has one of the higher capital costs.
This gate type is conducive to fish passage because it provides a wide clear waterway opening but it is either only open or closed.	Fish cannot pass during transition periods when water levels are rising or falling.
	This gate has one of the higher lifecycle costs.
	An electric actuator will be required to open and close this gate type. This will require regular routine maintenance.
	This gate type will only work with a rectangular culvert.

The Tideflex Valve scored as the fifth most favorable option. However, due to the fact that tideflex valves don't open very wide, they are not rated for fish passage. For this reason the tideflex valve is now considered less favorable and will not be used in the pump station alternatives.

Tideflex valve Pro/Con Table	
Pro	**Con**
This valve will open and close based on differential head across the gate. No electric actuator or air compressor is required.	This valve doesn't open very wide and debris will accumulate which will require routine inspections. Debris can be difficult to remove.
This valve has one of the lower capital costs.	This valve doesn't open very wide and is not conducive to fish passage,
This valve has one of the lower lifecycle costs.	This valve will only work with a circular culvert.

The Obermeyer gate scored as the least favorable option.

Obermeyer Gate Pro/Con Table	
Pro	**Con**
This gate provides a wide clear waterway opening. There shouldn't be issues with debris entrapment.	This gate has one of the higher capital costs.
This gate type is conducive to fish passage because it provides a wide clear waterway opening but it is either only open or closed.	This gate type will only work with a rectangular culvert.
	This gate has one of the higher lifecycle costs.
	An air compressor will be required to open and close this gate type. This gate will have multiple mechanical components in that will require routine maintenance

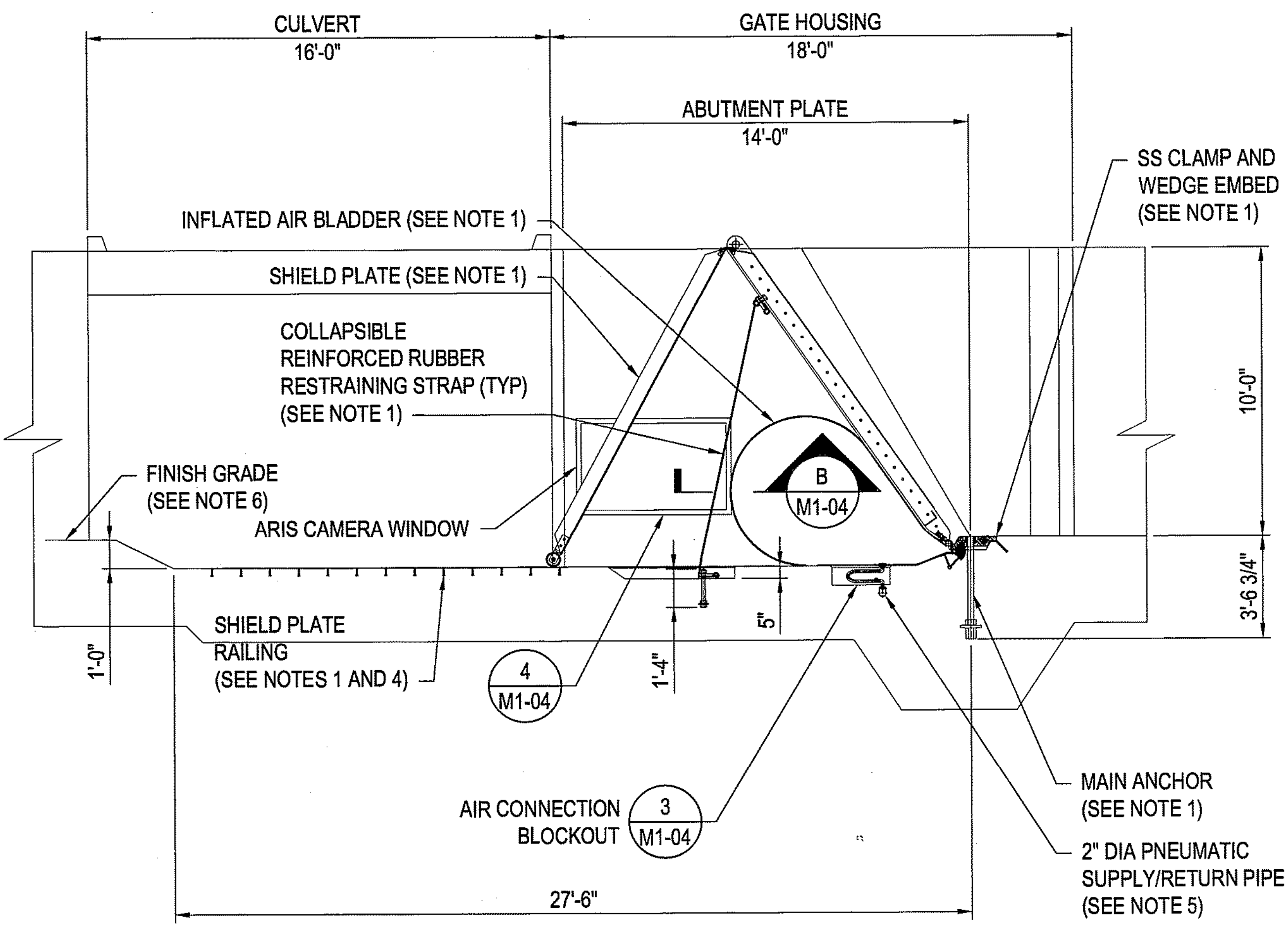
Top Hinged Flap Gate

Side Hinged Gate

Tideflex Valve

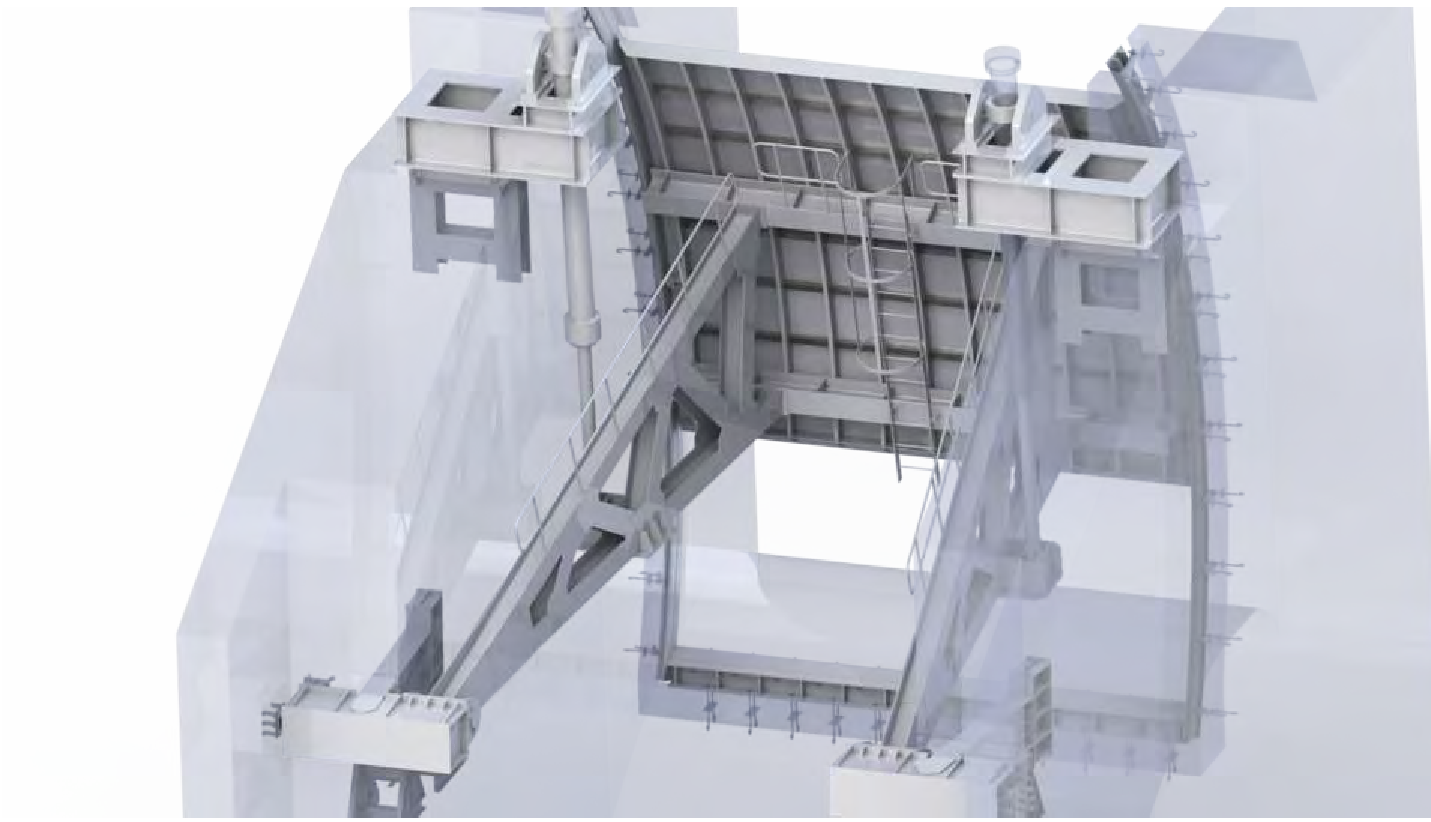
Sluice Gate

Obermeyer Gate



CULVERT
16'-0"
GATE HOUSING
18'-0"
ABUTMENT PLATE
14'-0"
SS CLAMP AND
WEDGE EMBED
(SEE NOTE 1)
INFLATED AIR BLADDER (SEE NOTE 1)
SHIELD PLATE (SEE NOTE 1)
COLLAPSIBLE
REINFORCED RUBBER
RESTRAINING STRAP (TYP)
(SEE NOTE 1)
10'-0"
FINISH GRADE
(SEE NOTE 6)
ARIS CAMERA WINDOW
B
M1-04
3'-6 3/4"
5"
SHIELD PLATE
RAILING
(SEE NOTES 1 AND 4)
1'-0"
4
M1-04
1'-4"
MAIN ANCHOR
(SEE NOTE 1)
AIR CONNECTION
BLOCKOUT
3
M1-04
2" DIA PNEUMATIC
SUPPLY/RETURN PIPE
(SEE NOTE 5)
27'-6"

Radial Gate



Stormwater Conveyance Evaluation

The following Stormwater Conveyance options were evaluated. Images of each option are provided at the end of this section.

- Wetwell Discharge - Route stormwater from White River Estates to the Government Canal Wetwell and then pump to the Government Canal downstream of the Levee using a “low flow” Jockey Pump.
- White River Discharge - Install a packaged pump station downstream of catch basin #27 to route stormwater from White River Estates directly to the White River.

The criteria used to assess and compare the relative feasibility of each stormwater conveyance option includes:

- Length – This criterion evaluates the length of new stormwater conveyance piping associated with each option. Options that will require 300 feet or less of new stormwater conveyance piping were given a rating of 1. Options that will require between 300 and 600 feet of new stormwater conveyance piping were given a rating of 2. Options that will require over 600 feet of new stormwater conveyance piping were given a rating of 3.
- Operation & Maintenance (O&M) – This criterion evaluates the ease of operating and maintaining the facilities associated with each stormwater conveyance option. Options that will require minimal maintenance from staff were given a rating of 1. Options that will require routine maintenance for additional mechanical equipment and structures at one location were given a rating of 2. Options that will require routine maintenance for additional mechanical equipment and structures at multiple locations as well as maintenance of an outfall in the White River were given a rating of 3.
- Capital Cost – This criterion evaluates the anticipated capital costs associated with each stormwater conveyance option. Options that are estimated to cost less than 2 million dollars were given a rating of 1. Options that are estimated to cost between 2 and 3 million dollars were given a rating of 2. Options that are estimated to cost over 3 million dollars were given a rating of 3.
- Real Estate Constraints – This criterion evaluates existing space constraints associated with each stormwater conveyance option. Options with no space constraints that will not potentially impact the location of the levee were given a rating of 1. Options with space constraints that will potentially impact the location of the levee were given a rating of 2. Options with space constraints that would require the relocation of the levee were given a rating of 3.

The overall results of the stormwater conveyance scoring matrix are shown in the Table below.

Stormwater Conveyance Scoring Matrix

Stormwater Conveyance Options	**Length**	**Maintenance**	**Capital Cost**	**Real Estate Constraints**	**Total Score**
Wetwell Discharge	3	2	3	1	**9**
White River Discharge	1	3	2	2	**8**

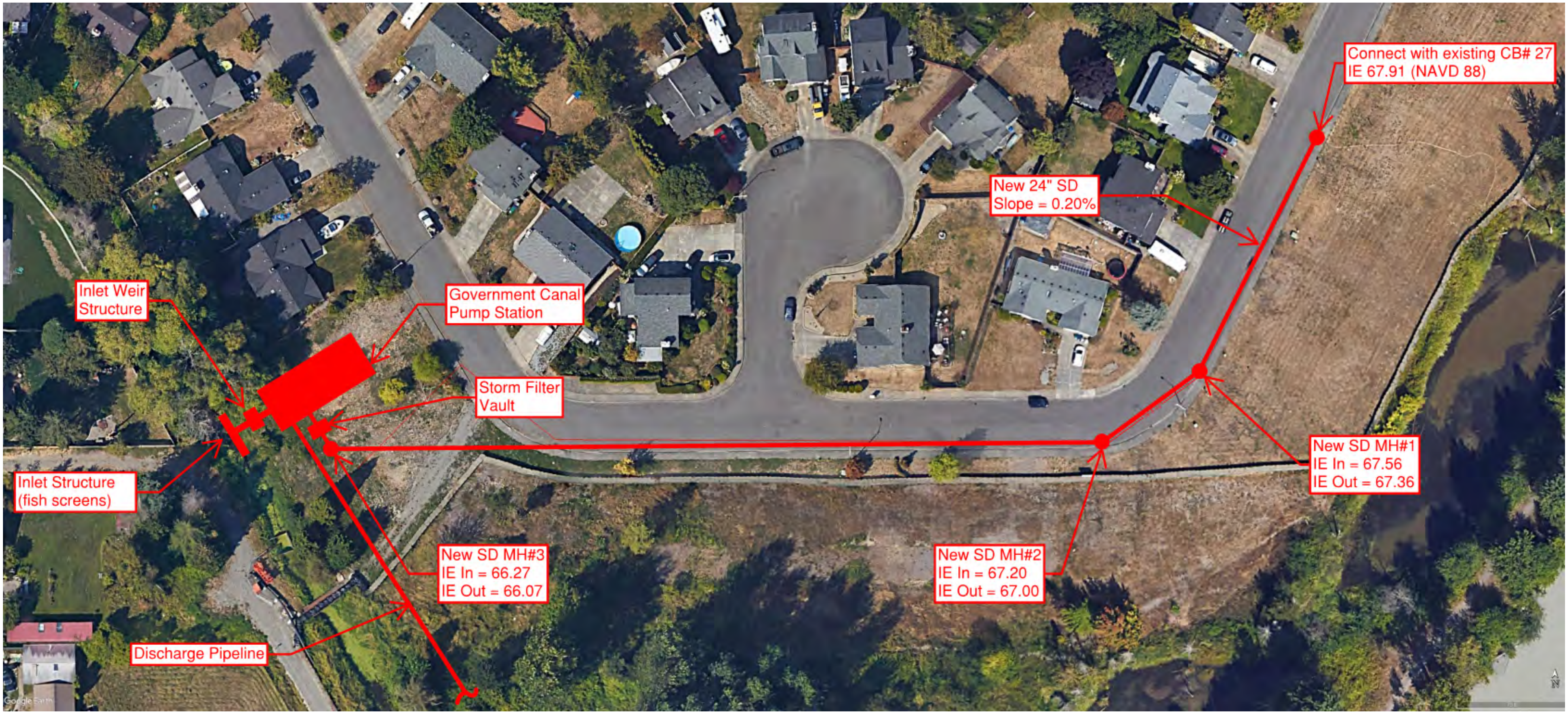
The White River Discharge is considered the most favorable option.

White River Discharge Pro/Con Table	
Pro	**Con**
This option has a very short length of conveyance piping. It will only have minor impacts to White River Drive.	This option requires the operation and maintenance of two separate pump stations as well as the maintenance of an outfall in the White River.
This option has the lowest estimated capital cost.	Depending on the final location of the levee the packaged pump station might have to be installed in the street.

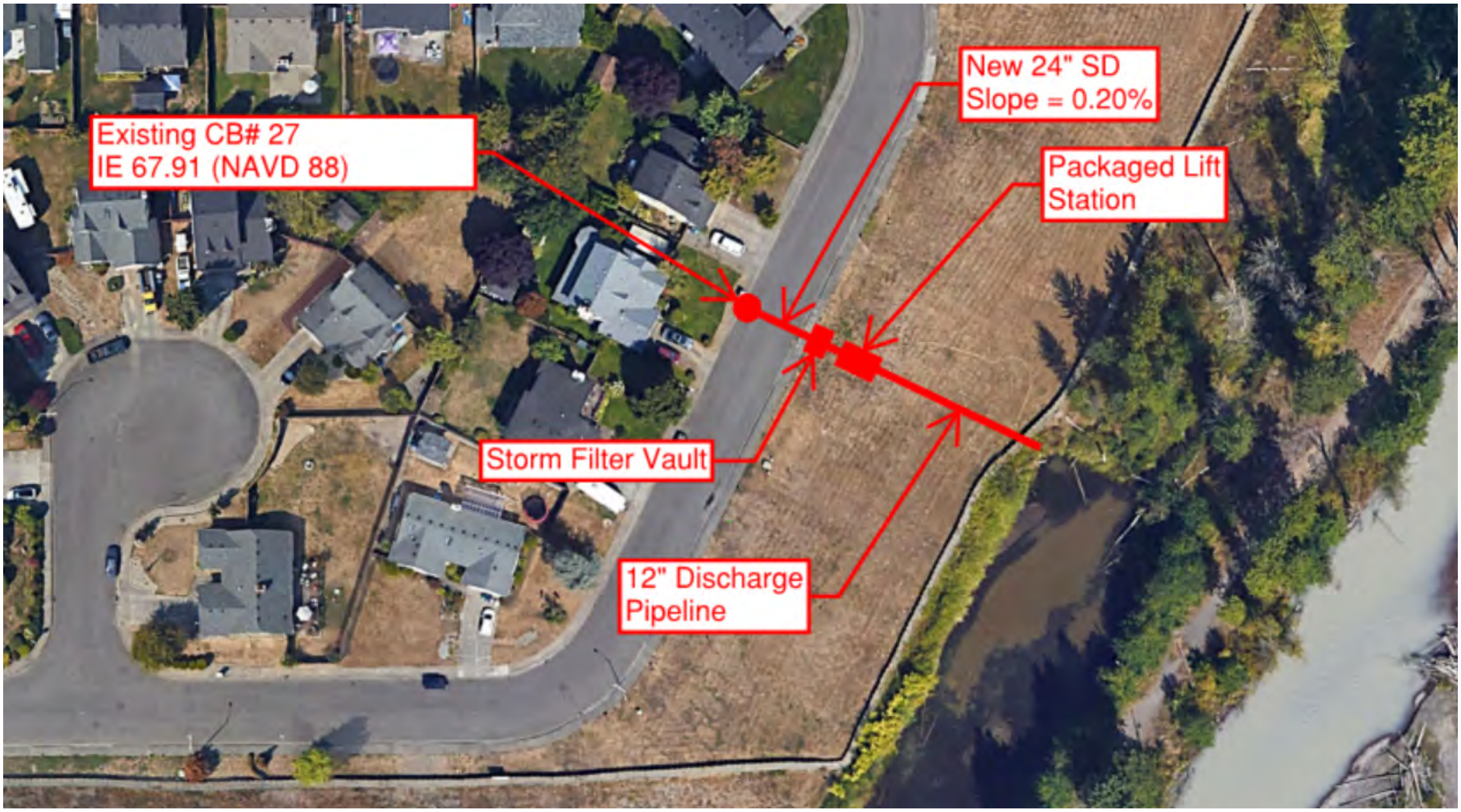
The Wetwell Discharge is considered the least favorable option.

Wetwell Discharge Pro/Con Table	
Pro	**Con**
Everything will be at one location rather than two.	This option will add additional routine maintenance to the Government Canal Pump Station by requiring a low flow jockey pump for the White River Estate stormwater flows and an overflow weir to keep water from the Government Canal out of the wetwell except during flooding events.
This option is not impacted by the location of the levee.	This option has a longer run of conveyance pipe in order to route stormwater to the Government Canal Pump Station wetwell. It will significantly impact White River Drive.
	This option had the highest capital cost.

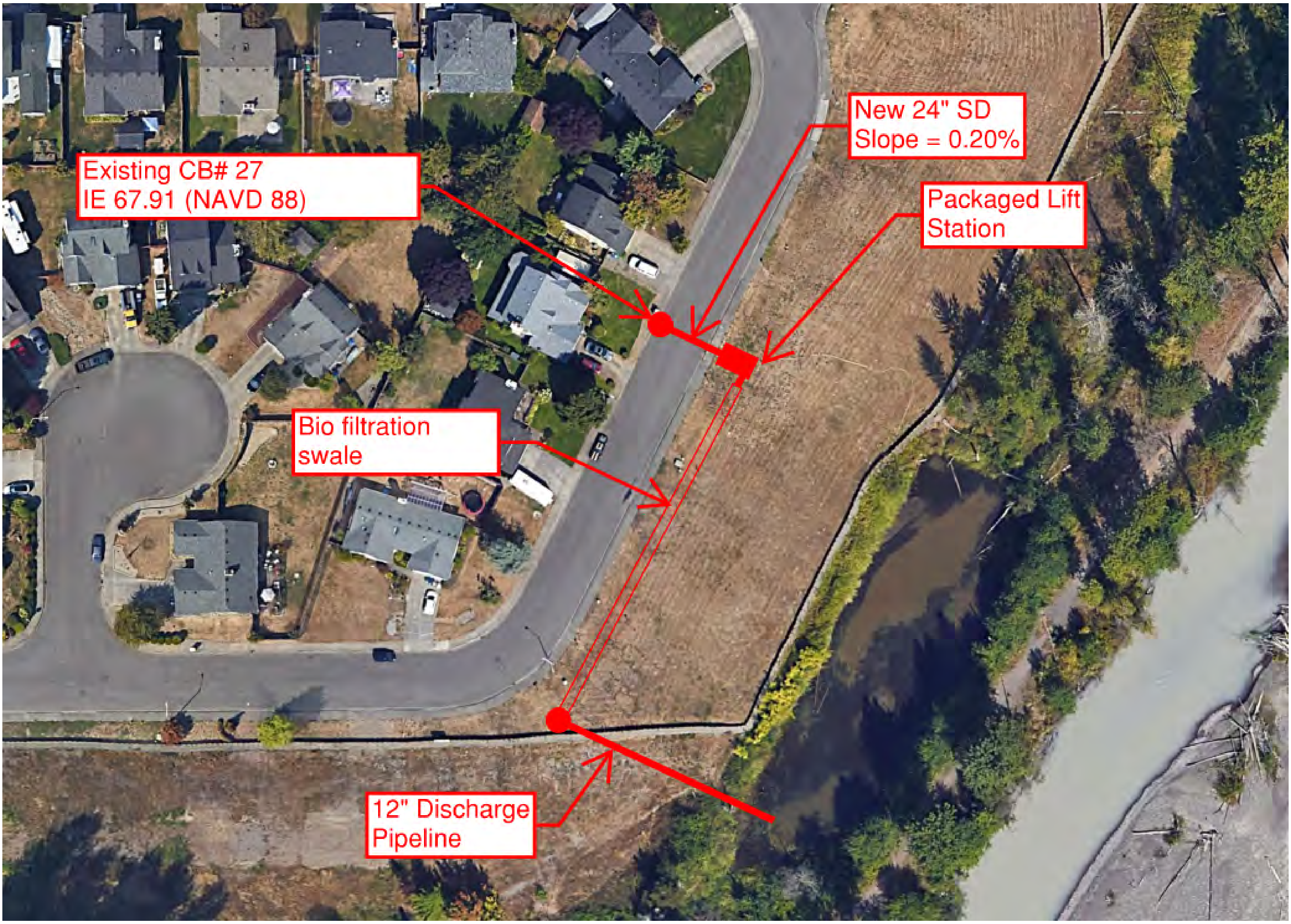
Wetwell Discharge


Connect with existing CB# 27
IE 67.91 (NAVD 88)
New 24" SD
Slope = 0.20%
Inlet Weir
Structure
Government Canal
Pump Station
Storm Filter
Vault
Inlet Structure
(fish screens)
New SD MH#1
IE In = 67.56
IE Out = 67.36
New SD MH#3
IE In = 66.27
IE Out = 66.07
New SD MH#2
IE In = 67.20
IE Out = 67.00
Discharge Pipeline

White River Discharge



White River Discharge with Storm Filter Vault



White River Discharge with Bio Filtration Swale

Stormwater Treatment Evaluation

The following stormwater treatment options were evaluated. Images of each stormwater treatment option are provided at the end of this section.

- Bio filtration Swale
- Wet Pond
- Wet Vault
- StormFilter

The criteria used to assess and compare the relative feasibility of each Stormwater Treatment option include:

- Treatment Performance – This criterion evaluates how effective the option is at treating stormwater. Options that are consistent in providing high quality treatment were given a rating of 1. Options that provide good treatment if adequately maintained were given a rating of 2. Options that provide highly variable treatment from storm to storm were given a rating of 3.
- Flexibility – This criterion evaluates the ability to expand the treatment option in the future for additional flows if needed. Options that are easy to expand in the future are given a rating of 1. Options where future expansion is possible but will require some work and may temporarily disrupt the stormwater system were given a rating of 2. Options were future expansion will be very difficult if not impossible were given a rating of 3.
- Footprint – This criterion evaluates the footprint associated with each stormwater treatment option. Options with footprints that will impact less than 1,000 square feet were given a rating of 1. Options with footprints that impact between 1,000 and 2,000 square feet were given a rating of 2. Option with footprints that will impact over 2,000 square feet were given a rating of 3.
- Maintenance – This criterion evaluates the level of routine maintenance that is anticipated for each option. Options with no mechanical components are assumed to need minimal routine maintenance and are given a rating of 1. Options that will require mechanical components but do not use proprietary technology were given a rating of 2. Options with mechanical components and proprietary technology are assumed to require routine maintenance on a regular basis and were given a rating of 3.
- Capital Cost – This criterion evaluates the estimated capital cost of building each stormwater treatment option. Estimated capital costs were based on a combination of historic data and vendor quotes. Options that were estimated to cost less 2 million dollars were given a rating of 1. Options that were estimated to cost between 2 and 3 million dollars were given a rating of 2. Options that were estimated to cost more than 3 million dollars were given a rating of 3.
- Lifecycle Costs – This criterion evaluates the life cycle costs associated with maintaining and replacing each stormwater treatment option. Options with lifecycle costs that were estimated to be less 2 million dollars were given a rating of 1. Options with lifecycle costs that were estimated to be between 2 and 3 million dollars were given a rating of 2. Options with Lifecycle costs that were estimated to be more than 3 million dollars were given a rating of 3.

The overall results of the stormwater treatment scoring matrix are shown in the Table below.

Stormwater Treatment Scoring Matrix							
Basic Stormwater Treatment	**Treatment Performance**	**Flexibility**	**Footprint**	**Maintenance**	**Capital Cost**	**Lifecycle Cost**	**Total Score**
Bio filtration Swale	3	3	2	2	1	2	**13**
Wet Pond	1	3	3	1	3	3	**14**
Wet Vault	2	3	3	3	3	3	**17**
StormFilter	2	2	1	3	1	2	**11**

The StormFilter is the most favorable option.

StormFilter Pro/Con Table	
Pro	**Con**
This option provides good stormwater treatment as long as the StormFilter cartridges are maintained	Depending on how dirty the stormwater is the StormFilter cartridges might need to be replaced every year.
If the initial vault is oversized then there would be space for additional StormFilter cartridges in the future should they be needed. Also, the initial vault could be designed to be deeper than necessary in order to allow for taller StormFilter cartridges in the future.	This option has the second highest lifecycle cost.
This option has a significantly smaller footprint than that other options considered.	
This option has a relatively low capital cost.	

The Bio filtration Swale is the second most favorable option.

Bio filtration Swale Pro/Con Table	
Pro	**Con**
The bio filtration swale has the second smallest estimated footprint.	The treatment performance of bio filtration swales are highly variable from storm to storm.
The bio filtration swale by itself will not require much maintenance. However, in order for the biofiltration swale to be functional in this application the stormwater runoff will need to be pumped to it.	In order to intercept White River Estates stormwater flows, the bio filtration swale will require stormwater to be pumped up to it.
The bio filtration swale has a relatively low capital cost.	It will be difficult to expand the bio filtration swale for additional flows after it is built should White River Estates see an increase in stormwater runoff
The bio filtration swale has the lowest estimated lifecycle cost.	The invert of the biofiltration swale needs to be above the tail water for the 2-year storm event in order to maintain its functionality. This will

	require pumping the stormwater to the bio filtration swale.

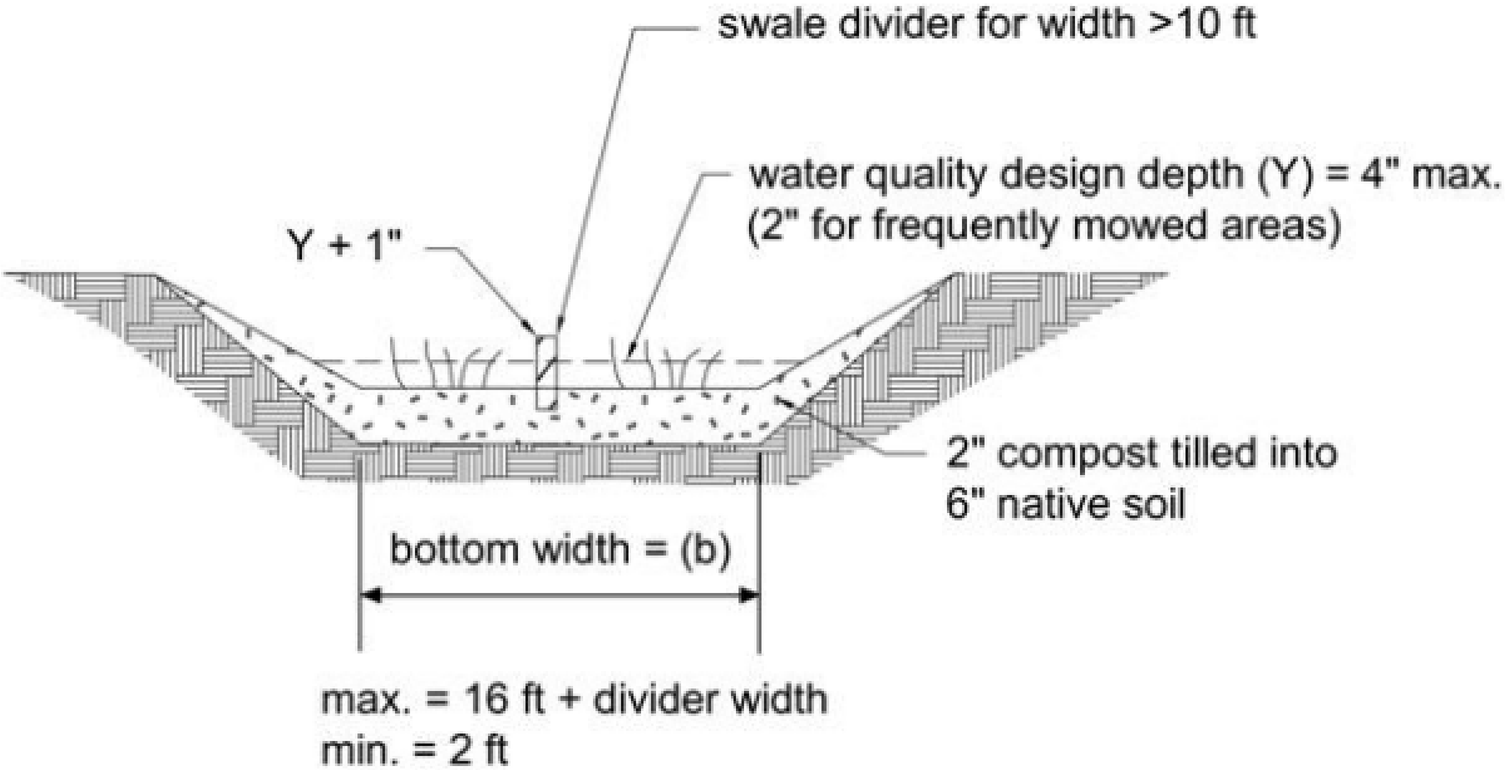
Wet Pond is the third most favorable option.

Wet Pond Pro/Con Table	
Pro	**Con**
This option is expected to provide the best stormwater treatment.	It will be difficult to expand the wet pond for additional flows after it is built should White River Estates see an increase in stormwater runoff
The wet pond by itself will not require much maintenance.	The wet pond has one of the largest estimated footprints
	The wet pond has the second largest estimated capital cost.
	The wet pond has the second largest estimated lifecycle cost.

The Wet Vault is the least favorable option.

Wet Vault Pro/Con Table	
Pro	**Con**
This option provides good stormwater treatment as long as the wet vault receives regular maintenance.	It will be difficult to expand the wet vault for additional flows after it is built should White River Estates see an increase in stormwater runoff
	The wet vault has one of the largest estimated footprints
	The wet vault will require routine maintenance to remove sediment, debris, and floating oil.
	The wet vault has the largest estimated capital cost.
	The wet pond has the largest estimated lifecycle cost.

Bio Filtration Swale



TYPICAL SWALE SECTION

NTS

Wet Pond

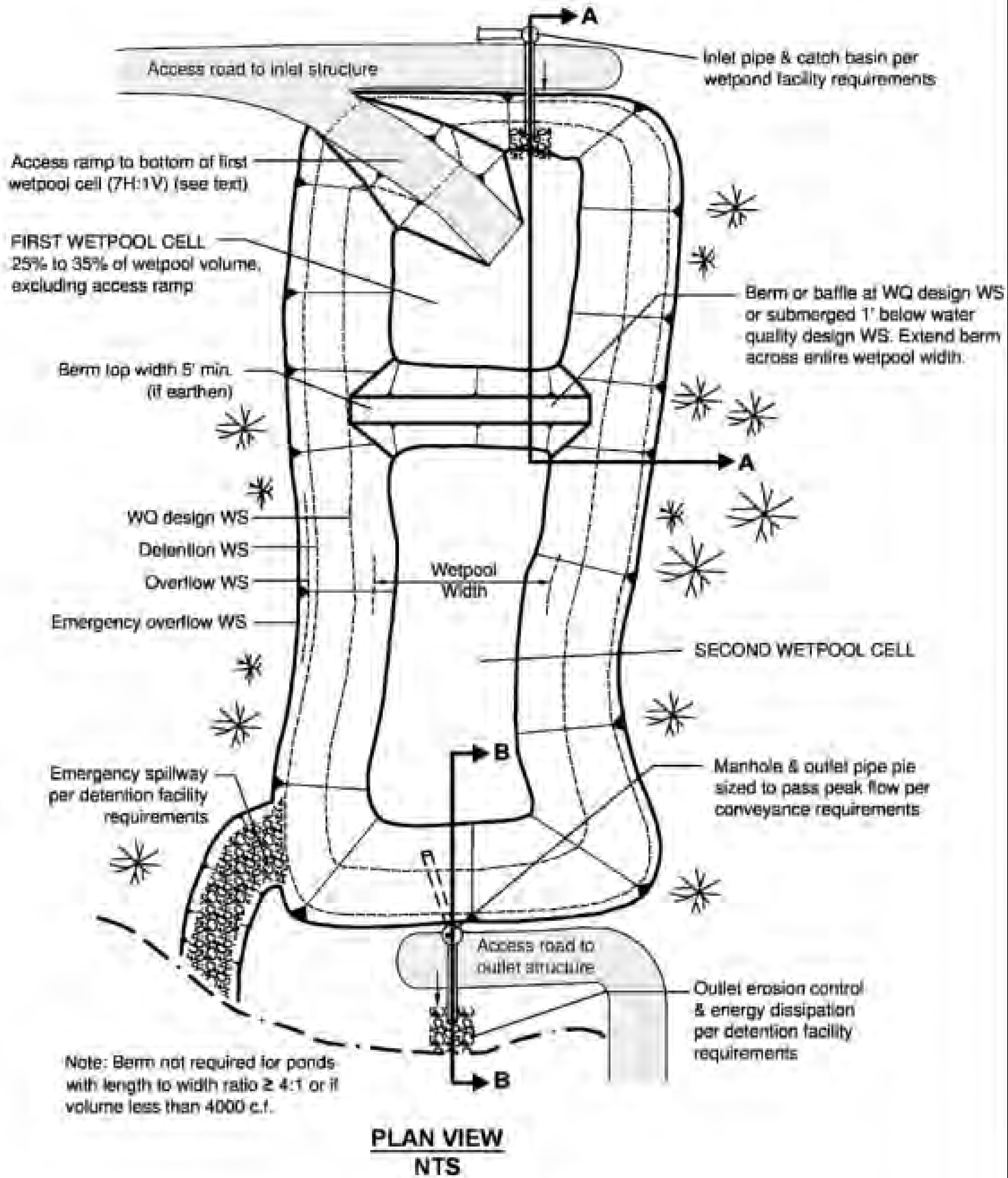
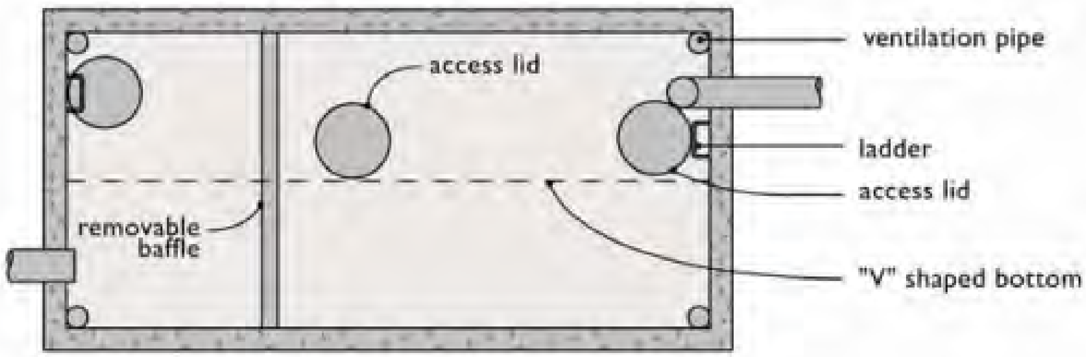
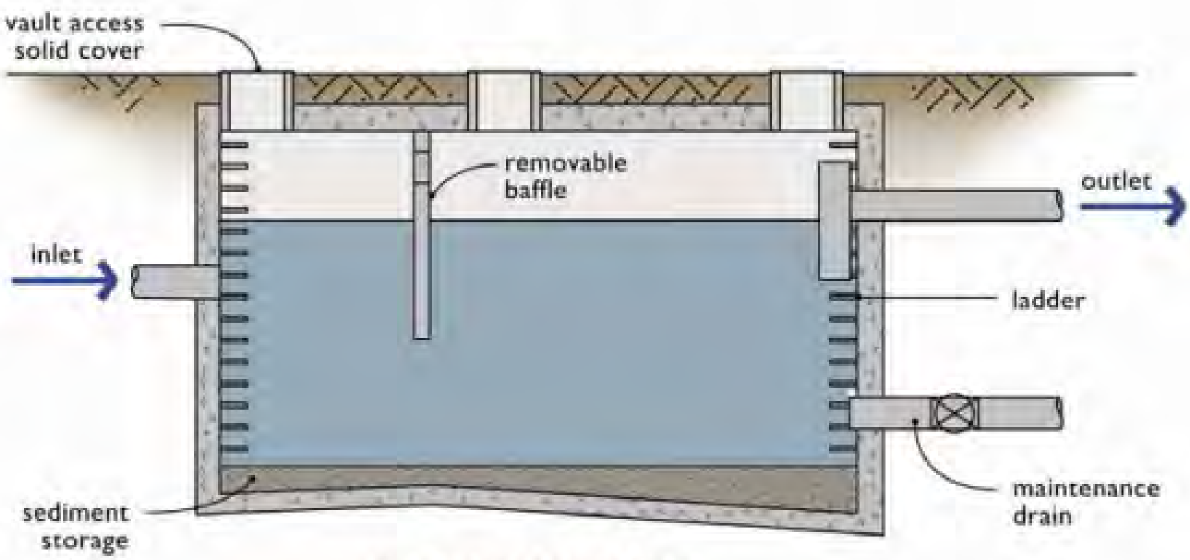


Figure 10.3.1a – Wetpond

Wet Vault

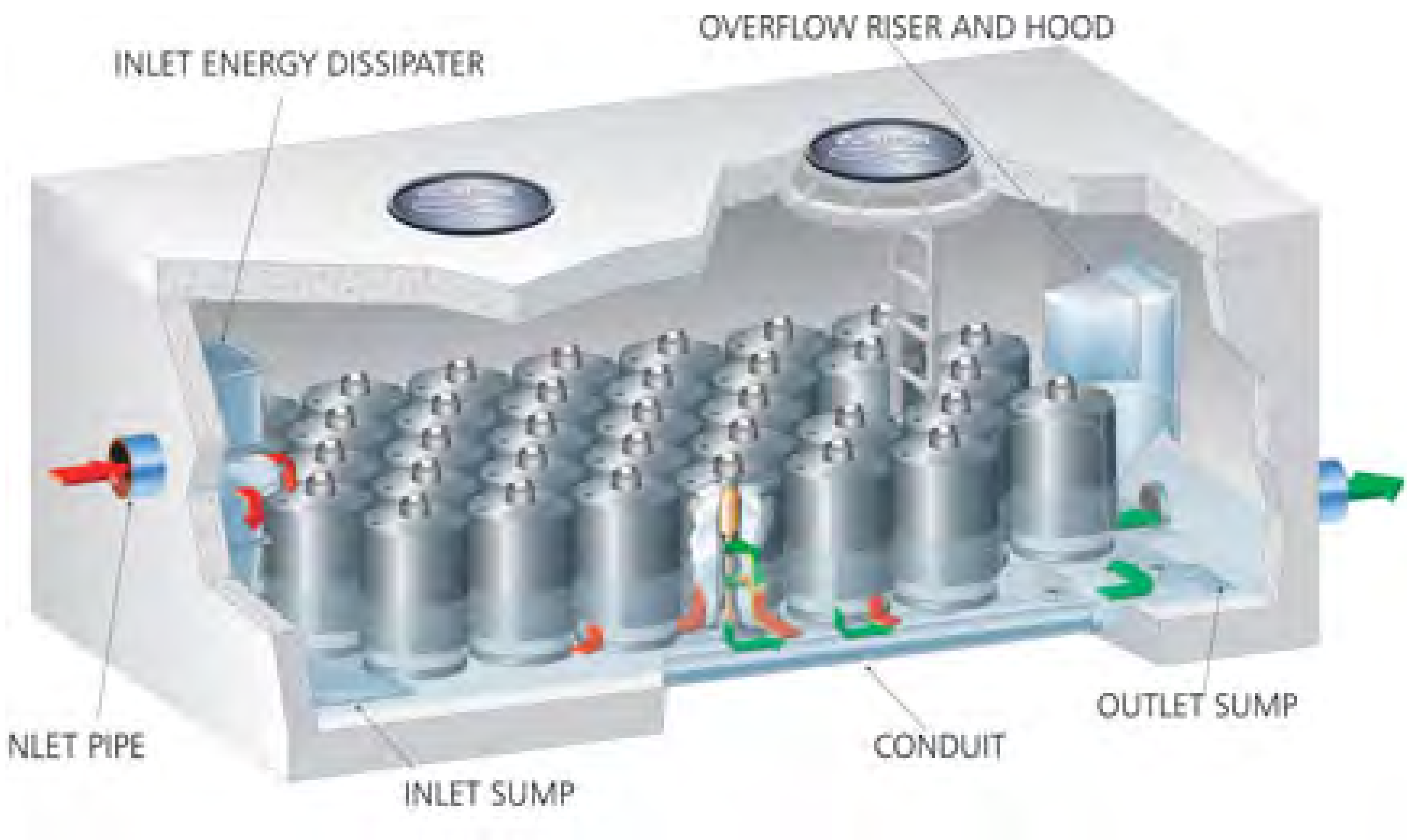


BIRD'S-EYE VIEW



SECTION PROFILE

StormFilter



OVERFLOW RISER AND HOOD
INLET ENERGY DISSIPATER
NLET PIPE
INLET SUMP
CONDUIT
OUTLET SUMP

APPENDIX C

Drawings

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER: E. SIMMONS
DRAWN BY: D. KENDALL
PROJECT NUMBER: 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

PROCESS FLOW DIAGRAM
ALTERNATIVE 1

0 1" 2"

FILENAME: Y001.DWG
SCALE: AS NOTED

SHEET
Figure 1

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER E. SIMMONS
DRAWN BY D. KENDALL
PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

PROCESS FLOW DIAGRAM
ALTERNATIVE 2

0 1" 2"
FILENAME Y001.DWG
SCALE AS NOTED

SHEET
Figure 2

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	E. SIMMONS
DRAWN BY	D. KENDALL
PROJECT NUMBER	10086942

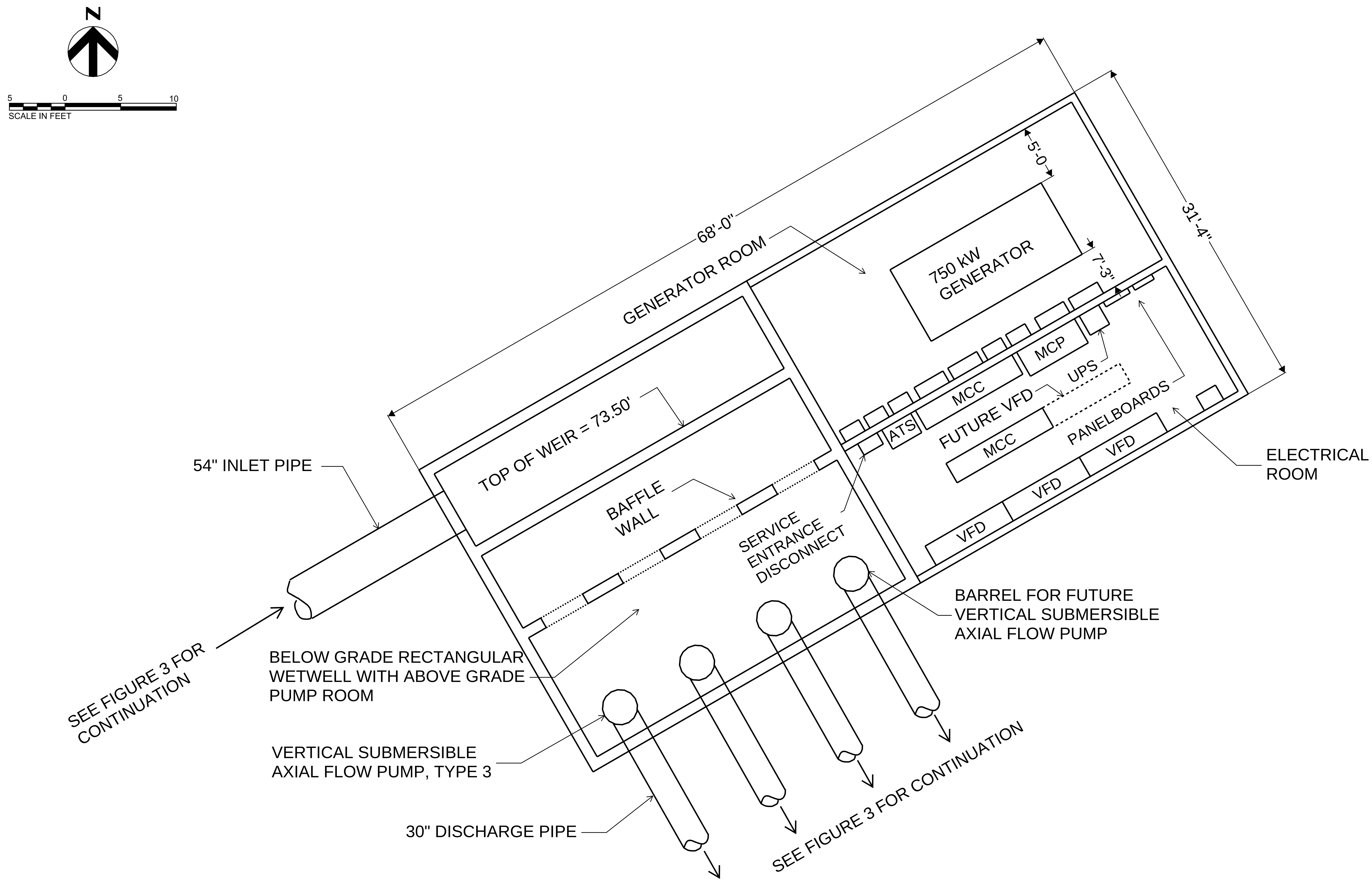
DRAFT
FOR INTERNAL DISCUSSION ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 2 SITE PLAN

FILENAME C001-ALT-2.DWG
SCALE AS NOTED

SHEET Figure 3



PROJECT MANAGER	E. SIMMONS
DRAWN BY	D. KENDALL
PROJECT NUMBER	10086942

ISSUE DATE DESCRIPTION

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 2
PUMP STATION PLAN

0 1" 2"

FILENAME Y001.DWG
SCALE AS NOTED

SHEET
Figure 4

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER E. SIMMONS
DRAWN BY D. KENDALL
PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

PROCESS FLOW DIAGRAM
ALTERNATIVE 3

0 1" 2"

FILENAME Y001.DWG
SCALE AS NOTED

SHEET
Figure 5

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER E. SIMMONS

DRAWN BY D. KENDALL

PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 3
SITE PLAN

FILENAME C001-ALT-3.DWG

SCALE AS NOTED

SHEET
Figure 6

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER E. SIMMONS
DRAWN BY D. KENDALL
PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 3
PUMP STATION PLAN

0 1" 2"

FILENAME Y001.DWG
SCALE AS NOTED

SHEET
Figure 7

PROJECT MANAGER E. SIMMONS

ISSUE	DATE	DESCRIPTION

DRAWN BY

PROJECT NUMBER 10086942

DRAFT FOR INTERNAL DISCUSSION ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

PROCESS FLOW DIAGRAM
ALTERNATIVE 4

0 1" 2"

FILENAME Y001.DWG

SCALE AS NOTED

SHEET **Figure 8**

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER	E. SIMMONS
DRAWN BY	D. KENDALL
PROJECT NUMBER	10086942

DRAFT FOR INTERNAL DISCUSSION ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 4
SITE PLAN

0 1" 2"

FILENAME	C001-ALT-4.DWG
SCALE	AS NOTED

SHEET
Figure 9

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER E. SIMMONS
DRAWN BY D. KENDALL
PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 4
PUMP STATION PLAN

0 1" 2"
FILENAME Y001.DWG
SCALE AS NOTED
SHEET Figure 10

HDR

ISSUE	DATE	DESCRIPTION

PROJECT MANAGER E. SIMMONS
DRAWN BY
PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

PROCESS FLOW DIAGRAM
ALTERNATIVE 5

0 1" 2"

FILENAME Y001.DWG
SCALE AS NOTED

SHEET
Figure 11

PROJECT MANAGER E. SIMMONS

ISSUE	DATE	DESCRIPTION

DRAWN BY D. KENDALL

PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 5
SITE PLAN

FILENAME C001-ALT-5.DWG

SCALE AS NOTED

SHEET
Figure 12

PROJECT MANAGER E. SIMMONS

ISSUE DATE DESCRIPTION

DRAWN BY D. KENDALL

PROJECT NUMBER 10086942

DRAFT
FOR INTERNAL
DISCUSSION
ONLY

KING COUNTY
GOVERNMENT CANAL PUMP STATION

ALTERNATIVE 5
PUMP STATION PLAN

0 1" 2"

FILENAME Y001.DWG

SCALE AS NOTED

SHEET

Figure 13

APPENDIX D

Cost Estimates

Construction Cost Estimates

King County Government Canal Alternative 2 Construction Cost	23-Dec-20			

Item #	Description	Unit	Unit Cost	Qty	Total
CONSTRUCTION COSTS					
1.00	**SITE WORK**				**$ 489,736**
	DUST CONTROL	LS	$ 100,000	1	$ 100,000
	CONSTRUCTION SURVEY STAKING	LS	$ 50,000	1	$ 50,000
	TEMPORARY FENCING	LF	$ 23	630	$ 14,490
	CLEARING AND GRUBBING	ACRE	$ 5,000	1	$ 2,927
	FINISH GRADING	SY	$ 5	2833	$ 14,167
	STORMWATEER POLLUTION PREVENTION PLAN	LS	$ 15,000	1	$ 15,000
	EROSION CONTROL	LS	$ 5,000	1	$ 5,000
	TRAFFIC CONTROL	LS	$ 5,000	1	$ 5,000
	LANDSCAPING AND IRRIGATION	SF	$ 12	23596	$ 283,152
2.00	**FISH SCREENS**				**$ 712,500**
3.00	**INTAKE STRUCTURE**				**$ 1,215,634**
	CONCRETE	CY	$ 1,279	465	$ 595,461
	EXCAVATION	CY	$ 50	2108	$ 105,400
	BACKFILL	CY	$ 48	156	$ 7,495
	HAULING	CY	$ 15	1952	$ 29,278
	SHORING	SF	$ 80	2850	$ 228,000
	DEWATERING	LS	$ 250,000	1	$ 250,000
4.00	**PUMP BUILDING**				**$ 3,119,549**
5.00	**PUMPS**				**$ 763,443**
6.00	**CULVERT AND FLOW CONTROL GATE**				**$ 348,588**
	PRECAST CONCRETE	LS	$ 168,588	1	$ 168,588
	SIDE HINGED GATE	EA	$ 90,000	2	$ 180,000
7.00	**YARD PIPING**				**$ 685,630**
	24" DIP	LF	$ 610	48	$ 29,280
	30" DIP	LF	$ 770	650	$ 500,500
	48" DIP	LF	$ 1,030	80	$ 82,400
	54" DIP	LF	$ 1,130	65	$ 73,450
8.00	**WHITE RIVER ESTATES STORMWATER**				**$ 1,026,039**
	TYPE 2 MH	EA	$ 3,839	1	$ 3,839
	STORM FILTER VAULT	EA	$ 221,808	1	$ 221,808
	PACKAGED PUMP STATION	LS	$ 660,312	1	$ 660,312
	12" PVC STORM DRAIN PIPE	LF	$ 370	22	$ 8,140
	24" PVC STORM DRAIN PIPE	LF	$ 530	38	$ 20,140
	12" DIP FORCEMAIN	LF	$ 430	260	$ 111,800
SUBTOTAL OF CONSTRUCTION COSTS					$ 7,675,489
DIRECT CONSTRUCTION COST MARKUPS					
	GENERAL CONDITIONS		10%		$ 1,535,098
	MOB/DEMOB		10%		$ 767,549
	OVERHEAD & PROFIT		8%		$ 614,039
	INSURANCE		1.5%		$ 118,203
	BONDING		1%		$ 76,755
SUBTOTAL OF DIRECT CONSTRUCTION COST MARKUPS					$ 3,111,643
SUBTOTAL OF DIRECT CONSTRUCTION COSTS					**$ 10,787,133**
	Contingency		30%		$ 3,236,140
	Sales Tax		10%		$ 1,078,713
	GRAND TOTAL				**15,101,986**

NOTES: 15,102,000

1. Cost data is based on data from RS Means, previous HDR estimates, SPU Unit Cost Report, and recent contractor bid information.
2. Costs for permitting, inspection/testing, and 3rd party construction management services are not included.

King County
Government Canal Alternative 3
Construction Cost

23-Dec-20

Item #	Description	Unit	Unit Cost	Qty	Total
CONSTRUCTION COSTS					
1.00	**SITE WORK**				**$ 489,903.66**
	DUST CONTROL	LS	$ 100,000.00	1	$ 100,000.00
	CONSTRUCTION SURVEY STAKING	LS	$ 50,000.00	1	$ 50,000.00
	TEMPORARY FENCING	LF	$ 23.00	630	$ 14,490.00
	CLEARING AND GRUBBING	ACRE	$ 5,000.00	0.59	$ 2,927.00
	FINISH GRADING	SY	$ 5.00	2833.33	$ 14,166.67
	STORMWATEER POLLUTION PREVENTION PLAN	LS	$ 15,000.00	1.00	$ 15,000.00
	EROSION CONTROL	LS	$ 5,000.00	1.00	$ 5,000.00
	TRAFFIC CONTROL	LS	$ 5,000.00	1.00	$ 5,000.00
	LANDSCAPING AND IRRIGATION	SF	$ 12.00	23610	$ 283,320.00
2.00	**FISH SCREENS**				**$ 412,500**
3.00	**INTAKE STRUCTURE**				**$ 39,550**
	54" PIPE	LF	$ 1,130.00	35	$ 39,550
3.00	**PUMP BUILDING**				**$ 3,516,152**
4.00	**PUMPS**				**$ 763,443**
5.00	**CULVERT AND FLOW CONTROL GATE**				**$ 342,588**
	PRECAST CONCRETE	LS	$ 168,588	1	$ 168,588
	MOTOR OPERATED SLIDE GATE	EA	$ 87,000	2	$ 174,000
6.00	**YARD PIPING**				**$ 640,800**
	30" DIP	LF	$ 770	500	$ 385,000
	36" DIP	LF	$ 830	60	$ 49,800
	48" DIP	LF	$ 1,030	200	$ 206,000
7.00	**WHITE RIVER ESTATES STORMWATER**				**$ 1,026,039**
	TYPE 2 MH	EA	$ 3,839	1	$ 3,839
	STORM FILTER VAULT	EA	$ 221,808	1	$ 221,808
	PACKAGED PUMP STATION	LS	$ 660,312	1	$ 660,312
	12" PVC STORM DRAIN PIPE	LF	$ 370	22	$ 8,140
	24" PVC STORM DRAIN PIPE	LF	$ 530	38	$ 20,140
	12" DIP FORCEMAIN	LF	$ 430	260	$ 111,800
SUBTOTAL OF CONSTRUCTION COSTS					**$ 7,230,977**
DIRECT CONSTRUCTION COST MARKUPS					
	GENERAL CONDITIONS		10%		$ 1,446,195
	MOB/DEMOB		10%		$ 723,098
	OVERHEAD & PROFIT		8%		$ 578,478
	INSURANCE		1.5%		$ 111,357
	BONDING		1%		$ 72,310
SUBTOTAL OF DIRECT CONSTRUCTION COST MARKUPS					$ 2,931,438
SUBTOTAL OF DIRECT CONSTRUCTION COSTS					**$ 10,162,415**
	Contingency		30%		$ 3,048,724
	Sales Tax		10%		$ 1,016,241
	GRAND TOTAL				**14,227,381**

NOTES: 14,227,000

1. Cost data is based on data from RS Means, previous HDR estimates, SPU Unit Cost Report, and recent contractor bid information.
2. Costs for permitting, inspection/testing, and 3rd party construction management services are not included.

King County
Government Canal Alternative 4
Construction Cost

23-Dec-20

Item #	Description	Unit	Unit Cost	Qty	Total
1.00	**SITE WORK**				**$ 468,736**
	DUST CONTROL	LS	$ 100,000.00	1	$ 100,000.00
	CONSTRUCTION SURVEY STAKING	LS	$ 50,000.00	1	$ 50,000.00
	TEMPORARY FENCING	LF	$ 23.00	630	$ 14,490.00
	CLEARING AND GRUBBING	ACRE	$ 5,000.00	0.59	$ 2,927.00
	FINISH GRADING	SY	$ 5.00	2833.33	$ 14,166.67
	STORMWATEER POLLUTION PREVENTION PLAN	LS	$ 15,000.00	1.00	$ 15,000.00
	EROSION CONTROL	LS	$ 5,000.00	1.00	$ 5,000.00
	TRAFFIC CONTROL	LS	$ 5,000.00	1.00	$ 5,000.00
	LANDSCAPING AND IRRIGATION	SF	$ 12.00	21846	$ 262,152.00
2.00	**FISH SCREENS**				**$ 712,500**
3.00	**INTAKE STRUCTURE**				**$ 1,588,248**
	CONCRETE	CY	$ 1,279.44	634	$ 810,975
	EXCAVATION	CY	$ 50.00	3927	$ 196,350
	BACKFILL	CY	$ 48.00	546	$ 26,207
	HAULING	CY	$ 15.00	3381	$ 50,715
	SHORING	SF	$ 80.00	3175	$ 254,000
	DEWATERING	LS	$ 250,000.00	1	$ 250,000
4.00	**PUMP BUILDING**				**$ 5,407,416**
5.00	**PUMPS**				**$ 1,020,000**
6.00	**CULVERT AND FLOW CONTROL GATE**				**$ 348,588**
	PRECAST CNCRETE	LS	$ 168,588	1	$ 168,588
	SIDE HINGED GATE	EA	$ 90,000	2	$ 180,000
7.00	**Yard Piping**				**475,600**
	24" DIP	LF	$ 610	650	396,500
	48" DIP	LF	$ 1,030	115	118,450
	54" DIP	LF	$ 1,130	70	79,100
8.00	**WHITE RIVER ESTATES STORMWATER**				**684,921**
	TYPE 2 MH	EA	$ 3,669	3	11,007
	FLOW SPLITTER	EA	$ 5,691	1	5,691
	STORM FILTER VAULT	EA	$ 221,808	1	221,808
	SUBMERSIBLE PUMPS	EA	$ 62,007	2	124,014
	12" PVC STORM DRAIN PIPE	LF	$ 370	40	14,800
	24" PVC STORM DRAIN PIPE	LF	$ 530	410	217,300
	12" DIP FORCEMAIN	LF	$ 430	210	90,300
SUBTOTAL OF CONSTRUCTION COSTS					$ 10,706,009
DIRECT CONSTRUCTION COST MARKUPS					
	GENERAL CONDITIONS		10%		$ 2,141,202
	MOB/DEMOB		10%		$ 1,070,601
	OVERHEAD & PROFIT		8%		$ 856,481
	INSURANCE		1.5%		$ 164,873
	BONDING		1%		$ 107,060
SUBTOTAL OF DIRECT CONSTRUCTION COST MARKUPS					$ 4,340,216
SUBTOTAL OF DIRECT CONSTRUCTION COSTS					**$ 15,046,225**
	Contingency		30%		$ 4,513,867
	Sales Tax		10%		$ 1,504,622
GRAND TOTAL					**$ 21,064,715**

NOTES: $ 21,065,000

1. Cost data is based on data from RS Means, previous HDR estimates, SPU Unit Cost Report, and recent contractor bid information.
2. Costs for permitting, inspection/testing, and 3rd party construction management services are not included.

King County
Government Canal Alternative 5
Construction Cost

23-Dec-20

Item #	Description	Unit	Unit Cost	Qty	Total
1.00	**SITE WORK**				**$ 345,615.40**
	DUST CONTROL	LS	$ 100,000.00	1	$ 100,000.00
	CONSTRUCTION SURVEY STAKING	LS	$ 50,000.00	1	$ 50,000.00
	TEMPORARY FENCING	LF	$ 23.00	448	$ 10,304.00
	CLEARING AND GRUBBING	ACRE	$ 5,000.00	0.34	$ 1,689.62
	FINISH GRADING	SY	$ 5.00	1635.56	$ 8,177.78
	STORMWATEER POLLUTION PREVENTION PLAN	LS	$ 15,000.00	1.00	$ 15,000.00
	EROSION CONTROL	LS	$ 5,000.00	1.00	$ 5,000.00
	TRAFFIC CONTROL	LS	$ 5,000.00	1.00	$ 5,000.00
	LANDSCAPING AND IRRIGATION	SF	$ 12.00	12537	$ 150,444.00
2.00	**FISH SCREENS**				**$ 412,500**
3.00	**INTAKE STRUCTURE**				**$ 749,513**
	CONCRETE	CY	$ 1,279	100	$ 128,513
	EXCAVATION	CY	$ 50	3060	$ 153,000
	BACKFILL	CY	$ 48	1700	$ 81,600
	HAULING	CY	$ 15	1360	$ 20,400
	SHORING	SF	$ 80	1450	$ 116,000
	DEWATERING	LS	$ 250,000	1	$ 250,000
4.00	**PUMP BUILDING**				**$ 4,528,378**
5.00	**PUMPS**				**$ 1,012,500**
6.00	**CULVERT AND FLOW CONTROL GATE**				**$ 342,588**
	PRECAST CONCRETE	LS	$ 168,588	1	$ 168,588
	MOTOR OPERATED SLIDE GATE	EA	$ 87,000	2	$ 174,000
7.00	**Yard Piping**				**$ 412,710**
	30" DIP	LF	$ 770	45	$ 34,650
	36" DIP	LF	$ 370	40	$ 14,800
	48" DIP	LF	$ 1,030	232	$ 238,960
	54" DIP	LF	$ 1,130	110	$ 124,300
8.00	**WHITE RIVER ESTATES STORMWATER**				**$ 1,026,039**
	TYPE 2 MH	EA	$ 3,839	1	$ 3,839
	STORM FILTER VAULT	EA	$ 221,808	1	$ 221,808
	PACKAGED PUMP STATION	LS	$ 660,312	1	$ 660,312
	12" PVC STORM DRAIN PIPE	LF	$ 370	22	$ 8,140
	24" PVC STORM DRAIN PIPE	LF	$ 530	38	$ 20,140
	12" DIP FORCEMAIN	LF	$ 430	260	$ 111,800
SUBTOTAL OF CONSTRUCTION COSTS					8,829,844
DIRECT CONSTRUCTION COST MARKUPS					
	GENERAL CONDITIONS		10%		$ 1,765,969
	MOB/DEMOB		10%		$ 882,984
	OVERHEAD & PROFIT		8%		$ 706,388
	INSURANCE		1.5%		$ 135,980
	BONDING		1%		$ 88,298
SUBTOTAL OF DIRECT CONSTRUCTION COST MARKUPS					$ 3,579,619
SUBTOTAL OF DIRECT CONSTRUCTION COSTS					**$ 12,409,463**
	Contingency		30%		$ 3,722,839
	Sales Tax		10%		$ 1,240,946
GRAND TOTAL					**17,373,248**

Lifecycle Cost Estimates

Calculate the 50 Year Life Cycle Cost for Alternative 2

Assumptions
1. Inflaction Rate = 3.0%
2. interest Rate = 6.0%
3. Pump Station will run when gates are closed. Based WSE's gate closure analysis the maximum duration of gate closure could be 468 hours between October 1 through April 30.
4. Pump Station will not run outside of the October 1 through April 30th window.
5. When Pump Station is running it will have a demand load of about 400 kVA. This is based on two 150 hp pumps in the Government Canal Pump Station running and loads from HVAC and electrical equipment.
6. Packaged lift station will have a demand load of about 50 kVA. This is based on one 35 hp pump running and electrical equipment.
8. Packaged lift station will operate year round.
9. Energy rate is based on average industrial electricity rates in Seattle (https://www.electricitylocal.com/states/washington/seattle).
10. Labor cost per hour is based on prevailing wage rates for electricians in King County (https://secure.lni.wa.gov/wagelookup/).
11. Replacement costs inlcude pumps, fish screens, and gates. One pump, fish screen, and gate will be replaced per year starting 25 years after installation until all of the pumps, fish screens and gates have been replaced.
12. The intake structure, building, and culvert will be designed for a 50-year life and are not included in the replacement costs.

Construction Cost
$ 15,102,000

Energy Cost

Government Canal Pump Station

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
468	400	$ 0.0595	$ 11,138.40

Packaged Lift Station

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
1872	50	$ 0.0595	$ 5,569.20

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 16,707.60	1.000	$ 16,707.60	<== Initial Cost
1	1.030	$ 17,208.83	0.943	$ 16,234.74	
2	1.061	$ 17,725.09	0.890	$ 15,775.27	
3	1.093	$ 18,256.85	0.840	$ 15,328.80	
4	1.126	$ 18,804.55	0.792	$ 14,894.97	
5	1.159	$ 19,368.69	0.747	$ 14,473.41	
6	1.194	$ 19,949.75	0.705	$ 14,063.79	
7	1.230	$ 20,548.24	0.665	$ 13,665.75	
8	1.267	$ 21,164.69	0.627	$ 13,278.99	
9	1.305	$ 21,799.63	0.592	$ 12,903.17	
10	1.344	$ 22,453.62	0.558	$ 12,537.98	
11	1.384	$ 23,127.23	0.527	$ 12,183.13	
12	1.426	$ 23,821.04	0.497	$ 11,838.33	
13	1.469	$ 24,535.67	0.469	$ 11,503.28	
14	1.513	$ 25,271.74	0.442	$ 11,177.72	
15	1.558	$ 26,029.90	0.417	$ 10,861.37	

16	1.605	$	26,810.79	0.394	$	10,553.97
17	1.653	$	27,615.12	0.371	$	10,255.27
18	1.702	$	28,443.57	0.350	$	9,965.03
19	1.754	$	29,296.88	0.331	$	9,683.00
20	1.806	$	30,175.78	0.312	$	9,408.95
21	1.860	$	31,081.06	0.294	$	9,142.66
22	1.916	$	32,013.49	0.278	$	8,883.91
23	1.974	$	32,973.89	0.262	$	8,632.48
24	2.033	$	33,963.11	0.247	$	8,388.16
25	2.094	$	34,982.00	0.233	$	8,150.76
26	2.157	$	36,031.46	0.220	$	7,920.08
27	2.221	$	37,112.41	0.207	$	7,695.92
28	2.288	$	38,225.78	0.196	$	7,478.11
29	2.357	$	39,372.55	0.185	$	7,266.47
30	2.427	$	40,553.73	0.174	$	7,060.82
31	2.500	$	41,770.34	0.164	$	6,860.98
32	2.575	$	43,023.45	0.155	$	6,666.80
33	2.652	$	44,314.16	0.146	$	6,478.12
34	2.732	$	45,643.58	0.138	$	6,294.78
35	2.814	$	47,012.89	0.130	$	6,116.62
36	2.898	$	48,423.27	0.123	$	5,943.51
37	2.985	$	49,875.97	0.116	$	5,775.30
38	3.075	$	51,372.25	0.109	$	5,611.85
39	3.167	$	52,913.42	0.103	$	5,453.02
40	3.262	$	54,500.82	0.097	$	5,298.69
41	3.360	$	56,135.85	0.092	$	5,148.73
42	3.461	$	57,819.92	0.087	$	5,003.01
43	3.565	$	59,554.52	0.082	$	4,861.41
44	3.671	$	61,341.16	0.077	$	4,723.83
45	3.782	$	63,181.39	0.073	$	4,590.13
46	3.895	$	65,076.83	0.069	$	4,460.22
47	4.012	$	67,029.14	0.065	$	4,333.99
48	4.132	$	69,040.01	0.061	$	4,211.33
49	4.256	$	71,111.21	0.058	$	4,092.14
50	4.384	$	73,244.55	0.054	$	3,976.33
Total Energy Cost		**$**	**1,957,809.49**		**$**	**453,814.66**

Operational Costs

Frequency of Routine Maintenance (visits per month)	No. of Personel	Labor Cost ($/hour)	Hours per vist per person	Cost per Year
1	2	$ 90.00	8	$ 17,280.00

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 17,280.00	1.000	$ 17,280.00	<== Initial Cost
1	1.030	$ 17,798.40	0.943	$ 16,790.94	
2	1.061	$ 18,332.35	0.890	$ 16,315.73	
3	1.093	$ 18,882.32	0.840	$ 15,853.96	
4	1.126	$ 19,448.79	0.792	$ 15,405.27	
5	1.159	$ 20,032.26	0.747	$ 14,969.27	
6	1.194	$ 20,633.22	0.705	$ 14,545.61	
7	1.230	$ 21,252.22	0.665	$ 14,133.94	
8	1.267	$ 21,889.79	0.627	$ 13,733.92	
9	1.305	$ 22,546.48	0.592	$ 13,345.23	
10	1.344	$ 23,222.88	0.558	$ 12,967.53	
11	1.384	$ 23,919.56	0.527	$ 12,600.53	
12	1.426	$ 24,637.15	0.497	$ 12,243.91	
13	1.469	$ 25,376.26	0.469	$ 11,897.38	
14	1.513	$ 26,137.55	0.442	$ 11,560.66	
15	1.558	$ 26,921.68	0.417	$ 11,233.48	
16	1.605	$ 27,729.33	0.394	$ 10,915.55	
17	1.653	$ 28,561.21	0.371	$ 10,606.62	
18	1.702	$ 29,418.04	0.350	$ 10,306.43	
19	1.754	$ 30,300.58	0.331	$ 10,014.74	
20	1.806	$ 31,209.60	0.312	$ 9,731.30	
21	1.860	$ 32,145.89	0.294	$ 9,455.89	
22	1.916	$ 33,110.27	0.278	$ 9,188.27	
23	1.974	$ 34,103.57	0.262	$ 8,928.22	
24	2.033	$ 35,126.68	0.247	$ 8,675.54	
25	2.094	$ 36,180.48	0.233	$ 8,430.00	
26	2.157	$ 37,265.90	0.220	$ 8,191.42	
27	2.221	$ 38,383.87	0.207	$ 7,959.59	
28	2.288	$ 39,535.39	0.196	$ 7,734.31	
29	2.357	$ 40,721.45	0.185	$ 7,515.42	
30	2.427	$ 41,943.10	0.174	$ 7,302.72	
31	2.500	$ 43,201.39	0.164	$ 7,096.04	
32	2.575	$ 44,497.43	0.155	$ 6,895.21	
33	2.652	$ 45,832.35	0.146	$ 6,700.06	
34	2.732	$ 47,207.32	0.138	$ 6,510.43	

35	2.814	$ 48,623.54	0.130	$ 6,326.18
36	2.898	$ 50,082.25	0.123	$ 6,147.13
37	2.985	$ 51,584.72	0.116	$ 5,973.16
38	3.075	$ 53,132.26	0.109	$ 5,804.11
39	3.167	$ 54,726.23	0.103	$ 5,639.84
40	3.262	$ 56,368.01	0.097	$ 5,480.22
41	3.360	$ 58,059.05	0.092	$ 5,325.12
42	3.461	$ 59,800.83	0.087	$ 5,174.41
43	3.565	$ 61,594.85	0.082	$ 5,027.96
44	3.671	$ 63,442.70	0.077	$ 4,885.66
45	3.782	$ 65,345.98	0.073	$ 4,747.39
46	3.895	$ 67,306.36	0.069	$ 4,613.03
47	4.012	$ 69,325.55	0.065	$ 4,482.47
48	4.132	$ 71,405.31	0.061	$ 4,355.61
49	4.256	$ 73,547.47	0.058	$ 4,232.34
50	4.384	$ 75,753.90	0.054	$ 4,112.55
Total Operational Cost		**$ 2,024,883.76**		**$ 469,362.28**

Replacement Costs

Submersible Axial Flow Pump Replacement Costs

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per pump)
$ 169,654	$ 49,200	$ 35,627	$ 254,481

Fixed T-Screens

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per screen)
$ 118,750	$ 34,438	$ 24,938	$ 178,125

Side Hinged Gates

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per gate)
$ 60,000.00	$ 17,400	$ 12,600	$ 90,000

750 kva Diesel Generator

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per generator)
$ 50,000.00	$ 14,500.00	$ 10,500.00	$ 75,000

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 1,730,943	1.000	$ 1,730,943.00	<== initial costs
25	2.094	$ 1,251,254	0.233	$ 291,540.53	<== replace 1 pump, 1 screen, 1 gate, 1 generator
26	2.157	$ 1,127,048	0.220	$ 247,736.35	<== replace 1 pump, 1 screen, 1 gate
27	2.221	$ 960,943	0.207	$ 199,268.77	<== replace 1 pump and 1 screen
28	2.288	$ 407,537	0.196	$ 79,726.54	<== replace 1 screen
Total Replacement Cost		**$ 5,477,724.86**		**$ 2,549,215.19**	

Calculate the 50 Year Life Cycle Cost for Alternative 3

Assumptions
1. Inflaction Rate = 3.0%
2. interest Rate = 6.0%
3. Pump Station will run when gates are closed. Based WSE's gate closure analysis the maximum duration of gate closure could be 468 hours between October 1 through April 30.
4. Pump Station will not run outside of the October 1 through April 30th window.
5. When Pump Station is running it will have a demand load of about 400 kVA. This is based on two 150 hp pumps in the Government Canal Pump Station running and loads from HVAC and electrical equipment
6. Packaged lift station will have a demand load of about 50 kVA. This is based on one 35 hp pump running and electrical equipment.
8. Packaged lift station will operate year round.
9. Energy rate is based on average industrial electricity rates in Seattle (https://www.electricitylocal.com/states/washington/seattle).
10. Labor cost per hour is based on prevailing wage rates for electricians in King County (https://secure.lni.wa.gov/wagelookup/).
11. Replacement costs inlcude pumps, fish screens, and gates. One pump, fish screen, and gate will be replaced per year starting 25 years after installation until all of the pumps, fish screens and gates have been replaced
12. The intake structure, building, and culvert will be designed for a 50-year life and are not included in the replacement costs.

Construction Cost
$ 14,227,000

Energy Cost

Government Canal Pump Station

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
468	400	$ 0.0595	$ 11,138.40

Packaged Lift Station

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
1872	50	$ 0.0595	$ 5,569.20

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 16,707.60	1.000	$ 16,707.60	<== Initial Cost
1	1.030	$ 17,208.83	0.943	$ 16,234.74	
2	1.061	$ 17,725.09	0.890	$ 15,775.27	
3	1.093	$ 18,256.85	0.840	$ 15,328.80	
4	1.126	$ 18,804.55	0.792	$ 14,894.97	
5	1.159	$ 19,368.69	0.747	$ 14,473.41	
6	1.194	$ 19,949.75	0.705	$ 14,063.79	
7	1.230	$ 20,548.24	0.665	$ 13,665.75	
8	1.267	$ 21,164.69	0.627	$ 13,278.99	
9	1.305	$ 21,799.63	0.592	$ 12,903.17	
10	1.344	$ 22,453.62	0.558	$ 12,537.98	
11	1.384	$ 23,127.23	0.527	$ 12,183.13	
12	1.426	$ 23,821.04	0.497	$ 11,838.33	
13	1.469	$ 24,535.67	0.469	$ 11,503.28	
14	1.513	$ 25,271.74	0.442	$ 11,177.72	
15	1.558	$ 26,029.90	0.417	$ 10,861.37	

16	1.605	$ 26,810.79	0.394	$ 10,553.97
17	1.653	$ 27,615.12	0.371	$ 10,255.27
18	1.702	$ 28,443.57	0.350	$ 9,965.03
19	1.754	$ 29,296.88	0.331	$ 9,683.00
20	1.806	$ 30,175.78	0.312	$ 9,408.95
21	1.860	$ 31,081.06	0.294	$ 9,142.66
22	1.916	$ 32,013.49	0.278	$ 8,883.91
23	1.974	$ 32,973.89	0.262	$ 8,632.48
24	2.033	$ 33,963.11	0.247	$ 8,388.16
25	2.094	$ 34,982.00	0.233	$ 8,150.76
26	2.157	$ 36,031.46	0.220	$ 7,920.08
27	2.221	$ 37,112.41	0.207	$ 7,695.92
28	2.288	$ 38,225.78	0.196	$ 7,478.11
29	2.357	$ 39,372.55	0.185	$ 7,266.47
30	2.427	$ 40,553.73	0.174	$ 7,060.82
31	2.500	$ 41,770.34	0.164	$ 6,860.98
32	2.575	$ 43,023.45	0.155	$ 6,666.80
33	2.652	$ 44,314.16	0.146	$ 6,478.12
34	2.732	$ 45,643.58	0.138	$ 6,294.78
35	2.814	$ 47,012.89	0.130	$ 6,116.62
36	2.898	$ 48,423.27	0.123	$ 5,943.51
37	2.985	$ 49,875.97	0.116	$ 5,775.30
38	3.075	$ 51,372.25	0.109	$ 5,611.85
39	3.167	$ 52,913.42	0.103	$ 5,453.02
40	3.262	$ 54,500.82	0.097	$ 5,298.69
41	3.360	$ 56,135.85	0.092	$ 5,148.73
42	3.461	$ 57,819.92	0.087	$ 5,003.01
43	3.565	$ 59,554.52	0.082	$ 4,861.41
44	3.671	$ 61,341.16	0.077	$ 4,723.83
45	3.782	$ 63,181.39	0.073	$ 4,590.13
46	3.895	$ 65,076.83	0.069	$ 4,460.22
47	4.012	$ 67,029.14	0.065	$ 4,333.99
48	4.132	$ 69,040.01	0.061	$ 4,211.33
49	4.256	$ 71,111.21	0.058	$ 4,092.14
50	4.384	$ 73,244.55	0.054	$ 3,976.33
Total Energy Cost		**$ 1,957,809.49**		**$ 453,814.66**

Operational Costs

Frequency of Routine Maintenance (visits per month)	No. of Personel	Labor Cost ($/hour)	Hours per vist per person	Cost per Year
1	2	$ 90.00	8	$ 17,280.00

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 17,280.00	1.000	$ 17,280.00	<== Initial Cost
1	1.030	$ 17,798.40	0.943	$ 16,790.94	
2	1.061	$ 18,332.35	0.890	$ 16,315.73	
3	1.093	$ 18,882.32	0.840	$ 15,853.96	
4	1.126	$ 19,448.79	0.792	$ 15,405.27	
5	1.159	$ 20,032.26	0.747	$ 14,969.27	
6	1.194	$ 20,633.22	0.705	$ 14,545.61	
7	1.230	$ 21,252.22	0.665	$ 14,133.94	
8	1.267	$ 21,889.79	0.627	$ 13,733.92	
9	1.305	$ 22,546.48	0.592	$ 13,345.23	
10	1.344	$ 23,222.88	0.558	$ 12,967.53	
11	1.384	$ 23,919.56	0.527	$ 12,600.53	
12	1.426	$ 24,637.15	0.497	$ 12,243.91	
13	1.469	$ 25,376.26	0.469	$ 11,897.38	
14	1.513	$ 26,137.55	0.442	$ 11,560.66	
15	1.558	$ 26,921.68	0.417	$ 11,233.48	
16	1.605	$ 27,729.33	0.394	$ 10,915.55	
17	1.653	$ 28,561.21	0.371	$ 10,606.62	
18	1.702	$ 29,418.04	0.350	$ 10,306.43	
19	1.754	$ 30,300.58	0.331	$ 10,014.74	
20	1.806	$ 31,209.60	0.312	$ 9,731.30	
21	1.860	$ 32,145.89	0.294	$ 9,455.89	
22	1.916	$ 33,110.27	0.278	$ 9,188.27	
23	1.974	$ 34,103.57	0.262	$ 8,928.22	
24	2.033	$ 35,126.68	0.247	$ 8,675.54	
25	2.094	$ 36,180.48	0.233	$ 8,430.00	
26	2.157	$ 37,265.90	0.220	$ 8,191.42	
27	2.221	$ 38,383.87	0.207	$ 7,959.59	
28	2.288	$ 39,535.39	0.196	$ 7,734.31	
29	2.357	$ 40,721.45	0.185	$ 7,515.42	
30	2.427	$ 41,943.10	0.174	$ 7,302.72	
31	2.500	$ 43,201.39	0.164	$ 7,096.04	
32	2.575	$ 44,497.43	0.155	$ 6,895.21	
33	2.652	$ 45,832.35	0.146	$ 6,700.06	
34	2.732	$ 47,207.32	0.138	$ 6,510.43	
35	2.814	$ 48,623.54	0.130	$ 6,326.18	

36	2.898	$ 50,082.25	0.123	$ 6,147.13
37	2.985	$ 51,584.72	0.116	$ 5,973.16
38	3.075	$ 53,132.26	0.109	$ 5,804.11
39	3.167	$ 54,726.23	0.103	$ 5,639.84
40	3.262	$ 56,368.01	0.097	$ 5,480.22
41	3.360	$ 58,059.05	0.092	$ 5,325.12
42	3.461	$ 59,800.83	0.087	$ 5,174.41
43	3.565	$ 61,594.85	0.082	$ 5,027.96
44	3.671	$ 63,442.70	0.077	$ 4,885.66
45	3.782	$ 65,345.98	0.073	$ 4,747.39
46	3.895	$ 67,306.36	0.069	$ 4,613.03
47	4.012	$ 69,325.55	0.065	$ 4,482.47
48	4.132	$ 71,405.31	0.061	$ 4,355.61
49	4.256	$ 73,547.47	0.058	$ 4,232.34
50	4.384	$ 75,753.90	0.054	$ 4,112.55
Total Operational Cost		**$ 2,024,883.76**		**$ 469,362.28**

Replacement Costs

Submersible Axial Flow Pump Replacement Costs

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per pump)
$ 169,654	$ 49,200	$ 35,627	$ 254,481

Cone Screens

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per screen)
$ 137,500	$ 39,875	$ 28,875	$ 206,250

Motor Operated Sluice Gates

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per gate)
$ 58,000.00	$ 16,820	$ 12,180	$ 87,000

750 Kva Diesel Generator

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per generator)
$ 50,000.00	$ 14,500.00	$ 10,500.00	$ 75,000

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 1,837,443	1.000	$ 1,837,443.00	<== initial costs
25	2.094	$ 1,303,860	0.233	$ 303,797.69	<== replace 1 pump, 1 screen, 1 gate, 1 generator
26	2.157	$ 1,181,232	0.220	$ 259,646.62	<== replace 1 pump, 1 screen, 1 gate
27	2.221	$ 1,023,417	0.207	$ 212,223.83	<== replace 1 pump and 1 screen
28	2.288	$ 471,885	0.196	$ 92,314.95	<== replace 1 screen
Total Replacement Cost		**$ 5,817,837.10**		**$ 2,705,426.08**	

Calculate the 50 Year Life Cycle Cost for Alternative 4

Assumptions
1. Inflaction Rate = 3.0%
2. interest Rate = 6.0%
3. Governement Canal pumps will run when gates are closed. Based WSE's gate closure analysis the maximum duration of gate closure could be 468 hours between October 1 through April 30.
4. Government Canal Pumps will not run outside of the October 1 through April 30th window.
5. When Government Canal pumps White River Estate pumps are running the pump station will have a demand load of about 600 kVA. This is based on three 140 hp Governmetn Canal Pumps running, one 35 hp White River Estate pump running, and other loads from HVAC and electrical equipment.
6. White River Estates pumps will operate four times as much as the Government Canal pumps.
7. Energy rate is based on average industrial electricity rates in Seattle (https://www.electricitylocal.com/states/washington/seattle).
8. Routine maintenance will be faster since all of the pumps are located at one spot.
9. Labor cost per hour is based on prevailing wage rates for electricians in King County (https://secure.lni.wa.gov/wagelookup/).

10. Replacement costs inlcude pumps, fish screens, and gates. One pump, fish screen, and gate will be replaced per year starting 25 years after installation until all of the pumps, fish screens and gates have been replaced.
11. The intake structure, building, and culvert will be designed for a 50-year life and are not included in the replacement costs.

Construction Cost
$ 21,065,000

Energy Cost

Government Canal and White River Estate Pumps running

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
468	600	$ 0.0595	$ 16,707.60

Only White River Estates Pumps Running

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
1404	50	$ 0.0595	$ 4,176.90

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 20,884.50	1.000	$ 20,884.50	<== Initial Cost
1	1.030	$ 21,511.04	0.943	$ 20,293.43	
2	1.061	$ 22,156.37	0.890	$ 19,719.09	
3	1.093	$ 22,821.06	0.840	$ 19,161.00	
4	1.126	$ 23,505.69	0.792	$ 18,618.71	
5	1.159	$ 24,210.86	0.747	$ 18,091.76	
6	1.194	$ 24,937.19	0.705	$ 17,579.73	
7	1.230	$ 25,685.30	0.665	$ 17,082.19	
8	1.267	$ 26,455.86	0.627	$ 16,598.73	
9	1.305	$ 27,249.54	0.592	$ 16,128.96	
10	1.344	$ 28,067.02	0.558	$ 15,672.48	
11	1.384	$ 28,909.03	0.527	$ 15,228.92	
12	1.426	$ 29,776.30	0.497	$ 14,797.91	
13	1.469	$ 30,669.59	0.469	$ 14,379.10	
14	1.513	$ 31,589.68	0.442	$ 13,972.15	

15	1.558	$ 32,537.37	0.417	$ 13,576.71
16	1.605	$ 33,513.49	0.394	$ 13,192.46
17	1.653	$ 34,518.90	0.371	$ 12,819.09
18	1.702	$ 35,554.46	0.350	$ 12,456.29
19	1.754	$ 36,621.10	0.331	$ 12,103.75
20	1.806	$ 37,719.73	0.312	$ 11,761.19
21	1.860	$ 38,851.32	0.294	$ 11,428.33
22	1.916	$ 40,016.86	0.278	$ 11,104.88
23	1.974	$ 41,217.37	0.262	$ 10,790.59
24	2.033	$ 42,453.89	0.247	$ 10,485.20
25	2.094	$ 43,727.51	0.233	$ 10,188.45
26	2.157	$ 45,039.33	0.220	$ 9,900.10
27	2.221	$ 46,390.51	0.207	$ 9,619.91
28	2.288	$ 47,782.23	0.196	$ 9,347.64
29	2.357	$ 49,215.69	0.185	$ 9,083.09
30	2.427	$ 50,692.16	0.174	$ 8,826.02
31	2.500	$ 52,212.93	0.164	$ 8,576.23
32	2.575	$ 53,779.32	0.155	$ 8,333.50
33	2.652	$ 55,392.70	0.146	$ 8,097.65
34	2.732	$ 57,054.48	0.138	$ 7,868.47
35	2.814	$ 58,766.11	0.130	$ 7,645.78
36	2.898	$ 60,529.09	0.123	$ 7,429.39
37	2.985	$ 62,344.97	0.116	$ 7,219.12
38	3.075	$ 64,215.32	0.109	$ 7,014.81
39	3.167	$ 66,141.78	0.103	$ 6,816.27
40	3.262	$ 68,126.03	0.097	$ 6,623.36
41	3.360	$ 70,169.81	0.092	$ 6,435.91
42	3.461	$ 72,274.90	0.087	$ 6,253.76
43	3.565	$ 74,443.15	0.082	$ 6,076.77
44	3.671	$ 76,676.45	0.077	$ 5,904.78
45	3.782	$ 78,976.74	0.073	$ 5,737.67
46	3.895	$ 81,346.04	0.069	$ 5,575.28
47	4.012	$ 83,786.42	0.065	$ 5,417.49
48	4.132	$ 86,300.01	0.061	$ 5,264.16
49	4.256	$ 88,889.01	0.058	$ 5,115.18
50	4.384	$ 91,555.69	0.054	$ 4,970.41
Total Energy Cost		**$ 2,447,261.86**		**$ 567,268.32**

Operational Costs

Frequency of Routine Maintenance (visits per month)	No. of Personel	Labor Cost ($/hour)	Hours per vist per person	Cost per Year
1	2	$ 90.00	6	$ 12,960.00

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 12,960.00	1.000	$ 12,960.00	<== Initial Cost
1	1.030	$ 13,348.80	0.943	$ 12,593.21	
2	1.061	$ 13,749.26	0.890	$ 12,236.80	
3	1.093	$ 14,161.74	0.840	$ 11,890.47	
4	1.126	$ 14,586.59	0.792	$ 11,553.95	
5	1.159	$ 15,024.19	0.747	$ 11,226.95	
6	1.194	$ 15,474.92	0.705	$ 10,909.21	
7	1.230	$ 15,939.17	0.665	$ 10,600.46	
8	1.267	$ 16,417.34	0.627	$ 10,300.44	
9	1.305	$ 16,909.86	0.592	$ 10,008.92	
10	1.344	$ 17,417.16	0.558	$ 9,725.65	
11	1.384	$ 17,939.67	0.527	$ 9,450.39	
12	1.426	$ 18,477.86	0.497	$ 9,182.93	
13	1.469	$ 19,032.20	0.469	$ 8,923.04	
14	1.513	$ 19,603.16	0.442	$ 8,670.50	
15	1.558	$ 20,191.26	0.417	$ 8,425.11	
16	1.605	$ 20,797.00	0.394	$ 8,186.66	
17	1.653	$ 21,420.91	0.371	$ 7,954.96	
18	1.702	$ 22,063.53	0.350	$ 7,729.82	
19	1.754	$ 22,725.44	0.331	$ 7,511.05	
20	1.806	$ 23,407.20	0.312	$ 7,298.48	
21	1.860	$ 24,109.42	0.294	$ 7,091.92	
22	1.916	$ 24,832.70	0.278	$ 6,891.20	
23	1.974	$ 25,577.68	0.262	$ 6,696.17	
24	2.033	$ 26,345.01	0.247	$ 6,506.65	
25	2.094	$ 27,135.36	0.233	$ 6,322.50	
26	2.157	$ 27,949.42	0.220	$ 6,143.56	
27	2.221	$ 28,787.91	0.207	$ 5,969.69	
28	2.288	$ 29,651.54	0.196	$ 5,800.74	
29	2.357	$ 30,541.09	0.185	$ 5,636.56	
30	2.427	$ 31,457.32	0.174	$ 5,477.04	
31	2.500	$ 32,401.04	0.164	$ 5,322.03	
32	2.575	$ 33,373.07	0.155	$ 5,171.40	
33	2.652	$ 34,374.26	0.146	$ 5,025.04	
34	2.732	$ 35,405.49	0.138	$ 4,882.83	
35	2.814	$ 36,467.66	0.130	$ 4,744.63	

36	2.898	$ 37,561.69	0.123	$ 4,610.35
37	2.985	$ 38,688.54	0.116	$ 4,479.87
38	3.075	$ 39,849.19	0.109	$ 4,353.08
39	3.167	$ 41,044.67	0.103	$ 4,229.88
40	3.262	$ 42,276.01	0.097	$ 4,110.17
41	3.360	$ 43,544.29	0.092	$ 3,993.84
42	3.461	$ 44,850.62	0.087	$ 3,880.81
43	3.565	$ 46,196.14	0.082	$ 3,770.97
44	3.671	$ 47,582.02	0.077	$ 3,664.25
45	3.782	$ 49,009.48	0.073	$ 3,560.54
46	3.895	$ 50,479.77	0.069	$ 3,459.77
47	4.012	$ 51,994.16	0.065	$ 3,361.85
48	4.132	$ 53,553.98	0.061	$ 3,266.71
49	4.256	$ 55,160.60	0.058	$ 3,174.25
50	4.384	$ 56,815.42	0.054	$ 3,084.42
Total Operational Cost		**$ 1,518,662.82**		**$ 352,021.71**

Replacement Costs

Submersible Solids Handling Pump Replacement Costs

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per pump)	
$ 170,000	$ 49,300	$ 35,700	$ 255,000	<== Large GC Pump
$ 44,671	$ 12,955	$ 9,381	$ 67,007	<== Small WRE Pump

Fixed T-Screens

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per screen)
$ 118,750	$ 34,438	$ 24,938	$ 178,125

Side Hinged Gates

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per gate)
$ 60,000.00	$ 17,400	$ 12,600	$ 90,000

0 Kva Diesel Generator

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per generator)
$ 50,000.00	$ 14,500.00	$ 10,500.00	$ 75,000

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 1,732,500	1.000	$ 1,732,500.00	<== initial costs
25	2.094	$ 1,392,638	0.233	$ 324,482.67	<== replace 1 GC pump, 1 WRE pump, 1 screen, 1 gate, 1 generator
26	2.157	$ 1,272,672	0.220	$ 279,746.17	<== replace 1 GC pump, 1 WRE pump, 1 screen, 1 gate
27	2.221	$ 962,096	0.207	$ 199,507.84	<== replace 1 GC pump and 1 screen
28	2.288	$ 990,959	0.196	$ 193,861.39	<== replace 1 GC pump and 1 screen
Total Replacement Cost		**$ 6,350,864.57**		**$ 2,730,098.05**	

Calculate the 50 Year Life Cycle Cost for Alternative 5

Assumptions
1. Inflaction Rate = 3.0%
2. interest Rate = 6.0%
3. Pump Station will run when gates are closed. Based WSE's gate closure analysis the maximum duration of gate closure could be 468 hours between October 1 through April 30.
4. Pump Station will not run outside of the October 1 through April 30th window.
5. When Pump Station is running it will have a demand load of about 100 kVA. This is based on loads from HVAC and electrical equipment.
6. Engine driven pumps will run on diesel and have a thermal efficiency of 30%.
7. Packaged lift station will have a demand load of about 50 kVA. This is based on one 35 hp pump running and electrical equipment.
8. Packaged lift station will operate year round.
9. Energy rate is based on average industrial electricity rates in Seattle (https://www.electricitylocal.com/states/washington/seattle).
10. Labor cost per hour is based on prevailing wage rates for electricians in King County (https://secure.lni.wa.gov/wagelookup/).

11. Replacement costs inlcude pumps, fish screens, and gates. One pump, fish screen, and gate will be replaced per year starting 25 years after installation until all of the pumps, fish screens and gates have been replaced.
12. The intake structure, building, and culvert will be designed for a 50-year life and are not included in the replacement costs.

Construction Cost
$ 17,373,000

Energy Cost

Government Canal Pump Station

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
468	100	$ 0.0595	$ 2,784.60

Packaged Lift Station

Hours of Operation per year	kW	Rate ($/kW Hour)	Cost per Year
1872	50	$ 0.0595	$ 5,569.20

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 8,353.80	1.000	$ 8,353.80	<== Initial Cost
1	1.030	$ 8,604.41	0.943	$ 8,117.37	
2	1.061	$ 8,862.55	0.890	$ 7,887.63	
3	1.093	$ 9,128.42	0.840	$ 7,664.40	
4	1.126	$ 9,402.28	0.792	$ 7,447.48	
5	1.159	$ 9,684.34	0.747	$ 7,236.71	
6	1.194	$ 9,974.87	0.705	$ 7,031.89	
7	1.230	$ 10,274.12	0.665	$ 6,832.88	
8	1.267	$ 10,582.34	0.627	$ 6,639.49	
9	1.305	$ 10,899.81	0.592	$ 6,451.58	

10	1.344	$ 11,226.81	0.558	$ 6,268.99
11	1.384	$ 11,563.61	0.527	$ 6,091.57
12	1.426	$ 11,910.52	0.497	$ 5,919.16
13	1.469	$ 12,267.84	0.469	$ 5,751.64
14	1.513	$ 12,635.87	0.442	$ 5,588.86
15	1.558	$ 13,014.95	0.417	$ 5,430.68
16	1.605	$ 13,405.40	0.394	$ 5,276.98
17	1.653	$ 13,807.56	0.371	$ 5,127.64
18	1.702	$ 14,221.79	0.350	$ 4,982.51
19	1.754	$ 14,648.44	0.331	$ 4,841.50
20	1.806	$ 15,087.89	0.312	$ 4,704.48
21	1.860	$ 15,540.53	0.294	$ 4,571.33
22	1.916	$ 16,006.74	0.278	$ 4,441.95
23	1.974	$ 16,486.95	0.262	$ 4,316.24
24	2.033	$ 16,981.56	0.247	$ 4,194.08
25	2.094	$ 17,491.00	0.233	$ 4,075.38
26	2.157	$ 18,015.73	0.220	$ 3,960.04
27	2.221	$ 18,556.20	0.207	$ 3,847.96
28	2.288	$ 19,112.89	0.196	$ 3,739.06
29	2.357	$ 19,686.28	0.185	$ 3,633.24
30	2.427	$ 20,276.87	0.174	$ 3,530.41
31	2.500	$ 20,885.17	0.164	$ 3,430.49
32	2.575	$ 21,511.73	0.155	$ 3,333.40
33	2.652	$ 22,157.08	0.146	$ 3,239.06
34	2.732	$ 22,821.79	0.138	$ 3,147.39
35	2.814	$ 23,506.44	0.130	$ 3,058.31
36	2.898	$ 24,211.64	0.123	$ 2,971.76
37	2.985	$ 24,937.99	0.116	$ 2,887.65
38	3.075	$ 25,686.13	0.109	$ 2,805.92
39	3.167	$ 26,456.71	0.103	$ 2,726.51
40	3.262	$ 27,250.41	0.097	$ 2,649.34
41	3.360	$ 28,067.92	0.092	$ 2,574.36
42	3.461	$ 28,909.96	0.087	$ 2,501.50
43	3.565	$ 29,777.26	0.082	$ 2,430.71
44	3.671	$ 30,670.58	0.077	$ 2,361.91
45	3.782	$ 31,590.70	0.073	$ 2,295.07
46	3.895	$ 32,538.42	0.069	$ 2,230.11
47	4.012	$ 33,514.57	0.065	$ 2,167.00
48	4.132	$ 34,520.01	0.061	$ 2,105.67
49	4.256	$ 35,555.61	0.058	$ 2,046.07
50	4.384	$ 36,622.27	0.054	$ 1,988.16
Total Energy Cost		**$ 978,904.74**		**$ 226,907.33**

Fuel Cost for Engine Driven Pumps

Determine annual cost of diesel fuel to run the three engine driven pumps.

Engine HP	Thermal Efficiency	Weight of 1 gal of Diesel Fuel (lbs)	BTU's for 1 lb of Diesel	Fuel Flow (GPH)	No. of Engines	Hours of Operation per year	Quantity of Fuel Required Per Year (Gallons)	Cost of Diesel ($/gal)	Annual Cost ($)
200	0.3	7	19857.14	12.21	3	468	17137.55	$ 2.65	$ 45,415

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 45,414.52	1.000	$ 45,414.52	<== Initial Cost
1	1.030	$ 46,776.95	0.943	$ 44,129.20	
2	1.061	$ 48,180.26	0.890	$ 42,880.26	
3	1.093	$ 49,625.67	0.840	$ 41,666.67	
4	1.126	$ 51,114.44	0.792	$ 40,487.42	
5	1.159	$ 52,647.87	0.747	$ 39,341.55	
6	1.194	$ 54,227.31	0.705	$ 38,228.11	
7	1.230	$ 55,854.13	0.665	$ 37,146.19	
8	1.267	$ 57,529.75	0.627	$ 36,094.88	
9	1.305	$ 59,255.65	0.592	$ 35,073.33	
10	1.344	$ 61,033.31	0.558	$ 34,080.68	
11	1.384	$ 62,864.31	0.527	$ 33,116.14	
12	1.426	$ 64,750.24	0.497	$ 32,178.89	
13	1.469	$ 66,692.75	0.469	$ 31,268.16	
14	1.513	$ 68,693.53	0.442	$ 30,383.22	
15	1.558	$ 70,754.34	0.417	$ 29,523.31	
16	1.605	$ 72,876.97	0.394	$ 28,687.75	
17	1.653	$ 75,063.28	0.371	$ 27,875.83	
18	1.702	$ 77,315.18	0.350	$ 27,086.89	
19	1.754	$ 79,634.63	0.331	$ 26,320.28	
20	1.806	$ 82,023.67	0.312	$ 25,575.37	
21	1.860	$ 84,484.38	0.294	$ 24,851.54	
22	1.916	$ 87,018.91	0.278	$ 24,148.19	
23	1.974	$ 89,629.48	0.262	$ 23,464.75	
24	2.033	$ 92,318.36	0.247	$ 22,800.66	
25	2.094	$ 95,087.92	0.233	$ 22,155.35	
26	2.157	$ 97,940.55	0.220	$ 21,528.32	
27	2.221	$ 100,878.77	0.207	$ 20,919.02	
28	2.288	$ 103,905.13	0.196	$ 20,326.98	
29	2.357	$ 107,022.29	0.185	$ 19,751.68	
30	2.427	$ 110,232.96	0.174	$ 19,192.67	
31	2.500	$ 113,539.94	0.164	$ 18,649.49	
32	2.575	$ 116,946.14	0.155	$ 18,121.67	
33	2.652	$ 120,454.53	0.146	$ 17,608.79	
34	2.732	$ 124,068.16	0.138	$ 17,110.43	
35	2.814	$ 127,790.21	0.130	$ 16,626.17	
36	2.898	$ 131,623.91	0.123	$ 16,155.62	

37	2.985	$ 135,572.63	0.116	$ 15,698.39
38	3.075	$ 139,639.81	0.109	$ 15,254.09
39	3.167	$ 143,829.00	0.103	$ 14,822.37
40	3.262	$ 148,143.87	0.097	$ 14,402.87
41	3.360	$ 152,588.19	0.092	$ 13,995.24
42	3.461	$ 157,165.84	0.087	$ 13,599.15
43	3.565	$ 161,880.81	0.082	$ 13,214.27
44	3.671	$ 166,737.24	0.077	$ 12,840.28
45	3.782	$ 171,739.35	0.073	$ 12,476.88
46	3.895	$ 176,891.53	0.069	$ 12,123.76
47	4.012	$ 182,198.28	0.065	$ 11,780.63
48	4.132	$ 187,664.23	0.061	$ 11,447.22
49	4.256	$ 193,294.15	0.058	$ 11,123.24
50	4.384	$ 199,092.98	0.054	$ 10,808.43
Total Fuel Cost		**$ 5,321,708.34**		**$ 1,233,556.82**

Operational Costs

Frequency of Routine Maintenance (visits per month)	No. of Personel	Labor Cost ($/hour)	Hours per vist per person	Cost per Year
1	2	$ 90.00	12	$ 25,920.00

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 25,920.00	1.000	$ 25,920.00	<== Initial Cost
1	1.030	$ 26,697.60	0.943	$ 25,186.42	
2	1.061	$ 27,498.53	0.890	$ 24,473.59	
3	1.093	$ 28,323.48	0.840	$ 23,780.94	
4	1.126	$ 29,173.19	0.792	$ 23,107.90	
5	1.159	$ 30,048.38	0.747	$ 22,453.90	
6	1.194	$ 30,949.84	0.705	$ 21,818.41	
7	1.230	$ 31,878.33	0.665	$ 21,200.91	
8	1.267	$ 32,834.68	0.627	$ 20,600.88	
9	1.305	$ 33,819.72	0.592	$ 20,017.84	
10	1.344	$ 34,834.31	0.558	$ 19,451.30	
11	1.384	$ 35,879.34	0.527	$ 18,900.79	
12	1.426	$ 36,955.72	0.497	$ 18,365.86	
13	1.469	$ 38,064.39	0.469	$ 17,846.07	
14	1.513	$ 39,206.33	0.442	$ 17,341.00	
15	1.558	$ 40,382.52	0.417	$ 16,850.21	
16	1.605	$ 41,593.99	0.394	$ 16,373.32	
17	1.653	$ 42,841.81	0.371	$ 15,909.92	
18	1.702	$ 44,127.06	0.350	$ 15,459.64	
19	1.754	$ 45,450.88	0.331	$ 15,022.11	

20	1.806	$ 46,814.40	0.312	$ 14,596.95
21	1.860	$ 48,218.84	0.294	$ 14,183.83
22	1.916	$ 49,665.40	0.278	$ 13,782.40
23	1.974	$ 51,155.36	0.262	$ 13,392.33
24	2.033	$ 52,690.02	0.247	$ 13,013.31
25	2.094	$ 54,270.72	0.233	$ 12,645.00
26	2.157	$ 55,898.85	0.220	$ 12,287.13
27	2.221	$ 57,575.81	0.207	$ 11,939.38
28	2.288	$ 59,303.09	0.196	$ 11,601.47
29	2.357	$ 61,082.18	0.185	$ 11,273.13
30	2.427	$ 62,914.64	0.174	$ 10,954.08
31	2.500	$ 64,802.08	0.164	$ 10,644.06
32	2.575	$ 66,746.15	0.155	$ 10,342.81
33	2.652	$ 68,748.53	0.146	$ 10,050.09
34	2.732	$ 70,810.99	0.138	$ 9,765.65
35	2.814	$ 72,935.31	0.130	$ 9,489.27
36	2.898	$ 75,123.37	0.123	$ 9,220.70
37	2.985	$ 77,377.08	0.116	$ 8,959.74
38	3.075	$ 79,698.39	0.109	$ 8,706.16
39	3.167	$ 82,089.34	0.103	$ 8,459.76
40	3.262	$ 84,552.02	0.097	$ 8,220.33
41	3.360	$ 87,088.58	0.092	$ 7,987.68
42	3.461	$ 89,701.24	0.087	$ 7,761.61
43	3.565	$ 92,392.27	0.082	$ 7,541.95
44	3.671	$ 95,164.04	0.077	$ 7,328.50
45	3.782	$ 98,018.96	0.073	$ 7,121.09
46	3.895	$ 100,959.53	0.069	$ 6,919.54
47	4.012	$ 103,988.32	0.065	$ 6,723.71
48	4.132	$ 107,107.97	0.061	$ 6,533.42
49	4.256	$ 110,321.21	0.058	$ 6,348.51
50	4.384	$ 113,630.84	0.054	$ 6,168.83
Total Operational Cost		**$ 3,037,325.64**		**$ 704,043.42**

Replacement Costs

Vertical Axial Flow Line-Shaft Pumps

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per pump)
$ 225,000	$ 65,250	$ 47,250	$ 337,500

Cone Screens

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per screen)
$ 137,500	$ 39,875	$ 28,875	$ 206,250

Motor Operated Sluice Gates

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per gate)
$ 58,000.00	$ 16,820	$ 12,180	$ 87,000

100 kva Diesel Generator

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per generator)
$ 20,000.00	$ 5,800.00	$ 4,200.00	$ 30,000

Diesel Engine

Material Cost	Labor Cost (29% of Material)	Equipment Cost (21% of Material)	Total (per generator)
$ 10,000.00	$ 2,900.00	$ 2,100.00	$ 15,000

Year	Inflation Factor	Future Cost	Compound Interest Factor	Present Worth Cost	
0	1.000	$ 2,086,500	1.000	$ 2,086,500.00	<== initial costs
25	2.094	$ 1,414,870	0.233	$ 329,662.87	<== replace 1 pump, 1 screen, 1 gate, 1 generator, 1 engine
26	2.157	$ 1,392,619	0.220	$ 306,111.58	<== replace 1 pump, 1 screen, 1 gate, 1 engine
27	2.221	$ 1,241,145	0.207	$ 257,373.74	<== replace 1 pump, 1 screen, 1 engine.
28	2.288	$ 471,885	0.196	$ 92,314.95	<== replace 1 screen
Total Replacement Cost		**$ 6,607,019.56**		**$ 3,071,963.15**	