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Technical Memorandum

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Subject: Updated PRS and OLSF Alternative Analysis

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Table of Contents

List of Figures ii
List of Tables iii
List of Abbreviations iv
Section 1: Summary of Additional Modeling Efforts 1
Section 2: Alternative Layouts 2
2.1 Alternative 1 (Recommended Alternative from PER) 2
2.2 Alternative 2 (PER Recommended Alternative with fewer pumps) 11
2.3 Alternative 3 (PER Alternative 1 Update) 16
2.4 Alternative 4 (Tank Only Option) 23
Section 3: Operation and Maintenance 29
Section 4: PRS and OLFS Alternative Cost 31
Section 5: Summary of Evaluation 32

List of Figures

Figure 2.1. Alternative 1 Hydraulic Profile 3
Figure 2.2. Alternative 1 Flow Diagram 4
Figure 2.3. Single Pump PRS Pump Curve with Design Points 5
Figure 2.4. Multi-Pump PRS Pump Curves with Design Points 6
Figure 2.5. Single-Pump Drain Pump Curve with Design Points 8
Figure 2.6. Single-Pump Drain Pump Curve with Design Points and Control Valve 8
Figure 2.7. Multi-Pump Drain Pump with Design Points and Control Valve 9
Figure 2.8. Alternative 2 Flow Diagram 11
Figure 2.9. Single-Pump PRS Pump Curve with Design Points 12
Figure 2.10. Multi-Pump PRS Pump Curve with Design Points 12
Figure 2.11. Single-Pump Drain Pump Curve with Design Points 14
Figure 2.12. Single-Pump Drain Pump Curve with Design Points and Control Valve 14
Figure 2.13. Alternative 3 Hydraulic Profile 16
Figure 2.14. Alternative 3 Flow Diagram 17
Figure 2.15. Single-Pump Curve with Design Points 18
Figure 2.16. Single-Pump Curve with Design Points and Control Valve 19

Figure 2.17. Multi-Pump Curves with Design Points and Control Valve 19
Figure 2.18. Single-Pump Curves with Design Points 21
Figure 2.19. Single-Pump Curves with Design Points 22
Figure 2.20. Alternative 4 Hydraulic Profile 23
Figure 2.21. Alternative 4 Flow Diagram 24
Figure 2.22. Single-Pump Curve with Design Points 25
Figure 2.23. Single-Pump Curve with Design Points and Control Valve 26
Figure 2.24. Multi-Pump Curve with Design Points and Control Valve 26

List of Tables

Table 1.1. Design Flows and Boundary Conditions 2
Table 2.1. Alt 1 PRS Pump Operating Conditions 7
Table 2.2. Alt 1 Drain Pump Operating Conditions 10
Table 2.3. Alt 1 Pump Details 10
Table 2.4. Alt 2 PRS Pump Operating Conditions 13
Table 2.5. Alt 2 Drain Pump Operating Conditions 15
Table 2.6. Alt 2 Pump Details 15
Table 2.7. Alt 3 PRS and Drain Pump Operating Conditions 20
Table 2.8. Alt 3 Pump Details 21
Table 2.9. Alt 4 Design Flows and Boundary Conditions 25
Table 2.10. Alt 4 Pump Operating Conditions 27
Table 2.11. Alt 4 Pump Specifications 28
Table 4.1. PRS & OLSF Alternative Characteristics 31
Table 4.2. PRS & OLSF Alternative Construction Cost 31

List of Abbreviations

DW	Dry Weather
ft	Feet
gpm	Gallons per minute
HART	Hydraulic Analysis Review Team
HGL	Hydraulic Grade Line
HP	Horsepower
OLSF	Offline Storage Facility
PER	Preliminary Engineering Report
POR	Preferred operating region
PRS	Pressure Reducing Station
NAVD88	North American Vertical Datum of 1988
SWD	Side water depth
TDH	Total dynamic head
WSE	Water surface elevation
WW	Wet Weather

Section 1: Summary of Additional Modeling Efforts

Brown and Caldwell (BC) submitted a Preliminary Engineering Report (PER) for the Wilroy Pressure Reducing Station (PRS) and Offline Storage Facility (OLSF) in September 2022 detailing an alternative analysis and recommendation for the new facility. Following completion of the PER, HRSD conducted additional system hydraulic modeling to determine the impacts to sanitary sewer overflow (SSO) quantity and volume for various options. BC has used this data to conduct additional pumping system modeling to optimize the layout and number of pumps for the PRS and OLSF. The revised system modeling by HRSD updated the boundary conditions used in the PER as follows:

- Hydraulic Grade Line (HGL) on suction side of PRS can be raised to an elevation of 36 feet (NAVD88) without adverse SSO impacts
- OLSF drain flowrates can increase to a maximum rate of 3,500 gpm
- A minimum OLSF drain flowrate of 2,000 gpm is desired
- HGL during OLSF draining was determined at different flowrates

The Wilroy facility will provide pressure relief and increase system capacity during wet weather events; and based on discussions with HRSD staff, diurnal use (“peak shaving”) is not anticipated at this time. The facility will have four main flow scenarios. A description of the scenarios, design flows, and boundary conditions used in this TM are provided below:

1. Dry weather flow scenario – During dry weather flow will bypass the PRS through the station bypass piping. Dry weather operation will occur whenever the hydraulic grade line (HGL) is below the PRS initiation setpoint. Dry weather operation will resume once the HGL drops below the PRS off setpoint, set below the initiation setpoint to avoid cycling.
2. PRS operating flow scenario – Once the HGL increases above the initiation setpoint the PRS will turn on and the bypass will close. The PRS will remain in operation until the shutdown setpoint is reached. The PRS flow will range from 4,000 gpm to 7,000 gpm.
3. PRS and OLSF operating flow scenario – Once the PRS reaches the maximum capacity of 7,000 gpm, excess flow will be directed to the OLSF up to a total flow of 15,462 gpm (7,000 gpm through PRS and 8,462 gpm to the OLSF).
4. Drain flow scenario – Once the wet weather event is over the OLSF will begin to drain.

An updated table of design flows and boundary conditions is presented in Table 1.1.

Table 1.1. Design Flows and Boundary Conditions

Scenario	Description	Flow Range (gpm)	Upstream HGL (ft)	Downstream HGL (ft)
1	Dry weather	<3,908[a]	<70	<70
2	PRS Operating	4,000 to 7,000	30	70 to 104[d]
3	PRS and OLSF Operating	7,000 to 15,462[b]	36[c]	70 to 104[d]
4	Drain	2,000 to 3,500[c]	--	43 to 110[c]

a. *Dry Weather (DW) Max from Hydraulic Analysis Review Team (HART) Report*

b. *Wet Weather (WW) Max from HART Report*

c. *From updated modeling effort*

d. *From HART Report*

e. *Elevations are presented in NAVD88*

Section 2: Alternative Layouts

2.1 Alternative 1 (Recommended Alternative from PER)

Alternative 1 is the recommended alternative from the PER (identified as Alternative 2 in the PER). This alternative located the OLSF at grade for the assumed project site (approximately 23 feet) and filled the tank using the PRS pumps. The pumping capacity of the PRS was selected to meet the peak wet weather flow presented in the HART Report of 15,462 gpm from upstream contributing sources. Once a flow of 7,000 gpm is reached, a control valve would open to allow flow in excess of 7,000 gpm to be directed towards the OLSF. The control valve will modulate to maintain 7,000 gpm downstream of the PRS. The hydraulic profile is presented as Figure 2.1. The drain operation HGL in the figure has been updated from the PER based on the updated modeling.

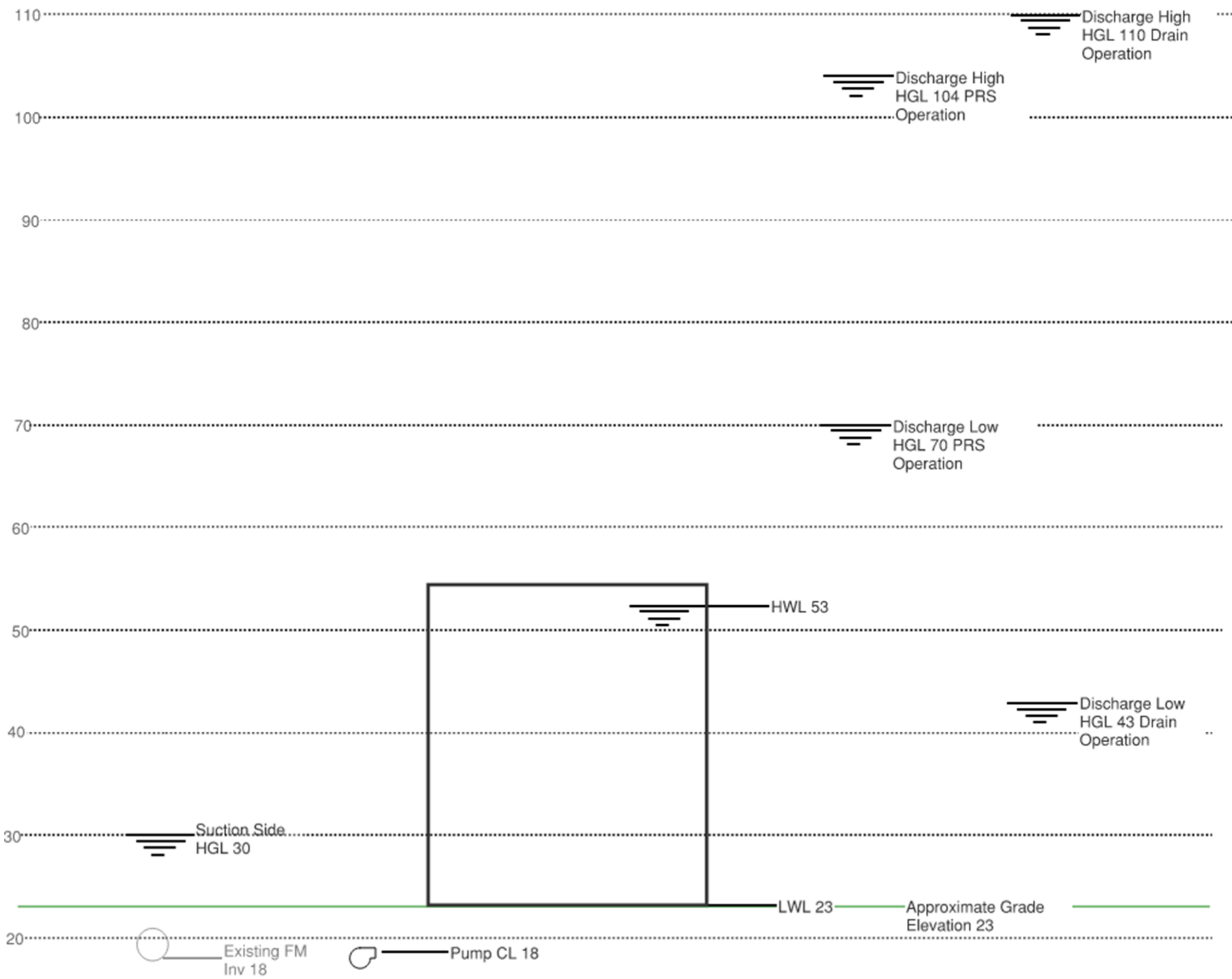

Figure 2.1. Alternative 1 Hydraulic Profile

Figure 2.2 shows a flow diagram for Alternative 1.

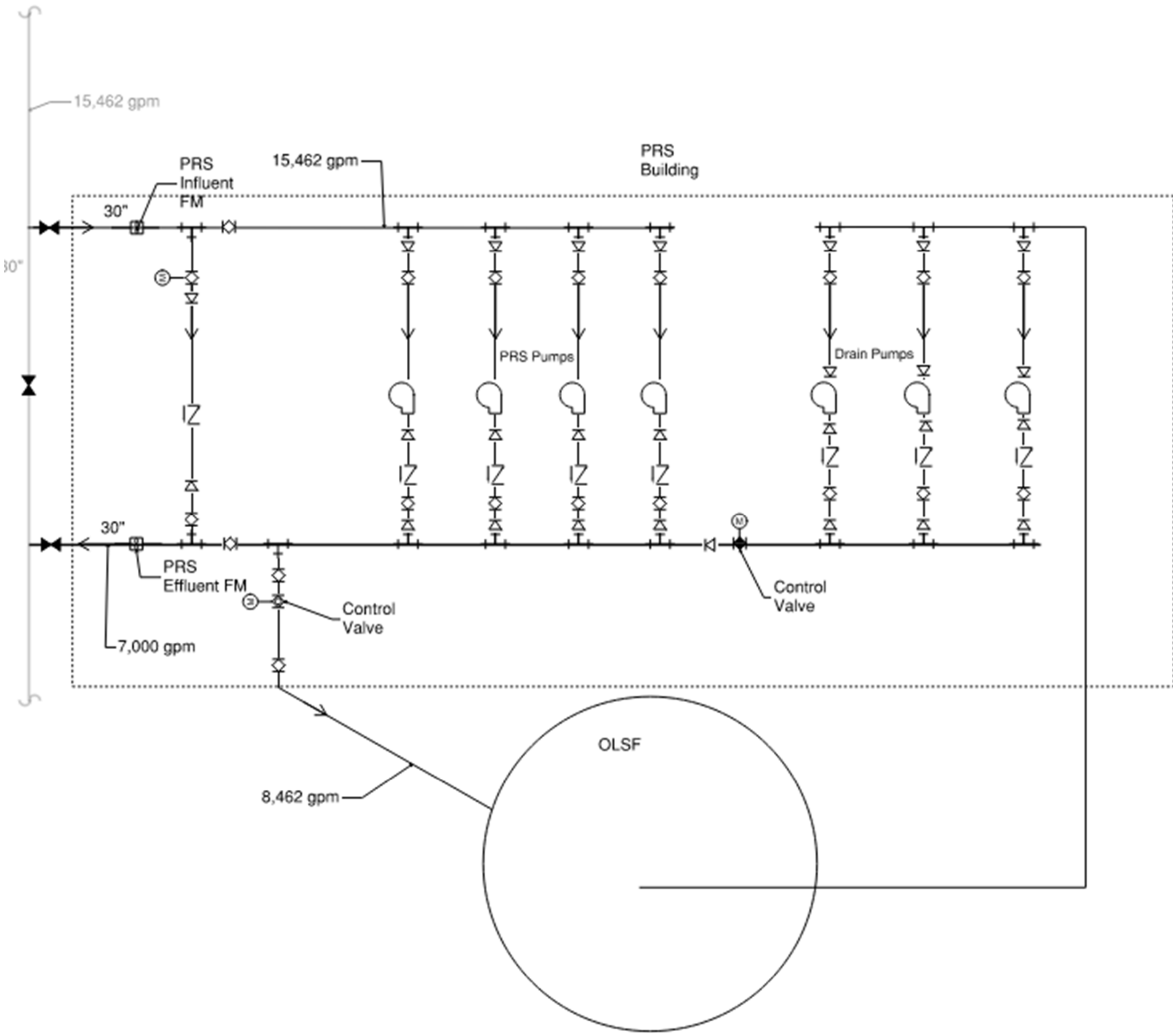

Figure 2.2. Alternative 1 Flow Diagram

Alternative 1 requires a control valve on the drain pump discharge. Grade is assumed to be at elevation 23 ft, so a tank with a 30-ft side water depth (SWD) would have a high-water surface elevation (WSE) of 53-ft. This would be 10-ft higher than the downstream HGL of 43-ft at the minimum drain flowrate of 2,000 gpm. When the static head is too low, a control valve is necessary to add head to raise the system curve into a preferred operating region (POR) for the selected pump. Once the static head reaches a point where the pump operates within the POR, the control valve can open fully.

It is possible that the tank could partially drain by gravity when the WSE is above the downstream HGL, additional piping and valves would be necessary.

Alternative 1 summary:

- OLSF is filled by PRS pumps (4 total, 3 Duty/1 Standby)
- OLSF is located at grade
- Control valve splits flow between downstream of the PRS and the OLSF
- PRS pumps sized for concurrent PRS and OLSF filling operation
- Drain pumps sized for draining (3 total, 2 Duty/1 Standby)
- Drain pumps located in the PRS
- Drain pumps require a control valve

The proposed PRS pump curve with design points is presented as Figure 2.3 and a multi-pump curve is presented in Figure 2.4. Refer to Table 2.1 for PRS operating conditions.

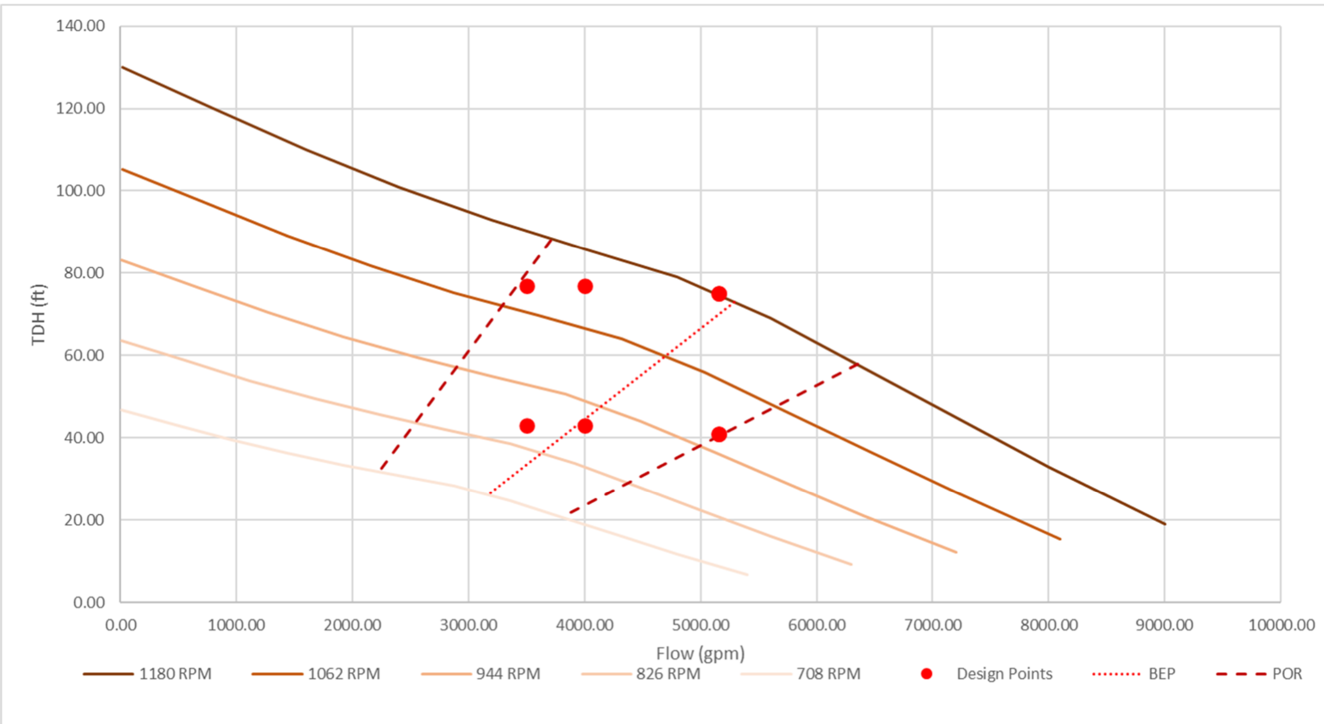

Figure 2.3. Single Pump PRS Pump Curve with Design Points

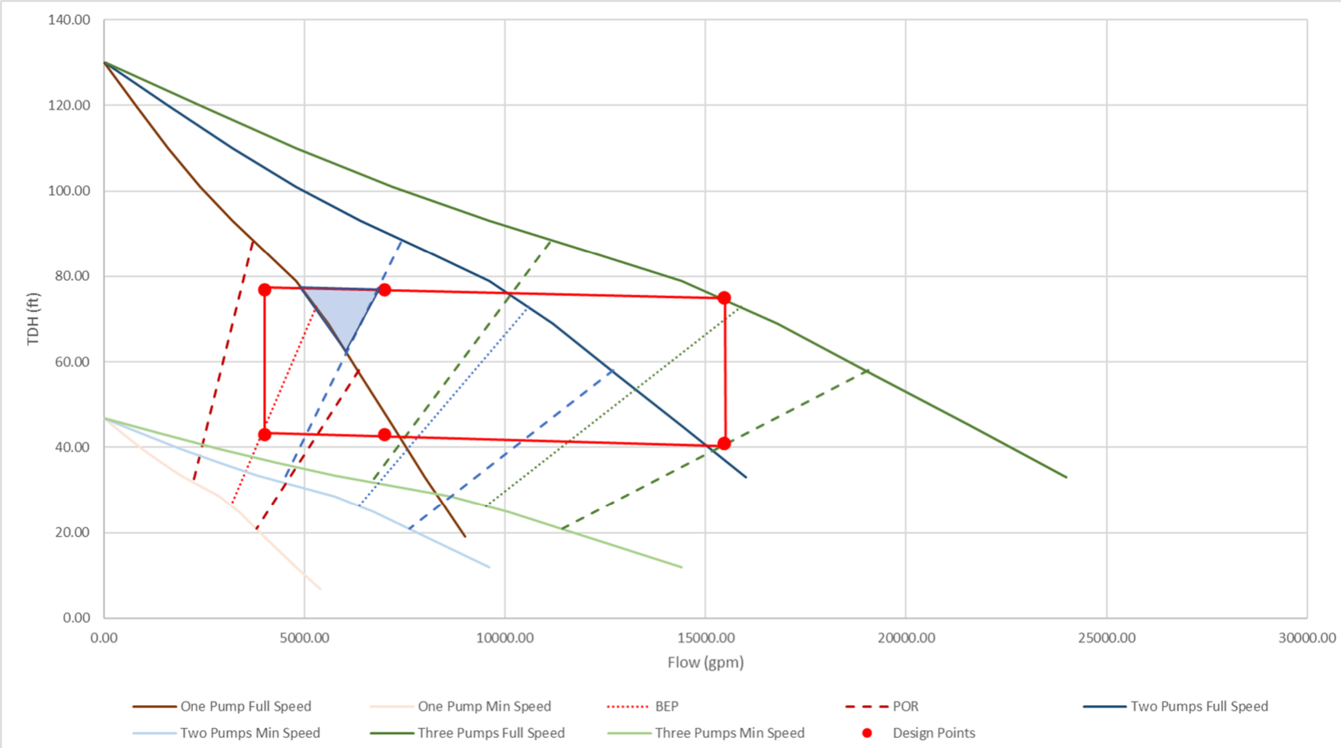

Figure 2.4. Multi-Pump PRS Pump Curves with Design Points

The anticipated operating zone for the pumps is represented by the red lines. From this zone, there is a portion of operation, represented by the blue triangle, showing operation outside of the POR but within the AOR. This occurs as the station transitions from one pump operating to two pumps operating at the maximum downstream HGL. Operation outside of the POR can increase maintenance and reduce service life but is not always possible to find a pump that can meet all operating conditions within the POR. Operation outside of the POR but within the AOR can be acceptable for conditions that occur infrequently. The pumps are not anticipated to operate often, approximately 196 hrs/year (Section 4.1.3 in the PER) and the zone of operation outside of the POR is small in comparison to the total anticipated operating zone. It is not known at this time where the majority of operation would occur within the anticipated operating zone. Additional system hydraulic modeling is needed to fully understand how the downstream HGL will change with increasing flowrate to develop accurate system curves and to develop average flowrates and system HGLs to better understand the frequency of operation outside of the POR.

Table 2.1 presents operating conditions for the PRS pumps.

Table 2.1. Alt 1 PRS Pump Operating Conditions

Flow (gpm)	Flow per pump (gpm)	Pumps Operating	HGL Discharge (ft)	HGL Suction (ft)	OLSF Elevation (ft)	TDH (ft)
4,000	4,000	1	70	30	N/A	43
4,000	4,000	1	104	30	N/A	77
7,000	3,500	2	70	30	N/A	43
7,000	3,500	2	104	30	N/A	77
15,462	5,154	3	104	36	23	75
15,462	5,154	3	104	36	53	75
15,462	5,154	3	70	36	23	41
15,462	5,154	3	70	36	53	41

Elevations are presented in NAVD88

The drain pump selection from the PER has been updated with the revised boundary conditions. The flowrate and discharge HGL from the updated modeling were higher than assumed in the PER. The updated drain pump and system curve is presented as Figure 2.5.

The control valve would use the WSE in the OLSF and the HGL on the discharge side to calculate a static head and provide backpressure when the static head is below the setpoint. This raises the design points into the selected pump's POR. Without the control valve, there are two operating points outside of the POR and one point off the pump curve. The control valve was selected to have a minimum static head of 30-ft, this was found through trial and error to determine the minimum static head that would keep all points within the POR of the preliminary pump selection. A preliminary sizing of the control valve requires a 12-inch ball valve on the drain pump discharge header that would be 44 to 48% open during control.

From Figure 2.5 below, the red design points represent the design points when the control valve is completely open. Figure 2.6 below shows the system when the control valve is in operation. The blue squares are the points when the control valve is engaged. Figure 2.7 shows a multi-pump curve with the design points and control valve.

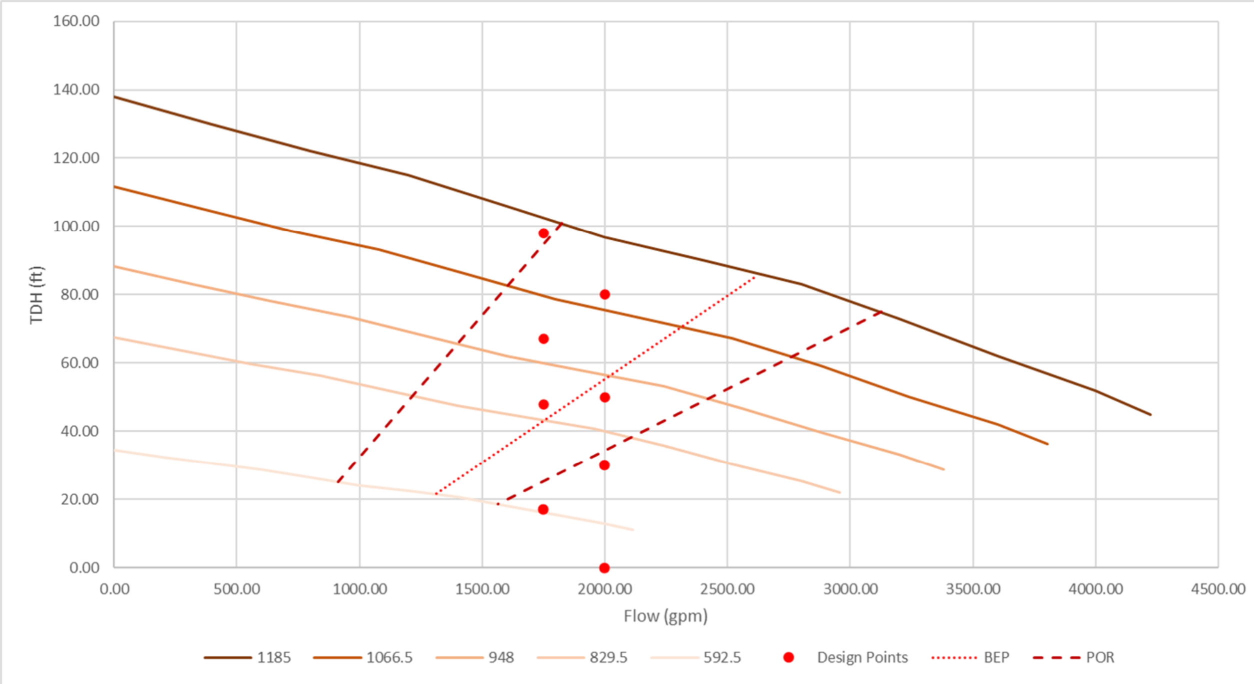

Figure 2.5. Single-Pump Drain Pump Curve with Design Points

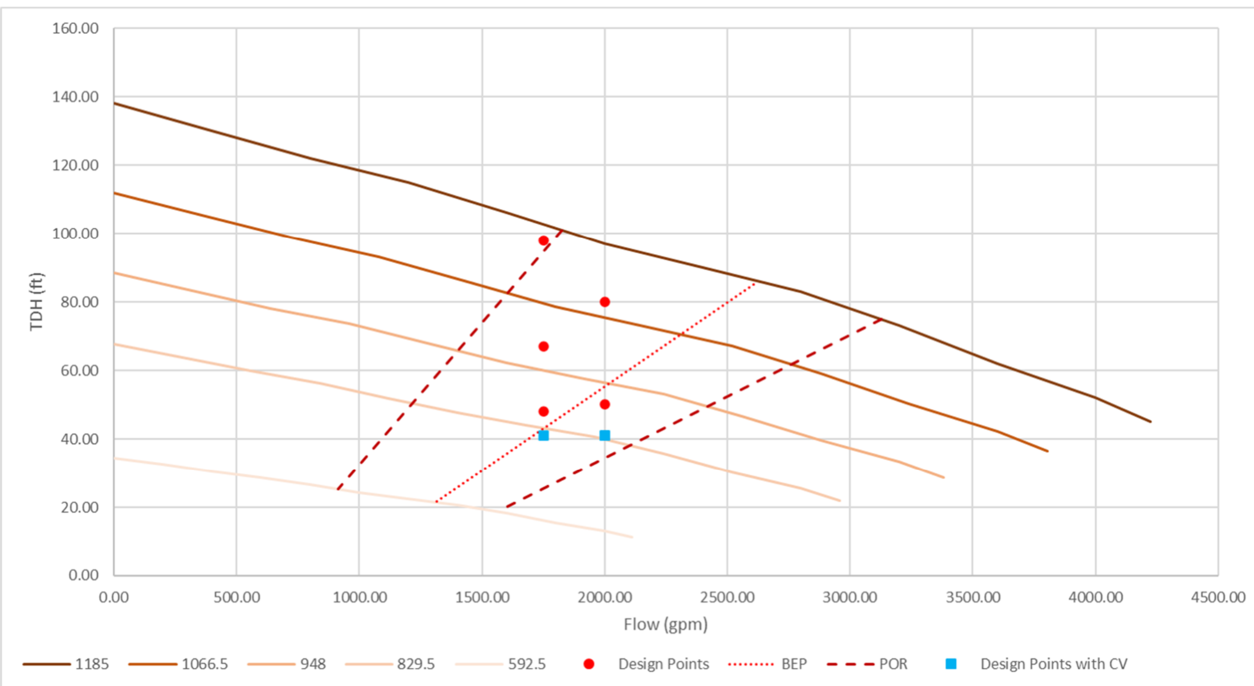

Figure 2.6. Single-Pump Drain Pump Curve with Design Points and Control Valve

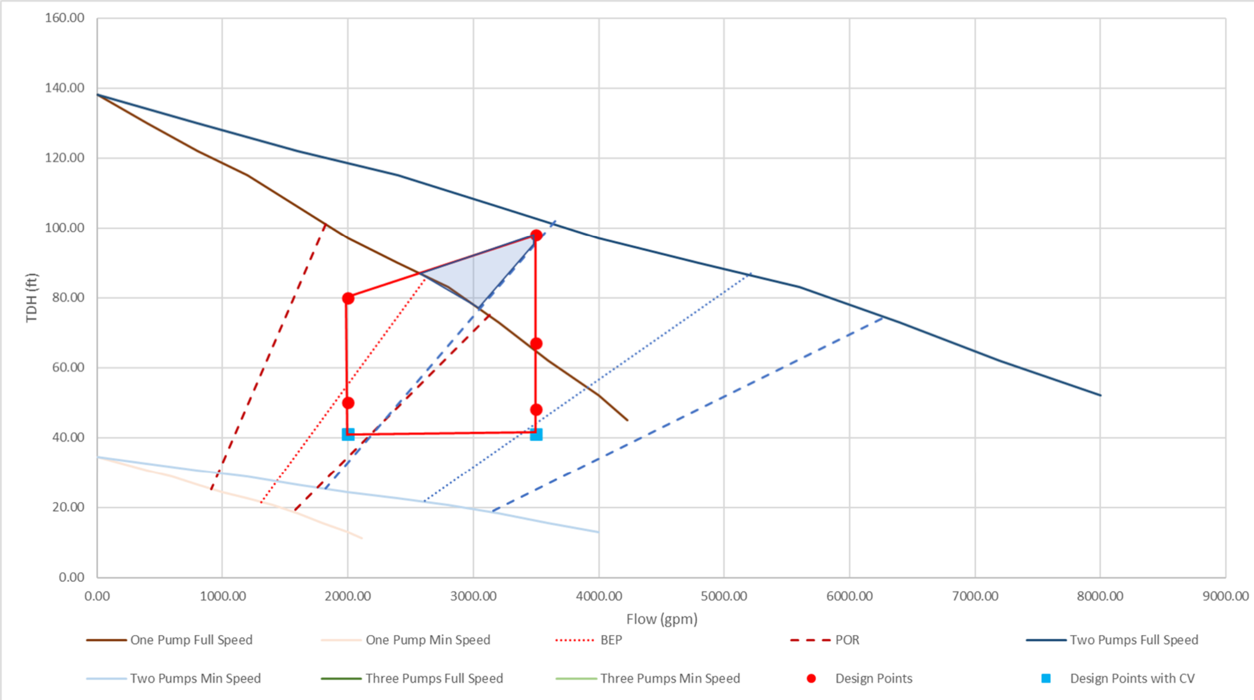

Figure 2.7. Multi-Pump Drain Pump with Design Points and Control Valve

The anticipated operating zone for the pumps is represented by the red lines. From the anticipated operating zone above, there is a portion of operation, represented by the blue triangle, showing operation outside of the POR but within the AOR. This occurs as the station transitions from one pump operating to two pumps operating at the maximum downstream HGL and maximum OLSF WSE. This can be controlled through programming by draining the tank at a slower rate at the maximum WSE and downstream HGL. As the WSE and/or HGL falls, the draining flowrate can be increased to keep the pumps operation with the POR. Reducing the drain rate increases the duration that water is stored in the OLSF, and the desire is to empty the tank as quickly as possible. But this strategy would still drain a full tank within 24-hrs which was considered an acceptable timeframe during the PER. As stated above, additional system hydraulic modeling is needed to fully understand how the downstream HGL will change with increasing flowrate to develop accurate system curves.

Table 2.2 presents operating conditions for the drain pumps.

Flow (gpm)	Flow per pump (gpm)	Pumps Operating	HGL Discharge (ft)	OLSF Elevation (ft)	TDH (ft)	TDH with control valve (ft)
3,500	1,750	2	60	53	23	41
3,500	1,750	2	110	23	67	N/A
3,500	1,750	2	110	53	98	N/A
3,500	1,750	2	60	23	48	N/A
2,000	2,000	1	43	53	0	41
2,000	2,000	1	93	23	50	N/A
2,000	2,000	1	93	53	80	N/A
2,000	2,000	1	43	23	30	41

Table 2.2. Alt 1 Drain Pump Operating Conditions

Elevations are presented in NAVD88

A summary of pump details for PRS and Drain pumps is presented in Table 2.3.

Parameter	PRS Pump	Drain Pump
Number of pumps	4	3
Manufacturer	Xylem	Xylem
Model	NT3306	NT3231
Max Motor, HP	140	90
Operating Speed, rpm	1180	1185
Voltage, V	460	460
Impeller Diameter, mm	410	405
BEP efficiency at max speed, %	79.3%	78.8%

Table 2.3. Alt 1 Pump Details

2.2 Alternative 2 (PER Recommended Alternative with fewer pumps)

Alternative 2 was further evaluated to determine if the station can provide the same level of functionality with fewer PRS and drain pumps. Alternative 2 reduced the number of PRS pumps from 4 to 3 (2 duty/1 standby) and drain pumps from 3 to 2 (1 duty/1 standby). The hydraulic profile for the station is identical to Alternative 1 (Figure 2.1) and the flow diagram is presented as Figure 2.8.

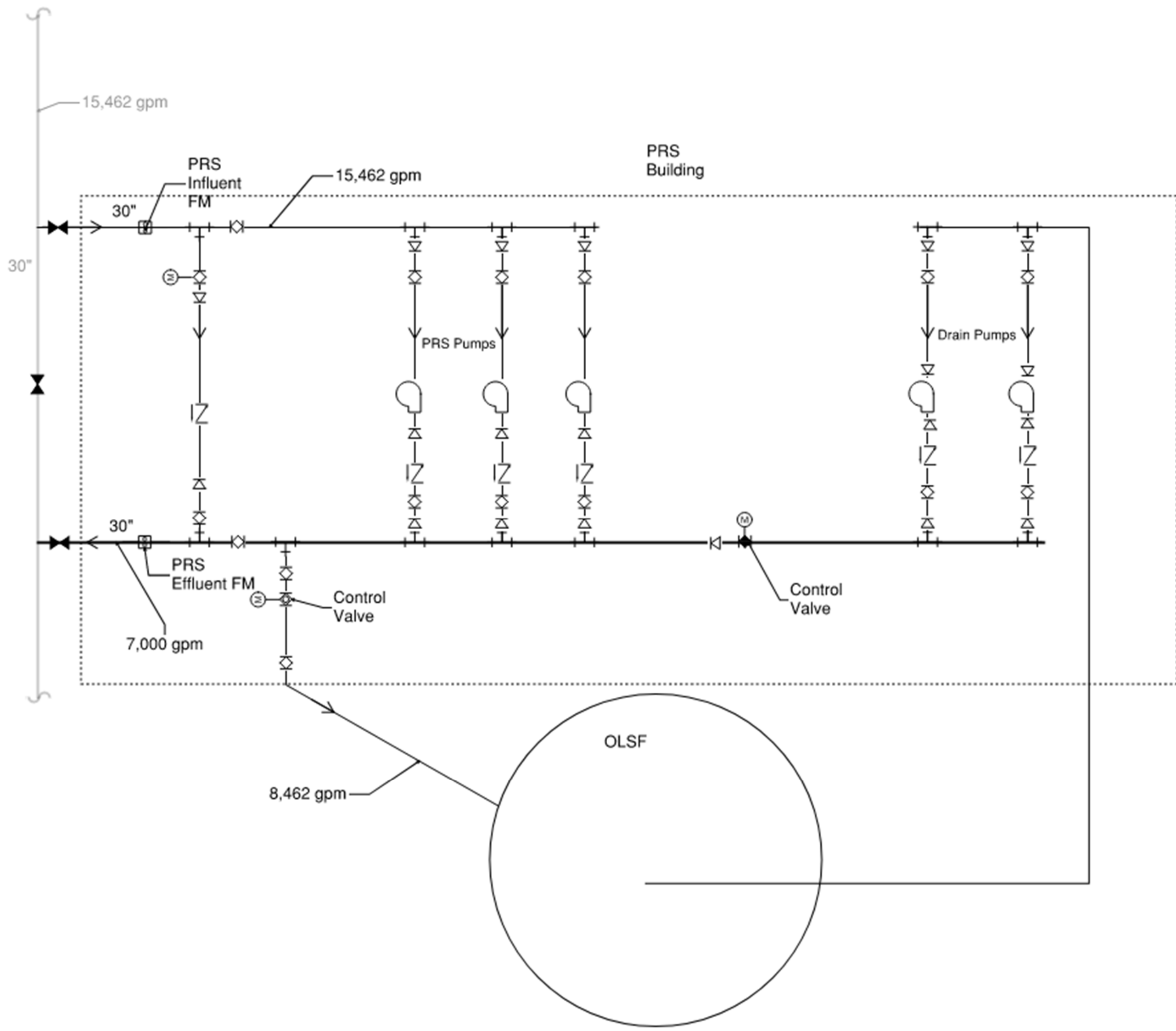

Figure 2.8. Alternative 2 Flow Diagram

Alternative 2 summary would match the summary of Alternative 1 with the following changes:

- 3 PRS Pumps (2 Duty/1 Standby)
- 2 Drain Pumps (1 Duty/1 Standby)

The pump curve and multi-pump curve for Alternative 2 is presented in Figures 2.9 and 2.10.

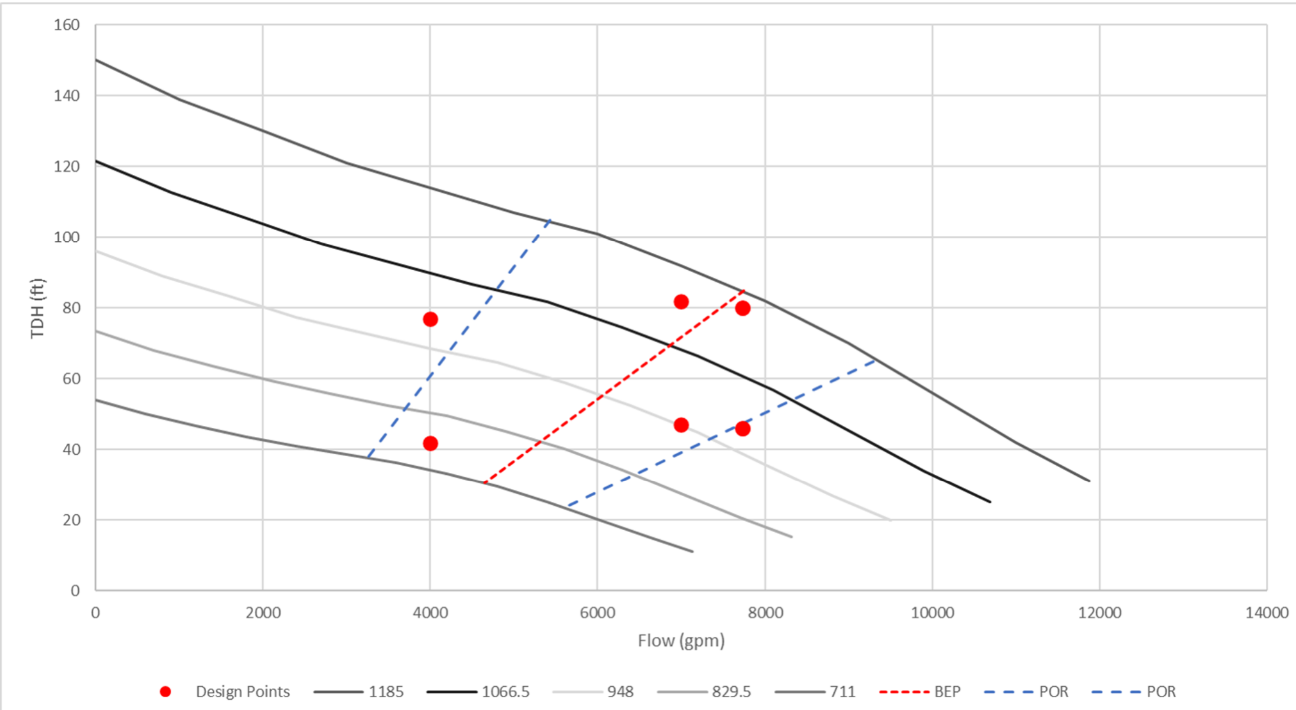

Figure 2.9. Single-Pump PRS Pump Curve with Design Points

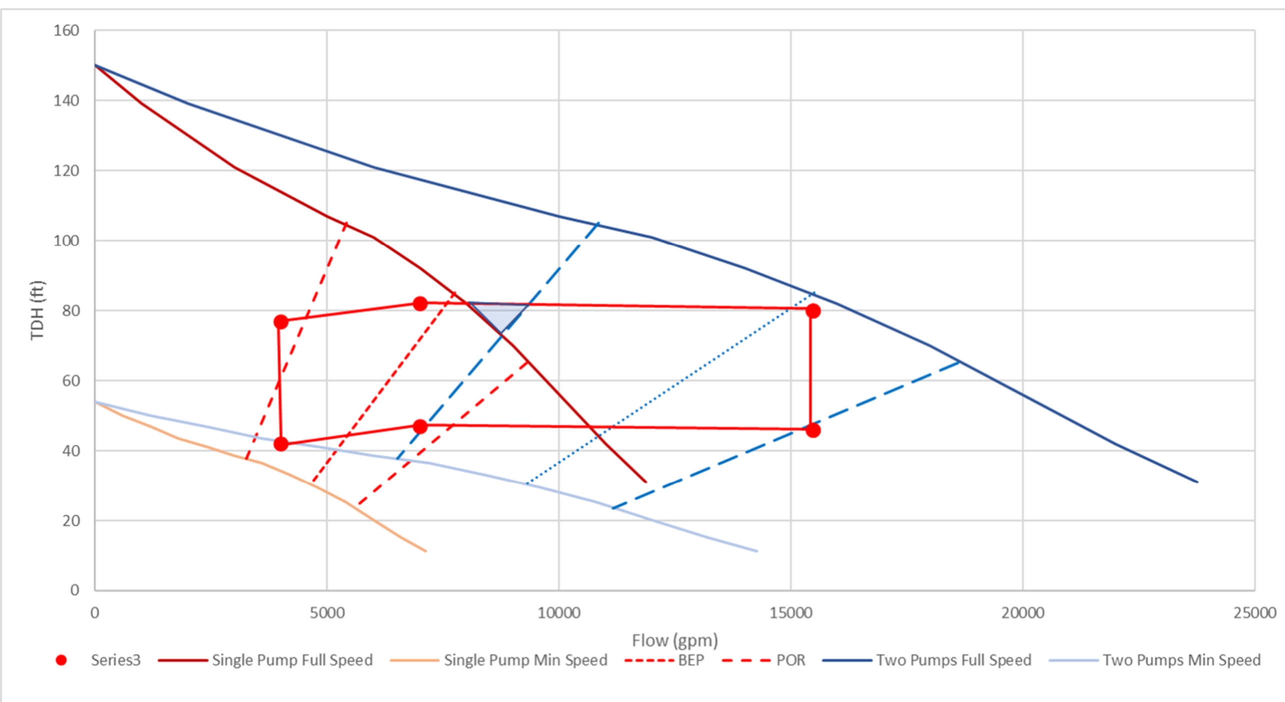

Figure 2.10. Multi-Pump PRS Pump Curve with Design Points

One design point lays outside of the POR (maximum discharge HGL and minimum flowrate) but the rest of the points are within the POR. The operating point occurs at the minimum flowrate and maximum downstream HGL, as flow increases the operating point would move within the POR.

The anticipated operating zone for the pumps is represented by the red lines. In this zone, there is a portion of operation, represented by the blue triangle, showing operation outside of the POR but within the AOR. This condition occurs as the system transitions from PRS operation to PRS and OLSF operation and occurs at the maximum downstream HGL. This is not anticipated to occur frequently because the OLSF is only anticipated to be in use for approximately 7 times per year (Section 4.1.3 in the PER) and operation outside of the POR only occurs when the transition occurs at the same time as maximum downstream HGL.

Table 2.4 provides the pump operating conditions for this alternative.

Table 2.4. Alt 2 PRS Pump Operating Conditions

Flow (gpm)	Flow per pump (gpm)	Pumps Operating	HGL Discharge (ft)	HGL Suction (ft)	OLSF Elevation (ft)	TDH (ft)
7000	7000	1	70	30	N/A	47
7000	7000	1	104	30	N/A	82
4000	4000	1	104	30	N/A	77
4000	4000	1	70	30	N/A	42
15462	7731	2	104	36	23	80
15462	7731	2	104	36	53	80
15462	7731	2	70	36	23	46
15462	7731	2	70	36	53	46

Elevations are presented in NAVD88

The pump curve for the drain system with the control valve open is presented in Figure 2.11. The following Figure 2.12 presents the pump curve with the control valve in operation. Without the control valve there are two operating points outside of the POR and three points off the pump curve. With the control valve in operation all points are within the POR. The control valve was selected to maintain a minimum static head of 85-ft at the high flow and 30-ft at the low flow. This would require optimization to develop a curve for the control valve that would change the static head setpoint as flow increases. A preliminary sizing of the control valve requires a 12-inch ball valve on the drain pump discharge header that would be 35 to 62% open during control.

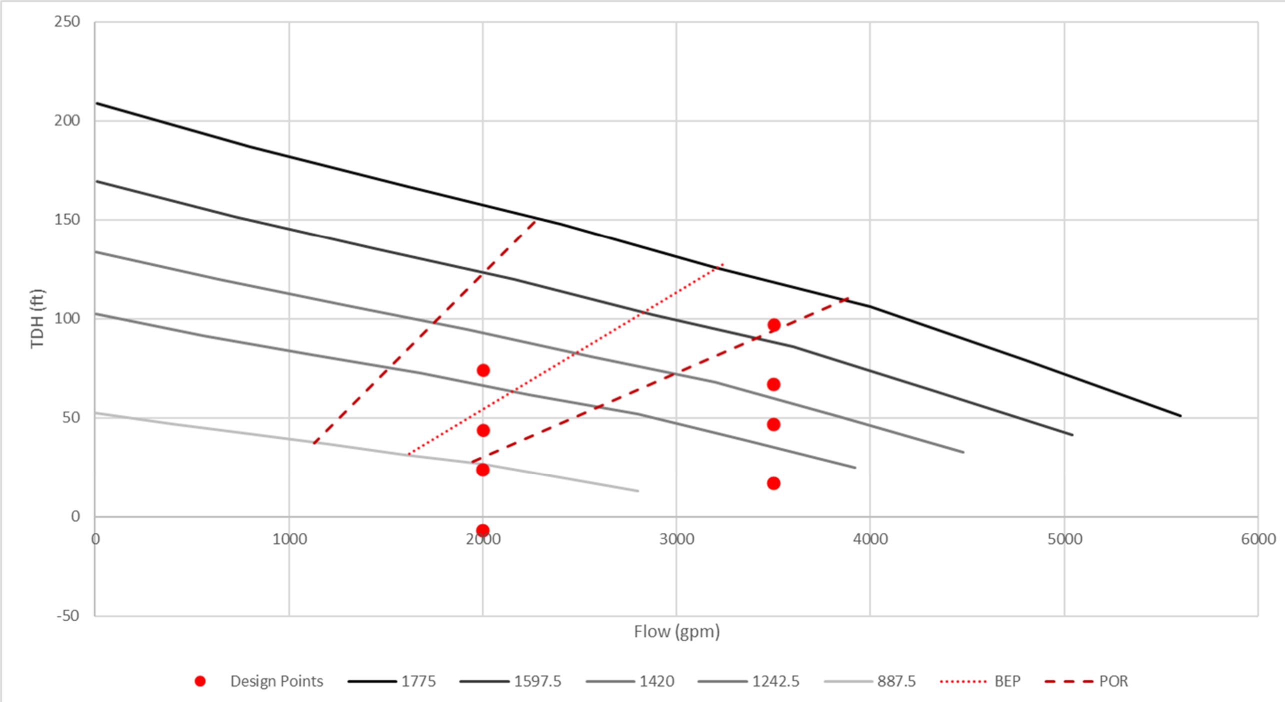

Figure 2.11. Single-Pump Drain Pump Curve with Design Points

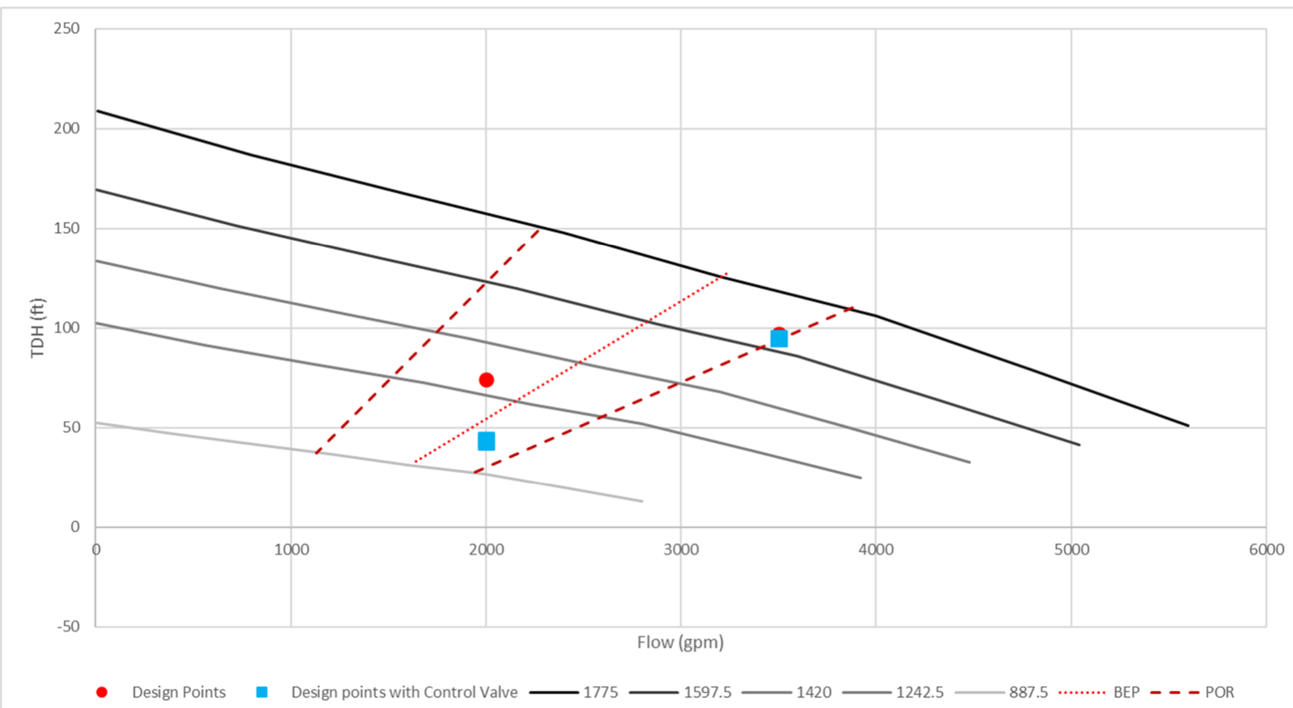

Figure 2.12. Single-Pump Drain Pump Curve with Design Points and Control Valve

Table 2.5 presents operating conditions for the drain pumps.

Flow (gpm)	Flow per pump (gpm)	Pumps Operating	HGL Discharge (ft)	OLSF Elevation (ft)	TDH (ft)	TDH with control valve (ft)
Table 2.5. Alt 2 Drain Pump Operating Conditions						
3,500	3,500	1	60	53	17	95
3,500	3,500	1	110	23	67	95
3,500	3,500	1	110	53	97	N/A
3,500	3,500	1	60	23	47	95
2,000	2,000	1	43	53	-7	43
2,000	2,000	1	93	23	44	N/A
2,000	2,000	1	93	53	74	N/A
2,000	2,000	1	43	23	24	44

Elevations are presented in NAVD88

Summary of pump details for PRS and Drain pumps is presented in Table 2.6.

Table 2.6. Alt 2 Pump Details

Parameter	PRS Pump	Drain Pump
Number of pumps	3	2
Manufacturer	Xylem	Xylem
Model	NT3356	NT3231
Max Motor, HP	215	185
Operating Speed, rpm	1185	1175
Voltage, V	460	460
Impeller Diameter, mm	455	340
BEP efficiency at max speed, %	82.7%	70.3%

2.3 Alternative 3 (PER Alternative 1 Update)

Alternative 3 took a concept from the PER (Alternative 1 from the PER) and further evaluated it to determine if the increase in suction side HGL from 30 to 36 would make the alternative more competitive. This concept was the preferred approach to filling the OLSF, as it relied on system pressure to fill the OLSF rather than pumping into the OLSF. In the PER, the tank was required to be buried to facilitate filling the tank at a suction side HGL of 30-ft. Allowing the suction side HGL to rise to 36-ft and increasing the tank diameter reduces the amount of the tank required to be buried, which reduces the excavation and dewatering costs for both the OLSF and PRS.

The number of pumps was also evaluated to determine if the drain pumps could be eliminated and the PRS pumps provide both PRS and draining operation.

Refer to Figure 2.13 and 2.14 for the hydraulic profile and flow diagram.

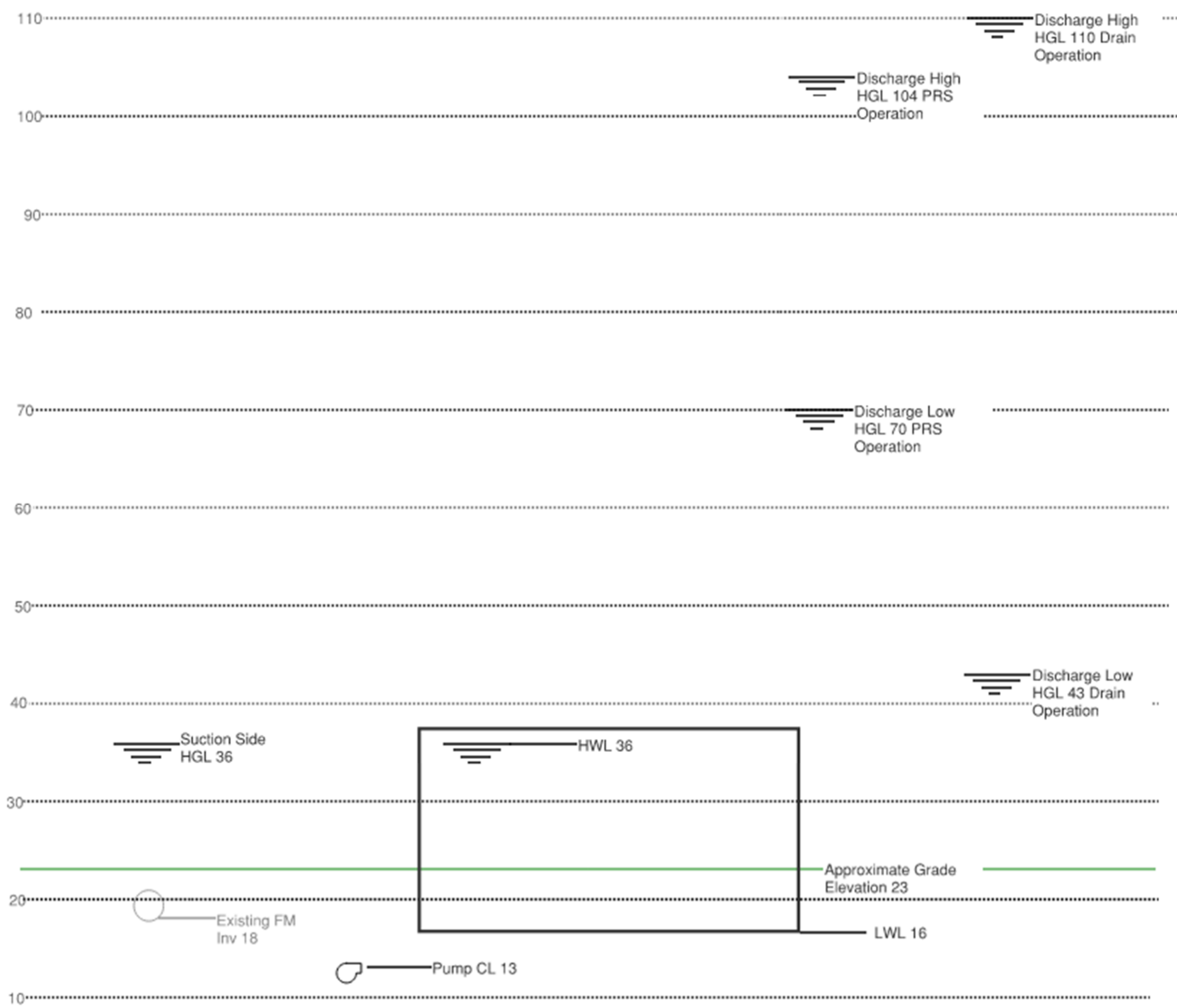

Figure 2.13. Alternative 3 Hydraulic Profile

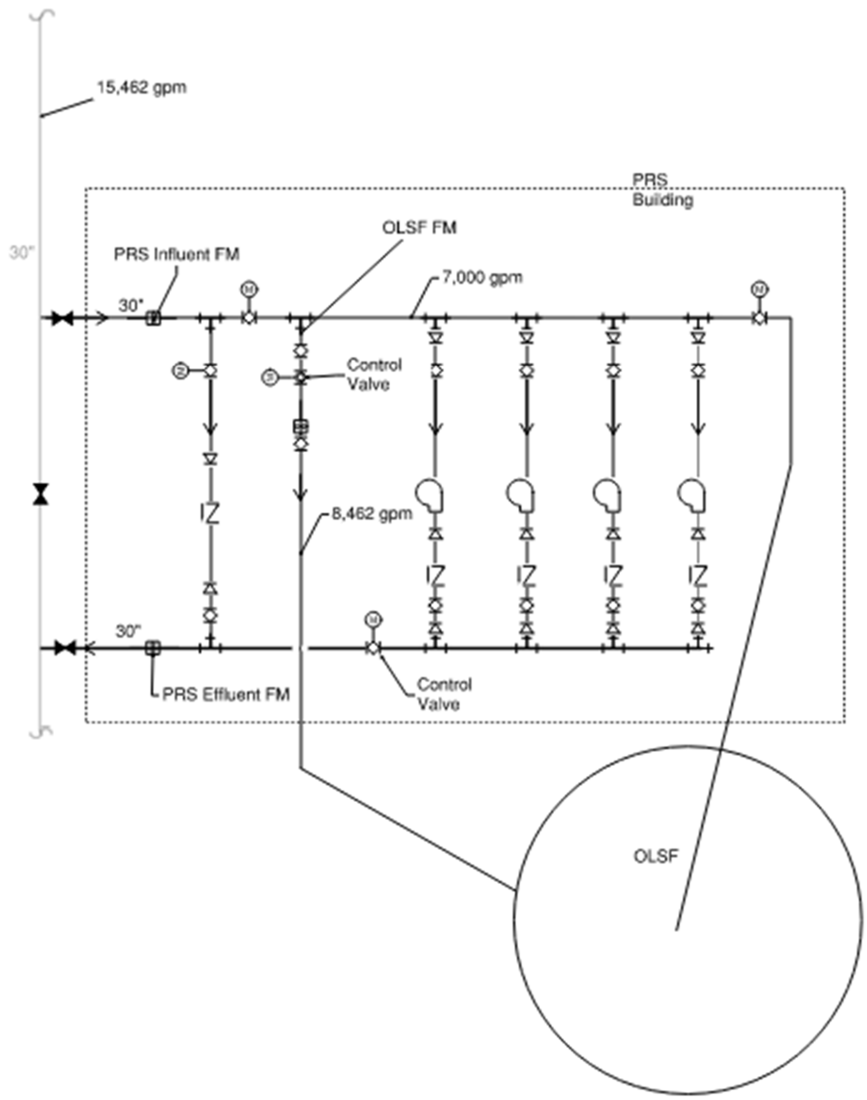

Figure 2.14. Alternative 3 Flow Diagram

Alternative 3 summary:

- OLSF is filled by upstream line pressure
- OLSF is located partially below grade
- Control valve controls flow into the OLSF
- Pumps sized for PRS and drain operation (4 total, 3 Duty/1 Standby)
- Pumps located in the PRS
- Pumps require a control valve during tank draining

Figure 2.15 shows the pump curve with design points for PRS and Drain operation with the control valve open, while Figure 2.16 shows the pump curve with design points and the control valve in operation and Figure 2.17 presents a multi-pump curve with design points and the control valve in operation.

Without the control valve there is one point outside of the POR and one point that falls off the curve. A control valve can address the operating point that lies off the curve by raising it up into the POR. It is possible that the pump could be slowed down enough to operate within the POR or a curve from another manufacturer would allow for this operating condition to be met without the use of a control valve. The operating point that lies outside of the POR is within the AOR as set by the pump manufacturer. The control valve does not bring this operating point with the POR. This condition is the maximum drain flowrate when the downstream HGL is highest and the tank is empty, this condition is not anticipated to occur often and can be controlled through programming by reducing the flowrate as the tank nears the low WSE.

The system requires a control valve on the discharge header with a static head setpoint of 24-ft. A preliminary sizing of the control valve requires a 12-inch ball valve on the drain pump discharge header that would be 25% open during control.

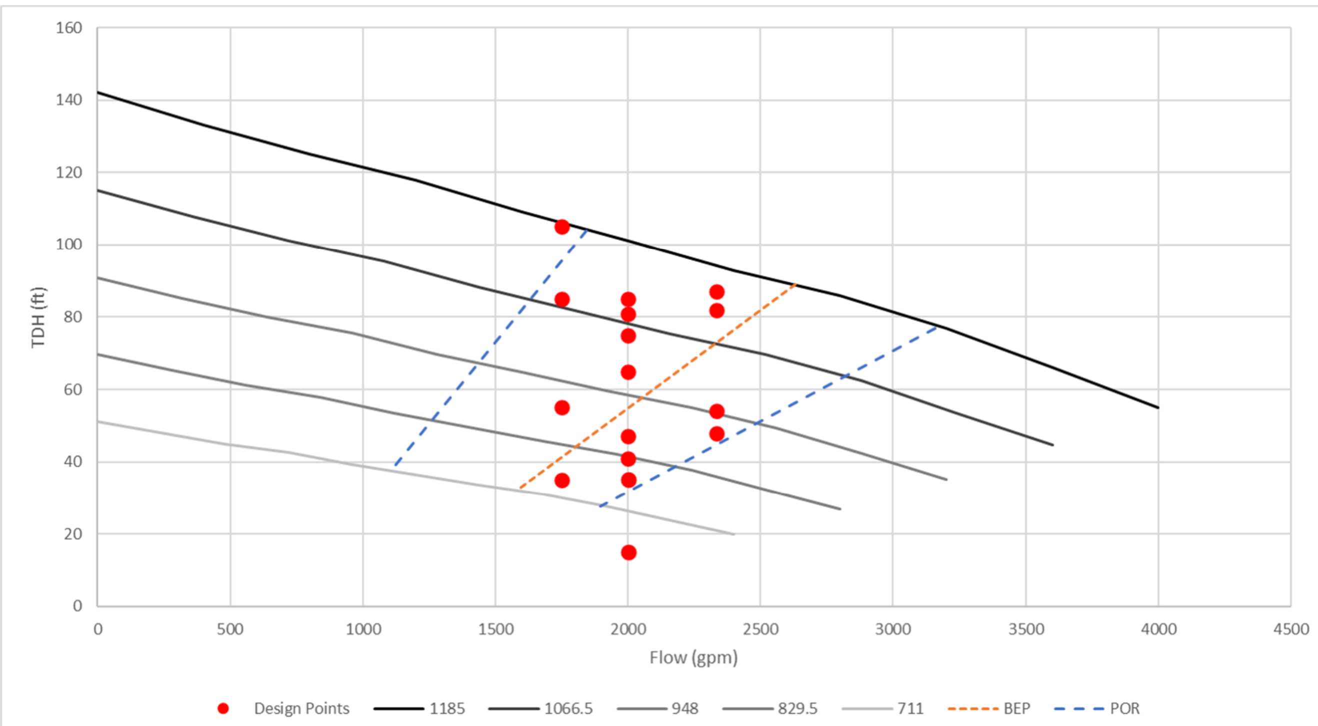

Figure 2.15. Single-Pump Curve with Design Points

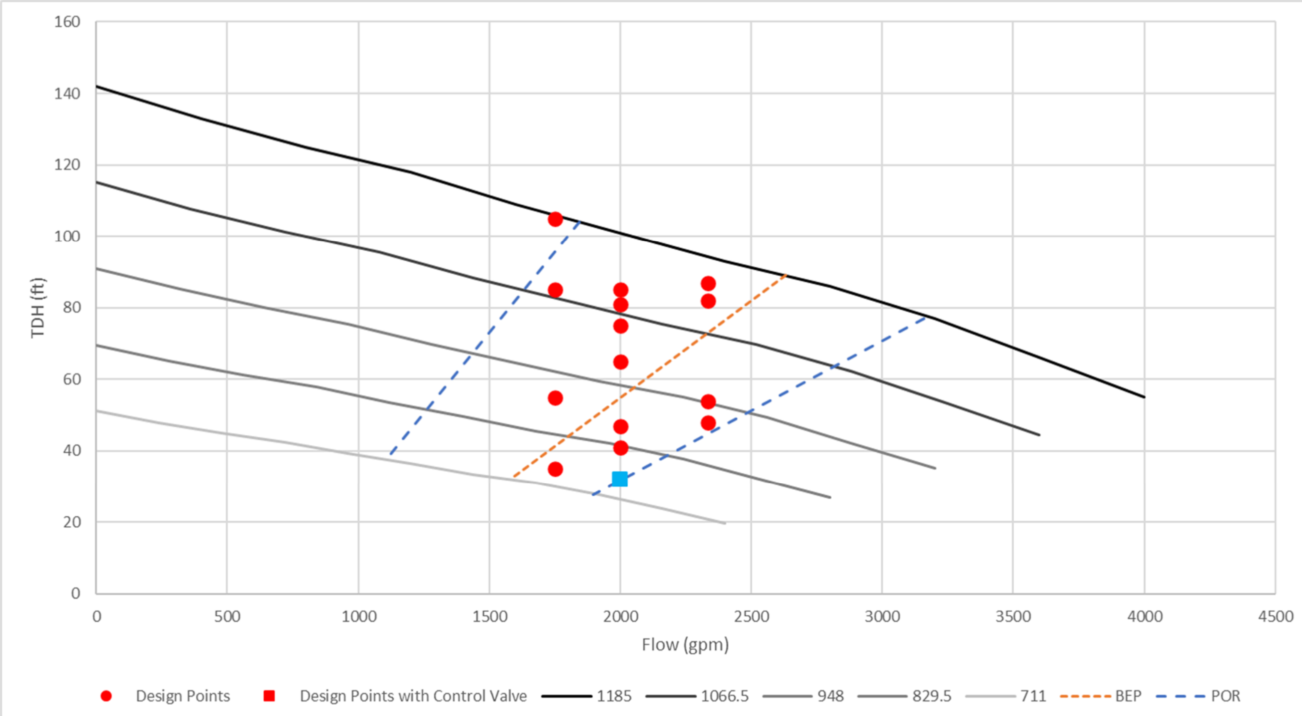

Figure 2.16. Single-Pump Curve with Design Points and Control Valve

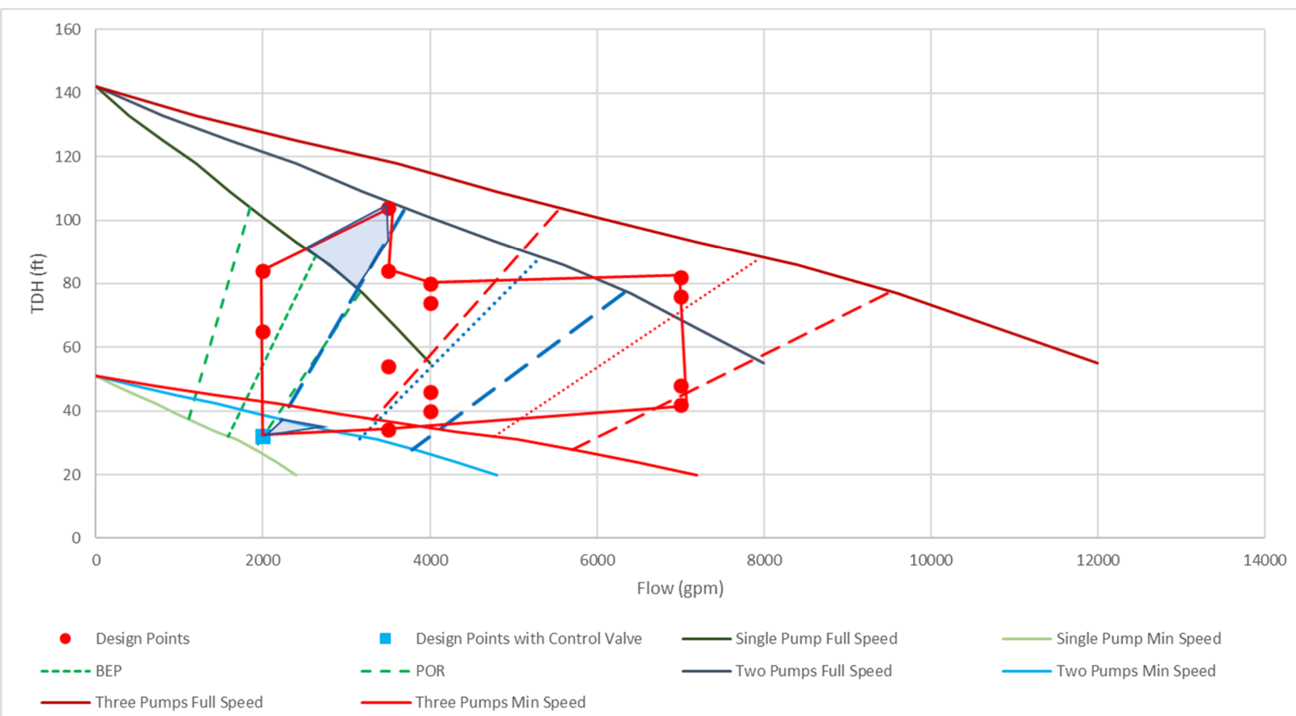

Figure 2.17. Multi-Pump Curves with Design Points and Control Valve

The anticipated operating zone for the pumps is represented by the red polygon. In this zone, there are portions of operation, represented by the two blue triangles, showing operation outside of the POR but within the AOR. One of the triangles occurs during drain operation at maximum downstream HGL and minimum OLSF and the other occurs at minimum downstream HGL and maximum OLSF. This can be controlled through programming by draining the tank at a slower rate to avoid these areas during drain operation.

Table 2.7 presents operating conditions for the PRS and drain pumps.

Table 2.7. Alt 3 PRS and Drain Pump Operating Conditions

Flow (gpm)	Flow per pump (gpm)	Pumps Operating	HGL Discharge (ft)	HGL Upstream (ft)	OLSF Elevation (ft)	TDH (ft)	TDH with control valve (ft)
7000	2333	3	70	30	N/A	54	N/A
7000	2333	3	104	30	N/A	87	N/A
4000	2000	2	104	30	N/A	81	N/A
4000	2000	2	70	30	N/A	47	N/A
7000	2333	3	70	36	N/A	48	N/A
7000	2333	3	104	36	N/A	82	N/A
4000	2000	2	104	36	N/A	75	N/A
4000	2000	2	70	36	N/A	41	N/A
3500	1750	2	60	N/A	36	35	N/A
3500	1750	2	110	N/A	36	85	N/A
3500	1750	2	110	N/A	16	105	N/A
3500	1750	2	60	N/A	16	55	N/A
2000	2000	1	43	N/A	36	15	32
2000	2000	1	93	N/A	36	65	N/A
2000	2000	1	93	N/A	16	85	N/A
2000	2000	1	43	N/A	16	35	N/A

Elevations are presented in NAVD88

A summary of pump details for PRS and Drain pumps is presented in Table 2.8.

Table 2.8. Alt 3 Pump Details	
Parameter	**Drain Pump**
Number of pumps	4
Manufacturer	Xylem
Model	NT3231
Max Motor, HP	90
Operating Speed, rpm	1185
Voltage, V	460
Impeller Diameter, mm	410
BEP efficiency at max speed, %	79.3%

Reducing the number of PRS pumps to 3 total (2 duty/1 standby) was also evaluated but a pump could not be found to meet the large spread in flowrates and TDHs. Figures 2.18 and 2.19 show the best fitting pump selections identified with 2 pumps operating rather than the 3 selected for this Alternative 3. Both figures represent the system without a control valve, a control valve would raise some of the design points into the POR but there would still be several design points located outside of the POR.

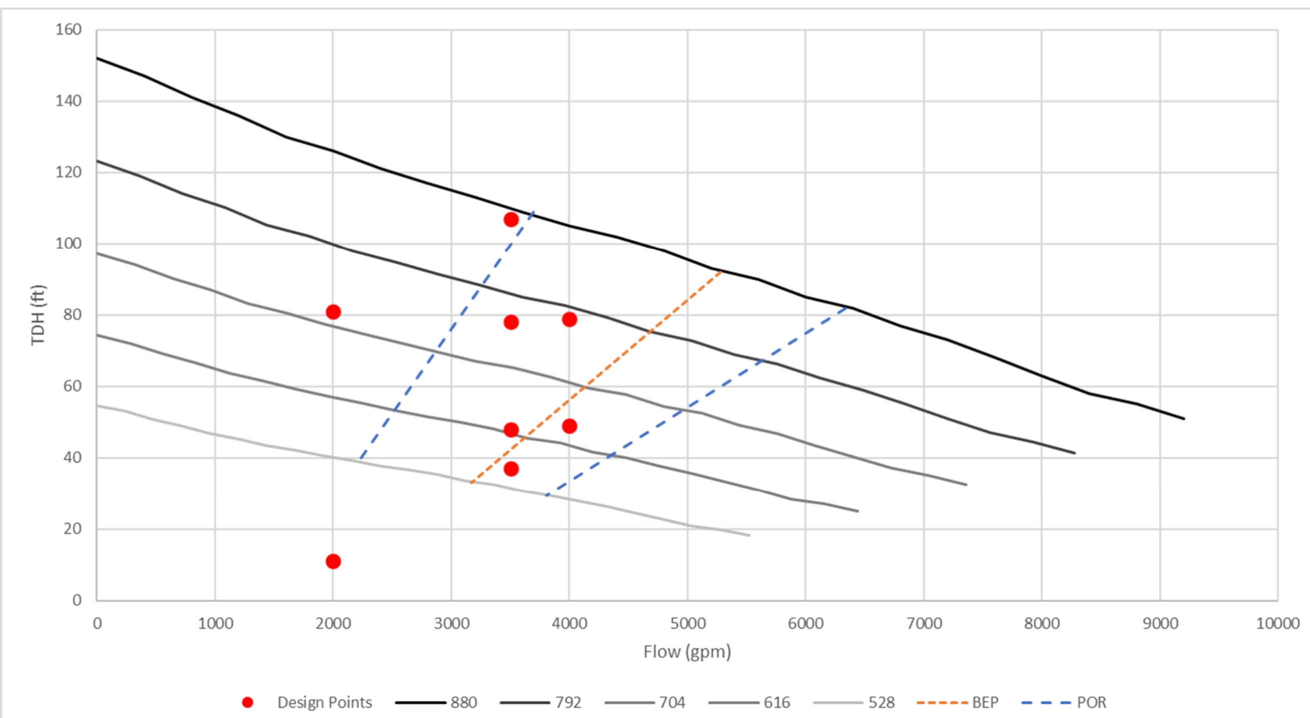

Figure 2.18. Single-Pump Curves with Design Points

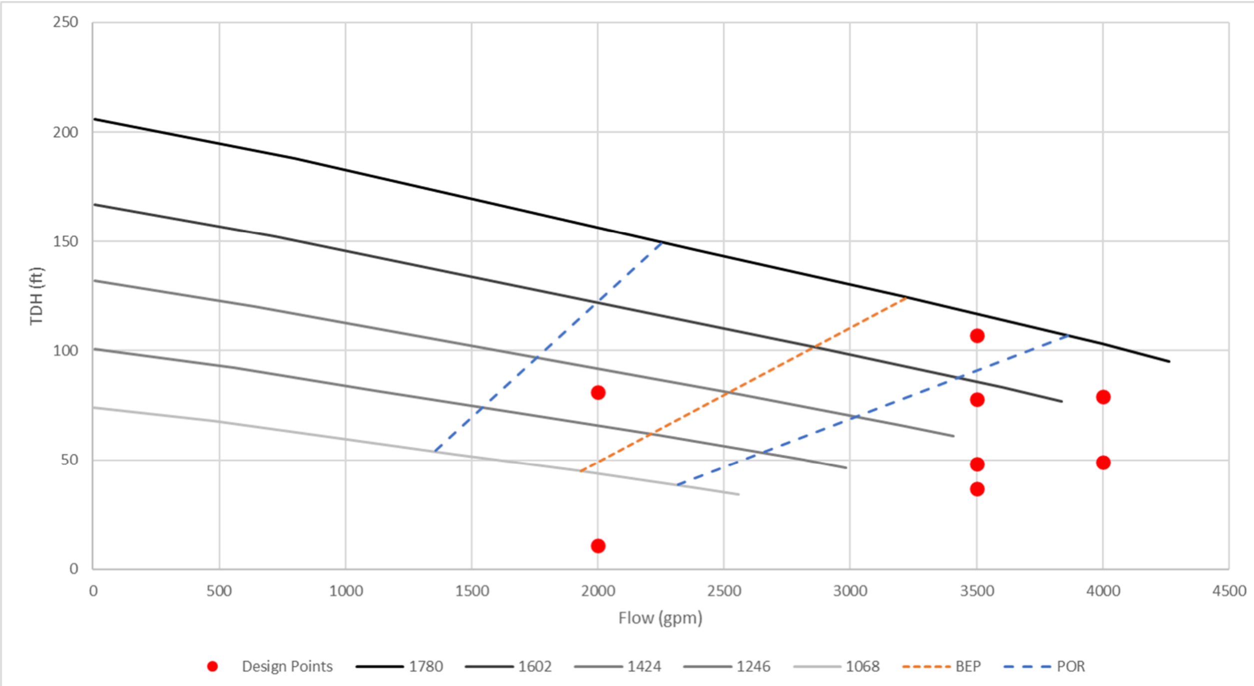

Figure 2.19. Single-Pump Curves with Design Points

2.4 Alternative 4 (Tank Only Option)

A new alternative was proposed by HRSD after the updated modeling runs. This alternative eliminates the PRS portion of the facility and maintains the OLSF and drain pumps. During wet weather all flow in the upstream force mains is diverted to the OLSF once the system HGL reaches a setpoint. For a period of time no flow would continue downstream of the OLSF until the tank reaches a level setpoint and the pumps are activated. The drain pumps would start once the water elevation in the OLSF reached a setpoint that would minimize pump cycling. The OLSF would be sized to provide 3 MG of storage above the pump start setpoint. The drain pumps would pump out of the tank at a rate of 4,000 gpm to 7,500 gpm, and any flow greater than 7,500 gpm would cause the water level in the OLSF to rise and be stored until after the wet weather event. Once the wet weather event is over, flow would stop being diverted to the OLSF, and the drain pumps would empty the tank at a rate between 2,000 gpm and 3,500 gpm. The max water elevation in the OLSF would be set at 36 feet to avoid SSOs upstream of the facility.

Refer to Figure 2.20 and 2.21 for the hydraulic profile and flow diagram.

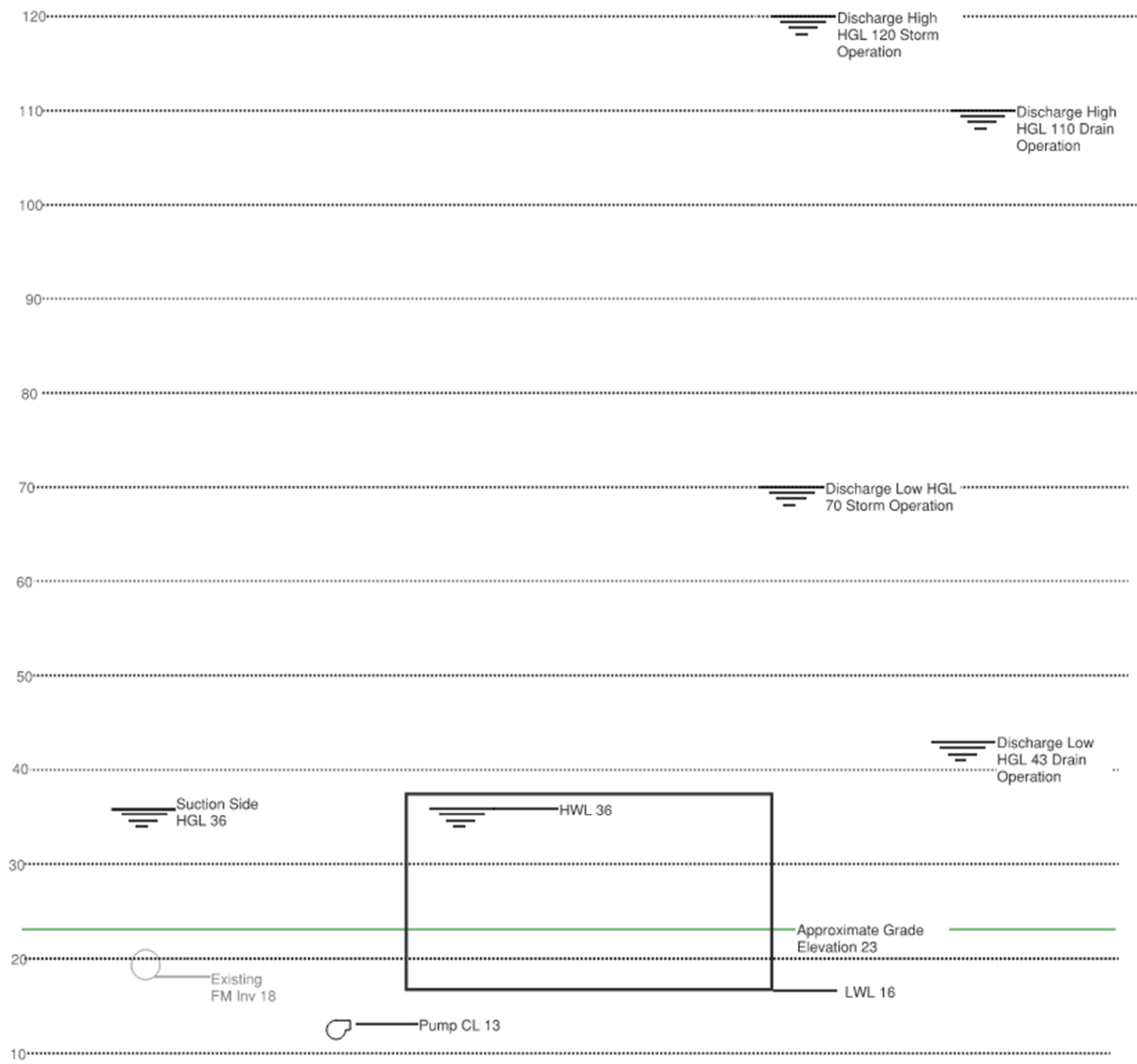

Figure 2.20. Alternative 4 Hydraulic Profile

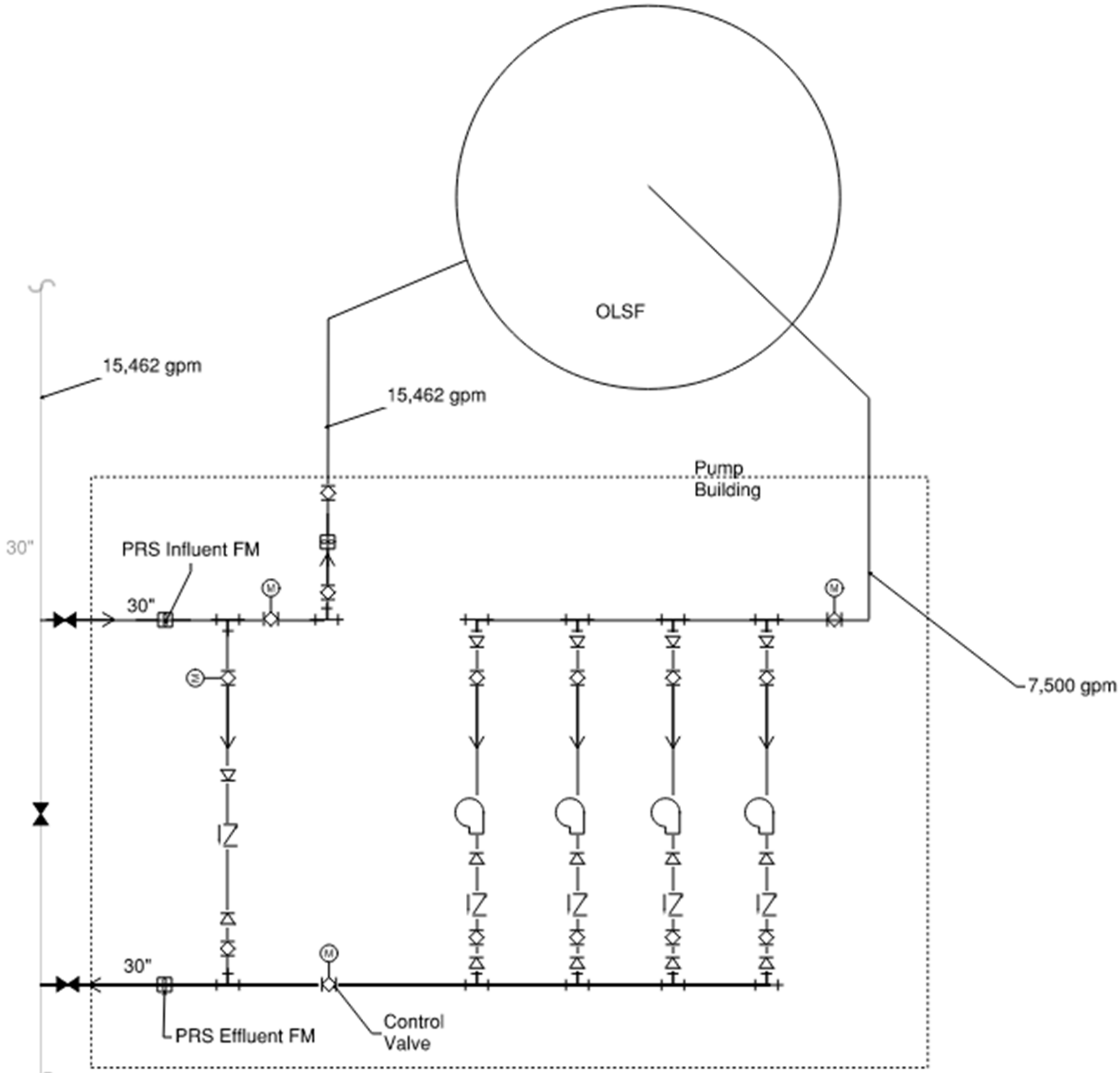

Figure 2.21. Alternative 4 Flow Diagram

Alternative 4 summary:

- OLSF is filled by upstream line pressure
- OLSF is located partially below grade
- Remote manual valve directs flow into the OLSF
- Pumps sized for wet weather and drain operation (4 total, 3 Duty/1 Standby)
- Pumps located in the pump station
- Pumps require a control valve during tank draining

Table 2.9 summarizes the flows and boundary conditions for the new alternative.

Table 2.9. Alt 4 Design Flows and Boundary Conditions

Scenario	Description	Flow Range (gpm)	Upstream HGL (ft)	Downstream HGL (ft)
1	Dry weather	<3,908	<70	<70
2	Filling OLSF during wet weather	4,000 to 15,462	36	--
3	Draining OLSF during wet weather	4,000 to 7,500	36	70 to 120
4	Drain OLSF post wet weather	2,000 to 3,500	--	43 to 110

Elevations are presented in NAVD88

The pump curve for the drain pumps with the control valve open is presented in Figure 2.22. The following Figure 2.23 is the pump curve with design points and the control valve in operation and Figure 2.24 presents a multi-pump curve with design points and the control valve in operation.

Without the control valve three operating points were off the pump curve. With the control valve all operating points fall within the POR.

The pumps would require a control valve on discharge header with a static head setpoint of 45-ft. A preliminary sizing of the control valve requires a 12-inch ball valve on the drain pump discharge header that would be 19 to 70% open during control.

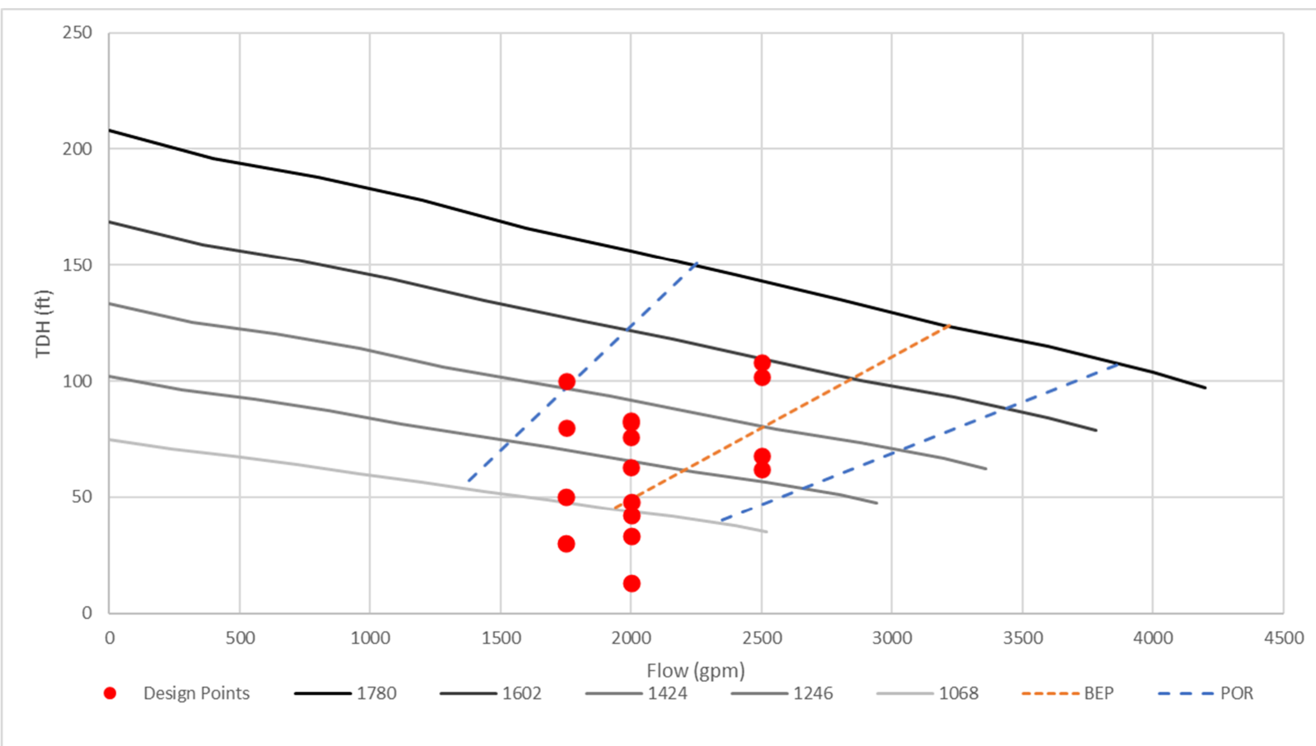

Figure 2.22. Single-Pump Curve with Design Points

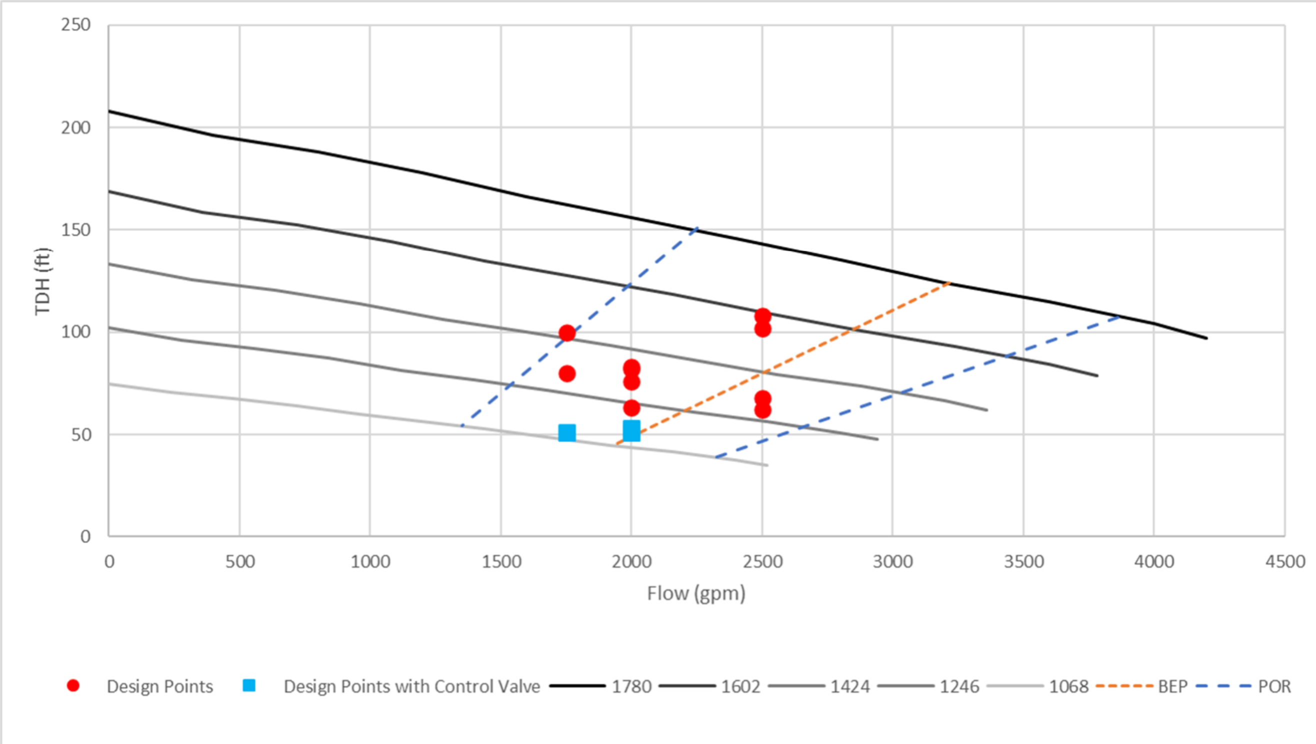

Figure 2.23. Single-Pump Curve with Design Points and Control Valve

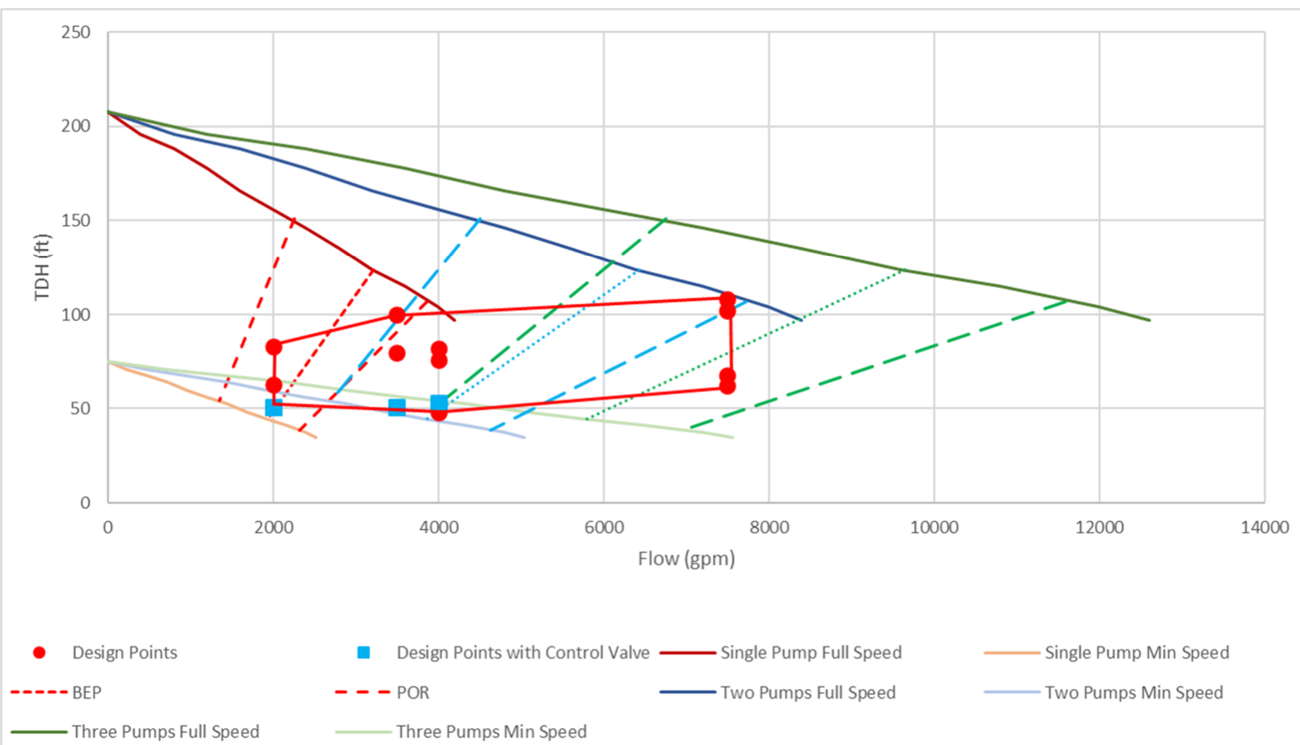

Figure 2.24. Multi-Pump Curve with Design Points and Control Valve

The anticipated operating zone for the pumps is represented by the red polygon. All operation is anticipated to occur within the POR.

Table 2.10 presents operating conditions for the pumps.

Table 2.10. Alt 4 Pump Operating Conditions

Flow (gpm)	Flow per pump (gpm)	Pumps Operating	HGL Discharge (ft)	OLSF Elevation (ft)	TDH (ft)	TDH with control valve (ft)
7500	2500	3	80	36	62	N/A
7500	2500	3	120	36	102	N/A
7500	2500	3	80	30	68	N/A
7500	2500	3	120	30	108	N/A
4000	2000	2	70	36	42	53
4000	2000	2	104	36	76	N/A
4000	2000	2	70	30	48	53
4000	2000	2	104	30	82	N/A
3500	1750	2	60	36	30	51
3500	1750	2	110	36	80	N/A
3500	1750	2	110	16	100	N/A
3500	1750	2	60	16	50	51
2000	2000	1	43	36	13	51
2000	2000	1	93	36	63	N/A
2000	2000	1	93	16	83	N/A
2000	2000	1	43	16	33	51

Elevations are presented in NAVD88

Summary of pump details for pumps is presented in Table 2.11.

Table 2.11. Alt 4 Pump Specifications

Parameter	Drain Pump
Number of pumps	4
Manufacturer	Xylem
Model	NT3231
Max Motor, HP	160
Operating Speed, rpm	1780
Voltage, V	460
Impeller Diameter, mm	340
BEP efficiency at max speed, %	70.3%

Section 3: Operation and Maintenance

Operation and maintenance of the facility for the updated alternatives was considered in this evaluation. Table 3.1 provides a summary comparing the O&M differences for the four alternatives.

Alternatives 3 and 4 have the fewest pumps to maintain and Alternative 3 uses the smallest pumps. The pumps are not anticipated to operate often enough to have significant differences in operating costs, but the cost for replacement parts will be lower for the smaller pumps. Smaller pumps can increase the potential for ragging compared with the larger pumps, but the preliminary pump selections are all based on Xylem N-impeller designs that have been used with good success in the HRSD system. Additional manufacturers and designs can be explored during detailed design.

Alternatives 1 and 2 have some operation with the PRS pumps outside of the POR. Alternatives 1 and 3 have some operation during tank draining outside of the POR that can be controlled through programming. While Alternative 4 has all operation within the POR. All scenarios are expected to operate within the POR either the majority of the time or all the time.

The OLSF for Alternatives 3 and 4 is shorter but wider. This is anticipated to increase maintenance associated with cleaning. Alternative 3 can still utilize a vacuum flushing system but would need additional vacuum pumps. The larger diameter would also increase the time to wash walls with water cannons. Alternative 4 is too large to use a vacuum flush system and would need to be cleaned manually with water cannons. An alternative would be to use multiple smaller tanks with a vacuum flush or a rectangular tank with multiple cells and tipping buckets. Both options would increase the overall construction cost.

The increase in OLSF size for Alternative 4 would also increase the headspace of the tank and increase the odor control system size and carbon consumption, increasing operating costs.

Alternative 4 has one control valve on the pump discharge header. Flow is not controlled into the OLSF so a simple remote open/close valve could be used reducing maintenance for the facility.

The OLSF for Alternative 4 is anticipated to be used more frequently since it would be used any time the PRS would be used. This would increase operation and maintenance costs associated with cleaning and odor control.

Table 3.1. Comparison of Pump Operation and Maintenance				
Criteria	Alternative 1. Recommendation from PER	Alternative 2. Recommendation from PER with Fewer Pumps	Alternative 3. Update of Alternative 1 from PER	Alternative 4. New Alternative without PRS
Number of Pumps (PRS + Drain) to maintain	7	5	4	4
Size of pumps	4 @ 140 HP 3 @ 90 HP	3 @ 215 HP 2 @ 185 HP	4 @ 90 HP	4 @ 160 HP
Total connected HP	830 HP	1,015 HP	360 HP	640 HP
PRS Pump Operating within POR	Portion outside POR	Portion outside POR	Portion outside of the POR during draining that can be controlled through programming	NA
Drain Pump Operating within POR	Portion outside POR that can be controlled through programming	All points within POR with CV		All points within POR with CV
OLSF Size (ft x ft)	30 x 130	30 x 130	20 x 160	20 x 180
Odor Control	No change from PER	No change from PER	Increased OLSF diameter increases headspace and volume of air treated.	Increased OLSF diameter increases headspace and volume of air treated. Increase use of OLSF increases odor control usage.
OLSF Cleaning	No change from PER	No change from PER	OLSF cleaning increases with larger diameter tank	OLSF cleaning increases with larger diameter tank The larger diameter is too large for vacuum flushing and would require manual cleaning with water cannons Increase use of OLSF increases cleaning activities
Number of Control Valves	2 (1 to split flow between FM and OLSF, 1 to control discharge pressure on drain pumps)	2 (1 to split flow between FM and OLSF, 1 to control discharge pressure on drain pumps)	2 (1 to direct flow to OLSF, 1 to control discharge pressure on drain pumps)	1 (to control discharge pressure on drain pumps)
Anticipated number of hrs PRS is in use	196 hrs/year	196 hrs/year	196 hrs/year	196 hrs/year
Anticipated number of days OLSF would be in use	7 days/year	7 days/year	7 days/year	40 days/year

Section 4: PRS and OLFS Alternative Cost

Relative construction cost for the four alternatives was considered in the evaluation. The capital costs of the various alternatives were compared to identify the preferred option. Costs presented are for comparison purposes and do not include all construction costs and markups. These totals do not include costs associated with architecture, plumbing, or I&C. The costs only include differences between the various alternatives and focus on the relative sizes of the PRS and OLSF, amount of excavation, shoring and dewatering required for the different alternatives, and the pump costs of the different alternatives. Table 4.1 defines some of the characteristics used in determining the cost and Table 4.2 shows the relative construction cost for the facilities.

Table 4.1. PRS & OLSF Alternative Characteristics

Alt. Option	Building Dimensions (ft x ft)	Building Area (SF)	Pump CL Elevation	OLSF Size (ft x ft)	Tank Finish Floor Elevation	Total Pumps	Total Excavation (CY)
1	125 x 85	10,625	18	30 x 130	23	7 (4 PRS, 3 Drain)	20,873
2	105 x 85	8,925	18	30 x 130	23	5 (3 PRS, 2 Drain)	19,362
3	85 x 85	7,225	13	20 x 160	16	4 (4 PRS/Drain)	46,110
4	85 x 85	7,225	13	20 x 180	16	4 (Drain Only)	53,441

Table 4.2. PRS & OLSF Alternative Construction Cost

Alt. Option	Building Cost[1]	OLSF Cost[2]	Pump Cost	Odor Control	Electrical	HVAC	Total Cost
1	$6,700,000	$5,100,000	$1,400,000	$270,000	$490,000	$54,000	$14,100,000
2	$5,900,000	$5,100,000	$1,400,000	$270,000	$490,000	$45,000	$13,300,000
3	$5,500,000	$7,100,000	$700,000	$350,000	$245,000	$37,000	$14,000,000
4	$5,500,000	$7,400,000	$800,000	$370,000	$280,000	$37,000	$14,400,000

1. *Cost includes excavation, shoring, and dewatering.*
2. *Cost includes excavation, shoring, dewatering, and cleaning system.*

Section 5: Summary of Evaluation

The costs presented in Section 4 show minimal difference between the four alternatives. The cost benefits for Alternatives 1 and 2, to locate the OLSF at grade, is offset by increased number of pumps and PRS size. And the cost benefits for Alternatives 3 and 4, to eliminate drain or PRS pumps, is offset by the increase in cost for the OLSF and increased excavation. Below is a summary of the alternatives.

The lowest cost option is Alternative 2. This alternative reduced the number of pumps, reducing the size of the PRS building. This alternative has drawbacks however, as it utilized the largest PRS and drain pumps and the preliminary PRS pump selection included some operation outside of the POR. Further refining may identify a selection that will allow for all operation within the POR, but the size of the pumps is not anticipated to become smaller.

Alternative 3 is the second lowest cost and reduces the number and size of the pumps. It also allows for the OLSF to fill off upstream line pressure. The diameter of the tank would increase to allow for 3 MG of storage while minimizing excavation. The preliminary pump selection included operation outside of the POR, but this could be addressed through programming.

Alternative 1 is the second most expensive and includes the most pumps and largest PRS pump station. It also included some pump operation outside of the POR.

Alternative 4 is the most expensive alternative and has additional drawbacks. Filling the OLSF first increases the frequency for cleaning and odor control. The OLSF would also be oversized to provide 3 MG of storage volume above the “pump on” level setting, and the increase in OLSF size increases excavation and tank costs. It is also too large for the recommended vacuum flushing technology so cleaning would be manual with water cannons. An alternative tank design could be explored utilizing automatic flushing, but as stated in Section 3 this would further increase construction cost. The pumps are also larger because the recommended max flow rate and discharge HGL is higher than the HART report. There is also some concern with how the system would react to stopping all forward flow downstream of the OLSF before the pumps turn on. This could impact operations at the treatment plant, create hydraulic transients, and cause other pump stations connected to the force main to operate off their pump curves. These impacts would need to be further evaluated if this alternative were selected. Alternative 4 did eliminate one control valve by changing the OLSF fill valve to a simple open/close valve that does not need to control the rate of flow into the OLSF.

While all options are viable, Alternative 3 is recommended. This alternative has the fewest and smallest pumps and allows for the OLSF to fill by upstream line pressure which is the preferred fill method. Increasing the upstream HGL reduced the cost of excavation, and the changes to drain pumping rate and discharge HGL made it feasible to utilize the PRS pumps for tank draining. Operation outside of the POR is anticipated to be able to be controlled through programming, and the smaller pump size should minimize the increase in maintenance costs compared with the other alternatives.

The alternative has the following characteristics.

- 20-ft x 160-ft Tank
  - Single circular tank
  - The tank foundation is located approximately 15 feet below grade
  - The tank includes a flushing foundation for a vacuum flushing system
- PRS Building
  - The PRS is a partially buried station
  - The building foundation is located approximately 17 feet below grade

- OLSF Fill/Drain Option
    - The tank is filled using the suction line pressure
    - PRS pumps utilized for tank draining