Gray & Osborne, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM

TO:	TRACY COLEMAN, PUBLIC WORKS DIRECTOR
FROM:	BJARNE JACOBSEN, P.E. JAY SWIFT, P.E.
DATE:	SEPTEMBER 30, 2022
SUBJECT:	BELMONT LOOP SEWER CAPACITY ANALYSIS CITY OF WOODLAND, COWLITZ/CLARK COUNTY, WASHINGTON G&O #21218.04 & #21417.08

INTRODUCTION

The purpose of this analysis is to determine if Lift Stations 4, 10, and 12, and their force mains, have adequate capacity to accommodate two new developments proposed to be constructed in the area served by the Lift Station 12 gravity sewer system. For the facilities that have inadequate capacity for the projected flows, recommendations for improvements are provided. (The recommendations are preliminary and will need to be further refined during the development of design of improvements.) The proposed new developments are as follows.

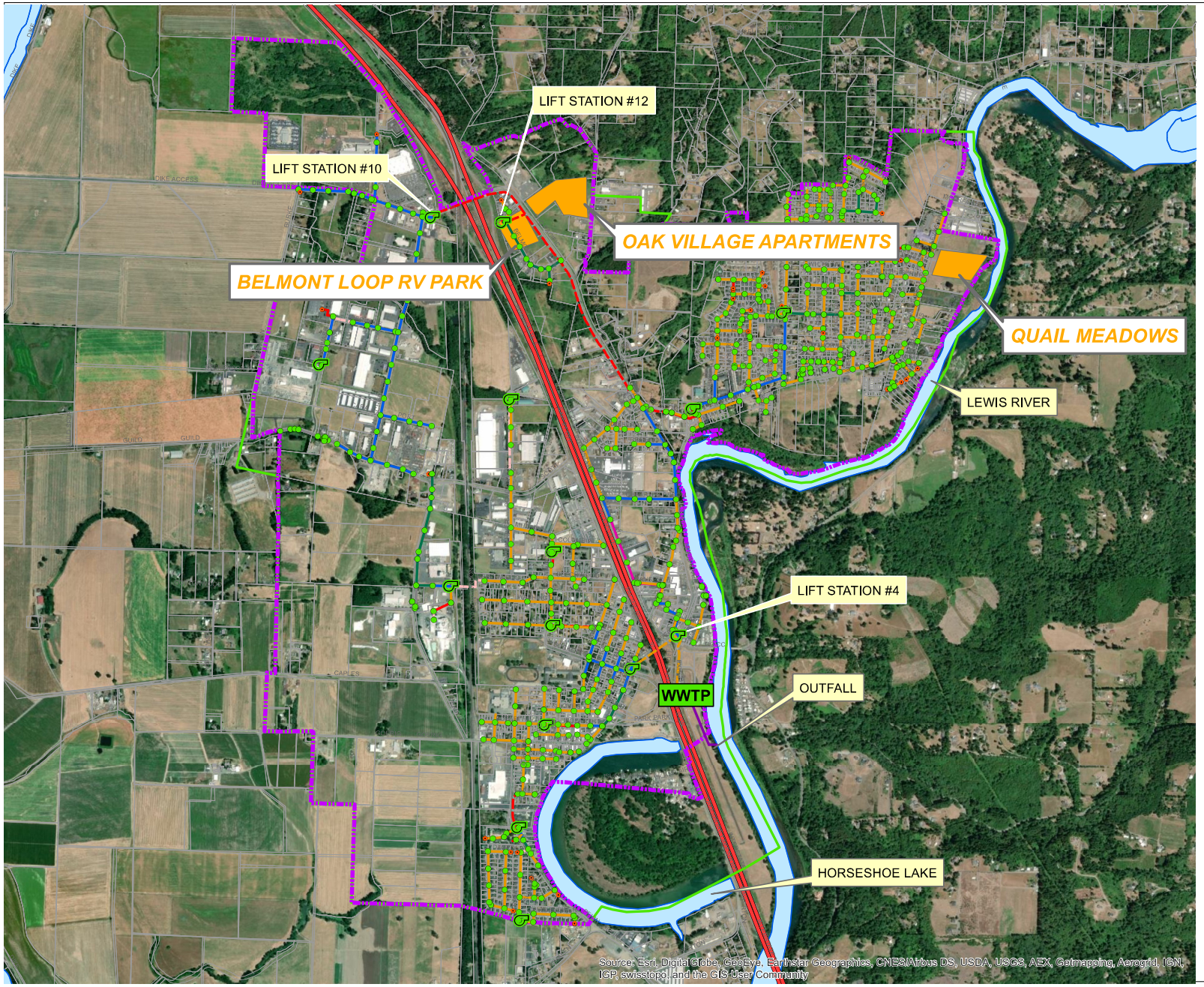
1. Belmont Loop RV Park

2. Oak Village Apartments

In addition, Lift Station 4 capacity was evaluated with the addition of the Quail Meadows development.

Figure 1 shows the locations of the lift stations and developments under consideration.

1130 Rainier Avenue S., Suite 300 Seattle, Washington 98144 (206) 284-0860 Fax (206) 283-3206



N

0 1,000 2,000 4,000 Feet

LEGEND:

- CITY LIMITS
- URBAN GROWTH BOUNDARY
- PARCEL
- STREAM
- LIFT STATION
- CLEAN OUT
- MANHOLE
- WWTP WASTEWATER TREATMENT PLANT

GRAVITY MAIN:

- 4"
- 6"
- 8"
- 10"
- 12"
- 15"
- 16"
- UNKNOWN DIAMETER

FORCE MAIN:

- 4"
- 6"
- 8"
- 12"

ORTHO PHOTO SOURCE: 2009 NAIP

CITY OF WOODLAND

BELMONT LOOP SEWER CAPACITY STUDY

FIGURE 1

LIFT STATION AND DEVELOPMENT LOCATIONS

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This analysis assumes that the flow contributed by these three developments will be in addition to the flows presented in the *General Sewer Plan, July 2017* (GSP), for the year 2033 conditions. Peak hour flows from these developments were estimated based on criteria presented in the GSP, as follows.

- Annual Average Flow: 135 gpd/ERU, excluding Infiltration/Inflow (I/I).
- Peaking Factor presented in *Criteria for Sewage Works Design* ("Orange Book"), based on population, to determine Peak Hour Wastewater Flow.
- An additional 1,100 gallons per acre per day (gpad) of peak hour I/I based on area of developed property.

Based on the above criteria, Peak Hour Flows for the three development scenarios were estimated, as shown in Table 1.

TABLE 1

Projected Year 2033 Flows

Scenario	Peak Hour Flow (gpm)		
	Lift Station 10	**Lift Station 12**	**Lift Station 4**
No development (beyond that specified in the GSP)	100	20	1,194
Add Belmont Loop RV	100	52	1,207
Add Belmont Loop RV and Oak Village Apartments	100	116	1,244
Add Belmont Loop RV, Oak Village Apartments, and Quail Meadows	100	116	1,252

Lift Station 10 shares a significant length of common force main with Lift Station 12, and the capacity of Lift Station 10 will be affected by increasing the capacity of Lift Station 12. In accordance with the GSP, Lift Station 10 will be required have to have a capacity of 100 gpm by the year 2033.

In accordance with Ecology's "Orange Book," the nominal capacity of all lift stations is established with the largest pump out of service. For Lift Stations 10 and 12 (which both have two equal-capacity pumps), the nominal capacity is when only one pump is running in each station when both lift stations are operating simultaneously. For Lift Station 4,

which has three equal-capacity pumps, the nominal capacity is when two pumps are running at the same time.

As stated above, the analyses in this Memorandum are based on the year 2033 flow projections presented in the GSP. Before any of the projects discussed in this Memorandum are implemented, it is recommended that the flow projections be extended so that facilities can be designed to meet the needs for at least a 20-year planning period.

DRAWDOWN TESTS

City of Woodland staff conducted drawdown tests for Lift Stations 10 and 12 on April 21, 2022. The capacities of the pumps in Lift Station 4 were established by reading the flow meter at the wastewater treatment plant. The pump capacities observed are summarized in Table 2. Since the flows from Lift Station 4 can be observed directly at the Wastewater Treatment Plant Influent Flow Meter, drawdown tests for Lift Station 4 were not required. The flows shown in Table 2 for Lift Station 4 are the actual flow meter readings.

TABLE 2

Drawdown Test Results

Lift Station	Condition	Observed Capacity (gpm)	Average Observed Capacity (gpm)
10	Pump 1 Pumping Alone	166	173
	Pump 2 Pumping Alone	180	
	Pump 1 Pumping when Lift Station 12 is Running	No Test	30
	Pump 2 Pumping when Lift Station 12 is Running	30	
12	Pump 1 Pumping Alone	248	244
	Pump 2 Pumping Alone	239	
	Pump 1 Pumping when Lift Station 10 is Running	209	204
	Pump 2 Pumping when Lift Station 10 is Running	199	
4	One Pump Running	760	760
	Two Pumps Running	910	910

ANALYSIS OF LIFT STATIONS 10 AND 12 DRAWDOWN TESTS

The above drawdown tests indicate that the capacity of Lift Station 10 is presently exceeded when operating simultaneously with Lift Station 12. This capacity issue has not been a problem because it is estimated that Lift Station 12 is operating less than 1 percent of the time. With the addition of new connections, the operating time of Lift Station 12 is expected to increase, thus increasing the time Lift Stations 10 and 12 will be required to operate at the same time.

System curves were developed for the various conditions, using the Hazen-Williams equation and adjusting the "C" factors to approximate the flow conditions observed during the drawdown tests. The system curves are shown on Figure 2 for Lift Station 10 and Figure 3 for Lift Station 12. The Hazen-Williams "C" factors that appear to fit the conditions the best, are shown in Table 3.

TABLE 3

Hazen-Williams "C" Factors Consistent with Drawdown Test Results for Lift Stations 10 and 12

	Lift Station 10	Lift Station 12
"C" Factor for Ductile Iron Pipe	95	115
"C" Factor for HDPE Pipe	100	130

Pipe length and static heads were obtained from the Record Drawings for the two lift stations. The Hazen-Williams "C" factors are estimated to be lower for the force mains constructed in association with Lift Station 10 than those for Lift Station 12 because the Lift Station 10 force mains are older than the Lift Station 12 force mains. A lower "C" factor represents more friction caused by wear or solids depositions over time. Lift Station 10 was constructed in 1994, while Lift Station 12 was constructed in 1999. The "C" factors shown in Table 3 are lower than might typically be expected for pipes this age. However, using these "C" factors to establish pump characteristics for an upgraded system should result in a conservative design.

It should be emphasized that the methodology used in this analysis is an estimate based upon available data and may not precisely reflect all system conditions. As can be seen on Figure 2, there is an anomaly in the drawdown test for Lift Station 10 when Lift Station 12 is operating at the same time. The drawdown test showed a pumping rate of 30 gpm for Pump 3, while the Hazen-Williams equation, using the "C" factors shown in Table 3, predicts a pumping rate of approximately 80 gpm. This anomaly could be due

to the check valves creating more friction than predicted because the flows are too low to fully open the check valves.

LIFT STATION 10 CAPACITY

The drawdown tests for Lift Station 10 show that the capacity of this station is inadequate for the projected year 2033 peak hour flow of 100 gpm, as presented in the GSP, when Lift Station 12 is operating. It is therefore recommended that the capacity of Lift Station 10 be upgraded to 100 gpm in the near future. The remainder of the information presented herein assumes that Lift Station 10 has been upgraded to 100 gpm and operates with that capacity when Lift Station 12 is operating.

The new pumps in Lift Station 10 should be rated at 100 gpm at a total dynamic head of 73 feet to be able to accommodate the projected 2033 peak hour flows with Lift Station 12 operating at 170 gpm at the same time (see below). The selected new pumps for Lift Station 10 would also have to operate satisfactorily when pumping alone, approximately at 200 gpm at 61-feet TDH, depending on the pump curve for the selected pump. The new pumps would be anticipated to be equipped with 10-hp motors to accommodate these conditions.

If the capacity of Lift Station 12 has to be increased because of additional developments in its service area, additional improvements to further increase capacity will also have to be made to Lift Station 10, as this lift station's head requirements would increase.

LIFT STATION 12 CAPACITY

Based on system curves developed with the Hazen-Williams formula and calibrated for the drawdown tests shown above, and the published pump curves for the existing pumps in Lift Station 12, the capacity of the pumps in Lift Station 12 (when Lift Station 10 is pumping at 100 gpm), is approximately 170 gpm. This is adequate capacity to accommodate the addition of Belmont Loop RV and Oak Village Apartments and thus, no improvements would be required for Lift Station 12.

If any other developments (beyond those listed above and those accounted for in the GSP) are connected to the sewer system served by Lift Station 12, improvements may have to be made to Lift Station 12.

LIFT STATIONS 10 AND 12 FORCE MAIN PRESSURE RATING

The pressures at which these pumps will be operating (up to 32 psi) will be well below the 65-psi pressure rating of the SDR 26 HDPE force main.

ANALYSIS OF LIFT STATION 4 FLOW METER READINGS

System curves were also developed for Lift Station 4, using the Hazen-Williams equation and adjusting the "C" factors to approximate the flow conditions observations during the drawdown tests. The system curves are shown on Figure 4. The Hazen-Williams "C" factors that appear to fit the conditions the best, are shown in Table 4.

TABLE 4

Hazen-Williams "C" Factors Consistent with Flow Meter Readings for Lift Station 4

	Lift Station 4
"C" Factor for Old Ductile Iron Pipe	92
"C" Factor for Newer Ductile Iron Pipe	128

The age of the older 8-inch force main from the Lift Station 4 site to the Wastewater Treatment Plant site is unknown. However, it was shown as "existing" on the Lift Station 4 Modification drawings, dated 1978; thus, it is at least 44 years old. Pipe lengths and static heads were obtained from the Record Drawings for Lift Station 4 and the Wastewater Treatment Plant headworks.

LIFT STATION 4 CAPACITY

The flow meter readings for Lift Station 4 shown in Table 2 indicate that the nominal capacity of Lift Station 4 is inadequate for the projected year 2033 flow conditions, as shown in Table 1. It is therefore recommended that the capacity of Lift Station 4 be upgraded in the near future. If the upgrade were to accommodate the Belmont Loop RV, the Oak Village Apartments, and Quail Meadows, the design flow for each pump would need be 626 gpm, for a total of 1,252 gpm when two pumps are operating, at a total dynamic head of approximately 98 feet. The selected new pumps for Lift Station 4 would also have to operate satisfactorily when only one pump is operating, likely in the neighborhood of 1,100 gpm at 90 feet TDH, depending on the pump curve for the selected pump. The new pumps would likely need to be equipped with 45-hp motors to accommodate these conditions.

Under the development conditions described above, the velocity in the 8-inch force main from Lift Station 4 to the wastewater treatment plan will approach 8 feet per second. This is considered the upper range for flow velocities in force mains. Because of the high velocity and the age of this force main, the City may want to consider replacing the

8-inch force main with a 10-inch force main. This option would eliminate the need for pump improvements at Lift Station 4. The replacement of the force main would provide Lift Station 4 with a nominal capacity of approximately 1,580 gpm, utilizing the existing pumps. The system curves for this scenario, together with the pump curve for the existing Lift Station 4 pumps, are shown on Figure 5.

This latter scenario with also result in lower power costs, as the pumps would remain 20 hp.

It is estimated that replacing the existing 8-inch force main from Lift Station 4 can be accomplished at a total project cost of approximately $1,900,000, including construction, sales tax, engineering, and contingencies. The total project cost estimate for replacing the pumps and electrical equipment (because the pumps will be higher horsepower than the existing installation) is approximately $1,200,000. These costs are not based on detailed quantity take-offs. They are based on actual bids for recent similar projects. Replacement of the existing force main will result in a reduction of power consumption by approximately 47,200 kilowatt-hours per year. At $0.08 per kilowatt-hour, this would be a savings of approximately $3,780 per year.

Furthermore, replacing an aging force main may avoid a failure of the aging force main that may be nearing the end of its useful life.

FIGURE 2

Performance Curve

Product: CP3127.091			Type: HT
Date: 2021-10-13	Project: LIFT STATION 10 SYSTEM CURVES		Curve No: 63-485-00-2202 / Issue: 4

	1/1-Load	3/4-Load	1/2-Load
Power Factor	0.88	0.85	0.77
Efficiency	83.8 %	84.7 %	83.7 %
Motor Data	---	---	---

Rated Power ...	7.5	hp
Starting Current ...	105	A
Rated Current ...	19	A
Rated Speed ...	1740	rpm
Tot. Mom. of Inertia ...	0.095	kgm2
No. of Blades	1	

Impeller Diameter: 200 mm

Motor #	Stator	Rev
21-10-4AL	12Y//	11

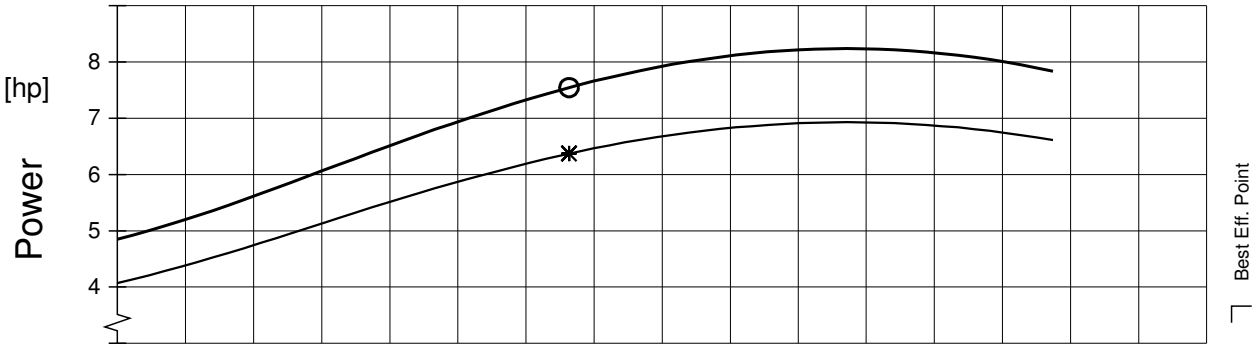
Freq.	Phases	Voltage	Poles
60 Hz	3	230 V	4

Geartype: --- Ratio: ---

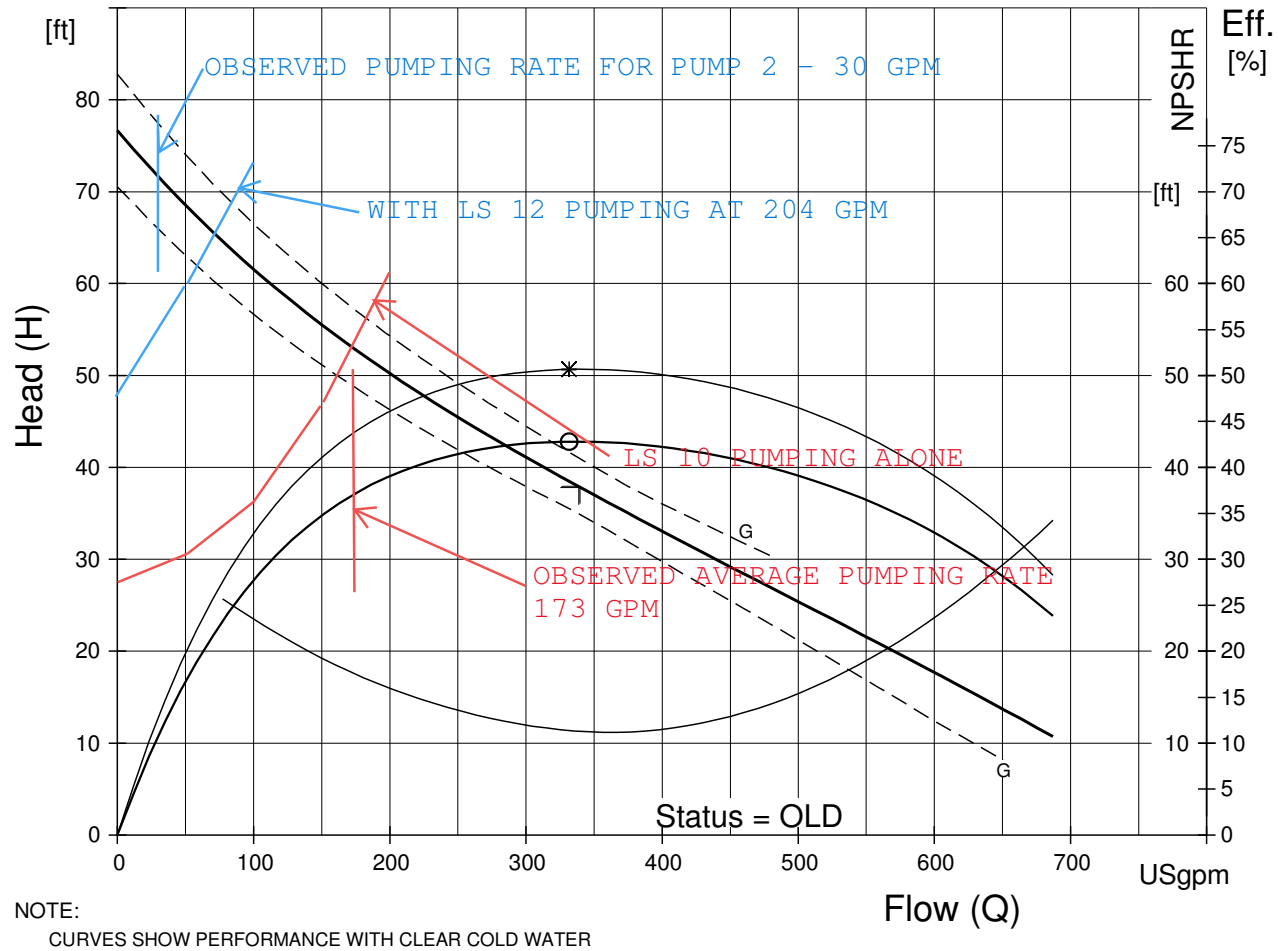
Comments: NEVA CLOG

Inlet/Outlet: -/ 4 inch

Imp. Throughlet: 2.9 inch



Duty-Point	Flow[USgpm]	Head[ft]	Power [hp]	Eff. [%]	NPSHR[ft]
B.E.P.	331.7	38.48	7.55 (6.38) *	42.8 (50.7) *	11.5



NOTE:
CURVES SHOW PERFORMANCE WITH CLEAR COLD WATER
* : Pump EFFICIENCY/Shaft POWER
O : Overall EFFICIENCY/Input POWER
NPSHR = NPSH3 + min. operational margin

Guarantee between limits (G) acc. to
ISO 9906:2012 & ANSI/HI 11.6:2012 / <10kW

unix AUTHOR: EHORTON SACU (rev:8.1)

FIGURE 3

Performance Curve

Product: CP3127.091			Type: HT
Date: 2021-10-13	Project: LIFT STATION 12 SYSTEM CURVES		Curve No: 63-483-00-3702 / Issue: 4

	1/1-Load	3/4-Load	1/2-Load
Power Factor	0.88	0.86	0.80
Efficiency	84.3 %	86.5 %	87.0 %
Motor Data	---	---	---

Rated Power ...	10	hp
Starting Current ...	134	A
Rated Current ...	25	A
Rated Speed ...	1720	rpm
Tot. Mom. of Inertia ...	0.11	kgm2
No. of Blades	1	

Impeller Diameter: 228 mm

Motor #	Stator	Rev
21-12-4AL	12Y//	15

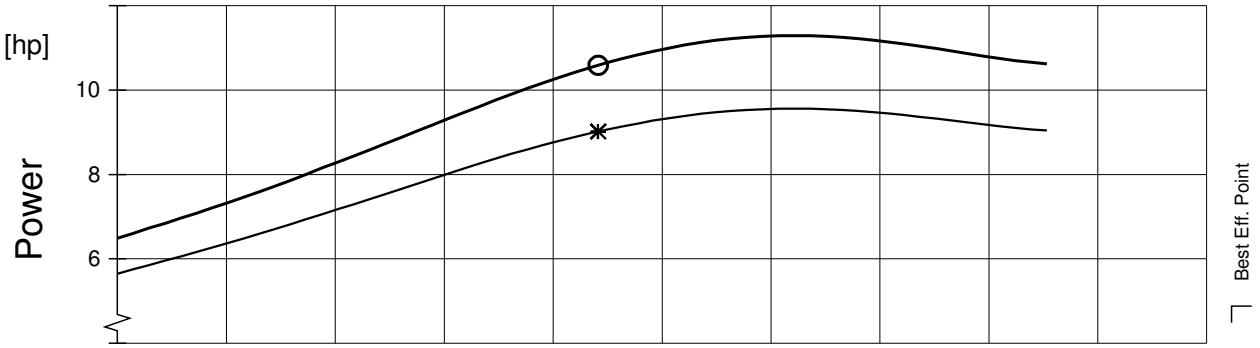
Freq.	Phases	Voltage	Poles
60 Hz	3	230 V	4

Geartype	Ratio
---	---

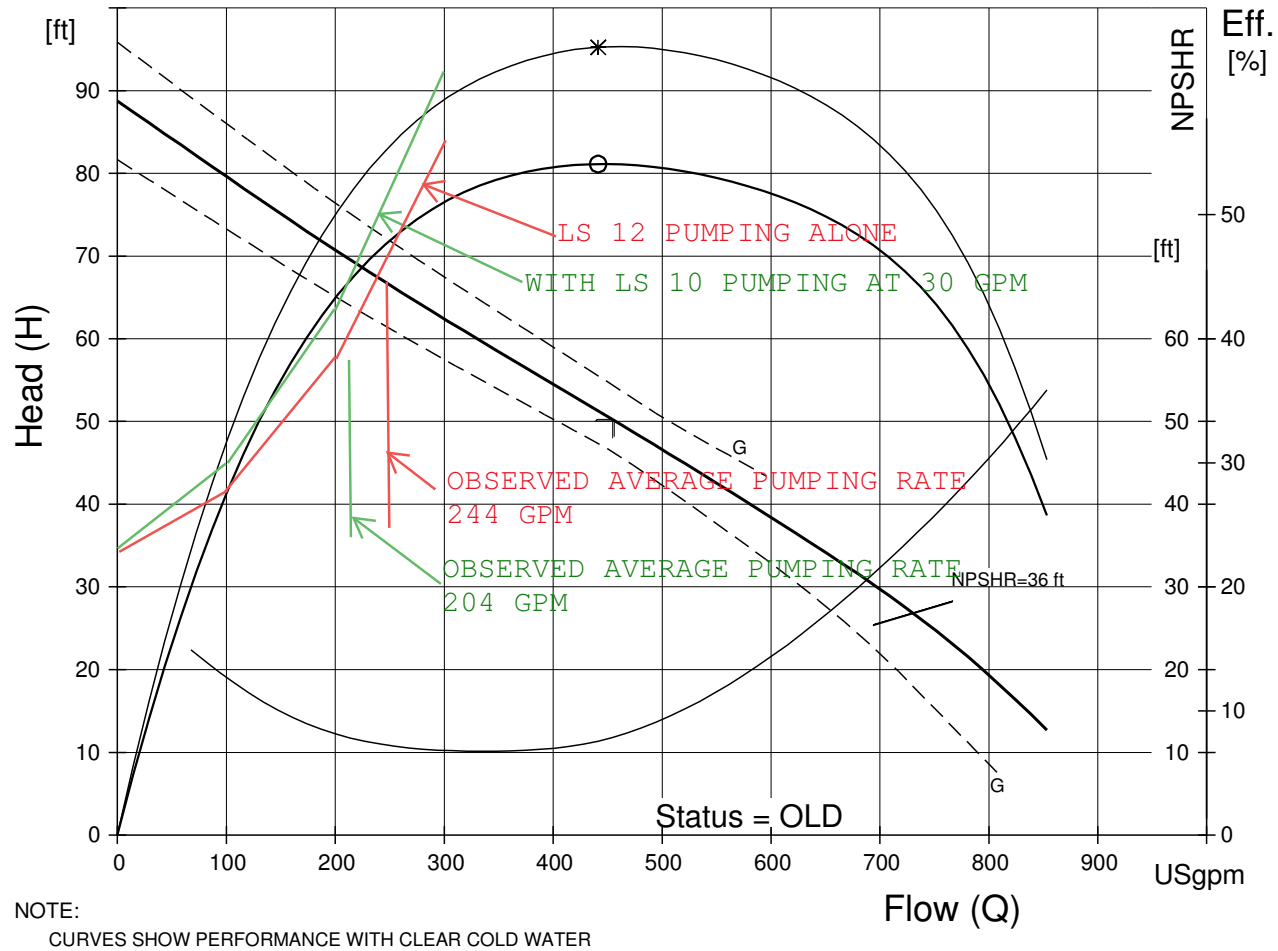
Comments

Inlet/Outlet: -/ 4 inch

Imp. Throughlet: 2.9 inch



Duty-Point	Flow[USgpm]	Head[ft]	Power [hp]	Eff. [%]	NPSHR[ft]
B.E.P.	441.3	51.3	10.6 (9.02) *	54.1 (63.5) *	11.5



NOTE:

CURVES SHOW PERFORMANCE WITH CLEAR COLD WATER

* : Pump EFFICIENCY/Shaft POWER

O : Overall EFFICIENCY/Input POWER

NPSHR = NPSH3 + min. operational margin

Guarantee between limits (G) acc. to

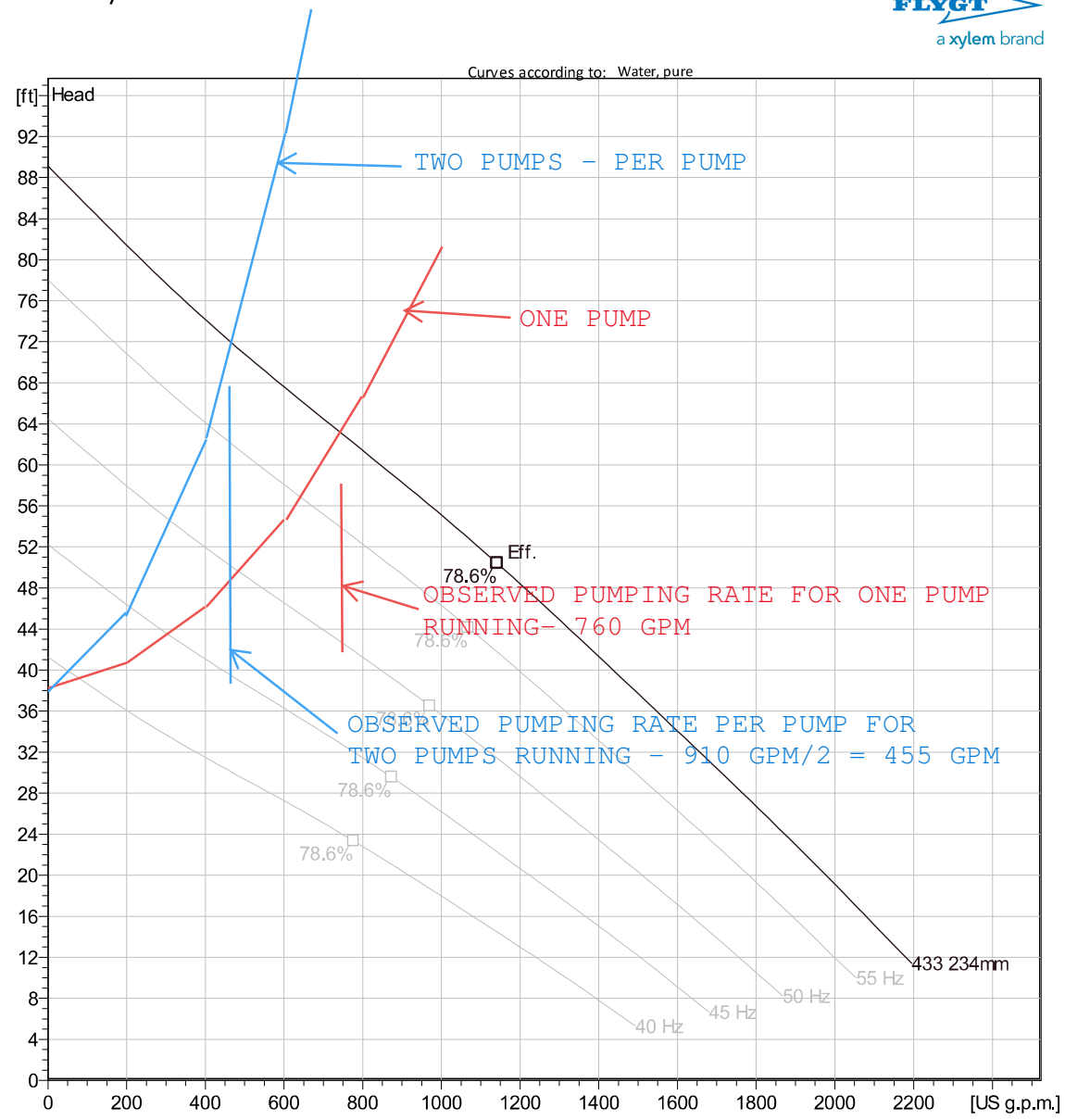
ISO 9906:2012 & ANSI/HI 11.6:2012 / <10kW

unix AUTHOR: EHORTON SACU (rev:8.1)

LIFT STATION 4

NP 3153 MT 3~ 433

VFD Analysis



Operating characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific Energy	NPSHre

FIGURE 4

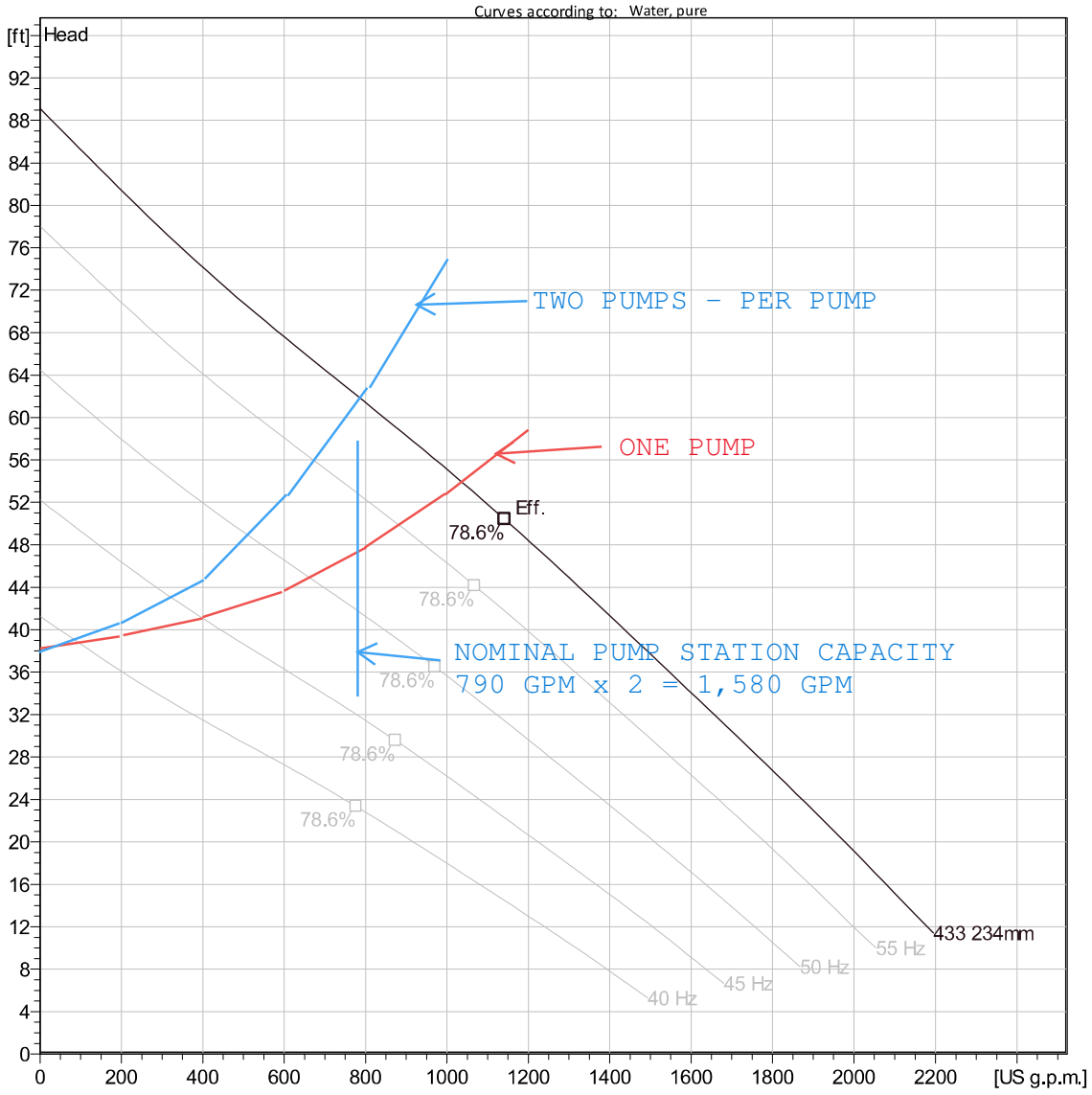
PUMP STATION PUMP AND SYSTEM CURVES

EXISTING FORCE MAIN

Project	**Created by**	Dave Bobbett	
Block	**Created on**	10/13/2021	**Last update** 10/13/2021

NP 3153 MT 3~ 433

VFD Analysis



Operating characteristics

Pumps / Systems	Frequency	Flow	Head	Shaft power	Flow	Head	Shaft power	Hydr.eff.	Specific Energy	NPSHre

FIGURE 5

PUMP STATION 4 PUMP AND SYSTEM CURVES

UPSIZING THE FORCE MAIN TO 10" DIAMETER

Project	**Created by**	Dave Bobbett	
Block	**Created on**	10/13/2021	**Last update** 10/13/2021