TREKK
DESIGN GROUP, LLC

City of Fair Grove, Missouri

Lift Station Technical Memorandum

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Abbreviations

ADDF	Average Dry Daily Flow
City	City of Fair Grove, Missouri
Dia.	Diameter
GPM	Gallons per Minute
I&I	Infiltration and Inflow
IN	Inches
LF	Linear Feet
PSI	Pounds per Square Inch
TDH	Total Dynamic Head
TREKK	TREKK Design Group

Memorandum

1 Introduction

TREKK Design Group performed an inspection of the main sanitary sewer lift station on August 22, 2018 for the City of Fair Grove, Missouri. This inspection was performed to evaluate the performance of the lift station and to make recommendations for improvements. This site, also known as Lift Station #3, is located on the west side of town along Highway CC and handles the majority of the flow for the City. There are two separate pumping stations at Site #3. The system was designed such that a primary station is used to handle the average dry daily flows and a secondary pump station is used during wet weather and peak events. The primary pump station has been frequently inoperable for the last 4 to 5 years and the secondary pump station is being used to handle all flows. (See Figure 1-1)

The primary lift station was constructed in 1992. This lift station uses two above grade suction style Cornell pumps model C4414T-30-4. At the time of inspection, these pumps were not functional. Influent to the lift station is directed to a 50,000 gallon holding chamber (15 Feet by 48 Feet). Discharge from the holding chamber flows into a 6 foot diameter wet well. The Cornell pumps, valves, vacuum components, and other appurtenances are located directly above the wet well. The water level in the holding chamber is controlled by the lift station pumps utilizing float controllers.

A secondary lift station was constructed in 2012. This lift station was installed into the holding chamber utilizing two KSB submersible pumps model KRT F 80-250/252XG-S. A concrete box was constructed on top of the holding chamber to provide access to the pumps, plumbing, and supporting devices. A valve box was added outside of the holding chamber to contain the check valves and isolation valves. Discharge from the valve box ties into the single force main connected to the primary lift station. The addition of the submersible pumps is intended to serve as a redundant pumping station to the primary lift station and as a secondary pumping system during peak events. The secondary system is regulated by a set of float controllers independent of the float controllers found in the wet well. The operators indicated that the holding tank was last cleaned when the KSB pumps were installed in the system.

The eight inch PVC force main extends 8,750 LF from Lift Station #3 to a connection located near the intersection of S Grove Rd and Old Mill Cir at which point the influent enters the gravity system at manhole NE-099. The profile of the force main indicates that the discharge is at the highest elevation within the pipeline. Some local high and low points were found along the pipeline where air relief valves have been installed. The change in elevation between the outflow elevations at the lift station to the inflow elevation at the manhole is approximately 105 Feet. An estimated discharge pressure of 15 PSI was used to evaluate the pump performance.

Figure 1-1: Fair Grove Lift Station #3

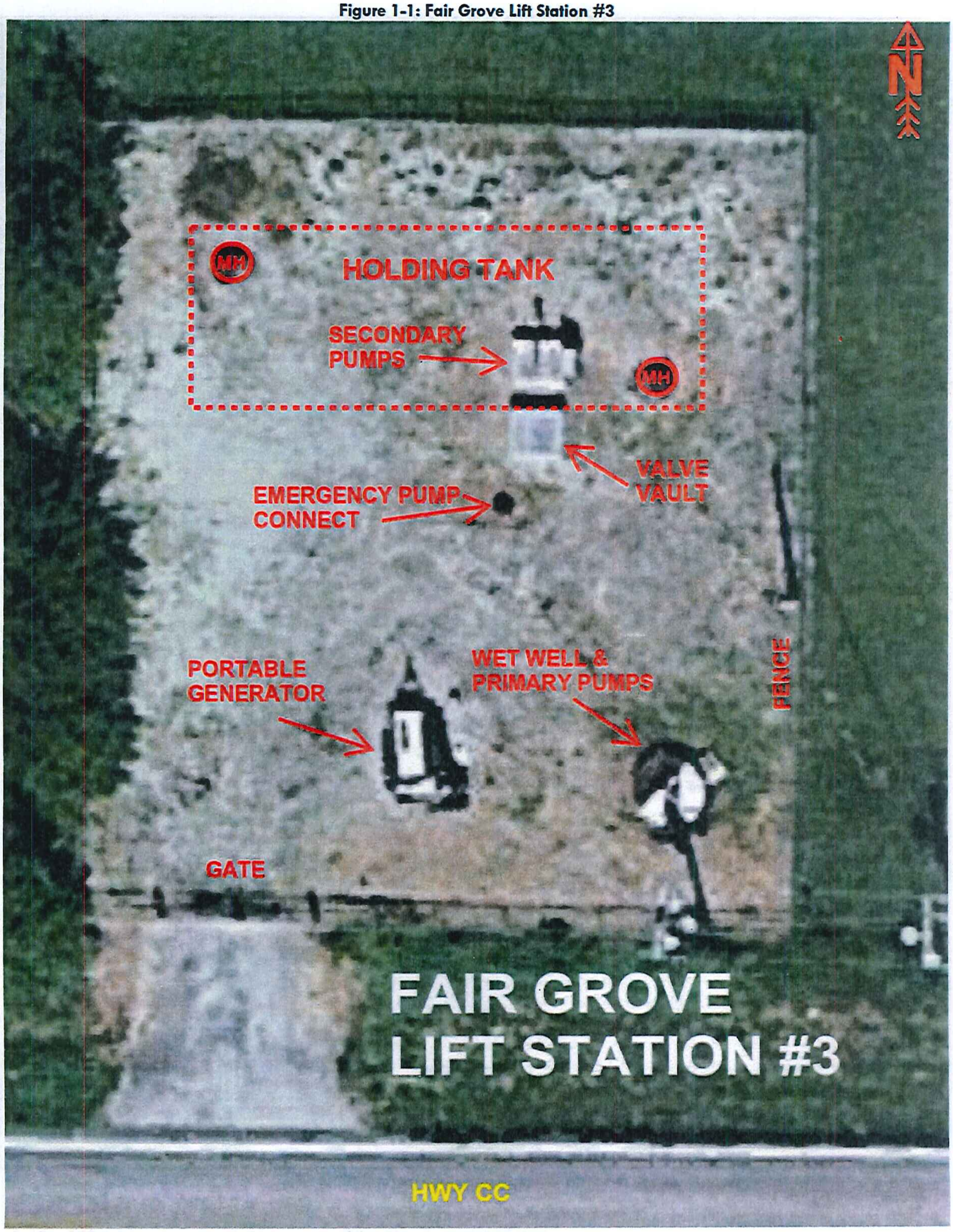
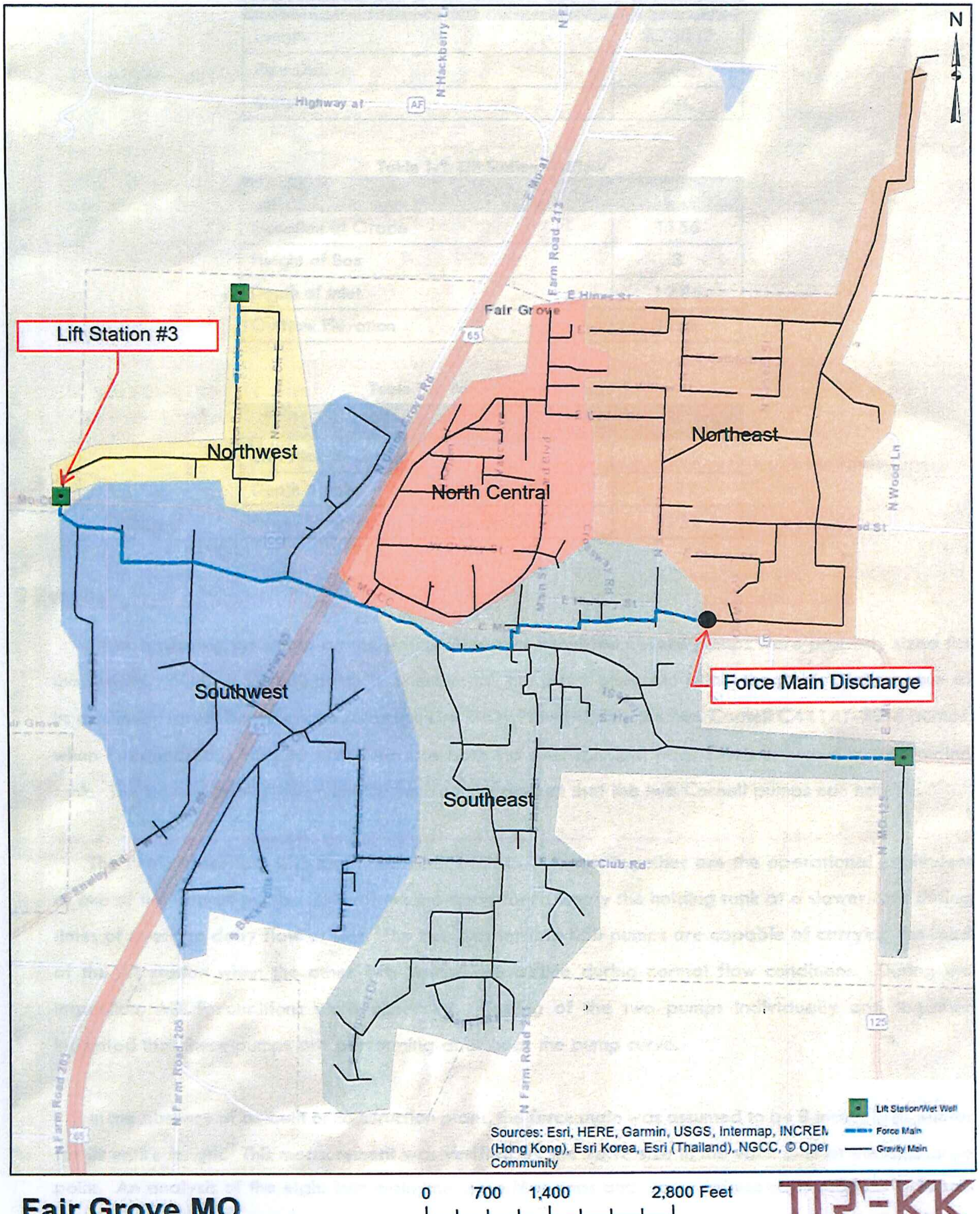


Figure 1-2: Lift Station and Force Main Location



Fair Grove MO
Lift Station and Force Main Location

TREKK DESIGN GROUP, LLC

Table 1-1: Force Main Characteristics

Length	8,750 LF
Pipe Dia.	8 Inch
Material	PVC

Table 1-2: Lift Station Outflow

	(Feet)
Elevation at Grade	1156
Height of Box	3
Depth of Inlet	12.85
Outflow Elevation	1146

Table 1-3: Force Main Discharge

	(Feet)
Elevation at Grade	1258
Depth of Inlet	6.92
Inflow Elevation at Manhole NE-099	1251

2 Results

After reviewing the pump curves, it was determined that the Cornell pumps were properly sized for the system. When a Cornell pump is operational, the pump operates within the peak performance of its efficiency curve. Based on the Average Dry Daily Flow (ADDF), the two Cornell C4414T-30-4 pumps, when functional, are able to accommodate both the average and peak flows collected in the holding tank. The added peak flows from I&I exceed the amount that the two Cornell pumps can handle.

The two submersible KSB KRT F 80-250/252XG-S pumps together are the operational equivalent of one of the Cornell pumps. This allows the operator to empty the holding tank at a slower rate during times of average daily flow or less. The two submersible KSB pumps are capable of carrying the load of the lift station when the other two pumps are offline during normal flow conditions. During the inspection, ADDF conditions were observed. Testing of the two pumps individually and together indicated that these pumps are performing at or near the pump curve.

In the absence of as-built or construction plans, the force main was assumed to be 8 inches in diameter for its entire length. This measurement was verified by the valve size in the vault and at the discharge point. An analysis of the eight inch main line using Mannings and Darcy-Weisbach equations indicates that functionality is maintained without excessive amounts of head loss. This is reflected in the system curve shown on the pumping analysis charts. (See figures 2-1, 2-2, and 2-3)

The amount of volume discharged from the holding tank during a standard pump cycle is insufficient to completely discharge the wastewater from the previous pump cycle. As such, between pump cycles, the wastewater becomes stagnant and can release hydrogen sulfide. H_2S can cause degradation of the concrete structures downstream of the discharge and as well as corrosion of the force main components that are not rated for highly acidic flow. The H_2S may also corrode the air relief valves within the system that can result in subsequent problems and costly maintenance issues. Velocities in the pipe are approximately 2.1 feet/second when a single KSB pump is running, which should provide enough movement to prevent settling within the pipe. However, the velocities may not be high enough to scour and clean the line of sediment accumulated between pump cycles.

Table 2-1: Cornell Pump and System Data

System Data		C4414T-30-4 Pumps	
Flow Rate (GPM)	**System TDH (Feet)**	**1 Pump Operating Head (Feet)**	**2 Pumps Operating Head (Feet)**
100	113	165	167
150	114	160	166
200	116	156	165
250	119	148	163
300	123	143	160
350	125	140	158
400	129	138	156
450	134	137	152
470	136	136	150
500	140	135	148
550	145	133	145
600	152	130	143
650	159	128	141
700	165	120	140

[shaded box] = Operating Point

Figure 2-1: Cornell Pump Curve and System Curve

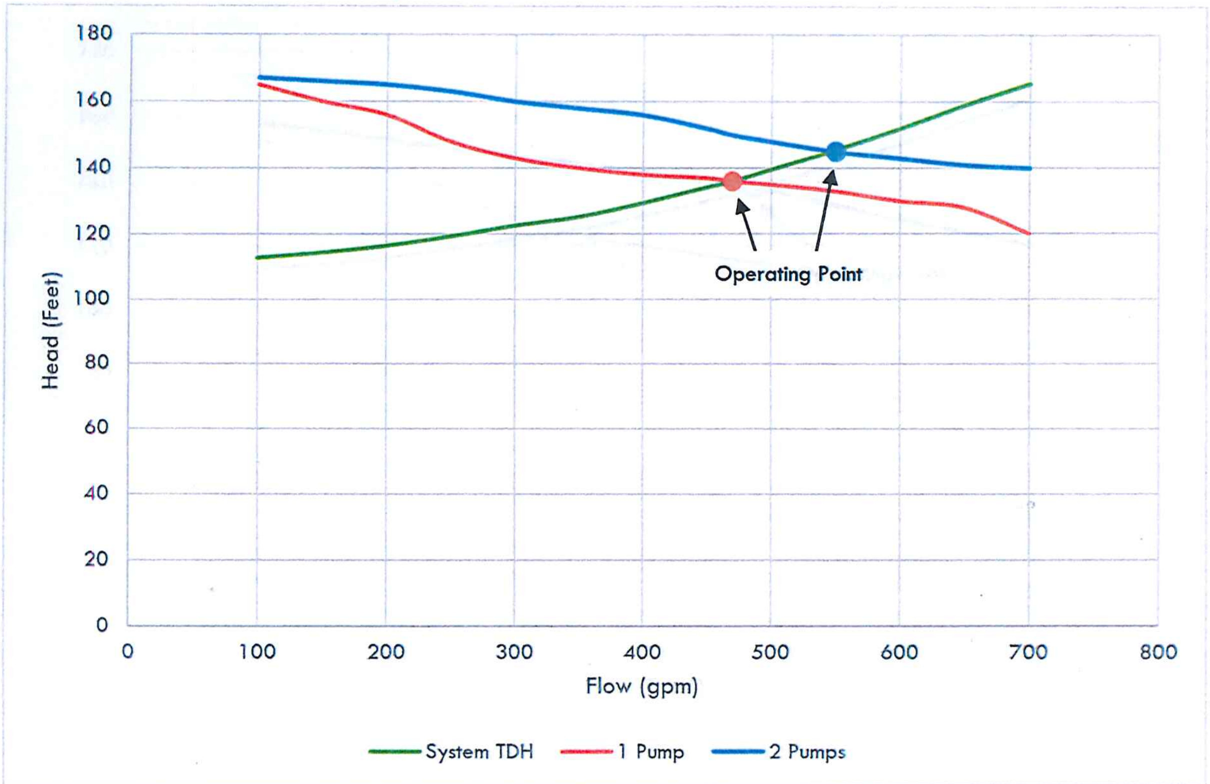


Table 2-2: KSB Pump and System Data

System Data		KRT F 80-250/252XG Pumps	
Flow Rate (GPM)	System TDH (Feet)	1 Pump Operating Head (Feet)	2 Pumps Operating Head (Feet)
100	113	153	158
150	114	148	156
200	116	143	153
250	119	137	151
300	123	128	148
325	124	124	147
350	125	120	146
400	129	111	143
450	134	102	140
485	138	95	138
500	140	91	137
550	146	81	133
600	152	70	128
650	159	60	124
700	165		120

(shaded) = Operating Point

Figure 2-2: KSB Pump Curve and System Curve

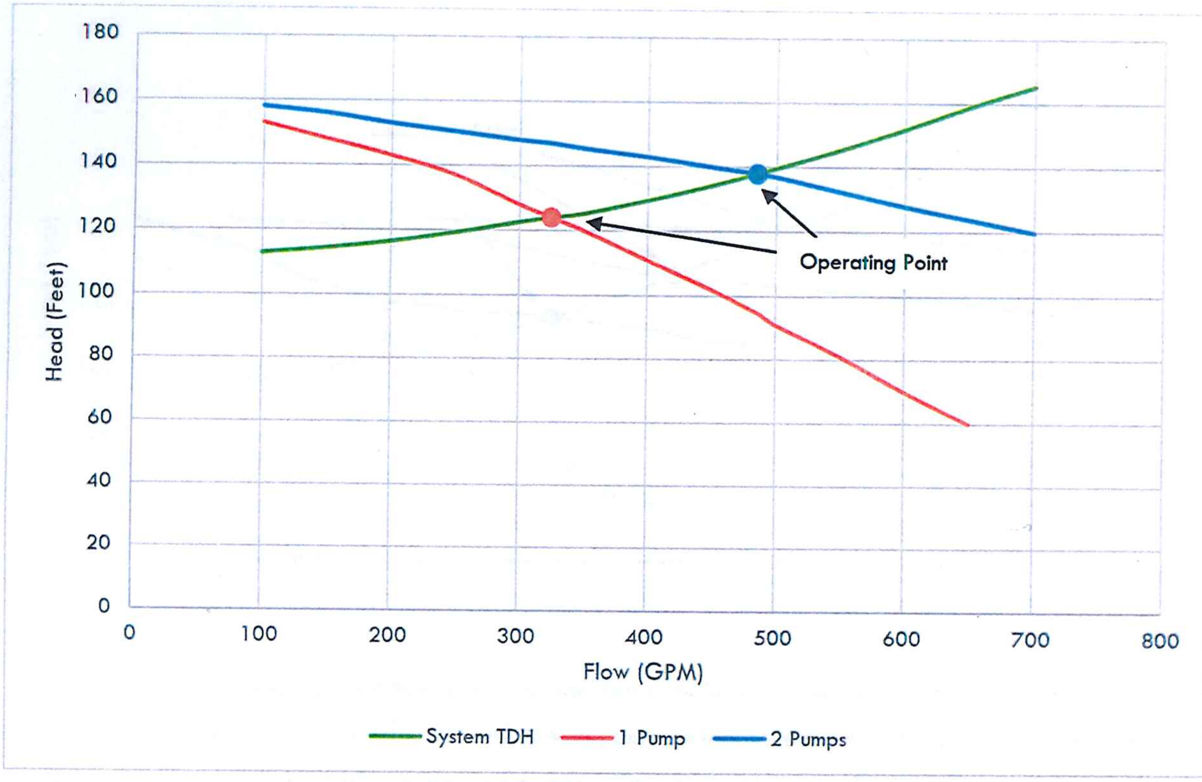
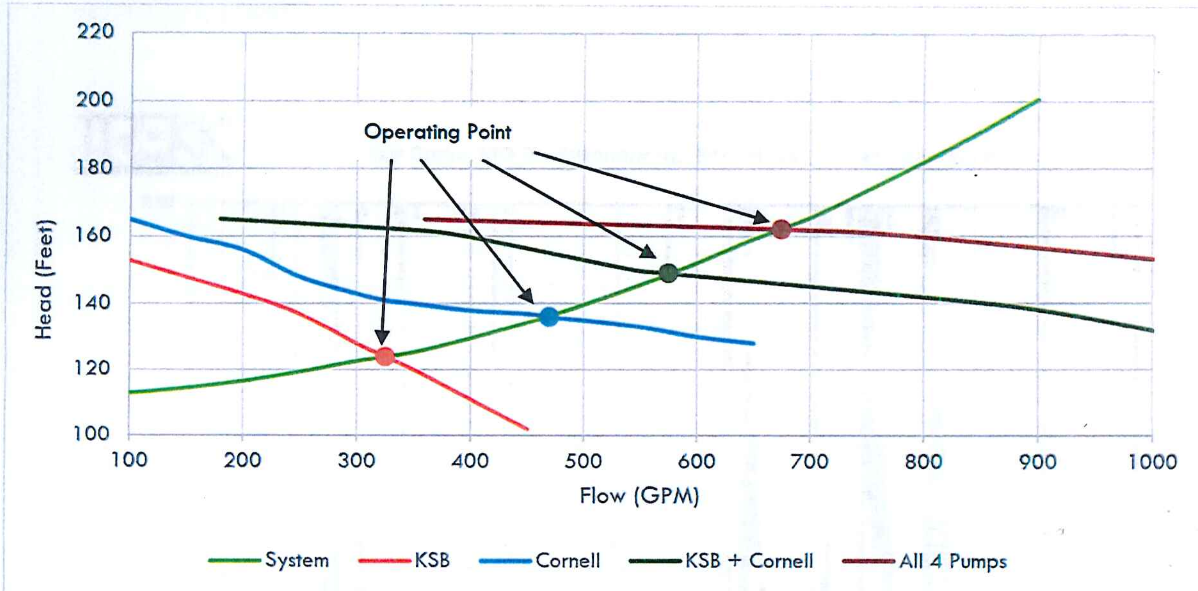


Table 2-3: Pump and System Data for Pump Combinations

TDH	System	KSB	Cornell	KSB + Cornell	All 4 Pumps
165	700		100	180	360
162	675		125	340	675
160	660		150	395	790
150	590	125	240	545	1090
149	575	140	249	575	
140	505	365	350	860	
136	470	260	470	940	
130	410	290	605	1027	
124	325	325	670	1090	
120	270	350	700	1175	

= Operating Point

Table 2-3: Pump Curves and System Curves for Pump Combinations



Based on discussions with the operator, the force main is running at capacity, and attempting to force more flow through the pipe with additional pumps will not yield a significant increase in flow when compared to the amount of energy being used. To add capacity to the line, flows to the lift station could be reduced, or a second line of equal or greater size could be installed. A second line would have the added benefit of a redundant line that could be used as a backup during repairs to the main pipeline. However, if I&I flows are reduced, an upgrade to the force main may not be needed for some time.

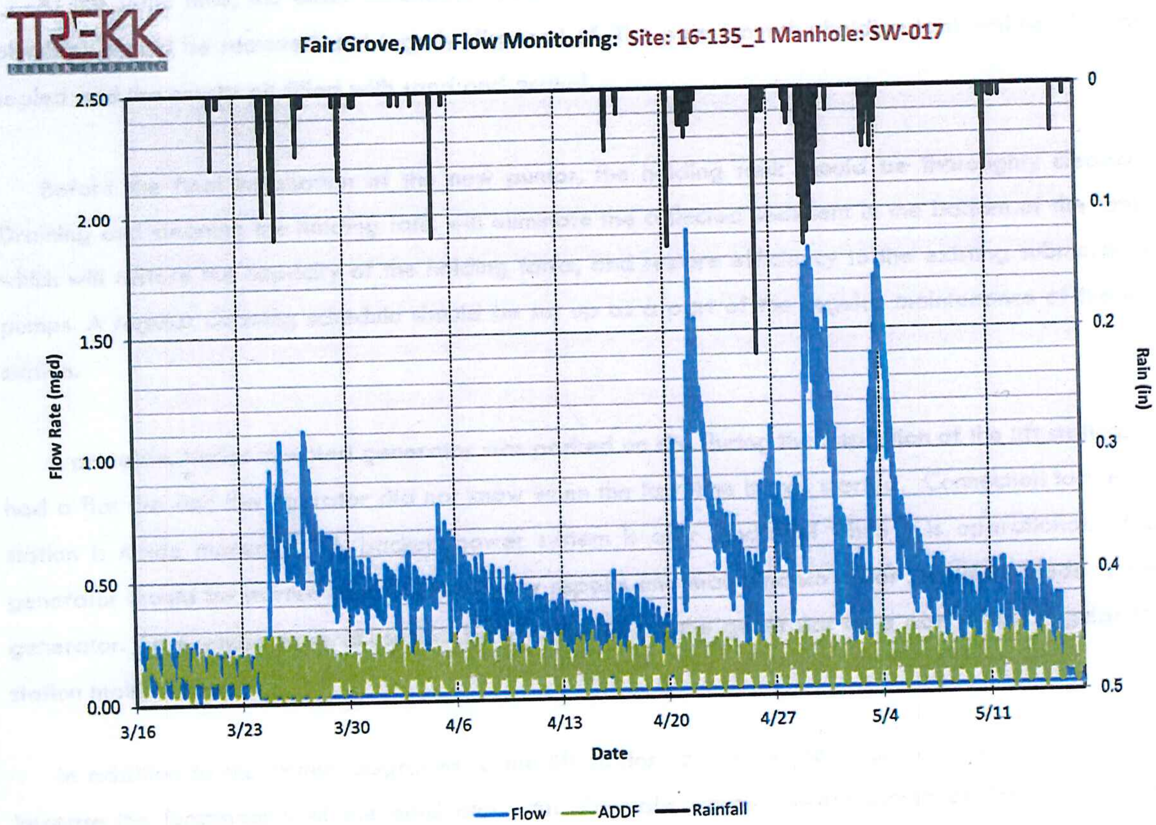
During dry weather flows, the peak influent flow to the lift station is less than the discharge rates of any single pump. The total wet weather inflows exceed the pumping capacity of the system during high frequency storms as shown in Table 2-4. The holding tank is also not large enough to hold all of the excess inflow while the pumps work to drain it. This results in frequent SSO events at the lift station.

Table 2-4: Influent Summary Table

	ADDF	1 Year	2 Year	5 Year	10 Year
Influent (GPM)	83	1,541	1,906	2,388	2,749

The hydrograph in Figure 2-4 shows the influent to the lift station over time, as measured by a flow meter installed in an upstream manhole, as well as rainfall data for the same time period.

Figure 2-4: Flow Hydrograph



3 Recommendations

The two primary pumps for the system are consistently inoperable and are undependable. The two Cornell pumps need to be replaced with a system that is reliable and requires less maintenance. A second pump installation could be made into the holding tank similar to the secondary system. This would allow for a smooth connection to the existing system and consistent layout. A new valve box would also need to be included to mirror the existing one on site. The existing wet well could be utilized to house the new submersible pumps, however there is not enough room for the required valves and plumbing inside the tank or between the tank and the fence. The location next to the existing secondary system can provide enough space without needing to overhaul the buried lines or add more area to the lift station.

The new submersible pumps should be sized similar to the larger Cornell pumps to maintain the current expected level of service. Installing a larger pump into the system would not have a significant increase in flow based on the system curve. Smaller pumps could be used, but this would decrease the capacity of the lift station.

At the same time, the older unreliable system may be decommissioned. The Cornell pumps and plumbing should be removed and legally disposed of. The pipe from the holding tank will need to be sealed and the empty pit filled with sand and gravel.

Before the final installation of the new pumps, the holding tank should be thoroughly cleaned. Draining and cleaning the holding tank will eliminate the collected sediment in the bottom of the tank, which will restore the capacity of the holding tanks, and restore efficiency to the existing submersible pumps. A regular cleaning schedule should be set up as a part of the regular maintenance of the lift station.

A portable, trailer mounted generator was parked on site during the inspection of the lift station. It had a flat tire and the operator did not know when the last time it was started. Connection to the lift station is made manually. A backup power system is only functional when it is operational. The generator should be started and any necessary repairs and maintenance issues should be made to the generator. An exercise program should be established for the generator as a part of the regular lift station maintenance.

In addition to the system upgrades to the lift station, a few simple upgrades could be made to increase the functionality of the generator. An automatic transfer switch should be installed on the electrical control panel. The transfer switch would allow the generator to be plugged in permanently (or removed when the generator would be needed elsewhere). The transfer switch could automatically start the generator during a loss of power and then use the power from the generator to run the lift station. With a few more modifications, the system could be set up to turn the generator on only when the lift station needs to provide power to the pumps during a primary power failure and shut off with the when the pumping cycle is complete.

During rainfall events, peak flows are causing SSOs at the lift station. While upgrading the entire lift station and force main to handle these peak flows is an option, a more economical solution would be to abate I&I in the upstream system. This would reduce peak flows to the lift station caused by rain events and improve the health and life span of the overall system.

Once I&I has been reduced in the system, an equalization basin or a secondary holding tank may be installed upstream of the lift station to prevent the SSOs from occurring without increasing the size of the pumps and the force main. The size of the holding tank is determined based on peak flows being received by the lift station. Based on current flow rates at the lift station a 3 Million Gallon tank will be needed to prevent SSO events during a 10 year frequency rain storm event. With the reduction of I&I

and wet weather peak flows, a smaller holding volume would be required. It is generally estimated that 30% of I&I can be removed, but reduction results are very system dependent. If 30% of I&I is removed, the tank size may be reduced to approximately 2 million gallons. The cost, plumbing needs, pumping alternatives, and location are all dependent on the volume required for the holding tank. The need for the holding tank and size should be evaluated in 5 years after an I&I reduction program has been implemented, with any additions or bypasses to the existing lift station also designed at that time.

It is also recommended that the City consider adding a calcium nitrate solution, such as BIOXIDE, at the lift station, to help control the formation of hydrogen sulfide gas for corrosion control. Manholes affected by H_2S have already been rehabilitated downstream of the discharge caused by the hydrogen sulfide gasses. Until the H_2S has been mitigated, the system will continue to degrade and require further repairs. Adding the calcium nitrate solution at the lift station, will not fix any existing degradation, but by adding the solution, further degradation can be prevented.

The force main is currently running at capacity. Under current operating conditions, the potential exists for settling and debris buildup within the pipe. By removing any debris and/or restrictions with a thorough cleaning, performance will approach what is shown in the graphs. An upgrade to the force main is not needed at this time, but may need to be considered in the future if I&I flows are not decreased and additions are made to the city.

4 Cost Estimate

Below is a summary of the probable costs for the aforementioned improvements:

Table 4-1: Opinion of Probable Costs

No.	Description	Quantity	Units	Unit Price	Cost
1	Mobilization and Bonding	1	LS	$ 140,000	$ 140,000
2	Pump Addition and Components	1	LS	$ 50,000	$ 50,000
3	Valve Vault and Components	1	LS	$ 80,000	$ 80,000
5	Concrete Structure Addition	1	LS	$ 30,000	$ 30,000
6	Wet Well Decommissioning	1	LS	$ 5,000	$ 5,000
7	Generator Repair and Electrical Updates	1	LS	$ 20,000	$ 20,000
8	Holding Tank Cleaning	1	LS	$ 10,000	$ 10,000
9	BIOXIDE Calcium Nitrate Solution	7300	GAL	$ 3	$ 21,900
10	Chemical Dosing System and Storage	1	LS	$ 75,000	$ 75,000
11	Equalization/Holding Tank Addition	1	LS	$1,120,600	$ 1,120,600
12	Erosion Control	1	LS	$ 2,000	$ 2,000
13	Contingency	10%			$ 160,000
Subtotal					**$ 1,714,500**
14	Engineering, Construction Inspection, and Legal	25%			$ 430,000
Total Project Cost					**$ 2,144,500**

*BIOXIDE solution cost is for one year period.

Funding for the project could be allocated for in the annual budget, included with an improvement project, or acquired through grants and/or loans as discussed in the Facility Plan. The cost of the improvements can be spread over multiple budget years, through a series of construction phases. For instance, a single pump could be installed during the upgrade while the second pump could be added on the following year's budget. The repairs to the generator can be made before the kickoff of the project, and the wet well decommissioning and/or Bioxide addition can be completed after the pump addition.

Comparing the amount of peak flow identified during flow monitoring to the maximum discharge rate from the lift station under existing conditions, a flow equalization or secondary holding tank upstream of the lift station is required to prevent sanitary sewer overflow events without increasing the size of the lift station. By reducing I&I within the system, the size and cost of the flow equalization/secondary holding tank may be significantly reduced and possibly eliminated. Therefore, it is recommended that the need and the size of the flow equalization basin or secondary holding tank be reevaluated after 5 years of rehabilitation in the collection system.

Figure 4-1: Conceptual Layout