

City of St. Joseph, Missouri

Facilities Plan

Technical Memorandum No. TM-CSO-9

Whitehead Pump Station Improvements



By



Work Order No. 09-001
B&V Project 163509

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Whitehead Pump Station Improvements

1.0 Executive Summary

The City of St. Joseph, Missouri (City) is developing a Facilities Plan for combined sewer overflow (CSO) control improvements that will be required by the United States Environmental Protection Agency (USEPA) and the Missouri Department of Natural Resources (MDNR) as part of the existing Long Term Control Plan (LTCP). Using a combined sewer system (CSS) model, various improvements were proposed in the LTCP to reduce the frequency and volume of CSOs. The LTCP recommended initial improvements to increase conveyance capacity at the Whitehead Pump Station to 80 million gallons per day (mgd), increase treatment capacity at the existing Water Protection facility (WPF) headworks to 88 mgd, and provide 61 mgd high rate treatment (HRT) and disinfection facilities.

This technical memorandum presents the improvements and upgrades required at the Whitehead Pump Station to increase conveyance to a minimum peak flow of 80 mgd and an optional peak flow of 88 mgd. The option of providing 88 mgd was requested by City staff for situations when the 8 mgd In-plant Influent Pump Station is out of service.

Based on the force main and pump station evaluation, the Whitehead Pump Station would require the following improvements to convey 80 mgd to the WPF and proposed HRT:

- Modifications to the existing pump discharge header to connect the entire header to the existing 36 inch force main.
- Addition of three new 250 horsepower (hp) drives and larger pump impellers to increase the existing pump station capacity to 30 mgd.
- Addition of valves to the existing pump station to increase flexibility for use during future conditions and allow isolation from both the 36 and 42 inch force mains.
- A new 50 mgd Excess Flow Pump Station with three 600 hp drives and pumps.

- Recirculation line at the proposed Excess Flow Pump Station to allow modulation of low flows downstream from this larger pump station.
- Relocation of a portion of the existing 42 inch force main to allow construction of the proposed Excess Flow Pump Station.
- A new overflow weir and 54 inch upstream gravity sewer to direct flows to the proposed Excess Flow Pump Station.
- Addition of a 480 volt, 2,000 kW backup power generator, underground power line, transformer, switchgear, and pull out breaker.
- New 1-½ inch bar screens at both the existing Whitehead and proposed Excess Flow Pump Stations.

The improvements listed above will allow a peak flow of 80 mgd to be conveyed to the WPF and proposed HRT at a projected project cost of \$24.6 million.

If the optional peak flow of 88 mgd is selected for the Whitehead Pump Station, modifications in addition to the aforementioned 80 mgd improvements would be required. The needed modifications to allow 88 mgd to be conveyed to the WPF and proposed HRT include:

- Addition of a parallel 36 inch force main next to the existing 42 inch force main to reduce peak flow velocities.
- Upsizing the proposed 50 mgd Excess Flow Pump Station capacity to 58 mgd. Downsizing the proposed 600 hp motors and drives to 500 hp units (power decreases due to new force main which reduces the peak dynamic head).

These modifications will allow a peak flow of 88 mgd to be conveyed to the WPF and proposed HRT at a projected project cost of \$29.0 million.

By conveying a combined 88 mgd through the headworks of the WPF and proposed HRT (either 80 mgd from the Whitehead Pump Station and 8 mgd from the In-plant Influent Pump Station or 88 mgd from the Whitehead Pump Station and 0 mgd from the In-plant Influent Pump Station), the proposed Whitehead Pump Station improvements

will help achieve the CSS conveyance goals for the CSO program. Figure ES-1 presents the proposed layout of the 80 mgd Whitehead Pump Station improvements while Table ES-1 summarizes the opinion of probable project costs. Table ES-2 summarizes the anticipated opinion of probable project costs for the 88 mgd option. The 88 mgd pump station layout would be identical to the 80 mgd option, with the exception of the additional proposed 36 inch force main.

The 88 mgd option is estimated to be approximately \$4.4 million more than the 80 mgd option. Although the pump sizes and associated power requirements would decrease because the new force main reduces the peak dynamic head, the capital cost of the proposed 36 inch force main would not be offset by the savings in operating costs with the pump reductions. Based upon a review of the necessary improvements (i.e., new force main or significant surge protection) and associated \$4.4 million cost increase required for the 88 mgd option, it is recommended that the 80 mgd option (i.e., 50 mgd Excess Flow Pump Station) be selected at the Whitehead Pump Station.

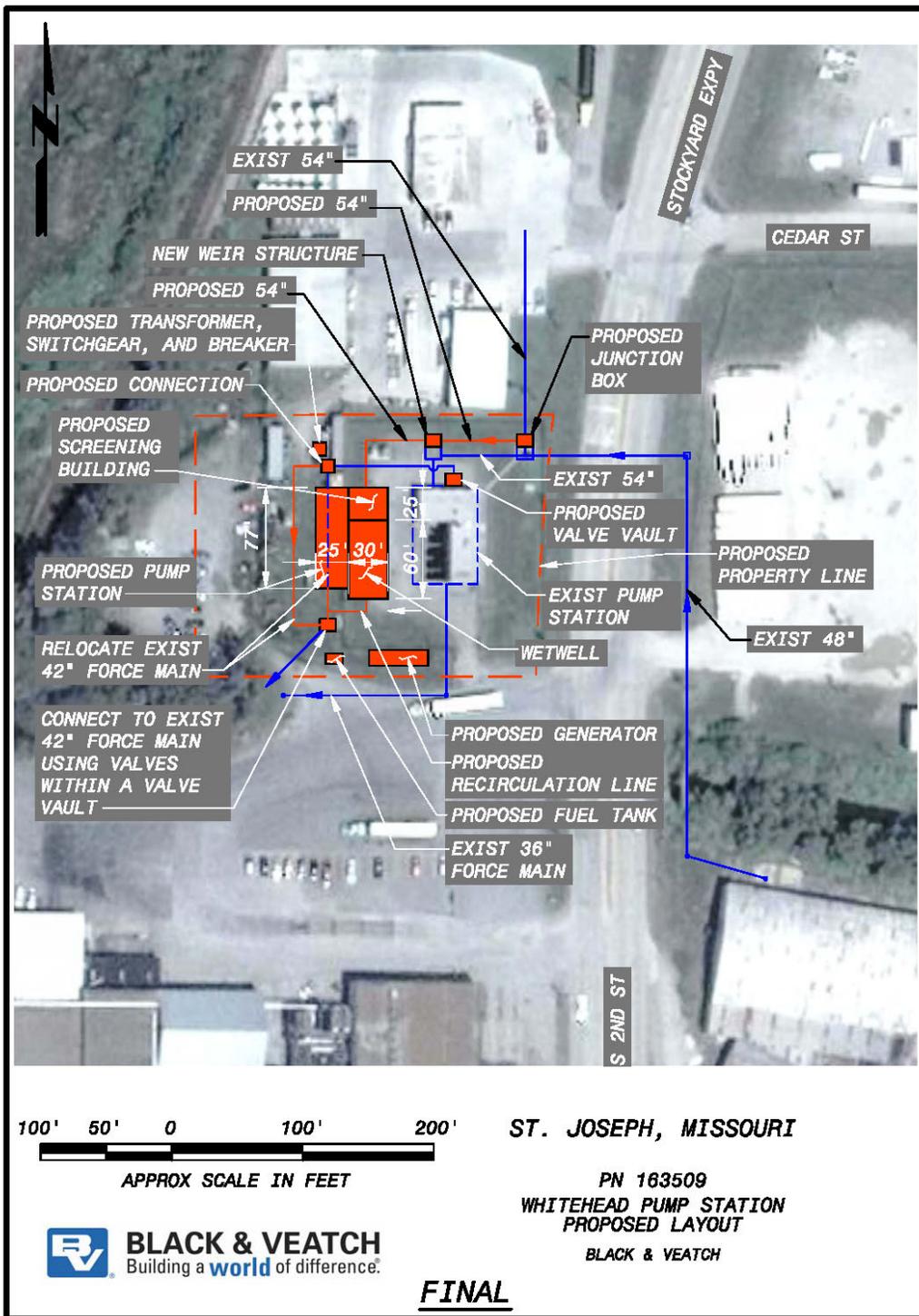


Figure ES-1 – Proposed 80 mgd Whitehead Pump Station Layout

Table ES-1	
Summary of Opinion of Probable Project Costs – 80 mgd Option ¹	
Item	Improvement Costs, \$
Excess Flow Pump Station	
Structure, Valves, and Piping	2,856,000
Equipment	3,192,000
Existing Whitehead Pump Station	
Structure, Valves, and Piping	166,000
Equipment	1,401,000
Collection System Upgrades	958,000
Backup Generator and Transformer	1,119,000
Flood Protection/Fill (placeholder) ²	
Site Remediation (placeholder) ²	1,723,000
<i>Subtotal</i>	11,415,000
E, I&C, Sitework, Contractor General Requirements ³	4,940,000
<i>Subtotal</i>	16,355,000
Contingency ⁴	4,089,000
Land Acquisition (placeholder) ^{2, 5}	35,000
Opinion of Probable Construction Cost	20,479,000
Engineering, Legal, and Administration ⁶	4,096,000
Opinion of Total Project Cost	24,575,000
<ol style="list-style-type: none"> 1. All costs presented in May 2009 dollars (ENR BCI = 4773). 2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities. 3. Electrical, instrumentation, and controls (E, I&C) estimated at 25% of the total of all equipment and structure costs but excludes collection system upgrades. Sitework estimated at 10% of the total of equipment, structures, and E, I&C costs. Contractor general requirements estimated at 12% of the total of equipment, structures, E, I&C, and sitework costs. 4. Project contingency is estimated at 25% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs. 5. Land acquisition cost is based on an estimate provided by the City from a recent purchase of land directly south of the WPF. 6. Engineering, legal, and administration (ELA) costs are estimated at 20% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition. 	

Table ES-2	
Summary of Opinion of Probable Project Costs – 88 mgd Option ¹	
Item	Improvement Costs, \$
Excess Flow Pump Station	
Structure, Valves, and Piping	2,856,000
Equipment	3,087,000
Existing Whitehead Pump Station	
Structure, Valves, and Piping	166,000
Equipment	1,401,000
Collection System & Force Main Upgrades	3,505,000
Backup Generator and Transformer	1,119,000
Flood Protection/Fill (placeholder) ²	-
Site Remediation (placeholder) ²	1,723,000
<i>Subtotal</i>	13,857,000
E, I&C, Sitework, Contractor General Requirements ³	5,472,000
<i>Subtotal</i>	19,329,000
Contingency ⁴	4,832,000
Land Acquisition (placeholder) ^{2, 5}	35,000
Opinion of Probable Construction Cost	24,196,000
Engineering, Legal, and Administration ⁶	4,839,000
Opinion of Total Project Cost	29,035,000
<ol style="list-style-type: none"> 1. All costs presented in May 2009 dollars (ENR BCI = 4773). 2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities. 3. Electrical, instrumentation, and controls (E, I&C) estimated at 25% of the total of all equipment and structure costs but excludes collection system upgrades. Sitework estimated at 10% of the total of equipment, structures, and E, I&C costs. Contractor general requirements estimated at 12% of the total of equipment, structures, E, I&C, and sitework costs. 4. Project contingency is estimated at 25% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs. 5. Land acquisition cost is based on an estimate provided by the City from a recent purchase of land directly south of the WPF. 6. Engineering, legal, and administration (ELA) costs are estimated at 20% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition. 	

2.0 Purpose of Technical Memorandum

The purpose of this technical memorandum is to determine the improvements needed to upgrade the existing Whitehead Pump Station to convey a minimum peak flow of 80 mgd and an optional peak flow of 88 mgd. The option of providing 88 mgd was requested by City staff for situations when the 8 mgd In-plant Influent Pump Station is

out of service. Specific activities performed for the Whitehead Pump Station facility assessment and documented herein include:

- Conducting a pump station inspection and evaluation (field notes included in Appendix A).
- Evaluating the force main capacity and performance.
- Evaluating the excess flow pump station requirements.
- Evaluating preliminary grit and screenings removal at the pump station.
- Developing conceptual layouts.
- Preparing an opinion of construction and operations and maintenance (O&M) costs.

3.0 Introduction

The City is developing a Facilities Plan for CSO control improvements that will be required by the USEPA and MDNR as part of the existing LTCP. As part of the CSS evaluation for the LTCP, Black & Veatch developed a hydrologic and hydraulic model of the CSS. The model was used for evaluating potential improvements to reduce the volume of CSOs from the CSS. The model encompasses the area of the City that is serviced by combined sewers, which is approximately the western half of the City.

Using the CSS model, various improvements were proposed in the LTCP to reduce the frequency and volume of CSOs. However, based on the high financial burden indicated in the Financial Capability Analysis for St. Joseph to implement all of these improvements, MDNR and the USEPA requested that the City determine a selection of projects based upon the LTCP Phase I improvements that provide the most cost effective CSO controls. From the complete list of recommended projects in the 2008 LTCP Update, the following projects were determined to provide the most cost-effective volumetric control of combined sewage (estimated control based on modeling results):

- Blacksnake and Whitehead stormwater separation conduits
- Increasing conveyance capacity at the Whitehead Pump Station to 80 mgd, increasing treatment capacity at the existing WPF headworks to 88 mgd, and providing 61 mgd high rate treatment (HRT) and disinfection facilities

- Roy's Branch partial sewer separation (in progress)

Specifically, improvements are required at the Whitehead Pump Station to increase its capacity to convey more wet weather flows to the WPF and proposed HRT facility. This technical memorandum discusses the improvements and upgrades required at the Whitehead Pump Station to increase conveyance to a minimum peak flow of 80 mgd and an optional peak flow of 88 mgd.

4.0 Description of the Existing Whitehead Pump Station

The Whitehead Pump Station was constructed in 1965 to convey combined sewer flows to the WPF. Five Worthington 20 inch pumps (Model MCZ-1) with electromagnetic (eddy current) drive units were installed along with a 4,700 foot 36 inch force main. The 36 inch force main delivers the pumped flows to the WPF. In the late 1970s, the pump station was modified by replacing three of the original eddy current drive units with adjustable frequency drive (AFDs). In addition to the three new AFD units, a 4,700 foot 42 inch force main was installed to convey flows from the new AFD units and pumps to the WPF. To connect the new 42 inch force main to the pump station, the original discharge header was separated into two headers with the installation of a concrete block. Both force mains currently connect to the pump station, one to each side of the separated header with no existing interconnections. The two force mains both pump to the existing aerated grit chamber at the WPF. Under the current operating strategy, the 42 inch force main carries dry weather and wet weather flows to the WPF. The 36 inch force main is only utilized in cases of emergency when the pumps conveying flow into the 42 inch force main are out of service. According to City staff, the 36 inch force main is used only two to three times a year.

In the late 1990s, three new AFD units were installed to replace the AFDs installed in the late 1970s. Therefore, the existing pump station currently has three AFD drive units on the 42 inch force main and two original eddy current drive units on the 36 inch force main. All the drive units are connected to 20 inch Worthington pumps. Table 1 summarizes the existing drive units and pumps installed on each force main, Figure 1

shows a schematic of the existing Whitehead Pump Station configuration and Figure 2 presents photographs of the existing pump station equipment.

Table 1		
Existing Whitehead Pump Station Drives and Pumps		
Force Main	Pumps	Drives
36 Inch Force Main	2 Worthington 20 inch Model MCZ-1 rated for 12,000 gpm at 35 feet	Electric Machinery motor and eddy current drive rated at 150 hp at 700 rpm
42 Inch Force Main	3 Worthington 20 inch Model MNZ rated for 9,000 gpm at 60 feet	GE motor VFD rated at 200 hp at 700 rpm

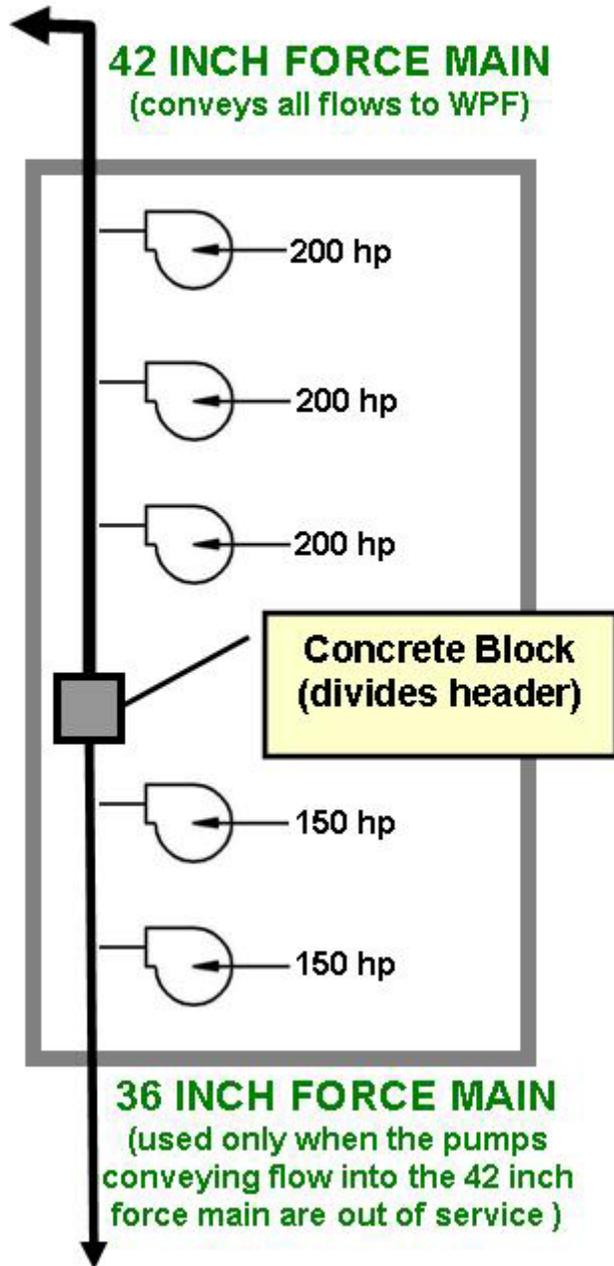


Figure 1 – Existing Whitehead Pump Station Configuration



Figure 2 – Whitehead Pump Station Drive Units and Pumps

The existing installed and firm capacity of the Whitehead Pump Station was calculated as part of the pump station evaluation. This information is useful to determine improvements required to upgrade the station to pass a minimum peak flow of 80 mgd and an optional 88 mgd to the WPF. Although a pump test was not performed to obtain the capacity estimates for the Whitehead Pump Station, a phototachometer was used to confirm the drive shaft speeds for each of the five drive units at 100 percent output. The phototachometer confirmed that the actual drive shaft speeds at 100 percent output were consistent with the 700 rpm nameplate ratings of the drive units and pumps. Based upon the information gathered, the Whitehead Pump Station capacity was developed. Table 2 presents this information while Figure 3 and Figure 4 present the system head curves and pump curves for the 36 inch and 42 inch force mains, respectively. Since the 36 inch and 42 inch force mains are separated and have no interconnections, the Whitehead Pump Station is technically two separate pump stations inside the same building. Therefore, the firm capacity of the Whitehead Pump Station assumes that the largest pump on each force main is out of service.

Table 2				
Whitehead Pump Station Capacity				
Pump Station	Pump Description	Drive Description	Installed Capacity	Firm Capacity
36 Inch Force Main	2 Worthington 20 inch Model MCZ-1 rated for 12,000 gpm at 35 feet	2 EM motors and eddy current drives rated at 150 hp at 700 rpm	13,000 gpm 18.7 mgd	8,750 gpm 12.6 mgd
42 Inch Force Main	3 Worthington 20 inch Model MNZ rated for 9,000 gpm at 60 feet	3 GE motor VFDs rated at 200 hp at 700 rpm	27,000 gpm 38.9 mgd	22,500 gpm 32.4 mgd
Total Whitehead Pump Station Capacity			40,000 gpm 57.6 mgd	31,250 gpm 45.0 mgd
<p>Note: The following assumptions were used to estimate the installed and firm capacity of the Whitehead Pump Station.</p> <ul style="list-style-type: none"> • Water Level at WPF Grit Basins = 818.5 ft • Pump Station Wetwell Elevation = 783.2 ft • No pump test was performed, force main roughness assumed to be C-Value =100 • Assumes electrical limitations are not present 				

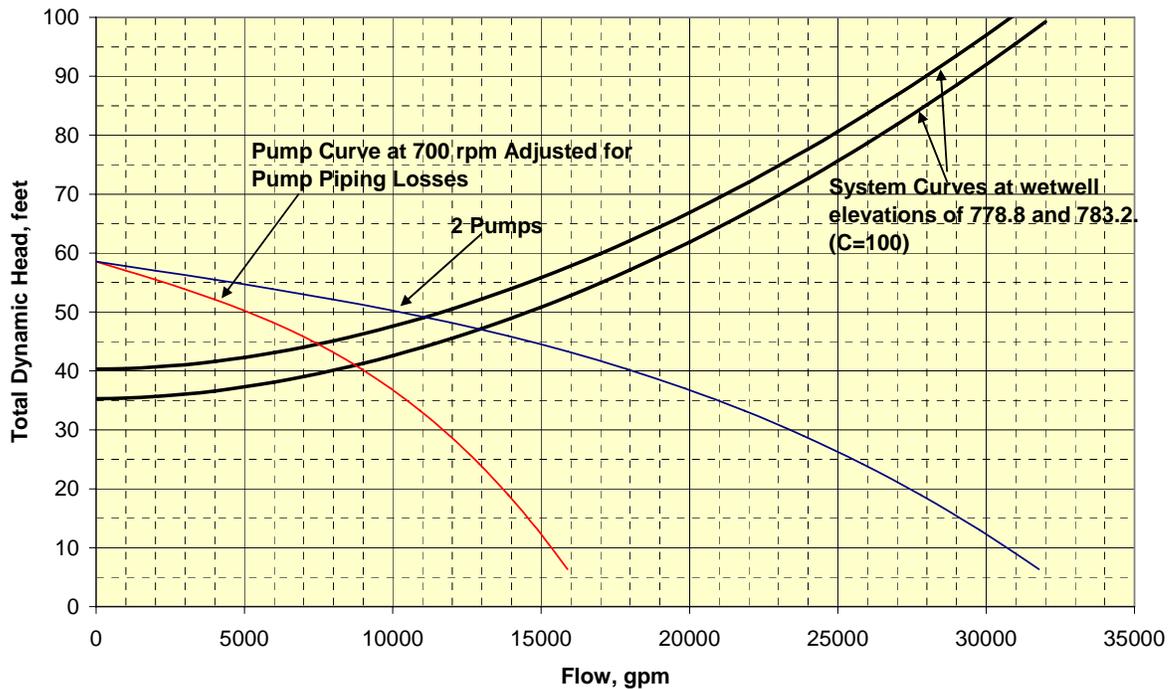


Figure 3 – 36 Inch Force Main System Head Curve and Capacity Estimate

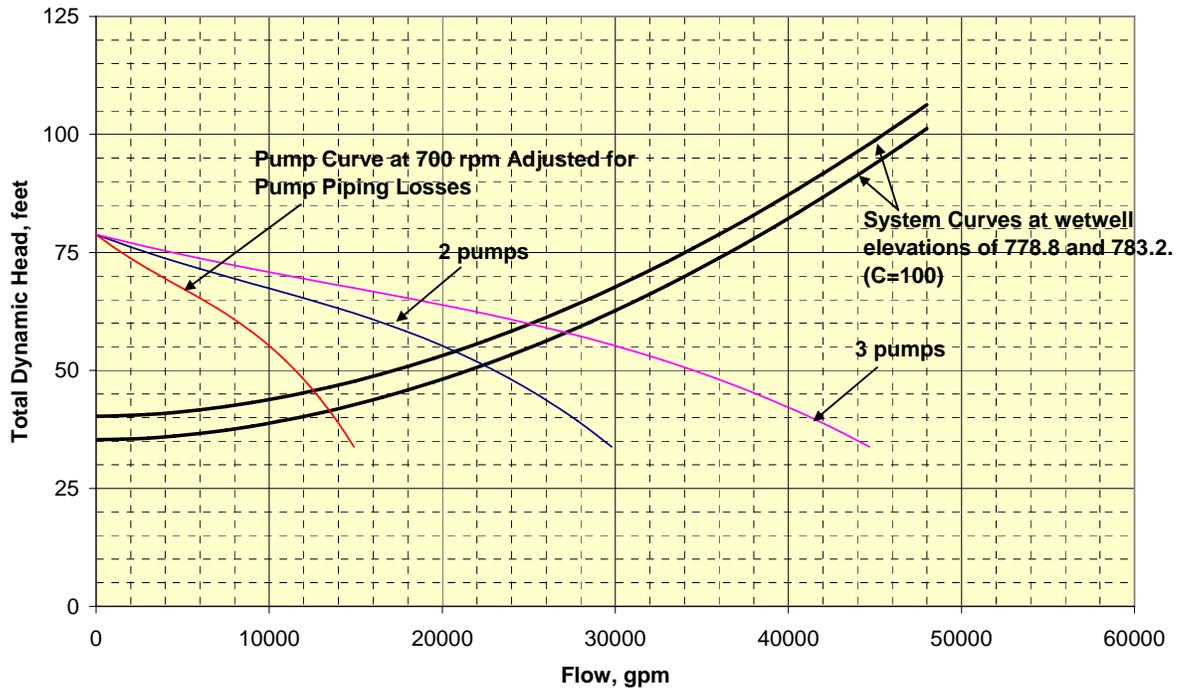


Figure 4 – 42 Inch Force Main System Head Curve and Capacity Estimate

When the pump station modifications were made in the late 1970s, City staff was told that the power supply to the pump station limited the number of pumps that could be run at any given time. Therefore, City staff has never operated more than three pumps simultaneously at the Whitehead Pump Station. As part of the pump station evaluation documented herein, the existing power supply to the pump station was reviewed.

The primary line delivering power to the Whitehead Pump Station is a 12.47 kV overhead line rated at 500 amps. The spare capacity of the 12.47 kV circuit adjacent to the Whitehead Pump Station is 5,500 kVA with the limiting factor at the Oak Street Substation (i.e., if more than 5,500 kVA of power is required for the Whitehead improvements, the Oak Street Substation would need to be improved). The existing underground primary line connecting the overhead line to the pump station transformer is fused at 100 amps. Kansas City Power and Light (KCPL) owns both the overhead and underground power lines. The Whitehead 480 volt mainframe switchgear and pull out

breaker are rated at 1,600 amps and 1,000 amps, respectively. The City owns both the switchgear and pull out breaker.

Table 3 documents the expected power requirements if all five existing pumps were running simultaneously at their nameplate rated horsepower. As indicated in Table 3, the current through the 480 volt pump station circuit would be approximately 1,055 amps if all the pumps were running simultaneously. This current exceeds the pull out breaker capacity of 1,000 amps by 55 amps. Therefore, running all five pumps at the Whitehead Pump Station would likely trip the 1,000 amp pull out breaker. However, the use of four existing pumps does not appear to be an issue, and the Whitehead Pump Station could operate four pumps without encountering a power limitation or tripping an existing breaker.

Drives	Motor Power Consumption			Electrical Power Consumption					Total Motor Power Usage, kW ^a
	Motor Power, hp	Motors Running	Total Motor Power Usage, hp ^a	Assumed Motor Efficiency	Volts	Phase	Power Factor	Amps ^a	
AFD	200	3	600	0.85	480	3	0.9	703	527
Eddy Current	150	2	300	0.85	480	3	0.9	352	263
Sum	--	5	900	--	--	--	--	1,055	790

a. Provides a summation of the current and power for the stated conditions (i.e., accounts for the number of pumps running).

5.0 Improvement Design Constraints

The WPF is rated to treat a design capacity of 27 mgd of combined sewer flows. Therefore, at a minimum, an improved Whitehead Pump Station must be able to pump the WPF capacity of 27 mgd. Furthermore, capture and treatment of wet weather flows is mandated to meet the requirements of the CSO LTCP. Therefore, the pump station must be designed to convey both the maximum WPF capacity and the proposed wet weather HRT facility capacity planned as part of the Phase IA CSO control improvements. The proposed Phase IA improvements are described in TM-CSO-3a (Phase IA CSO Control Recommended Improvements Model) and include the following projects:

- Blacksnake and Whitehead stormwater separation conduits
- Increasing conveyance capacity at the Whitehead Pump Station to 80 mgd (with option to convey 88 mgd), increasing treatment capacity at the existing WPF headworks to 88 mgd, and providing a 61 mgd HRT and disinfection facilities
- Roy's Branch partial sewer separation (in progress)

The Phase IA CSO control improvements are proposed to provide an annual wet weather percent capture of approximately 60 percent by sending a combined 88 mgd through the headworks of the WPF and proposed HRT. A detailed discussion regarding how the Phase IA improvements will help to achieve the overall CSO control program objectives is provided in TM-CSO-3a. Furthermore, a detailed evaluation of the HRT alternatives required to meet the CSO control objectives will be presented in the upcoming technical memorandum TM-CSO-10 – Wet Weather Treatment Facilities Assessment. In addition, the upcoming TM-WW-3 – Grit Removal Facilities will discuss grit and screening alternatives required for the WPF and proposed HRT alternatives and configurations. This section details the required capacity of the proposed Whitehead Pump Station improvements to convey a minimum peak flow of 80 mgd and an optional peak flow of 88 mgd.

As stated previously, it was determined that 88 mgd of CSS flow must be treated and disinfected during wet weather events to meet the Phase IA goal of treating 60 percent of the annual average wet weather flow. To convey 88 mgd to the WPF and proposed HRT facilities, it is anticipated that 80 mgd would be conveyed from an improved Whitehead Pump Station and 8 mgd would be conveyed from the existing In-plant Influent Pump Station. However, in situations where the existing In-plant Influent Pump Station is not operational, City staff requested the option for the Whitehead Pump Station to convey 88 mgd. Therefore, the flow schematics presented later within this section account for this potential situation by presenting both flow conditions for the Whitehead Pump Station. For costing purposes, discussed later within this TM, both the 80 mgd and 88 mgd options are presented for comparison purposes.

Currently, the design flow through the WPF primary clarifiers is permitted at 27 mgd. Therefore, 27 mgd of the combined sewer wet weather inflow from the Whitehead and In-plant Influent Pump Stations are proposed to be sent through the primary clarifiers for treatment at the WPF; with the remainder of the 88 mgd (i.e., 61 mgd) to be sent through the proposed wet weather HRT facility. Downstream of the primary clarifiers, three pretreated industrial waste streams enter the WPF to receive secondary treatment and are anticipated to account for 20 mgd of secondary treatment capacity under peak flow conditions. Therefore, the total effluent flow from the WPF is 47 mgd (i.e., 27 mgd entering primary clarification and 20 mgd of additional industrial flows directly entering secondary treatment facilities) while the effluent from the proposed HRT facility remains at 61 mgd.

The existing Whitehead Pump Station has a 36 inch and a 42 inch force main which deliver flows to the WPF. Under existing conditions, the 42 inch force main conveys both dry and wet weather flows to the WPF. City staff operate the 36 inch force main only in emergency situations. To convey a minimum peak flow of 80 mgd from the Whitehead Pump Station under proposed conditions, the existing operating strategy will need to change. With the construction of an HRT facility, new screening and grit removal facilities (i.e., headworks) will be required. An evaluation is currently underway to determine whether the WPF and HRT headworks can be a joint facility or should be separated. If the grit and screening facilities are kept separate, then it is preferable that each force main from the Whitehead Pump Station be capable of conveying the peak capacity of the proposed WPF or HRT facilities. However, for the purposes of this technical memorandum, it is assumed that the force mains convey flow to a combined downstream screening and grit facility. This allows flows to be optimized between the 36 inch and 42 inch force mains to achieve a total combined flow of 80 mgd with an option to convey 88 mgd.

Typically, a rule of thumb for force mains is to not exceed a velocity of 8 feet per second (fps). At velocities higher than 8 fps, water hammer can become a problem requiring additional surge protection to be installed. If both the 36 inch and 42 inch force mains deliver flow at a velocity of 8 fps, a total flow of 86 mgd can be delivered to the

WPF and proposed HRT facility. Therefore, it appears reasonable that a peak flow of 80 mgd can be delivered through the existing force mains.

However, it is also optimal to avoid extensive modifications to the existing Whitehead Pump Station if the pumps in the existing station can be reused for future flow conditions. With some modifications (discussed later within this technical memorandum), it appears that the existing pumps in the Whitehead Pump Station can be reconfigured to convey a maximum flow of 30 mgd through the 36 inch force main. This leaves the 42 inch force main to convey the remaining 50 mgd or 58 mgd for the 80 mgd and 88 mgd conditions, respectively. It is therefore proposed that the 36 inch force main be reconfigured to convey both dry and some wet weather flows to achieve a peak flow of 30 mgd while the 42 inch force main be reconfigured to convey a peak capacity of 50 or 58 mgd to the combined grit and screening facilities. Figure 5 presents this information in schematic form. Possible optimizations to this proposed configuration are discussed later in this technical memorandum.

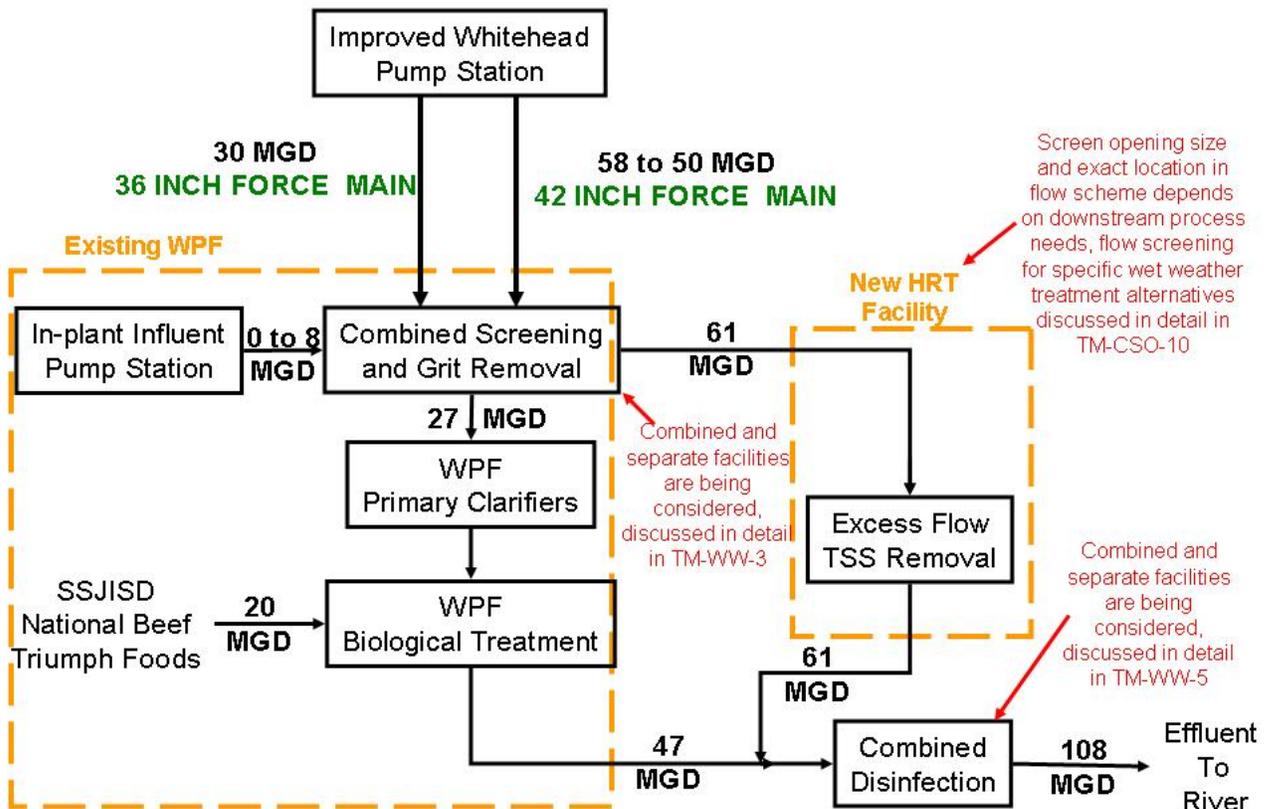


Figure 5 – Proposed Whitehead Pump Station Flow Schematic

6.0 Whitehead Improvement Recommendations

6.1 Pumps and Motors

The main objective of this technical memorandum is to determine the improvements at the Whitehead Pump Station needed to convey a minimum peak flow of 80 mgd to the WPF and proposed HRT facility with an option to convey 88 mgd. Upon review of Table 2, the firm capacity of the Whitehead Pump Station was determined to be 45.0 mgd with an installed capacity of 57.6 mgd. Therefore, improvements are needed to increase the capacity of the pump station to a minimum of 80 mgd. For the proposed improvements, an additional static head of 7 feet (water surface elevation at the downstream end of the force main is assumed to be 825 feet) has been assumed for the system head requirements for the 36 inch and 42 inch force mains. This assumption

provides additional flexibility to convey flows through a new, yet to be designed, WPF and HRT screening and grit facilities.

As stated previously, it is optimal to direct a peak flow of 30 mgd through the existing 36 inch force main while reconfiguring the 42 inch force main to handle a peak flow of 50 or 58 mgd for the 80 and 88 mgd conditions, respectively.

The required improvements to convey 30 mgd through the 36 inch force main include:

1. Modifying the existing discharge header by removing the concrete block and reconnecting the header with a valve and spool piece.
2. Adding valves to the existing pump station to increase flexibility for use during future conditions and allow isolation from both the 36 and 42 inch force mains. The typical configuration will be to have the existing pump station convey flows through the 36 inch force main and remain isolated from the 42 inch force main.
3. Upsizing the three existing 200 hp AFDs to 250 hp motors and drive units to pump a peak capacity of 30 mgd at a head of approximately 73 feet.
4. Replacing the three pump impellers associated with the proposed 250 hp motors with larger impellers designed to meet the new design conditions. The impellers will fit into the existing 20 inch Model MNZ Worthington pumps (leave the existing pumps in place and upsize the impellers).

The existing pumps can be retrofitted to convey a maximum flow of 30 mgd when using the 36 inch force main. If flows greater than 30 mgd are required through the 36 inch force main, all of the existing pumps would need to be replaced with larger units.

Since new pumps will likely be larger than the existing pumps, significant modifications to the existing pump station would be necessary to allow flows greater than 30 mgd to be conveyed. Therefore, a peak flow of 30 mgd conveyed through the 36 inch force main appears to be an optimal flow for the existing pump station to deliver under future conditions without requiring the entire station to be reconfigured. The two remaining 150 hp pumps are proposed to be left in place. These pumps could be used during

periods of low or average flow conditions to convey flows to the WPF. However, during peak flow conditions of 30 mgd, these pumps will not be able to generate enough head to convey a meaningful amount of flow to the downstream facilities and would therefore not be used.

The required improvements to convey the remaining 50 mgd through the 42 inch force main, for a total of 80 mgd, were also investigated and include the following modifications:

1. Construction of a new 50 mgd Excess Flow Pump Station next to the existing Whitehead Pump Station. The new pump station would have a 60 ft by 30 ft wetwell with an invert elevation of approximately 770 ft.
2. Installation of three 25 mgd pumps with 600 hp motors rated for approximately 85 ft of head (two duty units and one standby).
3. Installation of a new 42 inch force main to connect the proposed Excess Flow Pump Station to the existing 42 inch force main.
4. Installation of a recirculation line from the 42 inch force main back to the proposed Excess Flow Pump Station wetwell. The recirculation line will allow flows in the 42 inch force main to be modulated down to lower flows than a typical 25 mgd variable speed pump will allow (i.e., flows less than 12.5 mgd). A recirculation line will be needed if downstream facilities require a low flow startup or shutdown.
5. Relocation of a portion of the existing 42 inch force main to allow construction of the proposed Excess Flow Pump Station.
6. Installation of a new 54 inch gravity sewer and weir to convey flows to the proposed Excess Flow Pump Station from the existing upstream interceptor.

Figure 6 presents a schematic of the modifications required at the Whitehead Pump Station to convey 80 mgd to the WPF and proposed HRT facility. In addition, Figure 7 presents a plan view schematic of the proposed improvements and Figure 8

shows an approximate floor plan for the new excess flow pump station. All new facilities are shown in red on the two figures.

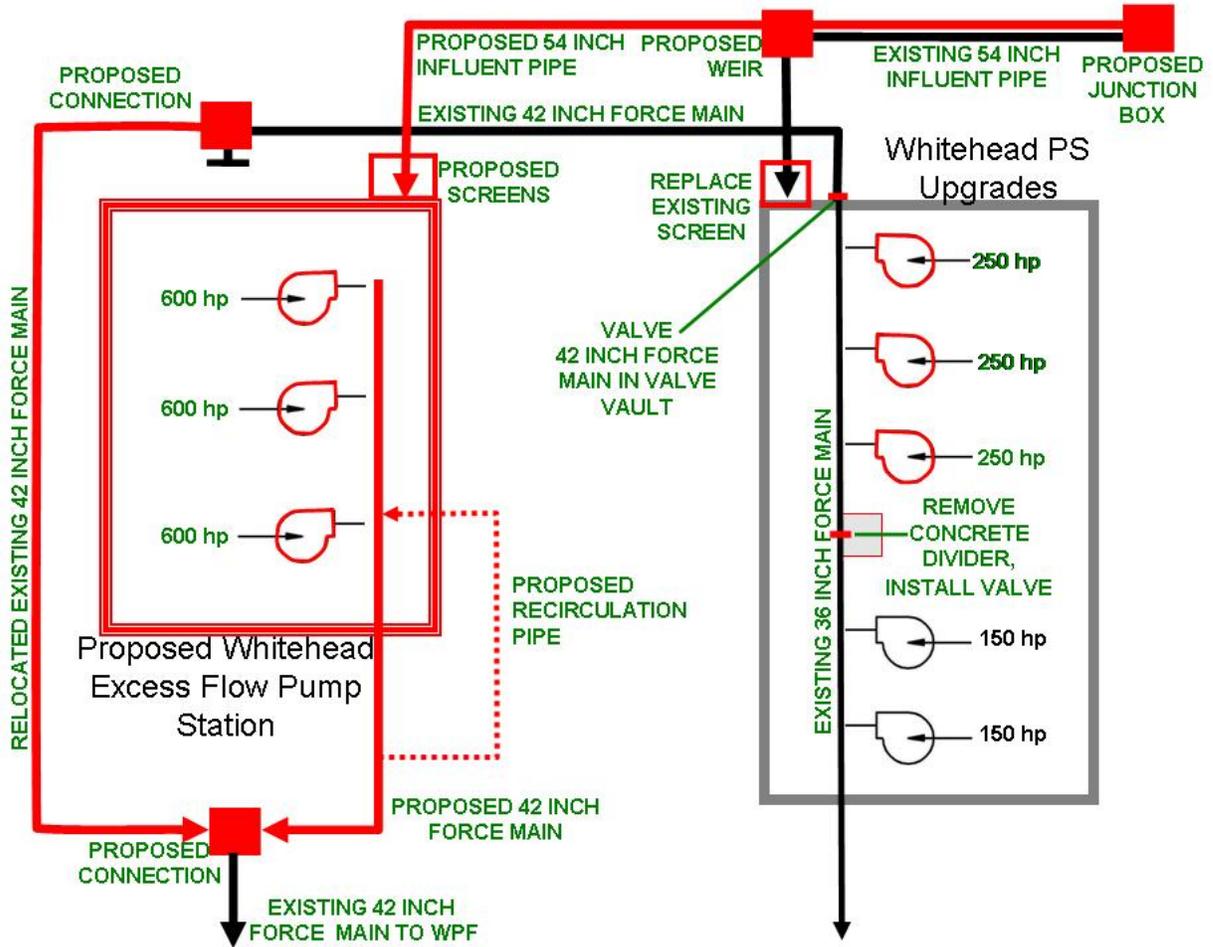


Figure 6 – Whitehead Pump Station Improvements Schematic

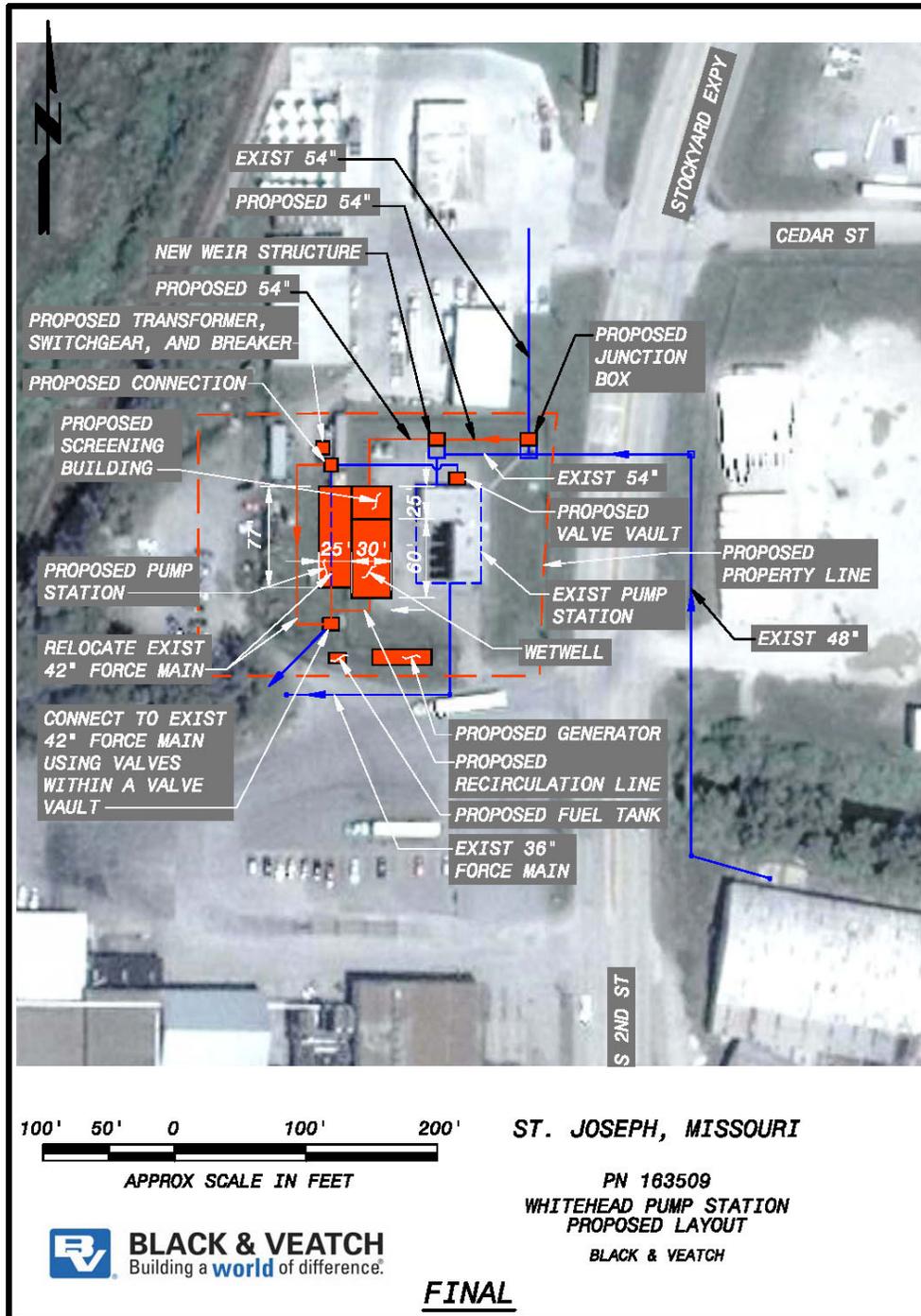


Figure 7 – Proposed 80 mgd Whitehead Pump Station Layout

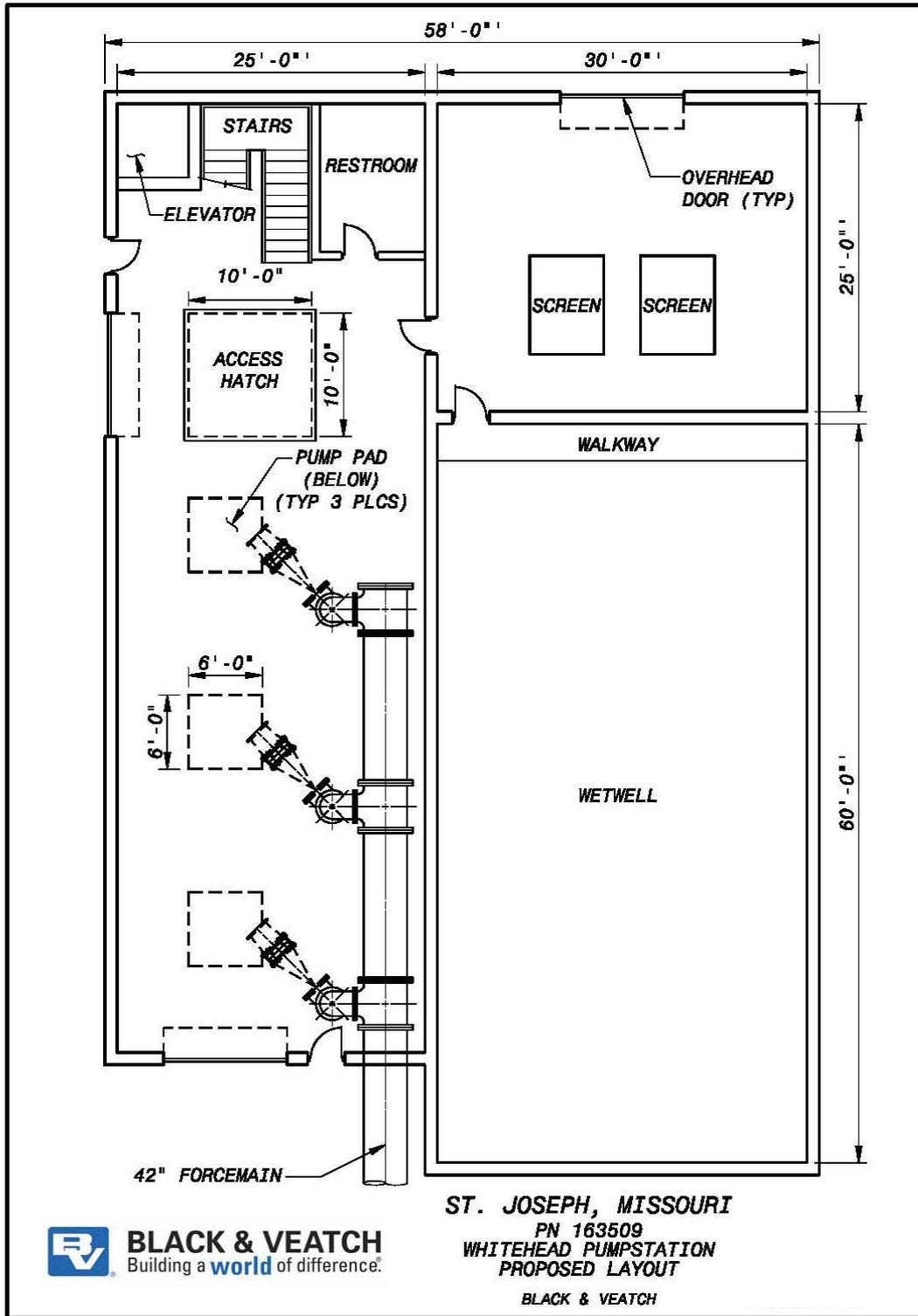


Figure 8 – Proposed Excess Flow Pump Station Floor Plan

The required improvements to convey the option of 58 mgd through the 42 inch force main, for a total of 88 mgd, were also investigated and include the following modifications to the aforementioned 50 mgd improvements:

1. Construction of a new 58 mgd Excess Flow Pump Station (instead of 50 mgd) next to the existing Whitehead Pump Station.
2. Installation of a new 4,700 ft 36 inch force main to parallel the existing 42 inch force main. This is required to reduce the velocity in the 42 inch force main during 58 mgd peak flow conditions. If a new force main is not added, the velocity will be 9.3 fps during the peak flow condition of 58 mgd requiring significant improvements to address surge protection. With the addition of a 36 inch parallel force main, the velocity will be approximately 5.5 fps in the 42 inch force main and 5.3 fps in the new 36 inch force main.
3. Installation of three 29 mgd pumps with 500 hp motors rated for approximately 65 ft of head (two duty units and one standby).

6.2 Power Upgrades

To convey 80 mgd to the WPF and proposed HRT facility, additional power upgrades would be required at the pump station. During peak flow conditions, two of the 600 hp motors would be running along with two of the 250 hp motors. However, there may be a need to start the third 250 hp unit while another 250 hp unit is powering down. Therefore, to account for this situation and to provide some operationally flexibility, it is assumed that the power improvements at the Whitehead Pump Station must be capable of running two of the 600 hp pumps and three of the 250 hp pumps simultaneously. Table 4 summarizes the power demand needed to satisfy this assumption.

Table 4 Improved Whitehead Power Demand for 80 mgd									
Drives	Motor Power Consumption			Electrical Power Consumption					Total Motor Power Usage, kW^a
	Motor Power, hp	Motors Running	Total Motor Power Usage, hp^a	Assumed Motor Efficiency	Volts	Phase	Power Factor	Amps^a	
Eddy Current	600	2	1200	0.85	480	3	0.9	1,407	1,053
Eddy Current	250	3	750	0.85	480	3	0.9	879	658
Eddy Current	150	0	0	0.85	480	3	0.9	0	0
Sum	--	5	1,950	--	--	--	--	2,286	1,711
a. Provides a summation of the current and power for the stated conditions (i.e., accounts for the number of pumps running).									

To convey 88 mgd to the WPF and proposed HRT facility, additional power upgrades would be required at the pump station. During peak flow conditions, two of the 500 hp motors would be running along with two of the 250 hp motors. However, there may be a need to start the third 250 hp unit while another 250 hp unit is powering down. Therefore, to account for this situation and to provide some operational flexibility, it is assumed that the power improvements at the Whitehead Pump Station to convey 88 mgd would include two 500 hp pumps and three 250 hp pumps operating simultaneously. Table 5 summarizes the power demand needed to satisfy this assumption.

Table 5 Improved Whitehead Power Demand for 88 mgd									
Drives	Motor Power Consumption			Electrical Power Consumption					Total Motor Power Usage, kW^a
	Motor Power, hp	Motors Running	Total Motor Power Usage, hp^a	Motor Efficiency	Volts	Phase	Power Factor	Amps^a	
Eddy Current	500	2	1000	0.85	480	3	0.9	1,172	877
Eddy Current	250	3	750	0.85	480	3	0.9	880	658
Eddy Current	150	0	0	0.85	480	3	0.9	0	0
Sum	--	5	1,750	--	--	--	--	2,052	1,535
a. Provides a summation of the current and power for the stated conditions (i.e., accounts for the number of pumps running).									

Each electrical component feeding power to the pump station has a capacity limitation. To illustrate the limitations of each of these components, Table 6 presents the horsepower equivalent of each existing electrical component at the Whitehead Pump Station. Based upon the assumed power demand at the pump station for the proposed 80 and 88 mgd conditions presented in Tables 4 and 5 respectively, it is recommended that a new underground line, transformer, switchgear, and pull out breaker be installed to handle the increased load at the Whitehead Pump Station. It is anticipated that the total power needed to operate the improved Whitehead Pump Station would be around 1,720 kilowatts (kW) for the 80 mgd condition (i.e., 50 mgd Excess Flow Pump Station) and 1,540 kW for the 88 mgd condition (i.e., 58 mgd Excess Flow Pump Station) (power consumption is less for the 88 mgd condition because of the new 36 inch force main reducing the overall system head). It is anticipated that the existing transformer and associated components would be left in place as the new equipment is installed.

Table 6							
Whitehead Power Supply							
	Volts	Amps	Phase	Power Factor	kW	Efficiency	hp
Overhead Line	12,470	500	3	0.9	9,719	0.85	11,079
Underground Line	12,470	100	3	0.9	1,944	0.85	2,216
Switch Gear	480	1,600	3	0.9	1,197	0.85	1,365
Pull Out Breaker	480	1,000	3	0.9	748	0.85	853

Currently, the existing Whitehead Pump Station does not have a power backup supply. Therefore, if power is lost at the pump station, all flows in the interceptor will be bypassed to the Missouri River. It is anticipated that a power backup at the pump station will be required for future conditions. Therefore, a power generator capable of supplying 2,000 kW at 480 volts is assumed to be needed at the pump station. The proposed generator as well as the proposed transformer, switchgear, and pull out breaker are presented in Figure 7.

6.3 Pump Station Screening and Grit Recommendations

A detailed screening and grit analysis is being performed for the WPF as part of the ongoing Facilities Plan. However, screening and grit removal performed at the Whitehead Pump Station could reduce and change the required facilities downstream and should therefore be discussed in this technical memorandum.

Although additional grit could be removed at the Whitehead Pump Station through the construction of new upstream grit removal facilities, there are a number of disadvantages to this approach. First, the existing interceptor must be able to convey, by gravity, a minimum peak flow of 80 mgd. Introducing an additional grit facility upstream from the pump station wetwell will create additional headlosses and reduce the conveyance capacity of the existing gravity interceptor. Furthermore, a potential grit facility upstream from the Whitehead Pump Station would have to be located at an elevation equal to or lower than the influent interceptor. The influent 54 inch interceptor at the Whitehead Pump Station is approximately 35 feet below grade forcing any potential grit facility to be lower than this elevation. Since the grit facility would have to be placed into the existing hydraulic profile of the influent interceptor, the elevation of the existing downstream screens would need to be lowered. This would be a major modification to the existing pump station. Finally, grit removal would still be required at the WPF resulting in City staff having to manage both a satellite grit facility at the Whitehead Pump Station as well as a proposed WPF grit facility. Based on these reasons, it is recommended that any new grit facilities be located at the WPF to help consolidate the structures and avoid hydraulic issues resulting from these potential modifications.

Unlike grit removal, screening must be performed at both the existing Whitehead Pump Station and the proposed Excess Flow Pump Station to protect the pumps. Currently, the Whitehead Pump Station has screens with 1-½ inch openings. However, for future conditions, the preliminary grit technologies being investigated for use at the WPF and upstream from the proposed HRT facilities require the use of at least ½ inch screens or smaller. Replacing the existing 1-½ inch Whitehead Pump Station screens with ½ inch screens would eliminate the need to provide additional ½ inch screening at

the WPF. However, City staff is concerned about high debris loading at the Whitehead screens and the potential for blinding and failure of the ½ inch screens due to increased trash and debris. In addition, information compiled from other communities provide evidence that downsizing screens from 1-½ inch to ½ inch can increase screening quantities by upwards of five to eight times. It is therefore recommended that the proposed Excess Flow Pump Station be fitted with 1-½ inch screens and the existing Whitehead Pump Station screens be replaced, in kind, with 1-½ inch screens when their useful life is reached. Although the existing 1-½ inch screens at the Whitehead Pump Station are currently operational, it is assumed for costing purposes, discussed later in this technical memorandum, that they are replaced as part of the upgrades.

6.4 Surge Protection

Protecting force mains against surge (i.e., water hammer) is an important consideration when designing pump stations. A pressure surge can occur when a pump station stops or starts suddenly. Surge can occur on either side of the pump, depending upon the configuration of the pump station. At the Whitehead Pump Station, a surge can only occur on the downstream side of the pump station. The interceptor feeding the pump station is connected to an open wetwell which can buffer any sudden changes at the pump station. However, downstream of the Whitehead Pump Station, surge issues can be caused in the force main if the pumps stop suddenly while running (i.e., loss of power). Physically, a shutdown surge occurs because water is moving down the force main with momentum. When the pump station stops, the momentum of the water continues to move water away from the pump station through the force main. However, at the pumps and check valves, water cannot easily pass through them once they are no longer operating. This, in turn, creates a momentary vacuum in the force main downstream from the pumps and check valves. This momentary vacuum is followed shortly thereafter by a pressure wave (i.e., surge) created when the vacuum collapses on itself.

The existing Whitehead Pump Station has two separate mechanisms to protect the downstream 36 inch and 42 inch force mains from a pressure surge. Currently, a surge tower is connected to the 36 inch force main. This tower is attached to the 36 inch force

main discharge header and extends through the roof of the pump station to an elevation of 846 feet. The surge tower provides a buffer to the 36 inch force main as it allows the pressure surge to be directed up and out of the station thus reducing the internal momentary pressure on the force main. The 42 inch force main has a surge relief valve that connects the 42 inch force main to the pump station wetwell. This is similar in concept to the surge tower as it provides a buffer to the force main by allowing water to pass from the force main to the wetwell during periods of high surge pressure.

Under proposed conditions with the existing discharge header recombined, the Whitehead Pump Station will have two existing surge protection devices that could be dedicated to the 36 inch force main. However, it is not yet known what the exact operating hydraulic gradeline will be at the WPF and proposed HRT facility since the WPF and HRT grit and screening facilities are not yet selected. For planning purposes, it was assumed that the hydraulic gradeline would be 825 feet at the headworks of the WPF and proposed HRT facility under future conditions as opposed to 818.5 feet for existing conditions. This assumed condition, along with the design flow rate of 30 mgd and associated dynamic head, will cause flow to overtop the existing surge tower. Therefore, it is assumed for the improvements and associated costs recommended herein that the surge tower is abandoned and replaced with a vacuum release/air valve as opposed to raising the elevation of the existing surge tower.

With the proposed vacuum release/air valve and existing surge relief valve, it is not anticipated that the 36 inch force main will need any additional protection from surge. Slow closing ball valves, as the City has installed in other pump stations, could be used to offset any remaining startup and shutdown surge conditions. At this time, however, the addition of ball valves to the existing pump station is not recommended for future conditions for the following reasons. Startup and shutdown surge conditions can be better offset and dampened by using programmable logical controls (PLCs) to “feather” on and off the proposed eddy current drives and pumps. PLCs allow computer technology to help offset the need for expensive, mechanical equipment. It is recommended that PLC technology be used in place of larger, expensive ball valves to offset any remaining startup and shutdown surge conditions.

It is anticipated that the proposed 50 mgd Excess Flow Pump Station would also need surge protection. For the new pump station, a combination air release/vacuum relief valve would be installed on the force main to dampen the possible effects of surge. These valves allow air to enter the force main eliminating the creation of a vacuum thus protecting the force main and pump station from a high surge induced pressure wave. As discussed previously, if the proposed Excess Flow Pump Station is increased to convey 58 mgd, a new 36 inch force main is proposed to reduce the velocity in the existing 42 inch force main. With the reduced velocities, normal surge protection (combination air release/vacuum relief valves) would be needed to adequately protect the proposed force mains. If, however, the proposed 36 inch force main is not constructed and the existing 42 inch force main conveys the 58 mgd (at a peak velocity of 9.3 fps), significant additional surge protection (surge tower, surge tank, multiple combination air release/vacuum relief valves) would be needed to protect the force main.

Possible optimizations between building a new force main to parallel the existing 42 inch force main or adding significant surge protection and not constructing a new force main may exist. However, for costing purposes presented in the following sections, a new force main is considered to be required if the proposed Excess Flow Pump Station must convey a peak flow of 58 mgd. Detailed optimization and value engineering can be performed during detailed design if warranted. In addition, neither the existing 36 inch nor 42 inch force mains have undergone a condition assessment. It is recommended that the force main conditions be assessed prior to initiating detail design of the Whitehead Pump Station and proposed Excess Flow Pump Station improvements. This will confirm the condition and verify that the proposed surge protection will be adequate.

7.0 Opinion of Probable Costs

Before presenting the construction, project, and O&M costs of the Whitehead Pump Station improvement recommendations, a summary of the historical City pump station maintenance costs is pertinent. The City has recently decided to use eddy current drives on all feasible pump applications due to maintenance issues with the AFD units used throughout the City's pump stations.

Eddy current drives are relatively simple in comparison to AFD units. An eddy current drive consists of a fixed speed motor and an eddy current clutch. The clutch contains a fixed speed rotor and an adjustable speed rotor separated by a small air gap. In an eddy current drive, a direct current in a field coil produces a magnetic field that determines the torque transmitted from the input rotor to the output rotor. The controller provides closed loop speed regulation by varying clutch current, only allowing the clutch to transmit enough torque to operate at the desired speed. Eddy current drives are simple to troubleshoot and repair by City staff.

AFD units vary speed in a completely different manner than eddy current drives. These drives use inverters to convert AC power to DC power. The DC power is then cycled at different frequencies in order to vary the speed of the motor. AFD drives utilize more complicated computerized circuitry, the inverts are sensitive to power disruptions, and are not as maintenance friendly as eddy current drives.

AFDs, however, are the current industry standard because they operate over larger speed ranges at higher efficiencies which results in lower operating costs. However, as stated previously, AFD maintenance issues can be more complicated and repair costs more expensive. Therefore, selecting the correct drive type for a specific application and location should reflect both operating and maintenance costs. Due to the maintenance costs associated with AFD repair, the City has decided to use eddy current drives for all feasible applications. Table 7 documents the City's historical pump station maintenance and repair costs. Table 7 itemizes the various installation and maintenance costs associated with the Cutler and Hammer AFD units in the Whitehead Pump Station. From 2000 to 2009, the City has spent approximately \$6,500 per year on maintaining the Whitehead AFDs. In comparison, although used sparingly, the cost of repairing the existing Whitehead 150 hp eddy drives over this same time period is estimated to be approximately \$200. The existing eddy current drives have been in operation since construction of the station in 1965 and have had no major repairs or breakdowns. The City has a good track record with eddy current drives and are comfortable with operating and repairing them using in-house City staff.

Furthermore, at the South St. Joseph Pump Station, KCP&L power quality problems resulted in all three AFD units being destroyed in 2007. Approximately \$70,000 was spent to repair all three AFD units at the drive manufacturer's facility (approximately \$23,300 per AFD). Six months following these repairs, another AFD unit was destroyed at the South St. Joseph Pump Station, resulting in another \$25,000 worth of repairs. Since the installation of the three new AFD units in the South St. Joseph Pump Station, the City has spent approximately \$100,000 in repair costs. These repair costs document the potential liability to the City if an AFD unit has to be repaired by the manufacturer. The higher complexity AFD units forced the City to ship the AFDs away rather than having in-house City maintenance staff perform the repairs. These considerations and issues have resulted in the City choosing to only use eddy current drives in the future. Although the eddy current drive efficiencies are lower than AFDs at speeds less than approximately 85 percent output, the potential for an increased electrical bill is more acceptable to City Staff than irregular, expensive capital expenditures that cannot be planned or budgeted.

For the O&M costing presented later within this section, eddy current drives are assumed to be operating at 85 percent efficiency. During detailed design, if the City still chooses to use eddy current drives, operating schemes to maximize the efficiency of the eddy current drives should be investigated to ensure that not only the maintenance costs but the operating costs are minimized for the benefit of the City.

Table 7		
Whitehead Cutler Hammer VFD Repair Costs		
Date of Expenditure	Type of Expenditure	Cost of Expenditure
2000	Purchase of three inverters	\$162,000.00
2000	Installation of inverters	\$150,000.00
05/03/01	Service call to determine problem and repair	\$3,348.203
06/09/03	10 Fuses @ \$62.40 each	\$624.00
10/02/03	Parts	\$10,848.70
12/08/03	*	\$0.00
09/21/04	Parts and Technical Service	\$4,776.74
08/11/04	Five Capacitors	\$422.65
08/31/04	Eight Capacitors	\$676.24
08/31/04	Capacitor Board	\$298.92
09/13/04	Three SCRs	\$1,256.28
09/21/04	Parts Order	\$9,287.04
10/13/04	Technical Service: 32 hours @ \$85.00/hr	\$2,720.00
02/20/08	Parts	\$1,623.27
2000-2009	Electricians' Labor Costs	\$22,000.00
Total Costs To Date		\$369,882.04
Maintenance Costs		\$57,882.04
Maintenance Cost Per Year (2000-2009)		\$6,431.34
* Received letter from Eaton Electrical notifying the City that all rights to the new drives had been sold to ATS Corp in Peoria, Illinois and that Eaton would no longer furnish parts or components for repair of the drives.		

7.1 Opinion of Probable Project Costs

A conceptual cost estimating methodology was employed to develop capital project costs for the proposed Whitehead pump station improvements. All project costs are given in May 2009 dollars (Engineering News Record (ENR) Building Cost Index (BCI) equal to 4473).

The new Excess Flow Pump Station and screenings building costs were determined, assuming brick and block wall construction. Consistent with construction history at the WPF, it was assumed that the pump station, wetwell, and screening buildings would be constructed on piles; piles were assumed to be 25 feet below the

bottom of the structures which will be located approximately 50 feet below grade. This will result in the bottom of the piles being located approximately 75 feet below grade.

Equipment costs for pump station drives, motors, pumps, impellers, and screens were based on vendor quotes. Equipment installation was estimated at 40 percent of the equipment cost for all equipment except for package systems such as the backup power generator; for this component, installation was estimated as 25 percent of the equipment cost. Table 8 provides a summary of the opinion of the probable project costs for the proposed Whitehead improvements.

A cost for the influent gravity sewer modifications (a weir and new 54 inch pipe) as well as costs for a new 42 inch force main to connect the proposed excess flow pump station to the existing 42 inch force main is included in Table 8 as a lump sum cost and denoted as "Collection System Upgrades." This cost is based on an assumed location for the proposed Excess Flow Pump Station (See Figure 7).

In addition to building, structure, and equipment costs estimated directly, other construction costs were estimated by applying a percentage to appropriate project costs as indicated in Footnote 3 of Table 8. The cost for electrical, instrumentation, and controls was estimated as 25 percent of the cost of equipment, installation, and structures (this cost excludes the backup power generator and new transformer that were calculated as separate line items). An allowance of 10 percent was applied for project sitework. Contractor general requirements were estimated at 12 percent and contingency was set at 25 percent. Costs related to engineering, legal, and administration are reflected in a 20 percent multiplier applied to all construction costs.

Additional site related costs are also reflected in the capital costs given in Table 8. The costs reflected in the table are shown as placeholders and will be refined once the final site for the pump station is decided. Site area for the pump station improvements was estimated and is presented on Figure 7. The flood protection line item estimates the amount of fill soil required for the proposed structure to be elevated out of the floodplain. For the proposed Excess Flow Pump Station, no fill is anticipated. The proposed Excess Flow Pump Station is planned to be located on industrial land with unknown environmental history. A placeholder for site remediation was therefore included

assuming that all of the disturbed soil on the site is remediated which includes 50 foot depth around the proposed pump station and 5 foot depth over the remaining site area. A unit cost of \$150 per cubic yard of soil remediated was used. This number should be considered as only a placeholder as site remediation costs are very specific to the site location and type of contamination encountered. Likewise, the land acquisition cost was estimated at \$1.33 per sq ft based on preliminary guidance from the City; this value was based on the purchase price of the property located to the south of the WPF. Actual land costs may vary significantly based on the selected site. Determination of site related costs must be revisited once the actual site has been finalized.

Appendix B presents additional details of the development of the conceptual capital costs. The total opinion of probable project cost for the 50 mgd Whitehead Pump Station improvements is approximately \$24.6 million. A summary of the project costs for this option is presented in Table 8. If the pump station is increased to 58 mgd, requiring a new 36 inch force main to be installed, the project cost is approximately \$29.0 million. A summary of the project costs for this option is presented in Table 9.

As indicated in Tables 8 and 9, the additional 8 mgd of flow for the 88 mgd option costs approximately \$4.4 million more than the 80 mgd option. This is due to the additional force main required to reduce the velocities in the existing 42 inch force main.

Table 8	
Summary of Opinion of Probable Project Costs Assuming a 50 mgd Excess Flow Pump Station ¹	
Item	Improvement Costs, \$
Excess Flow Pump Station	
Structure, Valves, and Piping	2,856,000
Equipment	3,192,000
Existing Whitehead Pump Station	
Structure, Valves, and Piping	166,000
Equipment	1,401,000
Collection System Upgrades	958,000
Backup Generator and Transformer	1,119,000
Flood Protection/Fill (placeholder) ²	
Site Remediation (placeholder) ²	1,723,000
<i>Subtotal</i>	11,415,000
E, I&C, Sitework, Contractor General Requirements ³	4,940,000
<i>Subtotal</i>	16,355,000
Contingency ⁴	4,089,000
Land Acquisition (placeholder) ^{2, 5}	35,000
Opinion of Probable Construction Cost	20,479,000
Engineering, Legal, and Administration ⁶	4,096,000
Opinion of Total Project Cost	24,575,000
<ol style="list-style-type: none"> 1. All costs presented in May 2009 dollars (ENR BCI = 4773). 2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities. 3. Electrical, instrumentation, and controls (E, I&C) estimated at 25% of the total of all equipment and structure costs but excludes collection system upgrades. Sitework estimated at 10% of the total of equipment, structures, and E, I&C costs. Contractor general requirements estimated at 12% of the total of equipment, structures, E, I&C, and sitework costs. 4. Project contingency is estimated at 25% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs. 5. Land acquisition cost is based on an estimate provided by the City from a recent purchase of land directly south of the WPF. 6. Engineering, legal, and administration (ELA) costs are estimated at 20% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition. 	

Table 9	
Summary of Opinion of Probable Project Costs Assuming a 58 mgd Excess Flow Pump Station ¹	
Item	Whitehead Improvement Costs, \$
Excess Flow Pump Station	
Structure, Valves, and Piping	2,856,000
Equipment	3,087,000
Existing Whitehead Pump Station	
Structure, Valves, and Piping	166,000
Equipment	1,401,000
Collection System & Force Main Upgrades	3,505,000
Backup Generator and Transformer	1,119,000
Flood Protection/Fill (placeholder) ²	-
Site Remediation (placeholder) ²	1,723,000
<i>Subtotal</i>	13,857,000
E, I&C, Sitework, Contractor General Requirements ³	5,472,000
<i>Subtotal</i>	19,329,000
Contingency ⁴	4,832,000
Land Acquisition (placeholder) ^{2, 5}	35,000
Opinion of Probable Construction Cost	24,196,000
Engineering, Legal, and Administration ⁶	4,839,000
Opinion of Total Project Cost	29,035,000
<ol style="list-style-type: none"> 1. All costs presented in May 2009 dollars (ENR BCI = 4773). 2. Site related costs are placeholders and must be revised following final siting of the facilities. Site related costs are provided for the site area required for the proposed facilities. 3. Electrical, instrumentation, and controls (E, I&C) estimated at 25% of the total of all equipment and structure costs but excludes collection system upgrades. Sitework estimated at 10% of the total of equipment, structures, and E, I&C costs. Contractor general requirements estimated at 12% of the total of equipment, structures, E, I&C, and sitework costs. 4. Project contingency is estimated at 25% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, and site remediation costs. 5. Land acquisition cost is based on an estimate provided by the City from a recent purchase of land directly south of the WPF. 6. Engineering, legal, and administration (ELA) costs are estimated at 20% of the total of all equipment, structures, E, I&C, sitework, contractor general requirements, flood protection/fill, site remediation costs, contingency, and land acquisition. 	

7.2 Opinion of Probable Operation and Maintenance Costs

Estimates of operations and maintenance (O&M) costs were determined for the new Excess Flow Pump Station. O&M costs associated with pumping are dependent upon the duration of pumping and the power expended during that time.

During dry weather, approximately 291 days during an average year, it is assumed that the existing Whitehead Pump Station pumps at a constant 17 mgd with a 200 hp motor. This equates to approximately 1.2 million kW/hrs of power usage annually. During wet weather conditions for the 80 mgd condition, both the existing Whitehead and proposed Excess Flow Pump Station would be operating with two 250 hp motors and two 600 hp motors, respectively. Based on a review of the wet weather capture volume presented in TM-CSO-3a and a review of historical WPF flows, the volume of annual wet weather flows was estimated. A detailed discussion of this procedure is included in TM-WW-5 – Disinfection Facilities. In summary, it is anticipated that 1,850 million gallons (MG) of flow would be treated during the approximately 74 rainy days per year. At a treatment rate of 80 mgd (30 mgd through the improved Whitehead Pump Station and 50 mgd through the proposed Excess Flow Pump Station) the wet weather run time of the pumps is approximately 560 hours annually. This equates to approximately 0.83 million kW/hrs of power usage annually. The true number and duration of rain events and pump volume occurring during any given year will vary widely from the average. The values presented herein represent the anticipated long term average operation costs at the Whitehead and proposed Excess Flow Pump Stations. The 88 mgd O&M costs are not presented herein as they are not significantly different (within 10 percent) of the 80 mgd O&M costs.

Table 10 presents the unit costs employed for O&M cost development. Unit costs shown in Table 10 for power were provided by the City. Annual O&M costs were determined by multiplying the unit costs in Table 10 by the quantities of each of the items required to operate and maintain the facilities for an average year. The annual O&M costs for the pump station are separated into the dry and wet weather components and are presented in Table 11. To develop annual maintenance costs at the Whitehead Pump Station, it was assumed that 4 man-hours per week were required to maintain both pump stations.

Table 10 O&M Unit Costs ¹	
Power ²	\$0.10/kW-hr
Labor (including benefits and overhead) ²	\$32.78/hr
1. All costs provided in May 2009 dollars. Except for those indicated as City provided, all unit costs based on Black & Veatch project experience. 2. Units costs based on data provided by the City.	

Table 11 80 mgd Whitehead Pump Station Annual O&M Costs	
Dry Weather	\$107,223
Wet Weather	\$84,555
Maintenance	\$6,819
Total	\$198,597

8.0 Design Level Optimizations and Value Engineering

It is recommended that a new Excess Flow Pump Station be constructed next to an improved Whitehead Pump Station. The stated design constraint was for the 36 inch force main to convey a peak flow of 30 mgd and the 42 inch force main to convey a peak flow of 50 mgd with an option to convey 58 mgd for a total of 88 mgd. During detailed design, there are several additional items that could be investigated to help optimize these proposed improvements and possibly reduce costs. The following list provides a summary of possible value engineering opportunities and design level optimizations that should be investigated as this project moves to detailed design.

- The City prefers using eddy current drives for all feasible applications. Under peak conditions, these drive units have similar efficiency to AFDs. However, for low flow applications, eddy current drives are not as efficient as AFD units. Optimization of the eddy current drive operation schemes using computer controls will be important to maximize the efficiency of the eddy current drives to ensure that excess power is not wasted.

- The two existing 150 hp motors connected to the 20-inch Model MCZ-1 pumps rated for 12,000 gpm at 35 feet of head will not be functional under the 30 mgd head conditions of the 36 inch force main. However, these pumps could be used during low to average flow conditions to reduce power consumption and maximize efficiency of the station. During detailed design, it may be feasible to move one or both of the existing 150 hp pumps from the Pump 1 and Pump 2 location to the Pump 4 and Pump 5 location to optimize power use.
- The addition of an interconnection between the 36 and 42 inch existing force mains may add flexibility to the conveyance system and allow flows to be moved from one force main to the other. However, under peak conditions (for the 80 mgd option), the head differential between the two force mains is estimated to be approximately 20 feet. Therefore, the use of an interconnection would need to be evaluated in detail to determine how an interconnection might be operated.
- If the water surface elevation (hydraulic gradeline) at the WPF and proposed HRT facility during peak flow conditions are significantly different than 825 feet (assumed for this investigation), updates to the pump and drive recommendations provided herein may be required. Furthermore, once the headworks operating hydraulic gradeline is known, the surge tower can be reevaluated to determine if, in fact, it needs to be modified or abandoned.
- Neither the exiting 36 inch nor 42 inch force mains have undergone a condition assessment. It is recommended that prior to initiating detailed design of the Whitehead Pump Station and proposed Excess Flow Pump Station improvements that the condition of both force mains be assessed. This will confirm the condition and verify that the proposed surge protection, presented herein, will be adequate to protect them. A condition assessment will help refine and optimize the final surge protection measures.

9.0 Summary and Conclusions

The Whitehead Pump Station will require significant improvements to convey a minimum peak flow of 80 mgd to the WPF and proposed HRT facility. The opinion of probable project cost to convey 80 mgd is \$24.6 Million. The improvements to convey 80 mgd will include the following:

- Three new 250 hp drives and pump impellers at the existing Whitehead Pump Station.
- Modifications (i.e., valve and spool piece) to the existing Whitehead Pump Station discharge header to reconnect the entire header to the existing 36 inch force main.
- Addition of isolation valves to the existing pump station to increase flexibility for use during future conditions. The valves will allow the pump station to be isolated from both the 36 and 42 inch force mains. The typical configuration will be to have the existing station pump convey flows through the 36 inch force main and remain isolated from the 42 inch force main.
- New 50 mgd Excess Flow Pump Station with three 600 hp drives and pumps.
- Recirculation line at the proposed Excess Flow Pump Station to allow better modulation of downstream flows.
- Relocation of a portion of the existing 42 inch force main to allow construction of the proposed Excess Flow Pump Station.
- A new overflow weir and upstream 54 inch gravity sewer to direct flows to the proposed Excess Flow Pump Station.
- Addition of a 480 volt, 2,000 kW backup generator, underground power line, transformer, switchgear, and pull out breaker.
- New 1-½ inch bar screens for both the existing Whitehead and proposed Excess Flow Pump Stations.

If the pump station is configured to convey 88 mgd, the opinion of probable project cost is \$29.0 million and the following modifications to the improvements listed above would be needed:

- New 58 mgd Excess Flow Pump Station (instead of a 50 mgd pump station) next to the existing Whitehead Pump Station.
- New 4,700 ft long, 36 inch diameter force main to parallel the existing 42 inch force main. This is required to reduce the velocity in the 42 inch force main during 58 mgd peak flow conditions. If a new force main is not added, the velocity will be 9.3 fps during a peak flow condition of 58 mgd. With the addition of a 36 inch parallel force main, the velocity will be approximately 5.5 feet per second in the 42 inch force main and 5.3 feet per second in the new 36 inch force main.
- Installation of three 29 mgd pumps with 500 hp motors rated for approximately 65 ft of head (two duty units and one standby unit).

The 88 mgd option is estimated to be approximately \$4.4 million more than the 80 mgd option. Although the pump sizes and associated power requirements would decrease because the new force main reduces the peak dynamic head, the capital cost of the proposed 36 inch force main would not be offset by the savings in operating costs with the pump reductions. Based upon a review of the necessary improvements (i.e., new force main or significant surge protection) and associated \$4.4 million cost increase required for the 88 mgd option, it is recommended that the 80 mgd option (i.e., 50 mgd Excess Flow Pump Station) be selected at the Whitehead Pump Station.

10.0 References

1. Black & Veatch Corporation, TM-CSO-3a – Phase IA CSO Control Recommended Improvements Model.

Appendix A

Whitehead Field Visit Notes

BLACK & VEATCH CORPORATION

City of St. Joseph, Missouri
Facilities Plan
Work Order 09-001

B&V Project 163509
B&V File B-1.2
April 29, 2009

Pump Station Site Visit Notes
April 22, 2009, 10:00 a.m. – 4:00 p.m.
St. Joseph, Missouri

Site Visit Attendees

<i><u>Name</u></i>	<i><u>Organization</u></i>	<i><u>Email</u></i>
Don Gilpin	City of St. Joseph	dgilpin@ci.st-joseph.mo.us 816-271-4693
Jim Schlaman	Black & Veatch	schlamanjc@bv.com 913-458-3359
Ted Stolinski	Black & Veatch	stolinski@bv.com 913-458-3448
Scott Stockam	Black & Veatch	stockamsd@bv.com 913-458-3414

From: Jim Schlaman

Any comments on the site visit notes should be sent to the author and copied to Matt Schultze (schultzeme@bv.com) and Dianne Honomichl (honomichlds@bv.com)

Action Items

<i><u>Action Item</u></i>	<i><u>Responsibility</u></i>	<i><u>Due Date</u></i>
City to provide information (if available) for the following items: 1. Impeller types for Whitehead, In-plant, and Faraon Street Pump Stations 2. Kimball design reports for Whitehead, In-plant, and Faraon Street Pump Stations (reports would discuss pump station upgrades/impeller modifications, may discuss electrical limitations at Whitehead and other issues not on drawings) 3. Specifications for Whitehead, In-plant, Brown’s Branch, and Faraon Street Pump Station bar screens (if available)	Don Gilpin, Craig Rippey	As Soon As Can Be Collected

<u><i>Action Item</i></u>	<u><i>Responsibility</i></u>	<u><i>Due Date</i></u>
4. Drawings for Faraon Street Pump Station force main 5. Kimball upgrades and drawings for Whitehead 42 inch force main 6. Specifications for the Muffin/Channel Monster at the existing grit basin (if available, otherwise B&V will obtain upon receipt of model number)		
Gain access to the transformer at Whitehead	KCPL Staff	Mid-May
Obtain drawings of influent pipe at Whitehead Pump Station	B&V Staff	ASAP
Help City address Faraon Street Pump Station H ₂ S issue	B&V Staff	Ongoing

Overview

B&V staff toured the following pump station facilities with Don Gilpin:

- In-plant Pump Station
- Whitehead Pump Station
- Faraon Street Pump Station
- Brown’s Branch Pump Station
- South St. Joseph Industrial Pump Station

The focus of the tour was to have Ted Stolinski (pumping expert) and Scott Stockam (electrical/power expert) visit and get familiar with the aforementioned pump stations. As part of the ongoing Facilities Plan, determining the existing capacity of the pump stations and developing recommendations for improvements is required. The following sections provide highlights of the pump station site visit along with the preliminary findings and observations for each station.

In-plant Pump Station

- a. Station has three pumps, installed in parallel.
- b. Station pumps into a force main which delivers flow to the WPF grit works.
- c. Two of the pumps are Fairbanks Morse 8 inch Model 5414D rated for 3,000 gpm at 28 feet. The pumps are driven by EM motors and eddy current couplings rated at 40 hp and 1,175 rpm.
- d. One pump is a Fairbanks Morse 6x8 Model 5413 rated for 1,600 gpm at 26.5 feet. The pump is driven by an EM Magna-drive rated at 20 hp and 1,135 rpm.
- e. There is no room for additional pumps in the existing station.
- f. The pumps deliver flow from the Missouri Avenue combined sewer system as well as side stream flows from the plant belt presses to the plant headworks facility. The

- stated side stream flows were estimated by WPF staff to be 1 to 2 mgd on an average dry weather day.
- g. During the trip, it was mentioned that stormwater runoff from the WPF site was directed to this pump station. From further discussions after the site visit, it was determined that stormwater runoff from the WPF site does not enter the In-plant Pump Station.
 - h. Recently, one of the original isolation valves was replaced with a ball valve. The ball valve closes more slowly and helps reduce surge issues if power is lost at the station.
 - i. Overall, City staff appears to be satisfied with the station's performance.



Figure 1 – In-plant Pump Station Motors and Pumps

Whitehead Pump Station

- a. Station has five pumps.
- b. Three pumps are placed in parallel and pump into a 42 inch force main which delivers flows to the WPF. The 42 inch force main is currently used to pump all dry weather flows and all wet weather flows.
- c. The remaining two pumps are also in parallel and pump flow into a 36 inch force main which delivers flows to the WPF.
- d. The 36 inch force main is used as the emergency backup to the 42 inch force main. Used typically two to three times a year.
- e. The two pumps connected to the 36 inch force main are Worthington 20 inch Model MCZ-1 rated for 12,000 gpm at 35 feet. The pumps are driven by EM motors and eddy current drives rated at 150 hp and 700 rpm.
- f. The three pumps connected to the 42 inch force main are Worthington 20 inch Model MNZ rated for 9,000 gpm at 60 feet. The pumps are driven by GE motors with VFDs rated at 200 hp and 700 rpm.

- g. There is no room for additional pumps in the existing station.
- h. The pumps deliver flows captured by the Main and Whitehead Interceptors to the WPF headworks facility.
- i. The pump station was built in the early 1960s. In the late 1970s, three new variable frequency drives (VFDs) and three new pumps were installed. In the late 1990s, the VFDs were replaced by newer models.
- j. Per Don Gilpin, Kimball Engineering (firm that designed pump station upgrades in the late 1970s) indicated that the station's 750 kVA transformer could not handle all five pumps running at one time. Based on this advice, the City has never run more than three pumps at any one time. The power supply at the Whitehead Pump Station needs to be checked to verify the actual power limitations of the station on the primary as well as the secondary of the transformer.
- k. Pump 5 at the station is operated the most frequently because inbound grit first collects in the wetwell in front of the Pump 5 intake. As a result, Pump 5 was recently replaced as it experiences more wear than the other pumps.
- l. Flow through the existing pump station influent channel and bar screen appears to be turbulent and fast. There may be a flow limitation at this location.
- m. There is no power backup at this station.
- n. City staff do not like the bar screens at the Whitehead Pump Station. Several bar screens have been used at this station and so far, none have seemed to work well.
- o. Overall, City staff believes this pump station operates well with the exception of the screens and excessive wear of Pump 5.



Figure 2 – Whitehead Pump Station Motors and Pumps

Faraon Street Pump Station

- a. Station has six pumps.
- b. Station also has one spare motor (not mounted).
- c. There are three constant speed pumps installed on the lowest level of the pump station. There are three variable speed pumps installed on the third level of the pump station. One constant speed and one variable speed pump are installed in series. Therefore, there are three pump pairs (one constant speed pump and one variable speed pump) that pump in parallel.
- d. The isolation flap valves downstream from the constant speed pumps are oriented in the vertical position. This orientation can allow debris to build up in the valve areas which can reduce and/or eliminate their operability.
- e. The pump station has two separate force mains. One force main is located on the second lowest level of the station and discharges to the lagoons to the east of the pump station. The main purpose of the constant speed pumps was to direct flow to the adjacent lagoons through this force main.
- f. The variable speed pumps located in the third lowest level of the station assist the constant speed pumps to pump into the approximately 3 mile long force main.
- g. During the visit, the dry weather flow at the station was approximately 3.3 mgd.
- h. The three pumps on the third level are Fairbanks Morse 8x8 Model 5415 rated for 3,500 gpm at 96 feet. The pumps are driven by Pacemaker motors with VFDs rated at 125 hp and 1,185 rpm.
- i. The three pumps in the lowest level are Fairbanks Morse 8 inch Model 5426 rated for 3,000 gpm at 96 feet. The pumps are driven by Pacemaker motors rated at 125 hp and 1,185 rpm.
- j. There is no room for additional pumps in the existing station.
- k. The pump station conveys flow from the east side of the City (102 River Watershed) directing it over the ridge line to the west to the combined sewer system line near 32nd and Olive Street. The combined sewer then conveys the flow to the WPF.
- l. There is a backup power generator at the station (diesel Caterpillar D348 SR4 engine/generator).
- m. The sewage coming into the station is septic. Hydrogen sulfide (H₂S) has significantly corroded the enclosed wetwell. City staff would like to convert the enclosed wetwell into an open air wetwell.
- n. Furthermore, a high amount of H₂S comes out of solution once the force main dumps flow into the gravity sewer near 32nd and Olive Street where odor problems and corrosion of the sewer have been observed.
- o. The City has been trying to control the H₂S problem using ferric chloride (FeCl₃). City staff indicated that the addition of FeCl₃ has also contributed to the degradation of the existing gravity sewer line that receives flows from the Faraon Street force main. It is the staff's opinion that the FeCl₃ does not appear to be working. The City would like to have a remedy for this problem.

- p. City staff is not satisfied with the performance of this station and believes it is in need of repair and rehabilitation. They would like to make major modifications, if possible.



Figure 3 – Faraon Street Pump Station Variable Speed Motors and Pumps



Figure 4 – Faraon Street Pump Station Constant Speed Motors and Pumps

Brown's Branch Pump Station

- a. Station has two pumps.
- b. Station has room for one more motor and pump.
- c. The pumps send flow into a force main that discharges into the Missouri Avenue Basin where it is conveyed by gravity to the WPF.
- d. The two pumps are Fairbanks Morse 8 inch Model 5414D rated for 3,000 gpm at 30 feet. The pumps are driven by EM motors rated at 40 hp and 1,175 rpm.

- e. The City is planning on installing a Channel Monster later in 2009. The station's existing screens often pull out raw fecal matter and City staff wants to replace them.
- f. Besides the replacement of the screens, this station operates well per City staff.



Figure 5 – Brown's Branch Pump Station Motors and Pumps

South St. Joseph Industrial Pump Station

- a. Station has three pumps.
- b. Station has no more room for additional pumps.
- c. The pumps convey flow through a force main that delivers it directly into the roughing filters at the WPF.
- d. The three pumps are Worthington 16 inch Model MNHZ rated 11,000 gpm at 88 feet. The pumps are driven by GE motors rated at 300 hp and 880 rpm.
- e. The City has had significant problems at this station with the VFD drive units and has spent a significant amount of capital resources to repair the units.
- f. The station's wetwell is in significant disrepair. Burns & McDonnell is under contract to repair/replace the wetwell.



Figure 6 – South St. Joseph Industrial Pump Station Motors and Pumps

Miscellaneous Site Visit Items

- a. Don Gilpin stated that the City will not install drives with inverters on any motors that are equal or larger than 200 hp due to maintenance issues with VFDs.
- b. Don Gilpin prefers eddy current magnetic drives because they have a proven history of low maintenance and longevity (40+ years) operating with very few issues. These systems are not available below 200 hp.

The pump station tour ended at approximately 4:00 p.m.

Appendix B

Opinion of Probable Project Cost Breakdown

**80 MGD PUMP STATION OPTION
OPINION OF PROBABLE PROJECT COST BREAKDOWN**

Item Description	Units	Unit Cost ¹	Quantity	Total Cost
New Excess Flow Pump Station				
Excess Flow Building Superstructure	sq ft	155.00	2,000	310,000
Exceeds Flow Screening Building Superstructure	sq ft	190.00	625	118,750
Painting	LS			45,000
Earthwork				
Structural Excavation	cu yd	20.00	6,200	124,000
Compacted Fill	cu yd	25.00	-	-
Granular Fill	cu yd	35.00	500	17,500
Piling (25 ft deep)	each	1625.00	80	130,000
Sheeting and Dewatering	LS			240,000
Concrete				
Slab on grade/footings	cu yd	530.00	600	318,000
Walls	cu yd	850.00	400	340,000
Suspended Slab and Beams	cu yd	950.00	150	142,500
Embedded Accessories	LS			23,000
Painting	LS			45,000
Elevator (51 ft lift), 2,500 lbl 5 story, 100 fpm, hydraulic	LS			250,000
Steel Pipe (Victaulic)				
24" Diameter	\$/lin-ft	840.00	45	37,800
42" Diameter	\$/lin-ft	1470.00	60	88,200
Ball Valves				
24"	each	52800.00	-	-
Iso-Valves				
24"	each	14700.00	6	88,200
Backflow valves				
24"	each	20300.00	3	60,900
42" Eccentric Plug Valve	each	81,200.00	2	162,400
Vertical Rolling Doors				
11 ft Tall, 10 ft wide	LS			12,000
Wet Well Corrosion Liner	sq ft	10.00	11,000	110,000
Bridge Crane 15 ton	LS			62,000
HVAC	sq ft	35.00	9,000	315,000
Plumbing	sq ft	10.00	9,000	90,000
Fire Protection	sq ft	3.50	9,000	31,500
Lightning Protection	LS			8,750
New Excess Flow Buidling				3,171,000
Existing Pump Station Building				
36" Eccentric Plug Valve	each	64,900.00	1	64,900
42" Eccentric Plug Valve	each	81,200.00	1	81,200
Piping Modifications for Installation of Plug Valves	LS			20,000
Existing Pump Station Building				166,000
Excess Flow Pump Station Equipment				
Pump w/600HP-720RPM WPI motor and 50 ft intermediate shafting	each	469,000.00	3	1,407,000
600 HP Magnetic Couplings	each	210,000.00	3	630,000
50 MGD 3/4", 55 ft Tall Mechanical Bar Screen,7'X7', Stainless Steel	each	420,000.00	2	840,000
Excess Flow Pump Station Equipment				2,877,000
Existing Pump Station Equipment Upgrades				
Replacement Impellers	each	56,000.00	3	168,000
250 HP Magnetic Couplings	each	87,500.00	3	262,500
(1) 250Hp/720RPM motor	each	43,400.00	3	130,200
27 MGD 3/4", 55 ft Tall Screen,7'X7', Stainless Steel	each	420,000.00	2	840,000
Existing Pump Station Equipment				1,401,000
Power Upgrades				
Generator	LS			875,000
4000 Gallon Fuel Tank	LS			87,500
2,500 Amp, 480 Volt Switchgear, Breaker, Pull Out Breaker	LS			156,250
Power Upgrades				1,119,000
Subtotal				8,734,000
Electrical, Instrumentation, & Controls	LS	25%		2,184,000
Subtotal				10,918,000
Collection System Upgrades				
Weir Strucutre (Concrete)	LS			50,000
Junction Box (Concrete)	each	80000.00	1	80,000
Gravity Sewer Pipe				
78-inch Diameter	\$/lin-ft	1560.00	-	-
54-inch Diameter	\$/lin-ft	1080.00	175	189,000
Force Main Vacuum/Air Release Valves				
42", 50 MGD Force Main	\$/lin-ft	630.00	400	252,000
New 42" Recirculation Line	\$/lin-ft	630.00	25	15,750
Sluice Gates	each	56000.00	2	112,000
Valve Vaults	each	80000.00	3	240,000
Collection System Upgrades				958,000
Subtotal				11,876,000
Sitework	LS	10%		1,188,000
Subtotal				13,064,000
General Requirements	LS	12%		1,568,000
Flood Protection (placeholder)	cu yd	25	-	-
Site Remediation (Placeholder)	cu yd	150	11,484	1,723,000
Subtotal				16,355,000
Contingency	LS	25%		4,089,000
Land Aqcuisition (placeholder)	sq ft	1.33	26,136.00	35,000
Opinion of Probable Construction Cost				20,479,000
Engineering, Legal, & Administration	LS	20%		4,096,000
Opinion of Probable Project Cost				24,575,000

Structure or Other Non-Equipment Costs
Equipment Costs

**88 MGD PUMP STATION OPTION
OPINION OF PROBABLE PROJECT COST BREAKDOWN**

Item Description	Units	Unit Cost ¹	Quantity	Total Cost
New Excess Flow Pump Station				
Excess Flow Building Superstructure	sq ft	155.00	2,000	310,000
Excees Flow Screening Building Superstructure	sq ft	190.00	625	118,750
Painting	LS			45,000
Earthwork				
Structural Excavation	cu yd	20.00	6,200	124,000
Compacted Fill	cu yd	25.00	-	-
Granular Fill	cu yd	35.00	500	17,500
Piling (25 ft deep)	each	1625.00	80	130,000
Sheeting and Dewatering	LS			240,000
Concrete				
Slab on grade/footings	cu yd	530.00	600	318,000
Walls	cu yd	850.00	400	340,000
Suspended Slab and Beams	cu yd	950.00	150	142,500
Embedded Accessories	LS			23,000
Painting	LS			45,000
Elevator (51 ft lift), 2,500 lbl 5 story, 100 fpm, hydraulic	LS			250,000
Steel Pipe (Victaulic)				
24" Diameter	\$/lin-ft	840.00	45	37,800
42" Diameter	\$/lin-ft	1470.00	60	88,200
Ball Valves				
24"	each	52800.00	-	-
Iso-Valves				
24"	each	14700.00	6	88,200
Backflow valves				
24"	each	20300.00	3	60,900
42" Eccentric Plug Valve	each	81,200.00	2	162,400
Vertical Rolling Doors				
11 ft Tall, 10 ft wide	LS			12,000
Wet Well Corrosion Liner	sq ft	10.00	11,000	110,000
Bridge Crane 15 ton	LS			62,000
HVAC	sq ft	35.00	9,000	315,000
Plumbing	sq ft	10.00	9,000	90,000
Fire Protection	sq ft	3.50	9,000	31,500
Lightning Protection	LS			8,750
New Excess Flow Buidling				3,171,000
Existing Pump Station Building				
36" Eccentric Plug Valve	each	64,900.00	1	64,900
New 42" Eccentric Plug Valve	each	81,200.00	1	81,200
Piping Modifications for Installation of Plug Valves	LS			20,000
Existing Pump Station Building				166,000
Excess Flow Pump Station Equipment				
Pump w/500HP-720RPM WPI motor and 50 ft intermediate shafting	each	469,000.00	3	1,407,000
500 HP Magnetic Couplings	each	175,000.00	3	525,000
50 MGD 3/4", 55 ft Tall Mechanical Bar Screen,7'X7', Stainless Steel	each	420,000.00	2	840,000
Excess Flow Pump Station Equipment				2,772,000
Existing Pump Station Equipment Upgrades				
Replacement Impellars	each	56,000.00	3	168,000
250 HP Magnetic Couplings	each	87,500.00	3	262,500
(1) 250Hp/720RPM motor	each	43,400.00	3	130,200
27 MGD 3/4", 55 ft Tall Screen,7'X7', Stainless Steel	each	420,000.00	2	840,000
Existing Pump Station Equipment				1,401,000
Power Upgrades				
Generator	LS			875,000
4000 Gallon Fuel Tank	LS			87,500
2,500 Amp, 480 Volt Switchgear, Breaker, Pull Out Breaker	LS			156,250
Power Upgrades				1,119,000
Subtotal				8,629,000
Electrical, Instrumentation, & Controls	LS	25%		2,157,000
Subtotal				10,786,000
Collection System Upgrades				
Weir Strucutre (Concrete)	LS			50,000
Junction Box (Concrete)	each	80000.00	1	80,000
Gravity Sewer Pipe				
78-inch Diameter	\$/lin-ft	1560.00	-	-
54-inch Diameter	\$/lin-ft	1080.00	175	189,000
Force Main Vacuum/Air Release Valves				
42", 58 MGD Force Main	\$/lin-ft	9500.00	3	28,500
New 42" Recirculation Line	\$/lin-ft	630.00	400	252,000
New 42" Recirculation Line	\$/lin-ft	630.00	25	15,750
New 36" Force Main	\$/lin-ft	540.00	4,700	2,538,000
Sluice Gates	each	56000.00	2	112,000
Valve Vaults	each	80000.00	3	240,000
Collection System Upgrades				3,505,000
Subtotal				14,291,000
Sitework	LS	10%		1,429,000
Subtotal				15,720,000
General Requirements	LS	12%		1,886,000
Flood Protection (placeholder)	cu yd	25	-	-
Site Remediation (Placeholder)	cu yd	150	11,484	1,723,000
Subtotal				19,329,000
Contingency	LS	25%		4,832,000
Land Acquisition (placeholder)	sq ft	1.33	26,136.00	35,000
Opinion of Probable Construction Cost				24,196,000
Engineering, Legal, & Administration	LS	20%		4,839,000
Opinion of Probable Project Cost				29,035,000

Structure or Other Non-Equipment Costs
Equipment Costs