George Butler Associates, Inc.
9801 Renner Blvd.
Lenexa, KS 66219

D E S I G N   M E M O R A N D U M

TO: Mr. Ray Seidelman, P.E., Project Manager, City of Lee's Summit

FROM: Tim Schneller, P.E. and Fred Lauer, P.E.

DATE: January 30, 2004

SUBJECT: Middle Big Creek / Mouse Creek Pump Station and Overflow Basin
City RFP No. 90-159
GBA Project Number 10025.00

This design memorandum will provide a basis for the design of the improvements to the Middle Big Creek and Mouse Creek basins. The following text is separated into four chapters. The first chapter discusses the warrants behind the design of the overflow basin, pump station, gravity sewer and future force main. The second chapter discusses how flow will be bypassed from the existing gravity line to the pump station and eventually into the overflow basin. The details of the overflow basin are presented in the third chapter. The design of the electrical, mechanical and structural features of the pump station is outlined in the final chapter.

CHAPTER 1 - GENERAL STATION INFORMATION

A. Project Location and Service Area

The proposed Middle Big Creek / Mouse Creek Pump Station and Overflow Basin facility (hereinafter referred to as the proposed facility) will be located near 150 Highway and Ward Road in Lee's Summit, Missouri. The City of Lee's Summit, Missouri (hereinafter referred to as the City) will purchase the property for the proposed facility. The proposed facility will serve the Middle Big Creek and Mouse Creek watersheds. Please refer to Exhibit A for the location of the project service area. The total area served by this station is 1,663 acres, 1,026 acres in the West Sub-basin and 637 acres in the North Sub-basin.

B. Purpose and Scope of Project

According to the *1998 Wastewater System Evaluation* for Lee's Summit, Missouri, the capacity of the sewer beneath Raintree Lake was near or at capacity with development in the watershed at that time and will be overloaded at ultimate development. With the potential for significant development west of Ward Road and North of Hwy. 150, the City has decided to pursue the construction of facilities to reduce the peak flows tributary to these sewers.

The anticipated tributary flows for the West Sub-basin and the North Sub-basin are as shown in the following table.

Table 1 - Tributary Area and Flow Rates

Condition	Description	West Sub-basin	North Sub-basin
Ultimate Development	Tributary Area (acres)	1,026	637
	Avg. Daily Dry Weather Flow (MGD)	1.03	0.64
	Peak Dry Weather Flow (MGD)	1.54	0.96
	Peak Infiltration (MGD)	0.51	0.32
	Peak Inflow (MGD)	8.65	6.12
	Future Total Peak Flow (MGD)	10.7	7.39

The flows shown in Table 1 are based on the City's design criteria: a peak dry weather flow (PDWF) of 1,500 gallons per acre, a peak infiltration of 500 gallons per day per acre, and a peak inflow calculated using the following formula

$$\text{Peak Inflow (in MGD)} = K * i * A * 0.6463167$$

where K is the dimensionless inflow coefficient, i is the rainfall intensity in inches per hour and A is the tributary area in acres. The City currently requires a K of 0.006. The rainfall intensity was calculated using the Kansas City rainfall intensity curves for a 50-year storm event with a time of concentration based on the following formula

$$\text{Time of Concentration} = 18.56 * \text{Area}^{0.2524}$$

Table 2 shows the modeled ultimate flows tributary to the main trunks under Raintree Lake. In this table, PDWF refers to peak dry weather flow and PWWF refers to peak wet weather flow.

Table 2 - Tributary Flows and Capacity for Sewers Under Raintree Lake

		Tributary Flow Rates*				
Upstream Manhole/Tee	Downstream Manhole/Tee	PDWF + Infiltration (MGD)	PWWF (MGD)	Pipe Dia. (inches)	Slope (%)	Gravity Full Flow Capacity** (MGD)
63-900T	64-005	6.46	39.64	24	0.42%	8.80
63-908T	63-900T	5.76	36.25	24	0.15%	5.26
63-909T	63-908T	5.75	36.24	24	1.02%	13.71
63-910T	63-909T	5.67	35.87	24	0.14%	5.08
61-900T	63-910T	5.40	32.57	24	0.18%	5.76
61-901T	61-900T	5.20	31.78	24	0.50%	9.60
61-902T	61-901T	5.17	31.64	20	0.19%	3.64
61-903T	61-902T	4.45	28.11	20	0.21%	3.83
61-142	61-903T	4.34	27.58	20	0.27%	4.34
61-905T	61-142	4.34	27.57	16	0.24%	2.26
61-906T	61-905T	1.35	7.66	14	0.37%	1.96
61-002BS	61-906T	1.28	7.39	14	3.91%	6.38
60-001BS	61-905T	2.05	10.70	16	0.45%	3.09

* Tributary flow rates were obtained from the sanitary sewer model with the conditions of ultimate development and 50-year storm.

** Gravity full flow capacity calculated using Mannings formula and "n" = 0.014

Table 2 also shows the full flow gravity capacities of the main trunk sewers under Raintree Lake that are tributary to the North Sub-basin and the West Sub-basin. None of the sewers shown has the full flow gravity capacity to pass the PWWF. Therefore, the City decided to construct a regional excess flow holding basin to store peak flows.

Table 2 also shows that six of the thirteen sewers have the full flow gravity capacity to pass the PDWF. For this reason, the City has also decided to pursue the construction of a small pump station to pump a dry weather flow of approximately 1 MGD.

Currently, the North Sub-basin flows into an interceptor between the homes on east side of Ward Road and Raintree Lake. The capacity of one segment of that interceptor, from basket structure 61-906T to manhole 61-905T, is 1.96 MGD. As Table 1 shows, the future total peak flow from the North Sub-basin exceeds this pipeline's capacity by approximately 5.43 MGD. To prevent back-ups in the connected homes on the east side of Ward Road, the City has decided to construct a parallel relief sewer to transport the excess flow to the proposed facility for storage.

It is possible that the system under the lake can pressurize and, therefore, pass more flow than in a gravity condition. Further investigation was performed to quantify the increased capacity. System models were prepared using WaterCAD modeling software by Haestad Methods. This software is used to model systems under pressure. Within the model, reservoirs were used to represent all flows from upstream areas tributary to the main branches under the Lake. The hydraulic grade line of each reservoir was set at the top of pipe elevation within basket structure 61-002BS to model a realistic pressurization of the system without pressurization of the line upstream of 61-002BS.

Initial model runs resulted in flow contributions from the branch lines that exceeded the anticipated flows when fully developed. Therefore, flow control valves were added on each branch pipeline to limit the contribution of flow from each branch pipeline to the anticipated flow for ultimate development along that branch. The flow control valves were not added to the reservoirs at 61-002BS and New Junction Structure #1 (JS #1). These points represent the locations where flow from the North Sub-basin and West Sub-basin will enter the system.

Exhibits B and C reveal the resulting capacities of the system under pressure. Exhibit B represents the system capacity under the condition of peak dry weather flows with peak infiltration at ultimate development. Exhibit C represents the system capacity under a 50-year peak wet weather flow condition at ultimate development.

The results of the pressure system models reveal that at ultimate development, the system will have very limited capacity to pass the peak wet weather flow. When peak wet weather flows are entering the system, the North Sub-basin can pass 1.28 MGD of the anticipated peak flow of 7.39 MGD, and the West Sub-basin can pass 2.21 MGD of the anticipated 10.7 MGD.

The model also shows that the system has sufficient capacity to pass the entire peak dry weather and peak infiltration flows for both the North and the West Sub-basins. However, there is a concern about frequent pressurization of the system under the lake. The installation of a dry weather pumping station will allow the system under the lake to maintain primarily gravity flow conditions.

C. Gravity Sewer and Future Force Main

The focus of this project is the relief of two existing gravity interceptor sewers that connect under Raintree Lake. Connections to both sewers will divert flows to the proposed facility. Please refer to Exhibit A in the back pocket of this report for a site map depicting the proposed connections.

The west sewer, which serves the West Sub-basin, traverses across the south side of the proposed facility site, then crosses Ward Road and passes under Raintree Lake. An overflow connection to the pump station will be constructed on this interceptor as it passes by the proposed facility.

The north sewer, which serves the North Sub-basin, crosses southward between the homes on the east side of Ward Road and Raintree Lake before passing under the lake. An overflow connection to this interceptor will be constructed north of MH T-1. A new parallel relief gravity sewer will transport the overflow south along the west side of Ward Road to the proposed facility.

In the future, the dry weather pumps will discharge into a future force main that will follow the new gravity sewer to the north and discharge northwest of the intersection of 150 Highway and Ward Road. Further discussion of the gravity sewers and force main is in Chapter 2.

D. Holding Basin

The new 3.17 million gallon basin will be approximately 16 feet deep and approximately 410 feet long by 160 feet wide at its top banks. The basin will be lined with clay and grass. A 16 foot wide, asphalt access road will be constructed from Ward Road to the site adjacent to the east side of the overflow basin. A ramp to the interior of the basin will be constructed to facilitate access for maintenance vehicles.

The elevations of residential basements to the west of the basin site are only a few feet above the flow line of the sewer adjacent to the basin site. Therefore, the basin must be either "gravity in/pump out" or "pump in/gravity out". Because of the high ground water from Raintree Lake adjacent to the basin site, the holding basin will operate through a "pump in/gravity out" mode. Chapter 3 describes the overflow basin in more detail.

E. Pump Station Type and General Function

The proposed facility will have a submersible pump station. Initially, the station will act as a wet weather pumping station by diverting sewer surcharges from the two existing sewers into an overflow basin for temporary storage. The new pump station will include the construction of an additional wet well for the future installation of dry weather pumps to transport the 1-MGD dry weather flow to the Mouse Creek interceptor. Chapter 4 describes the pump station in more detail.

F. Design Criteria

The proposed facility and associated infrastructure will be designed based on Missouri Department of Natural Resources (MDNR) regulations as modified by the Lee's Summit Design and Construction Manual. The facilities sizing will be based on the following flow criteria:

1. Peak Dry Weather Flow

1,500 gallons per day per acre

2. Peak Infiltration

500 gallons per day per acre

3. Peak Inflow

$Q = K * i * A$, where inflow coefficient "K" is 0.006, the rainfall intensity "i" is in inches per hour and is based on the time of concentration, and "A" is the area in acres.

CHAPTER 2 - GRAVITY SEWER AND FUTURE FORCE MAIN

A. Bypass Gravity Sewer Alignment

The proposed improvement will be designed to pass normal dry weather flows to the Raintree Lake collection system and to divert peak excess wet weather flows to the proposed facility. The diversions will occur at two locations. The diversion structures will be designed to bypass excess flows without mechanically operated equipment. The structures will be constructed around the existing pipe. Based on the depth of flow in the pipe, an opening in the top of the pipe will be constructed to divert only the excess flow from the existing pipe.

Based on the modeling of the system under pressure, it is apparent that the elevations at which flow is diverted within each of the diversion structures are a critical element of this project. Initially, the proposed diversions should be operated in a manner to avoid capturing flows from nuisance storms. As development occurs within the tributary Sub-basins over the years, diversion overflows must be adjusted to assure surcharging does not occur in the sewers under Raintree Lake. To allow for changes to the amount of flow that bypasses into the proposed facility, the diversions will be designed to be adjustable.

Based upon our evaluation, we have determined that an initial setting within the structures should be one that diverts storms that exceed a 5-year storm event at 25% development. The corresponding flow rate for this event is 1.60 MGD from the north sub-basin and 2.40 MGD from the west sub-basin. If these settings lead to surcharging in the nearest downstream basket structures as development continues, the diversions can be adjusted to bypass more flow to the proposed storage facility.

The following text describes the two diversion structures and the associated relief sewers. Refer to Exhibit D for a schematic diagram of the various junction structure (JS) locations and gravity sewer connections.

One of the diversion structures, JS #1, will be located on the existing 14" DIP that serves the West Sub-basin. As shown on Exhibit D, the structure will be located near the proposed facility site. The diverted excess flow will flow to the proposed facility through a new bypass gravity sewer. The new sewer will be installed between JS #1 and JS #2 and between JS #2 and the wet well. The new gravity sewer connecting to the existing gravity sewer from the west is approximately 470 linear feet of 24-inch diameter pipeline.

A new bypass gravity sewer will provide a diversion of excess peak wet weather flows from the North Sub-basin to the proposed facility. The new sewer, referred to in exhibits as Line A, will begin at the second diversion structure, JS #5, on the existing sewer on the east side of Ward Road, then cross under Ward Road and follow south along the west side of the road toward the facility. As it approaches the proposed facility access road, it will turn to the west and parallel the access road to the site. The bypass sewer will connect into JS #2. Refer to Exhibit D. At JS #2, the flows will merge with excess flows from the West Sub-basin and continue to the pump station wet well as a single gravity sewer. Line A will consist of approximately 3,100 linear feet of 24-inch diameter pipeline. Exhibit A in the back pocket of this report depicts the proposed sewer alignment. Appendix A includes preliminary design spreadsheets for Line A and an approximation of the profile for the proposed sewer based on surface elevations obtained from 2001 aerial photography.

As shown in the profile included in Appendix A, portions of the sewer will exceed the typical maximum construction depth for normal excavation equipment of 20 feet. Some portions of the sewer can be installed utilizing a benching method in which the ground surface is cut or benched to a depth that allows the normal excavation equipment to construct the sewer trench. Because of the additional space required for benching methods, the temporary construction easement for the alignment along Ward Road will be a 100-foot wide corridor, generally adjacent to street right-of-way. However, the benching construction methods are not feasible in some areas where the new sewer passes between a few homes in close proximity to the street right-of-way. Therefore, horizontal boring will likely be required to minimize disturbance to property owners in these areas. The geotechnical investigation of the alignment will provide the information necessary to determine the most reasonable method of installing sewers at such significant depths.

B. Future Force Main Alignment and Size

The future force main alignment will follow adjacent to the new gravity sewer, east to Ward Road and north along the west side of Ward Road. It will continue approximately northward to the upstream end of the Mouse Creek Interceptor, which is located approximately 1 mile northwest of the intersection of Ward Road and Missouri Route 150.

The key factor that determines the size of the future force main is the sewage velocity within the pipeline. In order to minimize the buildup of grit, a minimum velocity of about 2 feet per second is desirable. The maximum velocity should not exceed about 8 feet per second because of the high head losses and the possibility of water hammer that results. The entire range of anticipated flows over the life of the station should be considered when analyzing velocities within the force main. The dry weather pumps will likely be variable frequency drive (VFD) submersible pumps to accommodate the variance in dry weather inflows over the life of the station. Based upon preliminary sizing of the VFDs, the lowest anticipated flow through the future force main is approximately 600 gpm, while the highest flow is approximately 1400 GPM. The most reasonable size of force main to accommodate the full range of anticipated flows from the future dry weather pumps is 12-inches in diameter. The new pump station will include cast-in-place wall pipes to facilitate the future installation of this force main.

CHAPTER 3 - EXCESS FLOW HOLDING BASIN

A. Construction

The basin will be graded into a gradual hillside on the north side of Raintree Lake, approximately 800 feet west of Ward Road. It will have 3:1 side slopes and an eight-foot wide berm. The bottom of the basin will be sloped at 2% to a cast-in-place concrete outlet structure at the east end of the basin. A 7:1 sloped ramp will be graded into the basin for maintenance vehicle access. The basin will have 2-feet of freeboard above the high water level.

The basin will be lined with clay to prevent the seepage of sewage into the soils below the basin. The liner thickness will be determined based on soils testing and Missouri Department of Natural Resources guidelines. An additional 6 inches of clay will be compacted on top of the liner, scarified and then overlaid with 6 inches of topsoil. Erosion control blanket and turf-type fescue seed on the basin surface will prevent erosion.

B. Basin Sizing

Based on discussions with the City Council, the basin is to be sized to contain peak excess flow from a 100-year storm with one foot of freeboard to the top of berm elevation. The basin size was calculated as follows:

West Sub-basin:

Peak Dry Weather Flow = (1500 GPD/Ac) * 1,026 Ac = 1,539,000 GPD (1)

Peak Infiltration = (500 GPD/Ac) * 1,026 Ac = 513,000 GPD (2)

Peak Inflow, Q = k * i* A * 1.0083

Where, k = Inflow Coefficient = 0.006 (for City of Lee's Summit)

t_c = Time of Concentration = 18.43 * $A^{0.2524}$ = 106 minutes

i = 100-year Rainfall Intensity = 2.357333 inches/hour

Peak Inflow, Q = 14.63 CFS = 9.46 MGD (3)

West Sub-basin 100-year Peak Flow = Peak Dry Weather Flow + Peak Infiltration + Peak Inflow = (1) + (2) + (3) = 11.5 MGD

Total Rainfall = $(T_c/60)*i_{100}$ = (106 min/60 min/hr)*(2.357333 in/hr) = 4.16 in

Assuming that 1.5% of the rainfall enters sanitary sewer collection system, the volume of inflow entering the collection system = Rainfall entering * 0.015 * Area

= (4.16 * 0.015 / 12) * (1026 Acres * 43560 ft^2/Acre) * (7.48 gallons/ft^2)

= 1,738,362 gallons or 1.74 MG (4)

North Sub-basin

Peak Dry Weather Flow = (1500 GPD/Ac) * 637 Ac = 955,500 GPD (5)

Peak Infiltration = (500 GPD/Ac) * 637 Ac = 318,500 GPD (6)

Peak Inflow, Q = k * i* A * 1.0083

Where, k = Inflow Coefficient = 0.006 (for City of Lee's Summit)

t_c = Time of Concentration = 18.43 * $A^{0.2524}$ = 94 minutes

i = 100-year Rainfall Intensity = 2.714667 inches/hour

Peak Inflow, Q = 10.46 CFS = 6.76 MGD (7)

North Sub-basin 100-year Peak Flow = Peak Dry Weather Flow + Peak Infiltration + Peak Inflow = (5) + (6) + (7) = 8.03 MGD

Total Rainfall = $(T_c/60)*i_{100}$ = (94 min/60 min/hr)*(2.714667 in/hr) = 4.25 in

Assuming that 1.5% of the rainfall enters sanitary sewer collection system, the volume of inflow entering the collection system = Rainfall entering * 0.015 * Area

= (4.25 * 0.015 / 12) * (637 Acres * 43560 ft^2/Acre) * (7.48 gallons/ft^2)

= 1,102,625 gallons or 1.10 MG (8)

Total, combined 100-year Peak Flow for both basins = (1) + (2) + (3) + (5) + (6) + (7) = 19.53 MGD (30.22 CFS)

Total, combined volume of inflow entering the collection system = (4) + (8) = 2.84 MG

Total, combined peak inflow = (3) + (7) = 25.09 CFS

The inflow hydrograph is assumed to be a triangle with the peak inflow occurring at the time of concentration. The duration of inflow hydrograph is calculated as follows:

Inflow hydrograph duration =

= 2 * (Volume Rain Entering System / (Peak Inflow * (7.48/1,000,000))) / 3600 sec/hour

= 2 * (2.84 MG / (25.09 CFS * (7.48/1,000,000))) / 3600 = 8.41 Hours

Peak inflow entering the basin is the Total Peak Flow minus flow allowed to continue on to the Raintree Lake sewers (see Page 4) = 19.53 MGD – 1.28 MGD – 2.21 MGD = 16.04 MGD (24.83 cfs)

The duration of the flow into the basin is calculated by looking at the portion of the inflow hydrograph that is stored. The upper part of the inflow hydrograph triangle is allowed to flow to the Raintree Lake sewers and the remaining upper part is diverted to storage. The duration of the flow into the basin is calculated as follows using the Theorem of Similar Triangles:

Duration of flow into basin = (Duration of Inflow Hydrograph / Peak Inflow) * (Peak Flow Entering the Basin)

= (8.41 Hrs / 25.09 CFS) * (24.83 cfs) = 8.32 Hrs

Knowing the duration that flow entering the basin and the peak flow entering the basin, the required basin volume is calculated as follows:

Total Stored Volume = (Total Peak Flow Entering the Basin) * 0.646 * Duration of flow into basin / 24 / 2

= (30.22 cfs) * 0.646 * 8.32 Hrs / 24 / 2 = 3.38 MG

C. Description of Operation

The following text describes the operation of the basin. Please see Exhibit D for the arrangement of the piping and structures referred to in the descriptions.

1. Basin Fill Sequence

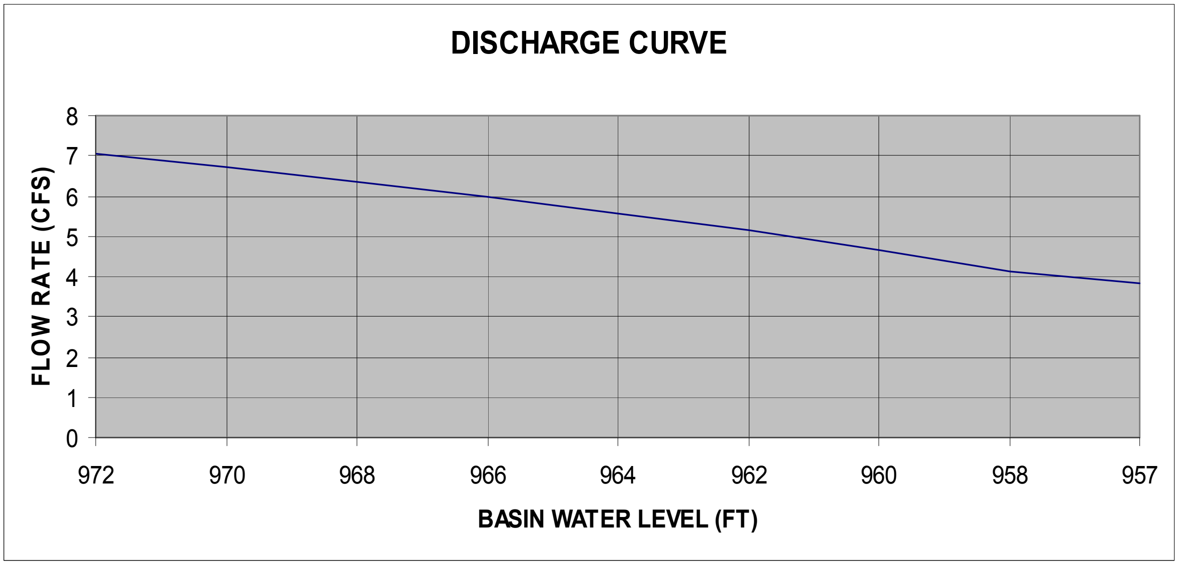
During the normal operation, the basin will store flow only during wet weather events. During a wet weather event, excess flow that overflows from the Junction Structure No. 1 and No. 5 will flow to the pump station wet well. The wet weather pumps in the pump station will lift the flow up to the basin. A normally closed, automated valve on the outlet in Junction Structure No. 3 will prevent discharge from the basin. An ultrasonic sensor located in the basin will allow City staff to monitor depth of water in the basin at a local control panel and the SCADA system.

2. Basin Drain

Discharge from the basin will not be initiated automatically. City staff, through either the local control panel or the SCADA system, will initiate the process of draining the basin. When the basin draining process has been initiated, the normally closed outlet valve will open. The flow from the outlet pipe will drain to JS #4 on West Sub-basin interceptor, then to the collection system under Raintree Lake. JS #4 will have a Tide-Flex check valve on the existing interceptor to the west to prevent flow from surcharging back to JS #1 and then to the wet well.

The discharge pipe from the basin outlet structure to JS #3 will be an 8-inch diameter pipe. With the basin full, this 8-inch pipe flowing flow will pass approximately 7 cfs.

The following chart shows the discharge curve for this 8-inch pipe based on varying depths of flow in the basin.



Because this flow rate is greater than the capacity of downstream and pipes less than 8-inch are not commonly used in sanitary sewer systems, a manually-operated sluice gate will be installed on the head of the 8-inch pipe at the outlet structure to allow throttling of the flow leaving the basin.

If the excess flows to the wet well cause the wet weather pumps to begin operation while the draining process is ongoing, the outlet valve will return to the normally closed position and remain in that position until City staff has re-initiated the draining process.

If the local control panel receives a signal from the ultrasonic level sensor in the basin indicating that the basin has been drained for 60 minutes, the local control panel will return the basin drain valve to the normally closed position.

CHAPTER 4 - PUMP STATION

The following text describes the pump station. Please see Exhibit D for the arrangement of the wet well, valve vault, and other structures referred to in the descriptions.

A. Station Type and Layout

The pump station will be designed with a self-cleaning, trench type wet well. The wet well will have two parallel trenches, one for wet weather pumps and one for future dry weather pumps. All pumps will be submersible pumps.

The wet weather pumps will pump directly into the basin. Each pump will have a separate discharge pipe that will discharge into the discharge channel. To prevent flow from returning to the wet well through pumps that are not operating, tide flex check valves will be constructed on the end of each discharge pipe.

The future dry weather pumps will pump through future, separate discharge piping into a valve vault in the basement of the electrical building. The future discharge pipes will connect into a future header in the valve vault. The future header will connect to the future force main to the Mouse Creek Interceptor.

Access to the pumps in the wet wells for maintenance will be available through access hatches on top of the wet well. The top of the wet well will be approximately two feet above grade to avoid the potential for vehicles to drive on the top of the wet well. Two exposed gooseneck pipes on opposite corners of the top of the wet well will provide ventilation. Both of the gooseneck pipes will have flanged connections to allow the potential future connection of an odor control system.

The valve vault will be located below grade with the electrical building built above the valve vault. The valve vault and electrical building will be located on the east side of the wet well. The motor control center will be located inside the electrical building on the north wall and an emergency power generator will be located on the north side of the building. The future force main will exit the valve vault through the south wall. Piping and valves for the force main will be installed in the future, but spool pieces will be cast in the walls to facilitate the future installation. The piping and electrical conduits between the wet well and the valve vault will be installed with this project.

The layout of the pump station took into consideration access for maintenance vehicles as well as drainage from the site.

B. Station Operation and Function Prior to Dry Weather Pump Installation

Initially, the proposed pump station will capture only excess flows that surcharge from the existing, undersized gravity sewers under Raintree Lake. Diversion structures will collect excess flows and convey them to the new pump station where wet weather pumps will discharge the flows into the excess flow holding basin.

The wet weather pumps will be sized for an anticipated peak wet weather flow of 14.6 MGD.

West Sub-basin:

Peak Dry Weather Flow = (1500 GPD/Ac) * 1,026 Ac = 1,539,000 GPD

Peak Infiltration = (500 GPD/Ac) * 1,026 Ac = 513,000 GPD

Peak Inflow, Q = k * i* A * 1.0083

Where, k = Inflow Coefficient = 0.006 (for City of Lee's Summit)

t_c = Time of Concentration = 18.43 * $A^{0.2524}$ = 106 minutes

i = 50-year Rainfall Intensity = 2.1573333 inches/hour

Peak Inflow, Q = 13.39 CFS = 8.65 MGD

West Sub-basin 50-year Peak Flow = Peak Dry Weather Flow + Peak Infiltration + Peak Inflow = 10.70 MGD

North Sub-basin:

Peak Dry Weather Flow = (1500 GPD/Ac) * 637 Ac = 955,500 GPD

Peak Infiltration = (500 GPD/Ac) * 637 Ac = 318,500 GPD

Peak Inflow, Q = k * i* A * 1.0083

Where, k = Inflow Coefficient = 0.006 (for City of Lee's Summit)

t_c = Time of Concentration = 18.43 * $A^{0.2524}$ = 94 minutes

i = 50-year Rainfall Intensity = 2.456 inches/hour

Peak Inflow, Q = 9.46 CFS = 6.11 MGD

North Sub-basin 50-year Peak Flow = Peak Dry Weather Flow + Peak Infiltration + Peak Inflow = 7.39 MGD

Total, combined 50-year Peak Flow for both basins = 18.09 MGD

* Sewer system can pass 3.49 MGD (refer to Exhibit B)

Firm capacity of wet weather pumps = 18.09 MGD – 3.49 MGD = 14.6 MGD

Two pumps will be used to pump the firm capacity of 14.6 MGD. The station will include a third wet weather pump for redundancy as required by the Missouri Department of Natural Resources. If all three pumps operate simultaneously, the station will pump 21.9 MGD into the basin. This will allow the station to pump more than the 100-year flow rate.

As described above, the pump station wet well will have two parallel trenches, one for the wet weather pumps and one for future dry weather pumps. A weir wall will separate the wet well trenches for the wet weather pumps and the future dry weather pumps. When dry weather pumps have been installed in this station, the dry weather flow will normally be confined in the dry weather pump intake trench.

Since this pump station will not have dry weather pumps initially, flows entering this station will cause the dry weather wet well trench to fill and spill over the weir wall into the wet weather trench where the water level will continue to rise until the wet weather pumps activate. The wet weather pumps will each discharge individually into a collection channel adjacent to the overflow basin. The collection channel will fill and spill over a weir on the west wall and into the holding basin.

As excess flows to the station subside, the wet weather pumps will draw the level down to a predetermined pump "off" level and the local control panel will stop the pump(s). To dewater the wet well, a sump pump will be temporary installed in the dry weather trench to dewater the trench by pumping the remaining flow into the wet weather trench. A permanently installed sump pump located at the north end of the wet weather trench, will dewater the trench by pumping flow into JS #3. Both sump pumps will operate continuously while there is liquid in the trenches.

The following calculations are based upon the HI's design guidelines and define the layout in the wet weather trench:

Suction bell diameter, D = 23.5" = 1.96'

Minimum pump spacing = 2.5 * D = 58.75"

Depth from floor to bottom of suction bell for the furthest pump from the gravity sewer inlet, D/4 =5.875"

Depth from floor to bottom of suction bell for the closest pump from to the gravity sewer inlet, D/2 = 11.75"

Velocity entering suction bells, $V = Q/A = (5{,}900 \text{ gpm} / (448.83 \text{ cfs/gpm})) / (PI * 1.96^2 / 4) = 4.4$ ft/sec

$F_D = V * (g * D)^{-0.5} = 4.4 * (32.2 * 1.96)^{-0.5} = 0.554$

Submergence = $(1 + (2.3 * F_D)) * D$ = 4.46' = 53"

Trench width = 2 * D = 3.92' = 47"

Height of trench = 2 * D + D/2 = 4.9’ = 59”

C. Station Operation and Function after Dry Weather Pump Installation

As described in Chapter 1 of this Design Memorandum, the existing interceptor under Raintree Lake will be overloaded by both peak wet weather flows and dry weather flows. In addition to the storage of excess wet weather flows in the basin, the City has decided to plan for the pumping of some portion of the dry weather flows. The City is planning for the pump station dry weather pumping capacity to be the difference between the interceptor capacity and the dry weather flows. This difference is approximately 2 MGD.

As shown in Table 2, the peak dry weather flow from the West Sub-basin is approximately 2.05 MGD and the peak dry weather flow from the North Sub-basin is approximately 1.28 MGD. Therefore, the future dry weather pump capacity will be based on the diverting the dry weather flow from the West Sub-basin.

When the dry weather pumps are installed, the temporary sump pump will be removed from the dry weather wet well to allow for the suction of the northernmost dry weather pump to be lowered into the sump pit of the wet well. As the dry weather pumping capacity is exceeded and the levels in the wet well continue to increase, the wet weather pumps activate and discharge into the holding basin for temporary storage.

The design of dry weather wet well trench and layout of the pumps will follow the Hydraulic Institute’s (HI) Pump Intake Design guidelines. According to the HI, the special geometric design features of the wet well provide for “cleaning of the structure to remove material that would otherwise be trapped and result in undesirable conditions.”

The dry weather trench will be located in line with the incoming gravity sewer pipe. A transition area upstream of the wet well will transition the flow from the circular channel of the pipe to a rectangular channel. A laminar flow condition develops before the flow reaches the wet well. Under normal flow conditions, the flow will surcharge into the upstream pipe. This allows the flow to dissipate energy before reaching the dry weather intake trench. When the flow enters the wet well, the entrance velocity is less than it was when it entered the upstream pipe. These smaller velocities will decrease the occurrence of vortices within the wet well trench.

The following calculations are based upon the HI’s design guidelines and define the layout in the dry weather trench:

Suction bell diameter, D = 13.5” = 1.125’

Minimum pump spacing = 2.5 * D = 33.75”

Depth from floor to bottom of suction bell for the furthest pump from the gravity sewer inlet, D/4 = 3.375”

Depth from floor to bottom of suction bell for the closest pump from to the gravity sewer inlet, D/2 = 6.75”

Velocity entering suction bells, V = Q/A = (1,050 gpm / (448.83 cfs/gpm)) / (PI * 1.125^2 / 4) = 2.4 ft/sec

$F_D = V * (g * D)^{-0.5} = 2.4 * (32.2 * 1.125)^{-0.5} = 0.399$

Submergence = (1 + (2.3 * F_D)) * D = 2.16’ = 26”

Trench width = 2 * D = 2.25’ = 27”

Height of trench = 2 * D + D/2 = 2.813’ = 33.75”

Top radius on ogee curve, r_1 = 2.33 * (Head on sluice gate, assuming 2’) = 4.66’

Bottom radius on ogee curve, $r_2 = 0.5 * r_1$ = 2.33’

D. Wet Weather Pump Exercising Operation

It is anticipated that the wet weather pumps will operate only a few times a year. In order to insure proper operation when required, the wet weather pumps will need to be exercised on a monthly basis. The new station’s design will allow the City to exercise the pumps throughout the year during normal or low sewer flow conditions.

To exercise the wet pumps, sufficient flow must enter the wet well to allow the pump to run continuously for at least 30 minutes. The design will employ the normal flow from the interceptor that passes by the site from the West Sub-basin. An automated knife gate valve will be installed in JS #1 on the outlet to the Raintree Lake sewers. When the cleaning cycle is initiated, this valve will close to cause all flow to overflow in JS #1 and drain into the wet well.

Since odors are a major concern, the exercising operation must avoid unnecessarily filling the holding basin with any sewage. A collection channel will be constructed along the wet well at the pump discharge points to contain the flow used for exercising. At the north end of the collection channel, an automated sluice gate will be installed to allow flow contained within the collection channel to reenter the wet well during the exercising process. The automated sluice will open at the beginning of the exercise operation and close when the exercise operation is complete.

When the wet well levels rise and the selected wet weather pump activates, the pumped flow will discharge into the collection channel, drain out of the open sluice gate back into the wet well. The cyclical process continues until a time delay in the local panel shuts down the wet weather pump and opens the knife gate valve in JS #1. After the sump pumps finish draining the wet well into JS #3 and on to the gravity sewer, the sluice gate on the collection channel closes and the station returns to normal operation.

E. Pumps and Motors

The station will initially be equipped with wet weather submersible pumps consisting of two duty pumps and one standby pump to accept wet weather flows. Each pump will be capable of operating at 5,900 gpm and approximately 40 feet of total dynamic head. The simultaneous operation of two pumps will provide 17 MGD of pumping capacity. The pumps will have 16-inch suction and discharge diameters and the motors will be 100 horsepower. The pumps will share a common wet well and discharge individually into the collection channel adjacent to the overflow basin.

Chapter 4 includes calculations that show the firm capacity of the wet weather pumps for the station to be 14.6 MGD. The station will include a third wet weather pump for redundancy as required by the Missouri Department of Natural Resources. If all three pumps are operated simultaneously, the station can pump 21.9 MGD. This will allow the station to pump more than the 100-year flow rate.

The dry weather pumps will be installed at a later date and pump into a future force main. They will consist of one duty and one standby pump to accept average daily flows of 1 MGD. The dry weather pumps will also share a common wet well.

A small temporary submersible grinder sump pump will be installed in the dry weather wet well and discharge into the wet weather wet well. It will be removed in the future when the dry weather pumps are installed. At that time, the volute of the northernmost dry weather pump will be installed at a slightly lower elevation in the sump of the wet well trench in order to drain the wet well.

A small permanent submersible grinder sump pump will be installed in the wet weather wet well, discharging into JS #3.

F. Electrical System

1. Emergency Power Generator

The pump station will include an emergency generator for backup power during a power outage or temporary interruption of power. The enclosure will be sound rated for 85 dB at full load 3'-4" from the sound source. The generator will operate in parallel with the electric utility and activated by an automatic transfer switch. The fuel cell for the generator will be a double-wall, belly tank. Lighting in and around the generator will work on both generator power and emergency battery power.

2. Motor Controls

The pumps operation will be activated and deactivated by water elevations in the wet wells. Pump manufacturers make recommendations for maximum pump starts per hour and minimum cycle times for their pumps. The number of starts per hour for submersible pumps typically is not more than ten starts per hour. Ten starts per hour equates to a minimum pump cycle time of 6 minutes. The wet wells will be sized to store sewage volumes that are sufficient to allow the selected pumps to meet this minimum cycle time requirement. The pump controls will provide alternation of the pumps to prevent uneven wear on one pump and to minimize the sewage volumes required for minimum cycle time.

Ultrasonic level sensors located in the wet wells communicating with programmable logic controllers (PLCs) in the motor control center will activate the pumps. The wet weather "lead pump on" elevation will be set based upon a pumping capacity of 5,900 gpm. The wet weather "lag pump on" elevation will be set based upon a pumping capacity of 11,800 gpm.

Float switches or pressure transducers located in the wet wells communicating with programmable logic controllers (PLCs) in the motor control center will also activate the temporary and permanent submersible sump pumps.

All power and control cables for the pumps located in the wet well will be connected to junction boxes that are side-mounted to the exterior of the wet well walls for ease of removal.

3. **Flow Metering**
The valve vault will be sized to allow the installation of a meter on the future force main prior to exiting the vault.

4. **Telemetry Systems and Alarms**
A connection to the Supervisory Control and Data Acquisition (SCADA) system will allow City staff to remotely monitor all pumps, the levels in the wet well and the overflow storage basin, the automated sluice gates, and the emergency generator. The pumps will be controlled locally and remotely. The local control panel will be capable of functioning without the connection to the SCADA system and will incorporate a programmable logic controller (PLC) and a panel front display.

G. Valve Vault and Electrical Building

The valve vault and electrical building will be a single-story building with a below-grade valve vault located on the east side of the pump station wet well.

The valve vault will be below grade and accessible from the electrical building by an interior stairwell on the east side of the building. Floor drains with P-traps will drain any nuisance water from the valve vault to the wet well. The floor drain traps will be filled with glycerin to prevent wet well gases from backing up through the floor drains and into the valve vault and electrical building. Tide-flex check valves will be installed on the drain lines inside the wet well to prevent the migration of odors and the backup of sewage from the wet well. In the future, when the dry weather pumps and force main are installed, the valve vault will contain swing check valves and plug valves for isolation.

The electrical building will be constructed of architectural cement masonry unit walls with a standing seam metal roof, pre-finished gutters and downspouts, and a vault skylight with domed ends. The building encloses the motor control panels, pump controls, alarm equipment and generator transfer switch. A monorail crane will be located inside the building to facilitate the removal of valves from the below-grade valve pit for maintenance. The monorail will guide the valves through floor access hatches and to double doors located on the south side of the electrical building where they can be loaded onto a maintenance vehicle.

H. Finishes

The station finishes will be as follows:

Station Component	Planned Finish
Exterior cast-in-place concrete - exposed	Curing compound only
Exterior cast-in-place concrete - below grade	Asphalt waterproofing
Exterior concrete masonry unit	Waterproofing only (color per city's direction)
Standing seam metal roof, guttering, and flashing	Baked enamel with clear coat (color per city's direction)
Interior cast-in-place concrete Electrical Building / Valve Vault	Polyamide epoxy (white color)
Interior Wet Well	Epoxy manhole liner (white color, if possible)
Interior drywall	Polyurethane (white color)
Exposed metal	Polyamide epoxy (brown color for raw sewage)