

LEE'S SUMMIT FIRE STATION #3

MICRO STORM WATER DRAINAGE STUDY

Storm Water Drainage Study Submitted: January 16, 2018

Proposed Fire Station located in:
SE ¼ of Section 2, Township 47N, Range 32W
Lee's Summit, Jackson County, Missouri

Little Blue River Watershed

Prepared For:
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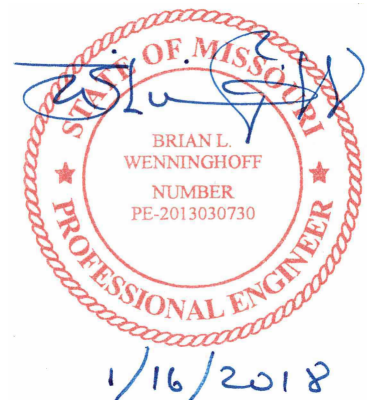


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1. General Information

Lee's Summit Fire Station #3 is a proposed fire station to be constructed on 2.23 acres of land. The property is just west of Pryor Road and a quarter mile north of SW 3rd Street. This locates the development within the southeast ¼ of Section 2, Township 47N, Range 32W in the Little Blue River watershed of Kansas City, Jackson County, Missouri. This 2.23 acre lot falls inside the overall 64 acre parcel number: 62-240-99-01-00-0-00-000.



Lee's Summit Fire Station #3 Vicinity Map

FEMA Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0416G classifies the Lee's Summit Fire Station #3 property as a "Zone X" Area. Zone X is the FEMA flood insurance rate zone that corresponds to "areas outside the 0.2-percent annual chance floodplain. Refer to Exhibit 1 for Floodplain Map depicting plat location with respect to designated floodplains.



Image taken from FEMA Floodway Map Community Panel Number 29095C0416G

2. Methodology

This Micro Stormwater Drainage Study has been prepared to analyze and fulfill all storm water requirements as specified by Section 5600 of the Kansas City Metropolitan Chapter – American Public Works Association (APWA) Standard Specifications & Design Criteria for comprehensive control.

The following methods were used in this study to model proposed conditions for storm water runoff:

- Haestad Methods, Inc. "PondPack" v8i
TR-55 Unit Hydrograph Method
 - 2-year, 10-year, and 100-year Return Frequency storms
 - 24-Hour SCS Type II Rainfall Distribution
 - SCS Runoff Curve Numbers per SCS TR-55
 - SCS TR-55 Methods for determination of Time of Concentration and Travel Time

3. Existing Conditions:

Under existing conditions the site is an undeveloped pervious open field. A small portion of the site naturally drains west while the majority of the site drains east towards NW Pryor Road.

4. Proposed Conditions:

The Proposed Conditions PondPack Model will show the Lot 1 site under proposed conditions. The proposed fire station will be located centrally on the lot. At the south end of the lot will be an extended dry detention pond labled Pond A. Through the use of sheet flow, concentrated curb flow and roof drains water will be conveyed to the pond from the majority of the proposed development. A small narrow portion on the west side of the proposed development will flow undetained offsite which maintains the original drainage pattern of the watershed.

Refer to Exhibit 1 for proposed conditions. Below is a summary of the subareas analyzed under proposed conditions.

Proposed Conditions - Watershed Summary									
Watershed	Subarea	Pervious Area (acres)	Impervious Area (acres)	Total Area (acres)	Pervious CN:	Impervious CN:	Composite Subarea CN:	Tc (hrs)	Notes
1	Lot 1	0.22 0.68	0.15 1.18	0.37 1.86	74 74	98 98	83.73 89.23	0.100 0.100	Lot 1 - Undetained Lot 1 - Detained by Pond A
		0.90	1.33	2.23					

5. Water Quality Volume Analysis with 40-hour Extended Detention

Section 5600 of the Kansas City Metropolitan Chapter – APWA Standard Specifications & Design Criteria states that for comprehensive control a 40-hour extended detention time must be achieved for the water quality volume. First, to calculate this water quality volume the proposed conditions outlined above and the methods outlined in chapter 6 of the 2012 BMP Manual were applied below.

Required Water Quality Treatment Volume												
Watershed	Subarea	Treatment Notes	Pervious Area (acres)	Impervious Area (acres)	DA =	DA =	I =	P =	Volumetric	Required WQ	Required WQ	Required WQ
					Total	Total	Percent Site	KC Metro	Runoff	Treatment	Treatment	Treatment
					Area	Area	Impervious	WQ Event	Coeficient	Volume	Volume	Volume
					(ft ²)	(acres)	%	(in)	Rv =	WQv =	WQv =	WQv =
									0.05 + 0.009I	P(Rv)	1.37*(Rv)(DA)	1.37*(Rv)(DA)
										(in)	(ac-ft)	(ft ³)
1	Lot 1	Lot 1 - Undetained	0.22	0.15	16,117	0.37	40.5%	1.37	0.415	0.568	0.018	763
		Lot 1 - Detained by Pond A	0.68	1.18	81,022	1.86	63.4%	1.37	0.621	0.851	0.132	5,744
Total			0.90	1.33	97,139	2.23						6,507

This yields a required water quality treatment volume of 6,507 ft³.

The extended dry detention pond will have 3:1 side slopes. The volume of the pond is approximately 1.158 acre-ft. The proposed elevation-area-volume table below for Pond A shows that the required water quality treatment volume is exceeded at elevation 971.20.

Pond A - Elevation-Area-Volume Table					
Elevation	Notes	Area ft ²	Area acres	Volume ft ³	Volume ac-ft
969.20	Bottom Orifice on Perf Riser	20	0.000	0	0.000
970.00	WQv Treatment El.	2,555	0.059	1,030	0.024
971.20		7,771	0.178	7,226	0.166
972.00		9,642	0.221	14,191	0.326
973.00		11,237	0.258	24,630	0.565
974.00		12,890	0.296	36,694	0.842
975.00	Top of Pond	14,608	0.335	50,443	1.158

Using this water quality treatment depth of two feet (971.20 – 969.20), the maximum allowable orifice diameter was calculated for a single orifice according to the 2012 BMP Manual.

Pond A - Single Orifice 40 Hour Extended Detention for Water Quality Volume		
Z_{wq} = WQv Treatment Depth Above Orifice =	2.00	ft
H_{wq} = Ave. Head of WQv Above Orifice = $0.5(Z_{wq})$ =	1.00	ft
WQv = Water Quality Volume =	7,226	ft ³
WQv = Water Quality Volume =	0.166	acre-ft
Extended Detention Time =	40	hrs
Q_{wq} = $(WQv(43,560))/(40(3600))$ =	0.050	cfs
C_o = Orifice Discharge Coefficient =	0.66	
π =	3.14	
D_o = Maximum Allowable WQ Orifice Diameter		
$D_o = 12(2)(Q_{wq}/(C_o(\pi)(2gH_{wq})^{-5}))^{-5} =$	1.32	inches

TOO SMALL

However, at 1.32 inches this diameter is smaller than the required 2" single orifice diameter. Instead a perforated riser will be used to achieve the 40-hour detention time for the water quality event according to the 2012 BMP Manual on the following page.

Pond A - Perforated Riser 40 Hour Extended Detention for Water Quality Volume		
Z_{wq} = WQv Treatment Depth Above Lowest Orifice (should be between 2 and 5 feet) =	2.00	ft
WQv = Water Quality Volume =	7,226	ft ³
WQv = Water Quality Volume =	0.166	acre-ft
Recommended Max Outlet Area per Row = A_o $A_o = WQv / (0.013(Z_{wq})^2 + 0.22(Z_{wq}) - 0.10) =$	0.42	in ²
Circular perforation diameter per row assuming a single column, D_1 (in) =	0.73	in
Number of columns (optimally 1), n_c =	1	column
Design circular perforation diameter (should be between 1 and 2 inches), D_{perf} (in) =	1.00	in
Number of rows (4" vertical spacing between perforations, center to center), n_r =	6.00	rows
Orifice 1 Flowline Elevation	969.20	
Orifice 2 Flowline Elevation	969.53	
Orifice 3 Flowline Elevation	969.87	
Orifice 4 Flowline Elevation	970.20	
Orifice 5 Flowline Elevation	970.53	
Orifice 6 Flowline Elevation	970.87	

This calculation produced six one inch diameter orifices to achieve the 40-hour detention time for the water quality event. In addition to the orifice design the drainage structure is 24" diameter perforated riser pipe with a top elevation of 972.75. The riser is then drained with an approximately 290 foot run of 12" RCP pipe that ties into the existing City storm water system.

6. Storm Water Detention Analysis

For storm water detention and peak flow management The City of Lee's Summit requires comprehensive flood control under section 5608 of the February 16, 2011 issue of "APWA Section 5600". This section specifies that this development's maximum release rate for post-development peak discharges shall be as follows:

- 50% (2-year) storm peak rate less than or equal to 0.5 ft³/s per site acre.
- 10% (10-year) storm peak rate less than or equal to 2.0 ft³/s per site acre.
- 1% (100-year) storm peak rate less than or equal to 3.0 ft³/s per site acre.

For the Kansas City area the 2-year, 10-year and 100-year 24-Hour SCS Type II rainfall depths are 3.5 inches, 5.3 inches and 7.7 inches respectively.

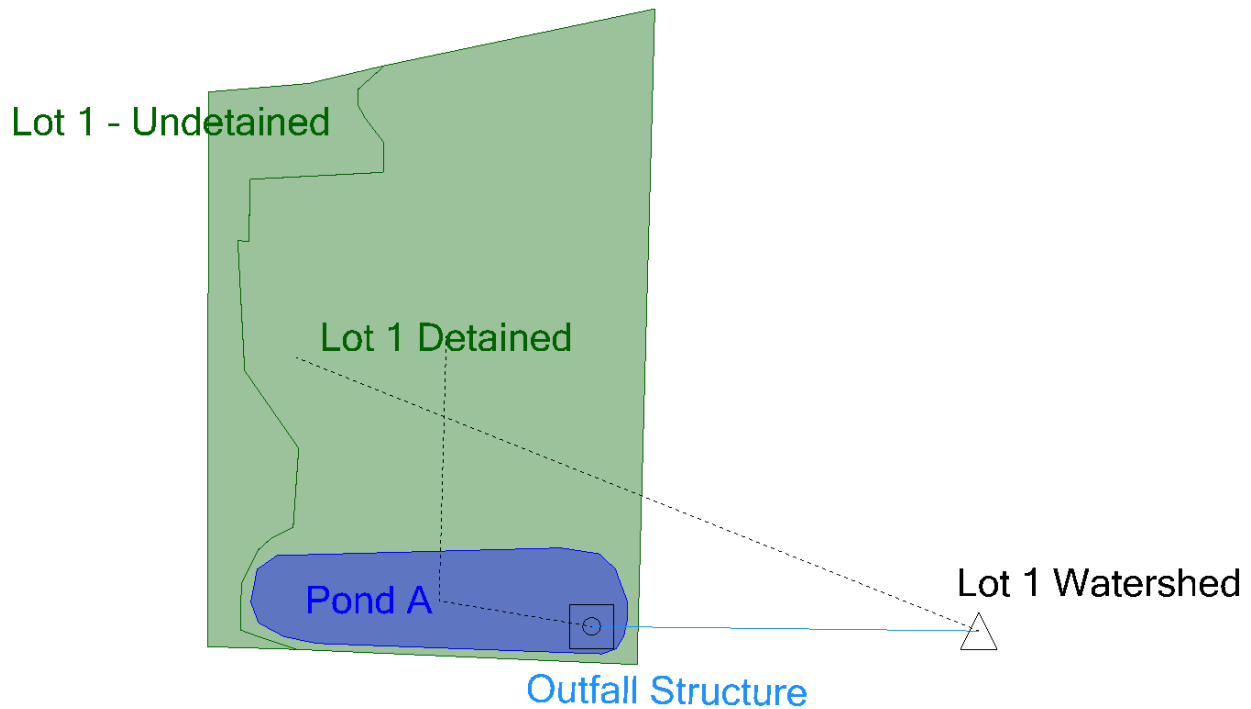
Modeling these three storms for Lot 1 (Watershed 1) yields the following table. Summing the proposed peak discharges of both the detained and undetained portions of the site yields results of 1.20 ft³/s, 2.16 ft³/s and 3.38 ft³/s.

Watershed 1 Proposed Peak Discharges					
Subarea	Return Event	Drainage Area	Allowable Proposed Peak Discharge*	Allowable Proposed Peak Discharge	Proposed Peak Discharge
	(years)	(acres)	(cfs/acre)	(cfs)	(cfs)
Lot 1	100	2.23	3.00	6.69	3.38
	10	2.23	2.00	4.46	2.16
	2	2.23	0.50	1.12	1.20

These proposed peak discharges are half of their respective allowable peak discharge rate except for the 2-year event. The 2 year event was exceeded by 0.08 ft³/s. While this is a minor exception it can be seen below that the proposed Pond A has more than 2 feet of freeboard for all events which provides exceptional flood protection during extreme events.

Extended Dry Detention Pond Freeboard			
Pond	Return Event	Max Water Surface Elevation	Freeboard
	(years)	(ft)	(ft)
Pond A	100	973.00	2.00
	10	972.48	2.52
	2	971.56	3.44

Proposed Conditions Model



Proposed Conditions – 2-Year Event

Scenario Summary				Storm Summary			
Scenario:	TR-55 (KC Metro) - Synthetic Curve, 2 yrs			Return Event Tag:	2_YR		
Output Increment:	0.010	hours		Total Depth:	3.5	in	
Duration:	35.000	hours		Rainfall Type:	Time-Depth Curve		
				Storm Event:	Typell 24hr (3.5 in)		

Executive Summary [Nodes]				Executive Summary [Links]				Messages			
	Label	Scenario	Return Event (years)	Truncation	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft ³ /s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)		
1	Lot 1 - Undetained	TR-55 (KC Metro) - Synt...	2	None	0.059	11.930	1.08	(N/A)	(N/A)		
2	Lot 1 Detained	TR-55 (KC Metro) - Synt...	2	None	0.369	11.930	6.63	(N/A)	(N/A)		
3	Lot 1 Watershed	TR-55 (KC Metro) - Synt...	2	None	0.356	11.940	1.20	(N/A)	(N/A)		
4	Pond A (IN)	TR-55 (KC Metro) - Synt...	2	None	0.369	11.930	6.63	(N/A)	(N/A)		
5	Pond A (OUT)	TR-55 (KC Metro) - Synt...	2	None	0.297	14.840	0.19	971.56	0.239		

Proposed Conditions – 10-Year Event

Scenario Summary		Storm Summary	
Scenario:	TR-55 (KC Metro) - Synthetic Curve, 10 yrs	Return Event Tag:	10_YR
Output Increment:	0.010 hours	Total Depth:	5.3 in
Duration:	35.000 hours	Rainfall Type:	Time-Depth Curve
		Storm Event:	Typell 24hr (5.3 in)

Executive Summary [Nodes] Executive Summary [Links] Messages

	Label	Scenario	Return Event (years)	Truncation	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft ³ /s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
1	Lot 1 - Undetained	TR-55 (KC Metro) - Synt...	10	None	0.110	11.930	1.98	(N/A)	(N/A)
2	Lot 1 Detained	TR-55 (KC Metro) - Synt...	10	None	0.639	11.930	11.20	(N/A)	(N/A)
3	Lot 1 Watershed	TR-55 (KC Metro) - Synt...	10	None	0.551	11.930	2.16	(N/A)	(N/A)
4	Pond A (IN)	TR-55 (KC Metro) - Synt...	10	None	0.639	11.930	11.20	(N/A)	(N/A)
5	Pond A (OUT)	TR-55 (KC Metro) - Synt...	10	None	0.441	15.740	0.24	972.48	0.442

Proposed Conditions – 100-Year Event

Scenario Summary		Storm Summary	
Scenario:	TR-55 (KC Metro) - Synthetic Curve, 100 yr	Return Event Tag:	100_YR
Output Increment:	0.010 hours	Total Depth:	7.7 in
Duration:	35.000 hours	Rainfall Type:	Time-Depth Curve
		Storm Event:	Typell 24hr (7.7 in)

Executive Summary [Nodes] Executive Summary [Links] Messages

	Label	Scenario	Return Event (years)	Truncation	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft ³ /s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
1	Lot 1 - Undetained	TR-55 (KC Metro) - Synt...	100	None	0.178	11.930	3.15	(N/A)	(N/A)
2	Lot 1 Detained	TR-55 (KC Metro) - Synt...	100	None	0.997	11.920	17.03	(N/A)	(N/A)
3	Lot 1 Watershed	TR-55 (KC Metro) - Synt...	100	None	0.906	11.930	3.38	(N/A)	(N/A)
4	Pond A (IN)	TR-55 (KC Metro) - Synt...	100	None	0.997	11.920	17.03	(N/A)	(N/A)
5	Pond A (OUT)	TR-55 (KC Metro) - Synt...	100	None	0.727	12.210	2.56	973.00	0.564

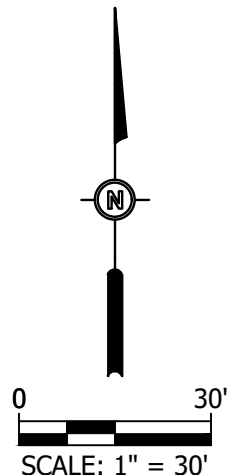
7. Summary

This Micro Stormwater Drainage Study has been prepared to analyze and fulfill all storm water requirements as specified by Section 5600 of the Kansas City Metropolitan Chapter – American Public Works Association (APWA) Standard Specifications & Design Criteria for comprehensive control. This project includes a proposed fire station to be constructed on 2.23 acres of land. The site is currently undeveloped vegetation. In order to meet the required discharges and water quality volume residence time an extended dry detention basin will be used to manage storm water.

8. Conclusions & Recommendations

Section 5600 of the Kansas City Metropolitan Chapter – APWA Standard Specifications & Design Criteria states that for comprehensive control a 40-hour extended detention time must be achieved for the water quality volume. Furthermore, calculations show that with the proposed increase in site imperviousness an overall water quality treatment volume of 6,507 ft³ is required. Utilizing a perforated riser exceeds this requirement with 7,226 ft³ treated. In addition to water quality volume extended detention time, APWA 5600 specifies maximum release rates for post-development peak discharges. These proposed peak discharges for the 100-year and 10-year events are half of their respective allowable peak discharge rates except for the 2-year event which was exceeded by 0.08 ft³/s. While this is a minor exception it should be noted that the proposed Pond A has more than 2 feet of freeboard for all events which provides exceptional flood protection during extreme events. Given that all storm water storm water requirements have been reasonably and safely fulfilled, the approval of this micro storm water drainage study is requested.

9. Exhibits



WATERSHED	SUBAREA	PERVIOUS AREA (ACRES)	IMPERVIOUS AREA (ACRES)	TOTAL AREA (ACRES)	PERVIOUS CN	IMPERVIOUS CN	COMPOSITE SUBAREA CN	NOTES
1	LOT 1	0.22	0.15	0.37	74	98	83.73	UNDETAINED
		0.68	1.18	1.86	74	98	89.23	DRAINS TO POND A
TOTAL		0.90	1.33	2.23				

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EXHIBIT 1
PROPOSED CONDITIONS
LEE'S SUMMIT FIRE STATION #3
LEE'S SUMMIT, MISSOURI

DESIGNED BY:	
DRAWN BY:	
APPROVED BY:	
DESIGN PROJ:	19622.000
CONST PROJ:	
SCALE:	
DATE:	01/2018
DRAWING NO:	1
SHEET NO:	