

# MACRO STORM WATER DRAINAGE STUDY

## LAKWOOD MULTI FAMILY

Site Acreage: 23.73 Acres

East of Anderson Drive & North of Velie Road  
Lee's Summit, MO

*PREPARED BY:*



Revision

Date	Comment	By
1-22-2022	City Comments	AEP

Matthew J. Schlicht, PE

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### **3. GENERAL INFORMATION**

This storm study has been prepared to evaluate potential hydrologic and hydraulic impacts related to the proposed development and recommend improvements designed to mitigate any anticipated negative downstream impacts. The proposed multi-family development contains 23.73 acres and is to consist of 10 duplex units and 66 single-family homes. The Development is bounded by Anderson Drive a residential collector to the south and west, single family homes to the north and I-470 to the east. See Exhibit A for an aerial image of the proposed project site along with an aerial image of the surrounding area. The existing site does not contain any storm sewer, wetlands nor BMPs. The site is located in Section 32, Township 49N, Range 31W, Lee's Summit, Jackson County, Missouri.

#### **3.1 FEMA FLOODPLAIN DETERMINATION**

The property is located in an Area of Minimal Flood Hazard, Zone X, according to FEMA Firm Map Number 29095C0313G, dated January 20, 2017.

See Exhibit B for a FIRMette which includes the proposed project site.

#### **3.2 NRCS SOIL CLASSIFICATION**

Soil classifications published by the United States Department of Agriculture/National Resources Conservation Service (USDA/NRCS) website for Jackson County, Missouri, Version 23, September 1, 2021. The existing site contains four major soil types:

10143	Snead-Urban Land Complex, 9 to 30 Percent Slopes Hydrologic Soils Group (HSG): Type D
60025	Urban Land-Harvester Complex, 2 to 9 Percent Slopes HSG: Type C
60125	Harvester-Urban Land Complex, 9 to 14 Percent Slopes HSG: Type C
99033	Udarents-Urban Land Complex, 2 to 9 Percent Slopes HSG: Type C

See Exhibit C for a detailed soils report of the proposed project site.

### **4. METHODOLOGY**

The study utilized existing city contours to create the Pre-Development Drainage Area Map. The study conforms to the requirements of the City of Lee's Summit, Missouri "Design and Construction Manual" and all applicable codes and criteria referred to therein.

Using the above criteria, the proposed site was evaluated using the Soil Conservation Service, SCS TR-55 method to calculate storm runoff volumes, peak rates of discharge, pre and post developed hydrographs and required storage volumes for detention facilities. TR-55 was first introduced in 1975 by the SCS particularly for small urbanizing watersheds. The analysis contains results for the 2, 10 and 100-year design storms.

Hydraflow Hydrographs Extension for AutoCAD Civil 3D was utilized to model the various SCS TR-55 stormwater rainfall runoff events. The following SCS TR-55 Unit Hydrograph variables were utilized;

- AMC II Soil Moisture Conditions
- 24-Hour SCS Type II Rainfall Distribution (Shape Factor 484)
- SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a to 2-2c)

Time of Concentration has been calculated using the following formulas:

- Sheet Flow (Max. 100 LF): APWA 5602.5 Time Inlet,  $T_1 = 1.8 * (1.1-C) * L^{1/2} / S^{1/3}$
- Shallow Concentrated Flow: SCS TR-55 Appendix F:
 

Unpaved	$V=16.1345(S)^{0.5}$
Paved	$V=20.3282(S)^{0.5}$

Shallow Concentrated Travel Time (min): SCS TR-55 Eq-3-1,  $T_t = L / V \times 60$

- Channel Flow Improved: Manning’s Equation (Full Flow)  
Channel Flow Unimproved: APWA 5602.7.A. Travel Time, Table 5602-6

<u>Avg. Channel Slope (%)</u>	<u>Velocity (fps)</u>
< 2	7
2 to 5	10
>5	15

## 5. EXISTING CONDITIONS ANALYSIS

The existing site consists entirely of treed land. The site contains twelve sub-basins referred to as Sub-basins A through L for the purposes of this report. Each sub-basin drains to a Point of Interest (POI) which corresponds to its given sub-basin drainage area. Sub-basins A, B, C, E, G, H, I, J and K drain to an enclosed storm sewer system running along Anderson Drive. Sub-basins H, I J and K are routed to attenuation basins on the west side of Anderson Drive. All twelve sub-basins consist of both overland and shallow concentrated drainage flow. Sub-basins D and F located in the northeast portion of the site drain to field inlets located in the adjoining development, Oak Ridge Meadows 3<sup>rd</sup> Plat. Sub-basin L located on the southeast portion of the property drains to the east where flow is collected and routed further downstream by a culvert under I-470. The Existing Drainage Area Map is located in Exhibit D.

The following tables summarize the results of the Existing Conditions analysis. Time of concentration calculations by sub-basin may be found in Exhibit E. A complete breakdown of TR-55 unit hydrographs may be found in Exhibit F.

Table 5-1 Existing Conditions Sub-basin Data

Sub-basin	Area (ac.)	CN	Tc (min.)
A	0.72	74	5.8
B	0.89	74	5.3
C	1.01	74	7.4
D	0.72	74	7.3
E	1.44	74	7.4
F	5.38	74	8.3
G	0.52	74	7.1
H	0.25	74	6.5
I	5.55	74	13.8
J	0.98	74	6.8
K	4.29	74	12.7
L	1.98	74	8.5

Table 5-2 Existing Conditions Sub-basin/Point of Interest Peak Discharge Rates

Sub-basin	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
A	1.66	3.38	6.10
B	2.05	4.17	7.53
C	2.09	4.27	7.77
D	1.49	3.04	5.54
E	2.98	6.08	11.08
F	11.15	22.73	41.39
G	1.08	2.20	4.00
H	0.58	1.17	2.12
I	9.07	18.91	34.74
J	2.03	4.14	7.54
K	7.37	15.32	28.08
L	3.91	8.02	14.65

Per APWA 5608.4 and City of Lee’s Summit criteria, post development peak discharge rates from the site shall not exceed those indicated below:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
- 1% storm peak rate less than or equal to 3.0 cfs per site acre

Based on the site geography and corresponding layout Allowable Release Rates were calculated at each POI based on the developed to undeveloped area ratio method for the proposed Development. The proposed Development runoff shall not be more than the peak discharge rates stated below. An allowable land usage map identifying proposed layout and undeveloped areas may be found in Exhibit G.

Allowable Release Example Calculations:

$$\text{Sub-basin A (2-Yr): } ((0.01 \times 0.5) + ((0.72 - 0.01 / 0.72) \times 1.66)) = \underline{1.64 \text{ cfs}}$$

Table 5-3 Existing Conditions Sub-basin/Point of Interest Allowable Peak Discharge Release Rates

Sub-basin	Total (ac)	Developed (ac)	Un-Developed (ac)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
A	0.72	0.01	0.71	1.64	3.36	6.05
B	0.89	0.11	0.78	1.86	3.89	6.95
C	1.01	0.87	0.14	0.73	2.34	3.70
D	0.72	0.61	0.11	0.53	1.68	2.66
E	1.44	0.97	0.46	1.45	3.91	6.5
F	5.38	3.29	2.09	5.97	15.41	25.95
G	0.52	0.39	0.13	0.46	1.33	2.17
H	0.25	0.15	0.09	0.30	0.75	1.27
I	5.55	4.51	1.04	3.95	12.56	20.04
J	0.98	0.40	0.59	1.41	3.26	5.69
K	4.29	3.81	0.48	2.73	9.33	14.56
L	1.98	0.98	1.01	2.47	6.02	10.37

The Development will contribute runoff to three distinct storm sewer systems. Sub-basins A, C, E, G, H, I, J and K located on the west side of the Development contribute to the storm sewer system along Anderson Drive. Multiple sub-basins are piped directly to attenuation basins running along the west side of Anderson Drive. Sub-basins B, D and F are located on the east side of the Development and contribute runoff to an enclosed

storm sewer system constructed with Oak Ridge Meadows 3<sup>rd</sup> Plat. Sub-basin L is located in the southeast portion of the property and contributes runoff to a culvert system running under I-470. Table 5-4 below details the cumulative allowable runoff which may be contributed to each storm sewer system.

Table 5-4 Cumulative Allowable Runoff to each Storm Sewer System

Sub-basin	Total (ac)	Developed (ac)	Un-Developed (ac)	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
A,C,E,G,H,I,J,K	14.76	11.12	3.64	12.67	36.84	59.97
B,D,F	6.99	4.01	2.98	8.36	20.97	35.56
L	1.98	0.98	1.01	2.47	6.02	10.37

## 6. PROPOSED CONDITIONS ANALYSIS

The Development will contain a mixture of multi and single family houses. A Land Usage Map for the proposed Development may be found in Exhibit H. Two single stage earthen detention basins are being proposed to attenuate proposed peak discharge rates. A detention basin will be constructed in the west, Sub-basin I(1), and one will be constructed in the west, Sub-basin F(1), to attenuate overall peak discharge rates below allowable peak discharge rates as shown in Table 5-4. The Proposed Drainage Area Map is located in Exhibit I.

Table 6-1 Proposed Conditions Sub-basin Data

Sub-basin	Area (ac.)	Composite CN	Tc (min.)
A	0.72	74	5.8
B	0.89	75	5.3
C	0.86	81	6.1
D	0.63	81	5.6
E	0.65	77	5.4
F	0.57	76	5.8
F(1)	3.74	79	7.2
G	0.18	77	5.5
H	0.09	74	5.4
I	0.11	74	5.0
I(1)	11.41	82	8.8
J	0.47	74	6.9
K	1.77	80	7.3
L	1.65	77	6.9

Table 6-2 Proposed Conditions Sub-basin/Point of Interest Peak Discharge Rates

Sub-basin	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
A	1.66	3.38	6.10
B	2.16	4.31	7.70
C	2.73	4.94	8.31
D	2.00	3.62	6.09
E	1.73	3.34	5.85
F	1.45	2.85	5.03
F(1)	9.82	18.47	31.75
G	0.48	0.93	1.62
H	0.21	0.42	0.76
I	0.25	0.52	0.93
I(1)	32.63	58.84	98.20

J	0.97	1.99	3.62
K	4.85	8.99	15.29
L	1.68	3.51	6.45
Combine (A,C,E,G,H,I,I(1),J,K)	45.20	82.56	139.03
Combine (B,D,F,F(1))	15.40	29.24	50.51

As shown above Sub-basins Combine (A,C,E,G,H,I,I(1),J,K) and Combine (B,D,F,F(1)) will require detention to attenuate peak discharge rates below Allowable Release Rates as shown in Table 5-4. Sub-basin L peak discharge rates are below allowable due to the reduction in area. Hydraflow limits the number of hydrographs that can be combined in one operation therefore Combine (A,C,E,G,H,I,I(1),J,K) was split into two hydrographs “West 1” and “West 2” prior to the final Combine (A,C,E,G,H,I,I(1),J,K) hydrograph.

## 6.1 DETENTION

Two new single stage earthen detention basins are being proposed in Sub-basin F(1) and Sub-basin I(1) to attenuate proposed peak discharge rates. The detention basin plan for each basin may be found in Exhibit J. Following are a list of design parameters for each detention system.

Designation: Detention Basin F(1)

Type: Earthen Basin

Side Slopes: 3:1 Max.

Bottom Slope: 2% Min., Turf Lined

Basin Bottom Elevation: 820.00 @ Influent Pipe

Basin Top Berm Elevation: 832.00

Basin Volume: 106,420 cf @ 832.00

Control Structure: 5'x6' Precast Concrete Box with Interior 6" Baffle/Weir Wall

Baffle Wall Orifices: (7) 1" Diameter on 4" Centers, FL=819.60 (Bottom Orifice)  
(1) 24" Diameter, FL=825.00

Baffle Wall Crest Elevation: 828.00

Control Structure Top Elevation: 830.00

Control Structure Overflow Weir Openings: N/A – NO Field Inlet Openings

Control Structure Influent/Effluent Pipe: 30" HDPE

Emergency Spillway: Earthen Broad Crested Weir, Crest Elevation=830.00, Crest Length=35'

Consecutive 100-YR Q=31.75 cfs, Emergency Spillway HGL=830.50', Freeboard=1.50'

Table 6-3 Proposed Conditions Detention Basin F(1) Data

	Peak Q In (cfs)	Tp In (min.)	Peak Q Out (cfs)	Tp Out (min)	Peak W.S.E.	Max. Storage Vol. (cf)
Basin F(1)						
2-Year	9.82	719	0.38	834	823.42	11,587
10-Year	18.47	718	0.82	804	825.13	22,799
100-Year	31.75	718	9.53	726	826.33	32,718

As shown in the table above all proposed peak flowrates have been attenuated. See Table 6-4 below for a summary of proposed peak discharge rates at point of interest B which consists of combined sub-basins B, D, F and post detained F(1).

Table 6-4 Proposed Conditions Post Detention Point of Interest Peak Discharge Rates

Point of Interest	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
B	5.81	11.18	20.85

As shown in the above table all peak discharge rates attributable to Proposed Sub-basins B, D, and F have been attenuated below both Existing and Allowable Peak Discharge rates as outlined in Tables 5-2 and 5-4, respectively.

A new single stage earthen detention basin I(1) is being proposed in Sub-basin I(1) to attenuate proposed peak discharge rates. As discussed previously the goal shall be to attenuate post development peak discharge rates at or below pre development rates. Following are a list of design parameters for the proposed detention system.

Designation: Detention Basin I(1)

Type: Earthen Basin

Side Slopes: 3:1 Max.

Bottom Slope: 2% Min., Turf Lined

Basin Bottom Elevation: 834.00 @ Inlet Pipe

Basin Top Berm Elevation: 850.00

Basin Volume: 156,464 cf @ 850.00

Control Structure: 5'x6' Precast Concrete Box with Interior 6" Baffle/Weir Wall

Baffle Wall Orifices: (17) 1" Diameter on 4" Centers, FL=833.60 (Bottom Orifice)  
(1) 18" Diameter, FL=843.00

Baffle Wall Crest Elevation: N/A

Control Structure Top Elevation: 849.25

Control Structure Overflow Weir Openings: All Sides – Crest=848.25

Control Structure Inlet/Effluent Pipe: TBD

Combination Emergency Spillway: Earthen Broad Crested Weir, Crest Elevation=848.25, Crest Length=86'

Control Structure, Crest Elevation=848.25, Crest Length=15.5'

Consecutive 100-YR Q=98.20 cfs, Emergency Spillway HGL=848.75', Freeboard=1.25'

Emergency spillway calculations for both basins may be found in Exhibit F. See Table 6-5 for a summary of detention basin data.

Table 6-5 Proposed Conditions Detention Basin I(1) Data

	Peak Q In (cfs)	Tp In (min.)	Peak Q Out (cfs)	Tp Out (min)	Peak W.S.E.	Max. Storage Vol. (cf)
Basin I(1)						
2-Year	32.63	719	1.12	858	842.23	44,353
10-Year	58.84	719	8.41	735	844.41	68,793
100-Year	98.20	719	18.79	731	847.67	114,482

As shown in the table above all proposed peak flowrates have been attenuated below both Existing and Allowable. See Table 6-6 below for a summary of proposed peak discharge rates at point of interest A which consists of combined sub-basins A, C, E, G, H, I, J, K and post detained I(1).

Table 6-6 Proposed Conditions Post Detention Point of Interest Peak Discharge Rates

Point of Interest	Q2 (cfs)	Q10 (cfs)	Q100 (cfs)
A	13.39	25.59	54.45

As shown in the above table all peak discharge rates attributable to Proposed Sub-basins A, C, E, G, H, I, J, K have been attenuated below both Existing and Allowable Peak Discharge Rates except for the Allowable 2-year as outlined in Tables 5-2 and 5-4, respectively. The proposed two year peak discharge rate is approximately 5.68% above the allowable rate and 49.9% of the 26.86 cfs existing peak discharge rate of which a large



percentage of the runoff contributes to attenuation basins on the west side of Anderson Drive. The proposed condition will minimize the existing undeveloped impact. Based on this data a waiver will be requested for the 2-year allowable peak discharge at POI A.

Table 6-7 Point of Interest Peak Discharge Comparison

	<b>Condition</b>	<b>Q2 (cfs)</b>	<b>Q10 (cfs)</b>	<b>Q100 (cfs)</b>
Point A	Proposed	13.39	25.59	54.45
	Existing	26.86	55.47	101.43
	Difference	-13.47	-29.88	-46.98
	Allowable	12.67	36.84	59.97
	Difference	0.72	-11.25	-5.52
Point B	Proposed	5.81	11.18	20.85
	Existing	14.69	29.94	54.46
	Difference	-8.88	-18.76	-33.61
	Allowable	8.36	20.97	35.56
	Difference	-2.55	-9.79	-14.71

Peak discharge rates at Points A and B will be reduced below existing for all design storms. Peak discharge rates at Points A and B will be reduced below allowable for all design storms except the 2-year at Point A.

## 7. 40 HOUR EXTENDED DETENTION

In addition to mitigation of peak flow rates, APWA Section 5608.4 also requires 40 hour extended detention of runoff from the local 90% mean annual event (1.37"/24-hour rainfall). The proposed detention facilities will release the water quality event over a period of 40-72 hours. See Exhibit K for 40 hour extended detention calculations for each basin.

## 8. CONCLUSIONS & RECOMMENDATIONS

This macro storm water drainage study reveals that the proposed Development will not generate any negative downstream hydraulic impacts. Two new earthen detention basins will be required to provide detention for the proposed development.

In conclusion, proposed peak discharge rates for POI A, B and L are below both existing and allowable release rates except for the 2-year allowable at Point A. A waiver will be requested for the 2-year event at Point A since the proposed reduction in peak discharge is 50.1% below existing and a large percentage of the area tributary to Point A is periphery to the proposed development. The study is in conformance with all applicable City of Lee's Summit standards and criteria therefore Engineering Solutions recommends approval of this macro storm water drainage study.