STORM DRAINAGE CALCULATIONS

Whataburger

1450 NE Douglas St.

Lee's Summit, MO 64086

BY

ms consultants, inc.
COLUMBUS, OHIO

January 2021

STORMWATER DRAINAGE SUMMARY

Whataburger

Lee's Summit, MO

CONTEXT

The subject parcel is located in Lee's Summit, Missouri on the west side of NE Douglas St. just south of NE Mulberry St. The subject parcel is 1.39 acres and is currently an undeveloped lot. The site will be developed into a Whataburger restaurant. The proposed development will utilize an ADS Stormtech underground chamber system and outlet control structure for the site stormwater management and discharge into the existing storm structure at the northeast corner of the site following existing drainage patterns.

TIME OF CONCENTRATION (Tc)

A minimum time of concentration of 5 minutes was used for both the existing and proposed time of concentration due to the minimal size of the lot and short travel time.

WEIGHTED CURVE NUMBER

Although not used due to detention requirements outlined below, the curve number for pre-development onsite conditions was determined to be 74.00 based on 1.39 acres of pasture, grassland, or range" in good condition per TR-55 method outlined in the APWA Design Criteria.

A weighted curve number was calculated for the proposed site conditions. A value of 98 was used for the impervious areas, which total 1.04 acres of the drainage area and a value of 74 was used for the areas with good grass cover which total 0.35 acres of the total drainage area. The watershed area drains via storm sewers into the proposed underground detention system and has a post development composite curve number of 92. The calculations for pre- and post-development runoff-coefficients are included in Appendix A.

RAINFALL INTENSITY

The rainfall depths and intensities were obtained from the NOAA rainfall atlas website. Rainfall intensities can be found in Appendix A.

DETENTION REQUIREMENTS

The development was designed to convey the peak discharge generated by the 1% storm per the Kansas City Metropolitan Chapter APWA Section 5600. Discharge from the developed site has been analyzed and released at rate less than 0.5 CFS per acre for the 2 year storm event, 2.0 CFS per acre for the 10 year storm, and 3.0 per acer for the 100 year.

The required detention volume generated by the overall development is contained in the proposed underground detention system. Calculations supporting the storm release and pond design can be found in Appendix B.

UGS

Storm Event	Pre-Dev Flow (CFS)	Allowable Release Rate (CFS)	Post Dev Rate (CFS)	Pond Discharge (CFS)	Pond Surface Elevation
2-year	2.89	0.70	5.82	0.26	1009.17
10-year	6.09	2.78	9.50	1.76	1010.05
100-year	12.70	4.17	16.08	3.77	1012.97

STORM SEWER DESIGN

The site consists of a proposed onsite stormwater pipe network that drains to an underground detention system, an outlet control structure, and a discharge pipe which outfalls to the existing storm system at the northeast corner of the parcel. The on-site storm sewer system has been designed using the rational method to convey the 25 year storm and checked to ensure that there will be no surcharging during a 25 year storm event. Catchment areas and drainage map can be found in Appendix C and storm sewer conveyance calculations are included in Appendix D.

OUTLET CONTROL STRUCTURE

The water quality volume is controlled within the outlet control structure by a 1.4" circular orifice at elevation 1006.75. The 2 yr. - 100 yr. storm is controlled within the outlet control structure by two 6" orifices at elevation 1009.00 and a 4' wide weir wall set within the structure at elevation 1013.00. The top of structure is elevation 1014.50 with the 100 yr. pond elevation at 1012.97. The outlet control structure can be found in the site civil plans in Appendix F.

WATER QUALITY

On-site water quality requirements are being met through the use of the proposed isolator row in the UGS system and additional water quality storage volume within the underground storage systems and released through the outlet control structure. The water quality orifice on the outlet control structure has been designed to release the water quality volume over a period of 40 hours for the detention storage. The MARC/APWA BMP Manual requires a water quality volume based on the equation WQv = Rv x P x A / 12. The proposed site has provide 0.11 acre-feet of water quality volume at an elevation of 1008.14. The calculations are included in Appendix E.

SUMMARY

As indicated above and shown within the attachments, stormwater calculations have been performed using PondPack and spreadsheets to meet the city of Lee's Summit, Missouri Design Criteria including using 30% stone voids for the UGS instead of the industry standard of 40% and does not exceed the post development allowable release rates using comprehensive control.

APPENDIX A

CURVE NUMBER VALUES, & RAINFALL DATA

PondPack Pond Routing Input (UGS)

PROJECT: Whataburger
Drainage Area: 1.39 acres

Existing Conditions: Analysis Boundary

Cover Type/Condition	Soil Type	Area (sf)	Area (ac)	CN
Open Space - Meadow	C	60,461	1.39	74
Woods - Good Condition	-	0	0.00	77
Gravel	-	0	0.00	91
Impervious	-	0	0.00	98
TOTAL:		60,461	1.39	74

Developed Conditions: Analysis Boundary

Cover Type/Condition	Soil Type	Area (sf)	Area (ac)	CN
Open Space - Good Condition	C	15,307	0.35	74
Woods	-	0	0.00	77
Gravel	-	0	0.00	91
Impervious Area	C	45,145	1.04	98
TOTAL		60,452	1.39	92

NOAA Atlas 14, Volume 8, Version 2
Location name: Lees Summit, Missouri, USA*
Latitude: 38.9425°, Longitude: -94.3752°
Elevation: 999.68 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

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PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.414 (0.330-0.516)	0.483 (0.384-0.602)	0.597 (0.474-0.746)	0.694 (0.548-0.870)	0.831 (0.636-1.07)	0.939 (0.703-1.23)	1.05 (0.761-1.40)	1.16 (0.812-1.59)	1.32 (0.887-1.85)	1.44 (0.944-2.04)
10-min	0.607 (0.483-0.756)	0.707 (0.563-0.881)	0.874 (0.694-1.09)	1.02 (0.802-1.27)	1.22 (0.932-1.57)	1.38 (1.03-1.80)	1.54 (1.12-2.05)	1.70 (1.19-2.33)	1.93 (1.30-2.71)	2.10 (1.38-2.99)
15-min	0.740 (0.589-0.921)	0.862 (0.686-1.07)	1.07 (0.846-1.33)	1.24 (0.978-1.55)	1.48 (1.14-1.92)	1.68 (1.26-2.19)	1.87 (1.36-2.50)	2.08 (1.45-2.84)	2.35 (1.59-3.30)	2.57 (1.69-3.65)
30-min	1.02 (0.817-1.28)	1.20 (0.956-1.50)	1.49 (1.18-1.87)	1.74 (1.37-2.18)	2.09 (1.60-2.69)	2.36 (1.77-3.08)	2.63 (1.91-3.52)	2.92 (2.04-3.99)	3.30 (2.22-4.63)	3.60 (2.36-5.11)
60-min	1.34 (1.07-1.67)	1.57 (1.25-1.96)	1.96 (1.56-2.45)	2.29 (1.81-2.88)	2.77 (2.12-3.58)	3.14 (2.35-4.11)	3.52 (2.56-4.71)	3.92 (2.74-5.37)	4.46 (3.01-6.26)	4.89 (3.21-6.94)
2-hr	1.65 (1.33-2.05)	1.94 (1.56-2.40)	2.43 (1.94-3.01)	2.85 (2.26-3.55)	3.44 (2.66-4.43)	3.92 (2.96-5.10)	4.41 (3.23-5.87)	4.93 (3.47-6.71)	5.63 (3.82-7.85)	6.17 (4.08-8.71)
3-hr	1.87 (1.50-2.30)	2.20 (1.77-2.71)	2.76 (2.21-3.41)	3.24 (2.58-4.02)	3.94 (3.06-5.06)	4.51 (3.42-5.85)	5.09 (3.74-6.75)	5.71 (4.04-7.75)	6.56 (4.47-9.12)	7.22 (4.80-10.2)
6-hr	2.25 (1.82-2.75)	2.66 (2.15-3.26)	3.37 (2.72-4.14)	3.99 (3.20-4.92)	4.90 (3.83-6.26)	5.64 (4.30-7.28)	6.40 (4.74-8.45)	7.22 (5.14-9.75)	8.35 (5.74-11.6)	9.24 (6.18-12.9)
12-hr	2.65 (2.16-3.22)	3.17 (2.58-3.85)	4.05 (3.29-4.94)	4.83 (3.90-5.91)	5.97 (4.70-7.58)	6.90 (5.30-8.85)	7.87 (5.86-10.3)	8.90 (6.38-11.9)	10.3 (7.14-14.2)	11.5 (7.72-15.9)
24-hr	3.11 (2.54-3.75)	3.71 (3.04-4.48)	4.76 (3.88-5.76)	5.68 (4.61-6.90)	7.02 (5.56-8.86)	8.11 (6.28-10.3)	9.26 (6.94-12.1)	10.5 (7.56-14.0)	12.2 (8.47-16.6)	13.5 (9.16-18.6)
2-day	3.66 (3.01-4.38)	4.31 (3.55-5.16)	5.44 (4.46-6.53)	6.43 (5.25-7.76)	7.89 (6.29-9.88)	9.08 (7.07-11.5)	10.3 (7.80-13.4)	11.7 (8.48-15.4)	13.5 (9.48-18.3)	15.0 (10.2-20.5)
3-day	4.06 (3.36-4.85)	4.71 (3.89-5.62)	5.83 (4.80-6.97)	6.82 (5.59-8.19)	8.29 (6.64-10.3)	9.49 (7.43-12.0)	10.8 (8.16-13.9)	12.1 (8.85-16.0)	14.0 (9.88-19.0)	15.5 (10.7-21.2)
4-day	4.40 (3.65-5.23)	5.04 (4.17-5.99)	6.15 (5.08-7.33)	7.13 (5.86-8.54)	8.59 (6.90-10.7)	9.78 (7.68-12.3)	11.0 (8.41-14.2)	12.4 (9.09-16.3)	14.3 (10.1-19.3)	15.8 (10.9-21.5)
7-day	5.21 (4.34-6.15)	5.87 (4.89-6.95)	7.02 (5.83-8.32)	8.02 (6.63-9.55)	9.47 (7.63-11.7)	10.6 (8.39-13.3)	11.9 (9.07-15.1)	13.2 (9.69-17.2)	14.9 (10.6-20.0)	16.4 (11.3-22.1)
10-day	5.89 (4.93-6.94)	6.64 (5.55-7.82)	7.88 (6.56-9.30)	8.93 (7.41-10.6)	10.4 (8.41-12.7)	11.6 (9.17-14.4)	12.8 (9.83-16.2)	14.1 (10.4-18.3)	15.8 (11.3-21.0)	17.1 (11.9-23.1)
20-day	7.85 (6.61-9.18)	8.87 (7.46-10.4)	10.5 (8.81-12.3)	11.8 (9.87-13.9)	13.6 (11.0-16.4)	15.0 (11.9-18.3)	16.3 (12.5-20.4)	17.6 (13.0-22.6)	19.3 (13.8-25.4)	20.5 (14.4-27.5)
30-day	9.49 (8.02-11.0)	10.7 (9.06-12.5)	12.7 (10.7-14.8)	14.3 (11.9-16.7)	16.3 (13.2-19.5)	17.8 (14.1-21.6)	19.2 (14.8-23.9)	20.6 (15.3-26.3)	22.4 (16.0-29.2)	23.6 (16.6-31.5)
45-day	11.6 (9.82-13.4)	13.1 (11.1-15.2)	15.4 (13.0-17.9)	17.2 (14.5-20.1)	19.6 (15.9-23.3)	21.3 (16.9-25.7)	22.8 (17.6-28.2)	24.3 (18.1-30.7)	26.1 (18.8-33.9)	27.2 (19.2-36.2)
60-day	13.4 (11.4-15.5)	15.1 (12.8-17.4)	17.7 (15.0-20.5)	19.7 (16.6-22.9)	22.3 (18.1-26.3)	24.1 (19.2-28.9)	25.7 (19.9-31.6)	27.2 (20.3-34.3)	29.0 (20.9-37.5)	30.2 (21.4-40.0)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

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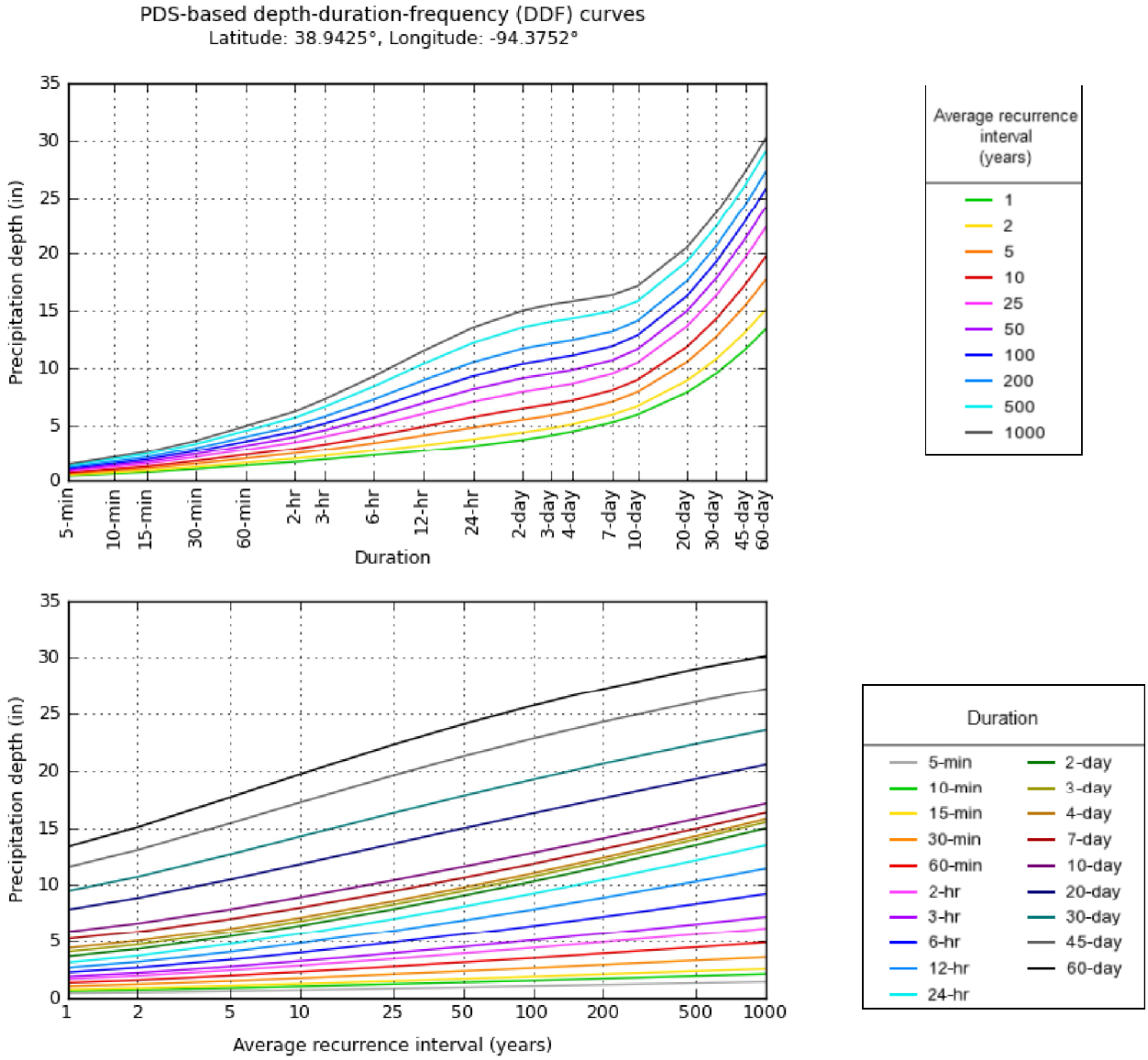

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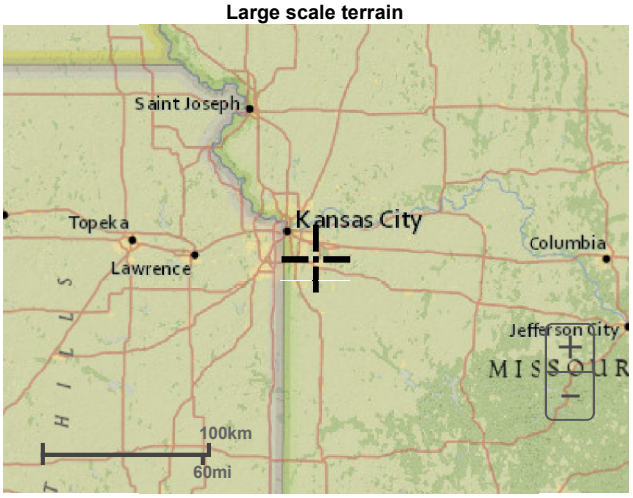

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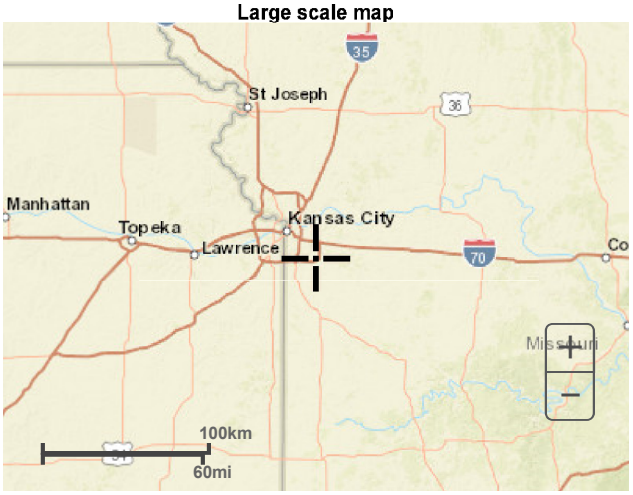

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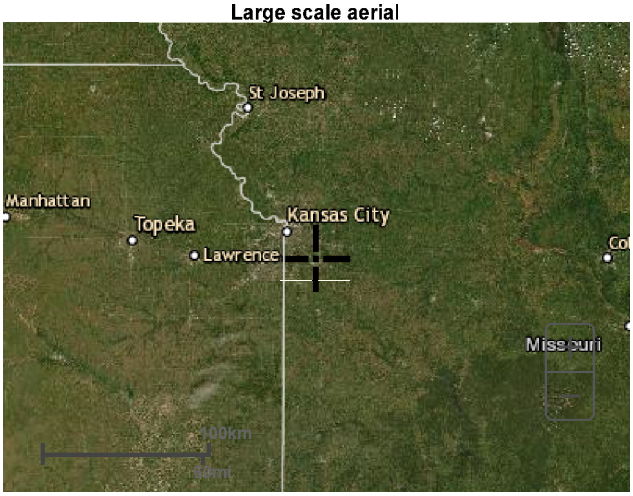

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Location name: Lees Summit, Missouri, USA*
Latitude: 38.9391°, Longitude: -94.3793°
Elevation: 1017.4 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

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PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	4.97 (4.00-6.13)	5.80 (4.66-7.15)	7.16 (5.74-8.86)	8.33 (6.62-10.3)	9.97 (7.69-12.8)	11.3 (8.50-14.6)	12.6 (9.19-16.7)	14.0 (9.79-18.9)	15.8 (10.7-22.0)	17.3 (11.4-24.3)
10-min	3.64 (2.93-4.49)	4.24 (3.41-5.23)	5.24 (4.20-6.49)	6.10 (4.85-7.57)	7.30 (5.63-9.34)	8.25 (6.22-10.7)	9.22 (6.73-12.2)	10.2 (7.17-13.9)	11.6 (7.83-16.1)	12.6 (8.32-17.8)
15-min	2.96 (2.38-3.65)	3.45 (2.77-4.26)	4.26 (3.41-5.28)	4.96 (3.95-6.16)	5.94 (4.58-7.60)	6.71 (5.06-8.69)	7.50 (5.47-9.92)	8.31 (5.83-11.3)	9.42 (6.36-13.1)	10.3 (6.77-14.5)
30-min	2.05 (1.65-2.53)	2.40 (1.93-2.96)	2.99 (2.39-3.69)	3.48 (2.77-4.32)	4.17 (3.22-5.34)	4.71 (3.56-6.10)	5.27 (3.84-6.97)	5.84 (4.09-7.92)	6.61 (4.46-9.18)	7.20 (4.74-10.1)
60-min	1.34 (1.08-1.65)	1.57 (1.26-1.94)	1.96 (1.57-2.42)	2.29 (1.83-2.85)	2.76 (2.13-3.54)	3.14 (2.37-4.07)	3.52 (2.57-4.67)	3.92 (2.75-5.33)	4.47 (3.02-6.22)	4.89 (3.22-6.89)
2-hr	0.826 (0.668-1.01)	0.970 (0.784-1.19)	1.21 (0.977-1.49)	1.42 (1.14-1.76)	1.72 (1.34-2.19)	1.96 (1.49-2.53)	2.21 (1.62-2.91)	2.46 (1.74-3.33)	2.82 (1.92-3.90)	3.09 (2.05-4.33)
3-hr	0.622 (0.504-0.759)	0.731 (0.592-0.893)	0.917 (0.741-1.12)	1.08 (0.867-1.33)	1.31 (1.02-1.67)	1.50 (1.15-1.93)	1.70 (1.25-2.23)	1.90 (1.35-2.56)	2.19 (1.49-3.01)	2.41 (1.60-3.36)
6-hr	0.376 (0.306-0.455)	0.445 (0.362-0.539)	0.563 (0.457-0.684)	0.667 (0.539-0.814)	0.818 (0.643-1.04)	0.941 (0.723-1.20)	1.07 (0.795-1.40)	1.21 (0.862-1.62)	1.40 (0.961-1.91)	1.55 (1.03-2.14)
12-hr	0.220 (0.180-0.265)	0.263 (0.215-0.317)	0.336 (0.275-0.406)	0.401 (0.326-0.486)	0.496 (0.392-0.624)	0.572 (0.442-0.728)	0.653 (0.488-0.849)	0.738 (0.531-0.983)	0.857 (0.594-1.17)	0.951 (0.642-1.31)
24-hr	0.129 (0.107-0.155)	0.155 (0.127-0.185)	0.198 (0.163-0.238)	0.237 (0.193-0.285)	0.292 (0.233-0.366)	0.338 (0.263-0.427)	0.386 (0.290-0.498)	0.436 (0.316-0.577)	0.506 (0.353-0.686)	0.562 (0.382-0.768)
2-day	0.076 (0.063-0.090)	0.090 (0.074-0.107)	0.113 (0.093-0.135)	0.134 (0.110-0.160)	0.164 (0.131-0.204)	0.189 (0.148-0.237)	0.215 (0.163-0.275)	0.242 (0.177-0.318)	0.281 (0.198-0.378)	0.311 (0.213-0.423)
3-day	0.056 (0.047-0.067)	0.065 (0.054-0.077)	0.081 (0.067-0.096)	0.095 (0.078-0.113)	0.115 (0.092-0.142)	0.132 (0.103-0.165)	0.149 (0.114-0.191)	0.168 (0.123-0.220)	0.194 (0.137-0.260)	0.215 (0.148-0.291)
4-day	0.046 (0.038-0.054)	0.052 (0.044-0.062)	0.064 (0.053-0.076)	0.074 (0.061-0.088)	0.089 (0.072-0.110)	0.102 (0.080-0.127)	0.115 (0.088-0.146)	0.129 (0.095-0.168)	0.149 (0.105-0.199)	0.164 (0.113-0.222)
7-day	0.031 (0.026-0.036)	0.035 (0.029-0.041)	0.042 (0.035-0.049)	0.048 (0.040-0.056)	0.056 (0.046-0.069)	0.063 (0.050-0.078)	0.070 (0.054-0.089)	0.078 (0.058-0.101)	0.089 (0.063-0.118)	0.097 (0.067-0.130)
10-day	0.025 (0.021-0.029)	0.028 (0.023-0.032)	0.033 (0.027-0.038)	0.037 (0.031-0.044)	0.043 (0.035-0.053)	0.048 (0.038-0.059)	0.053 (0.041-0.067)	0.059 (0.043-0.075)	0.066 (0.047-0.087)	0.071 (0.050-0.095)
20-day	0.016 (0.014-0.019)	0.018 (0.016-0.021)	0.022 (0.018-0.025)	0.025 (0.021-0.029)	0.028 (0.023-0.034)	0.031 (0.025-0.038)	0.034 (0.026-0.042)	0.037 (0.027-0.047)	0.040 (0.029-0.052)	0.043 (0.030-0.057)
30-day	0.013 (0.011-0.015)	0.015 (0.013-0.017)	0.018 (0.015-0.020)	0.020 (0.017-0.023)	0.023 (0.018-0.027)	0.025 (0.020-0.030)	0.027 (0.021-0.033)	0.029 (0.021-0.036)	0.031 (0.022-0.040)	0.033 (0.023-0.043)
45-day	0.011 (0.009-0.012)	0.012 (0.010-0.014)	0.014 (0.012-0.016)	0.016 (0.013-0.018)	0.018 (0.015-0.021)	0.020 (0.016-0.024)	0.021 (0.016-0.026)	0.022 (0.017-0.028)	0.024 (0.017-0.031)	0.025 (0.018-0.033)
60-day	0.009 (0.008-0.011)	0.010 (0.009-0.012)	0.012 (0.010-0.014)	0.014 (0.012-0.016)	0.015 (0.013-0.018)	0.017 (0.013-0.020)	0.018 (0.014-0.022)	0.019 (0.014-0.024)	0.020 (0.015-0.026)	0.021 (0.015-0.028)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

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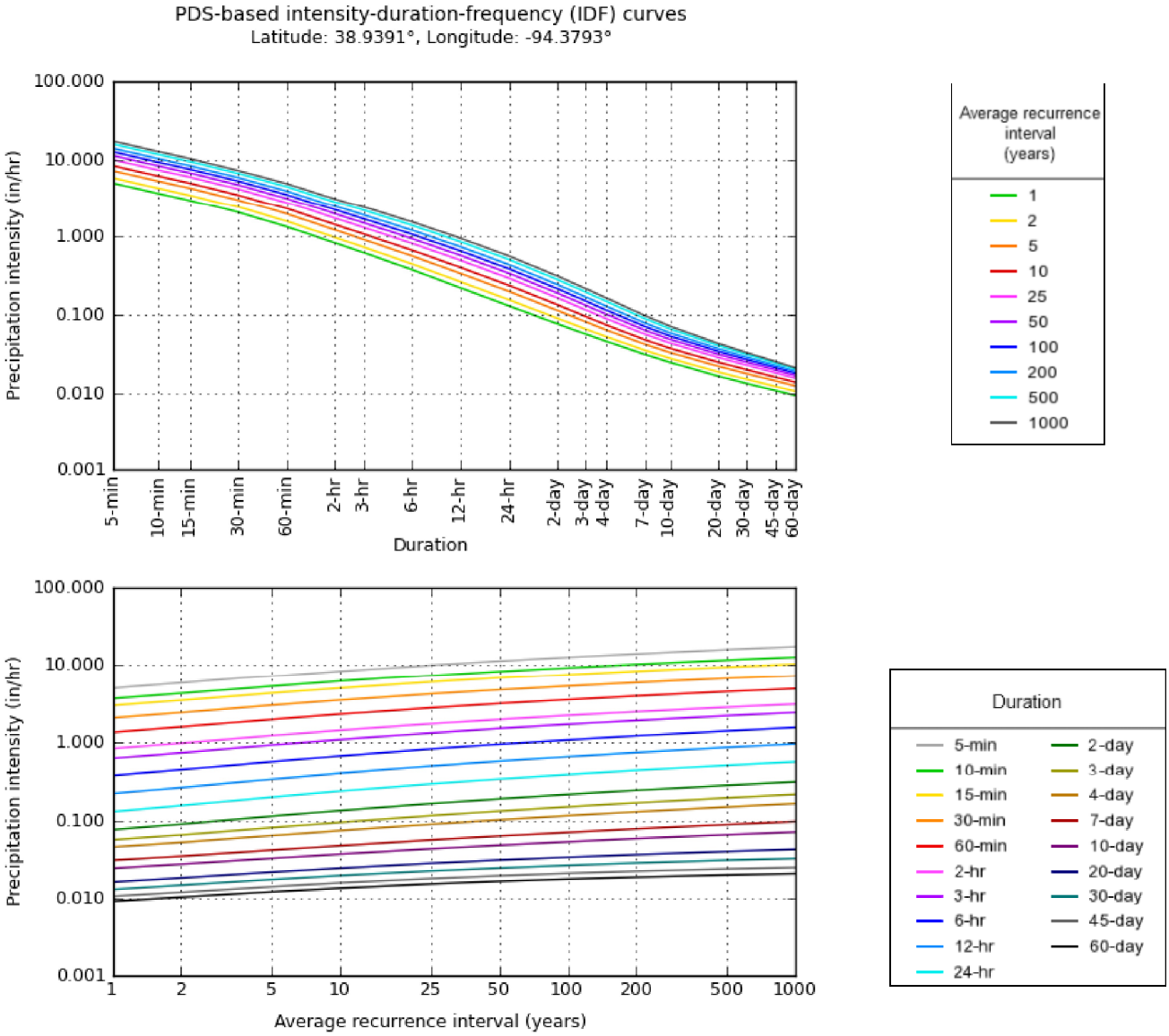

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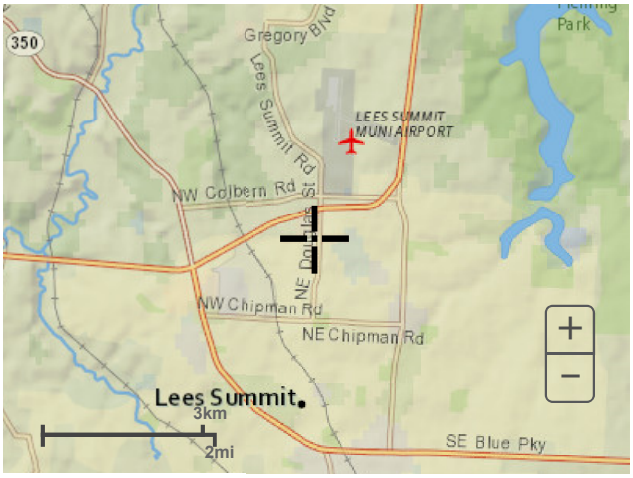
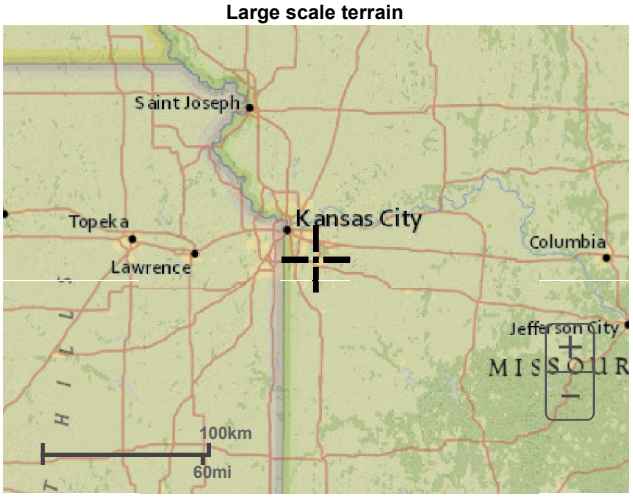
Maps & aerials

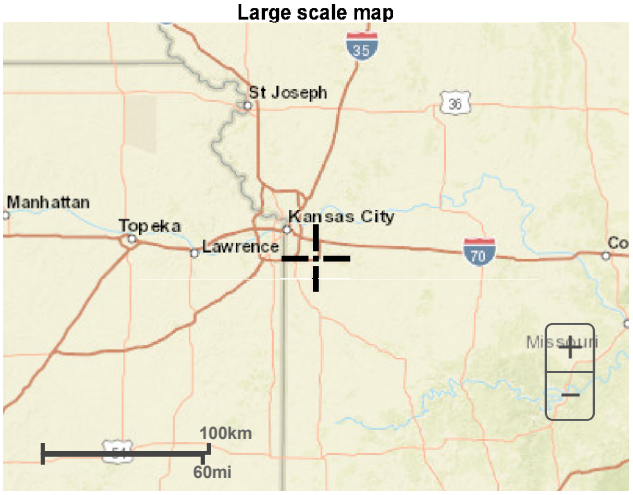
Small scale terrain



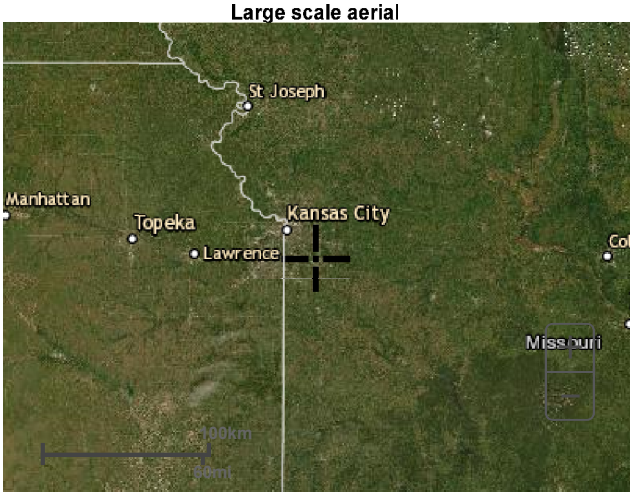
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Job Description: **Whataburger**
Job No: 62-40497
Computed By: JML
Date: 1/21/2021

Checked By:
Date:

POST CONSTRUCTION STORMWATER MANAGEMENT SUMMARY

Lee's Summit NOAA - 24-Hour Rainfall Totals						
Return Period (yr)	*2-yr*	*5-yr*	*10-yr*	*25-yr*	*50-yr*	*100-yr*
24-hr Depth (in)	3.70	X	5.70	X	X	9.30

Project Peak Runoff Volume Mitigation Summary			
	UGS		
Pre-Development			
Project Drainage Area (ac)	1.39		
Curve Number (CN)	74		
Impervious Area (ac)	0.00		
Post-Development			
Project Drainage Area (ac)	1.39		
Curve Number (CN)	92		
Impervious Area (ac)	1.04		
Increase in Impervious Area (ac)	1.04		

Project Peak Runoff Rate Mitigation Summary				
Pre-Development				
POI Drainage Area (ac)		1.39		
Curve Number (CN)		74		
Time of Concentration, T_c (min.)		5.00		
Post-Development				
POI Drainage Area (ac)		1.39		
Curve Number (CN) to Pond		92		
Time of Concentration, T_c,to Pond (mins)		5.00		
	Storm Frequency	**UGS**		
Pre-project Peak Runoff Rate to POI (cfs)	2-yr	2.89		
Post-project Peak Runoff Rate to POI (cfs) - No Control		5.82		
Required Peak Runoff Release Rate (cfs)		0.70		
Post-project Peak Runoff Rate to POI (cfs) - Outlet Structure		0.26		
Net Change to Peak Runoff Rate to POI (cfs)		-2.63		
Release Rate Percentage at POI		9%		
Pre-project Peak Runoff Rate to POI (cfs)	10-yr	6.09		
Post-project Peak Runoff Rate to POI (cfs) - No Control		9.50		
Required Peak Runoff Release Rate (cfs)		2.78		
Post-project Peak Runoff Rate to POI (cfs) - Outlet Structure		1.76		
Net Change to Peak Runoff Rate to POI (cfs)		-4.33		
Release Rate Percentage at POI		29%		
Pre-project Peak Runoff Rate to POI (cfs)	100-yr	12.70		
Post-project Peak Runoff Rate to POI (cfs) - No Control		16.08		
Required Peak Runoff Release Rate (cfs)		4.17		
Post-project Peak Runoff Rate to POI (cfs) - Outlet Structure		3.77		
Net Change to Peak Runoff Rate to POI (cfs)		-8.93		
Release Rate Percentage at POI		30%		

APPENDIX B

POND DETENTION CALCULATIONS

Table of Contents

Wataburger Lees Summit

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
CM-1	Pre 2 yr	2	0.160	11.950	2.89
CM-1	Post 2 yr	2	0.328	11.900	5.82
CM-1	Pre 10 yr	10	0.337	11.900	6.09
CM-1	Post 10 yr	10	0.550	11.900	9.50
CM-1	Pre 100 yr	100	0.701	11.900	12.70
CM-1	Post 100 yr	100	0.958	11.900	16.08

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
O-1	Pre 2 yr	2	0.160	11.950	2.89
O-1	Post 2 yr	2	0.140	13.350	0.26
O-1	Pre 10 yr	10	0.337	11.900	6.09
O-1	Post 10 yr	10	0.355	12.150	1.76
O-1	Pre 100 yr	100	0.701	11.900	12.70
O-1	Post 100 yr	100	0.758	12.100	3.77

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
PO-1 (IN)	Post 2 yr	2	0.328	11.900	5.82	(N/A)	(N/A)
PO-1 (OUT)	Post 2 yr	2	0.140	13.350	0.26	1,009.17	0.210
PO-1 (IN)	Post 10 yr	10	0.550	11.900	9.50	(N/A)	(N/A)
PO-1 (OUT)	Post 10 yr	10	0.355	12.150	1.76	1,010.05	0.299
PO-1 (IN)	Post 100 yr	100	0.958	11.900	16.08	(N/A)	(N/A)
PO-1 (OUT)	Post 100 yr	100	0.758	12.100	3.77	1,012.97	0.499

Storm Event	2 year
Return Event	2 years
Duration	24.000 hours
Depth	3.7 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.388 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	5.97 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	5.82 ft³/s

Drainage Area	
SCS CN (Composite)	92.000
Area (User Defined)	1.388 acres
Maximum Retention (Pervious)	0.9 in
Maximum Retention (Pervious, 20 percent)	0.2 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	2.8 in
Runoff Volume (Pervious)	0.328 ac-ft

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.328 ac-ft

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670

Wataburger Lees Summit

Subsection: Unit Hydrograph Summary
Label: CM-1

Return Event: 2 years
Storm Event: 2 year

SCS Unit Hydrograph Parameters	
Unit peak, qp	18.87 ft³/s
Unit peak time, Tp	0.056 hours
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	2 year
Return Event	2 years
Duration	24.000 hours
Depth	3.7 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.388 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.933 hours
Flow (Peak, Computed)	2.98 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.950 hours
Flow (Peak Interpolated Output)	2.89 ft³/s

Drainage Area	
SCS CN (Composite)	74.000
Area (User Defined)	1.388 acres
Maximum Retention (Pervious)	3.5 in
Maximum Retention (Pervious, 20 percent)	0.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	1.4 in
Runoff Volume (Pervious)	0.160 ac-ft

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.160 ac-ft

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670

SCS Unit Hydrograph Parameters	
Unit peak, qp	18.87 ft³/s
Unit peak time, Tp	0.056 hours
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Wataburger Lees Summit

Subsection: Unit Hydrograph Summary
Label: CM-1

Return Event: 10 years
Storm Event: 10 year

Storm Event	10 year
Return Event	10 years
Duration	24.000 hours
Depth	5.7 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.388 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	9.70 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	9.50 ft³/s

Drainage Area	
SCS CN (Composite)	92.000
Area (User Defined)	1.388 acres
Maximum Retention (Pervious)	0.9 in
Maximum Retention (Pervious, 20 percent)	0.2 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	4.8 in
Runoff Volume (Pervious)	0.550 ac-ft

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.550 ac-ft

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670

Wataburger Lees Summit

Subsection: Unit Hydrograph Summary
Label: CM-1

Return Event: 10 years
Storm Event: 10 year

SCS Unit Hydrograph Parameters	
Unit peak, qp	18.87 ft³/s
Unit peak time, Tp	0.056 hours
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	10 year
Return Event	10 years
Duration	24.000 hours
Depth	5.7 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.388 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	6.39 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	6.09 ft³/s

Drainage Area	
SCS CN (Composite)	74.000
Area (User Defined)	1.388 acres
Maximum Retention (Pervious)	3.5 in
Maximum Retention (Pervious, 20 percent)	0.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	2.9 in
Runoff Volume (Pervious)	0.337 ac-ft

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.337 ac-ft

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670

SCS Unit Hydrograph Parameters	
Unit peak, qp	18.87 ft³/s
Unit peak time, Tp	0.056 hours
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Storm Event	100 year
Return Event	100 years
Duration	24.000 hours
Depth	9.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.388 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	16.37 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	16.08 ft³/s

Drainage Area	
SCS CN (Composite)	92.000
Area (User Defined)	1.388 acres
Maximum Retention (Pervious)	0.9 in
Maximum Retention (Pervious, 20 percent)	0.2 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	8.3 in
Runoff Volume (Pervious)	0.959 ac-ft

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.958 ac-ft

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670

Wataburger Lees Summit

Subsection: Unit Hydrograph Summary
Label: CM-1

Return Event: 100 years
Storm Event: 100 year

SCS Unit Hydrograph Parameters	
Unit peak, qp	18.87 ft³/s
Unit peak time, Tp	0.056 hours
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Wataburger Lees Summit

Subsection: Unit Hydrograph Summary
Label: CM-1

Return Event: 100 years
Storm Event: 100 year

Storm Event	100 year
Return Event	100 years
Duration	24.000 hours
Depth	9.3 in
Time of Concentration (Composite)	0.083 hours
Area (User Defined)	1.388 acres

Computational Time Increment	0.011 hours
Time to Peak (Computed)	11.922 hours
Flow (Peak, Computed)	13.13 ft³/s
Output Increment	0.050 hours
Time to Flow (Peak Interpolated Output)	11.900 hours
Flow (Peak Interpolated Output)	12.70 ft³/s

Drainage Area	
SCS CN (Composite)	74.000
Area (User Defined)	1.388 acres
Maximum Retention (Pervious)	3.5 in
Maximum Retention (Pervious, 20 percent)	0.7 in

Cumulative Runoff	
Cumulative Runoff Depth (Pervious)	6.1 in
Runoff Volume (Pervious)	0.702 ac-ft

Hydrograph Volume (Area under Hydrograph curve)	
Volume	0.701 ac-ft

SCS Unit Hydrograph Parameters	
Time of Concentration (Composite)	0.083 hours
Computational Time Increment	0.011 hours
Unit Hydrograph Shape Factor	483.432
K Factor	0.749
Receding/Rising, Tr/Tp	1.670

Wataburger Lees Summit

Subsection: Unit Hydrograph Summary
Label: CM-1

Return Event: 100 years
Storm Event: 100 year

SCS Unit Hydrograph Parameters	
Unit peak, qp	18.87 ft³/s
Unit peak time, Tp	0.056 hours
Unit receding limb, Tr	0.222 hours
Total unit time, Tb	0.278 hours

Wataburger Lees Summit

Subsection: Outlet Input Data
Label: Composite Outlet Structure - 1

Return Event: 2 years
Storm Event: 2 year

Requested Pond Water Surface Elevations	
Minimum (Headwater)	1,006.75 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	1,014.50 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Orifice-Circular	Orifice - 1	Forward	Culvert - 1	1,006.75	1,014.50
Orifice-Circular	Orifice - 2	Forward	Culvert - 1	1,009.00	1,014.50
Rectangular Weir	Weir - 1	Forward	Culvert - 1	1,013.00	1,014.50
Culvert-Circular	Culvert - 1	Forward	TW	1,005.75	1,014.50
Tailwater Settings	Tailwater			(N/A)	(N/A)

Wataburger Lees Summit

Subsection: Outlet Input Data
Label: Composite Outlet Structure - 1

Return Event: 2 years
Storm Event: 2 year

Structure ID: Orifice - 1 Structure Type: Orifice-Circular	
Number of Openings	1
Elevation	1,006.75 ft
Orifice Diameter	1.4 in
Orifice Coefficient	0.600

Structure ID: Orifice - 2 Structure Type: Orifice-Circular	
Number of Openings	2
Elevation	1,009.00 ft
Orifice Diameter	6.0 in
Orifice Coefficient	0.600

Structure ID: Weir - 1 Structure Type: Rectangular Weir	
Number of Openings	1
Elevation	1,013.00 ft
Weir Length	4.00 ft
Weir Coefficient	3.00 (ft^0.5)/s

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	12.0 in
Length	53.70 ft
Length (Computed Barrel)	53.74 ft
Slope (Computed)	0.040 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.200
Kb	0.031
Kr	0.200
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0045
M	2.0000
C	0.0317
Y	0.6900

Inlet Control Data	
T1 ratio (HW/D)	1.075
T2 ratio (HW/D)	1.177
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	1,006.83 ft	T1 Flow	2.75 ft³/s
T2 Elevation	1,006.93 ft	T2 Flow	3.14 ft³/s

Structure ID: TW
Structure Type: TW Setup, DS Channel

Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft^3/s
Flow Tolerance (Maximum)	10.000 ft^3/s

Wataburger Lees Summit

Subsection: Level Pool Pond Routing Summary
Label: PO-1 (IN)

Return Event: 100 years
Storm Event: 100 year

Infiltration	
Infiltration Method (Computed)	No Infiltration

Initial Conditions	
Elevation (Water Surface, Initial)	1,006.75 ft
Volume (Initial)	0.000 ac-ft
Flow (Initial Outlet)	0.00 ft³/s
Flow (Initial Infiltration)	0.00 ft³/s
Flow (Initial, Total)	0.00 ft³/s
Time Increment	0.050 hours

Inflow/Outflow Hydrograph Summary			
Flow (Peak In)	16.08 ft³/s	Time to Peak (Flow, In)	11.900 hours
Flow (Peak Outlet)	3.77 ft³/s	Time to Peak (Flow, Outlet)	12.100 hours

Elevation (Water Surface, Peak)	1,012.97 ft
Volume (Peak)	0.499 ac-ft

Mass Balance (ac-ft)	
Volume (Initial)	0.000 ac-ft
Volume (Total Inflow)	0.958 ac-ft
Volume (Total Infiltration)	0.000 ac-ft
Volume (Total Outlet Outflow)	0.758 ac-ft
Volume (Retained)	0.199 ac-ft
Volume (Unrouted)	-0.001 ac-ft
Error (Mass Balance)	0.1 %

Wataburger Lees Summit

Subsection: Pond Inflow Summary
Label: PO-1 (IN)

Return Event: 2 years
Storm Event: 2 year

Summary for Hydrograph Addition at 'PO-1'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	CM-1

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (hours)	Flow (Peak) (ft^3/s)
Flow (From)	CM-1	0.328	11.900	5.82
Flow (In)	PO-1	0.328	11.900	5.82

Wataburger Lees Summit

Subsection: Pond Inflow Summary
Label: PO-1 (IN)

Return Event: 10 years
Storm Event: 10 year

Summary for Hydrograph Addition at 'PO-1'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	CM-1

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (hours)	Flow (Peak) (ft^3/s)
Flow (From)	CM-1	0.550	11.900	9.50
Flow (In)	PO-1	0.550	11.900	9.50

Summary for Hydrograph Addition at 'PO-1'

Upstream Link	Upstream Node
<Catchment to Outflow Node>	CM-1

Node Inflows

Inflow Type	Element	Volume (ac-ft)	Time to Peak (hours)	Flow (Peak) (ft^3/s)
Flow (From)	CM-1	0.958	11.900	16.08
Flow (In)	PO-1	0.958	11.900	16.08

Wataburger Lees Summit

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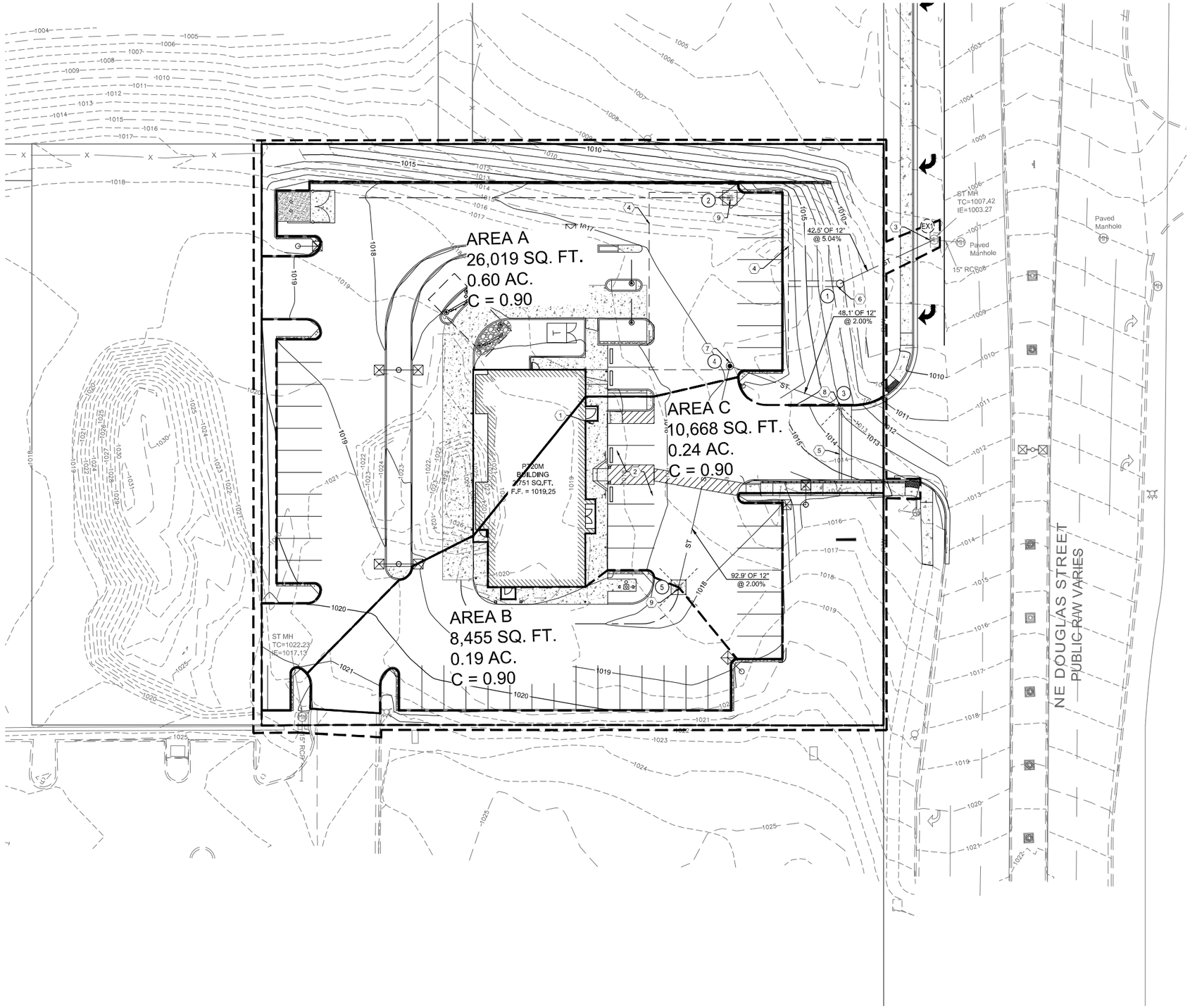
APPENDIX C

CATCHMENT AREAS & DRAINAGE MAP

Catchment Areas
Project Name: WB Lees Summit
Project Number: 62-40497
Date: 10/16/2020

Catchment Areas			
	sq.ft.	Ac.	c
A			
Impervious	26,019	0.60	0.90
Gravel	0	0.00	0.50
Grass	0	0.00	0.30
Total	26,019	0.60	0.90
B			
Impervious	8,455	0.19	0.90
Gravel	0	0.00	0.50
Grass	0	0.00	0.30
Total	8,455	0.19	0.90
C			
Impervious	10,668	0.24	0.90
Gravel	0	0.00	0.50
Grass	0	0.00	0.30
Total	10,668	0.24	0.90



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REVISION/DATE/DESCRIPTION

60% Plan Set	10/20/20
90% Plan Set	11/17/20
100% Plan Set	12/16/20

WHATABURGER

ms consultants, inc.
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2221 Schrock Road
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fax 614.898.7570

PROJECT

WHATABURGER
PT20M BUILDING

1450 NE DOUGLAS ST.
LEE'S SUMMIT, MO
64086

SHEET TITLE

CATCHMENT AREA PLAN

MISSOURI ONE CALL SYSTEM

The Missouri One Call System is a communications system which was established to help prevent damage to underground facilities and to promote safety. Missouri One Call operators are on duty 24 hours a day, seven days a week.

Missouri One Call provides a telephone number for contractors and the general public to call for notification of their intent to use equipment for excavation, grading, blasting, boring, demolition or other types of similar work.

1-800-DIG-RITE or 811

MAKE THE CALL...IT'S THE LAW

DRAWN BY:	LLK/AMA
CHECKED BY:	KEA
PROJECT NO:	40497-01

DRAWING

CA

APPENDIX D

STORM CONVEYANCE CALCULATIONS

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	92.9	0.19	0.19	0.90	0.17	0.17	5.0	5.0	9.9	1.69	5.46	4.06	12	2.00	1010.00	1011.86	1010.50	1012.41	1016.85	1017.70	5 to 4

WB Lees Area B | Number of lines: 1 | Run Date: 12/16/2020

NOTES:Intensity = 37.95 / (Inlet time + 3.40) ^ 0.63; Return period =Yrs. 25 ; c = cir e = ellip b = box

Storm Sewer Tabulation

Station		Len	Drng Area		Rnoff coeff	Area x C		Tc		Rain (I)	Total flow	Cap full	Vel	Pipe		Invert Elev		HGL Elev		Grnd / Rim Elev		Line ID
Line	To Line	(ft)	Incr (ac)	Total (ac)	(C)	Incr	Total	Inlet (min)	Syst (min)	(in/hr)	(cfs)	(cfs)	(ft/s)	Size (in)	Slope (%)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	
1	End	48.0	0.24	0.24	0.90	0.22	0.22	5.0	5.0	9.9	2.14	5.46	4.13	12	2.00	1010.00	1010.96	1010.63	1011.59	1016.85	1013.00	3 to 4

WB Lees Area C

Number of lines: 1

Run Date: 3/3/2021

NOTES:Intensity = 37.95 / (Inlet time + 3.40) ^ 0.63; Return period =Yrs. 25 ; c = cir e = ellip b = box

APPENDIX E

WATER QUALITY CALCULATION

WATER QUALITY VOLUME CALCULATIONS- Drainage Area into Pond

Project Name: **WB Lees Summit**

Project Number: **62-40497**

Date: **10/16/2020**

UGS 1

WQ_v = Rv * P * A / 12

Post Construction				
Total Area	60,452	SF	1.39	acres
Impervious Area	45,145	SF	1.04	acres
Gravel Area	0.0	SF	0.00	acres
i =	0.75			

Rv = 0.05 + 0.9i

Rv=	0.72	Volumetric Runoff Coefficient

P = 0.90 inch precipitation depth

A = Area draining into the BMP in acres

P =	1.37			
A =	1.39			
WQ_v =	0.11	ac-feet	4,983.73	ft^3

WATER QUALITY VOLUME CALCULATIONS- Drainage Area into Pond

Project Name: WB Lees Summit
Project Number: 62-40497
Date: 1/21/2021

UGS

VOLUMETRIC STAGE STORAGE

STAGE	TOT VOL (ft^3)	TOT VOL (ac-ft)
1006.75	0.00	0.000
1007.00	437.00	0.010
1008.00	3,727.00	0.086
1009.00	8,420.00	0.193
1010.00	12,821.00	0.294
1011.00	16,764.00	0.385
1013.50	22,668.00	0.520

WQv = 4,983.73 cf **WQelev =** 1008.14

WQv- Orifice #1:

PIPE DIA.	1.4	in	0.117	ft			
total PIPE A	1.539	in^2	0.011	ft^2			
C	0.6						
INV.	1006.75						
STAGE	**Q1 (CFS)**	**Q2 (CFS)**	**Q (CFS)**	**Q AVG (CFS)**	**INC VOL (CFT)**	**INC DRAW (HR)**	**TOT DRAW (HR)**
1006.75	0.000	0	0				
				0.03	4738	44.4	
1008.14	0.059	0.000	0.06				44.4

APPENDIX F

COMPLETE SITE CIVIL PLANS