Drainage Report

For

Hillcrest Addition

Springhill Road
Bryant, Arkansas

Revised: July 22, 2024

Prepared By:

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Project Information

Project Title: Hillcrest Addition

Project Description: 13 lot single family development located on the West side of Springhill Road, North of and adjacent to Hurricane Gardens, Bryant, Arkansas (address: 3927 Springhill Road)

Owner/Developer: Springhill – Hwy 5 Development, LLC
816 East Oak Street
Conway, Arkansas 72032

Engineer of Record: Lemons Engineering Consultants, Inc.
Tim Lemons, PE
204 Cherry Street
Cabot, Arkansas 72023
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General Information

This proposed development shall include 13 single family lots. This property is essentially the Northern Most tract of land within the city limits of Bryant as they presently exist. The property to the North of the subject site is developed with duplex style residential structures. The property to the South is an established subdivision (Hurricane Gardens). The property drains North to South. There have been several reports of drainage issues by the residents of Hurricane Gardens. At present, the drainage from the subject property, and that to the north of the subject property, flows onto Hurricane Gardens. No detention exists on the property located north of the subject property. In this report, we will design a detention facility to accommodate the possible increase in flow for the subject property (Hillcrest Addition). Also, our goal is to divert a large majority of the drainage falling onto Hurricane Gardens. This diversion will force the runoff to the proposed detention facility on Hillcrest Addition as shown in the civil plans.

Project Vicinity Map

Hydrological Computations

For this analysis, we will use the Rational Method in determining culvert sizes, culvert capacity computations, and other related issues on site. The total watershed size for this development is estimated at 10.57 acres. Attention is called to the Watershed Map included in this report. As per the Rational Method, the following equation is used:

$Q = C \times I \times A$, where:

Q = Flowrate (cfs)
C = Runoff Coefficient
I = Intensity (from tables)
A = area (acres)

The selection of the appropriate intensity is based on the estimated time of concentration (tc).

Determination of Runoff Coefficients "C"

In determining the Pre Construction C, we must consider the property to the North that is developed, and discharging onto the subject property. The C factor for Pre and Post Conditions are based on Table 400-1 "Runoff Coefficients for Surface Types" as provided in the Bryant Drainage Manual. A factored (weighted) value of C is determined in the following tables:

Pre Construction Conditions

Storm Event	Off Site C1	Off Site A1 (acres)	Off Site C2	Off Site A2 (acres)	On Site C3	On Site A3 (acres)	On Site C4	On Site A4 (acres)	Weighted C Factor
2	0.75	3.04	0.29	4.73	0.75	0.19	0.29	4.59	0.41
5	0.8	3.04	0.32	4.73	0.8	0.19	0.32	4.59	0.44
10	0.83	3.04	0.35	4.73	0.83	0.19	0.35	4.59	0.47
25	0.88	3.04	0.39	4.73	0.88	0.19	0.39	4.59	0.52
50	0.92	3.04	0.42	4.73	0.92	0.19	0.42	4.59	0.55
100	0.97	3.04	0.46	4.73	0.97	0.19	0.46	4.59	0.59

C1 (off site for homes, streets, etc.)
C2 (off site for grass, landscaping, etc.)
C3 (on site for homes, streets, etc.)
C4 (on site for grass. Landscaping, etc.)

A1 (off site area for C1)
A2 (off site area for C2)
A3 (on site area for C3)
A4 (on site area for C4)

Post Construction Conditions

Storm Event	Off Site C1	Off Site A1 (acres)	Off Site C2	Off Site A2 (acres)	On Site C3	On Site A3 (acres)	On Site C4	On Site A4 (acres)	Weighted C Factor
2	0.75	3.04	0.29	4.73	0.75	1.81	0.29	3.07	0.47
5	0.8	3.04	0.32	4.73	0.8	1.81	0.32	3.07	0.50
10	0.83	3.04	0.35	4.73	0.83	1.81	0.35	3.07	0.53
25	0.88	3.04	0.39	4.73	0.88	1.81	0.39	3.07	0.58
50	0.92	3.04	0.42	4.73	0.92	1.81	0.42	3.07	0.61
100	0.97	3.04	0.46	4.73	0.97	1.81	0.46	3.07	0.66

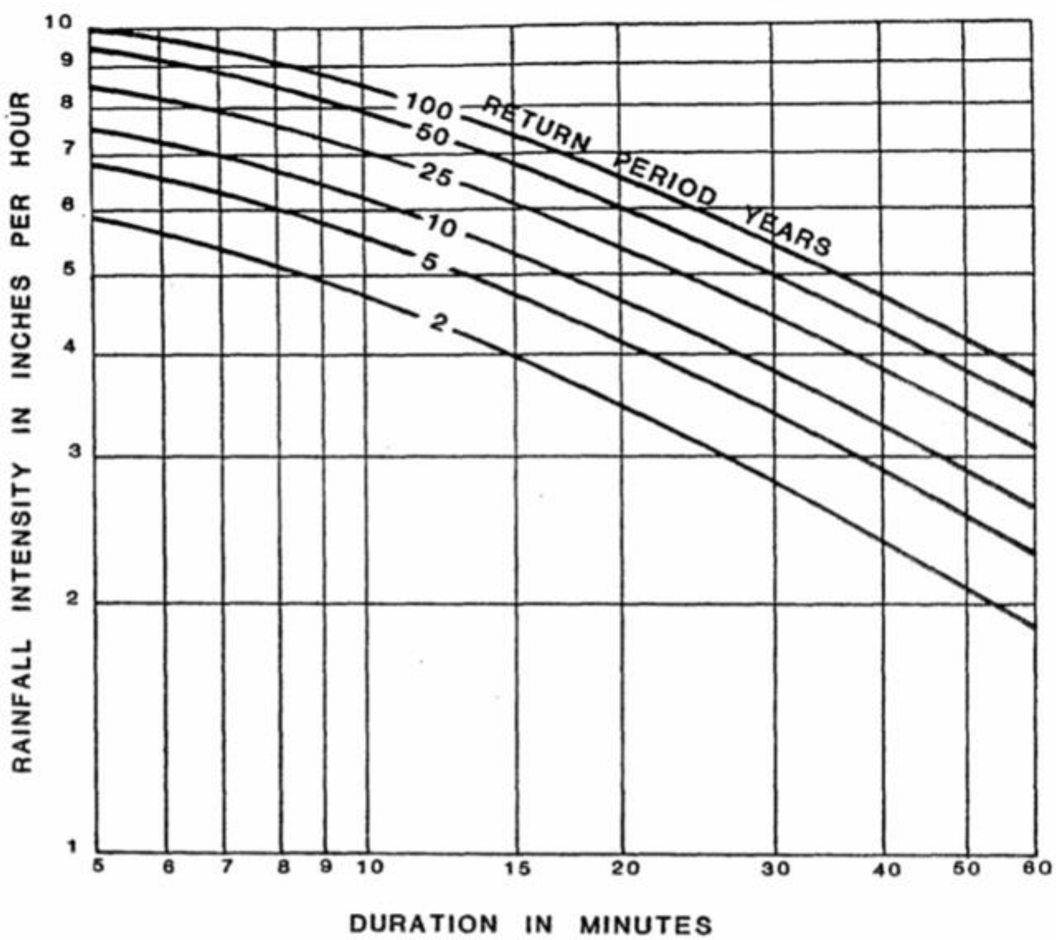
C1 (off site for homes, streets, etc.)
C2 (off site for grass, landscaping, etc.)
C3 (on site for homes, streets, etc.)
C4 (on site for grass. Landscaping, etc.)

A1 (off site area for C1)
A2 (off site area for C2)
A3 (on site area for C3)
A4 (on site area for C4)

The above variable values will be used in designing the Detention Facility. For culvert design, we will use the Post C values for the 25 year storm.

Determination of Intensity Values "I"

For this analysis, we will use the Intensity – Duration - Frequency Chart from the Little Rock Drainage Manual. Whereas the calculated value of I shall be used for Detention, we will use a tc (time of concentration) of 5 min for the culverts to also provide a conservative value.



INTENSITY - DURATION - FREQUENCY

LITTLE ROCK

SOURCE : HYDRO 35 & T.P. No. 40

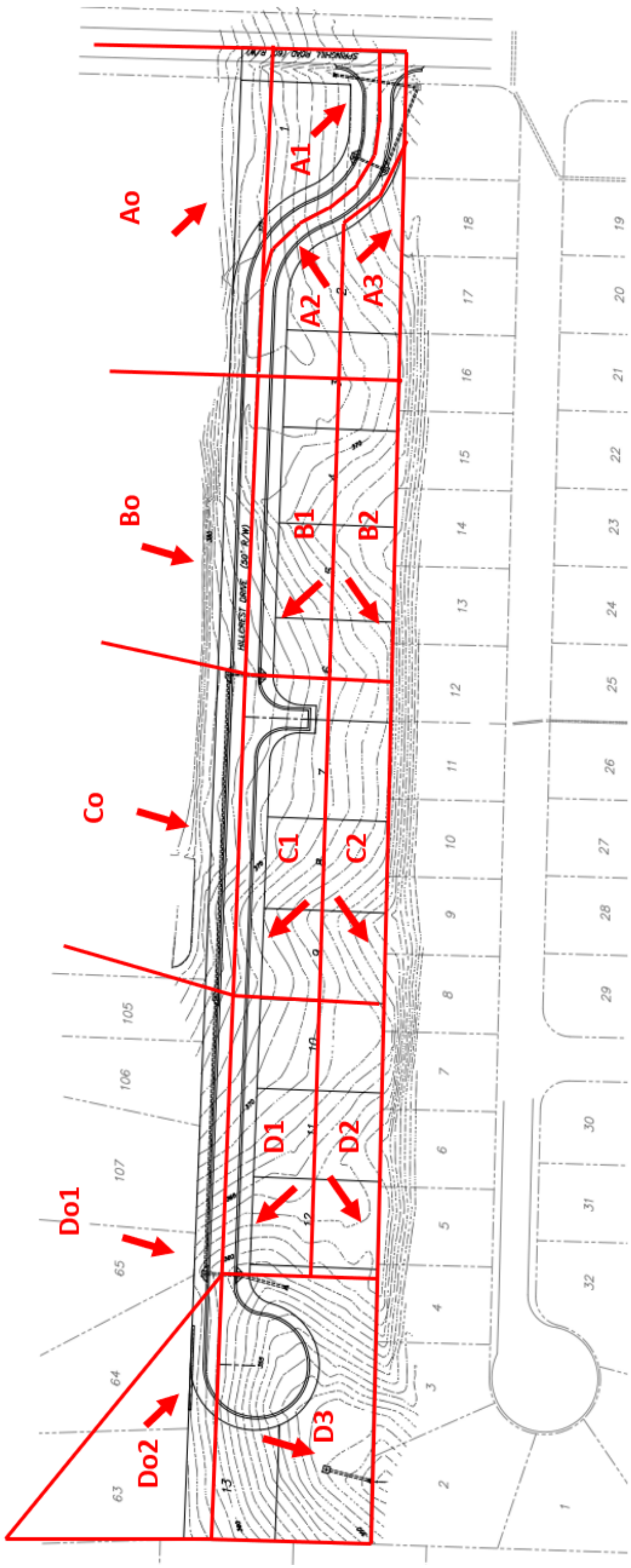
Determination of Flowrates for Culverts & Spreadflow

Attention is called to the following chart which provides C, Intensity, Area, and Flowrate (Q) of each Tract. Again, the Rational Method is being used for all basins. Attention is called to the Maps on the next two pages for a detailed drawings showing the various watershed tracts. The 25 year storm event will be used for culvert design. A conservative tc of 5 minutes is used for the culvert design.

Tract	C (post)	I	A	Q
		(in/hr)	(ac)	(cfs)
Ao	0.58	8.5	2	9.86
Bo	0.58	8.5	1.53	7.54
Co	0.58	8.5	1.73	8.53
Do1	0.58	8.5	1.92	9.47
Do2	0.58	8.5	0.59	2.91
A1	0.58	8.5	0.54	2.66
A2	0.58	8.5	0.29	1.43
A3	0.58	8.5	0.25	1.23
B1	0.58	8.5	0.47	2.32
B2	0.58	8.5	0.33	1.63
C1	0.58	8.5	0.49	2.42
C2	0.58	8.5	0.36	1.77
D1	0.58	8.5	0.44	2.17
D2	0.58	8.5	0.32	1.58
D3	0.58	8.5	1.15	5.67

Drainage Watershed Map (Off Site)

Drainage Watershed Map (On Site)



Culvert Sizing

All culverts are sized to meet a 25 year storm, and the Rational Method is used. We will use a Manning's Coefficient of 0.012 shall be for all culverts (concrete and HDPE).

FES 1a
Q = Qao (2/3) = 9.86 (2/3) = 6.58 cfs
Use 18" @ 0.7%
Q capacity = 9.23 cfs
V actual = 5.80 fps (d/D = 0.61)

Inlet 1
Q = Qao (2/3) + Qa1 = 9.86 (2/3) + 2.66 = 9.24 cfs
Use 18" @ 1.1%
Q capacity = 12.30 cfs
V actual = 7.45 fps (d/D = 0.66)

Inlet 2
Q = Inlet 1 + Qa2 = 9.24 + 1.43 = 10.67 cfs
Use 18" @ 1.4%
Q capacity = 13.87 cfs
V actual = 8.44 fps (d/D = 0.67)

Junction Box 3 (verify capacity)
Q = Qao + Qa1 + Qa2 + Exist 18" in Hurricane Gardens
(Culvert in Hurricane Gardens is an 18" ADS at 0.46%, Capacity = 7.95 cfs at d/D=0.85)
Q = 9.86 + 2.66 + 1.43 + 7.95 = 21.90 cfs
Existing 24" Discharging from Junc Box is 24" ADS @ 5.20%
Q capacity = 57.58 cfs ***Capacity appears to exist***
V actual = 16.61 fps (d/D = 0.43)

Inlet 4
Q = Qb1 = 2.32 cfs
Use 18" @ 0.5%
Q capacity = 8.29 cfs
V actual = 4.00 fps (d/D = 0.38)

Inlet 5
Q = Inlet 4 + Qbo = 2.32 + 7.54 = 9.86 cfs
Use 18" @ 1.0%
Q capacity = 11.73 cfs
V actual = 7.35 fps (d/D = 0.71)

Inlet 6
Q = Inlet 5 + Qco = 9.86 + 8.53 = 18.39 cfs
Use 18" @ 4.60%
Q capacity = 25.15 cfs
V actual = 15.18 fps (d/D = 0.65)

Inlet 7
Q = Inlet 6 + Qdo1 = 18.39 + 9.47 = 27.86 cfs
Use 24" @ 2.0%
Q capacity = 35.71 cfs
V actual = 12.22 fps (d/D = 0.67)

Inlet 8
Q = Inlet 7 + Qd1 = 27.86 + 2.17 = 30.03 cfs
Use 18" @ 2.25%
Q capacity = 37.87 cfs
V actual = 13.06 fps (d/D = 0.69)

Street Spreadflow Analysis (Gutter Capacity)

In this Section of the Report, we will examine how the stormwater in the street gutters may impact in proposed inlets. We will use our 27' street width (back of curb to back of curb), while giving allowances for the vertical portion of the curb on each side. The crown on the street shall be 3.0%. The available street width, to handle the stormwater, has a width of 26'. Our goal is to provide a minimum "non submerged" street width ("clear space") of 8 feet. A Manning's Coefficient of 0.12 is used for the pavement surface. Attention is called to the Appendix for the spreadsheets used to evaluate these areas.

Check Inlet 1 & 2 – Hillcrest Drive

Inlet 1

Q = Qa0(1/2) + Qa1/2 = 9.86 (0.5) + 2.66 (0.5) = 6.26 cfs
Gutter Slope = 1.50%
Height of water (from gutter) = 0.30’
Width of water (from gutter) = 10.0’
Clear space (half street) = 13.0 – 10.0’ = 3.0’

Inlet 2

Q = Qa2 = 1.43 cfs
Gutter Slope = 1.50%
Height of water (from gutter) = 0.17’
Width of water (from gutter) = 5.5’
Clear space (half street) = 13.0 – 5.5’ = 7.5’

Total Clear Space = 3.0 + 7.5 = 10.5’

Check Inlet 4 & 5 – Hillcrest Drive

Inlet 4

Q = Qb1 = 2.32 cfs
Gutter Slope = 0.5%
Height of water (from gutter) = 0.26’
Width of water (from gutter) = 8.5’
Clear space (half street) = 13.0 – 8.5’ = 4.5’

Inlet 5

Q = Qbo = 7.54 fps
Gutter Slope = 0.5%
Height of water (from gutter) = 0.39’
Width of water (from gutter) = 13.0’
Clear space (half street) = 13.0 – 13.0’ = 0.0’

Total Clear Space = 4.5 + 0.0 = 4.5’

TRY 10 YEAR STORM

Inlet 4

Q = Qb1 = 1.97 cfs
Gutter Slope = 0.5%
Height of water (from gutter) = 0.23’
Width of water (from gutter) = 7.5’
Clear space (half street) = 13.0 – 7.5’ = 5.5’

Inlet 5

Q = Qbo = 6.41 fps
Gutter Slope = 0.5%
Height of water (from gutter) = 0.36’
Width of water (from gutter) = 12.0’
Clear space (half street) = 13.0 – 12.0’ = 1.0’

Total Clear Space = 5.5 + 1.0 = 6.5’

Check Inlet 6 & Across Street – Hillcrest Drive

Inlet 6

Q = Qco = 8.53 cfs

Gutter Slope = 2.67%

Height of water (from gutter) = 0.30'

Width of water (from gutter) = 10.0'

Clear space (half street) = 13.0 – 10.0' = 3.0'

Across from Inlet 6

Q = Qc1 = 2.42 cfs

Gutter Slope = 2.67%

Height of water (from gutter) = 0.18'

Width of water (from gutter) = 6.0'

Clear space (half street) = 13.0 – 6.0' = 7.0'

Total Clear Space = 3.0 + 7.0 = 10.0'

Check Inlet 7 & 8 – Hillcrest

Inlet 7

Q = Qdo1(1/2) = 9.47 (0.5) = 4.74 cfs

Gutter Slope = 4.88%

Height of water (from gutter) = 0.21'

Width of water (from gutter) = 7.0'

Clear space (half street) = 13.0 – 7.0' = 6.0'

Inlet 8

Q = Qc1 + Qd1 = 2.42 + 2.17 = 4.59 cfs

Gutter Slope = 4.88%

Height of water (from gutter) = 0.21'

Width of water (from gutter) = 7.0'

Clear space (half street) = 13.0 – 7.0' = 6.0'

Total Clear Space = 6.0 + 6.0 = 12.0'

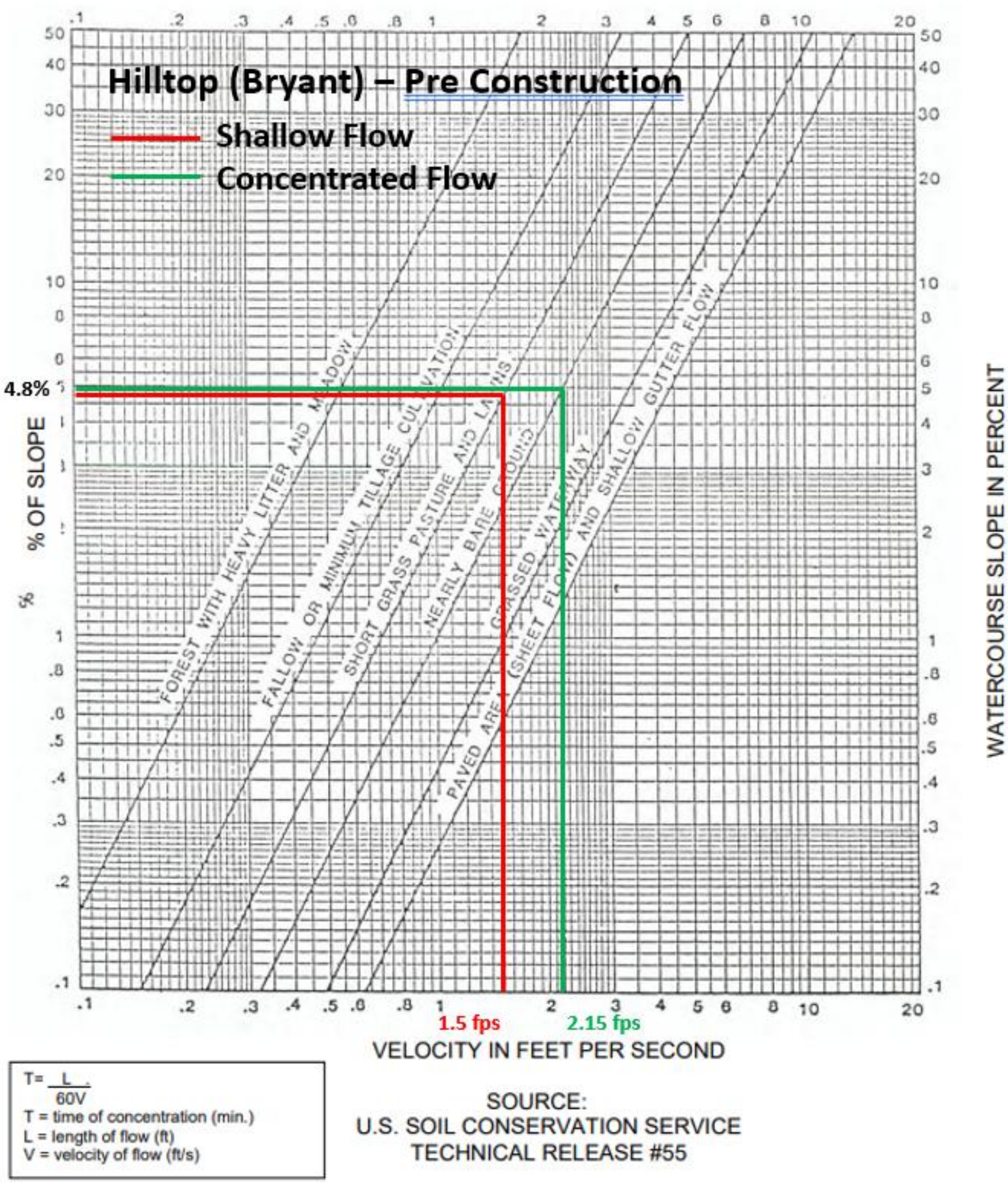
Detention Facility Computations

In this section, we will size the detention facility located in the Common Area (West side of the project). At the completion of this section, a summary of pre and post flows will be provided. Whereas the time of concentration will be used to determine the intensity (I), the runoff coefficient (C) for each storm analysis shall be based on that determined on pages 5 and 6 of this report.

Time of Concentration (tc)

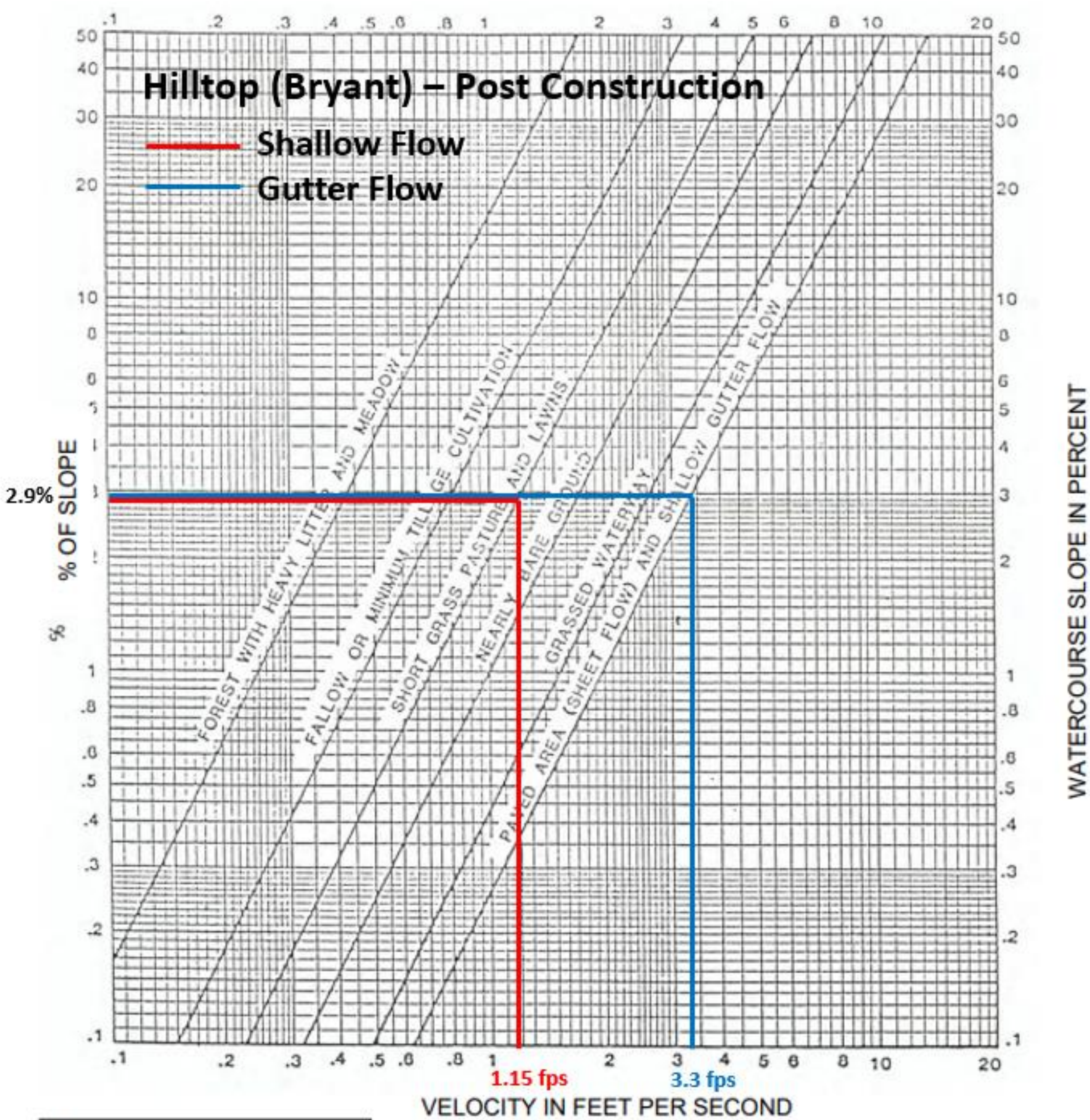
In determining the time of concentration, we must first determine the velocity of the runoff based on the type of ground cover and type of flow. The total tc is a sum of the tc for overland flow, the tc for shallow concentrated flow, and the tc for channelized flow. For this analysis, we will use the US Soil Conservation Service Technical Release #55, "Watercourse Slope vs Velocity" graph. A Pre Construction and Post Construction graph for each watershed is provided on the following pages.

Pre Construction Time of Concentration (tc)



Pre-Construction tc = Σ(L/(60)(V)) = 6 min

Post Construction Time of Concentration (tc)



$T = \frac{L}{60V}$

T = time of concentration (min.)
L = length of flow (ft)
V = velocity of flow (ft/s)

SOURCE:
U.S. SOIL CONSERVATION SERVICE
TECHNICAL RELEASE #55

Pre-Construction tc = Σ(L/(60)(V)) = 9 min

Flow Comparisons (Pre and Post Flow)

Storm Event (Year)	C Pre	tc Pre	I Pre (in/hr)	A Pre (ac)	Q Pre (cfs)	C Post	tc Post	I Post (in/hr)	A Post (ac)	Q Post (cfs)	Increase (cfs)
2	0.41	6	5.70	4.33	**10.12**	0.47	9	4.90	9.73	**22.41**	**12.29**
5	0.44	6	6.50	4.33	**12.38**	0.50	9	5.80	9.73	**28.22**	**15.83**
10	0.47	6	7.20	4.33	**14.65**	0.53	9	6.50	9.73	**33.52**	**18.87**
25	0.52	6	8.20	4.33	**18.46**	0.58	9	7.40	9.73	**41.76**	**23.30**
50	0.55	6	9.20	4.33	**21.91**	0.61	9	8.20	9.73	**48.67**	**26.76**
100	0.59	6	9.70	4.33	**24.78**	0.66	9	8.80	9.73	**56.51**	**31.73**

Stage – Storage Table

The following Stage Storage Table is provided, based on the grading plan contained in the Civil Plans. The accumulative storage is provided in the right most column.

TYPE 3			
Stage - Storage for Irregular Detention Basin			
Top Elev	Bottom Elev	Increment	
352.5	345.5	0.5	
Stage	Area	Δ Volume	Volume
msl	sf	cf	cf
345.50	1	0	0
346.00	1369.09	342.52	342.52
346.50	1853.30	805.60	1148.12
347.00	2337.51	1047.70	2195.82
347.50	2951.40	1322.23	3518.05
348.00	3565.28	1629.17	5147.22
348.50	4240.13	1951.35	7098.57
349.00	4914.98	2288.78	9387.35
349.50	5637.46	2638.11	12025.46
350.00	6359.93	2999.35	15024.81
350.50	7118.75	3369.67	18394.48
351.00	7877.57	3749.08	22143.56
351.50	8673.71	4137.82	26281.38
352.00	9469.85	4535.89	30817.27
352.50	10265.99	4933.96	35751.23

Stage – Discharge Table

The following Stage Discharge Table is provided, based on the grading plan contained in the Civil Plans. The discharge structure planned for this facility is shown later in this report.

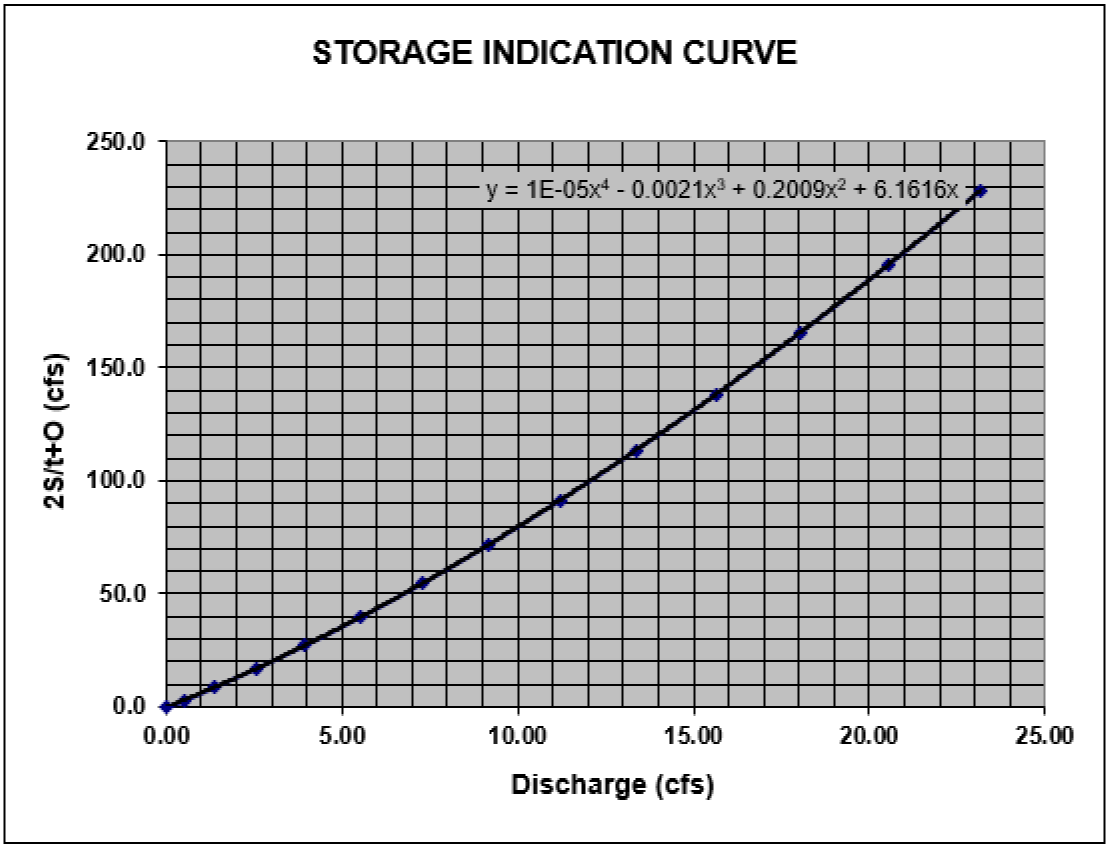
TYPE 2

Stage - Discharge for Rectangular Weir

FL Discharge	Beginning Elevation	Elevation Increment	Top of Basin
345.50	345.50	0.50	352.50

Stage	Head (H)	Weir Length (L)	Area (A)	Orifice Coefficient (C)	Velocity	Discharge (Q)
msl	ft	ft	sf		ft/s	cfs
345.50	0.00	0.42	0.00	3.33	0.00	0.00
346.00	0.50	0.42	0.21	3.33	2.35	0.49
346.50	1.00	0.42	0.42	3.33	3.33	1.40
347.00	1.50	0.42	0.63	3.33	4.08	2.57
347.50	2.00	0.42	0.84	3.33	4.71	3.96
348.00	2.50	0.42	1.05	3.33	5.27	5.53
348.50	3.00	0.42	1.26	3.33	5.77	7.27
349.00	3.50	0.42	1.47	3.33	6.23	9.16
349.50	4.00	0.42	1.68	3.33	6.66	11.19
350.00	4.50	0.42	1.89	3.33	7.06	13.35
350.50	5.00	0.42	2.10	3.33	7.45	15.64
351.00	5.50	0.42	2.31	3.33	7.81	18.04
351.50	6.00	0.42	2.52	3.33	8.16	20.56
352.00	6.50	0.42	2.73	3.33	8.49	23.18
352.50	7.00	0.42	2.94	3.33	8.81	25.90

Storage Indication Curve



Alternate Routing Time

The following spreadsheets represent the Hydrograph Routing for the various storm events. In each case, the Routing Storm Duration time was adjusted to provide the maximum storage required. A time of 40 minute time storm duration is used.

2 YEAR STORM EVENT

Coefficients for Storage Indication Curve from Chart			
Ax^4	Bx^3	Cx^2	Dx
0.0000	-0.0021	0.2009	6.1616

HYDROGRAPH ROUTING FOR 2 YEAR DESIGN STORM

Routing Storm Duration

40 **minutes**

	1	2	3	4	5	6	7	8
Time min	I_1 cfs	I_1+I_2 cfs	$2S_1/t$-Q_1 cfs	$2S_2/t$+Q_2 cfs	Q_2 cfs	S_2 cf	2S/t-Q from eqn.	Col 4 - 7
0	0.00	10.98	0	10.975	0	0	10.976	-0.001
5	6.10	17.07	7.596	24.668	1.690	1392.8	24.668	0.000
10	10.98	21.95	17.474	39.425	3.597	3160.7	39.426	-0.001
15	10.98	21.95	28.474	50.425	5.475	5092.4	50.425	0.000
20	10.98	21.95	36.855	58.806	6.785	6546.0	58.806	0.000
25	10.98	21.95	43.324	65.274	7.741	7659.7	65.275	-0.001
30	10.98	21.95	48.360	70.311	8.457	8522.6	70.310	0.001
35	10.98	21.95	52.304	74.255	9.003	9196.1	74.255	0.000
40	10.98	15.85	55.407	71.260	9.424	9724.6	71.261	-0.001
45	4.88	4.88	53.050	57.928	9.105	9323.2	15.037	42.891
50	0.00	0.00	53.376	53.376	2.376	8332.8	0.000	53.376
55	0.00	0.00	53.576	53.576	0.000	8006.5	0.000	53.576
60	0.00	0.00	53.776	53.776	0.000	8036.5	0.000	53.776

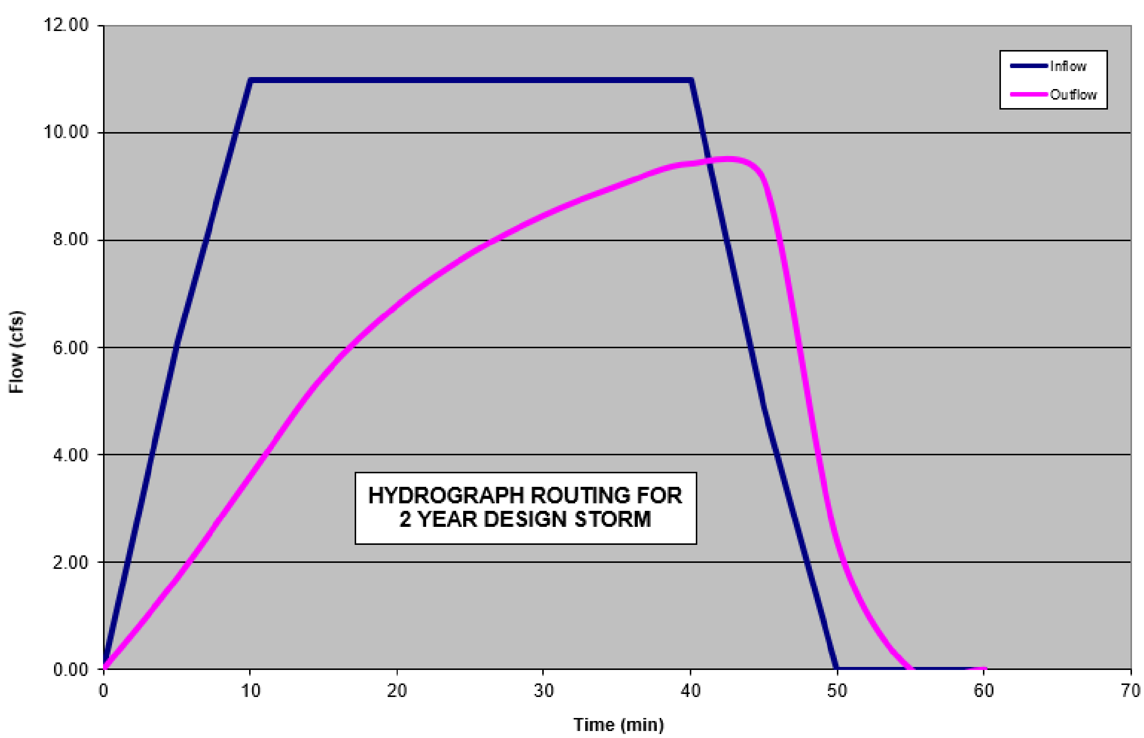
Actual Maximum Storage needed is 9724.6 cubic feet

Maximum Storage required is achieved at an elev. = 349.15

Maximum Allowable (undeveloped) Discharge is 10.12 cfs

Maximum Discharge for the above storm is 9.42 cfs

DETENTION HYDROGRAPH



5 YEAR STORM EVENT

Coefficients for Storage Indication Curve from Chart			
Ax^4	Bx^3	Cx^2	Dx
0.0000	-0.0021	0.2009	6.1616

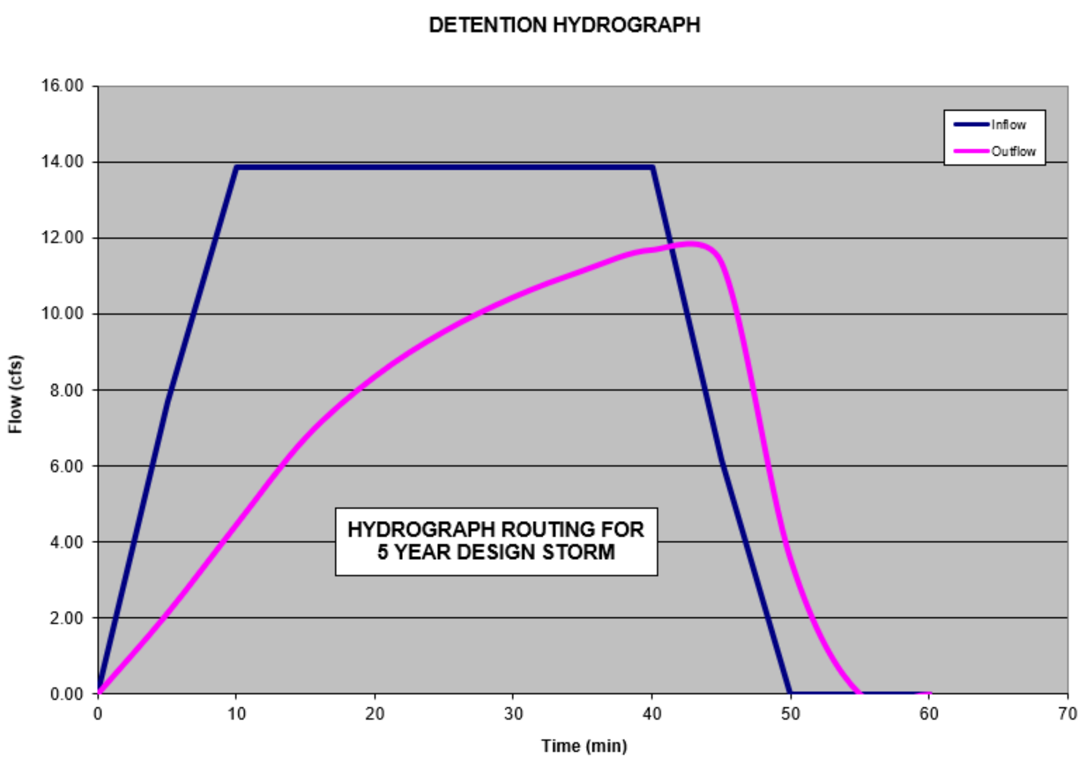
HYDROGRAPH ROUTING FOR 5 YEAR DESIGN STORM

Routing Storm Duration

40 **minutes**

	1	2	3	4	5	6	7	8
Time min	I_1 cfs	I_1+I_2 cfs	$2S_1/t-Q_1$ cfs	$2S_2/t+Q_2$ cfs	Q_2 cfs	S_2 cf	2S/t-Q from eqn.	Col 4 - 7
0	0.00	13.87	0	13.865	0	0	13.864	0.001
5	7.70	21.57	9.649	31.217	2.108	1763.5	31.218	-0.001
10	13.87	27.73	22.316	50.047	4.450	4015.0	50.048	-0.001
15	13.87	27.73	36.564	64.295	6.741	6495.9	64.294	0.000
20	13.87	27.73	47.595	75.326	8.350	8391.8	75.325	0.001
25	13.87	27.73	56.251	83.981	9.537	9868.2	83.980	0.001
30	13.87	27.73	63.103	90.834	10.439	11031.3	90.834	0.000
35	13.87	27.73	68.561	96.292	11.136	11954.6	96.291	0.001
40	13.87	20.03	72.929	92.956	11.682	12691.5	92.955	0.001
45	6.16	6.16	70.258	76.420	11.349	12241.1	23.433	52.987
50	0.00	0.00	69.555	69.555	3.532	10933.2	0.000	69.555
55	0.00	0.00	69.755	69.755	0.000	10433.3	0.000	69.755
60	0.00	0.00	69.955	69.955	0.000	10463.3	0.000	69.955

Actual Maximum Storage needed is 12691.5 cubic feet
Maximum Storage required is achieved at an elev. = 349.66
Maximum Allowable (undeveloped) Discharge is 12.38 cfs
Maximum Discharge for the above storm is 11.68 cfs



10 YEAR STORM EVENT

Coefficients for Storage Indication Curve from Chart			
Ax^4	Bx^3	Cx^2	Dx
0.0000	-0.0021	0.2009	6.1616

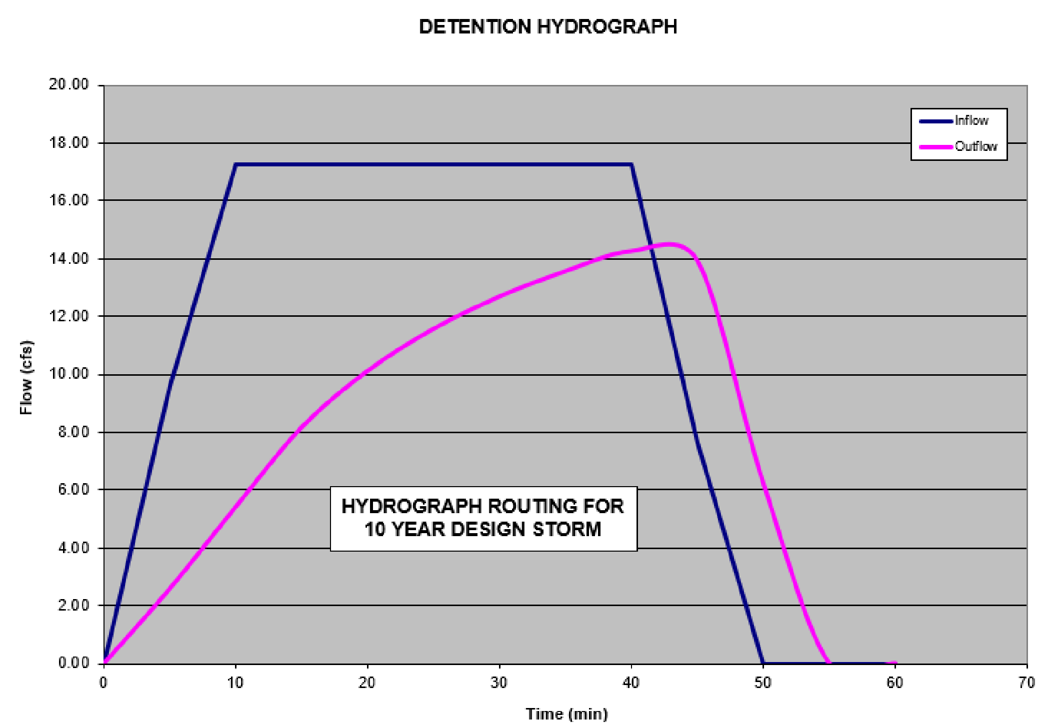
HYDROGRAPH ROUTING FOR 10 YEAR DESIGN STORM

Routing Storm Duration

40 **minutes**

	1	2	3	4	5	6	7	8
Time min	I_1 cfs	I_1+I_2 cfs	$2S_1/t-Q_1$ cfs	$2S_2/t+Q_2$ cfs	Q_2 cfs	S_2 cf	2S/t-Q from eqn.	Col 4 - 7
0	0.00	17.28	0	17.276	0	0	17.275	0.001
5	9.60	26.87	12.094	38.967	2.591	2202.7	38.968	-0.001
10	17.28	34.55	28.129	62.680	5.419	5032.2	62.679	0.001
15	17.28	34.55	46.336	80.887	8.172	8176.2	80.888	-0.001
20	17.28	34.55	60.648	95.199	10.120	10615.1	95.199	-0.001
25	17.28	34.55	72.052	106.604	11.573	12543.8	106.603	0.001
30	17.28	34.55	81.223	115.774	12.690	14087.0	115.773	0.001
35	17.28	34.55	88.642	123.193	13.566	15331.2	123.192	0.001
40	17.28	24.95	94.672	119.626	14.261	16339.9	119.625	0.001
45	7.68	7.68	91.770	99.448	13.928	15854.7	44.900	54.548
50	0.00	0.00	87.177	87.177	6.236	13981.9	0.000	87.177
55	0.00	0.00	87.377	87.377	0.000	13076.5	0.000	87.377
60	0.00	0.00	87.577	87.577	0.000	13106.5	0.000	87.577

Actual Maximum Storage needed is 16339.9 cubic feet
Maximum Storage required is achieved at an elev. = 350.17
Maximum Allowable (undeveloped) Discharge is 14.65 cfs
Maximum Discharge for the above storm is 14.26 cfs



25 YEAR STORM EVENT

Coefficients for Storage Indication Curve from Chart			
Ax^4	Bx^3	Cx^2	Dx
0.0000	-0.0021	0.2009	6.1616

HYDROGRAPH ROUTING FOR 25 YEAR DESIGN STORM

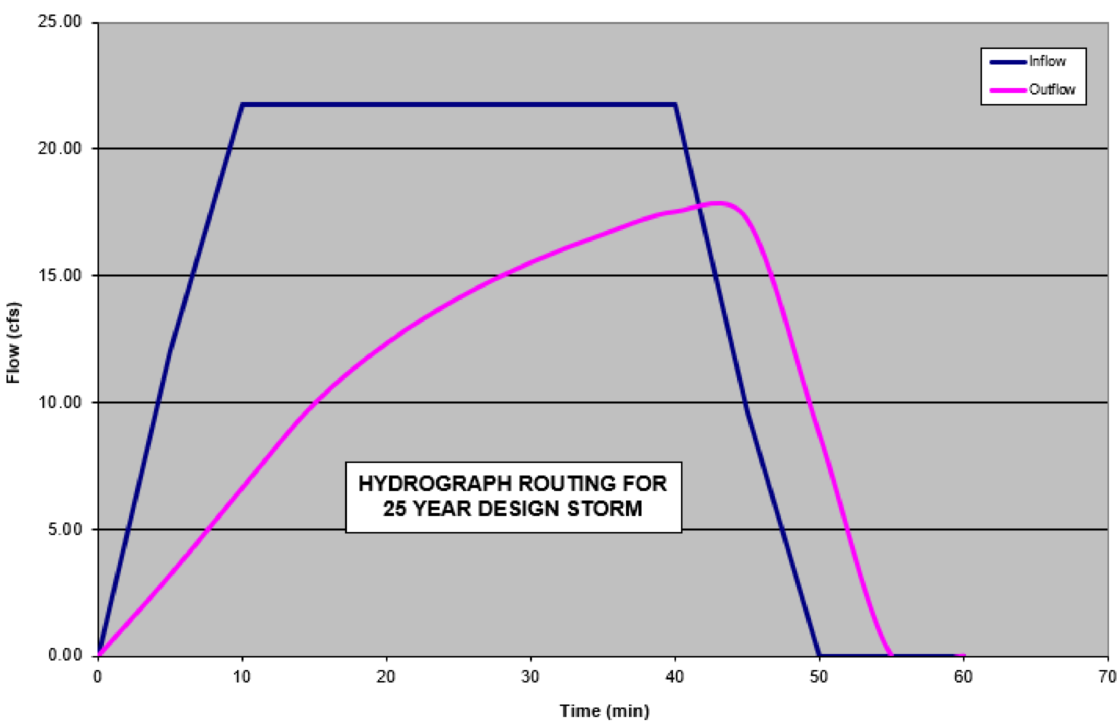
Routing Storm Duration

40 **minutes**

	1	2	3	4	5	6	7	8
Time	I_1	I_1+I_2	$2S_1/t-Q_1$	$2S_2/t+Q_2$	Q_2	S_2	2S/t-Q	Col 4 - 7
min	cfs	cfs	cfs	cfs	cfs	cf	from eqn.	
0	0.00	21.73	0	21.727	0	0	21.726	0.001
5	12.07	33.80	15.322	49.119	3.203	2778.7	49.119	0.001
10	21.73	43.45	35.854	79.308	6.633	6373.0	79.309	-0.001
15	21.73	43.45	59.397	102.851	9.956	10402.8	102.852	-0.001
20	21.73	43.45	78.198	121.652	12.327	13578.6	121.651	0.001
25	21.73	43.45	93.417	136.872	14.117	16130.2	136.873	-0.001
30	21.73	43.45	105.847	149.301	15.512	18203.9	149.302	-0.001
35	21.73	43.45	116.062	159.516	16.620	19902.2	159.515	0.001
40	21.73	31.38	124.494	155.877	17.511	21300.7	155.878	-0.001
45	9.66	9.66	121.486	131.143	17.196	20802.3	66.870	64.273
50	0.00	0.00	113.880	113.880	8.731	18361.7	0.000	113.880
55	0.00	0.00	114.080	114.080	0.000	17082.0	0.000	114.080
60	0.00	0.00	114.280	114.280	0.000	17112.0	0.000	114.280

Actual Maximum Storage needed is 21300.7 cubic feet
Maximum Storage required is achieved at an elev. = 350.82
Maximum Allowable (undeveloped) Discharge is 18.46 cfs
Maximum Discharge for the above storm is 17.51 cfs

DETENTION HYDROGRAPH



50 YEAR STORM EVENT

Coefficients for Storage Indication Curve from Chart			
Ax^4	Bx^3	Cx^2	Dx
0.0000	-0.0021	0.2009	6.1616

HYDROGRAPH ROUTING FOR 50 YEAR DESIGN STORM

Routing Storm Duration

40 **minutes**

	1	2	3	4	5	6	7	8
Time	I_1	I_1+I_2	$2S_1/t-Q_1$	$2S_2/t+Q_2$	Q_2	S_2	2S/t-Q	Col 4 - 7
min	cfs	cfs	cfs	cfs	cfs	cf	from eqn.	
0	0.00	25.82	0	25.819	0	0	25.818	0.001
5	14.34	40.16	18.320	58.482	3.749	3310.4	58.483	-0.001
10	25.82	51.64	43.072	94.710	7.705	7616.6	94.711	-0.001
15	25.82	51.64	71.661	123.298	11.524	12477.8	123.299	-0.001
20	25.82	51.64	94.757	146.394	14.270	16354.1	146.395	-0.001
25	25.82	51.64	113.668	165.305	16.363	19504.6	165.304	0.000
30	25.82	51.64	129.287	180.924	18.009	22094.4	180.923	0.001
35	25.82	51.64	142.266	193.903	19.329	24239.2	193.903	0.000
40	25.82	37.29	153.099	190.392	20.402	26025.1	190.393	-0.001
45	11.47	11.47	150.165	161.640	20.114	25541.8	49.651	111.989
50	0.00	0.00	148.250	148.250	6.795	23226.7	0.000	148.250
55	0.00	0.00	148.450	148.450	0.000	22237.4	0.000	148.450
60	0.00	0.00	148.650	148.650	0.000	22267.4	0.000	148.650

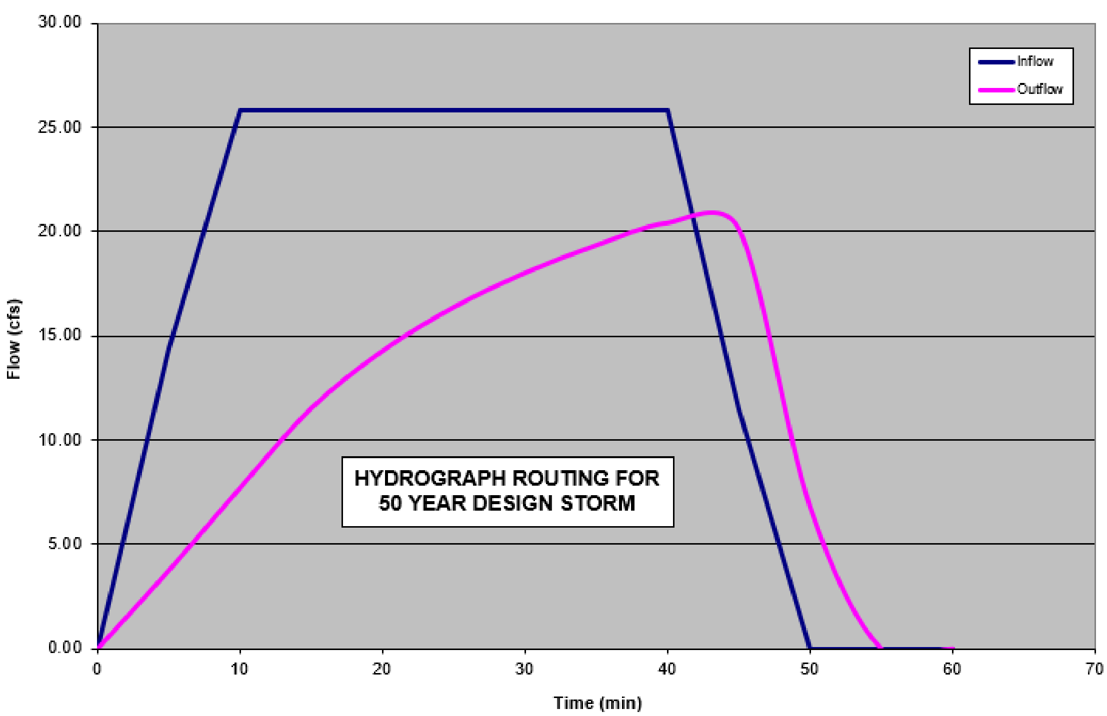
Actual Maximum Storage needed is 26025.1 cubic feet

Maximum Storage required is achieved at an elev. = 351.46

Maximum Allowable (undeveloped) Discharge is 21.91 cfs

Maximum Discharge for the above storm is 20.4 cfs

DETENTION HYDROGRAPH



100 YEAR STORM EVENT

Coefficients for Storage Indication Curve from Chart			
Ax^4	Bx^3	Cx^2	Dx
0.0000	-0.0021	0.2009	6.1616

HYDROGRAPH ROUTING FOR 100 YEAR DESIGN STORM

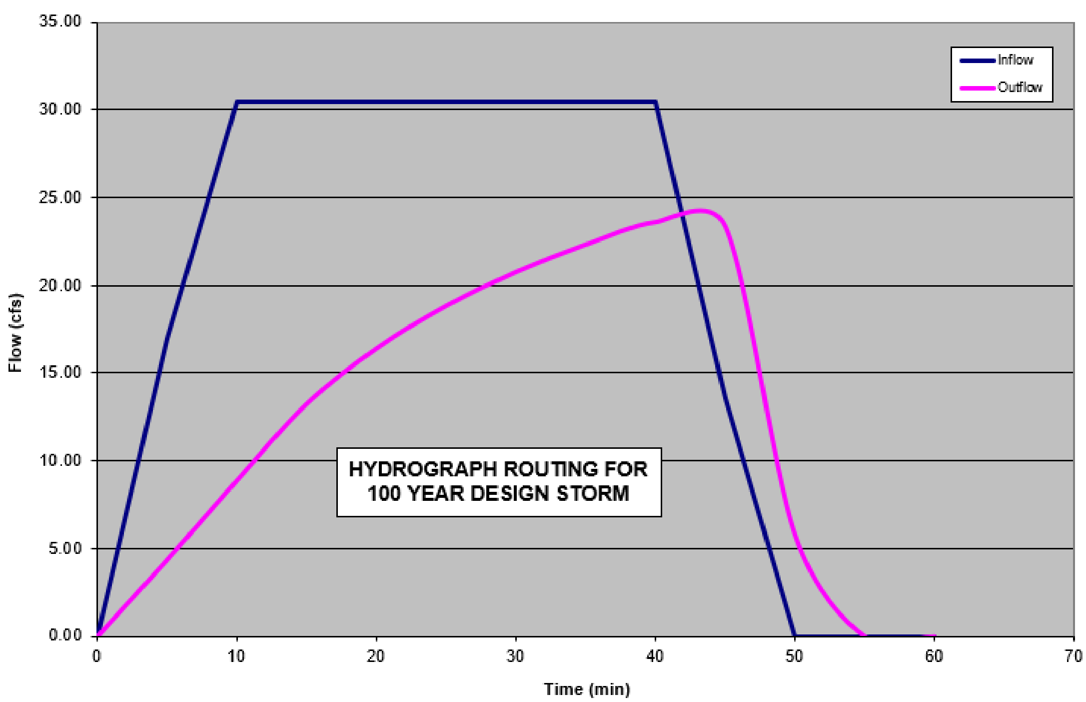
Routing Storm Duration

40 **minutes**

	1	2	3	4	5	6	7	8
Time	I_1	I_1+I_2	$2S_1/t-Q_1$	$2S_2/t+Q_2$	Q_2	S_2	2S/t-Q	Col 4 - 7
min	cfs	cfs	cfs	cfs	cfs	cf	from eqn.	
0	0.00	30.50	0	30.504	0	0	30.503	0.001
5	16.95	47.45	21.786	69.236	4.359	3921.7	69.235	0.001
10	30.50	61.01	51.461	112.468	8.888	9052.3	112.469	-0.001
15	30.50	61.01	85.963	146.970	13.253	14882.3	146.971	-0.001
20	30.50	61.01	114.142	175.149	16.414	19583.4	175.148	0.001
25	30.50	61.01	137.459	198.466	18.845	23445.6	198.467	-0.001
30	30.50	61.01	156.918	217.925	20.774	26653.8	217.926	-0.001
35	30.50	61.01	173.253	234.260	22.336	29338.3	234.259	0.001
40	30.50	44.06	187.027	231.088	23.617	31596.5	231.087	0.001
45	13.56	13.56	184.348	197.905	23.370	31157.7	41.366	156.539
50	0.00	0.00	186.482	186.482	5.811	28814.0	0.000	186.482
55	0.00	0.00	186.682	186.682	0.000	27972.3	0.000	186.682
60	0.00	0.00	186.882	186.882	0.000	28002.3	0.000	186.882

Actual Maximum Storage needed is 31596.5 cubic feet
Maximum Storage required is achieved at an elev. = 352.17
Maximum Allowable (undeveloped) Discharge is 24.78 cfs
Maximum Discharge for the above storm is 23.62 cfs

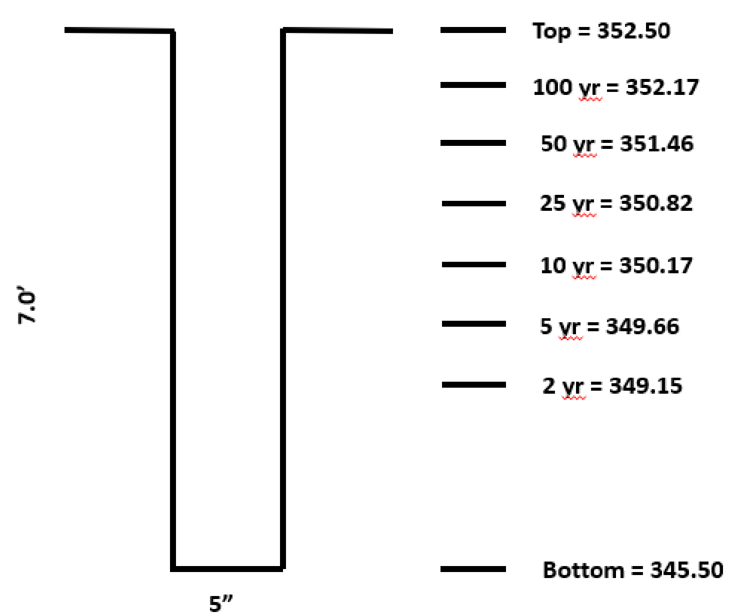
DETENTION HYDROGRAPH

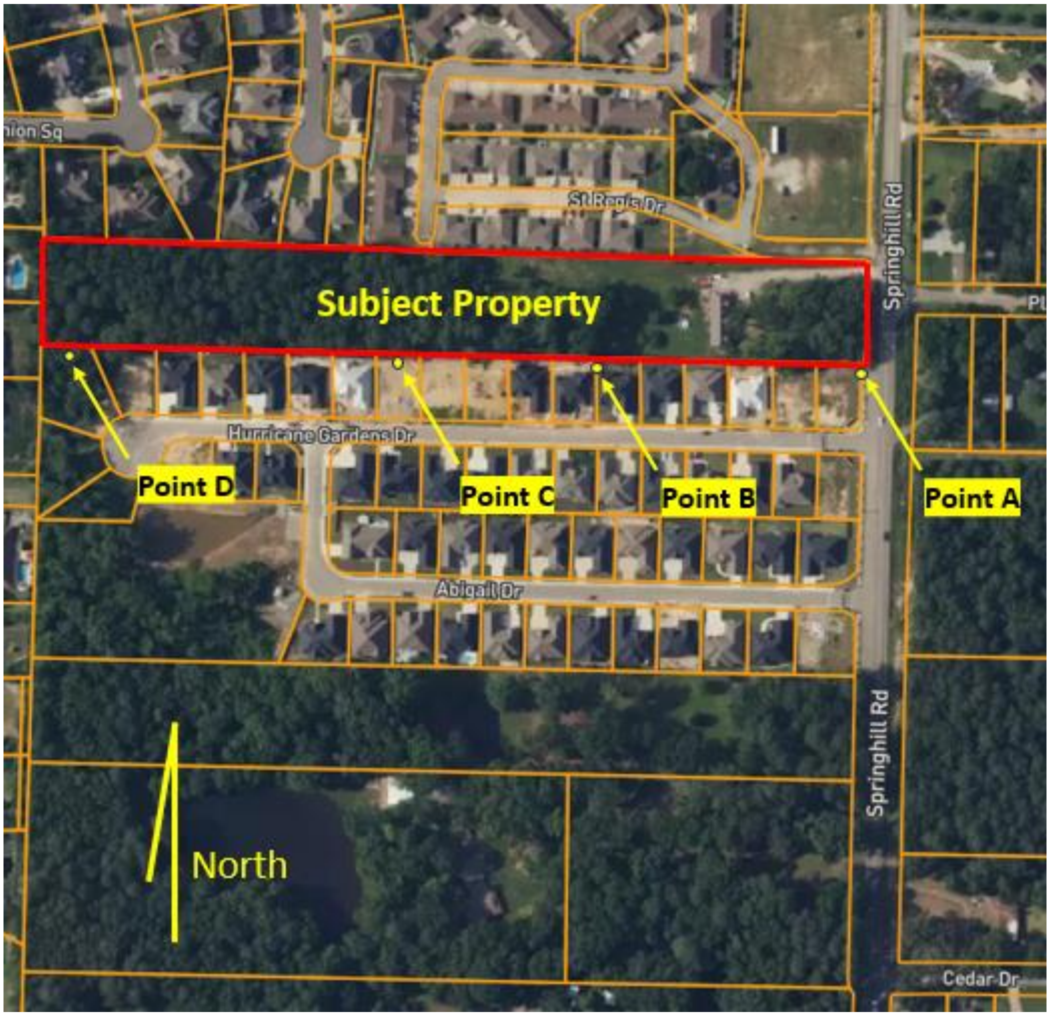


Summary – Detention

Storm Event	Volume Needed (cf)	WSE	Max Discharge Allowed (cfs)	Max Discharge Model (cfs)
2	9724.6	349.15	10.12	9.42
5	12691.5	349.66	12.38	11.68
10	16339.9	350.17	14.65	14.26
25	21300.7	350.82	18.46	17.51
50	26025.1	351.46	21.91	20.40
100	31596.5	352.17	24.78	23.62

Discharge Structure Detail





Study Point Summary (25 yr Storm)

Study Point	Pre Construction	Post Construction	Change
A	15.18 cfs	16.93 cfs	1.75 cfs*
B	11.49 cfs	1.63 cfs	-9.86 cfs
C	12.72 cfs	1.77 cfs	-10.95 cfs
D	18.46 cfs	17.51 cfs	-0.95 cfs
Total:			**-20.01 cfs**

* *Existing culvert originating at the Junction Box near the NE corner of Hurricane Gardens has adequate capacity to accept this slight increase in flow.*

Engineering Certification

I, Tim Lemons, Arkansas Registered Professional Engineer No. 7373, hereby certify that the drainage reports, and calculations contained in this report, have been prepared in accordance with sound engineering practice and principles, and based on best known available data. Improvements as outlined in this report and depicted on the preliminary plat and design drawings should not increase the risk of endangerment to life or have negative impacts on adjacent or downstream property or watersheds.

Timothy B. Lemons, PE
Arkansas Professional Engineer, #7373

Appendix

GUTTER CAPACITY OF STREETS - 27' BC to BC								
Slope = 0.5%, n = 0.012								
Width (ft)	**Slope**	**Height (ft)**	**Area (sf)**	**R**	**R^2/3**	**S**	**S^1/2**	**Q (cfs)**
0.5	0.030	0.02	0.00	0.01	0.04	0.00500	0.0707	0.00
1	0.030	0.03	0.02	0.01	0.06	0.00500	0.0707	0.01
1.5	0.030	0.05	0.03	0.02	0.08	0.00500	0.0707	0.02
2	0.030	0.06	0.06	0.03	0.10	0.00500	0.0707	0.05
2.5	0.030	0.08	0.09	0.04	0.11	0.00500	0.0707	0.09
3	0.030	0.09	0.14	0.04	0.13	0.00500	0.0707	0.15
3.5	0.030	0.11	0.18	0.05	0.14	0.00500	0.0707	0.22
4	0.030	0.12	0.24	0.06	0.15	0.00500	0.0707	0.32
4.5	0.030	0.14	0.30	0.07	0.16	0.00500	0.0707	0.44
5	0.030	0.15	0.38	0.07	0.18	0.00500	0.0707	0.58
5.5	0.030	0.17	0.45	0.08	0.19	0.00500	0.0707	0.75
6	0.030	0.18	0.54	0.09	0.20	0.00500	0.0707	0.94
6.5	0.030	0.20	0.63	0.10	0.21	0.00500	0.0707	1.17
7	0.030	0.21	0.74	0.10	0.22	0.00500	0.0707	1.43
7.5	0.030	0.23	0.84	0.11	0.23	0.00500	0.0707	1.71
8.5	0.030	0.26	1.08	0.13	0.25	0.00500	0.0707	2.39
9	0.030	0.27	1.22	0.13	0.26	0.00500	0.0707	2.79
9.5	0.030	0.29	1.35	0.14	0.27	0.00500	0.0707	3.22
10	0.030	0.30	1.50	0.15	0.28	0.00500	0.0707	3.69
10.5	0.030	0.32	1.65	0.16	0.29	0.00500	0.0707	4.21
11	0.030	0.33	1.82	0.16	0.30	0.00500	0.0707	4.76
11.5	0.030	0.35	1.98	0.17	0.31	0.00500	0.0707	5.36
12	0.030	0.36	2.16	0.18	0.32	0.00500	0.0707	6.01
12.5	0.030	0.38	2.34	0.19	0.33	0.00500	0.0707	6.70
13	0.030	0.39	2.54	0.19	0.33	0.00500	0.0707	7.44

GUTTER CAPACITY OF STREETS - 27' BC to BC								
Slope = 1.50%, n = 0.012								
Width	**Slope**	**Height**	**Area**	**R**	**R^2/3**	**S**	**S^1/2**	**Q**
(ft)		**(ft)**	**(sf)**					**(cfs)**
0.5	0.030	0.02	0.00	0.01	0.04	0.01500	0.1225	0.00
1	0.030	0.03	0.02	0.01	0.06	0.01500	0.1225	0.01
1.5	0.030	0.05	0.03	0.02	0.08	0.01500	0.1225	0.04
2	0.030	0.06	0.06	0.03	0.10	0.01500	0.1225	0.09
2.5	0.030	0.08	0.09	0.04	0.11	0.01500	0.1225	0.16
3	0.030	0.09	0.14	0.04	0.13	0.01500	0.1225	0.26
3.5	0.030	0.11	0.18	0.05	0.14	0.01500	0.1225	0.39
4	0.030	0.12	0.24	0.06	0.15	0.01500	0.1225	0.55
4.5	0.030	0.14	0.30	0.07	0.16	0.01500	0.1225	0.76
5	0.030	0.15	0.38	0.07	0.18	0.01500	0.1225	1.01
5.5	0.030	0.17	0.45	0.08	0.19	0.01500	0.1225	1.30
6	0.030	0.18	0.54	0.09	0.20	0.01500	0.1225	1.64
6.5	0.030	0.20	0.63	0.10	0.21	0.01500	0.1225	2.03
7	0.030	0.21	0.74	0.10	0.22	0.01500	0.1225	2.47
7.5	0.030	0.23	0.84	0.11	0.23	0.01500	0.1225	2.97
8.5	0.030	0.26	1.08	0.13	0.25	0.01500	0.1225	4.15
9	0.030	0.27	1.22	0.13	0.26	0.01500	0.1225	4.83
9.5	0.030	0.29	1.35	0.14	0.27	0.01500	0.1225	5.58
10	0.030	0.30	1.50	0.15	0.28	0.01500	0.1225	6.40
10.5	0.030	0.32	1.65	0.16	0.29	0.01500	0.1225	7.29
11	0.030	0.33	1.82	0.16	0.30	0.01500	0.1225	8.25
11.5	0.030	0.35	1.98	0.17	0.31	0.01500	0.1225	9.29
12	0.030	0.36	2.16	0.18	0.32	0.01500	0.1225	10.41
12.5	0.030	0.38	2.34	0.19	0.33	0.01500	0.1225	11.61
13	0.030	0.39	2.54	0.19	0.33	0.01500	0.1225	12.89

GUTTER CAPACITY OF STREETS - 27' BC to BC

Slope = 2.67%, n = 0.012

Width (ft)	Slope	Height (ft)	Area (sf)	R	R^2/3	S	S^1/2	Q (cfs)
0.5	0.030	0.02	0.00	0.01	0.04	0.02670	0.1634	0.00
1	0.030	0.03	0.02	0.01	0.06	0.02670	0.1634	0.02
1.5	0.030	0.05	0.03	0.02	0.08	0.02670	0.1634	0.05
2	0.030	0.06	0.06	0.03	0.10	0.02670	0.1634	0.12
2.5	0.030	0.08	0.09	0.04	0.11	0.02670	0.1634	0.21
3	0.030	0.09	0.14	0.04	0.13	0.02670	0.1634	0.34
3.5	0.030	0.11	0.18	0.05	0.14	0.02670	0.1634	0.52
4	0.030	0.12	0.24	0.06	0.15	0.02670	0.1634	0.74
4.5	0.030	0.14	0.30	0.07	0.16	0.02670	0.1634	1.01
5	0.030	0.15	0.38	0.07	0.18	0.02670	0.1634	1.34
5.5	0.030	0.17	0.45	0.08	0.19	0.02670	0.1634	1.73
6	0.030	0.18	0.54	0.09	0.20	0.02670	0.1634	2.18
6.5	0.030	0.20	0.63	0.10	0.21	0.02670	0.1634	2.70
7	0.030	0.21	0.74	0.10	0.22	0.02670	0.1634	3.29
7.5	0.030	0.23	0.84	0.11	0.23	0.02670	0.1634	3.96
8.5	0.030	0.26	1.08	0.13	0.25	0.02670	0.1634	5.53
9	0.030	0.27	1.22	0.13	0.26	0.02670	0.1634	6.44
9.5	0.030	0.29	1.35	0.14	0.27	0.02670	0.1634	7.44
10	0.030	0.30	1.50	0.15	0.28	0.02670	0.1634	8.53
10.5	0.030	0.32	1.65	0.16	0.29	0.02670	0.1634	9.72
11	0.030	0.33	1.82	0.16	0.30	0.02670	0.1634	11.01
11.5	0.030	0.35	1.98	0.17	0.31	0.02670	0.1634	12.40
12	0.030	0.36	2.16	0.18	0.32	0.02670	0.1634	13.89
12.5	0.030	0.38	2.34	0.19	0.33	0.02670	0.1634	15.49
13	0.030	0.39	2.54	0.19	0.33	0.02670	0.1634	17.20

GUTTER CAPACITY OF STREETS - 27' BC to BC

Slope = 4.88%, n = 0.012

Width (ft)	Slope	Height (ft)	Area (sf)	R	R^2/3	S	S^1/2	Q (cfs)
0.5	0.030	0.02	0.00	0.01	0.04	0.04880	0.2209	0.00
1	0.030	0.03	0.02	0.01	0.06	0.04880	0.2209	0.02
1.5	0.030	0.05	0.03	0.02	0.08	0.04880	0.2209	0.07
2	0.030	0.06	0.06	0.03	0.10	0.04880	0.2209	0.16
2.5	0.030	0.08	0.09	0.04	0.11	0.04880	0.2209	0.28
3	0.030	0.09	0.14	0.04	0.13	0.04880	0.2209	0.46
3.5	0.030	0.11	0.18	0.05	0.14	0.04880	0.2209	0.70
4	0.030	0.12	0.24	0.06	0.15	0.04880	0.2209	1.00
4.5	0.030	0.14	0.30	0.07	0.16	0.04880	0.2209	1.37
5	0.030	0.15	0.38	0.07	0.18	0.04880	0.2209	1.81
5.5	0.030	0.17	0.45	0.08	0.19	0.04880	0.2209	2.34
6	0.030	0.18	0.54	0.09	0.20	0.04880	0.2209	2.95
6.5	0.030	0.20	0.63	0.10	0.21	0.04880	0.2209	3.65
7	0.030	0.21	0.74	0.10	0.22	0.04880	0.2209	4.45
7.5	0.030	0.23	0.84	0.11	0.23	0.04880	0.2209	5.35
8.5	0.030	0.26	1.08	0.13	0.25	0.04880	0.2209	7.48
9	0.030	0.27	1.22	0.13	0.26	0.04880	0.2209	8.71
9.5	0.030	0.29	1.35	0.14	0.27	0.04880	0.2209	10.06
10	0.030	0.30	1.50	0.15	0.28	0.04880	0.2209	11.54
10.5	0.030	0.32	1.65	0.16	0.29	0.04880	0.2209	13.14
11	0.030	0.33	1.82	0.16	0.30	0.04880	0.2209	14.88
11.5	0.030	0.35	1.98	0.17	0.31	0.04880	0.2209	16.76
12	0.030	0.36	2.16	0.18	0.32	0.04880	0.2209	18.77
12.5	0.030	0.38	2.34	0.19	0.33	0.04880	0.2209	20.94
13	0.030	0.39	2.54	0.19	0.33	0.04880	0.2209	23.25