STORMWATER CALCULATIONS

TOWN OF ZEBULON

WAKE COUNTY, NC

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The project area of 1.38 ac (60,200 ft^2) is an undeveloped, grassed, and wooded lot. The development proposes building 12 residential lots. This will also include the necessary infrastructure (i.e., roadways, sidewalks, and public utilities) needed to facilitate the development.

The Town of Zebulon requires new residential development to meet NCDEQ stormwater regulations and requires that "Structural and non-structural BMPs shall be used to ensure there is no net increase in peak flow leaving the site from the pre-development conditions for the one-year, 24-hour storm". A stormwater wet pond, SCM #1, has been proposed to meet the requirements.

The proposed disturbed area for this project is 45,981 ft^2 (1.06 ac) with a total of 21,121 ft^2 (0.48 ac) of impervious areas. 46,412 ft^2 of the site, including all the impervious areas, is being captured by SCM #1. Pre onsite drainage goes to POI#1 while post onsite drainage goes to both POI#1 and POI#2.

The simple method and the SA/DA method were used for sizing the pond. AutoCAD Civil 3D and Storm Water Management Model (SWMM) were used for the design and routing of the pond.

For stormwater control measure sizing, we were more conservative in a way that instead of 35%, we assumed there is 50% of impervious area after site development. One reason to make this conservative approach is to consider 70% of each residential as the impervious area (rooftop and driveway).

Table 1 – SCM #1 Volumes

	Required	Provided
Water Quality Volume	2,539 cf	3,183 cf
Permanent Pool Volume	3,269 cf	3,309 cf
Forebay Volume	654 cf	678 cf

Summary

The post development discharge from the site at POI #1 and #2 for 1-year & 24-hour storm event is 17% less than the pre-development discharge at POI #1 meeting the requirements set for by both the Town of Zebulon and NCDEQ. The emergency spillway is not triggered during the 1-year& 24-hour storm event. Phosphorus and nitrogen have been reduced for this site.

Stormwater Control Measure Sizing

Project: **True Homes - Zebulon - 712 Arendell**
SCM **SCM 1 (Wet Pond)**
Date: **9/23/2021**
Rev.:
Rev.2:

DETERMINE SCM TYPE AND DIMENSIONS

Simple Method: Pond Runoff Volume

Simple Method - V = 3630*Rv*Rd*A

Rd - Rainfall Depth (inches)=	1	
Rv = 0.05+0.9*Ia		
Rv = Runoff Coefficient		
Ia = Impervious fraction = Impervious drainage area/ Total drainage area		
A = Drainage area (ac.) =	1.38	ac
Impervious portion of drainage area (ac.) =	0.70	ac

Ia =	0.507
Rv = 0.05 +0.9*Ia	
Rv =	0.506

Water Quality Volume Required:	WQV = DV = 3630 *Rv*Rd*A =	**2,539**	**cf**
Water Quality Volume Provided:		**3,183**	**cf**

MDC WET POND Sizing:

Option 1: HRT Method (Main Pool Hydraulic Retention Time)

Vmp = 0.87*HRT/Ts*DV

Vmp	Volume of main pool
HRT	Hydraulic Residence Time (14 days)
Ts	Time between storm events (5 days)
DV	Design Volume (cf)

Design Volume from simple method

Vmp = 0.87 * (HRT/TS) * WQV

WQV =	2,539	cf
Vmp =	**6,185**	**cf**

Determine Min. SA of Main Pool:

Davg = Vpp / SA = Vmp / Amp

Amp =	Vmp / Davg			
Amp =	**2,062**	**sf**	Choose Depth =	**3** **ft**
Plus 20% Forebay=	**412**	**sf**		
App =	**2,474**	**sf**		

$$D_{avg} = \frac{V_{PP}}{SA}$$

Where:

D_{avg}	=	Average depth (feet)
V_{PP}	=	Main pool volume at permanent pool elevation (feet^3)
SA	=	Main pool area at permanent pool elevation (feet^2)

(Per MDC, when calculating the average depth, only the main pool is considered. The forebay is excluded from the calculation.)

Option 2: SA/DA and Average Depth Method

Impervious Ratio =	0.507	
Choose Permanent Pool Avg Depth, Davg =	3	ft

From MDC 1, Table 1: Piedmont and Mountain SA/DA Table

SA/DA (%) =	1.81	%
DA (acres) =	1.38	ac

Therefore, SA = DA * coefficient

SA =	0.025	ac
SA (main pool) =	**1,090**	**sf**
Plus 20% Forebay =	**218**	**sf**
SA (total) =	**1,308**	**sf**

Find Volume of Permanent Pool

Davg = Vpp / SA = Vmp / Amp

Vmp = Davg * Amp

Vmp =	**3,269**	**cf**
Plus 20% Forebay =	**654**	**cf**
Vpp =	**3,923**	**cf**

SUMMARY: Determine SCM Type and Volume/Area/Depth

Wet Ponc HRT Method 1:	Vpp (cf) =	6,185	App (sf) =	2,474	Davg =	3
Wet Ponc SA/DA Method 2:	**Vpp (cf) =**	**3,923**	**App (sf) =**	**1,308**	**Davg =**	**3**

NCDEQ Stormwater BMP Manual

Table 1: Piedmont and Mountain SA/DA Table (Adapted from Driscoll, 1986)

Percent Impervious Cover	Permanent Pool Average Depth (ft)					
	3.0	4.0	5.0	6.0	7.0	8.0
10%	0.51	0.43	0.37	0.30	0.27	0.25
20%	0.84	0.69	0.61	0.51	0.44	0.40
30%	1.17	0.81	0.84	0.72	0.61	0.56
40%	1.51	1.22	1.09	0.91	0.78	0.71
50%	1.79	1.47	1.31	1.13	0.95	0.87
60%	2.09	1.73	1.49	1.31	1.12	1.03
70%	2.51	2.04	1.80	1.56	1.34	1.17
80%	2.92	2.36	2.07	1.82	1.62	1.40
90%	3.25	2.64	2.31	2.04	1.84	1.59

Desired Depth = 3 ft

	Imp.	Ratio
Lower Limit =	0.5	1.79
Upper Limit =	0.6	2.09

Acutal Surface Area Ratio = **1.81**

Temporary pool		
depth	1	ft
(From BMP Orifice Sizing excel file)		
Main pool		
depth	3	ft
(From SCM Sizing Calcs-WP excel file)		

Elevation		
Ground elv	311.9	ft
Distance to pond	130	ft
slope	0.5%	
dif elv	0.65	ft
SSMN		
Rim	313	ft
Inv in	309.22	ft
Inv out	309.03	ft
Forebay		
main pool elv	310	ft
Depth	3.0	ft
Bottem elv	307.0	ft
Sediment storage in Forebay		
Sediment storage depth	12	inch
Sediment storage bottom elv (Entrance)	306	ft
Sediment storage bottom elv (Exit)	306.5	ft
Main pool		
main pool elv	310	ft
Depth	3	ft
bottom elv	307	ft
Sediment storage depth	6	inch
sediment storage bottom elv	306.5	ft

Forebay							
Designed forebay (SCM #1)						Design Criteria	PASS
	Area (ft2)	Area (ac)	depth	elevation	Volume	volume	
Bottom	73	0.0017	3	307	678	654	
Top	429	0.0098		310			

Main Pool							
Designed main pool (SCM #1)						Design Criteria	PASS
	Area (ft2)	Area (ac)	depth	elevation	Volume	Volume	
Bottom	436	0.0100	3	307	3309	3,269	
Top	1951	0.0448		310			

Temporary pool							
Designed temporary pool (SCM #1)						Design Criteria	PASS
	Area (ft2)	Area (ac)	depth	elevation	Volume	Volume	
Bottom	2380	0.0546	1	310	3183	2,539	
Top	4061	0.0932		311			

SCM Orifice Sizing

Orifice Sizing - BMP A WETPOND

$$Q = Cd \times A \times \sqrt{2gh}$$

Total Volume to be discharged from Ponds (Q) = 2,539 cf
Depth of Storage (H) = 1.0

2 days to Discharge - 172,800 seconds

Q2 = 0.014693 cfs

$$A2 = \frac{Q2}{Cd \times \sqrt{2gh}}$$

Cd = 0.60
g = 32.2
H/3 = h = 0.33

A2 = 0.0053 sf $A=\pi R^2=\pi D^2/4$
0.761 sq in
diameter **0.984** inches $D=\sqrt{4A/\pi}$

5 Days to Discharge - 432,000 seconds

Q5 = 0.005877 cfs

$$A5 = \frac{Q5}{Cd \times \sqrt{2gh}}$$

Cd = 0.60
g = 32.2
H/3 = h = 0.33

A5 = 0.002 sf
0.304 sq in
diameter **0.623** inches

Orifice Chosen

diameter = **0.90** inches
A = 0.0044 sf

Q = Cd x A x sqrt(2 x g x h)
Q = 0.0123 cfs

time = 206736.30 seconds
Time = 2.39 days

NOAA Rainfall Data

NOAA Atlas 14, Volume 2, Version 3
Location name: Zebulon, North Carolina, USA*
Latitude: 35.8281°, Longitude: -78.3171°
Elevation: 312.79 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M.Yekta, and D. Riley

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	0.405 (0.369-0.445)	0.468 (0.428-0.513)	0.531 (0.486-0.581)	0.601 (0.549-0.658)	0.671 (0.609-0.733)	0.729 (0.659-0.796)	0.780 (0.701-0.852)	0.828 (0.740-0.905)	0.881 (0.781-0.964)	0.932 (0.819-1.02)
10-min	0.647 (0.590-0.710)	0.749 (0.685-0.820)	0.851 (0.778-0.930)	0.962 (0.877-1.05)	1.07 (0.971-1.17)	1.16 (1.05-1.27)	1.24 (1.12-1.35)	1.31 (1.17-1.43)	1.39 (1.24-1.53)	1.47 (1.29-1.61)
15-min	0.808 (0.738-0.888)	0.941 (0.861-1.03)	1.08 (0.984-1.18)	1.22 (1.11-1.33)	1.36 (1.23-1.48)	1.47 (1.33-1.61)	1.57 (1.41-1.71)	1.66 (1.48-1.81)	1.75 (1.56-1.92)	1.84 (1.62-2.02)
30-min	1.11 (1.01-1.22)	1.30 (1.19-1.42)	1.53 (1.40-1.67)	1.76 (1.61-1.93)	2.01 (1.82-2.19)	2.21 (2.00-2.42)	2.40 (2.16-2.62)	2.58 (2.30-2.82)	2.79 (2.48-3.06)	2.98 (2.62-3.27)
60-min	1.38 (1.26-1.52)	1.63 (1.49-1.79)	1.96 (1.79-2.14)	2.30 (2.09-2.51)	2.67 (2.43-2.92)	3.00 (2.71-3.28)	3.31 (2.97-3.61)	3.62 (3.23-3.95)	4.00 (3.55-4.38)	4.36 (3.83-4.78)
2-hr	1.62 (1.46-1.79)	1.91 (1.74-2.10)	2.33 (2.12-2.56)	2.77 (2.50-3.04)	3.28 (2.95-3.59)	3.75 (3.36-4.10)	4.20 (3.74-4.60)	4.67 (4.13-5.12)	5.30 (4.64-5.80)	5.88 (5.10-6.45)
3-hr	1.71 (1.55-1.90)	2.03 (1.85-2.25)	2.48 (2.25-2.74)	2.96 (2.68-3.27)	3.55 (3.19-3.90)	4.09 (3.66-4.50)	4.63 (4.11-5.09)	5.21 (4.58-5.72)	5.99 (5.21-6.58)	6.72 (5.79-7.41)
6-hr	2.05 (1.87-2.27)	2.43 (2.22-2.68)	2.97 (2.70-3.27)	3.56 (3.23-3.91)	4.28 (3.86-4.69)	4.95 (4.43-5.42)	5.63 (5.00-6.15)	6.35 (5.59-6.94)	7.35 (6.38-8.03)	8.30 (7.11-9.09)
12-hr	2.42 (2.20-2.66)	2.87 (2.62-3.15)	3.52 (3.21-3.86)	4.23 (3.85-4.64)	5.12 (4.63-5.60)	5.97 (5.35-6.51)	6.83 (6.06-7.44)	7.77 (6.81-8.46)	9.07 (7.83-9.88)	10.3 (8.78-11.3)
24-hr	2.86 (2.65-3.09)	3.46 (3.21-3.74)	4.39 (4.07-4.75)	5.14 (4.76-5.56)	6.21 (5.71-6.71)	7.08 (6.49-7.65)	8.01 (7.30-8.66)	9.01 (8.15-9.75)	10.4 (9.35-11.3)	11.6 (10.3-12.6)
2-day	3.31 (3.07-3.57)	3.99 (3.71-4.30)	5.02 (4.66-5.42)	5.86 (5.42-6.32)	7.03 (6.48-7.59)	7.99 (7.33-8.62)	9.00 (8.22-9.73)	10.1 (9.15-10.9)	11.6 (10.4-12.6)	12.9 (11.5-14.1)
3-day	3.51 (3.27-3.78)	4.22 (3.94-4.55)	5.29 (4.92-5.69)	6.15 (5.71-6.61)	7.36 (6.80-7.91)	8.34 (7.67-8.97)	9.37 (8.58-10.1)	10.5 (9.52-11.3)	12.0 (10.8-13.0)	13.3 (11.9-14.4)
4-day	3.71 (3.47-3.98)	4.46 (4.16-4.79)	5.56 (5.19-5.96)	6.44 (6.00-6.90)	7.68 (7.11-8.23)	8.69 (8.01-9.32)	9.74 (8.94-10.5)	10.9 (9.90-11.7)	12.4 (11.2-13.4)	13.7 (12.3-14.8)
7-day	4.32 (4.03-4.62)	5.16 (4.83-5.53)	6.36 (5.94-6.80)	7.32 (6.82-7.83)	8.65 (8.03-9.26)	9.72 (9.00-10.4)	10.8 (9.99-11.6)	12.0 (11.0-12.9)	13.7 (12.4-14.7)	15.0 (13.5-16.2)
10-day	4.93 (4.62-5.25)	5.87 (5.50-6.26)	7.13 (6.68-7.60)	8.12 (7.59-8.65)	9.48 (8.84-10.1)	10.6 (9.82-11.3)	11.7 (10.8-12.5)	12.8 (11.8-13.8)	14.5 (13.2-15.5)	15.7 (14.3-16.9)
20-day	6.61 (6.22-7.03)	7.83 (7.36-8.33)	9.34 (8.78-9.94)	10.5 (9.89-11.2)	12.2 (11.4-13.0)	13.5 (12.6-14.4)	14.8 (13.8-15.8)	16.2 (15.0-17.3)	18.1 (16.6-19.3)	19.5 (17.9-21.0)
30-day	8.21 (7.74-8.71)	9.68 (9.13-10.3)	11.4 (10.7-12.1)	12.7 (11.9-13.5)	14.4 (13.5-15.3)	15.8 (14.8-16.8)	17.2 (16.0-18.2)	18.5 (17.2-19.7)	20.4 (18.9-21.8)	21.8 (20.1-23.4)
45-day	10.4 (9.91-11.0)	12.3 (11.6-12.9)	14.2 (13.4-15.0)	15.6 (14.8-16.5)	17.6 (16.6-18.6)	19.1 (18.0-20.1)	20.5 (19.3-21.7)	22.0 (20.6-23.3)	24.0 (22.3-25.5)	25.4 (23.6-27.1)
60-day	12.5 (11.9-13.2)	14.7 (13.9-15.4)	16.8 (15.9-17.6)	18.4 (17.4-19.3)	20.5 (19.4-21.6)	22.1 (20.8-23.3)	23.6 (22.2-24.9)	25.1 (23.6-26.6)	27.1 (25.4-28.8)	28.6 (26.7-30.4)

[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.

Please refer to NOAA Atlas 14 document for more information.

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PF graphical

NOAA Atlas 14, Volume 2, Version 3
Location name: Zebulon, North Carolina, USA*
Latitude: 35.8281°, Longitude: -78.3171°
Elevation: 312.79 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

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NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

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	4.86 (4.43-5.34)	5.62 (5.14-6.16)	6.37 (5.83-6.97)	7.21 (6.59-7.90)	8.05 (7.31-8.80)	8.75 (7.91-9.55)	9.36 (8.41-10.2)	9.94 (8.88-10.9)	10.6 (9.37-11.6)	11.2 (9.83-12.3)
10-min	3.88 (3.54-4.26)	4.49 (4.11-4.92)	5.11 (4.67-5.58)	5.77 (5.26-6.31)	6.41 (5.83-7.01)	6.96 (6.30-7.61)	7.44 (6.69-8.12)	7.87 (7.03-8.60)	8.36 (7.42-9.16)	8.81 (7.74-9.66)
15-min	3.23 (2.95-3.55)	3.76 (3.44-4.12)	4.30 (3.94-4.71)	4.86 (4.44-5.32)	5.42 (4.92-5.92)	5.88 (5.32-6.42)	6.27 (5.64-6.84)	6.62 (5.92-7.24)	7.02 (6.22-7.68)	7.37 (6.48-8.08)
30-min	2.22 (2.02-2.43)	2.60 (2.38-2.85)	3.06 (2.80-3.34)	3.53 (3.22-3.86)	4.01 (3.65-4.38)	4.43 (4.00-4.84)	4.80 (4.32-5.24)	5.15 (4.61-5.63)	5.58 (4.95-6.11)	5.97 (5.24-6.54)
60-min	1.38 (1.26-1.52)	1.63 (1.49-1.79)	1.96 (1.79-2.14)	2.30 (2.09-2.51)	2.67 (2.43-2.92)	3.00 (2.71-3.28)	3.31 (2.97-3.61)	3.62 (3.23-3.95)	4.00 (3.55-4.38)	4.36 (3.83-4.78)
2-hr	0.808 (0.732-0.895)	0.957 (0.872-1.05)	1.16 (1.06-1.28)	1.38 (1.25-1.52)	1.64 (1.48-1.80)	1.87 (1.68-2.05)	2.10 (1.87-2.30)	2.34 (2.07-2.56)	2.65 (2.32-2.90)	2.94 (2.55-3.23)
3-hr	0.570 (0.517-0.634)	0.676 (0.616-0.748)	0.825 (0.749-0.912)	0.987 (0.893-1.09)	1.18 (1.06-1.30)	1.36 (1.22-1.50)	1.54 (1.37-1.70)	1.73 (1.53-1.90)	1.99 (1.74-2.19)	2.24 (1.93-2.47)
6-hr	0.343 (0.312-0.379)	0.406 (0.371-0.448)	0.496 (0.452-0.547)	0.594 (0.539-0.653)	0.714 (0.644-0.783)	0.826 (0.741-0.905)	0.940 (0.834-1.03)	1.06 (0.933-1.16)	1.23 (1.07-1.34)	1.39 (1.19-1.52)
12-hr	0.201 (0.183-0.221)	0.238 (0.218-0.261)	0.292 (0.267-0.321)	0.351 (0.319-0.386)	0.425 (0.384-0.465)	0.495 (0.444-0.540)	0.567 (0.503-0.618)	0.645 (0.565-0.702)	0.753 (0.650-0.820)	0.857 (0.729-0.934)
24-hr	0.119 (0.111-0.129)	0.144 (0.134-0.156)	0.183 (0.170-0.198)	0.214 (0.198-0.232)	0.259 (0.238-0.279)	0.295 (0.270-0.319)	0.334 (0.304-0.361)	0.375 (0.340-0.406)	0.435 (0.390-0.472)	0.484 (0.430-0.526)
2-day	0.069 (0.064-0.074)	0.083 (0.077-0.090)	0.105 (0.097-0.113)	0.122 (0.113-0.132)	0.146 (0.135-0.158)	0.166 (0.153-0.180)	0.188 (0.171-0.203)	0.210 (0.191-0.227)	0.242 (0.217-0.263)	0.268 (0.239-0.293)
3-day	0.049 (0.045-0.052)	0.059 (0.055-0.063)	0.073 (0.068-0.079)	0.085 (0.079-0.092)	0.102 (0.094-0.110)	0.116 (0.107-0.125)	0.130 (0.119-0.140)	0.145 (0.132-0.157)	0.167 (0.150-0.181)	0.185 (0.165-0.201)
4-day	0.039 (0.036-0.041)	0.047 (0.043-0.050)	0.058 (0.054-0.062)	0.067 (0.062-0.072)	0.080 (0.074-0.086)	0.090 (0.083-0.097)	0.101 (0.093-0.109)	0.113 (0.103-0.122)	0.129 (0.117-0.140)	0.143 (0.128-0.154)
7-day	0.026 (0.024-0.027)	0.031 (0.029-0.033)	0.038 (0.035-0.040)	0.044 (0.041-0.047)	0.051 (0.048-0.055)	0.058 (0.054-0.062)	0.065 (0.059-0.069)	0.072 (0.066-0.077)	0.081 (0.074-0.088)	0.089 (0.080-0.096)
10-day	0.021 (0.019-0.022)	0.024 (0.023-0.026)	0.030 (0.028-0.032)	0.034 (0.032-0.036)	0.040 (0.037-0.042)	0.044 (0.041-0.047)	0.049 (0.045-0.052)	0.054 (0.049-0.057)	0.060 (0.055-0.065)	0.066 (0.060-0.071)
20-day	0.014 (0.013-0.015)	0.016 (0.015-0.017)	0.019 (0.018-0.021)	0.022 (0.021-0.023)	0.025 (0.024-0.027)	0.028 (0.026-0.030)	0.031 (0.029-0.033)	0.034 (0.031-0.036)	0.038 (0.035-0.040)	0.041 (0.037-0.044)
30-day	0.011 (0.011-0.012)	0.013 (0.013-0.014)	0.016 (0.015-0.017)	0.018 (0.017-0.019)	0.020 (0.019-0.021)	0.022 (0.021-0.023)	0.024 (0.022-0.025)	0.026 (0.024-0.027)	0.028 (0.026-0.030)	0.030 (0.028-0.032)
45-day	0.010 (0.009-0.010)	0.011 (0.011-0.012)	0.013 (0.012-0.014)	0.014 (0.014-0.015)	0.016 (0.015-0.017)	0.018 (0.017-0.019)	0.019 (0.018-0.020)	0.020 (0.019-0.022)	0.022 (0.021-0.024)	0.024 (0.022-0.025)
60-day	0.009 (0.008-0.009)	0.010 (0.010-0.011)	0.012 (0.011-0.012)	0.013 (0.012-0.013)	0.014 (0.013-0.015)	0.015 (0.014-0.016)	0.016 (0.015-0.017)	0.017 (0.016-0.018)	0.019 (0.018-0.020)	0.020 (0.019-0.021)

[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.

Please refer to NOAA Atlas 14 document for more information.

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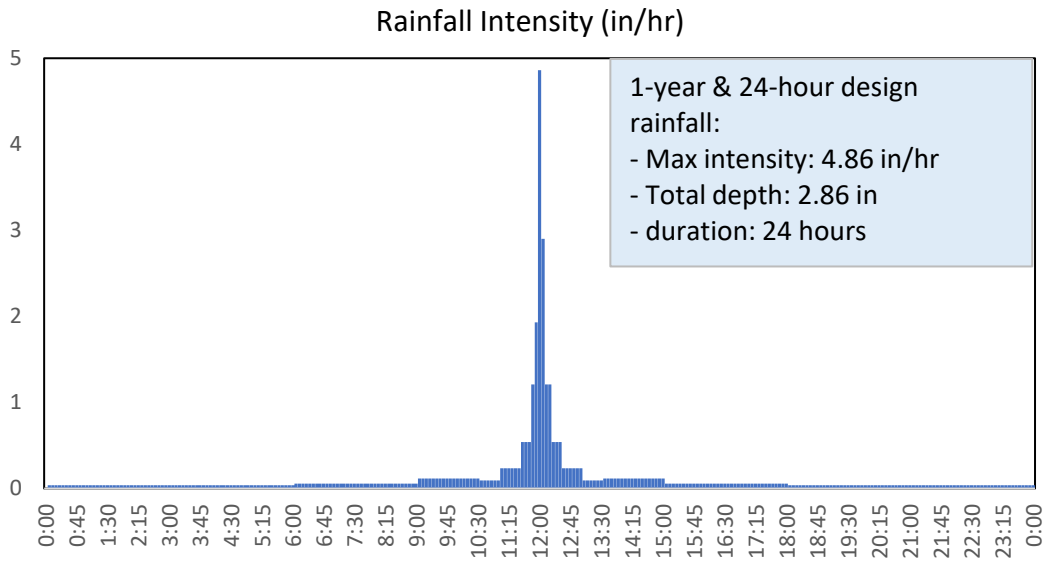
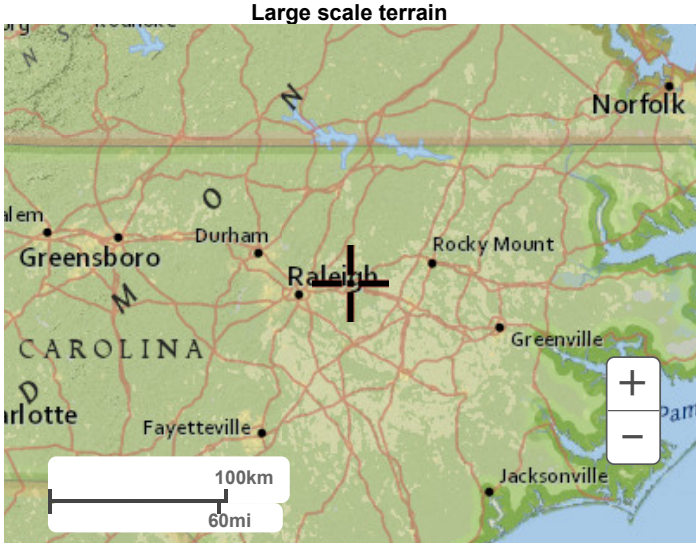
PF graphical

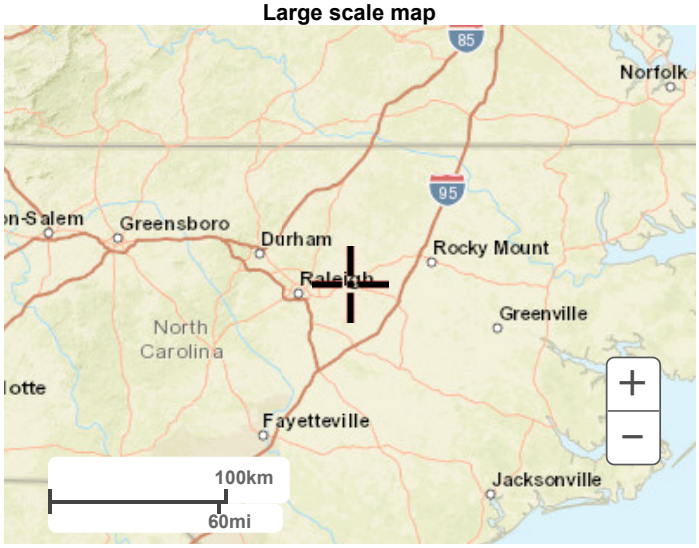

Rainfall Intensity (in/hr)
5
4
3
2
1
0
1-year & 24-hour design rainfall:
- Max intensity: 4.86 in/hr
- Total depth: 2.86 in
- duration: 24 hours
0:00
0:45
1:30
2:15
3:00
3:45
4:30
5:15
6:00
6:45
7:30
8:15
9:00
9:45
10:30
11:15
12:00
12:45
13:30
14:15
15:00
15:45
16:30
17:15
18:00
18:45
19:30
20:15
21:00
21:45
22:30
23:15
0:00

Drainage Area Maps

Large scale terrain



Large scale map



Large scale aerial

EX. 4' WOOD FENCE

EX. GRAVEL

URBAN SET-ASIDE OPEN SPACE (AMENITIZED)

COMMUNITY CONGREGATION AREA

ROAD B
16' PRIVATE R/W

10+00

10+69

ROAD A
16' PRIVATE R/W

11+00

12+00

13+00

13+23

WET POND
BOT: 307.00
BOT: 306.00

310

OCS #301
TOP: 311.00
INV IN: 310.00
INV OUT: 309.75

135 LF 15" HDPE @ 0.50%

EX. CURB

EX. GRAVEL

312

313

314

311

12

11

1

2

3

4

5

6

7

8

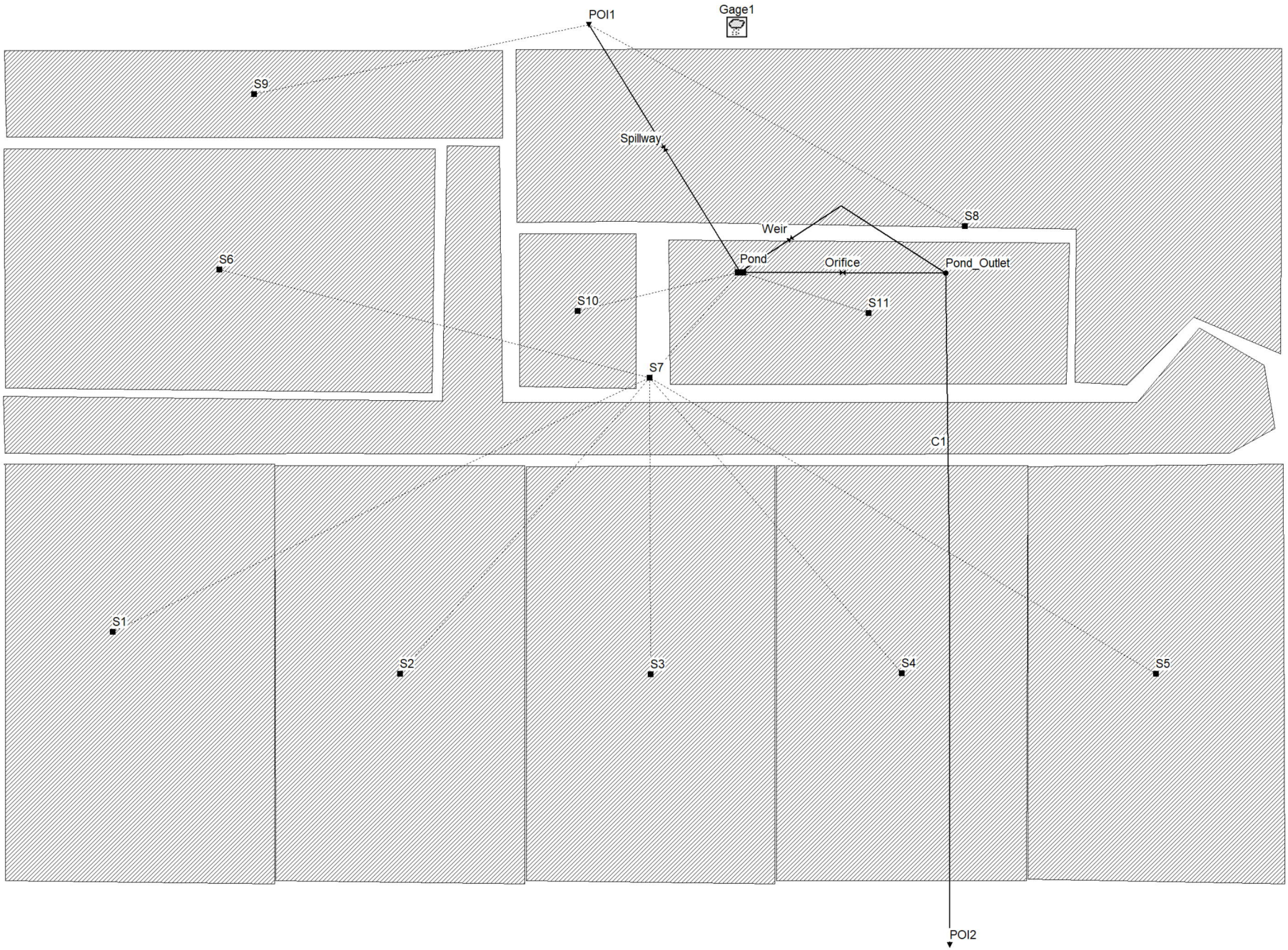
9

10

WithBMP.inp

ls Window Help

Study Area Map



Pre/Post Development Runoff

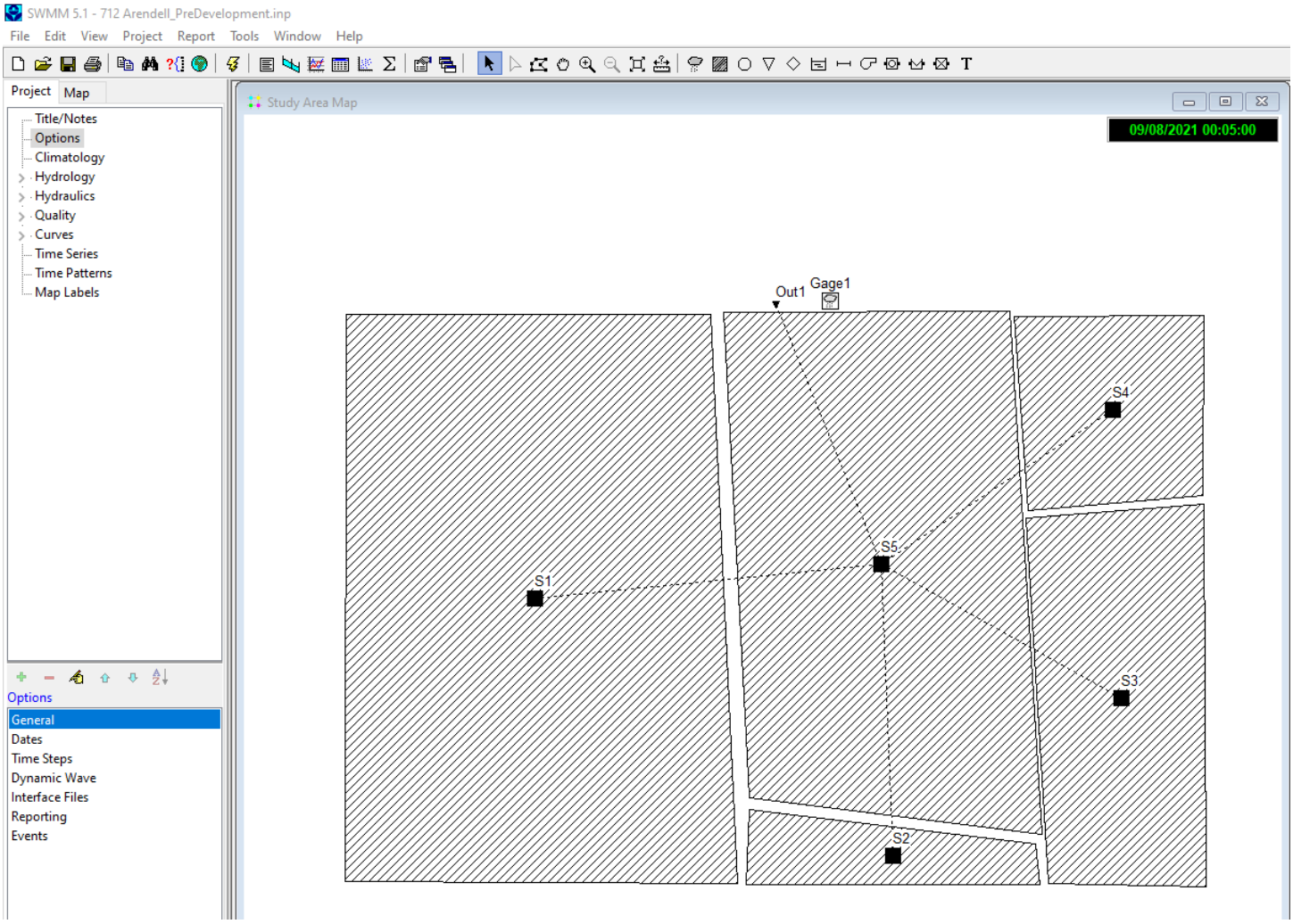
Stormwater peak flow

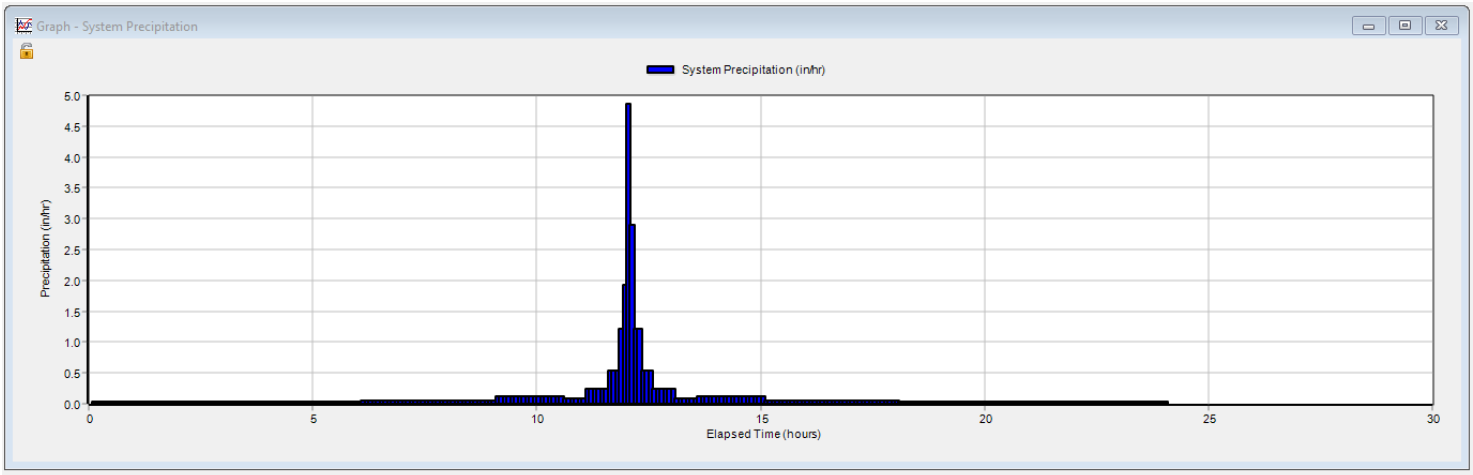
Storm Water Management Model (SWMM) developed by EPA is used to simulate the rainfall-runoff process in this project.

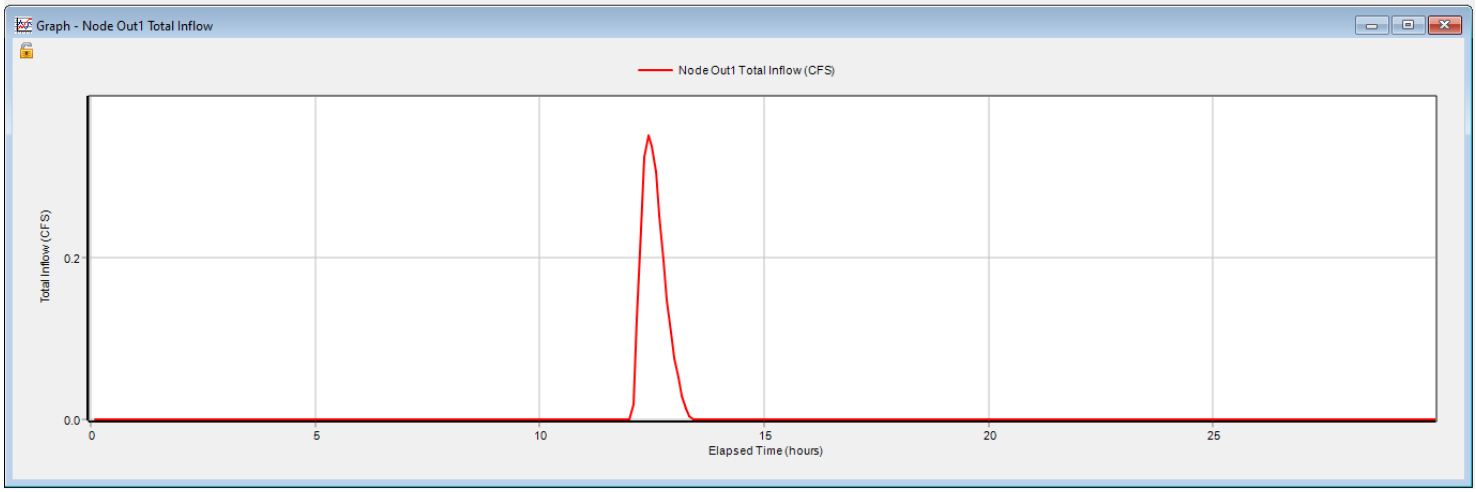
SWMM uses a nonlinear reservoir model to estimate surface runoff produced by rainfall over a subcatchment. The model was first published by Chen and Shubinski (1971) and included in the original release of SWMM (Metcalf and Eddy et al., 1971a). This method is closer to the reality than rational or SCM curve number methods. Although SWMM can be manipulated to use rational or SCM methods, its better to use more realistic methods such as the kinematic wave approach for routing rainfall-runoff process.

- ***Pre-development:***

The pre-development situation is simulated using SWMM model (**Error! Reference source not found.**), the peak flow before development is 0.35 cfs.

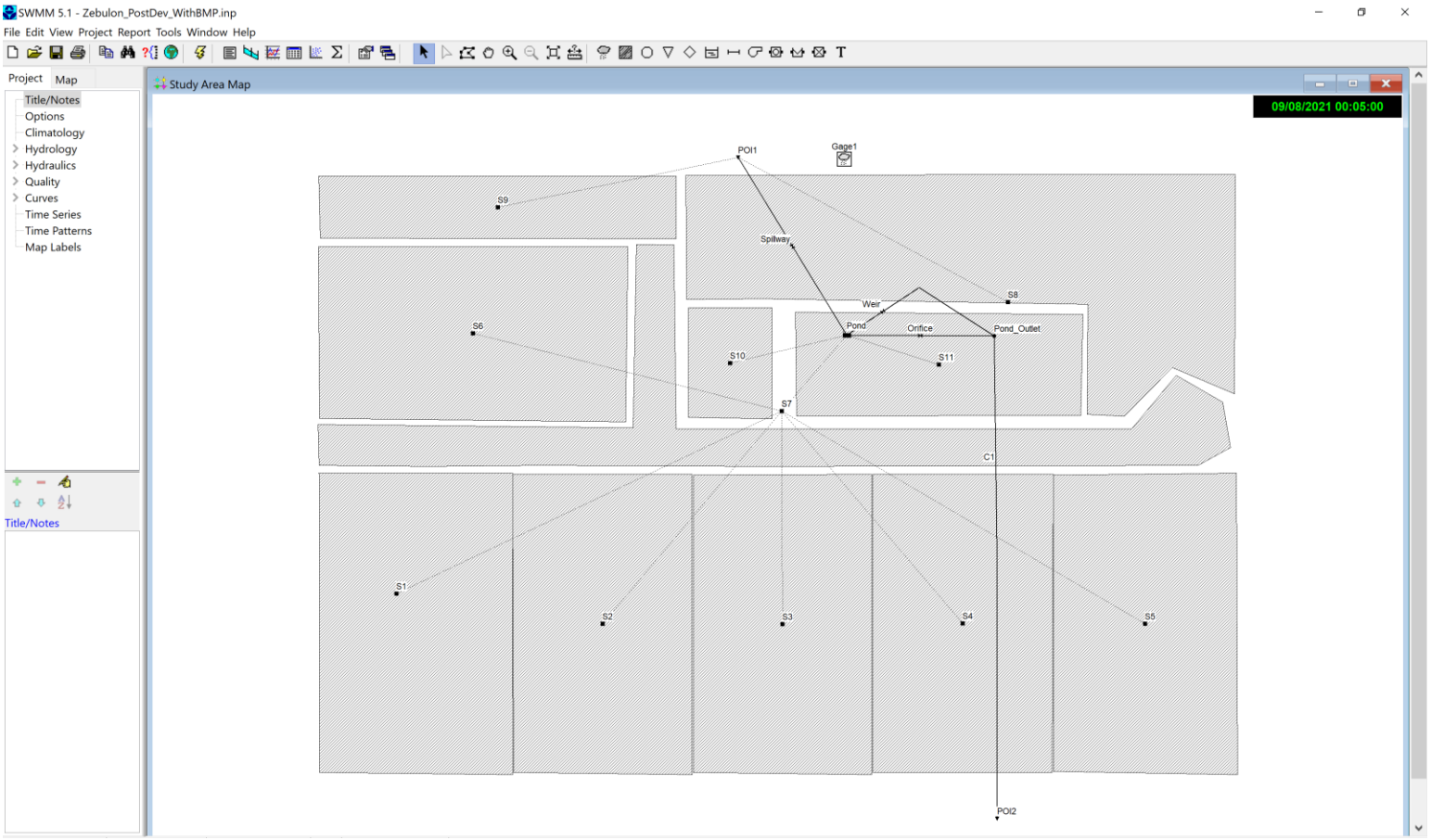



Graph - System Precipitation
System Precipitation (in/hr)
Precipitation (in/hr)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
Elapsed Time (hours)


Graph - Node Out1 Total Inflow
Node Out1 Total Inflow (CFS)
Total Inflow (CFS)
0.2
0.0
0
5
10
15
20
25
Elapsed Time (hours)

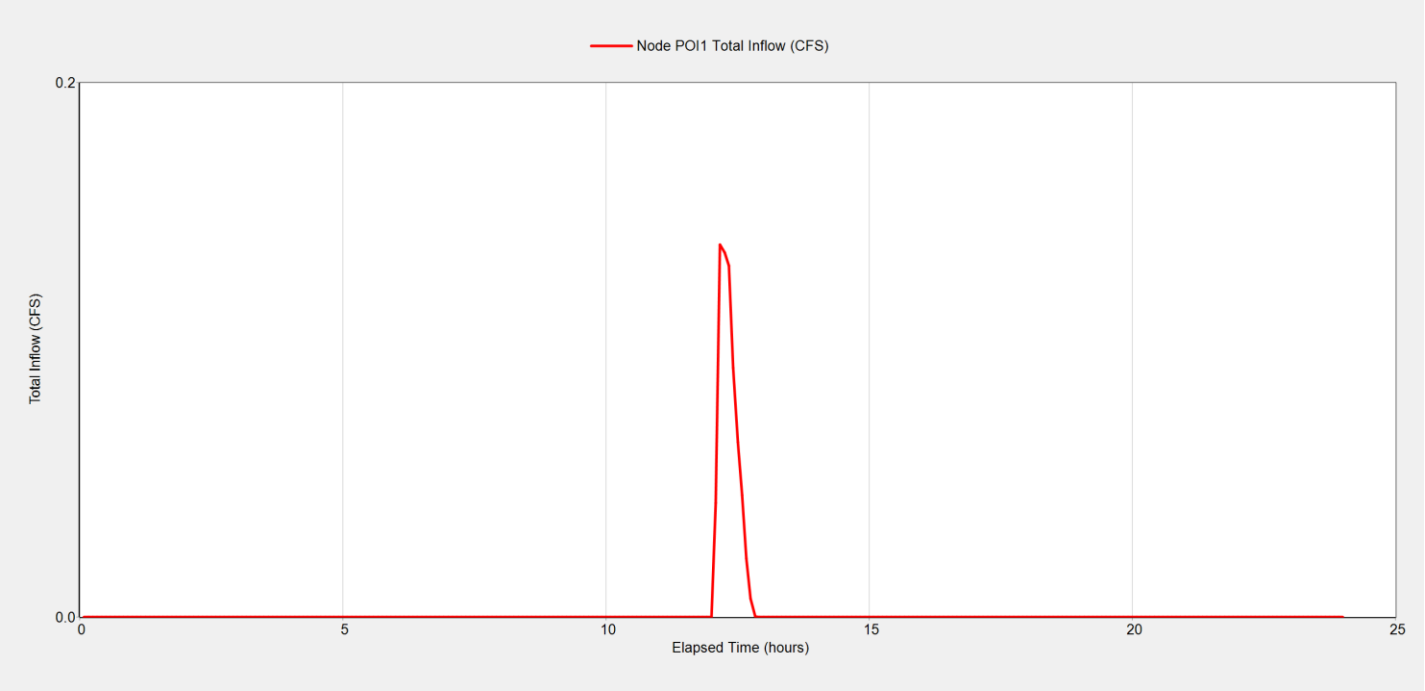
- ***Post-development:***

Another SWMM model is built to simulate rainfall-runoff process for post-development situation in which 12 private lots, a road, and a wet pond were located. There are 11 subcatchments in the watershed in which runoff from 9 of them would flow to the pond, while runoff from 2 of them (S8 and S9) would be released to the "POI1". The area of these two subcatchments that are not flowing to the pond is about 14,000 sf.

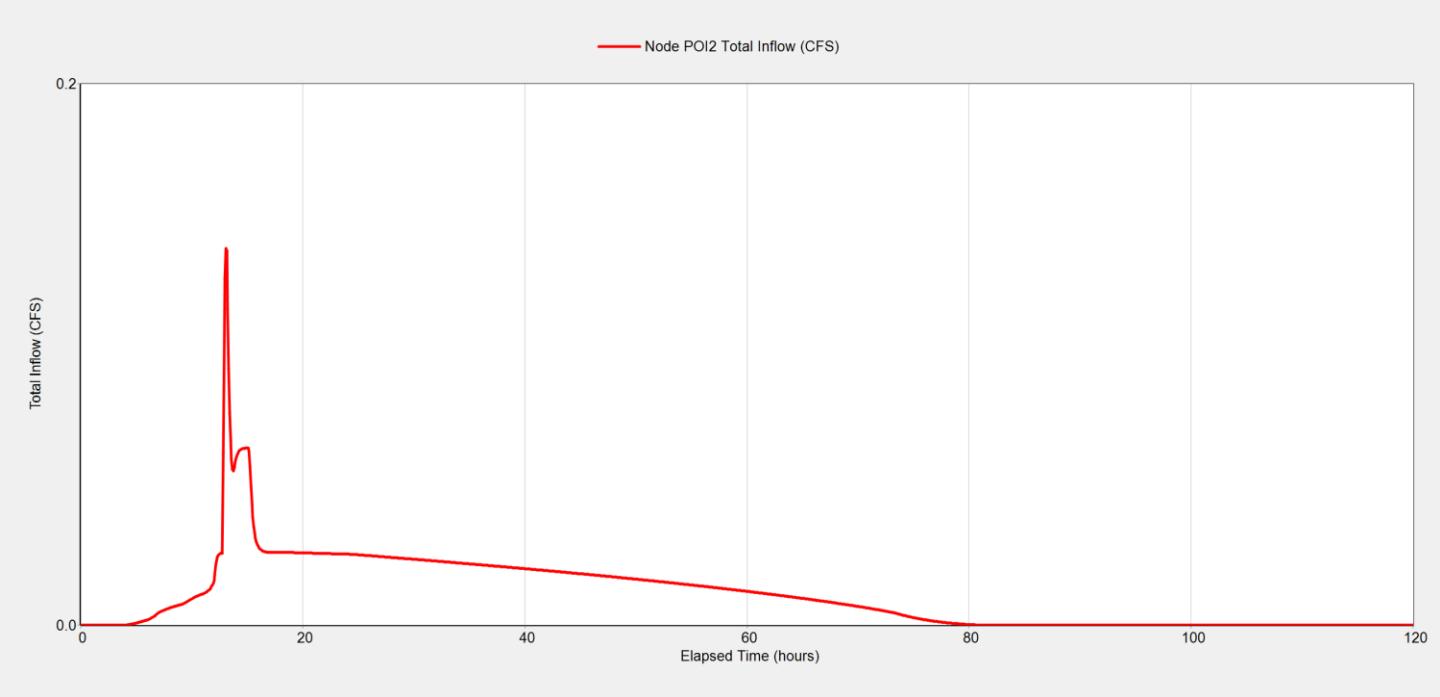


After running the model, the runoff analyses in the outlets, links, and nodes are as follow.

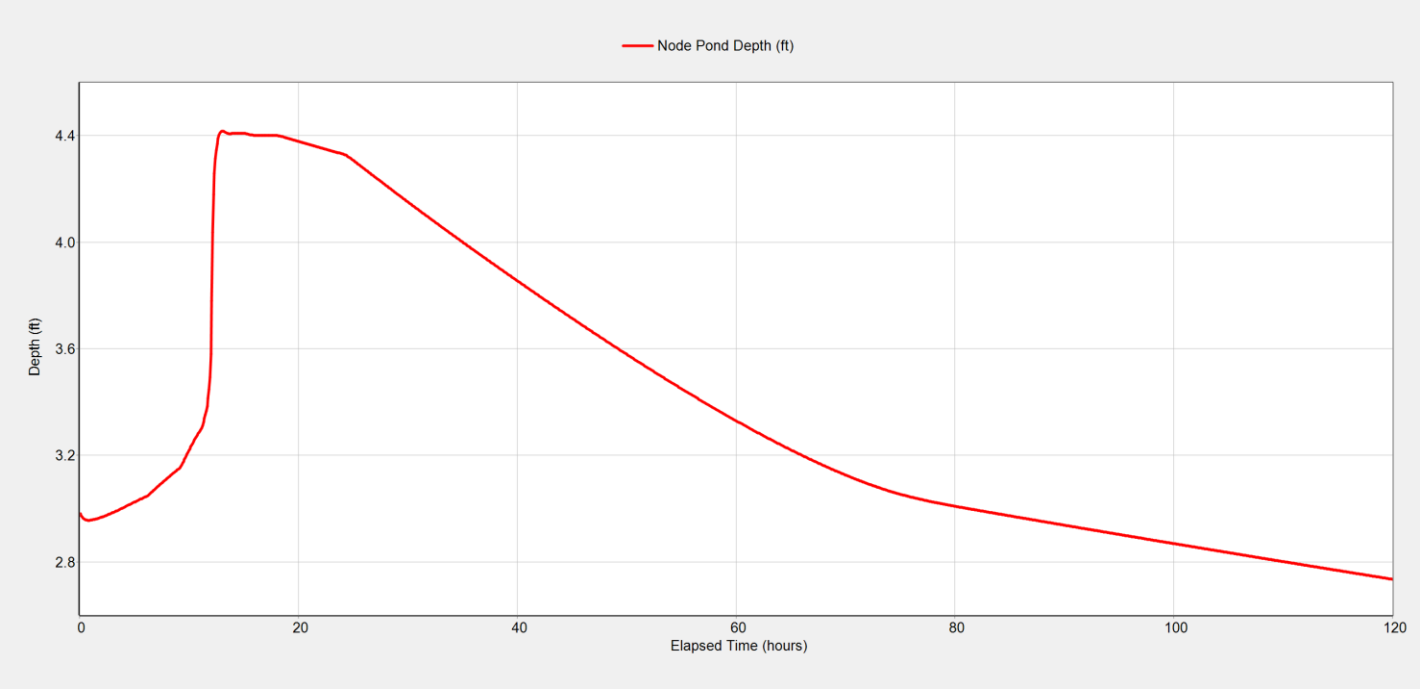
POI#1 Inflow (Stormwater runoff at the first POI)



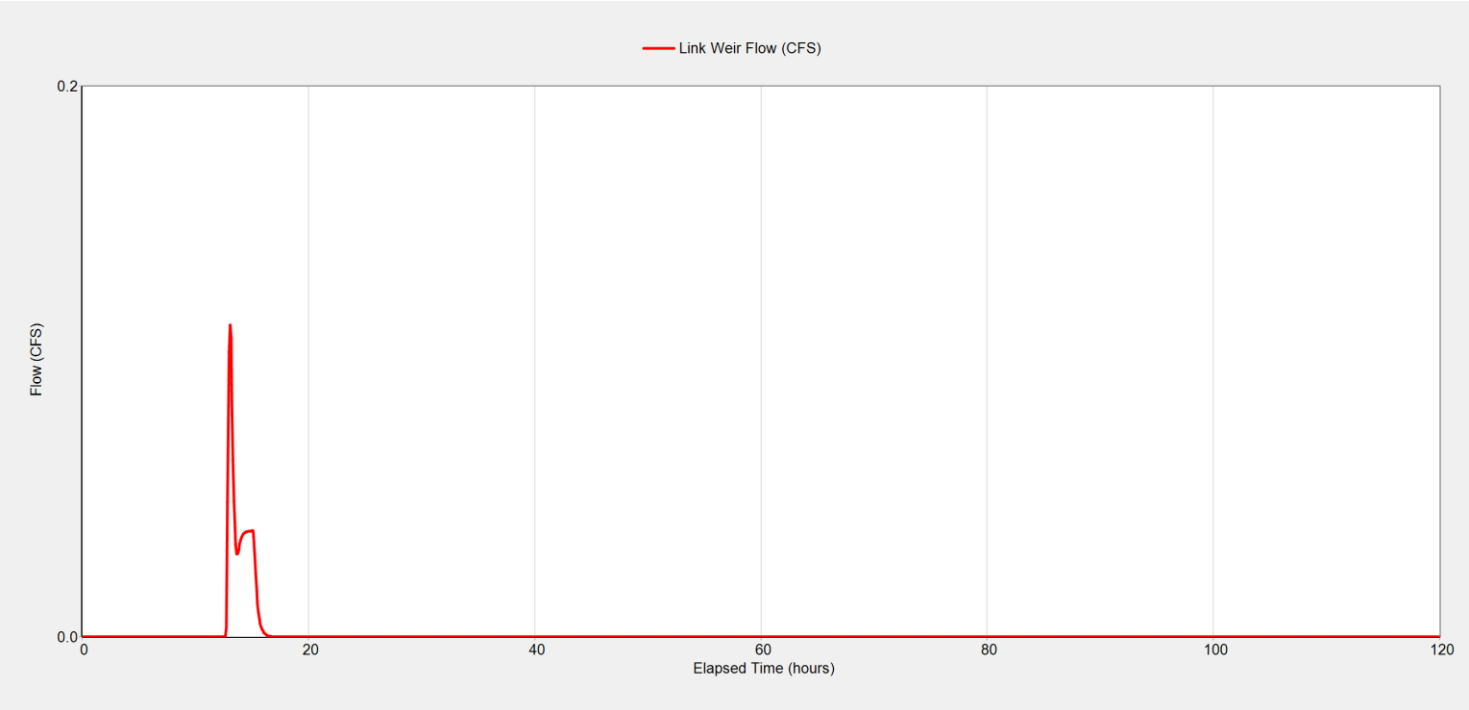
POI#2 Inflow (Stormwater runoff at the second POI)



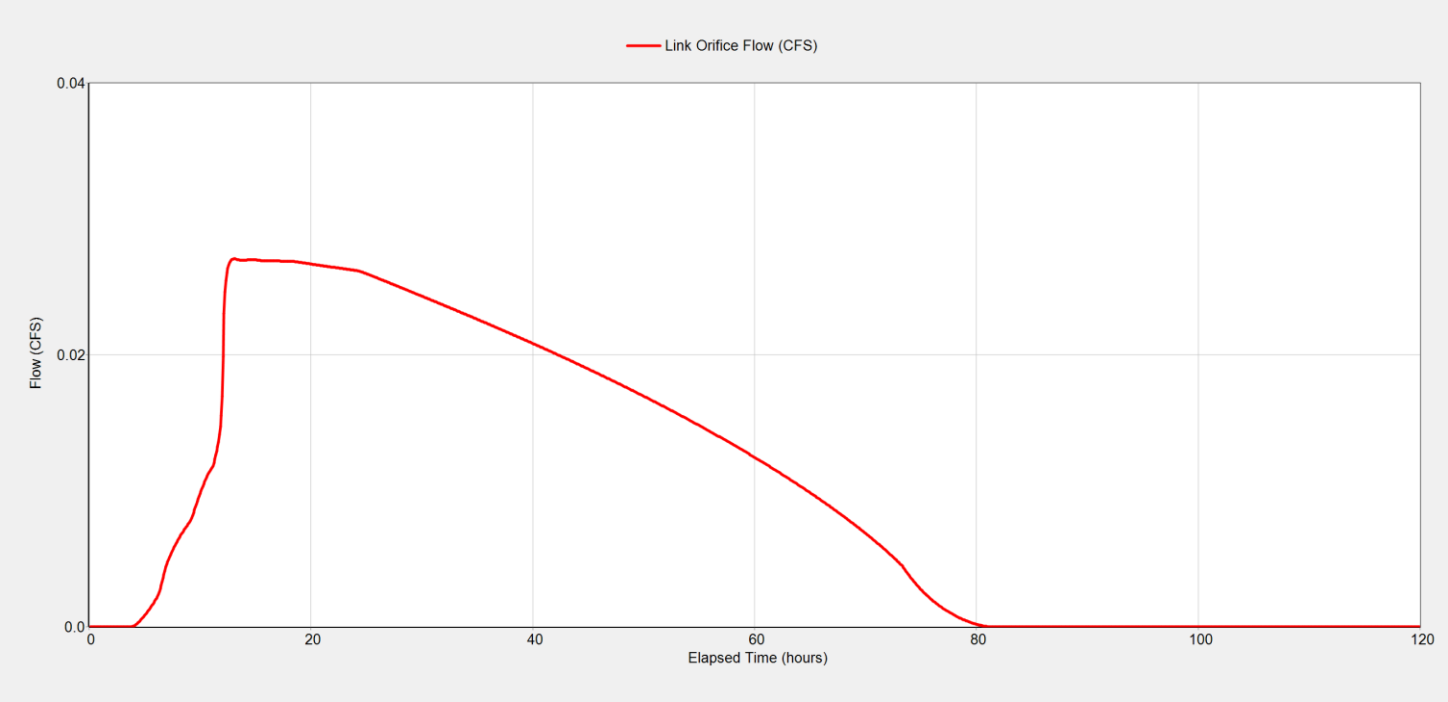
Pond depth



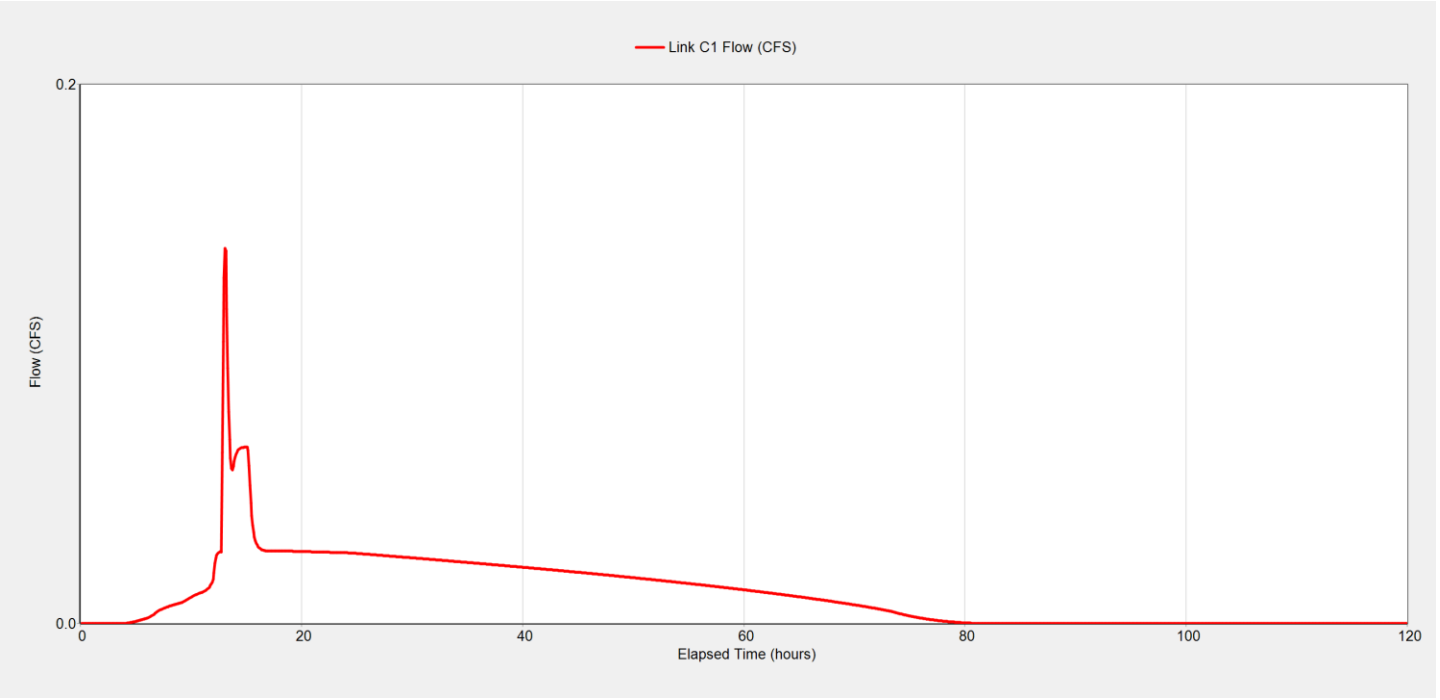
Flow at the weir.



Flow at the orifice



Flow at the pipe that connects pond outlet to the stormwater manhole.



“POI#1” total inflow: Peak flow at POI#1 is 0.14 cfs while before development, it was 0.35 cfs.

“POI#2” total inflow: The peak flow goes to the stormwater manhole is 0.15 cfs. This is the section Point of Interest (POI2).

“Pond” depth: Initial depth of pond is 3 ft (main pool). Depth increase in pond up to 4.4 feet which is the weir elevation. There are some overflow through the weir in the pond outlet structure. After about 70 hours, depth of pond would goes down to the main pool level, means the temporary pool flow out to the outlet. Therefore, runoff volume drawdown time is less than 3 days.

It should be mentioned that there is no flow at the emerfenxy “spillway”, means that the spillway is not activated based on the storm event. So, all runoffs are capture in the wet pond and released by the outlet structure to the stormwater pipeline manhole. So, the inflow at “POI#1” comes from two subcatchments that are not connected to the pond (S8 and S9), means the design SCM cannot influence on this overflow at this POI.

Considering both watershed POIs, the total peak flow in both outlets (post-development) is 0.29 cfs, which is 17% less than pre-development peak flow (0.35 cfs).

Nutrient Offset

Project Summary

Project Name:	712 Arendell-True home-Zebulon				
Project Area (ft^2):	60,200 ft^2		1.3820 acres	Submission Date:	
Disturbed Area (ft^2):	45,981 ft^2		1.0556 acres		
County:	Wake		Local Jurisdiction:	Zebulon	
Development Land Use Type:	Single Family Residential		Owner Type:	Private	
Development Activity Type:	Development - New		Designated Downtown Area?	no	
Nutrient Management Watershed:	Neuse		Subwatershed:	Neuse - 03020203	
Phosphorus Delivery Zone:	Neuse - Contentnea		Nitrogen Delivery Zone:	Neuse - Contentnea	
Phosphorus Delivery Factor (%):	100%		Nitrogen Delivery Factor (%):	100%	
Phosphorus Loading Rate Target (lb/ac/yr):	*0.97*		*Nitrogen Loading Rate Target (lb/ac/yr):*	*7.05*	
Phosphorus Load Target at Site (lb/yr):	1.35		Nitrogen Load Target at Site (lb/yr):	9.74	
Phosphorus Load Leaving Site w/SCMs (lb/yr):	1.17		Nitrogen Load Leaving Site w/SCMs (lb/yr):	8.59	
P Offsite Buy-Down Threshold Loading Rate (lb/ac/yr):	N/A		N Offsite Buy-Down Threshold Loading Rate	N/A	
Total P Load Reduction Needed (lb/yr):	0.00		Total N Load Reduction Needed (lb/yr):	0.00	
P Load Treatment Balance at Site (lb/yr):	-0.18		N Load Treatment Balance at Site (lb/yr):	-1.16	
P Load Treatment Balance at Lake (lb/yr):	-0.18		N Load Treatment Balance at Lake (lb/yr):	-1.16	

Nutrient Export Summary

	Pre-Project Whole Site Conditions	Post-Project Whole Site without SCMs	Post-Project Whole Site with SCMs	Post-Project SCM-Treated Area	Post-Project Untreated Area
Percent Impervious (for runoff calculation) (%)	0.0%	58.9%	58.9%	75.3%	3.6%
Percent Built-Upon Area (BUA) (%)	0.0%	50.7%	50.7%	65.7%	0.0%
Annual Runoff Volume (ft^3/yr)	10,231	119,477	109,725	105,767	3,958
Annual Runoff % Change (relative to pre-D)	0%	1068%	972%		
Total Nitrogen EMC (mg/L)	2.48	1.31	1.26	1.23	1.92
Total Nitrogen Load Leaving Site (lb/yr)	1.58	9.74	8.59	8.11	0.47
Total Nitrogen Loading Rate (lb/ac/yr)	*1.15*	*7.05*	*6.21*	*7.61*	*1.50*
Total Nitrogen % Change (relative to pre-D)	0%	515%	442%		
Total Phosphorus EMC (mg/L)	1.07	0.18	0.17	0.15	0.66
Total Phosphorus Load Leaving Site (lb/yr)	0.68	1.35	1.17	1.00	0.16
Total Phosphorus Loading Rate (lb/ac/yr)	*0.49*	*0.97*	*0.84*	*0.94*	*0.51*
Total Phosphorus % Change (relative to pre-D)	0%	97%	71%		

SCM/Catchment Summary

SCM ID and Type	Volume Reduction (%)	TN Out (mg/L)	TP Out (mg/L)	*TN Out (lbs/ac/yr)*	*TP Out (lbs/ac/yr)*	TN Reduction (%)	TP Reduction (%)
Catchment 1	8.44%	1.23	0.15	*7.61*	*0.94*	12.44%	15.09%
101: Wet Pond per MDC	8.44%	1.23	0.15	*7.61*	*0.94*	12.44%	15.09%
102: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
103: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
Catchment 2	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
201: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
202: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
203: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
Catchment 3	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
301: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
302: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
303: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
Catchment 4	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
401: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
402: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
403: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
Catchment 5	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
501: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
502: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
503: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
Catchment 6	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
601: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
602: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%
603: NA	0.00%	0.00	0.00	*0.00*	*0.00*	0.00%	0.00%

SCM rows in red have a data entry error for the SCM that makes an error in the calculation.

Nutrient Management Strategy Watershed - Nutrient Offset Credit Reporting Form

Please complete and submit the following information to the local government permitting your development project to characterize it and assess the need to purchase nutrient offset credits. Contact and rule implementation information can be found online at:

http://deq.nc.gov/about/divisions/water-resources/planning/nonpoint-source-management/nutrient-offset-information

PROJECT INFORMATION

Applicant Name:					
Project Name:	712 Arendell-True home-Zebulon				
Project Address:	712 North Arendell Ave				
Date: *(mm/dd/yyyy)*		**Development Land Use Type:**	Single Family Residential		
County:	Wake	**Development Activity Type:**	Development - New		
Pre-Project Built-Upon Area %:	0.00%			**Project Latitude:**	0
Post-Project Built-Upon Area %:	50.68%			**Project Longitude:**	0

WATERSHED INFORMATION

Nutrient Management Watershed:	Neuse	**N Offsite Threshold Rate (lb/ac/yr):**	N/A
Subwatershed:	Neuse - 03020203	**P Offsite Threshold Rate (lb/ac/yr):**	N/A
Nitrogen Delivery Zone:	Neuse - Contentnea	**Nitrogen Delivery Factor:**	100%
Phosphorus Delivery Zone:	Neuse - Contentnea	**Phosphorus Delivery Factor:**	100%

NUTRIENT OFFSET REQUEST

Nitrogen Load Offset Needs

(A) Untreated Loading Rate (lbs/ac/yr)	(B) Treated Loading Rate (lbs/ac/yr)	(C) Loading Rate Target (lbs/ac/yr)	(D) Reduction Need (lbs/ac/yr) B - C	(E) Project Size (ac)	(F) Offset Duration (yrs)	(G) Delivery Factor (%)	(H) State Buy Down Amount (lbs) D * E * F * G	*(L) (Where Applicable)* Local Gov't Buy Down Amount (lbs)
7.05	6.21	7.05	-0.84	1.3820	30	100%	**0.00**	

Phosphorus Load Offset Needs

(A) Untreated Load Rate (lbs/ac/yr)	(B) Treated Load Rate (lbs/ac/yr)	(C) Loading Rate Target (lbs/ac/yr)	(D) Reduction Need (lbs/ac/yr) B - C	(E) Project Size (ac)	(F) Offset Duration (yrs)	(G) Delivery Factor (%)	(H) State Buy Down Amount (lbs) D * E * F * G	*(L) (Where Applicable)* Local Gov't Buy Down Amount (lbs)
0.97	0.84	0.97	-0.13	1.3820	30	100%	**0.00**	

LOCAL GOVERNMENT AUTHORIZATION

Local Government Name:	Zebulon		
Staff Name:		**Phone:**	
Staff Email:		**Date:**	
Local Government Authorizing Signature:			