June 15, 2016

Town of Pittsboro
PO Box 759
Pittsboro, NC 27312

RE: Davie Street Cottages – 100-year storm information
Underfoot Project #C15013.00

To whom it may concern,

On behalf of our client, Mr. Mike Dasher of Orange Development Group, this letter serves to answer the request made at the Board of Commissioner's meeting help on Monday June 13, 2016. Councilman Fiocco asked to see the approximate elevations of the 100-year storm for the pre and post development conditions. The following is a summary of analysis preformed to answer this question.

Pre-development

A model of the existing site conditions using HydroCAD software was prepared. The site was modeled as a "detention basin" with the existing contours on site and along Davie Street serving as the limits of the basin and the existing cross culvert (laid with reverse slope) underneath Davie street used as the pond outfall pipe. The maximum water surface elevation was calculated at +/- 87.7 for the 100-year, 20 minute storm and was then plotted on the existing site topography to represent the likely limits of backwater on the site in its current condition.

Post-development

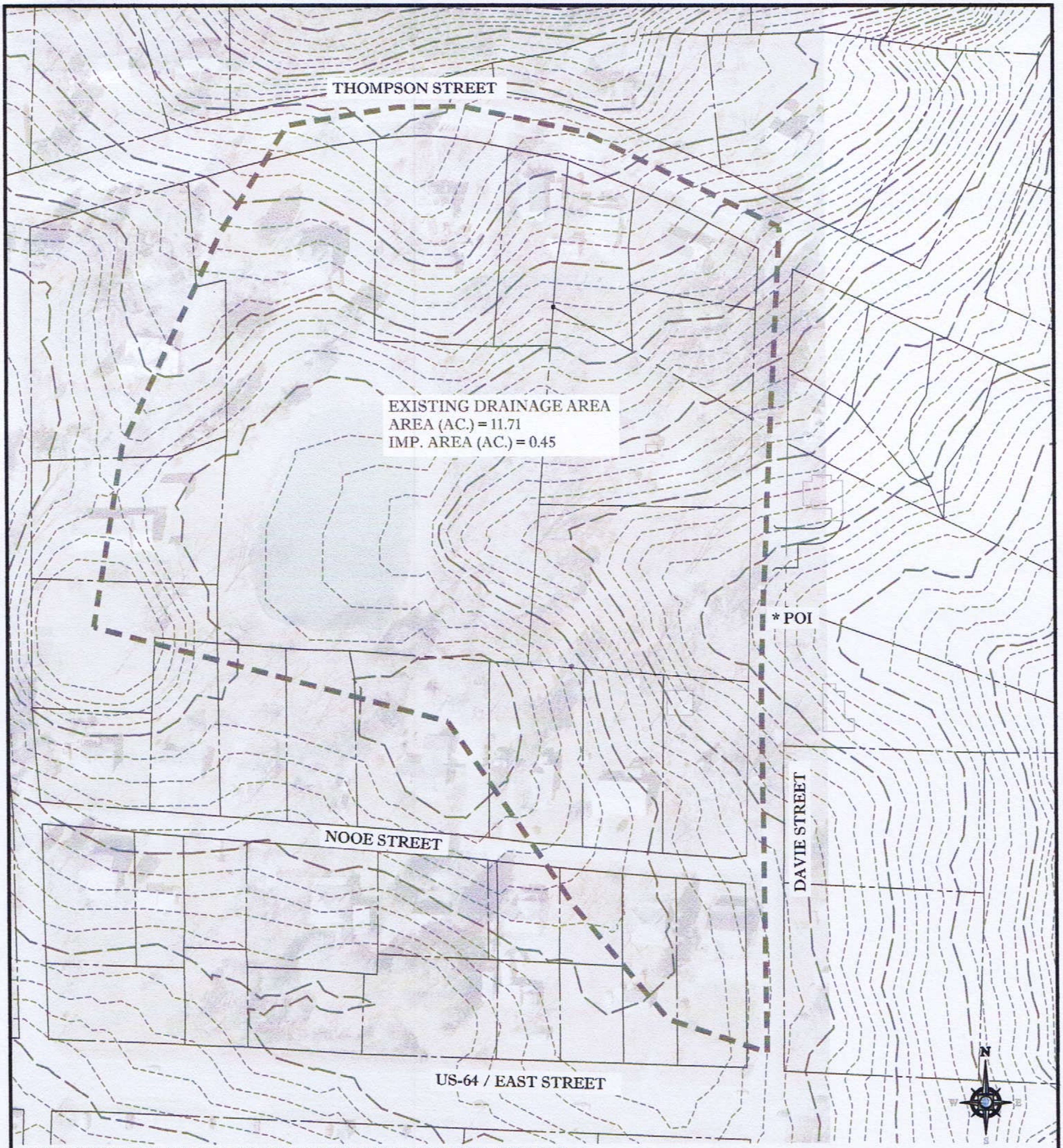
The previously approved stormwater calculations were used as the basis to analyze the anticipated maximum water surface elevation at the proposed weir box (CB 105) at the western portion of the site where the by-pass system starts. The weir is sized so that it should capture the full flows from the anticipated 100-year storm. Given full capture by the weir, the hydraulic grade line (HGL) of the pipe was interpolated from the StormCAD HGL profiles at +/- 292.3. This elevation was then plotted on the combined site topography to represent the likely limits of backwater off- site based on the proposed design.

Supporting documentation for these findings is attached to this letter for reference. I am hopeful that this answers any outstanding questions. If you have any additional questions, please feel free to contact me directly at 919.244.0494 or llovelace@underfootengineering.com.

Respectfully submitted:

Landon M. Lovelace

Landon M. Lovelace, PE, LEED AP-ND, NCLID



H:\2014\NCR142045\DRAWINGS\EXHIBITS\DRAINAGE AREA MAPS\NCR142045 DRAINAGE AREA MAPS.DWG PRINTED BY: MROSELLI 4.01.15 @ 1:36 PM LA

PROJECT NAME:

DAVIE STREET COTTAGES
DAVIE STREET
PITTSBORO, NC

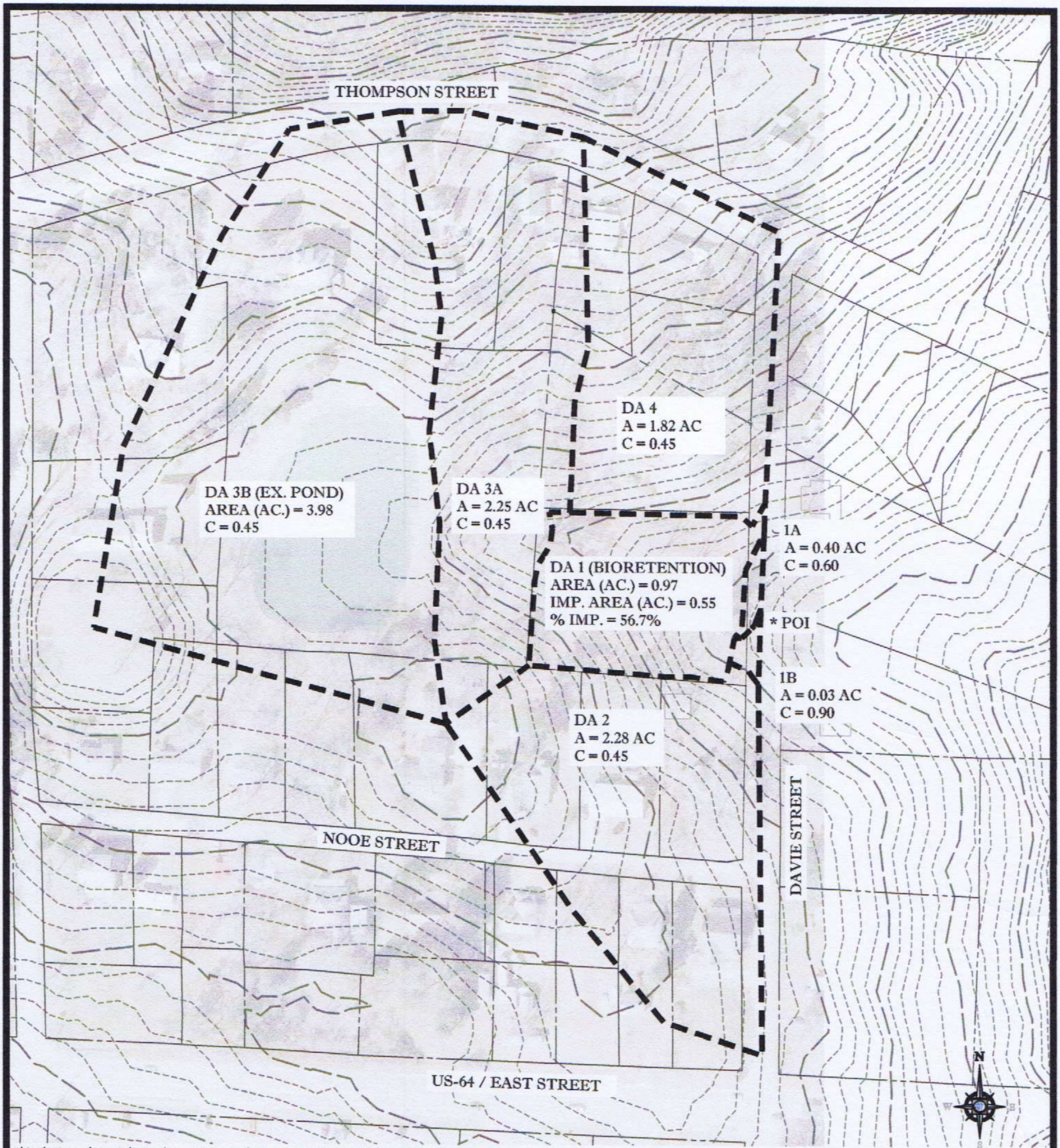
SHEET TITLE:

DRAINAGE AREAS: EXISTING

SHEET 1 OF 2

BOHLER ENGINEERING

SCALE:	DATE:	CAD ID:	PROJECT NUMBER:
1" = 150'	3/20/2015	MAR	NCR142045



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PROJECT NAME:

DAVIE STREET COTTAGES

DAVIE STREET

PITTSBORO, NC

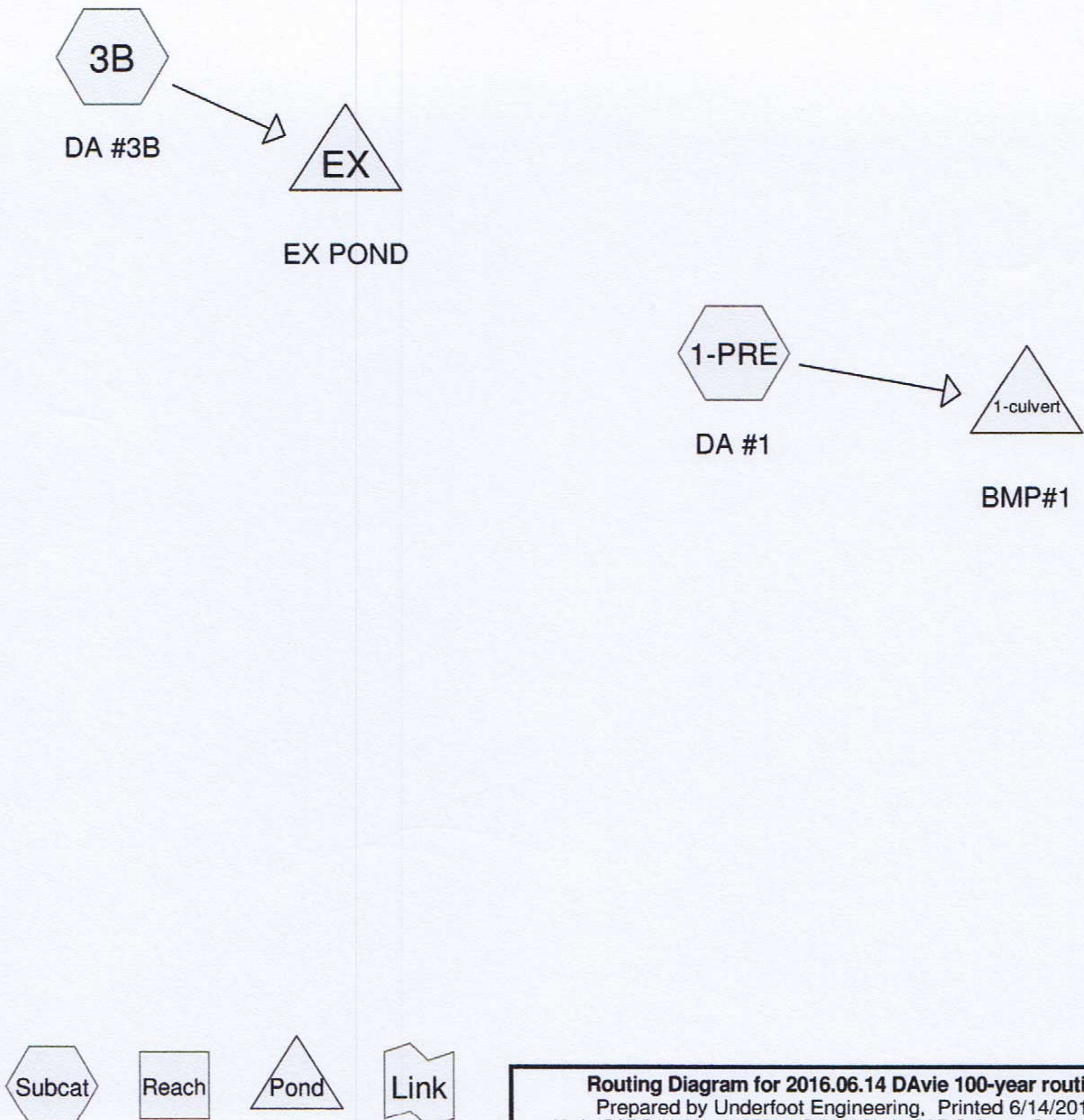
SHEET TITLE:

DRAINAGE AREAS: PROPOSED

SHEET 2 OF 2

SCALE:	DATE:	CAD ID:	PROJECT NUMBER:
1" = 150'	3/20/2015	MAR	NCR142045

BOHLER ENGINEERING



Routing Diagram for 2016.06.14 DAvie 100-year routing
Prepared by Underfoot Engineering, Printed 6/14/2016

Summary for Subcatchment 1-PRE: DA #1

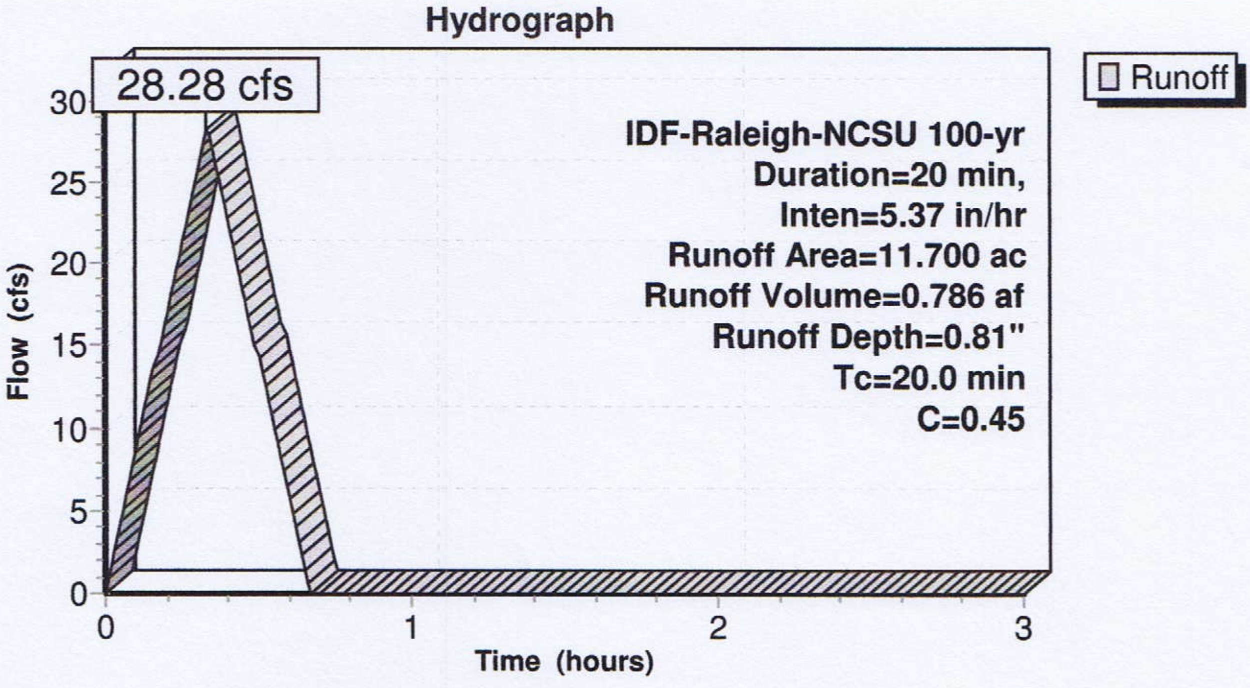
Runoff = 28.28 cfs @ 0.33 hrs, Volume= 0.786 af, Depth= 0.81"

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
IDF-Raleigh-NCSU 100-yr Duration=20 min, Inten=5.37 in/hr

Area (ac)	C	Description
11.700	0.45	Ex Conditions
11.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0					**Direct Entry,**

Subcatchment 1-PRE: DA #1



Summary for Subcatchment 3B: DA #3B

Runoff = 11.86 cfs @ 0.17 hrs, Volume= 0.327 af, Depth= 0.98"

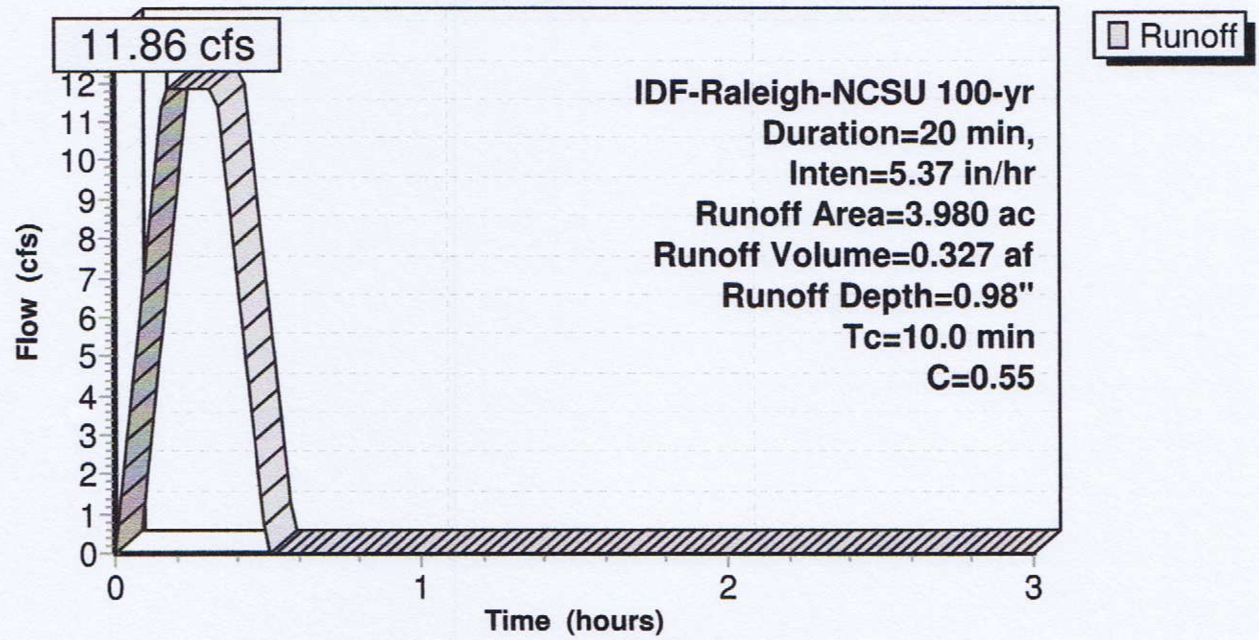
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
IDF-Raleigh-NCSU 100-yr Duration=20 min, Inten=5.37 in/hr

Area (ac)	C	Description
3.980	0.55	Composite
3.980		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry,**

Subcatchment 3B: DA #3B

Hydrograph



Summary for Pond 1-culvert: BMP#1

Inflow Area = 11.700 ac, 0.00% Impervious, Inflow Depth = 0.81" for 100-yr event
Inflow = 28.28 cfs @ 0.33 hrs, Volume= 0.786 af
Outflow = 22.43 cfs @ 0.40 hrs, Volume= 0.786 af, Atten= 21%, Lag= 4.3 min
Primary = 22.43 cfs @ 0.40 hrs, Volume= 0.786 af

Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs / 3
Peak Elev= 87.68' @ 0.40 hrs Surf.Area= 6,663 sf Storage= 4,325 cf

Plug-Flow detention time= 2.0 min calculated for 0.783 af (100% of inflow)
Center-of-Mass det. time= 2.0 min (22.0 - 20.0)

Volume	Invert	Avail.Storage	Storage Description
#1	84.50'	126,471 cf	**Custom Stage Data (Conic)** Listed below

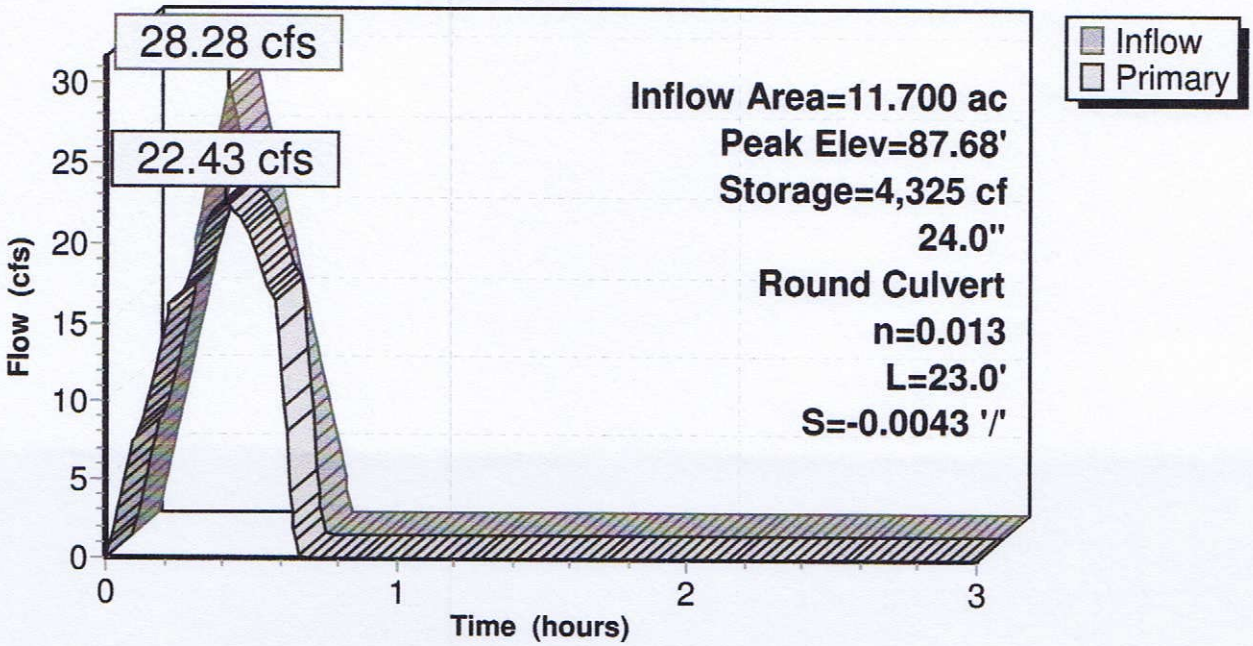
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
84.50	2	0	0	2
85.00	30	7	7	31
86.00	194	100	107	198
87.00	1,822	870	977	1,829
88.00	8,974	4,947	5,923	8,985
89.00	15,302	11,998	17,922	15,325
90.00	21,064	18,106	36,028	21,107
91.00	26,986	23,964	59,992	27,054
92.00	33,010	29,947	89,939	33,109
93.00	40,170	36,531	126,471	40,301

Device	Routing	Invert	Outlet Devices
#1	Primary	84.60'	**24.0" Round Culvert** L= 23.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 84.50' / 84.60' S= -0.0043 '/' Cc= 0.900 n= 0.013, Flow Area= 3.14 sf

Primary OutFlow Max=22.42 cfs @ 0.40 hrs HW=87.68' (Free Discharge)
↑**1=Culvert** (Barrel Controls 22.42 cfs @ 7.14 fps)

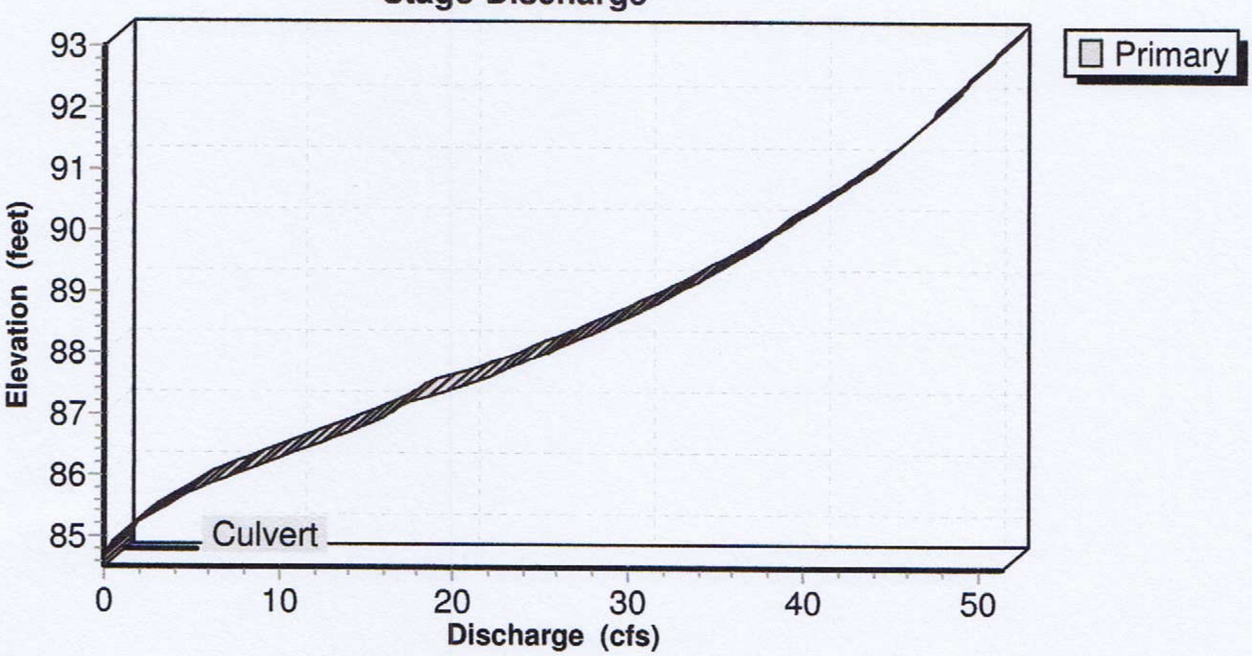
Pond 1-culvert: BMP#1

Hydrograph



Pond 1-culvert: BMP#1

Stage-Discharge



Summary for Pond EX: EX POND

Inflow Area = 3.980 ac, 0.00% Impervious, Inflow Depth = 0.98" for 100-yr event
Inflow = 11.86 cfs @ 0.17 hrs, Volume= 0.327 af
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-3.00 hrs, dt= 0.01 hrs
Peak Elev= 100.00' @ 0.50 hrs Surf.Area= 39,560.004 ac Storage= 0.327 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	39,780.000 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

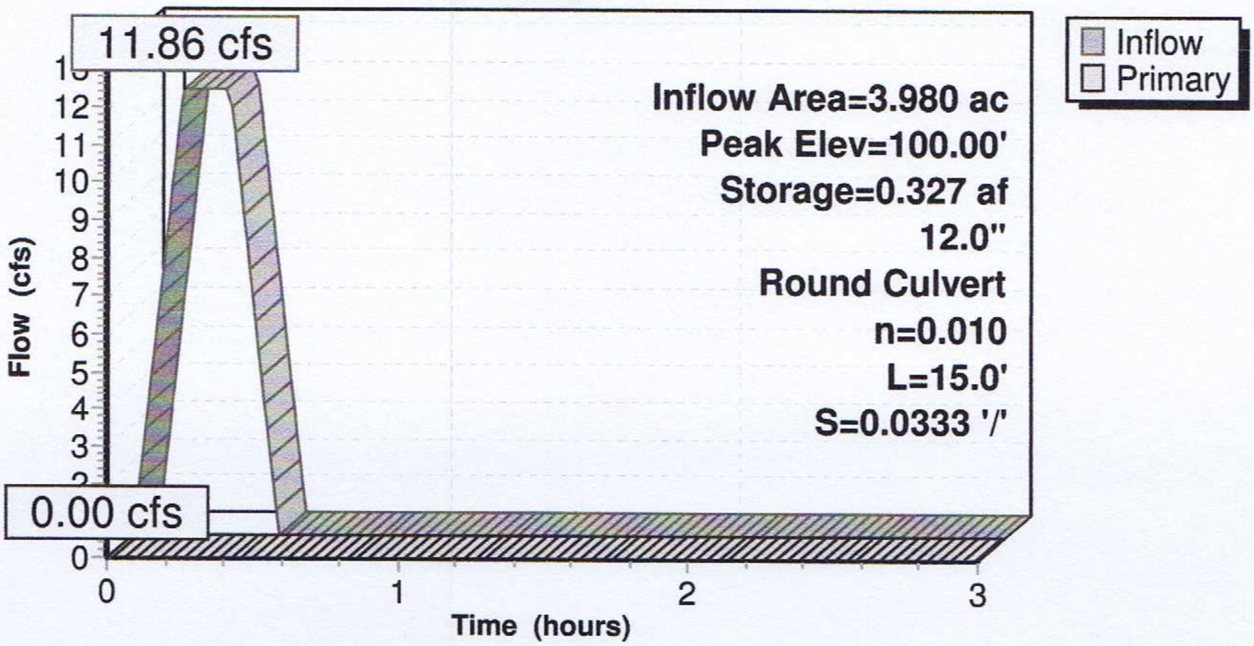
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
100.00	39,560.000	0.000	0.000
101.00	40,000.000	39,780.000	39,780.000

Device	Routing	Invert	Outlet Devices
#1	Primary	100.50'	**12.0" Round Culvert** L= 15.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 100.50' / 100.00' S= 0.0333 '/' Cc= 0.900 n= 0.010, Flow Area= 0.79 sf

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=100.00' (Free Discharge)
↑—**1=Culvert** (Controls 0.00 cfs)

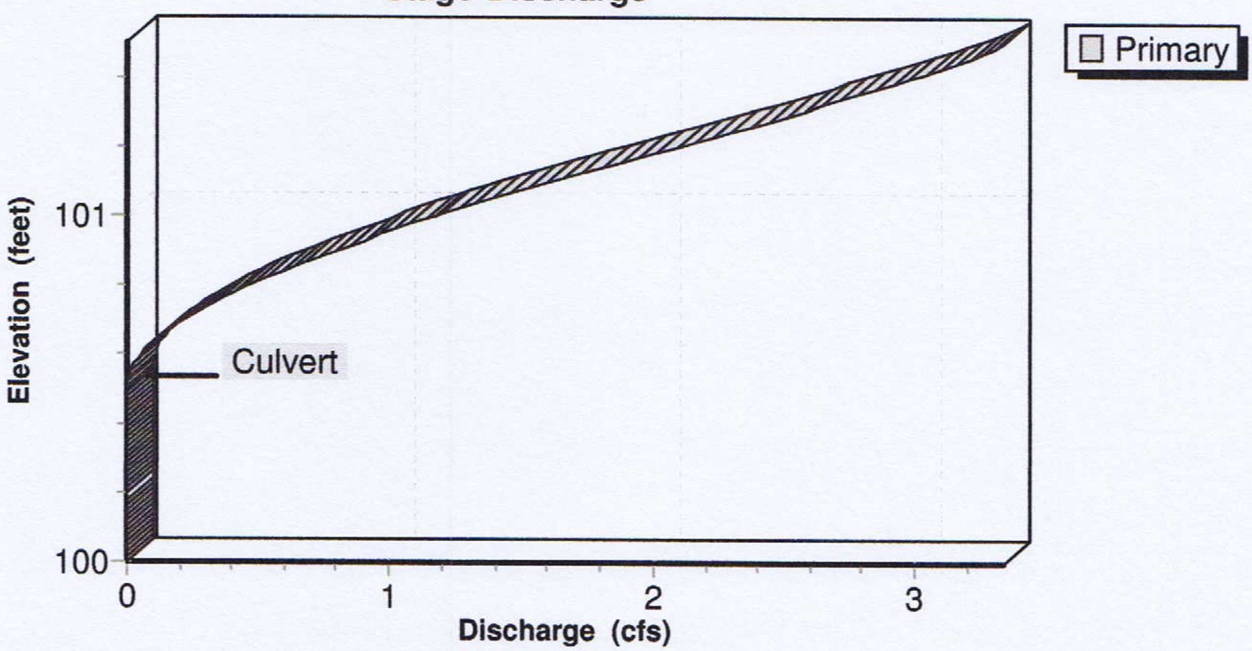
Pond EX: EX POND

Hydrograph



Pond EX: EX POND

Stage-Discharge



BOHLER ENGINEERING NC, PLLC

JOB NO.	NCR142045		
SHEET NO.		OF	
CALCULATED BY	MAR	DATE	04/03/2015
CHECK BY		DATE	
SCALE		OF	

RECTANGULAR WEIR FLOW RATE EQUATION FOR STM-105

REQUIRED

10 YR = 20.20 CFS (0.45)(7.22)(3.98+2.25)

25 YR = 22.32 CFS " (7.96) "

100 YR = 25.23 " (9.00) "

EQUATION

10 ; 25-YR

$Q = C L H^{3/2}$

$= ~~3.32~~ (8')(1')^{3/2}$

$= 26.56$ CFS → OK

No Head

$Q = 2.8 (8)(1')^{3/2} = 22.4$ OK

100-YR - 1' Head based on HGL

$Q = 3.32 (8)(1')^{3/2} = 26.56$ → OK

TABLE 51.—VALUES OF C IN THE FORMULA, $Q = CLH^{3/2}$ FOR BROAD-CRESTED WEIRS

Measured head in feet, H	Breadth of crest of weir in feet										
	0.50	0.75	1.00	1.50	2.00	2.50	3.00	4.00	5.00	10.00	15.00
0.2	2.80	2.75	2.69	2.62	2.54	2.48	2.44	2.38	2.34	2.49	2.68
0.4	2.92	2.80	2.72	2.64	2.61	2.60	2.58	2.54	2.50	2.56	2.70
0.6	3.08	2.89	2.75	2.64	2.61	2.60	2.68	2.69	2.70	2.70	2.70
0.8	3.30	3.04	2.85	2.68	2.60	2.60	2.67	2.68	2.68	2.69	2.64
1.0	3.32	3.14	2.98	2.75	2.66	2.64	2.65	2.67	2.68	2.68	2.63
1.2	3.32	3.20	3.08	2.86	2.70	2.65	2.64	2.67	2.66	2.69	2.64
1.4	3.32	3.26	3.20	2.92	2.77	2.68	2.64	2.65	2.65	2.67	2.64
1.6	3.32	3.29	3.28	3.07	2.89	2.75	2.68	2.66	2.65	2.64	2.63
1.8	3.32	3.32	3.31	3.07	2.88	2.74	2.68	2.66	2.65	2.64	2.63
2.0	3.32	3.31	3.30	3.03	2.85	2.76	2.72	2.68	2.65	2.64	2.63
2.5	3.32	3.32	3.31	3.28	3.07	2.89	2.81	2.72	2.67	2.64	2.63
3.0	3.32	3.32	3.32	3.32	3.20	3.05	2.92	2.73	2.66	2.64	2.63
3.5	3.32	3.32	3.32	3.32	3.32	3.19	2.97	2.76	2.68	2.64	2.63
4.0	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.70	2.64	2.63
4.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.74	2.64	2.63
5.0	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.07	2.79	2.64	2.63
5.5	3.32	3.32	3.32	3.32	3.32	3.32	3.32	3.32	2.88	2.64	2.63

TABLE 62.—VALUES OF C IN THE FORMULA $Q = CLH^{3/2}$ FROM EXPERIMENTS AT CORNELL UNIVERSITY ON MODELS RESEMBLING EXISTING DAMS (EXCEPT THAT THE LAST TWO EXPERIMENTS WERE MADE ON ACTUAL DAMS)

No. of figure	Length of model in feet	Head in feet, H									
		0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
64	7.94	....	3.30	3.32	3.36	3.40	3.43	3.48	3.53	3.62	3.72
64	15.97	3.32	3.44	3.46	3.42	3.41	3.46	3.50			
65	7.98	....	3.38	3.46	3.51	3.55	3.58	3.62	3.68	3.74	3.83
65	15.97	3.22	3.48	3.61	3.67	3.70	3.72				
66	15.97	3.15	3.45	3.64	3.75	3.82	3.87	3.88			
67	15.97	3.23	3.34	3.43	3.52	3.59	3.64				
68	15.97	3.18	3.30	3.37	3.42	3.46	3.49	3.52	3.54		
69	15.97	3.28	3.50	3.54	3.52	3.36	3.31	3.30			
70	15.97	3.53	3.54	3.55	3.50	3.35	3.27	3.25	3.25		
71	15.93	3.13	3.14	3.10	3.14	3.20	3.26	3.31	3.37		
72	....	3.09	3.11	3.33							
73	....	....	3.80								

Handbook of Hydraulics, 1939.
H. W. King, McGraw Hill, NY.

A. Weir Types and Coefficients

Important: C has dimensions and they are almost always in English units. Also, be cautious when determining C and H because some tables of C have been determined by including the velocity head, $v^2/2g$, in H and other consider H to be the depth of water above the weir (Fig. 1), thus, look closely at how weir coefficient have been developed. For those of you who like to relate engineering hydraulic equation back to fluid mechanics, note that embedded in C are physical constants, like $g = 32.2$ ft/s^2. There are literally an infinite variety of weir forms but two common, simple forms are the sharp and broad crested weirs (Fig. A.1)

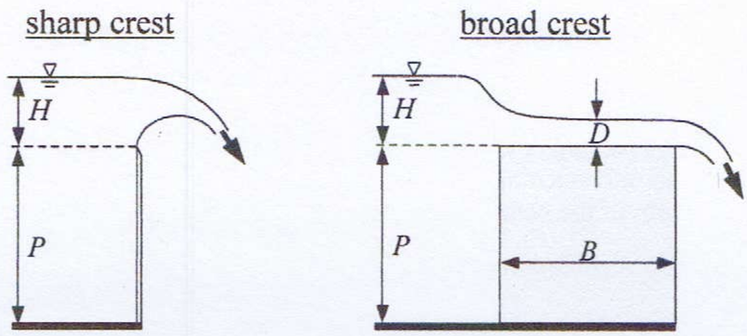


Figure A.1: Schematic of a sharp and broad crested weir profiles.

Table A.1: Coefficients for sharp crested weirs:

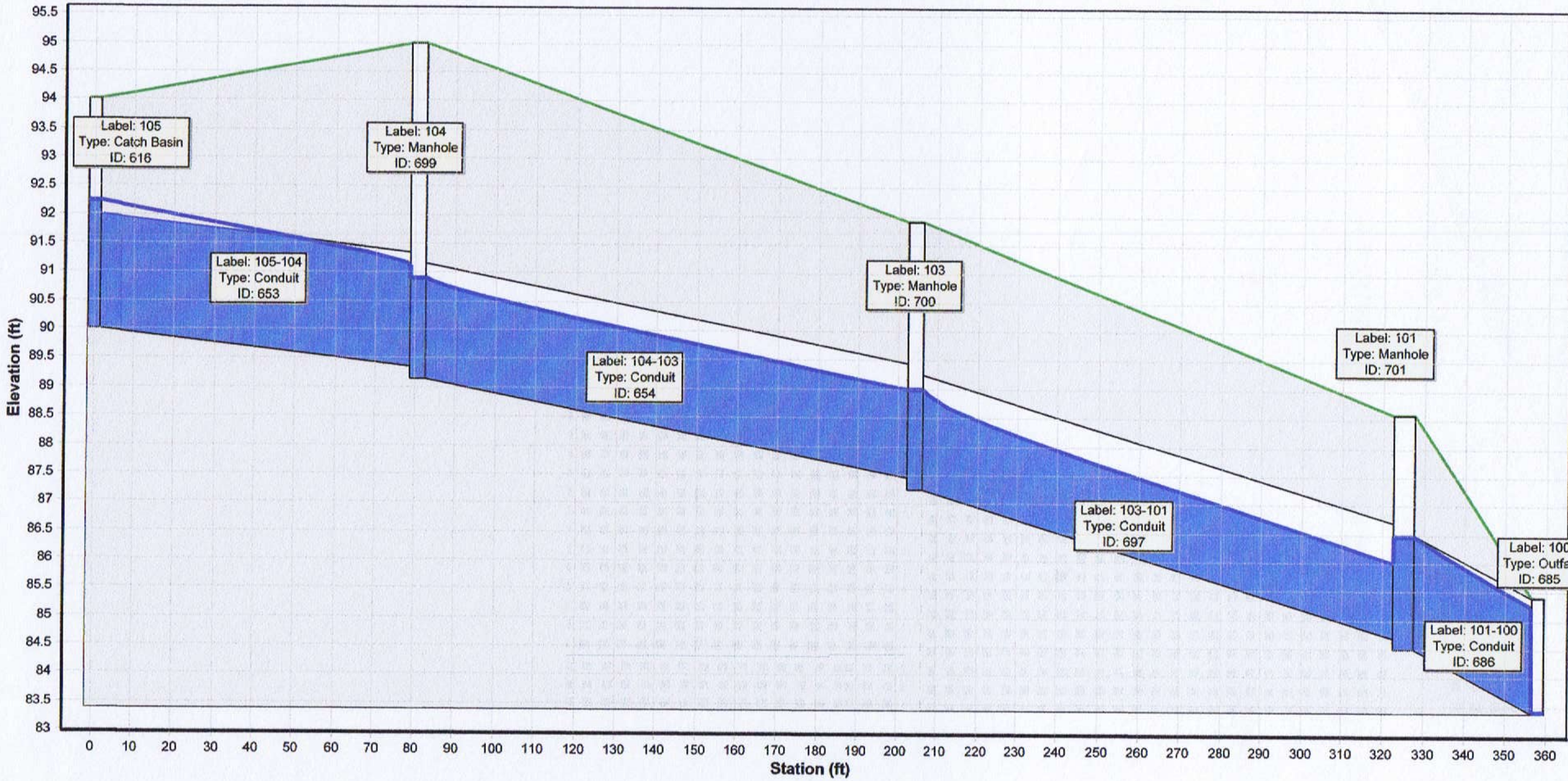
C	comments
3.2	generic satisfactory value as long as the upstream channel width is >1.5L H = depth above the weir
$3.21 + 0.4\frac{H}{P}$	commonly used equation for H/P<10 H = depth above the weir
$5.70\left(1+\frac{P}{H}\right)^{1.5}$	commonly used equation for H/P>15; the weir acts as a sill. H = depth above the weir

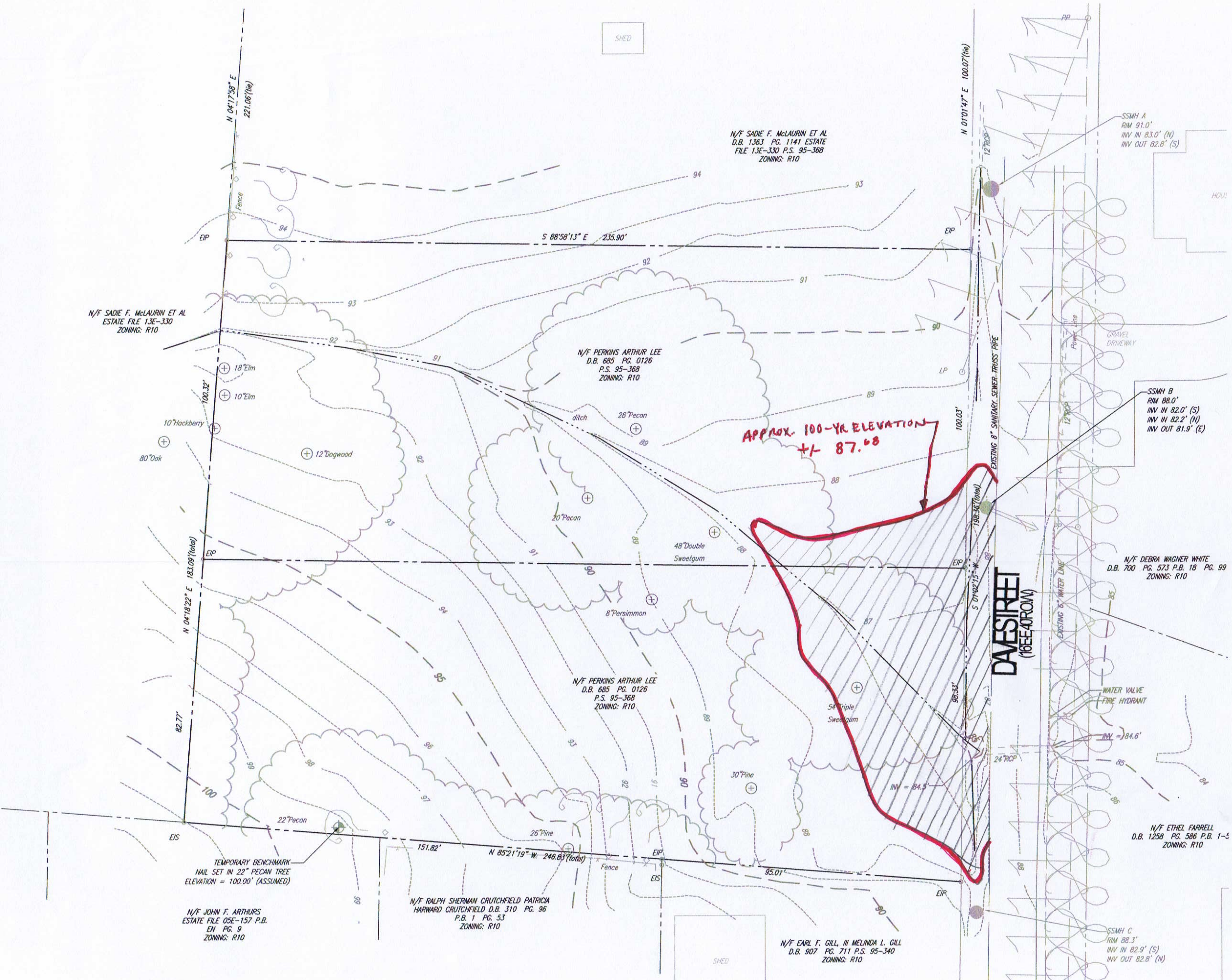
Tables are attached for broad crested weirs and references are provided at the end for good references related to weirs.

Special Notes:

- Drop spillways consisting of a sharp crested and downstream vertical drop are not advised for drops > 3 m.
- For large drops (>1 m), consider aerating the nappe to keep the flow from "sucking" onto the downstream spillway face and potentially compromising its structural integrity.

105-100 - 100 Year Storm

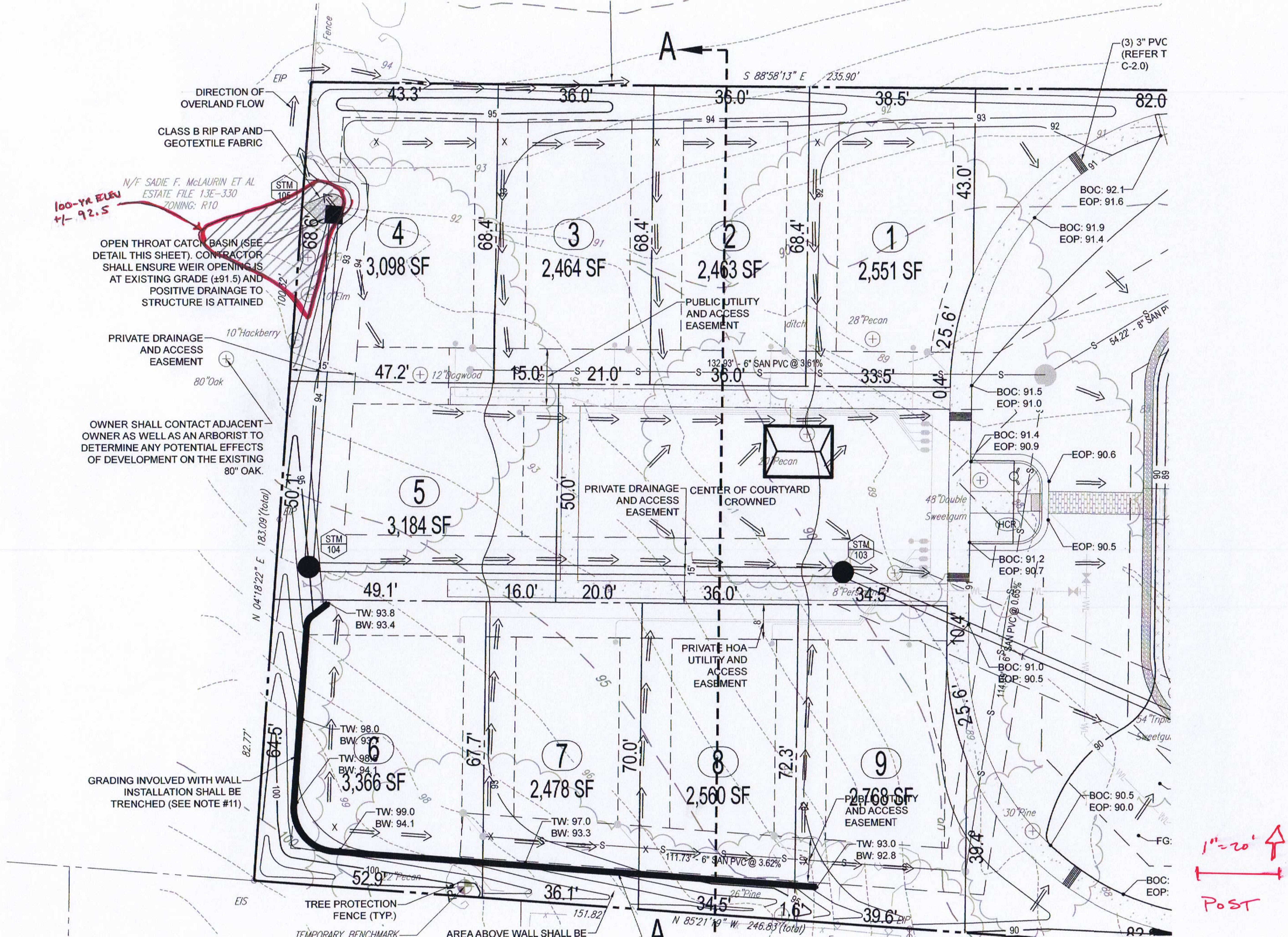




Routed as a pond w/ Ex. culvert as outfall. 100-yr, 20 min T_c.
Max WSEL = 87.68

1" = 30'

PRE


DIRECTION OF OVERLAND FLOW
CLASS B RIP RAP AND GEOTEXTILE FABRIC
N/F SADIE F. McLAURIN ET AL ESTATE FILE 13E-330 ZONING: R10
100-YR ELEV +/- 92.5
OPEN THROAT CATCH BASIN (SEE DETAIL THIS SHEET). CONTRACTOR SHALL ENSURE WEIR OPENING IS AT EXISTING GRADE (±91.5) AND POSITIVE DRAINAGE TO STRUCTURE IS ATTAINED
PRIVATE DRAINAGE AND ACCESS EASEMENT
80"Oak
OWNER SHALL CONTACT ADJACENT OWNER AS WELL AS AN ARBORIST TO DETERMINE ANY POTENTIAL EFFECTS OF DEVELOPMENT ON THE EXISTING 80" OAK.
GRADING INVOLVED WITH WALL INSTALLATION SHALL BE TRENCHED (SEE NOTE #11)
TREE PROTECTION FENCE (TYP.)
TEMPORARY BENCHMARK
AREA ABOVE WALL SHALL BE
S 88°58'13" E 235.90'
N 04°18'22" E 183.09'(total)
N 85°21'19" W 246.83'(total)
4 3,098 SF
3 2,464 SF
2 2,463 SF
1 2,551 SF
5 3,184 SF
6 3,366 SF
7 2,478 SF
8 2,560 SF
9 2,768 SF
PUBLIC UTILITY AND ACCESS EASEMENT
PRIVATE DRAINAGE AND ACCESS EASEMENT
CENTER OF COURTYARD CROWNED
PRIVATE HOA UTILITY AND ACCESS EASEMENT
STM 105
STM 104
STM 103
132.93' - 6" SAN PVC @ 3.61%
111.73' - 6" SAN PVC @ 3.62%
114.80' - 6" SAN PVC @ 0.65%
54.22' - 8" SAN PVC
TW: 93.8 BW: 93.4
TW: 98.0 BW: 93.7
TW: 98.0 BW: 94.1
TW: 99.0 BW: 94.1
TW: 97.0 BW: 93.3
TW: 93.0 BW: 92.8
BOC: 92.1 EOP: 91.6
BOC: 91.9 EOP: 91.4
BOC: 91.5 EOP: 91.0
BOC: 91.4 EOP: 90.9
BOC: 91.2 EOP: 90.7
BOC: 91.0 EOP: 90.5
BOC: 90.5 EOP: 90.0
EOP: 90.6
EOP: 90.5
(3) 3" PVC (REFER T C-2.0)
10"Hackberry
10"Elm
12"Dogwood
28"Pecan
20"Pecan
48"Double Sweetgum
30"Pine
26"Pine
22"Pecan
54"Triple Sweetgum
HCR
Fence
EIP
EIS
A
1"=20'
POST