CULVERT COMPUTATIONS

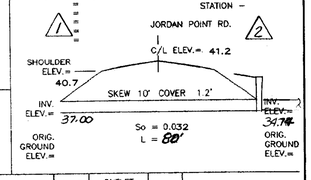
HYDROLOGICAL DATA – 5.11AC — *Structure #1*

C = 0.54
TC = 200 @ 2% — 17.5 MIN.
1700' TRAVEL – 53' FALL — 9.2 MIN.

T_C = 27 MINS — 27 MIN.
I_{10} = 3.7
I_{100} = 5.1

AHW CONTROLS
100 YR. FLOOD PLAIN — ELEV.=
DESIGN AHW DEPTH — ELEV.=
STRUCTURES — ELEV.=

FREQ. — TW ELEV.
STATION –



DISCHARGES USED
Q_{10} = 10.2 cfs
Q_{100} = 17.6 cfs
Q_x =
Q_x =
Q_x =

RISK ASSESSMENT — ADT –
DETOURS AVAILABLE – — LENGTH –
OVERTOPPING STAGE –
FLOOD PLAIN MANAGEMENT –
CRITERIA and SIGNIFICANT IMPACT –

CULVERT TYPE & SIZE	Q	Q/B	HEADWATER COMPUTATIONS: INLET CONT. HW/D	HW	OUTLET CONTROL Ke	dc	(dc+D)/2	ho	H	LSo	HW	CONT. HW ELEV.	OUTLET VELOCITY C.M.	Smooth	END TREAT.	COMMENTS
30x19	10.2		.88	1.39	0.2	0.9	1.24	.5	.3	2.56	0	38.59			DI	Hydraulic Grade at = 37.92
			1.40	2.22	0.2	1.1	1.34	.6	.75	2.26	0	39.42			DI	100 YR HW

CULVERT COMPUTATIONS

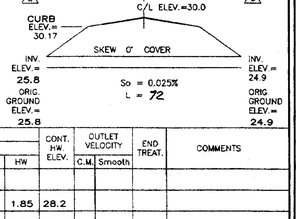
HYDROLOGICAL DATA – 19.28 AC. — *Structure #10*

C = 0.32
TC = 200 @ 3% — 20 MIN.
1200' TRAVEL – 30' FALL — 9 MIN.

T_C = 29 MINS — 29 MIN.
I_{10} = 3.56
I_{100} = 5.0

AHW CONTROLS
100 YR. FLOOD PLAIN — ELEV.=
DESIGN AHW DEPTH — ELEV.=
STRUCTURES — ELEV.=

FREQ. — TW ELEV.
STATION –



DISCHARGES USED
Q_{10} = 21.94 cfs
Q_{100} = 38.5 cfs
Q_x =
Q_x =
Q_x =

RISK ASSESSMENT — ADT –
DETOURS AVAILABLE – — LENGTH –
OVERTOPPING STAGE –
FLOOD PLAIN MANAGEMENT –
CRITERIA and SIGNIFICANT IMPACT –

CULVERT TYPE & SIZE	Q	Q/B	HEADWATER COMPUTATIONS: INLET CONT. HW/D	HW	OUTLET CONTROL Ke	dc	(dc+D)/2	ho	H	LSo	HW	CONT. HW ELEV.	OUTLET VELOCITY C.M.	Smooth	END TREAT.	COMMENTS
30"	21.9		.96	2.4	0.5	1.7	2.35	2.35	0.4	0.9	1.85	28.2				
	38.5		1.53	3.95	0.5	2.2	3.3	3.3	1.4	0.9	3.8	29.75				

HYDRAULIC GRADE LINE COMPUTATIONS

10 YEAR STORM RETURN PERIOD

STRUCT TO STRUCT	OUTLET WATER SURFACE ELEV	Do	Qo	Lo	Sfo	Hf	JUNCTION LOSSES: Vo	Ho	Qi	Vi	QM	Hi	deg	H deg	Ht	1.3 Ht	0.5 Ht	FINAL H	INLET WATER SURF ELEV	RIM ELEV	COMMENTS
1	2	3	4	5			8	9	10	11	12	13	14	15	16	17	18	19	20	21	
4-3	35.17	30/19	10.9	80	.0022	.18	5.5	.12	8.8	5.5	48.4	.16	40	.20	.48	.62	–	.80	35.97	38.21	
3-2	35.97	30/19	9.9	48	.0019	.09	5.5	.12	9.8	11	108	.46	40	.20	.98	1.27	–	1.36	37.33	38.21	
2-1	37.33	30/19	8.8	80	.0015	.12	11	.47	—	—	—	—	—	—	.47	–	–	.59	37.92	41.0	E. Rd 156
19-37	18.79	15	1.3	70	.0008	.06	4.0	.07	—	—	—	—	—	—	.07	.09	–	.09	18.88	19.68	
10-9	26.40	18	6.8	30	.004	.12	12	.56	3.6	4.5	16.2	.11	90	.22	.89	1.16	–	1.28	27.28	29.65	
9-7A	27.28	18	3.6	152	.0011	.17	4.5	.08	3.6	4.2	15.1	.10	30	.12	.30	.35	.17	.34	27.62	31.27	15-1
7A-7	27.62	15	3.6	152	.0013	.46	4.2	.07	2.2	4.2	9.2	.10	90	.20	.37	.48	–	.94	28.56	30.97	
7-6	28.56	15	2.2	32	.0012	.04	4.2	.07	—	—	—	—	—	—	.07	.09	–	.13	28.69	30.97	
9-8	27.28	15	3.2	32	.0024	.08	5.5	.18	—	—	—	—	—	—	.18	.23	–	.31	27.59	29.65	
13-12	16.00	15	5.7	143	.0028	1.13	6.6	.37	5.7	5.1	29.1	.14	0	0	.51	.66	–	1.79	17.79	20.90	
12-11	17.79	15	3.1	36	.0024	.07	5.1	.10	3.1	—	—	—	—	—	.10	.13	–	.20	17.99	20.90	
16-15	16.00	15	5.3	152	.0028	1.21	6.0	.28	5.3	5.5	29.2	.33	0	0	.41	.79	–	2.00	18.00	20.95	
15-14	18.00	15	2.9	36	.002	.06	5.5	.23	2.9	—	—	—	—	—	.23	.30	–	.36	18.36	20.95	
23-22	16.60	24	11.1	34	.002	.07	5.0	.10	11.1	5.0	55.5	.14	30	.47	.71	—	–	.78	17.78	21.00	MH
22-21	17.78	24	11.1	132	.001	.27	5.0	.10	11.1	5.0	55.5	.14	0	0	.24	.31	–	.58	18.36	19.50	
21-19	18.36	18	9.5	34	.0028	.25	6.5	.16	9.5	4.7	44.7	.12	0	0	.28	.36	.18	.48	18.79	19.50	15-1
19-18	18.79	18	5.4	95	.0025	.24	6.5	.16	5.4	4.7	25.4	.29	10	.09	.64	.83	.42	.66	19.45	19.90	15-1
18-17	19.45	15	3.5	70	.0028	.20	4.7	.17	3.5	—	—	—	—	—	.18	.23	–	.43	19.88	20.48	
34-33	16.62	24	7.2	95	.001	.05	5.0	.10	7.2	4.3	36.9	.10	50	.14	.34	.34	–	.39	17.01	23.80	MH
33-32	17.01	24	7.2	195	.001	.15	4.3	.07	7.2	4.7	33.8	.12	90	.24	.43	.56	–	.71	17.72	23.38	
32-30A	17.72	24	6.2	76	.0008	.06	4.7	.09	6.2	4.3	27.9	.11	30	.11	.31	.40	–	.46	18.18	26.20	
30A-30	18.18	24	5.5	198	.0006	.12	4.5	.08	5.5	4.8	26.4	.13	0	0	.21	.21	–	.33	18.51	26.70	MH
30-29	18.51	21	5.6	300	.0012	.36	4.8	.09	5.6	5.0	32.5	.18	40	.22	.49	.49	–	.85	19.36	22.80	MH
29-25	19.36	18	5.6	140	.0027	.38	5.8	.13	1.5	5.8	8.7	.18	50	.26	.57	.74	–	1.12	20.48	23.81	
25-24	20.48	15	1.5	34	.0008	.03	5.8	.13	—	—	—	—	—	—	.13	.17	–	.20	20.68	23.81	
25-26	20.48	15	3.6	208	.003	.62	4.7	.13	3.6	3.3	11.9	.06	90	.12	.31	.40	–	1.02	21.50	26.19	
26-27	21.50	15	1.4	34	.0007	.02	3.3	.04	—	—	—	—	—	—	.04	.05	–	.07	21.57	26.19	
32-31	17.72	15	1.3	30	.0006	.02	6.5	.16	—	—	—	—	—	—	.16	.21	–	.23	17.95	23.38	
17-38	19.88	15	1.9	70	.001	.07	5.1	.12	—	—	—	—	—	—	.12	.16	–	.16	20.04	20.85	

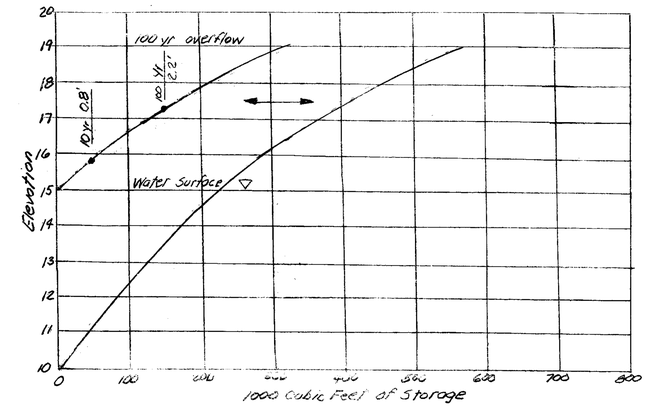
STORMDRAIN COMPUTATIONS

10 YEAR STORM RETURN PERIOD

DRAIN. AREA	STRM.	FROM POINT	TO POINT	DRAIN ACRES	RUNOFF COEF C	CA INCREMENT	CA ACCUMULATED	INLET TIME MIN	RAIN FALL IN/HR	RUNOFF Q CFS	INVERT ELEVATIONS UPPER END	INVERT ELEVATIONS LOWER END	PIPE LENGTH FT	PIPE SLOPE FT/FT	PIPE DIA IN	CAPACITY CFS	VEL. IN PIPE FT/SEC	FLOW TIME IN PIPE MIN		Capacity REMARKS %
1		1	2	5.82	.42	2.44	2.44	28	3.6	8.8	37.00	34.74	80	.028	30/19	38	11	.12		23
2		2	3	.45	.65	.29	2.73	28	3.6	9.8	34.64	34.40	48	.005	30/19	16	5.5	.15		61
3		3	4	.44	.65	.29	3.02	28	3.6	10.9	34.30	33.90	80	.005	30/19	16	5.5	.25		68
6		6	7	.98	.50	.49	.49	18	4.5	2.2	28.00	27.84	32	.005	15	4.7	4.0	.13		47
7		7	7A	.46	.70	.32	.81	18	4.5	3.6	27.74	26.98	152	.005	15	4.7	4.0	.63		77
		7A	9	—	—	—	.81	18	4.5	3.6	26.88	26.12	152	.005	18	7.5	4.5	.56		48
9		9	out	.78	.30	.23	1.52	18	4.5	6.8	26.82	24.90	30	.038	18	21	10.6	.05		32
8		8	9	1.29	.55	.71	.71	18	4.5	3.2	26.38	26.22	32	.01	15	6.5	5.5	.10		49
11		11	12	1.17	.55	.64	.64	15	4.9	3.1	17.62	17.28	36	.01	15	6.5	5.5	.11		48
12		12	13	.92	.58	.53	1.17	15	4.9	5.7	17.15	15.00	143	.015	15	8.0	7.0	.34		71
14		14	15	1.03	.55	.57	.57	14	5.1	2.9	16.60	16.24	36	.01	15	6.5	5.5	.11		47
15		15	16	.77	.60	.46	1.03	14	5.1	5.3	16.18	15.00	155	.0076	15	6.5	5.8	.44		82
17		17	18	.36	.60	.22	.69	18	4.5	3.1	17.00	16.64	70	.005	15	4.7	4.0	.29		66
18		18	19	.62	.70	.43	1.20	18	4.5	5.4	16.54	16.06	95	.005	18	7.5	4.5	.35		72
19		19	21	.69	.48	.33	1.08	19	4.4	4.8	15.94	15.68	34	.008	21	6.5	5.9	.10		74
21		21	22	.48	.70	.34	1.53	19	4.4	6.7	15.58	15.18	132	.003	24	13	4.0	.46		52
23		22	23	0	–	—	1.53	20	4.3	6.6	15.14	15.00	34	.004	24	15	4.8	.12		44
27		27	26	.34	.70	.24	.24	10	5.8	1.4	21.74	21.58	34	.004	15	5.0	3.3	.17		28
26		26	25	1.23	.48	.59	.83	20	4.3	3.6	21.48	20.10	208	.0065	15	5.2	4.1	.74		69
25		25	29	.69	.65	.45	1.30	20	4.3	5.6	20.00	18.80	145	.008	18	9.5	5.8	.42		59
24		24	25	.62	.65	.40	.26	10	5.8	1.5	20.27	20.10	34	.005	15	4.7	3.7	.15		32
—		29	30	—	—	—	1.30	20	4.3	5.6	18.33	16.90	285	.005	21	11	4.8	.99		51
—		30	30A	—	—	—	1.30	21	4.2	5.5	16.80	16.53	90	.003	24	13.5	4.4	.34		41
30A		30A	32	.30	.60	.18	1.48	21	4.2	6.2	16.43	15.83	200	.003	24	13.5	4.5	.74		46
31		31	32	.46	.60	.28	.28	18	4.5	1.3	19.50	19.18	32	.01	15	6.5	4.7	.10		24
32		32	33	.33	.60	.20	1.76	22	4.1	7.2	15.73	15.30	145	.003	24	12.5	4.3	.56		58
—		33	34	—	—	—	1.76	22	4.1	7.2	15.20	15.02	45	.004	24	14.5	5.0	.15		50
37		37	19	.79	.4	.32	.32	18	4.5	1.3	16.36	16.06	50	.006	15	5.0	4.0	.21		26
38		38	17	.93	.4	.47	.47	18	4.5	1.9	17.70	17.00	70	.01	15	6.5	5.1	.23		29
																		ove		50

CURB INLET COMPUTATIONS

NUMBER	TYPE	LENGTH (FT)	STATION (area)	DRAINAGE AREA (AC)	C	CA	sum CA	I (INCHES)	Q IN (CFS)	Q_b, CARRYOVER (CFS)	Q_t, GUTTER FLOW (CFS)	S, GUTTER SLOPE (FT/FT)	S_x, CROSS SLOPE (FT/FT)	T, SPREAD (FT)	W (FT)	W/T	S_w (FT/FT)	Sw/Sx	Eo (App. 9C-8)	$a = 12W(S_w - S_x)$ + Local Depression	$S'_w = a/(12W)$	$S_e = S_x + S'_w(E_o)$, (FT/FT)	COMPUTE LENGTH, L_T (FT) (App. 9C-17)	L, SPECIFIED LENGTH (FT)	L/L_T	E (App. 9C-18)	Q_i, INTERCEPTED (CFS)	Q_b, CARRYOVER (CFS)	Sag Inlets Only: h (FT)	d (FT)	d/h	T, SPREAD @ SAG (FT)	REMARKS
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)	(31)	(32)	(33)	
2	3A	2.5	2	.75	.65	.29	.29	4"	1.16	0	1.16																						
3	3A	2.5	3	.44	.65	.29	.29		1.16	0	1.16																						
6	2A	2.5	6	.98	.5	.49	.49		1.96	0	1.96																						
7	2A	2.5	7	.46		.32	.32		1.28	0	1.28																						
7A	2A	2.5	—	0	–	0	0		0	0	0																						
8	2A	2.5	8	1.29	.55	.71	.71		2.84	0	2.84																						
9	2A	2.5	9	.78	.3	.23	.23		.92	0	.92																						
11	3A	2.5	11	1.17	.55	.64	.64		2.56	0	2.56																						
12	3A	2.5	12	.92	.58	.53	.53		2.12	0	2.12																						
14	3A	2.5	14	1.03	.55	.57	.57		2.28	0	2.28																						
15	3A	2.5	15	.77	.6	.46	.46		1.84	0	1.84																						
17	3A	2.5	17	.70	.55	.39	.39		1.56	.08	1.64																						
18	3A	2.5	18	.62	.7	.43	.43		1.72	0	1.72																						
19	3A	2.5	19	.84	.4	.34	.28		1.12	.04	1.16																						
21	3A	2.5	21	.98	.7	.34	.34		1.36	0	1.36																						
24	3A	2.5	24	.62	.65	.40	.40		1.60	0	1.60																						
25	3A	2.5	25	.69	.65	.45	.45		1.80	0	1.80																						
26	3B	10	26	1.23	.48	.59	.59		2.36	0	2.36	.016	.02	6.8	2	.29	.08	4	.77	1.61	.06	.06	9.8	10	1.02	–	2.36	0						
27	3B	10	27	.34	.7	.24	.24		.96	0	.96	.016	.02	4.5	2	.53	.08	4	.97	1.61	.06	.08	8.2	10	1.22	–	.96	0						
30A	2A	25	30A	.30	.6	.18	.18		.72	0	.72																		.29	.16	.55	4.7	
31	2B	12	31	.46	.6	.28	.28		1.12	0	1.12	.034	.02	3.8	2	.63	.08	4	.98	1.61	.06	.08	11.0	12	1.09	–	1.12	0						
32	2B	12	32	.33	.6	.20	.20		.80	0	.80	.034	.02	3.0	2	.63	.08	4	.98	1.61	.06	.08	11.0	12	1.09	–	0.8	0						
37	3B	8	37	.79	.4	.32	.32		1.28	0	1.28	.01	.02	6.0	2	.33	.08	4	.83	1.61	.06	.07	9.5	8	.84	.97	1.24	.04						
38	3B	10	38	.93	.4	.47	.47	4"	1.88	0	1.88	.013	.02	6.8	2	.29	.08	4	.76	1.61	.06	.07	12	10	.83	.96	1.80	.08						



BMP Pond Capacity Graph

Pond Flood Sizing

DCR CRITICAL STORM DURATION METHOD

T_{d10} = Storm Duration, min
C = Runoff Factor
A = Drainage Area, Acres
a & b = Local Factors
t_c = Time of Concentration, min
Q_i = Flow in, CFS
Q_o = Flow out, CFS
V_s = Volume of Storage, Cubic Feet

10 Year Storm

a = 188.62
b = 21.39

$$T_{d10} = \sqrt{\frac{2CAa\left(b - \frac{t_c}{4}\right)}{q_o}} - b$$

$$T_{d10} = \sqrt{\frac{2(0.5)(16.51)(188.62)\left(21.39 - \frac{21}{4}\right)}{6.5}} - 21.39$$

$T_{d10} = \sqrt{76.84} - 21.39 = 66.31$ min ⇒ 3979 sec

$V_s = \frac{1}{2} T_b (Q_i - Q_o)$

$V_s = (0.5)(3979)(3.3 - 6.5) = 52,721$ CF ⇒ h = 0.8'

100 Year Storm

a = 283.12
b = 24.09

$$T_{d100} = \sqrt{\frac{2CAa\left(b - \frac{t_c}{4}\right)}{q_o}} - b$$

$$T_{d100} = \sqrt{\frac{2(0.5)(16.51)(283.12)\left(24.09 - \frac{21}{4}\right)}{6.5}} - 24.09$$

$T_{d100} = \sqrt{13,547} - 24.09 = 92.30$ min ⇒ 5538 sec

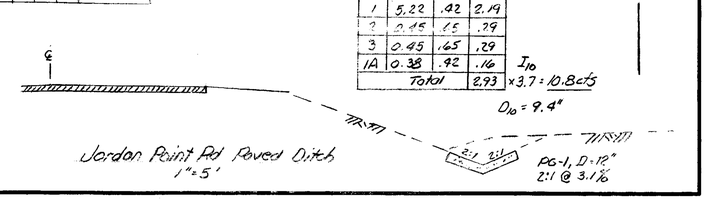
$V_s = \frac{1}{2} T_b (Q_i - Q_o)$

$V_s = (0.5)(5538)(6.2 - 6.5) = 153,680$ CF ⇒ h = 2.2'

#	Area	C	CA
1	5.22	.42	2.19
2	2.15	.15	.29
3	0.45	.65	.29
1A	0.38	.42	.16
Total			2.93

I_{10} ×3.7 = 10.8 cfs

D_{10} = 9.4"



REVISIONS	BY
10-7-13	
12-4-13	
2-3-14	
3-17-14	
4-24-14	

Architectural Graphics
6676 LAKESHORE DRIVE
QUINTON, VIRGINIA 23141
804-551-6944

DRAINAGE CALCULATIONS WITH CULVERTS
EAGLE PRESERVE
AT JORDAN ON THE JAMES

SEAL: COMMONWEALTH OF VIRGINIA — WALTER K. ALTMAN III — No. 11030 — 4/24/14 — PROFESSIONAL ENGINEER

DRAWN : PBM	CHECKED : WMA
DATE : 8-19-13	
SCALE : AS NOTED	
JOB NO. :	
SHEET C22	
OF 35 SHEETS	