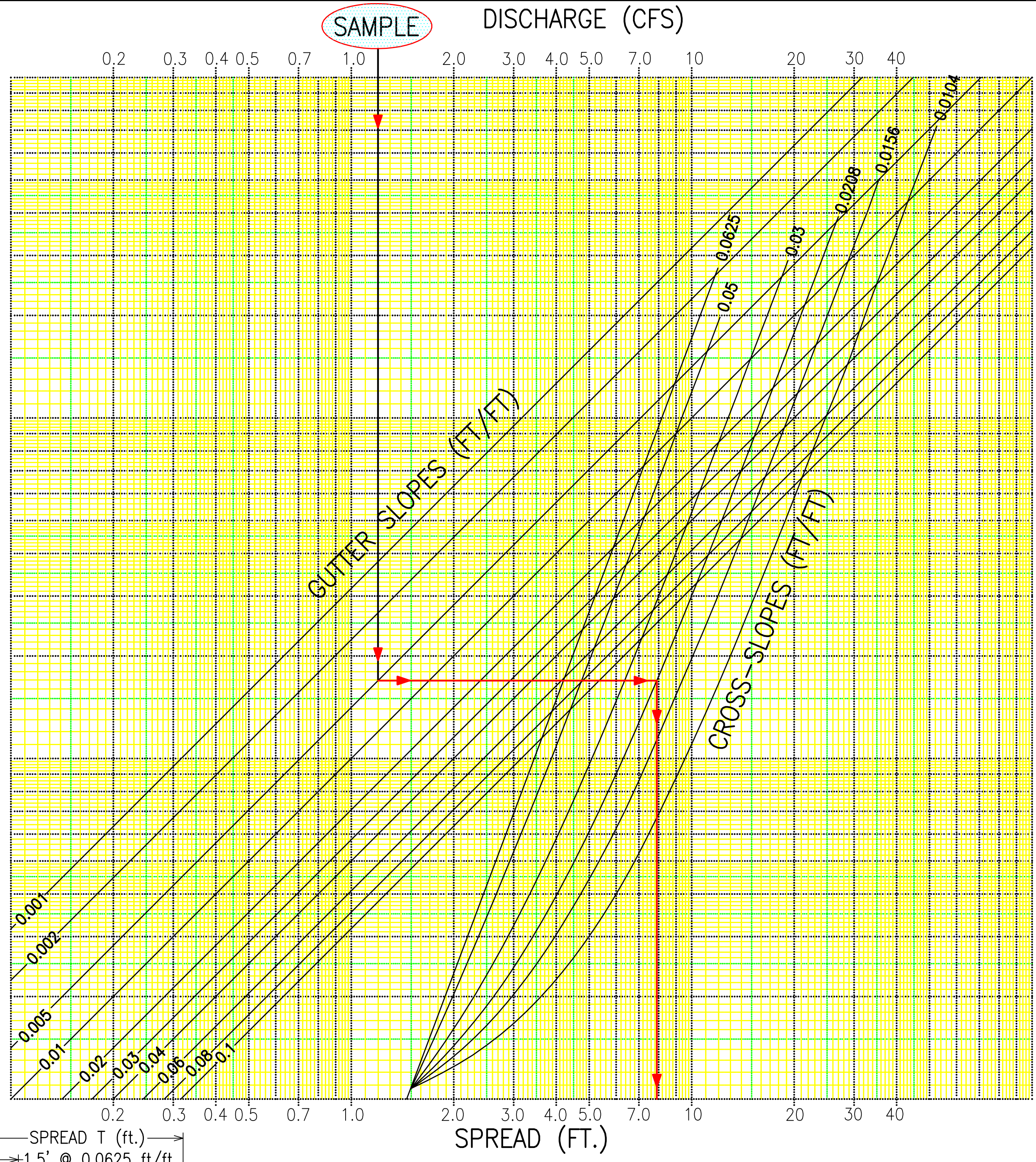


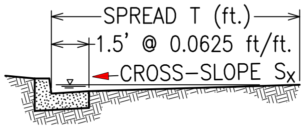


Chart adapted from following formula,

$$Q = \frac{0.56}{n} \times S_o^{1/2} \times S_x^{5/3} \times T^{8/3}$$

adjusted for composite Cross-Slope,
where n = 0.015;
and S_o is gutter slope in ft/ft.

SAMPLE: 1.2 cfs Discharge with 0.005 ft/ft Gutter Slope and 0.0208 ft/ft Cross-Slope yields Spread of 7.9'.

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

FLOW IN 7" STANDARD BALTIMORE COUNTY CURB & GUTTER

ISSUED: MARCH, 2005
REVISED:
REVISED:

PLATE

DB-1

INLET TYPE	STD. DETAIL	DESIGN PLATE	CURB & GUTTER STREET		ALLEY	OPEN SECTION ROAD		YARD	SWALE	NOTES
			IN SUMP	ON GRADE		ROADSIDE	MEDIAN			
A, B	D–2.00 thru D–2.05	DB–8 (Sump) DB–10 (On-Grade)	●	Note 1		Note 4			Note 7	A–1, B–1: Use With Lateral Pipe A–2, B–2: Use With Longitudinal Pipe Behind Curb
E Grate	D–2.06	DB–9			●			●		Preferred Alley Inlet
E Comb., Dbl. E Comb.	D–2.07, 9, 10	DB–4, 5, 8	●	●		Note 4			Note 7	Curb & Gutter Street Inlet for Use Where Parking Is Prohibited & ADT $\geq$ 5000. Note 2.
J Inlet, Mod. Grate	D–2.13, 4	Size Spillway Weirs Under Grates				Note 3	●		●	
Special K	D–2.15	Size Spillway Weirs Under Grates							●	Non–Traffic Bearing – Not For Use Near Road Shoulder
S Single Grate	D–2.16A, B	DB–9			●		●	●	●	
Type S Comb.	D–2.18	DB–8 (Sump)	●	●		Note 4			Note 7	Note 2.
S Dbl. Grate Tandem	D–2.19A, B	DB–9			●		●	●	●	
S Comb.–Dbl. Grate Tandem	D–2.20	DB–6, 7, 8	●	●		Note 4			Note 7	Note 2.
Y–1	D–2.22A, B	Check Weirs Cap'y. Vs. Pipe Cap'y.						●		For Use In Sump Only Non–Traffic Bearing – Not For Use On or Near Road or Shoulder
Y–2	D–2.23	Note 5						●		Not For Use Adjacent to Wooded Areas.
Y–3	D–2.24A, B	Q_{MAX} = 3.0 cfs						●		
Y–4	D–2.25A, B	Q_{MAX} = 3.0 cfs						●		
Y–5	D–2.25C	Check Weirs Cap'y. Vs. Pipe Cap'y.						●		
MdSHA COG	MdSHA 374.51 Through MdSHA 374.67	SHA 61.1–431.0		✳ Note 1						✳ For Use in MdSHA Right–of–Way Only
MdSHA COS		SHA 61.1–431.1	✳							

NOTES:

1. Use Curb Opening Inlets on grade only where utilities are too close to curb to allow placement of a Type E Combination or a Type S Combination Inlet.
2. Indicated Combination inlets to be depressed per Standard Detail D–2.26 only when so noted on plans.
3. Type J Inlet for use in roadside swale only where curb and gutter will not be added later.
4. Set face of inlet curb piece at ultimate location of curb and gutter.
5. Use BPR "Hydraulic Capacity of Grate Inlet In Sump" (rev. 8/68) with A = 2.7 sf and P = 8.8 ft. Assume 50% clogging.
6. The Director of Public Works will consider waiving any requirements hereon for reasonable cause upon receipt of a written request.
7. Where swale is intercepted by road drain system, an opening in the rear wall of inlet under headpiece or top slab is used to collect swale flow. Show special design on Plans.

2/12/2008 1:26 PM

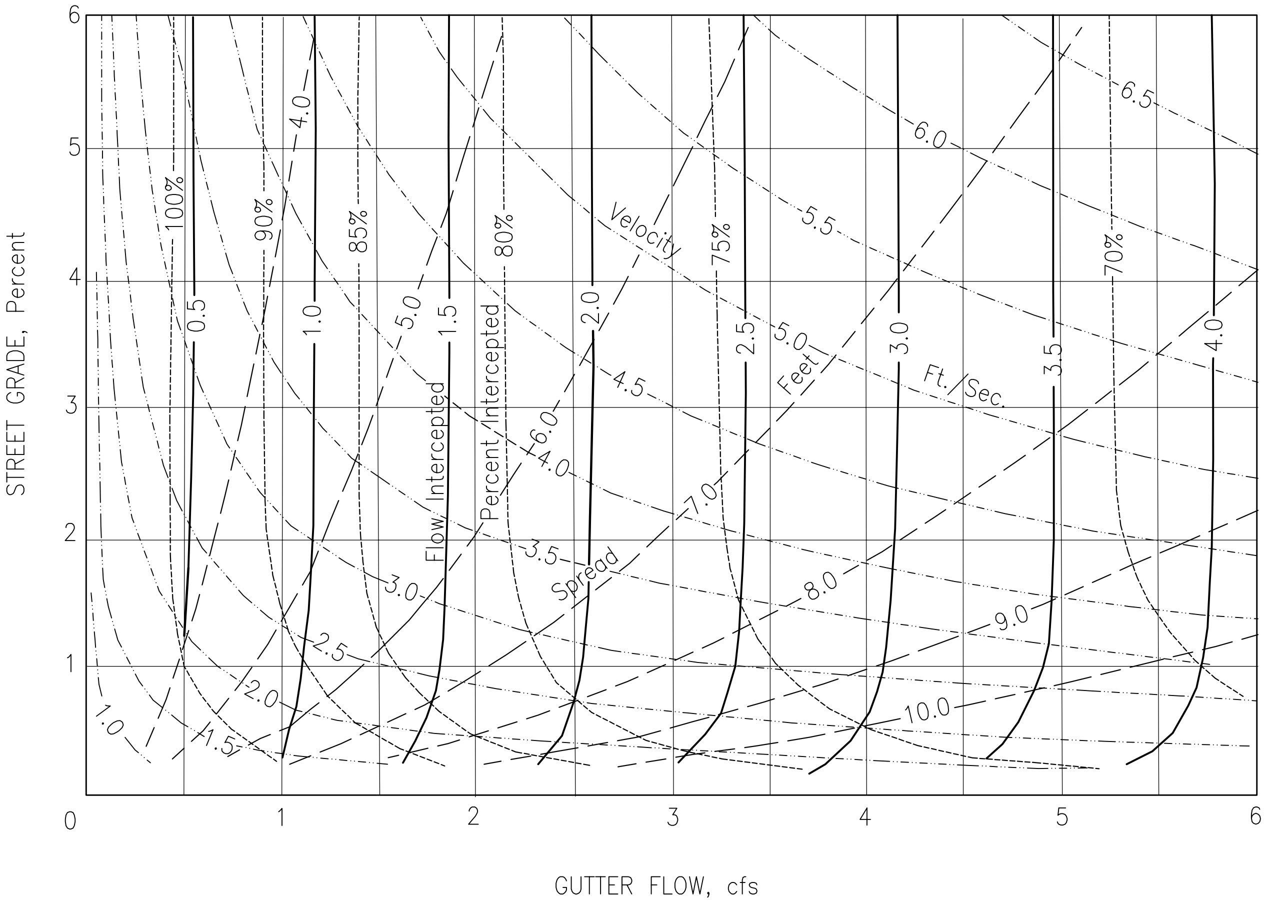
DEPARTMENT OF PUBLIC WORKS
STORM DRAIN DESIGN

STORM DRAIN INLET SELECTION

ISSUED: September 20, 2000
REVISED:
REVISED:

PLATE
DB-2

DB–02.DWG



NOTES

1. Gutter Capacities determined using $Q = 0.56\ (z/n)\ s^{1/2}\ y^{8/3}$; $n = 0.015$
2. Inlet capacities based upon Chapter 4, "The Design of Stormwater Inlets", Johns Hopkins University.
3. Use for Combination Inlets, Undepressed Grates, and Cross-slope of 1:32 (3/8":1) only.
4. Chart capacities shown for parallel bar grates. Use for curved vane grates per the Korpman memo dated March 16, 1998.

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

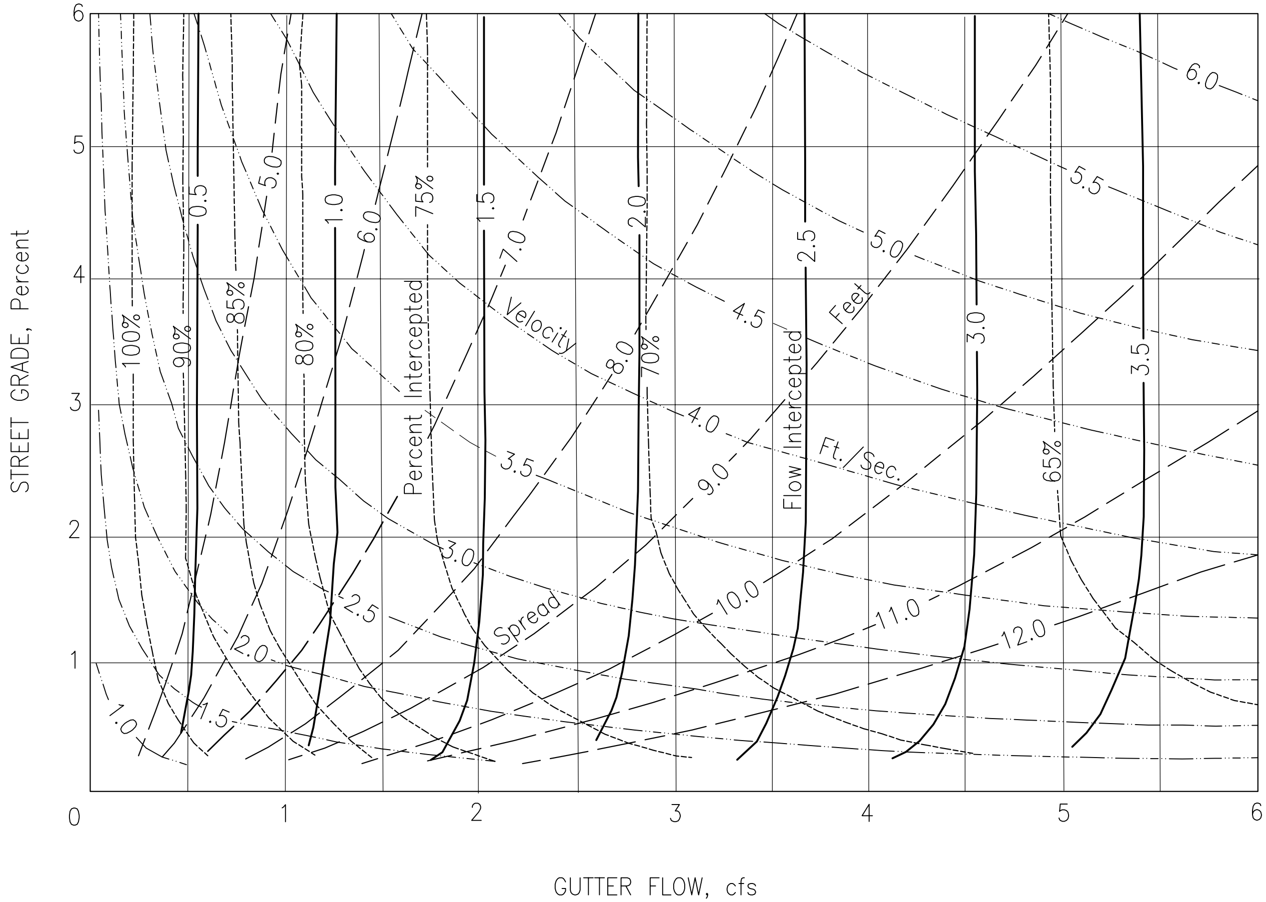
INLET CAPACITY CURVES

"E" COMBINATION OR "H" COMBINATION INLETS

UNDEPRESSED - CROSS SLOPE 1:32

ISSUED: JUNE 10, 2004
REVISED:
REVISED:

PLATE
DB-3



NOTES

1. Gutter Capacities determined using $Q = 0.56\ (z/n)\ s^{1/2}\ y^{8/3}$; $n = 0.015$
2. Inlet capacities based upon Chapter 4, "The Design of Stormwater Inlets", Johns Hopkins University.
3. Use for Combination Inlets, Undepressed Grates, and Cross-slope of 1:32 (3/8":1) only.
4. Chart capacities shown for parallel bar grates. Use for curved vane grates per the Korpman memo dated March 16, 1998.

BALTIMORE COUNTY MARYLAND

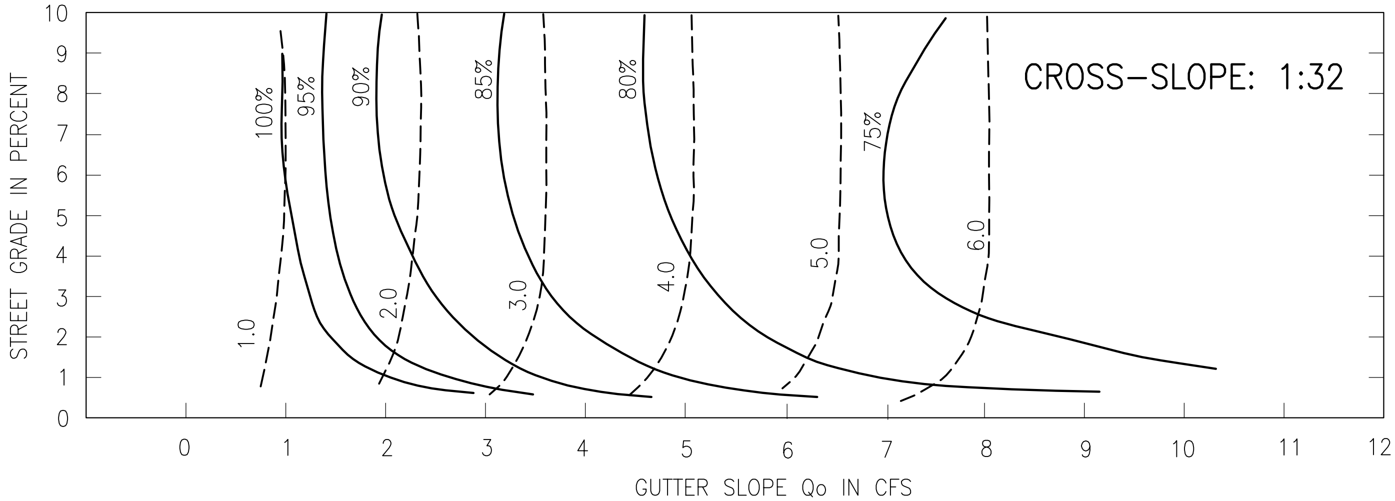
DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

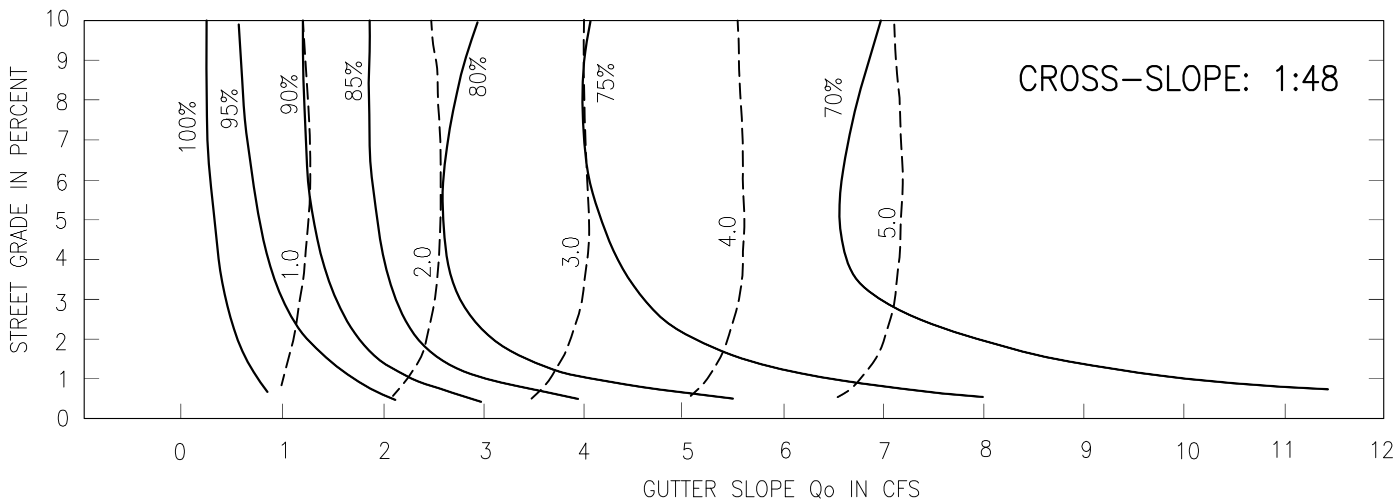
INLET CAPACITY CURVES
"E" COMBINATION OR "H" COMBINATION INLETS
UNDEPRESSED - CROSS SLOPE 1:48

ISSUED: JUNE 9, 2004
REVISED:
REVISED:

PLATE
DB-4

DB-04.dwg 2/12/2008 1:44 PM





KEY

——— PERCENT INTERCEPTED

– – – INTERCEPTED DISCHARGE

MANNINGS n = 0.013

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

INLET CAPACITY CURVES

UNDEPRESSED DOUBLE E COMBINATION INLETS

ISSUED: APRIL, 2005

REVISED:

REVISED:

PLATE

DB-5

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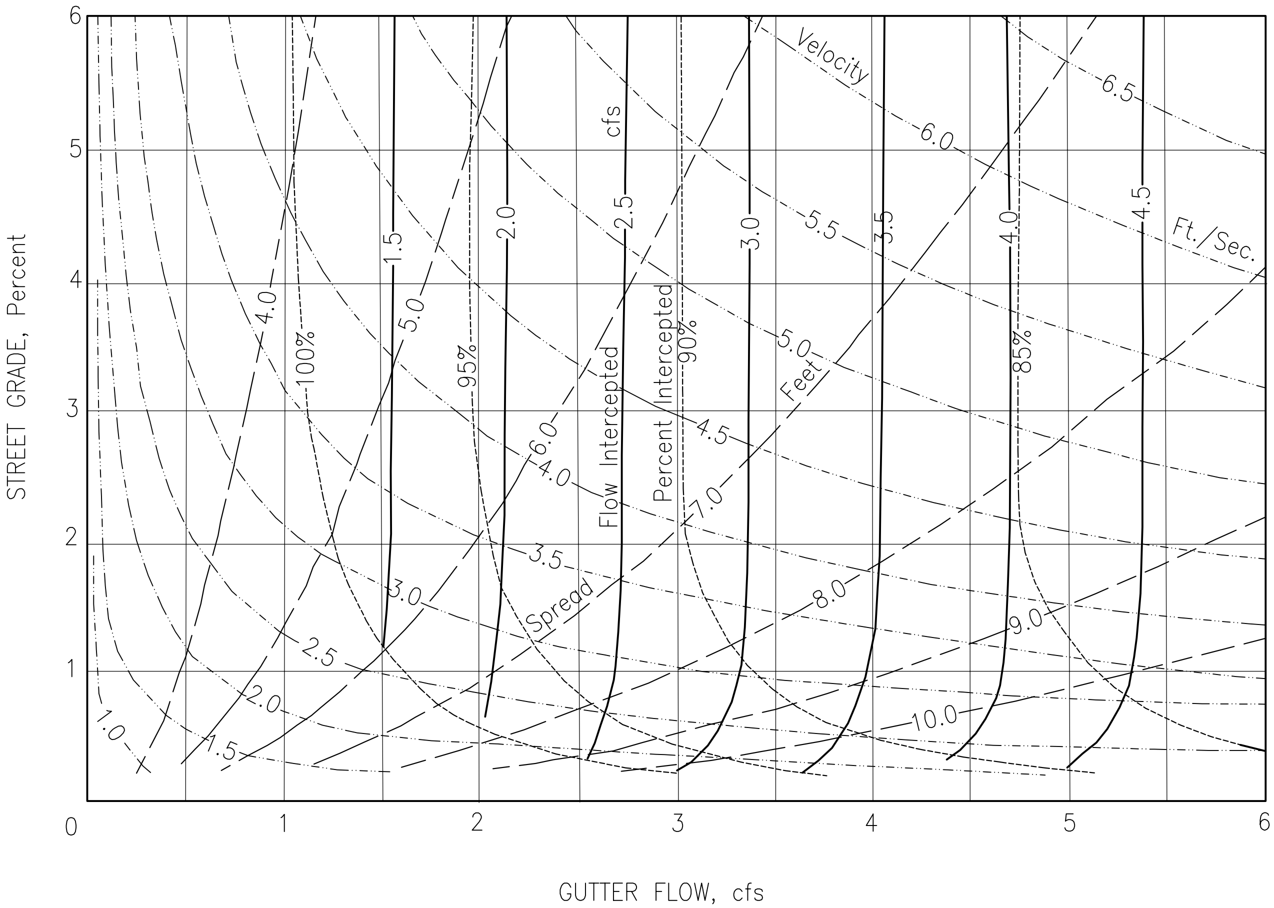
DB-05.dwg



NOTES

1. Gutter Capacities determined using
   $Q = 0.56\ (z/n)\ s^{1/2}\ y^{8/3}$; $n = 0.015$
2. Inlet capacities based upon Chapter 4, "The Design of Stormwater Inlets", Johns Hopkins University.
3. Use for Combination Inlets, Undepressed Grates, and Cross-slope of 1:32 (3/8":1) only.
4. Chart capacities shown for parallel bar grates. Use for curved vane grates per the Korpman memo dated March 16, 1998.

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

INLET CAPACITY CURVES

"S" COMBINATION INLET - DOUBLE GRATE TANDEM

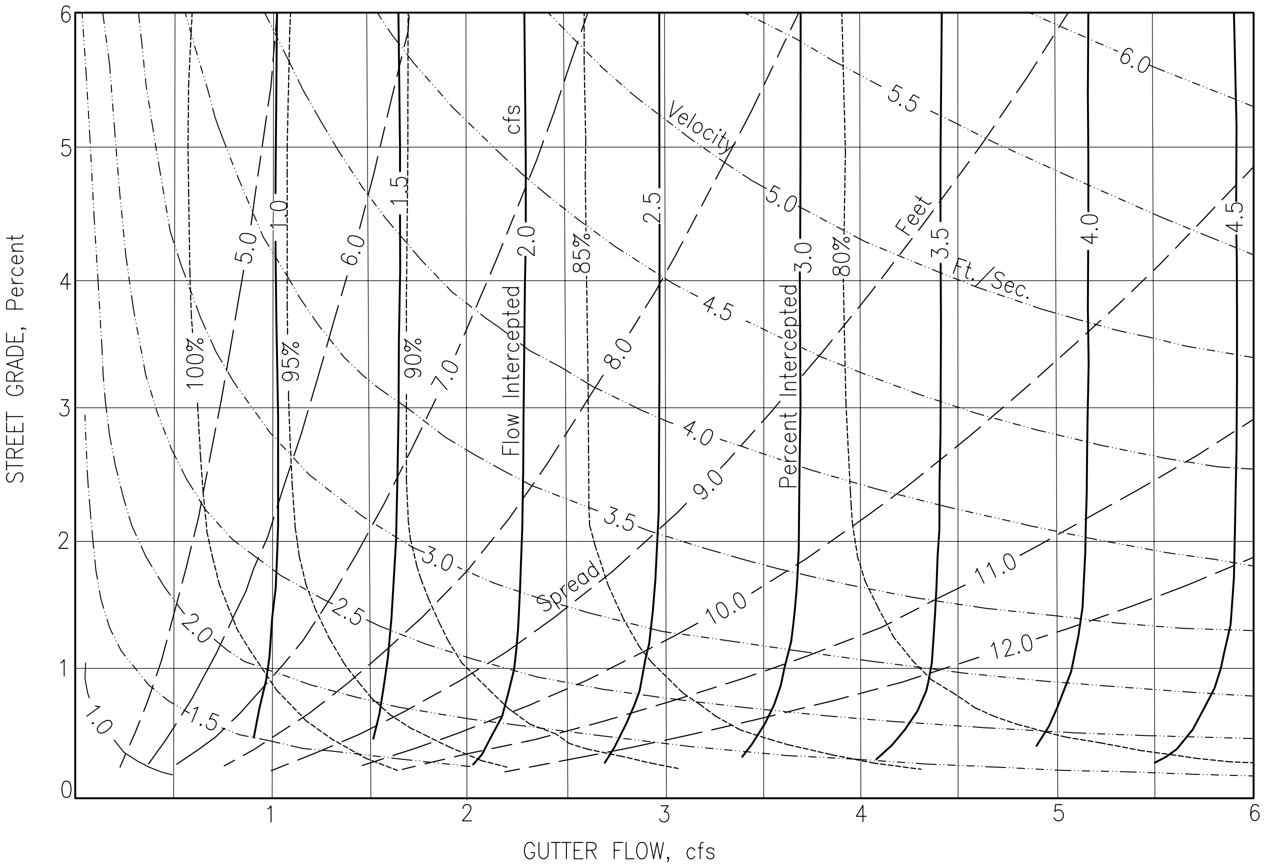
UNDEPRESSED - CROSS SLOPE 1:32

ISSUED: JUNE 10, 2004
REVISED:
REVISED:

PLATE

DB-6

DB-06.dwg 2/14/2008 12:21 PM



NOTES

1. Gutter Capacities determined using
   $Q = 0.56\ (z/n)\ s^{1/2}\ y^{8/3}$; n = 0.015
2. Inlet capacities based upon Chapter 4, "The Design of Stormwater Inlets", Johns Hopkins University.
3. Use for Combination Inlets, Undepressed Grates, and Cross-slope of 1:32 (3/8":1) only.
4. Chart capacities shown for parallel bar grates. Use for curved vane grates per the Korpman memo dated March 16, 1998.

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

INLET CAPACITY CURVES

"S" COMBINATION INLET - DOUBLE GRATE TANDEM

UNDEPRESSED - CROSS SLOPE 1:48

ISSUED: JUNE 10, 2004

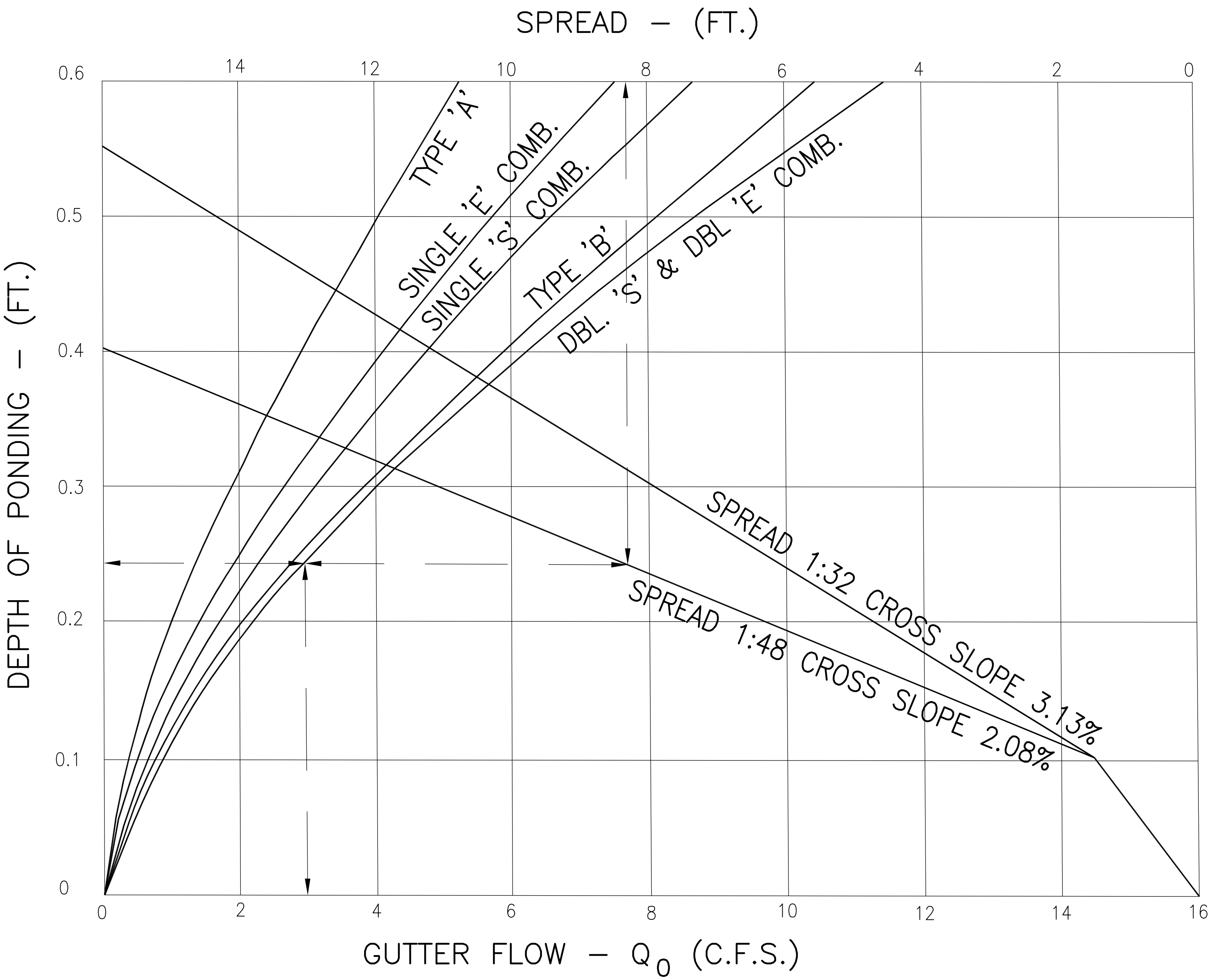
REVISED:

REVISED:

PLATE

DB-7

DB-07.dwg 2/14/2008 12:25 PM



Given:
Q_0 = 3.0 c.f.s.
Dbl. 'S' comb. inlet
1:48" cross slope

Find:
d = 0.24'
spread = 8.2'

DEPARTMENT OF PUBLIC WORKS

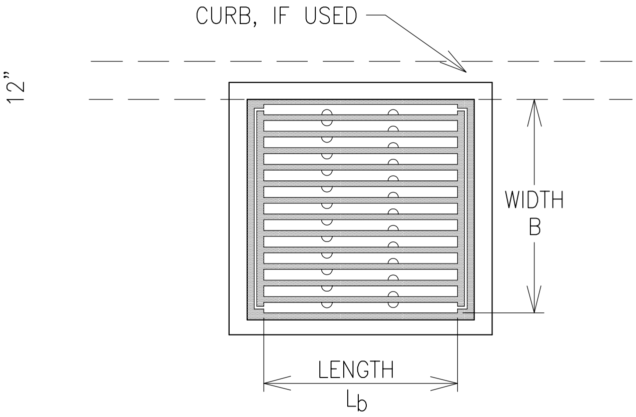
STORM DRAINAGE DESIGN

INLET CAPACITY CURVES FOR SUMPS

ISSUED:
REVISED: MAY 18, 2004
REVISED:

PLATE

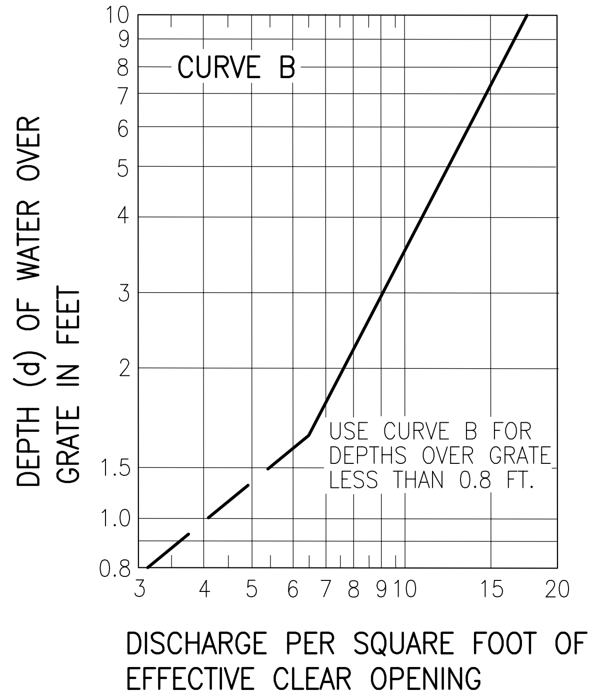
DB-8

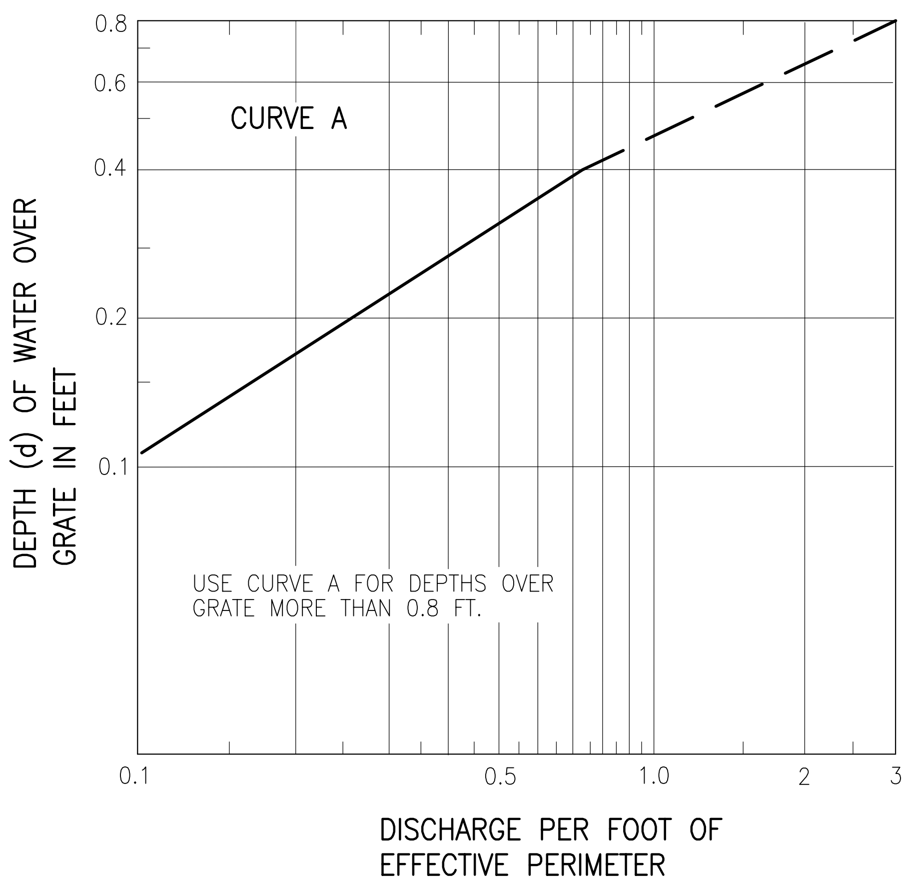


$P = 2B + L_b$ (WITH CURB)
$P = 2(B + L_b)$, (WITHOUT CURB)

A = AREA OF CLEAR OPENING IN GRATE.

TO ALLOW FOR CLOGGING, DIVIDE P OR A BY 2 BEFORE OBTAINING d.





Bureau of Public Roads, August 1968

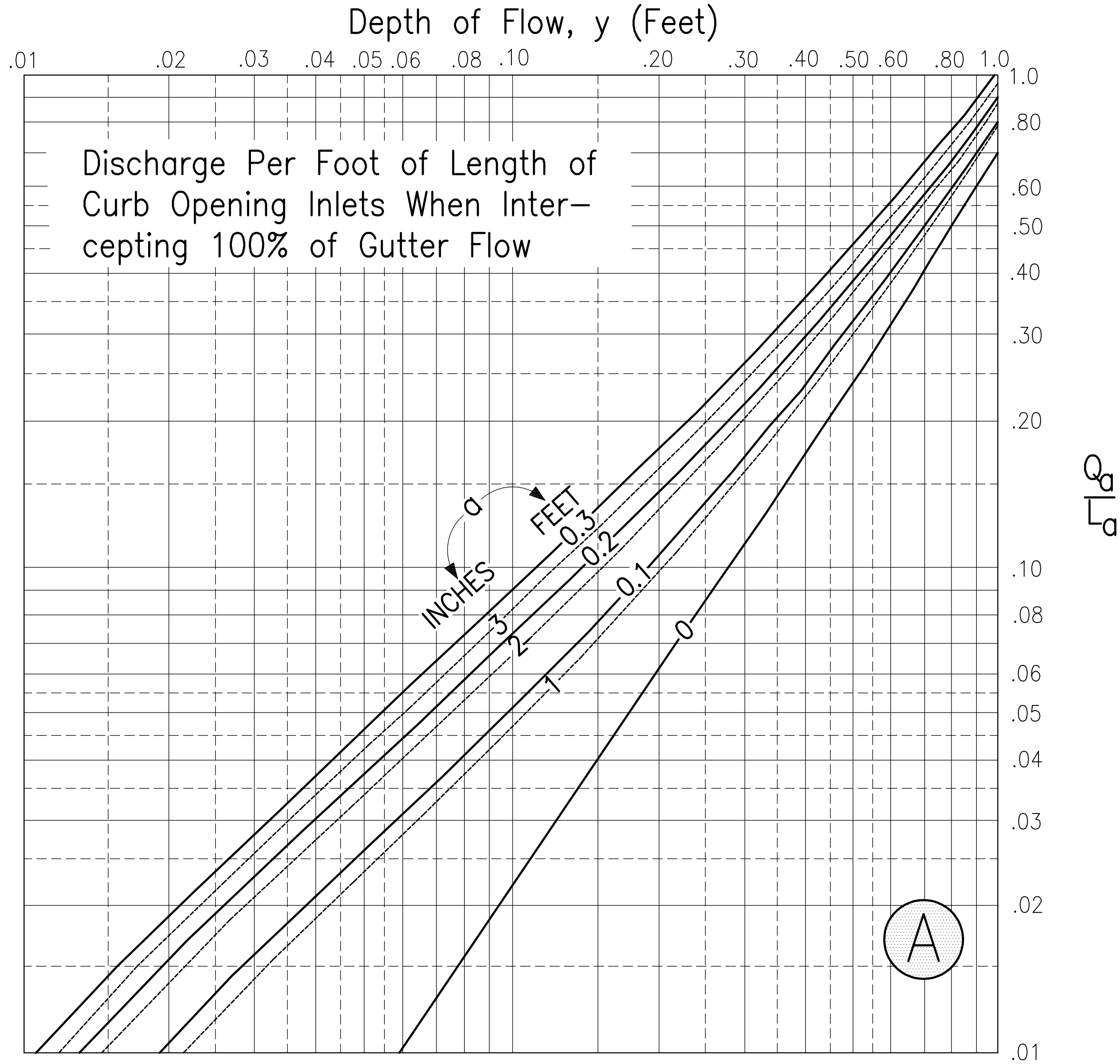
BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

GRATE INLET IN SUMP
HYDRAULIC CAPACITY

ISSUED: MARCH, 2005
REVISED:
REVISED:

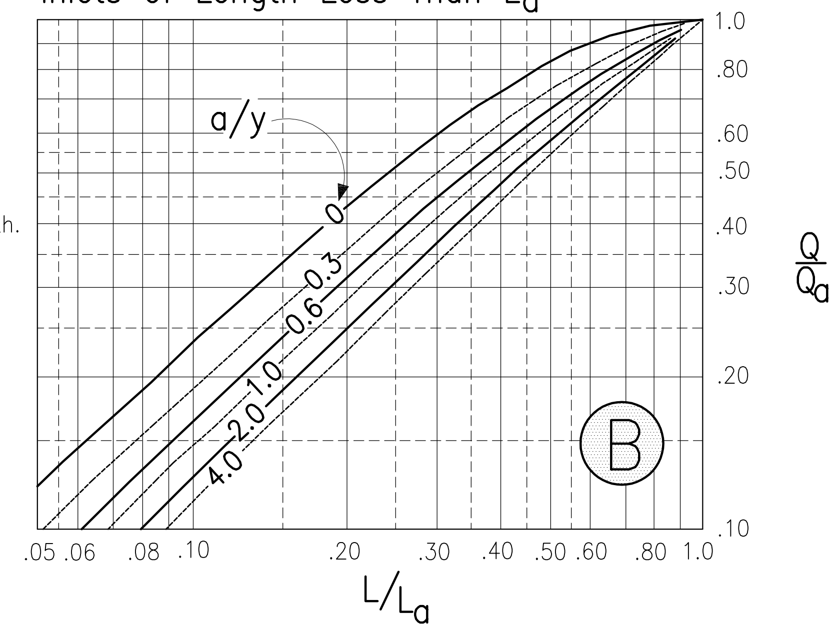
PLATE
DB-9



STEPS

1. Determine depth of flow y from DB-1.
2. Depression a = 0 for traffic lane; maximum 1" depth for parking lane.
3. Determine Q_a/L_a from chart (A).
4. Determine L_a by dividing gutter flow Q by Q_a/L_a. The length L_a is the length required for 100% interception of gutter flow.
5. Compute ratio L/L_a where L is the actual length of the inlet opening to be used. Determine ratio a/y, where a is inlet depression and y is flow depth.
6. From chart (B), determine Q/Q_a, the proportion of total flow intercepted.
7. Determine intercepted Q by multiplying Q/Q_a by Q_a.
8. Carryover to next inlet = $Q_a - Q$.

Partial Interception Ratio for Inlets of Length Less Than L_a



DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

CURB OPENING INLET CAPACITY

ON CONTINUOUS GRADE

ISSUED: MARCH, 2005
REVISED:
REVISED:

PLATE
DB-10

TYPES OF STRUCTURE LOSSES

TYPE A LOSS: Entrance and Exit Losses
TYPE B LOSS: Loss Due to Change in Velocity Head
TYPE C LOSS: Loss Due to Change in Direction of Flow
TYPE D LOSS: Loss Due to Incoming Flow

MULTIPLIERS APPLICABLE TO LOSSES THROUGH STRUCTURES

TYPE STRUCTURE	DEFLECTION	MULTIPLIER FOR A Loss	B Loss	C Loss	D Loss
BEND STRUCTURE	90°	0	1	1	1
	45°	0	1	2/3	1
BEND STRUCTURE WITH MANHOLE <u>OR</u> CONNECTION	90°	0	1	3/2	1
	45°	0	1	1	1
BEND STRUCTURE WITH MANHOLE <u>AND</u> CONNECTION	90°	0	1	2	1
	45°	0	1	4/3	1
JUNCTION CHAMBER		0	1	1	1/2
JUNCTION CHAMBER W/MH		0	1	3/2	1/2
MANHOLES (Note 2) (30" & SMALLER PIPE)	90°	1	1	2	1
	45°	1	1	1	1
	22.5°	1	1	2/3	1
MANHOLES (Note 2) (33" & LARGER PIPE)	90°	C (Note 1)	1	2	1
	45°	C (Note 1)	1	1	1
	22.5°	C (Note 1)	1	2/3	1
WYES		0	1	1	1

NOTES

1. Use C Loss Curve for 33" and larger pipe.
2. Manholes or inlets with channeled inverts. See Std. Detail G-15.

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

HEAD LOSSES IN STRUCTURES

MULTIPLIERS

ISSUED: MARCH 25, 2004
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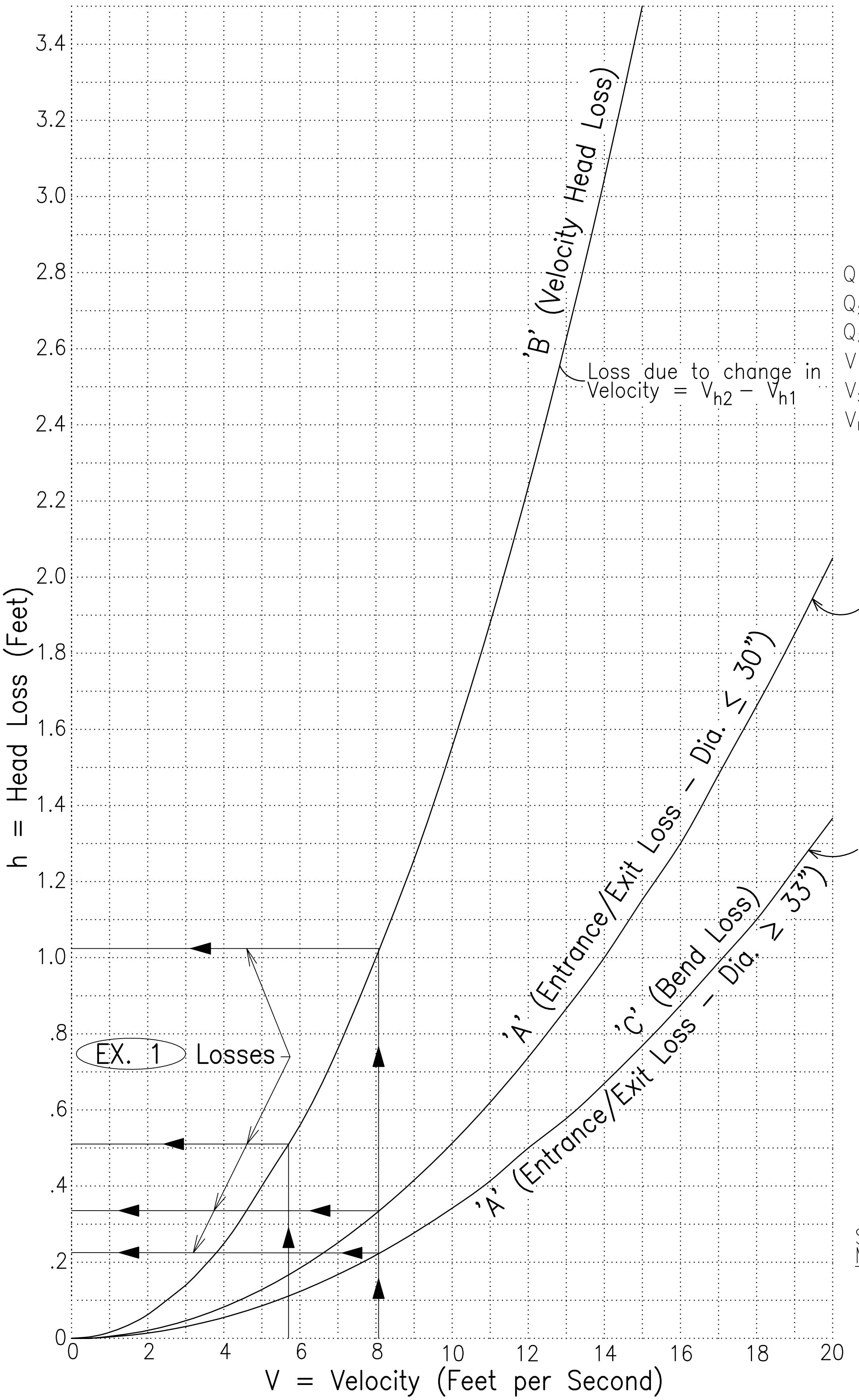
REVISED:

PLATE
DB-11



Use Larger of V_1 Or V_2

Use Larger of V_1 Or V_2

FORMULAS

$$\text{B Loss} = \frac{V_2^2}{2g} - \frac{V_1^2}{2g}$$

$$\text{A Loss} = 0.33 \times \frac{V^2}{2g}$$

$$\text{C Loss} = 0.22 \times \frac{V^2}{2g}$$

V = Larger of V_1 or V_2

Q_1 = Upstream Flow, cfs
Q_2 = Downstream Flow, cfs
Q_3 = Branch Flow, cfs
V_1 = Upstream Velocity, fps
V_2 = Downstream Velocity, fps
V_h = Velocity Head, ft = $V^2/2g$

NOTE

SEE STD. DB-11 REGARDING MULTIPLIER FOR STRUCTURE TYPE

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

HEAD LOSSES IN STRUCTURES
'A', 'B' & 'C' LOSSES

ISSUED: JULY 30, 2003
REVISED:
REVISED:

PLATE
DB-12

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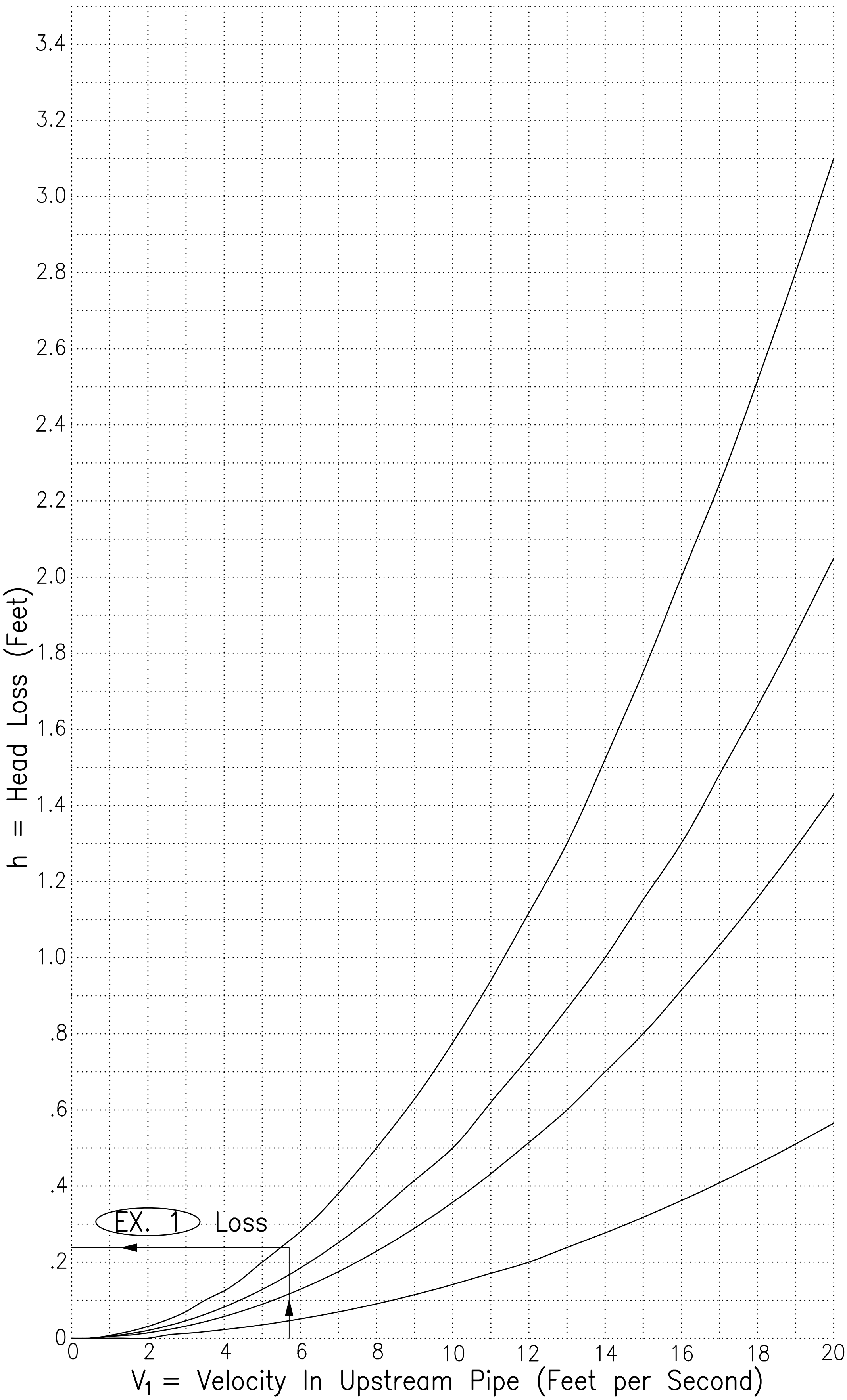
DB-12.dwg



FORMULA

$$D\ Loss = \frac{V_1^2}{2g} \times \left(1 - \frac{Q_1}{Q_1 + Q_3}\right)$$

NOTE

SEE STD. DB-11 REGARDING MULTIPLIER FOR STRUCTURE TYPE

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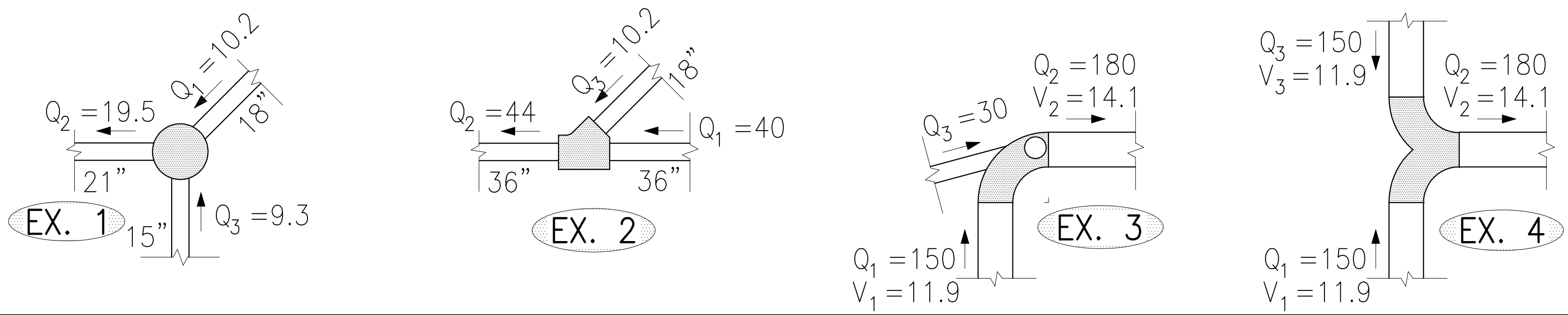
DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

HEAD LOSSES IN STRUCTURES 'D' LOSS

ISSUED: JULY 30, 2003
REVISED:
REVISED:

PLATE
DB-13

DB-13.dwg



LOCATION: Wiseburg
BY: REJ CHECK: BKB
DATE: 6-30-04

HYDRAULIC GRADIENT TABULATION

Sheet 1 of 1
J.O. 4-2-0018 Dist. 7 c 3
10 Year Storm Frequency, Except As Noted

Structure From	Structure To	Q1 cfs	Q3 cfs	Q2 fps	V1 fps	V2 fps	Pipe n= Dia.	Length	So	Sf	Structure Type	Bend Angle	Pipe Loss Ft	A Loss Ft	B Loss Ft	C Loss Ft	D Loss Ft	Σ Str Loss Ft	Gradient Elev.-Ft	Remarks
DNSTR.	MH			19.5		8.1	21"													
	MH	10.2	9.3	19.5	5.7	8.1	–	–	–	–	MH	45°		0.34'	0.51'	0.18'	0.20'	1.23'		EX. 1
MH	UPSTR.			10.2		5.7	18"													
DNSTR.	WYE			44		6.2	36"													
	WYE	40	9.3	44	5.7	6.2	–	–	–	–	WYE	45°		0	0.07'	0.10'	0.03'	0.20'		EX. 2
WYE	UPSTR.			40		5.7	36"													
DNSTR.	BEND			180		14.1	?													
	BEND	150	30	180	11.9	14.1	–	–	–	–	BEND	90°		0	1.10'	1.38'	0.35'	2.83'		EX. 3
BEND	UPSTR.			150		11.9	?													
DNSTR.	JCT.			195		13.5	?													
	JCT.	130	65	195	12.3	13.5	–	–	–	–	JCT.	90°		0	0	0	0	0		EX. 1
JCT.	UPSTR.			130		12.3	?													

BALTIMORE COUNTY MARYLAND

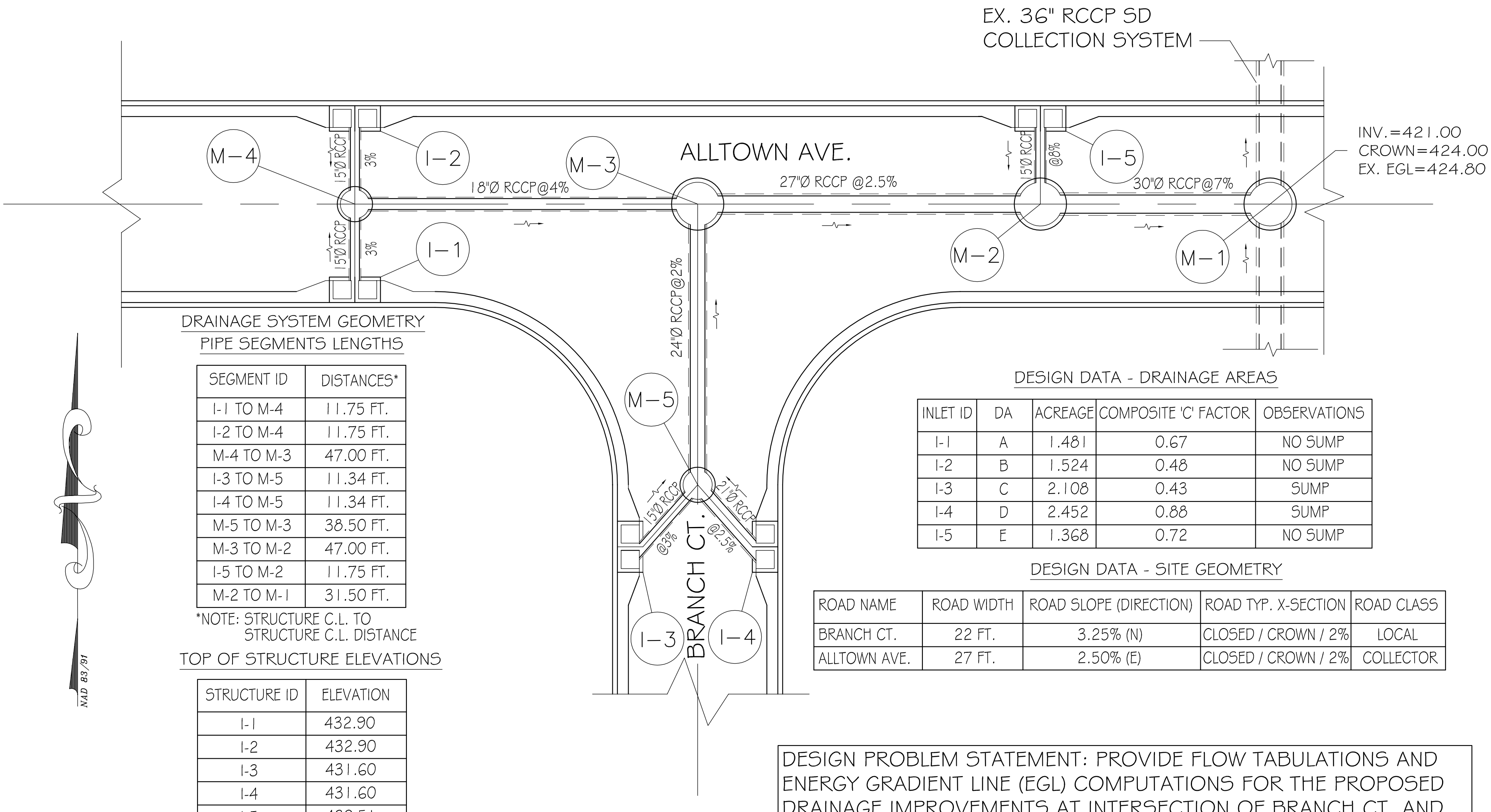
DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

HEAD LOSSES IN STRUCTURES

EXAMPLES

ISSUED: MAY 2004
REVISED:
REVISED:

PLATE
DB-14



DRAINAGE SYSTEM GEOMETRY
PIPE SEGMENTS LENGTHS

SEGMENT ID	DISTANCES*
I-1 TO M-4	11.75 FT.
I-2 TO M-4	11.75 FT.
M-4 TO M-3	47.00 FT.
I-3 TO M-5	11.34 FT.
I-4 TO M-5	11.34 FT.
M-5 TO M-3	38.50 FT.
M-3 TO M-2	47.00 FT.
I-5 TO M-2	11.75 FT.
M-2 TO M-1	31.50 FT.

*NOTE: STRUCTURE C.L. TO STRUCTURE C.L. DISTANCE

TOP OF STRUCTURE ELEVATIONS

STRUCTURE ID	ELEVATION
I-1	432.90
I-2	432.90
I-3	431.60
I-4	431.60
I-5	430.51
M-1	430.00
M-2	430.80
M-3	431.97
M-4	433.14
M-5	431.70

DESIGN DATA - DRAINAGE AREAS

INLET ID	DA	ACREAGE	COMPOSITE 'C' FACTOR	OBSERVATIONS
I-1	A	1.481	0.67	NO SUMP
I-2	B	1.524	0.48	NO SUMP
I-3	C	2.108	0.43	SUMP
I-4	D	2.452	0.88	SUMP
I-5	E	1.368	0.72	NO SUMP

DESIGN DATA - SITE GEOMETRY

ROAD NAME	ROAD WIDTH	ROAD SLOPE (DIRECTION)	ROAD TYP. X-SECTION	ROAD CLASS
BRANCH CT.	22 FT.	3.25% (N)	CLOSED / CROWN / 2%	LOCAL
ALLTOWN AVE.	27 FT.	2.50% (E)	CLOSED / CROWN / 2%	COLLECTOR

DESIGN PROBLEM STATEMENT: PROVIDE FLOW TABULATIONS AND ENERGY GRADIENT LINE (EGL) COMPUTATIONS FOR THE PROPOSED DRAINAGE IMPROVEMENTS AT INTERSECTION OF BRANCH CT. AND ALLTOWN AVE. ALL PERTINENT DESIGN DATA ARE ARE AS PRESENTED ON THIS PAGE.

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

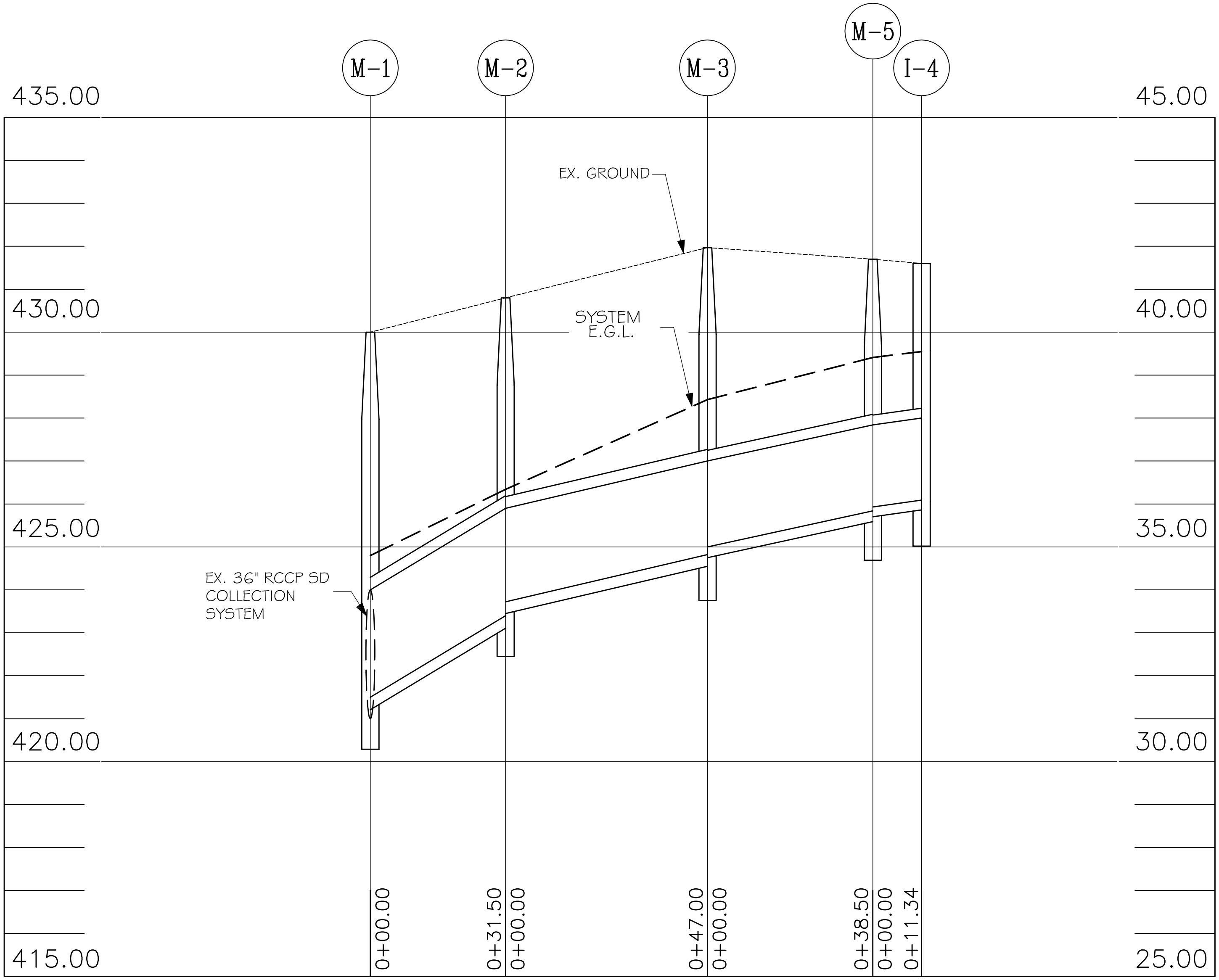
DESIGN EXAMPLE - DRAINAGE IMPROVEMENTS AT INTERSECTION OF BRANCH CT. AND ALLTOWN AVE.

FLOW TABULATIONS AND EGL COMPUTATION - SITE DATA

ISSUED: JANUARY 8, 2009
REVISED:
REVISED:

PLATE
DB-14A

DB-14AA.dwg 1/8/2009 3:54 PM



IMPORTANT NOTES:

1. THIS PLOT IS EXCLUSIVELY MEANT TO PROVIDE AN EXAMPLE OF ENERGY GRADIENT LINE (E.G.L.) PLOTTING ALONG ANY STORM DRAIN PIPE SISTEM. IT MAY NOT BE USED AS A SAMPLE PROFILE. REFER TO THE SAMPLE DRAWING, INCLUDED IN THE MANUAL, FOR THE INFORMATION THAT NEEDS TO BE INCLUDED ON AN ENGINEERED PIPE SYSTEM PROFILE.
2. FOLLOWING THE E.G.L. CALCULATION ROUTINE(S) (INCLUDED IN THIS EXAMPLE AND IN THIS UPDATED EDITION OF THE DESIGN MANUAL), E.G.L. SHOULD ALWAYS BE PLOTTED ABOVE THE CROWN OF PIPE IN ORDER TO KEEP CONSISTENCY WITH THE FULL FLOW ASSUMPTION, AS STATED IN THIS MANUAL .
3. SHOULD A THIRD PARTY DECIDE TO PLOT A HYDRAULIC GRADIENT LINE (H.G.L.) INSTEAD OF THE E.G.L., THE COMPUTATION MUST BE APPROVED BY THE BUREAU OF ENGINEERING; THE ANALYSIS MUST BE CONDUCTED FOR PARTIAL FLOW CONDITIONS AND ITS APPROVAL WILL BE CONDITIONAL UPON PROVIDING SATISFACTORY DOCUMENTATION FOR THE LOCAL LOSS PROCEDURES AND COEFFICENTS CONSIDERING PARTIAL DEPTH FLOW.

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

DESIGN EXAMPLE - DRAINAGE IMPROVEMENTS AT INTERSECTION OF BRANCH CT. AND ALLTOWN AVE.
FLOW TABULATIONS AND EGL COMPUTATION - E.G.L. PLOT

ISSUED: JANUARY 8, 2009
REVISED:
REVISED:

PLATE
DB-14B

DB-14B.dwg 1/9/2009 4:42 PM

LOCATION: Branch Ct. @ Alltown Ave.
BY: __________ CHECK:_______

STORM DRAIN FLOW TABULATION

DATE:

Sheet _1_ of _1_
J.O. __________ Dist. __c __
10 Year Storm Frequency, except as noted

Location		Area	Acres		Coeff.	CA	ΣCA	Time of Concentration-Minutes			Intens.	Q=CiA	Pipe	n =			Remarks
From	To		Sub.	Total	"C"			Inlet	Drain	Total	"i"	cfs	Size	Slope	Vel.	Length	
I-1	M-4	A	1.481	1.481	0.67	0.99	0.99	6.50	0.00	6.50	6.670	6.6	15	1.044	5.38	11.75	Tt=0.04 (Travel time<min.>)
I-2	M-4	B	1.524	1.524	0.48	0.73	0.73	6.00	0.00	6.00	6.790	5.0	15	0.590	4.04	11.75	Tt=0.05
M-4	M-3	A+B		3.005			1.72	6.50	0.04	6.54	6.670	11.5	18	1.192	6.49	47.00	Tt=0.12
I-3		C	2.108		0.43	0.91		8.10			7.160	6.5					SUMP
I-3	M-5	C		2.108	0.43	0.91	0.91	8.10	0.00	8.10	7.160	6.5					
I-3	M-5	C	*	2.390	0.43	1.03	1.03	8.10	0.00	8.10	6.310	6.5	15	1.013	5.30	11.34	Tt=0.04 (SUMP)
I-4		D	2.452		0.88	2.16		5.00			8.040	17.3					
				2.452	0.88	2.16	2.16	5.00	0.00	5.00	8.040	17.3					
I-4	M-5	D	*	2.795	0.88	2.46	2.46	5.00	0.00	5.00	7.050	17.3	21	1.198	7.21	11.34	Tt=0.03 (SUMP)
M-5	M-3	C+D		4.560			3.49	8.10	0.04	8.14	6.310	22.1	24	0.948	7.01	38.50	Tt=0.09
M-3	M-2	A-D		7.565			5.21	8.14	0.09	8.23	6.290	32.8	27	1.120	8.24	47.00	Tt=0.10
I-5	M-2	E	1.368	1.368	0.72	0.98	0.98	6.00	0.00	6.00	6.790	6.7	15	1.060	5.42	11.75	Tt=0.04
M-2	M-1	A-E		8.933			6.19	8.23	0.10	8.33	6.270	39.0	30	0.895	7.91	31.50	Tt=0.07

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

DESIGN EXAMPLE - DRAINAGE IMPROVEMENTS AT INTERSECTION OF BRANCH CT. AND ALLTOWN AVE.

FLOW TABULATION COMPUTATIONS

ISSUED: JANUARY 8, 2009
REVISED:
REVISED:

PLATE

DB-14C

DB-14C.dwg 1/8/2009 4:41 PM

LOCATION: Alltown Heights
BY: A.A. CHECK: B.B.
DATE: 8/21/08

HYDRAULIC GRADIENT TABULATION

Sheet 1 of 1
J.O. 4-2-707 Dist. 13 c 1
10 Year Storm Frequency, except as noted

Structure From	Structure To	Q1 cfs	Q3 cfs	Q2 cfs	V1 fps	V2 fps	Pipe n= 0.014 Dia.(")	Lgth.(ft)	So(%)	Sf(%)	Structure Type	Bend Angle	Pipe Loss Ft	A Loss Ft	B Loss Ft	C Loss Ft	D Loss Ft	Σ Str Loss-Ft	Gradient Elev. - Ft	Remarks
	M-1																		**424.8**	Ex. system E.G.L. (start EGL elev.)
M-1	M-2			38.81		7.91	30	32	7	0.9			0.28						425.08	
	M-2	32.77	6.65	38.81	8.24	7.91					Manhole	0.00		0.348	-0.083	0.000	0.178	0.44	**426.34***	*crown elev. (425.90) is highest, so 425.90+0.44
M-2	M-3			32.77		8.24	27	47	2.5	1.12			0.53						426.87	
	M-3	22.02	11.47	32.77	7.01	8.24					Manhole	90.00		0.348	0.291	0.464	0.261	1.36	**428.43***	*highest crown elevation governs
M-3	M-5			22.02		7.01	24	39	2	0.95			0.36						428.79	
	M-5	17.34	6.50	22.02	7.21	7.01					Manhole	45.00		0.266	-0.044	0.178	0.220	0.62	**429.41***	*highest crown elevation governs
M-5	I-4			17.34		7.21	21	11	2.5	1.2			0.14						429.55	
	I-4	17.34	0.00	17.34	7.21	7.21					Inlet	0.00		0.266	0.000	0.000	0.000	0**	**429.55**	**terminal structure
M-5	I-3			6.5		5.3	15	11	3	1.01			0.11						429.66	
	I-3	6.50	0.00	6.5	5.3	5.3					Inlet	0.00		0.144	0.000	0.000	0.000	0**	**429.66**	**terminal structure
M-3	M-4			11.47		6.49	18	47	4	1.19			0.56						428.99	
	M-4	6.60	4.96	11.47	5.38	6.49					Manhole	90.00		0.216	0.205	0.288	0.193	0.9	**429.89**	
M-4	I-1			6.6		5.38	15	12	3	1.04			0.12						430.01	
	I-1	6.60	0.00	6.6	5.38	5.38					Inlet	0.00		0.148	0.000	0.000	0.000	0**	**430.01**	**terminal structure
M-4	I-2			4.96		4.04	15	12	3	0.59			0.07						429.96	
	I-2	4.96	0.00	4.96	4.04	4.04					Inlet	0.00		0.084	0.000	0.000	0.000	0**	**429.96**	**terminal structure
M-2	I-5			6.65		5.42	15	12	8	1.06			0.12						426.46	
	I-5	6.65	0.00	6.65	5.42	5.42					Inlet	0.00		0.151	0.000	0.000	0.000	0**	**426.82**	**terminal structure

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

DESIGN EXAMPLE - DRAINAGE IMPROVEMENTS AT INTERSECTION OF BRANCH CT. AND ALLTOWN AVE.
ENERGY GRADE LINE (EGL) COMPUTATIONS

ISSUED: JANUARY 8, 2009
REVISED:
REVISED:

PLATE
DB-14D

DB-14D.dwg 1/8/2009 5:24 PM

Project: Branch Ct. @ Alltown Ave. Intersection Drainage Improvements

By: ___ DATE: January 9, 2009

Checked By: ___ DATE:

Branch Ct. @ Alltown Ave.

HYDRAULIC GRADE COMPUTATION

10 YR STORM UNLESS OTHERWISE NOTED

OUTFALL #:	M-1
TAILWATER DEPTH :	424.80
CROWN OF PIPE :	423.70

START HGL @ ELEVATION: 424.80

		FROM:	M-1		TO:	M-1				32 L.F.	30 IN	CL. IV RCP @ 0.90 %	0.28
		CURRENT STR. NUMBER:	M-2		TYPE:	MANHOLE				DEFLECTION:	0.0	=	425.08
NEW DIA:	27	Q1	32.77	cfs	V1:	8.24	fps	'A'	0.348	dn 0.50	INVERT 'IN' 423.40	CROWN OF PIPE 'IN' =	425.90
		Q2	38.81	cfs	V2:	7.91	fps	'B'	-0.083			PARTIAL FLOW HGL ELEV. =	423.90
NEW DIA:		Q3	6.65	cfs	V3:	5.42	fps	'C'	0.000				
		Q3/Q1	20.29	%				'D'	0.178			TOTAL LOSSES =	0.44
MANNING'S												HYDRAULIC GRADE ELEVATION =	426.34
`n' VALUE	0.013	TOP ELEVATION =	430.80		CLEARANCE =	4.46	FT.			INVERT 'OUT'	423.65	CROWN OF PIPE 'OUT' =	425.90
												HGL ELEVATION:	426.34

		FROM:	M-2		TO:	M-3				47 L.F.	27 IN	CL. IV RCP @ 1.12 %	0.53
		CURRENT STR. NUMBER:	M-3		TYPE:	MANHOLE				DEFLECTION:	90.0	=	426.87
NEW DIA:	27	Q1	22.02	cfs	V1:	7.01	fps	'A'	0.348	dn 0.50	INVERT 'IN' 424.82	CROWN OF PIPE 'IN' =	427.07
		Q2	32.77	cfs	V2:	8.24	fps	'B'	0.291			PARTIAL FLOW HGL ELEV. =	425.32
NEW DIA:	18	Q3	11.47	cfs	V3:	6.49	fps	'C'	0.464				
		Q3/Q1	52.09	%				'D'	0.261			TOTAL LOSSES =	1.36
MANNING'S												HYDRAULIC GRADE ELEVATION =	428.43
`n' VALUE	0.013	TOP ELEVATION =	431.97		CLEARANCE =	3.54	FT.			INVERT 'OUT'	425.07	CROWN OF PIPE 'OUT' =	427.32
												HGL ELEVATION:	428.43

		FROM:	M-3		TO:	M-5				39 L.F.	24 IN	CL. IV RCP @ 0.95 %	0.36
		CURRENT STR. NUMBER:	M-5		TYPE:	MANHOLE				DEFLECTION:	45.0	=	428.79
NEW DIA:	21	Q1	17.34	cfs	V1:	7.21	fps	'A'	0.266	dn 0.40	INVERT 'IN' 425.84	CROWN OF PIPE 'IN' =	427.84
		Q2	22.02	cfs	V2:	7.01	fps	'B'	-0.044			PARTIAL FLOW HGL ELEV. =	426.24
NEW DIA:	15	Q3	6.50	cfs	V3:	5.30	fps	'C'	0.178				
		Q3/Q1	37.49	%				'D'	0.220			TOTAL LOSSES =	0.62
MANNING'S												HYDRAULIC GRADE ELEVATION =	429.41
`n' VALUE	0.013	TOP ELEVATION =	431.70		CLEARANCE =	2.29	FT.			INVERT 'OUT'	426.09	CROWN OF PIPE 'OUT' =	427.84
												HGL ELEVATION:	429.41

		FROM:	M-5		TO:	I-4				11 L.F.	21 IN	CL. IV RCP @ 1.20 %	0.14
		CURRENT STR. NUMBER:	I-4		TYPE:	INLET				DEFLECTION:	0.0	=	429.55
NEW DIA:	21	Q1	17.34	cfs	V1:	7.21	fps	'A'	0.266	dn 0.40	INVERT 'IN' 426.37	CROWN OF PIPE 'IN' =	428.12
		Q2	17.34	cfs	V2:	7.21	fps	'B'	0.000			PARTIAL FLOW HGL ELEV. =	426.77
NEW DIA:	0	Q3	0.00	cfs	V3:	0.00	fps	'C'	0.000				
		Q3/Q1	0.00	%				'D'	0.000			TOTAL LOSSES =	0.00
MANNING'S												HYDRAULIC GRADE ELEVATION =	429.55
`n' VALUE	0.013	TOP ELEVATION =	431.60		CLEARANCE =	2.05	FT.			INVERT 'OUT'	N/A	CROWN OF PIPE 'OUT' =	428.12
												HGL ELEVATION:	429.55

END OF STORM DRAIN SEGMENT

		FROM:	M-5		TO:	I-3				11 L.F.	15 IN	CL. IV RCP @ 1.01 %	0.11
		CURRENT STR. NUMBER:	I-3		TYPE:	INLET				DEFLECTION:	0.0	=	429.66
NEW DIA:	15	Q1	6.50	cfs	V1:	5.30	fps	'A'	0.144	dn 0.26	INVERT 'IN' 426.87	CROWN OF PIPE 'IN' =	428.12
		Q2	6.50	cfs	V2:	5.30	fps	'B'	0.000			PARTIAL FLOW HGL ELEV. =	427.13
NEW DIA:	0	Q3	0.00	cfs	V3:	0.00	fps	'C'	0.000				
		Q3/Q1	0.00	%				'D'	0.000			TOTAL LOSSES =	0.00
MANNING'S												HYDRAULIC GRADE ELEVATION =	429.66
`n' VALUE	0.013	TOP ELEVATION =	431.60		CLEARANCE =	1.94	FT.			INVERT 'OUT'	N/A	CROWN OF PIPE 'OUT' =	428.12
												HGL ELEVATION:	429.66

END OF STORM DRAIN SEGMENT

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

DESIGN EXAMPLE - DRAINAGE IMPROVEMENTS AT INTERSECTION OF BRANCH CT. & ALLTOWN AVE.

ENERGY GRADE LINE COMPUTATIONS (Microsoft Excel®)

ISSUED: JANUARY 9, 2009

REVISED:

REVISED:

PLATE

DB-14E

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		FROM:	M-3		TO:	M-4					47 L.F.	18 IN	CL. IV RCP	@ 1.19 %	0.56
		CURRENT STR. NUMBER:	M-4		TYPE:	MANHOLE				DEFLECTION:	90.0			=	428.99
NEW DIA:	15	Q1	6.60	cfs	V1:	5.38	fps	'A'	0.216	dn	0.35	INVERT 'IN'	427.45	CROWN OF PIPE 'IN' =	428.95
		Q2	11.47	cfs	V2:	6.49	fps	'B'	0.205					PARTIAL FLOW HGL ELEV. =	427.80
NEW DIA:	15	Q3	4.96	cfs	V3:	4.04	fps	'C'	0.288						
		Q3/Q1	75.15	%				'D'	0.193					TOTAL LOSSES =	0.90
MANNING'S														HYDRAULIC GRADE ELEVATION =	429.89
`n' VALUE	0.013	TOP ELEVATION =	433.14		CLEARANCE =	3.25	FT.			INVERT 'OUT'	427.70			CROWN OF PIPE 'OUT' =	428.95
														HGL ELEVATION:	429.89

		FROM:	M-4		TO:	I-1					12 L.F.	15 IN	CL. IV RCP	@ 1.04 %	0.12
		CURRENT STR. NUMBER:	I-1		TYPE:	INLET				DEFLECTION:	0.0			=	430.01
NEW DIA:	15	Q1	6.60	cfs	V1:	5.38	fps	'A'	0.148	dn	0.26	INVERT 'IN'	428.05	CROWN OF PIPE 'IN' =	429.30
		Q2	6.60	cfs	V2:	5.38	fps	'B'	0.000					PARTIAL FLOW HGL ELEV. =	428.31
NEW DIA:	0	Q3	0.00	cfs	V3:	0.00	fps	'C'	0.000						
		Q3/Q1	0.00	%				'D'	0.000					TOTAL LOSSES =	0.00
MANNING'S														HYDRAULIC GRADE ELEVATION =	430.01
`n' VALUE	0.013	TOP ELEVATION =	432.90		CLEARANCE =	2.89	FT.			INVERT 'OUT'	N/A			CROWN OF PIPE 'OUT' =	429.30
														HGL ELEVATION:	430.01

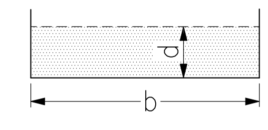
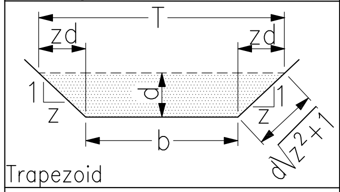
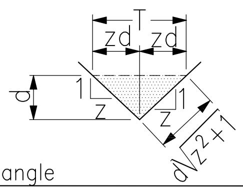
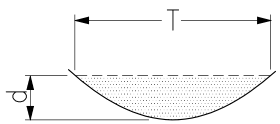
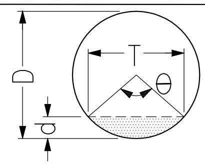
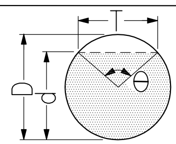
END OF STORM DRAIN SEGMENT

		FROM:	M-4		TO:	I-2					12 L.F.	15 IN	CL. IV RCP	@ 0.59 %	0.07
		CURRENT STR. NUMBER:	I-2		TYPE:	INLET				DEFLECTION:	0.0			=	429.96
NEW DIA:	15	Q1	4.96	cfs	V1:	4.04	fps	'A'	0.084	dn	0.20	INVERT 'IN'	428.05	CROWN OF PIPE 'IN' =	429.30
		Q2	4.96	cfs	V2:	4.04	fps	'B'	0.000					PARTIAL FLOW HGL ELEV. =	428.25
NEW DIA:	0	Q3	0.00	cfs	V3:	0.00	fps	'C'	0.000						
		Q3/Q1	0.00	%				'D'	0.000					TOTAL LOSSES =	0.00
MANNING'S														HYDRAULIC GRADE ELEVATION =	429.96
`n' VALUE	0.013	TOP ELEVATION =	432.90		CLEARANCE =	2.94	FT.			INVERT 'OUT'	N/A			CROWN OF PIPE 'OUT' =	429.30
														HGL ELEVATION:	429.96

END OF STORM DRAIN SEGMENT

		FROM:	M-2		TO:	I-5					12 L.F.	15 IN	CL. IV RCP	@ 1.06 %	0.12
		CURRENT STR. NUMBER:	I-5		TYPE:	INLET				DEFLECTION:	0.0			=	426.46
NEW DIA:	15	Q1	6.65	cfs	V1:	5.42	fps	'A'	0.151	dn	0.26	INVERT 'IN'	425.57	CROWN OF PIPE 'IN' =	426.82
		Q2	6.65	cfs	V2:	5.42	fps	'B'	0.000					PARTIAL FLOW HGL ELEV. =	425.83
NEW DIA:	0	Q3	0.00	cfs	V3:	0.00	fps	'C'	0.000						
		Q3/Q1	0.00	%				'D'	0.000					TOTAL LOSSES =	0.00
MANNING'S														HYDRAULIC GRADE ELEVATION =	426.82
`n' VALUE	0.013	TOP ELEVATION =	430.51		CLEARANCE =	3.69	FT.			INVERT 'OUT'	N/A			CROWN OF PIPE 'OUT' =	426.82
														HGL ELEVATION:	426.82

END OF STORM DRAIN SYSTEM

SECTION	AREA A	WETTED PERIMETER P	HYDRAULIC RADIUS R	TOP WIDTH T	CRITICAL DEPTH FACTOR, Z
 Rectangle	bd	$b + 2d$	$\frac{bd}{b + 2d}$	b	$bd^{1.5}$
 Trapezoid	$bd + zd^2$	$b + 2d\sqrt{z^2 + 1}$	$\frac{bd + zd^2}{b + 2d\sqrt{z^2 + 1}}$	$b + 2zd$	$\frac{[(b+zd)d]^{1.5}}{\sqrt{b + 2zd}}$
 Triangle	zd^2	$2d\sqrt{z^2 + 1}$	$\frac{zd}{2\sqrt{z^2 + 1}}$	$2zd$	$\frac{\sqrt{2}}{2} zd^{2.5}$
 Parabola	$\frac{2}{3} dT$	$T + \frac{8d^2}{3T}$ NOTE 1	$\frac{2dT^2}{3T^2 + 8d^2}$ NOTE 1	$\frac{3a}{2d}$	$\frac{2}{9}\sqrt{6}\, Td^{1.5}$
 Circle < Half−full NOTE 2	$\frac{D^2}{8}\left(\frac{\pi\theta}{180} - \sin\theta\right)$	$\frac{\pi D\theta}{360}$	$\frac{45D}{\pi\theta}\left(\frac{\pi\theta}{180} - \sin\theta\right)$	$D \sin\frac{\theta}{2}$ OR $2\sqrt{d(D-d)}$	$a\sqrt{\frac{a}{D \sin\frac{\theta}{2}}}$
 Circle > Half−full NOTE 3	$\frac{D^2}{8}\left(2\pi - \frac{\pi\theta}{180} + \sin\theta\right)$	$\frac{\pi D(360-\theta)}{360}$	$\frac{45D}{\pi(360-\theta)}\left(2\pi - \frac{\pi\theta}{180} + \sin\theta\right)$	$D \sin\frac{\theta}{2}$ OR $2\sqrt{d(D-d)}$	$a\sqrt{\frac{a}{D \sin\frac{\theta}{2}}}$

1. Satisfactory approximation for interval $0 < d/T < 0.25$. When $d/T > 0.25$, use
$$p = \frac{1}{2}\sqrt{16d^2 + T^2} + \frac{T^2}{8d}\,\mathrm{SINH}^{-1}\frac{4d}{T}$$
2. $\theta = 4\,\mathrm{SIN}^{-1}\sqrt{d/D}$
3. $\theta = 4\,\mathrm{COS}^{-1}\sqrt{d/D}$

Insert θ in degrees in chart equations. (Notes 2 and 3)

4. Small z = side slope horizontal distance; Large Z = critical depth section factor.

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

OPEN CHANNEL FLOW SECTIONS
GEOMETRIC RELATIONSHIPS

ISSUED: FEBRUARY, 2006

REVISED:

REVISED:

PLATE

DB-15

2/19/2008 1:42 PM

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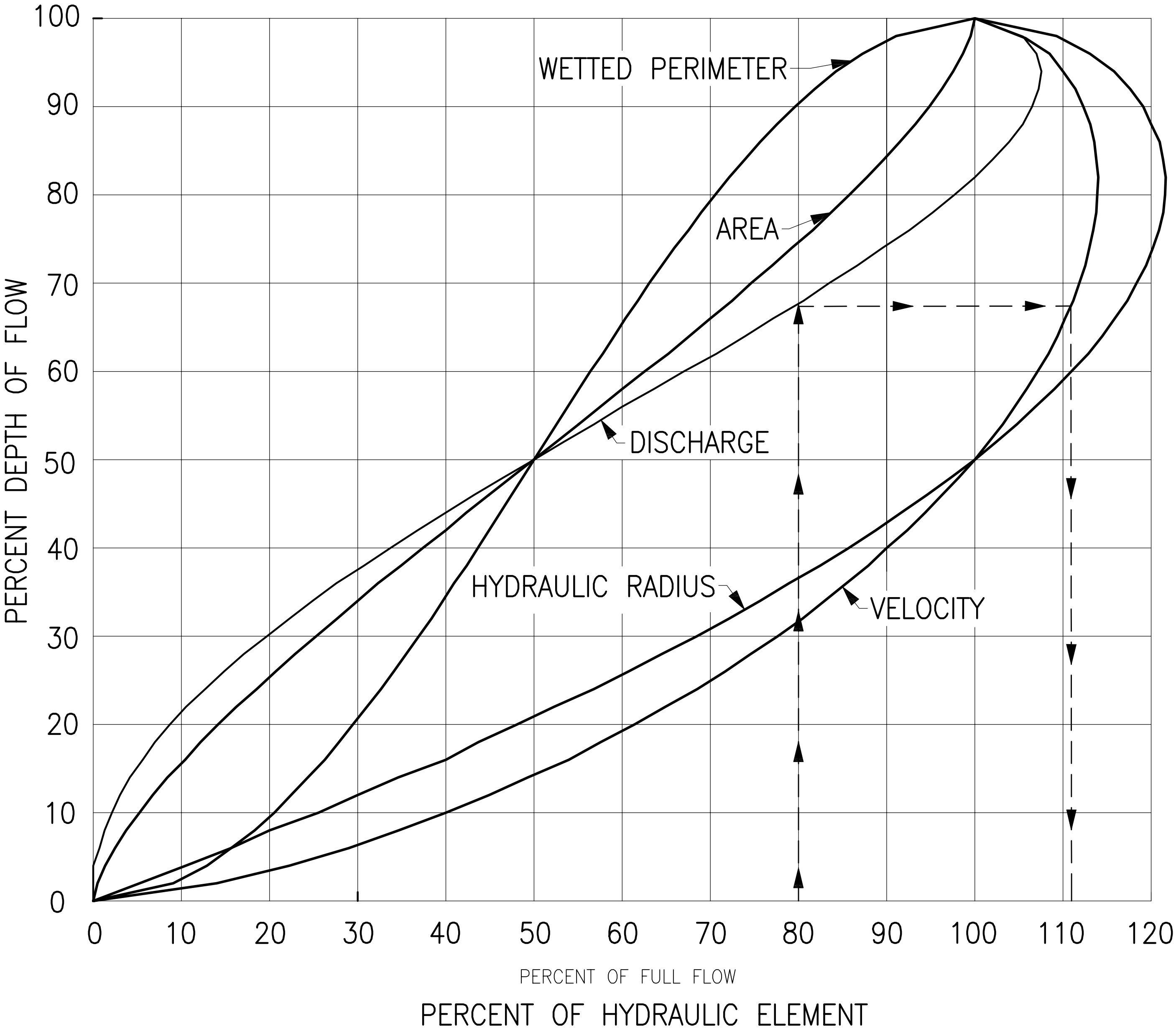


EXAMPLE

GIVEN – Discharge flowing full, 15 cfs; velocity =7 cfs.

DETERMINE – Velocity and depth of flow when discharge is 12 cfs.

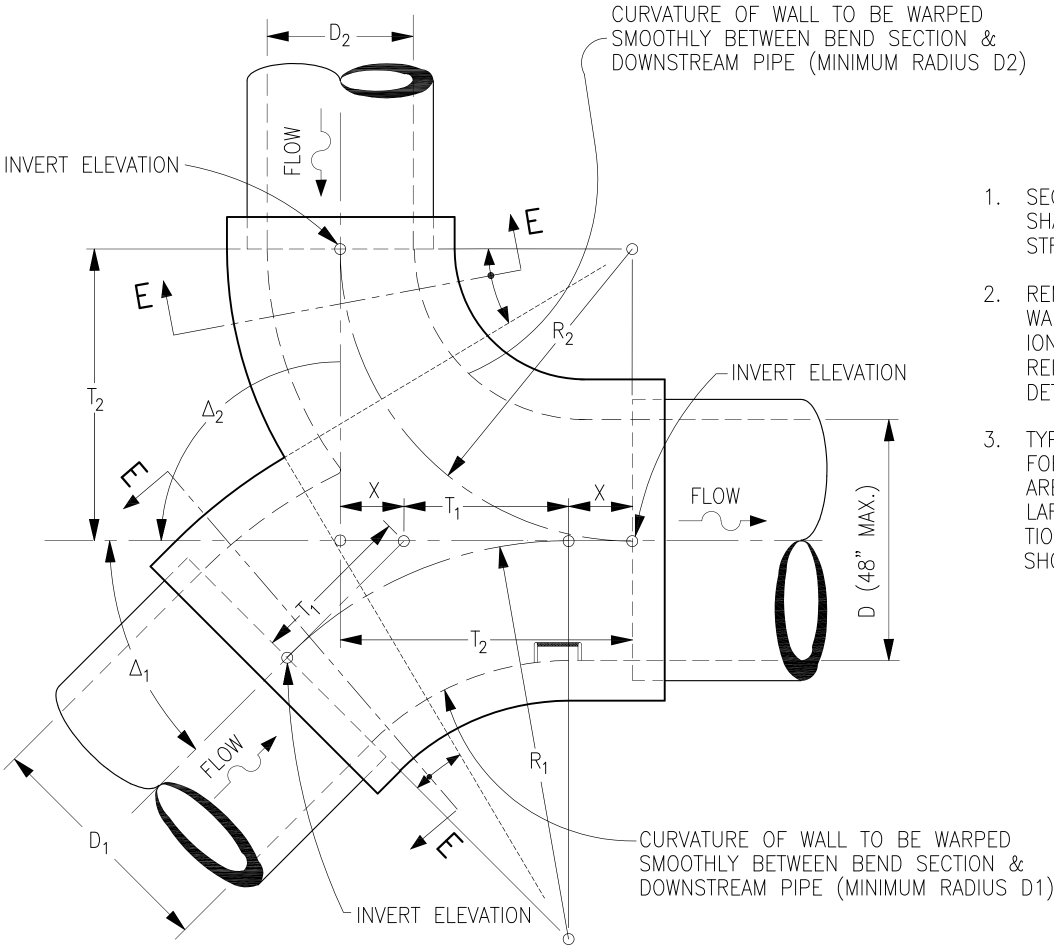
SOLUTION – Enter chart at 80% (12/15) of value for full section of Hydraulic Elements. Obtain depth of flow 68% of full flow depth and velocity = 112.5% x 7 = 7.9 cfs.

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

HYDRAULIC ELEMENTS CIRCULAR SECTION

ISSUED:
REVISED: MAY 18, 2004
REVISED:

PLATE
DB-16



PLAN

(AS SHOWN ON CONTRACT DRAWINGS)

NOTES:

1. SECTIONS E–E (BETWEEN LIMITS SHOWN) SHALL CONFORM TO STANDARD BEND STRUCTURE. (SEE STD. DETAIL D–4.03).
2. REMAINING PORTION OF STRUCTURE TO BE WARPED SMOOTHLY BETWEEN BEND SECTIONS & DOWNSTREAM PIPE. FOR TOP SLAB REINFORCEMENT IN THIS PORTION, SEE STD. DETAIL D–4.03.
3. TYPE I JUNCTION CHAMBER SHALL BE USED FOR 48" & SMALLER PIPE WHERE VELOCITIES ARE LESS THAN 15 FPS. FOR PIPE SIZES LARGER THAN 48" DIAMETER, SPECIAL JUNCTION CHAMBERS SHALL BE DESIGNED AND SHOWN ON CONSTRUCTION DRAWINGS.

PROCEDURE & CONSIDERATIONS FOR DETAILING

1. DETERMINE Δ_1 AND Δ_2 FROM PIPE ALIGNMENTS
2. DETERMINE R_1 AND R_2 WHERE $R_1 = 2D_1$ AND $R_2 = 2D_2$.
3. COMPUTE T_1 AND T_2 WHERE $T_a = R_a \tan(\Delta_a/2)$, FOR $a = 1, 2$
4. DETERMINE X WHERE $X = |T_1 - T_2| / 2$
5. LAY OUT STRUCTURE ON CONTRACT DRAWINGS AS SHOWN ABOVE, WITH DIMENSIONS AND NOTES AS SHOWN.

2/19/2008 3:45 PM

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

TYPE I JUNCTION CHAMBER

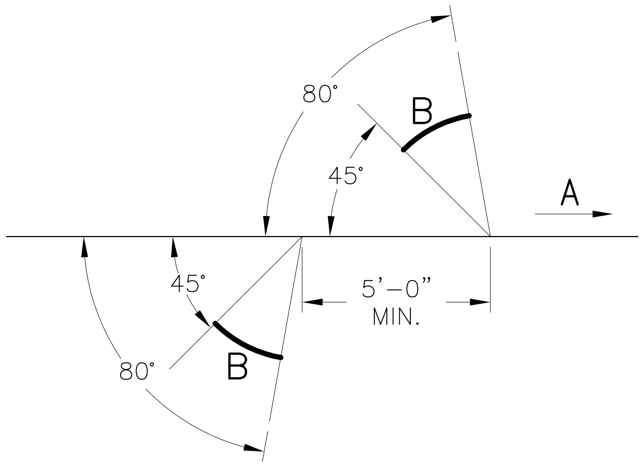
METHOD OF DETAILING ON CONTRACT DRAWINGS

ISSUED:
REVISED: MAY, 2004
REVISED:

PLATE

DB-18

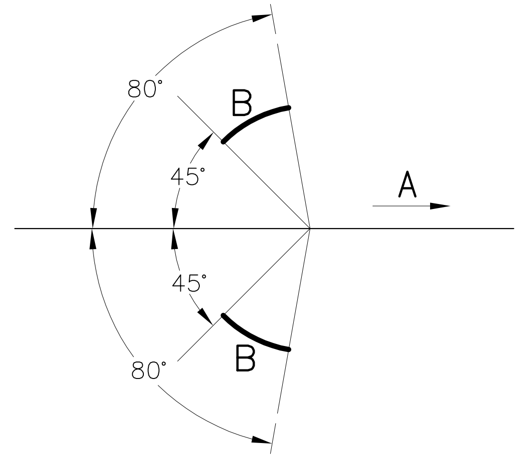
DB-18.DWG



A	B
33" & Larger	15" & Smaller
42" & Larger	18" & Smaller

CUT–INS

(To be used only for inlet connections)

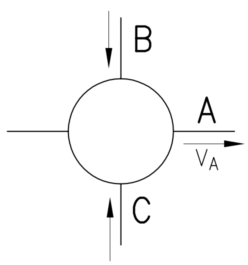


A	B
33" & Larger	15" & Smaller
36" & Larger	18" & Smaller

WYE BRANCHES

(Preformed and/or brick)

Applicable only to Cast–In–Place Manholes. See DB–20 for Precast Manholes.

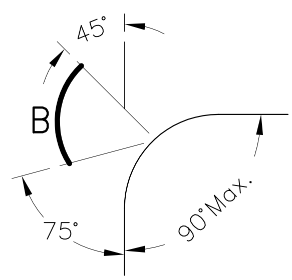


MAX. DIA.		
A	B	C
36"	36"	36"
36"	36"	36"
36"	36"	36"
36"	36"	36"

TYPE 'A' MANHOLE

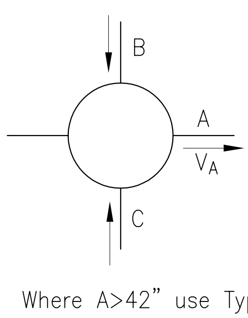
See Standard Details for use of Type 'B' Shallow Manholes. Use same maximum diameters as shown for Type 'A' Manholes

TYPE 'B' MANHOLE



MAX. DIA.	
A	B
30"–33"	15"–21"
36"–42"	15"–24"
48"–54"	15"–27"
60"–72"	15"–36"

BEND STRUCTURE WITH CONNECTION



MAX. DIA.		
A	B	C
72"	–	–
72"	18"	15"
72"	21"	–

Where A>42" use Type 'C' Manhole

TYPE 'C' MANHOLE

For Junction Chamber criteria see plate no. DB–18. Maximum connections to bend structures shall also apply to elliptical pipe or pipe arches of equivalent diameter.

The letter accompanying a heavy arc indicates the horizontal range of allowable approach angles of a lateral incoming pipe into the particular type of structure indicated.

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

STORM DRAIN STRUCTURES

GENERAL CRITERIA

ISSUED:
REVISED: MAY 19, 2004
REVISED:

PLATE

DB-19

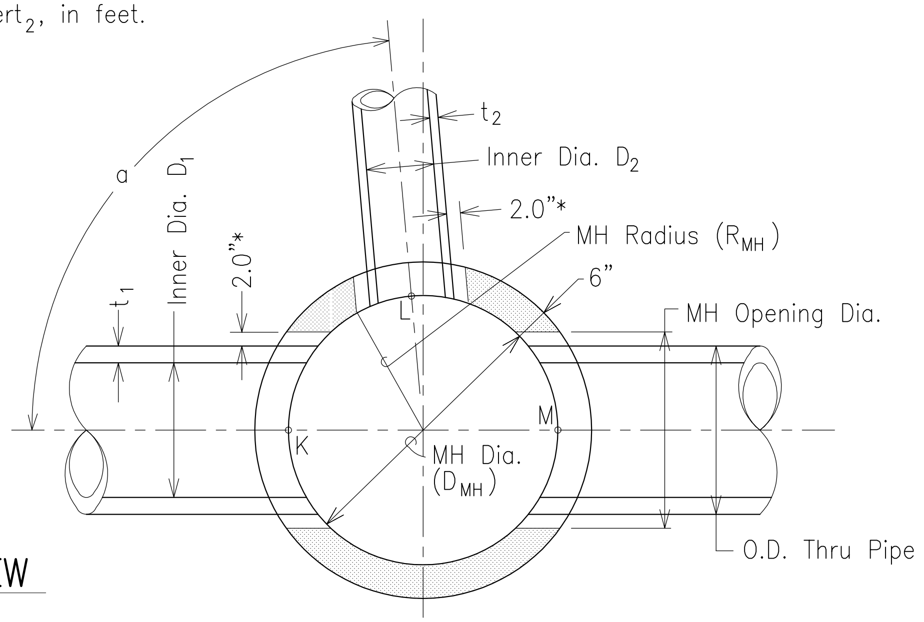
7/31/2009 11:06 AM

DB-19.dwg

DETERMINE: angle a, the minimum angle between the centerline of an incoming pipe to the centerline of the incoming end of the through pipe through a particular diameter manhole (Subtended by arc $\widehat{KL}$);

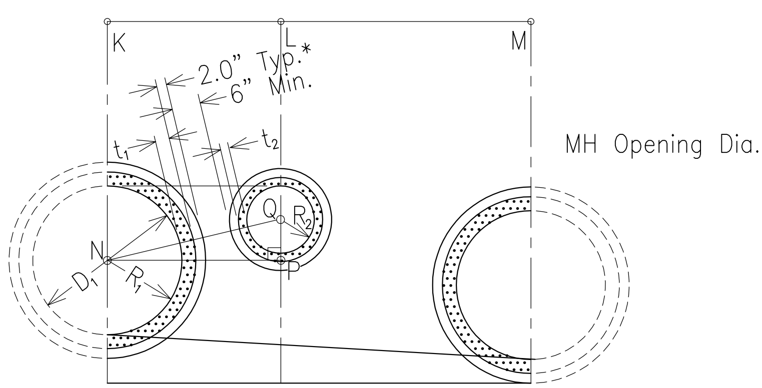
WHERE:
1. 6" of reinforced manhole wall must remain between pipe openings,
2. Pipe axes intersect at center of manhole.
3. Pipes may enter at any elevation relative to each other. Normally, interior top pipe elevations match.
4. Opening in MH wall is 4" in diameter larger than outer diameter (O.D.) of pipe.
5. Concrete pipe thickness is assumed below and for computing DB–20C through DB–20F. Pipe thickness will vary for other types of pipe. Check manufacturer data.
6. Dimensions are in inches unless otherwise noted.
7. Angle of incoming pipe with outfall pipe is always greater than 90 degrees.

GIVEN: D_1, D_2, D_{MH}, in inches.
$Invert_1$, $Invert_2$, in feet.



PLAN VIEW

* 2 inches per Bob Weller, Atlantic Precast, 12/5/01



PROJECTED VIEW OF INTERIOR MH WALL (ARC $\widehat{KLM}$)

1/27/2009 11:57 AM

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

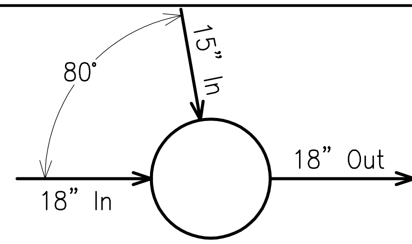
PRECAST MANHOLES
SIZING TO ACCOMMODATE PIPES

ISSUED: JANUARY, 2009
REVISED:
REVISED:

PLATE
DB-20A

DB–20A.DWG

EXAMPLE 1:



Given: D_1 = 18" (Through Pipe)
D_2 = 15" (Incoming Pipe Spur)
D_{MH} = 48"
$Invert_1$ = 104.40
$Invert_2$ = 104.65 (Tops of pipes match elevation)

Spur Angle of entry = 80 degrees measured from incoming thru pipe center-line to center-line of spur pipe
There is no angle break in 18" through pipe in manhole.

Calculations:

$R_1 = D_1 / 2 = 9$ inches; $R_2 = D_2 / 2 = 7.5$ inches

$t_1 = (D_1 / 12) + 1 = 2.5$ inches; $t_2 = (D_2 / 12) + 1 = 2.25$ inches

$\overline{NQ} = R_1 + R_2 + t_1 + t_2 + 10 = 9 + 7.5 + 2.5 + 2.25 + 10 = 31.25$ in.

$\overline{PQ} = [(Invert_2 + D_2 / 24) - (Invert_1 + D_1 / 24)] \times 12 =$
$= [(104.65 + 15 / 24) - (104.4 + 18 / 24)] \times 12 =$
$= [105.275 - 105.15] \times 12 = 0.125 \times 12 = 1.5$ in.

$\overline{NP} = \sqrt{\overline{NQ}^2 - \overline{PQ}^2} = \sqrt{31.25^2 - 1.5^2} = 31.2140$

Angle a = $(360° \times \overline{NP}) / (\pi \times D_{MH}) = 74.5179$ degrees

Conclusions:

Since Spur Angle of entry is greater than Angle a, but less than 90 degrees, the proposed Spur Angle of entry will acceptably provide the required 6" of reinforced wall between pipe openings.

The same result can be determined using the 18 x 15 curve on Design Plate DB-20C, used for 48 inch diameter manholes.

1/27/2009 2:45 PM

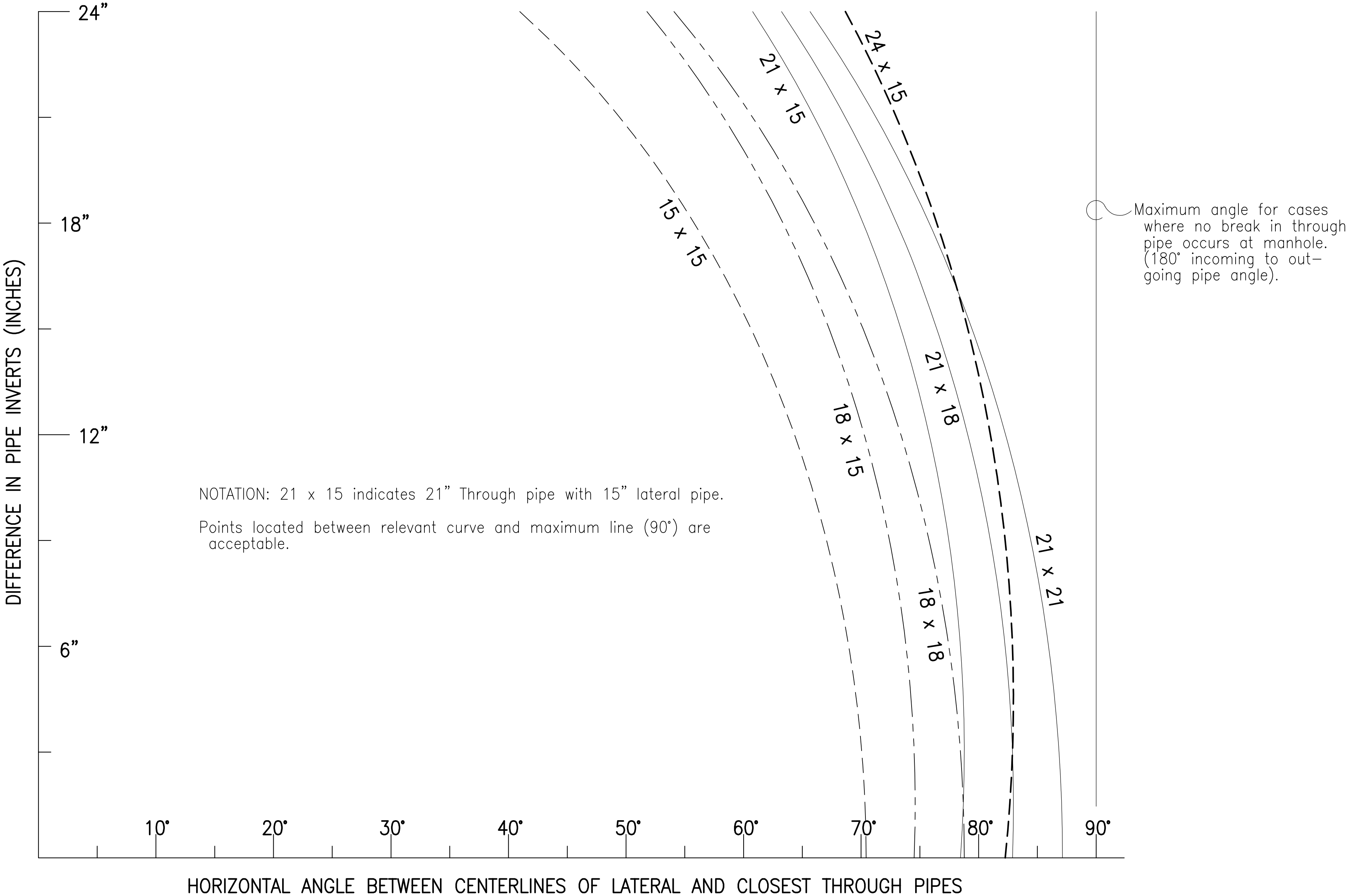
BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

PRECAST MANHOLES
SIZING TO ACCOMMODATE PIPES

ISSUED: JANUARY, 2009
REVISED:
REVISED:
PLATE
DB-20B

DB-20B.DWG



DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

Pipe Spacing - Pipes Entering 48" Diameter Manhole

Minimum Angles Between Lateral and Through Pipes to Maintain 6" Reinforced Wall

ISSUED: JANUARY, 2009

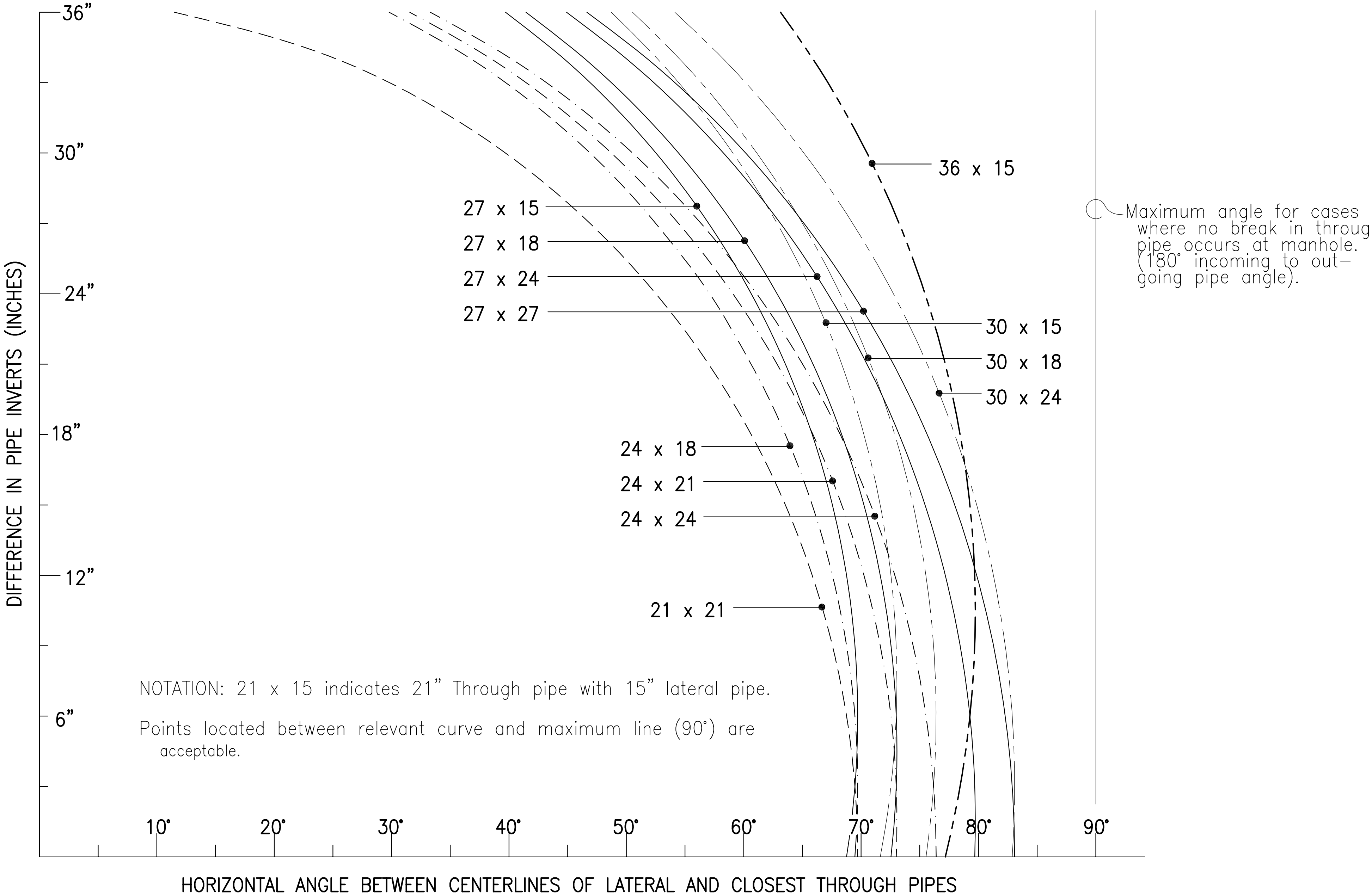
REVISED:

REVISED:

PLATE

DB-20C

DB-20C.dwg 1/29/2009 12:36 PM



DEPARTMENT OF PUBLIC WORKS
STORM DRAINAGE DESIGN

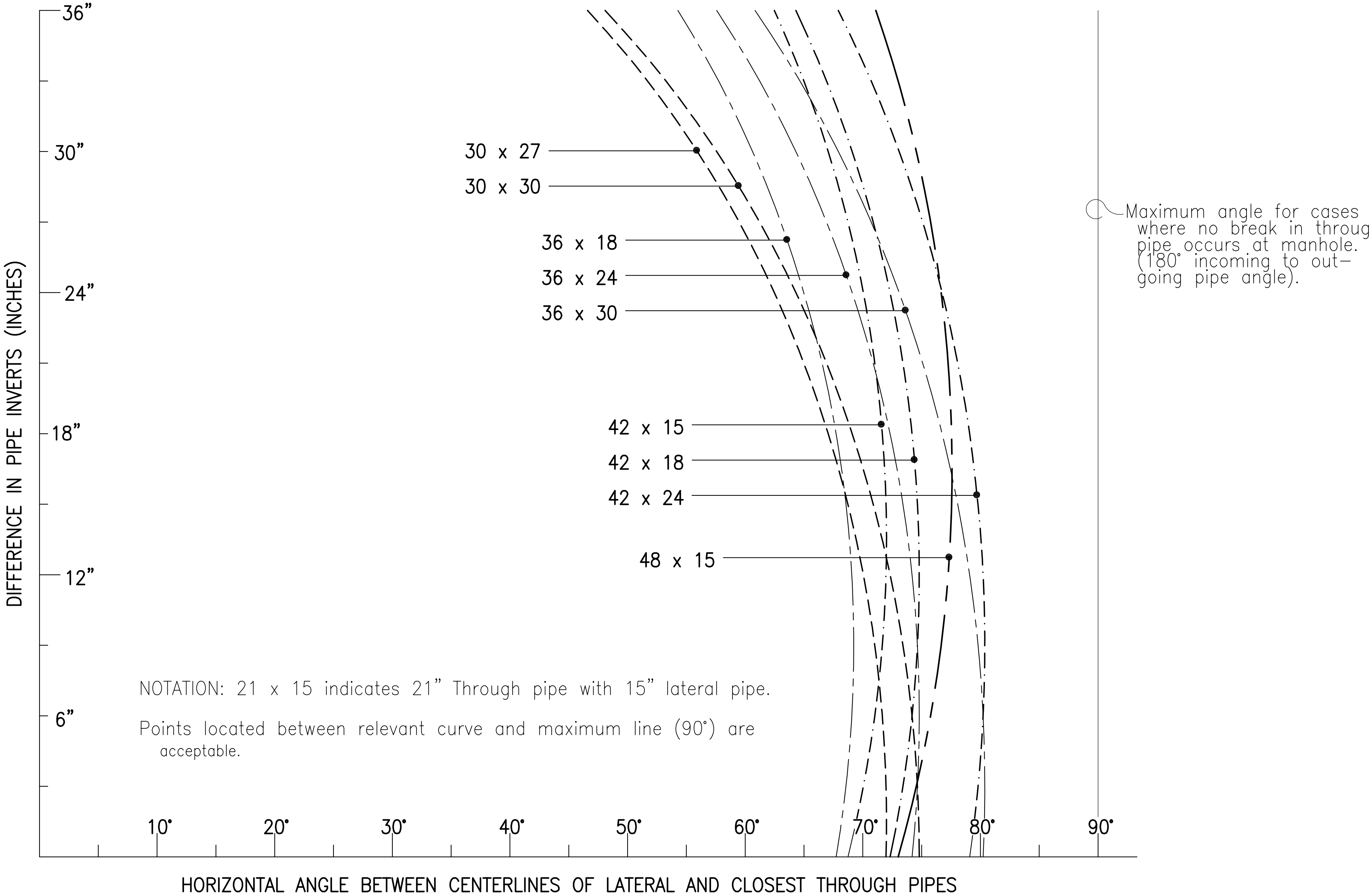
Pipe Spacing - Pipes Entering 60" Diameter Manhole

Minimum Angles Between Lateral and Through Pipes to Maintain 6" Reinforced Wall

ISSUED: JANUARY, 2009
REVISED:
REVISED:

PLATE
DB-20D

DB-20D.dwg 1/26/2009 1:06 PM



DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

Pipe Spacing - Pipes Entering 72" Diameter Manhole

Minimum Angles Between Lateral and Through Pipes to Maintain 6" Reinforced Wall

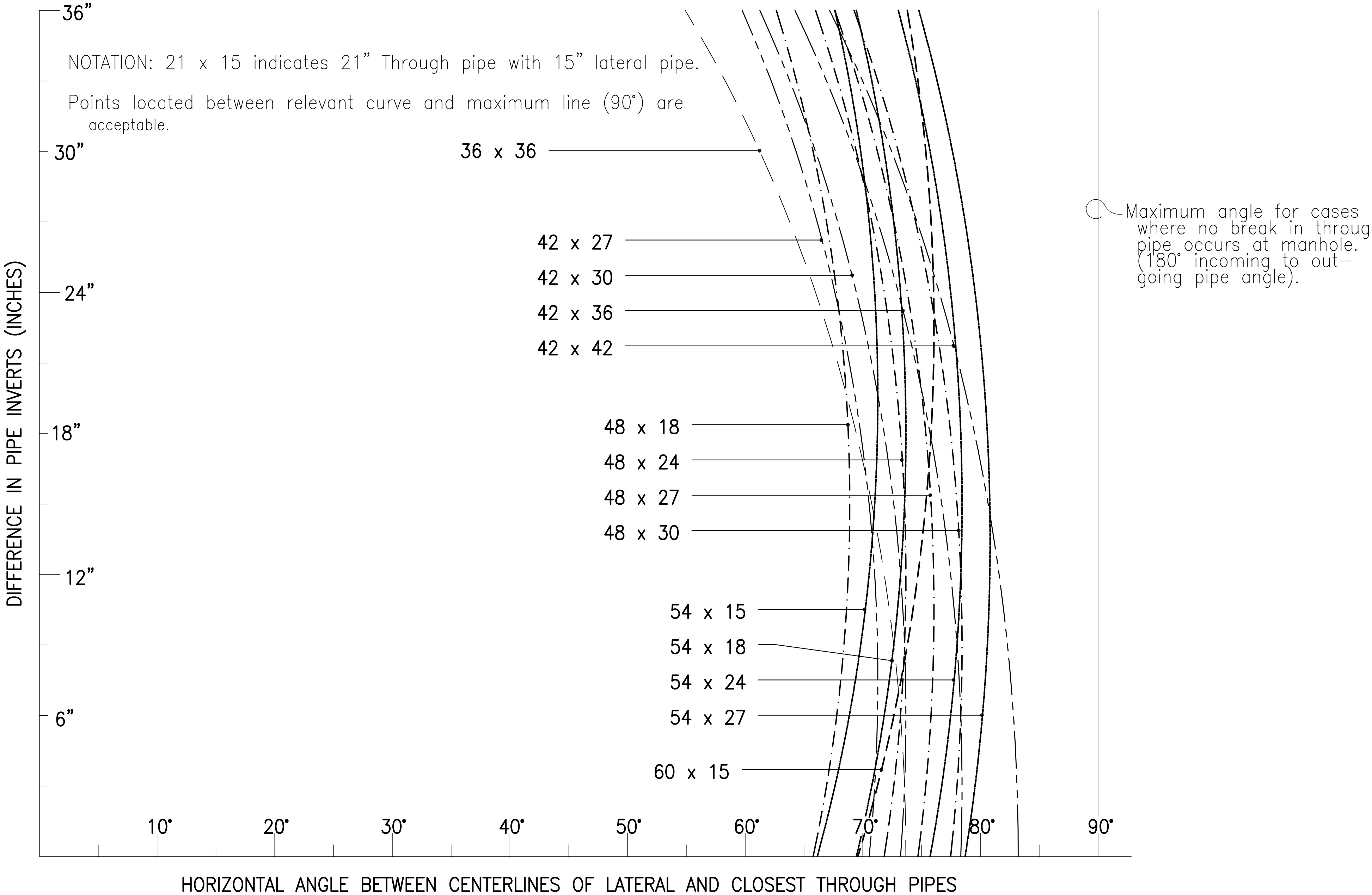
ISSUED: JANUARY, 2009

REVISED:

REVISED:

PLATE

DB-20E



DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

Pipe Spacing - Pipes Entering 84" Diameter Manhole

Minimum Angles Between Lateral and Through Pipes to Maintain 6" Reinforced Wall

ISSUED: JANUARY, 2009

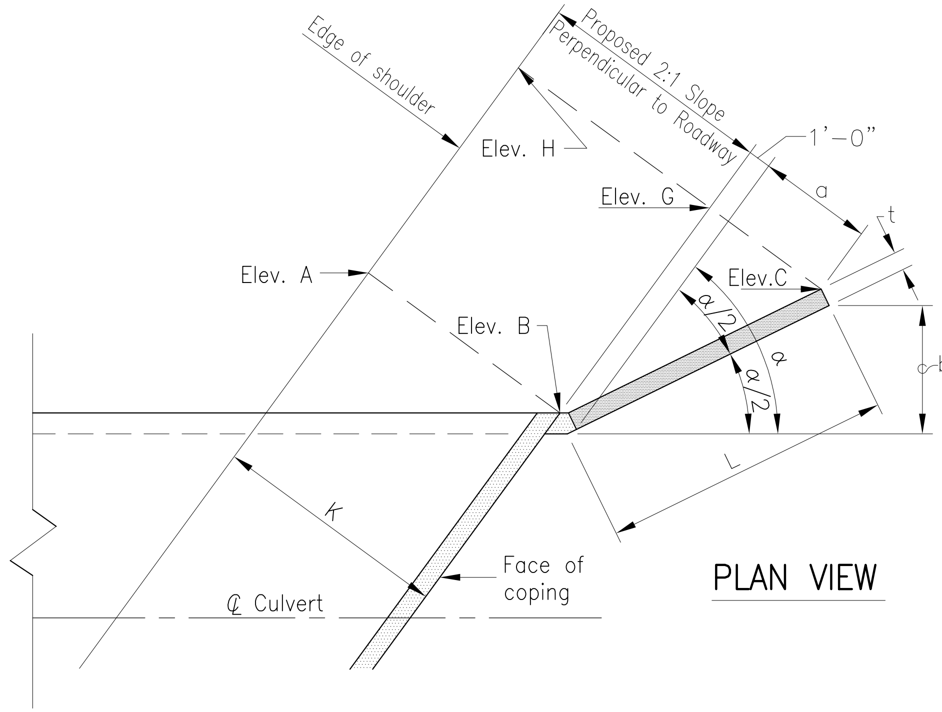
REVISED:

REVISED:

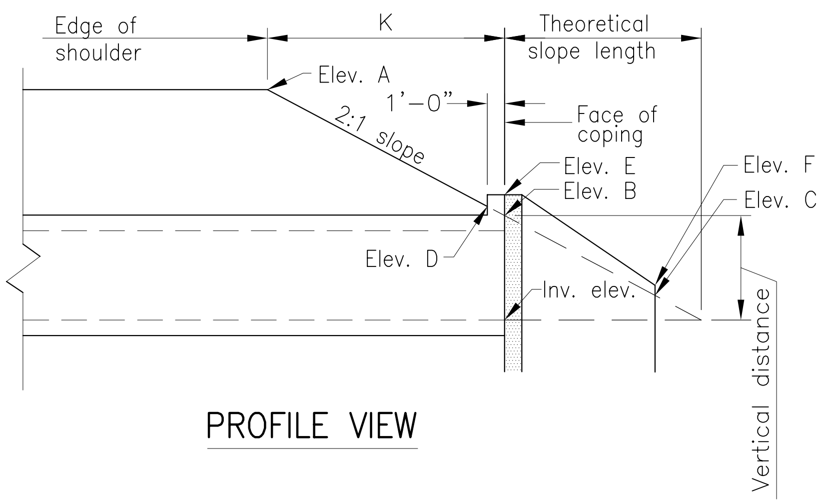
PLATE

DB-20F

DB-20F.dwg 1/29/2009 12:32 PM



PLAN VIEW



PROFILE VIEW

LAYOUT OF CULVERT WING WALLS	
Elevation A	Grade at edge of shoulder determined by profile grade and roadway slope.
K/2	Horizontal distance edge of shoulder to face of caping perpendicular to roadway divided by 2.
Elevation B	Elevation A–K/2
Inv. elev.	
Vert. distance	Elevation B – Invert elevation
a+b+t	Theoretical length of slope
t	Thickness of wall
a+b	
a=b	(a+b)/2
*[a/sin(α/2)]= [b/sin(α/2)]	Theoretical length of wing wall = L
Elevation D	Elevation A – [(K–1)/2]
Elevation E	Elevation D + 6"
Elevation H	Grade at edge of shoulder determined by profile grade and roadway slope.
Elevation G	Elevation H – (K/2)
Elevation C	Elevation G – [(a+1)/2] to nearest 3"

*Set wing wall length to next larger 6" increment.

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

LAYOUT OF CULVERT WINGWALLS

ISSUED: MAY 18, 2004

REVISED:

REVISED:

PLATE

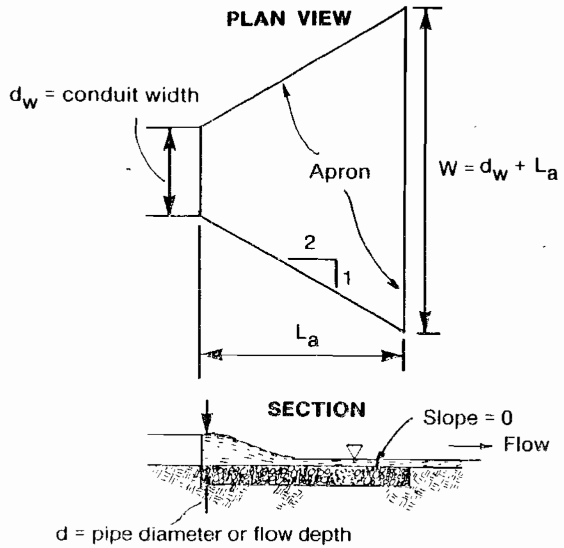
DB-21

2/19/2008 4:35 PM

DB-21.dwg

NOTES:

1. Tailwater <$0.5d_o$ = minimum tailwater condition
2. d_w = pipe diameter or box culvert width
3. For rectangular sections or partially full pipes, use depth of flow and velocity
4. Velocities shown are for pipes flowing full



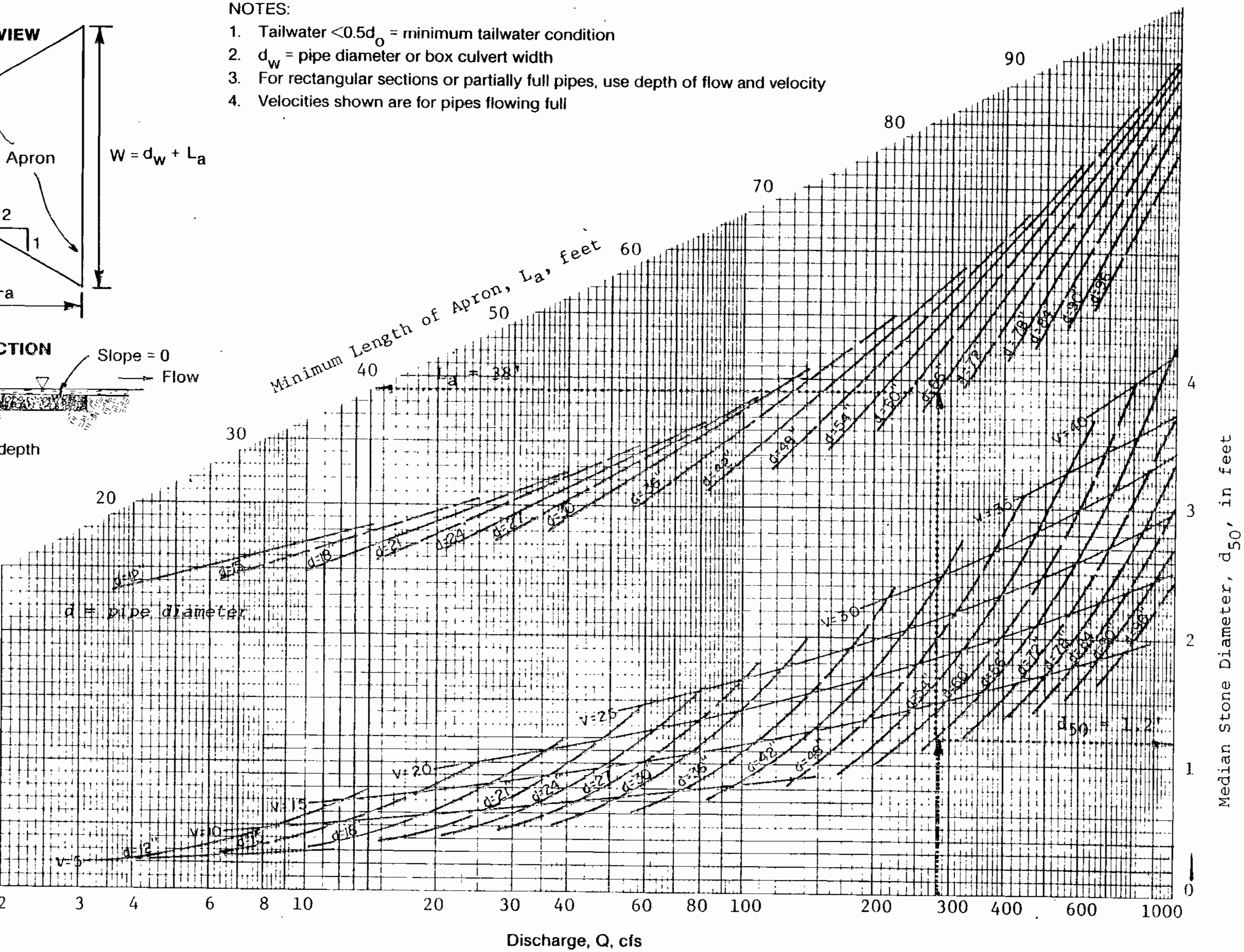
Pipe Flow Example

Given:

- Q = 280 cfs
- d = 66″
- TW = 2 ft

Find:

- d_{50} = 1.2′
- L_a = 38′
- W = 43.5′



Reference: Goldman et al. (1986).

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

DESIGN OF RIPRAP APRON

MINIMUM TAILWATER CONDITIONS

ISSUED: JULY 30, 2003

REVISED:

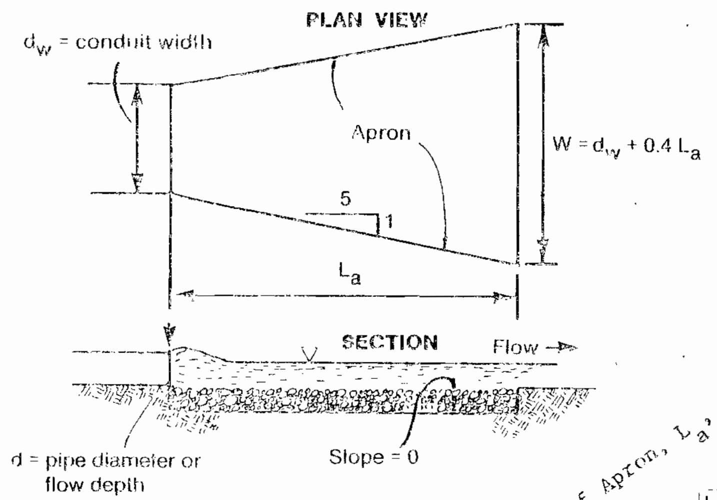
REVISED:

PLATE

DB-23

NOTES:

1. Tailwater $\geq 0.5d_o$ = maximum tailwater condition
2. d_w = pipe diameter or box culvert width
3. For rectangular sections or partially full pipes, use depth of flow and velocity
4. Velocities shown are for pipes flowing full



Box Culvert Example

Given:

Q = 230 cfs

B = 10′ D = 5.5′

d = 5.0′ = 60″

TW = 5.0′

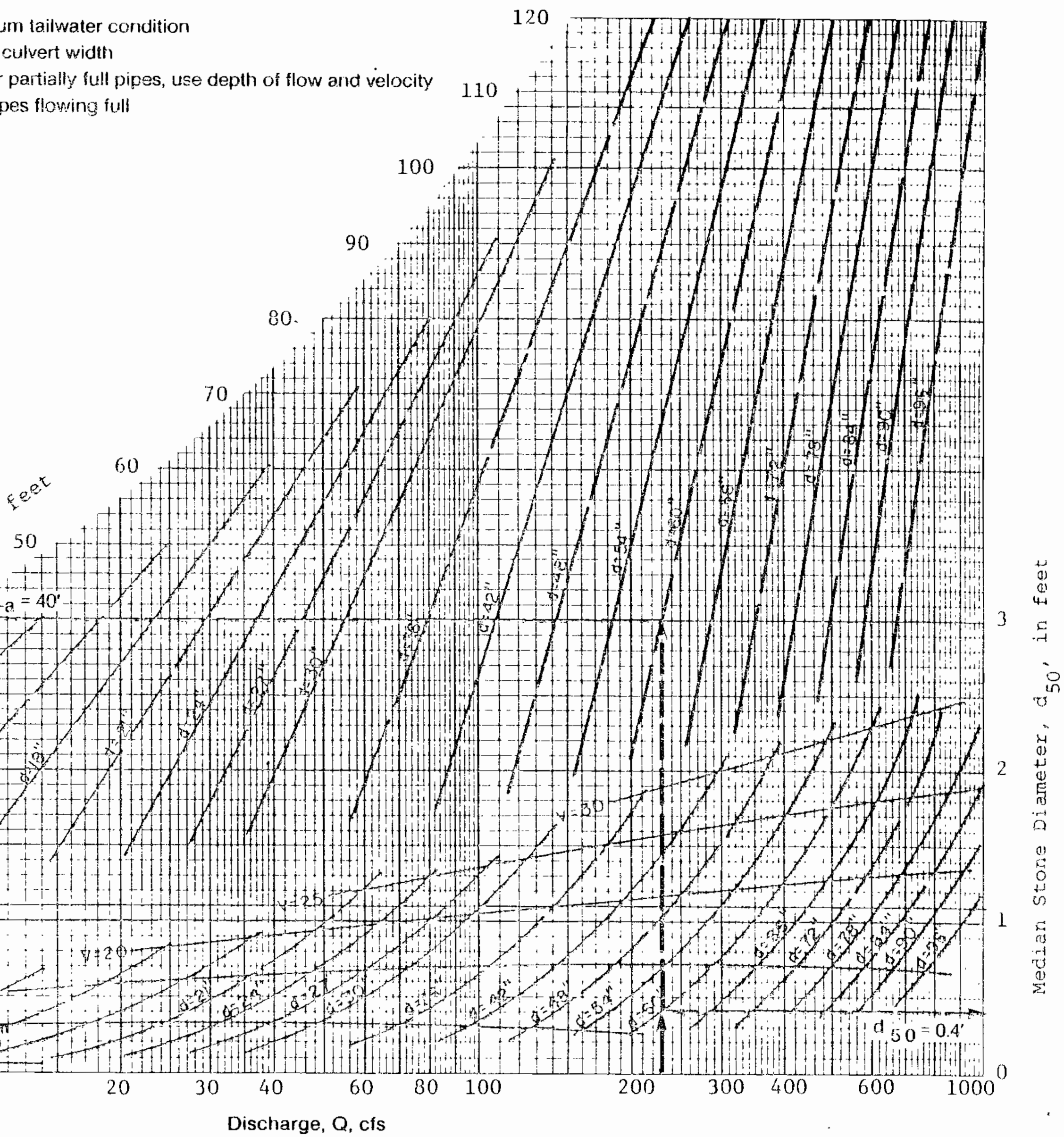
V = 12 fps

Find:

d_{50} = 0.4′

L_a = 40′

W = 26′



Reference: Goldman et al. (1986).

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

DESIGN OF RIPRAP APRON

MAXIMUM TAILWATER CONDITIONS

ISSUED: JULY 30, 2003

REVISED:

REVISED:

PLATE

DB-24

PERMISSIBLE DEPTH TABLE – REINFORCED CEMENT CONCRETE PIPE

PIPE DIA.	CLASS III		CLASS IV		CLASS V	
	MIN. DEPTH	MAX. DEPTH	MIN. DEPTH	MAX. DEPTH	MIN. DEPTH	MAX. DEPTH
12"	NOT USED		3	14	3	ALL PIPE CAN BE USED TO OVER 30 FEET IN DEPTH.
15"			3	22	3	
18"			3	23	3	
21"			3	24	3	
24"			4	25	4	
27"			4	20	4	
30"			4	21	4	
36"			5	22	5	
42"			5	21	5	
48"			6	22	6	
54"			6	23	6	
60"			7	23	7	
66"			7	24	7	
72"			8	25	8	

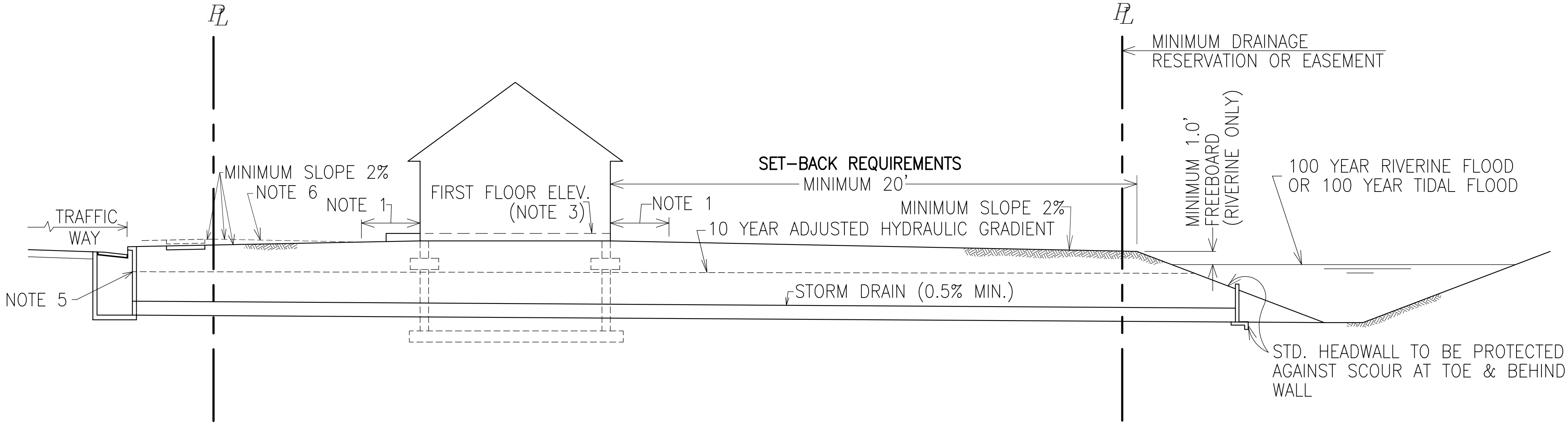
FIGURES SHOWN IN TABLE ARE MEASURED FROM INVERT OF PIPE TO GRADE.

EXCEPT AS OTHERWISE NOTED, ALL VALUES ARE IN FEET.

PIPE SHALL NOT BE USED WHERE BLANK SPACES OCCUR WITHIN THE TABLE.

VALUES SHOWN ARE FOR CONCRETE PIPE MEETING ALL REQUIREMENTS OF ASTM C-76 PIPE FOR THE INDICATED CLASS.

2/19/2008 4:42 PM



NOTES

NEW STRUCTURES OR ADDITIONS ADJACENT TO FLOODPLAIN

1. DESIRED SLOPE OF GROUND FOR 10' ADJACENT TO BUILDING IS 5% (ALL SIDES OF BUILDING).
2. THE 20' MINIMUM BUILDING SETBACK SHALL APPLY TO THE FRONT, REAR AND SIDES OF ALL RESIDENTIAL, COMMERCIAL, INDUSTRIAL OR INSTITUTIONAL STRUCTURES.
3. FIRST FLOOR ELEVATION TO BE 2 FEET ABOVE MAXIMUM FLOOD LEVEL OF 100-YEAR STORM (RIVERINE OR TIDAL).
4. BASEMENT CONSTRUCTION BELOW THE MAXIMUM FLOOD SHALL BE IN ACCORDANCE WITH ALL REQUIREMENTS OF THE CURRENT BALTIMORE COUNTY BUILDING CODE.
5. STORM DRAIN SHALL BE SIZED SO THAT 10 YEAR ADJUSTED HYDRAULIC GRADIENT IS 1'-6" MINIMUM BELOW THE ESTABLISHED GRADE (TOP OF CURB).
6. WHEN GROUND SLOPES TOWARD BUILDING, FLOW SHALL BE DIRECTED AROUND SIDES OF BUILDING USING ADEQUATELY SIZED SWALES OR DRAINS.
7. SEE SET-BACK REQUIREMENTS ABOVE. SET-BACK IS MEASURED FROM 100 YEAR FLOODPLAIN PLUS ONE-FOOT VERTICAL FREEBOARD.

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

TYPICAL SECTION THROUGH LOT SHOWING MINIMUM DRAINAGE REQUIREMENTS

ISSUED:	
REVISED:	FEBRUARY, 1985
REVISED:	MARCH, 2005

PLATE

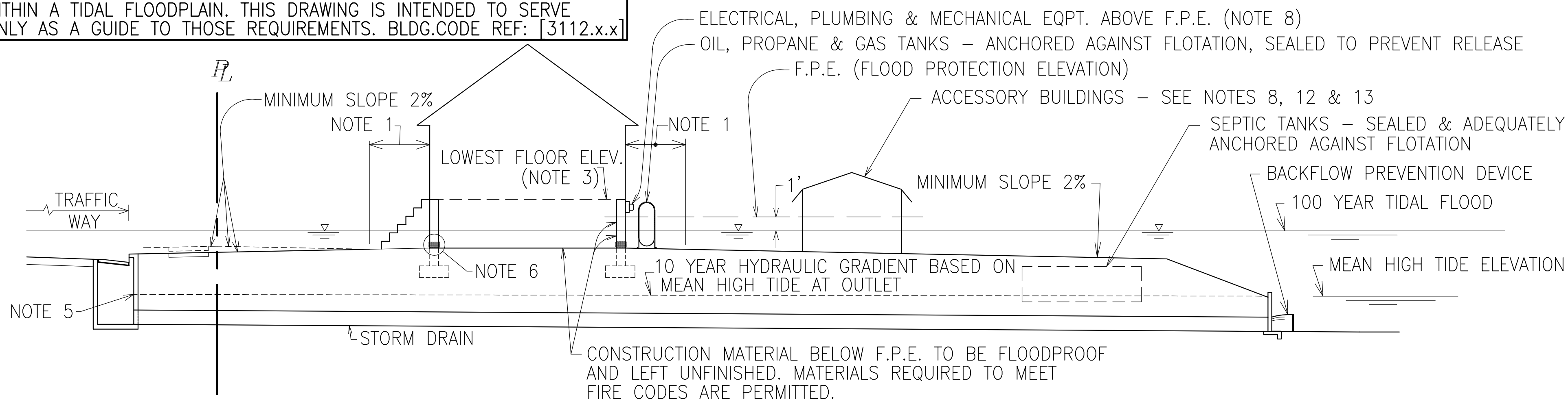
DF-1

7/31/2009 11:24 AM

DF-1.dwg

REFER TO THE LATEST VERSION OF THE BALTIMORE COUNTY BUILDING CODE FOR AUTHORITATIVE REQUIREMENTS REGARDING CONSTRUCTION WITHIN A TIDAL FLOODPLAIN. THIS DRAWING IS INTENDED TO SERVE ONLY AS A GUIDE TO THOSE REQUIREMENTS. BLDG.CODE REF: [3112.x.x]

COUNTY CODE REFERENCE: ARTICLE 32 TITLE 8



NOTES

1. DESIRED SLOPE OF GROUND FOR 10' ADJACENT TO BUILDING IS 5% AWAY FROM BUILDING ON ALL SIDES.
2. THE 10 YEAR HYDRAULIC GRADIENT SHALL BE BASED UPON MEAN HIGH TIDE AT THE OUTLET.
3. LOWEST FLOOR ELEVATION TO BE 2 FEET ABOVE MAXIMUM FLOOD LEVEL OF 100–YEAR STORM (1' ABOVE F.P.E.).
4. NO BASEMENT (FLOORS BELOW GRADE ON ALL 4 SIDES) WHEN 100 YEAR TIDAL FLOODPLAIN ENCROACHES ON HOUSE FOOTPRINT.
5. STORM DRAIN SHALL BE SIZED SO THAT 10 YEAR HYDRAULIC GRADIENT IS BELOW THE ESTABLISHED GRADE OF STREET.
6. TWO WATER EQUALIZING VENTS, ON DIFFERENT WALLS– BOTTOM 12" OR LESS ABOVE GRADE EXPOSED TO FLOOD; VENT AREA = 1 SQ.IN. PER SQ.FT. OF CONTAINED AREA.
7. ACCEPTABLE USES FOR ENCLOSED SPACES BELOW F.P.E.: GARAGE PARKING WITH UNFINISHED WALLS, ACCESS TO BUILDINGS & UNFINISHED STORAGE (LIMITED USE).
8. THE FOLLOWING MUST BE ABOVE F.P.E.: HVAC EQUIP– MENT, ELECTRICAL EQUIPMENT & OUTLETS, HOT WATER HEATER, WASHER, DRYER, FREEZERS/REFRIGERATORS, WATER PRESSURE TANK & PUMP, AND BATHROOM FIXTURES. ELECTRICAL DISTRIBUTION PANEL BOXES MUST BE 2' ABOVE F.P.E.
9. ENTRANCES TO INTERIOR AREAS BELOW THE F.P.E. WILL BE LOCATED, ORIENTED & CONSTRUCTED TO MINIMIZE FLOOD DAMAGES.
10. THESE REGULATIONS WILL APPLY TO EXISTING STRUCTURES WHEN PROPOSED IMPROVEMENTS TO STRUCTURE EXCEED 50 PERCENT OF THE ASSESSED VALUE OF THE STRUCTURE.
11. AN ELEVATION CERTIFICATE WILL BE REQUIRED AT THE TIME OF THE FRAMING INSPECTION FOR NEW & IMPROVED STRUCTURES.
12. A NON–CONVERSION AGREEMENT (RECORDED IN PROPERTY RECORDS) IS REQUIRED WHEN AREAS INSIDE HOUSE OR ACCESSORY BUILDING(S) >300 S.F. ARE BELOW F.P.E.
13. ACCESSORY STRUCTURES (<900 S.F.) SHALL BE USED ONLY FOR PARKING AND/OR LIMITED STORAGE. THESE STRUCTURES MUST BE ANCHORED AGAINST FLOTATION & VENTED PER NOTE 6. ACCESSORY STRUCTURES OVER 900 S.F. ARE NOT PERMITTED.
14. DESIGNATED HISTORIC STRUCTURES MAY BE EXEMPTED FROM REQUIREMENTS THAT WOULD IMPACT THEIR HISTORIC STATUS.
15. MANUFACTURED BUILDINGS – ON PERMANENT FOUNDATION; ANCHORED AGAINST FLOTATION & 90 MPH WINDS.
16. WATER SUPPLY, SEWER/SEPTIC, FUEL, ELECTRIC, COMMUNI– CATIONS UTILITIES SEALED TO PREVENT INFILTRATION BY, AND CONTAMINATION OF, FLOOD WATERS.
17. NON–RESIDENTIAL STRUCTURES MAY BE FLOODPROOFED TO F.P.E.

BALTIMORE COUNTY MARYLAND

DEPARTMENT OF PUBLIC WORKS

STORM DRAINAGE DESIGN

GUIDELINES FOR LOT LOCATED WITHIN A TIDAL FLOODPLAIN

ISSUED: October, 2004

REVISED:

REVISED:

PLATE

DF-2

7/31/2009 12:06 PM

DF-2.dwg