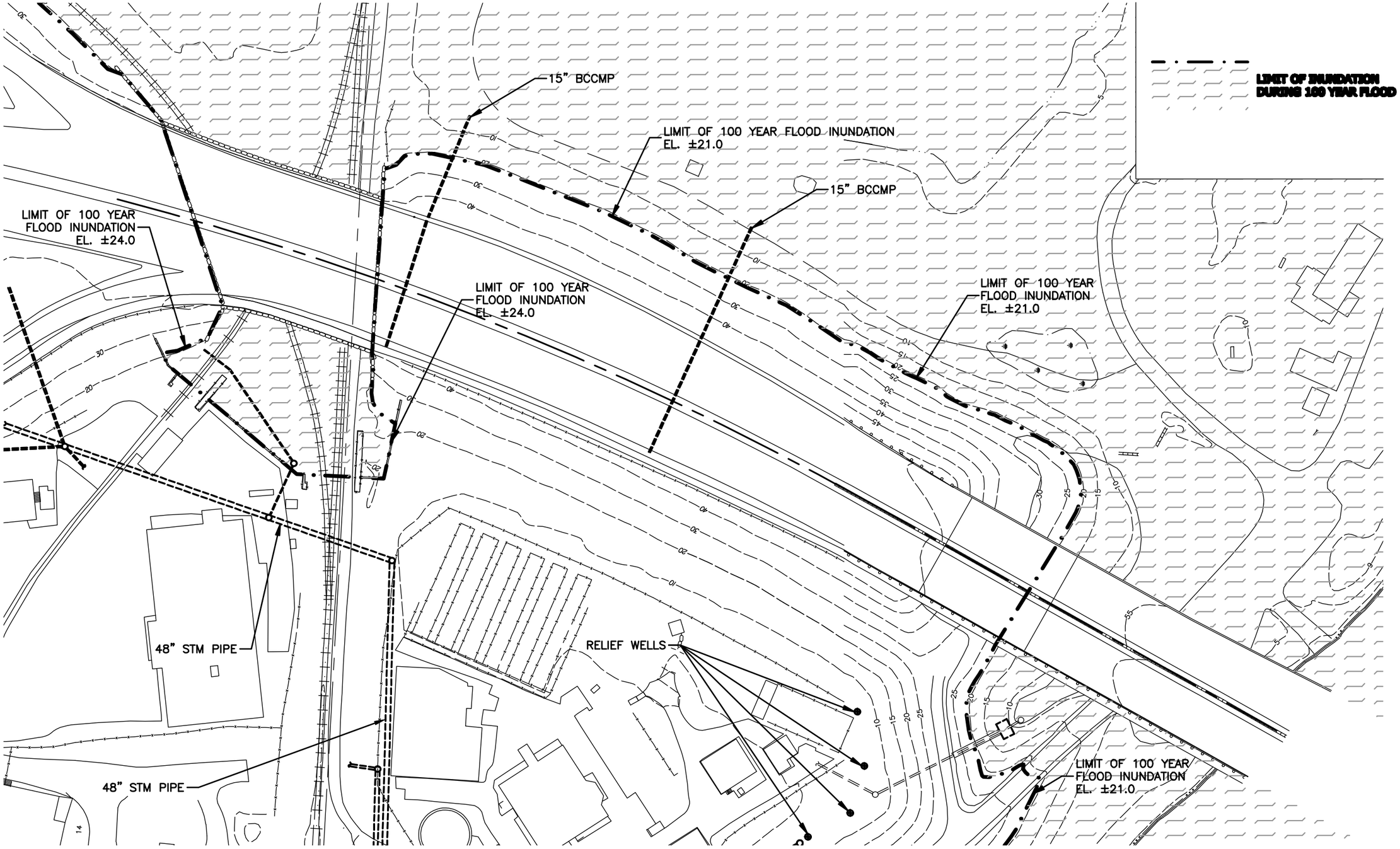
Connecticut Route 8 Embankment

Riverside Inundation Limits Map

Drawing: G:\SDSKPROJ\1560-119\DWG\CURRENT\LEVEE-DRAINAGE-MAP.DWG Layout: Tab1 OF 1



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CT ROUTE 8 EMBANKMENT - RIVERSIDE INUNDATION LIMITS

FEMA LEVEE CERTIFICATION
HOUSATONIC & NAUGATUCK RIVERS

DERBY, CONNECTICUT

FAB	CJR	MJJ
DESIGNED	DRAWN	CHECKED

SCALE --

DATE NOV. 2010

PROJECT NO. 1560-119

1 OF 1
SHEET NO.

Plotted by: CHRISH On this date: Tue, 2010 December 14 - 6:30pm

Stone Riprap Size Evaluation

Naugatuck River

Engineering,
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JOB Derby/Ansonia Levee Certification (1560-119)
SHEET NO. 1 OF 18
CALCULATED BY FAB DATE 11/19/10
CHECKED BY EAH DATE 11/19/10
SCALE Scour Analysis - Embankment Protection

- Riprap Criteria (from ConnDOT Drainage Manual, section 9.2.10)

Riprap Type	D50 (ft)	Layer Thickness (in)	Gravel Bedding Thickness (in)
Modified	< 0.42	12	6
Intermediate	0.42 < d50 < 0.67	18	6
Standard	0.67 < d50 < 1.25	36	12

- Naugatuck River

- Using data found in the report prepared by Howard, Needles, Tammen and Bergendoff, "Restudy of Stream Encroachment Lines for Flood Control in Connecticut, Part II - Determination of Encroachment Lines, Section 1 - Naugatuck River Through Towns of Derby and Ansonia".

Q = 41,300 cfs
V = 12.35 ft/s (highest found within Derby / Ansonia reach)
d = ±23.3 feet, s = 0.0034 ft/ft, 3:1 side slopes

1) Velocity Approach:

$$D_{50} = \frac{0.001\ V_a^3}{(d)^{0.5}(K_1)^{1.5}}$$, where: D_{50} = median riprap size (ft)
V_a = velocity in the main channel (ft/s)
d = average flow depth (ft)

$$K_1 = \left(1 - \frac{\sin^2\theta}{\sin^2\phi}\right)^{1/2}$$, where: θ = bank angle with the horizontal = 15° (1:3)
ϕ = riprap material's angle of repose = 40° (very angular)

from Figure 7-26 from ConnDOT Drainage Manual:
K_1 = 0.866

$$D_{50} = \frac{0.001 \times 12.35^3}{(23.3)^{0.5} \times 0.866} = 0.494 \text{ ft}$$

Applying a correction factor C, from Figure 7-28 from ConnDOT Drainage Manual:
for SF = 1.2, C = 1.05 (S_s = 2.65)

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JOB Derby / Ansonia - Levee Certification (1560-115)
SHEET NO. 2 OF 18
CALCULATED BY FAB DATE 11/19/10
CHECKED BY EAH DATE 11/19/10
SCALE Scour Analysis - Embankment Protec

$d_{50} = 0.494\ ft \times 1.05$

$d_{50} = 0.52\ ft$ (Intermediate riprap) ◄

2) Shear Stress Approach:

$\tau = \gamma R S$, where: τ = average shear stress (lb/ft^2)
γ = unit height of water ($62.4\ lb/ft^3$)
R = hydraulic radius, or depth of flow (ft)
S = energy slope, or average bed slope (ft/ft)

$S = 62.4 \times 23.3 \times 0.00154$
$\tau = 2.24\ lb/ft^2$

$\tau = \tau_p$ (permissible shear stress)
$\tau_p = \gamma R S$
$\tau_p = 5 D_{50}$
$5 D_{50} = \gamma R S$
$D_{50} = \frac{\gamma R S}{5} = \frac{\tau_p}{5}$

$D_{50} = 2.24 / 5 = 0.45\ ft$ (Intermediate riprap) ◄

3) Verification of results using the "Graphical Determination of Minimum "D_{50}" for Graded Stone Riprap Channel Protection", dated April 1966 by the New England Division, Corps of Engineers.

from attached graph (Page 5):

$D_{50} = 0.55\ ft$ (Intermediate riprap) ◄

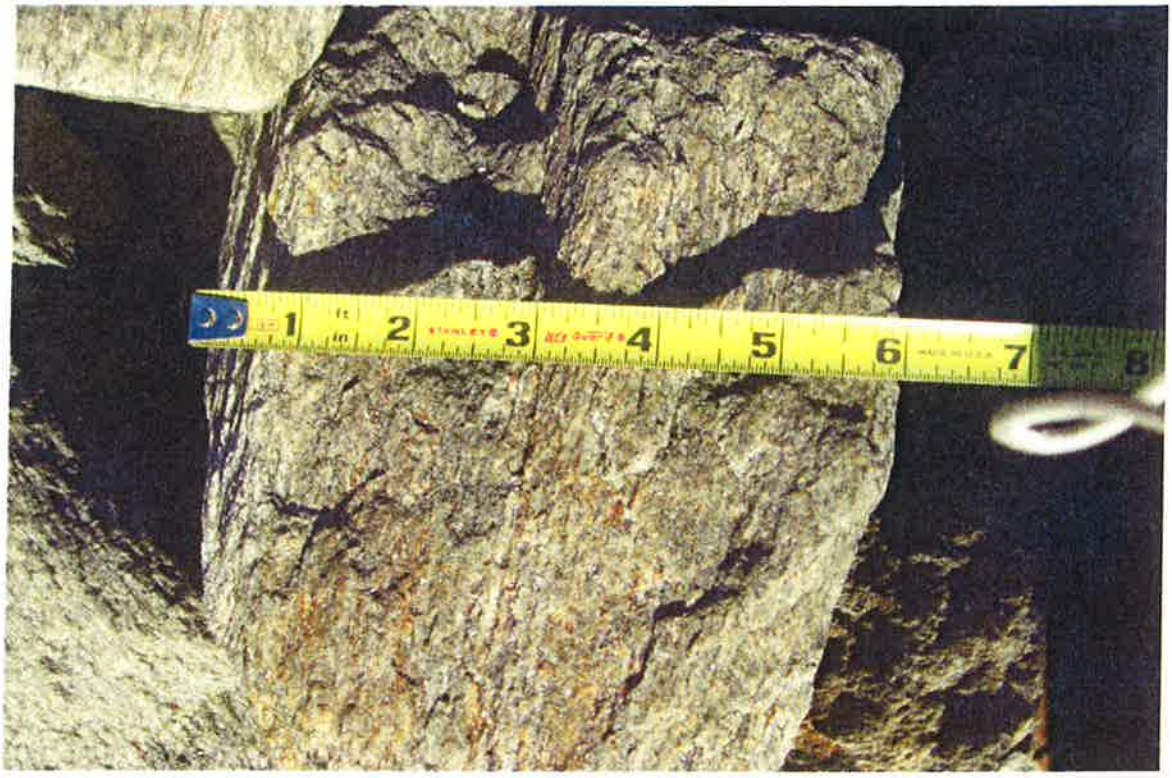



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6/18

ESTABLISHMENT OF STREAM ENCROACHMENT LINES FOR PARTICULAR STREAMS IN CONNECTICUT

PART II - DETERMINATION OF ENCROACHMENT LINES

SECTION I - NAUGATUCK RIVER THROUGH TOWNS OF DERBY-ANSONIA

HOWARD, NEEDLES, TAMMEN & BERGENDOFF

CONSULTING ENGINEERS

TABLE I - DISCHARGE DATA

LOCATION	MEAN ANNUAL FLOOD	DRAINAGE AREA (SQ. MI.)	MAIN CHANNEL SLOPE (FT./MI.)	TRIBUTARY CHANNEL SLOPE (FT./MI.)	WEIGHTED BASIN SLOPE (FT./MI.)	BASIN COEFFICIENT	COMPUTED MEAN ANNUAL FLOOD	7 TIMES MEAN ANNUAL FLOOD
			(DERBY - ANSONIA)					
			CONSIDERING THOMASTON DAM					
AT CONFLUENCE WITH HOUSATONIC	*	215.4	15.7	48.8	32.25	0.85	5905	41,340
			NOT CONBIDERING THOMASTON DAM					
AT CONFLUENCE WITH HOUSATONIC	*	309.9	15.5	57.9	36.7	0.85	9670	67,690

* NOT AVAILABLE

THE DESIGN FLOOD FOR 7 TIMES THE MEAN ANNUAL FLOOD AS IT WOULD BE REDUCED BY THE THOMASTON DAM WAS COMPARED WITH THE EFFECT THAT THOMASTON DAM WOULD HAVE HAD ON PAST FLOODS AND ON THE U.S. CORPS OF ENGINEERS TYPICAL TRIBUTARY CONTRIBUTION FLOOD (TTCF). THIS COMPARISON IS SHOWN IN TABLE II BELOW. REFERENCE IS MADE TO VOLUME 3, "REFERENCE DATA", OF THE REPORT "THE RESOURCES OF THE NEW ENGLAND - NEW YORK REGION", BY THE NEW ENGLAND - NEW YORK INTER-AGENCY COMMITTEE FOR THE DATA FROM WHICH THIS COMPARISON WAS MADE.

TABLE II

COMPARISON OF FLOW REDUCTION AT CONFLUENCE WITH HOUSATONIC RIVER CAUSED BY THOMASTON DAM

FLOOD	DISCHARGE CFS	DISCHARGE REDUCED BY THOMASTON DAM	% REDUCTION
7 X MEAN ANNUAL	67,690	41,370	38.9
SEPT. 1938	26,000	16,300	37.3
JAN. 1949	32,700	21,800	33.4
JUNE 1952	9,200	5,900	35.9
TTCF	32,200	22,200	31.1

BASED UPON THIS COMPARISON, IT IS CONSIDERED THAT THE DESIGN FLOOD BELOW THOMASTON DAM IS SUBSTANTIALLY CORRECT.

THE ACTUAL FLOW USED IN DETERMINING THE WATER SURFACE PROFILE THROUGH THIS SECTION IS 41,300 CFS.

3. DETERMINATION OF WATER SURFACE PROFILE: -- A. GENERAL HYDRAULIC THEORY: THE STANDARD STEP METHOD OF BACKWATER COMPUTATION USING BERNOULLI'S THEOREM WAS USED IN DEVELOPING THE WATER SURFACE PROFILE FOR ESTABLISHING STREAM ENCROACHMENT LINES FOR THE TOWNS OF DERBY-ANSONIA. THIS THEOREM SIMPLY STATED IS: THE SUM OF THE WATER SURFACE ELEVATION AND

TABLE IV

DERBY-ANSONIA SECTION -- ROUGHNESS COEFFICIENTS USED IN BACKWATER COMPUTATIONS

SECTION	RIVER STATION	VALUE OF N	
		MAIN CHANNEL	OVERBANK
D-1	10+00	.035	.045
D-2 (NEW HAVEN RAILROAD BRIDGE)	12+15	.035	.045
D-3	15+71	.035	
D-4	22+38	.035	
D-5 (MAIN ST. BRIDGE)	23+72		
D-6	26+06	.035	
D-7	31+60	.045	
D-8	38+40	.045	
D-9	43+00	.045	
D-10	50+35	.035	
D-11	57+88	.035	
D-12	62+25	.035	
D-13	66+85	.035	
D-14 (DIVISION STREET)	68+10		
A-1	71+85		
A-2	74+30	.035	
A-3	80+55	.040	
A-4	84+42	.040	
A-5	90+30	.040	
A-6	95+35	.040	

TABLE IV (CONT'D)

SECTION	RIVER STATION	VALUE OF N: MAIN CHANNEL	VALUE OF N: OVERBANK
A-7	98+00	.040	
A-8	101+80	.040	
A-9 (NEW HAVEN RAILROAD BRIDGE)	103+00		
A-10	105+05	.035	
A-11	109+00	.035	
A-12 (BRIDGE ST. BRIDGE)	110+10		
A-13	111+90	.035	
A-14	117+30	.040	
A-15	122+20	.035	
A-16	126+05	.035	
A-17 (PROPOSED MAPLE ST. BRIDGE)	126+80	.035	
A-18	128+10	.035	
A-19	131+15	.035	
A-20	135+35	.035	
A-21	139+65	.035	
A-22 (AMERICAN BRASS CO. BRIDGE)	140+60	.035	
A-23	142+40	.035	
A-24	151+90	.035	
A-25	158+00	.035	
A-26	166+05	.035	
A-27	174+15	.035	
A-28	184+60	.035	

CROSS-SECTION. THESE CURVES ARE A PART OF THE ACCOMPANYING DATA FOR THIS REPORT.

D. STARTING ELEVATION: BECAUSE OF THE CONDITIONS PREVALENT AT THE LOWER END OF THIS REACH JUST ABOVE THE CONFLUENCE WITH THE HOUSATONIC, IT IS DIFFICULT TO OBTAIN A DEFINITE STARTING ELEVATION FOR THIS SECTION OF THE NAUGATUCK RIVER. THESE CONDITIONS CONSIST OF:

1. EXTREMELY WIDE AND FLAT CROSS SECTIONS.
2. TWO BRIDGES CAUSING CONSIDERABLE CONSTRICTION TO THE WIDE FLAT CROSS SECTIONS.
3. AN INDEFINITE AMOUNT OF EXCAVATION NOW BEING DONE IN THIS VICINITY.
4. TIDAL FLUCTUATION.

HOWEVER, USING VARIOUS SLOPES AND ROUGHNESS FACTORS, SEVERAL NORMAL DEPTH COMPUTATIONS WERE MADE. THESE INDICATED THAT THE NORMAL DEPTH AT THE INITIAL CROSS SECTION LIES BETWEEN 16.0 FEET M.S.L. AND 18.0 FEET M.S.L. IT IS THIS FIRM'S CONSIDERED OPINION THAT TO SET STREAM ENCROACHMENT LINES THAT ARE COMMENSURATE WITH THE WORK DONE ON OTHER SECTIONS OF THE NAUGATUCK RIVER THAT BANK-FUL STAGE CONDITIONS OUGHT TO BE MET. THE 18.0 FEET M.S.L. NORMAL DEPTH MEETS THESE CONDITIONS AT THE STARTING POINT AND UPSTREAM AS WELL. CONSEQUENTLY, AN ELEVATION OF 18.0 FEET WAS USED AS THE STARTING ELEVATION.

*

TO VERIFY THIS ELEVATION AS BEING REASONABLE AND ESSENTIALLY CORRECT, A SECOND BACKWATER COMPUTATION WAS ACCOMPLISHED USING 17.0 FEET AS A STARTING ELEVATION. THE COMPUTATION CONVERGED WITH THAT FOR 18.0 FEET AT APPROXIMATELY 6,000 FEET UPSTREAM FROM THE INITIAL POINT.

E. Computations for determination of the water surface profile started at Cross-section D-1 at elevation 18.0 feet and proceeded upstream. Overbank was considered at all cross-sections and disregarded at those cross-sections where the discharge for overbank was less than 10% of the total discharge. Backwater computations are shown in Table V.

Given below are other considerations accounted for in the computation.

1. The New Haven Railroad Bridge at Cross-section D-2 was analyzed as a submerged orifice using a value of C of 0.70. The use of the orifice formula is explained in Part I of this report.

The available waterway area used in determining the loss of head at this bridge is made up of two parts: the total area under the main bridge, and one-half the total area under the approach trestle on the westerly side of the bridge. The factor of one-half was used to account for the loss in effective area from the closely spaced pile bents. The computation for the head loss at this bridge is shown in Table VI.

2. Main Street or Highway 34 Bridge at Cross-section D-5 in Derby was analyzed using D'Aubuisson's Formula with a K value of 0.85. Explanation of this formula is found in Part I of this report.

The computation for this bridge is shown as Table VII.

3. Between Cross-sections D-10 and D-11 on the southwest side at the channel a recently constructed levee constricts the channel. The assumption was made for computation for the water surface profile that this levee is straightened in such a manner as to make the channel capacity commensurate with the capacity upstream and downstream. This constriction is shown on Plate 3.

TABLE V

BACKWATER COMPUTATIONS FOR NAUGATUCK RIVER THROUGH TOWNS OF DERBY AND ANSONIA

SECTION	STATION	REACH LENGTH L	ASSUMED W.S.EL.	AREA A	CONVEYANCE K	N	K/N = K'	SLOPE (Q/K)² = S	AVERAGE SLOPE S AVG.	SAVG L = H_F	K'S½ = Q	V	V²Q	V² AVG.	$\frac{V^2}{2G} = HV$	$HV_1 - HV_2$	OTHER LOSSES	TOTAL HEAD	ENERGY GRADIENT	COMPUTED W.S.EL.
																			18.50	18.0*
	10+00		18.0*	5190	44,000	.035	1,257,000				31,600	6.09	1,171,400							
			**	2500	17,250	.045	383,300				9,700	3.88	146,000							
							1,640,300	.000632			41,300		1,317,400	31.9	.50	- .18		- .04		
		215							.000660	.14		6.62		43.9	.68				18.64	17.96
D-2+	12+15		18.0	6235	55,130	.035	1,575,000	.000687									1.30			
		NEW HAVEN RAILROAD BRIDGE: SEE P. 24 FOR DETERMINATION OF THIS LOSS.										6.10		37.2	.58				19.84	19.26
D-2++	12+15		19.3	6770	63,100	.035	1,803,000	.000525								.02		.21		
		356							.000542	.19		6.00		36.0	.56				20.03	19.47
D-3	15+71		19.5	6880	61,200	.035	1,749,000	.000558								- .14		.26		
		667							.000600	.40		6.73		45.2	.70				20.43	19.73
D-4	22+38		19.7	6140	57,000	.035	1,628,570	.000643								- .54	.11	- .33		
		109							.000876	.10		8.94		79.9	1.24				20.64	19.40
D-5++	23+47		19.4	4620	43,300	.035	1,237,000	.00111									1.87			
	23+72	MAIN STREET BRIDGE: SEE P. 25 FOR DETERMINATION OF THIS LOSS.										8.04		64.6	1.00				22.27	21.27
D-5x	23+97		21.3	5140	51,400	.035	1,465,000	.000792								- .29		- .08		
		209							.000986	.21		9.11		82.9	1.29				22.48	21.19
D-6	26+06		21.2	4535	42,100	.035	1,202,800	.00118								.90		1.40		
		554							.000897	.50		5.01		25.1	.39				22.98	22.59
D-7	31+60		22.6	8250	75,000	.045	1,667,000	.000614								.23		.51		
		680							.000418	.28		3.24		10.5	.16				23.26	23.10
D-8	38+40		23.1	12750	124,500	.045	2,766,700	.000223								.01		.11		
		460							.000213	.10		3.07		9.4	.15				23.36	23.21
D-9	43+00		23.2	13450	130,500	.045	2,900,000	.000203								- .89	.18	- .21		
		735							.000677	.50		8.19		67.1	1.04				24.04	23.00
D-10	50+35		23.0	5040	42,600	.035	1,217,000	.00115								.36		1.01		
		753							.000861	.65		6.61		43.7	.68				24.69	24.01
D-11	57+88		24.0	6245	60,500	.035	1,728,600	.000571								-1.69	.34	- .75		
		437							.00137	.60		12.35		152.4	2.37				25.63	23.26
* D-12	62+25		23.3	3345	31,000	.035	885,700	.00217	.00170	.78						.97		1.75		
		460										9.51		90.3	1.40				26.41	25.01
D-13	66+85		25.0	4345	41,100	.035	1,174,000	.00124	.00152	.14						- .13		.01		
		95										9.93		98.6	1.53				26.55	25.02
D-14xx	67+80		25.0	4160	34,200	.035	977,000	.00179									1.77			
		DIVISION STREET BRIDGE: SEE P. 26 FOR DETERMINATION OF THIS LOSS.										8.86		78.5	1.22				28.01	26.79
D-14#	68+20		26.8	4660	39,000	.035	1,114,000	.00137								.38		.76		
		365							.00103	.38									28.39	27.55
A-1	71+85		27.5	5080	51,200	.035	1,463,000				38,520	7.58	2,215,000							
				835	4,750	.045	105,600				2,780	3.33	30,800							
							1,568,600	.000693			41,300		2,245,600	54.4	.84					
		245							.000781	.13						.03		.22		
A-2	74+30		27.8	5740	49,000	.035	1,400,000	.000870				7.20		51.9	.81	.64		.99	28.58	27.77
		625							.000557	.35										

* SEE P. 17 FOR DETERMINATION OF THIS STARTING ELEVATION.
** OVERBANK: 250' AT AVERAGE BOTTOM ELEV. 8.0' M.S.L.
\+ CROSS-SECTION D-2 WITHOUT NEW HAVEN RAILROAD BRIDGE.
++ CROSS-SECTION D-5 WITHOUT MAIN STREET BRIDGE USED AT DOWNSTREAM FACE OF THE BRIDGE.
x CROSS-SECTION D-5 WITHOUT MAIN STREET BRIDGE USED AT UPSTREAM FACE OF BRIDGE.
xx CROSS-SECTION D-14 USED AT DOWNSTREAM FACE OF PROPOSED DIVISION STREET BRIDGE.
\# CROSS-SECTION D-14 USED AT UPSTREAM FACE OF PROPOSED DIVISION STREET BRIDGE.

TABLE V

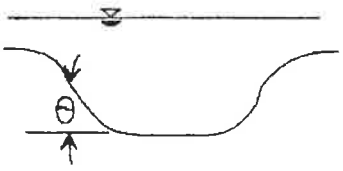
BACKWATER COMPUTATIONS FOR NAUGATUCK RIVER THROUGH TOWNS OF DERBY AND ANSONIA

SECTION	STATION	REACH LENGTH L	ASSUMED W.S.EL.	AREA A	CONVEYANCE K	N	K/N = K'	SLOPE $(Q/K)^2$ = S	AVERAGE SLOPE S AVG.	SAVG L = H_f	K'S½ = Q	V	V^2Q	V^2 AVG.	$\frac{V^2}{2G} = HV$	HV 1 - HV 2	OTHER LOSSES	TOTAL HEAD	ENERGY GRADIENT	COMPUTED W.S.EL.
A-3	80+55		28.8	12,350	105,500	.040	2,640,000	.000245				3.34		11.2	.17				28.93	28.76
		387							.000281	.11						- .04		.07		
A-4	84+42		28.8	11,300	93,000	.040	2,320,000	.000317				3.65		13.3	.21				29.04	28.83
		588							.000395	.23						- .07		.16		
A-5	90+30		28.9	9,650	76,000	.040	1,900,000	.000474				4.28		18.3	.28				29.27	28.99
		505							.000332	.17						.13		.30		
A-6	95+35		29.3	13,250	119,500	.040	2,980,000	.000191				3.12		9.8	.15				29.44	29.29
		265							.000226	.06						- .06		0		
A-7	98+00		29.3	11,200	102,000	.040	2,550,000	.000262				3.68		13.6	.21				29.50	29.29
		380							.000823	.31						- .54	.11	- .12		
A-8	101+80		29.1	5,950	44,400	.040	1,110,000	.001384				6.94		48.2	.75				29.92	29.17
A-12	110+10	NEW HAVEN RAILROAD BRIDGE: SEE P. 27 FOR DETERMINATION OF THIS LOSS															2.33			
A-13+	110+70	BRIDGE STREET BRIDGE: SEE P. 28 FOR DETERMINATION OF THIS LOSS															.58			31.50*
		660	32.1	5,520	51,000	.035	1,460,000	.000801				7.48		56.0	.87				32.95	32.08
A-14	117+30		32.7	5,360	43,200	.040	1,080,000	.001460	.001130	.75						- .05		.70		
		490										7.70		59.4	.92				33.70	32.78
A-15	122+20		33.2	4,820	42,200	.035	1,207,000	.001172	.001316	.64						- .22		.42		
		385										8.56		73.3	1.14				34.34	33.20
A-16	126+05		33.2	4,200	39,400	.035	1,126,000	.001348	.001260	.49						- .36		.13		
		75										9.83		96.6	1.50				34.83	33.33
A-17	126+80		32.7	3,380	31,200	.035	891,000	.002150	.001749	.13						- .82	.16	- .53		
		MAPLE STREET BRIDGE: ASSUMED LOSS IS										12.20		149.0	2.32				35.12	32.80
A-17	126+80		33.7	3,600	34,100	.035	974,000	.001800									1.00			
		130										11.48		132.0	2.05				35.85	33.80
A-18	128+10		33.3	2,950	24,000	.035	685,000	.003640	.002720	.35						- .99	.20	- .44		
		305										14.00		196.0	3.04				36.40	33.36
A-19	131+15		35.6	4,200	40,800	.035	1,165,000	.001254	.002447	.75						1.54	.15	2.44		
		420										9.83		96.6	1.50				37.30	35.80
A-20	135+35		36.0	3,740	34,800	.035	995,000	.001724	.001489	.63						- .40		.23		
		430										11.05		122.1	1.90				37.93	36.03
A-21	139+65		36.6	3,760	38,200	.035	1,091,000	.001430	.001577	.68						.02		.70		
		85										10.99		121.0	1.88				38.61	36.73
#	140+50		36.8	3,760	38,200	.035	1,091,000	.001430	.001430	.12						0		.12		
		AMERICAN BRASS COMPANY BRIDGE: SEE P. 29 FOR DETERMINATION OF THIS LOSS.										10.99		121.0	1.88				38.73	36.85
#	140+70		39.0	4,230	45,600	.035	1,305,000	.001000									2.15			
		170										9.76		95.4	1.48				40.48	39.00
A-23	142+40		39.5	4,910	46,900	.035	1,340,000	.000950	.000975	.16						.38		.54		
		950										8.40		70.5	1.10				40.64	39.54
A-24	151+90		40.2	4,160	39,000	.035	1,114,000	.001380	.001165	1.11						- .43		.68		
												9.92		98.5	1.53				41.75	40.22

* UPSTREAM WATER AT NEW HAVEN RAILROAD BRIDGE IS DOWNSTREAM WATER SURFACE FOR BRIDGE STREET BRIDGE.

\+ ~~CROSS-SECTION A-13 MOVED TO UPSTREAM FACE OF BRIDGE STREET BRIDGE.~~

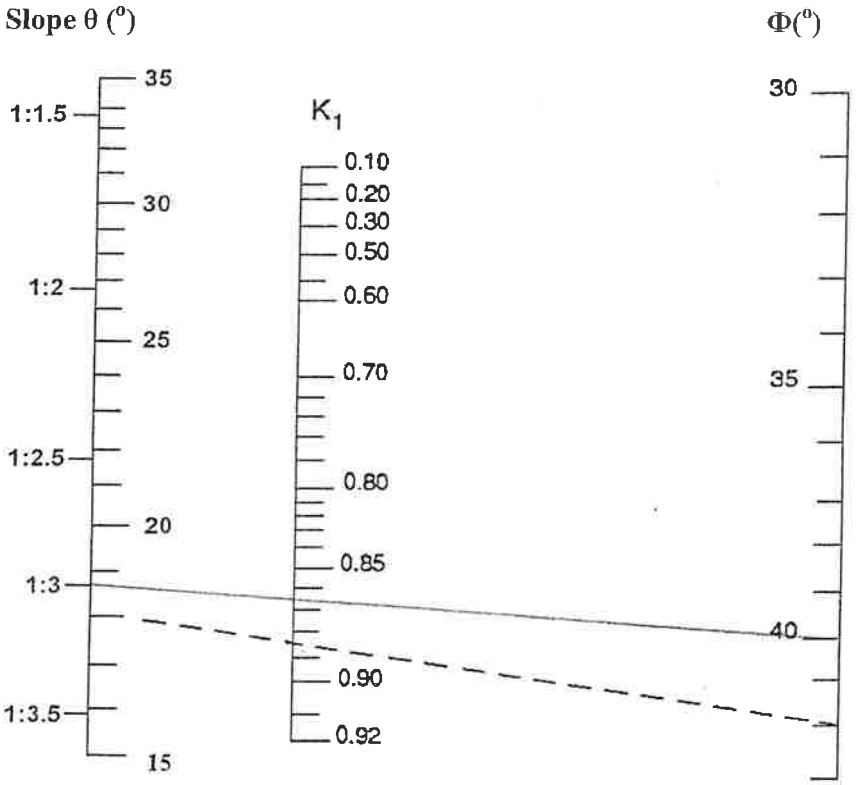
\# CROSS-SECTION AT AMERICAN BRASS COMPANY BRIDGE WITHOUT BRIDGE.



$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\Phi}\right]^{0.5}$$

θ = Bank angle with horizontal

θ =Bank angle with horizontal
Φ = Material angle of repose
See Figure 7-27 or 7-27.1



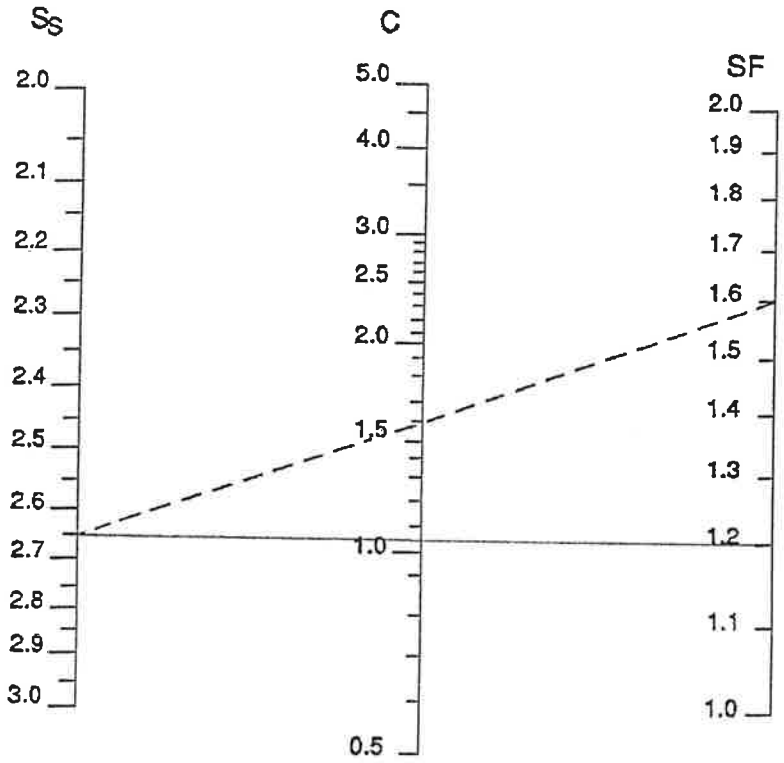
Example

Given:	Find:	Solution:
θ = 18°	K_1	Φ = 42°
Very angular		K_1 = 0.885
D_{50} = 457 mm (1.5 ft)		

Figure 7-26 Bank Angle Correction Factor (K_1) Nomograph

$$C=1.61SF^{1.5}/(S_S-1)^{1.5}$$

CORR=D_{50}CORRECTION FACTOR
SF = STABILITY FACTOR
S_S= SPECIFIC GRAVITY OF ROCK



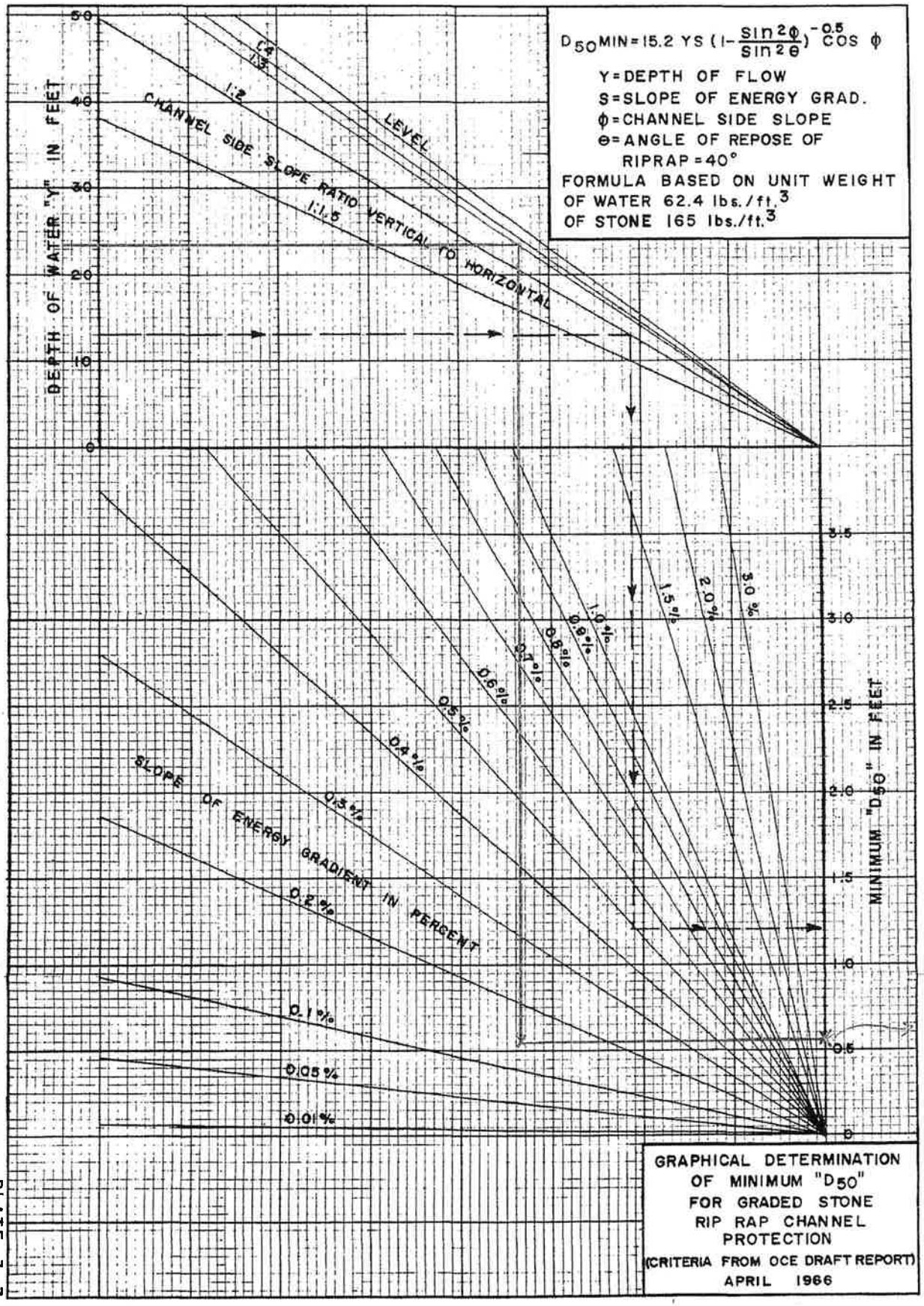
Example:

Given:	Find:	Solution:
S_S=2.65	C	C=1.59
SF= 1.60		

Figure 7-28 Correction Factor For Riprap Size (metric or English)

Naugatuck River

17/18



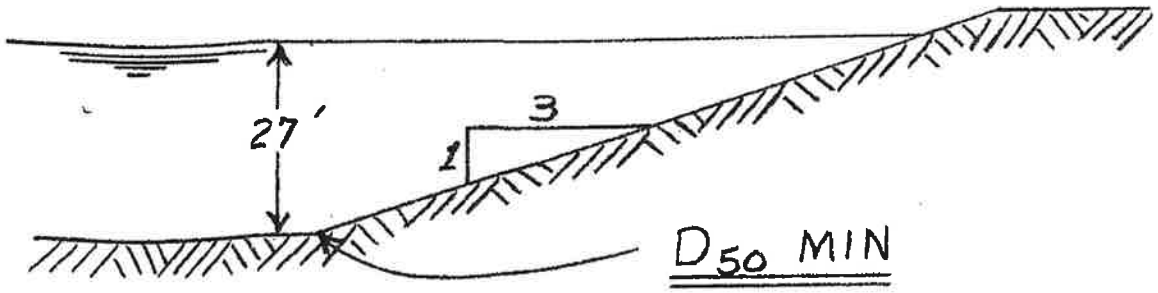
$d_{50} = 0.55 ft$

GRAPHICAL DETERMINATION OF MINIMUM "D_{50}" FOR GRADED STONE RIP RAP CHANNEL PROTECTION
(CRITERIA FROM OCE DRAFT REPORT)
APRIL 1966

PLATE 3-7

SUBJECT DERBY L.P.P.
COMPUTATION STONE RIPRAP DESIGN - D_{50} MIN'S
COMPUTED BY PLM CHECKED BY DATE 11-7-67

TYPICAL SECTION NAUGATUCK RIVER



D_{50} MIN

Y = 27.0'

SIDE SLOPE = 1 ON 3

V = 12 '/sec.

n = 0.035

S = 0.001

D_{50} MIN = 0.5 Feet (Intermediate Riprap)

PLATE 3-10

Stone Riprap Size Evaluation

Housatonic River

Engineering,
Landscape Architecture
and Environmental Science

MILONE & MACBROOM®
99 Realty Drive
Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB Derby / Ansonia - Levee Construction (1560-119)
SHEET NO. 1 OF 10
CALCULATED BY FAB DATE 11/19/10
CHECKED BY EAH DATE 11/19/10
SCALE Scour Analysis - Embankment Protection

Housatonic River

- Using data found in the report "Design Memorandum 3: Hydraulic Analysis and Riprap Design", by Army Corps of Engineers, dated April 1968.

V = 17 ft/s
s = 0.0018 ft/ft
n = 0.035
Side slope = 3:1
d = ± 32 ft

- Verify velocity:

$V = \frac{1.49}{n} \times R^{2/3} \times S^{1/2}$, R = hydraulic radius = depth of flow (ft)
S = channel slope (ft/ft)

$V = \frac{1.49}{0.035} \times 32^{2/3} \times 0.0018^{1/2} = 18.16 \text{ ft/s} \approx 18 \text{ ft/s}$

- FEMA FIS for New Haven County, effective 12/17/2010

- Depth of flow at base flood (1% annual chance flood)

± 21 feet @ D/s railroad (Section J)
0.0008 ft/ft slope, mean velocity of floodway = 10.2 ft/s

⇒ As a conservative approach, the information from "Design Memorandum 3" was used in the computations.

1) Velocity Approach:

$D_{50} = \frac{0.001 \times 17^3}{32^{1/2} \times 0.866} = 1.0 \text{ feet}$

C = 1.05
$D_{50} = 1 \times 1.05 = 1.05 \text{ feet}$ (standard riprap) ◄

Engineering,
Landscape Architecture
and Environmental Science

MILONE & MACBROOM®
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Cheshire, Connecticut 06410
(203) 271-1773 Fax (203) 272-9733

JOB Derby / Ansonia - Levee Certification (1560-113)
SHEET NO. 2 OF 10
CALCULATED BY EAB DATE 11/13/10
CHECKED BY EAH DATE 11/13/10
SCALE Scour Analysis - Embankment Protect

2) Shear Stress Approach.

$\tau = 62.4 \times 32 \times 0.0018$

$\tau = 3.59 \text{ lb/ft}^2$

$D_{50} = 3.59/5 = 0.72 \text{ ft}$ (standard riprap) ◄

3) Graphical Approach

from attached graph (Page 6)

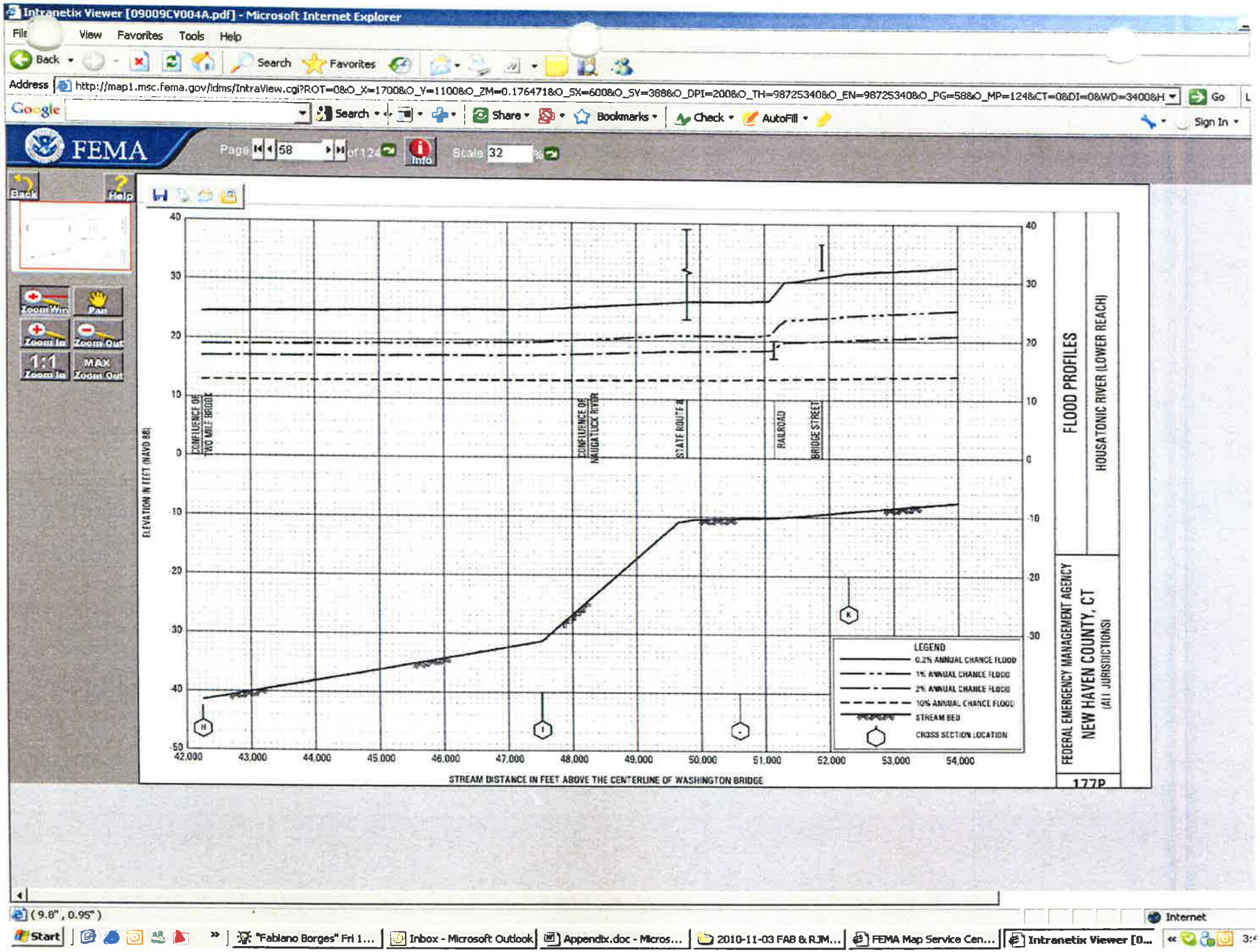
$D_{50} = 0.8 \text{ ft}$ (standard riprap) ◄






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Intranetix Viewer [09009CV004A.pdf] - Microsoft Internet Explorer
FEMA
Page 58 of 124
Scale 32
FLOOD PROFILES
HOUSATONIC RIVER (LOWER REACH)
FEDERAL EMERGENCY MANAGEMENT AGENCY
NEW HAVEN COUNTY, CT
(ALL JURISDICTIONS)
177P
ELEVATION IN FEET (NAVD 88)
STREAM DISTANCE IN FEET ABOVE THE CENTERLINE OF WASHINGTON BRIDGE
CONFLUENCE OF TWO MILE BROOK
CONFLUENCE OF NAUGATUCK RIVER
STATE ROUTE 8
RAILROAD
BRIDGE STREET
LEGEND
0.2% ANNUAL CHANCE FLOOD
1% ANNUAL CHANCE FLOOD
2% ANNUAL CHANCE FLOOD
10% ANNUAL CHANCE FLOOD
STREAM BED
CROSS SECTION LOCATION

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
Housatonic River (Lower Reach)								
A	6,920	2,500	26,819	6.3	9.8	9.0	9.0	0.0
B	9,500	1,483	22,940	7.3	10.2	10.2	10.2	0.0
C	12,080	1,187	19,889	8.4	10.9	10.9	10.9	0.0
D	14,660	1,426	27,318	6.1	11.6	11.6	11.9	0.3
E	17,240	1,201	18,330	9.2	11.9	11.9	12.0	0.1
F	19,820	1,021	20,232	8.3	12.6	12.6	12.8	0.2
G	22,400	987	15,488	10.9	13.6	13.6	13.6	0.0
H	42,250	671	25,037	6.6	19.0	19.0	19.9	0.9
I	47,530	552	18,999	8.9	19.7	19.7	20.6	0.9
* J	50,500	683	12,706	10.2	20.7	20.7	21.6	0.9
K	52,300	526	13,981	9.3	24.3	24.3	25.2	0.9
L	60,200	456	13,231	9.8	35.7	35.7	36.1	0.4
M	63,480	600	17,440	7.5	38.1	38.1	38.9	0.8
N	66,250	679	18,346	7.1	39.5	39.5	40.3	0.8
O	73,750	700	18,087	7.2	43.0	43.0	44.0	1.0
P	81,760	644	1,548	8.4	49.0	49.0	50.0	1.0
Q	84,120	436	1,189	10.9	52.5	52.5	53.2	0.7
R	85,560	310	8,600	15.1	54.8	54.8	55.5	0.7

[1]Stream distance in feet from the centerline of Washington Bridge
[2]This width extends beyond county boundary

TABLE 14

FEDERAL EMERGENCY MANAGEMENT AGENCY

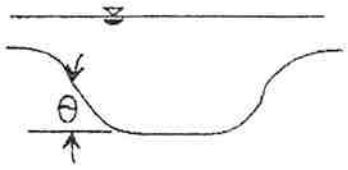
NEW HAVEN COUNTY, CT (ALL JURISDICTIONS)

FLOODWAY DATA

HOUSATONIC RIVER (LOWER REACH)

6/10

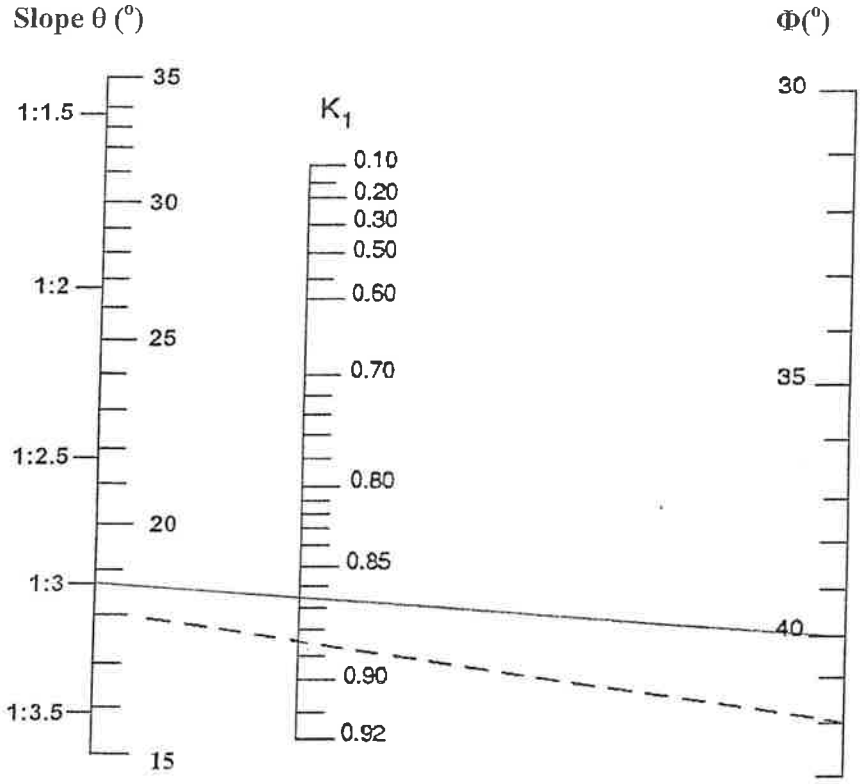
7/10



$$K_1 = \left[1 - \frac{\sin^2\theta}{\sin^2\Phi}\right]^{0.5}$$

θ = Bank angle with horizontal

θ =Bank angle with horizontal
Φ = Material angle of repose
See Figure 7-27 or 7-27.1



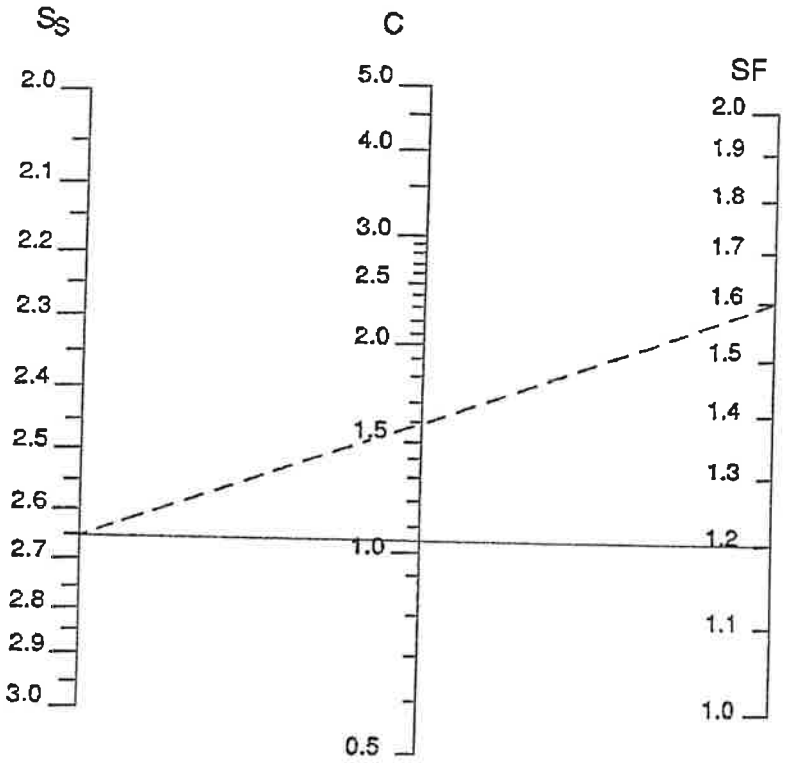
Example

Given:	Find:	Solution:
θ = 18°	K_1	Φ = 42°
Very angular		K_1 = 0.885
D_{50} = 457 mm (1.5 ft)		

Figure 7-26 Bank Angle Correction Factor (K_1) Nomograph

$$C=1.61SF^{1.5}/(S_S-1)^{1.5}$$

CORR=D_{50}CORRECTION FACTOR
SF = STABILITY FACTOR
S_S= SPECIFIC GRAVITY OF ROCK



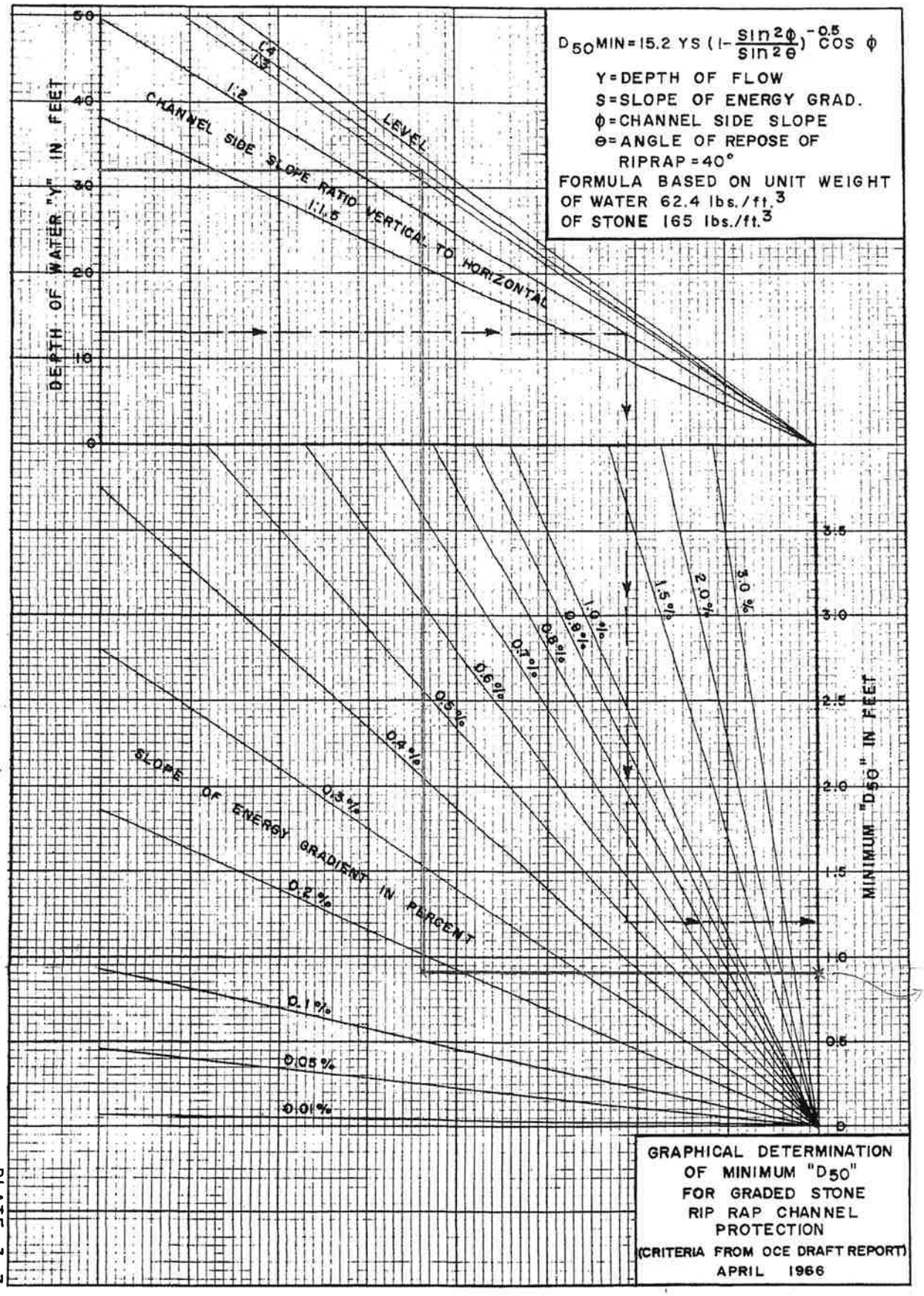
Example:

Given:	Find:	Solution:
S_S=2.65	C	C=1.59
SF= 1.60		

Figure 7-28 Correction Factor For Riprap Size (metric or English)

Housatonic River

9/30



$d_{50} = 0.9$ ft

PLATE 3-7

NED FORM 223
Rev Sept 49

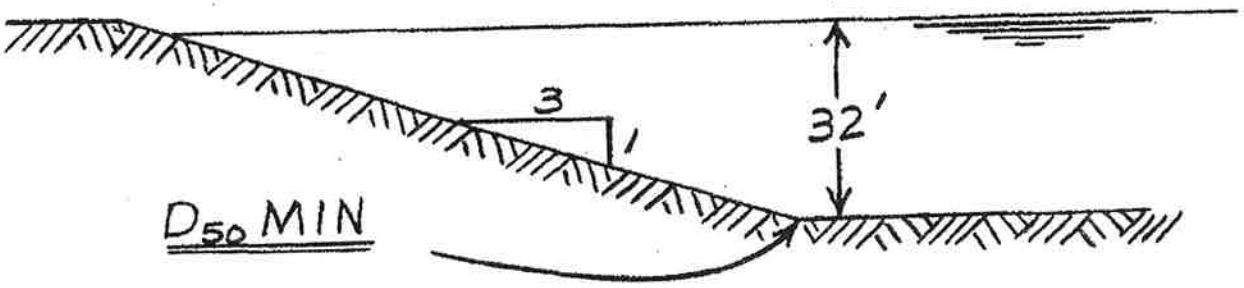
NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

PAGE

SUBJECT DERBY L.P.P.
COMPUTATION STONE RIPRAP DESIGN
COMPUTED BY PLM CHECKED BY DATE 11-7-67

10/10

HOUSATONIC RIVER
TYPICAL SECTION #2



Y = 32.0 FeeT
SIDE SLOPE = 1 on 3
V = 17 '/sec.
n = 0.035
S = 0.0018

D_{50} MIN = 0.9 FeeT (Standard Riprap)

PLATE 3-9