9601 1989

WAYNE Co.
1989

CF
FAC
WAYNE C
PLOMIT

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
P.O. Box 27687 · Raleigh, North Carolina 27611-7687

James G. Martin, Governor
William W. Cobey, Jr., Secretary

William L. Meyer
Director

December 6, 1989

Mr. Jim Woodie
Municipal Engineering Services Co., P.A.
P.O. Box 97
Garner, NC 27529

RE: Completeness Review - Wayne County Landfill, Amendment to Permit #96-01.

Dear Mr. Woodie:

The Solid Waste Section has conducted a preliminary review of the referenced project. In accordance with the N.C. Solid Waste Management Rules and the corresponding guidelines outlined in the "Design Requirements for Vertical Expansions of Existing Sanitary Landfills" document, the following information/revisions are required to continue the review process:

(1) .0504 (2)(a) - Drawing number 2 of 8 (topography map) needs to show the following:

Potential/Existing ground-water monitoring sites.

The monitoring well system needs to be reviewed to see if in compliance with regulations. For further information, please contact Bobby Lutfy (N.C. Solid Waste Hydrogeologist). At present, no monitoring wells are are shown on plan.

(2) .0504 (2)(d) - The Erosion Control Plan needs to note difference between permanent and temporary measures. Location of silt fence not shown on plan (borrow area also needs to be addressed).

(3) .0504 (2)(g) - Site Development:

(I) Show sequence of filling operations denoted by area (i.e., area #1, 2, etc.). Area #1 can be used as example for silt fence and temporary erosion control measures.

(II) Show progression of fill and borrow areas.

(III) Develop plan to minimize active working area (fill & borrow) to insure proper seeding on inactive areas.

(IV) Borrow area to be permanently seeded at completion of usage.

(4) .0504 (2)(h) - A written report containing the following:

(I) A copy of the deed description - if borrow area not included in deed, a Mining Permit must be issued by the Land Quality Section.

(II) Anticipated lifetime of project needs to be recalculated *(see below).

(III) Description of systematic usage of area, operation, orderly development and completion of sanitary landfill.

(IV) Earthwork calculations - Determination of availability and adequacy of soils for final and daily cover *(see below).

(V) A plan to utilize least permeable soil for final cover *(see below).

No more than two feet of soil can be removed from existing landfill cover. Final cover soil should be taken from proposed borrow area as permeability results show acceptable soil (not from existing cover). The removal of soil from the existing cover should be done in sequence with vertical development to protect existing site.

.0504 (1)(g)(iii) - Equipment

Equipment needs should be reevaluated. A Rex 350 Compactor and D6H Caterpillar Dozer are not sufficient for the proper removal of soil from the existing cover and borrow area - unless carried out in a haphazard manner.

These comments are intended to expedite the review of the application, and in no way do they restrict the Section's right to request additional information following the technical review process.

As per our phone conversation, please forward a revised copy of the plan and report to Land Quality at the following address:

Pat McClean
1502 North Market Street
P.O. Box 1507
Washington, NC 27889

If there are any questions, or you would like to schedule a meeting to discuss the application, please contact our office at (919) 733-0692.

Sincerely,

James C. Coffey

James C. Coffey, Supervisor
Technical Operations Branch
Solid Waste Section

JCC/mj

cc: Suzanne Molloy

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
P.O. Box 27687 · Raleigh, North Carolina 27611-7687

James G. Martin, Governor
William W. Cobey, Jr., Secretary

William L. Meyer
Director

December 1, 1989

Mr. W. Wyman Yelton
County of Wayne
Box 227
Greensboro, NC 27530

RE: Acknowledgement of Receipt Wayne County Vertical Expansion, Amendment to Permit #96-01.

Dear Mr. Yelton:

On December 1, 1989, the Solid Waste Section received the referenced application. The Section is currently analyzing the application for completeness. The Section will acknowledge receipt of a complete application.

Respectfully,

James C. Coffey

James C. Coffey, Supervisor
Technical Operations Branch
Solid Waste Section

JCC/mj

cc: Jeffrey L. Beehler
Municipal Engineering
P.O. Box 97
Garner, NC 27529

Susan Molloy

State of North Carolina
Department of Environment, Health, and Natural Resources
Division of Solid Waste Management
P.O. Box 27687 · Raleigh, North Carolina 27611-7687

James G. Martin, Governor
William W. Cobey, Jr., Secretary

William L. Meyer
Director

October 9, 1989

Mr. Will R. Sullivan, County Manager
County of Wayne
Box 227
Goldsboro, NC 27530

RE: Acknowledgement of Receipt - Wayne County Vertical Expansion, Amendment to Permit

Dear Mr. Sullivan:

On October 6, 1989, the Solid Waste Section received the referenced application. The Section is currently analyzing the application for completeness. The Section will acknowledge receipt of a complete application.

Respectfully,

James C Coffey

James C. Coffey
Environmental Supervisor
Solid Waste Section
Solid Waste Management Division

JCC/mj

cc: Municpal Engineering

PERMEABILITY TEST RESULTS
WAYNE COUNTY LANDFILL

Boring	Permeability (cm/sec)	Dry Density (pcf)
2	2.8×10^{-6}	118.1
3	2.3×10^{-6}	109.8
5	1.5×10^{-7}	106.3

E.M.A. INC. Consulting Engineers

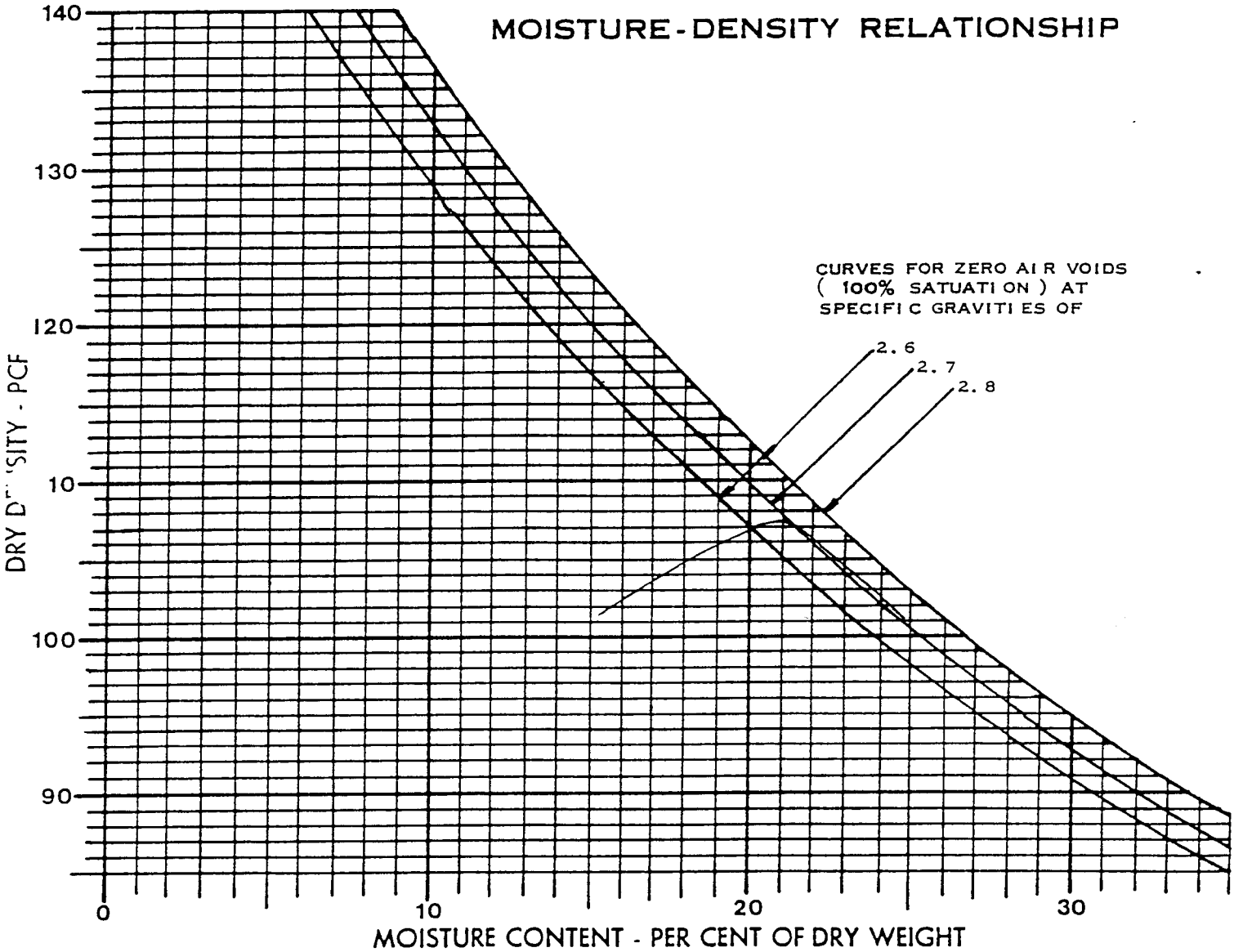
MEMBER A.S.C.E. - OVER 30 YEARS OF PROFESSIONAL ENGINEERING SERVICES
CIVIL, STRUCTURAL, GEOTECHNICAL ENGINEERING • MATERIALS TESTING SERVICES
401 GLENWOOD AVE. • P.O. BOX 12447 • RALEIGH, NC 27605
919/828-0801

client: Municipal Engineering

project: Wayne County Landfill

date: 9-25-89

job number: 89118-05



MOISTURE DENSITY RELATION	METHOD OF TEST	MAX DRY DENSITY PCF	OPTIMUM MOISTURE CONT. %	SOIL DESCRIPTION
1	ASTM D 698 Method A	107.5	21.0	Clayey silt Boring 5

SUBMITTED BY: Tracy Thomas

E.M.A. INC. Consulting Engineers

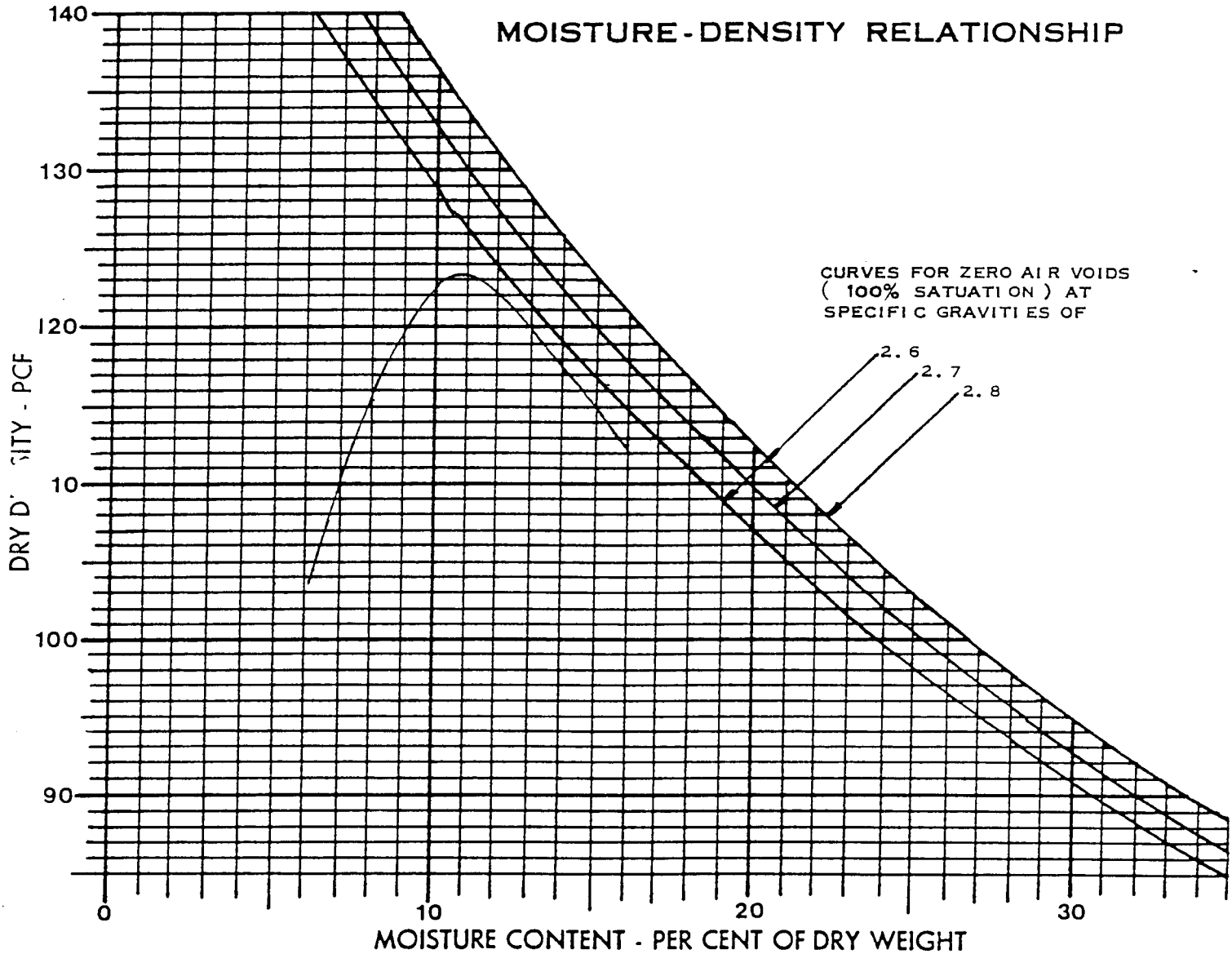
MEMBER A.S.C.E. - OVER 30 YEARS OF PROFESSIONAL ENGINEERING SERVICES
CIVIL, STRUCTURAL, GEOTECHNICAL ENGINEERING • MATERIALS TESTING SERVICES
401 GLENWOOD AVE. • P.O. BOX 12447 • RALEIGH, NC 27605
919/828-0801

client: Municipal Engineering

project: Wayne County Landfill

date: 9-22-89

job number: 89118-05



MOISTURE DENSITY RELATION	METHOD OF TEST	MAX DRY DENSITY PCF	OPTIMUM MOISTURE CONT. %	SOIL DESCRIPTION
2	ASTM D 698 Method A	123.5	10.5	Silty sand Boring 3

SUBMITTED BY: Tracy Thomas

E.M.A. INC. Consulting Engineers

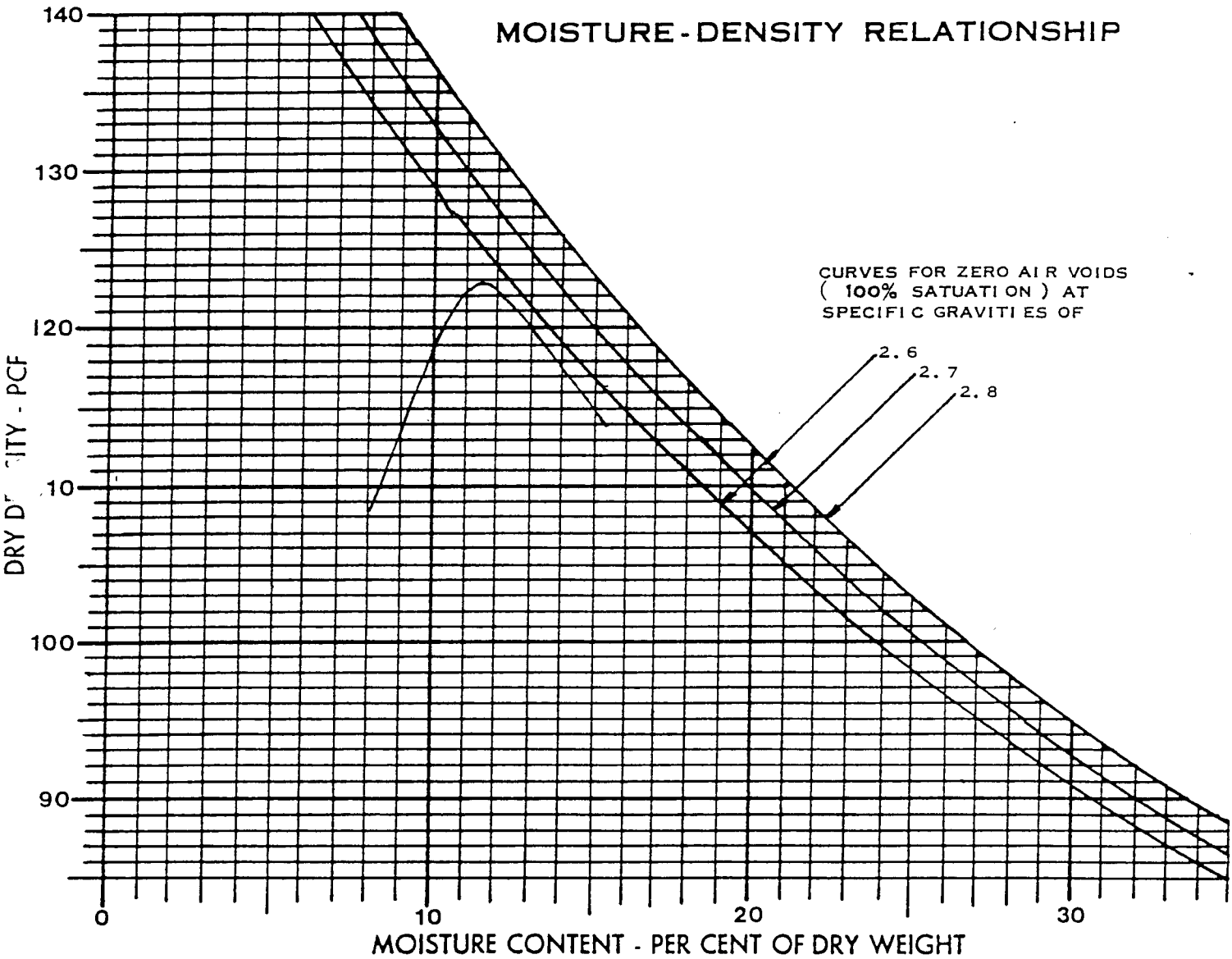
MEMBER A.S.C.E. - OVER 30 YEARS OF PROFESSIONAL ENGINEERING SERVICES
CIVIL, STRUCTURAL, GEOTECHNICAL ENGINEERING • MATERIALS TESTING SERVICES
401 GLENWOOD AVE. • P.O. BOX 12447 • RALEIGH, NC 27605
919/828-0801

client: Municipal Engineering

project: Wayne County Landfill

date: 9-25-89

job number: 89118-05



MOISTURE DENSITY RELATION	METHOD OF TEST	MAX DRY DENSITY PCF	OPTIMUM MOISTURE CONT. %	SOIL DESCRIPTION
3	ASTM D 698 Method A	123.0	11.5%	Clayey Sand Boring 2

SUBMITTED BY: Tracy Thomas

LOG OF BORING NO. 1

PROJECT: TMW'S JOB NO.: 89 118.05

TYPE: FA-AS LOCATION: Golds Bold Land Fill

DATE:

TESTS ASSIGNED BY:
TESTED BY:

DATE:

DRILLED BY:
LOGGED BY:

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL (SURF. EL:)	SAND OR GRAVEL (VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (SATURATED, WET, MOIST, DAMP)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
				MED. SAND										
5														
				FINE SANDY SILT										
10														
				FINE SANDY CLAY										
15														
				CLAYEY FINE SAND										

COMPLETION DEPTH: 18.5' DEPTH TO WATER IN BORING: 16.5'

DATE: 9-15-89

EMA INC.
Consulting Engineers

PLATE

LOG OF BORING NO. 2

PROJECT: TMW's JOB NO.: 89118 OS

TYPE: FA – AS LOCATION: Goldsboro Landfill

DATE:

TESTS ASSIGNED BY:

TESTED BY:

DATE

LOGGED BY:

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL SURF. EL:	SAND OR GRAVEL: VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE SILT OR CLAY: SOFT, FIRM, STIFF, VERY STIFF, HARD	MOISTURE: SATURATED, WET, MOIST, DRY	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
				Med. Sand										
5														
				[illegible]										
10														
				[illegible] Clay										
15														
				Clayed Med Sand										
20														
				[illegible]										
				Bulk Sample										

COMPLETION DEPTH: 18.5 DEPTH TO WATER IN BORING: 14.10'

DATE: 9-15-89

EMA INC.
Consulting Engineers

PLATE

LOG OF BORING NO. 3

PROJECT: [illegible] Well JOB NO.: 89118-05

TYPE: FA — LOCATION: Goldsboro Landfill

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL (SURF. EL:)	SAND OR GRAVEL (VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (SATURATED, WET, MOIST, DAMP)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
				Med Sand										
				" "										
5				Slightly Clayey Med to coarse Sand										
7				" " " " "										
8				[illegible]										
				Slightly clay [illegible] Sand & Gravel										
10														
				" "										
13.5				Well put in at 13.5										
15														
				BULK SAMPLE										

COMPLETION DEPTH: [illegible] DEPTH TO WATER IN BORING: 1[illegible]

DATE: [illegible]-15-[illegible]

EMA INC.
Consulting Engineers

PLATE

DATE:

TESTS ASSIGNED BY:

TESTED BY:

DATE

DRILLED BY:

LOGGED BY:

LOG OF BORING NO. 4

PROJECT: Temporary Monitoring Wells JOB NO.: 89118.05

TYPE: FA LOCATION: Goldsboro [illegible]

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL SURF. EL:	SAND OR GRAVEL (VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (NATURALLY, WET, MOIST, DAMP)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
				[illegible]										
5														
10				" "										
11.5				[illegible] to fine sand										
13.5				Fine sandy silty clay										

COMPLETION DEPTH: 13.5 DEPTH TO WATER IN BORING: 7.6'

DATE: [illegible]

EMA INC.
Consulting Engineers

PLATE

DATE: 9/18/81 TESTS ASSIGNED BY: TESTED BY: DRILLED BY: [illegible] LOGGED BY:

LOG OF BORING NO. 5

PROJECT: Temporary Monitoring Well JOB NO.: 89118 03

TYPE: FA - AS LOCATION: Goldsboro Land Fill

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL (SURF. EL:)	SAND OR GRAVEL (VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (SATURATED, WET, MOIST, DAMP)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
1.5				Med to Fine Sand										
				Slightly Clayed Med to Fine Sand										
5				" " " " "										
6				Fine Sand & Silty Clay	X									
10					X									
11.5				" " " " "	X									
5				Soft Slightly Clayed Fine to Med Sand										
18.5				" " " " "										
				Well put in at 18.5										
				Bulk Sample										

COMPLETION DEPTH: DEPTH TO WATER IN BORING: 10.7

DATE: 9-13-

EMA INC.
Consulting Engineers

PLATE

DATE: 18-89 TESTS ASSIGNED BY: TESTED BY:

CHECKED BY: Don Bentham DATE: 18-89 TESTS ASSIGNED BY: TESTED BY:

LOG OF BORING NO. 6

PROJECT: Temporary Monitoring Well JOB NO.: 89118.05

TYPE: FA LOCATION: Goldsboro Landfill

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL (SURF. EL:)	SAND OR GRAVEL (VERY LOOSE, LOOSE, MEDIUM DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (SATURATED, WET, MOIST, DRY)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
				Slightly [illegible]										
5				[illegible]										
10				[illegible]										
				[illegible]										

COMPLETION DEPTH: 18.5 DEPTH TO WATER IN BORING: 15'

DATE: 9-18-89

EMA INC.
Consulting Engineers

PLATE

LOG OF BORING NO. 7

PROJECT: Temporary Monitoring Well JOB NO.: 89118.05

TYPE: FA LOCATION: Goldsboro Land Fill

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL (SURF. EL:)	SAND OR GRAVEL (VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (SATURATED, WET, MOIST, DAMP)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_p TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
				Fine to med. SAND										
0				" " " "										
				Slightly clayey Med to Fine Sand										
5														
10				" " " " "										
11				Fine Sandy Silty Clay										
				" " " "										
15														
18.5				" " " "										
				Well put in AT 18.5										

COMPLETION DEPTH: 18.5 DEPTH TO WATER IN BORING: 12.4

DATE: 9-18-89

DRILLED BY: Don Kenthall DATE: 7-18-89 TESTS ASSIGNED BY: TESTED BY: DATE:

LOGGED BY:

EMA INC.
Consulting Engineers

PLATE

LOG OF BORING NO. 8

PROJECT: Temporary Monitoring Well JOB NO.: 89118 05

TYPE: FA - LOCATION: Gulf Basin Land Fill

DEPTH (FT)	SAMPLE NUMBER	SAMPLER TYPE	RECOVERED / ADVANCED	DESCRIPTION OF MATERIAL (SURF. EL:)	SAND OR GRAVEL (VERY LOOSE, LOOSE, MED DENSE, DENSE, VERY DENSE) / SILT OR CLAY (SOFT, FIRM, STIFF, VERY STIFF, HARD)	MOISTURE (SATURATED, WET, MOIST, DAMP)	BLOWS PER 6"	UNIT DRY WEIGHT (PCF)	WATER CONTENT (%)	LIQUID LIMIT	PLASTIC LIMIT	PENETROMETER (Q_P TSF)	UNCONFINED COMPRESSION (COHESION, TSF)	REMARKS
1.5				Fine to med Sand										
				Slightly clayed Fine to med Sand										
5				" " " " "										
6.5				Fine sandy silty Clay										
10														
13.5				Well put in at 13.5										
15														

COMPLETION DEPTH: 13.5 DEPTH TO WATER IN BORING: 12.4

DATE: 9-18-89

EMA INC.
Consulting Engineers

PLATE

DATE:

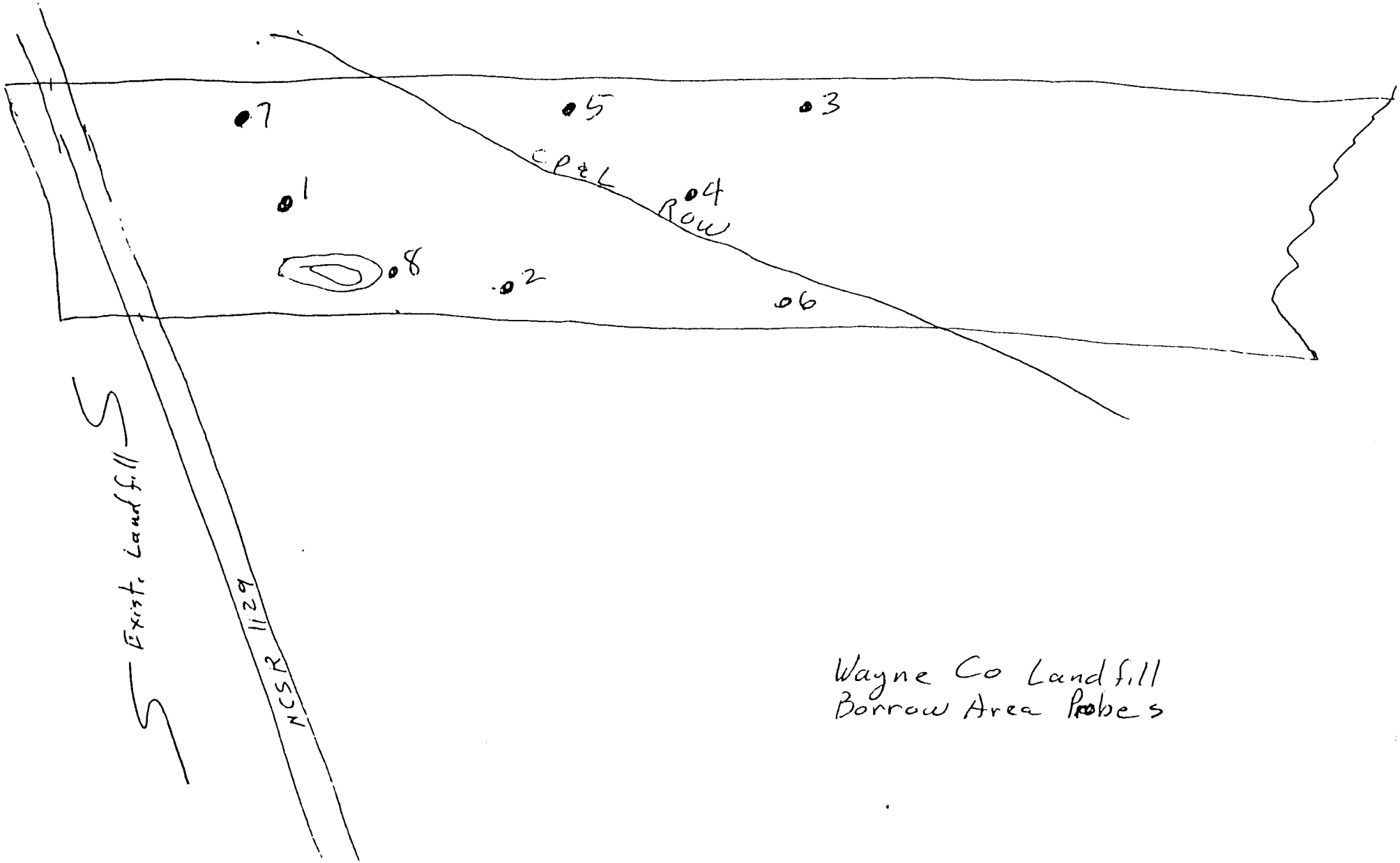
TESTS ASSIGNED BY:

TESTED BY:

DATE

DRILLED BY:

LOGGED BY:



Wayne Co Landfill
Borrow Area Probes

WAYNE CO. VERTICAL EXPANSION

SOIL TYPE C/B (DUE TO INSTALLATION OF INLETS & DRAIN PIPE USE TYPE B)

$\therefore C_N = 70$

$Q_{10} = 5.9$ IN.

SLOPE FACTORS:

2% MIN. $\Rightarrow$ = 1.13 (1-50 AC. from TABLE 17-2 - SOIL CONS. DIST. STDS.)

$\therefore$ 5 AC. (Q_{10}) = 12.25 (1.13) = 13.84 cfs (3 of 21 - ES-1027)

33% $\Rightarrow$ 1.12 (1-50 AC. from TABLE 17-2 - SOIL CONS. DIST. STDS.)

$\therefore$ 5 AC. (Q_{10}) = 18.5 (1.12) = 20.72 cfs (17 of 21 ES-1027)

DETERMINE INLET CFS

INLET #1 (AREA DD1B)

AVG. SLOPES: TOT. A = 6.38 AC. $A_{(2\%)}$ = 5.15 AC. $A_{(33\%)}$ = 1.23 AC.

5.15/6.38 = 81% 1.23/6.38 = 19%

81 (2) + 19 (33)/100 = 7.89 % Say 8% $\therefore$ S.F. = 0.92

(23.5)(0.92) = 21.62 cfs

INLET #2 (AREA DD1E)

AVG. SLOPES: TOT. A = 8.34 AC. $A_{(2\%)}$ = 6.63 AC. $A_{(33\%)}$ = 1.71 AC.

6.63/8.34 = 79% 1.71/8.34 = 21%

79(2) + 21(33)/100 = 8.51 % Say 9% $\therefore$ S.F. = 0.93

30.5 (0.93) = 28.37 cfs

INLET #3 (AREA DD3B)

AVG. SLOPES: TOT. A = 2.29 AC. $A_{(2\%)}$ = 1.35 AC. $A_{(33\%)}$ = 0.94 AC.

1.35/2.29 = 59% 0.94/2.29 = 41%

59(2) + 41(33)/100 = 14.71 % Say 15% $\therefore$ S.F. = 0.99

$(2.29/5)^{2/3}$ (0.99)(18.5) = 10.35 cfs

INLET #4 (AREA DD5A)

AVG. SLOPES: TOT. A = 6.53 AC. $A_{(2\%)}$ = 5.15 AC $A_{(33\%)}$ = 1.38 AC.

$5.15/6.53 = 79\%$ $1.38/6.53 = 21\%$

$79(2) + 21(33)/100 = 8.51\%$ Say 9% ∴ S.F. = 0.93

$(24)(0.93) = \underline{22.32 \text{ cfs}}$

DETERMINE CFS TO DIVERSION DITCHES

DIVERSION DITCH #1

BEGINNING TO F.E.S. #1 (AREAS DD1A & DD1C)

AVG. SLOPES: TOT. A = 3.33 AC. $A_{(2\%)}$ = 2.42 AC. $A_{(33\%)}$ = 0.91 AC.

$2.42/3.33 = 73\%$ $0.91/3.33 = 27\%$

$73(2) + 27(33)/100 = 10.37$ Say 11% ∴ S.F. = 0.95

$Q_{10} = (3.33/5)^{2/3}(0.95)(18.5) = \underline{13.39 \text{ cfs}}$

F.E.S. #1 TO F.E.S. #2 (AREAS DD1A, DD1B, DD1C & DD1D)

AVG. SLOPES: TOT. A = 13.18 AC $A_{(2\%)}$ = 7.57 AC. $A_{(11\%)}$ = 1.94 AC. $A_{(33\%)}$ = 3.67

$7.57/13.18 = 57\%$ $1.94/13.18 = 15\%$ $3.67/13.18 = 28\%$

$57(2) + 15(11) + 28(33)/100 = 12.03\%$ Say 12% ∴ S.F. = 0.96

$Q_{10} = (47)(0.96) = \underline{45.12 \text{ cfs}}$

F.E.S. #2 TO SILT BASIN (AREAS DD1A TO DD1F)

AVG. SLOPES: TOT. A = 24.29 AC. $A_{(2\%)}$ = 14.2 AC. $A_{(11\%)}$ = 1.94 AC.

$A_{(15\%)}$ 1.51 AC. $A_{(33\%)}$ = 6.64 AC.

$14.2/24.29 = 59\%$ $1.94/24.29 = 8\%$ $1.51/24.29 = 6\%$ $6.64/24.29 = 27\%$

$59(2) + 8(11) + 6(15) + 27(33)/100 = 11.87\%$ Say 12% ∴ S.F. = 0.96

$Q_{10} = (78)(0.96) = \underline{74.88 \text{ cfs}}$

DIVERSION DITCH #2 (AREA DD2A)

A = 5.67 Ac. AVG. ≅ 5% SLOPE ∴ S.F. = 1.04

Q_{10} = 17.7 (1.04) = 18.41 cfs

DIVERSION DITCH #3

BEGINNING TO F.E.S. #3 (AREA DD3A)

AVG. SLOPES: TOT. A = 2.66 Ac. $A_{(2\%)}$ = 1.51 Ac. $A_{(33\%)}$ = 1.15 Ac.

1.51/2.66 = 57% 1.15/2.66 = 43%

57(2) + 43(33)/100 = 15.33 say 16% ∴ S.F. = 1.00

$Q_{10} = (2.66/5)^{2/3}(1.0)(18.5)$ = 12.13 cfs

F.E.S. #3 TO B.C.P. (AREAS DD3A, DD3B & DD3C)

AVG. SLOPES: TOT. A = 7.01 Ac. $A_{(2\%)}$ = 2.86 Ac. $A_{(33\%)}$ = 4.15 Ac.

2.86/7.01 = 41% 4.15/7.01 = 59%

41(2) + 59(33)/100 = 20.29% say 21% ∴ S.F. = 1.05

Q_{10} = 26 (1.05) = 27.3 cfs

DIVERSION DITCH #4 (AREA DD4A)

A = 1.08 Ac.

$Q_{10} = (1.08/5)^{2/3}(20.72)$ = 7.42 cfs

DIVERSION DITCH #5

B.C.P. TO SILT BASIN (AREAS DD3A, DD3B, DD3C, DD4A, DD5A & DD5B)

AVG. SLOPES: TOT. A = 18.88 Ac. $A_{(2\%)}$ = 8.73 Ac. $A_{(15\%)}$ = 3.53 Ac. $A_{(33\%)}$ = 6.62 Ac.

8.73/18.88 = 46% 3.53/18.88 = 19% 6.62/18.88 = 35%

46(2) + 19(15) + 35(33)/100 = 15.32% say 16% ∴ S.F. = 1.00

Q_{10} = 63 (1.00) = 63 cfs

DETERMINE CFS TO SIZE B.C.P.

(AREAS DD3A, DD3B, DD3C, DD4A & DD5A)

TOT. A = 14.62 Ac. $A_{(2\%)}$ = 8.01 Ac. $A_{(33\%)}$ = 6.61 Ac.

8.01/14.62 = 55% 6.61/14.62 = 45%

55(2) + 45(33) / 100 = 15.95% Say 16% ∴ S.F. 1.00

Q_{10} = 51 (1.00) = 51 cfs

TRAPEZOIDAL DIVERSION DITCHES

DIV. DITCH #1 BEGINNING TO BOTTOM / FILL (AREA DD1A ONLY)

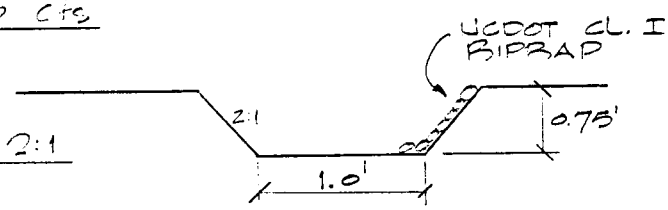
TOT. A = 2.76 Ac. $A_{(2\%)}$ = 2.42 Ac. $A_{(33\%)}$ = 0.34 Ac.

2.42/2.76 = 88% 0.34/2.76 = 12%

88(2) + 12(33) / 100 = 5.72% Say 6% ∴ S.C.F. 1.07

$Q_{10} = (2.76/5)^{2/3}(16)(1.07) = 11.5$ cfs

DITCH SLOPE = 10%



B = 1.0' y = 0.75' n = 0.04 M = 2:1

$A = By + 2y^2 = 1.88$ ft.²

$P = B + 2y\sqrt{M^2+1} = 4.35$ ft.

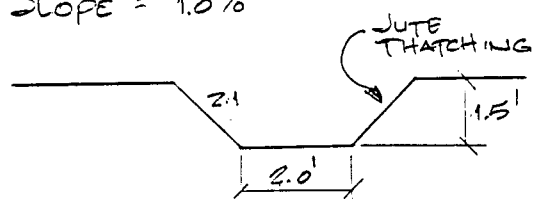
$R = A/P = 1.88/4.35 = 0.43$

$Q_{DES} = 1.49/n\,(A)(R^{2/3})(S^{1/2}) = (1.49/0.04)(1.88)(0.43^{2/3})(.10^{1/2}) = 12.58$ cfs > 11.5 cfs

$V_{10} = Q_{10}/(Q_{10}/Q_{DES})A$ = 6.69 fps > 4.0 fps ∴ LINE w/ CL. I RIPRAP

TOT./FILL TO F.E.S. #1

Q_{10} = 13.39 cfs (from sh. 2) DITCH SLOPE = 1.0%



B = 2.0' y = 1.5' n = 0.04 M = 2:1

$A = 2.0(1.5) + 2(1.5^2) = 7.5$ ft.²

$P = 2.0 + 2(1.5)(2^2+1)^{1/2} = 8.71'$

$R = 7.5/8.71 = 0.86$

$Q_{DES} = (1.49/0.04)(7.5)(0.86^{2/3})(0.01^{1/2}) = 25.35$ cfs > 13.39 cfs

$V_{10} = 13.39/0.53(7.5) = 3.37$ fps < 4.0 fps ∴ USE JUTE THATCHING

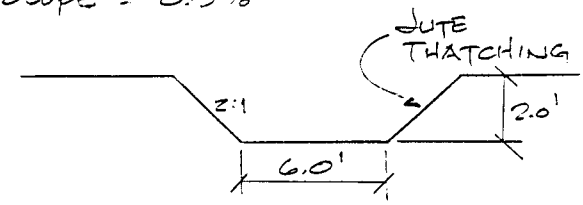
Trapezoidal Diversion Ditches (cont.)

Div. Ditch #1

F.E.S. #1 to F.E.S. #2

$Q_{10} = 45.12$ cfs (from sh. 2) Ditch Slope = 0.5%

$B = 6.0'$ $y = 2.0'$ $n = 0.04$ $M = 2:1$



$A = 6.0(2.0) + 2.0(2.0^2) = 20$ ft.^{2}

$P = 6.0 + [2(2.0)](2^2+1)^{1/2} = 14.94$

$R = 20/14.94 = 1.34$

$Q_{DES} = (1.49/0.04)(20)(1.34^{2/3})(0.005^{1/2}) = \underline{64.09 \text{ cfs}} > 45.12$ cfs

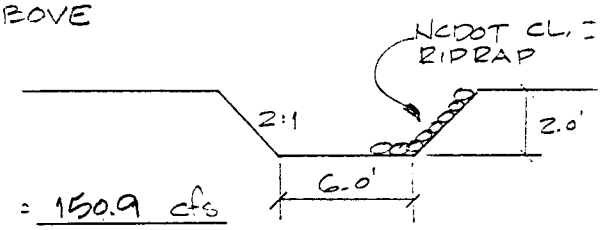
$V_{10} = 45.12/0.70(20) = \underline{3.20 \text{ fps}} < 4.0$ ∴ Jute Thatching

F.E.S. #2 to Silt Basin

$Q_{10} = 74.88$ cfs (from sh. 2) Ditch Slope = 2.77% Max.–1.61% Min

Use same ditch section as above

$B = 6.0'$ $y = 2.0'$ $n = 0.04$ $M = 2:1$



$A = 20$ ft.^{2} $P = 14.94$ $R = 1.34$

∴ Max. $Q_{DES} = (1.49/0.04)(20)(1.34^{2/3})(0.0277^{1/2}) = \underline{150.9 \text{ cfs}}$

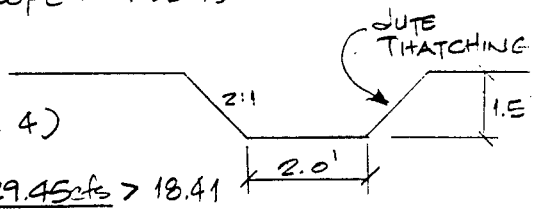
Min. $Q_{DES} = (1.49/0.04)(20)(1.34^{2/3})(0.0161^{1/2}) = \underline{115.01 \text{ cfs}} > 74.88$ cfs

$V_{10} = 74.88/0.65(20) = \underline{5.75 \text{ fps}} > 4.0$ fps ∴ Riprap req'd

Diversion Ditch #2

$Q_{10} = 18.41$ cfs (from sh. 3) Ditch Slope = 1.36%

$B = 2.0'$ $y = 1.5'$ $n = 0.04$ $M = 2:1$



$A = 7.5$ ft.^{2} $P = 8.71$ $R = 0.86$ (from sh. 4)

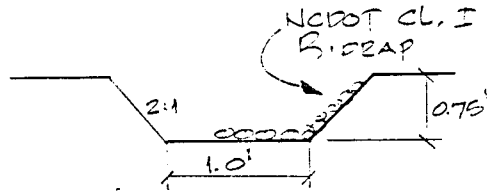
$Q_{DES} = (1.49/0.04)(7.5)(0.86^{2/3})(0.0136^{1/2}) = \underline{29.45 \text{ cfs}} > 18.41$

$V_{10} = 18.41/0.63(7.5) = \underline{3.93 \text{ fps}} < 4.0$ fps ∴ Jute Thatching

TRAPEZOIDAL DIVERSION DITCHES (cont.)

DIVERSION DITCH #3

BEGINNING TO BOTTOM / FILL



$Q_{10} = 12.12$ cfs (sh. 3) DITCH SLOPE = 10%

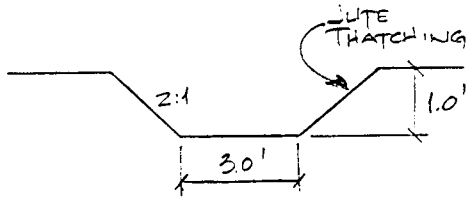
$B = 1.0'$ $y = 0.75'$ $n = 0.04$ $M = 2:1$

$A = 1.88$ ft.^{2} $P = 4.35'$ $R = 0.43$ (from sh. 4)

$Q_{DES} = (1.49/0.04)(1.88)(0.43^{2/3})(0.10^{1/2}) = \underline{12.58 \text{ cfs}} > 12.12$ cfs

$V_{10} = 12.12/0.96(1.88) = \underline{6.7 \text{ fps}} > 4.0$ fps ∴ LINE w/ RIPRAP

BOT. / FILL TO F.E.S. #3



$Q_{10} = 12.12$ cfs (sh. 3) DITCH SLOPE = 1.43%

$B = 3.0'$ $y = 1.0'$ $n = 0.04$ $M = 2:1$

$A = 3.0(1.0) + 2(1.0^2) = 5.0$ ft.^{2}

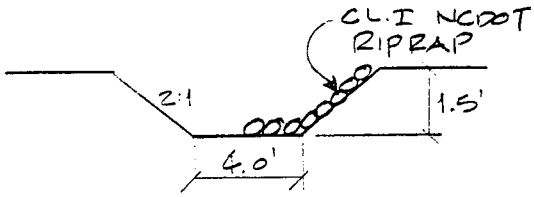
$P = 3.0 + 2(1.0)(2^2+1)^{1/2} = 7.47$

$R = 5.0/7.47 = 0.67$

$Q_{DES} = (1.49/0.04)(5.0)(0.67^{2/3})(0.0143^{1/2}) = \underline{17.03 \text{ cfs}} > 12.12$ cfs

$V_{10} = 12.12/0.71(5.0) = \underline{3.41 \text{ fps}} < 4.0$ fps ∴ USE JUTE THATCHING

F.E.S. #3 TO R.C.P.



$Q_{10} = 27.3$ cfs (sh. 3) DITCH SLOPE = 1.56%

$B = 4.0'$ $y = 1.5'$ $n = 0.04$ $M = 2:1$

$A = 4.0(1.5) + 2(1.5^2) = 10.5$ ft.^{2}

$P = 4.0 + 2(1.5)(2^2+1)^{1/2} = 10.71$

$R = 10.5/10.71 = 0.98$

$Q_{DES} = (1.49/0.04)(10.5)(0.98^{2/3})(0.0156^{1/2}) = \underline{48.19 \text{ cfs}} > 27.3$ cfs

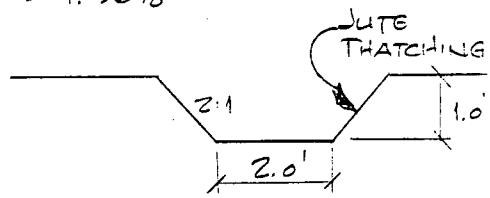
$V_{10} = 27.3/0.57(10.5) = \underline{4.59 \text{ fps}} < 4.0$ fps ∴

TRAPEZOIDAL DIVERSION DITCHES (cont.)

DIVERSION DITCH #4

$Q_{10} = 7.42$ cfs (from Sh. 3) DITCH SLOPE = 1.56%

$B = 2.0'$ $y = 1.0'$ $n = 0.04$ $M = 2:1$



$A = 2.0(1.0) + 2(1.0^2) = 4.0$ ft.^{2}

$P = 2.0 + 2(1.0)(2^2+1)^{1/2} = 6.47$

$R = 4.0/6.47 = 0.62$

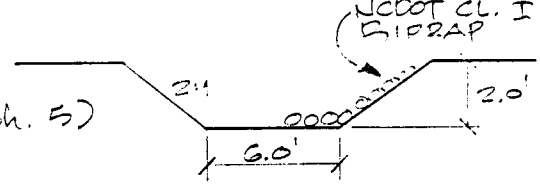
$Q_{DES} = (1.49/0.04)(4.0)(0.62^{2/3})(0.0156^{1/2}) = \underline{13.51 \text{ cfs}} > 7.42$ cfs

$V_{10} = 7.42/0.55(4.0) = \underline{3.37 \text{ fps}} < 4.0$ ∴ USE JUTE THATCHING

DIVERSION DITCH #5

$Q_{10} = 63$ cfs (from Sh. 3) DITCH SLOPE = 1.85% (max.) - 1.0% (min.)

$B = 6.0'$ $y = 2.0'$ $n = 0.04$ $M = 3:1$



$A = 20$ ft.^{2} $P = 14.94$ $R = 1.34$ (from Sh. 5)

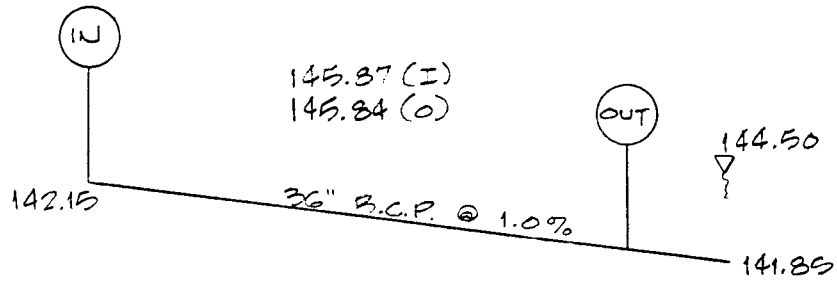
$Q_{DES.} = (1.49/0.04)(20)(1.34^{2/3})(0.01^{1/2})$

$= \underline{90.64 \text{ cfs}} > 63$ cfs

$V_{10} = 63/0.70(20) = \underline{4.53 \text{ fps}} > 4.0$ ∴ LINE W/ RIPRAP

PIPE CALCS.

B.C.P. UNDER ACCESS DRIVE (1)



Q_{10} = 51 cfs (from sh. 4) PIPE = 36" B.C.P. (INLET CONTROL)

INLET: H_W/D = 1.24' H_W = 3.72'

OUTLET: K_e = 0.5 LENGTH = 30' H = 1.34'

d_c = 2.30' T_W = 2.65'

OUTLET VELOCITY = 9.3 fps > 4.0 ∴ OUTLET PROTECTION REQ'D

OUTLET PROTECTION

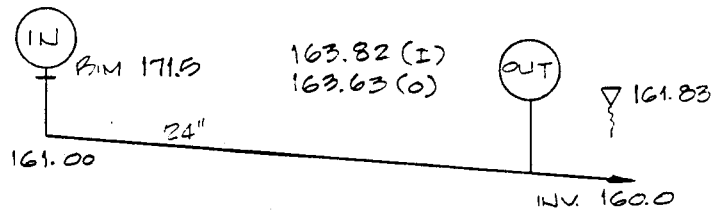
USE MIN. L = 10'

W = 3.0' + (0.4)(10) = 7.0'

d_{50} = 0.5'

PAD THICKNESS = 2(d_{50}) = 1.0'

INLET #1 TO F.E.S. #1 (2)



Q_{10} = 21.62 cfs (from sh. 1) PIPE 24" B.C.P. (INLET CONTROL)

INLET: H_W/D = 1.41 H_W = 2.82'

OUTLET: K_e = 1.0 LENGTH = 50' H = 1.8' d_c = 1.65' T_W = 1.83'

OUTLET VELOCITY = 9.8 fps > 4.0 fps ∴ OUTLET PROTECTION REQ'D

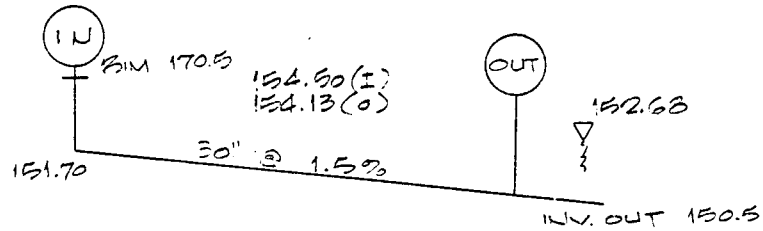
OUTLET PROTECTION

L = 11.0' W = 2.0 + (0.4)(11) = 6.4' SAY 6.5' d_{50} = 0.5' THK. PAD = 1.0'

PIPE CALCS. (cont.)

INLET #2 TO F.E.S. #2 (3)

Q_{10} = 28.37 cfs (from sh. 1) PIPE 30" R.C.P. (INLET CONTROL)



INLET: H_w/D = 1.12' H_w = 2.80'

OUTLET: k_e = 1.0 LENGTH = 80' H = 1.45' d_c = 1.85' T_w = 2.18'
OUTLET VELOCITY = 9.4 fps > 4.0 fps ∴ OUTLET PROTECTION REQ'D

OUTLET PROTECTION

USE MIN. L = 10'

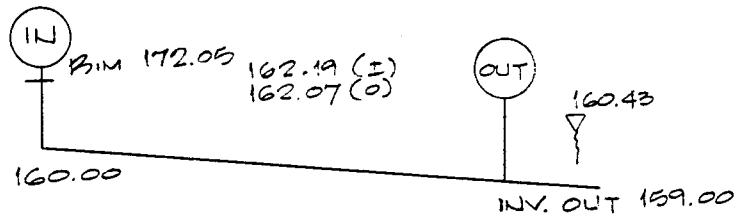
W = 2.5' + (0.4)(10') = 6.5'

d_{50} = 0.5'

THICKNESS/PAD = 1.0'

INLET #3 TO F.E.S. #3 (4)

Q_{10} = 10.85 cfs (from sh. 1) PIPE 18" R.C.P.



INLET: H_w/D = 1.46' H_w = 2.19'

OUTLET: k_e = 1.0 LENGTH = 50' H = 1.64' d_c = 1.35' T_w = 1.43'

OUTLET VELOCITY = 8.2 fps > 4.0 fps ∴ OUTLET PROTECTION REQ'D

OUTLET PROTECTION

USE MIN. L = 10'

W = 1.5' + (0.4)(10') = 5.5'

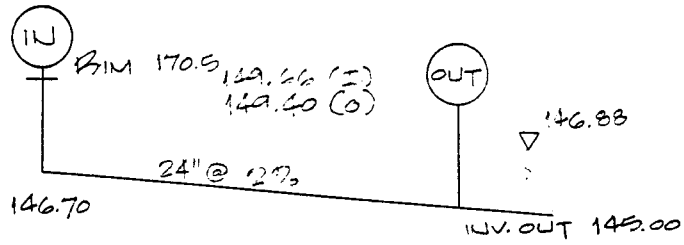
d_{50} = 0.5'

PAD THICKNESS = 1.0'

PIPE CALCS. (cont.)

INLET #4 TO F.E.S. #4

Q_{10} = 22.32 cfs (from sh. 2) 24" R.C.P. (INLET CONTROL)



INLET: $HW/D = 1.48'$ $HW = 2.96'$

OUTLET: $k_e = 1.0$ $H = 2.52'$ $d_c = 1.75'$ $T_W = 1.88'$

OUTLET VELOCITY = 9.9 fps > 4.0 fps ∴ OUTLET PROTECTION REQ'D

OUTLET PROTECTION

$L = 13.0'$

$W = 2.0 + (0.4)(13.0) = 7.2'$

$d_{50} = 0.5'$

PAD THICKNESS = 1.0'

SILT BASINS

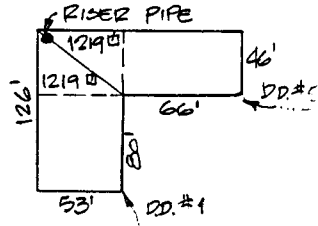
RISER BASIN (#1) TOTAL DRAINAGE AREA = 43.17 Ac. * CLEAN 2x/YR.

USE L-SHAPE BASIN DUE TO LIMITATIONS ON SPACE

AREA (DD#1) = 24.29 Ac. ∴ WIDTH REQ'D = $\left[24.29\,(900) \div 4'\,DP/2\right]^{1/2} \cong 53' \times 106' \times 4'$ DP.

AREA (D.D. #5) = 18.88 Ac ∴ WIDTH REQ'D = $\left[18.88\,(900) \div 4'\,DP/2\right]^{1/2} \cong 46' \times 92' \times 4'$ DP.

CONSIDER DESIGN AS 2 SEPERATE BASINS FOR BOT. SIZING
(53' x 46') ÷ 2 = 1219 S.F. (PORTION OF COMMON SECTION FOR EACH SIDE)
{[24.29 x 900) ÷ 4] - 1219}/53' ≅ 80' & 80' + 46' = 126' > 2(53') ∴ OK
{[(18.88 x 900) ÷ 4] - 1219}/46' ≅ 66' & 66' + 53' = 119' > 2(46') ∴ OK



DETERMINE FLOWS

D.A. = 43.17 Ac. Q_2 = 3.3 in. Q_5 = 5.0 in. Q_{10} = 5.9 in. Q_{25} = 6.9 in.

SLOPE AVG.: $A_{(2\%)}$ = 22.93 Ac. $A_{(11\%)}$ = 1.94 Ac. $A_{(15\%)}$ = 5.04 Ac. $A_{(33\%)}$ = 13.26 Ac

$$\text{SLOPE} = \left[(22.93/43.17)(2) + (1.94/43.17)(11) + (5.04/43.17)(15) + (13.26/43.17)(33)\right]/100$$

= 13.53% Say 14% ∴ SCF = 0.98

Q_2 = 48 (0.98) = **47.0 CFS**

Q_5 = 91 (0.98) = **89.2 CFS**

Q_{10} = 120 (0.98) = **117.6 CFS**

Q_{25} = 160 (0.98) = **156.8 CFS**

SIZE PRINCIPAL SPILLWAY

CONDUIT: 36" CMP x 100' LG. H = 4.0'

∴ $Q_{con.}$ = 57.66 (1.08) = 62.3 cfs

USE 48" RISER w/ 1.12' HEAD ABOVE CREST

Q_{RIS} = 47.0 cfs < 62.3 cfs ∴ RISER GOVERNS

SIZE EMERGENCY SPILLWAY

$Q_\Delta = Q_{25} - Q_{con}$ = 156.8 CFS − 47.0 CFS = 109.8 CFS

Use 20' SPILLWAY H_p = 1.6' b = 20' V_c = 5.3 fps SC = 2.5%

LINE SPILLWAY & SLOPE w/ RIPRAP

SILT BASINS (cont.)

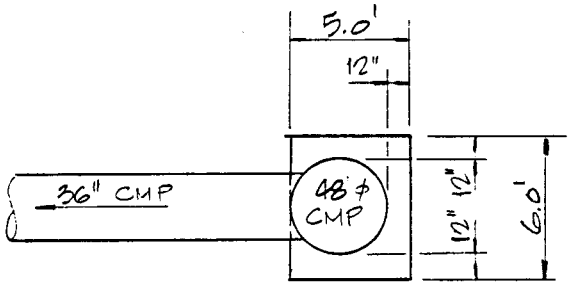
RISER BASIN (cont.) - CONC. RISER PIPE BASE

REQ'D DOWNWARD FORCE = 1.1(2.78)(π)(2.0²) × 62.4 #/ft³ = 2397.9 #

CONC. WGT. = 144 #/ft.³

PIPE WGT. = 68#/ft. × 2.78 = 189 #

CONC REQ'D = (2397.9 - 189)/(144 - 62.4) = 27.1 ft.³

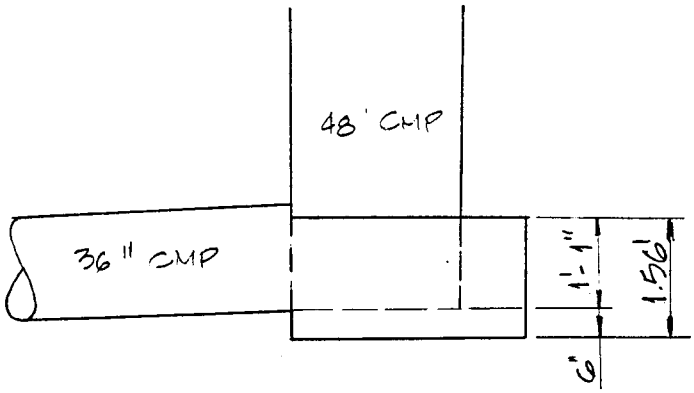


CONC. AREA = 5.0 (6.0) = 30 ft.²

RISER PIPE AREA = π (2.0²) = 12.6 ft²

NET AREA = 30 - 12.6 = 17.4

THICKNESS REQ'D = 27.1/17.4 = 1.56'



CONDUIT OUTLET PROTECTION

$Q_{con.}$ = 47.0 CFS 36" CMP @ 2.0% slope

V = 8.0 fps > 4.0 fps ∴ RIPRAP REQ'D

L = 10 W = 3.0 + (0.4)(10) = 7.0' d_{50} = 0.5' THK/PAD = 1.0'

SILT BASINS (cont.)

SILT BASIN #2

D.A. = 5.67 Ac. AVG. SLOPE ≅ 5% ∴ SCF = 1.04

Q_{10} = 17.7 cfs (from sh. 3) Q_{25} = 6.9 in.

Q_{25} = 23 (1.04) = 23.9 cfs

VOLUME REQ'D = 5.67 (1800)(0.5) = 5103 ft.³ * CLEAN 2x/YR

DEPTH = 5' 5103/5 = 1020.6

BOT. SIZE = 23' x 46'

SPILLWAY

14' SPILLWAY Q = 24 CFS V_c = 3.7 fps H_p = 0.3' S_c = 3.2

SILT BASIN #3 (BORROW AREA)

D.A. = 8.78 Ac.

AVG. SLOPE: APPROX. 5% @ 100% 95% @ 1.6%

5(100) + 95(1.6)/100 = 6.52%

∴ SCF = 1.09

Q_{25} = 1.09 (34) = 37.1 cfs

VOLUME REQ'D = 8.78 (1800)(0.5) = 7902 ft.³ * CLEAN 2x/YR.

DEPTH = 5' ∴ 7902/5 = 1580.4 ft.²

BOT. SIZE = 29' x 58'

SPILLWAY

b = 14' Q = 41 cfs V_c = 4.1 fps S_c = 2.9% H_p = 1.0'

BORROW AREA SOIL CLASSIFICATION

HYDROLOGIC CLASSIFICATION

GOLDSBORO C/B (from EXHIBIT 17-1; SOIL CONS. DIST. STDS.)

THERE WILL BE NO ARTIFICIAL DRAINAGE SYSTEM

∴ HYDROLOGIC CLASSIFICATION IS GROUP C

CONSIDER AREA TO BE WOODS W/ POOR HYDROLOGIC CONDITION ∴ $C_N = 77$ (USE CURVE NUMBER 80)

5 AC. FLAT SLOPE - $Q_{10} = 19.0$ cfs (from sh. 5 of 21 - ES-1027 - SOIL CONSERVATION DISTRICT STANDARDS)

5 AC. MODERATE SLOPE - $Q_{10} = 24.0$ cfs (from sh. 12 of 12 - ES-1027 - SOIL CONS. DIST. STDS.)

CLEAN WATER DIVERSION DITCHES - BORROW AREA

PERMANENT DITCHES

P.D. #1

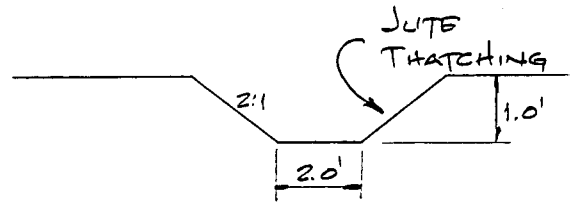
DETERMINE RUNOFF

TOT A = 2.02 AC. AVG. SLOPE ≅ 3% ∴ S.F. = 0.96

$(2.02/5)^{2/3}(24.0)(0.96) = \underline{12.6 \text{ cfs}}$

SIZE DITCH

$Q_{10} = 8.4$ cfs SLOPE ≅ 2%



$\underline{B = 2.0' \quad y = 1.0' \quad n = 0.04 \quad M = 2:1}$

$A = 2.0(1.0) + 2(1.0^2) = 4.0 \text{ ft}^2$

$P = 2.0 + 2(1.0)(2^2+1)^{1/2} = 6.47$

$R = 4.0/6.47 = 0.62$

$Q_{DES} = (1.49/0.04)(4.0)(0.62^{2/3})(0.02^{1/2}) = \underline{15.3 \text{ cfs}} > 12.6$ cfs OK

$V_{10} = 12.6/(12.6/15.3)(4.0) = 3.83$ fps < 4.0 fps ∴ LINE W/ JUTE THATCH

P.D. #2

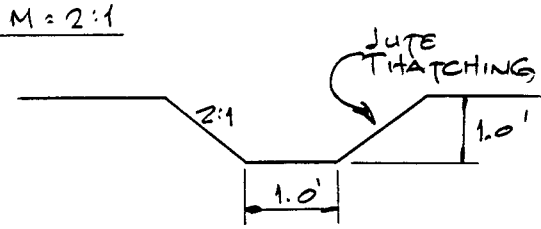
DETERMINE RUNOFF

TOT. A. = 0.38 AC. AVG. SLOPE ≅ 1.5% ∴ S.F. = 1.07

$(0.38/5)^{2/3}(19.0)(1.07) = \underline{3.6 \text{ cfs}}$

SIZE DITCH - $\underline{B = 1.0' \quad y = 1.0' \quad n = 0.04 \quad M = 2:1}$

$Q_{10} = 3.6$ cfs SLOPE = 0.9%



$A = 1.0(1.0) + 2(1.0^2) = 3.0 \text{ ft}^2$

$P = 1.0 + 2(1.0)(2^2+1)^{1/2} = 4.23$

$R = 3.0/4.23 = 0.71$

$Q_{DES} = (1.49/0.04)(3.0)(0.71^{2/3})(0.009^{1/2}) = 8.4$ cfs > 3.6 cfs

$V_{10} = 3.6/(3.6/8.4)(3.0) = 2.8$ fps < 4.0 fps ∴ LINE W/ JUTE THATCHING

Clean Water Div. Ditches (cont.)

Permanent Ditches

P.D. #3

Determine Runoff

Tot. A = 0.96 Ac. Avg. Slope ≅ 2%

$(0.96/5)^{2/3}(19.0)(1.13) = 7.1$ cfs

Size Ditch

$Q_{10} = 7.1$ cfs Slope = 0.83%

Use same ditch as P.D. #2

$A = 3.0$ ft.^{2} $P = 4.23$ $R = 0.71$

$Q_{DES} = (1.49/0.04)(3.0)(0.71^{2/3})(0.0083^{1/2}) = 8.1$ cfs > 7.1 cfs OK

$V_{10} = 7.1/((7.1/8.1)(3.0)) = 2.7$ fps < 4.0 fps ∴ Line w/ Jute Thatching

Temporary Ditches

T.D. #1

Determine Runoff

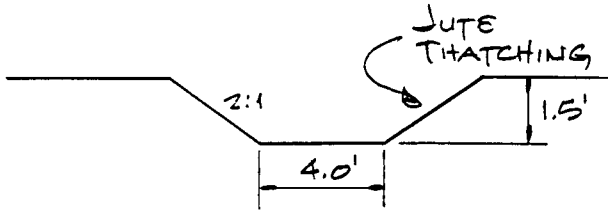
Tot. A = 4.65 Ac. Avg. Slope ≅ 2%

$(4.65/5)^{2/3}(19.0)(1.13) = 20.5$ cfs

Size Ditch

$Q_{10} = 20.5$ cfs Slope = 0.59%

$B = 4.0'$ $y = 1.5'$ $n = 0.04$ M: 2:1



$A = 4.0(1.5) + 2(1.5^2) = 10.5$ ft.^{2}

$P = 4.0 + 2(1.5)(2^2+1)^{1/2} = 10.71$

$R = 10.5/10.71 = 0.98$

$Q_{DES.} = (1.49/0.04)(10.5)(0.98^{2/3})(0.0059^{1/2}) = 24.1$ cfs > 20.5 cfs OK

$V_{10} = 20.5/((20.5/24.1)(10.5)) = 2.3$ fps < 4.0 fps ∴ Line w/ Jute Thatch

CLEAN WATER DIV. DITCHES (cont.)

TEMPORARY DITCHES

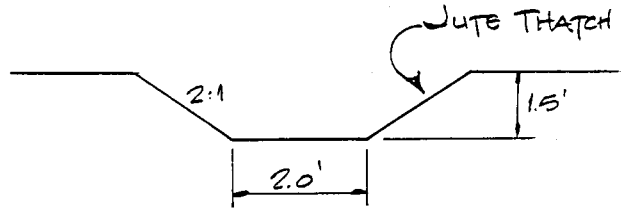
T.D. #2

DETERMINE RUNOFF

TOT. A = 3.00 AC. AVG. SLOPE ≅ 2%

$(3.0/5)^{2/3}(19.0)(1.13) = 15.2$ cfs

SIZE DITCH



$Q_{10} = 15.2$ cfs slope = 0.83%

$B = 2.0'$ $y = 1.5'$ $n = 0.04$ $M = 2:1$

$A = 2.0(1.5) + 2(1.5^2) = 7.5$ ft.^{2}

$P = 2.0 + 2(1.5)(2^2+1)^{1/2} = 8.71$

$R = 7.5/8.71 = 0.86$

$Q_{DES.} = (1.49/0.04)(7.5)(0.86^{2/3})(0.0083^{1/2}) = 23.0$ cfs > 15.2 cfs OK

$V_{10} = 15.2/((15.2/23.0)(7.5)) = 3.1$ fps < 4.0 fps ∴ LINE W/ JUTE THATCHING

SILT FENCE

ALL SILT FENCE IN BORROW AREA HAS LESS THAN 0.25 ACRES DRAINAGE AREA PER 100 L.F. ∴ SILT FENCE IS ADEQUATE.

ALL SILT FENCE IN FILL AREA HAS LESS THAN 0.25 ACRES DRAINAGE AREA PER 100 L.F. ∴ SILT FENCE IS ADEQUATE

PROJECT: G89099
WAYNE CO. VERT. EXPANSION

DESIGNER: JJBeehler
CHKD:
DATE: 9/6/89

HYDROLOGIC & CHANNEL INFORMATION

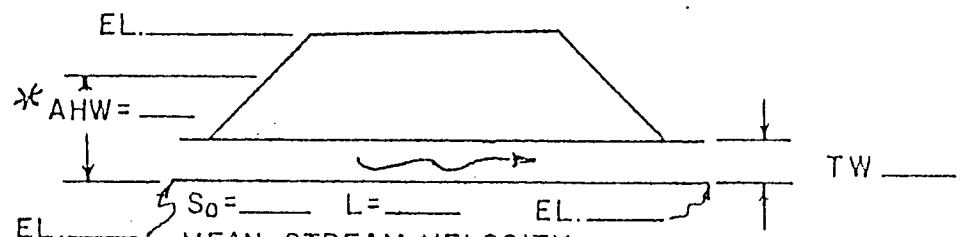
Q_1 = _____ TW_1 = _____

Q_2 = _____ TW_2 = _____

(Q_1 = DESIGN DISCHARGE
Q_2 = CHECK DISCHARGE)

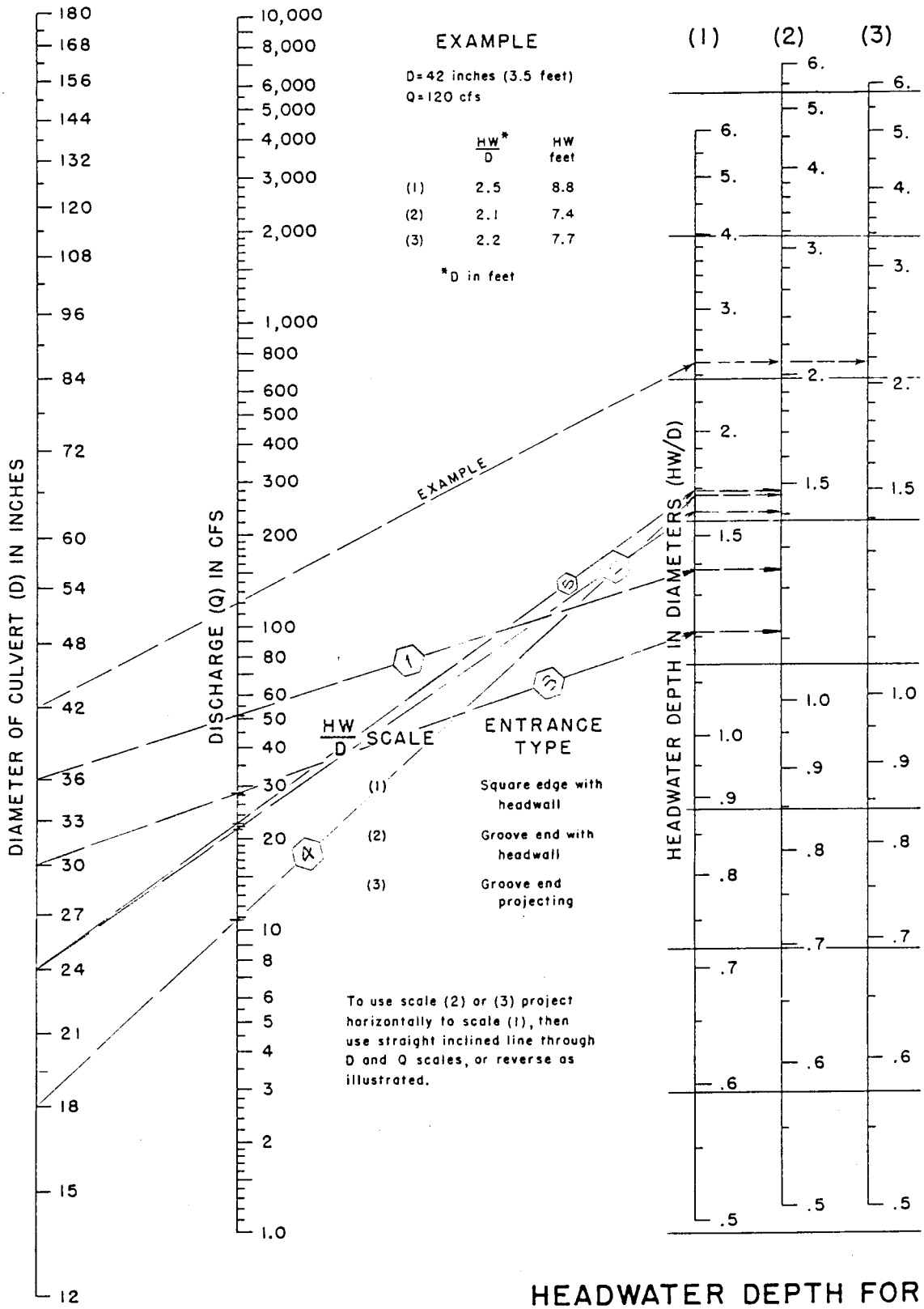
SKETCH

STATION: _____



MEAN STREAM VELOCITY = _____
MAX. STREAM VELOCITY = _____

CULVERT DESCRIPTION (ENTRANCE TYPE)	Q (CFS)	SIZE (IN.)	HEADWATER. COMPUTATION: INLET CONT. HW/D (A)	INLET CONT. HW	OUTLET CONTROL HW = H + h_o − LS_o: K_e (B)	H (C)	d_c (D)	$\frac{d_c+D}{2}$	TW	h_o	LS_o	HW	CONTROLLING HW	OUTLET (E) VELOCITY	LENGTH (FT.)	OUTLET PROTECTION REQ'D (F)	COMMENTS
(1) R.C.P. @ ACCESS DR.	51	36"	1.24	3.72	0.5	1.34	2.30	2.65	2.65				IN	9.3	30	YES	
(2) D.I. #1 TO F.E.S. #1	21.62	24"	1.41	2.82	1.0	1.8	1.65	1.83	1.83				IN	9.8	50	YES	
(3) D.I. #2 TO F.E.S. #2	28.37	30"	1.12	2.80	1.0	1.45	1.85	2.18	2.18				IN	9.4	80	YES	
(4) D.I. #3 TO F.E.S. #3	16.85	18"	1.46	2.19	1.0	1.64	1.35	1.43	1.43				IN	8.2	50	YES	
(5) D.I. #4 TO F.E.S. #4	22.32	24"	1.48	2.96	1.0	2.52	1.75	1.88	1.88				IN	9.9	85	YES	



HEADWATER DEPTH FOR CONCRETE PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

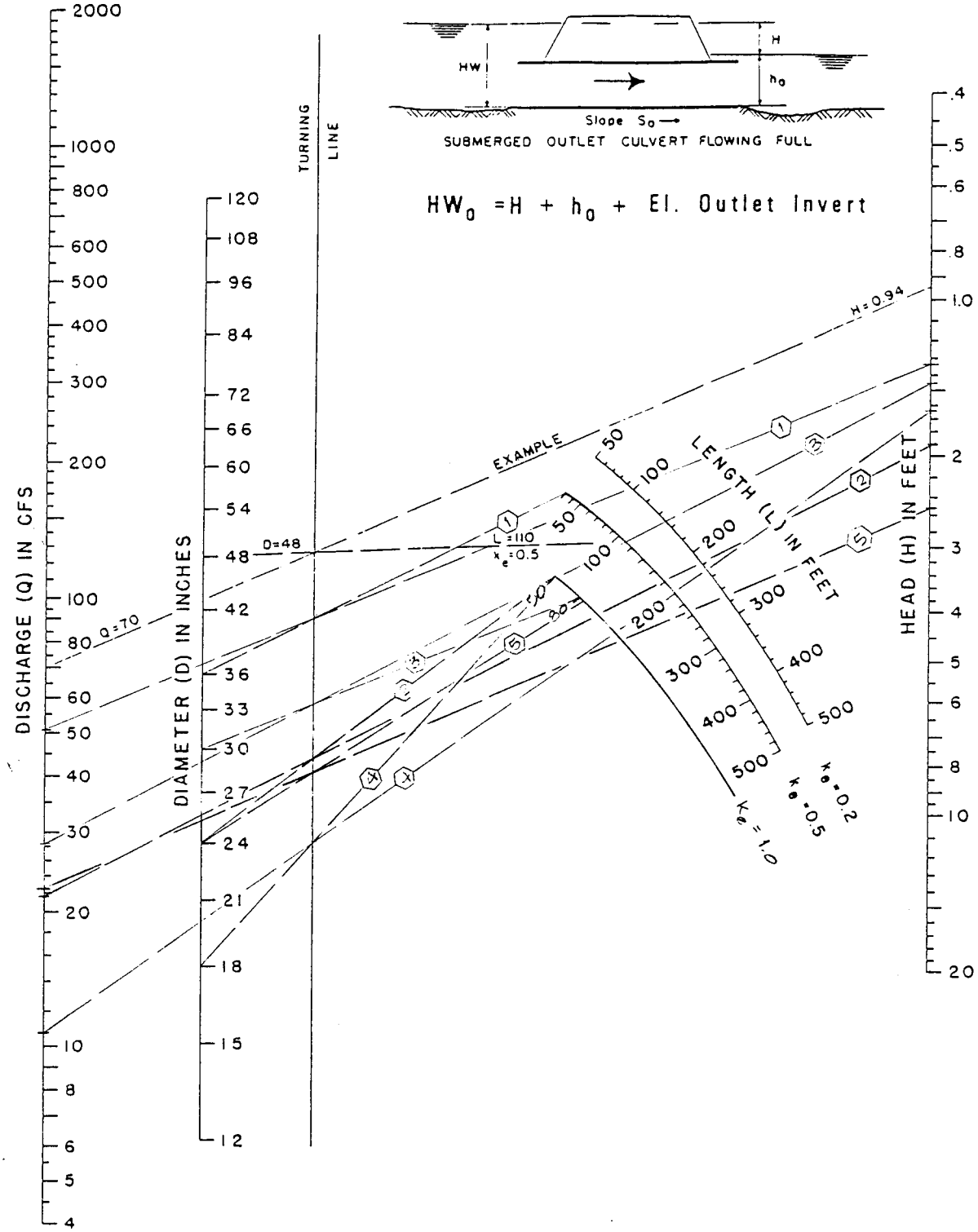
STORM DRAINAGE
PIPE DESIGN ANALYSIS

Roughness Coefficients

1. Storm Sewer	"n"
Concrete Pipe (incl. debris, etc.)	.013
C. M. Pipe (not paved)	.024
Street Plate C. M. Pipe	.033
Natural Stream Channel	.030
Artificial Earth Channel	.030
Concrete Lined Open Channel	.015
Grassed Earth Channel	.060

2. Sanitary Sewer	"n"
V. C. Pipe (incl. debris, slime, etc.)	.013
Concrete Pipe (" " " " ")	.013

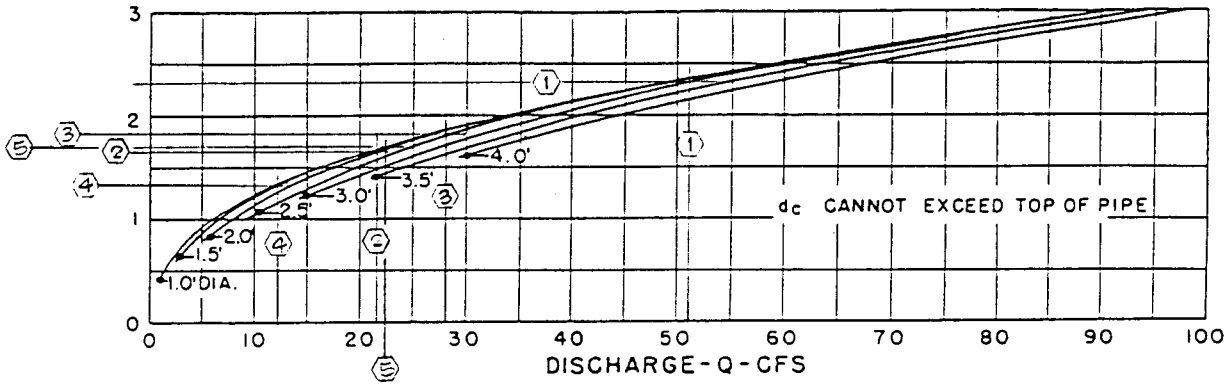
3. Entrance Loss Coefficients (Ke)	Ke
Straight Junction	.2
22° bend	.3
45° bend	.4
90° bend	.6
3 way junction(same elev. & diam.)	.8
4 way junction(" " " ")	1.0
Dead end & drop inlet	1.0
HDW entrance (straight)	0.2
HDW entrance (angular)	0.5

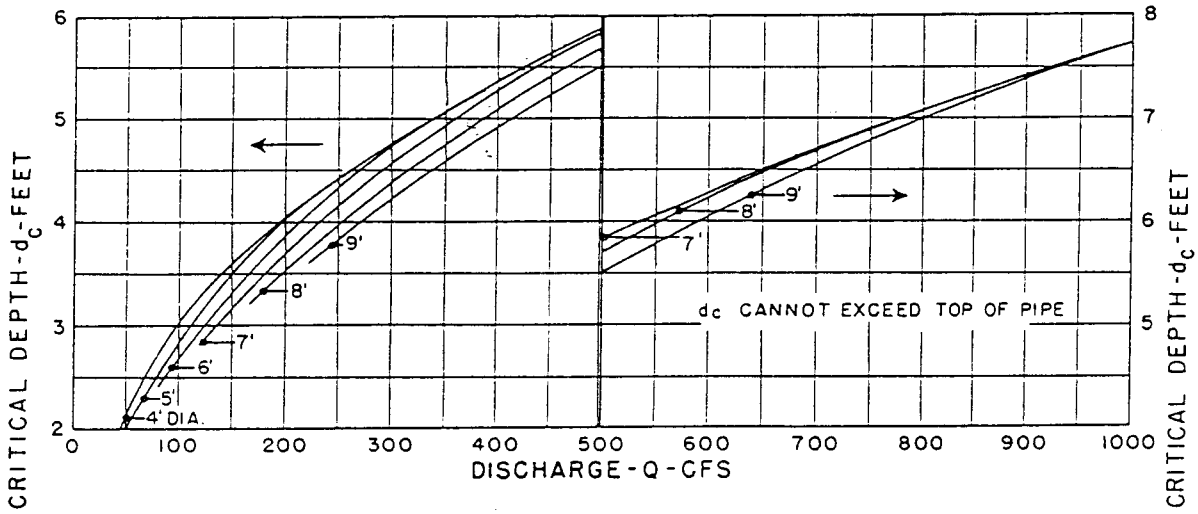


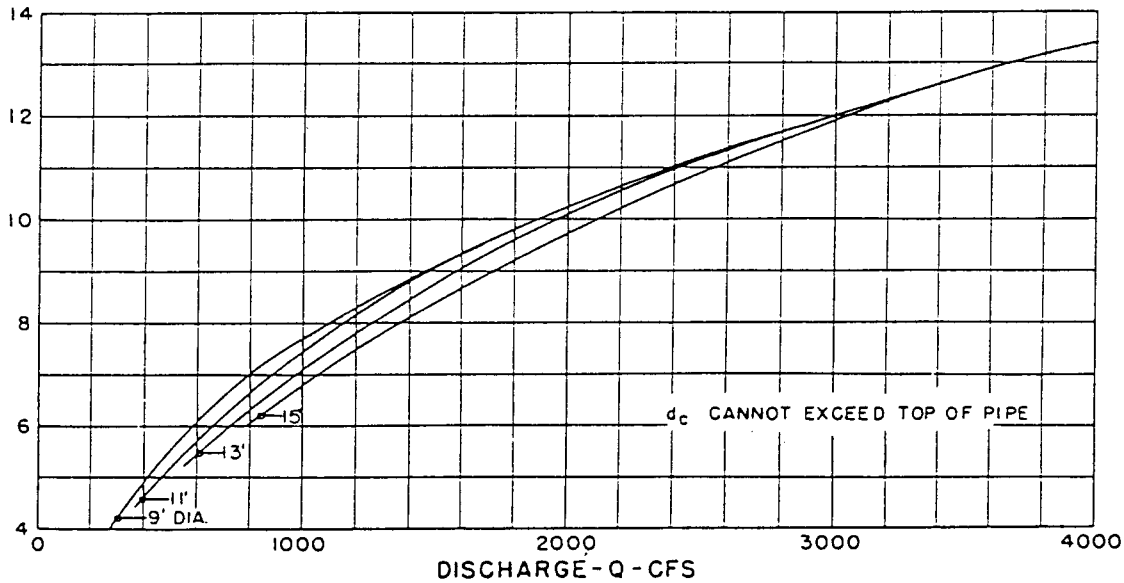
HEAD FOR
CONCRETE PIPE CULVERTS
FLOWING FULL
n = 0.012

BUREAU OF PUBLIC ROADS JAN. 1963

CHART 7 - 2





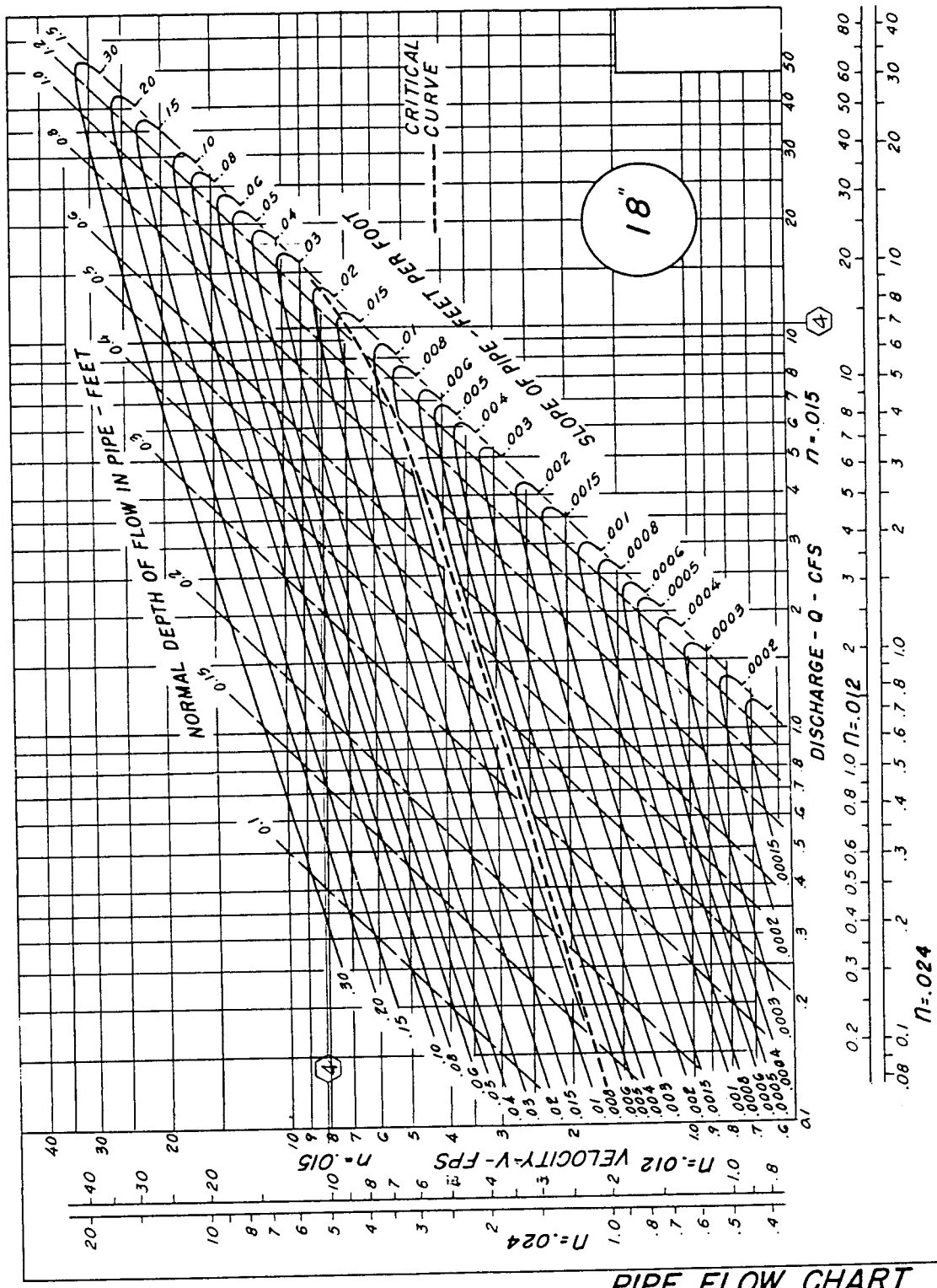


BUREAU OF PUBLIC ROADS

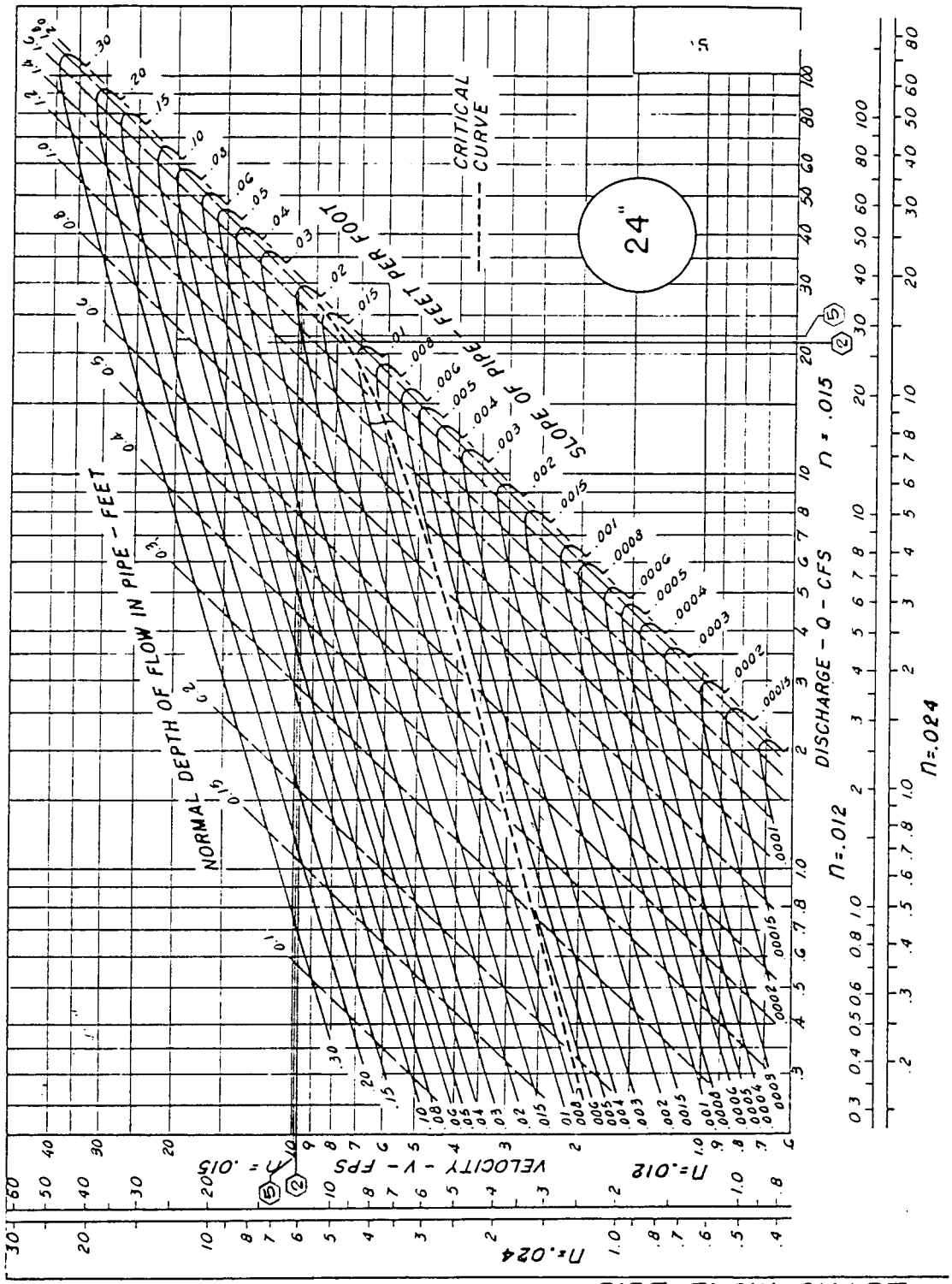
JAN. 1964

CRITICAL DEPTH
CIRCULAR PIPE

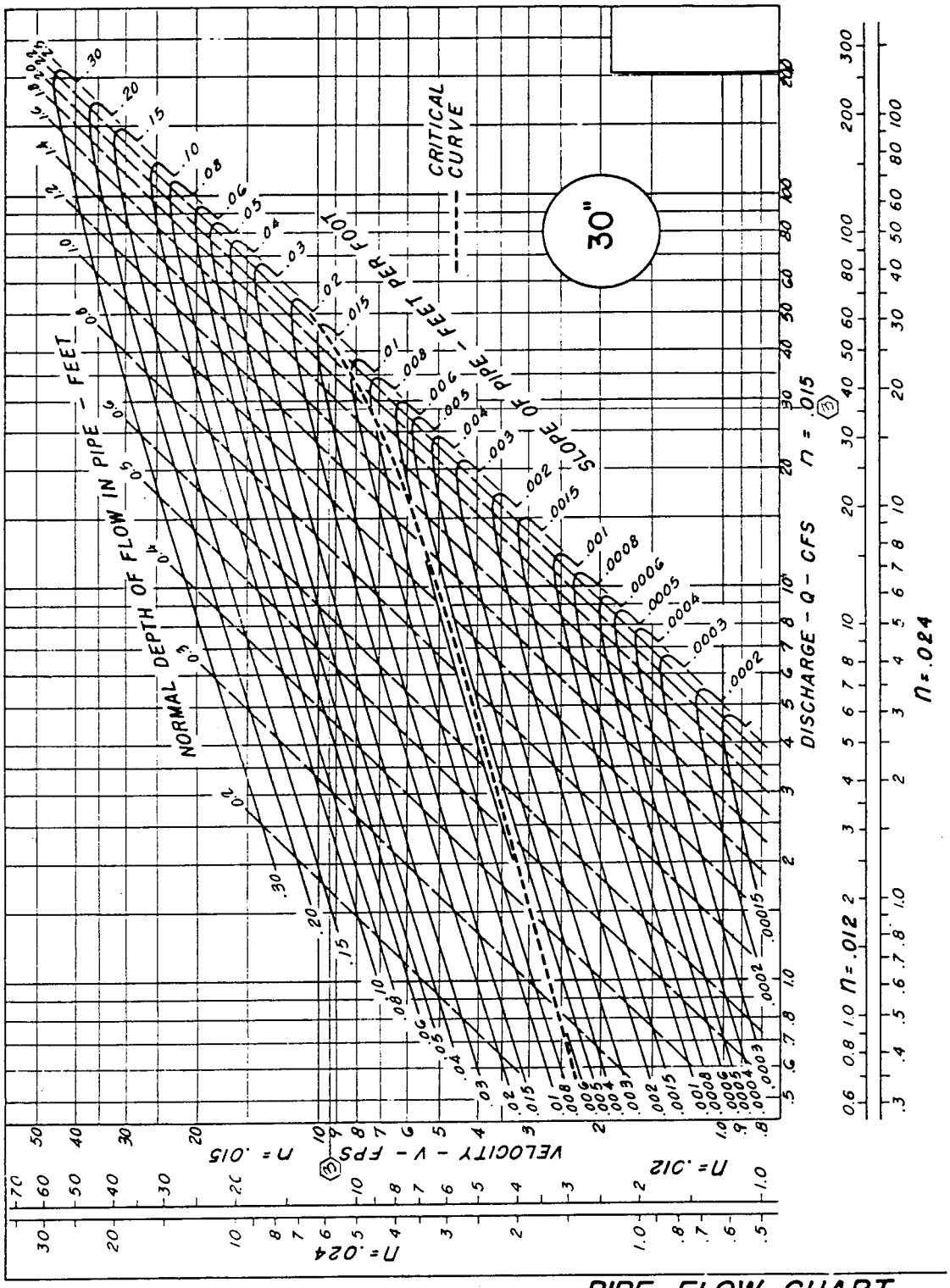
CHART 7 - 9



PIPE FLOW CHART
18-INCH DIAMETER

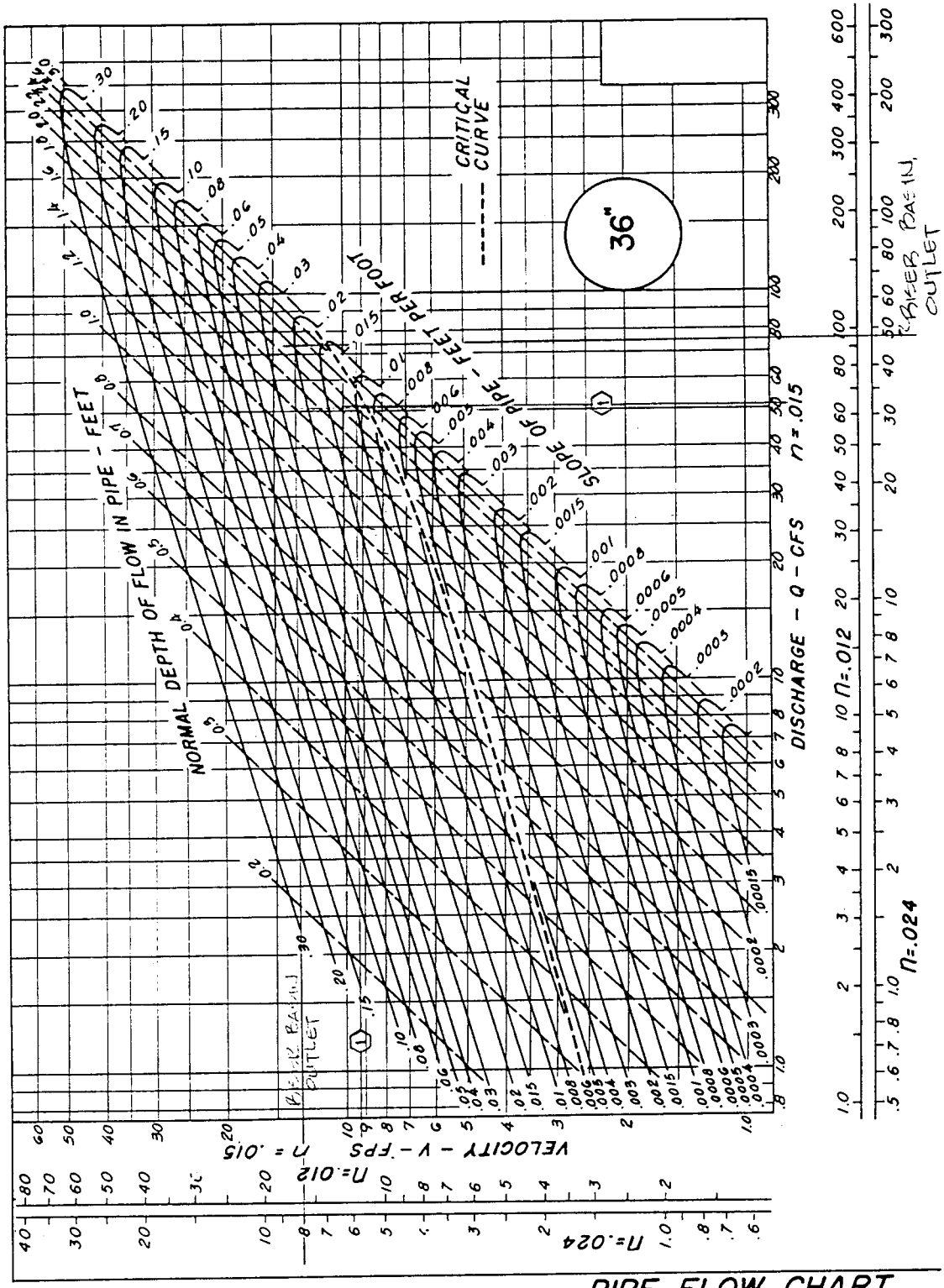


PIPE FLOW CHART
24-INCH DIAMETER

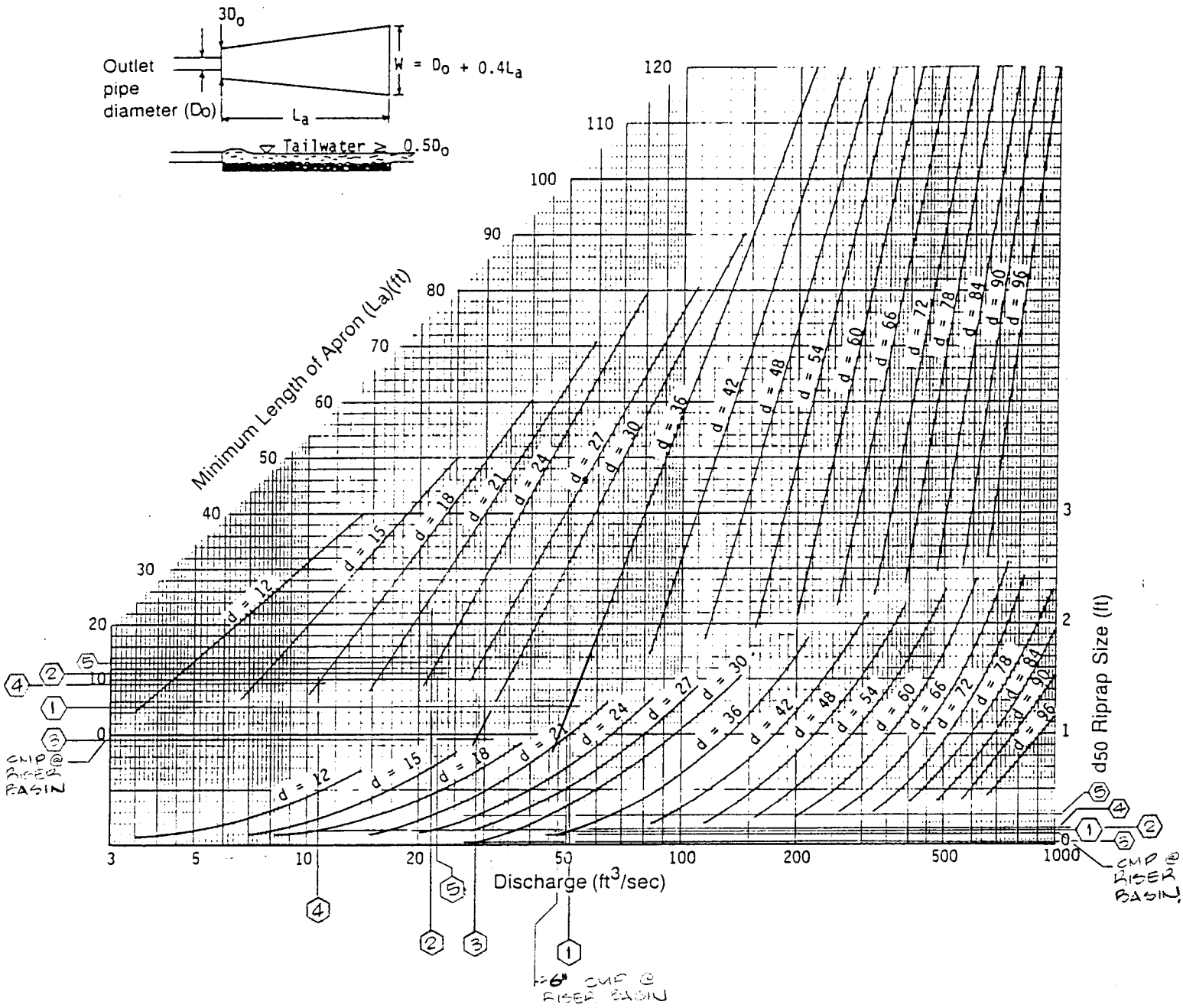


PIPE FLOW CHART
30-INCH DIAMETER

E-2



PIPE FLOW CHART
36-INCH DIAMETER



Curves may not be extrapolated.

Figure 8.06b Design of outlet protection from a round pipe flowing full, maximum tailwater condition ($T_w \geq 0.5$ diameter).