Coal Combustion Residuals (CCR) Run-on and Run-off Control System Plan

Virginia Electric and Power Company
Mount Storm Power Station
Phase B Disposal Area
Grant County, West Virginia

GAI Project Number: C141182.02

October 2016

Prepared by: GAI Consultants
Murrysville Office
4200 Triangle Lane
Export, Pennsylvania 15632

Prepared for: Dominion Virginia Power
5000 Dominion Boulevard
Glen Allen, Virginia 23060

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Table of Contents

Certification/Statement of Professional Opinion

The Coal Combustion Residuals Run-on and Run-off Control System Plan (Plan) for the Mount Storm Phase B Disposal Area was prepared by GAI Consultants (GAI). The Plan was based on certain information that, other than for information GAI originally prepared, GAI has relied on but not independently verified. This Certification/Statement of Professional Opinion is therefore limited to the information available to GAI at the time the Plan was written. On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the State of West Virginia that the Plan has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances at the same time, and in the same locale. It is my professional opinion that the Plan was prepared consistent with the requirements of section 257.81 of the United States Environmental Protection Agency's "Disposal of Coal Combustion Residuals From Electric Utilities," published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (40 CFR 257 Subpart D).

The use of the words "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty or legal opinion.

GAI Consultants, Inc.

John R. Klamut, P.E.
Engineering Manager

Date 10/14/2016

JOHN R. KLAMUT
20866

Acronyms

CCR	Coal Combustion Residuals
CCR Rule	“Disposal of Coal Combustion Residuals From Electric Utilities” 40 CFR § 257 Subpart D (2015)
CFR	Code of Federal Regulations
Dominion	Virginia Electric and Power Company d/b/a Dominion
EPA	United States Environmental Protection Agency
GAI	GAI Consultants
Phase B	Phase B Disposal Area
Plan	Run-on and Run-off Control System Plan
Station	Mount Storm Power Station
WV	West Virginia

1.0 Introduction

The Mount Storm Power Station (Station) is owned by Virginia Electric and Power Company d/b/a Dominion Virginia Power (Dominion) and is located in Mount Storm, West Virginia (WV). The Station uses the Phase B Disposal Area (Phase B) for the long term storage of coal combustion residuals (CCR).

Phase B is located on Dominion property at the Station in Grant County, WV (39°11’05”N 79°17’05”W), and is generally bounded by Mount Storm Lake on the east and south, Interstate 48 on the west, and West Virginia Route 93 on the north.

Phase B is regulated as an existing CCR landfill under the United States Environmental Protection Agency’s (EPA’s) “Disposal of Coal Combustion Residuals From Electric Utilities” published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule).

2.0 Purpose

Phase B is a landfill permitted to receive CCR material from Station operations. Phase B was designed to be constructed in two stages. During each stage of operation, diversion channels minimize stormwater from flowing onto the active portion of the landfill, and run-off channels collect and control stormwater that has contacted the active portion of the landfill.

Title 40 of the Code of Federal Regulations (CFR) § 257.81 requires that the run-on control system has been designed, constructed, operated, and maintained to prevent flow onto the active portion of Phase B during peak discharge of a 25-year, 24-hour storm. Similarly, the run-off control system must be designed, constructed, operated, and maintained to collect and control the water volume resulting from a 25-year, 24-hour storm.

This Plan is prepared pursuant to the requirements in the United States Environmental Protection Agency’s “Disposal of Coal Combustion Residuals From Electric Utilities” published in the Federal Register on April 17, 2015 with an effective date of October 19, 2015 (CCR Rule), § 257.81(c).

3.0 Run-on and Run-off Control System Plan (Plan)

As required by 40 CFR § 257.81(c), this Plan includes the following:

- Documentation of how the run-on and run-off control systems have been designed to meet the applicable requirements of § 257.81; and
- Documentation that the Plan is supported by appropriate engineering calculations:
  - Supporting calculations for Sedimentation Pond 015 are provided in the Hydrologic and Hydraulic Design Report (GAI, 2007), which is part of Solid Waste NPDES Permit No. WV0110256*.*
  - Other supporting calculations are provided in Appendix A.

3.1 Run-on Controls

The run-on control system consists of a series of diversion ditches that minimize stormwater contact with CCR.

3.1.1 Diversion Ditches

Diversion ditches to the northern and southern sides of Sediment Pond 015 are designed to control peak flows to the Pond resulting from at least the 25-year, 24-hour storm event. The diversion ditches direct run-on around the sediment pond and eventually discharge to Mount Storm Lake.

3.2 Run-off Control System

The run-off control system consists of a series of collection ditches that collect and control CCR contact water. The Phase B benches, collection ditches, collection culverts, and sedimentation ponds are designed to control the peak flow from at least the 25-year, 24-hour storm event. The run-off control system meets the applicable requirements of 40 CFR § 257.81.

3.2.1 Bench Capacity

The benches are designed to control peak flows resulting from at least the 25-year, 24-hour storm event. Stormwater that contacts benches is directed toward the collection ditches.

3.2.2 Collection Ditches

Collection ditches are constructed around the perimeter of the active portions of Phase B to direct contact water to the sedimentation ponds. The collection ditches are designed to be lined with vegetation/turf reinforcement, grouted rip-rap, rip-rap, or armor-lined depending on the location, flow velocities, and channel slopes. The collection ditch capacities control at least the 25-year, 24-hour storm during all phases of construction of Phase B. The collection ditches discharge contact water both directly and through a series of culverts to the sedimentation control ponds.

3.2.3 Collection Culverts

Collection culverts control run-off from the collection ditches. The culverts are designed to control at least the 25-year, 24-hour storm. The collection culverts discharge to the sedimentation control ponds.

3.2.4 Sedimentation Ponds

Sedimentation Ponds 014 and 015 control run-off from the collection ditches. The sedimentation ponds are designed to control and discharge the peak flow from a 25-year, 24-hour storm. The primary spillway is a riser and discharge pipe that controls flow during normal operation. The emergency spillway is capable of at least passing the 25-year peak discharge without overtopping the crests of the ponds. Both the primary and emergency spillways discharge to a combined spillway channel, and eventually to Mount Storm Lake.

The sedimentation ponds are maintained by cleaning out sediment as necessary when the wet storage area is reduced below a set volume.

4.0 References

GAI Consultants. *Phase B Ditch Design Calculations 88-108-70*; March 1994.

GAI Consultants. *Application for Class F Industrial Waste Landfill Facility, Life of Station Ash Disposal Facility – Phase A & B;* December 1990.

GAI Consultants. *Hydrologic and Hydraulic Design Report, Sedimentation Pond 015, NPDES Permit No. WV0110256;* January 2007.

GAI Consultants. *Phase B – Pond #3 Modification Design Calculations;* February 1992.

State of West Virginia, Department of Environmental Protection. *Solid Waste National Pollutant Discharge Elimination System Permit No. WV0110256*; April 2014.

United States Environmental Protection Agency (EPA). 40 CFR Parts 257 and 261, *Hazardous and Solid Waste Management Disposal System; Disposal of Coal Combustion Residual from Electric Utilities, Final Rule*; April 2015.

APPENDIX A

Hydraulics and Hydrology Calculations

HYDRAULICS AND HYDROLOGY CALCULATIONS

CHANNELS

Calculation package includes:
1. Design Calculations, Ditches A through F - Phase B

TRANSMITTAL MEMO

GAI CONSULTANTS, INC.
Engineers • Geologists
Planners • Environmental Specialists

570 Beatty Road • Pittsburgh
Monroeville, Pa. 15146
412-856-6400

CENTRAL FILES
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To: Mr. Bob Williams
Virginia Power Company
5000 Dominion Boulevard
Glen Allen, Virginia 23060

Project No.: 88-108-70

Date: March 2, 1994

We are sending you the materials listed below:

☒ attached
☐ under separate cover

No. Copies	Description	Drawing No.	Dated
1 Each	1986 - Design Calculations, Ditches A through F - Phase B 1990 - Redesign for Ditches B & C - Phase B 1991 - Evaluation of Existing Ditch 3B - Phase B 1992 - Redesign of Ditch F - Phase B		

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GAI CONSULTANTS, INC.

By: James L Snodgrass
James L. Snodgrass, P.E.

1986 DESIGN CALCULATIONS

Calculation Designation	Drawing Designation
SED 2P	DITCH A
SED 1S	DITCH B
SED 1P	DITCH C
SED 1T	DITCH D
SED 2Q	DITCH E
SED 1Q	DITCH F

NOTE: All ditches will be redesigned to post-mining conditions.

SUBJECT Revise Channel SED1P & North area

BY NJB DATE 6/24/86 PROJ. NO. 84-215-4
CHKD. BY ______ DATE ______ SHEET NO. 1 OF ______

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Channel SED1P revised to match final layout

Refer to worksheet #624

WATERSHED	AREA (acres)
B	9.6
C	3.8
L	24.3
M	9.4
N	4.8
O	1.7
P	7.6
Q	17.7
R	10.3
S	12.8
TOTAL	102 ac.

SUBJECT

BY DATE 6/24/06 PROJ. NO.

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Channel SE01S Watershed = Area N

Longest Path - Channel flow from HP 3591 to entrance of channel SE01U.

length of channel = 3300'
avg. slope ~ 2.5%
estimate velocity = 3.5fps.

$T_c = \frac{3300'}{3.5 fps}$ 943 sec = .26 hr. use T_c = 0.3 hr

HO_p 658

RO = 2.89 in (P = 5", CN = 80)

DA = 4.8 ac.

$Q_p =$ 658 cfs/mi^2-in × 4.8 ac /640 ac/mi^2 × 2.89 in

= 14 cfs.

SUBJECT

BY DATE 6/24/86 PROJ. NO.

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Channel SED 1T

Watershed is Area M

Longest Path: 45' @ S = 33% estimated velocity = 20 fps
470' @ S = 1% V_e = 1.5 fps
720' @ S = 7.2% V_e = 7 fps

$$T_c = \frac{45}{20} + \frac{470}{1.5} + \frac{720}{7} = 2.25 + 313 + 103 = 418 \text{ sec} = 0.12 \text{ hr}$$

Use Tc = 0.1 hr , HQp = 991

DA = 9.4 ac RO = 2.89 in

Qp = 991 cfs / mi² - in × 9.4 ac / 640 ac / mi² × 2.89 in
= 42 cfs

SUBJECT
BY DATE 6/24/86 PROJ. NO.
CHKD. BY DATE SHEET NO. 3 OF

Channel SED1U

Watershed = M+N + B + P = 9.4 + 4.8 + 9.6 + 7.6 = 31.4 ac.

M+N @ CN=80
B+P @ CN=65

$$\overline{CN} = \frac{(9.4+4.8)(80) + (9.6+7.6)(65)}{31.4} = 71.8$$

$$RO = \frac{(P-0.2S)^2}{P+0.8S} \qquad CN = \frac{1000}{10+S} \therefore S = \frac{1000}{CN} - 10$$

P=5.0'' S= 3.9 RO= 2.19

Final longest Path: Channel SED1S to SED1U

SED1S = 943 sec
SED1U ~ 1100' @ 0.5% V= 2
340' @ 7.4% V= 10
750' @ 3.8% V= 7

$$T_c = 943 + \frac{1100}{2} + \frac{340}{10} + \frac{750}{7} = 943 + 550 + 34 + 107 = 1634 \text{ sec}$$

= 0.45 hr use T_c = 0.4 hr, HO_p = 575

Q_p = HO × DA × RO

$$Q_p = 575 \times \frac{31.4}{640} \times 2.19 = 62 \text{ cfs}$$

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Channel SED 1R   Watershed = area L for green reach

T_c → see Path #2, Sed Pond #1 sheet 2 of 2

Flows from HP @ 3571.5 to El 3563.5

T_c = 530 + 295 + 205 + 70 + 163 = 1263 sec = 0.35 hr

use T_c = 0.3 hr, q_p = 658 cfs/mi²-in

CN = 80 → RO = 2.89 in

Area = 24.3 ac.

Q_p = 658 cfs/mi²-in × 2.89 in × 24.3 ac / 640 ac/mi²

= 72 cfs

yellow reach: add area S → 12.8 ac.

DA = 12.8 + 24.3 = 37.1 ac

do not increase T_c

Q_p = 658 × 2.89 × 37.1 / 640 = 110 cfs.

SUBJECT

BY   DATE 6/24/86   PROJ. NO.

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Channel SED 1P   Watershed is area R + C + O + S + L
from El. 3505.5 to 3446.7

Area = 10.3 + 3.8 + 1.7 + 24.3 + 12.8 = 52.9 ac.

$$CN = \frac{(3.8+1.7)(65)+(10.3+24.3+12.8)(80)}{52.9} = 78.4$$

$$S = \frac{1000}{CN} - 10 = 2.76 \qquad P = 5''$$

$$RO = \frac{(P-.2S)^2}{P+.8S} = 2.74 \text{ in}$$

Tc → longest drainage path is from HP @ 3592.5 in area L

Path: SED 1R green − 1263 sec
SED 1R yellow − 560' @ S = 10.4% use V = 12 fps
SED 1P El 3505.5 to 3446.7 ~800' @ 8.1% use V = 10

$$Tc = 1263 + \frac{560}{12} + \frac{800}{10} = 1263 + 47 + 80 = 1390 \text{ sec} = 0.39 \text{ hr}$$

use Tc = 0.4 hr → HO_p = 575

$$Q_p = DA \times RO \times HO_p$$

$$= 52.9/640 \times 2.74 \times 575 = 130 \text{ cfs}$$

Channel SED1P Orange reach

Watershed = Total = 102 ac.

Longest drainage path:

Tc of SED1U = 1634 sec

Tc of SED1P red reach = 1390 sec

extend path from SED1U.

Tc = 1634 sec
+ 260' @ 4.5% est V = 10 fps
+ 940' @ 2.0% est V = 7 fps.

$$T_c = 1634 + \frac{260}{10} + \frac{940}{7} = 1794 \text{ sec} = 0.5 \text{ hr} \Rightarrow HO_p = 496$$

$$\overline{CN} = \frac{(P+O+B+C)\,65 + (Q+R+S+L+M+N)(80)}{102}$$

$$= \frac{(\overset{(22.7)}{7.6+1.7+9.6+3.8})65 + (102-22.7)(80)}{102}$$

$\overline{CN} = 76.7 \Rightarrow RO = 2.62$ in

$Q_p = DA \times RO \times HO_p$

$= 102/640 \times 2.62 \times 496 = 207$ cfs.

SUBJECT

BY DATE 6/24/86 PROJ NO

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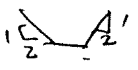
ITCH	DESIGN Q (CFS)	LINING	n	SHAPE	BOTTOM WIDTH (FT)	MAX VELOCITY (FPS)	MIN DEPTH (FT)	MIN VELOCITY (FPS)	MAX DEPTH (FT)	DESIGN DEPTH (FT)	TF
ED1S	14	grass	.045		3′	3.8 S=2.9%	0.8	3.5 S=2.1	0.9		
SED 1T	42	enka or riprap	.04	"	"	7.8 S=7.2%	1.05				
SED 1U	62	grass	.045	"	"	6.3 S=3.8	1.6	3 S=0.5%	2.6		
		enka or riprap	.04	"	"	8.9 S=7.4	1.3	6.9 S=3.8	1.5		
SED 1R green	72	grass	.045	"	"	4.6 S=1.4%	2.2				
yellow blue	110	riprap	.04	"	"	11.8 S=10.4%	1.6				
SED 1P red Q 3505.5 34467	130	riprap or enka	.04			11.1 S=8.1	1.8	9.0 S=4.5	2.1		
orange	207	~~grass~~ riprap or enka	~~.045~~ .04			10.0 S=4.5	2.6	~~6.8~~ 7.5 S=2.0	3.2 3.1		

SUBJECT Mt. Storm Hydrology Stage 1

BY NJB DATE 3/28 PROJ. NO. 84-215-4

CHKD. BY DATE SHEET NO. 1 OF 1

WATERSHEDS A-J and Q shown on slope drain worksheet #328

WATERSHEDS K-P shown on ditch watershed worksheet #331

WATERSHED	AREA (ACRES)
A	0.3
B	7.5
C	12.2
D	0.8
E	0.5
F	0.5
G	1.8
H	1.5
J	0.4
K	2.9
L	5.1
M	7.9
N	4.7
O	6.0
P	16.6
Q	4.1

Void 6/24/86
channels around north area
were revised - see calcs for
channel SED1P, 6/24/86

SUBJECT Mt Storm Stage 1 Hydrology

BY NGS DATE 3/31/86 PROJ. NO. 84-215-4

CHKD. BY DATE SHEET NO. 7 OF

Channel SED 2P

Reach: El 3583 to El 3517 (blue on worksheet #331)

Longest Path

Swale flow 540' @ S=1% V=2 fps
Slopedrain S-24 60' @ 25.3% V=11.4
channel flow 365' @ 5% V=7
740' @ 3.5% V=6

$$T_c = \frac{540}{2} + \frac{60}{11.4} + \frac{365}{7} + \frac{740}{6} = 270 + 5. + 52 + 123$$

$= 450$ sec $= 0.125$ hr

use $T_c = 0.1$ hr $\Rightarrow$ $HQ_p = 991$ cfs/in-mi^2

RO = 2.89 in

DA = Q + S-24 + S-25 = 4.1 + 3.0 + 4.2 = 11.3 ac.

$Q_p = 991 \times 2.89 \times (11.3)/640$

= 51 cfs.

SUBJECT MH Storm Stage I Hydrology

BY NJB DATE 3/31/86 PROJ. NO. 84-215-4

CHKD. BY DATE SHEET NO. 8 OF

Channel SED 2P

Reach: El 3517 to El 3492 (green on worksheet.)

Find Longest Path

Route 1 - Extend previous flow path

Previous flow	450 sec
Channel flow	310' @ S=4.4% V=8 fps
	160' @ S=7.2% V=9.5 fps

$$T_c = 450 + \frac{310}{8} + \frac{160}{9.5} = 506 \text{ sec}$$

Route 2 - Follow bench to slope drain S-1

Swale flow	1590' @ S=1% V=2 fps
slope drain S-1	60' @ S=25% V=13.5
Channel flow	310' @ S=4.4 V=8
	160' @ S=7.2 V=9.5

$$T_c = \frac{1590}{2} + \frac{60}{13.5} + \frac{310}{8} + \frac{160}{9.5} = \underline{\underline{855 \text{ sec}}} = 0.24 \text{ hr}$$

use $T_c = 0.20$ hr $\Rightarrow HQ_p = 796$ cfs/mi²-in

DA = 11.3 + S-1 + S-2 + A

11.3 + 15.7 + 5.5 + 0.3 = 32.8

Q_p = 796 cfs/mi²-in × 2.89 in × 32.8 ac / 640 ac/mi²

= 118 cfs.

Channel SED2P

Reach: El 3492 to El 3380 (orange on worksheet)

Longest Path:

Previous path 855 sec

~~Additional~~ Channel 1385' @ S = 7.7% V = 10 fps ej.

490' @ S = 1% V = 5 fps ej.

$$T_c = 855 + \frac{1385}{10} + \frac{490}{5} = 1092 \text{ sec} = 0.30 \text{ hr.}$$

$HO_p = 658$ cfs/in-mi^2

RO = 2.89 in

DA = 32.8 + S-3 + S-4 + B

= 32.8 + 6.7 + 4.8 + 7.5

= 51.8 ac.

Qp = 658 × 2.89 × 51.8/640

= 154 cfs.

Revised 7/25

DA = 32.8 + ORANGE = 32.8 + S-3 + S-4 + D-B + D-A + REMAINING ORANGE

= 32.8 + 1.6 + 2.0 + 8.9 + 6.6 + 8.5 = 60.4 ac.

Qp = 658 × 2.89 × 60.4/640 = 179 cfs.

Stage II - Qp = 194 - use Stage II Qp for channel design

SUBJECT Mt Storm Stage I Hydrology

BY NJB DATE 3/31/86 PROJ. NO. 84-215-4

CHKD. BY DATE SHEET NO. 10 OF

Channel SED 1 Q

Reach: El 3530 to El 3470.75 (yellow on worksheet)

Longest drainage path:

Overland flow: 310' @ S=1.4% V=1.2 Fig 3.1 TR-55 "nearly bare ground"

Swale flow: 1605 @ 1% V=2 fps e.j.
Slopedrain S-10: 45' @ 28.7% V=14.5 fps slopedrain calcs.
Channel flow: 225' @ 6.8% V=9 e.j.
120' @ 12.2% V=12 e.j.

$$T_c = \frac{310}{1.2} + \frac{1605}{2} + \frac{45}{14.5} + \frac{225}{9} + \frac{120}{12}$$

$$= 258 + 803 + 3 + 25 + 10 = 1099 \text{ sec} = 0.305 \text{ hr}$$

Use $T_c = 0.30$ hr $\Rightarrow HO_p = 658$ cfs/in-mi^2

RO = 2.89 in

DA = S-10 + S-11 + S-12 + F

= 10.7 + 8.7 + 4.6 + 0.5

= 24.5 ac

$$Q_p = HO_p \times DA \times RO$$

$$= 658 \text{ cfs}/\cancel{mi^2}\cdot\cancel{in} \times 2.89 \cancel{in} \times 24.5 \,ac/640 \,\cancel{ac}/\cancel{mi^2}$$

= 73 cfs.

SUBJECT Mt Storm Staged Hydrology

BY NJB DATE 3/31/86 PROJ. NO. 84-215-4

CHKD. BY DATE SHEET NO. 11 OF

Channel SED1Q

Reach: El 3470.75 to El 3418.24 (red on worksheet)

Longest drainage path:

Previous path: 1099 sec

Additional channel: 120' @ S = 13.4% V = 13 fps ej

120' @ S = 12.6% V = 13 ej.

280' @ S = 4.4% V = 9

270' @ S = 3.4% V = 8

$$T_c = 1099 + \frac{240}{13} + \frac{280}{9} + \frac{270}{8} = 1182 \text{ sec} = 0.328 \text{ hr}$$

use $T_c = 0.30$ hr ⇒ $HO_p = 658$ cfs/in-mi^2

RO = 2.89 in

DA = 24.5 + S-13 + S-14 + S-15 + G

= 24.5 + 4.6 + 4.9 + 5.2 + 1.8 =

= 41 ac

$Q_p = HO_p \times DA \times RO$

$= 658 \times 41/640 \times 2.89$

= 122 cfs

SUBJECT Mt. Storm Stage I Hydrology
BY NJB DATE 3/31/86 PROJ. NO. 84-215-4
CHKD. BY DATE SHEET NO. 12 OF

Channel SED 2Q

Reach: El 3530 to El 3493.6 (red on worksheet)

Find Longest drainage path:

Route 1 - From High Point @ El 3548.5

Overland flow : 280' @ S=1.4% V=1.2 Fig 3.1 Nearly Bareground
Slope drain S-9 45' @ S=28.7% V=10.6 slope drain calcs.
Channel flow 275' @ 1.4% V=2.5 ej.
slope drain S-8 60' @ 25.5% V=11.5 slope drain calcs
channel flow 420' @ 4.5% V=6 ej.
510' @ 1.7% V=4
630' @ 2.4% V=5
50' @ 4.5% V=6

$$T_c = \frac{280}{1.2} + \frac{45}{10.6} + \frac{275}{2.5} + \frac{60}{11.5} + \frac{420}{6} + \frac{510}{4} + \frac{630}{5} + \frac{50}{6} = 685 \text{ sec}.$$

Route 2 - From High Point @ El 3517

Overland Flow : 560' @ S=1.4% V=1.2 fps Fig 3.1
Slope drain S-7 65' @ S=23.7% V=12.1 slope drain calcs
Channel flow 510' @ 1.7% V= 4 ej.
630' @ 2.4% V=5 ej.
50' @ 4.5% V=6 ej.

$$T_c = \frac{560}{1.2} + \frac{65}{12.1} + \frac{510}{4} + \frac{630}{5} + \frac{50}{6} = 734 \text{ sec} = 0.20 \text{ hr}$$

$T_c = 0.20$ hr $\Rightarrow$ HOp = 796 cfs/in-mi^2

RO = 2.89 in^3

SUBJECT Mt Storm Stage 1 Hydrology

BY NJB DATE 3/31/86 PROJ. NO. 84-215-4

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DA = (S-9) + (S-8) + (S-7) + E + D

= 0.9 + 1.9 + ~~4.9~~ + 0.8 + 0.5
10.2 (7/25)

= ~~9.0~~ ac. 14.3 ac (7.25)

Qp = 796 × 2.89 × ~~9.0~~ /640 = ~~32~~ cfs
14.3 51

Channel SED 2a

Reach: El 3467.75 to El 3380 (blue on worksheet)

Find Longest drainage path:

Route 1: Extend previous path.

Previous reach: 734 sec
Channel flow: 410' @ 2.9% V=7 fps ej
220' @ 7.6% V=10 ej
260' @ 22.7% V=15 ej.

$$T_c = 734 + \frac{410}{7} + \frac{220}{10} + \frac{260}{15} = 734 + 59 + 22 + 17 = 832 \text{ sec}$$

Route 2: from drainage break @ El 3498.5

Overland flow 700' @ S=1.4% V=1.2 fps
Swale flow 650' @ S=1% V=2 fps
Slope drain S-6 60' @ S=25.1% V=12.8 fps
Channel flow 410' @ 2.9% V=7
220' @ 7.6% V=10
260' @ 22.7% V=15

$$T_c = \frac{700}{1.2} + \frac{650}{2} + \frac{60}{12.8} + \frac{410}{7} + \frac{220}{10} + \frac{260}{15}$$

$$= 583 + 325 + 5 + 59 + 22 + 17 = 1011 \text{ sec}$$

Route 3 : from High Point @ El 3515.4

Overland flow: 45' @ S = 33% V = 5.5 fps Fig 3.1 Nearly bare
" " 170' @ S = 1.4% V = 1.2
Swale flow 1320' @ 1% V = 2
Slopedrain S-6 60' @ 25.1% V = 12.8
Channel flow 410' @ 2.9% V = 7
220' @ 7.6% V = 10
260' @ 22.7% V = 15

$$T_c = \frac{45}{5.5} + \frac{170}{1.2} + \frac{1320}{2} + \frac{60}{12.8} + \frac{410}{7} + \frac{220}{10} + \frac{260}{15}$$

$$= 8.2 + 142 + 660 + 5 + 59 + 22 + 17 = 913 \text{ sec}$$

Longest Path: T_c = 1011 sec = 0.28 hr use T_c = 0.30 hr

HO_p = 658 cfs/in-mi^2

DA = 9.0 + (S-6) + (S-5) + C

= 9.0 + 10.3 + 7.2 + 12.2 = 38.7 ac.
7/25 DA = 14.3 + S-6 + BLUE = 14.3 + 12.4 + ~0.5 = 27.2 ac.

$Q_p = HO_p \times DA \times RO$

= 658 × ~~38.7~~ 27.2 /640 × 2.89 = ~~45~~ 81 cfs.

SUBJECT Mt Storm - Collection Channels - Stage 1 (worst case for channels SED1P, SED1Q & SED2Q)

BY NJB DATE 4/1/86 PROJ NO 84-215-4

CHKD BY J DATE SHEET NO. 15 OF

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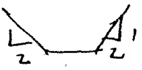
DITCH	DESIGN Q (CFS)	LINING	n	SHAPE	BOTTOM WIDTH (FT)	MAX VELOCITY (FPS)	MIN DEPTH (FT)	MIN VELOCITY (FPS)	MAX DEPTH (FT)	DESIGN DEPTH (FT)
SED1P ①	10 green	grass	.045		3	3.8 S=3.5	.65	3.3 S=2.5	.7	
"	120 red	riprap	.04	"	"	11.4 S=9.0	1.7			
					4	11.4 S=9	1.6			
②	193 blue	riprap	.04	"	3	15.0 S=13.2	2.0	11.0 S=6.0	2.3	
	259 yellow	"	"	"	"	10.6 S=4.3	2.9	7.7 S=1.9	3.4	
SED1Q	73 yellow	grass riprap	.045 .04	"	"	11.5 S=12.2	1.3	7.1 8.7 S=6.0	3.6 1.5	
	1.22 red	grass riprap	.045 .04	"	"	13.4 S=13.4	1.6	8.0 7.8 S=3.4	1.6 2.1	
		grass	.045	.	"			7.3 S=3.4	2.3	

SUBJECT Mt Storm Collection Channels - Stage 1

BY NJB DATE 4/1/86 PROJ. NO 84-215-4

CHKD BY DATE SHEET NO. 16 OF

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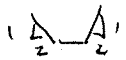
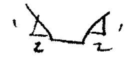
	DESIGN Q (CFS)	LINING	n	SHAPE	BOTTOM WIDTH (FT)	MAX VELOCITY (FPS)	MIN DEPTH (FT)	MIN VELOCITY (FPS)	MAX DEPTH (FT)	DESIGN DEPTH (FT)	
* SED2Q	32 red	grass	.045		3	6.4 S=6.3	1.0	4.0 S=1.7	1.4		.9/.4
"	115 blue	riprap	.04		3	10.4 S=7.6	1.7	7.4 S=2.9	2.2		.99/.6
"	"	grass fabriform	.045 .03	"	3	19.5 S=22.7	1.15	>6.8	2.3		.5 2.5
					5	18.3	.9				2.9
					10	16.2	.65				3.4
					15	14.2	.5				3.4
			.025	'	3	22.3	1.05				
					5	21.2	0.85				

*revised 7/25

SUBJECT Mt Storm Stage I Riprap Design

BY NJB DATE 4/3/86 PROJ. NO. 84-215-4

CHKD. BY DATE SHEET NO. 17 OF

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SED 1, R #1P
Type 8
V = 11.8,
11.1
R-7
→ Rip 8.

DESIGN RIPRAP

DETERMINE STONE SIZE FROM FIG 2, p. 11-16

USE $D_{MAX} = 1.5 \times D_{50}$

USE DEPTH = 1.5 × D_{MAX}

CHANNEL	Q cfs	SLOPE %	V fps	D_{50} ft	D_{50} in	D_{MAX} in	DEPTH	RIPRAP TYPE
SED1P	120	9.0	11.4	1.15	13.8	21	2' 7"	R-7
"	193	13.2	15.0	2.0	24.0	36	4' 6"	R-8
"	"	6.0	11.0	1.05	12.6	19	2' 4"	R-6
	259	4.3	10.6	1.0	12.0	18	2' 3"	R-6
SED1Q	73	12.2	11.5	1.15	13.8	21	2' 7"	R-7
"	"	6.0	8.7	0.65	7.8	12	1' 6"	R-5
"	122	13.4	13.4	1.6	19.2	29	3' 7"	R-8
SED2Q	115	7.6	10.4	.95	11.4	17	2' 2"	R-6
"		2.9	7.4	0.5	6.0	9	1' 2"	R-4

← use Enkamat

→ use grouted riprap 6/86

SUBJECT Mt Storm Stage 1 Riprap design

BY NJB DATE 4/3/86 PROJ. NO. 84-215-4
CHKD. BY DATE SHEET NO. 18 OF

DESIGN RIPRAP:

CHECK TO SEE THAT n value IN CHANNEL CALCS IS OK.

CHECK $|n_c - n_d| \leq .005$ where $n_c = .0395\ D_{50}^{1/6}$

Ref: p57 Design of Stable Channels with Flexible Linings

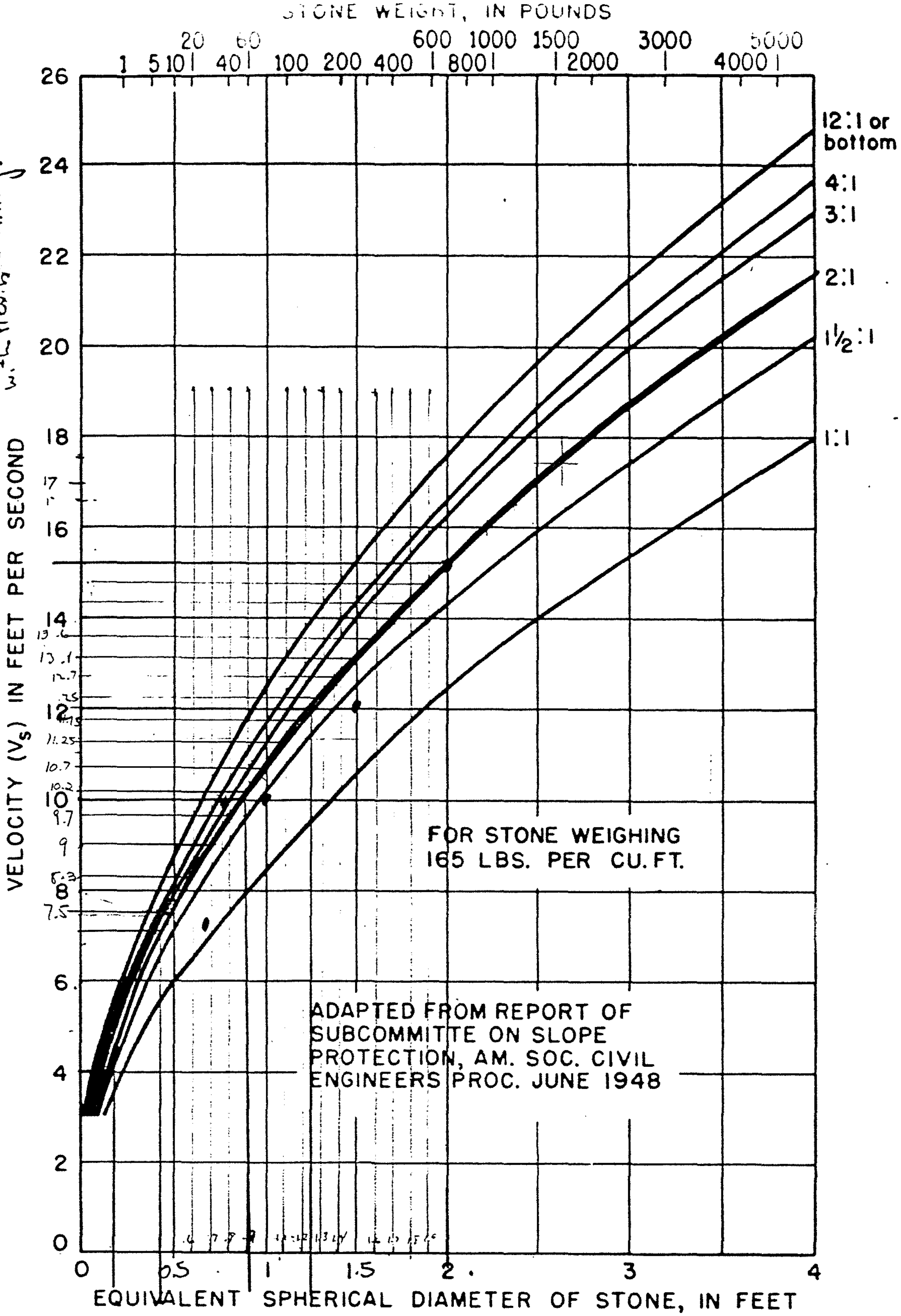
CHANNEL	D50	n_c	nd	$\|n_c - n_d\|$
SE01P	1.15	.040	.04	0
"	2.0	.044	.04	.004 < .005 ✓
"	1.05	.040	.04	0
"	1.0	.040	.04	0
SE01Q	1.15	.040	.04	0
"	0.65	.037	.04	.003 < .005 ✓
"	1.6	.043	.04	.003 < .005 ✓
SE02Q	.95	.039	.04	.001 < .005 ✓
"	0.5	.0352	.04	.0048 < .005 ✓

Design of Stable Channels with Flexible Linings

← p.57

$\boxed{n = 0.0395\ D_{50}^{1/6}}$

$c - n_d \mid \leq 0.005$



FOR STONE WEIGHING 165 LBS. PER CU.FT.

ADAPTED FROM REPORT OF SUBCOMMITTE ON SLOPE PROTECTION, AM. SOC. CIVIL ENGINEERS PROC. JUNE 1948

FIG. 2-SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

$D_{max} = 1.5 \times D_{50}$

$Depth = 1.5 \times D_{max}$

• PA DER STANDARDS

NG

f rock lining of the class

n structural defects and materials; from an ap- graphic examination for ents:

width nor thickness less

nined in accordance with -dry basis.

smallest to the largest

2. Size and Gradation.

	Percent Passing (Square Openings)					
Class, Size No. (NCSA)	R-8	R-7	R-6	R-5	R-4	R-3
Rock Size (Inches) (D_{50})						
48	100*					
30		100*				
24	15-50		100*			
18		15-50		100*		
15	0-15					
12			15-50		100*	
9		0-15		15-50		
6			0-15		15-50	100*
4				0-15		
3					0-15	15-50
2						0-15
Nominal Placement Thickness (inches)	48	36	30	24	18	12

* Maximum Allowable Rock Size.

DITCHES B & C REVISED - CALCULATIONS

(DITCH D DELETED BY MINE PIT CONFIGURATION CHANGE)

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SUBJECT VEPCO - MT. STORM
CHANNEL DESIGN - REVISION OF DITCHES B, C, AND D
BY MTP DATE 9/5/90 PROJ. NO. 88-108-30
CHKD. BY JLS DATE 9/12/90 SHEET NO. 1 OF 19

TASK: THE AREA BETWEEN DITCHES B AND C WILL NOT BE DEVELOPED AS ORIGINALLY PLANNED. THE AREA IS SHOWN ON THE ATTACHED DRAWING 84-215-E137 (CROSS-HATCHED AREA). INSTEAD DITCH A WILL BE EXTENDED AS SHOWN ON DRAWING 84-215-E137. THEREFORE, A PORTION OF DITCH A WILL BE RE-DESIGNED.

USE THE SCS - TR 55 GRAPHICAL METHOD TO DETERMINE PEAK DISCHARGE.

SUBJECT VEPCO - MT STORM

CHANNEL DESIGN - REVISION OF DITCHES B, C AND D

BY MTP DATE 9/9/90 PROJ. NO. 88-108-30

CHKD. BY JLS DATE 9/12/90 SHEET NO. 1A OF 19

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SUMMARY (TRAPEZOIDAL CHANNELS)

CHANNEL	DESIGN Q (CFS)	BOTTOM WIDTH	DEPTH (W/F.B)	VELOCITY	LINING
2	153	6	3	9.7	RIP-RAP (R-5)
3	33	3	3	3.3	GRASS
4	7	3	1.5	3.7	GRASS
5	186	6	3	9.3	RIP-RAP (R-5)

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SUBJECT VEPCO – MT. STORM
CHANNEL DESIGN – REVISION OF DITCHES B, C, AND D
BY MTP DATE 9/6/90 PROJ. NO. 88-108-30
CHKD. BY JLS DATE 9/12/90 SHEET NO. 2 OF 19

DESIGN CRITERIA

1) DESIGN STORM
25 YEAR/24 HOUR STORM – 5 IN.
(FROM 84-215-4, MT. STORM LIFE-OF-STATION ASH DISPOSAL FACILITY – PHASE B, 30% SUBMITTAL)

*INCREASE THIS FLOW BY 25% PER JLS

2) CHANNEL FREEBOARD – 0.5 ft. (MIN.)
(FROM REFERENCE CITED ABOVE)

*USE 1 ft PER JLS

3) RUNOFF CURVE NUMBERS
ACTIVE AREA – 80
AREA BEING RECLAIMED – 75
RECLAIMED AREA – 70
OFF-SITE AREAS – 65 (HYDROLOGIC SOIL GROUP C)

(FROM REFERENCE CITED ABOVE)

4) TRAPEZOIDAL CHANNEL W/ WIDE BASE IS PREFERABLE (PER JLS)

5) THE ASH PILE WILL HAVE 3H:1V SIDE SLOPES BETWEEN BENCHES. (FROM REFERENCE CITED ABOVE)

THE SLOPE IN AREA 2A IS 1 OR 2% PER JLS

CHANNEL SLOPES BASED ON LAYOUT OF EXISTING BUFFALO COAL CO.

SUBJECT VEPCO. - MT. STORM

CHANNEL DESIGN - REVISION OF DITCHES B, C, AND D

BY MTP DATE 9/7/90 PROJ. NO. 88-108-30

CHKD. BY JLS DATE 9/12/90 SHEET NO. 3 OF 19

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CHANNEL 1

WAS DESIGNED PREVIOUSLY BUT I WAS UNABLE LOCATE CALCS. TO GET FLOW. PER JLS, TAKE SECTION AND PROFILE FROM DRAWINGS 84-215-E148 AND 84-215-E141, RESPECTIVELY. USE THIS INFORMATION TO CALCULATE Q.

CHANNEL 1 IS TYPE 2:

TRAPEZOID, 3' BOTTOM WIDTH, 1'-6" DEEP, GRASS LINED, 2:1 S.S.

$$\text{MIN. SLOPE} = \frac{3593.5 - 3588}{210} = 2.6\%$$

USE MANNINGS EQUATION

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

WHERE: Q = FLOW
A = CROSS-SECTIONAL AREA
P = WETTED PERIMETER
R = A/P (HYDRAULIC RADIUS)
S = SLOPE OF CHANNEL

$$A = 3 \times 1 + 2(1)^2 = 5 \text{ ft}^2$$

$$R = \frac{3 \times 1 + 2(1)^2}{3 + 2(1)\sqrt{2^2+1}} = 0.67 \text{ ft}$$

$$Q = \frac{1.49}{0.045}(5)(0.67)^{2/3}(0.026)^{1/2}$$

GRASS LINED (FROM PREVIOUS CALCS.) → 0.045

$$= 165.56(0.76)(0.16)$$

$$= 20 \text{ cfs}$$

INCREASE THIS BY 25% PER JLS

20 cfs × 1.25 = 25 cfs

SUBJECT VEPCO - MT. STORM
CHANNEL DESIGN - REVISION OF DITCHES B, C, AND D
BY MTP DATE 9/7/90 PROJ. NO. 88-108-30
CHKD. BY JLS DATE 9/12/90 SHEET NO. 4 OF 19

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RUN-OFF CURVE NUMBERS (AREAS SHOWN ON DRAWING 84-215-E137)

CHANNEL 2

		AREA (mi^2)	CN	AREA × CN
ASSUME HALF ACTIVE AND HALF RECLAIMED	2A	0.028	80	2.24
	....	0.028	70	1.96
	2B	0.008	65	0.52
		0.064		4.72

$CN_{WEIGHTED} = 4.72/0.064 = 74$

CHANNEL 3

	AREA (mi^2)	CN	AREA × CN
3A	0.007	80	0.56
	~~0.0036~~	~~70~~	~~0.252~~
3B	0.005	65	0.325
	0.012		0.885

$CN_{WEIGHTED} = 0.885/0.012 = 74$

CHANNEL 4

	AREA (mi^2)	CN	AREA × CN
4A	0.002	65	0.13
4B	0.001	80	0.08
	0.003		0.21

$CN_{WEIGHTED} = 0.21/0.003 = 70$

88-168-30

5/19

Worksheet 2: Runoff curve number and runoff

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 2 Checked JLS Date 9/12/90

Circle one: Present [✓ Developed]

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
				Totals =		

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ——— = ———; Use CN = 74 See sheet 4

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25		
Rainfall, P (24-hour) .... in	5		
Runoff, Q .... in (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	2.2		

SEE SHEET 7A

88-108-30

6/19

Worksheet 2: Runoff curve number and runoff

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 3 Checked JLS Date 9/12/90

Circle one: Present [✓ Developed] ____________

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
				Totals =		

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ____ = ____; Use CN = $\boxed{74}$ SEE SHEET 4

2. Runoff

		Storm #1	Storm #2	Storm #3
Frequency	yr	25		
Rainfall, P (24-hour)	in	5		
Runoff, Q (Use P and CN with table 2-1, fig. 2-1, or eqs. 2-3 and 2-4.)	in	2.2		

SEE SHEET 7A

Worksheet 2: Runoff curve number and runoff

Project VEPCO - MT STORM By MTP Date 9/7/90
Location AREA 4 Checked JLS Date 9/12/90
Circle one: Present [✓ Developed] ______

1. Runoff curve number (CN)

Soil name and hydrologic group (appendix A)	Cover description (cover type, treatment, and hydrologic condition; percent impervious; unconnected/connected impervious area ratio)	CN 1/			Area ☐ acres ☐ mi^2 ☐ %	Product of CN x area
		Table 2-2	Fig. 2-3	Fig. 2-4		
				Totals =		

1/ Use only one CN source per line.

CN (weighted) = $\frac{\text{total product}}{\text{total area}}$ = ____ = ____; Use CN = $\boxed{70}$ See Sheet 4

2. Runoff

	Storm #1	Storm #2	Storm #3
Frequency .... yr	25		
Rainfall, P (24-hour) .... in	5		
Runoff, Q .... in	2		

(Use P and CN with table 2-1, [✓ fig. 2-1], or eqs. 2-3 and 2-4.)

See sheet 7A

VEPCO - MT. STORM
CHANNEL DESIGN - REVISION OF DITCHES B,C,D 7A/19
88-108-30
MTP JLS
9/12/90 9/12/90

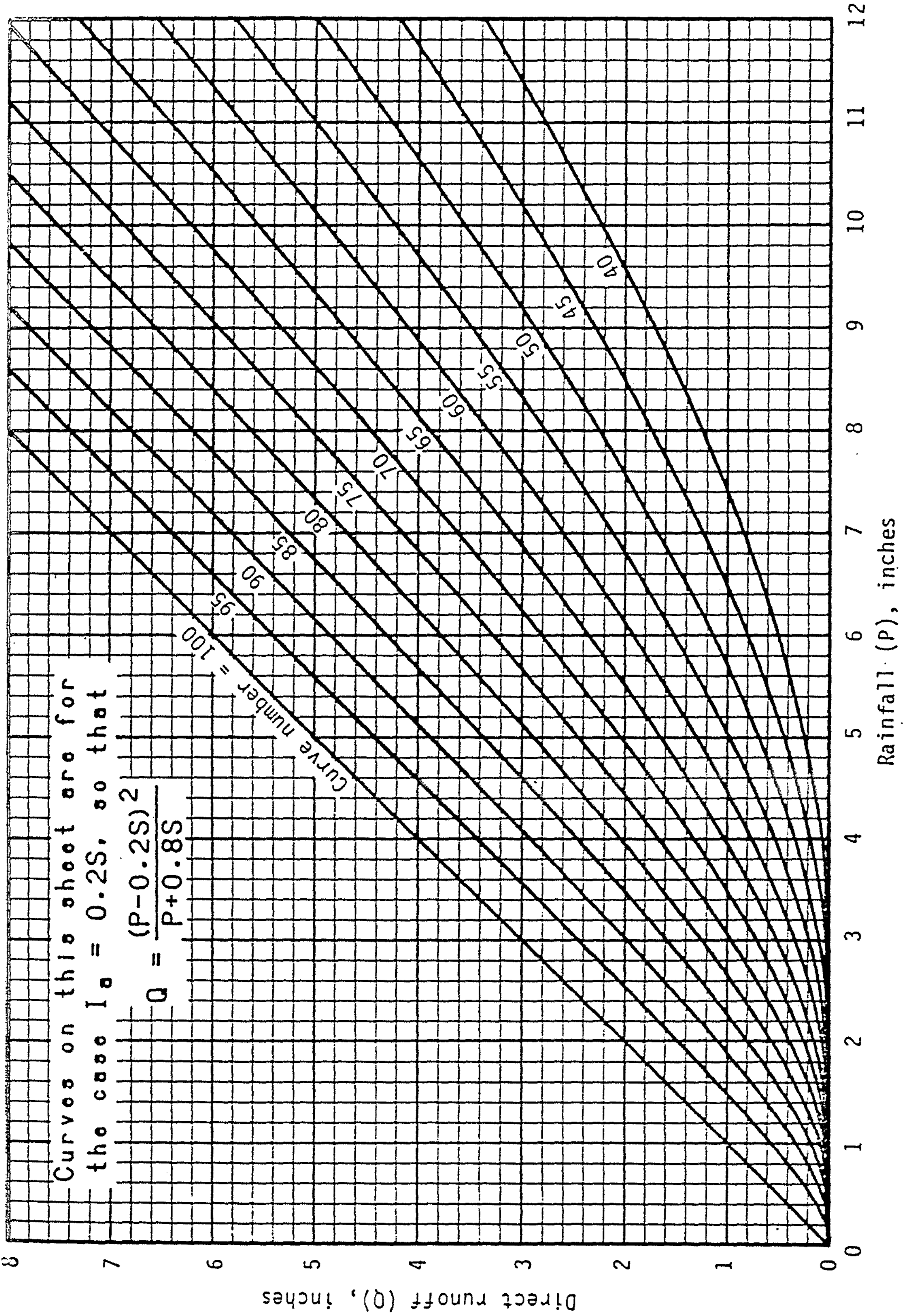


Figure 2-1.—Solution of runoff equation.

texture is g
HSG classi

Cover type

Table 2-2 a
vegetation,
are a numb
The most c
photograph

Treatment

Treatment
table 2-2b)
agricultura
such as co
practices, s
tillage.

Rainfall
1.0
1.2
1.4
1.6
1.8
2.0
2.5
3.0
3.5
4.0
4.5
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0

¹Interpolat

Worksheet 3: Time of concentration (T_c) or travel time (T_t) 88-108-30

8/19

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 2A Checked JJS Date 9/12/90

Circle one: Present [✓ Developed]

Circle one: T_c [✓ T_t through subarea]

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments. SEE DRAWING 84-215-E13

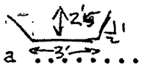
Sheet flow (Applicable to T_c only)

Segment ID		a-b		
1. Surface description (table 3-1) .... SEE SHEET 10A		BARE SOILS		
2. Manning's roughness coeff., n (table 3-1) .. SEE SHEET 10A		0.011		
3. Flow length, L (total L $\le$ 300 ft)	ft	300		
4. Two-yr 24-hr rainfall, P_2	in	5		
5. Land slope, s	ft/ft	~0.01		
6. $T_t = \dfrac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ (2.24, 0.16) Compute T_t	hr	0.05	+	= 0.05

Shallow concentrated flow

Segment ID		b-c		
7. Surface description (paved or unpaved)		UNPAVED		
8. Flow length, L	ft	900		
9. Watercourse slope, s	ft/ft	~0.01		
10. Average velocity, V (figure 3-1) .... SEE SHEET 10B	ft/s	1.6		
11. $T_t = \dfrac{L}{3600\ V}$ Compute T_t	hr	0.16	+	= 0.16

Channel flow



Segment ID		c-d		
12. Cross sectional flow area, a	ft^2	20		
13. Wetted perimeter, p_w .. $3 + 2(2.5)\sqrt{2^2+1}$	ft	14.2		
14. Hydraulic radius, $r = \dfrac{a}{p_w}$ Compute r	ft	1.4		
15. Channel slope, s ... 3561-3468/1400 .... FROM JJP LAYOUT	ft/ft	0.07		
16. Manning's roughness coeff., n RIP-RAP		0.04		
17. $V = \dfrac{1.49\ r^{2/3}_{1.25}\ s^{1/2}_{.26}}{n}$ Compute V	ft/s	12.1		
18. Flow length, L	ft	1400		
19. $T_t = \dfrac{L}{3600\ V}$ Compute T_t	hr	0.03	+	= 0.03

FROM PREVIOUS CALCS. → 16.

20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19) .... hr 0.24

Worksheet 3: Time of concentration (T_c) or travel time (T_t) 88-108-30

9/19

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 3A Checked JLS Date 9/12/90

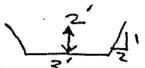
Circle one: Present [✓ Developed]

Circle one: T_c [✓ T_t through subarea]

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments. SEE DRAWING 84-215-E137

Sheet flow (Applicable to T_c only) Segment ID		a - b		
1. Surface description (table 3-1) SHEET 10A		SHORT GRASS		
2. Manning's roughness coeff., n (table 3-1) SEE SHEET 10A		0.15		
3. Flow length, L (total L ≤ 300 ft)	ft	250		
4. Two-yr 24-hr rainfall, P_2	in	.5		
5. Land slope, s 3 1 1/3 = 0.33 ✓ PREVIOUS DESIGN CRITERIA	ft/ft	0.33		
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{0.5}\ s^{0.4}}$ 18.2 2.24 .64 Compute T_t	hr	0.09	+	= 0.09
Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1) SEE SHEET 10B	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=



Channel flow Segment ID		b - d		
12. Cross sectional flow area, a	ft^2	13		
13. Wetted perimeter, p_w $3+2(2)\sqrt{2^2+1}$	ft	11.9		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	1.1		
15. Channel slope, s	ft/ft	~ 0.01		
16. Manning's roughness coeff., n GRASS		0.045		
17. $V = \frac{1.49\ r^{2/3}_{5.6}\ s^{1/2}_{.1}}{n}$ Compute V	ft/s	18.5		
18. Flow length, L	ft	750		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.01	+	= 0.01
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			0.10

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

88-108-30

10/19

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 4A Checked HS Date 9/12/90

Circle one: Present [✓ Developed]

Circle one: T_c [✓ T_t through subarea]

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

Include a map, schematic, or description of flow segments. SEE DRAWING 84-215-E137

Sheet flow (Applicable to T_c only) Segment ID		a-b		
1. Surface description (table 3-1) SHEET 10A		SHORT GRASS		
2. Manning's roughness coeff., n (table 3-1) SEE SHEET 10A ..		0.15		
3. Flow length, L (total L ≤ 300 ft)	ft	150		
4. Two-yr 24-hr rainfall, P_2	in	5		
5. Land slope, s	ft/ft	0.01		
6. $T_t = \frac{0.007\ (nL)^{0.8}_{1.4}}{P_{2\ 2.24}^{0.5}\ s^{0.4}_{0.16}}$ Compute T_t	hr	0.03	+	= 0.03

Shallow concentrated flow Segment ID				
7. Surface description (paved or unpaved)				
8. Flow length, L	ft			
9. Watercourse slope, s	ft/ft			
10. Average velocity, V (figure 3-1) SEE SHEET 10B	ft/s			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr		+	=

Channel flow Segment ID		b-c		
12. Cross sectional flow area, a SAME AS 3A	ft^2	13		
13. Wetted perimeter, p_w	ft	11.9		
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	1.1		
15. Channel slope, s 3441 - 3422.9/350	ft/ft	0.05		
16. Manning's roughness coeff., n GRASS LINED		0.045		
17. $V = \frac{1.49\ r^{2/3}_{1.1}\ s^{1/2}_{.22}}{n}$ Compute V	ft/s	8.01		
18. Flow length, L	ft	450		
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.02	+	= 0.02
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr			0.05

VEPCO - MT. STORM
CHANNEL DESIGN - REVISION OF DITCHES B,C,D
88-108-30
MTP
9/12/90

10A/19

Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t:

$$T_t = \frac{0.007\,(nL)^{0.8}}{(P_2)^{0.5}\,s^{0.4}} \qquad \text{[Eq. 3-3]}$$

where

T_t = travel time (hr),
n = Manning's roughness coefficient (table 3-1),
L = flow length (ft),
P_2 = 2-year, 24-hour rainfall (in), and
s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n[1]
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤20%	0.06
Residue cover >20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses[2]	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:[3]	
Light underbrush	0.40
Dense underbrush	0.80

[1] The n values are a composite of information compiled by Engman (1986).
[2] Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.
[3] When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

VEPCO - MT. STORM
CHANNEL DESIGN - REVISION OF DITCHES B, C, D
88-108-30
MTP
9/12/90

108/19

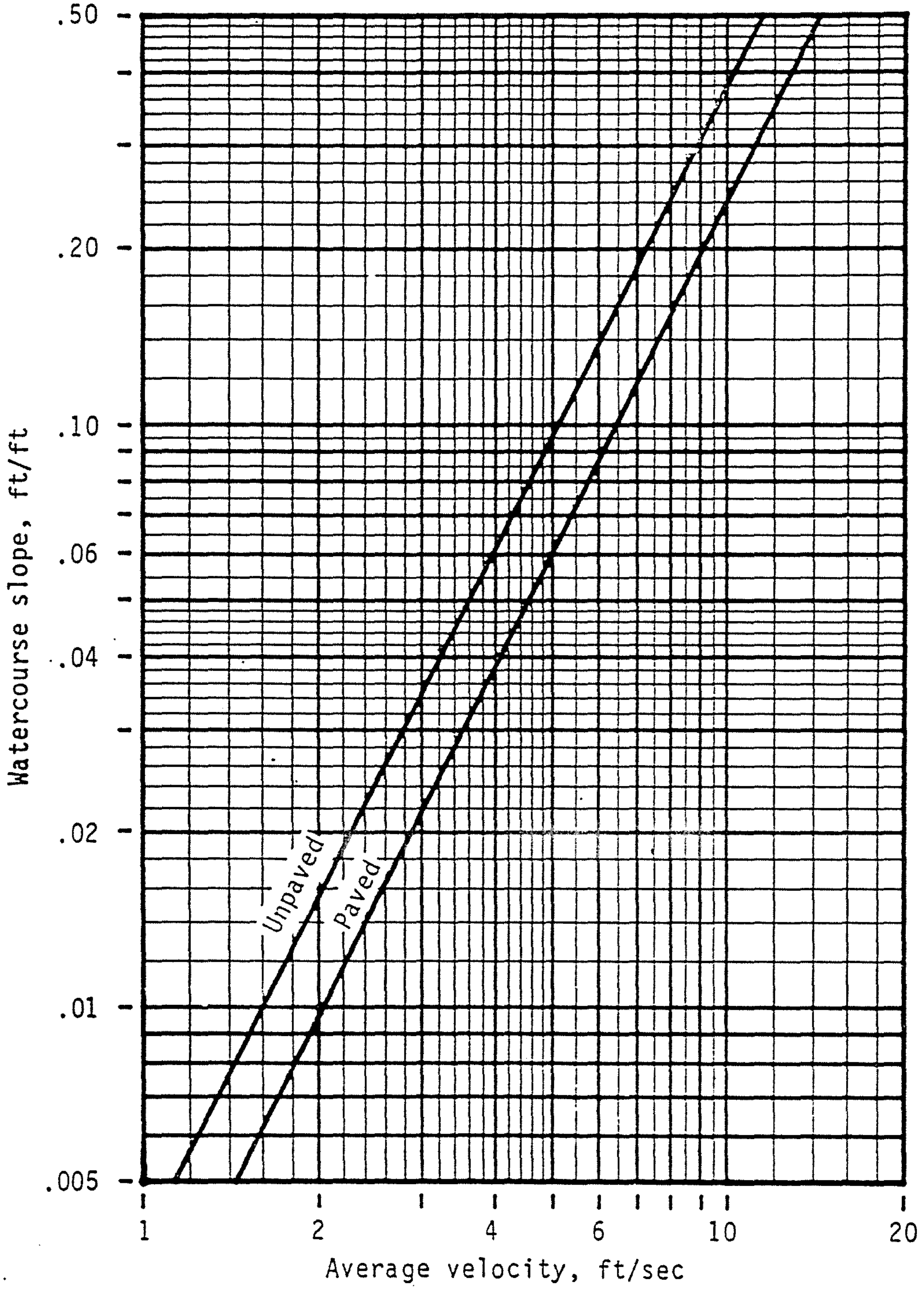


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Sheet flow

Sheet flow is f
occurs in the h
the friction va
roughness coei
raindrop impa
obstacles such
erosion and tr
values are for
foot or so. Tab
sheet flow for

For sheet flow
kinematic solu
compute T_t:

Table 3-1.—I

Smooth surface
bare soil) .....

Fallow (no res

Cultivated soil
  Residue cove
  Residue cove

Grass:
  Short grass
  Dense grass
  Bermudagra

Range (natura

Woods:[3]
  Light under
  Dense under

---

[1] The n values a
(1986).
[2] Includes specie
grass, blue gra
[3] When selecting
is the only part

88-108-30

11/19

Worksheet 4: Graphical Peak Discharge method

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 2 Checked JLS Date 9/12/90

Circle one: Present [✓ Developed]

1. Data:

Drainage area .... A_m = 0.064 mi^2 (acres/640)

Runoff curve number .... CN = 74 (From worksheet 2) SHEET 5

Time of concentration .. T_c = 0.24 hr (From worksheet 3) SHEET 8

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.) SEE SHEET 13A	in	0.703		
5. Compute I_a/P		0.141		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II) SEE SHEET 13B	csm/in	725		
7. Runoff, Q .... (From worksheet 2). SHEET 5	in	2.2		
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	102		

88-608-30

12/1

Worksheet 4: Graphical Peak Discharge method

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 3 Checked LLS Date 9/12/90

Circle one: Present [✓ Developed]

1. Data:

Drainage area .... A_m = 0.012 mi^2 (acres/640)

Runoff curve number .... CN = 74 (From worksheet 2) SHEET 6

Time of concentration .. T_c = 0.10 hr (From worksheet 3) SHEET 9

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

		Storm #1	Storm #2	Storm #3
2. Frequency	yr	25		
3. Rainfall, P (24-hour)	in	5		
4. Initial abstraction, I_a .... (Use CN with table 4-1.) SEE SHEET 13A	in	0.703		
5. Compute I_a/P		0.141		
6. Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II) SEE SHEET 13B	csm/in	1000		
7. Runoff, Q .... (From worksheet 2). SHEET 6	in	2.2		
8. Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9. Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	26.4		

Worksheet 4: Graphical Peak Discharge method

Project VEPCO - MT. STORM By MTP Date 9/7/90

Location AREA 4 Checked JLS Date 9/12/90

Circle one: Present [✓ Developed]

1. Data:

Drainage area .... A_m = 0.003 mi^2 (acres/640)

Runoff curve number .... CN = 70 (From worksheet 2) SHEET 7

Time of concentration .. T_c = 0.05 hr (From worksheet 3) SHEET 10

Rainfall distribution type = II (I, IA, II, III)

Pond and swamp areas spread throughout watershed ...... = 0 percent of A_m (____ acres or mi^2 covered)

			Storm #1	Storm #2	Storm #3
2.	Frequency	yr	25		
3.	Rainfall, P (24-hour)	in	5		
4.	Initial abstraction, I_a .... (Use CN with table 4-1.) SEE SHEET 13A	in	0.857		
5.	Compute I_a/P		0.171		
6.	Unit peak discharge, q_u .... (Use T_c and I_a/P with exhibit 4-II) SEE SHEET 13B	csm/in	975		
7.	Runoff, Q .... (From worksheet 2). SHEET 7	in	2		
8.	Pond and swamp adjustment factor, F_p .... (Use percent pond and swamp area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		1.0		
9.	Peak discharge, q_p .... (Where $q_p = q_u A_m Q F_p$)	cfs	5.9		

Chapter 4: Graphical Peak Discharge method

This chapter presents the Graphical Peak Discharge method for computing peak discharge from rural and urban areas. The Graphical method was developed from hydrograph analyses using TR-20, "Computer Program for Project Formulation—Hydrology" (SCS 1983). The peak discharge equation used is

$$q_p = q_u A_m Q F_p \qquad \text{[Eq. 4-1]}$$

where

q_p = peak discharge (cfs);
q_u = unit peak discharge (csm/in);
A_m = drainage area (mi^2);
Q = runoff (in); and
F_p = pond and swamp adjustment factor.

The input requirements for the Graphical method are as follows: (1) T_c (hr), (2) drainage area (mi^2), (3) appropriate rainfall distribution (I, IA, II, or III), (4) 24-hour rainfall (in), and (5) CN. If pond and swamp areas are spread throughout the watershed and are not considered in the T_c computation, an adjustment for pond and swamp areas is also needed.

Peak discharge computation

For a selected rainfall frequency, the 24-hour rainfall (P) is obtained from appendix B or more detailed local precipitation maps. CN and total runoff (Q) for the watershed are computed according to the methods outlined in chapter 2. The CN is used to determine the initial abstraction (I_a) from table 4-1. I_a/P is then computed.

If the computed I_a/P ratio is outside the range shown in exhibit 4 (4-I, 4-IA, 4-II, and 4-III) for the rainfall distribution of interest, then the limiting value should be used. If the ratio falls between the limiting values, use linear interpolation. Figure 4-1 illustrates the sensitivity of I_a/P to CN and P.

Peak discharge per square mile per inch of runoff (q_u) is obtained from exhibit 4-I, 4-IA, 4-II, or 4-III by using T_c (chapter 3), rainfall distribution type, and I_a/P ratio. The pond and swamp adjustment factor is obtained from table 4-2 (rounded to the nearest table value). Use worksheet 4 in appendix D to aid in computing the peak discharge using the Graphical method.

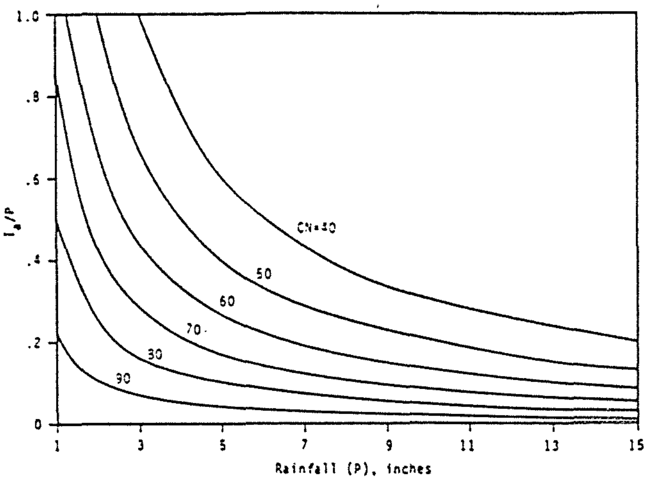


Figure 4-1.—Variation of I_a/P for P and CN.

Table 4-1.—I_a values for runoff curve numbers

Curve number	I_a (in)	Curve number	I_a (in)
40	3.000	70	0.857
41	2.878	71	0.817
42	2.762	72	0.778
43	2.651	73	0.740
44	2.545	74	0.703
45	2.444	75	0.667
46	2.348	76	0.632
47	2.255	77	0.597
48	2.167	78	0.564
49	2.082	79	0.532
50	2.000	80	0.500
51	1.922	81	0.469
52	1.846	82	0.439
53	1.774	83	0.410
54	1.704	84	0.381
55	1.636	85	0.353
56	1.571	86	0.326
57	1.509	87	0.299
58	1.448	88	0.273
59	1.390	89	0.247
60	1.333	90	0.222
61	1.279	91	0.198
62	1.226	92	0.174
63	1.175	93	0.151
64	1.125	94	0.128
65	1.077	95	0.105
66	1.030	96	0.083
67	0.985	97	0.062
68	0.941	98	0.041
69	0.899		

Exhibit 4-II: Unit peak discharge (q_u) for SCS type II rainfall distribution

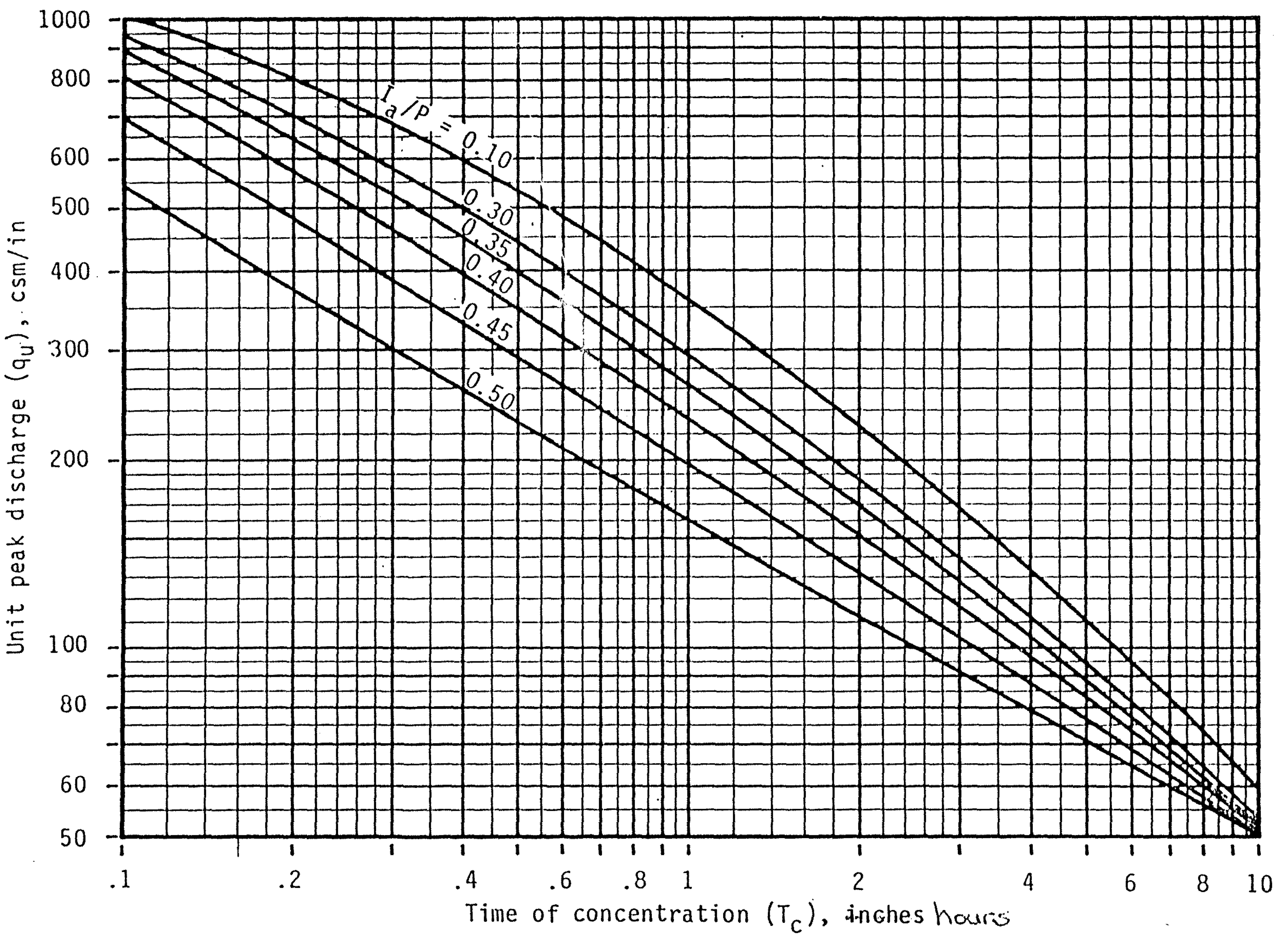


Exhibit 4-III: Unit peak discharge (q_u) for SCS type III rainfall distribution

138/19

SUBJECT VEPCO — MT. STORM
CHANNEL DESIGN - REVISION OF DITCHES B, C, AND D
BY MTP DATE 9/6/90 PROJ. NO. 88-108-30
CHKD. BY DLS DATE 9/12/90 SHEET NO. 14 OF 19

THE SHAPE, DIMENSIONS, AND REQUIRED LINING FOR EACH CHANNEL WILL BE OBTAINED BY APPLYING MANNING'S EQUATION FOR OPEN CHANNEL FLOW.

$$K' = \frac{Qn}{b^{8/3} S^{1/2}}$$

GIVEN Q, n, and b THE DEPTH OF FLOW AND VELOCITY CAN BE DETERMINED.

CHANNEL FREEBOARD = 1 ft - SEE SHEET 2

DESIGN OF CHANNEL LINING WILL BE BASED ON THE MAXIMUM VELOCITY OF FLOW THROUGH THE CHANNEL SECTION.

CHANNEL	FLOW (cfs)	Cum. FLOW (cfs)
1	25	25
2	102×1.25 = 128	153
3	26.4×1.25 = 33	33
4	5.9×1.25 = 7	7
5	NEGLIGIBLE	186

SUBJECT VEPCO - MT STORM
CHANNEL DESIGN - REVISION OF DITCHES B, C, AND D
BY MTP DATE 9/10/90 PROJ. NO. 88-108-30
CHKD. BY ______ DATE ______ SHEET NO. 15 OF 19

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[illegible] @ 3% min slope
D = 1.98'
STILL USE 3' DEPTH

CHANNEL 2

$Q = 153$ cfs

$n = 0.04$

$b = 6$ ft

$ss = 2:1$

$S_{AVE} = 3557 - 3468/1600 = 0.06$

$$K' = \frac{(153)(0.04)}{(6^{8/3})(0.06^{1/2})} = \frac{6.12}{(120)(.24)} = 0.213$$

SEE SHEET 17 → $D/b = 0.28 \Rightarrow D = 1.68$ ft

$V = Q/A = 153/6(1.68) + 2(1.68)^2 = 9.7$

*RIP-RAP LINED
NSA No. R-5 (SEE SHEET 18)
4" TO 18" STONE (9" AVG.)

FREEBOARD = 1.0 ft

TOTAL DEPTH = 1.68 ft + 1.0 ft = 2.68 ft

CHANNEL 3

$Q = 33$ cfs

$n = 0.045$

$b = 3$ ft

$ss = 2:1$

$S_{AVE} = \sim 0.01$

$$K' = \frac{(33)(0.045)}{(3^{8/3})(0.01^{1/2})} = \frac{1.49}{1.88} = 0.793$$

$D/b = 0.54 \Rightarrow D = 1.62$ ft

$V = Q/A = 33/3(1.62) + 2(1.62)^2 = 3.3$ ft/sec *GRASS-LINED

FREEBOARD = 1.0 ft

TOTAL DEPTH = 1 [illegible] 1.0 ft = 2.62 ft

SUBJECT VEPCO - MT. STORM

CHANNEL DESIGN - REVISION OF DITCHES B, C, AND D

BY MTP DATE 9/10/90 PROJ. NO. 88-108-30

CHKD. BY JLS DATE 9/12/90 SHEET NO. 16 OF 19

CHANNEL 4

$Q = 7$ cfs

$n = 0.045$

$b = 3$ ft

$ss = 2:1$

$S_{AVE.} = 0.05$

$$K' = \frac{(7)(0.045)}{(3^{8/3})(0.05^{1/2})} = \frac{0.315}{4.2} = 0.075$$

$$D/b = 0.16 \Rightarrow D = 0.48 \text{ ft}$$

$$V = Q/A = 7/3(0.48)+2(0.48)^2 = 3.7 \text{ ft/sec}$$ * GRASS - LINED

FREEBOARD = 1.0 ft

TOTAL DEPTH = 0.48 ft + 1.0 ft = 1.48 ft

CHANNEL 5

$Q = 186$ cfs

$n = 0.04$

$b = 6$ ft

$ss = 2:1$

$S_{AVE} = 3468 - 3445.5/420 = 0.05$

$$K' = \frac{(186)(0.045)}{(6^{8/3})(0.05^{1/2})} = \frac{8.37}{26.58} = 0.315$$

$$D/b = 0.34 \Rightarrow D = 2.0 \text{ ft}$$

$$V = Q/A = 186/6(2)+2(2)^2 = 9.3 \text{ ft/sec}$$ * RIP-RAP LINED (NSA No. R-5)

FREEBOARD = 1 ft

TOTAL DEPTH = 2 ft + 1 ft = 3 ft

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BY MTP DATE 9/10/90 PROJ. NO. 88-108-30
CHKD. BY ______ DATE ______ SHEET NO. 17 OF 19

REFERENCE: BRATER AND KING, HANDBOOK OF HYDRAULICS, TABLE 7-11

TO FIND D (= DEPTH OF WATER) IN TRAPEZOIDAL CHANNEL

WHERE $K' = \frac{Q n}{b^{2.67} S^{0.50}}$, b = BOTTOM WIDTH

$\frac{D}{b}$	K' 2-1	$\frac{D}{b}$	K' 2-1	$\frac{D}{b}$	K' 2-1	$\frac{D}{b}$	K' 2-1	$\frac{D}{b}$	K' 2-1
.01	.00069	.46	.574	.91	2.42	1.36	6.01	1.81	11.7
.02	.00221	.47	.599	.92	2.48	1.37	6.11	1.82	11.9
.03	.00436	.48	.625	.93	2.54	1.38	6.21	1.83	12.1
.04	.00708	.49	.652	.94	2.60	1.39	6.32	1.84	12.2
.05	.01033	.50	.679	.95	2.66	1.40	6.42	1.85	12.4
.06	.0141	.51	.707	.96	2.73	1.41	6.53	1.86	12.5
.07	.0183	.52	.736	.97	2.79	1.42	6.64	1.87	12.7
.08	.0231	.53	.765	.98	2.85	1.43	6.75	1.88	12.9
.09	.0282	.54	.795	.99	2.92	1.44	6.86	1.89	13.0
.10	.0339	.55	.826	1.00	2.99	1.45	6.97	1.90	13.2
.11	.0400	.56	.857	1.01	3.05	1.46	7.08	1.91	13.4
.12	.0466	.57	.889	1.02	3.12	1.47	7.20	1.92	13.5
.13	.0537	.58	.922	1.03	3.19	1.48	7.31	1.93	13.7
.14	.0612	.59	.956	1.04	3.26	1.49	7.43	1.94	13.9
.15	.0692	.60	.990	1.05	3.33	1.50	7.54	1.95	14.0
.16	.0777	.61	1.02	1.06	3.40	1.51	7.66	1.96	14.2
.17	.0866	.62	1.06	1.07	3.48	1.52	7.78	1.97	14.4
.18	.0960	.63	1.10	1.08	3.55	1.53	7.90	1.98	14.6
.19	.1059	.64	1.13	1.09	3.62	1.54	8.02	1.99	14.7
.20	.1163	.65	1.17	1.10	3.70	1.55	8.15	2.00	14.9
.21	.127	.66	1.21	1.11	3.78	1.56	8.27	2.01	15.1
.22	.139	.67	1.25	1.12	3.85	1.57	8.40	2.02	15.3
.23	.150	.68	1.29	1.13	3.93	1.58	8.52	2.03	15.5
.24	.163	.69	1.33	1.14	4.01	1.59	8.65	2.04	15.6
.25	.176	.70	1.37	1.15	4.09	1.60	8.78	2.05	15.8
.26	.189	.71	1.41	1.16	4.17	1.61	8.91	2.06	16.0
.27	.203	.72	1.46	1.17	4.25	1.62	9.04	2.07	16.2
.28	.217	.73	1.50	1.18	4.34	1.63	9.17	2.08	16.4
.29	.232	.74	1.54	1.19	4.42	1.64	9.30	2.09	16.6
.30	.248	.75	1.59	1.20	4.51	1.65	9.44	2.10	16.8
.31	.264	.76	1.63	1.21	4.59	1.66	9.57	2.11	17.0
.32	.281	.77	1.68	1.22	4.68	1.67	9.71	2.12	17.2
.33	.298	.78	1.73	1.23	4.77	1.68	9.85	2.13	17.4
.34	.316	.79	1.78	1.24	4.86	1.69	9.99	2.14	17.6
.35	.334	.80	1.83	1.25	4.95	1.70	10.13	2.15	17.8
.36	.353	.81	1.88	1.26	5.04	1.71	10.3	2.16	18.0
.37	.372	.82	1.93	1.27	5.13	1.72	10.4	2.17	18.2
.38	.392	.83	1.98	1.28	5.22	1.73	10.6	2.18	18.4
.39	.413	.84	2.03	1.29	5.32	1.74	10.7	2.19	18.6
.40	.434	.85	2.08	1.30	5.41	1.75	10.8	2.20	18.8
.41	.456	.86	2.14	1.31	5.51	1.76	11.0	2.21	19.0
.42	.478	.87	2.19	1.32	5.61	1.77	11.1	2.22	19.2
.43	.501	.88	2.25	1.33	5.71	1.78	11.3	2.23	19.4
.44	.525	.89	2.31	1.34	5.81	1.79	11.4	2.24	19.6
.45	.549	.90	2.36	1.35	5.91	1.80	11.6	2.25	19.8

18/19

Table A

Quarried Stone for Erosion & Sediment Control (5)

GRADED RIPRAP STONE

NSA No.	Size Inches (sq. openings) Max.	Avg. (1)	Min. (2)	Wave Height (3) (ft.)	Velocity (4) (ft./sec.)	Filter Stone NSA Size No.
R-1	1½	¾	(No. 8)	—	2.5	FS-1
R-2	3	1½	1	0.3	4.5	FS-1
R-3	6	3	2	0.5	6.5	FS-2
R-4	12	6	3	1.0	9.0	FS-2
R-5	18	9	5	1.5	11.5	FS-2
R-6	24	12	7	2.0	13.0	FS-3
R-7	30	15	12	2.5	14.5	FS-3
R-8	48	24	15	4.0	—	FS-3

ARMOR STONE*

NSA No.	Wt. in Short Tons Max.	Avg.	Min. (2)	Wave Height (ft.)(6)	Filter Stone
A-1	4.0	3.0	2.0	8.0	(See supplemental engineering notes)
A-2	6.0	4.5	3.0	10.0	
A-3	8.0	6.5	5.0	12.0	

*One or more underlayers may be required in addition to stone filter.

FILTER STONE

NSA No.	Size Inches (sq. openings) Max.	Avg.	Min. (2)
FS-1	⅜	No. 30	No. 100
FS-2	2	No. 4	No. 100
FS-3	6½	2.5	No. 16

Figure A*

Notes: (1) "Average size" is that size exceeded by at least 50 percent of the total weight of the tonnage shipped; i.e., 50 percent of the tonnage shall consist of pieces larger than the "average" size (normally half the specified nominal top size).

(2) Pieces smaller than the minimum size shown shall not exceed 15 percent of the tonnage shipped.

(3) Wave height is the vertical distance from wave crest to wave trough. The wave height given in the table is the average height of the one-third highest waves in the incident wave train.

(4) The stream velocity is the velocity at mid-stream or at a point 10 feet from the bank, whichever is closest to the bank.

(5) The table assumes a stone dry density of 165 pounds per cu. ft.

(6) The stone industry generally is unable to economically produce armor stone in sizes to fit the 6-ft. wave height category. Therefore, the reader should use NSA No. A-1.

19/

SECTION 850—ROCK LINING

DESCRIPTION—This work is construction of rock lining of the class

MATERIAL—

Rock.

General. Acceptable quality; sound; free from structural defects and substances, such as soil, shale, and organic materials; from an ap-
Type A source from Bulletin 14.
to use, submit samples to the MTD for petrographic examination for
ty. The rock must meet the following requirements:

- No shale seams.
- Hard and angular shaped rock with neither width nor thickness less than one-third its length.
- Minimum specific gravity of 2.5, as determined in accordance with PTM No. 506, bulk-saturated, but surface-dry basis.
- Each load of rock well-graded, from the smallest to the largest size.

2. Size and Gradation.

	Percent Passing (Square Openings)					
Class, Size No. (NCSA)	R-8	R-7	R-6	R-5	R-4	R-3
Rock Size (Inches)						
48	100*					
30		100*				
24	15-50		100*			
18		15-50		100*		
15	0-15					
12			15-50		100*	
9		0-15		15-50		
6			0-15		15-50	100*
4				0-15		
3					0-15	15-50
2						0-15
Nominal Placement Thickness (inches)	48	36	30	24	18	12

* Maximum Allowable Rock Size.

PA DOT PUB. 408

DITCH 3B CALCULATIONS

SUBJECT DITCH 3B CAPACITY AND 25YR 10HR STORM REQ.
BY JLS DATE 10/9/91 PROJ. NO. 88-108-40
CHKD. BY ______ DATE ______ SHEET NO. 1 OF 3

THE 25YR 24HR STORM REQUIREMENT FOR DITCH 3B FROM THE HYDROLOGY CALCS FOR POND #3 IS 499 CFS. THE AS BUILT CAPACITY OF DITCH 3B IS 636 CFS BETWEEN STATION 15+19 AND 17+62. ∴ DITCH 3B WILL EASILY CONVEY THE 25YR 24HR STORM.

USE UPSTREAM SLOPE, STATION X-SECTION, $n = 0.04$ TO EVALUATE Q AND V FOR DITCH 3B.

SECTION 19+05 to 21+19 $S = 1.0\%$

(.5FT FREEBOARD)

$Q_{.5} = \frac{1.49}{0.04}(123.4)\left(\frac{123.4}{42}\right)^{2/3}(.01)^{1/2}$

$= 943$ CFS

$V_{.5} = 943/123.4 = 7.64$ FPS

(FLOW AT TOP OF ROCK)

$Q_F = \frac{1.49}{0.04}(145.6)\left(\frac{145.6}{44}\right)^{2/3}(0.01)^{1/2}$

$= 1204$ CFS

$V_F = 1204/145.6 = 8.27$ FPS

SECTION 17.62 TO 19+05 $S = 1.7\%$

$Q_{.5} = \frac{1.49}{.04}(89.1)\left(\frac{89.1}{40}\right)^{2/3}(.017)^{1/2}$

$= 738$ CFS

$V_{.5} = 738/89.1 = 8.28$ FPS

$Q_F = \frac{1.49}{0.04}(112.1)\left(\frac{112.1}{45}\right)^{.67}(0.017)^{1/2}$

$= 1000.5$ CFS

$V_{.5} = 1000.5/112.1 = 8.92$

SECTION 15+19 TO 17+62 $S = 1.3\%$

$Q_{.5} = \frac{1.49}{.04}(87.5)\left(\frac{87.5}{39}\right)^{2/3}(.013)^{1/2}$

$= 636.9$ CFS

$V_{.5} = 636.9/87.5 = 7.28$ FPS

$Q_F = \frac{1.49}{.04}(110.2)\left(\frac{110.2}{44}\right)^{2/3}(0.013)^{1/2}$

$= 863.4$ CFS

$V_F = 7.83$

SUBJECT

BY JLS DATE 7/6/91 PROJ. NO. 88-108-40
CHKD. BY DATE SHEET NO. 3 OF 3

SECTION 12+63 TO 15+19 S = 2.2%

$$Q_{.5} = \frac{1.49}{.04}(108.7)\left(\frac{108.7}{41}\right)^{2/3}(.022)^{\frac{1}{2}} \qquad Q_F = \frac{1.49}{.04}(133.4)\left(\frac{133.4}{44}\right)^{2/3}(.022)^{\frac{1}{2}}$$

= 1150 CFS.

STATION 37+00 TO 38+63 1.2%

$$Q_{.5} = \frac{1.49}{.04}(167.75)\left(\frac{167.75}{47}\right)^{2/3}(.012)^{\frac{1}{2}}$$

= 1598.7 CFS

$$\begin{array}{r} 57.9 \\ -\ 52.2 \\ \hline 5.5 \end{array}$$

DITCH F CALCULATIONS

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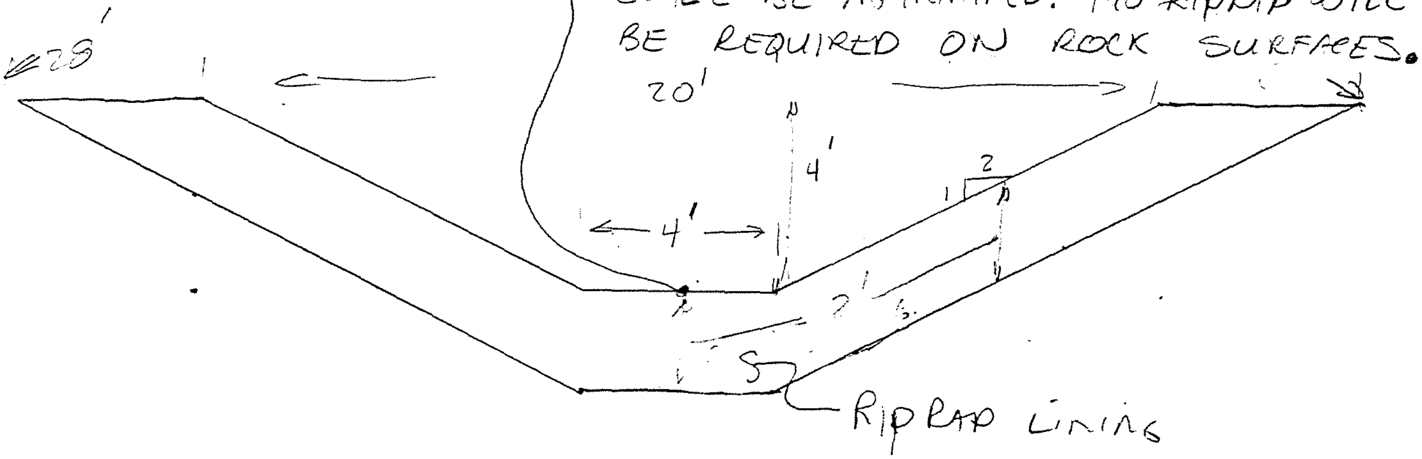
SUBJECT CHANNEL DETAIL FOR WEST CELL/CELL 2 CHANNEL

BY LLS DATE 1/11/92 PROJ. NO. 88-108-60

CHKD. BY ____ DATE ____ SHEET NO. ____ OF ____

INVERT AS SHOWN ON THE PROFILE. DETAIL AS SHOWN IS FOR CONSTRUCTION IN SOIL CUT OR SOIL FILL. IF ROCK EXCAVATION IS REQUIRED THE INVERT ELEVATION AND CHANNEL ~~CONFIGURATION~~ CROSS-SECTION SHALL BE MAINTAINED. NO RIPRAP WILL BE REQUIRED ON ROCK SURFACES.



REFERENCE MAPPING OF SURVEY OF ORIGINAL GROUND, SEPTEMBER 1992, T. MACAULEY

SUBJECT Virginia Power : Mount Storm

BY MRL DATE 1/5/93 PROJ. NO. 88 - 108 - 60

CHKD. BY JLS DATE 1/8/93 SHEET NO. 1 OF 7

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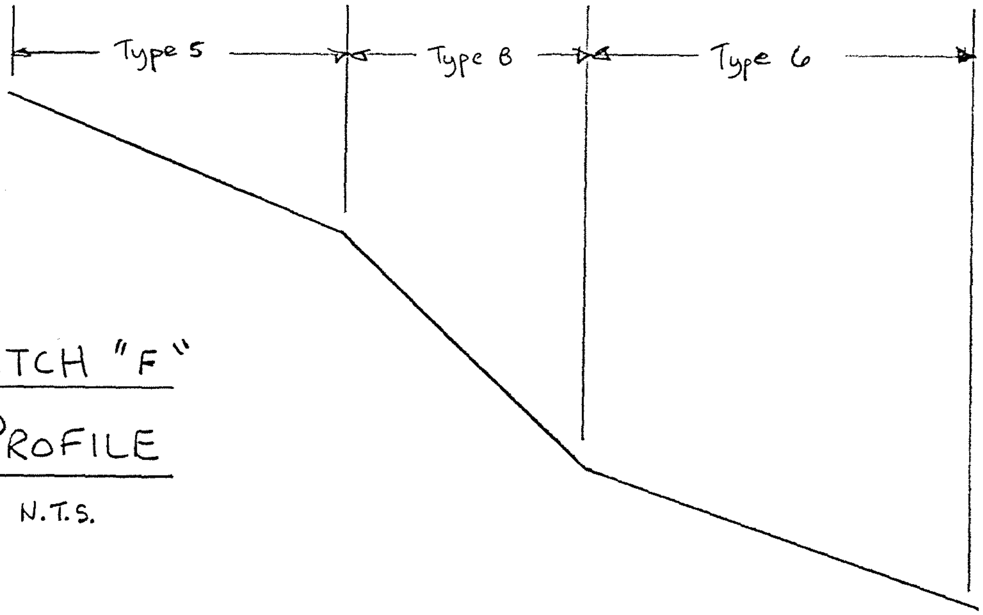
CHANNEL CAPACITY

Due to revised topography, ditch "F" [GAI drawing No. 84-215-E137] needs to be modified to handle the peak discharges. Calculate the existing capacity of ditch "F".

Ditch "F" consists of 3 channel types according to the original design.



DITCH "F" PROFILE

N.T.S.

Calculate slopes (reference : GAI drawing No. 84-215-E146)

Type 5 : $\frac{3528.5 - 3498}{462 - 0} = \frac{30.5}{462} = 0.066 = 6.6\%$

Type 8 : $\frac{3498 - 3431.5}{995 - 462} = \frac{66.5}{533} = 0.125 = 12.5\%$

Type 6 : $\frac{3431.5 - 3414.5}{1450 - 995} = \frac{17}{455} = 0.037 = 3.7\%$

SUBJECT Virginia Power : Mount Storm

BY MRL DATE 1/5/93 PROJ. NO. 88-108-60

CHKD. BY JLS DATE 1/8/93 SHEET NO. 2 OF 7

GAI CONSULTANTS, INC.
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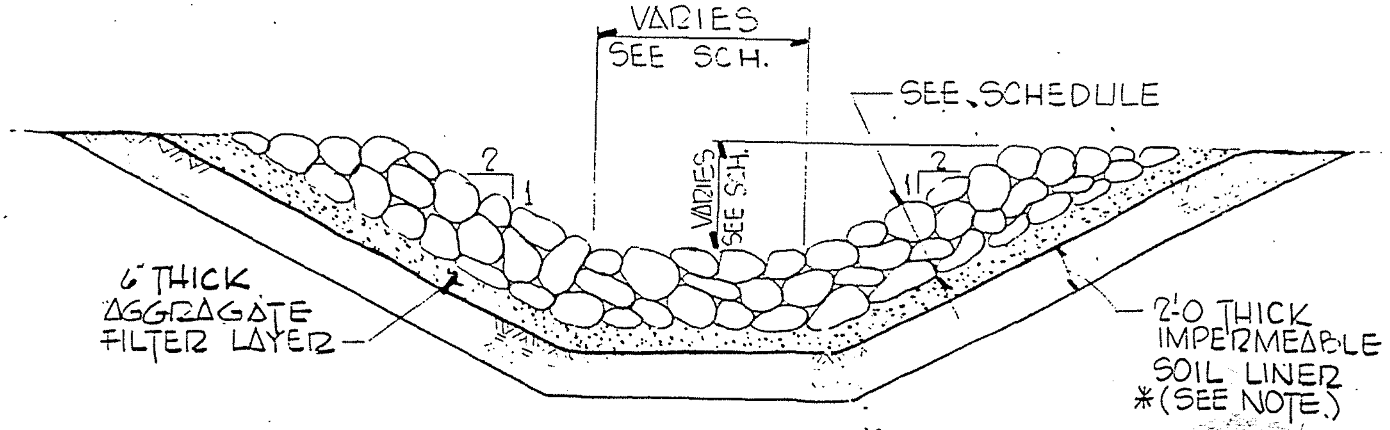
* DRAINAGE CHANNEL SCHEDULE

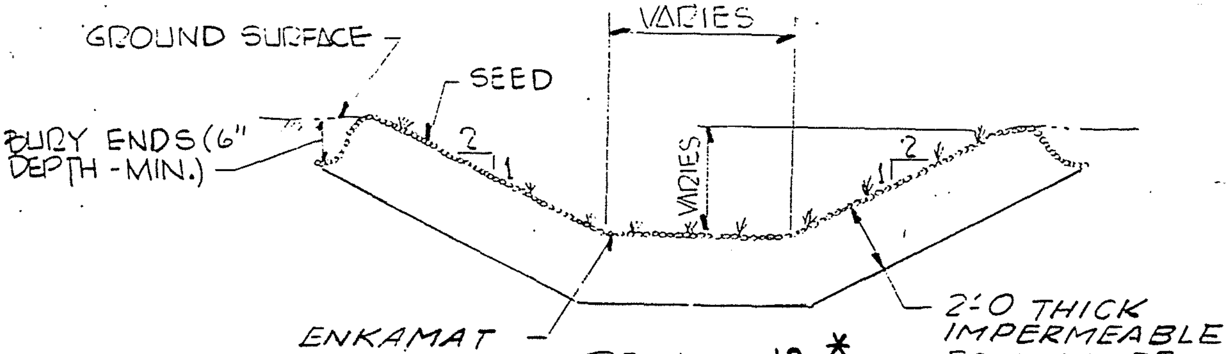
TYPE	SHAPE	WIDTH	DEPTH	LINING	DETAIL Nº
1	TRIANGULAR	—	1'-0	GRASS	10
2	TRAPEZOID	3'-0	1'-6		12
3			2'-0		12
4			3'-0	GRASS	12
● 5			2'-0	MAT LINED	13
● 6			3'-0		13
7			4'-0	MAT LINED	13
● 8		3'-0	2'-6	RIP-RAP LINED	11
9	TRAPEZOID	3'-6	3'-0	RIP-RAP LINED	11
10	TRAPEZOID	3'-0	4'-0	GROUTED RIP-RAP	16

* Reference: GAI drawing No, 84-215-E148



DETAIL-11 *
RIP-RAP LINED TRAPEZOIDAL DRAINAGE CHANNEL

N.T.S.



DETAIL-13 *
MAT-LINED CHANNEL

N.T.S.

SUBJECT VIRGINIA POWER: MOUNT STORM

BY MRL DATE 1/5/93 PROJ. NO. 88-108-60

CHKD. BY JLS DATE 1/8/93 SHEET NO. 3 OF 7

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Calculate available design channel capacity using the "SWALE DESIGN" subroutine of the "Penn State Urban Hydrology Model" (PSUHM) computer program.

	BW	S.S.	Depth	n	slope	Q
Type 5 MAT LINED	3.0'	2:1	2.0'	0.04	0.066	148.5 CFS
Type 8 RIP-RAP LINED	3.0'	2:1	2.5'	0.04	0.125	330.4 CFS
Type 6 MAT LINED	3.0'	2:1	3.0'	0.04	0.037	268.8 CFS

The Mount Storm hydrology and hydraulics calculations binder (project No. 84-215-4) shows the design peak discharge for ditch "F" (labeled as ditch SED1Q in the calculations binder) as being 122 CFS. However, this design peak discharge is only for runoff from the ash disposal pile and does not include runoff from the offsite areas east of the ditch.

SUBJECT Virginia Power : Mount Storm

BY MRL DATE 1/6/93 PROJ. NO. 88-108-60

CHKD. BY JLS DATE 1/8/93 SHEET NO. 4 OF 7

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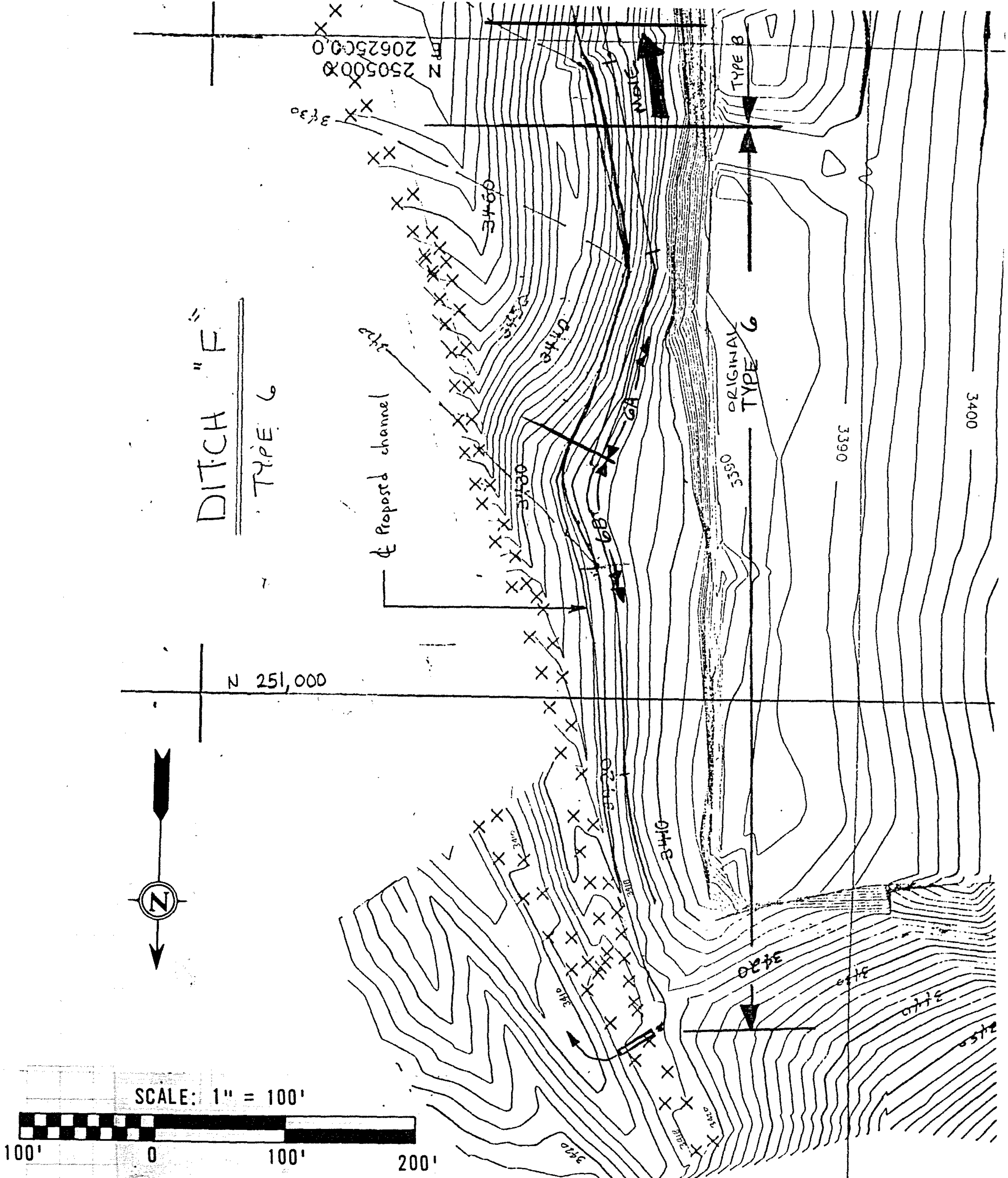

SUBJECT Virginia Power : Mount Storm

BY MRL DATE 1/6/93 PROJ. NO. 88-108-60
CHKD. BY JLS DATE 1/8/93 SHEET NO. 5 OF 7

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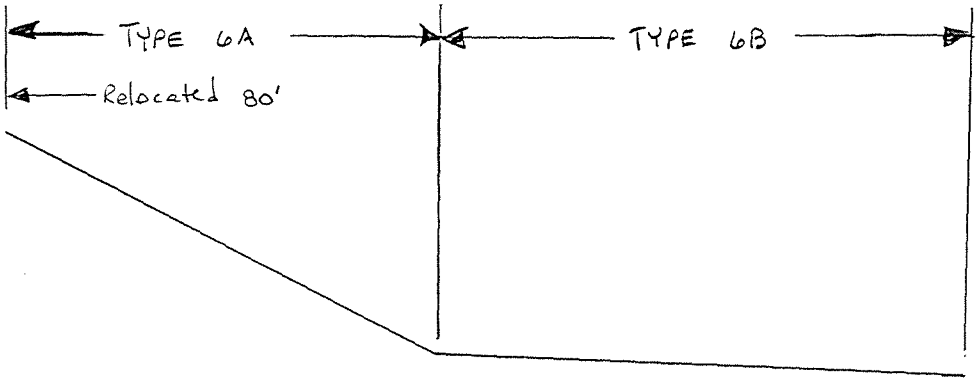
REVISED PROFILE (N.T.S.)



Calculate slopes (reference: sheet 4)

Type 6A : $\frac{3440-3424}{330'} = \frac{16}{330} = 0.048 = 4.8\%$

Type 6B : $\frac{3424-3418}{450'} = \frac{6}{450} = 0.013 = 1.3\%$

The original type 6 channel was designed to handle a peak discharge of 270 CFS (see sheet 3). Design channel types 6A and 6B to handle 270 CFS.

									USE			
	Q (CFS)	n	s.s.	slope (ft/ft)	B.W. (ft)	d (ft)	Froude No.	V (ft/sec.)	B.W.	d.*	Lining	Detail No.
Type 6A	270	0.04	2:1	0.048	4.0	2.7	1.5	10.9	4'-0	3'-0	Rip-rap Lined	11
Type 6B	270	0,04	2:1	0.013	4.0	3.6	0.8	6.7	4'-0	4'-0	Mat Lined	13

freeboard would have been added. However it is assumed that the design discharge

SUBJECT Virginia Power : Mount Storm

BY MRL DATE 1/9/93 PROJ. NO. 88-108-60

CHKD. BY JLS DATE 1/11/93 SHEET NO. 6 OF 7

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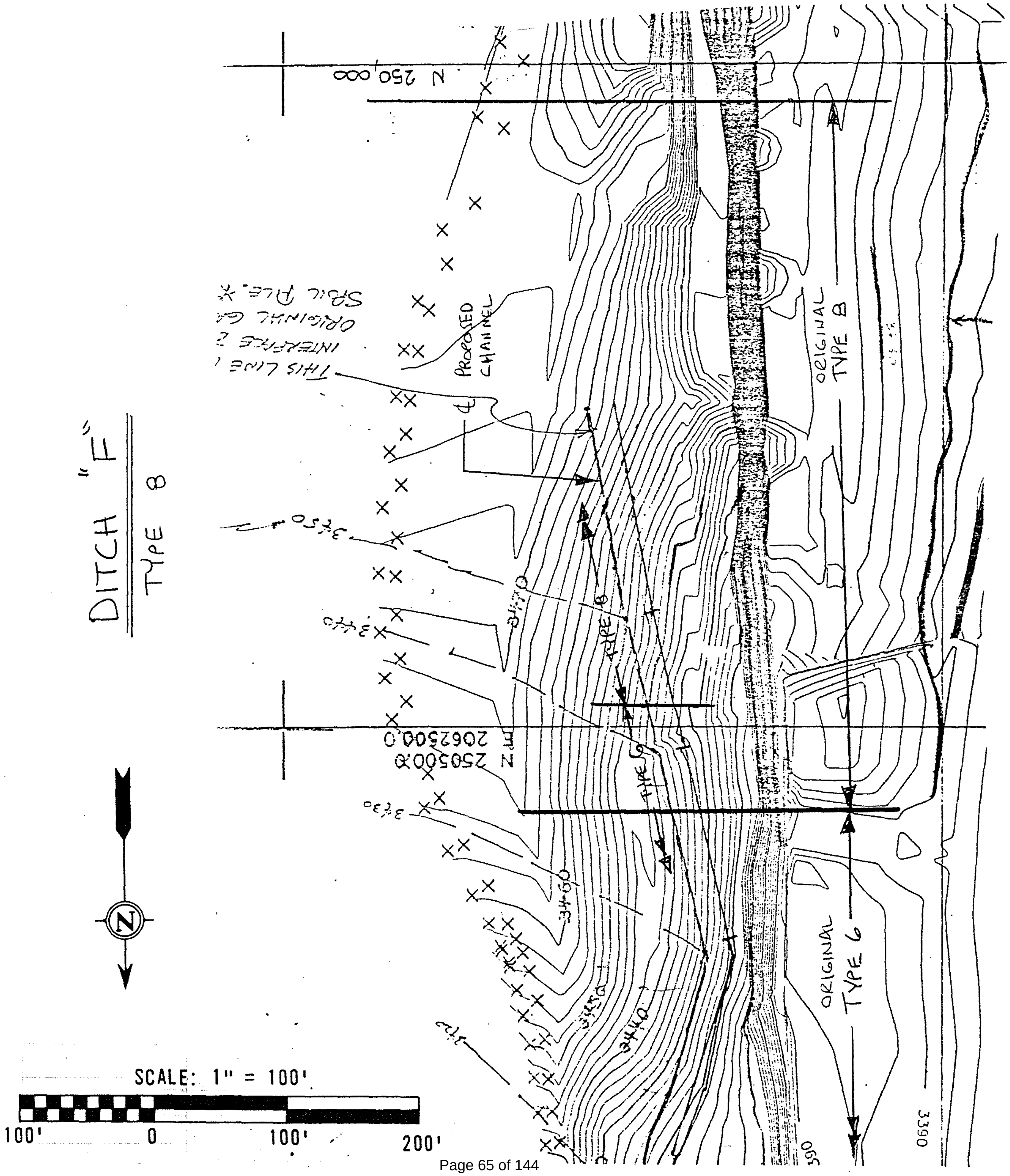

SUBJECT VIRGINIA POWER : MOUNT STORM

BY MRL DATE 1/9/93 PROJ. NO. 88-108-60
CHKD. BY JLS DATE 1/11/93 SHEET NO. 7 OF 7

CHANNEL TYPE 8

Compare the proposed channel slope with the design slope.

Design slope = 12.5 % (see sheet 1)

Proposed slope = $\frac{3470 - 3440}{230'} = \frac{30'}{230'} = 13.0\%$

The type 6 channel is designed to handle 270 CFS. Design the type 8 channel to handle 270 CFS.

	Q	n	S.S.	slope	B.W.	d	Froude	V	USE			
	(CFS)			(Ft/Ft)	(Ft.)	(Ft)	No.	(Ft/sec.)	B.W.	d*	Lining	Detail No.
Type 8	270	0.04	2:1	0.13	4.0	2.1	2.4	15.8	4'-0	2'-6	Rip-rap Lined	11

* See footnote on sheet 5

SEDIMENTATION PONDS

Calculation package includes:
1. Pond No. 3 (Pond 014) Modification Design Calculations

MOUNT STORM POWER STATION

PHASE B MINE / ASH DISPOSAL SITE

POND No. 3

MODIFICATION DESIGN

CALCULATIONS

88-108-51

SUBJECT VEPCO - MOUNT STORM
Hydrology and Hydraulics Calculations
BY MRL DATE 2/11/92 PROJ. NO. 88-108-51
CHKD. BY DATE SHEET NO. 1 OF 43

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OBJECTIVES

Design an addition to the existing pond # 3 (WVDOE permit # S-2001-86) so that the pond meets all requirements of the West Virginia Erosion and sediment Control Handbook for Developing Areas and the West Virginia Solid Waste Management Regulations. Locate the addition south of the existing pond #3. The existing pond #3 will be referred to as the primary sedimentation pond and the new addition will be referred to as the secondary sedimentation pond.

A sediment dewatering pond is also to be constructed west of the proposed secondary sedimentation pond. Sediments cleaned out of the primary and secondary sedimentation ponds are to be placed in the sediment dewatering pond to dewater. Discharge from the sediment dewatering pond will outlet into the secondary sedimentation pond.

REFERENCES

① Hydrology calculations by SER, 4/91, sheets 1 of 4 through 4 of 4.

② Hydraulic calculations by SER, 4/91, sheets 1 of 16 through 16 of 16.

③ Erosion and Sediment Control Handbook for Developing Areas, West Virginia. USDA Soil Conservation Service.

④ Solid Waste Management Regulations, Title 47, Series 38, West Virginia Department of Natural Resources. Effective Date: May 1990.

⑤ USDA Soil Conservation Service Technical Release 20 (TR-20), "Computer Program for Project Formulation Hydrology".

⑥ USDA Soil Conservation Service Technical Release No. 2, "Earth Spillways".

⑦ USDA Soil Conservation Service Engineering Handbook, Section 5, "Hydraulics".

⑧ USDA Soil Conservation Service Technical Release No. 55, "Urban Hydrology for Small Watersheds", June 1986

HYDROLOGY

CALCULATE THE 2, 10, 50-YEAR 24-HOUR AND THE 100-YEAR 6HOUR HYDROGRAPHS, AND ROUTE THEM THROUGH POND #3, USING TR-55 AND TR-20 (REF 8 AND 5)

DRAINAGE AREA = 230 ACRES = 0.36 SQ MILES

PLANIMETERED FROM ATTACHED WORKSHEET.

THE FOLLOWING LAND USES AND PERCENT OF DRAINAGE AREA ARE REFERENCED TO THE ATTACHED WORKSHEET. (see sheet 7)

FLY ASH	34.8%	80 ACRES
COAL REFUSE	43.5%	100 ACRES
STABALIZED (RECLAIMED AREA)	21.7%	50 ACRES

THE FLY ASH AREA IS THE PROPOSED FLY ASH PILE. USE A CN VALUE OF 80 FOR ACTIVE SURFACES AS PREVIOUSLY USED BY NJB IN "MT STORM SEDIMENTATION POND #1" DATED 6/23/86 PROJECT 84-215-4. USE A CN VALUE OF 76 FOR REVEGATATED PILE SURFACES.*

THE COAL REFUSE AREA IS THE EXISTING AND PROPOSED MINE SPOILS. ASSUME THIS AREA TO BE WELL VEGATATED. USE CN = 76 (REF 8)

*ASSUME A MAXIMUM OF 40 ACRES OF THE FLY ASH AREA WILL BE ACTIVE AND 40 AC. WILL BE ▲REVEGETATED AND STABILIZED AT THE TIME THE ENTIRE FLY ASH AREA DRAINS TO THIS POND.

SUBJECT Mt Storm

BY SER DATE 4/19/91 PROJ. NO. 88-108-41

CHKD. BY MRL DATE 5/22/91 SHEET NO. 4 OF 43

REV. MRL 2/20/92

THE STABILIZED AREA CONSISTS OF 20% WOOD GOOD COND AND 80% DISTURBED AND STABILIZED (WITH GOOD GRASS COVER). ASSUME HSG D (MOST CONSERVATIVE) USE CN = 77 FOR WOODS, GOOD COND. AND CN = 80 GRASSLAND, GOOD COND.

$$\overline{CN} = 0.348(80 \cdot 0.5 + 76 \cdot 0.5) + 0.435(76) + 0.217(77 \cdot 0.2 + 80 \cdot 0.8) = .348 \cdot 78 + 0.435 \cdot 76 + .217(79.4)$$

$$\boxed{\overline{CN} = 77}$$

$P_{2,24} = 2.88''$
$P_{5,24} = 3.75''$
$P_{10,24} = 4.60''$
$P_{25,24} = 4.98''$
$P_{50,24} = 5.75''$
$P_{100,24} = 6.30''$

SEE "EROSION AND SEDIMENT CONTROL HANDBOOK FOR DEVELOPING AREAS, WEST VIRGINIA", USSCS NO DATE (ESCHDA WV)

$P_{100,24} / P_{100,6} = 1.36$ FROM SHEET 6
$P_{100,6} = 4.63''$

TIME OF CONCENTRATION, t_c

A REPRESENTATIVE FLOW PATH IS SHOWN ON THE ATTACHED WORKSHEET. IT IS CONSIDERED AS REPRESENTATIVE OF THE WATERSHED. THE PROPOSED FLYASH PILES BENCH'S ARE NOT INCLUDED ON THE PATH SINCE THEY WOULD OVER ESTIMATE THE t_c FOR THE AREA (THE BENCHES ADD FLOW TIME BUT ONLY A SMALL AREA WOULD BE REPRESENTED BY THIS LARGER t_c). t_c ESTIMATE SHOWN ON SHEET 5.

sheet 5 of 43

Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project MT STORM By JER Date 4/19/91

Location Checked MRL Date 5/22/91

Circle one: ~~Present~~ Developed

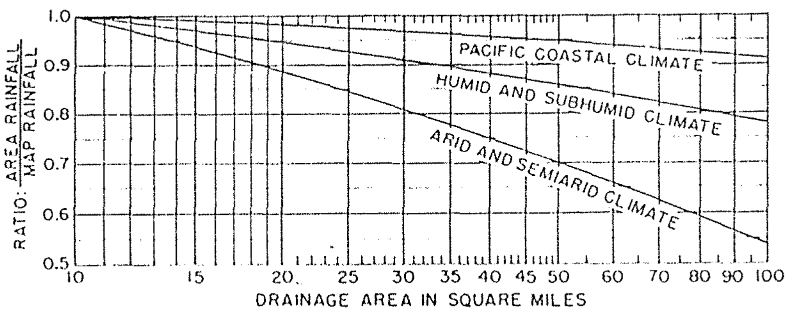
Circle one: [✓ T_c] T_t through subarea

NOTES: Space for as many as two segments per flow type can be used for each worksheet.

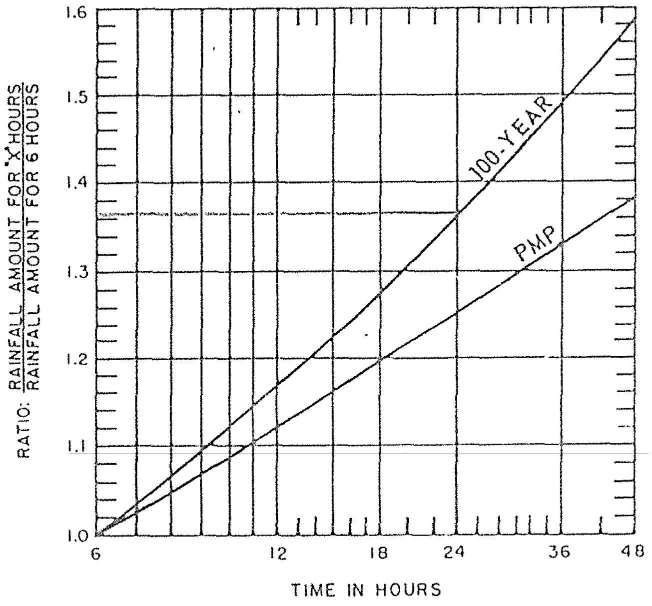
Include a map, schematic, or description of flow segments.

Sheet flow (Applicable to T_c only) Segment ID		a-b			
1. Surface description (table 3-1)		WOODS			
2. Manning's roughness coeff., n (table 3-1)		0.40			
3. Flow length, L (total L $\le$ 300 ft)	ft	100			
4. Two-yr 24-hr rainfall, P_2	in	2.9			
5. Land slope, s $\frac{20}{210}$	ft/ft	0.095			
6. $T_t = \frac{0.007\ (nL)^{0.8}}{P_2^{\ 0.5}\ s^{0.4}}$ Compute T_t	hr	0.20	+	=	0.20
Shallow concentrated flow Segment ID		b-c			
7. Surface description (~~paved or~~ unpaved)		UNPAVED			
8. Flow length, L	ft	710			
9. Watercourse slope, s $\frac{3605-3500}{810}$	ft/ft	0.130			
10. Average velocity, V (figure 3-1)	ft/s	5.8			
11. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.03	+	=	0.03
Channel flow Segment ID		c-d			
12. Cross sectional flow area, a	ft^2	6.75			
13. Wetted perimeter, p_w	ft	9.49			
14. Hydraulic radius, $r = \frac{a}{p_w}$ Compute r	ft	0.71			
15. Channel slope, s $\frac{3500-3340}{4900}$	ft/ft	0.033			
16. Manning's roughness coeff., n		0.045			
17. $V = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$ Compute V	ft/s	4.8			
18. Flow length, L	ft	4900			
19. $T_t = \frac{L}{3600\ V}$ Compute T_t	hr	0.28	+	=	0.28
20. Watershed or subarea T_c or T_t (add T_t in steps 6, 11, and 19)	hr				0.51 ≡ 0.5

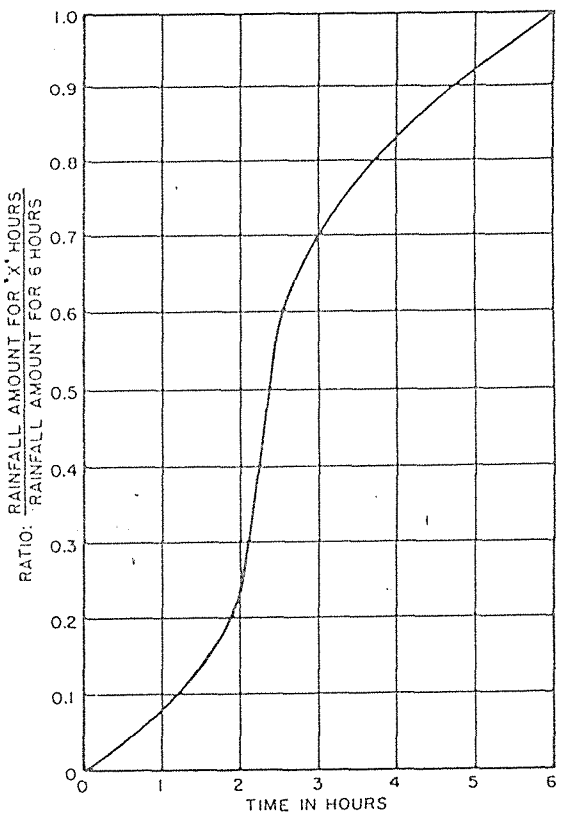
EXISTING DITCH IS A V-NOTCH WITH 3:1 SIDE SLOPES AND RIP-RAP LINED. ASSUME DEPTH OF 1.5FT.



(A) AREAL PRECIPITATION ADJUSTMENTS FOR DRAINAGE AREAS 10 to 100 SQUARE MILES



(B.) RELATIVE INCREASE IN RAINFALL AMOUNT FOR STORM DURATIONS OVER SIX HOURS



(C.) SIX HOUR DESIGN STORM DISTRIBUTION

FIGURE 2-6

EMERGENCY SPILLWAY AND FREEBOARD

VOLUME ADJUSTMENTS AND STORM DISTRIBUTION

FOR AREAS WHERE NWS REFERENCES DO NOT CONTAIN AN APPLICABLE PROCEDURE

Sheet 6 of 43

SUBJECT VEPCO - MOUNT STORM

BY MRL DATE 2/20/92 PROJ. NO. 88-108-51

CHKD. BY DATE SHEET NO. 7 OF 43

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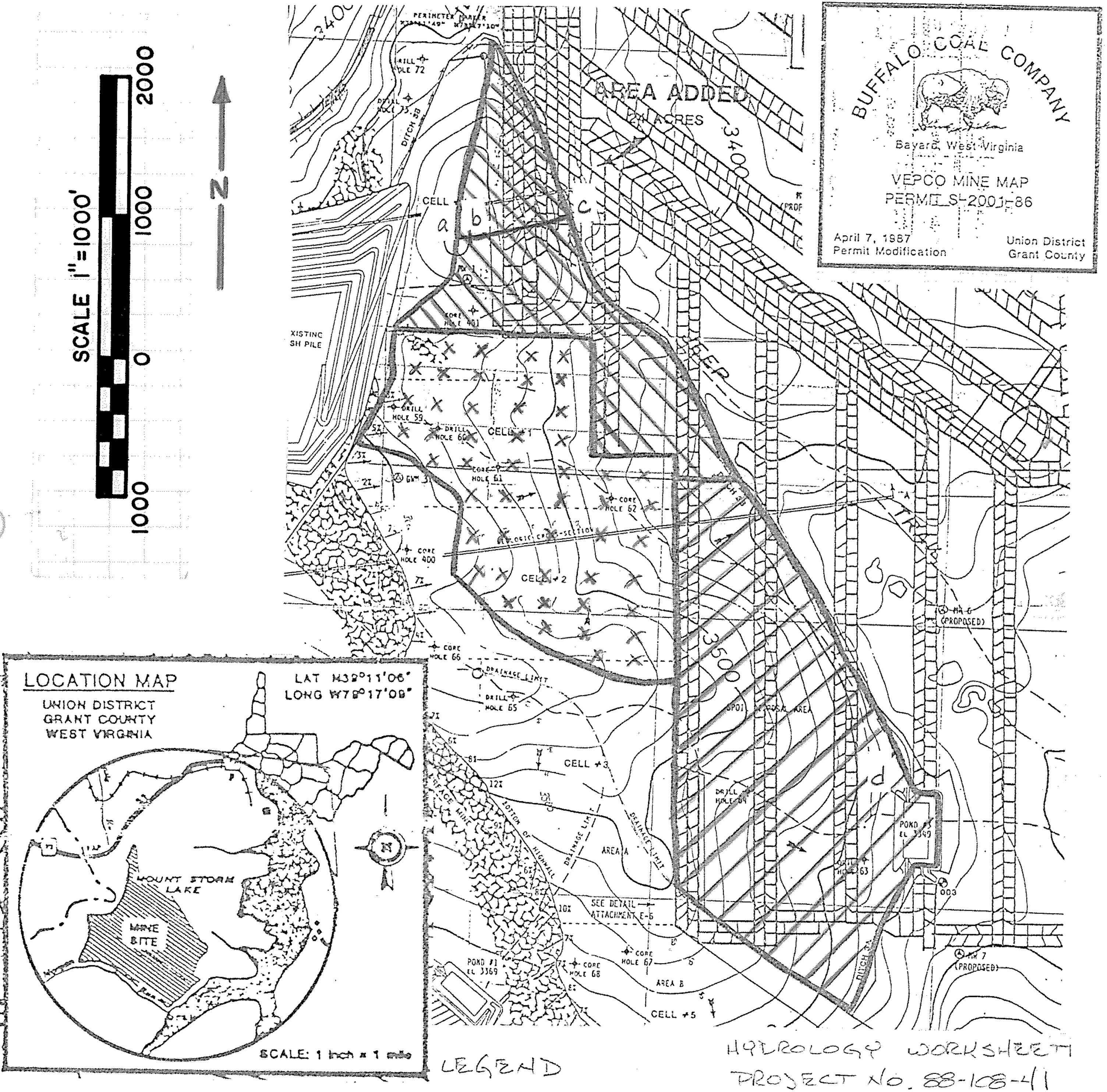


HYDROLOGY WORKSHEET
PROJECT NO. 88-108-41

LEGEND

▧ RECLAIMED AREA BY SER 5/8/91

XXX
XXX FLY ASH DISPOSAL AREA

▨ MINE REFUSE DISPOSAL AREA

SUBJECT VEPCO – MOUNT STORM

BY MRL DATE 1/15/92 PROJ. NO. 88-108-51

CHKD. BY KMB DATE 3/30/92 SHEET NO. 8 OF 43

HYDROLOGY

SUMMARY OF HYDROLOGIC CALCULATIONS

Drainage area = 230 acres = 0.36 mi.^{2} (see sheet 3)
Runoff curve number = 77 (see sheet 4)
Time of concentration = 0.5 hours (see sheet 5)

PRECIPITATION AMOUNTS (see sheet 4)

P_2, 24 hour = 2.88"
P_5, 24 hour = 3.75"
P_{10}, 24 hour = 4.60"
P_{25}, 24 hour = 4.98"
P_{50}, 24 hour = 5.75"
P_{100}, 24 hour = 6.30"

P_{100}, 6 hour = 4.63"

ESTIMATE THE BOTTOM OF POND ELEVATION FOR THE 11/30/91 PRECISION SURVEY COMPANY TOPOGRAPHY MAP THAT SHOWS THE EXISTING POND #3

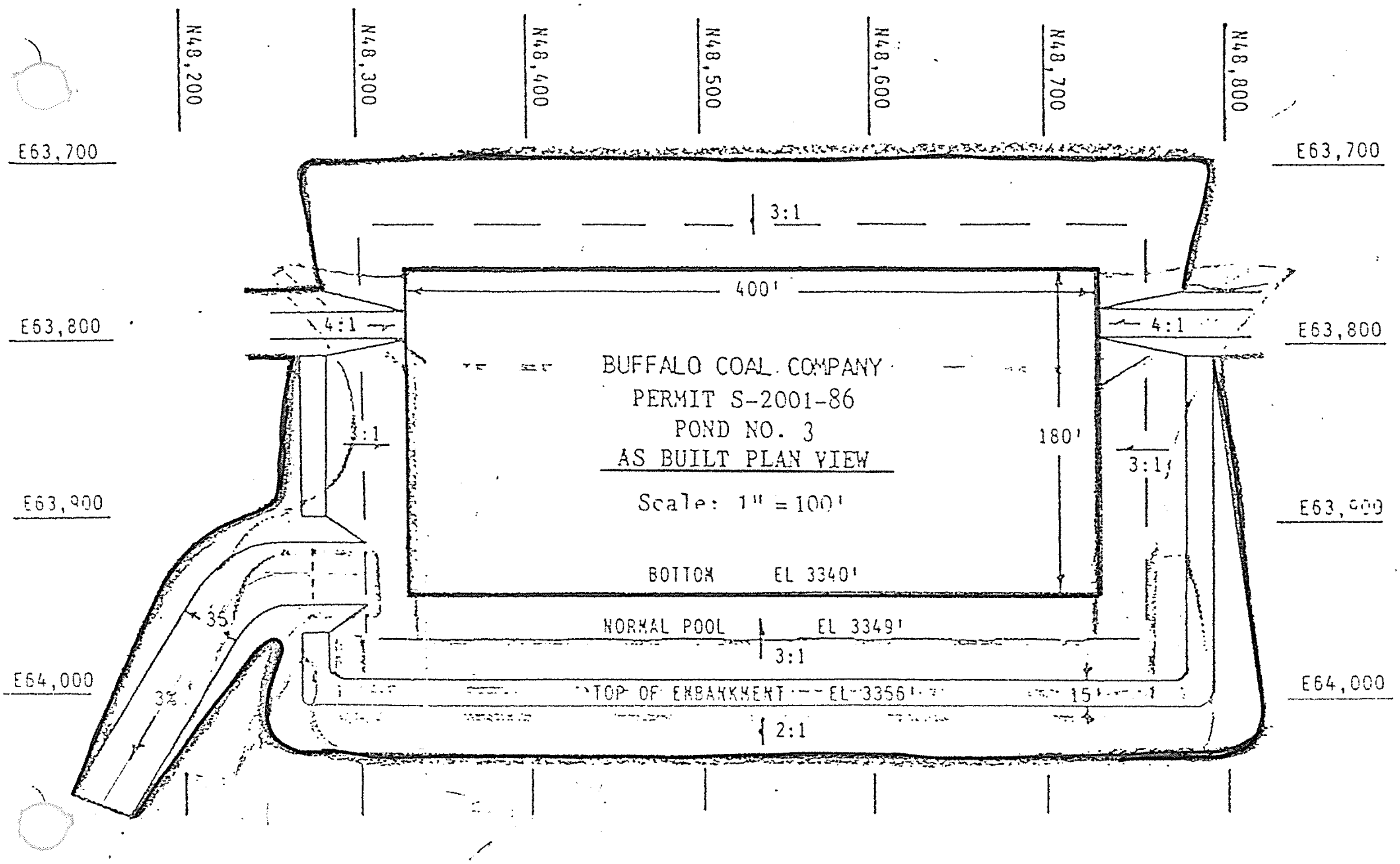
	Elevations from the "As Built Plan View" (see sheet 10)	Elevations from the 11/30/91 topo. map (see sheet 10A)	Elevation Differential (ft.)	Estimated elevations for the 11/30/91 topo. map
Top of embankment	3356'	≈ 3353'	3	——
Normal Pool / E.S. Crest	3349'	≈ 3345'	4	——
Pond Bottom	3340'		Assume 3	≈ 3337'

Using 3 instead of 4 will yield more conservative storage calculations (i.e. less storage) for existing pond 3.

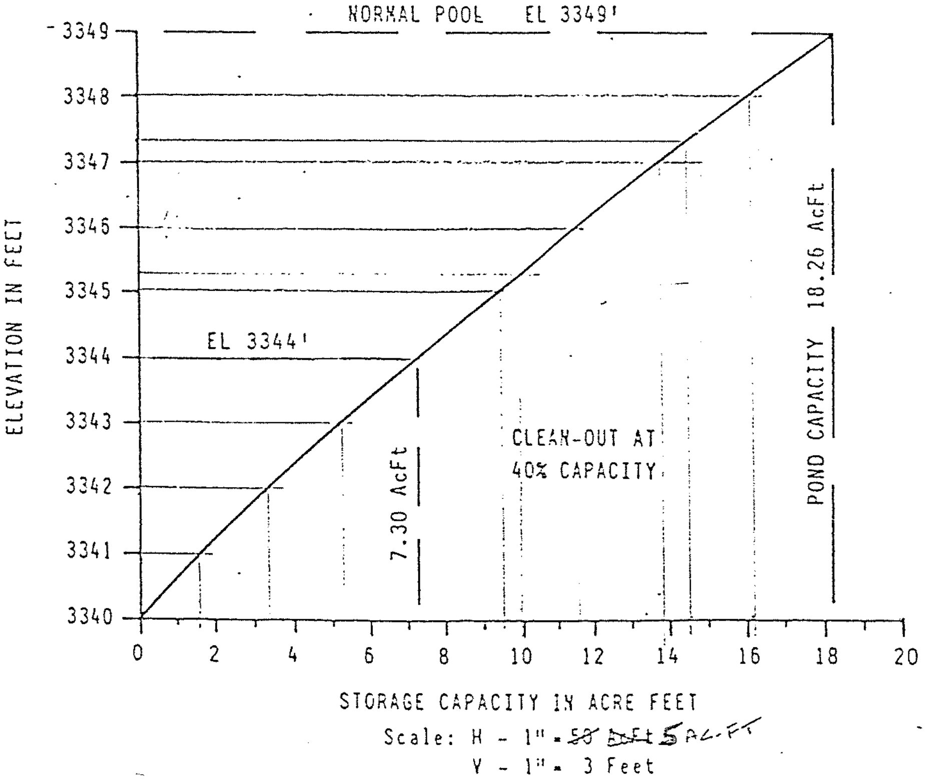
ASSUME POND BOTTOM ELEVATION = 3337

VEPCO - MOUNT STORM

SHEET 10 of 43



As Built STAGE STORAGE CURVE



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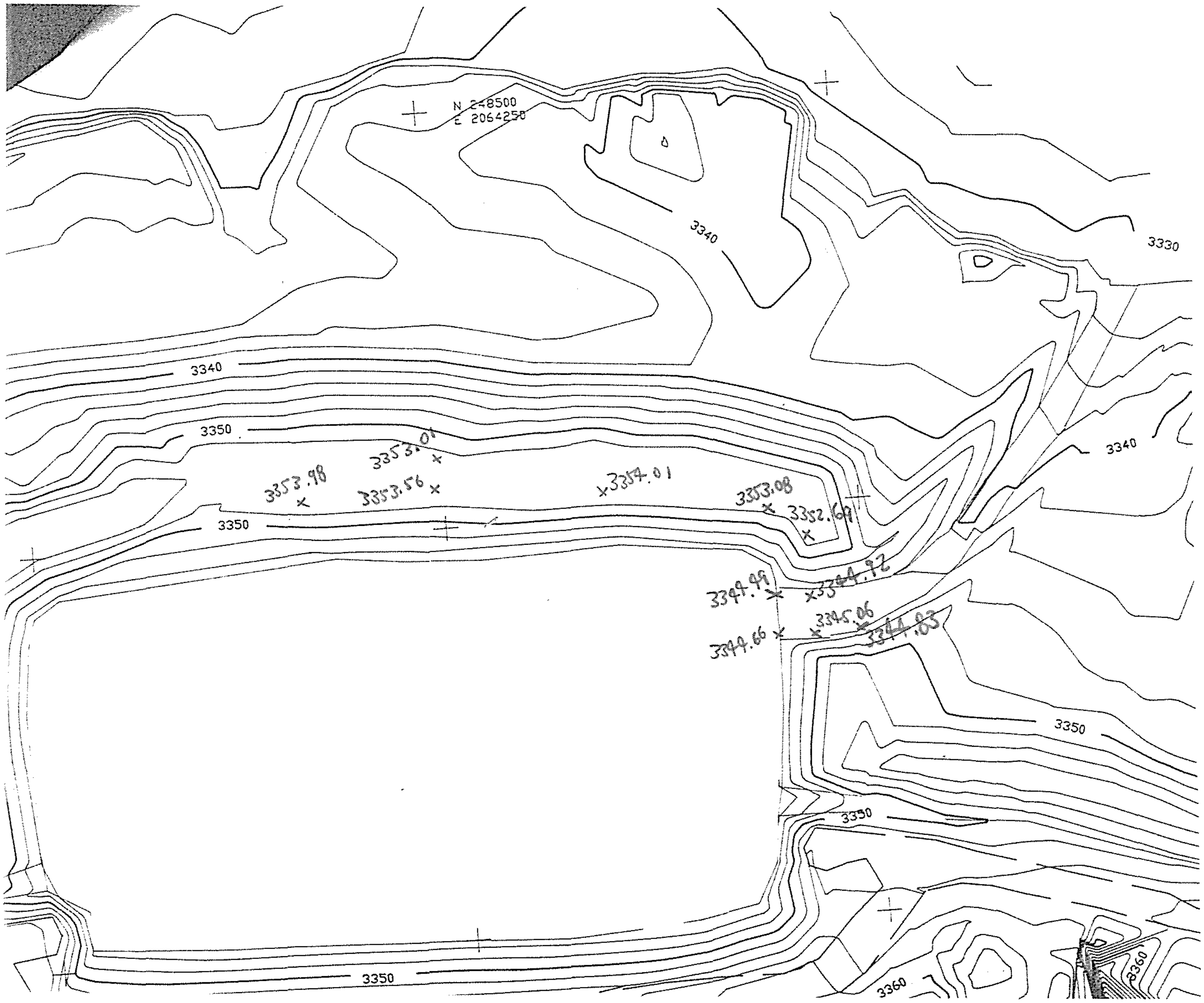
SUBJECT Vepco - Mount storm

BY KMB DATE 3/30/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 10A OF 43

REDUCED PORTION OF 11/30/91 TOPOGRAPHIC MAP BY PRECISION SURVEY COMPANY



POINT ELEVATIONS
TAKEN FROM FILE
USED TO CREATE
TOPOGRAPHY MAP.

SUBJECT VEPCO - MOUNT STORM

BY MRL DATE 1/15/92 PROJ. NO. 88-108-51

CHKD. BY KMB DATE 3/31/92 SHEET NO. 11 OF 43

STORAGE REQUIREMENTS

SEDIMENT STORAGE (V_s)

The West Virginia Solid Waste Management Regulations require 0.125 Ac. Ft. of sediment storage per acre of disturbed drainage area.

✓ Disturbed drainage area = 40 acres (see sheet 3)

$$V_s = 0.125 \frac{Ac.Ft.}{Ac.} \times 40 Ac. = \underline{\underline{5 Ac.-Ft.}}$$

RUNOFF STORAGE (V_R)

The West Virginia Erosion and Sediment Control Handbook requires that the 2-year 24-hour storm runoff, in addition to the sediment storage, be stored.

✓ $P_{2, 24 hour}$ = 2.88" (see sheet 8)

Runoff (@ CN = 77) = 0.99" (from USDA SCS TR 16)

$$V_R = \frac{.99 in Ft}{12 in} \times 230 Ac. = \underline{\underline{19.0 Ac.-Ft.}}$$

TOTAL STORAGE (V_T)

$$V_T = V_s + V_R = 5 Ac.-Ft + 19 Ac.-Ft = \underline{\underline{24 Ac.-Ft}}$$

The crest of the principal spillway shall be set at an elevation at or above 24 Ac.-Ft. storage.

SUBJECT VEPco - Mount Storm

BY MRL DATE 3/27/92 PROJ. NO. 88-108-51

CHKD. BY KMB DATE 3/31/92 SHEET NO. 12 OF 43

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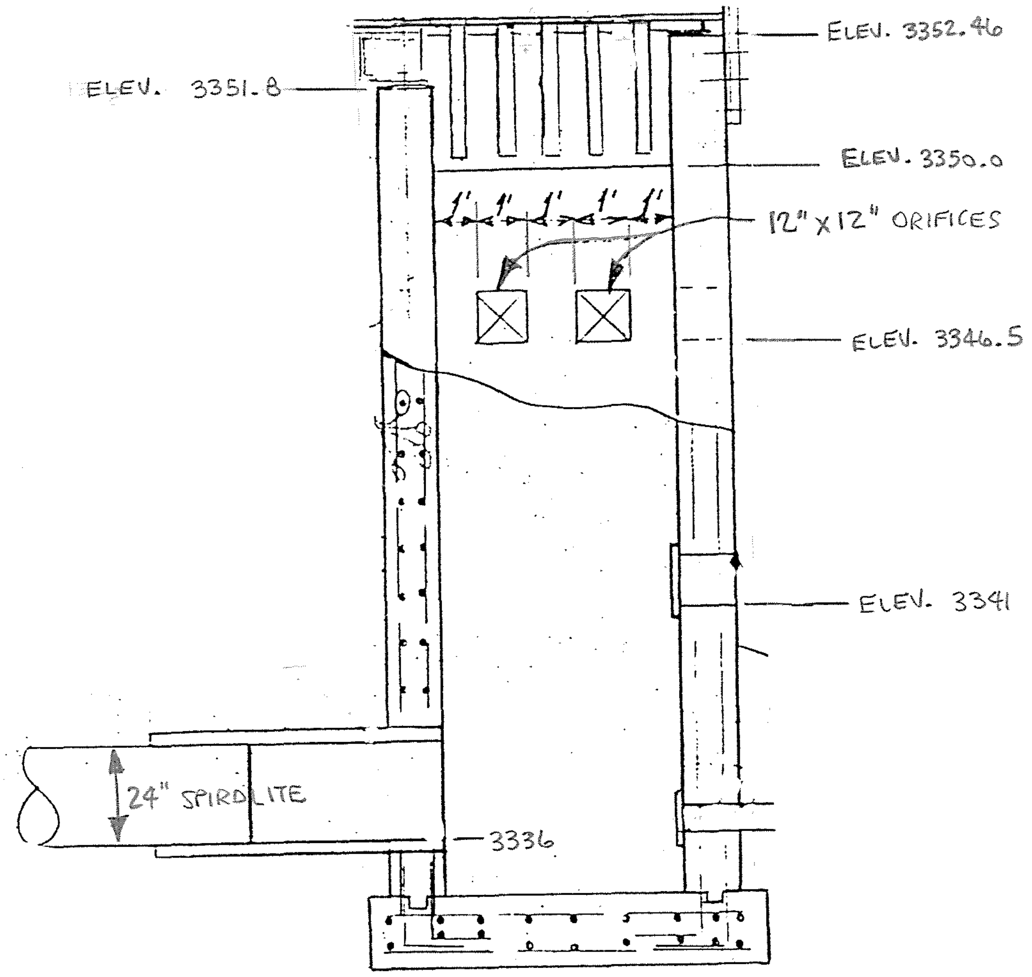
HYDRAULICS

A riser as shown below will be built in the pond #3 addition. Analyze the hydraulics of the riser and conduit to determine if all applicable hydraulic and storage requirements are satisfied.



SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 13 OF 43

CONCRETE RISER

THE CONCRETE RISER CONSISTS OF TWO SEPARATE INLET SECTIONS. THERE ARE 5 SQUARE ORIFICES LOCATED ON THE SIDE OF THE RISER AND AN OPENING IN THE TOP OF THE RISER.

ORIFICE AND WEIR FLOW WILL BE CONSIDERED FOR EACH OF THESE INLET SECTIONS.

THE FIRST INLET ENCOUNTERED CONSISTS OF 5 12" x 12" SQUARE ORIFICES. THE INVERT OF THESE ORIFICES IS AT ELEVATION 3346.5.

FOR THESE ORIFICES, CONSIDER WEIR AND ORIFICE FLOW.

WEIR FLOW: $Q = CLH^{3/2}$

L = length of crest = 12" = 1'
H = head above weir crest.
C = weir coefficient, usually 3.1

HOWEVER, FOR A WEIR WITH SUCH A SMALL CREST, C VARIES WITH HEAD AS SHOWN BELOW (TAKEN FROM TABLE 5-3 OF BRATER & KING'S 'HANDBOOK OF HYDRAULIC

VALUES OF C FOR 1' WEIR BREADTH

HEAD (ft)	C	HEAD (ft)	C	HEAD (ft)	C
0.2	2.69	1.6	3.28	4.5	3.32
0.4	2.72	1.8	3.31	5.0	3.32
0.6	2.75	2.0	3.30	5.5	3.32
0.8	2.85	2.5	3.31		
1.0	2.98	3.0	3.32		
1.2	3.08	3.5	3.32		
1.4	3.20	4.0	3.32		

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 14 OF 43

CONCRETE RISER
12" ORIFICES

WEIR FLOW WILL EXIST ON THESE ORIFICES UNTIL THE TOP OF THE ORIFICE IS REACHED.

WATER ELEVATION (FT)	HEAD ABOVE CREST (FT)	"C"	FLOW/ORIFICE (cfs)	TOTAL WEIR FLOW FOR 5 ORIFICES (CFS)
3346.5	0	–	0	0
3346.75	0.25	2.70	0.34	1.7
3347.0	0.5	2.74	0.97	4.9
3347.25	0.75	2.83	1.8	9.0
3347.5	1.0	2.98	3.0	15.0

$$Q = C(1\ ft)(H)^{3/2}$$

ORIFICE FLOW: $Q = CA\sqrt{2gH}$

A = area of orifice, ft^2 = 1 ft^2

H = head above centerline of orifice

VALUES OF C ARE TAKEN FROM TABLE 4-3 OF BRATER & KING'S "HANDBOOK OF HYDRAULICS" FOR A 1.0' SQUARE ORIFICE:

HEAD (FT)	C
0.8	0.597
1.0	0.599
1.5	0.601
2	0.602
3	0.603
4	0.602

} USE A VALUE OF 0.6

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 15 OF 43

CONCRETE RISER
12" ORIFICES

ORIFICE FLOW IS CAPABLE OF BEGINNING ONCE WATER LEVEL PASSES THE TOP OF THE ORIFICE.

WATER ELEVATION (FT)	HEAD ABOVE ORIFICE ℄ (FT)	FLOW/ORIFICE (CFS)	TOTAL ORIFICE FLOW FOR 5 ORIFICES (CFS)
3348	1.0	4.81	24.0
3349	2.0	6.81	34.0
3350	3.0	8.34	41.7
3351	4.0	9.63	48.2
3352	5.0	10.8	54.0
3353	6.0	11.8	59.0

THE CENTERLINE OF THE ORIFICE IS AT 3347.0

$$Q = 4.81\sqrt{H}$$

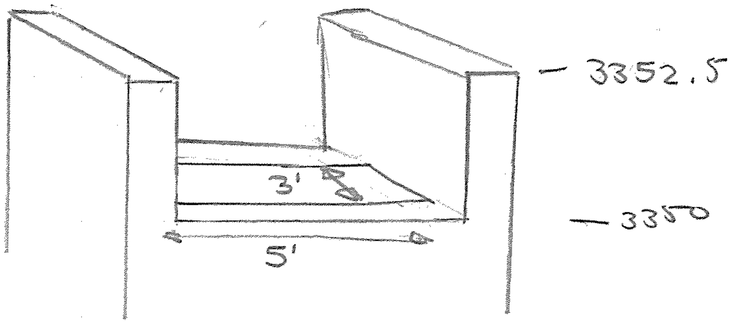
SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 16 OF 43

CONCRETE RISER
TOP OF RISER

THE CONCRETE RISER TOP WILL PASS FLOW. THE GEOMETRY OF THIS IS:



THEREFORE, THE WEIR CONSISTS OF TWO 5' LENGTHS AND THE ORIFICE AREA IS 15 SQUARE FEET.

FOR WEIR FLOW $Q = CLH^{3/2}$. THIS WILL ONCE AGAIN BE A BROAD-CRESTED WEIR. USE THE SAME VALUES OF C AS IN THE CASE WITH THE ORIFICES - BOTH WEIRS HAVE A BREADTH OF 12"

WATER ELEVATION (FT)	HEAD ABOVE CREST (FT)	"C"	FLOW/SIDE OF WEIR (CFS)	TOTAL FLOW (CFS)
3350	0	—	0	0
3350.5	0.5	2.78	4.91	9.82
3351	1	2.98	14.9	29.8
3351.5	1.5	3.24	29.8	59.6
3352	2	3.30	46.7	93.4
3352.5	2.5	3.31	65.4	131
3353	3	3.32	86.3	173

$$Q = C(5\ ft)(H)^{3/2}$$

CONCRETE RISER
TOP OF RISER

ORIFICE FLOW AT THE TOP OF THE CONCRETE RISER WILL ALSO BE ANALYZED.

$$Q = CA\sqrt{2gh}$$

ONCE AGAIN, USE $C = 0.6$
$A = 5 \times 3 = 15$ sq. feet

$$\Rightarrow Q = 72.2\sqrt{h}$$

WATER ELEVATION (FT)	HEAD ABOVE ORIFICE (FT)	FLOW (CFS)
3350	0	0
3350.5	0.5	51.1
3351	1	72.2
3351.5	1.5	88.4
3352	2	102
3352.5	2.5	114
3353	3	125

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 18 OF 43

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OUTLET PIPE CAPACITY

IT IS DESIRED TO DETERMINE THE CAPACITY OF THE SPIROLITE PIPE USED IN THE CONCRETE RISER.

THIS PIPE IS 24" IN DIAMETER - SPIROLITE - USE A MANNING'S "n" OF 0.012.

THE PIPE IS ON A SLOPE OF 1% OVER A LENGTH OF APPROXIMATELY 100 FEET.

THE PIPE INLET INVERT IS AT ELEVATION 3336.

USE THE METHODS PRESENTED IN THE "EROSION AND SEDIMENT POLLUTION CONTROL PROGRAM MANUAL" FOR THE COMMONWEALTH OF PENNSYLVANIA TO DETERMINE PIPE CAPACITY. THIS FORMULA IS (FROM pg. 4.53 OF THE MANUAL)

$$Q = a\left[(2gh)/(1+K_m+K_pL)\right]^{1/2}$$

a : area of pipe (sq. ft) : $\frac{\pi}{4}\left(\frac{24}{12}\right)^2 = 3.14$ ft

g = 32.2 ft/s^2

h : head above 0.6 diam above outlet invert

K_m - assume 1.0

K_p : pipe friction = $(5087\ n^2)/d_i^{4/3}$

d_i = diam. in inches = 24

n = 0.012

$$K_p = (5087 \times 0.012^2)/24^{4/3} = 0.0106$$

L = 100 ft

$$Q = 3.14\left[(2\times32.2)h/(1+1+(0.0106)(100))\right]^{1/2}$$

$$= 3.14\left[64.4h/3.06\right]^{1/2} = 14.4\sqrt{h}$$

The invert of the outlet pipe is 3336 - (100)(0.01) = 3335.

therefore, 0.6 diam = 3335 + $0.6 \times \frac{24}{12}$ = 3336.2

SUBJECT Pond # 3 Modification
Spiral Pipe Substitution

BY MRL DATE 9/8/92 PROJ. NO. 88-108-51

CHKD. BY DATE SHEET NO. OF

RISER OUTLET PIPE

Design called for : "class 160 Spirolite HDPE as manufactured by Spiral Engineered Systems, Gulf Plastic Fabricated Products Company, Norcross, Georgia, or approved equal." The drawings indicate 24"ø.

Specific site conditions indicate that :

- The pipe will be subjected to an overburden load of 15.5' of embankment material plus traffic on top of this overburden.
- The pipe will be bedded with AASHTO #57 stone
- The 24"ø pipe is to fit inside a 30"ø RCP.
- A mannings "n" of 0.012 was used.

Engineering data of Spirolite

- gasket joint that meets ASTM F-477
- diameter = 24" + 2(1.7") = 27.4" (will fit within 30" RCP)

Engineering data of Titeline

Leakage rate = 50 gallons / inch of ø / mile / day

manning "n" = 0.010 (o.k.)
gaskets meet requirements of ASTM F477
"withstands deep burials in excess of 20 feet"

backfill required is free-draining sands and gravels.
→ soil fill O.K. ?

→ Outside diameter ?

NOT PART OF DESIGN CALCULATIONS

SUBJECT VEPCO – MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 19 OF 43

PIPE CAPACITY

WATER SURFACE ELEVATION (ft)	HEAD ON OUTLET (ft)	PIPE CAPACITY (cfs)
3341	4.8	31.5
3342	5.8	34.7
3343	6.8	37.6
3344	7.8	40.2
3345	8.8	42.7
3346	9.8	45.1
3346.5	10.3	46.2
3347	10.8	47.3
3348	11.8	49.5
3349	12.8	51.5
3350	13.8	53.5
3351	14.8	55.4
3352	15.8	57.2
3353	16.8	59.0
3346.75	10.55	46.7
3347.25	11.05	47.9
3347.5	11.3	48.4

SUBJECT VEPCO – MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 20 OF 43

CONCRETE RISER

THERE ARE, THEREFORE, TWO SEPARATE CASES TO ANALYZE FOR WHICH TYPE OF FLOW IS LIMITING:

– ORIFICES

WATER ELEVATION (FT)	WEIR FLOW (CFS)	ORIFICE FLOW (CFS)	PIPE FLOW (CFS)	LIMITING FLOW (CFS)
3346.5	0		46.2	0
3346.75	1.7		46.7	1.7
3347.0	4.9		47.3	4.9
3347.25	9.0		47.9	9.0
3347.5	15.0		48.4	15.0
3348		24.0	49.5	24.0
3349		34.0	51.5	34.0
3350		41.7	53.5	41.7
3351		48.2	55.4	48.2
3352		54.0	57.2	54.0
3353		59.0	59.0	59.0

– RISER BOX

3350	0	0	53.5	0
3351	29.8	72.2	55.4	29.8
3352	93.4	102	57.2	57.2
3353	173	125	59.0	59.0

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/9/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 21 OF 43

CONCRETE RISER

TOTAL STAGE - DISCHARGE FOR THE RISER. THIS TAKES INTO ACCOUNT ADDING BOX & ORIFICE FLOWS & THE PIPE LIMITATION.

WATER ELEVATION (FT)	FLOW (CFS)
3346.5	0
3346.75	1.7
3347.0	4.9
3347.25	9.0
3347.5	15.0
3348	24.0
3349	34.0
3350	41.7
3351	55.4
3352	57.2
3353	59.0

NOTE: AT 3351, 48.2 + 29.8 = 78.0, WHICH IS GREATER THAN THE PIPE CAP. OF 55.4
THE SAME APPLIES TO 3352 & 3353

INTERPOLATING 3348.5 29.0

SUBJECT VEPCO – MOUNT STORM

BY KMB DATE 3/10/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 22 OF 43

EMERGENCY SPILLWAY

THE EMERGENCY SPILLWAY ANALYSIS WILL BE PERFORMED USING METHODS PRESENTED IN THE U.S. DEPARTMENT OF AGRICULTURE'S SOIL CONSERVATION SERVICE TECHNICAL RELEASE 2. EXAMPLE 1A FROM SUPPLEMENT A WILL BE FOLLOWED.

THE NEXT PAGE SHOWS A PLAN AND PROFILE SKETCH OF THE EMERGENCY SPILLWAY AREA. THE TWO PAGES FOLLOWING THE SKETCH ARE CHARTS FROM TR-2 THAT WILL BE USED IN THE ANALYSIS.

THE METHODOLOGY TO BE USED IS AS FOLLOWS:

1) FIND THE EQUIVALENT WIDTH w OF THE TRAPEZOIDAL SECTIO
THIS USES CHART ES-98
2) DETERMINE H_p FROM CHART ES-124.

A FLOWRATE WILL INITIALLY BE ASSUMED AND WATER SURFACE ELEVATIONS WILL BE DETERMINED FROM THIS. THE ELEVATION OF THE FLAT PART OF THE SPILLWAY IS 3348.5. H_p IS REFERENCED TO THIS ELEVATION.

SIDE SLOPES ON THE SPILLWAY ARE 3:1
USE "n" = 0.04
b = base width = 35'
USE L = 80' (L = 75'; 80' IS CONSERVATIVE)

SUBJECT VEPCO - MOUNT STORM

BY MRL DATE 3/27/92 PROJ. NO. 88-108-51
CHKD. BY KMB DATE 3/31/92 SHEET NO. 22 A OF 43

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EMERGENCY SPILLWAY OUTLET CHANNEL

To use chart ES-124, flow in the outlet channel must be supercritical. Check the emergency spillway outlet channel for supercritical flow at maximum discharge. Also, calculate the maximum velocity in the outlet channel during maximum discharge.

Maximum discharge occurs at elevation 3349.4. (see sheet 39)

Emergency spillway discharge at elevation 3349.4 = 100 CFS. (see sheet 29)

```
                           INPUT INFORMATION:

   FLOW         MANNING'S        CHANNEL         SIDESLOPE        BOTTOM
   RATE            'N'            GRADE                           WIDTH
  (cfs.)                        (ft./ft.)        (_H:1V)          (ft.)
 %100.00          0.040           0.0600            3.00            35.0


                              SOLUTION:

          THE NORMAL DEPTH IN THE CHANNEL IS  0.50 ft. OR  5.9 in.

 AREA   WETTED    HYDRAULIC   FROUDE   VELOCITY   VELOCITY   TOTAL    RIP-RAP
       PREIMETER   RADIUS     NUMBER               HEAD     ENERGY   SIZE (D50)
 ft^2)   (ft)       (ft)              (ft/sec)     (ft)      (ft)      (in)
 18.08   38.13      0.47       2.00     5.53       0.48      0.97       7.7
      RIP-RAP IS NOT REQUIRED IF THE SOIL LINING OF THE CHANNEL IS COHESIVE
```

SUPERCRITICAL FLOW

RESULTS: AT Q = 100 CFS, flow is supercritical and velocity = 5.5 fps.

The run-of-mine rock to be used in the outlet channel will be adequate channel protection.

NOTE: Supercritical flow starts around 3 CFS of flow.

```
                            INPUT INFORMATION:

    FLOW            MANNING'S          CHANNEL          SIDESLOPE        BOTTOM
    RATE               'N'              GRADE                            WIDTH
   (cfs.)                            (ft./ft.)          (_H:1V)          (ft.)
   %100.00            0.040             0.0800             3.00             35.0


                               SOLUTION:

          THE NORMAL DEPTH IN THE CHANNEL IS  0.45 ft. OR  5.5 in.

 AREA    WETTED     HYDRAULIC    FROUDE    VELOCITY    VELOCITY   TOTAL    RIP-RAP
        PREIMETER    RADIUS      NUMBER                  HEAD     ENERGY  SIZE (D50)
(ft^2)    (ft)        (ft)                 (ft/sec)      (ft)      (ft)      (in)
 16.54    37.88       0.44        2.59       6.05        0.57      1.02       9.6
```

"Check run" made to see if it was O.K to steepen the outlet slope. At 8 %, it was O.K. because ....

- flow remained supercritical
- outlet velocity only increased to 6.05 fps.

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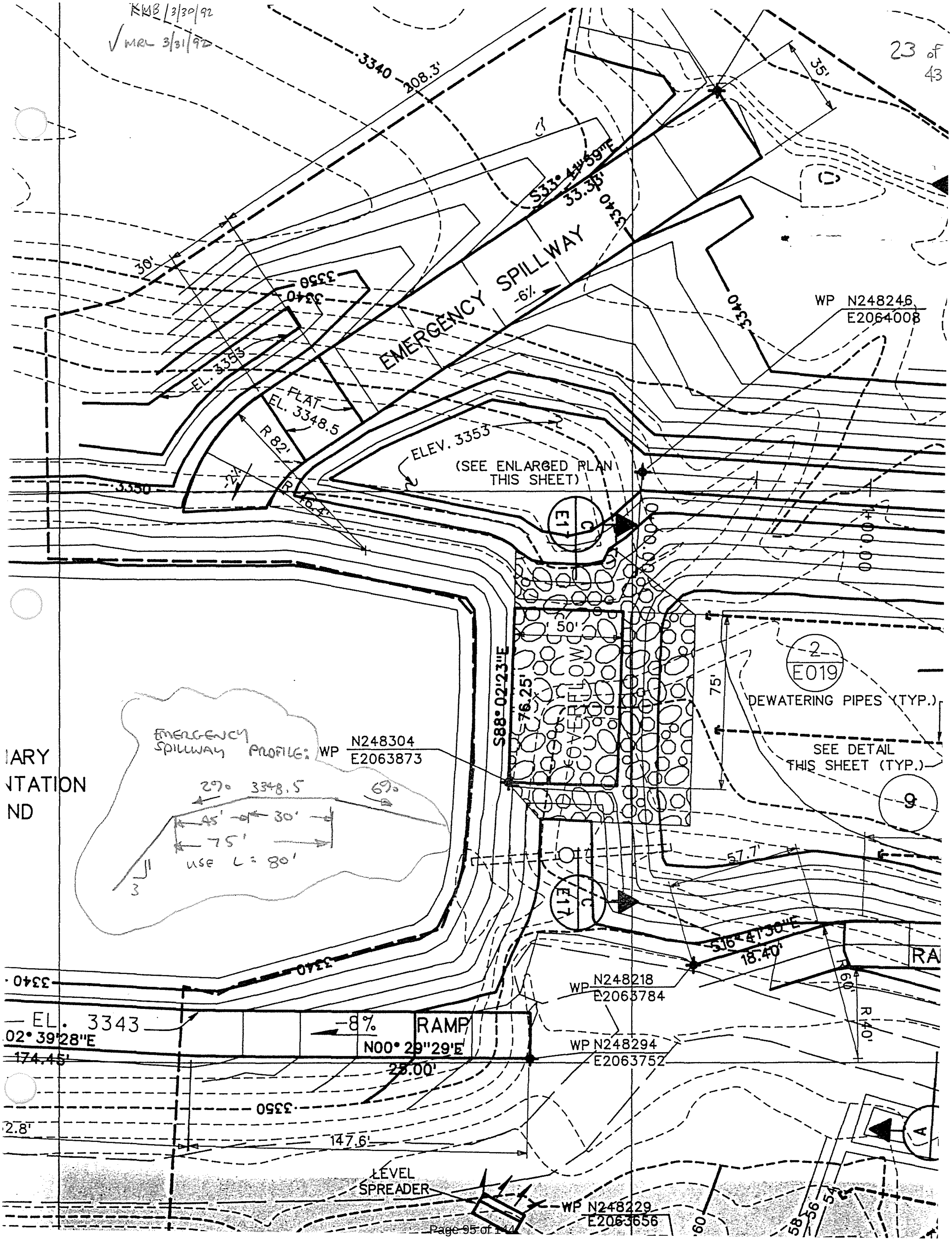
CALCULATIONS.

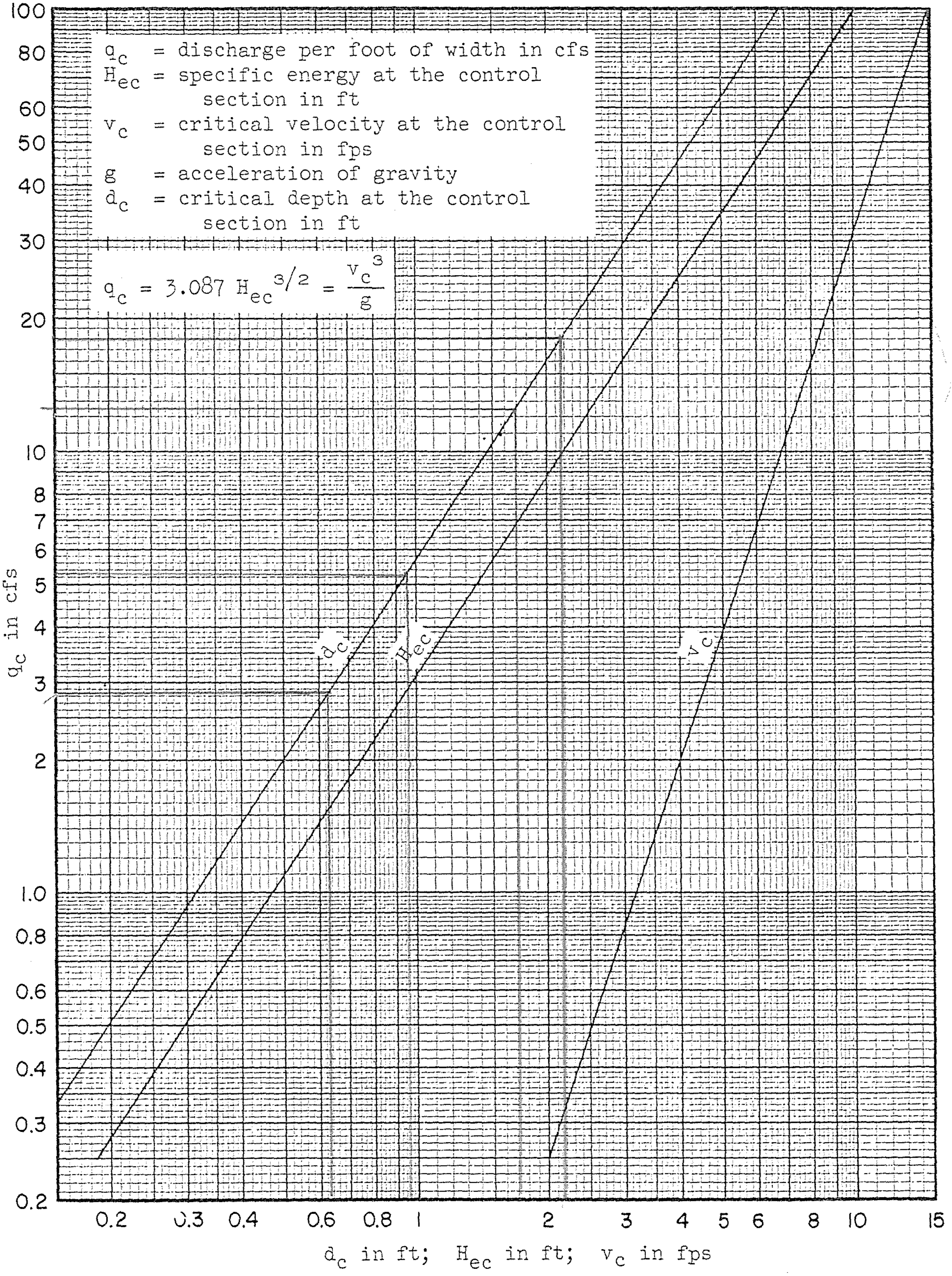
KMB 3/30/92

✓ MRL 3/31/92

23 of 43



EARTH SPILLWAYS : Plot of q_c vs d_c; q_c vs H_{ec}; q_c vs v_c



q_c = discharge per foot of width in cfs
H_{ec} = specific energy at the control section in ft
v_c = critical velocity at the control section in fps
g = acceleration of gravity
d_c = critical depth at the control section in ft

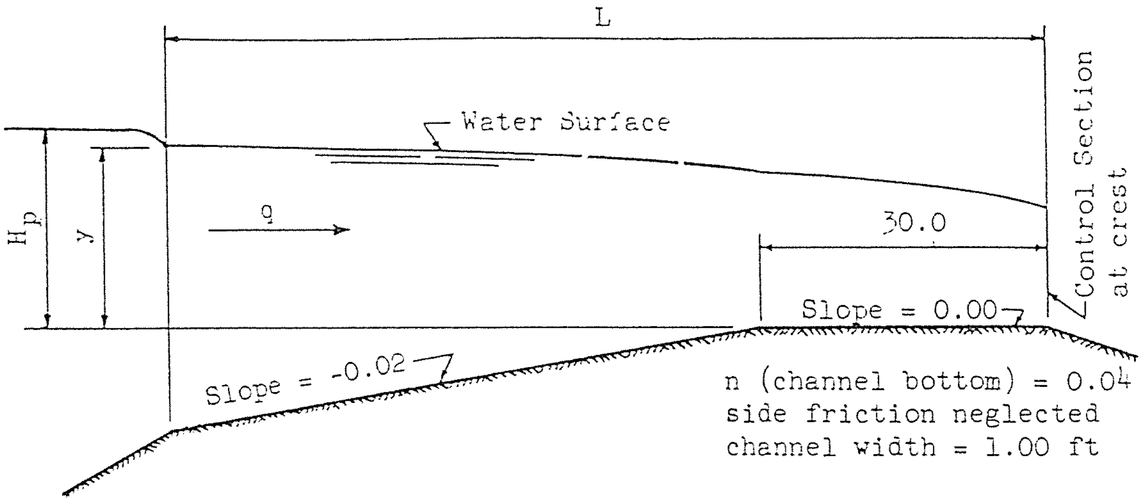
$$q_c = 3.087\ H_{ec}{}^{3/2} = \frac{v_c{}^3}{g}$$

REFERENCE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - DESIGN SECTION

STANDARD DWG. NO.
ES-98
SHEET 1 OF 4
DATE 4-27-55

EARTH SPILLWAYS: Values of H_p and y for given values of q and L



n (channel bottom) = 0.04
side friction neglected
channel width = 1.00 ft

H_p given in top figures; $y = H_p - v^2/2g$ given in bottom figures

L in ft	q = 5 cfs	q = 10 cfs	q = 15 cfs	q = 20 cfs	q = 30 cfs	q = 40 cfs
20.0	1.58 1.37	2.40 2.02	3.09 2.55	3.68 2.98	4.75 3.76	5.72 4.47
30.0	1.63 1.45	2.47 2.12	3.15 2.66	3.75 3.11	4.82 3.91	5.79 4.63
40.0	1.68 1.55	2.52 2.26	3.20 2.82	3.81 3.30	4.88 4.14	5.85 4.89
60.0	1.72 1.64	2.56 2.39	3.27 3.00	3.89 3.53	4.96 4.40	5.93 5.19
80.0	1.73 1.68	2.60 2.47	3.30 3.09	3.93 3.64	5.01 4.56	5.99 5.38
100.0	1.74 1.70	2.62 2.52	3.33 3.16	3.96 3.72	5.05 4.67	6.03 5.51
120.0	1.75 1.72	2.63 2.55	3.35 3.21	3.98 3.78	5.08 4.75	6.06 5.61
140.0	1.76 1.73	2.64 2.57	3.36 3.24	4.00 3.83	5.09 4.81	6.09 5.69
160.0	1.76 1.74	2.65 2.59	3.37 3.27	4.01 3.86	5.11 4.86	6.11 5.75
180.0	1.76 1.74	2.65 2.60	3.38 3.29	4.02 3.89	5.12 4.90	6.13 5.81
200.0	1.76 1.75	2.65 2.61	3.39 3.31	4.04 3.92	5.14 4.94	6.14 5.85

REFERENCE

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION - DESIGN SECTION

STANDARD DWG. NO.
ES-124
SHEET 3 OF 7
DATE 11-21-56

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/10/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 26 OF 43

EMERGENCY SPILLWAY

USE $Q = 100$ cfs

TRY $q = Q/b = 100/35 = 2.86$ cfs $\Rightarrow d_c = 0.62$
(dc FROM ES-98)

$w = 35 + 3(0.62) = 36.9$ ft $\Rightarrow q = 2.71$ cfs

$q = 2.71$ cfs $\Rightarrow d_c = 0.60$

$w = 35 + 3(0.60) = 36.8$ ft $\Rightarrow q = 2.72$ cfs

$q = 2.72$ cfs $\Rightarrow d_c = 0.60$ ✓

$w = 36.8$ ft

FOR $L = 80'$:

q	H_e
0	0
2.72	
5	1.73

$\Rightarrow H_e = 0.94$ ft

$H_e = 0.94$ ft $\Rightarrow$ ELEVATION = 3349.4 ft
FLOW = 100 cfs

EMERGENCY SPILLWAY

Q = 200 cfs

USE $w = 37.8$ ft : $q = 200/37.8 = 5.29$ cfs
$\Rightarrow d_c = 0.95$ ft $\Rightarrow w = 35 + 3(0.95) = 37.8$ ✓

FOR L = 80':

q	Hp
5	1.73
5.29	
10	2.60

$\Rightarrow H_p = 1.78$

ELEVATION = 3350.3 FLOW = 200 cfs

Q = 300 cfs

USE $w = 38.7$ ft : $q = 300/38.7 = 7.75$ cfs
$\Rightarrow d_c = 1.23$ ft $\Rightarrow w = 35 + 3(1.23) = 38.7$ ✓

FOR L = 80' :

q	Hp
5	1.73
7.75	
10	2.60

$\Rightarrow H_p = 2.21'$

ELEVATION = 3350.7 FLOW = 300 cfs

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/10/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 28 OF 43

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EMERGENCY SPILLWAY

Q = 500 cfs

USE $w = 40.1'$: $q = 500/40.1 = 12.5$ cfs
$\Rightarrow d_c = 1.70$ ft $\Rightarrow w = 35 + 3(1.70) = 40.1$ ft ✓

FOR L = 80':

q	Hp
10	2.60
12.5	
15	3.30

$\Rightarrow Hp = 2.95$

ELEVATION = 3351.45 FLOW = 500 cfs

Q = 750 cfs

USE $w = 41.5'$: $q = 750/41.5 = 18.1$ cfs
$\Rightarrow d_c = 2.17'$ $\Rightarrow w = 35 + 3(2.17) = 41.5$ ft ✓

FOR L = 80' ;

q	Hp
15	3.30
18.1	
20	3.93

$\Rightarrow Hp = 3.69$

ELEVATION = 3352.2 FLOW = 750 cfs

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/10/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 29 OF 43

EMERGENCY SPILLWAY

$Q = 1000$ cfs

USE $w = 42.8'$: $q = 1000/42.8 = 23.4$ cfs

$\Rightarrow d_c = 2.6$ ft $\Rightarrow w = 35 + 3(2.6) = 42.8'$

FOR $L = 80'$:

q	Hp
20	3.93
23.4	
30	5.01

$\Rightarrow H_p = 4.30$

ELEVATION = 3352.8 FLOW = 1000 cfs

SUMMARY OF RESULTS

FLOW (cfs)	ELEVATION (ft)
100	3349.4
200	3350.3
300	3350.7
500	3351.45
750	3352.2
1000	3352.8

THIS YIELDS (THROUGH INTERPOLATION)

ELEVATION (FT)	FLOW (cfs)	
3348.5	0	(GIVEN)
3349	55	
3350	167	
3351	380	
3352	683	
3353	≈1100	

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/10/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 30 OF 43

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STAGE - DISCHARGE FOR TOTAL POND

WATER ELEVATION (FT)	RISER FLOW (CFS)	E. SPILLWAY FLOW (CFS)	TOTAL FLOW (cfs)
3346.5	0	0	0
3346.75	1.7	0	1.7
3347.0	4.9	0	4.9
3347.25	9.0	0	9.0
3347.5	15.0	0	15.0
3348	24.0	0	24.0
3348.5	29.0	0	29.0
3349	34.0	55	89
3350	41.7	167	209
3351	55.4	380	435
3352	57.2	683	740
3353	59.0	1100	1160

SUBJECT VEPCO - MT. STORM

BY KMB DATE 3/11/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 31 OF 43

THE STAGE - STORAGE DATA FOR THE POND SYSTEM MUST BE DETERMINED. THERE ARE TWO PONDS CONNECTED BY AN OVERFLOW AT ELEVATION 3345. THE STAGE - DISCHARGE DOES NOT START UNTIL 3346.5, SO THE STORAGES BELOW THIS WILL JUST BE ADDED TOGETHER AS THE ELEVATIONS OF THE TWO PONDS WILL BE ABLE TO EQUALIZE.

TOTAL STORAGE OF THE TWO PORTIONS (see next 2 pages)

	STORAGES (ac. ft)		
ELEVATION (ft)	PRIMARY SEDIMENTATION POND	SECONDARY SED. POND	TOTAL
3337	0	0	0
3338	1.47	0.20	1.67
3340	4.71	1.66	6.37
3342	8.25	4.00	12.2
3344	12.3	6.72	19.0
3346	16.8	9.88	26.7
3348	21.9	13.5	35.4
3350	27.4	17.5	44.9
3352	33.4	22.0	55.4
3353	36.6	24.4	61.0

INTERPOLATED TOTAL STORAGES FOR ELEVATIONS:

3346.5 - 28.9
3346.75 - 30.0
3347.0 - 31.0
3347.25 - 32.1
3347.5 - 33.2
3348.5 - 37.8
3349 - 40.2
3351 - 50.2

3341 - 9.28

SUBJECT VEPCO - MT. STORM
STAGE - STORAGE DATA

BY KMB DATE 3/11/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 32 OF 43

TOPO MAP SCALE 1" = 50 FT. 1 in.^{2} = 2500 Ft.^{2}

PRIMARY SEDIMENTATION POND

ELEV.	DIFFERENCE IN ELEV.	AREA		AVERAGE AREA	INTERVAL STORAGE	TOTAL STORAGE	
		IN^2	ACRES	ACRES	AC. FT.	AC. IN.	AC. FT.
3337		24.4	1.40				0
	1			1.47	1.47		
3338		26.8	1.54				1.47
	2			1.62	3.24		
3340		29.4	1.69				4.71
	2			1.77	3.54		
3342		32.2	1.85				8.25
	2			2.01	4.02		
3344		37.6	2.16				12.3
	2			2.29	4.58		
3346		42.1	2.42				16.8
	2			2.53	5.06		
3348		46.0	2.64				21.9
	2			2.75	5.50		
3350		49.9	2.86				27.4
	2			2.97	5.94		
3352		53.6	3.08				33.4
	1			3.17	3.17		
3353		56.6	3.25				36.6

SUBJECT VEPCO - MT. STORM
STAGE- STORAGE DATA

BY KMB DATE 3/11/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 33 OF 43

TOPO MAP SCALE 1" = 50 FT. 1 in.² = 2500 ft.²

SECONDARY SEDIMENTATION POND

ELEV.	DIFFERENCE IN ELEV.	AREA		AVERAGE AREA	INTERVAL STORAGE	TOTAL STORAGE	
		IN²	ACRES	ACRES	AC. FT.	AC. IN.	AC. FT.
3337		0	0				0
	1			0.20	0.20		
3338		6.94	0.40				0.20
	2			0.73	1.46		
3340		18.4	1.06				1.66
	2			1.17	2.34		
3342		22.1	1.27				4.09
	2			1.36	2.72		
3344		25.3	1.45				6.72
	2			1.58	3.16		
3346		29.8	1.71				9.88
	2			1.81	3.62		
3348		33.2	1.91				13.5
	2			2.01	4.02		
3350		36.6	2.10				17.5
	2			2.22	4.44		
3352		40.6	2.33				22.0
	1			2.41	2.41		
3353		43.2	2.48				24.4

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/11/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 34 OF 43

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THUS, THE STAGE - STORAGE - DISCHARGE DATA IS :

STAGE (Ft)	STORAGE (ac. ft)	DISCHARGE (cfs)
3337	0	0
3338	1.67	0
3340	6.37	0
3341	9.28	0
3342	12.2	0
3344	19.0	0
3346	26.7	0
3346.5	28.9	0
3346.75	30.0	1.7
3347	31.0	4.9
3347.25	32.1	9.0
3347.5	33.2	15.0
3348	35.4	24.0
3348.5	37.8	29.0
3349	40.2	89
3350	44.9	209
3351	50.2	435
3352	55.4	740
3353	61.0	1160

✓MRL 3/31/92

Sheet 35 of 43

```
:*>   **********80-80 LIST OF INPUT DATA FOR TR-20 HYDROLOGY******************

)B TR-20                      FULLPRINT          SUMMARY   NOPLOTS
:TLE 111 MOUNT STORM    POND #3  WITH MODIFICATIONS        KMB 3/30/92
5 STRUCT      10
3                      3337.0      0.0         0.0
3                      3338.0      0.001       1.67
3                      3340.0      0.002       6.37
3                      3341.0      0.003       9.28
3                      3342.0      0.004       12.2
3                      3344.0      0.005       19.0
3                      3346.0      0.006       26.7
3                      3346.5      0.007       28.9
3                      3346.75     1.7         30.0
3                      3347.0      4.9         31.0
3                      3347.25     9.0         32.1
3                      3347.5      15.0        33.2
3                      3348.0      24.0        35.4
3                      3348.5      29.0        37.8
3                      3349.0      89.0        40.2
3                      3350.0      209.0       44.9
3                      3351.0      435.0       50.2
3                      3352.0      740.0       55.4
3                      3353.0      1160.0      61.0
9 ENDTBL
5 RUNOFF 1 010       5 0.36        77.         0.5         1
5 RESVOR 2    10 5   6 3341.0                              1 1
  ENDATA
7 [illegible]
7 INCREM 6             0.10
7 COMPUT 7 010      10 0.          2.88        1.          2 2  01  01  2-YR
  ENDCMP 1
7 COMPUT 7 010      10 0.          4.60        1.          2 2  01  03 10-YR
  ENDCMP 1
7 COMPUT 7 010      10 0.          5.75        1.          2 2  02  05 50-YR
  ENDCMP 1
7 COMPUT 7 010      10 0.          4.63        6.          6 2  02  06 100-YR
  ENDCMP 1
  ENDJOB 2

******************************END OF 80-80 LIST********************************
```

```
R2   Q 03-30-92  11:34       MOUNT STORM    POND #3  WITH MODIFICATIONS        KMB 3/30/92                       JOB  1   PASS   1
    REV PC 09/83(.2)                                                                                                  PAGE   1



XECUTIVE CONTROL OPERATION LIST                                                                                 RECORD ID


ISTING OF CURRENT DATA



          STRUCT NO.     ELEVATION  DISCHARGE     STORAGE
 STRUCT       10

                          3337.00        .00         .00
                          3338.00        .00        1.67
                          3340.00        .00        6.37
                          3341.00        .00        9.28
                          3342.00        .00       12.20
                          3344.00        .00       19.00
                          3346.00        .01       26.70
                          3346.50        .01       28.90
                          3346.75       1.70       30.00
                          3347.00       4.90       31.00
                          3347.25       9.00       32.10
                          3347.50      15.00       33.20
                          3348.00      24.00       35.40
                          3348.50      29.00       37.80
                          3349.00      89.00       40.20
                          3350.00     209.00       44.90
                          3351.00     435.00       50.20
                          3352.00     740.00       55.40
                          3353.00    1160.00       61.00
 ENDTBL

                     TIME INCREMENT
 DIMHYD                        .0200

                .0000      .0300      .1000      .1900      .3100
                .4700      .6600      .8200      .9300      .9900
               1.0000      .9900      .9300      .8600      .7800
                .6800      .5600      .4600      .3900      .3300
                .2800      .2410      .2070      .1740      .1470
                .1260      .1070      .0910      .0770      .0660
                .0550      .0470      .0400      .0340      .0290
                .0250      .0210      .0180      .0150      .0130
                .0110      .0090      .0080      .0070      .0060
                .0050      .0040      .0030      .0020      .0010
                .0000      .0000      .0000      .0000      .0000
```

SCS
Dimensionless
Hydrograph

sheet 37 of 43

```
20    03-30-92  11:34       MOUNT STORM    POND #3  WITH MODIFICATIONS       KMB 3/30/92                 JOB  1   PASS   1
   REV PC 09/83(.2)                                                                                            PAGE   2


ENDTBL

COMPUTED PEAK RATE FACTOR =  484.00


   TABLE NO.       TIME INCREMENT
RAINFL 1                    .5000

               .0000        .0080        .0170        .0260        .0350
               .0450        .0550        .0650        .0760        .0870
               .0990        .1120        .1260        .1400        .1560
               .1740        .1940        .2190        .2540        .3030
               .5150        .5830        .6240        .6550        .6820
               .7060        .7280        .7480        .7660        .7830
               .7990        .8150        .8300        .8440        .8570
               .8700        .8820        .8930        .9050        .9160
               .9260        .9360        .9460        .9560        .9650
               .9740        .9830        .9920       1.0000       1.0000
ENDTBL

   TABLE NO.       TIME INCREMENT
RAINFL 2                    .2500
```

24-hour Type II storm distribution

```
               .0000        .0020        .0050        .0080        .0110
               .0140        .0170        .0200        .0230        .0260
               .0290        .0320        .0350        .0380        .0410
               .0440        .0480        .0520        .0560        .0600
               .0640        .0680        .0720        .0760        .0800
               .0850        .0900        .0950        .1000        .1050
               .1100        .1150        .1200        .1260        .1330
               .1400        .1470        .1550        .1630        .1720
               .1810        .1910        .2030        .2180        .2360
               .2570        .2830        .3870        .6630        .7070
               .7350        .7580        .7760        .7910        .8040
               .8150        .8250        .8340        .8420        .8490
               .8560        .8630        .8690        .8750        .8810
               .8870        .8930        .8980        .9030        .9080
               .9130        .9180        .9220        .9260        .9300
               .9340        .9380        .9420        .9460        .9500
               .9530        .9560        .9590        .9620        .9650
               .9680        .9710        .9740        .9770        .9800
               .9830        .9860        .9890        .9920        .9950
               .9980       1.0000       1.0000       1.0000       1.0000
ENDTBL
```

```
                .0290       .0320       .0350       .0380       .0410
                .0440       .0470       .0510       .0550       .0590
                .0630       .0670       .0710       .0750       .0790
                .0840       .0890       .0940       .0990       .1040
                .1090       .1140       .1200       .1260       .1330
                .1400       .1470       .1540       .1620       .1710
                .1810       .1920       .2040       .2170       .2330
                .2520       .2770       .3180       .6380       .6980
                .7290       .7520       .7700       .7850       .7980
                .8090       .8190       .8290       .8380       .8460
                .8540       .8610       .8680       .8740       .8800
                .8860       .8920       .8970       .9020       .9070
                .9120       .9170       .9210       .9250       .9290
                .9330       .9370       .9410       .9450       .9490
                .9530       .9570       .9600       .9630       .9660
                .9690       .9720       .9750       .9780       .9810
                .9840       .9870       .9900       .9930       .9960
                .9980      1.0000      1.0000      1.0000      1.0000
ENDTBL

   TABLE NO.       TIME INCREMENT
RAINFL 6                    .0200
```

6-hour emergency spillway and freeboard hydrograph

```
                .0000       .0080       .0162       .0246       .0333
                .0425       .0524       .0630       .0743       .0863
                .0990       .1124       .1265       .1420       .1595
                .1800       .2050       .2550       .3450       .4370
                .5300       .6030       .6330       .6600       .6840
                .7050       .7240       .7420       .7590       .7750
                .7900       .8043       .8180       .8312       .8439
                .8561       .8678       .8790       .8898       .9002
                .9103       .9201       .9297       .9391       .9483
                .9573       .9661       .9747       .9832       .9916
               1.0000      1.0000      1.0000      1.0000      1.0000
ENDTBL
```

sheet 39 of 43

```
R2    Q 03-30-92  11:34       MOUNT STORM    POND #3  WITH MODIFICATIONS       KMB 3/30/92                   JOB  1   SUMMARY
  REV PC 09/83(.2)                                                                                                  PAGE  14


UMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
               (A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
                A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

ECTION/    STANDARD                RAIN   ANTEC  MAIN          PRECIPITATION                            PEAK DISCHARGE
TRUCTURE    CONTROL    DRAINAGE   TABLE   MOIST  TIME   -------------------------   RUNOFF   ------------------------------------
   ID      OPERATION     AREA       #     COND  INCREM  BEGIN    AMOUNT  DURATION   AMOUNT   ELEVATION   TIME       RATE       RATE
                       (SQ MI)                   (HR)   (HR)     (IN)     (HR)      (IN)       (FT)      (HR)      (CFS)      (CSM)


  ALTERNATE     1    STORM     1
SECTION  10  RUNOFF       .36       2      2     .10      .0      2.88     24.00      .99        ---      12.21     181.82      505.0
TRUCTURE 10  RESVOR       .36       2      2     .10      .0      2.88     24.00      .00      3346.35    25.40?       .01?       .0

  ALTERNATE     1    STORM     3
SECTION  10  RUNOFF       .36       2      2     .10      .0      4.60     24.00     2.29        ---      12.20     439.95     1222.1
TRUCTURE 10  RESVOR       .36       2      2     .10      .0      4.60     24.00     1.20      3348.42    14.63      28.17       78.3

  ALTERNATE     2    STORM     5
SECTION  10  RUNOFF       .36       2      2     .10      .0      5.75     24.00     3.26        ---      12.20     628.16     1744.9
TRUCTURE 10  RESVOR       .36       2      2     .10      .0      5.75     24.00     2.16      3349.43    12.88     141.01      391.7

    ERNATE      2    STORM     6
S     N  10  RUNOFF       .36       6      2     .10      .0      4.63      6.00     2.31        ---       2.67     352.78      979.9
TRUCTURE 10  RESVOR       .36       6      2     .10      .0      4.63      6.00     1.28      3348.88     4.98      75.04      208.4
```

2 yr storm < 3346.5 ok

10 yr storm < 3348.5 ok

50 yr 3349.43 + 2 = 3351.43 < 3353 ok

100 yr 3348.88 + 1 = 3349.88 < 3353 ok

SUBJECT VEPCO – MOUNT STORM

BY KMB DATE 3/11/92 PROJ. NO. 88-108-51

CHKD. BY MRL DATE 3/31/92 SHEET NO. 40 OF 43

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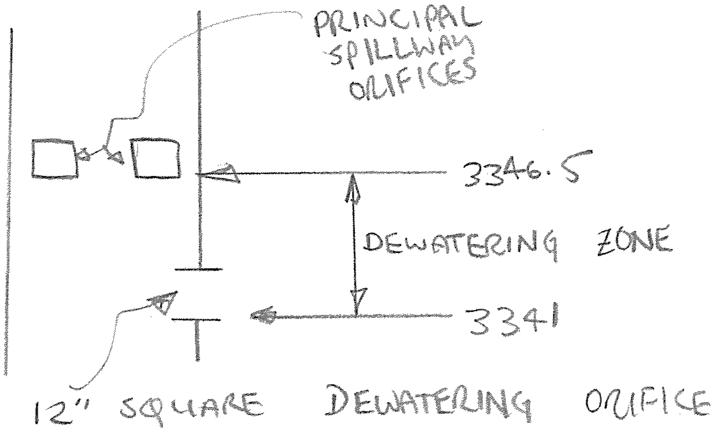
DEWATERING

DETERMINE THE DEWATERING TIME FROM THE CREST OF THE PRINCIPAL SPILLWAY TO THE CREST OF THE DEWATERING ORIFICE. THIS IS THE VOLUME REQUIRED TO STORE THE 2-YR 24-HR STORM. THE CONFIGURATION OF THE SYSTEM IS :



ORIFICE FLOW WILL BE ANALYZED BETWEEN ELEVATIONS 3346.5 AND 3342. WEIR FLOW WILL BE ANALYZED THROUGHOUT THE ACTUAL ORIFICE.

THE EQUATIONS FOR THESE FLOW TYPES WERE DETERMINED PREVIOUSLY:

WEIR FLOW : $Q = CLH^{3/2}$ (L=1). USE AN AVERAGE VALUE OF "C" FOR A SPAN OF 1' OF HEAD:

HEAD (FT)	0.2	0.4	0.6	0.8	1.0	avg.
C	2.69	2.72	2.75	2.85	2.98	2.80

∴ $Q = 2.80\ H^{3/2}$ "H" TAKEN TO 3341

ORIFICE FLOW : $Q = 4.81\sqrt{H}$
"H" TAKEN TO 3341.5

SUBJECT VEPCO - MOUNT STORM

BY KMB DATE 3/11/92 PROJ. NO. 88-108-51
CHKD. BY MRL DATE 3/31/92 SHEET NO. 41 OF 43

DEWATERING

ELEVATION (FT)	HEAD (FT)	STOR. (ac.ft)	DIFF STOR (ac.ft)	Q (cfs)	AVG. Q (cfs)	INC. TIME (hrs)	CUM. TIME (hrs)
3346.5	5.0†	28.9		10.8			0
			2.2		10.5	2.5	
3346	4.5†	26.7		10.2			2.5
			3.9		9.6	4.9	
3345	3.5†	22.8**		9.0			7.4
			3.8		8.3	5.5	
3344	2.5†	19.0		7.6			12.9
			3.4		6.75	6.1	
3343	1.5†	15.6**		5.9			19.0
			3.4		4.35	9.4	
3342	1.0*	12.2		2.80			28.4
			2.9		1.4	25.1	
3341	0*	9.28		0			53.5

† ORIFICE FLOW
* WEIR FLOW
** INTERPOLATED

WITH THE SLUICE GATE ON THE DEWATERING ORIFICE OPEN ALL THE WAY, THE 2 YEAR STORM VOLUME CAN DEWATER IN 2.2 DAYS.

REQUIRED DEWATERING TIME IS BETWEEN 1 AND 8 DAYS (REFERENCE 4)

SUBJECT VEPCO – MOUNT STORM

BY MRL DATE 3/27/92 PROJ. NO. 88-108-51

CHKD. BY KMB DATE 3/31/92 SHEET NO. 42 OF 43

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REQUIREMENT SUMMARY

SEDIMENT STORAGE

- Required sediment storage = 5 acre-feet (see sheet 11)

Sediment can be stored up to elevation 3341 in both the primary and secondary sedimentation ponds. In the primary pond alone, 6.48 acre-feet of sediment (interpolated value) can be stored. Thus, sediment storage is adequate. (See sheet 31)

PRINCIPAL SPILLWAY

- Storage between the sediment storage elevation and the principal spillway crest must be adequate to contain the 2-year 24-hour storm runoff volume.

Required runoff volume = 19 acre-feet (see sheet 11)

Available storage volume = 19.62 acre-feet

$$\left[\begin{array}{ll} 28.9 \text{ Ac.-Ft.} & @\ 3346.5 \\ -\ \underline{9.28 \text{ Ac-Ft}} & @\ 3341.0 \\ 19.62 \text{ Ac. Ft.} & \end{array}\right]$$ (see sheet 34)

Also, when routing the 2-year storm through the ponds using TR-20, maximum water surface elevation = 3346.35, which is less than the principal spillway crest of 3346.5. (see sheet 39)

- The principal spillway can dewater the 2-year 24-hour storm runoff volume in 2.2 days. (see sheet 41) The required dewatering time is between 1 and 8 days.

SUBJECT VEPCO - MOUNT STORM

BY MRL DATE 3/27/92 PROJ. NO. 88-108-51

CHKD. BY KMB DATE 3/31/92 SHEET NO. 43 OF 43

EMERGENCY SPILLWAY

- The emergency spillway is not to flow during a 10-year 24-hour storm. (Reference 3)

When the 10-year storm is routed through the pond using TR-20, maximum water surface elevation = 3348.4 (see sheet 39) Since the emergency spillway crest is at elevation 3348.5, no flow occurs.

- The emergency spillway shall be a minimum of 1.5 feet above the principal spillway crest. (Reference 4). The proposed design calls for a 2 foot difference. (3348.5 - 3346.5)

- The 50-year, 24-hour storm shall pass through the emergency spillway with 2 feet of freeboard. (Reference 3).

When the 50-year storm is routed through the pond, the maximum water surface elevation = 3349.4. (see sheet 39). Available Freeboard = 3.6 feet. (3353 - 3349.4)

- The 100-year, 6-hour storm shall pass through the emergency spillway with 1 foot of freeboard. (Reference 4)

When the 100-year, 6-hour storm is routed through the pond, the maximum water surface elevation = 3348.9. (see sheet 39) Available Freeboard = 4.1 feet. (3353 - 3348.9)

```
*     ************80-80 LIST OF INPUT DATA FOR TR-20 HYDROLOGY*****************

JOB TR-20                     FULLPRINT          SUMMARY   NOPLOTS
TITLE 111 MOUNT STORM    POND #3  WITH MODIFICATIONS        KMB 3/30/92
 3 STRUCT      10
 8                      3337.0      0.0         0.0
 8                      3338.0      0.001       1.67
 8                      3340.0      0.002       6.37
 8                      3341.0      0.003       9.28
 8                      3342.0      0.004       12.2
 8                      3344.0      0.005       19.0
 8                      3346.0      0.006       26.7
 8                      3346.5      0.007       28.9
 8                      3346.75     1.7         30.0
 8                      3347.0      4.9         31.0
 8                      3347.25     9.0         32.1
 8                      3347.5      15.0        33.2
 8                      3348.0      24.0        35.4
 8                      3348.5      29.0        37.8
 8                      3349.0      89.0        40.2
 8                      3350.0      209.0       44.9
 8                      3351.0      435.0       50.2
 8                      3352.0      740.0       55.4
 8                      3353.0      1160.0      61.0
 9 ENDTBL
 6 RUNOFF 1 010       5 0.36        77.         0.5         1
 6 RESVOR 2    10 5   6 3341.0                              1 1
   ENDATA
 7    T
 7    REM 6             0.10
 7 COMPUT 7 010      10 0.          2.88        1.          2 2  01  01  2-YR
   ENDCMP 1
 7 COMPUT 7 010      10 0.          4.60        1.          2 2  01  03 10-YR
   ENDCMP 1
 7 COMPUT 7 010      10 0.          5.75        1.          2 2  02  05 50-YR
   ENDCMP 1
 7 COMPUT 7 010      10 0.          4.63        6.          6 2  02  06 100-YR
   ENDCMP 1
   ENDJOB 2

******************************END OF 80-80 LIST********************************
```

```
TR   EQ 03-30-92  11:34       MOUNT STORM    POND #3  WITH MODIFICATIONS        KMB 3/30/92                    JOB  1   PASS   1
     REV PC 09/83(.2)                                                                                                   PAGE   1



EXECUTIVE CONTROL OPERATION LIST                                                                               RECORD ID


LISTING OF CURRENT DATA



           STRUCT NO.     ELEVATION   DISCHARGE     STORAGE
3 STRUCT      10

8                          3337.00          .00         .00
8                          3338.00          .00        1.67
8                          3340.00          .00        6.37
8                          3341.00          .00        9.28
8                          3342.00          .00       12.20
8                          3344.00          .00       19.00
8                          3346.00          .01       26.70
8                          3346.50          .01       28.90
8                          3346.75         1.70       30.00
8                          3347.00         4.90       31.00
8                          3347.25         9.00       32.10
8                          3347.50        15.00       33.20
8                          3348.00        24.00       35.40
8                          3348.50        29.00       37.80
8                          3349.00        89.00       40.20
8                          3350.00       209.00       44.90
8                          3351.00       435.00       50.20
8                          3352.00       740.00       55.40
8                          3353.00      1160.00       61.00
9 ENDTBL

                      TIME INCREMENT
4 DIMHYD                       .0200

8                  .0000        .0300        .1000        .1900        .3100
8                  .4700        .6600        .8200        .9300        .9900
8                 1.0000        .9900        .9300        .8600        .7800
8                  .6800        .5600        .4600        .3900        .3300
8                  .2800        .2410        .2070        .1740        .1470
8                  .1260        .1070        .0910        .0770        .0660
8                  .0550        .0470        .0400        .0340        .0290
8                  .0250        .0210        .0180        .0150        .0130
8                  .0110        .0090        .0080        .0070        .0060
8                  .0050        .0040        .0030        .0020        .0010
8                  .0000        .0000        .0000        .0000        .0000
```

```
9 ENDTBL

  COMPUTED PEAK RATE FACTOR =  484.00


     TABLE NO.       TIME INCREMENT
5 RAINFL 1                    .5000

8                 .0000       .0080       .0170       .0260       .0350
8                 .0450       .0550       .0650       .0760       .0870
8                 .0990       .1120       .1260       .1400       .1560
8                 .1740       .1940       .2190       .2540       .3030
8                 .5150       .5830       .6240       .6550       .6820
8                 .7060       .7280       .7480       .7660       .7830
8                 .7990       .8150       .8300       .8440       .8570
8                 .8700       .8820       .8930       .9050       .9160
8                 .9260       .9360       .9460       .9560       .9650
8                 .9740       .9830       .9920      1.0000      1.0000
9 ENDTBL

     TABLE NO.       TIME INCREMENT
5 RAINFL 2                    .2500

8                 .0000       .0020       .0050       .0080       .0110
8                 .0140       .0170       .0200       .0230       .0260
8                 .0290       .0320       .0350       .0380       .0410
8                 .0440       .0480       .0520       .0560       .0600
8                 .0640       .0680       .0720       .0760       .0800
8                 .0850       .0900       .0950       .1000       .1050
8                 .1100       .1150       .1200       .1260       .1330
8                 .1400       .1470       .1550       .1630       .1720
8                 .1810       .1910       .2030       .2180       .2360
8                 .2570       .2830       .3870       .6630       .7070
8                 .7350       .7580       .7760       .7910       .8040
8                 .8150       .8250       .8340       .8420       .8490
8                 .8560       .8630       .8690       .8750       .8810
8                 .8870       .8930       .8980       .9030       .9080
8                 .9130       .9180       .9220       .9260       .9300
8                 .9340       .9380       .9420       .9460       .9500
8                 .9530       .9560       .9590       .9620       .9650
8                 .9680       .9710       .9740       .9770       .9800
8                 .9830       .9860       .9890       .9920       .9950
8                 .9980      1.0000      1.0000      1.0000      1.0000
9 ENDTBL
```

```
    TABLE NO.       TIME INCREMENT
5 RAINFL 3                   .5000

8                .0000        .0100        .0220        .0360        .0510
8                .0670        .0830        .0990        .1160        .1350
8                .1560        .1790        .2040        .2330        .2680
8                .3100        .4250        .4800        .5200        .5500
8                .5770        .6010        .6230        .6440        .6640
8                .6830        .7010        .7190        .7360        .7530
8                .7690        .7850        .8000        .8150        .8300
8                .8440        .8580        .8710        .8840        .8960
8                .9080        .9200        .9320        .9440        .9560
8                .9670        .9780        .9890       1.0000       1.0000
9 ENDTBL

    TABLE NO.       TIME INCREMENT
5 RAINFL 4                   .5000

8                .0000        .0040        .0080        .0120        .0160
8                .0200        .0250        .0300        .0350        .0400
8                .0450        .0500        .0550        .0600        .0650
8                .0700        .0750        .0810        .0870        .0930
8                .0990        .1050        .1110        .1180        .1250
8                .1320        .1400        .1480        .1560        .1650
8                .1740        .1840        .1950        .2070        .2200
8                .2360        .2550        .2770        .3030        .4090
8                .5150        .5490        .5830        .6050        .6240
8                .6400        .6550        .6690        .6820        .6940
8                .7050        .7160        .7270        .7380        .7480
8                .7580        .7670        .7760        .7840        .7920
8                .8000        .8080        .8160        .8230        .8300
8                .8370        .8440        .8510        .8580        .8640
8                .8700        .8760        .8820        .8880        .8940
8                .9000        .9060        .9110        .9160        .9210
8                .9260        .9310        .9360        .9410        .9460
8                .9510        .9560        .9610        .9660        .9710
8                .9760        .9800        .9840        .9880        .9920
8                .9960       1.0000       1.0000       1.0000       1.0000
9 ENDTBL

    TABLE NO.       TIME INCREMENT
5 RAINFL 5                   .5000

8                .0000        .0020        .0050        .0080        .0110
8                .0140        .0170        .0200        .0230        .0260
```

```
8               .0290      .0320      .0350      .0380      .0410
8               .0440      .0470      .0510      .0550      .0590
8               .0630      .0670      .0710      .0750      .0790
8               .0840      .0890      .0940      .0990      .1040
8               .1090      .1140      .1200      .1260      .1330
8               .1400      .1470      .1540      .1620      .1710
8               .1810      .1920      .2040      .2170      .2330
8               .2520      .2770      .3180      .6380      .6980
8               .7290      .7520      .7700      .7850      .7980
8               .8090      .8190      .8290      .8380      .8460
8               .8540      .8610      .8680      .8740      .8800
8               .8860      .8920      .8970      .9020      .9070
8               .9120      .9170      .9210      .9250      .9290
8               .9330      .9370      .9410      .9450      .9490
8               .9530      .9570      .9600      .9630      .9660
8               .9690      .9720      .9750      .9780      .9810
8               .9840      .9870      .9900      .9930      .9960
8               .9980     1.0000     1.0000     1.0000     1.0000
9 ENDTBL

    TABLE NO.       TIME INCREMENT
5 RAINFL 6                   .0200

8               .0000      .0080      .0162      .0246      .0333
8               .0425      .0524      .0630      .0743      .0863
8               .0990      .1124      .1265      .1420      .1595
8               .1800      .2050      .2550      .3450      .4370
8               .5300      .6030      .6330      .6600      .6840
8               .7050      .7240      .7420      .7590      .7750
8               .7900      .8043      .8180      .8312      .8439
8               .8561      .8678      .8790      .8898      .9002
8               .9103      .9201      .9297      .9391      .9483
8               .9573      .9661      .9747      .9832      .9916
8              1.0000     1.0000     1.0000     1.0000     1.0000
9 ENDTBL
```

```
                    STANDARD CONTROL INSTRUCTIONS



6 RUNOFF 1  10       5         .3600     77.0000       .50001 0 0 1 0 1
6 RESVOR 2    10 5   6    3341.0000                         1 1 0 1 0 1
  ENDATA


END OF LISTING
```

```
EXECUTIVE CONTROL OPERATION INCREM     MAIN TIME INCREMENT =   .10 HOURS                                    RECORD ID


EXECUTIVE CONTROL OPERATION COMPUT     FROM XSECTION  10  TO STRUCTURE 10                                   RECORD ID  2-YR
       STARTING TIME =   .00    RAIN DEPTH =  2.88    RAIN DURATION=  1.00    RAIN TABLE NO.= 2    ANT. MOIST. COND= 2
       ALTERNATE NO.= 1         STORM NO.= 1    MAIN TIME INCREMENT =   .10 HOURS


OPERATION RUNOFF   CROSS SECTION  10
          OUTPUT HYDROGRAPH=  5
          AREA=    .36 SQ MI   INPUT RUNOFF CURVE= 77.    TIME OF CONCENTRATION=   .50 HOURS
          INTERNAL HYDROGRAPH TIME INCREMENT=  .0667 HOURS

          PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
             12.21                        181.82                       (RUNOFF)
             16.46                         10.17                       (RUNOFF)
             17.66                          8.63                       (RUNOFF)
             19.68                          7.03                       (RUNOFF)
             23.67                          5.43                       (RUNOFF)

  RUNOFF VOLUME ABOVE BASEFLOW =   .99 WATERSHED INCHES,    229.51 CFS-HRS,    18.97 ACRE-FEET;   BASEFLOW =    .00 CFS


OP    ION RESVOR   STRUCTURE 10
          INPUT HYDROGRAPH= 5     OUTPUT HYDROGRAPH= 6
          SURFACE ELEVATION= 3341.00

*** WARNING-NO PEAK FOUND, MAXIMUM DISCHARGE =         .01 CFS.

          PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
             25.40                          .01                      3346.35

TIME(HRS)         FIRST HYDROGRAPH POINT =   .00 HOURS      TIME INCREMENT =  .10 HOURS      DRAINAGE AREA =    .36 SQ.MI.
  13.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  14.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  15.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  16.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  17.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  18.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  19.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  20.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  21.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  22.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  23.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  24.00     DISCHG         .01        .01        .01        .01        .01        .01        .01        .01        .01        .01
  25.00     DISCHG         .01        .01        .01        .01        .01        .01        .01

  RUNOFF VOLUME ABOVE BASEFLOW =   .00 WATERSHED INCHES,      .08 CFS-HRS,      .01 ACRE-FEET;   BASEFLOW =    .00 CFS
```

```
EXECUTIVE CONTROL OPERATION ENDCMP     COMPUTATIONS COMPLETED FOR PASS   1                                  RECORD ID
```

```
EXECUTIVE CONTROL OPERATION COMPUT     FROM XSECTION  10  TO STRUCTURE 10                             RECORD ID 10-YR
        STARTING TIME =   .00    RAIN DEPTH =  4.60    RAIN DURATION=  1.00    RAIN TABLE NO.= 2    ANT. MOIST. COND= 2
        ALTERNATE NO.= 1         STORM NO.= 3    MAIN TIME INCREMENT =   .10 HOURS


OPERATION RUNOFF   CROSS SECTION  10
           OUTPUT HYDROGRAPH=  5
           AREA=    .36 SQ MI   INPUT RUNOFF CURVE= 77.    TIME OF CONCENTRATION=   .50 HOURS
           INTERNAL HYDROGRAPH TIME INCREMENT=  .0667 HOURS

           PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
              12.20                         439.95                      (RUNOFF)
              19.67                          13.72                      (RUNOFF)
              23.66                          10.45                      (RUNOFF)

  RUNOFF VOLUME ABOVE BASEFLOW =  2.29 WATERSHED INCHES,    532.05 CFS-HRS,    43.97 ACRE-FEET;   BASEFLOW =    .00 CFS


OPERATION RESVOR   STRUCTURE 10
           INPUT HYDROGRAPH= 5     OUTPUT HYDROGRAPH= 6
           SURFACE ELEVATION= 3341.00

           PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
              14.63                          28.17                     3348.42

TIME(HRS)          FIRST HYDROGRAPH POINT =    .00 HOURS      TIME INCREMENT =  .10 HOURS      DRAINAGE AREA =    .36 SQ.MI.
  12.00     DISCHG         .00       .00       .01       .01       .01      1.22      6.13     11.54     16.26     19.26
  13.00     DISCHG       21.66     23.60     24.60     25.27     25.83     26.29     26.68     27.01     27.28     27.51
  14.00     DISCHG       27.69     27.84     27.96     28.05     28.11     28.16     28.17     28.17     28.14     28.10
  15.00     DISCHG       28.04     27.97     27.90     27.82     27.75     27.66     27.57     27.46     27.35     27.23
  16.00     DISCHG       27.12     27.00     26.88     26.77     26.65     26.54     26.43     26.32     26.20     26.07
  17.00     DISCHG       25.93     25.79     25.64     25.50     25.35     25.21     25.07     24.93     24.80     24.66
  18.00     DISCHG       24.52     24.37     24.21     24.04     23.75     23.43     23.11     22.80     22.50     22.20
  19.00     DISCHG       21.92     21.65     21.38     21.13     20.88     20.64     20.41     20.19     19.97     19.76
  20.00     DISCHG       19.54     19.30     19.05     18.79     18.53     18.26     18.01     17.76     17.51     17.27
  21.00     DISCHG       17.05     16.82     16.61     16.40     16.20     16.01     15.82     15.64     15.46     15.29
  22.00     DISCHG       15.13     14.96     14.76     14.57     14.39     14.21     14.04     13.88     13.73     13.58
  23.00     DISCHG       13.44     13.31     13.18     13.06     12.95     12.84     12.73     12.63     12.53     12.43
  24.00     DISCHG       12.32     12.17     11.98     11.72     11.38     11.00     10.58     10.16      9.74      9.33
  25.00     DISCHG        8.95      8.68      8.42      8.17      7.92      7.68      7.44      7.22      7.00      6.79
  26.00     DISCHG        6.58      6.38      6.19      6.00      5.82      5.64      5.47      5.31      5.14      4.99
  27.00     DISCHG        4.85      4.72      4.60      4.48      4.36      4.25      4.13      4.03      3.92      3.82
  28.00     DISCHG        3.72      3.62      3.53      3.44      3.35      3.26      3.17      3.09      3.01      2.93
  29.00     DISCHG        2.86      2.78      2.71      2.64      2.57      2.50      2.44      2.37      2.31      2.25

  RUNOFF VOLUME ABOVE BASEFLOW =  1.20 WATERSHED INCHES,    279.32 CFS-HRS,    23.08 ACRE-FEET;   BASEFLOW =    .00 CFS


EXECUTIVE CONTROL OPERATION ENDCMP     COMPUTATIONS COMPLETED FOR PASS   2                            RECORD ID
```

```
EXECUTIVE CONTROL OPERATION COMPUT     FROM XSECTION  10  TO STRUCTURE 10                              RECORD ID 50-YR
        STARTING TIME =   .00    RAIN DEPTH =  5.75    RAIN DURATION=  1.00    RAIN TABLE NO.= 2    ANT. MOIST. COND= 2
        ALTERNATE NO.= 2         STORM NO.= 5    MAIN TIME INCREMENT =   .10 HOURS


OPERATION RUNOFF   CROSS SECTION  10
           OUTPUT HYDROGRAPH=  5
           AREA=    .36 SQ MI   INPUT RUNOFF CURVE= 77.    TIME OF CONCENTRATION=   .50 HOURS
           INTERNAL HYDROGRAPH TIME INCREMENT=  .0667 HOURS

           PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
              12.20                         628.16                       (RUNOFF)
              19.66                          18.24                       (RUNOFF)
              23.66                          13.84                       (RUNOFF)

  RUNOFF VOLUME ABOVE BASEFLOW =  3.26 WATERSHED INCHES,    757.14 CFS-HRS,    62.57 ACRE-FEET;   BASEFLOW =    .00 CFS


OPERATION RESVOR   STRUCTURE 10
           INPUT HYDROGRAPH= 5     OUTPUT HYDROGRAPH= 6
           SURFACE ELEVATION= 3341.00

           PEAK TIME(HRS)             PEAK DISCHARGE(CFS)          PEAK ELEVATION(FEET)
              12.88                         141.01                      3349.43

TIME(HRS)         FIRST HYDROGRAPH POINT =    .00 HOURS      TIME INCREMENT =  .10 HOURS      DRAINAGE AREA =    .36 SQ.MI.
  12.00     DISCHG        .01        .01        .01      12.86      26.73      69.62     109.96     130.88     139.60     140.93
  13.00     DISCHG     137.94     132.44     125.59     118.14     110.57     103.17      96.14      89.61      83.69      78.24
  14.00     DISCHG      73.25      68.72      64.62      60.90      57.53      54.44      51.60      48.96      46.49      44.20
  15.00     DISCHG      42.12      40.28      38.69      37.35      36.19      35.13      34.09      33.08      32.12      31.25
  16.00     DISCHG      30.50      29.86      29.33      28.99      28.95      28.92      28.88      28.84      28.79      28.72
  17.00     DISCHG      28.64      28.55      28.46      28.36      28.27      28.17      28.08      27.99      27.89      27.80
  18.00     DISCHG      27.70      27.58      27.45      27.31      27.17      27.02      26.88      26.73      26.58      26.44
  19.00     DISCHG      26.30      26.16      26.03      25.89      25.76      25.63      25.51      25.38      25.26      25.14
  20.00     DISCHG      25.00      24.86      24.70      24.54      24.36      24.19      24.01      23.69      23.36      23.04
  21.00     DISCHG      22.74      22.44      22.15      21.87      21.60      21.34      21.09      20.84      20.61      20.38
  22.00     DISCHG      20.16      19.95      19.74      19.54      19.35      19.17      18.99      18.82      18.65      18.49
  23.00     DISCHG      18.33      18.18      18.04      17.90      17.76      17.63      17.51      17.38      17.26      17.14
  24.00     DISCHG      17.01      16.84      16.62      16.33      15.97      15.56      15.11      14.54      13.93      13.34
  25.00     DISCHG      12.76      12.21      11.67      11.16      10.67      10.20       9.75       9.32       8.94       8.67
  26.00     DISCHG       8.40       8.15       7.90       7.66       7.43       7.20       6.99       6.77       6.57       6.37
  27.00     DISCHG       6.18       5.99       5.81       5.63       5.46       5.29       5.13       4.98       4.84       4.71
  28.00     DISCHG       4.59       4.47       4.35       4.24       4.13       4.02       3.91       3.81       3.71       3.62
  29.00     DISCHG       3.52       3.43       3.34       3.25       3.17       3.09       3.00       2.93       2.85       2.78

  RUNOFF VOLUME ABOVE BASEFLOW =  2.16 WATERSHED INCHES,    502.74 CFS-HRS,    41.55 ACRE-FEET;   BASEFLOW =    .00 CFS


EXECUTIVE CONTROL OPERATION ENDCMP     COMPUTATIONS COMPLETED FOR PASS   3                             RECORD ID
```

```
EXECUTIVE CONTROL OPERATION COMPUT     FROM XSECTION  10  TO STRUCTURE 10                                 RECORD ID 100-YR
        STARTING TIME =   .00    RAIN DEPTH =  4.63    RAIN DURATION=  6.00    RAIN TABLE NO.= 6    ANT. MOIST. COND= 2
        ALTERNATE NO.= 2         STORM NO.= 6    MAIN TIME INCREMENT =   .10 HOURS


OPERATION RUNOFF   CROSS SECTION  10
           OUTPUT HYDROGRAPH=  5
           AREA=    .36 SQ MI   INPUT RUNOFF CURVE= 77.    TIME OF CONCENTRATION=   .50 HOURS
           INTERNAL HYDROGRAPH TIME INCREMENT=  .0667 HOURS

           PEAK TIME(HRS)             PEAK DISCHARGE(CFS)           PEAK ELEVATION(FEET)
               2.67                         352.78                        (RUNOFF)

  RUNOFF VOLUME ABOVE BASEFLOW =  2.31 WATERSHED INCHES,    537.76 CFS-HRS,    44.44 ACRE-FEET;   BASEFLOW =    .00 CFS


OPERATION RESVOR   STRUCTURE 10
           INPUT HYDROGRAPH= 5     OUTPUT HYDROGRAPH= 6
           SURFACE ELEVATION= 3341.00

           PEAK TIME(HRS)             PEAK DISCHARGE(CFS)           PEAK ELEVATION(FEET)
               4.98                          75.04                       3348.88

T    IRS)          FIRST HYDROGRAPH POINT =    .00 HOURS      TIME INCREMENT =  .10 HOURS      DRAINAGE AREA =    .36 SQ.MI.
   2.00     DISCHG          .00         .00         .00         .00         .00         .00         .00         .01         .01         .01
   3.00     DISCHG          .01         .13        3.29        7.91       13.59       18.00       21.62       24.45       25.96       27.35
   4.00     DISCHG        28.64       38.22       48.97       57.16       63.30       67.78       70.94       73.04       74.30       74.91
   5.00     DISCHG        75.03       74.79       74.28       73.61       72.82       71.96       71.05       70.11       69.15       68.20
   6.00     DISCHG        67.27       66.18       64.29       60.76       55.40       48.87       42.05       35.60       29.80       28.61
   7.00     DISCHG        28.15       27.69       27.23       26.77       26.31       25.87       25.42       24.99       24.56       24.14
   8.00     DISCHG        23.48       22.70       21.94       21.21       20.51       19.83       19.17       18.53       17.91       17.32
   9.00     DISCHG        16.74       16.19       15.65       15.13       14.50       13.86       13.25       12.67       12.11       11.58
  10.00     DISCHG        11.07       10.58       10.11        9.67        9.24        8.88        8.61        8.35        8.10        7.85
  11.00     DISCHG         7.62        7.38        7.16        6.94        6.73        6.53        6.33        6.14        5.95        5.77
  12.00     DISCHG         5.60        5.43        5.26        5.10        4.95        4.81        4.69        4.56        4.45        4.33
  13.00     DISCHG         4.22        4.11        4.00        3.89        3.79        3.69        3.60        3.50        3.41        3.32
  14.00     DISCHG         3.24        3.15        3.07        2.99        2.91        2.84        2.76        2.69        2.62        2.55
  15.00     DISCHG         2.48        2.42        2.36        2.29        2.23        2.18        2.12        2.06        2.01        1.96
  16.00     DISCHG         1.91        1.86        1.81        1.76        1.72        1.69        1.66        1.64        1.62        1.60
  17.00     DISCHG         1.58        1.56        1.54        1.52        1.50        1.48        1.47        1.45        1.43        1.41
  18.00     DISCHG         1.39        1.38        1.36        1.34        1.32        1.31        1.29        1.27        1.26        1.24
  19.00     DISCHG         1.23        1.21        1.20        1.18        1.17        1.15        1.14        1.12        1.11        1.09
  20.00     DISCHG         1.08        1.07        1.05        1.04        1.03        1.01        1.00         .99         .98         .96
  21.00     DISCHG          .95         .94         .93         .92         .90         .89         .88         .87         .86         .85
  22.00     DISCHG          .84         .83         .82         .81         .80         .79         .78         .77         .76         .75
  23.00     DISCHG          .74         .73         .72         .71         .70         .69         .68         .67         .67         .66
  24.00     DISCHG          .65         .64         .63         .63         .62         .61         .60         .59         .59         .58
  25.00     DISCHG          .57         .56         .56         .55         .54         .54         .53         .52         .52         .51
  26.00     DISCHG          .50         .50         .49         .48         .48         .47         .47         .46         .45         .45
```

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  27.00    DISCHG         .44       .44       .43       .43       .42       .42       .41       .41       .40       .40
  28.00    DISCHG         .39       .39       .38       .38       .37       .37       .36       .36       .35       .35
  29.00    DISCHG         .34       .34       .34       .33       .33       .32       .32       .31       .31       .31

  RUNOFF VOLUME ABOVE BASEFLOW =  1.28 WATERSHED INCHES,    298.04 CFS-HRS,    24.63 ACRE-FEET;   BASEFLOW =    .00 CFS


EXECUTIVE CONTROL OPERATION ENDCMP     COMPUTATIONS COMPLETED FOR PASS   4                                   RECORD ID




EXECUTIVE CONTROL OPERATION ENDJOB                                                                           RECORD ID
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SUMMARY TABLE 1 - SELECTED RESULTS OF STANDARD AND EXECUTIVE CONTROL INSTRUCTIONS IN THE ORDER PERFORMED
                  (A STAR(*) AFTER THE PEAK DISCHARGE TIME AND RATE (CFS) VALUES INDICATES A FLAT TOP HYDROGRAPH
                   A QUESTION MARK(?) INDICATES A HYDROGRAPH WITH PEAK AS LAST POINT.)

SECTION/     STANDARD               RAIN  ANTEC  MAIN          PRECIPITATION                                PEAK DISCHARGE
STRUCTURE     CONTROL    DRAINAGE  TABLE  MOIST  TIME   -------------------------  RUNOFF   -------------------------------------
   ID        OPERATION     AREA      #    COND   INCREM  BEGIN    AMOUNT  DURATION  AMOUNT    ELEVATION   TIME        RATE        RATE
                          (SQ MI)                 (HR)   (HR)     (IN)     (HR)     (IN)       (FT)      (HR)       (CFS)       (CSM)


   ALTERNATE     1    STORM     1
XSECTION  10   RUNOFF       .36      2      2     .10      .0      2.88    24.00      .99        ---      12.21      181.82      505.0
STRUCTURE 10   RESVOR       .36      2      2     .10      .0      2.88    24.00      .00     3346.35     25.40?        .01?        .0

   ALTERNATE     1    STORM     3
XSECTION  10   RUNOFF       .36      2      2     .10      .0      4.60    24.00     2.29        ---      12.20      439.95     1222.1
STRUCTURE 10   RESVOR       .36      2      2     .10      .0      4.60    24.00     1.20     3348.42     14.63       28.17       78.3

   ALTERNATE     2    STORM     5
XSECTION  10   RUNOFF       .36      2      2     .10      .0      5.75    24.00     3.26        ---      12.20      628.16     1744.9
STRUCTURE 10   RESVOR       .36      2      2     .10      .0      5.75    24.00     2.16     3349.43     12.88      141.01      391.7

   ALTERNATE     2    STORM     6
X    ION  10   RUNOFF       .36      6      2     .10      .0      4.63     6.00     2.31        ---       2.67      352.78      979.9
S    TURE 10   RESVOR       .36      6      2     .10      .0      4.63     6.00     1.28     3348.88      4.98       75.04      208.4
```

```
SUMMARY TABLE 3 - DISCHARGE (CFS) AT XSECTIONS AND STRUCTURES FOR ALL STORMS AND ALTERNATES

XSECTION/          DRAINAGE
STRUCTURE            AREA      STORM NUMBERS..........
  ID               (SQ MI)           1          3          5          6


 STRUCTURE  10           .36
   ALTERNATE    1                  .01      28.17        .00        .00
   ALTERNATE    2                  .00        .00     141.01      75.04

 XSECTION   10           .36
   ALTERNATE    1               181.82     439.95        .00        .00
   ALTERNATE    2                  .00        .00     628.16     352.78
```

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END OF  1 JOBS IN THIS RUN
```

CULVERTS

Calculation package includes:

1. Mt. Storm Haul Road Cross Culvert Design

SUBJECT Mt Storm Haulroad
Cross Culvert Design
BY PWC DATE 6/24/96 PROJ. NO. 88-108-85
CHKD. BY KMB DATE 7/1/96 SHEET NO. 1 OF 6

It is proposed to replace the existing CMP cross-culverts on the Mt Storm haulroad with RCP culverts. The design discharge of the culverts is unknown. The location of the RCP culverts will be the same as the existing CMP culverts, including the same slopes. Since the design Q for each culvert is unknown, calculate Q_{max} for the CMP culvert using Manning's Equation, assuming Full Flow. Then size an RCP culvert using Manning's Equation and Q_{max}. Since the design Q and headwater calcs are not available for the CMP culverts, inlet control cannot be effectively evaluated for each cross-culvert.

The lengths and inverts of each existing cross-culvert is from survey data provided by Virginia Power.

Manning's n values

Minimum pipe size shall be 12" RCP

RCP : $n = 0.015$
CMP : $n = 0.025$

note: Culvert 1 is an existing 30" RCP

Culvert 2

$$S = \frac{3320.48\,Ft - 3319.67\,Ft}{40.9\,Ft} = 0.0198\,Ft/Ft$$

21" CMP :

$$Q = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$n = 0.025$

$$R = \frac{A}{WP} = \frac{\frac{\pi D^2}{4}}{\pi D} = \frac{D}{4} = \left(\frac{21\,in}{4}\right)\left(\frac{Ft}{12\,in}\right) = 0.4375\,Ft$$

$$A = \frac{\pi D^2}{4} = \frac{\pi\left[(21\,in)\left(\frac{Ft}{12\,in}\right)\right]^2}{4} = 2.405\,Ft^2$$

SUBJECT Mt Storm Haulroad
Cross Culvert Design
BY PWC DATE 6/24/96 PROJ. NO. 88-108-85
CHKD. BY KMB DATE 7/1/96 SHEET NO. 2 OF 6

$$Q_{max} = \left(\frac{1.486}{0.025}\right)\left(0.4375\right)^{2/3}\left(0.0198\right)^{1/2}\left(2.405\right) = 11.6\ cfs$$

$$Q_{max} = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$$R = \frac{d}{4}\ Ft \qquad \text{pipe Flowing Full}$$

$$A = \frac{\pi d^2}{4}$$

$$Q_{max} = \left(\frac{1.486}{n}\right)\left(\frac{d}{4}\right)^{2/3} S^{1/2}\left(\frac{\pi d^2}{4}\right)$$

$$d^{8/3} = \frac{(Q_{max})(n)(4)^{2/3}(4)}{(1.486)(S^{1/2})(\pi)}$$

$$d = \left(\frac{2.159\ n\ Q_{max}}{S^{1/2}}\right)^{3/8}$$

$$d = \left[\frac{(2.159)(0.015)(11.6)}{(0.0198)^{1/2}}\right]^{3/8}$$

$$d = (1.445 Ft)\left(\frac{12\ in}{Ft}\right) = 17 in \qquad \text{Say } 18''$$

$\therefore$ Use 18" RCP

Culvert 3

$$S = \frac{3321.18\ Ft - 3316.07\ Ft}{43.6\ Ft} = 0.117 Ft/Ft$$

18" CMP

SUBJECT Mt Storm Haulroad
Cross Culvert Design
BY Pwc DATE 6/24/96 PROJ. NO. 88-108-85
CHKD. BY KMB DATE 7/1/96 SHEET NO. 3 OF 6

$$Q_{max} = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$n = 0.025$
$R = d/4 = \left(\frac{1.5Ft}{4}\right) = 0.375Ft$
$S = 0.117 \; Ft/Ft$
$A = \frac{\pi D^2}{4} = \frac{(\pi)(1.5Ft)^2}{4} = 1.767 \; Ft^2$

$$Q_{max} = \left(\frac{1.486}{0.025}\right)(0.375)^{2/3}(0.117)^{1/2}(1.767) = 18.7 \; cFs$$

$$d = \left(\frac{2.159 \, n \, Q_{max}}{S^{1/2}}\right)^{3/8}$$

$$d = \left[\frac{(2.159)(0.015)(18.7)}{(0.117)^{1/2}}\right]^{3/8}$$

$$d = (1.239Ft)\left(\frac{12 \, in}{Ft}\right) = 14.9 \, in$$ Say 15"

∴ use 15" RCP

Culvert 4

$$S = \frac{3324.95 \, Ft - 3322.37Ft}{40Ft} = 0.0645 \; Ft/Ft$$

30" CMP

$$Q_{max} = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$n = 0.025$
$R = d/4 = \left(\frac{2.5Ft}{4}\right) = 0.625 \; Ft$
$S = 0.0645 \; Ft/Ft$
$A = \frac{\pi d^2}{4} = \frac{\pi (2.5Ft)^2}{4} = 4.909 \; Ft^2$

SUBJECT Mt Storm Haulroad
Cross Culvert Design
BY PWC DATE 6/24/96 PROJ. NO. 88-108-85
CHKD. BY KMB DATE 7/1/98 SHEET NO. 4 OF 6

$$Q_{max} = \left(\frac{1.486}{0.025}\right)(0.625)^{2/3}(0.0645)^{1/2}(4.909) = 54.2\ cfs$$

$$d = \left(\frac{2.159\ n\ Q_{max}}{S^{1/2}}\right)^{3/8}$$

$$d = \left[\frac{(2.159)(0.015)\ (54.2)}{(0.0645)^{1/2}}\right]^{3/8}$$

$$d = (2.065\,Ft)\left(\frac{12\,in}{Ft}\right) = 24.8\ in \qquad Say\ 27''$$

∴ use 27" RCP *

* the actual design discharge for this culvert should be evaluated against available head water at the site to determine if a 24" RCP will be sufficient at the site.

Culvert 5

$$S = \frac{3319.15\,Ft - 3317.20\,Ft}{39.9\,Ft} = 0.0489\ Ft/Ft$$

30" CMP

$$Q_{max} = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$n = 0.025$
$R = 0.625\ Ft$
$S = 0.0489\ Ft/Ft$
$A = 4.909\ Ft^2$

$$Q_{max} = \left(\frac{1.486}{0.025}\right)(0.625)^{2/3}(0.0489)^{1/2}(4.909) = 47.2\ cfs$$

SUBJECT Mt Storm Haulroad
Cross-Culvert Design
BY PWC DATE 6/24/96 PROJ. NO. 88-108-85
CHKD. BY KMB DATE 7/1/96 SHEET NO. 5 OF 6

$$d = \left(\frac{2.159\, n\, Q_{max}}{S^{1/2}}\right)^{3/8}$$

$$d = \left[\frac{(2.159)(0.015)(47.2)}{(0.0489)^{1/2}}\right]^{3/8}$$

$$d = (2.065\,Ft)\left(\frac{12\,in}{Ft}\right) = 24.8\,in \qquad \text{Say } 27''$$

∴ use 27" RCP*

* the actual design discharge for this culvert should be evaluated against available headwater at the site to determine if a 24" RCP will be sufficient at the site.

Culvert 6

$$S = \frac{3334.94\,Ft - 3330.73\,Ft}{57.0\,Ft} = 0.0739\ Ft/Ft$$

36" CMP

$$Q_{max} = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$$n = 0.025$$

$$R = \frac{d}{4} = \frac{3Ft}{4} = 0.75\ Ft$$

$$S = 0.0739\ Ft/Ft$$

$$A = \frac{\pi d^2}{4} = \frac{\pi (3Ft)^2}{4} = 7.069\ Ft^2$$

$$Q_{max} = \left(\frac{1.486}{0.025}\right)(0.75)^{2/3}(0.0739)^{1/2}(7.069) = 94.3\,cfs$$

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Environmental Specialists

SUBJECT Mt Storm Haulroad
Cross Culvert Design
BY PWC DATE 6/24/96 PROJ. NO. 88-108-85
CHKD. BY KMB DATE 7/1/96 SHEET NO. 6 OF 6

$$d = \left(\frac{2.159 n Q_{max}}{S^{1/2}}\right)^{3/8}$$

$$d = \left[\frac{(2.159)(0.015)(94.3)}{(0.0739)^{1/2}}\right]^{3/8}$$

$$d = (2.477 Ft)\left(\frac{12 in}{Ft}\right) = 29.7 in$$ Say 30"

∴ Use 30" RCP

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SUBJECT Mt Storm Roadway Improvements - 1996
Coal Yard Entrance Road / Coal Dump Road

BY PWC DATE 7/11/96 PROJ. NO. 88-108-85

CHKD. BY DATE 7-11-96 SHEET NO. 1 OF 1

Determine the disturbed areas associated with construction of the 1996 roadway improvements for the Coal Yard Entrance Road / Coal Dump Road. The cut and fill lines for the roadway improvements are shown on the attached Drwg No. 88-108-E77. As shown on the drawing, a portion of the roadway will be constructed as a future, separate project. Also, a portion of the site drains to the Low-volume treatment plant for the Mt Storm Power Station. The Low-volume treatment system is included in the NPDES permit for the Power Station. The remainder of the site drains as uncontrolled discharges (i.e. not covered by an NPDES permit).

Current Construction

1) Watershed draining to Low-volume treatment system (NPDES discharges)

disturbed area = Area 1 = 1.17 acres

2) Uncontrolled drainage areas

disturbed area = Area 2 + Area 3 = 0.51 ac + 1.83 ac = 2.34 acres

Future Construction

disturbed area = Area 4 = 1.14 acres

DRAINAGE CONTROL

Calculation package includes:
1. Phase B Drainage Control

SUBJECT PHASE B DRAINAGE CONTROL
CELL 3
BY JLS DATE 3/11+12/96 PROJ. NO. 88-108-84
CHKD. BY PWC DATE 3/12/96 SHEET NO. 1 OF 3

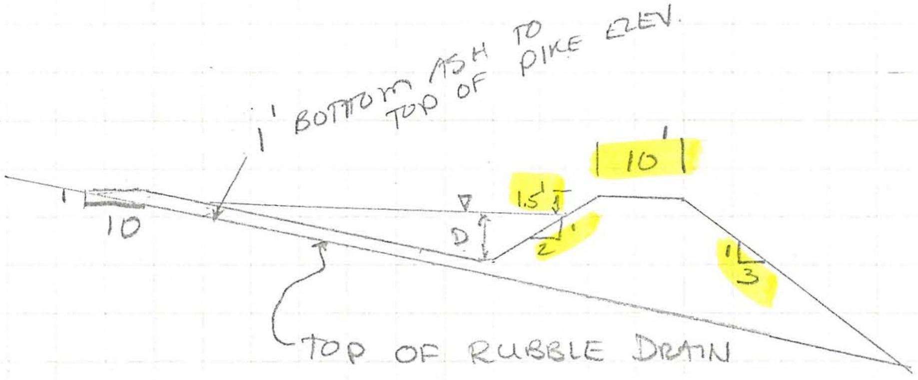
DRAINAGE CONTROL DIKE ANALYSIS.

CONSTRUCT BOTTOM ASH DRAINAGE CONTROL DIKES ON CONTOURS TO CONTAIN AND CONTROL RUN-OFF FOR UP TO 5 INCHES OF RAINFALL AND 100% RUNOFF

DATA:

AVG SLOPE OF MINE FLOOR - 10%
DIKE UPSTREAM FACE - 2:1
" DOWNSTREAM " - 3:1
PROVIDE 1.5 FEET FREE BOARD WITH SHALE LINED SPILL WAYS AT ENDS OF DIKES
TOP WIDTH OF DIKE - 10'

TYPICAL SECTION



SUBJECT PHASE B DRAINAGE CONTROL
CELL 3

BY JLS DATE 3/11&12/96 PROJ. NO. 88-108-84
CHKD. BY PWC DATE 3/13/96 SHEET NO. 2 OF 3

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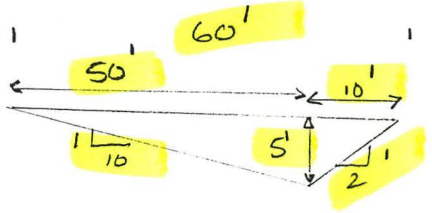
FOR D = 5' DETERMINE DIKE SPACING



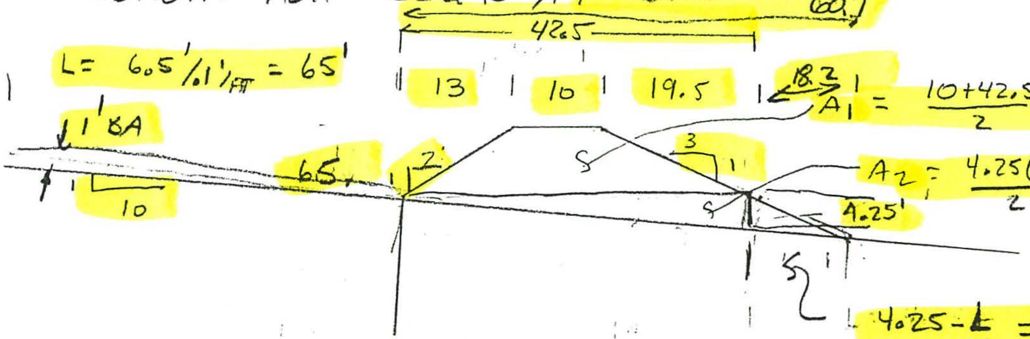
$V/_{FT\ WIDTH} = \frac{60' \times 5'}{2} = 150\ CF$

5" RUNOFF/FT WIDTH = 150 CF

$\frac{150\ CF/_{FT}}{5''/_{FT}}\ \frac{12''}{FT}$ = 360' BETWEEN DIKES

BOTTOM ASH REQ'D /FT DIKE = 60.7'

L = 6.5'/.1'/FT = 65'



$A_1 = \frac{10+42.5}{2}(6.5) = 170.625$ Ⓘ

$A_2 = \frac{4.25(42.5)}{2} = 90.3$ Ⓘ

$4.25 - \frac{L}{3} = \bar{o}$ .1L   L = 0

L = 18.2'

$A_3 = \frac{18.2(4.25)}{2} = 38.675$ Ⅱ

$A_{DIKE}/_{FT} = 170.625 + 90.3 + 38.675$
= 299.6 SQFT

$V/_{FT} = 299.6/_{27} = 11.1\ CY/FT$

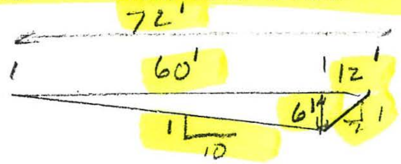
$V_{BA}/_{FT} = \frac{65(1)}{27} = 2.4\ CY/FT$

SUB TOTAL = 13.5 CY/FT + 1' ADDITIONAL BUILT WIDTH OF DIKE TO MAINTAIN 5' DEPTH $\frac{(1 \times 61)}{27} = 2.25CY$
+ 2.25
15.75 CY/FT SAY 16

SECTION WIDTH = BOTTOM ASH DRAIN + DIKE
= 60.7 + 65 = 125.7 SAY 130'

SUBJECT PHASE B DRAINAGE CONTROL
CELL 3
BY JLS DATE 3/11&12/96 PROJ. NO. 88108-84
CHKD. BY PWC DATE 3/13/96 SHEET NO. 3 OF 3

FOR D= 6' DETERMINE DIKE SPACING

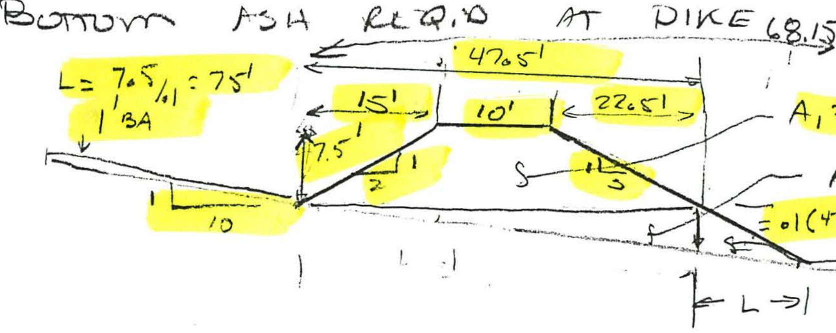


$V/FT_{WIDTH} = \frac{72 \times 6}{2} = 216$ CF

5" RUNOFF/FT WIDTH = ~~216~~CF

$\frac{216 \ CF/FTW}{5"/FTW} \times 12"/FT = 518$ FT

BOTTOM ASH REQ'D AT DIKE



$A_1 = \frac{47.5+10}{2}(7.5) = 215.625$ I

$A_2 = \frac{47.5(4.75)}{2} = 112.82$ II

= .1(47.5)= 4.75'

$A_3 = \frac{20.65(4.75)}{2} = 49.0$ III

$L \ 4.75 - \frac{L}{3} = -.1L$

L= 20.65

20.35

$A_{DIKE} = 215.625 + 112.82 + 49 = 377.465$ SAY 377.5

$V/FT = 377.5/27 = 14.0$ CY/FT

$V_{BA}/FT = \frac{75(1)}{27} = 2.8$ CY/FT

SUB-TOTAL = 16.8 CY/FT

+ 2.55

TOTAL = 19.3 SAY 20 CY/FT

+1 FT OF BOTTOM ASH FOR WIDTH OF DIKE TO MAINTAIN 6' DEPTH $\frac{1 \times 69}{27} = 2.55$ CY

SECTION WIDTH = 68.15+75= 143.15 SAY 145'