Technical Reclamation Memorandum

TRM # 13

Kentucky Department for Surface Mining Reclamation and Enforcement

Date: August 5, 1983

From: Robert E. Nickel, Director
Division of Permits

Subject: Kentucky Graphical Method for Sediment Pond Design

The Kentucky Department for Surface Mining Reclamation and Enforcement has developed a simple graphical procedure which can be used to design embankment and excavated sediment ponds to meet effluent limitations for total suspended solids and average settleable solids. When an applicant has properly used this design method, the department will consider the applicant to have demonstrated that the proposed ponds can reasonably be expected to meet effluent limitations. The design method, called the "Kentucky Graphical Method for Sediment Pond Design," is included in the attached document, Design of Sediment Ponds to Meet Effluent Limitations for Suspended and Settleable Solids, which also describes other approved design methods. The Department appreciates the assistance and advice provided by the Surface Coal Mining Technical Advisory Committee during the development of this document. The Department intends to ultimately develop a comprehensive sediment control manual which would include the sediment pond design procedures discussed in this document and other onsite sediment control practices.

The Graphical Method uses simple graphs, tables, and a few straightforward calculations to directly compute an acceptable pond design. A non-programmable hand calculator with log x and y^x functions is all that is needed; neither programmable calculators nor computers are necessary. A worksheet is provided on which the calculations are entered step-by-step.

The peaks and volumes of inflows to the pond site from the 10 and 25-year, 24-hour rainfall events are given by direct calculation, and do not require that the pond watershed be divided into subwatersheds. The procedure takes into account the size, length, slope, and vegetative cover of the watershed, and also the extent of the mining disturbance in the watershed.

The characteristics of the specific pond site are considered in two factors which are calculated directly from the stage-volume curve for the site. For excavated ponds, optional graphs are provided for these factors.

For embankment ponds, the principal spillway can be either the conduit-riser type or the trickle tube type, with an open channel emergency spillway. For conduit-riser spillways, a 3-inch diameter dewatering orifice is located midway between the principal spillway crest and the top of the sediment storage. For excavated ponds, a single trapezoidal open spillway is used.

In brief, the method:

(a) determines the peaks and volumes of the 10 and 25-year, 24-hour runoff events;

(b) determines the sediment storage volume required;

(c) determines the necessary storage volume between the top of the sediment storage and the principal spillway, and thereby determines the elevation of the principal spillway crest;

(d) determines the size of the pipe principal spillway for embankment ponds, or the width of the trapezoidal open spillway for excavated ponds;

(e) for embankment ponds, determines the volume and depth above the principal spillway crest which results from the passage of the 10-year, 24-hour storm runoff, and thereby determines the necessary elevation of the emergency spillway crest;

(f) determines the volume and depth above the emergency spillway crest for embankment ponds, or above the single open spillway crest for excavated ponds, which results from the passage of the 25-year, 24-hour storm runoff; and with allowances for freeboard and settlement thereby determines the elevation of the top of the embankment.

Excavated ponds are limited to a levee height of approximately 5 feet. Embankment ponds are limited to a storage volume of 20 acre-feet impounded between the upstream toe of the embankment and the emergency spillway crest, and a structure height of 20 feet between the upstream toe of the embankment and the crest of the emergency spillway.

Questions or comments about the Kentucky Graphical Method should normally be directed to Dick Rohlf or John Drake at (502) 564-2377, or to Jim Wade or Bobby Salyers at (502) 564-2320.

Attachments

TRM #13

DESIGN OF SEDIMENT PONDS

TO MEET

EFFLUENT LIMITATIONS FOR SUSPENDED AND SETTLEABLE SOLIDS

August 1983

Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Department for Surface Mining Reclamation and Enforcement

0587S

I. INTRODUCTION

A. Background

The Surface Mining Control and Reclamation Act of 1977 (SMCRA) established a comprehensive permit process for the permanent regulatory program. This process requires that the applicant conduct a thorough examination of the proposed mining site and develop a mining and reclamation plan which will enable the operation to be carried out in compliance with SMCRA. Furthermore, SMCRA requires that the applicant affirmatively demonstrate that reclamation as required by the Act can be accomplished by his reclamation plan and the regulatory authority must agree before the permit can be issued.

With respect to sediment control, this means that the applicant must develop a site-specific sediment control plan and fully describe that plan in the permit application, including a demonstration to the Department for Surface Mining Reclamation and Enforcement that the performance standards for sediment will be met under that plan. For sediment ponds, the applicant must demonstrate to the department that the ponds can reasonably be expected to meet the effluent limitations for suspended and settleable solids.

B. Purpose

The purpose of this manual is to describe methods which an applicant can use to demonstrate in his permit application that effluent discharges from his sediment ponds can reasonably be expected to meet the effluent limitations for settleable solids and suspended solids. All pond designs submitted to the department must include the method or basis of design used. It is not acceptable to only submit drawings which establish the size and configuration of the ponds. In other words, the design must include the applicant's engineering determinations and calculations which show why he believes the pond can reasonably be expected to meet effluent limitations. Use of approved methods in the manner described in this manual will fulfill this requirement. This manual does not address detailed structural design and construction practices for sediment ponds. Rather, it addresses criteria and procedures for determining the size of sediment ponds and the size and configuration of spillways necessary to meet effluent limitations for suspended and settleable solids.

This manual provides:

1. A simple graphical design method which can be used to determine a pond size and spillway configuration which can reasonably be expected to meet effluent limitations for settleable solids and suspended solids. If the applicant includes information in his application which shows that he used this design method properly, the department will approve the selected pond size and spillway configuration and no further demonstration of the sediment control performance of the pond will be required prior to issuance of the permit (except as may be required for total suspended solids as discussed below).

2. Identification of other accepted engineering design methods which the department presently considers acceptable without further demonstration.

3. Procedures for use of monitoring data to demonstrate compliance of existing ponds (TRM #8 procedure).

4. A discussion of how the department will evaluate any proposed design method for which a person seeks department approval.

5. A description of the documentation which must be included in the permit application for each of the above.

C. Effluent Limitations for Total Suspended Solids (TSS) and Settleable Solids (SS)

Source of discharge	30 day average	Maximum for any one day	
	TSS (mg/l)	TSS (mg/l)	SS (ml/l)
Active Mining Areas	35	70	-
Alternate Limitation*	-	-	.5
Postmining Areas**	-	-	.5
Drainage from Underground Workings	35	70	-
Coal Preparation Plants*** and Associated Areas	35	70	-
Alternate limitation*	-	-	.5

* This alternate limitation applies for discharges resulting from all precipitation events less than or equal to 10-year, 24-hour event. No limitation applies for larger events.

** No limitation applies for precipitation events greater than the 10-year, 24-hour event.

*** New preparation plant water circuits are to have no discharge except for occasional approved purges.

D. Compliance with Total Suspended Solids Limitation

The design procedures discussed in this manual are for the purpose of determining a pond size and spillway configuration that will achieve the effluent limitation for settleable solids during precipitation events. However, discharges during base flow conditions and discharges from underground workings and pit pumpage must meet the effluent limitations for total suspended solids. It is difficult to analyze pond performance for these types of discharges because of the high degree of variability of the untreated TSS concentrations and particle size distributions for these discharges. In general, for the purposes of permit review, the department will assume that if the pond is designed to meet the settleable solids limitation, the pond will be adequate to meet the total suspended solids limitations. If past performance or site-specific conditions indicate that there may be a problem in meeting the TSS limitations, such as when underground mine drainage or pit pumpage contain a high concentration of clay size particles, the design engineer should consider this in his design. The department reserves the right to require, on a case-by-case basis, additional control measures as necessary to achieve the TSS limitations, both at the permit review stage and during enforcement.

II. KENTUCKY GRAPHICAL METHOD FOR SEDIMENT POND DESIGN

The "Kentucky Graphical Method for Sediment Pond Design," developed by the Kentucky Department for Surface Mining Reclamation and Enforcement, uses a straightforward graphical procedure and supplemental calculations to arrive at a sediment pond size and spillway configuration which can reasonably be expected to meet effluent limitations for sediment. The method is applicable to embankment ponds with either conduit/riser or "trickle tube" principal spillways, and to excavated ponds (dugouts).

The method is applicable to the design of new ponds, but cannot be used directly to determine how existing ponds will perform. The method uses simplified procedures to determine the peaks and volumes of inflows resulting from the 10-year and 25-year, 24-hour precipitation events, and does not require that watersheds be divided into subwatersheds. Sediment loads are accounted for through the percentage of the pond watershed disturbed by mining operations and the extent of revegetation of the disturbed area, and through watershed length and slope. The method includes a worksheet which provides step-by-step instructions on how to use the method. The full method is provided as an attachment to this document, along with some example designs.

When an applicant uses this method the application should clearly state that this method was used and should contain:

1. The pond site, watershed, and disturbed areas in the watershed, shown on the large scale Mining and Reclamation Map.

2. The stage-area and stage-volume curves for the pond site;

3. The completed worksheet;

4. The engineer's certified detailed drawings for the embankment and other structures; and

5. The engineer's certification of design.

III. OTHER ACCEPTED METHODS

A. General

This section sets forth other methods for sediment pond design or analysis which are accepted by the department at the present time. For each method, this section describes the information which must be submitted in the application. Where the applicant uses one of these methods, the department reserves the right to determine whether the method was properly applied in a specific case, since any method is valid only when it is used properly.

B. Sediment Pond Design Guideline - Procedures for Hand Calculators (KDSMRE Technical Memorandum #10, April 1983 as modified by TRM #11, May 1983)

This method provides the design engineer with appropriate equations and graphical relationships which can be used with a hand calculator to determine a pond size, and a principal spillway size and configuration, which can reasonably be expected to meet the effluent limitations for settleable and suspended solids. It also determines an emergency spillway size which will adequately control storm runoff. This method is applicable both to the design of new ponds and the analysis of existing ponds.

The method allows the designer to consider the site specific conditions of the watershed and the proposed mining operation, and thereby arrive at a cost effective design for the site. The method includes direct calculations of the watershed peak runoffs and volumes, and a trial and error procedure to size the pond. TRM #10 contains a program for the HP 41 CV programmable calculator, which can greatly speed up the trial and error sizing procedure.

When an applicant uses this method, the application should clearly state that this method was used and should contain:

1. The pond site, watershed, and disturbed areas, shown on the large scale Mining and Reclamation Map. If complex subwatersheds are used, a separate map or drawing at any appropriate scale should be provided to show the watershed configuration used.

2. The stage-area and stage-volume curves for the pond site;

3. Completed worksheets 1-6 from TRM #10;

   At the designer's option, he may use the simplified graphical methods in the "Kentucky Graphical Method for Sediment Pond Design" to develop the peaks and volumes of watershed runoff to the sediment pond. In this case, appropriate pages from the "Graphical" worksheet should be substituted for worksheets 1 and 2 of TRM #10.

4. The engineer's certified detailed drawings for the embankment and other structures; and

5. The engineer's certification of design.

C. SEDIMOT II Computer Program - University of Kentucky, College of Agriculture, Department of Agricultural Engineering

SEDIMOT II, available through the University of Kentucky and several private facilities, is a well known computer program for the site-specific development of sediment loads and design of sediment ponds. The program allows the design engineer to consider in great detail the site specific characteristics of the watershed and proposed mining operation and thus achieve a cost effective design for the site. The program can be used both to design new ponds and to evaluate the performance of existing ponds.

When the applicant uses the program, the application should clearly state that this method was used and should contain:

1. The pond site, watershed, and disturbed areas, shown on the large scale Mining and Reclamation map. If complex subwatersheds or multiple structure analysis is used, a separate map or drawing at any appropriate scale should be provided to show the watershed configuration used.

2. The stage-area and stage-volume curves for the pond site;

3. In the original application, one complete unseparated original of the program printout including a full listing of the input parameters and results. Copies of the application which do not contain the original printout(s) should contain (1) a letter referencing the original printout(s), and identifying which ponds were designed by this method, and (2) a summary of the printout results for those ponds.

4. The engineer's certified detailed drawings for the embankment and other structures; and

5. The engineer's certification of design.

D. DEPOSITS Computer Program - University of Kentucky, College of Agriculture, Department of Agricultural Engineering

DEPOSITS is a well known computer program for designing new sediment ponds and for evaluating the performance of existing ponds. Sediment loads must be developed separately and input to the program. It is available through the University of Kentucky and several private facilities.

When the applicant uses this program, the application should clearly state that this method was used and should contain:

1. The pond site, watershed, and disturbed areas, shown on the large scale Mining and Reclamation Map. If complex subwatersheds are used, a separate map or drawing at any appropriate scale should be provided to show the watershed configuration used.

2. The stage-area and stage-volume curves for the pond site;

3. In the original application, one complete unseparated original of the program printout including a full listing of the input parameters and results. Copies of the application which do not contain the original printout(s) should contain (1) a letter referencing the original printout(s), and identifying which ponds were designed by this method, and (2) a summary of the printout results for those ponds.

4. The engineer's certified detailed drawings for the embankment and other structures; and

5. The engineer's certification of design.

E. KDSMRE TRM #8 procedure for using monitoring data to evaluate the performance of existing ponds.

Other methods (including B, C, D above) can be used to evaluate the performance of existing ponds. However, where adequate water quality monitoring data exists, the applicant can use this data to show the actual performance of ponds and extrapolate the actual performance to show the probable performance of the ponds at the 10-year, 24-hour storm event. TRM #8 (January 1983) describes the recommended procedure in detail.

When TRM #8 was issued, ponds would have to show a peak settleable solids concentration of less than 0.5 ml/1 at the 10-year, 24-hour event. Due to EPA's recent reinterpretation of its rules, the standard is now an average of 0.5 ml/1, rather than peak. Since past water quality monitoring data show instantaneous values of concentration, these data when extrapolated to the 10-year, 24-hour event should be less than 4.4 ml/1 for conduit-riser spillways and 2.8 ml/1 for trickle tube spillways. These values correspond to an average value of 0.5 ml/1. TRM #11 (May 1983) explains this more fully.

IV. DEPARTMENT APPROVAL OF DESIGN METHODS

When any person proposes a design method and seeks to have the department evaluate the method and approve it for subsequent use in permit applications, the person must demonstrate to the satisfaction of the department that the method produces results which are reasonably consistent with the methods already approved. The person will be required to submit documentation including:

1. a narrative description of the technical basis of the method, including identification of those components of the method which are already well known (include appropriate reference material) and which components are new;

2. a description of the range of pond types and sizes, watershed sizes and conditions, and types of mining disturbances, which the method is intended to cover;

3. a clear statement of conditions in which the method is not applicable;

4. worked examples in which the method has been applied throughout the full range of conditions described in 2., including all necessary data and results.

5. where computer programs are part of the method, a complete listing of the program(s) and original printouts of input data and results for the examples in 4. above.

The department will review the proposed method and evaluate it against one or more of the approved methods described above. The department may require the person to submit additional documentation beyond that originally submitted. The department will then provide the person with a written decision either

1. disapproving the method,

2. accepting the method with stated conditions, limitations or restrictions upon its use, or

3. approving the method.

Such requests for department approval of a design method should not be submitted as part of a permit application, but should be submitted independently of any permit application. The department will not give approval, conditional approval, or disapproval to a proposed design method in connection with a specific permit application. Because the department has statutory and regulatory time limits within which to issue or deny permits and because decisions on proposed design methods cannot necessarily be completed within these time limits, evaluation of proposed design methods must be separated from decisions on permits.

KENTUCKY GRAPHICAL METHOD FOR SEDIMENT POND DESIGN

August 1983

Commonwealth of Kentucky
Natural Resources and Environmental Protection Cabinet
Department for Surface Mining Reclamation and Enforcement

TRM #13

EMBANKMENT POND DESIGN WORKSHEET

Kentucky Graphical Method for Pipe Spillways

Application No. ______________________ Pond No. ____________________

WATERSHED HYDROLOGY	Key
Total disturbed area A_d ________ acres / Drainage area A_w ________ acres x 100 = Total % disturbed P_d ________ %	A_d A_w P_d
Hydraulic length of watershed = L_h ____________ feet	L_h
Elevation at the most remote point in pond watershed (upstream point for hydraulic length) = E_u ________ ft	E_u
Watershed elevation at sediment pond (downstream point for hydraulic length) = E_d __________ ft	E_d
Average watershed slope S_w along the hydraulic length = 100 x (E_u ________ - E_d ________)/L_h ________ = S_w __________ %	S_w
Watershed slope-length factor F_s = L_h ______/(S_w ______)$^{0.5}$ = F_s ________	F_s
Unit peak runoff from Figure 1 = q_u ___________ cfs/acre-inch, weighted for _________ % forest and __________ % grassland	q_u
Premining unit peak runoff (weighted) from Figure 1 (P_d usually = 0%) = q_u^{pm} __________ cfs/acre-inch	q_u^{pm}

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10-year, 24-hour rainfall from Table 1 = P_{10} ________________ inches — P

10-year, 24-hour runoff (weighted) from Figure 2 = Q_{10} ________________ inches — Q_{10}

10-year, 24-hour inflow volume to pond Q_{vi}^{10} =

Q_{10} __________ x A_w __________ /12 = Q_{vi}^{10} __________ acre-feet — Q_{vi}^{10}

10-year, 24-hour peak inflow to pond Q_{pi}^{10} = q_u __________ x Q_{10} __________

x A_w __________ = Q_{pi}^{10} __________ cfs — Q_{pi}^{10}

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25-year, 24-hour rainfall from Table 1 = P_{25} ________________ inches — P_{25}

25-year, 24-hour runoff (weighted) from Figure 2 = Q_{25} ________________ inches — Q_{25}

25-year, 24-hour inflow volume to pond Q_{vi}^{25} =

Q_{25} __________ x A_w __________ /12 = Q_{vi}^{25} __________ acre-feet — Q_{vi}^{25}

25-year, 24-hour peak inflow to pond Q_{pi}^{25} = q_u __________ x Q_{25} __________

x A_w __________ = Q_{pi}^{25} __________ cfs — Q_{p}

Premining 25-year, 24-hour runoff (weighted) to pond site Q_{25}^{pm} =

(P_d usually = 0%) Q_{25}^{pm} __________ inches — Q_{25}^{pm}

Premining 25-year, 24-hour peak inflow to pond site Q_{pi}^{pm} =

q_u^{pm} __________ x Q_{25}^{pm} __________ x A_w __________ = Q_{pm}^{pi} __________ cfs — Q_{pi}^{pm}

SEDIMENT POOL

Minimum sediment storage = 0.075 x A_d __________ = __________ acre-feet

Design sediment storage used = V_s __________ acre-feet — V_s

Elevation top of sediment pool from stage-volume curve = E_s __________ feet — E_s

STAGE-VOLUME RELATIONSHIP

To describe the incremental stage-volume relationship above the sediment pool with equation $\Delta E = k(\Delta V)^t$, pick points (E_1, V_1) and (E_2, V_2) directly from the stage-volume curve. Pick E_1 approximately 4 feet above the sediment pool, near the principal spillway elevation. Pick E_2 approximately 8 feet above the sediment pool, near the 10-year, 24-hour maximum water surface elevation.

$t = \log\ [(E_1 - E_s)/(E_2 - E_s)]/\log\ [(V_1 - V_s)/(V_2 - V_s)]$

$t = \log\ [(E_1$ ________ $- E_s$ ________$)/(E_2$ ________ $- E_s$ ________$)]/$

$\log\ [(V_1$ ________ $- V_s$ ________$)/(V_2$ ________ $- V_s$ ________$)]$

$t =$ __________

E_1
E_2
V_1
V_2
t

$k = (E_2 - E_s)/(V_2 - V_s)^t$

$k = (E_2$ ________ $- E_s$________$)/(V_2$________ $- V_s$________$)^t$ ________

$k =$ __________

k

PRINCIPAL SPILLWAY POOL

Find adjusted % disturbed area P_a at time of maximum disturbance:

Percent of disturbed area unrevegetated P_0 ______________% — P_0

Percent with revegetation 0 - 2 months old P_{0-2} ______________% — P_{0-2}

Percent with revegetation 2 - 12 months or older P_{2-12} ______________% — P_{2-12}

$(P_0 + P_{0-2} + P_{2-12} = 100\%)$

Adjusted % disturbed P_a from Figure 5 $= P_a$ __________% — P_a

Disturbance factor F_d from Figure 6 $= F_d$ __________% — F_d

Principal spillway pool volume V_{sp}^{10} for runoff volume of 10 acre-feet from

Figure 7 or 8 $= V_{sp}^{10}$ ________acre-feet — V_{sp}^{10}

Factors (a, b) to adjust V_{sp}^{10} for actual inflow volume Q_{vi}^{10}

For conduit/riser from Figures 10 & 11: (a)__________ (b)__________ a

For trickle tube from Figures 12 & 13: (a)__________ (b)__________ b

Adjusted principal spillway pool volume V_{sp} =

V_{sp}^{10} ________ + [a ________ x (Q_{vi}^{10} ________ $- 10)^2$] +

[b ________ x (Q_{vi}^{10} ________ - 10)] = V_{sp} ________ acre-feet

V_{min} = 0.15 x (Q_{vi}^{10} ________$)^{0.25}$ = V_{min} ________ acre-feet V_{min}

If V_{sp} is less than V_{min} then set $V_{sp} = V_{min}$

Final V_{sp} ________ acre-feet V_{sp}

Final volume V_p at principal spillway crest =

V_s ________ + V_{sp} ________ = V_p ________ acre-feet V_p

Principal spillway pool depth D_{sp} above sediment pool =

k ________ x V_{sp} ________ $^{t\_\_\_\_}$ = D_{sp} ________ ft D_{sp}

Elevation of principal spillway crest E_p =

E_s ________ + D_{sp} ________ = E_p ________ feet E_p

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(Conduit/riser only) Elevation of dewatering orifice E_o =

(E_s ________ + E_p ________)/2 = E_o ________ ft E_o

Storage volume between orifice and principal spillway crest V_{op} =
(Use V_{op} = 0 for trickle tubes)

V_{sp} ________ x $[1.0 - 0.5^{1/t}]$ ________ = V_{op} ________ acre-feet V

(Table 2)

EMERGENCY SPILLWAY POOL

Estimated storage volume V^*_{se} between top of sediment pool and emergency

spillway = V_{sp} ________ x $[1.0/(0.5^{1.0/t})]$ ________ (Table 2) = V^*_{se} ________ ac-ft | V^*_{se}

Depth D^*_{se} corresponding to estimated V^*_{se} =

k ________ x V^*_{se} ________ ^{t} ____ = D^*_{se} ____________ feet | D^*_{se}

Estimated storage volume V^*_{pe} above principal spillway =

V^*_{se} ________ - V_{sp} ________ = V^*_{pe} ____________ acre-ft | V^*_{pe}

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Initial storage/inflow volume ratio R^*_v =

V^*_{pe} ________ $/(Q^{10}_{vi}$ ________ - V_{op} ________) = R^*_v ________ | R^*_v

Take R^*_v to Figure 16 or 17, get initial outflow/inflow discharge ratio =

R^*_q ________ | R^*_q

Estimated peak outflow Q^*_{po} = R^*_q ______ x Q^{10}_{pi} ______ = Q^*_{po} ______ cfs | Q^*_{po}

For conduit/riser spillways, elevation difference between conduit outlet invert

and riser crest = H_{ic} ____________ feet. Use H_{ic} = 0 for trickle tubes. | H_{ic}

Head on principal spillway H^*_p =

D^*_{se} ________ - D_{sp} ________ + H_{ic} ________ = H^*_p ________ feet | H^*_p

Find intersection of H^*_p and Q^*_{po} in Figure 19 or 20. Read left to next

pipe spillway size. Selected pipe spillway size = S_d ____________ inches | S_d

Peak conduit outflow Q^{10}_{po} at head H^*_p from Figure 19 or 20 = Q^{10}_{po} ________ cfs | Q^{10}_{po}

Final outflow/inflow discharge ratio $R_q^{10} = Q_{po}^{10}$ ______ / Q_{pi}^{10} ______ $= R_q^{10}$ ______ | R_q^{10}

Final storage/inflow volume ratio from Figure 16 or 17 = R_v^{10} __________ | R_v^{10}

Final storage volume V_{pe} between principal and emergency spillways =

R_v^{10} ________ x (Q_{vi}^{10} _________ - V_{op} _________) = V_{pe} __________ acre-ft | V_{pe}

Final depth D_{se} from sediment pool to emergency spillway =

k _______ x (V_{sp} _______ + V_{pe} _______)$^{t\_\_\_\_}$ = D_{se} ____________ feet | D_{se}

Final elevation at emergency spillway E_e =

E_s _________ + D_{se} _________ = E_e ________ feet | E_e

Final pond volume at emergency spillway V_e = V_s __________ +

V_{sp} __________ + V_{pe} __________ = V_e __________ acre-feet | V_e

EMERGENCY SPILLWAY DESIGN

Side Slopes z = __________ (zH:1.0V) | z

Q_{vi}^{25} _________ - Q_{vi}^{10} _________ = ΔQ_{vi} _____________ acre-feet | ΔQ_{vi}

Q_{pi}^{25} _________ - Q_{pi}^{10} _________ = ΔQ_{pi} _____________ cfs | ΔQ_{pi}

Selected head on emergency spillway = H_e _____________ ft | H_e

Select a value of H_e which gives acceptable spillway bottom widths.
H_e between 0.5 and 1.0 will work well in many cases.

Pond volume V_{25} at maximum water surface elevation $= [(D_{se}$ ________ +

H_e ________)/k ________ $]^{1.0/t}$ ______ + V_s ________ = V_{25} ________ ac-ft | V_{25}

Volume ratio R_v^{25} = (V_{25} ________ − V_e ________)/ ΔQ_{vi} ________ = R_v^{25} ________ | R_v^{25}

Take volume ratio R_v^{25} to Figure 22, get discharge ratio = R_q^{25} ________ | R_q^{25}

Routed emergency spillway discharge Q_{eo} =

ΔQ_{pi} ________ x R_q^{25} ________ = Q_{eo} ________ cfs | Q_{eo}

Take H_e to Figure 23, get discharge for triangular part of emergency

spillway = Q_{tr} ________ cfs | Q_{tr}

Take H_e to Figure 24, get discharge per foot of width in rectangular

part of emergency spillway = Q_b ________ cfs/ft | Q_b

Spillway bottom width BW =

(Q_{eo} ________ − Q_{tr} ________)/Q_b ________ = BW ________ ft | BW

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Principal Spillway Discharge Q_{po}^{25}

Head on principal spillway H_p^{25} =

Conduit/riser: H_{ic} ______ + D_{se} ______ − D_{sp} ______ + H_e ______ = H_p^{25} ______ ft | H_p^{25}

Trickle tube: D_{se} ______ − D_{sp} ______ + H_e ______ = H_p^{25} ______ ft

From Figure 19 or 20 , discharge = Q_{po}^{25} ________ cfs | Q_{po}^{25}

Combined Discharge for Principal and Emergency Spillways Q_{pe} =

Q_{eo} ________ + Q_{po}^{25} ________ = Q_{pe} ________ cfs | Q_{pe}

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Structure Height from Upstream Toe of Embankment to

Crest of Emergency Spillway = SH_{te} ____________ ft

Structure Volume Impounded from Upstream Toe of Embankment to Crest of Emergency Spillway = V_{te} ________ acre-feet

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Elevation of Top of Dam E_t =

elevation at centerline base of dam ________ ft. + 1.05 x (embankment height from centerline base of dam to emergency spillway crest ________ ft. + H_e ________ ft. + freeboard, 1 ft. minimum ________ ft.) = E_t ____________ ft.

SH_{te}

V_{te}

E_t

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SUMMARY OF SEDIMENT POND DESIGN
EMBANKMENT POND

	assumed elevation (if used)	msl elevation
Sediment pool elevation, E_s	____________ ft.	____________ ft.
Dewatering orifice elevation, E_o	____________ ft.	____________ ft.
Principal spillway elevation, E_p	____________ ft.	____________ ft.
Emergency spillway elevation, E_e	____________ ft.	____________ ft.
Top of dam elevation, E_t	____________ ft.	____________ ft.

Sediment pool volume, V_s	____________ ac-ft.
Principal spillway size, S_d	____________ in.
Total volume at principal spillway, V_p	____________ ac-ft.
Total volume at emergency spillway, V_e	____________ ac-ft.
Structure height at emergency spillway, SH_{te}	____________ ft.
Structure volume at emergency spillway, V_{te}	____________ ac.-ft.
Emergency spillway side slopes, zH:1V	____________ z
Emergency spillway bottom width, BW	____________ ft.

EXCAVATED POND DESIGN WORKSHEET

Kentucky Graphical Method for Trapezoidal Open Spillways

Application No. ______________________ Pond No. ____________________

WATERSHED HYDROLOGY

	Key
Total disturbed area A_d __________ acres / Drainage area A_w __________ acres x 100 = Total % disturbed P_d ________ %	A_d A_w P_d
Hydraulic length of watershed = L_h ____________ feet	L_h
Elevation at the most remote point in pond watershed (upstream point for hydraulic length) = E_u _________ ft	E_u
Watershed elevation at sediment pond (downstream point for hydraulic length) = E_d ___________ ft	E_d
Average watershed slope S_w along the hydraulic length = 100 x (E_u _________ - E_d _________)/L_h _________ = S_w ___________ %	S_w
Watershed slope-length factor F_s = L_h _______/(S_w _______)$^{0.5}$ = F_s __________	F_s
Unit peak runoff from Figure 1 = q_u ____________ cfs/acre-inch, weighted for __________ % forest and ___________ % grassland	q_u
Premining unit peak runoff (weighted) from Figure 1 (P_d usually = 0%) = q_u^{pm} __________ cfs/acre-inch	q_u^{pm}

* * * * * * * * * * * * * * * * * * *

10-year, 24-hour rainfall from Table 1 = P_{10} ________ inches — P_{10}

10-year, 24-hour runoff (weighted) from Figure 2 = Q_{10} ________ inches — Q_{10}

10-year, 24-hour inflow volume to pond Q_{vi}^{10} =

Q_{10} ________ x A_w ________ /12 = Q_{vi}^{10} ________ acre-feet — Q_{vi}^{10}

10-year, 24-hour peak inflow to pond Q_{pi}^{10} = q_u ________ x Q_{10} ________

x A_w ________ = Q_{pi}^{10} ________ cfs — Q_{pi}^{10}

* * * * * * * * * * * * * * * * * * *

25-year, 24-hour rainfall from Table 1 = P_{25} ________ inches — P_{25}

25-year, 24-hour runoff (weighted) from Figure 2 = Q_{25} ________ inches — Q_{25}

25-year, 24-hour inflow volume to pond Q_{vi}^{25} =

Q_{25} ________ x A_w ________ /12 = Q_{vi}^{25} ________ acre-feet — Q_{vi}^{25}

25-year, 24-hour peak inflow to pond Q_{pi}^{25} = q_u ________ x Q_{25} ________

x A_w ________ = Q_{pi}^{25} ________ cfs — (

Premining 25-year, 24-hour runoff (weighted) to pond site from Figure 2, Q_{25}^{pm}

(P_d usually = 0%) = Q_{25}^{pm} ________ inches — Q_{25}^{pm}

Premining 25-year, 24-hour peak inflow to pond site Q_{pi}^{pm} =

q_u^{pm} ________ x Q_{25}^{pm} ________ x A_w ________ = Q_{pi}^{pm} ________ cfs — Q_{pi}^{pm}

SEDIMENT STORAGE VOLUME

Minimum sediment storage = 0.075 x A_d ________ = ________ acre-feet

Design sediment storage used = V_s ________ acre-feet — V_s

STAGE-VOLUME RELATIONSHIP

Throughout this design method, relative elevations, rather than msl elevations, should be used in the computations. Any consistent datum for relative elevations can be used. When all computations are completed, the relative elevations can be converted to msl elevations on the summary sheet.

The incremental stage-volume relationship above the sediment pool is described by equation $\Delta E = k(\Delta V)^t$. At the designer's option, t and k may be taken directly from Figures 3 and 4 for excavated ponds which are trapezoidal in cross-section. Select the pond width W_s ________ ft. at the sediment pool, and the pond side slopes Z_d ________:1. Then the pond length at the sediment pool = $2W_s + 10Z_d = L_s$ ________ft. Read t and k from Figures 3 and 4 and enter t and k below. | W_s Z_d L_s

For pond cross-sections other than trapezoidal, or at the designer's option, pick points (E_1, V_1) and (E_2, V_2) directly from the stage-volume curve. The pond should have a minimum length/average width ratio of 2:1, where length and average width are measured at the elevation of the open spillway crest. Pick E_1 approximately 2 ft. above the sediment pool, near the open spillway crest elevation. Pick E_2 approximately 5 ft. above the sediment pool, near the maximum 10-year, 24-hour water surface elevation.

Relative elevation E_s of top of sediment pool = E_s ________ feet | E_s

$t = \log[(E_1 - E_s)/(E_2 - E_s)]/\log[(V_1 - V_s)/(V_2 - V_s)]$

$t = \log[(E_1$ ________ $- E_s$ ________$)/(E_2$ ________ $- E_s$ ________$)]/$

$\log[(V_1$ ________ $- V_s$ ________$)/(V_2$ ________ $- V_s$ ________$)]$ | E_1 E_2 V_1 V_2

t = ________ (calculated) or t = ________ (from Figure 3) | t

$k = (E_2 - E_s)/(V_2 - V_s)^t$

$k = (E_2$ ________ $- E_s$________$)/(V_2$________ $- V_s$________$)^t$ ________

k = ________ (calculated) or k = ________ (from Figure 4) | k

VOLUME AND ELEVATION AT OPEN SPILLWAY CREST

Find adjusted % disturbed area P_a at time of maximum disturbance:

Percent of disturbed area unrevegetated P_0 ____________% P_0

Percent with revegetation 0 - 2 months old P_{0-2} ____________% P_{0-2}

Percent with revegetation 2 - 12 months or older P_{2-12} ____________% P_{2-12}

($P_0 + P_{0-2} + P_{2-12} = 100\%$)

Adjusted % disturbed P_a from Figure 5 = P_a _________% P_a

Disturbance factor F_d from Figure 6 = F_d _________% F_d

Spillway pool volume V_{sp}^{10} for runoff volume of 10 acre-feet from Figure 9

= V_{sp}^{10} ________acre-feet V_{sp}^{10}

From Figure 14, factor a to adjust V_{sp}^{10} for actual inflow volume Q_{vi}^{10} =

a _________ a

From Figure 15, factor b to adjust V_{sp}^{10} = b _________ b

Volume V_{sp} between sediment pool and open spillway crest, adjusted for

actual inflow volume Q_{vi}^{10} =

V_{sp}^{10} _________ + [a _________ x (Q_{vi}^{10} _________ - 10)^2]

+ [b ________ x (Q_{vi}^{10} ________ - 10)] = V_{sp} ________ acre-ft

V_{min} = 0.15 x (Q_{vi}^{10} _______)$^{0.25}$ = V_{min} _________ acre-feet V_{min}

If V_{sp} is less than V_{min} then set $V_{sp} = V_{min}$

Final V_{sp} ___________ acre-feet V_{sp}

Total pond volume V_p at open spillway crest =

V_s _________ + V_{sp} _________ = V_p _________ acre-feet V_p

Depth D_{sp} between open spillway crest and sediment pool =

k ________ x (V_{sp} ________)$^{t\_\_\_\_}$ = D_{sp} ________ ft ($D_{sp} \geq$ 1.5 ft.) | D_{sp}

Relative elevation of open spillway crest E_p =

E_s ________ + D_{sp} ________ = E_p ________ | E_p

LENGTH AND WIDTH OF POND

Ponds with Trapezoidal Cross Section

When t and k have been determined from Figures 3 and 4, use this calculation to determine W_p and L_p. This insures a ratio of $L_p/W_p \geq$ 2:1 for all $1.5 \leq D_{sp} \leq 5$. When t and k have been calculated from a stage-volume curve, determine W_p and L_p for the pond site and enter at other pond configurations below.

Width of pond W_p at open spillway crest elevation =

W_s ________ + (2 x Z_d ________ x D_{sp} ________) = W_p ________ ft | W_p

Length of pond L_p at open spillway crest elevation =

2 x W_s ________ + 10 x Z_d ________ + (2 x Z_d ________ x D_{sp} ________)

= L_p ________ ft | L_p

Other Pond Configurations

W_p ________ ft

L_p ________ ft

($L_p/W_p \geq 2.0$)

OPEN SPILLWAY SIDE SLOPES AND BOTTOM WIDTH

Storage volume V_{s10} between top of sediment pool and

10-year, 24-hour water surface = V_{sp} ________ x [1.0/(0.4$^{1.0/t}$)] ________ (Table 3) = | V_{s10}

V_{s10} ________ acre-feet

Depth D_{s10} corresponding to V_{s10} =

k ________ x V_{s10} ________^{t____} = D_{s10} ________ feet | D_{s10}

Storage volume V_{p10} between open spillway crest and

10-year, 24-hour water surface = V_{s10} ________ - V_{sp} ________ =

V_{p10} ____________ acre-ft | V_{p10}

* * * * * * * * * * * * * * * * * *

Storage/inflow volume ratio R_v^{10} =

V_{p10} ________ $/Q_{vi}^{10}$ ________ = R_v^{10} ________ | R_v^{10}

Take R_v^{10} to Figure 18, get initial outflow/inflow discharge ratio = R_q^{10} ________ | R_q^{10}

Peak outflow Q_{po}^{10} = R_q^{10} ______ x Q_{pi}^{10} ______ = Q_{po}^{10} ______ cfs | Q_{po}^{10}

Head on open spillway H_{10} =

D_{s10} ______ - D_{sp} ______ = H_{10} ________ feet | H_{10}

Find intersection of H_{10} and Q_{po} in Figure 21. Select side slopes

z ______ H:1V, and round bottom width to nearest 0.5 foot = | z

BW ________ ft | BW

25-YEAR, 24-HOUR ROUTED DISCHARGE IN OPEN SPILLWAY

Assume R_q^{25} = R_q^{10} = R_q^{25} ________ | R_q^{25}

Peak outflow Q_{po}^{25} = R_q^{25} ________ x Q_{pi}^{25} ________ = Q_{po}^{25} ____________ cfs | Q_{po}^{25}

Take Q_{po}^{25} and BW to Figure 21, get head on open spillway = H_{25} ____________ ft | H_{25}

(H_{25} + 1.0) must not exceed 5.0 feet.

ELEVATION OF TOP OF DIKE E_t =

E_p ________ ft. + H_{25} ________ ft. + freeboard,

1 ft. minimum ________ ft.) = E_t ____________ ft. | I

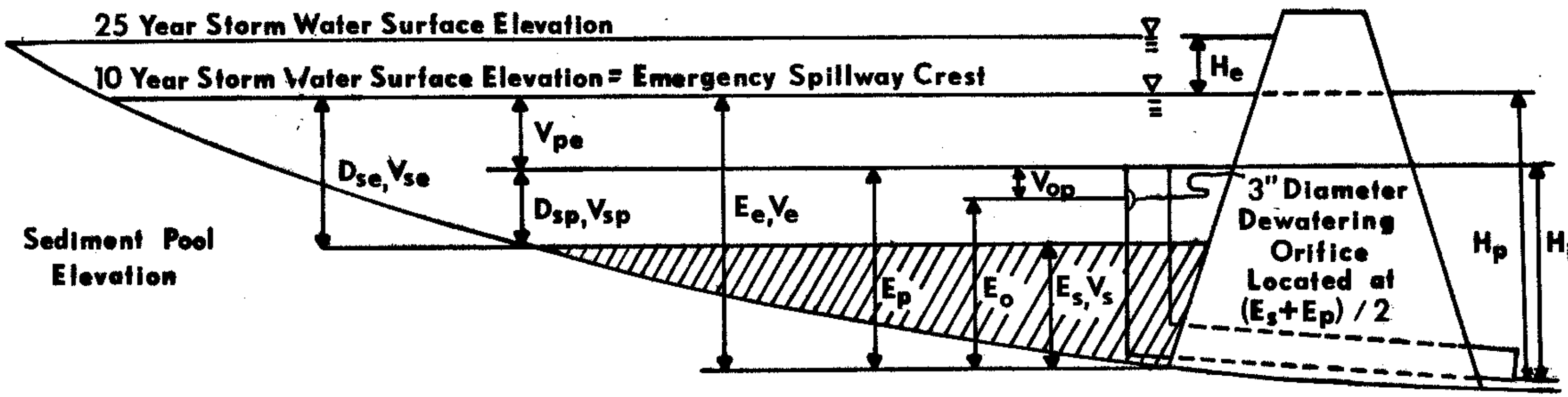
SUMMARY OF SEDIMENT POND DESIGN
EXCAVATED POND

	relative elevation	msl elevation
Lowest point in natural ground, E_{ng}		______________ ft.
Sediment pool elevation, E_s	______________ ft.	* ______________ ft.
Open spillway crest elevation, E_p	______________ ft.	* ______________ ft.
Top of dike elevation, E_t	______________ ft.	* ______________ ft.

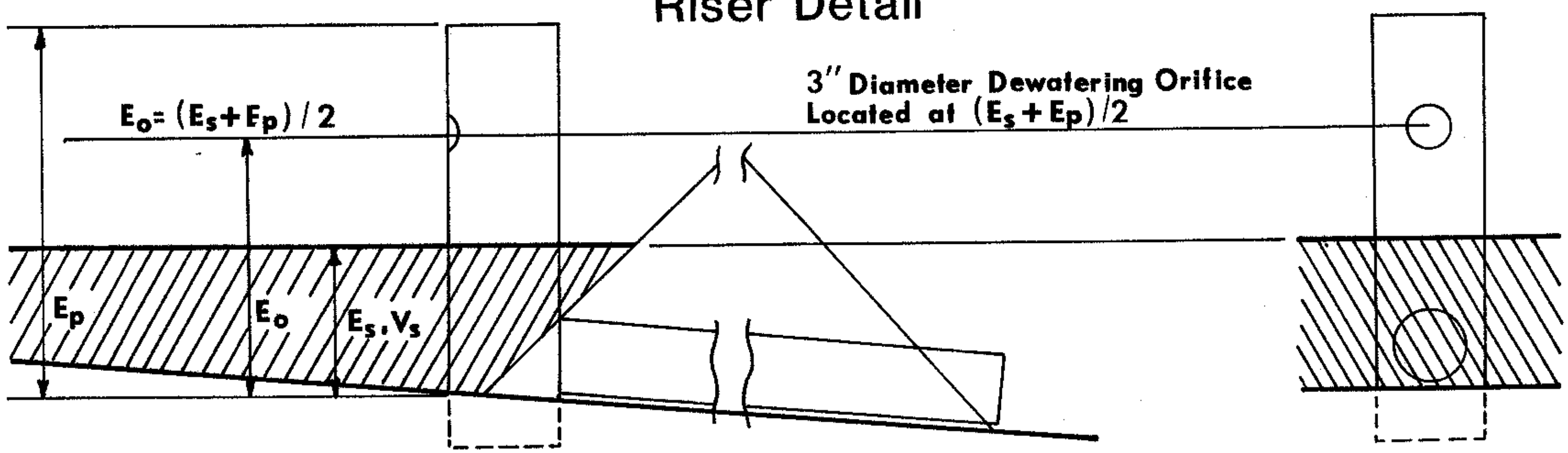
*This design procedure uses relative elevations to determine the necessary size and shape of the basin to be excavated. That basin is then "fitted into" the natural ground at the site. The actual msl elevations for the excavated pond and dike are determined from the relative elevations by matching the relative elevation E_p of the open spillway crest to the actual msl elevation E_{ng} of the lowest point in the natural ground surface at the spillway site. The msl elevations corresponding to relative elevations E_s, E_p, and E_t are determined by adding the quantity ($E_{ng} - E_p$) to the relative elevations E_s, E_p, and E_t.

Sediment pool volume, V_s	______________ ac-ft.
Total volume at open spillway crest, V_p	______________ ac-ft.
Open spillway side slopes, zH:1V	______________ z
Open spillway bottom width, BW	______________ ft.
Pond side slopes, Z_d:1	______________ Z_d
Average width of pond, W_p	______________ ft.
Length of pond, L_p	______________ ft.

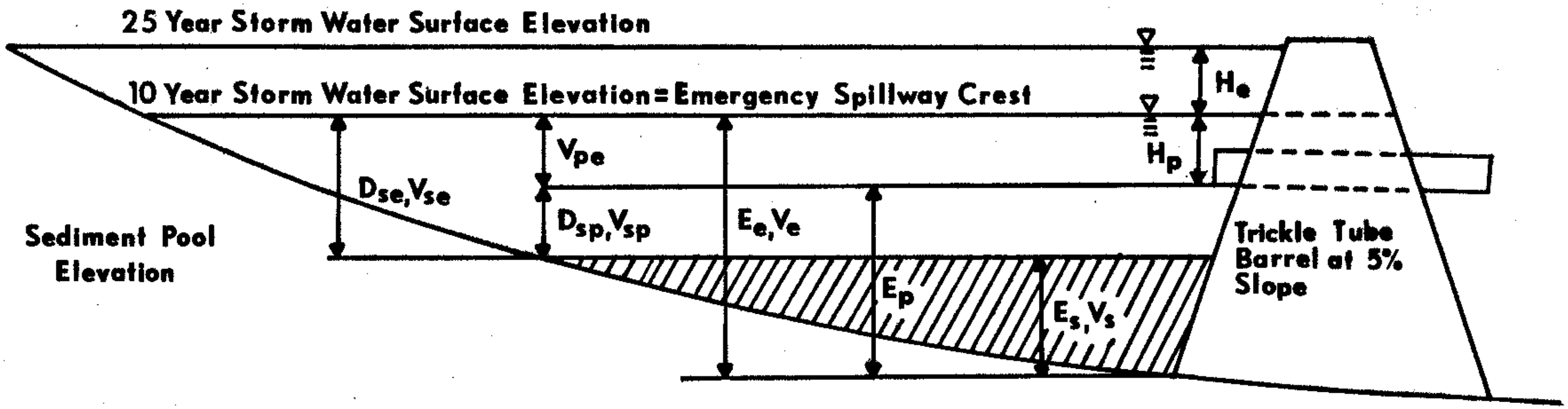
Definition Sketch for Conduit and Riser Principal Spillways



Riser Detail



Definition Sketch for Trickle Tube Principal Spillways



Definition Sketch for Trapezoidal Open Spillways (Excavated Ponds)

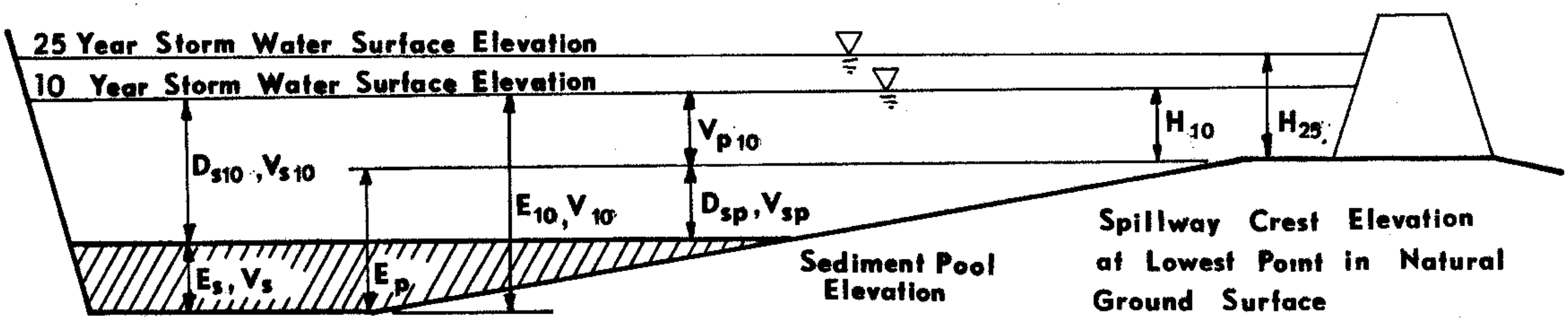


TABLE 1

10-Year and 25-Year, 24 Hour Rainfall Amounts

County	Frequency (Years) 10	25	County	Frequency (Years) 10	25
Adair	4.6	5.4	Graves	5.1	5.8
Allen	4.8	5.6	Grayson	4.7	5.5
Anderson	4.4	5.2	Green	4.6	5.4
Ballard	5.1	5.8	Greenup	4.0	4.6
Barren	4.7	5.5	Hancock	4.7	5.4
Bath	4.2	4.9	Hardin	4.6	5.3
Bell	4.5	5.2	Harlan	4.4	5.1
Boone	4.2	4.9	Harrison	4.2	5.0
Bourbon	4.3	5.0	Hart	4.6	5.4
Boyd	4.0	4.6	Henderson	4.8	5.5
Boyle	4.5	5.2	Henry	4.4	5.1
Bracken	4.2	4.9	Hickman	5.2	5.9
Breathitt	4.3	4.9	Hopkins	4.8	5.5
Breckinridge	4.6	5.4	Jackson	4.4	5.1
Bullitt	4.5	5.2	Jefferson	4.5	5.2
Butler	4.8	5.5	Jessamine	4.4	5.1
Caldwell	4.9	5.6	Johnson	4.1	4.7
Calloway	5.0	5.8	Kenton	4.2	4.9
Campbell	4.2	4.9	Knott	4.3	4.9
Carlisle	5.1	5.8	Knox	4.5	5.2
Carroll	4.3	5.1	Larue	4.6	5.3
Carter	4.0	4.7	Laurel	4.5	5.2
Casey	4.5	5.3	Lawrence	4.0	4.7
Christian	4.9	5.7	Lee	4.3	5.0
Clark	4.3	5.0	Leslie	4.4	5.0
Clay	4.4	5.1	Letcher	4.3	4.9
Clinton	4.7	5.5	Lewis	4.0	4.7
Crittenden	4.9	5.6	Lincoln	4.5	5.2
Cumberland	4.7	5.5	Livingston	4.9	5.7
Daviess	4.7	5.5	Logan	4.8	5.6
Edmonson	4.7	5.5	Lyon	4.9	5.7
Elliott	4.1	4.7	McCracken	5.0	5.8
Estill	4.3	5.0	McCreary	4.6	5.3
Fayette	4.3	5.1	McLean	4.8	5.5
Fleming	4.1	4.8	Madison	4.3	5.1
Floyd	4.2	4.8	Magoffin	4.2	4.8
Franklin	4.4	5.1	Marion	4.5	5.3
Fulton	5.2	5.9	Marshall	5.0	5.7
Gallatin	4.3	5.0	Martin	4.1	4.7
Garrard	4.4	5.2	Mason	4.1	4.8
Grant	4.2	5.0	Meade	4.6	5.3

Table 1 (continued)

County	Frequency (Years) 10	25	County	Frequency (Years) 10	25
Menifee	4.2	4.9	Rockcastle	4.4	5.2
Mercer	4.4	5.2	Rowan	4.1	4.8
Metcalfe	4.7	5.5	Russell	4.6	5.4
Monroe	4.7	5.6	Scott	4.3	5.1
Montgomery	4.2	5.0	Shelby	4.4	5.2
Morgan	4.1	4.8	Simpson	4.8	5.6
Muhlenberg	4.8	5.5	Spencer	4.5	5.2
Nelson	4.5	5.3	Taylor	4.6	5.3
Nicholas	4.2	4.9	Todd	4.9	5.6
Ohio	4.7	5.5	Trigg	5.0	5.7
Oldham	4.4	5.2	Trimble	4.4	5.1
Owen	4.3	5.1	Union	4.8	5.5
Owsley	4.3	5.0	Warren	4.8	5.5
Pendleton	4.2	4.9	Washington	4.5	5.2
Perry	4.3	5.0	Wayne	4.6	5.4
Pike	4.2	4.8	Webster	4.8	5.5
Powell	4.3	5.0	Whitley	4.5	5.3
Pulaski	4.5	5.3	Wolfe	4.2	4.9
Robertson	4.2	4.9	Woodford	4.4	5.1

TABLE 2

Function Evaluations for Conduit/Riser and Trickle Tube Spillways

Values of $[1/0.5^{1/t}]$

t	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	4.00	3.89	3.79	3.70	3.61	3.53	3.45	3.37	3.30	3.24
0.6	3.17	3.11	3.05	3.00	2.95	2.90	2.86	2.81	2.77	2.73
0.7	2.69	2.65	2.62	2.58	2.55	2.52	2.49	2.46	2.43	2.40
0.8	2.38	2.35	2.33	2.31	2.28	2.26	2.24	2.22	2.20	2.18
0.9	2.16	2.14	2.12	2.11	2.09	2.07	2.06	2.04	2.03	2.01
1.0	2.00									

Values of $[1-0.5^{1/t}]$

t	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	.750	.743	.736	.730	.723	.716	.710	.704	.697	.691
0.6	.685	.679	.673	.667	.661	.656	.650	.645	.638	.634
0.7	.629	.623	.618	.613	.608	.603	.598	.594	.589	.584
0.8	.580	.575	.571	.566	.562	.558	.553	.549	.545	.541
0.9	.537	.533	.529	.525	.522	.518	.514	.511	.507	.503
1.0	.500									

TABLE 3

Function Evaluations for Trapezoidal Open Spillways

Values of $[1/0.4^{1/t}]$

t	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.5	6.25	6.03	5.82	5.63	5.46	5.29	5.14	4.99	4.85	4.73
0.6	4.61	4.49	4.38	4.28	4.19	4.09	4.01	3.93	3.85	3.77
0.7	3.70	3.63	3.57	3.51	3.45	3.39	3.34	3.29	3.24	3.19
0.8	3.14	3.10	3.06	3.02	2.98	2.94	2.90	2.87	2.83	2.80
0.9	2.77	2.74	2.71	2.68	2.65	2.62	2.60	2.57	2.55	2.52
1.0	2.50									

TABLE 4

Minimum Head for Full Pipe Flow

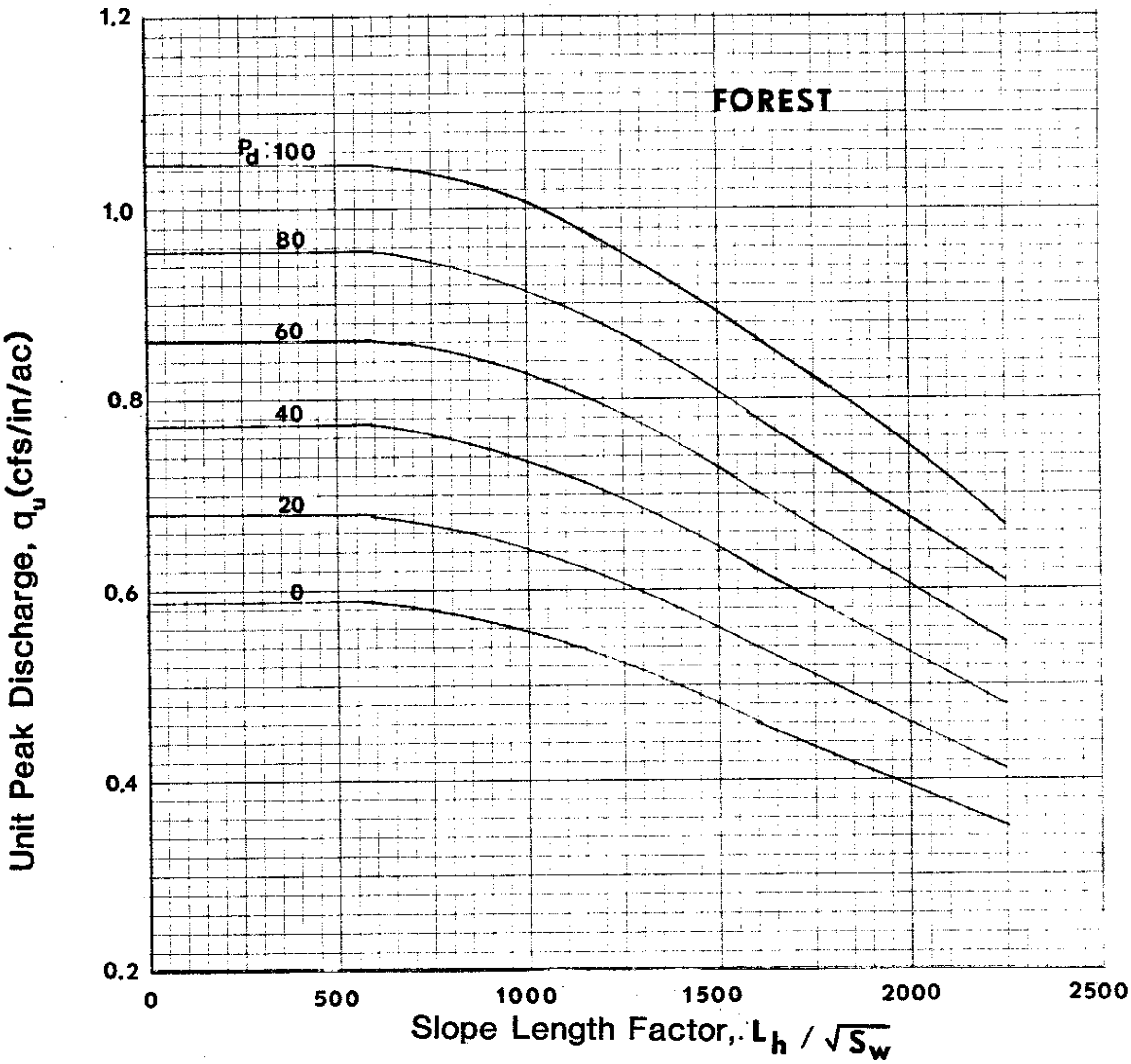
Conduit and Riser

Diameter(1) (in)	H_m (2) (ft)
12 C - 18 R	0.6
15 C - 24 R	0.7
18 C - 30 R	0.8
24 C - 36 R	1.1
30 C - 42 R	1.6

Trickle Tube

Diameter (in)	H_m (2) (ft)
12	1.4
15	2.0
18	2.5
24	3.1
30	4.0

(1) 12 C - 18 R = 12" conduit and 18" riser
(2) H_m = Head above the riser crest or trickle tube invert, (ft.)



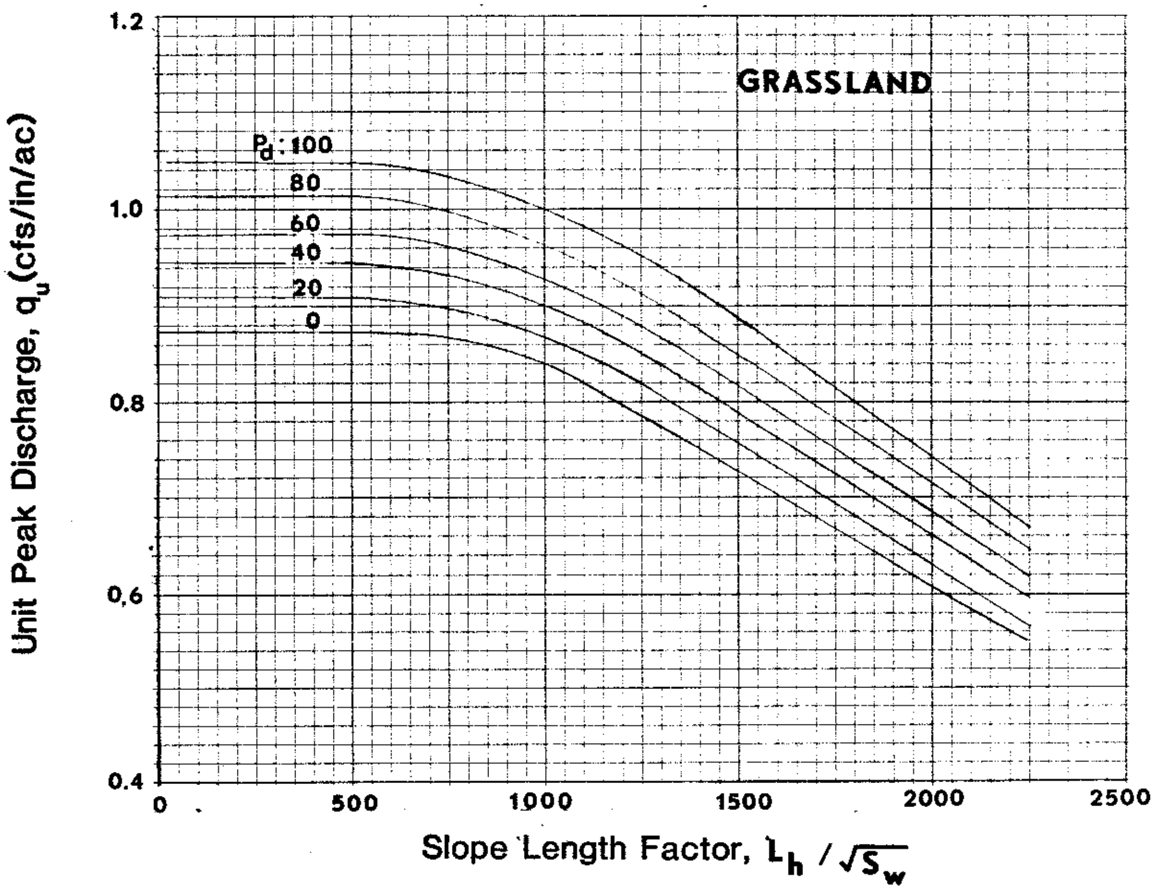
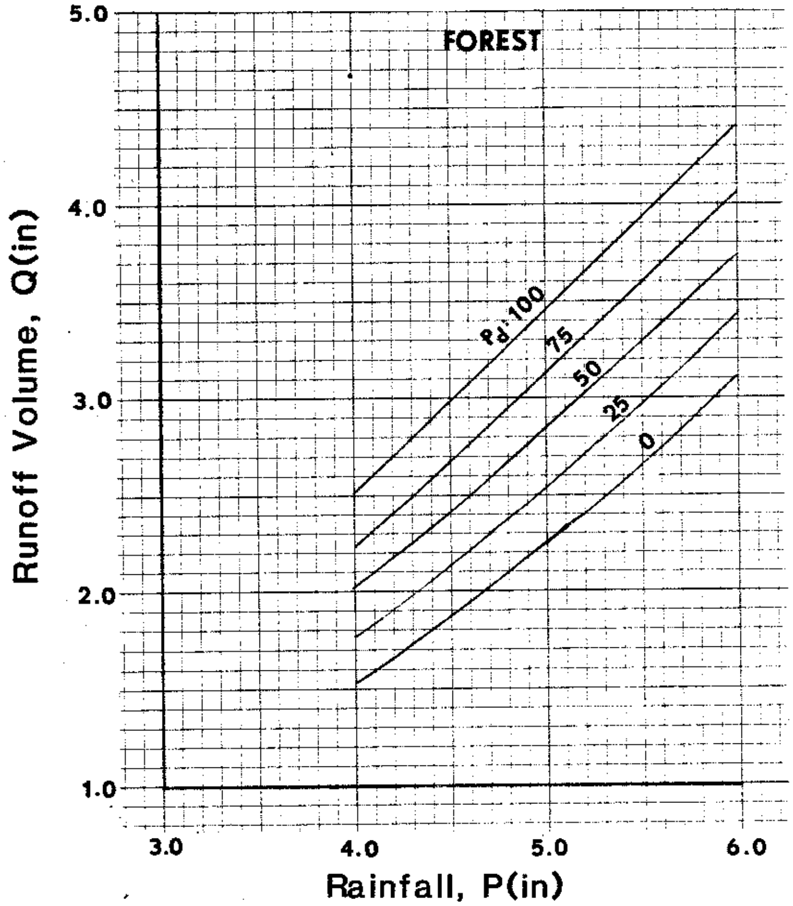


Figure 1 Unit Peak Discharge



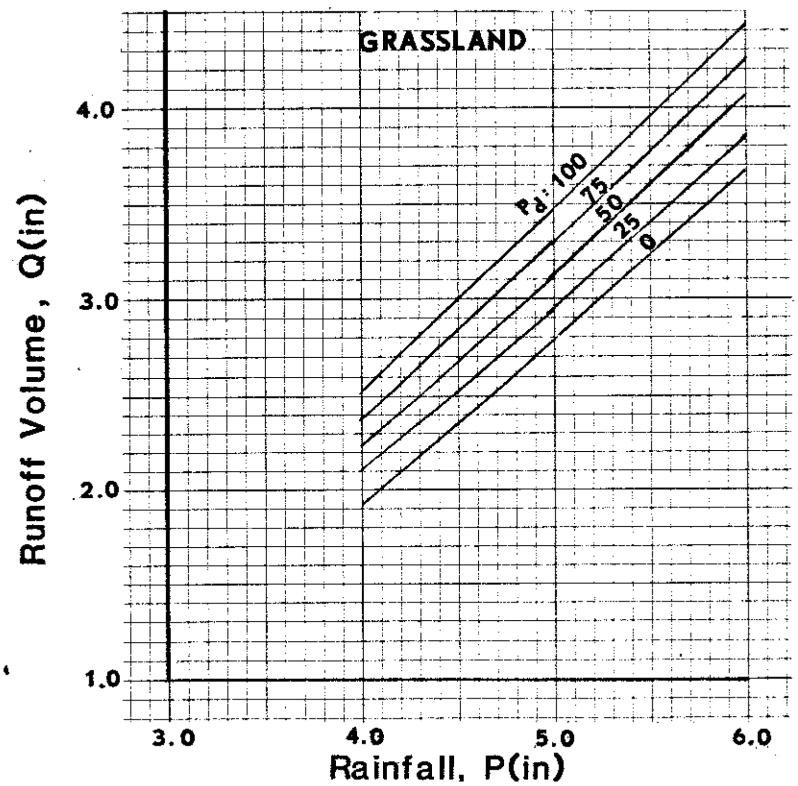


Figure 2 Rainfall runoff relationship.

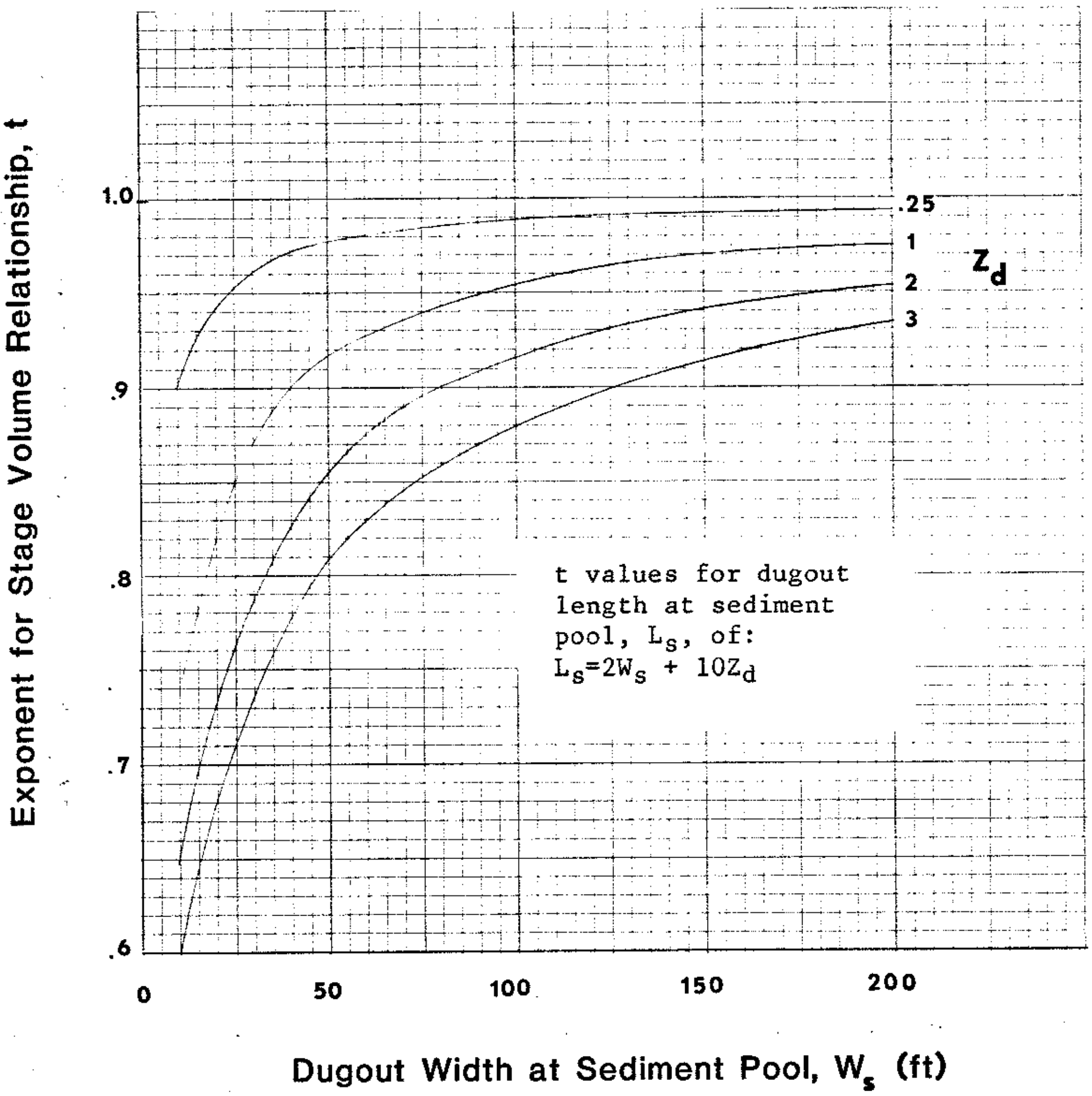


Figure 3 t values for excavated ponds with trapezoidal open spillways.

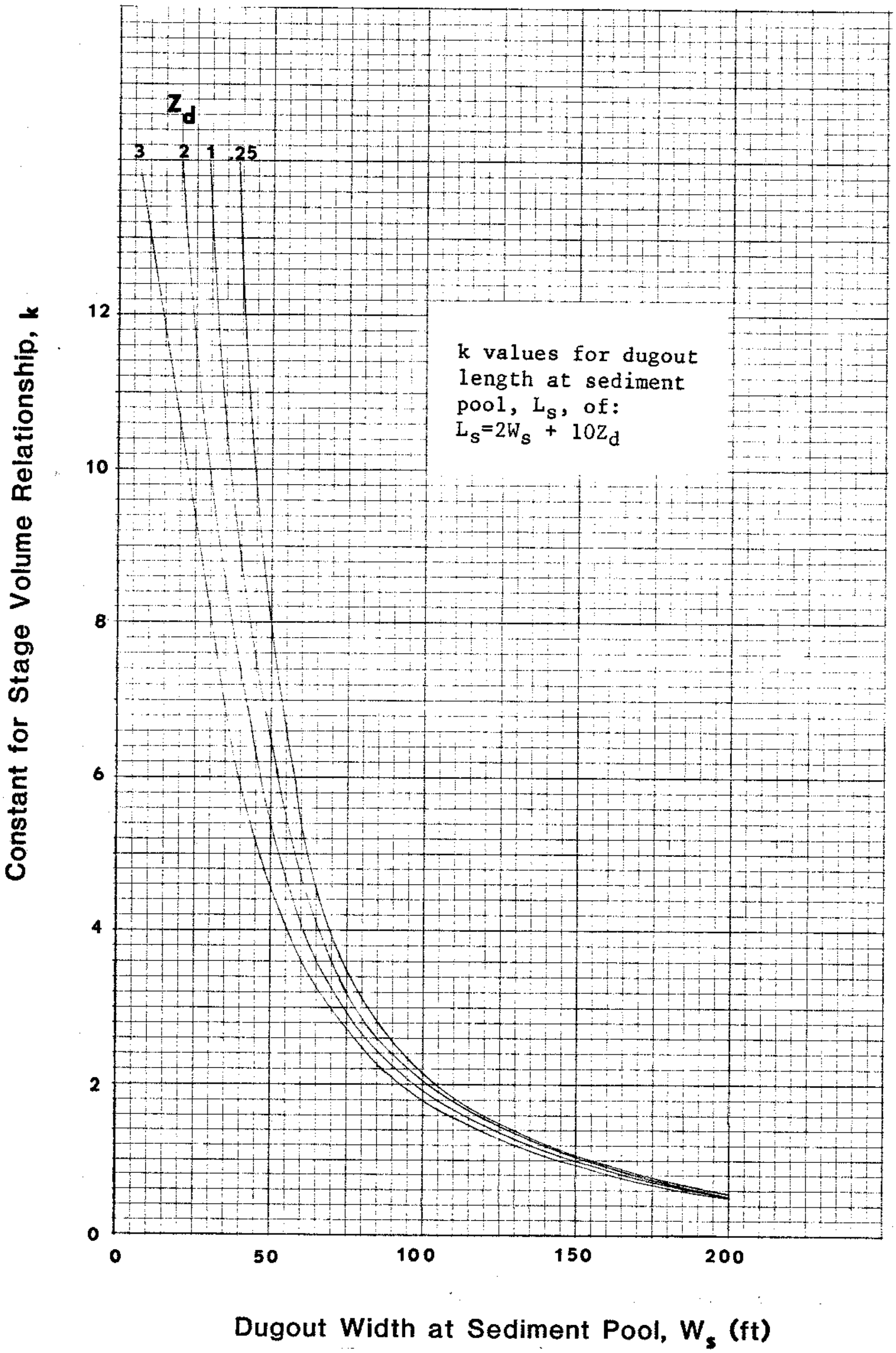
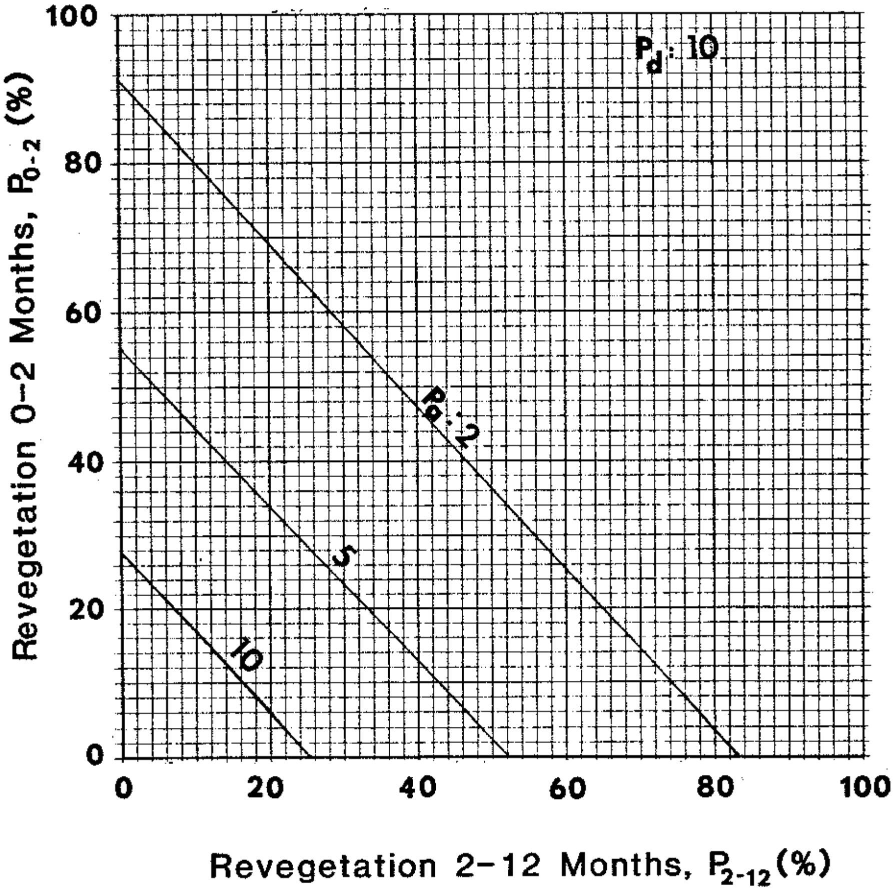


Figure 4 k values for excavated ponds with trapezoidal open spillways.



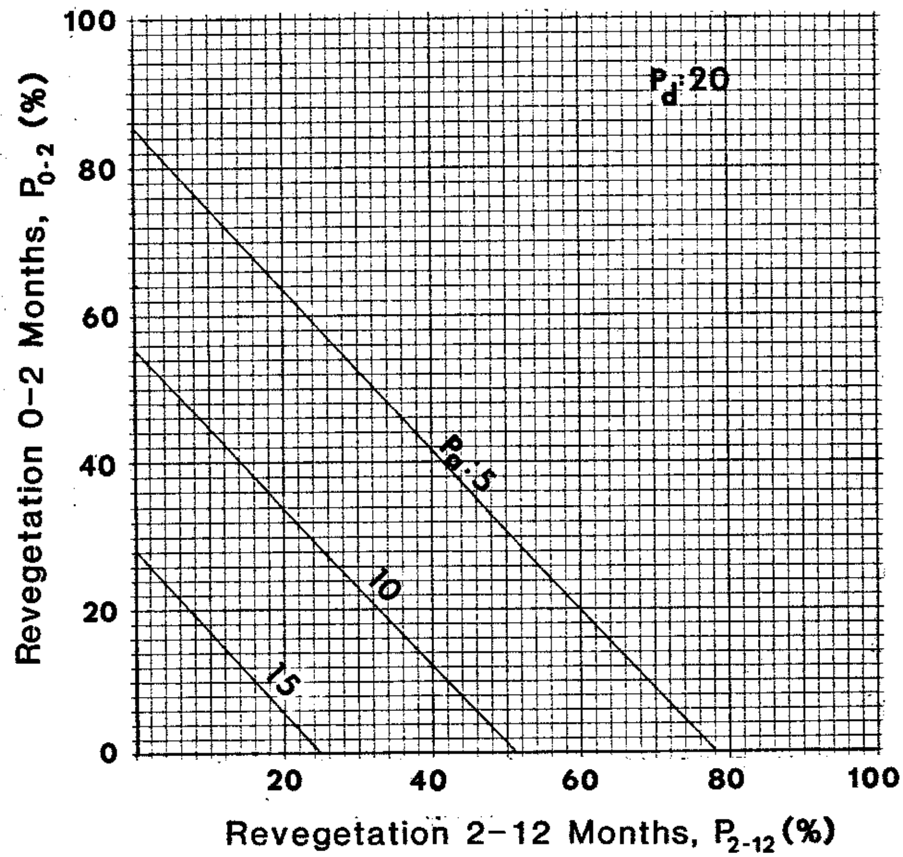
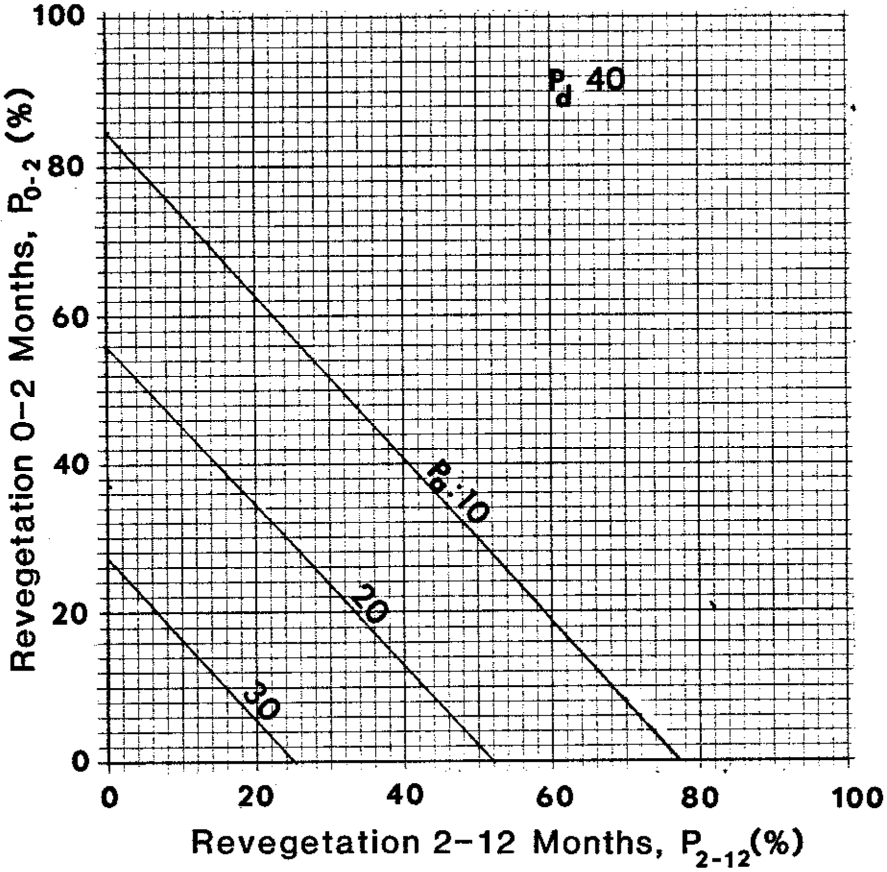


Figure 5 Percent disturbed adjusted for partial revegetation.



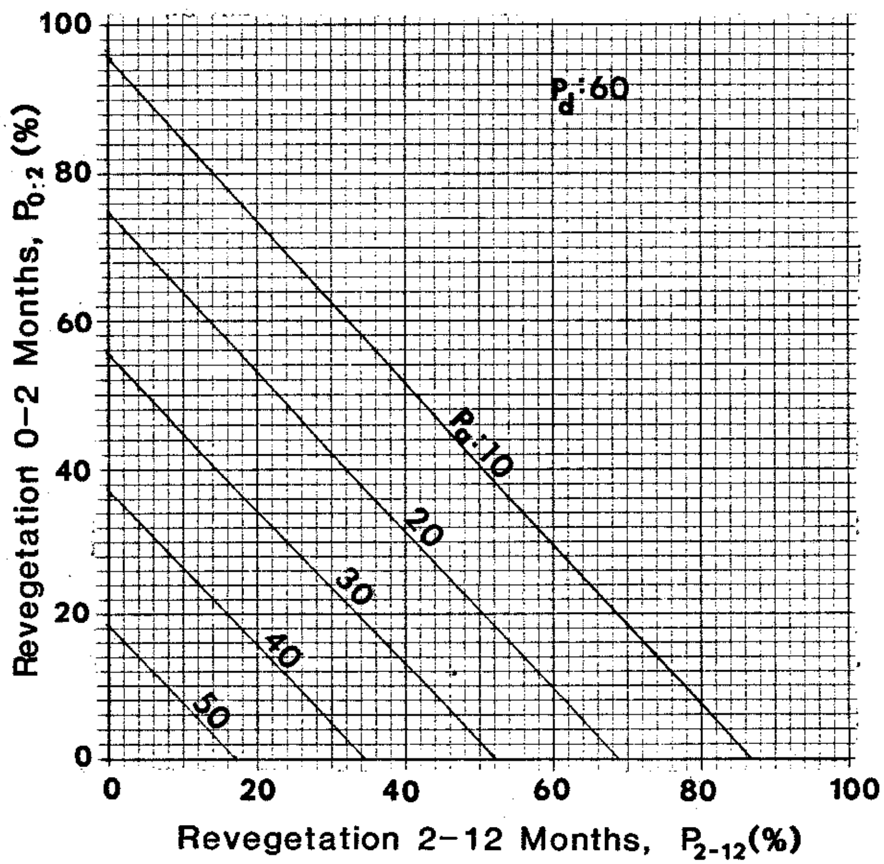
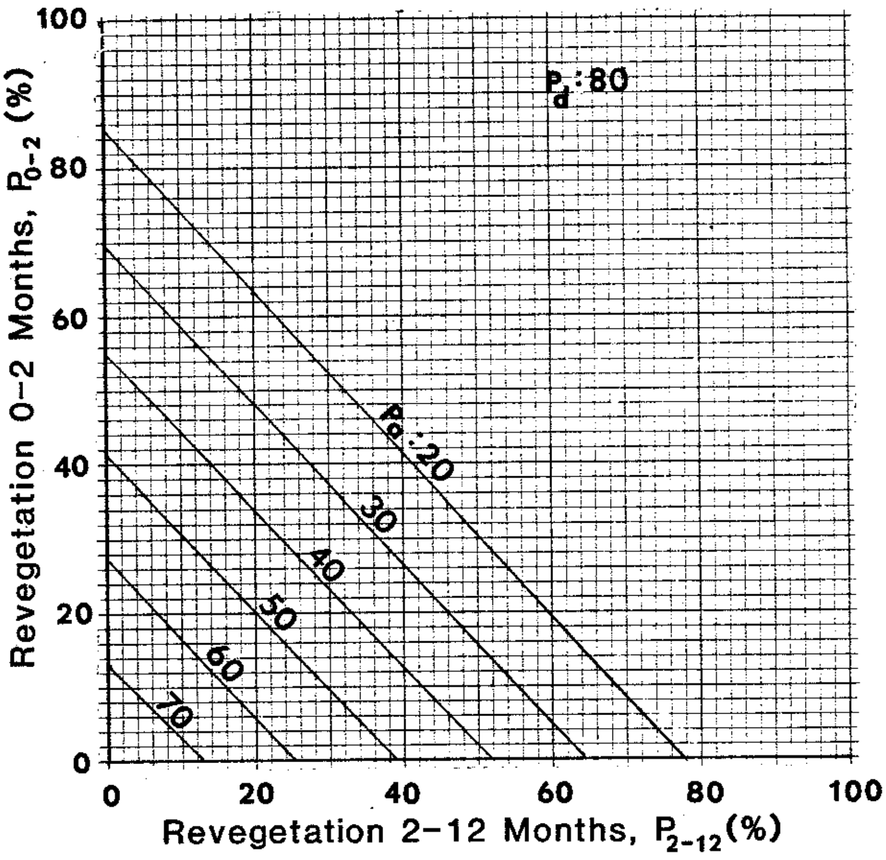


Figure 5 Continued.



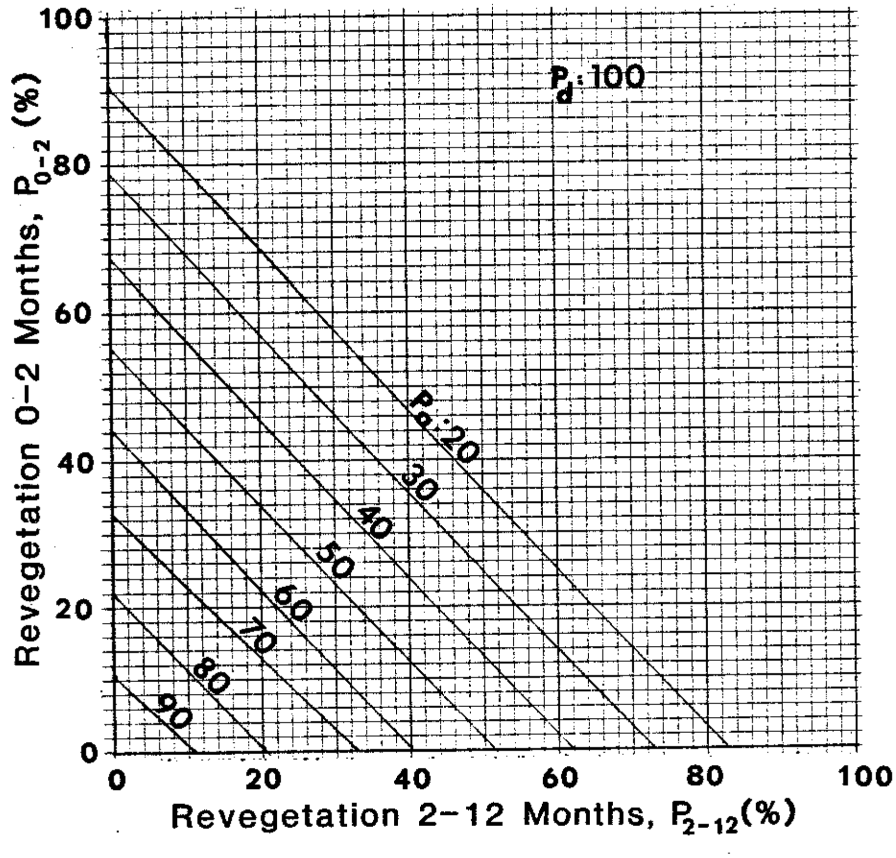


Figure 5 Continued.

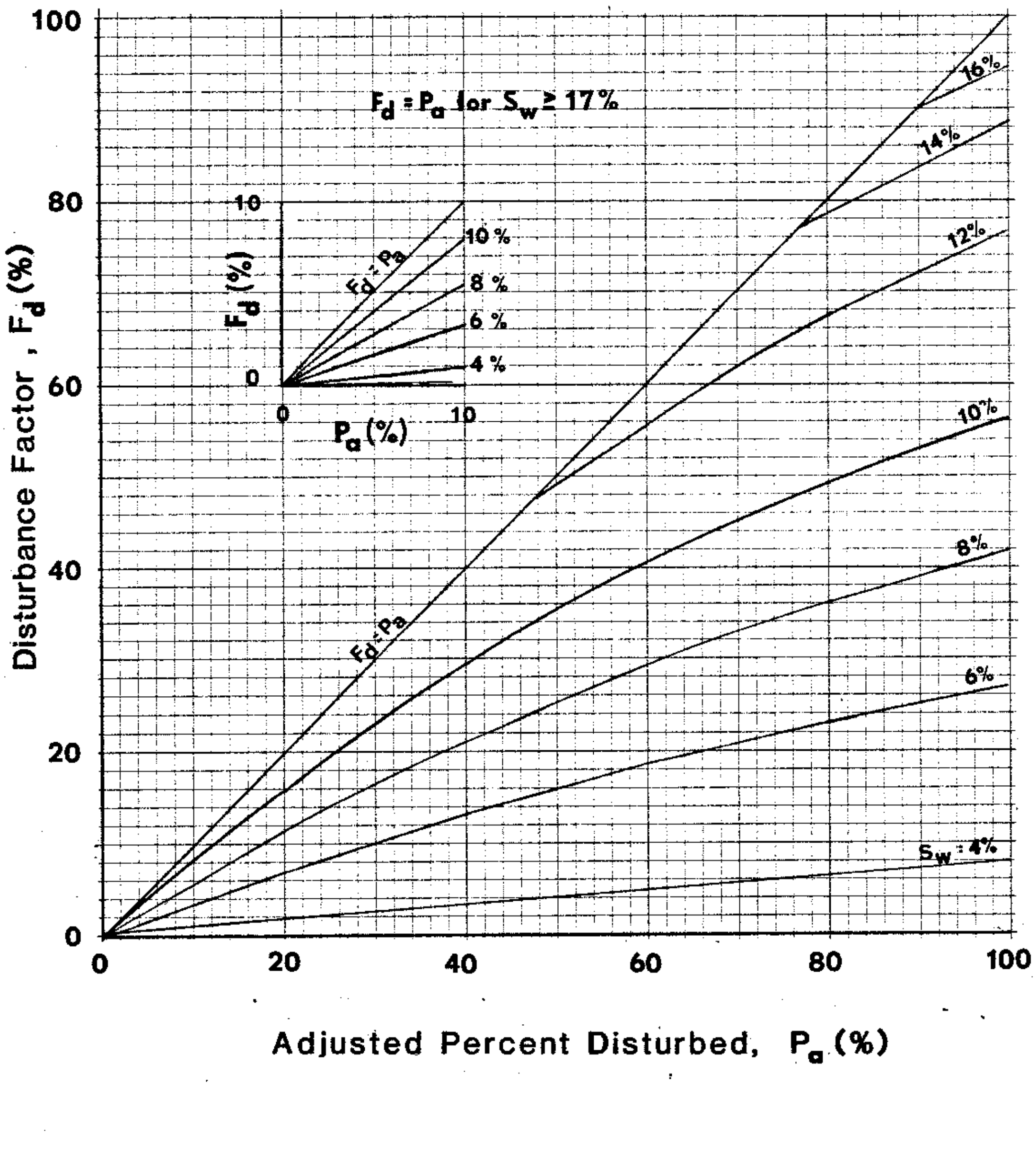
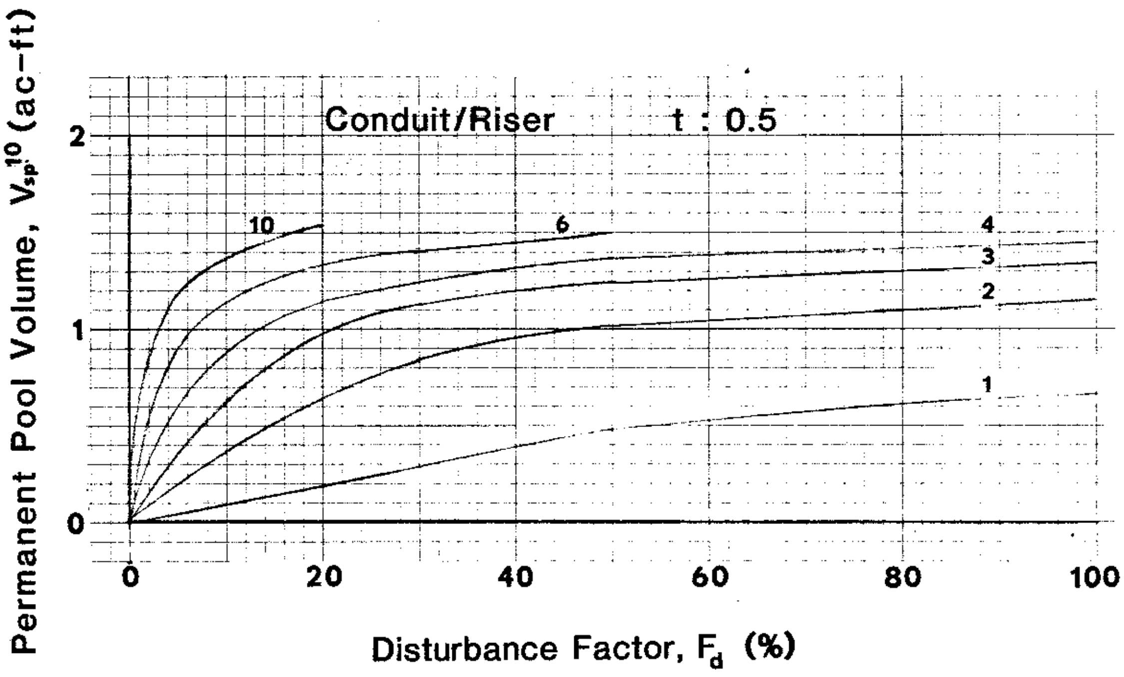


Figure 6 Disturbance factor.



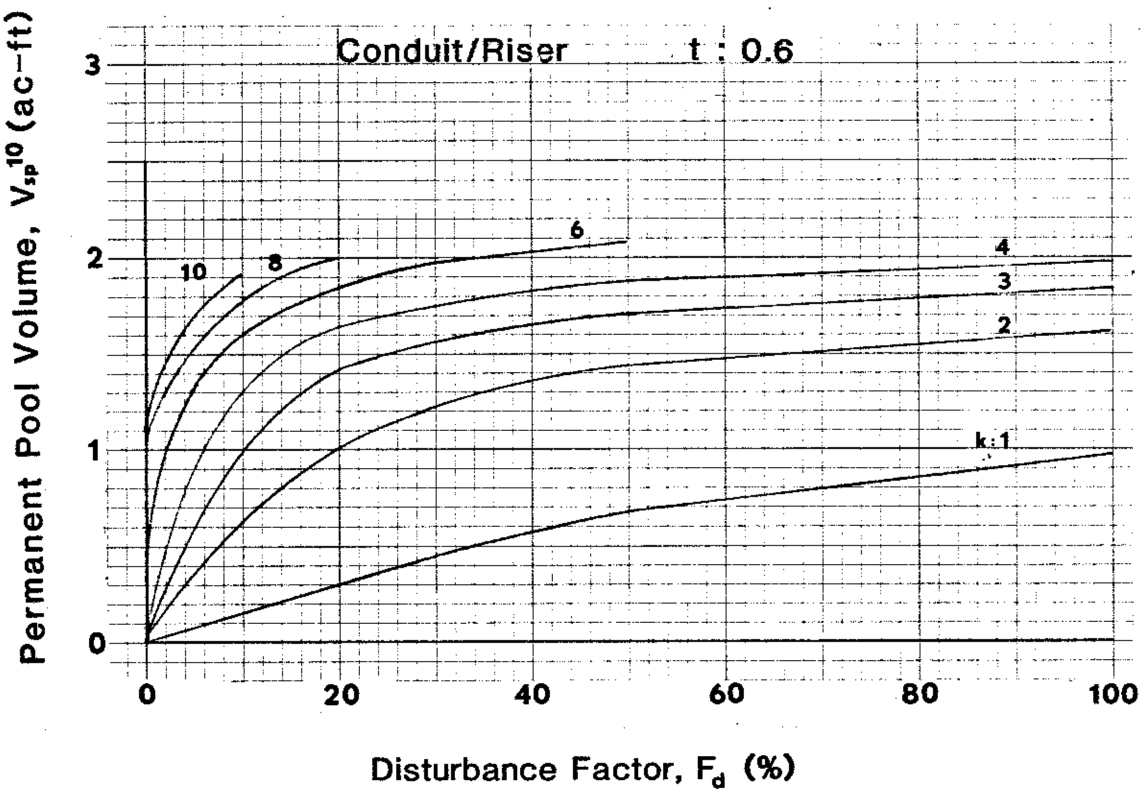
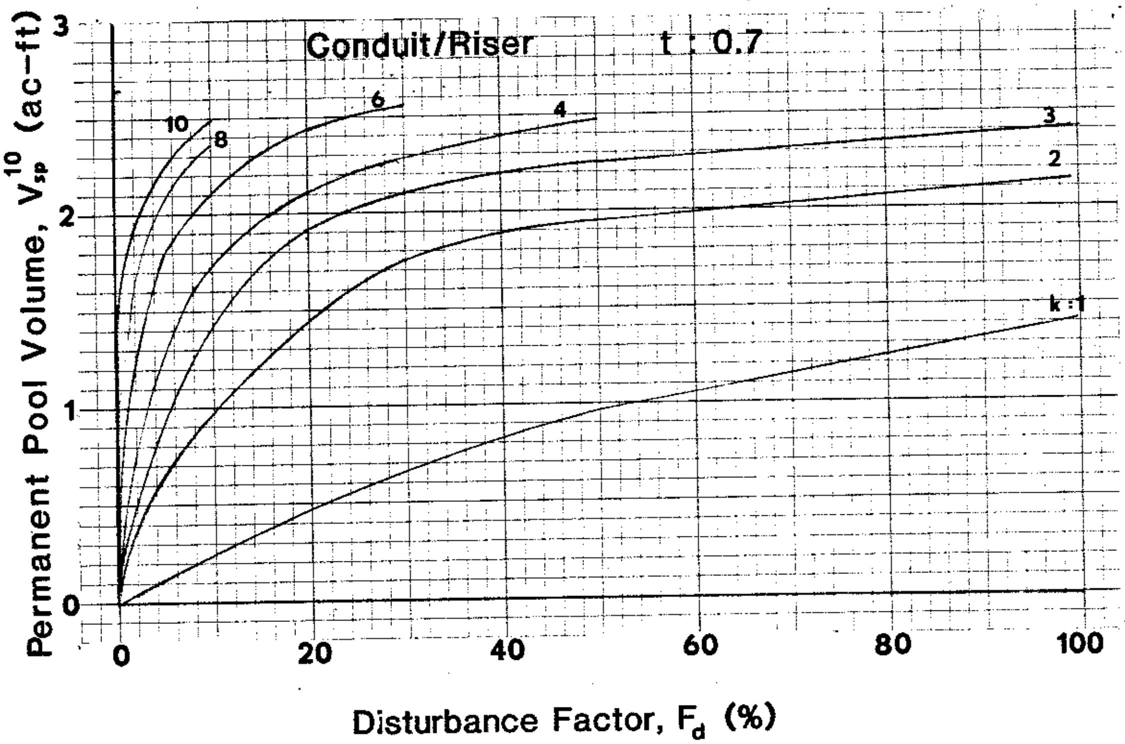


Figure 7 Permanent pool volume for conduit and riser principal spillways.



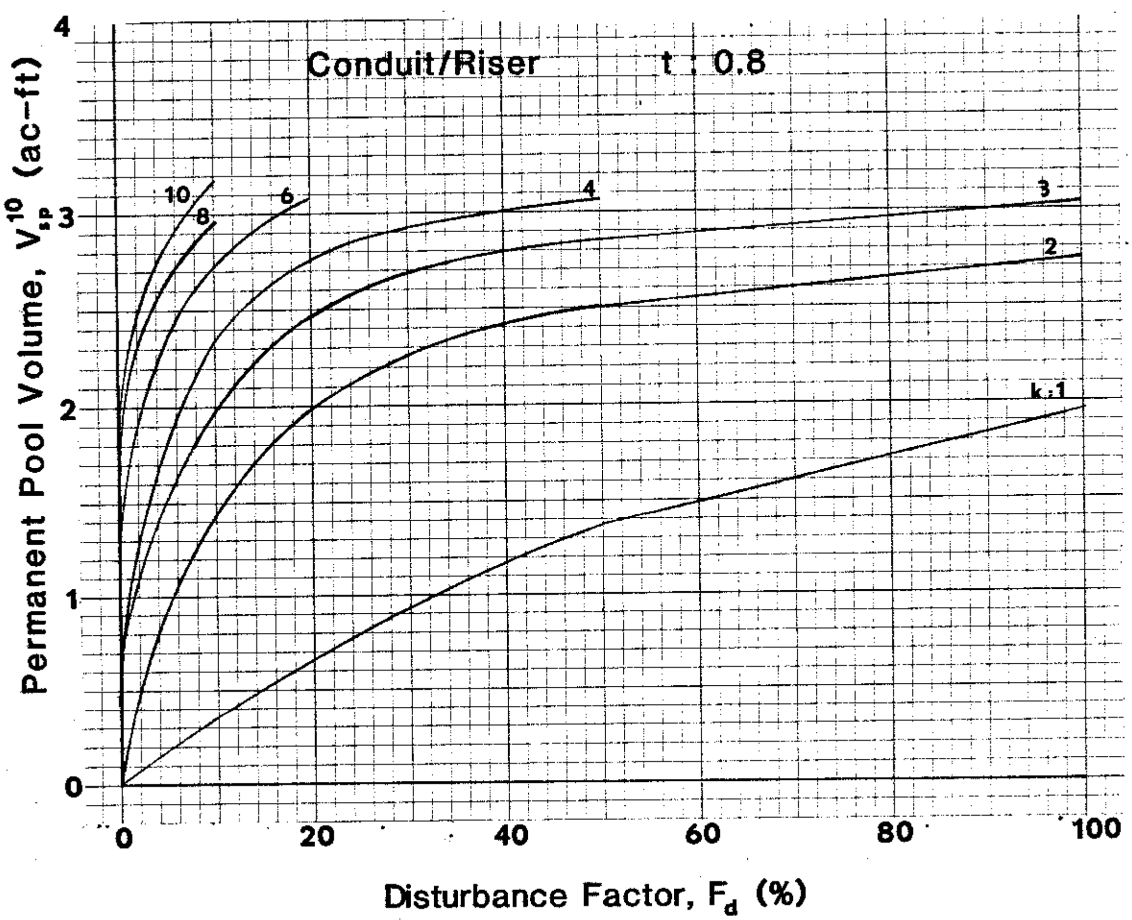
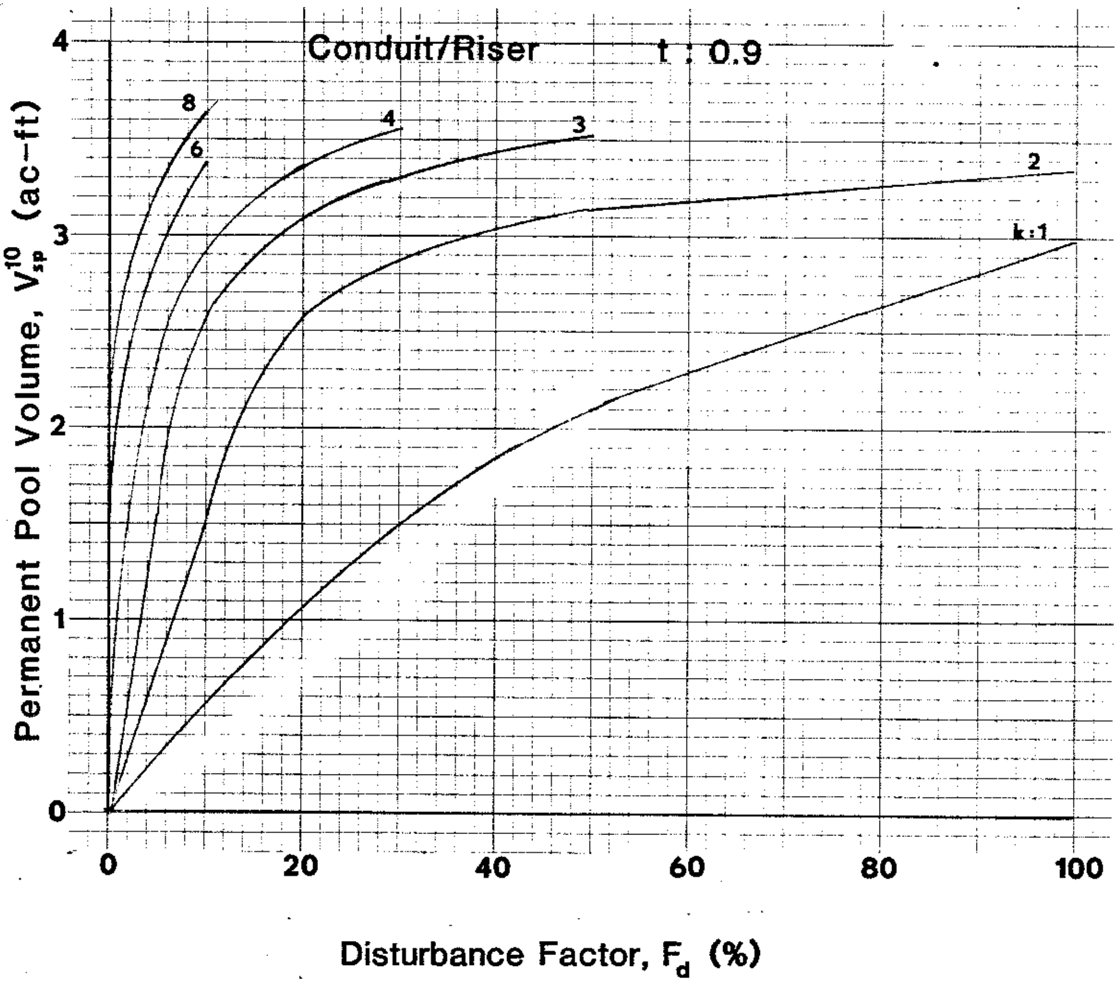


Figure 7 Continued.



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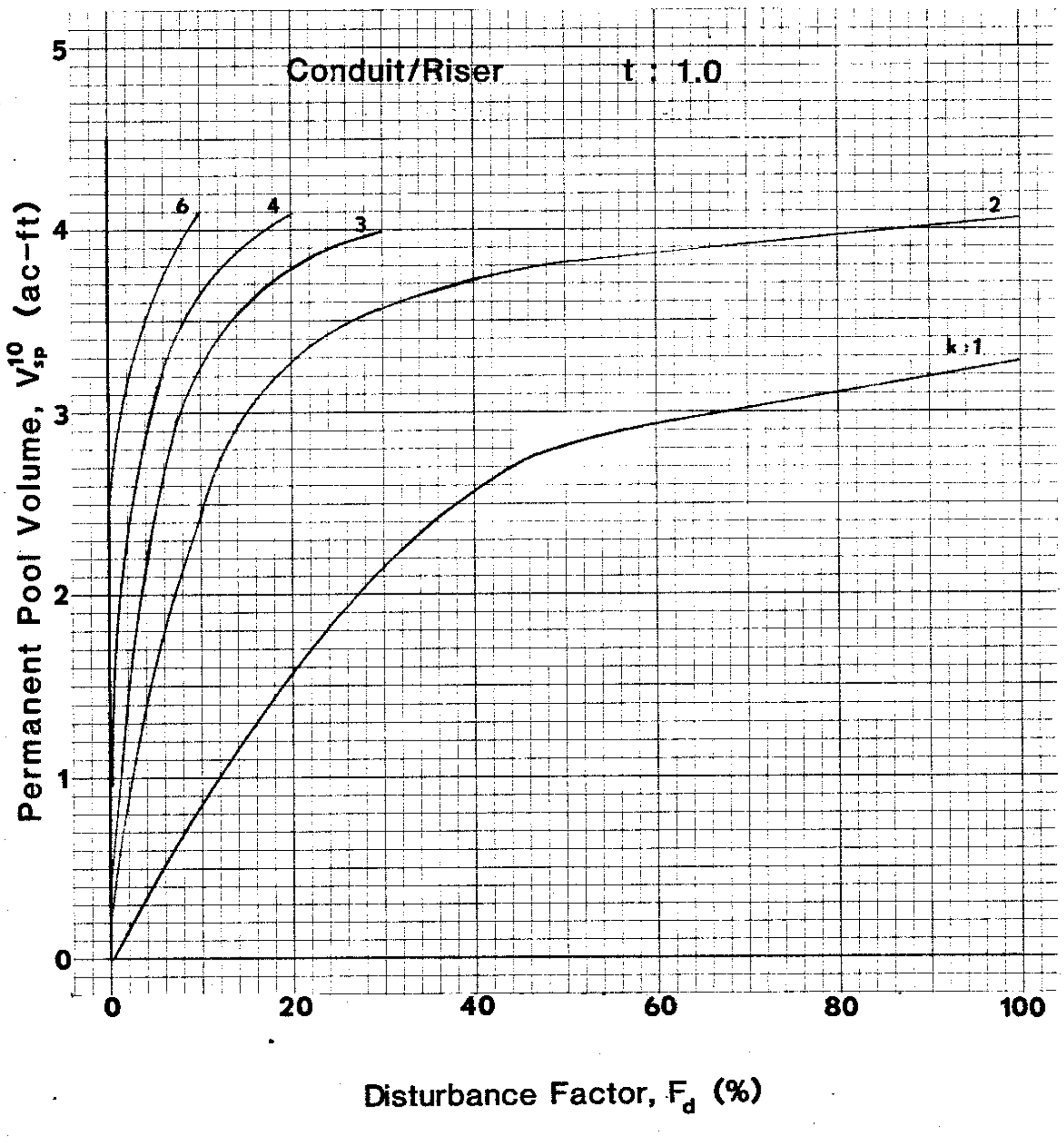
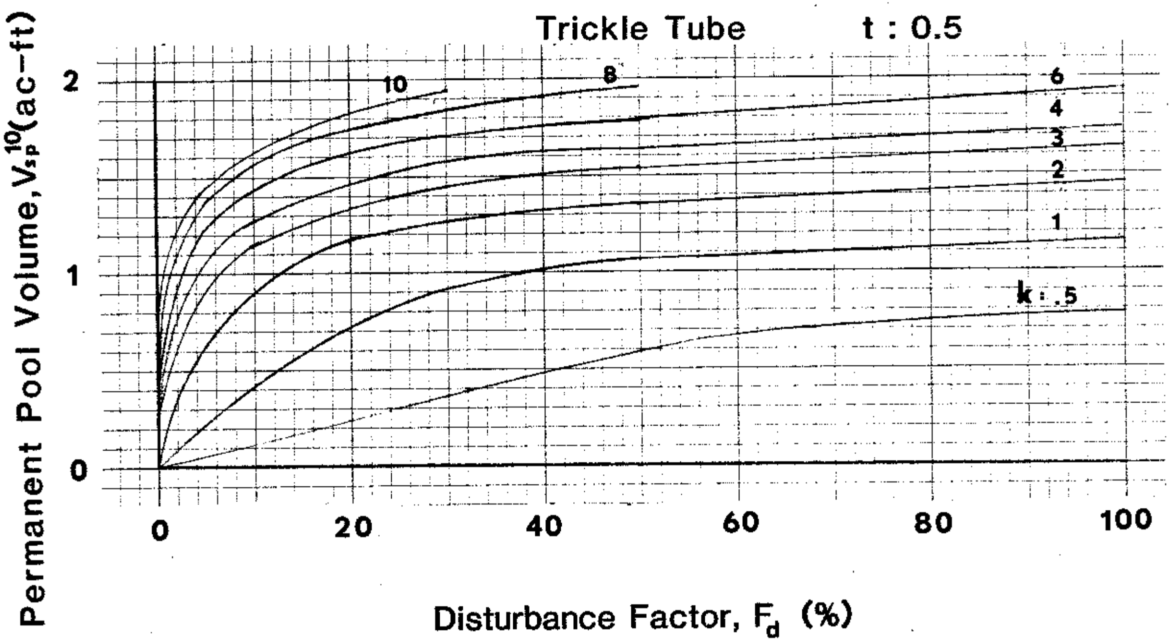


Figure 7 Continued.



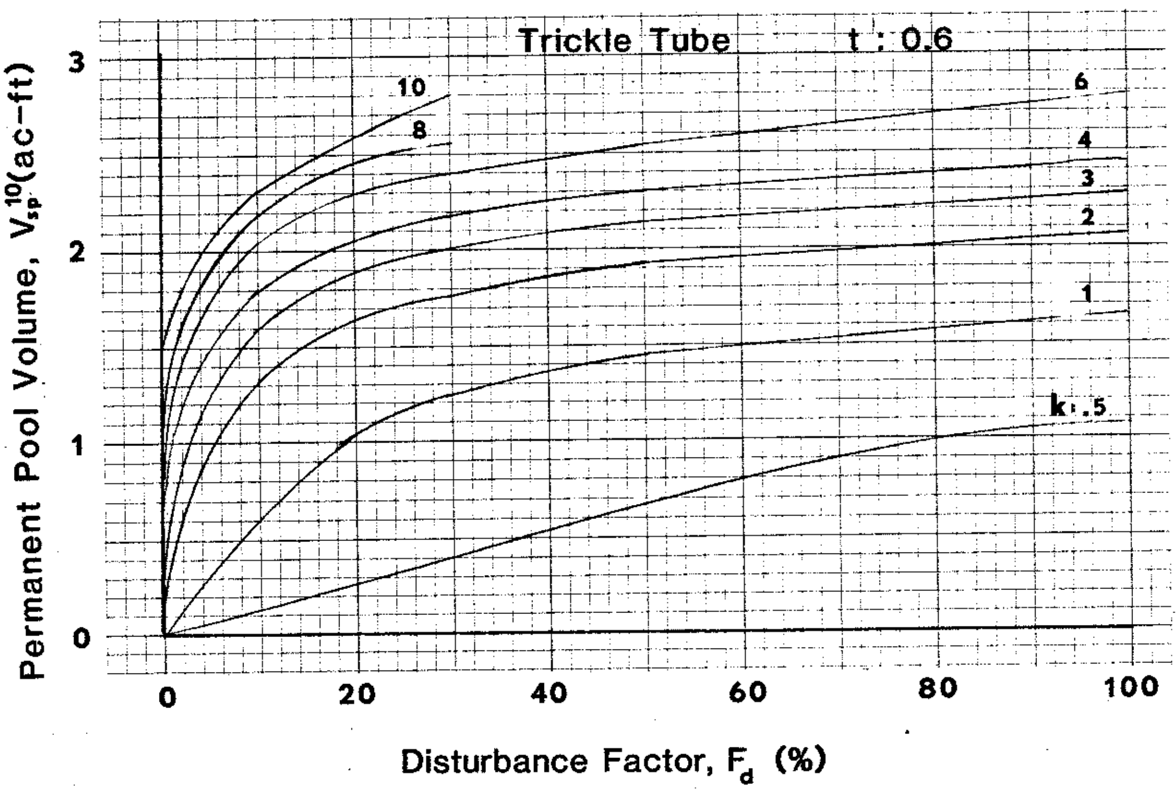


Figure 8 Permanent pool volume for trickle tube principal spillways.

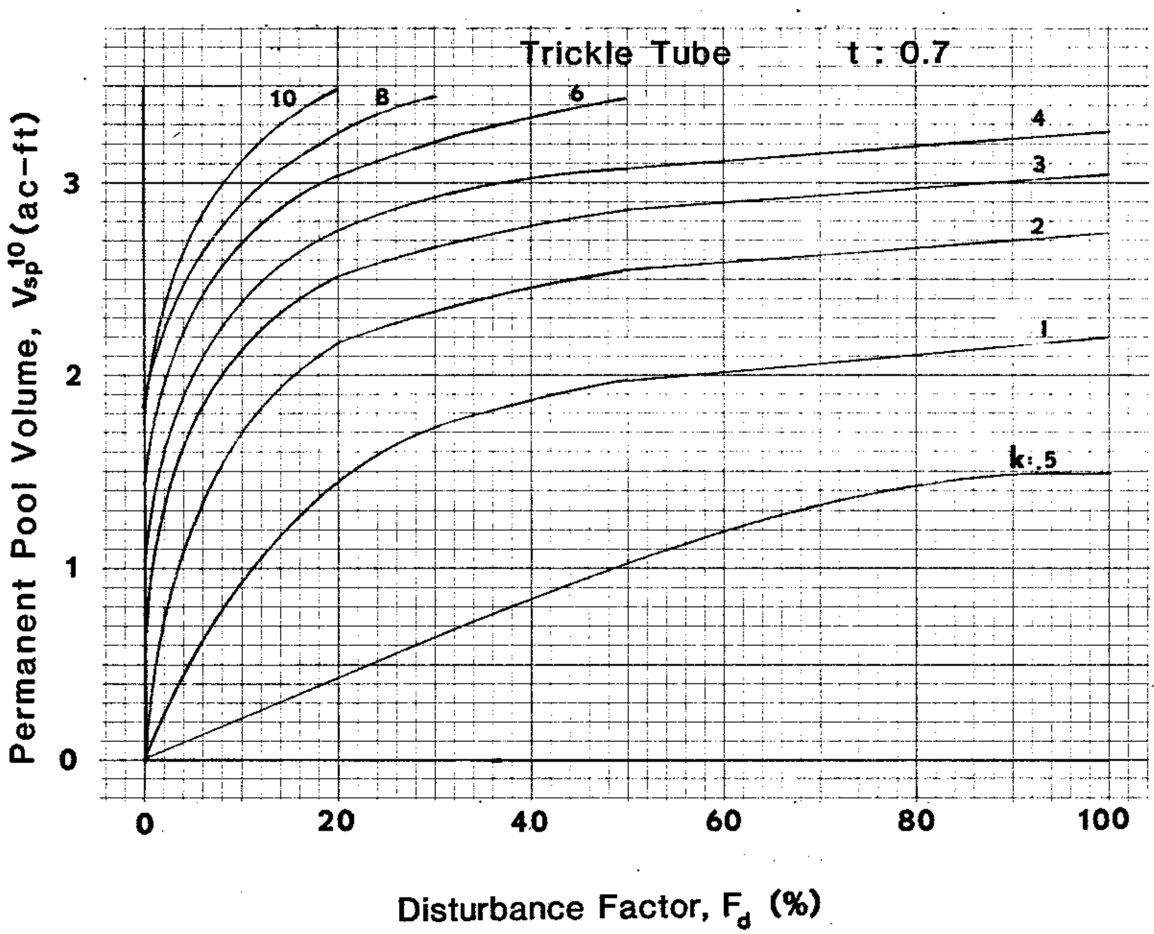


Figure 8 Continued.

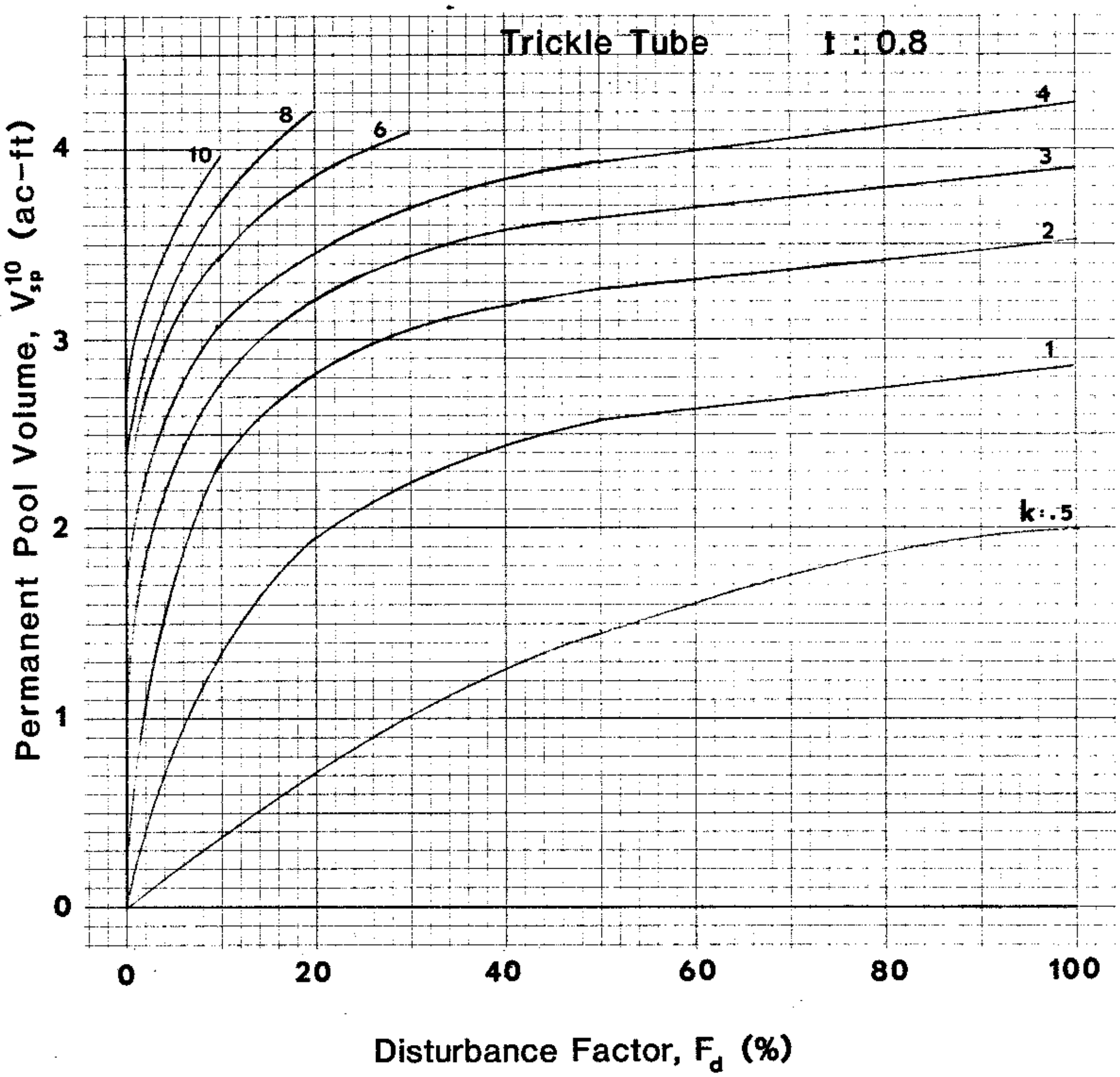


Figure 8 Continued.

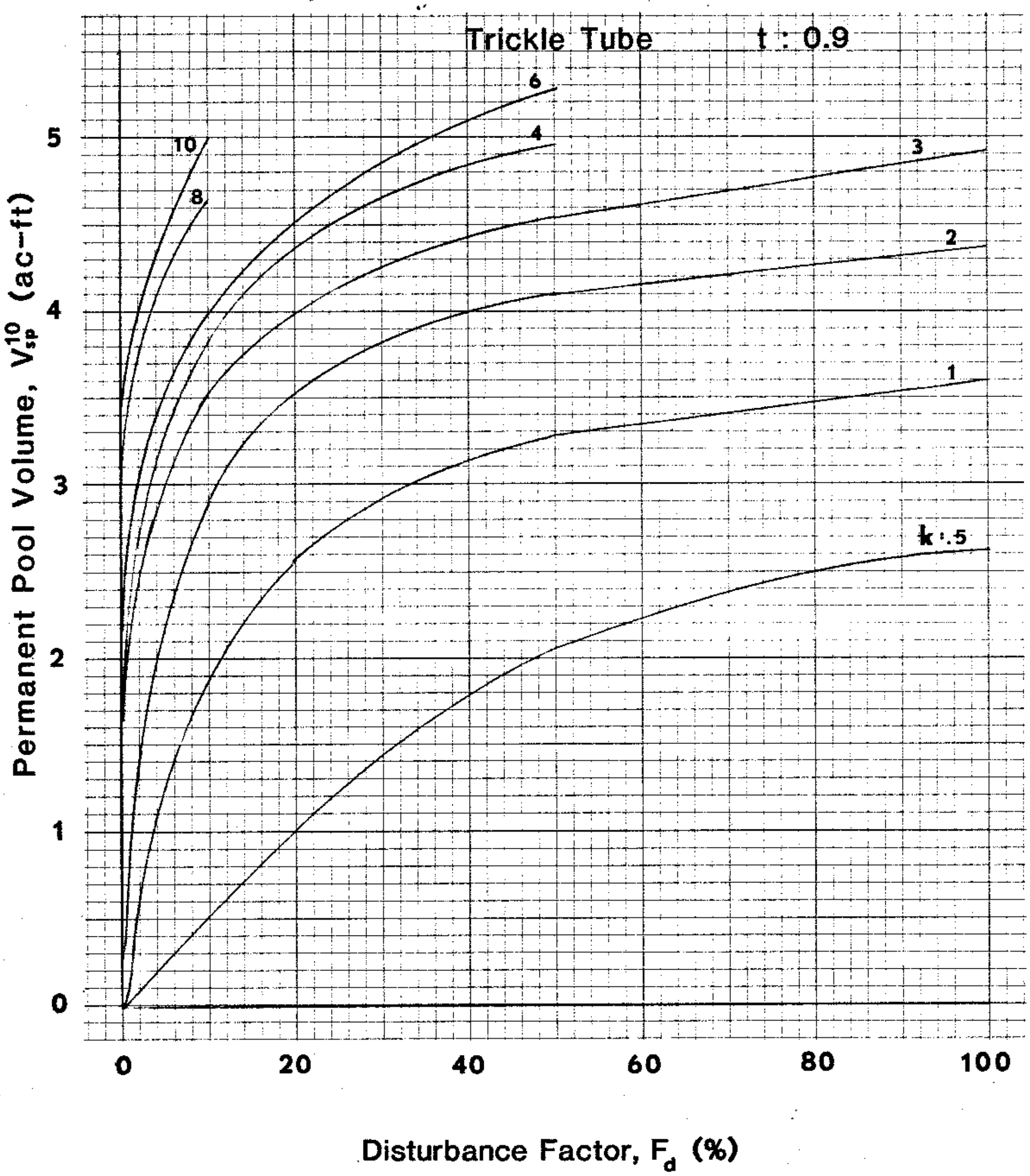


Figure 8 Continued.

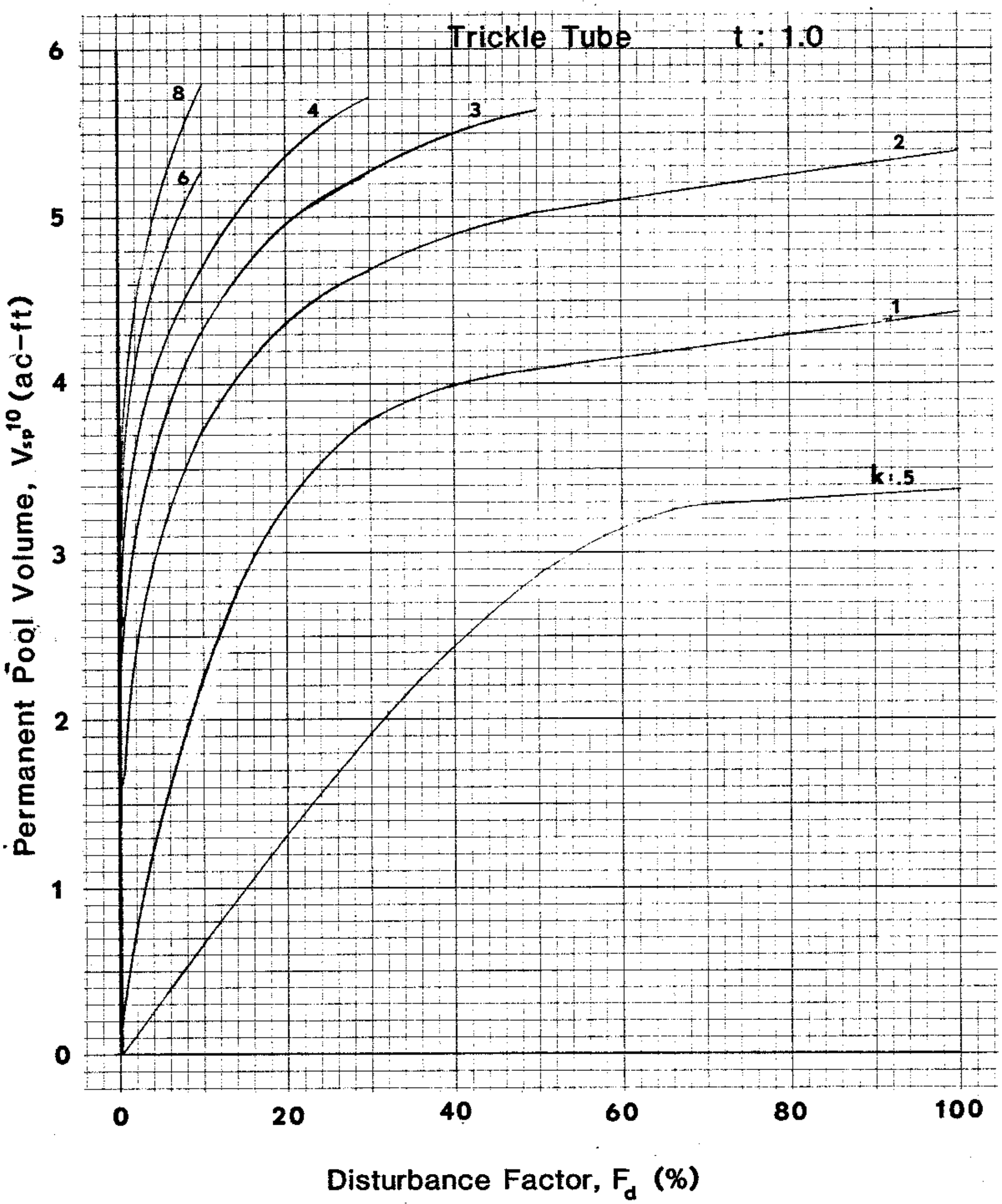


Figure 8 Continued.

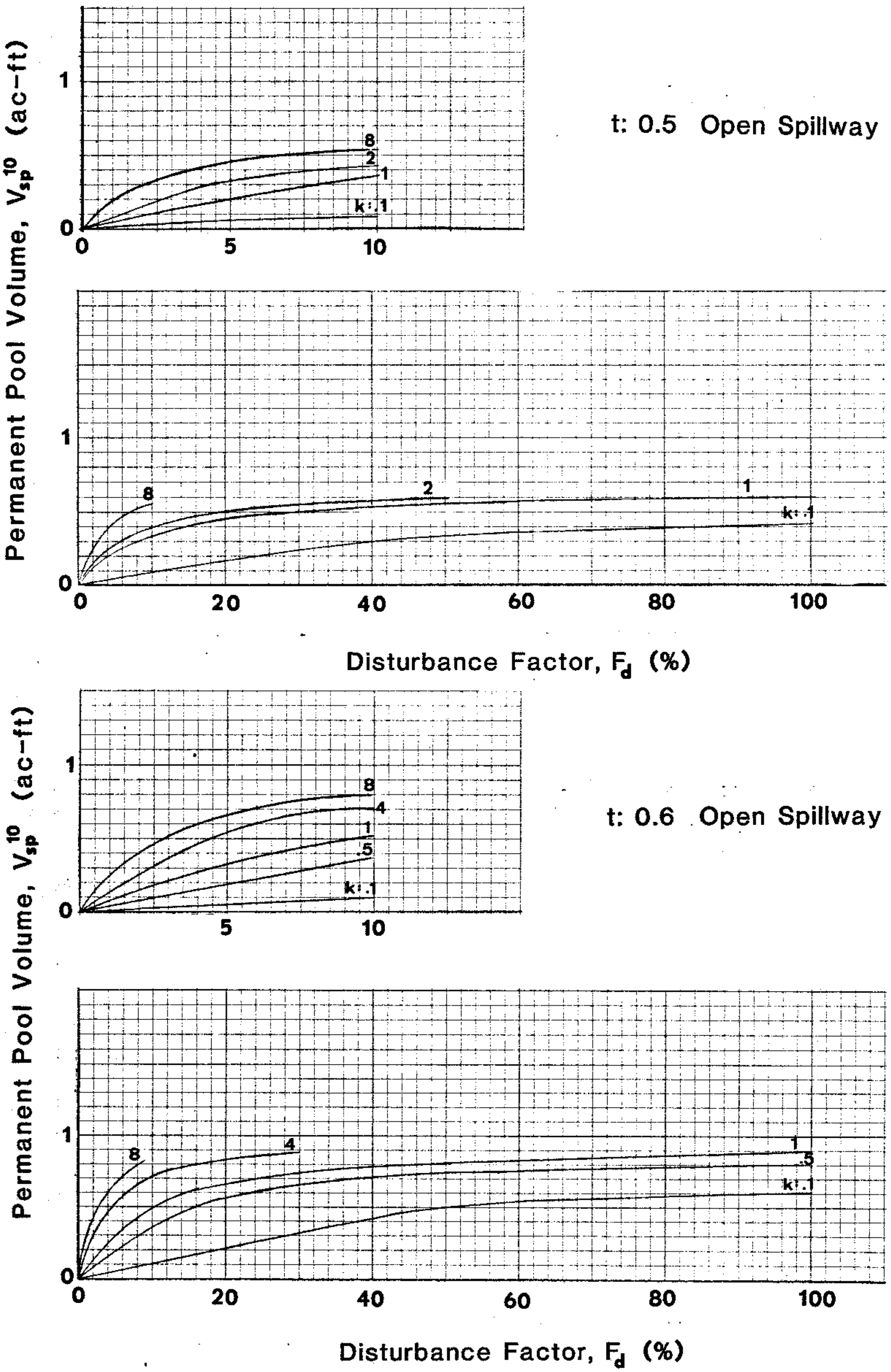
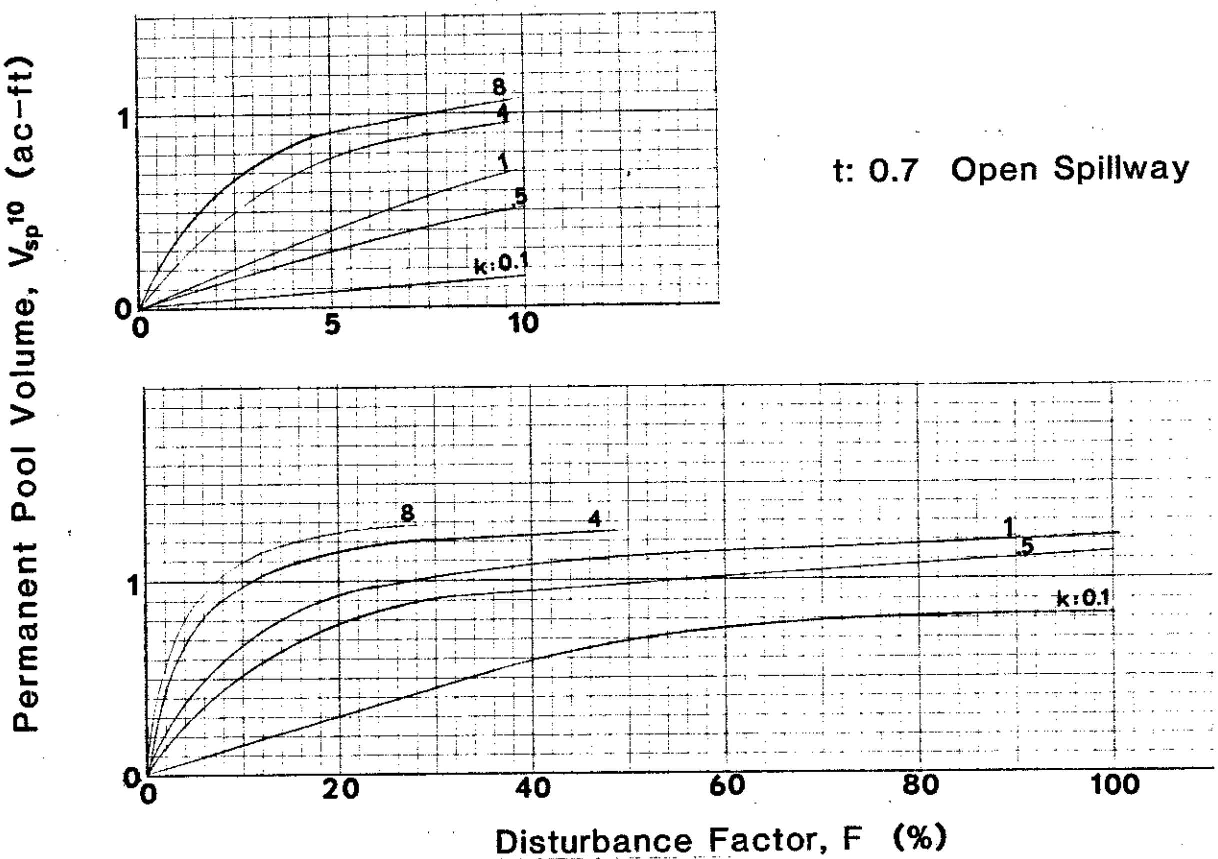


Figure 9 Permanent pool volume for trapezoidal open spillways.



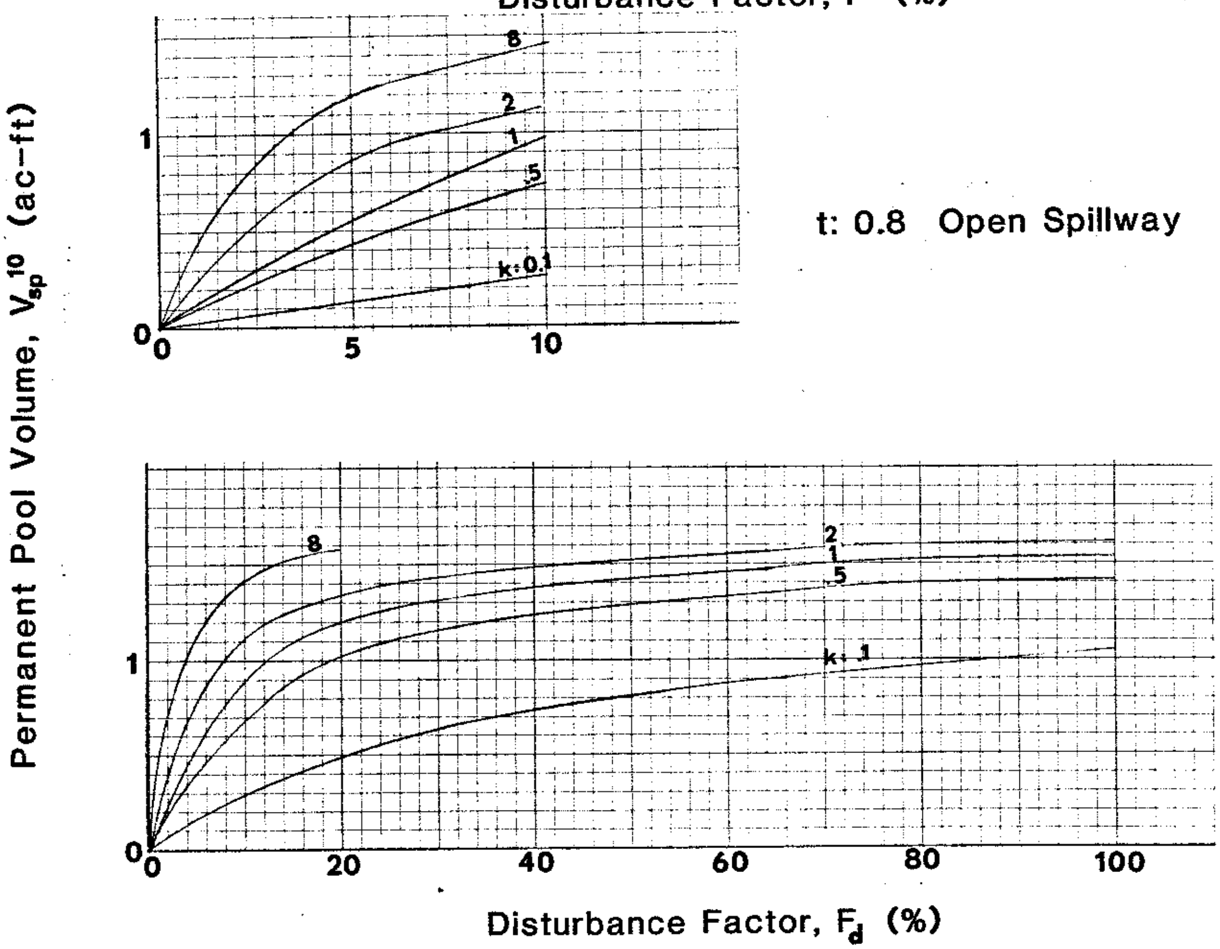


Figure 9 Continued.

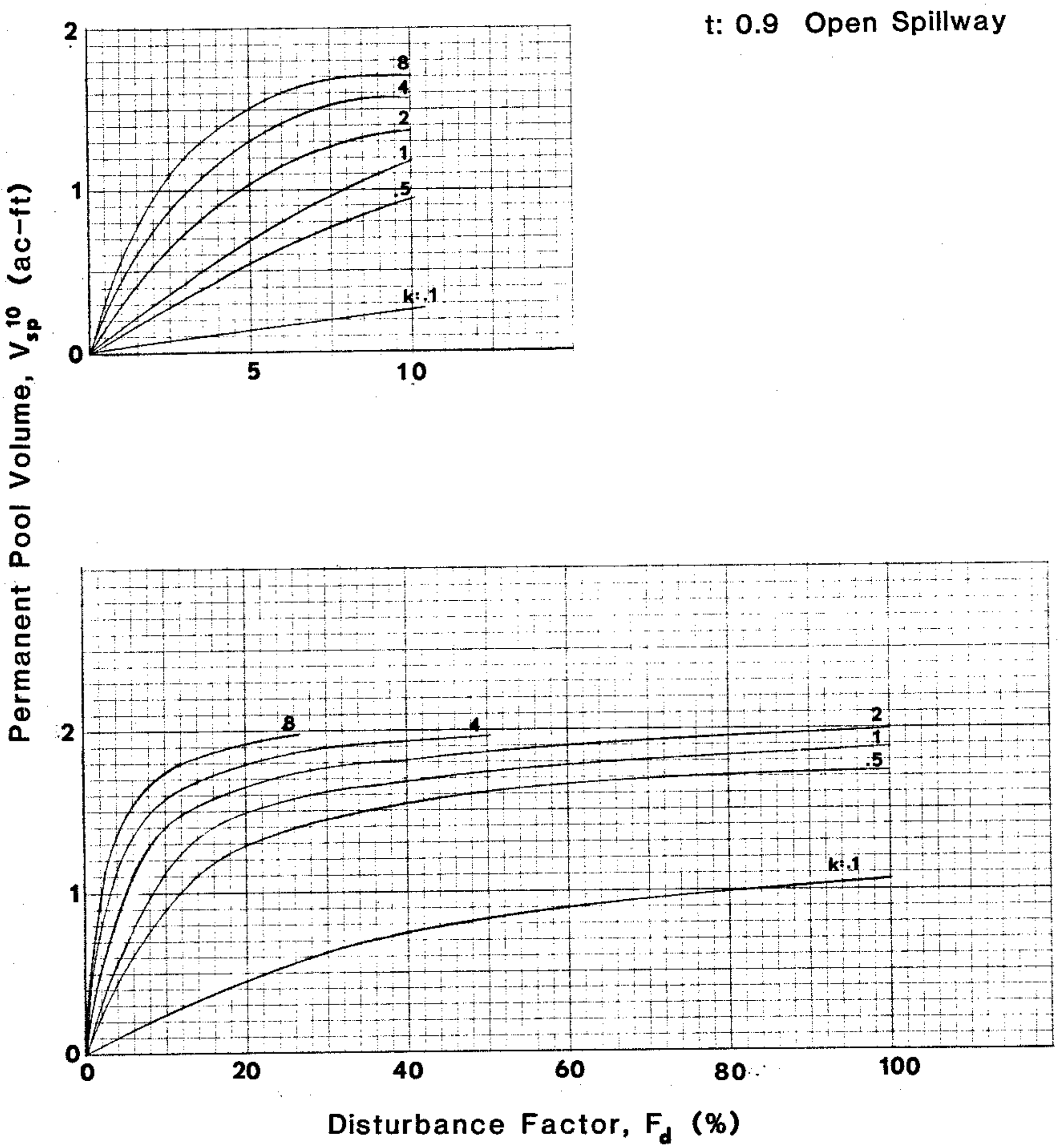


Figure 9 Continued.

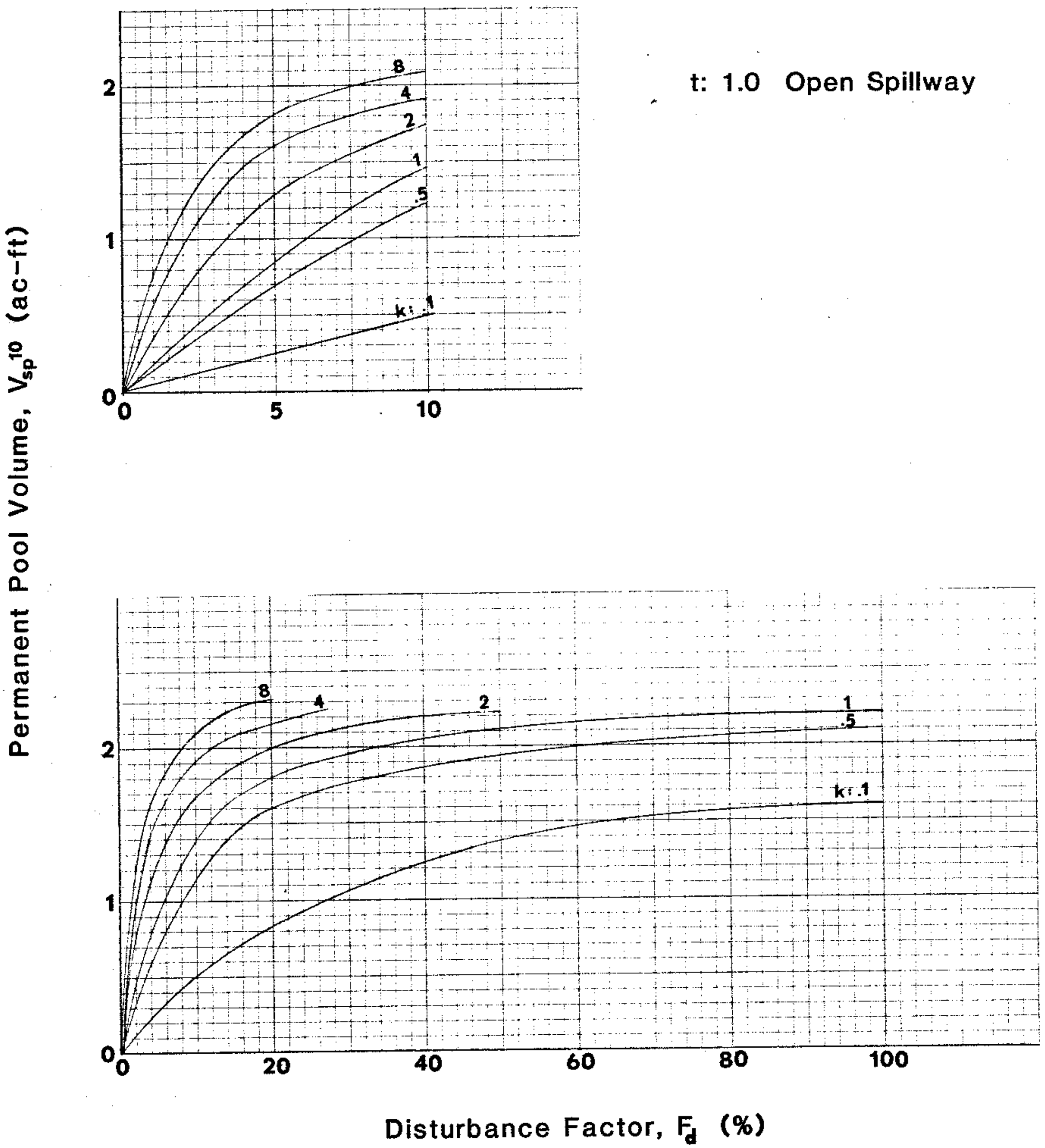


Figure 9 Continued.

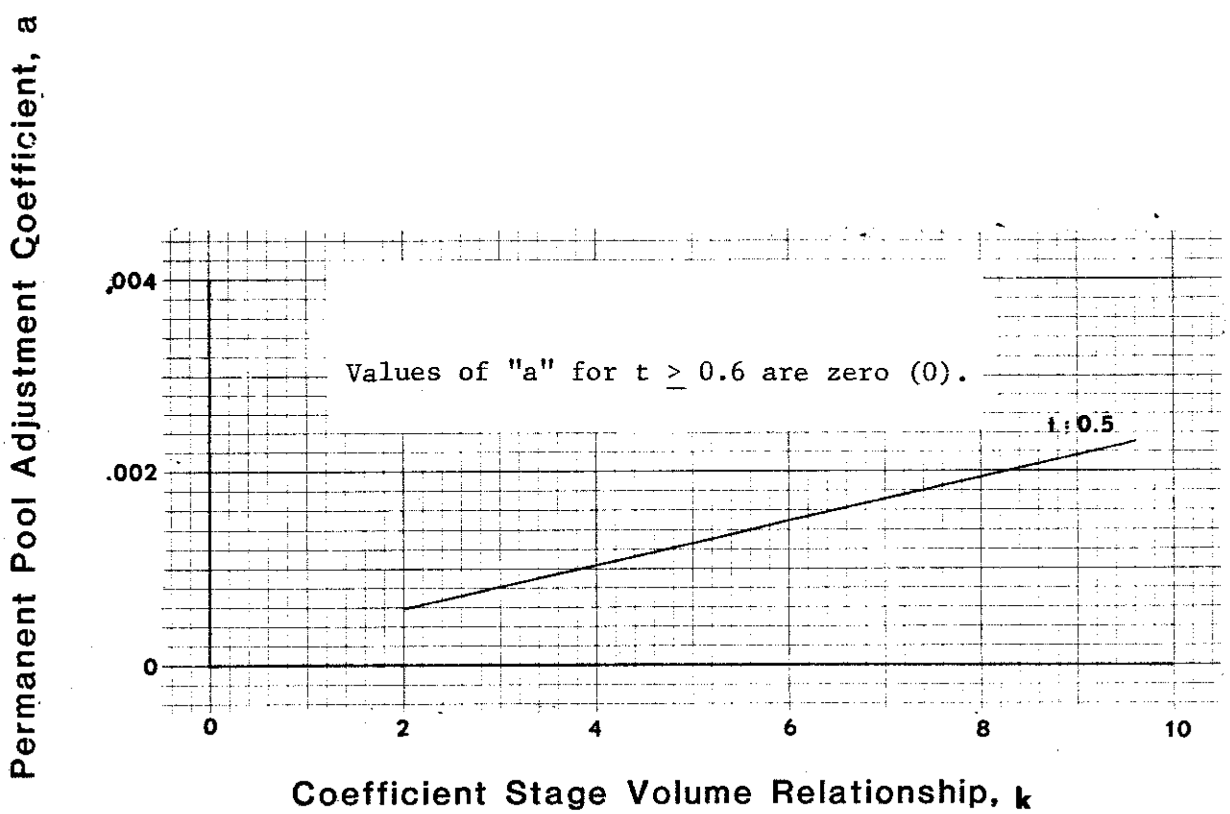


Figure 10 Permanent pool adjustment coefficient (a) for conduit and riser principal spillways.

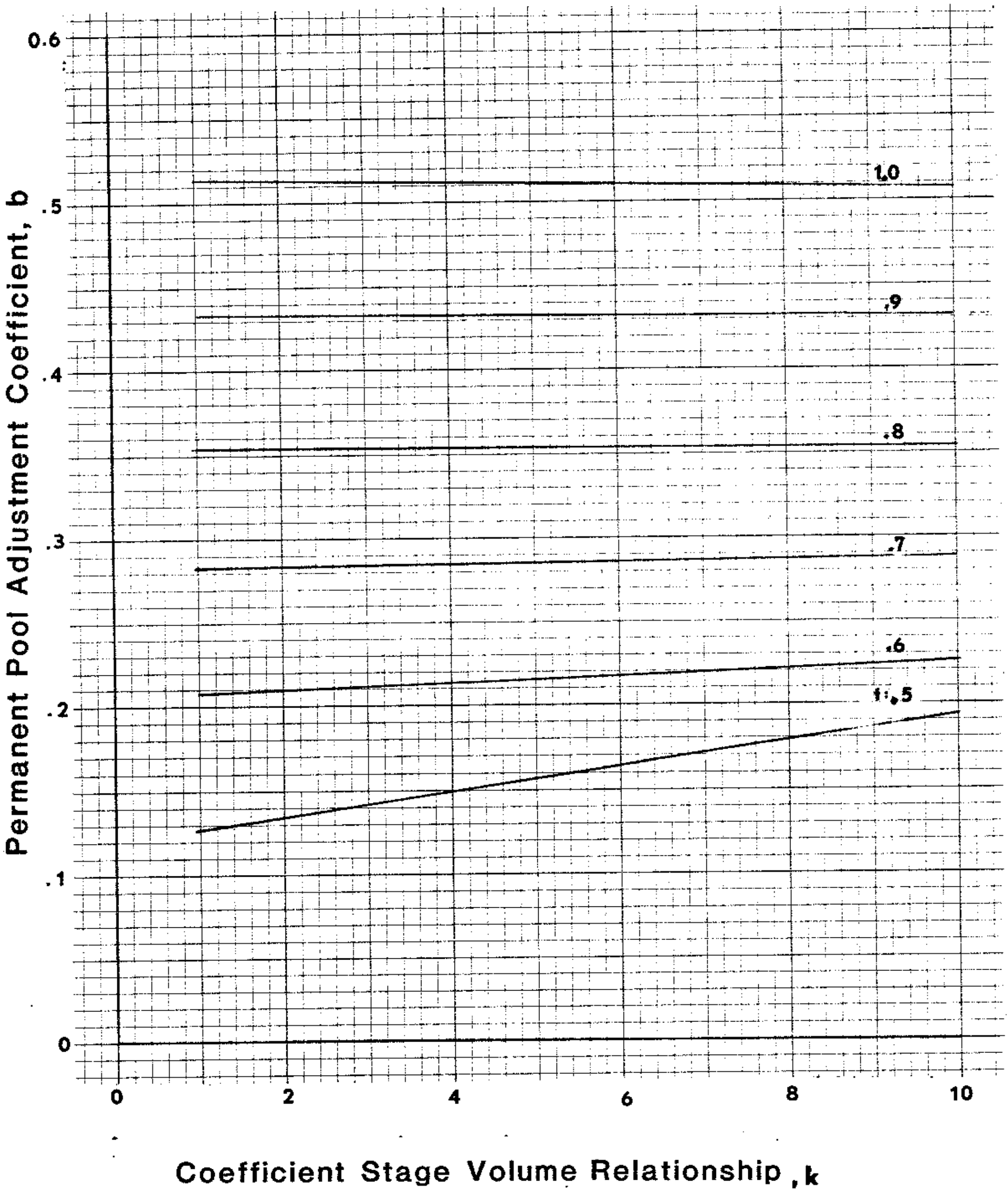


Figure 11 Permanent pool adjustment coefficient (b) for conduit and riser principal spillways.

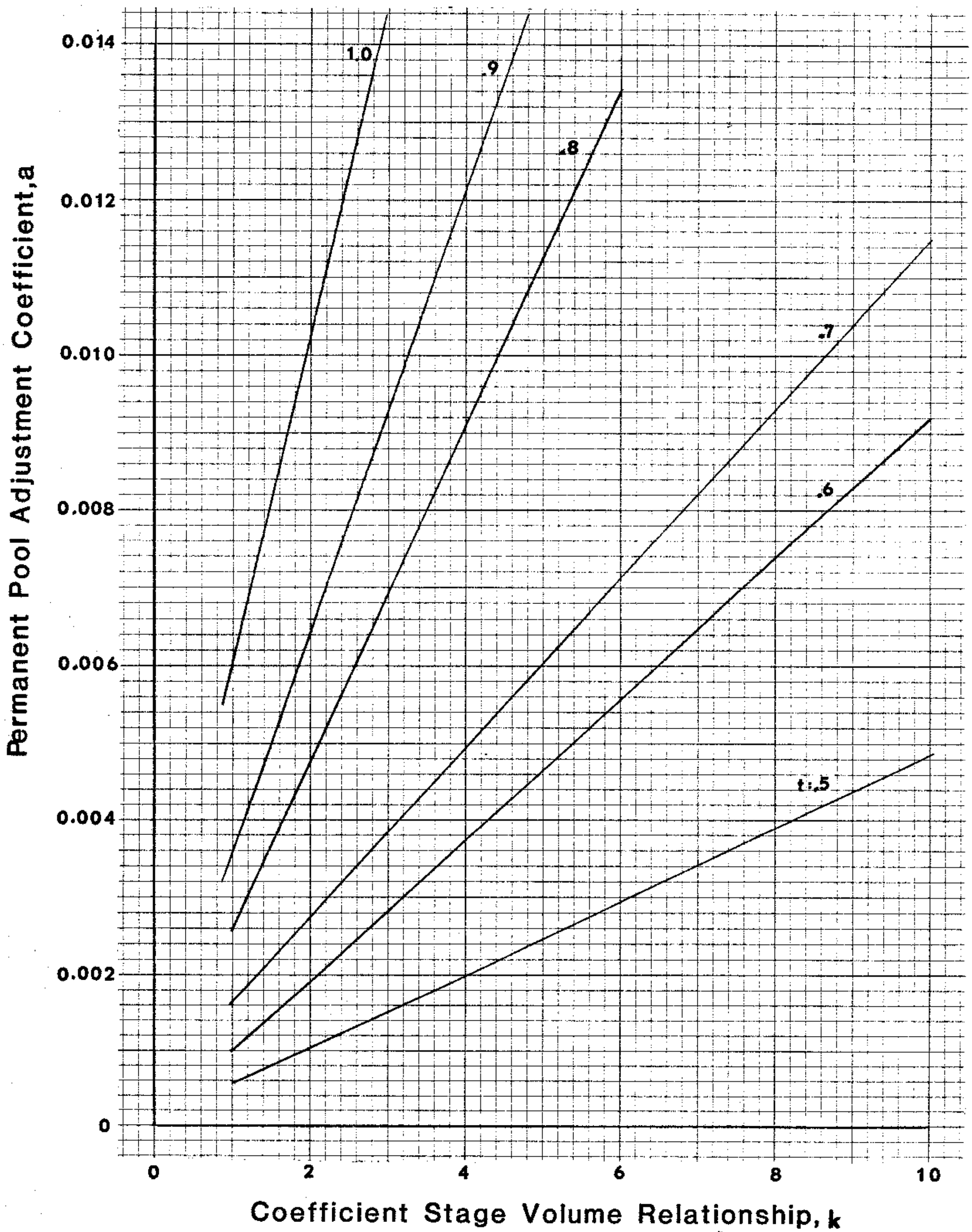


Figure 12 Permanent pool adjustment coefficient (a) for trickle tube principal spillways.

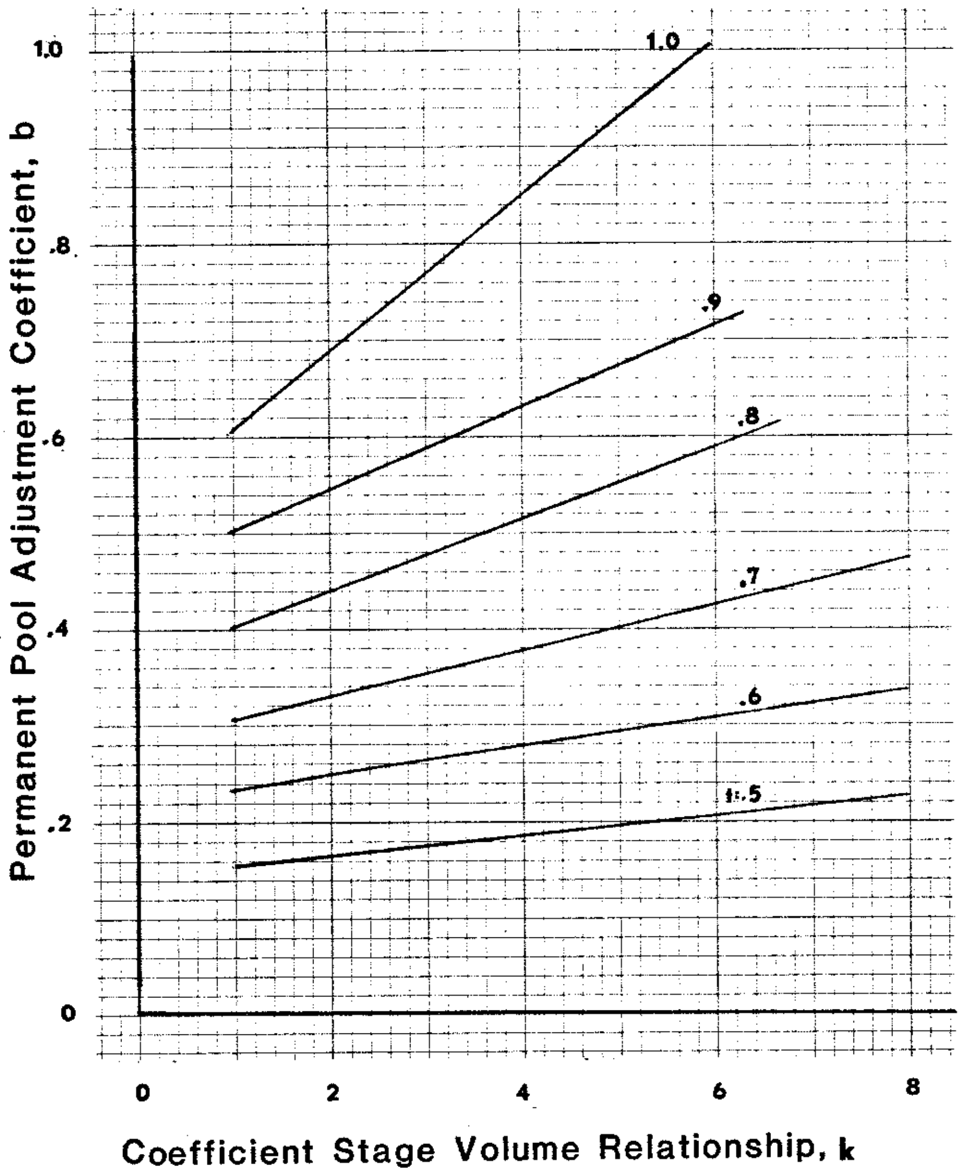


Figure 13 Permanent pool adjustment coefficient (b) for trickle tube principal spillways.

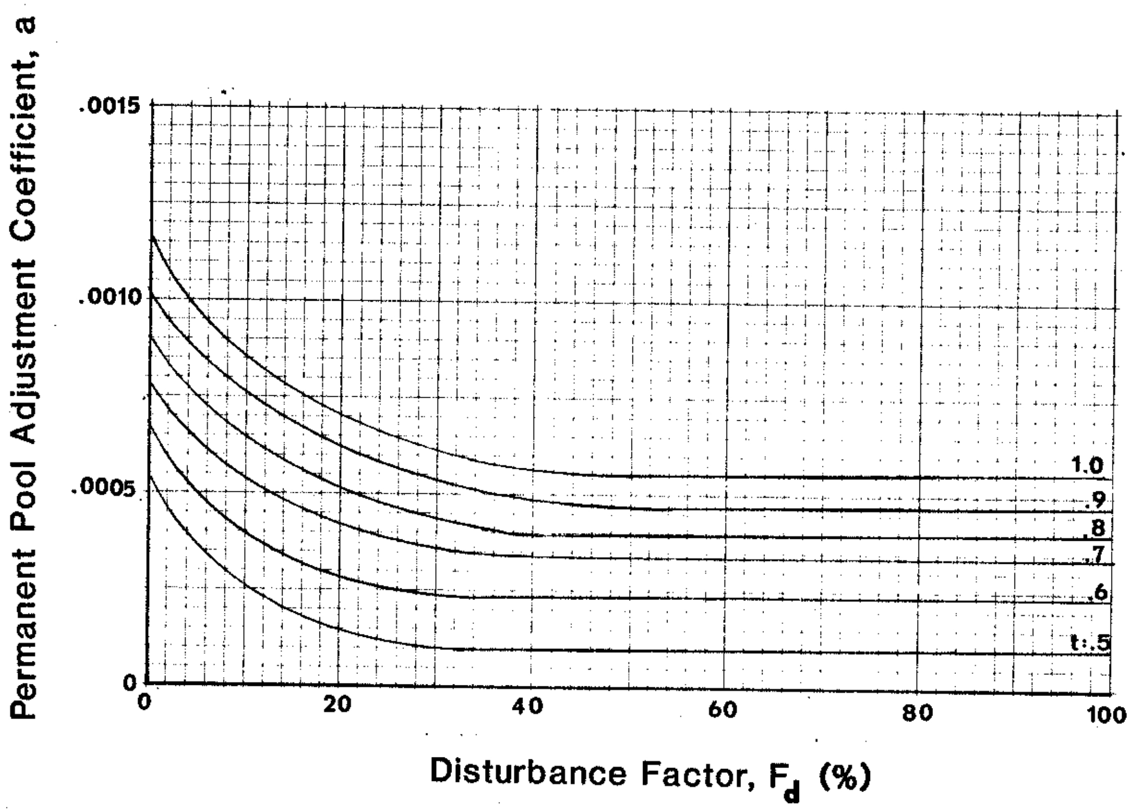


Figure 14 Permanent pool adjustment coefficient (a) for trapezoidal open principal spillways.

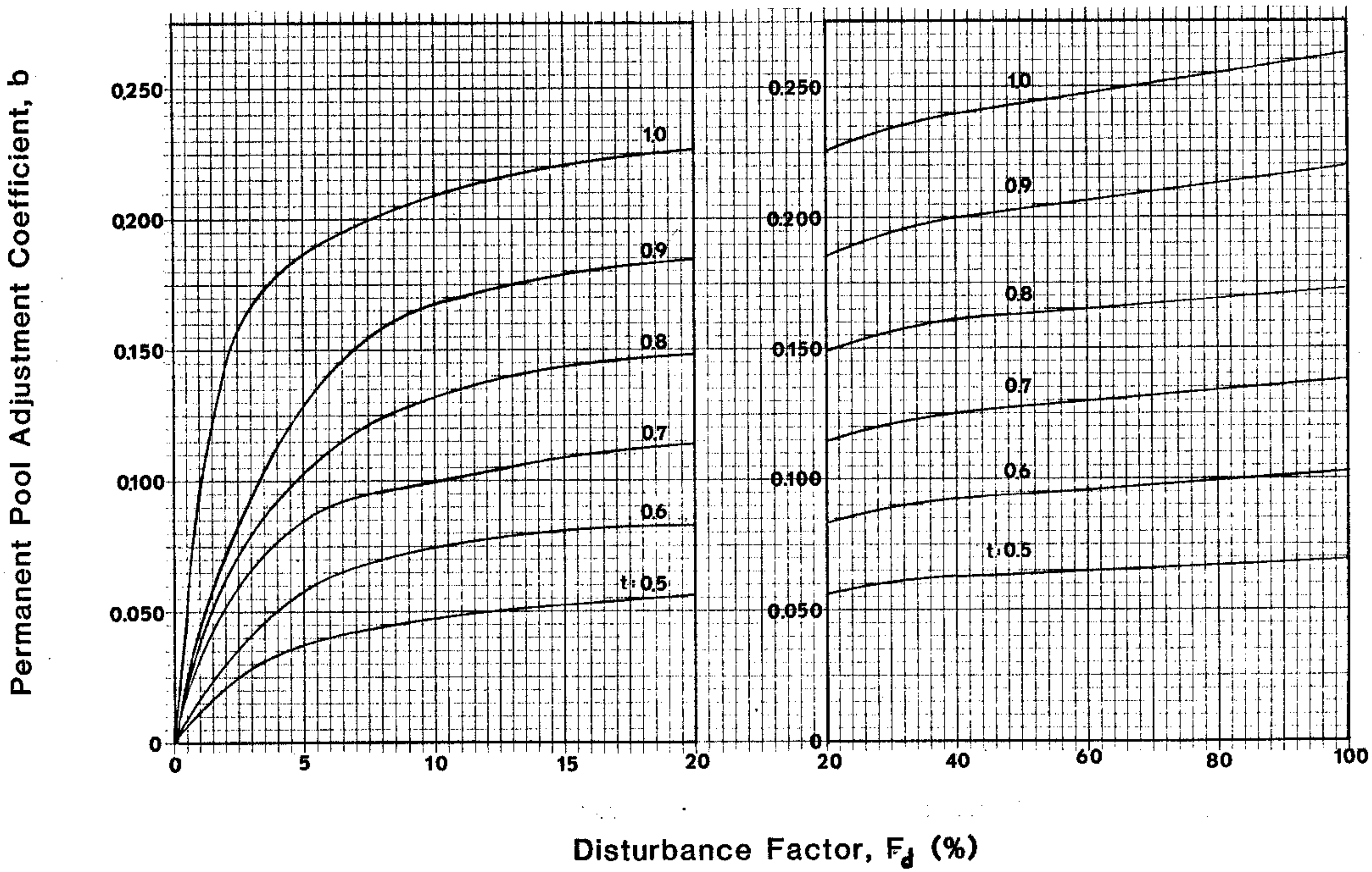


Figure 15 Permanent pool adjustment coefficient (b) for trapezoidal open principal spillways.

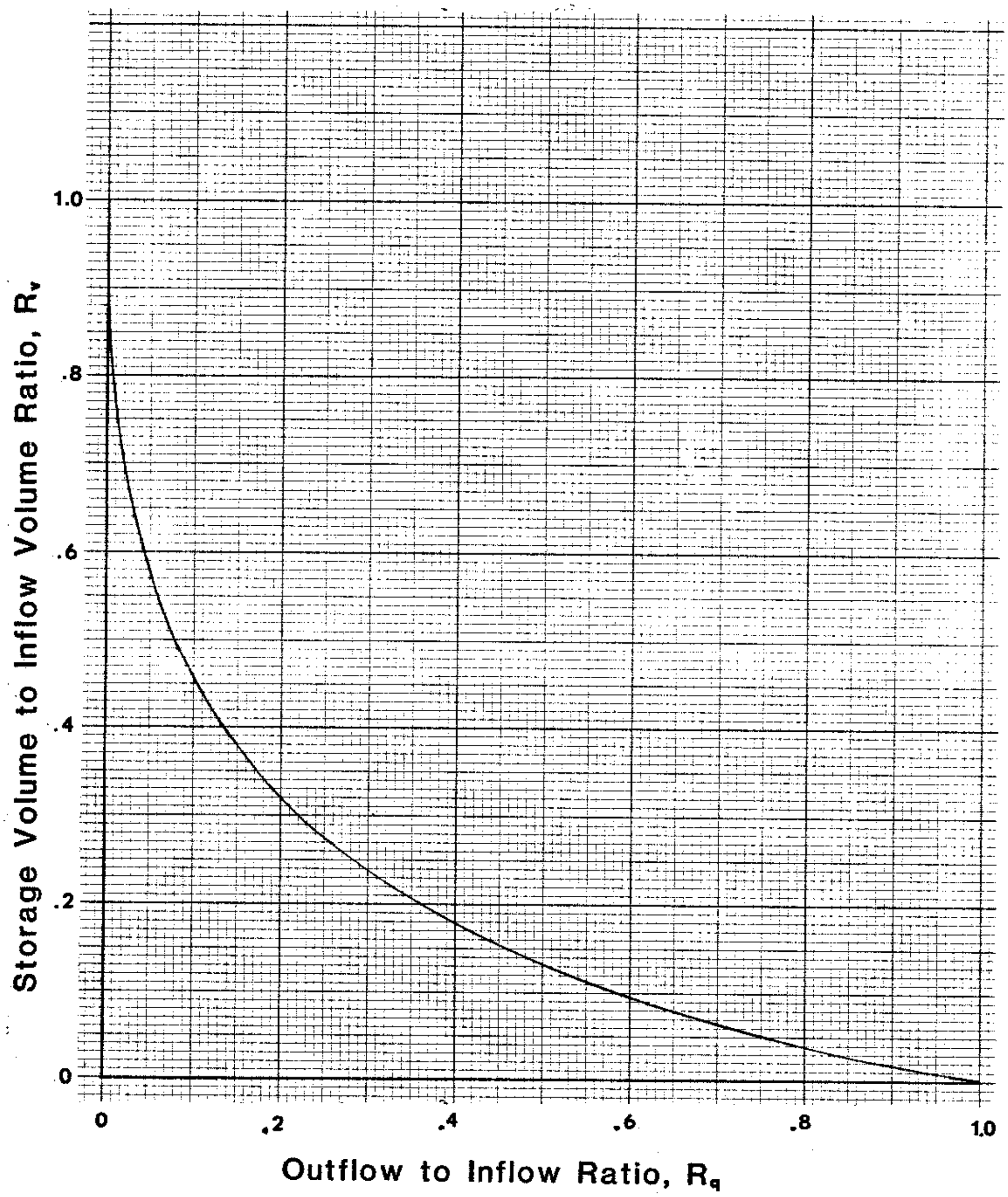


Figure 16 Routed peak discharge for conduit and riser principal spillways.

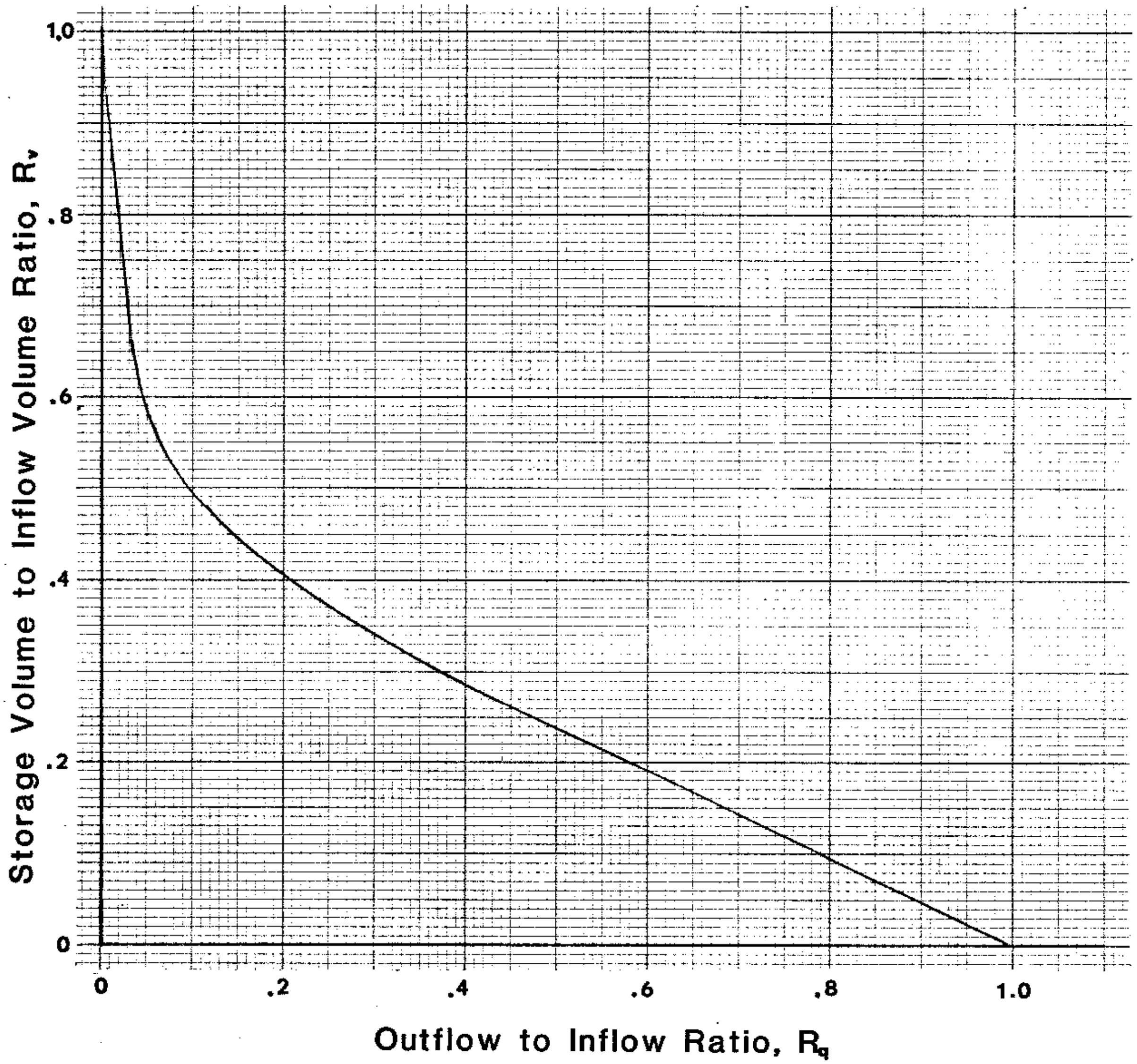


Figure 17 Routed peak discharge for trickle tube principal spillways.

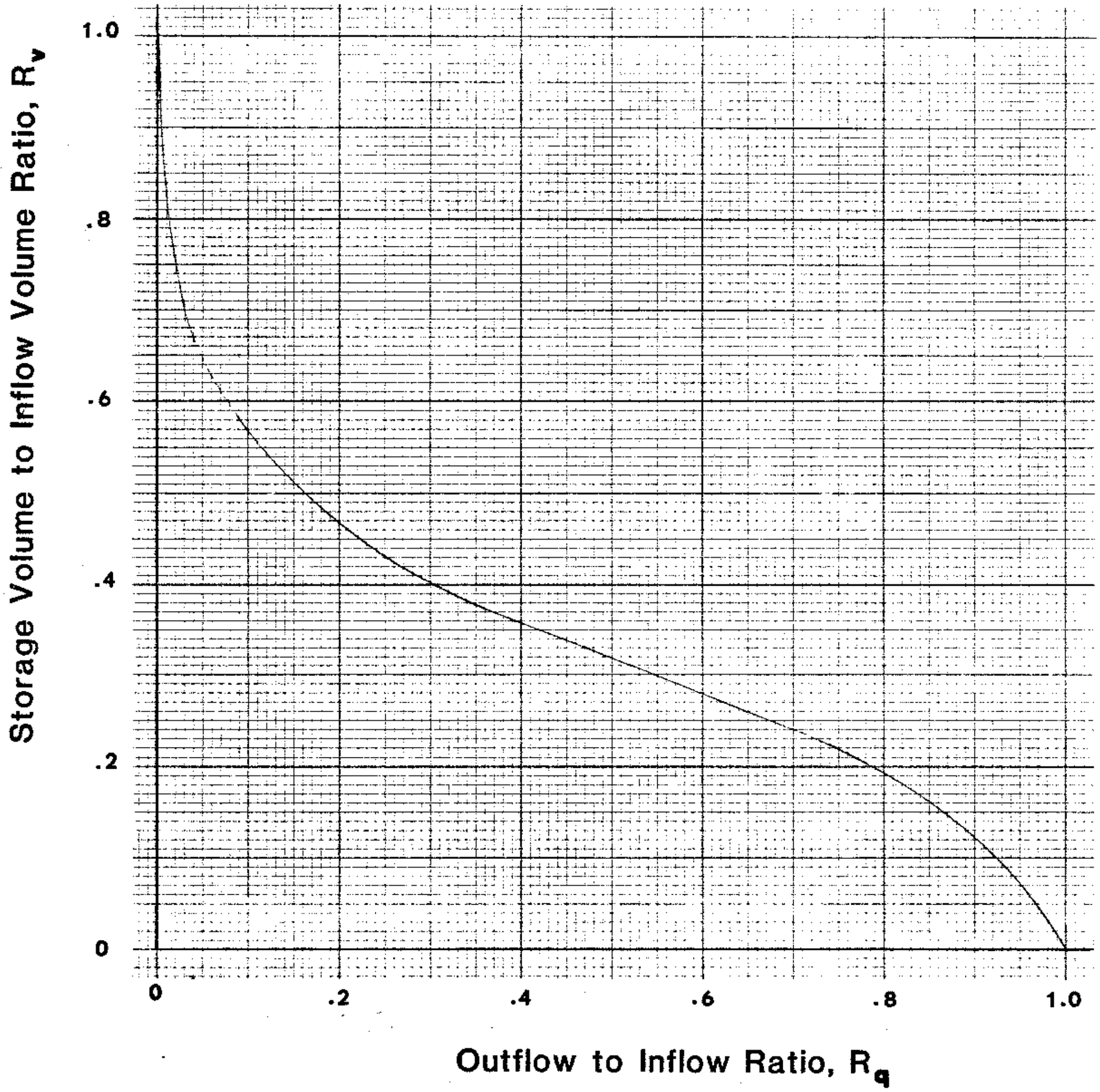


Figure 18 Routed peak discharge for trapezoidal open principal spillways.

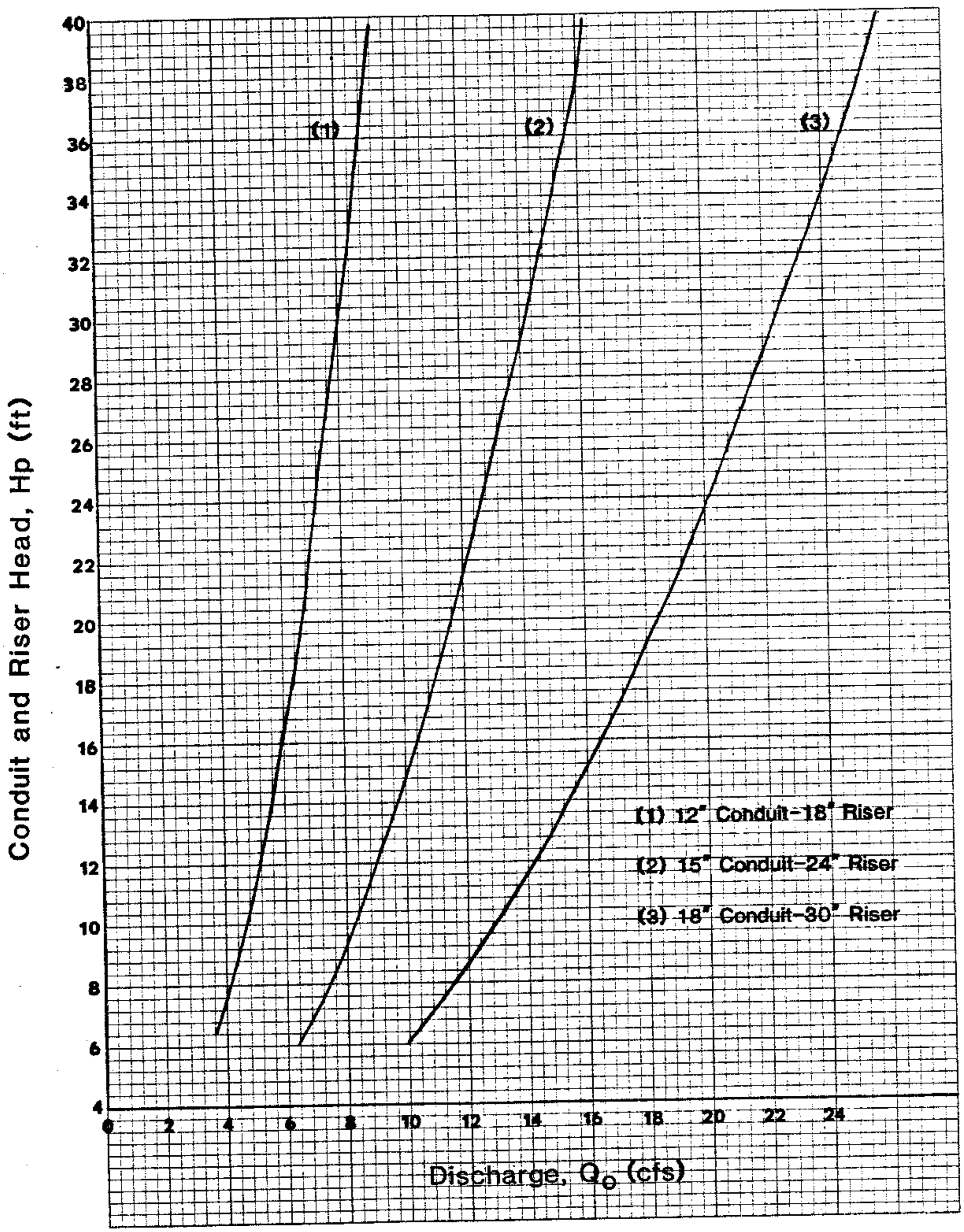


Figure 19 Stage-discharge relationships for selected conduit and riser principal spillways.

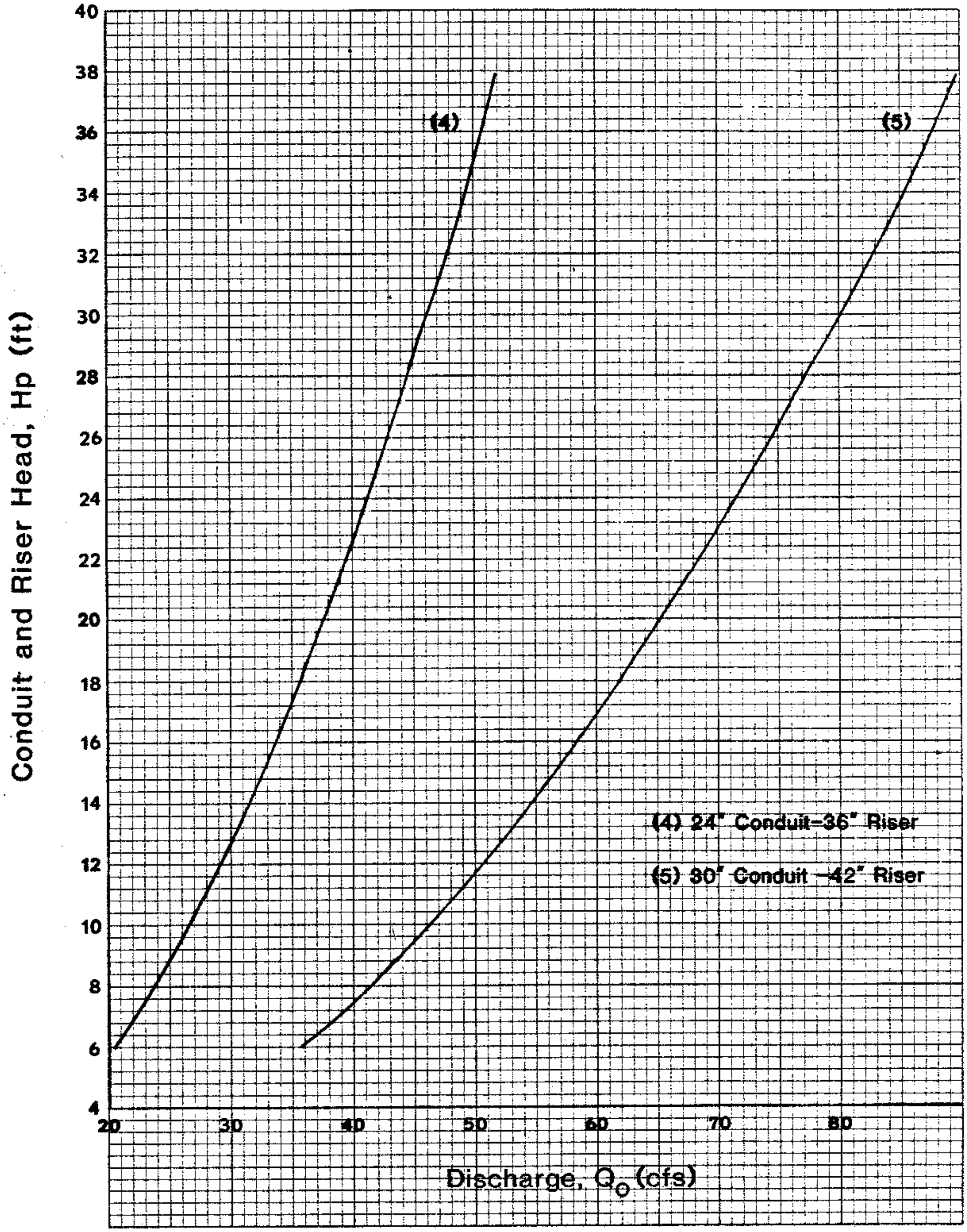


Figure 19 Continued.

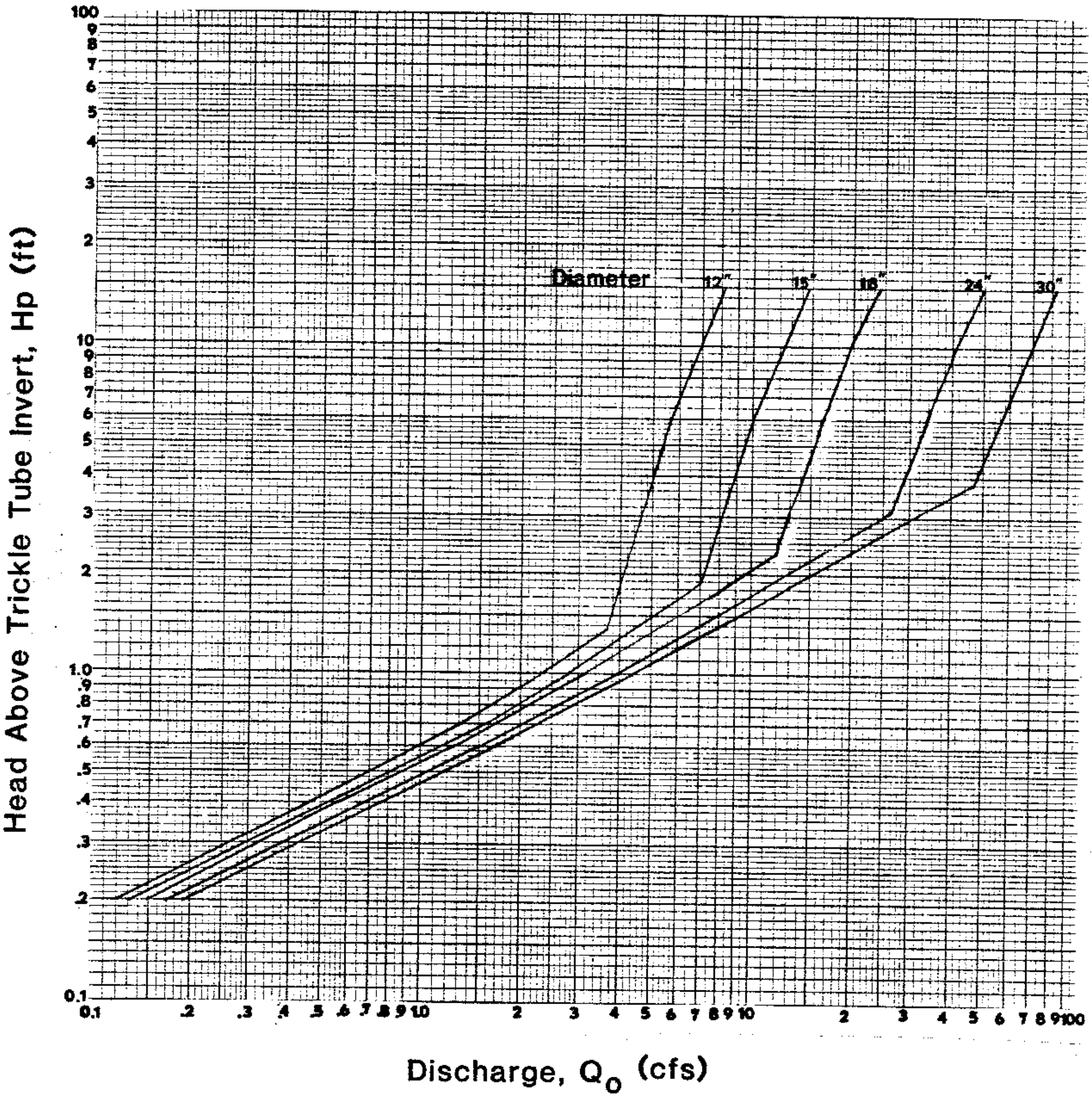


Figure 20 Stage-discharge relationships for selected trickle tube principal spillways.

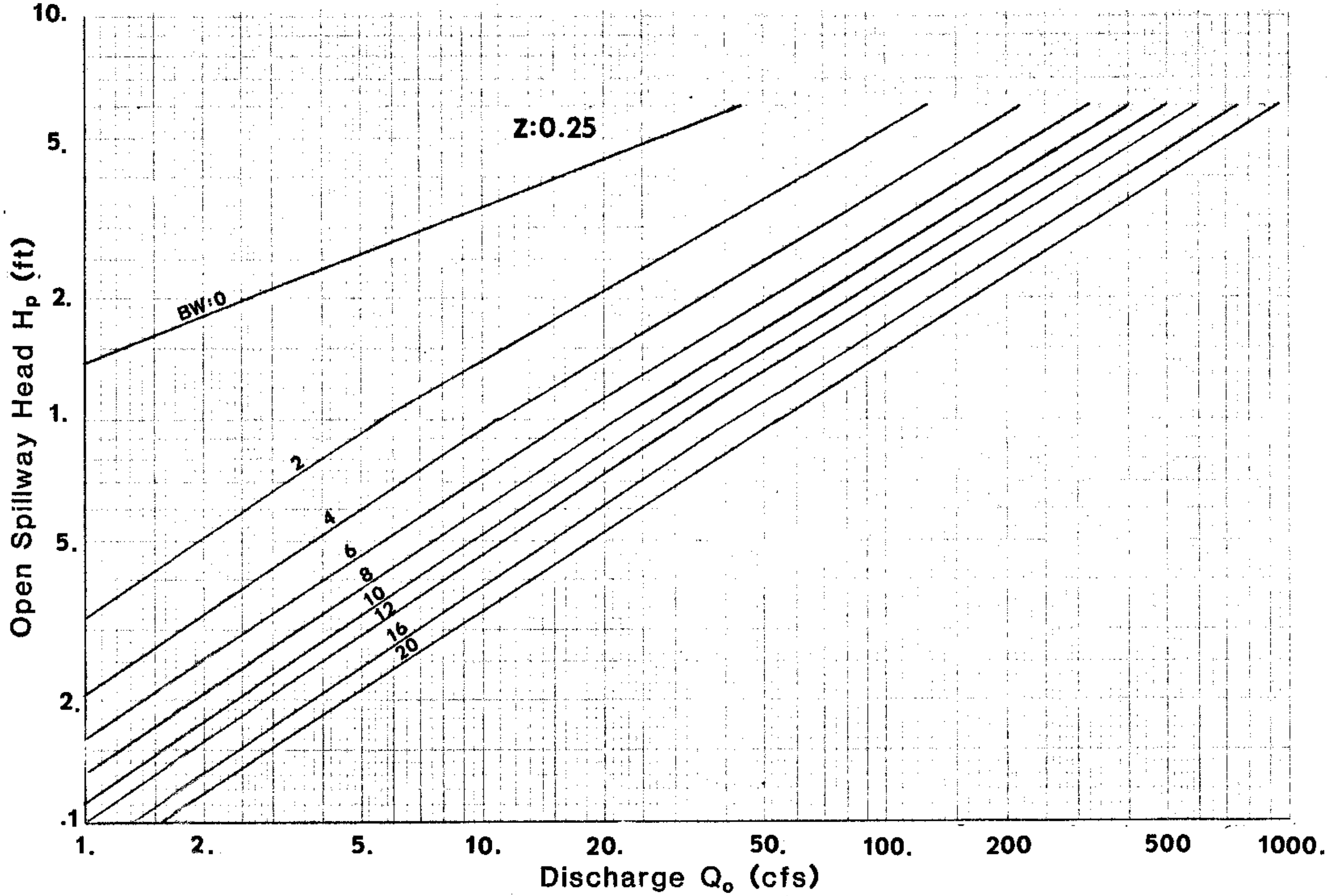


Figure 21 Stage-discharge relationships for selected trapezoidal open spillways.

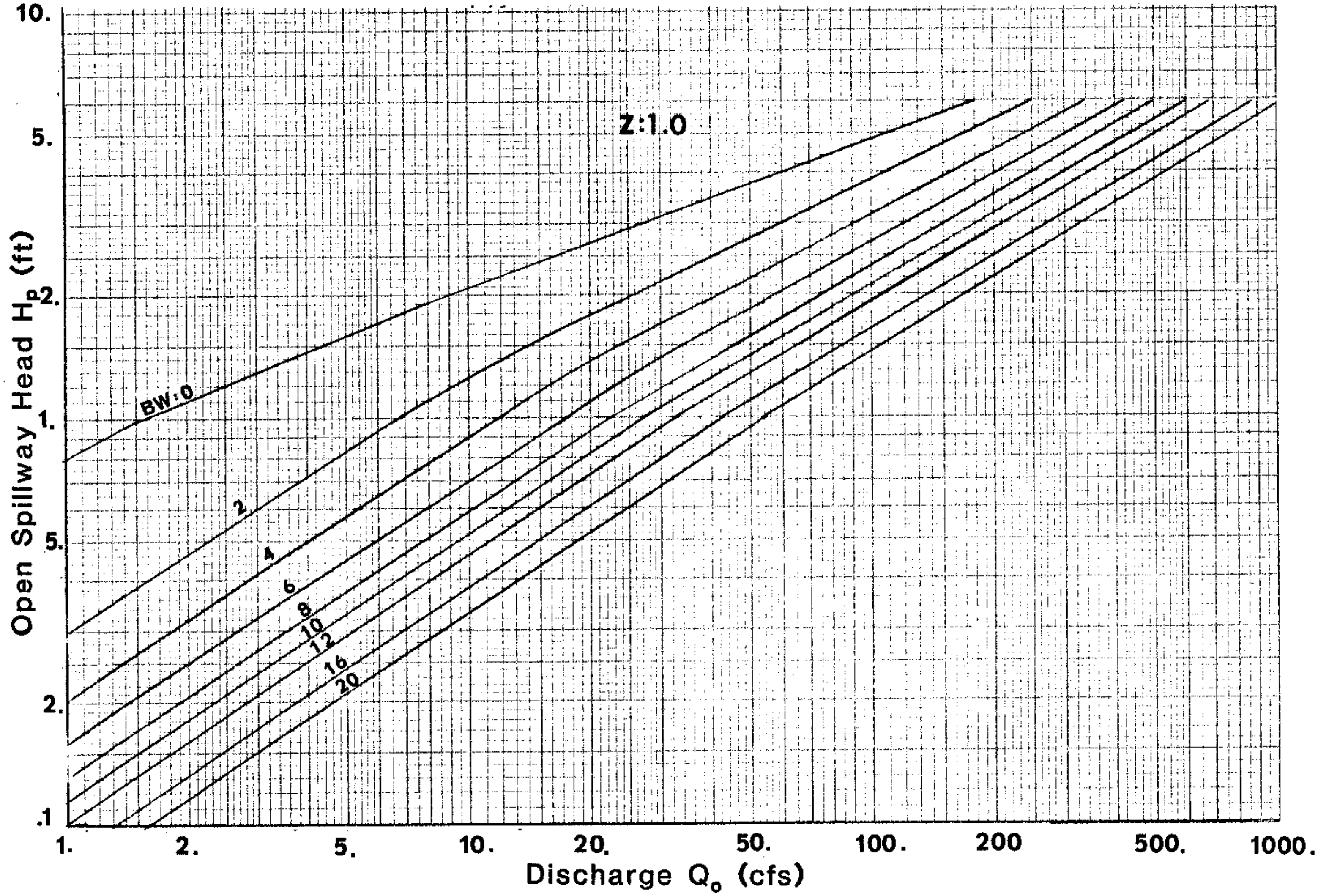


Figure 21 Continued.

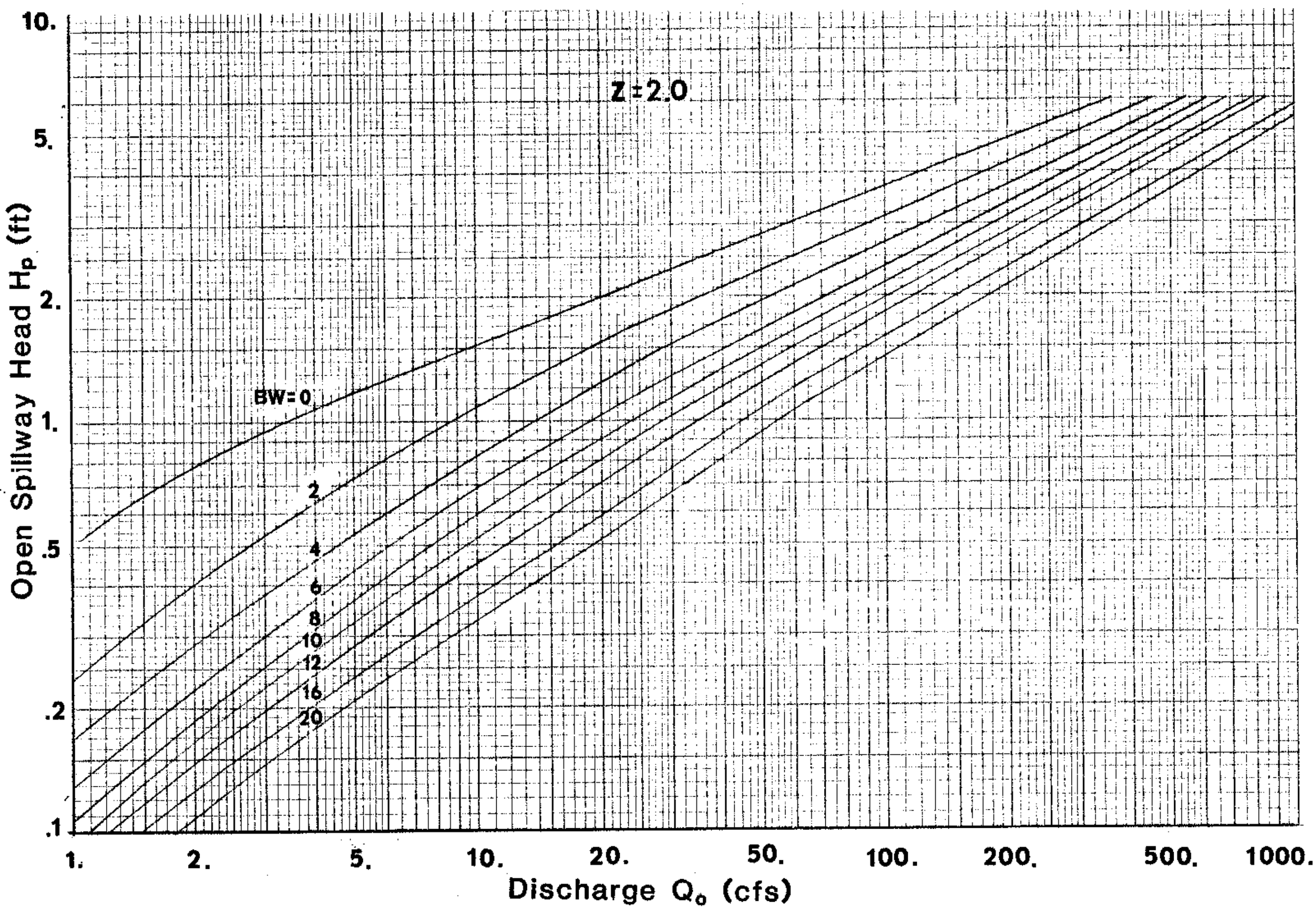


Figure 21 Continued.

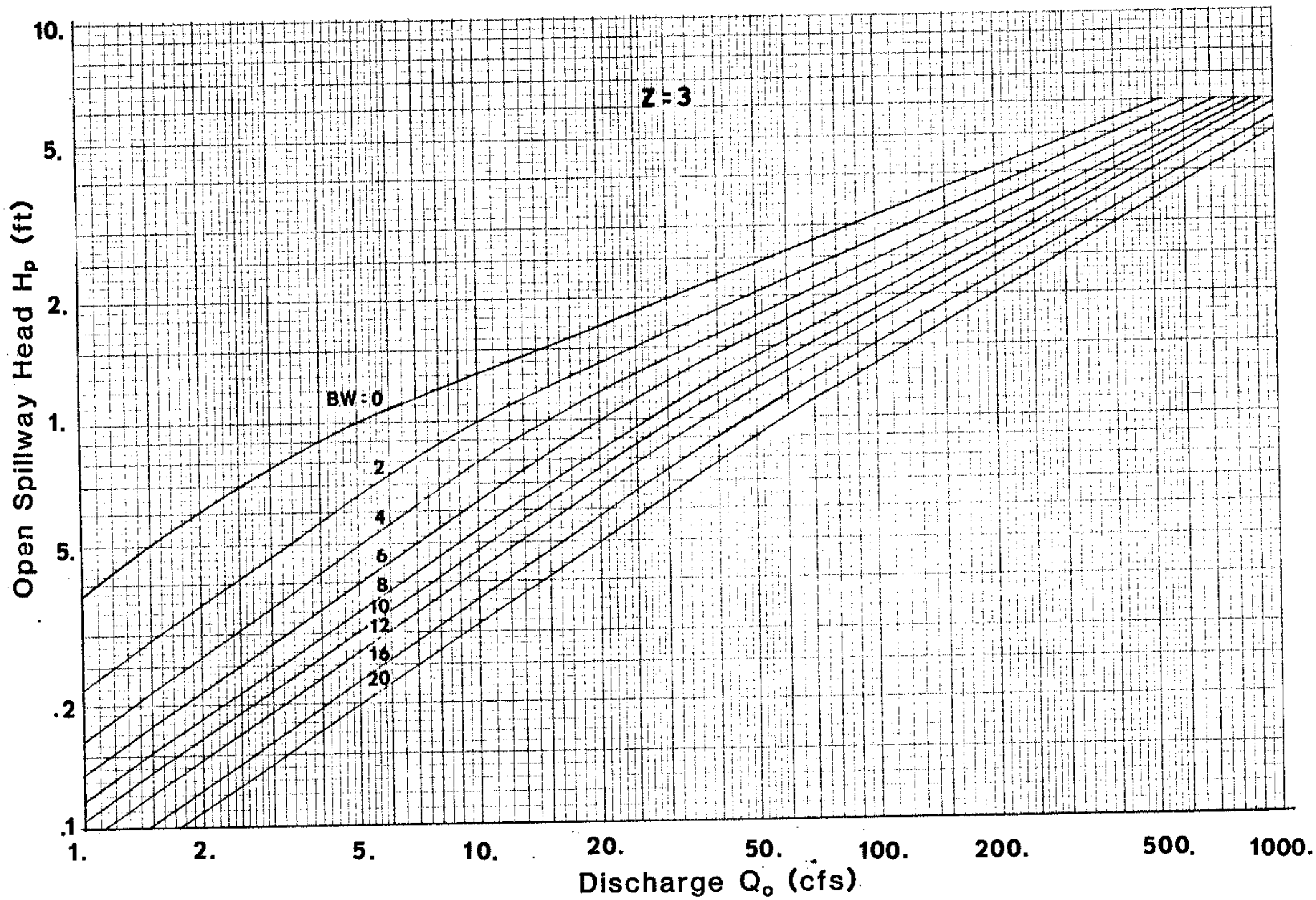


Figure 21 Continued.

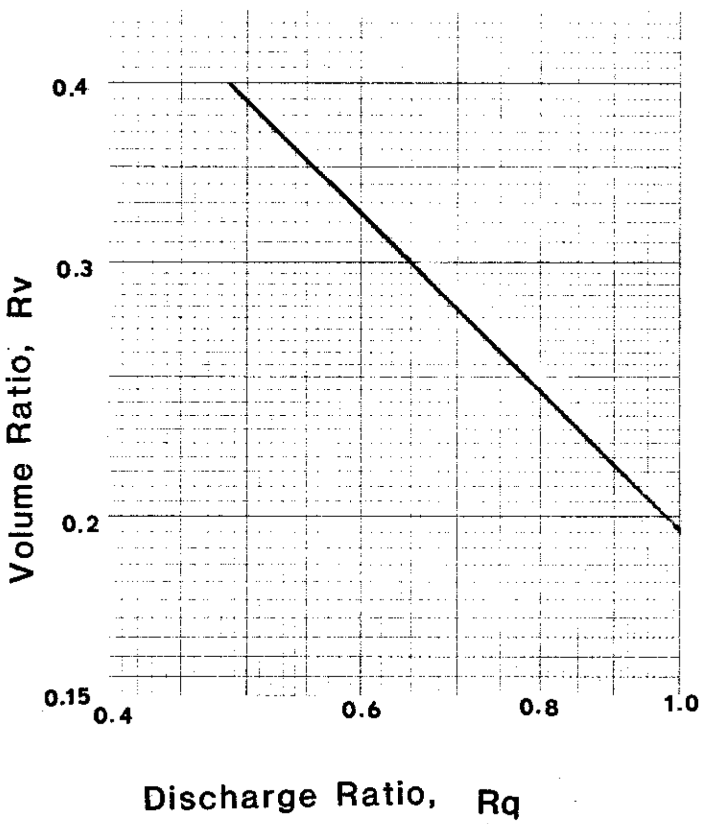


Figure 22 Routed peak discharge for trapezoidal emergency spillways.

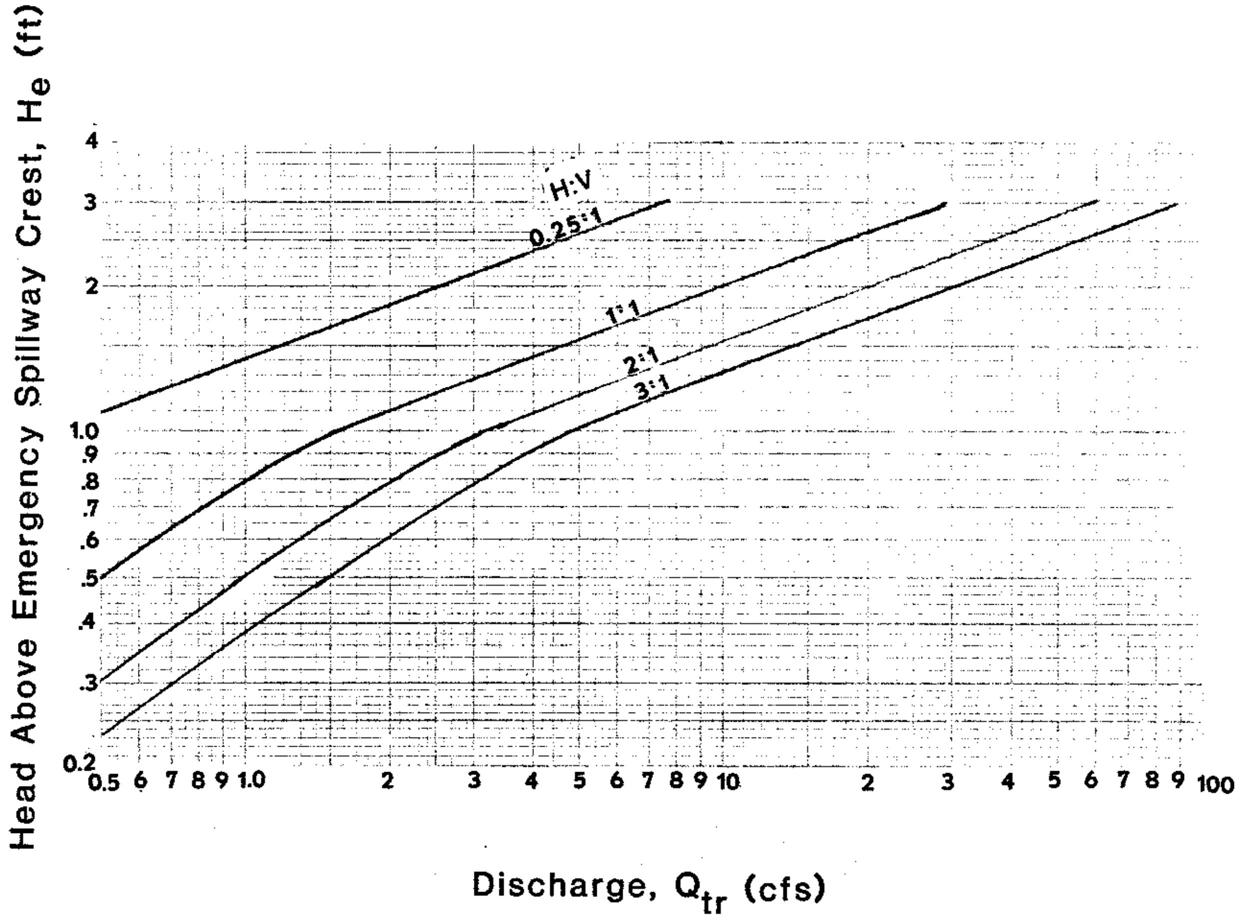


Figure 23 Stage-discharge relationships for the triangular portion of a trapezoidal emergency spillway.

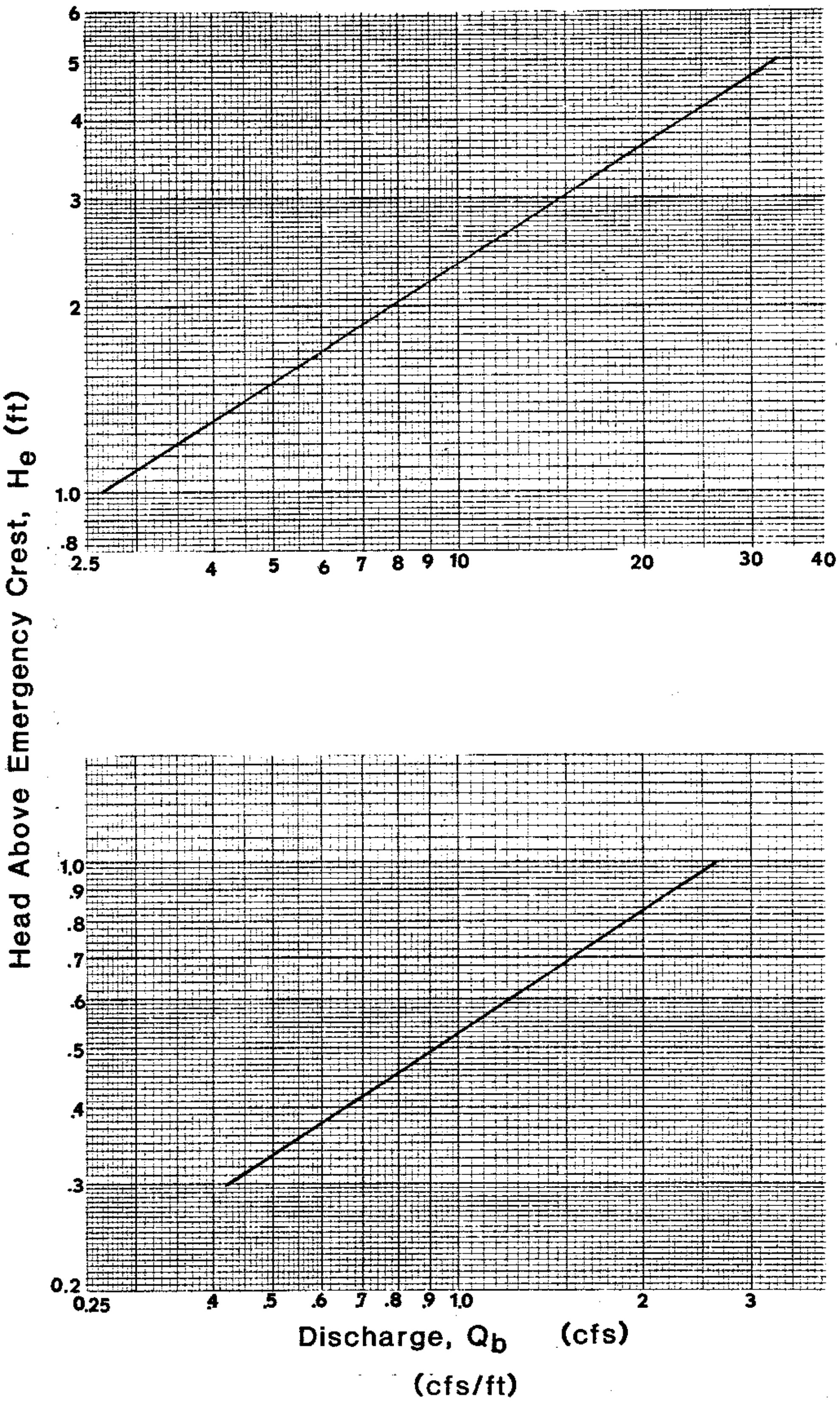


Figure 24 Stage-discharge relationships for the rectangular portion of a trapezoidal emergency spillway.

EMBANKMENT POND DESIGN WORKSHEET

Kentucky Graphical Method for Pipe Spillways

Application No. EMBANKMENT POND EXAMPLE Pond No. CONDUIT - RISER

WATERSHED HYDROLOGY

	Key
Total disturbed area A_d 14.0 acres / Drainage area A_w 63.0 acres x 100 = Total % disturbed P_d 22 %	A_d A_w P_d
Hydraulic length of watershed = L_h 2100 feet	L_h
Elevation at the most remote point in pond watershed (upstream point for hydraulic length) = E_u 1700 ft	E_u
Watershed elevation at sediment pond (downstream point for hydraulic length) = E_d 1300 ft	E_d
Average watershed slope S_w along the hydraulic length = 100 x (E_u 1700 - E_d 1300)/L_h 2100 = S_w 19 %	S_w
Watershed slope-length factor F_s = L_h 2100 /(S_w 19)$^{0.5}$ = F_s 482	F_s
Unit peak runoff from Figure 1 = q_u 0.69 cfs/acre-inch, weighted for 100 % forest and 0 % grassland	q_u
Premining unit peak runoff (weighted) from Figure 1 (P_d usually = 0%) = q_u^{pm} 0.59 cfs/acre-inch	q_u^{pm}

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10-year, 24-hour rainfall from Table 1 = P_{10} 4.1 inches | P_{10}

10-year, 24-hour runoff (weighted) from Figure 2 = Q_{10} 1.8 inches | Q_{10}

10-year, 24-hour inflow volume to pond Q_{vi}^{10} =

Q_{10} 1.8 x A_w 63 /12 = Q_{vi}^{10} 9.45 acre-feet | Q_{vi}^{10}

10-year, 24-hour peak inflow to pond Q_{pi}^{10} = q_u 0.69 x Q_{10} 1.8

x A_w 63 = Q_{pi}^{10} 78.2 cfs | Q_{pi}^{10}

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25-year, 24-hour rainfall from Table 1 = P_{25} 4.7 inches | P_{25}

25-year, 24-hour runoff (weighted) from Figure 2 = Q_{25} 2.2 inches | Q_{25}

25-year, 24-hour inflow volume to pond Q_{vi}^{25} =

Q_{25} 2.2 x A_w 63 /12 = Q_{vi}^{25} 11.55 acre-feet | Q_{vi}^{25}

25-year, 24-hour peak inflow to pond Q_{pi}^{25} = q_u 0.69 x Q_{25} 2.2

x A_w 63 = Q_{pi}^{25} 95.6 cfs | Q_{pi}^{25}

Premining 25-year, 24-hour runoff (weighted) to pond site Q_{25}^{pm} =

(P_d usually = 0%) Q_{25}^{pm} 2.0 inches | Q_{25}^{pm}

Premining 25-year, 24-hour peak inflow to pond site Q_{pi}^{pm} =

q_u^{pm} 0.59 x Q_{25}^{pm} 2.0 x A_w 63 = Q_{pm}^{pi} 74.3 cfs | Q_{pi}^{pm}

SEDIMENT POOL

Minimum sediment storage = 0.075 x A_d 14 = 1.05 acre-feet

Design sediment storage used = V_s 1.05 acre-feet | V_s

Elevation top of sediment pool from stage-volume curve = E_s 9.0 feet | E_s

STAGE-VOLUME RELATIONSHIP

To describe the incremental stage-volume relationship above the sediment pool with equation $\Delta E = k(\Delta V)^t$, pick points (E_1, V_1) and (E_2, V_2) directly from the stage-volume curve. Pick E_1 approximately 4 feet above the sediment pool, near the principal spillway elevation. Pick E_2 approximately 8 feet above the sediment pool, near the 10-year, 24-hour maximum water surface elevation.

$t = \log [(E_1 - E_s)/(E_2 - E_s)]/\log [(V_1 - V_s)/(V_2 - V_s)]$

$t = \log [(E_1$ 13.0 $- E_s$ 9.0 $)/(E_2$ 17.0 $- E_s$ 9.0 $)]/$ E_1 E_2

$\log [(V_1$ 2.73 $- V_s$ 1.05 $)/(V_2$ 5.50 $- V_s$ 1.05 $)]$ V_1 V_2

$t =$ 0.712 — t

$k = (E_2 - E_s)/(V_2 - V_s)^t$

$k = (E_2$ 17.0 $- E_s$ 9.0 $)/(V_2$ 5.50 $- V_s$ 1.05 $)^t$ 0.712

$k =$ 2.76 — k

PRINCIPAL SPILLWAY POOL

Find adjusted % disturbed area P_a at time of maximum disturbance:

Percent of disturbed area unrevegetated P_0 29 % — P_0

Percent with revegetation 0 - 2 months old P_{0-2} 71 % — P_{0-2}

Percent with revegetation 2 - 12 months or older P_{2-12} 0 % — P_{2-12}

($P_0 + P_{0-2} + P_{2-12} = 100\%$)

Adjusted % disturbed P_a from Figure 5 = P_a 8 % — P_a

Disturbance factor F_d from Figure 6 = F_d 8 % — F_d

Principal spillway pool volume V_{sp}^{10} for runoff volume of 10 acre-feet from

Figure 7 or 8 = V_{sp}^{10} 1.16 acre-feet — V_{sp}^{10}

Factors (a, b) to adjust V_{sp}^{10} for actual inflow volume Q_{vi}^{10}

For conduit/riser from Figures 10 & 11: (a) 0 (b) 0.29 — a

For trickle tube from Figures 12 & 13: (a) N/A (b) N/A — b

Adjusted principal spillway pool volume V_{sp} =

V_{sp}^{10} 1.16 + [a 0 x (Q_{vi}^{10} 9.45 $- 10)^2]$ +

[b 0.29 x (Q_{vi}^{10} 9.45 $- 10)]$ = V_{sp} 1.00 acre-feet

$V_{min} = 0.15 \times (Q_{vi}^{10}$ 9.45 $)^{0.25}$ = V_{min} 0.26 acre-feet — V_{min}

If V_{sp} is less than V_{min} then set $V_{sp} = V_{min}$

Final V_{sp} 1.00 acre-feet — V_{sp}

Final volume V_p at principal spillway crest =

V_s 1.05 + V_{sp} 1.00 = V_p 2.05 acre-feet — V_p

Principal spillway pool depth D_{sp} above sediment pool =

k 2.76 x V_{sp} 1.00 $^{t\ 0.712}$ = D_{sp} 2.8 ft — D_{sp}

Elevation of principal spillway crest E_p =

E_s 9.0 + D_{sp} 2.8 = E_p 11.8 feet — E_p

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(Conduit/riser only) Elevation of dewatering orifice E_o =

(E_s 9.0 + E_p 11.8)/2 = E_o 10.4 ft — E_o

Storage volume between orifice and principal spillway crest V_{op} =

(Use V_{op} = 0 for trickle tubes)

V_{sp} 1.00 x $[1.0 - 0.5^{1/t}]$ 0.62 = V_{op} 0.62 acre-feet — V_{op}

(Table 2)

EMERGENCY SPILLWAY POOL

Estimated storage volume V^*_{se} between top of sediment pool and emergency spillway = V_{sp} 1.00 x $[1.0/(0.5^{1.0/t})]$ 2.65 (Table 2) = V^*_{se} 2.65 ac-ft | V^*_{se}

Depth D^*_{se} corresponding to estimated V^*_{se} =

k 2.76 x V^*_{se} 2.65 $^{t\,0.712}$ = D^*_{se} 5.5 feet | D^*_{se}

Estimated storage volume V^*_{pe} above principal spillway =

V^*_{se} 2.65 - V_{sp} 1.00 = V^*_{pe} 1.65 acre-ft | V^*_{pe}

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Initial storage/inflow volume ratio R^*_v =

V^*_{pe} 1.65 /(Q^{10}_{vi} 9.45 - V_{op} 0.62) = R^*_v 0.19 | R^*_v

Take R^*_v to Figure 16 or 17, get initial outflow/inflow discharge ratio = R^*_q 0.38 | R^*_q

Estimated peak outflow Q^*_{po} = R^*_q 0.38 x Q^{10}_{pi} 78.2 = Q^*_{po} 29.7 cfs | Q^*_{po}

For conduit/riser spillways, elevation difference between conduit outlet invert and riser crest = H_{ic} 15.0 feet. Use H_{ic} = 0 for trickle tubes. | H_{ic}

Head on principal spillway H^*_p =

D^*_{se} 5.5 - D_{sp} 2.8 + H_{ic} 15.0 = H^*_p 17.7 feet | H^*_p

Find intersection of H^*_p and Q^*_{po} in Figure 19 or 20. Read left to next pipe spillway size. Selected pipe spillway size = S_d 18-30 inches | S_d

Peak conduit outflow Q^{10}_{po} at head H^*_p from Figure 19 or 20 = Q^{10}_{po} 17.3 cfs | Q^{10}_{po}

Final outflow/inflow discharge ratio $R_q^{10} = Q_{po}^{10}$ 17.3 / Q_{pi}^{10} 78.2 = R_q^{10} 0.22 | R_q^{10}

Final storage/inflow volume ratio from Figure 16 or 17 = R_v^{10} 0.30 | R_v^{10}

Final storage volume V_{pe} between principal and emergency spillways =

R_v^{10} 0.30 x (Q_{vi}^{10} 9.45 - V_{op} 0.62) = V_{pe} 2.65 acre-ft | V_{pe}

Final depth D_{se} from sediment pool to emergency spillway =

k 2.76 x (V_{sp} 1.00 + V_{pe} 2.65)$^{\text{to } 0.712}$ = D_{se} 6.9 feet | D_{se}

Final elevation at emergency spillway E_e =

E_s 9.0 + D_{se} 6.9 = E_e 15.9 feet | E_e

Final pond volume at emergency spillway V_e = V_s 1.05 +

V_{sp} 1.00 + V_{pe} 2.65 = V_e 4.70 acre-feet | V_e

EMERGENCY SPILLWAY DESIGN

Side Slopes z = 2 (zH:1.0V) | z

Q_{vi}^{25} 11.55 - Q_{vi}^{10} 9.45 = ΔQ_{vi} 2.10 acre-feet | ΔQ_{vi}

Q_{pi}^{25} 95.6 - Q_{pi}^{10} 78.2 = ΔQ_{pi} 17.4 cfs | ΔQ_{pi}

Selected head on emergency spillway = H_e 0.7 ft | H_e

Select a value of H_e which gives acceptable spillway bottom widths. H_e between 0.5 and 1.0 will work well in many cases.

Pond volume V_{25} at maximum water surface elevation = $[(D_{se}$ 6.9 + H_e 0.7 $)/k$ 2.76 $]^{1.0/t\ 0.712}$ + V_s 1.05 = V_{25} 5.20 ac-ft | V_{25}

Volume ratio R_v^{25} = (V_{25} 5.20 − V_e 4.70)/ ΔQ_{vi} 2.10 = R_v^{25} 0.24 | R_v^{25}

Take volume ratio R_v^{25} to Figure 22, get discharge ratio = R_q^{25} 0.82 | R_q^{25}

Routed emergency spillway discharge Q_{eo} =

ΔQ_{pi} 17.4 x R_q^{25} 0.82 = Q_{eo} 14.3 cfs | Q_{eo}

Take H_e to Figure 23, get discharge for triangular part of emergency spillway = Q_{tr} 1.7 cfs | Q_{tr}

Take H_e to Figure 24, get discharge per foot of width in rectangular part of emergency spillway = Q_b 1.55 cfs/ft | Q_b

Spillway bottom width BW =

(Q_{eo} 14.3 − Q_{tr} 1.7)/Q_b 1.55 = BW 8.1 ft | BW

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Principal Spillway Discharge Q_{po}^{25}

Head on principal spillway H_p^{25} =

Conduit/riser: H_{ic} 15.0 + D_{se} 6.9 − D_{sp} 2.8 + H_e 0.7 = H_p^{25} 19.8 ft | H_p^{25}

Trickle tube: D_{se} N/A − D_{sp} N/A + H_e N/A = H_p^{25} N/A ft

From Figure 19 or 20 , discharge = Q_{po}^{25} 13.3 cfs | Q_{po}^{25}

Combined Discharge for Principal and Emergency Spillways Q_{pe} =

Q_{eo} 14.3 + Q_{po}^{25} 13.3 = Q_{pe} 32.6 cfs | Q_{pe}

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Structure Height from Upstream Toe of Embankment to Crest of Emergency Spillway = SH_{te} 15.9 ft | SH_{te}

Structure Volume Impounded from Upstream Toe of Embankment to Crest of Emergency Spillway = V_{te} 4.70 acre-feet | V_{te}

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Elevation of Top of Dam E_t =

elevation at centerline base of dam 1300 ft. + 1.05 x (embankment height from centerline base of dam to emergency spillway crest 17.9 ft. + H_e 0.7 ft. + freeboard, 1 ft. minimum 1.0 ft.) = E_t 1320.6 ft. | E_t

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SUMMARY OF SEDIMENT POND DESIGN
EMBANKMENT POND

	assumed elevation (if used)	msl elevation
Sediment pool elevation, E_s	9.0 ft.	1311.0 ft.
Dewatering orifice elevation, E_o	10.4 ft.	1312.4 ft.
Principal spillway elevation, E_p	11.8 ft.	1313.8 ft.
Emergency spillway elevation, E_e	15.9 ft.	1317.9 ft.
Top of dam elevation, E_t	ft.	1320.6 ft.

Sediment pool volume, V_s	1.05 ac-ft.
Principal spillway size, S_d	18-30 in.
Total volume at principal spillway, V_p	2.05 ac-ft.
Total volume at emergency spillway, V_e	4.70 ac-ft.
Structure height at emergency spillway, SH_{te}	15.9 ft.
Structure volume at emergency spillway, V_{te}	4.70 ac.-ft.
Emergency spillway side slopes, zH:1V	2 z
Emergency spillway bottom width, BW	8.1 ft.

EXCAVATED POND DESIGN WORKSHEET

Kentucky Graphical Method for Trapezoidal Open Spillways

Application No. EXCAVATED POND EXAMPLE Pond No. OPEN SPILLWAY

WATERSHED HYDROLOGY | **Key**

Total disturbed area A_d 25.4 acres / Drainage area A_w 79.6 acres x 100 = Total % disturbed P_d 32 % — A_d, A_w, P_d

Hydraulic length of watershed = L_h 2800 feet — L_h

Elevation at the most remote point in pond watershed (upstream point for hydraulic length) = E_u 525 ft — E_u

Watershed elevation at sediment pond (downstream point for hydraulic length) = E_d 400 ft — E_d

Average watershed slope S_w along the hydraulic length =

100 x (E_u 525 - E_d 400)/L_h 2800 = S_w 4.5 % — S_w

Watershed slope-length factor F_s = L_h 2800 /(S_w 4.5 $)^{0.5}$ = F_s 1320 — F_s

Unit peak runoff from Figure 1 = q_u 0.74 cfs/acre-inch, weighted for 45 % forest and 55 % grassland — q_u

Premining unit peak runoff (weighted) from Figure 1 (P_d usually = 0%) = q_u^{pm} 0.66 cfs/acre-inch — q_u^{pm}

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10-year, 24-hour rainfall from Table 1 = P_{10} 4.8 inches — P_{10}

10-year, 24-hour runoff (weighted) from Figure 2 = Q_{10} 2.7 inches — Q_{10}

10-year, 24-hour inflow volume to pond Q_{vi}^{10} =

Q_{10} 2.7 x A_w 79.6 /12 = Q_{vi}^{10} 17.9 acre-feet — Q_{vi}^{10}

10-year, 24-hour peak inflow to pond Q_{pi}^{10} = q_u 0.74 x Q_{10} 2.7

x A_w 79.6 = Q_{pi}^{10} 159 cfs — Q_{pi}^{10}

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25-year, 24-hour rainfall from Table 1 = P_{25} 5.5 inches — P_{25}

25-year, 24-hour runoff (weighted) from Figure 2 = Q_{25} 3.2 inches — Q_{25}

25-year, 24-hour inflow volume to pond Q_{vi}^{25} =

Q_{25} 3.2 x A_w 79.6 /12 = Q_{vi}^{25} 21.2 acre-feet — Q_{vi}^{25}

25-year, 24-hour peak inflow to pond Q_{pi}^{25} = q_u 0.74 x Q_{25} 3.2

x A_w 79.6 = Q_{pi}^{25} 188 cfs — Q_{pi}^{25}

Premining 25-year, 24-hour runoff (weighted) to pond site from Figure 2, Q_{25}^{pm}

(P_d usually = 0%) = Q_{25}^{pm} 3.0 inches — Q_{25}^{pm}

Premining 25-year, 24-hour peak inflow to pond site Q_{pi}^{pm} =

q_u^{pm} 0.66 x Q_{25}^{pm} 3.0 x A_w 79.6 = Q_{pi}^{pm} 158 cfs — Q_{pi}^{pm}

SEDIMENT STORAGE VOLUME

Minimum sediment storage = 0.075 x A_d 25.4 = 1.90 acre-feet

Design sediment storage used = V_s 1.90 acre-feet — V_s

STAGE-VOLUME RELATIONSHIP

Throughout this design method, relative elevations, rather than msl elevations, should be used in the computations. Any consistent datum for relative elevations can be used. When all computations are completed, the relative elevations can be converted to msl elevations on the summary sheet.

The incremental stage-volume relationship above the sediment pool is described by equation $\Delta E = k(\Delta V)^t$. At the designer's option, t and k may be taken directly from Figures 3 and 4 for excavated ponds which are trapezoidal in cross-section. Select the pond width W_s 100 ft. at the sediment pool, and the pond side slopes Z_d 2 :1. Then the pond length at the sediment pool = $2W_s + 10Z_d = L_s$ 220 ft. Read t and k from Figures 3 and 4 and enter t and k below.

W_s
Z_d
L_s

For pond cross-sections other than trapezoidal, or at the designer's option, pick points (E_1, V_1) and (E_2, V_2) directly from the stage-volume curve. The pond should have a minimum length/average width ratio of 2:1, where length and average width are measured at the elevation of the open spillway crest. Pick E_1 approximately 2 ft. above the sediment pool, near the open spillway crest elevation. Pick E_2 approximately 5 ft. above the sediment pool, near the maximum 10-year, 24-hour water surface elevation.

Relative elevation E_s of top of sediment pool = E_s 0.0 feet

E_s

$t = \log[(E_1 - E_s)/(E_2 - E_s)]/\log[(V_1 - V_s)/(V_2 - V_s)]$

$t = \log[(E_1$ ________ $- E_s$ ________$)/(E_2$ ________ $- E_s$ ________$)]/$

$\log[(V_1$ ________ $- V_s$ ________$)/(V_2$ ________ $- V_s$ ________$)]$

E_1
E_2
V_1
V_2

t = ________ (calculated) or t = 0.916 (from Figure 3)

t

$k = (E_2 - E_s)/(V_2 - V_s)^t$

$k = (E_2$ ________ $- E_s$ ________$)/(V_2$ ________ $- V_s$ ________$)^{t\ ________}$

k = ________ (calculated) or k = 1.91 (from Figure 4)

k

VOLUME AND ELEVATION AT OPEN SPILLWAY CREST

Find adjusted % disturbed area P_a at time of maximum disturbance:

Percent of disturbed area unrevegetated P_0 28 % | P_0

Percent with revegetation 0 - 2 months old P_{0-2} 38 % | P_{0-2}

Percent with revegetation 2 - 12 months or older P_{2-12} 34 % | P_{2-12}

$(P_0 + P_{0-2} + P_{2-12} = 100\%)$

Adjusted % disturbed P_a from Figure 5 $= P_a$ 11 % | P_a

Disturbance factor F_d from Figure 6 $= F_d$ 1.6 % | F_d

Spillway pool volume V_{sp}^{10} for runoff volume of 10 acre-feet from Figure 9

$= V_{sp}^{10}$ 0.41 acre-feet | V_{sp}^{10}

From Figure 14, factor a to adjust V_{sp}^{10} for actual inflow volume Q_{vi}^{10} =

a 0.00098 | a

From Figure 15, factor b to adjust V_{sp}^{10} = b 0.072 | b

Volume V_{sp} between sediment pool and open spillway crest, adjusted for actual inflow volume Q_{vi}^{10} =

V_{sp}^{10} 0.41 + [a 0.00098 x (Q_{vi}^{10} 17.9 - 10)^2]

+ [b 0.072 x (Q_{vi}^{10} 17.9 - 10)] = V_{sp} 1.04 acre-ft

V_{min} = 0.15 x (Q_{vi}^{10} 17.9)$^{0.25}$ = V_{min} 0.31 acre-feet | V_{min}

If V_{sp} is less than V_{min} then set $V_{sp} = V_{min}$

Final V_{sp} 1.04 acre-feet | V_{sp}

Total pond volume V_p at open spillway crest =

V_s 1.90 + V_{sp} 1.04 = V_p 2.94 acre-feet | V_p

Depth D_{sp} between open spillway crest and sediment pool =

k $\underline{1.91}$ x (V_{sp} $\underline{1.04}$)$^{t\ \underline{.916}}$ = D_{sp} $\underline{2.0}$ ft ($D_{sp} \geq 1.5$ ft.) D_{sp}

Relative elevation of open spillway crest E_p =

E_s $\underline{0}$ + D_{sp} $\underline{2.0}$ = E_p $\underline{2.0}$ $\underline{E_p}$

LENGTH AND WIDTH OF POND

Ponds with Trapezoidal Cross Section

When t and k have been determined from Figures 3 and 4, use this calculation to determine W_p and L_p. This insures a ratio of $L_p/W_p \geq 2:1$ for all $1.5 \leq D_{sp} \leq 5$. When t and k have been calculated from a stage-volume curve, determine W_p and L_p for the pond site and enter at other pond configurations below.

Width of pond W_p at open spillway crest elevation =

W_s $\underline{100}$ + (2 x Z_d $\underline{2}$ x D_{sp} $\underline{2.0}$) = W_p $\underline{103}$ ft $\underline{W_p}$

Length of pond L_p at open spillway crest elevation =

2 x W_s $\underline{100}$ + 10 x Z_d $\underline{2}$ + (2 x Z_d $\underline{2}$ x D_{sp} $\underline{2.0}$)

= L_p $\underline{228}$ ft $\underline{L_p}$

Other Pond Configurations

W_p ______ ft

L_p ______ ft

($L_p/W_p \geq 2.0$)

OPEN SPILLWAY SIDE SLOPES AND BOTTOM WIDTH

Storage volume V_{s10} between top of sediment pool and

10-year, 24-hour water surface = V_{sp} $\underline{1.04}$ x [1.0/(0.4$^{1.0/t}$)] $\underline{2.71}$ (Table 3) = V_{s10}

V_{s10} $\underline{2.82}$ acre-feet

Depth D_{s10} corresponding to V_{s10} =

k $\underline{1.91}$ x V_{s10} $\underline{2.82}^{t\ \underline{.916}}$ = D_{s10} $\underline{4.9}$ feet D_{s10}

Storage volume V_{p10} between open spillway crest and

10-year, 24-hour water surface = V_{s10} 2.82 - V_{sp} 1.04 =

V_{p10} 1.78 acre-ft — V_{p10}

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Storage/inflow volume ratio R_v^{10} =

V_{p10} 1.78 $/Q_{vi}^{10}$ 17.9 = R_v^{10} 0.10 — R_v^{10}

Take R_v^{10} to Figure 18, get initial outflow/inflow discharge ratio = R_q^{10} 0.92 — R_q^{10}

Peak outflow Q_{po}^{10} = R_q^{10} 0.92 x Q_{pi}^{10} 159 = Q_{po}^{10} 146 cfs — Q_{po}^{10}

Head on open spillway H_{10} =

D_{s10} 4.9 - D_{sp} 2.0 = H_{10} 2.9 feet — H_{10}

Find intersection of H_{10} and Q_{po} in Figure 21. Select side slopes

z 2 H:1V, and round bottom width to nearest 0.5 foot = — z

BW 6.0 ft — BW

25-YEAR, 24-HOUR ROUTED DISCHARGE IN OPEN SPILLWAY

Assume R_q^{25} = R_q^{10} = R_q^{25} 0.92 — R_q^{25}

Peak outflow Q_{po}^{25} = R_q^{25} 0.92 x Q_{pi}^{25} 188 = Q_{po}^{25} 173 cfs — Q_{po}^{25}

Take Q_{po}^{25} and BW to Figure 21, get head on open spillway = H_{25} 3.2 ft — H_{25}

(H_{25} + 1.0) must not exceed 5.0 feet.

ELEVATION OF TOP OF DIKE E_t =

E_p 2.0 ft. + H_{25} 3.2 ft. + freeboard,

1 ft. minimum 1.0 ft.) = E_t 6.2 ft. — E_t

SUMMARY OF SEDIMENT POND DESIGN
EXCAVATED POND

	relative elevation	msl elevation
Lowest point in natural ground, E_{ng}		400 ft.
Sediment pool elevation, E_s	0 ft.	* 398 ft.
Open spillway crest elevation, E_p	2.0 ft.	* 400 ft.
Top of dike elevation, E_t	6.2 ft.	* 404.2 ft.

*This design procedure uses relative elevations to determine the necessary size and shape of the basin to be excavated. That basin is then "fitted into" the natural ground at the site. The actual msl elevations for the excavated pond and dike are determined from the relative elevations by matching the relative elevation E_p of the open spillway crest to the actual msl elevation E_{ng} of the lowest point in the natural ground surface at the spillway site. The msl elevations corresponding to relative elevations E_s, E_p, and E_t are determined by adding the quantity ($E_{ng} - E_p$) to the relative elevations E_s, E_p, and E_t.

Sediment pool volume, V_s	1.90	ac-ft.
Total volume at open spillway crest, V_p	2.94	ac-ft.
Open spillway side slopes, zH:1V	2:1	z
Open spillway bottom width, BW	6.0	ft.
Pond side slopes, Z_d:1	2:1	Z_d
Average width of pond, W_p	108	ft.
Length of pond, L_p	228	ft.