United States Department of Agriculture

Soil Conservation Service

P.O. Box 2890
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20013

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TECHNICAL RELEASE 60, REVISED OCTOBER 1985
210-VI
AMENDMENT 1

SUBJECT: ENG - EARTH DAMS AND RESERVOIRS

Purpose. To eliminate the parameter H and redefine the parameters L, T, and H_W in the peak breach discharge criteria; to define the hydrologic boundaries for areas 1, 2, and 3 on page 2-10; and to update the requirements for the design of diaphragms used in piping and seepage control.

Effective Date. Effective when received.

Explanation of Changes. The equations for the theoretical breach width, T, and the related peak discharge, Q_{max}, in category 3, page 1-2 of TR-60 are applicable only when the water depth, H_W, is equal to the height of the dam. The enclosed replacement page contains the following revisions, which are applicable to a full range of H_W values:

1. The definition for the parameters L, T, and H_W are changed, and

2. The parameter H is eliminated and is replaced by the parameter H_W in two equations.

The 100-year, 10-day runoff map on page 2-10 should be divided into three areas, i.e., areas 1, 2, and 3; but the hydrologic boundaries and the area numbers were not shown. The revised page shows distinct boundary lines and area numbers to delineate and identify the areas.

The design of the drainage diaphragm used in piping and seepage control needs to meet only the requirements of Soil Mechanic Note No. 1; thus, the exception is eliminated.

Filing Instructions. Remove pages 1-1, 1-2, 2-9, 2-10, 6-7 and 6-8 of TR-60 (revised October 1985) and replace with the enclosed pages.

DIST: TR-60

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Distribution. Make this Amendment available to all offices having a copy of TR-60. Additional copies may be obtained from the Consolidated Forms and Publication Distribution Center by ordering TR-60A.

ROBERT R. SHAW
Deputy Chief for Technology

Enclosures

General

Dam Classification

In determining dam classification, a number of factors are to be considered. Consideration is to be given to the damage that might occur to existing and future developments should the dam suddenly release large quantities of water downstream due to a breach, failure or landslide into the reservoir. The effect of failure on public confidence is an important factor. State and local regulations and the responsibility of the involved public agencies are to be recognized. The stability of the spillway materials, the physical characteristics of the site and the valley downstream, and the relationship of the site to industrial and residential areas including controls of future development all have a bearing on the amount of potential damage in the event of a failure.

Dam classification is determined by the above conditions. It is not determined by the criteria selected for design. The policy on classification is in 210-V, Part 520, Subpart C DAMS (National Engineering Manual).

Classes of Dams

The following classes of dams have been established by policy and repeated here for convenience of the user.

Class (a). --Dams located in rural or agricultural areas where failure may damage farm buildings, agricultural land, or township and country roads.

Class (b). --Dams located in predominantly rural or agricultural areas where failure may damage isolated homes, main highways or minor railroads or cause interruption of use or service of relatively important public utilities.

Class (c). --Dams located where failure may cause loss of life, serious damage to homes, industrial and commercial buildings, important public utilities, main highways, or railroads.

Peak Breach Discharge Criteria

Breach routings are used to help delineate the area potentially impacted by inundation should a dam fail and can be used to aid dam classification.

Stream routings made of the breach hydrograph are to be based upon topographic data and hydraulic methodologies mutually consistent in their accuracy and commensurate with the risk being evaluated.

The minimum peak discharge of the breach hydrograph 1/ regardless of the technique used to analyze the downstream inundation area, is as follows:

1/ The breach hydrograph is the outflow hydrograph attributed to the sudden release of water in reservoir storage due to a dam breach.

1. For depth of water at the dam at the time of failure $\geq$ 103 feet.

$$Q_{max} = 65\ H_w^{1.85}$$

2. For depth of water at the dam at the time of failure < 103 feet.

$$Q_{max} = 1100\ B_r^{1.35}, \qquad \text{where } B_r = \frac{V_s\ H_w}{A}$$

but is not to be less than

$$Q_{max} = 3.2\ H_w^{2.5}$$

and need not exceed

$$Q_{max} = 65\ H_w^{1.85}$$

3. When the width of the valley, L, at the water surface elevation corresponding to the depth, H_w, is less than

$$T = \frac{65\ H_w^{0.35}}{0.416},$$

replace the equation

$$Q_{max} = 65\ H_w^{1.85}$$

in categories 1 and 2 above with the equation

$$Q_{max} = 0.416\ L\ H_w^{1.5}$$

Where,

Q_{max} = the peak breach discharge, cfs.

B_r = breach factor, acre.

V_s = reservoir storage at the time of failure, acre-feet.

H_w = depth of water at the dam at the time of failure; however, if the dam is overtopped, depth is set equal to the height of dam, feet.

A = cross-sectional area of embankment at the assumed location of breach, usually the template section (normal to the dam longitudinal axis) at the general flood plain location, sq. ft.

T = theoretical breach width at the water surface elevation corresponding to the depth, H_w, for the equation $Q_{max} = 65\ H_w^{1.85}$, feet.

L = width of the valley at the water surface elevation corresponding to the depth, H_w, feet.

TABLE 2-5

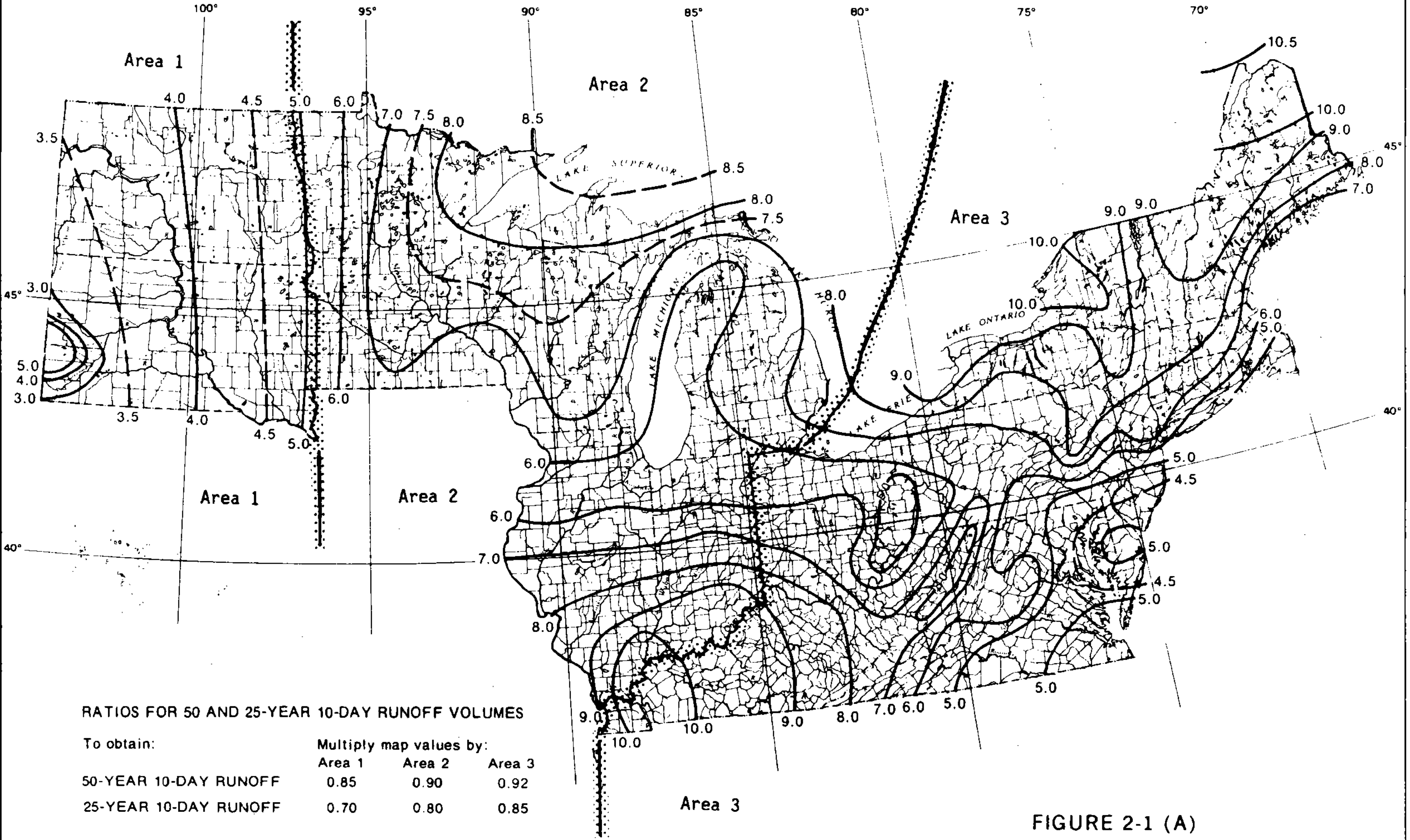
MINIMUM EMERGENCY SPILLWAY HYDROLOGIC CRITERIA

Class of Dam	Product of Storage x Effective Height	Existing or Planned Upstream Dams	Precipitation Data for 1/	
			Emergency Spillway Hydrograph	Freeboard Hydrograph
(a) 2/	less than 30,000	none	P_{100}	$P_{100} + 0.12\ (PMP - P_{100})$
	greater than 30,000	none	$P_{100} + 0.06\ (PMP - P_{100})$	$P_{100} + 0.26\ (PMP - P_{100})$
	all	any 3/	$P_{100} + 0.12\ (PMP - P_{100})$	$P_{100} + 0.40\ (PMP - P_{100})$
(b)	all	none or any	$P_{100} + 0.12\ (PMP - P_{100})$	$P_{100} + 0.40\ (PMP - P_{100})$
(c)	all	none or any	$P_{100} + 0.26\ (PMP - P_{100})$	PMP

1/ P_{100} = Precipitation for 100-year return period. PMP = Probable maximum precipitation.

2/ Dams involving industrial or municipal water are to use minimum criteria equivalent to that of class (b).

3/ Applies when the upstream dam is located so that its failure could endanger the lower dam.



RATIOS FOR 50 AND 25-YEAR 10-DAY RUNOFF VOLUMES

To obtain:	Multiply map values by: Area 1	Area 2	Area 3
50-YEAR 10-DAY RUNOFF	0.85	0.90	0.92
25-YEAR 10-DAY RUNOFF	0.70	0.80	0.85

FIGURE 2-1 (A)
100-YEAR, 10-DAY RUNOFF (INCHES)
PRINCIPAL SPILLWAY HYDROGRAPH

JANUARY 1971, REV. APRIL 1976, OCTOBER 1990

Only joints incorporating a round rubber gasket set in a positive groove which will prevent its displacement from either internal or external pressure under the required joint extensibility are to be used on precast concrete pipe conduits. Concrete pipe must have steel joint rings providing rubber to steel contact in the joint.

Articulation of the conduit (freedom for required rotation) is to be provided at each joint in the conduit, at the junction of the conduit with the riser and any outlet structure. Concrete bedding for pipe conduits need not be articulated. Cradles are to be articulated if on yielding foundations. Welded steel pipe conduits need not be articulated if the pipe and bedding rest directly on firm bedrock.

Piping and Seepage Control - Use a filter and drainage diaphragm around any structure that extends through the embankment to the downstream slope. Design the diaphragm with single or multizones to meet the requirements of Soil Mechanics Note No. 1.

Locate the diaphragm aligned approximately parallel to the centerline of the dam or approximately perpendicular to the direction of seepage flow. Extend the diaphragm horizontally and vertically into the adjacent embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation.

Design the diaphragms to extend the following minimum distances from the surface of rigid conduits:

1. Horizontally and vertically upward 3 times the outside diameter of circular conduits or the vertical dimension of rectangular box conduits except that:

    a. the vertical extension need be no higher than the maximum potential reservoir water level, and

    b. the horizontal extension need be no further than 5 feet beyond the sides and slopes of any excavation made to install the conduit.

2. Vertically downward:

    a. for conduit settlement ratios (δ) of 0.7 and greater (reference SCS Technical Release No. 5), the greater of (1) 2 feet or (2) 1 foot beyond the bottom of the trench excavation made to install the conduit. Terminate the diaphragm at the surface of bedrock when it occurs within this distance. Additional control of general seepage through an upper zone of weathered bedrock may be needed.

    b. 1.5 times the outside diameter of circular conduits or the outside vertical dimension of box conduits for conduit settlement ratios (δ) less than 0.7.

Design the diaphragms to extend in all directions a minimum of 2 times the outside diameter from the surface of flexible conduits, except that the diaphragm need not extend beyond the limits in 1a and 1b above nor beyond a bedrock surface beneath the conduit.

Provide minimum diaphragm thickness of 3 feet and minimum thickness of 1 foot for any zone of a multizone system. Use larger thickness when needed for (1) capacity, (2) tieing into embankment or foundation drainage systems, (3) accommodating construction methods, or (4) other reasons.

For homogeneous dams, locate the diaphragm in the downstream section of the dam such that it is:

1. Downstream of the cutoff trench,

2. Downstream of the centerline of the dam when no cutoff trench is used, and

3. Upstream of a point where the embankment cover (upstream face of the diaphragm to the downstream face of the dam) is at least one-half of the difference in elevation between the top of the diaphragm and the maximum potential reservoir water level.

For zoned embankments, locate the diaphragm downstream of the core zone and/or cutoff trench, maintaining the minimum cover as indicated for homogeneous dams. When the downstream shell is more pervious than the diaphragm material, locate the diaphragm at the downstream face of the core zone.

It is good practice to tie these diaphragms into the other drainage systems in the embankment or foundation. Foundation trench drains and/or embankment chimney drains that meet the minimum size and location limits are sufficient and no separate diaphragm is needed.

Design the minimum capacity of outlets for diaphragms not connected to other drains by assuming the coefficient of permeability (k) in the zone upstream of the diaphragm is 100 times the coefficient of permeability in the compacted embankment material. Assume this zone has a cross-sectional area equal to the diaphragm area and the seepage path distance equal to that from the embankment upstream toe to the diaphragm. This higher permeability simulates a sealed filter face at the diaphragm with partially filled cracks and openings in the upstream zone.

For channels, chutes or other open structures, seepage and piping control can be accomplished in conjunction with drainage for reduction of uplift and water loads. The drain, properly designed to filter the base soils, is to intercept areas of potential cracking caused by shrinkage, differential settlement or heave and frost action. These structures