velocity held to a maximum of 5 FPS, the flow is going to have to be subcritical. The procedure now is to select a trial discharge and check it out. Try 6 cfs on Figure 3-1; V_c is 5.8 FPS and S_c is 2.3%. S_e/S_c is 1.8/2.3 or .78. On Figure 3-2 at S_e/S_c = .78 and at the velocity curve read to left .93. Now .93 times 5.8 FPS is 5.4 FPS, hardly down to 5 FPS which was set up as permissible. Try a lower unit discharge, say 5 cfs on Figure 3-1. V_c is 5.4 and S_c is 2.4%. S_e/S_c is 1.8/2.4 = .75. At the base of Figure 3-2 at .75 to the velocity curve and at the left read .92. Now .92 x 5.4 is 4.95 FPS; less than 5 FPS which is permissible. Thus, a unit discharge of 5 cfs will satisfy the given conditions. While bracketing this unit discharge, attention should be given to what is happening at the energy curve on Figure 3-2, very little change in H_e over H_{ec} in the vicinity of S_e/S_c of .78 or .75. In this example the H_p may be solved as in previous examples using a unit discharge of about 5.0 or 5.2.

<u>Summary of Spillway Design</u>

Spillway capacities should be designed with a control section, if at all practical (using only Figure 3-1). Where design values become excessively great, because of exit slope limitations or other reasons, consideration should be given to passing the flow at subcritical. Flow at or in the near vicinity of critical is unstable flow. Consequently, for design of channels where flow is of long duration (such as irrigation or drainage works), the flow should not be designed to operate at or very close to critical; however, on such things as pond spillways (designed on a peak of short duration) this unstableness is not considered so important.

Realistic estimate of roughness and permissible velocities should be made (Reference to SCS-TP-61, or good general texts).

On Figure 3-1, other values of n on the S_c or alpha curves may be interpolated or extrapolated horizontally (logarithmically) on the graph. Additional lines would serve only to clutter the appearance of the graph

How long a distance from a control section down the exit channel should critical slope exist or be exceeded in order to have a control section? This is a good question. It should be remembered that on natural unexcavated exit slopes there is no lateral confinement of the cross-section of flow beyond the entrance and there is, thus, a natural flow transition or "spread" particular to each site. However, at present, it is considered wise to consider the critical slope beyond the control section for a minimum distance of at least 50 to 100 feet.

The curves on Figure 3-2 are not extended to their limits (zero for vel. head and velocity curves and infinity for depth and energy curves) because the line slopes become so great in this range that values cannot be accurately selected from the curves. Too, when S_e/S_c values for any one section become less than about .10, the discharge of such a section is so far from its maximum (critical) that consideration should be given to selecting an alternate spillway site.

CHART FOR ESTIMATING HYDRAULIC DIMENSIONS AND VALUES OF FARM POND SPILLWAYS

Figure 3-1

Plot of: q_c versus d_c; q_c versus H_{ec}; q_c versus V_c; q_c versus S_c; and α versus H_{ec}

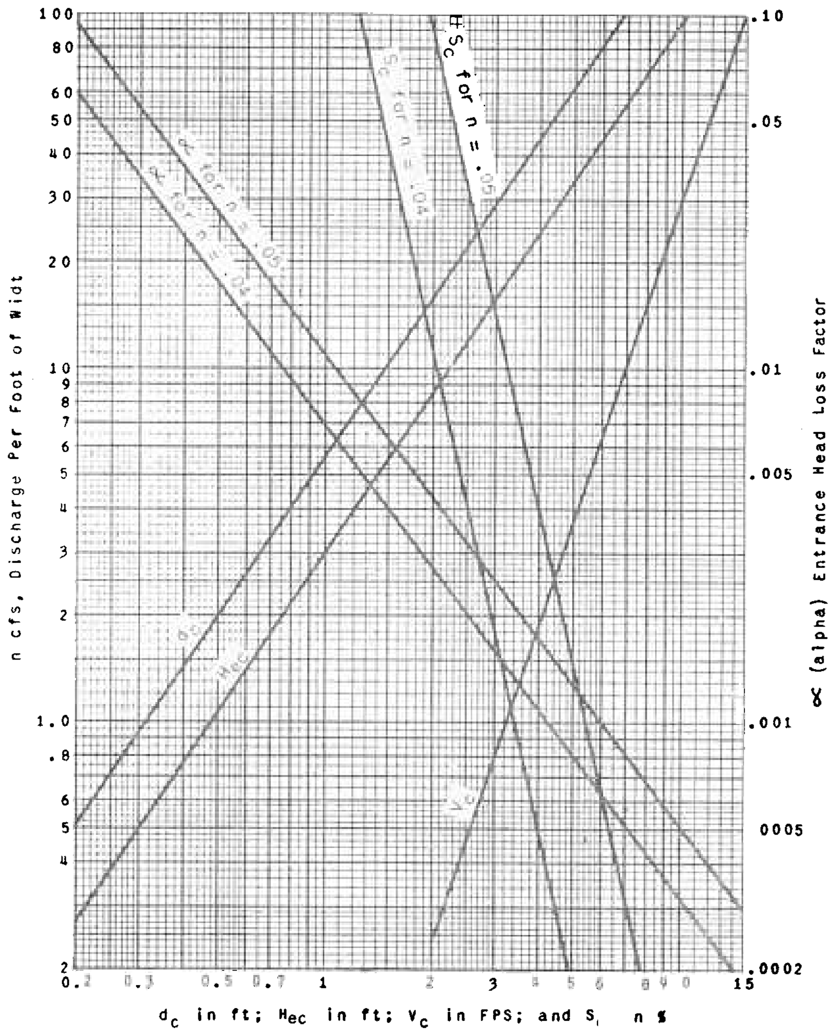

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Figure 3-2

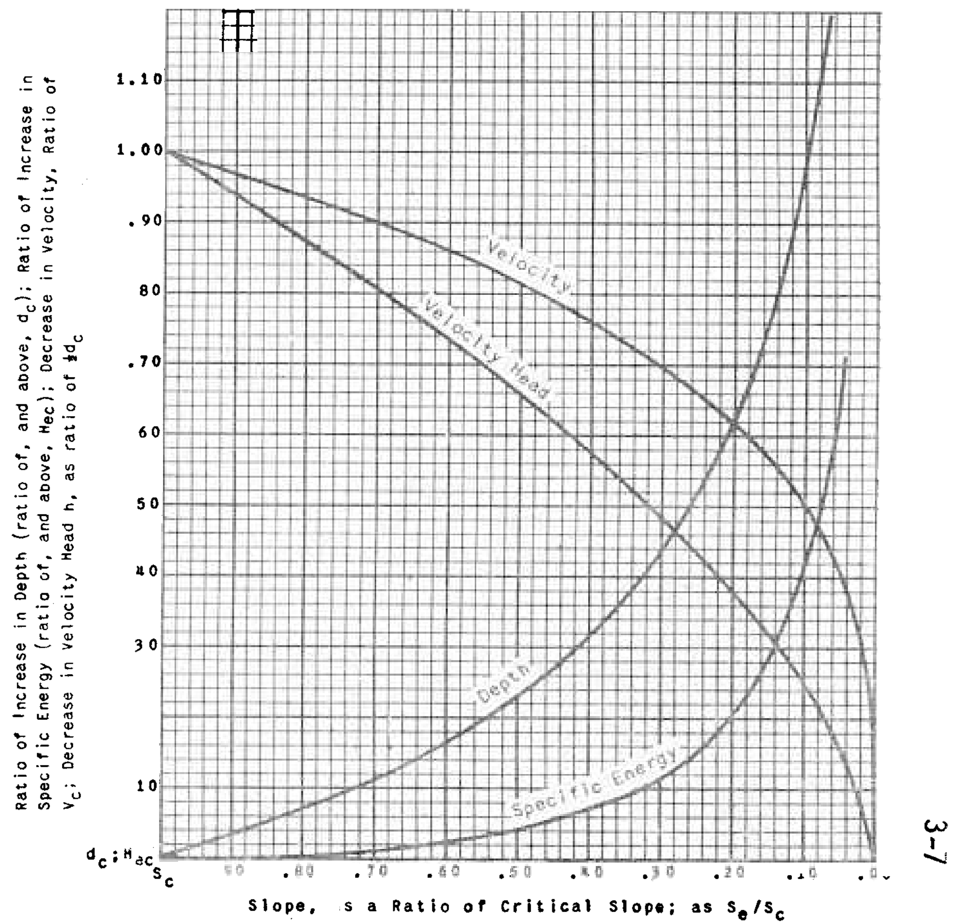
For any one unit discharge q (discharge per foot of width) and its associated critical depth d_c, critical Velocity V_c, specific energy H_{ec}, roughness n and critical Slope S_c:

THIS IS A PLOT OF:

d/d_c Vs. S_e/S_c (Depth Curve) V/V_c Vs. S_e/S_c (Velocity Curve)

H_e/H_{ec} Vs. S_e/S_c (Specific Energy Curve) $h/\frac{1}{2}d_c$ Vs. S_e/S_c (Vel. Head Curve)

WHERE: S_e is the available natural spillway slope; d is depth, subcritical; H_e is specific energy, subcritical, as d + h; V is velocity, subcritical; h is Velocity head, subcritical; $\frac{1}{2}d_c$ is Velocity head, critical.



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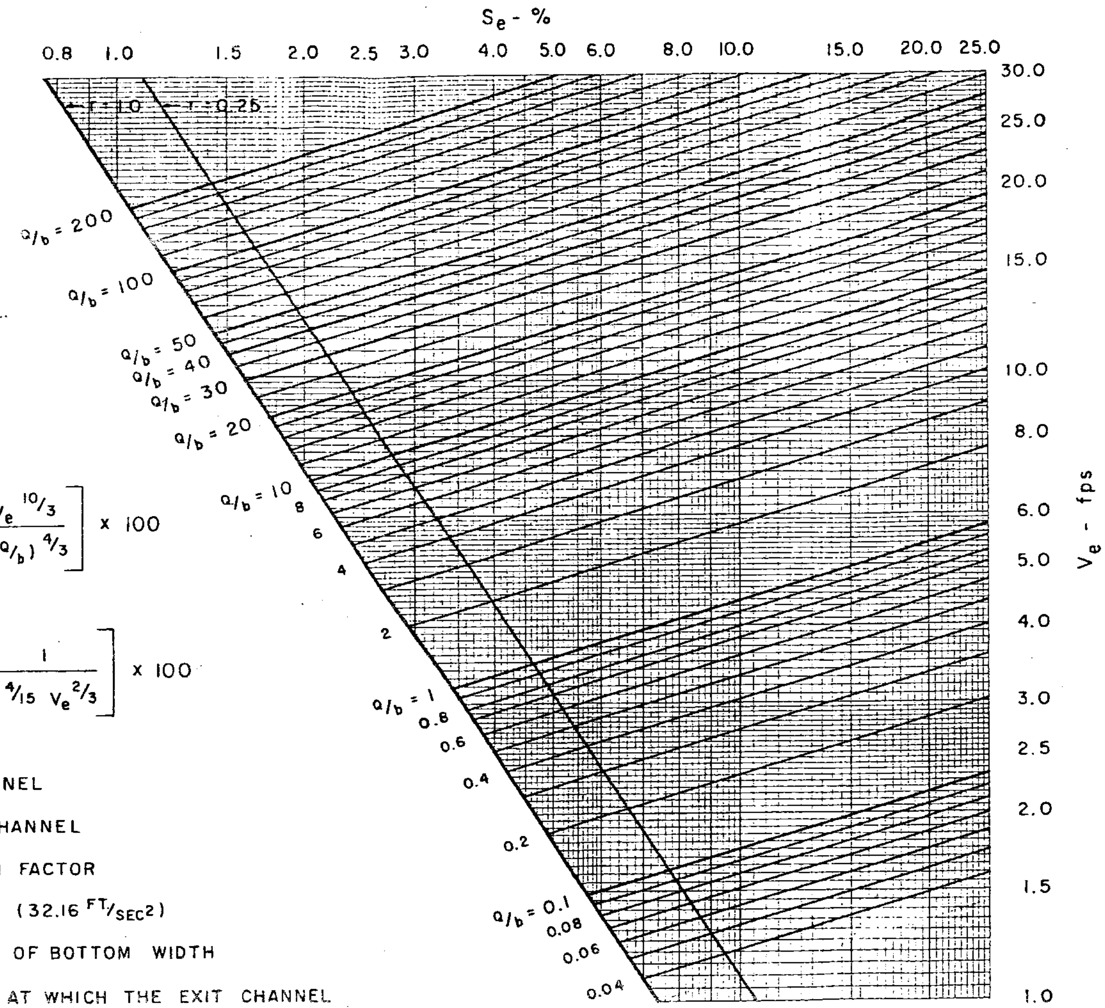
UD METHOD: EMERGENCY SPILLWAY HYDRAULICS, VELOCITY CHARTS

n = 0.040



$$\% S_e = \left[\frac{n^2}{1.486^2}\right] \times \left[\frac{V_e^{10/3}}{(q/b)^{4/3}}\right] \times 100$$

$$\% S_e = \left[\frac{g^{4/3}\, n^2}{1.486^2}\right] \times \left[\frac{1}{r^{4/15}\, V_e^{2/3}}\right] \times 100$$

S_e = SLOPE OF EXIT CHANNEL

V_e = VELOCITY IN EXIT CHANNEL

n = MANNING'S FRICTION FACTOR

g = GRAVITY CONSTANT (32.16 $^{FT}/_{SEC^2}$)

q/b = DISCHARGE PER FOOT OF BOTTOM WIDTH

r = RATIO OF DISCHARGE AT WHICH THE EXIT CHANNEL SLOPE IS EQUAL TO THE CRITICAL SLOPE.

REFERENCE

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