# Design of Earth Spillways

This EFM Supplement provides a rapid method of determining the size of earth spillways required for a specific discharge. Various widths may be selected to fit a particular site, and the corresponding pool level necessary to provide the desired flow can easily be determined. These tables and procedures should be used for most CO-01 work. TR-2, 35, and 39 should be used for large complex sites.

## Section 1

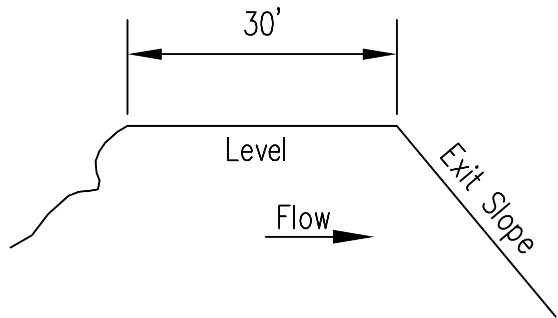
Tables 1, 2, and 3 may be used to design emergency spillways directly. For example, the flow needed for an emergency spillway is 80 c.f.s. It is determined that a 50 foot level crest will fit the site with only minor excavation. From Table 2, you could use a 73 foot spillway 1.0 foot deep, plus 1.0 foot freeboard or a total depth of 2.0 feet with an exit channel slope between 5 and 25 percent. The other choices would be w of 22 feet, HP of 1.5 feet, total depth of 2.5 feet, exit slopes between 4 and 9 percent; or w of 12 feet, HP of 2.0 feet, total depth of 3.0 feet, with exit slopes between 3 and 5 percent.

The bottom width, crest length, exit slopes and elevations of the crest and top of dam or wing dike should be recorded on the appropriate data sheet such as ILL-105, 106, or 107. Entrance channels should have a negative grade of 1.0 percent or more.

Table 1
Emergency Spillway Table Bottom Widths In Feet
Based on "C" Retardance Any Side Slope

| HP IN FEET | | | |
|---|---|---|---|
| C.F.S. | 1.0 | 1.5 | 2.0 |
| 10 | 7 | | |
| 15 | 10 | | |
| 20 | 13 | | |
| 25 | 17 | | |
| 30 | 20 | | |
| 35 | 24 | 9 | |
| 40 | 27 | 10 | |
| 45 | 30 | 11 | |
| 50 | 33 | 12 | |
| 60 | 40 | 15 | 8 |
| 70 | 47 | 17 | 10 |
| 80 | 54 | 19 | 11 |
| 90 | 60 | 22 | 13 |
| 100 | 67 | 24 | 14 |
| 125 | 84 | 30 | 17 |
| 150 | 100 | 36 | 21 |
| 175 | 117 | 42 | 24 |
| 200 | 134 | 48 | 28 |
| 250 | 167 | 60 | 34 |
| 300 | 200 | 72 | 41 |
| 350 | 234 | 84 | 48 |
| 400 | 267 | 96 | 55 |

| Exit Channel Slope In Percent | | | |
|---|---|---|---|
| Minimum | 5 | 4 | 3 |
| Maximum | 15 | 8 | 4 |

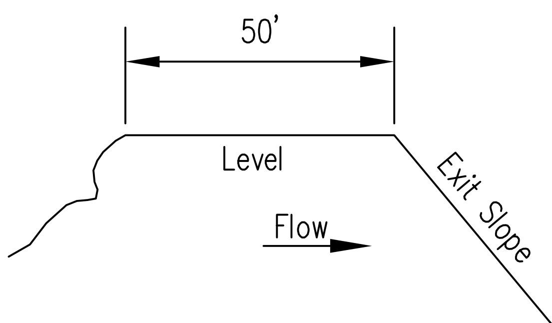



Widths greater than 100' not recommended except in special circumstances.

Table 2
Emergency Spillway Table Bottom Widths In Feet
Based on "C" Retardance Any Side Slope

| HP IN FEET | | | |
|---|---|---|---|
| C.F.S. | 1.0 | 1.5 | 2.0 |
| 10 | 9 | | |
| 15 | 14 | | |
| 20 | 18 | | |
| 25 | 23 | | |
| 30 | 27 | 8 | |
| 35 | 32 | 10 | |
| 40 | 36 | 11 | |
| 45 | 41 | 12 | |
| 50 | 45 | 14 | |
| 60 | 55 | 16 | 9 |
| 70 | 64 | 19 | 11 |
| 80 | 73 | 22 | 12 |
| 90 | 82 | 24 | 14 |
| 100 | 91 | 27 | 15 |
| 125 | 104 | 34 | 19 |
| 150 | 136 | 41 | 22 |
| 175 | 159 | 47 | 26 |
| 200 | 182 | 54 | 30 |
| 250 | 228 | 68 | 38 |
| 300 | 273 | 81 | 45 |
| 350 | 318 | 95 | 52 |
| 400 | 364 | 108 | 60 |

| Exit Channel Slope In Percent | | | |
|---|---|---|---|
| Minimum | 5 | 4 | 3 |
| Maximum | 25 | 9 | 5 |

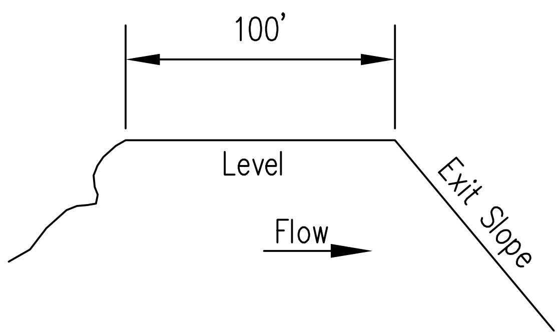



Widths greater than 100' not recommended except in special circumstances.

Table 3
Emergency Spillway Table Bottom Widths In Feet
Based on "C" Retardance Any Side Slope

| | HP IN FEET | | |
|---|---|---|---|
| C.F.S. | 1.0 | 1.5 | 2.0 |
| 10 | 17 | | |
| 15 | 25 | | |
| 20 | 33 | | |
| 25 | 42 | 9 | |
| 30 | 50 | 10 | |
| 35 | 58 | 12 | |
| 40 | 67 | 14 | |
| 45 | 75 | 16 | |
| 50 | 83 | 17 | 9 |
| 60 | 100 | 21 | 11 |
| 70 | 117 | 24 | 12 |
| 80 | 133 | 28 | 14 |
| 90 | 150 | 31 | 16 |
| 100 | 166 | 35 | 18 |
| 125 | 208 | 43 | 22 |
| 150 | 250 | 52 | 27 |
| 175 | 291 | 60 | 31 |
| 200 | 333 | 69 | 35 |
| 250 | 417 | 86 | 44 |
| 300 | 500 | 104 | 53 |
| 350 | 584 | 121 | 62 |
| 400 | 667 | 138 | 70 |

| Exit Channel Slope In Percent | | | |
|---|---|---|---|
| Minimum | 5 | 4 | 3 |
| Maximum | 25 | 11 | 5 |




Widths greater than 100' not recommended except in special circumstances.

## Section 2

The following chart and table were prepared from information in Technical Release No. 2, Supplement A to T. R. 2, ES-124, and ES-129, altered for "C" retardance. This is only a simplified method for the special cases normally encountered in CO-01 work and provides greater flexibility in design than Tables 1, 2, and 3.

### Discussions of the Method and Assumptions Used

Spillway side slopes of 3 to 1 were used in the development of the chart. Flatter slopes will make the design more conservative.

The columns of the table were based on inlet channel lengths of 40', 80', and 120'. It is believed they are sufficiently accurate for the ranges indicated.

The slope of the exit channel must be within the limits indicated in the table to insure the creation of a control section and to keep velocities within safe limits. The slope must be maintained beyond the toe of the fill, then may become steeper. If used for an auxiliary spillway, slope must convey discharge to stable grade at non-erosive velocities.

It is recommended that the critical velocity $V_c$, be in the range of 4.0 to 6.0 f.p.s. Low velocities require low depths of flow and are not dependable if the spillway should become restricted with dense vegetation, debris, etc. High velocities may create undesirable erosion.

The profile along the centerline of spillway must conform to one of the types described, or must be such that entrance losses in the designed channel are less than those for which the table was prepared and from which the design data was determined.

A roughness factor (n) of 0.04 was used except for $V_c$ of 5.0 or less where "C" retardance (per TP-61) was used.

### Definitions

L - Length of inlet channel

Hp - Height of pool. The difference in elevation between the crest of spillway and pool level necessary to create the specific discharge. Freeboard must be added to this value.

Definitions (Cont.)

$V_c$ - Critical velocity. This occurs at control section. Velocity is less upstream and greater downstream.

$S_o$ Min - Minimum permissible slope of the exit channel.

$S_o$ Max - Maximum permissible slope of the exit channel.

Use of Table 4 and Chart

1. Select a spillway "type" from one of those described below Table 4. If you cannot exactly construct one of these types, select the type which has slightly higher entrance losses than your design.

2. Determine length of entrance channel, L, from your design.

3. Determine capacity required using State Design Criteria.

4. Select a critical velocity (or range of velocities) for design.

5. On the chart #1, read bottom width (or range of widths) for design.

6. Select a width (from item 5) best suited for the site.

7. From Table 4, read $H_p$ and $S_o$ for the particular velocity, length of entrance and spillway type selected.

8. Add freeboard required by State Design Criteria.

Example

1. Type 3 spillway is selected.

2. L = 65 feet (from site topography).

3. Q = 100 c.f.s.

4. $V_c$ = 4.0 to 6.0 f.p.s.

5. From chart, bottom width = 11', 16', 23', 34', or 48' (for $V_c$ = 6.0, 5.5, etc.)

6. 23' is selected as best fitting site. ($V_c$ = 5.0).

7. Read $H_p$ = 1.7, $S_o$ = 4% to 15%.

8. Add freeboard of 1 foot. Top of fill is then 2.7' above crest of spillway.

Note: Interpolation should not be necessary for most cases, but may be used if desired. Be sure to use the same $V_c$ in both the chart and table for final design.

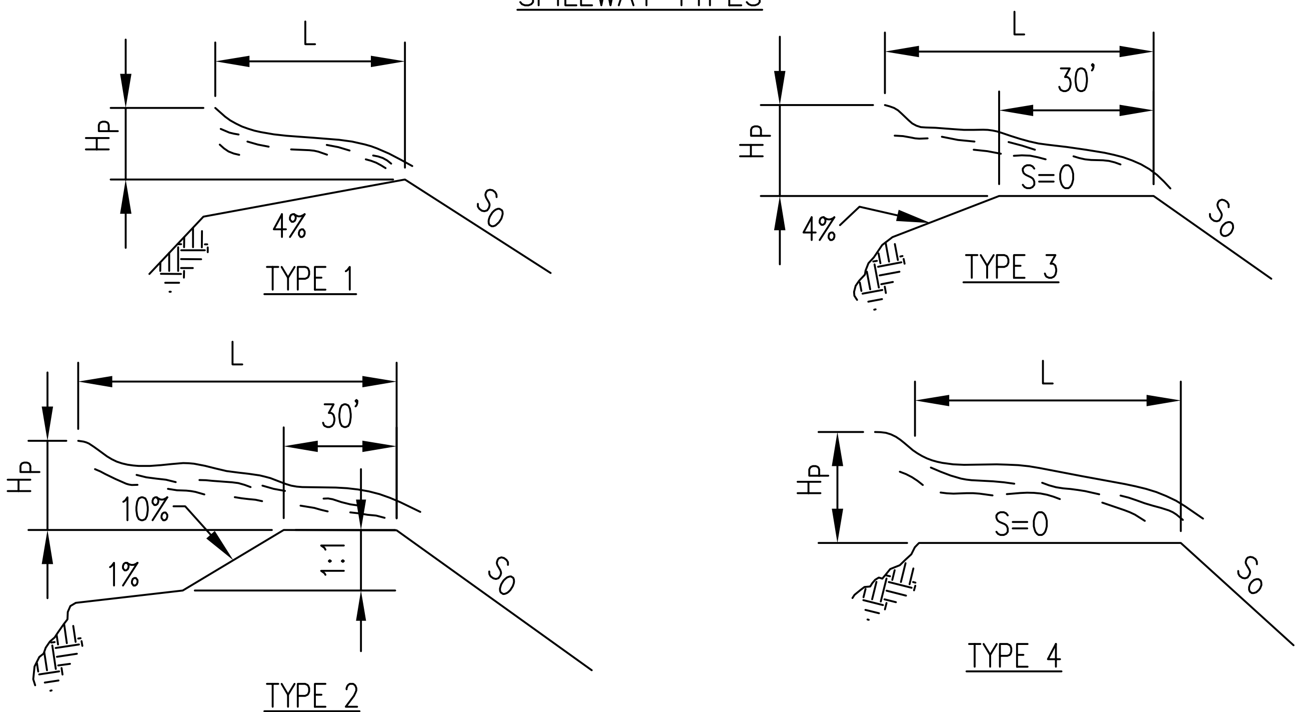
## Earth Spillway Design – Table 4

Read $H_P$ , $S_O$ min, $S_O$ max, for selected $V_C$ , L, Type of spillway.

(Table gives pool level, only--additional freeboard not included).

| Vc | So Min | So Max | L-50' or Less | | | | L-50' to 100' | | | | L-100' to 150' | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Type | | | | Type | | | | Type | | | |
| | | | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| 3.5 | 5% | 15% | 1.1 | 1.3 | 1.3 | 1.3 | 1.1 | 1.3 | 1.3 | 1.4 | 1.1 | 1.3 | 1.3 | 1.5 |
| 4.0 | 4% | 15% | 1.2 | 1.4 | 1.4 | 1.4 | 1.2 | 1.4 | 1.4 | 1.5 | 1.2 | 1.4 | 1.4 | 1.6 |
| 4.5 | 4% | 15% | 1.3 | 1.5 | 1.5 | 1.5 | 1.3 | 1.5 | 1.6 | 1.7 | 1.4 | 1.5 | 1.6 | 1.8 |
| 5.0 | 4% | 15% | 1.4 | 1.6 | 1.6 | 1.6 | 1.4 | 1.6 | 1.7 | 1.8 | 1.5 | 1.6 | 1.7 | 1.8 |
| 5.5 | 4% | 15% | 1.6 | 1.7 | 1.7 | 1.7 | 1.6 | 1.7 | 1.8 | 1.9 | 1.6 | 1.7 | 1.8 | 2.0 |
| 6.0 | 3% | 14% | 1.9 | 2.0 | 2.0 | 2.0 | 1.9 | 2.0 | 2.1 | 2.2 | 1.9 | 2.0 | 2.1 | 2.3 |
| 6.5 | 3% | 9% | 2.2 | 2.3 | 2.3 | 2.3 | 2.2 | 2.3 | 2.4 | 2.5 | 2.2 | 2.3 | 2.4 | 2.6 |
| 7.0 | 3% | 8% | 2.5 | 2.6 | 2.6 | 2.6 | 2.5 | 2.6 | 2.7 | 2.8 | 2.5 | 2.6 | 2.7 | 2.9 |
| 7.5 | 3% | 6% | 2.8 | 2.9 | 2.9 | 2.9 | 2.8 | 2.9 | 3.0 | 3.1 | 2.8 | 2.9 | 3.0 | 3.3 |
| 8.0 | 3% | 5% | 3.1 | 3.2 | 3.2 | 3.2 | 3.1 | 3.2 | 3.3 | 3.4 | 3.2 | 3.2 | 3.4 | 3.6 |

### SPILLWAY TYPES



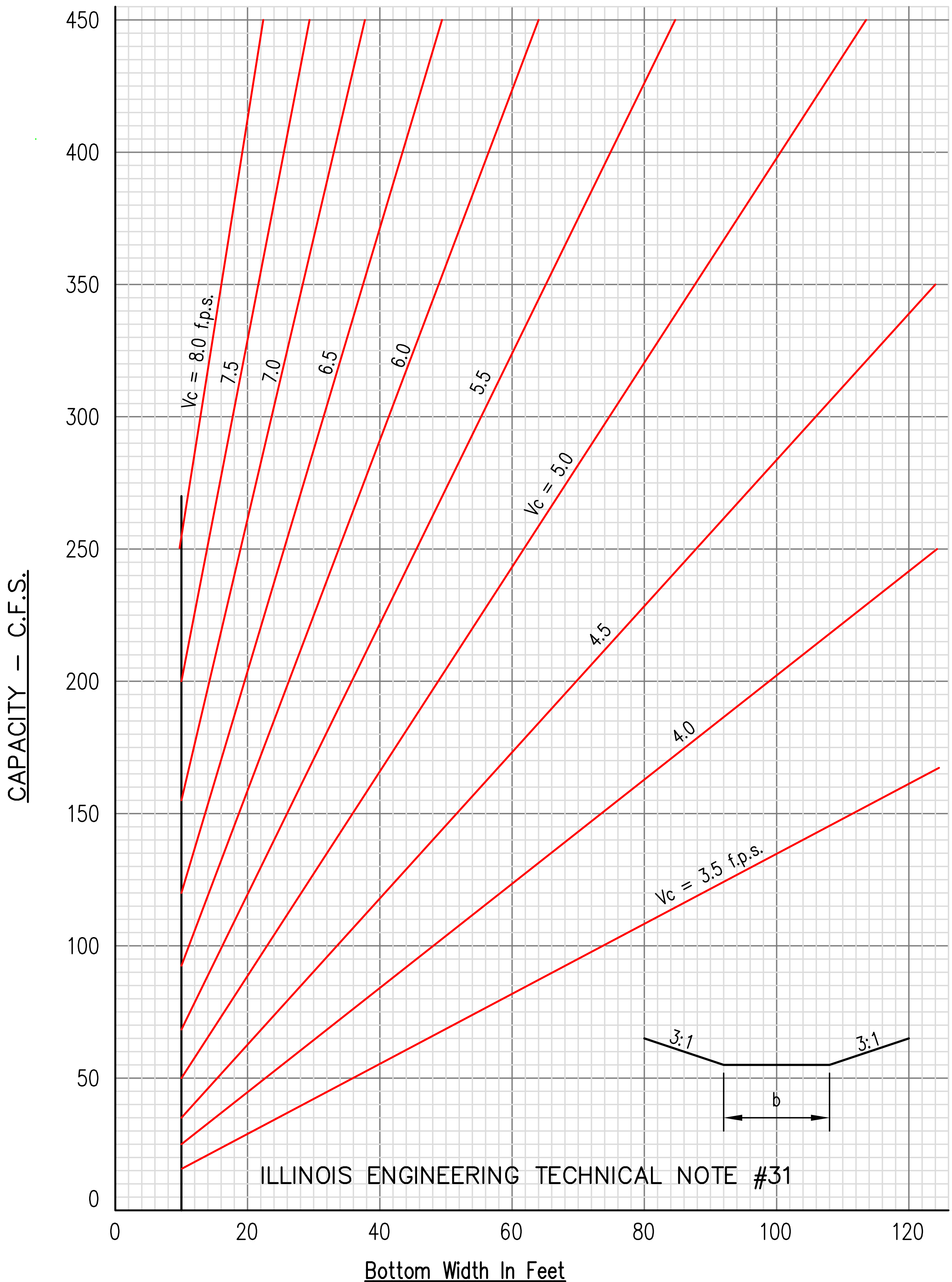
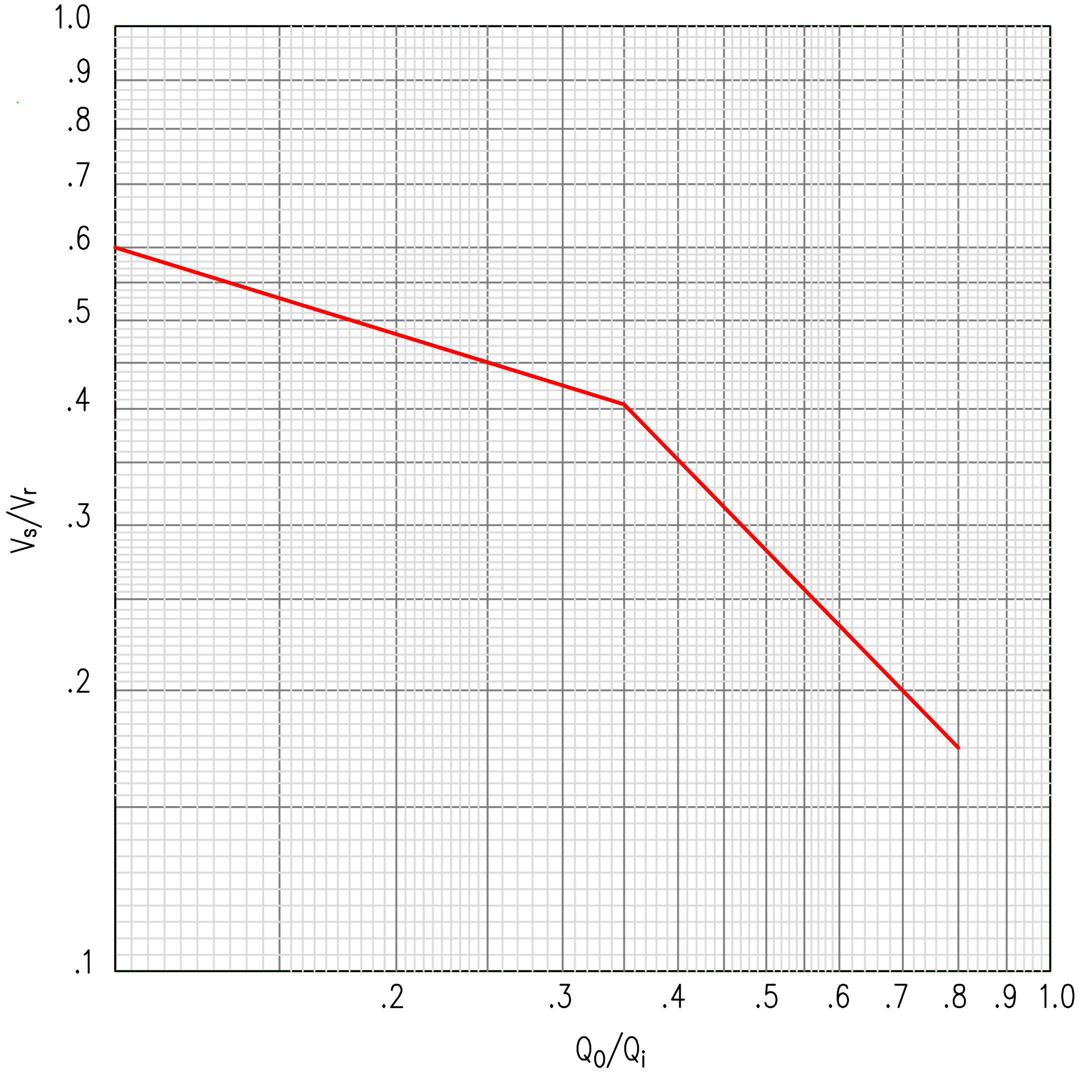

CAPACITY – C.F.S.
450
400
350
300
250
200
150
100
50
0
Vc = 8.0 f.p.s.
7.5
7.0
6.5
6.0
5.5
Vc = 5.0
4.5
4.0
Vc = 3.5 f.p.s.
3:1
3:1
b
ILLINOIS ENGINEERING TECHNICAL NOTE #31
0
20
40
60
80
100
120
Bottom Width In Feet

Chart #1




APPROXIMATE RESERVOIR ROUTING
24 HOUR RAINFALL
HIGH OUTFLOW RATES

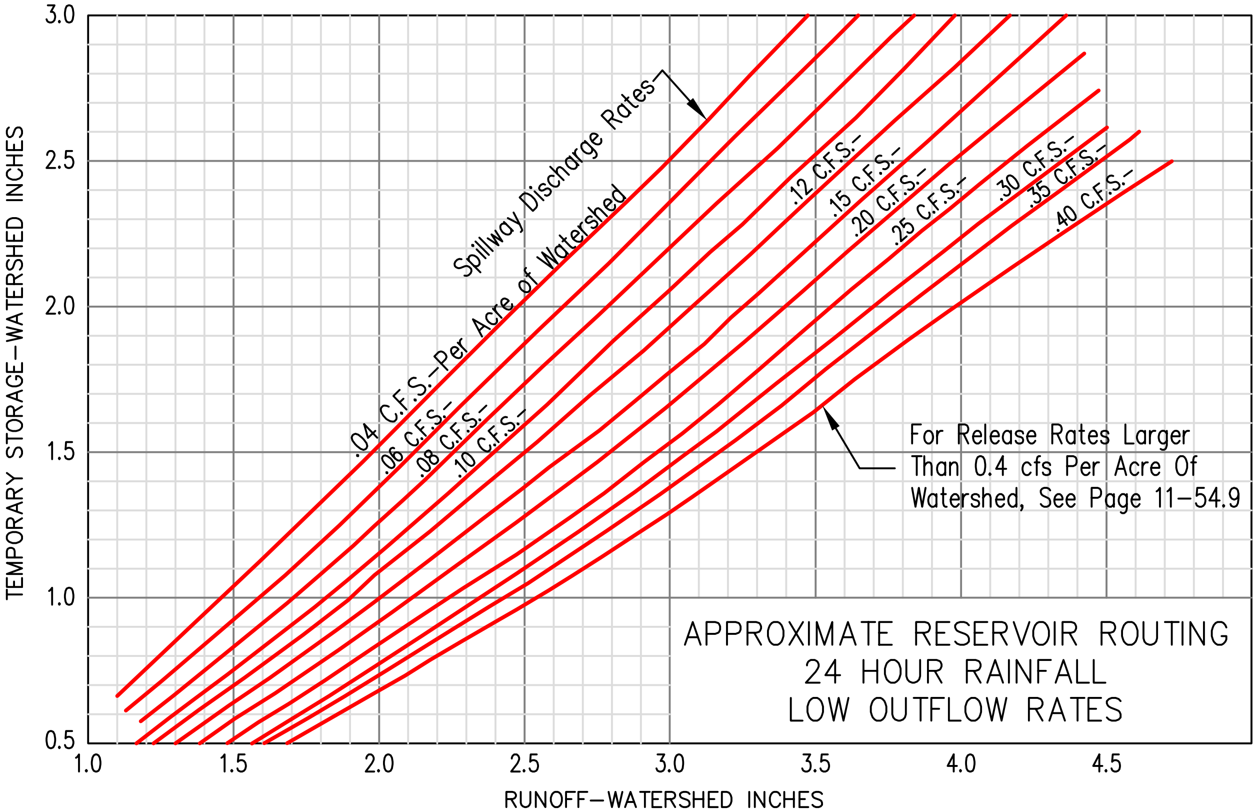
$V_S$ = Volume of Storage, Acre-Feet

$V_r$ = Volume of Runoff, Acre-Feet

$Q_0$ = Spillway Discharge, C.F.S.

$Q_i$ = Peak Rate of Inflow from a 24 Hour Design Storm, C.F.S.

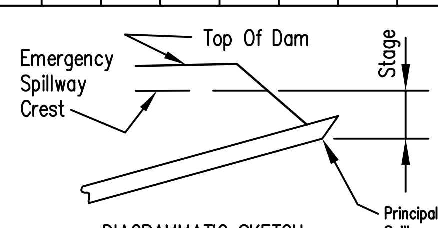
For Use With Watersheds Less Than 250 Acres With Spillway Discharge Greater Than .40 c.f.s. Per Acre Of Watershed




POND STAGE CHART FOR SMALL DRAINAGE AREAS WHEN PRINCIPAL SPILLWAY DISCHARGE IS NOT CONSIDERED IN CALCULATING FLOW THROUGH THE EMERGENCY SPILLWAY

*Chart gives stage required to store a 2 year, 6 hour, rainfall

| Drainage Area Acres | Runoff Curve Numbers | SURFACE AREAS (Acres) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.8 | 1.0 | 1.2 | 1.4 | 1.6 | 1.8 | 2.0 | 2.2 | 2.6 | 3.0 | 3.5 |
| | | Stage Required, feet 1/ | | | | | | | | | | | | | | | |
| 30 | 90 | | | | | | | | 3.0 | 2.5 | 2.2 | 1.9 | 1.8 | 1.6 | 1.3 | 1.2 | 1.0 |
| | 80 | | | | | | 3.0 | 2.5 | 2.1 | 1.8 | 1.6 | 1.4 | 1.3 | 1.1 | 1.0 | | |
| | 70 | | | | 3.0 | 2.7 | 2.0 | 1.6 | 1.3 | 1.1 | 1.0 | | | | | | |
| | 60 | | 3.0 | 2.3 | 1.8 | 1.5 | 1.1 | 1.0 | | | | | | | | | |
| 25 | 90 | | | | | | | 3.0 | 2.4 | 2.1 | 1.8 | 1.6 | 1.5 | 1.3 | 1.1 | 1.0 | |
| | 80 | | | | | 3.0 | 2.6 | 2.1 | 1.8 | 1.5 | 1.3 | 1.2 | 1.1 | 1.0 | | | |
| | 70 | | | 3.0 | 2.8 | 2.3 | 1.8 | 1.4 | 1.2 | 1.0 | | | | | | | |
| | 60 | 3.0 | 2.3 | 1.8 | 1.4 | 1.2 | 1.0 | | | | | | | | | | |
| 20 | 90 | | | | | | 3.0 | 2.3 | 1.9 | 1.6 | 1.4 | 1.3 | 1.2 | 1.0 | | | |
| | 80 | | | | 3.0 | 2.8 | 2.1 | 1.7 | 1.4 | 1.2 | 1.1 | 1.0 | | | | | |
| | 70 | | | 2.8 | 2.2 | 1.8 | 1.4 | 1.1 | 1.0 | | | | | | | | |
| | 60 | 3.0 | 2.0 | 1.5 | 1.2 | 1.0 | | | | | | | | | | | |
| 15 | 90 | | | | | 3.0 | 2.3 | 1.8 | 1.5 | 1.3 | 1.1 | 1.0 | | | | | |
| | 80 | | | 3.0 | 2.6 | 2.2 | 1.6 | 1.3 | 1.1 | 1.0 | | | | | | | |
| | 70 | | 2.7 | 2.0 | 1.6 | 1.3 | 1.0 | | | | | | | | | | |
| | 60 | 2.0 | 1.3 | 1.0 | | | | | | | | | | | | | |
| 10 | 90 | | | 3.0 | 2.4 | 2.0 | 1.5 | 1.2 | 1.0 | | | | | | | | |
| | 80 | | 2.7 | 2.0 | 1.6 | 1.3 | 1.0 | | | | | | | | | | |
| | 70 | 2.5 | 1.7 | 1.3 | 1.0 | | | | | | | | | | | | |
| | 60 | 1.5 | 1.0 | | | | | | | | | | | | | | |
| 5 | 90 | 3.0 | 2.0 | 1.5 | 1.2 | 1.0 | | | | | | | | | | | |
| | 80 | 2.0 | 1.3 | 1.0 | | | | | | | | | | | | | |
| | 70 | 1.5 | 1.0 | | | | | | | | | | | | | | |
| | 60 | 1.0 | | | | | | | | | | | | | | | |



DIAGRAMMATIC SKETCH

1/ Stage required is difference in feet between the principal spillway crest and crest of the emergency spillway.