## SECTION 23 – COMPUTATION OF REQUIRED CAPACITY

0506. The basis of surface drainage calculation is an estimate of the maximum rate at which rain will fall. Unless hydrological data are available, it is usual to base this estimate on an assessment of the maximum anticipated fall, in inches, in on hour.

0507. A proportion of the rainfall will percolate into the soil, the normal drainage system is designed to handle the remainder (called " the run-off") which flows over the surface . The relation between the amount of run-off and the total rainfall is known as the run-off factor (r). This varies with the nature of the surface and with the type of country, and it is most important to remember that different empirical formula assume different values for the factor r. Great care is necessary to apply the correct value of r for the method of calculation being used.

0508. Three methods of assessing drainage requirements are given below.

**Computation of Area Discharge**

0509. The capacity of the drainage system at any point should be sufficient to handle the discharge from the whole drainage area above that point. This area is best determined by measurement from a contoured map. If this is impracticable any estimate should be reasonably generous.

0510. The quantity of water to be disposed of can be computed from the approximate formula Q=A x i x r
Where Q= quantity of discharge (cu ft per sec)
A= area of catchment area (acres)
i= predicted maximum rainfall (ins in 1 hour)
r= run-off factor

Values of r for use with this formula are given in Table 5.1 but it should be noted that they are applicable to comparatively level ground. On slopes steeper than 1 in 60 (approx. 1 degree) comparatively little percolation occurs. The factor should be increased by 0.1 for every degree of slope up to a maximum factor of 1.0.

0511. Results obtained from this formula are very approximate. If the effect of flooding would be serious the value of Q should be increased by from 10 to 50 percent.

## TABLE 5.1 – RUN-OFF FACTORS FOR COMPARATIVELY FLAT GROUND

(Applicable to empirical formula Q= Ax I x r)

| Ser No. | Type of surface | Value of r |
|---|---|---|
| 1. | Asphalt pavements | 0.80 to 0.95 |
| 2. | Concrete pavements | 0.70 to 0.90 |
| 3. | Gravel or macadam pavements | 0.35 to 0.70 |
| 4. | Impervious soils | 0.40 to 0.70 |
| 5. | Impervious soils with turf | 0.35 to 0.60 |
| 6. | Pervious soils | 0.10 to 0.45 |
| 7. | Pervious soils with turf | 0.05 to 0.30 |

**Talbot's Formula**

0512. The area of waterway to be provided in culverts handling the discharge from a particular drainage area can also be assessed from the empirical formula;

$$a=f^4 \sqrt{A^3}$$

Where, a= area of waterway (sqft)

$f$=run off factor, based on the type of country

A= drainage area (acres)

This formula is based on a pack rainfall intensity of 4 ins per hr. Adjustments for smaller intensities are not recommended and this formula is not suitable for structures with a waterway opening greater than 400 sq ft. Value of obtained from this formula are given in Table 5.2.

## TABLE 5.2: AREAS OF WATERWAYS FOR CULVERTS

| Drainage area (A) | | Area of waterway (a) (sqft)* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Mountainous land | Hilly land | | Rolling land | | Flat land | |
| Acres | Square miles | f=1 | f=0.8 | f=0.6 | f=0.5 | f=0.4 | f=0.3 | f=0.2 |

| (a) | (b) | (c) | (d) | (e) | (f) | (g) | (h) | (j) |
|---|---|---|---|---|---|---|---|---|
| 1 | 0.0016 | 1.0 | 0.8 | 0.6 | 0.5 | 0.4 | 0.3 | 0.2 |
| 2 | 0.0031 | 1.7 | 1.4 | 1.0 | 0.8 | 0.7 | 0.5 | 0.3 |
| 4 | 0.0062 | 2.8 | 2.2 | 1.7 | 1.4 | 1.1 | 0.8 | 0.6 |
| 6 | 0.0094 | 3.8 | 3.0 | 2.3 | 1.9 | 1.5 | 1.1 | 0.8 |
| 8 | 0.0125 | 4.8 | 3.8 | 2.9 | 2.4 | 1.9 | 1.4 | 1.0 |
| 10 | 0.016 | 5.6 | 4.5 | 3.4 | 2.8 | 2.2 | 1.7 | 1.2 |
| 15 | 0.023 | 7.6 | 6.1 | 4.6 | 3.8 | 3.0 | 2.3 | 1.5 |
| 20 | 0.031 | 9.5 | 7.6 | 5.7 | 4.7 | 3.8 | 2.8 | 1.9 |
| 30 | 0.047 | 13.0 | 10.0 | 7.7 | 6.4 | 5.1 | 3.8 | 2.6 |
| 40 | 0.062 | 16.0 | 13.0 | 9.5 | 8.0 | 6.4 | 4.8 | 3.2 |
| 60 | 0.094 | 22.0 | 18.0 | 13.0 | 11.0 | 8.8 | 6.6 | 4.4 |
| 80 | 0.125 | 27.0 | 22.0 | 16.0 | 13.0 | 11.0 | 8.1 | 5.4 |
| 100 | 0.156 | 32.0 | 26.0 | 19.0 | 16.0 | 13.0 | 9.6 | 6.4 |
| 150 | 0.234 | 43.0 | 34.0 | 26.0 | 21.0 | 17.0 | 13.0 | 8.6 |
| 200 | 0.312 | 53.0 | 42.0 | 32.0 | 27.0 | 21.0 | 16.0 | 11.0 |
| 250 | 0.39 | 63.0 | 50.0 | 38.0 | 31.0 | 25.0 | 19.0 | 13.0 |
| 300 | 0.47 | 72.0 | 58.0 | 43.0 | 36.0 | 29.0 | 22.0 | 14.0 |
| 400 | 0.62 | 89.0 | 71.0 | 53.0 | 45.0 | 36.0 | 27.0 | 18.0 |
| 500 | 0.78 | 106.0 | 85.0 | 64.0 | 53.0 | 42.0 | 32.0 | 21.0 |
| 600 | 0.94 | 121.0 | 97.0 | 73.0 | 61.0 | 48.0 | 36.0 | 24.0 |

* Value obtained form the formula a= $f\sqrt[4]{A^3}$(see para 92).

**Computation of Run-off From Existing Channels**

0513. It is sometimes possible to locate the flood level in an existing natural water channel. In such cases the volume of run-off can be computed from manning's formula.

0514. Manning's formula is:-

$$Q=a \times \frac{1.486}{n} \times \sqrt[3]{R^2} \times \sqrt{S}$$

Where Q=volume of discharge (cft per sec)
a= cross sectional area of waterway (sqft)
n=coefficient of roughness of surface
R=mean hydraulic radius

= <u>cross sectional area (a)</u> (see Figure 5.1)
length of wetted perimeter (P)
S= slope of hydraulic gradient
= drop of water surface in feet per 100 ft
Suitable values for the coefficient n are:-

| | | |
|---|---|---|
| Rock or bare earth, smooth and uniform | | n = 0.025 |
| ditto | , good condition | n= 0.030 |
| ditto | , fair condition | n= 0.033 |
| ditto | , bed condition | n= 0.035 |
| Turf or natural weed growth | | n= 0.040 |

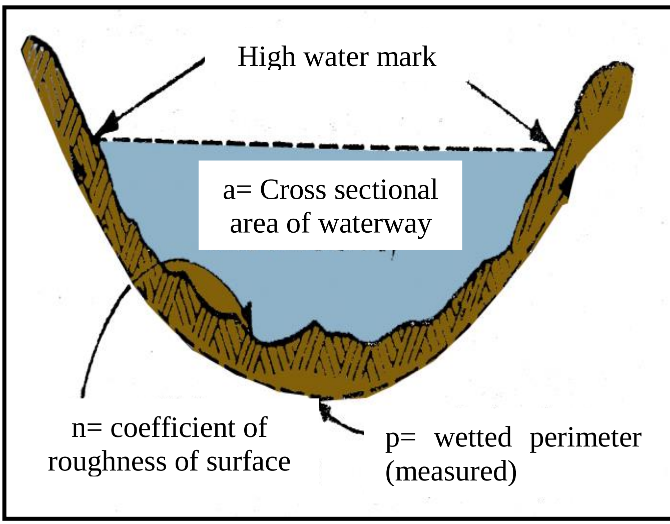


Figure 5.1: Determination of Run-off from an Existing Channel