ROHINI
COLLEGE OF ENGINEERING AND TECHNOLOGY
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DEPARTMENT OF AGRICULTURAL ENGINEERING

AI3402 SOIL AND WATER CONSERVATION ENGINEERING

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UNIT-2 ESTIMATION OF SOIL EROSION

Runoff Estimation– SCS Curve Number Method

2.11 Introduction

The soil conservation service curve number (SCS-CN) method was developed in 1954 and is documented in section 4 of the National Engineering Handbook (NEH-4) published by the Soil Conservation Service (now called as Natural Resources Conservation Service) of the United States Department of Agriculture (USDA) in 1956.

It is one of the most popular methods for computing the volume of surface runoff for a given rainfall event from small agricultural, forest and urban watersheds. The method is simple, easy to understand and use; stable, and useful for ungauged watersheds. The primary reasons for its wide applicability and acceptability lies in the fact that it accounts for most runoff producing watershed characteristics: soil type, land use/treatment, surface condition and antecedent moisture condition.

2.12 Determination of Curve Number

The SCS-CN method is based on the water balance equation and two fundamental hypotheses. The first hypothesis equates the ratio of the actual amount of direct surface runoff (Q) to the total rainfall (P) (or maximum potential surface runoff) to the ratio of the amount of actual infiltration (F) to the amount of the potential maximum retention (S). The second hypothesis relates the initial abstraction (Ia) to the potential maximum retention, thus the SCS-CN method consists of:

(a) Water Balance Equation:

$P = I_a + F + Q$ (12.1)

(b) Proportional Equality Hypothesis:

$Q/P\text{-}Ia = F/S$ (12.2)

(c) I_a -S hypothesis

$I_a = \lambda S$ (12.3)

Where P= total rainfall; Ia =initial abstraction; F= cumulative infiltration excluding Ia; Q= direct runoff; and S= potential maximum retention or infiltration.

Combining equations 12.1 and 12.2, it becomes

$Q = (P - I_a)^2/(P - I_a + S)$ (12.4)

Equation is valid for $P \geq Ia$. For $\lambda = 0.2$, the equation can be written as:

$Q = (P - 0.2\ S)^2/(P + 0.8\ S)$ (12.5)

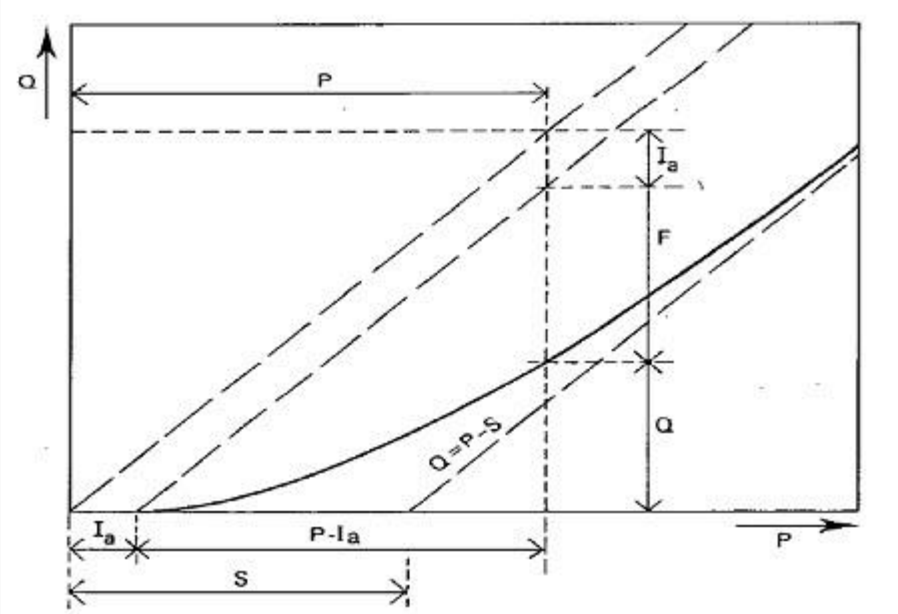

Fig. 12.1. Accumulated runoff Q versus accumulated rainfall P according to the Curve number Method. (Source: http://edepot.wur.nl/183157)

Thus the existing SCS-CN method is a one parameter model for computing surface runoff from daily storm rainfall, for the method was originally developed using daily rainfall-runoff data of annual extreme flows. S is a constant and is the maximum difference of (P-Q) that can occur for the given storm and watershed condition. S is limited by either the rate of infiltration at the soil surface or the amount of water storage available in the soil profile, whichever gives the smaller S value. Since parameter S can vary in the range of $0 \leq S \leq \infty$, it is mapped into a dimensionless curve number(CN), varying in a more workable range $0 \leq CN \leq 100$, as follows: (Actually, to make Eq. 12.6 mathematically workable, the CN limit should be $0 < CN \leq 100$)

$$S = (1000/CN) - 10 \qquad (12.6)$$

The underlying difference between S and CN is that the former is a dimensional quantity (L) whereas the latter is a non-dimensionless quantity. The CN theoretically varies from 0 to 100.

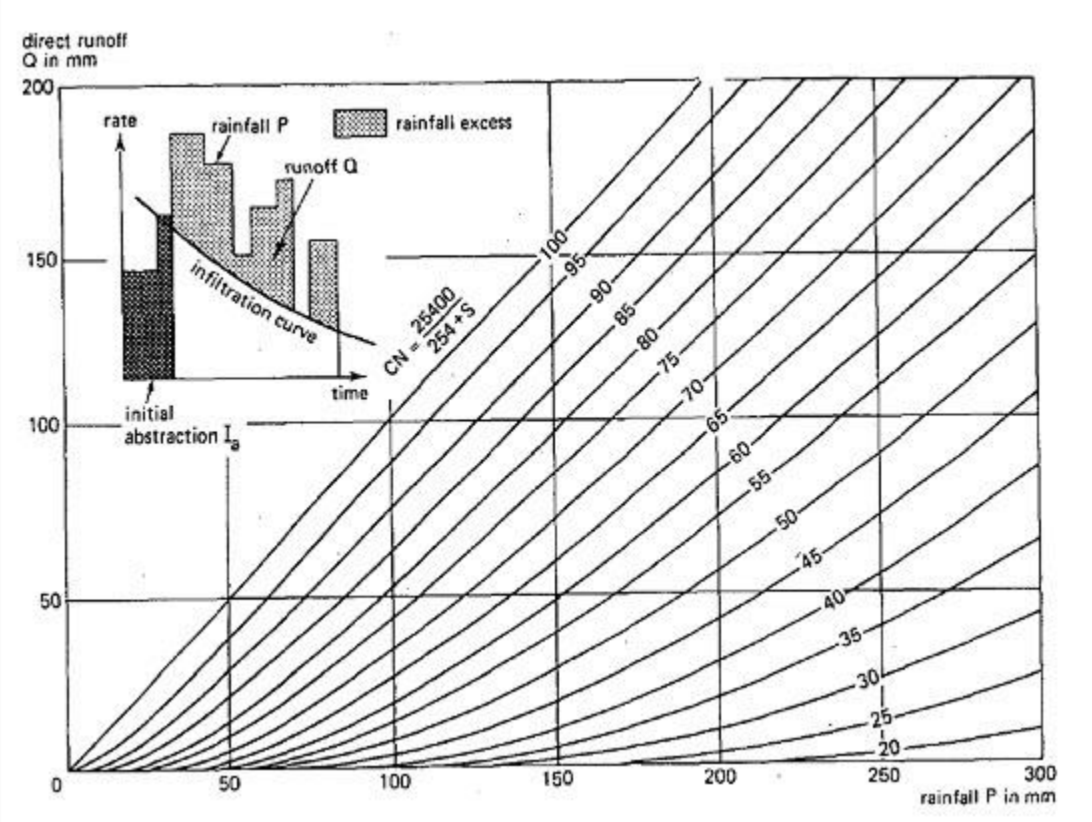

Fig. 12.2. Graphical solution of equation 12.4 showing runoff depth Q as a function of rainfall depth P and curve number. Source: http://edepot.wur.nl/183157)

2.13 Factors Affecting SCS Curve Number

The Curve Number is a dimensionless parameter indicating the runoff response characteristic of a drainage basin. In the Curve Number Method, the CN is related to land use, land treatment, hydrological condition, hydrological soil group, and antecedent soil moisture condition in the drainage basin.

(a) Land Use or Cover

Land use represents the surface conditions in a drainage basin and is related to the degree of cover. In the SCS method, the following categories are distinguished:

Fallow- is the agricultural land use with the highest potential for runoff because the land is kept bare; Row crops- are field crops planted in rows far enough apart that most of the soil surface is directly exposed to rainfall; Small grain- planted in rows close enough that the soil surface is not directly exposed to rainfall; Close-seeded legumes or rotational meadow- are either planted in close rows or broadcasted. This kind of cover usually protects the soil throughout the year; Pasture range- is native grassland used for grazing, whereas meadow is grassland protected from grazing and generally mown for hay; Woodlands- are usually small isolated groves of trees being raised for farm use.

(b) Practice in relation to Hydrological Condition

Land treatment applies mainly to agricultural land uses. It includes mechanical practices such as contouring or terracing, and management practices such as rotation of crops, grazing control, or burning.

Rotations are planned sequences of crops (row crops, small grain, and close-seeded legumes or rotational meadow). Hydrologically rotations range from poor to good. Poor rotations are generally one-crop land uses (monoculture) or combinations of row crops, small grains, and fallow. Good rotations generally contain close-seeded legumes or grass.

For grazing control and burning (pasture range and forest), the hydrological condition is classified as poor, fair, or good. Pasture range is classified as poor when heavily grazed and less than half the area is covered; as fair when not heavily grazed and between one-half to three-quarters of the area is covered; and as good when lightly grazed and more than three-quarters of the area is covered. Woodlands are classified as poor when heavily grazed or regularly burned; as fair when grazed but not burned; and as good when protected from grazing.

(c) Hydrological Soil Group

Soil properties greatly influence the amount of runoff. In the SCS method, these properties are represented by a hydrological parameter: the minimum rate of infiltration obtained for a bare soil after prolonged wetting. The influence of both the soil's surface condition (infiltration rate) and its horizon (transmission rate) are thereby included. This parameter, which indicates a soil's runoff potential, is the qualitative basis of the classification of all soils into four groups. The Hydrological Soil Groups, as defined in the SCS-CN method, are:

Group A: Soils having high infiltration rates even when thoroughly wetted and a high rate of water transmission. Examples are deep, well to excessively drained sands or gravels.

Group B: Soils having moderate infiltration rates when thoroughly wetted and a moderate rate of water transmission. Examples are moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

Group C: Soils having low infiltration rates when thoroughly wetted and a low rate of water transmission. Examples are soils with a layer that impedes the downward movement of water or soils of moderately fine to fine texture.

Group D: Soils having very low infiltration rates when thoroughly wetted and a very low rate of water transmission. Examples are clayey soils with a high swelling potential, soils with a permanently high water table, soils with a clay pan or clay layer at or near the surface, or shallow soils over nearly impervious material. Table 12.1 shows Land use categories and associated curves number, according to soil group; commercial land has different curve number.