Standard Operating Procedures (SOP) 5.1.2

Tools For Runoff Volume Monitoring

Adopted from: < streams.osu.edu/book/PowerPoints/**runoff**-chapter5.ppt> accessed11/19/09

Knowing runoff volumes is important in managing watersheds and assessing projects. Runoff volumes are affected by various factors: type of precipitation, duration, amount, and intensity of precipitation. In addition, the type of watershed also influences the amount of runoff. Watershed size, topography, shape, orientation, geology, interflow, soil, and land use are important factors in determining runoff volumes.

Land development typically introduces impervious surfaces that lead to increased runoff during storms (Figure 1). Development usually requires the removal of native vegetation and the leveling of land, which reduces rain water retention time. Native vegetation intercepts rainwater in its foliage and plant root uptake. Un-even surfaces increase surface friction which results in an increase in retention time, which then allows rain water to infiltrate for a longer period before runoff can occur. Thus, with more development comes less surface infiltration and an increase of impervious surfaces.

Impervious surfaces are surfaces which do not allow water to penetrate. Examples of impervious surfaces are roofs, paved roads, parking lots, un-fractured bedrock, tight soils (clays), and plastic sheeting. Groundwater recharge is reduced by impervious surfaces. Impervious surfaces increase the amount of runoff, which fills our waterways and may lead to flooding during storm events. During the first rains, impervious surfaces facilitate large amounts of contaminant transport. Filth (oil, lead, trash, fecal mater) from roads is directly washed into storm drains that empty into rivers, stream and the ocean. Low Impact Development (LID) implements ways to offset this by incorporating infiltration within the development or improvement project and protect water quality.

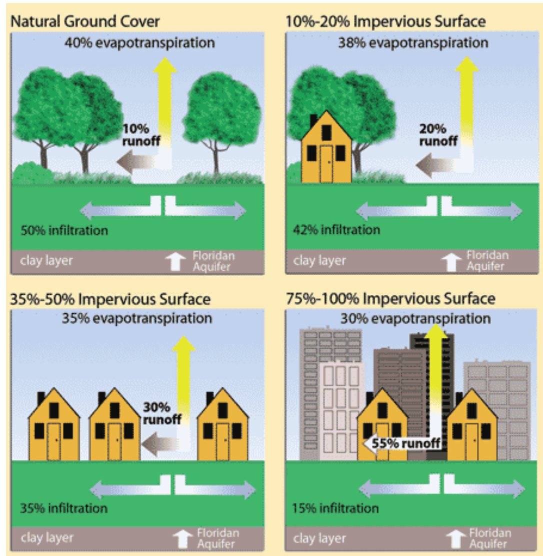

Figure 1 – Increased Runoff and Increased Impermeable Surfaces
http://www.sarasotabay.org/images/lowimpact_development.gif

Land Use Mapping:

Land use mapping of drainage attributes can also be useful tools for runoff management An area can be mapped by land use and its relation to drainage. For example, an old woodland with porous soil would have low runoff, yet a paved industrial site of the same area would have high runoff. Mapping areas by land use can help estimate resources required for water quality protection.

Land Use	Drainage
Industrial	High ↑
Commercial	
Residential high density	
Residential medium density	
Residential low density	
Farming	
Parks	
Woodlands	
Swamps	
Lakes	Low ↓

Determining Runoff Volume:

A good place for installing a runoff gage, or measuring discharge other ways, is at the outlet of a watershed or sub-watershed project area, whose area and stream base flow is known. Discharge for an urban area is expected to be larger than discharge from rural areas in a watershed of the same size.

$S = (1000/CN) - 10$ $\qquad$ $Q = [(P - 0.2\,S)^2] / (P + 0.8\,S)$ $\qquad$ (Bedient & Huber, 1989)

Where: S – potential abstraction (term is related to soil type and moisture condition)

CN – the curve number varies dependent on soil group and moisture condition. (See tables 5.1 & 5.2)

Q – Direct runoff (excess rainfall) in inches
P – Rainfall depth, inches
After calculating Q, multiply by watershed area to get volume

Example:

Tom's house is just downstream of a 4-acre watershed that presently has mature forest on top of a Crosby soil. He is worried that the new townhouse development will increase the amount of water flowing in the creek by his house.

Using a 2 inch storm determine the increase in water volume that will flow by Tom's house due to the development.

1) Calculate the S numbers S = (1000/CN) – 10
Crosby soil is type C
CN (AMC II) mature forest is 70
CN (AMC II) townhouse is 90
Convert to AMC III - worst case scenario
CN 70(1.21) = 84.7
CN 90(1.07) = 96.3
S (forest) = (1000 / 84.7) – 10 = 1.81
S (townhouses) = (1000 / 96.3) – 10 = 0.38

2) Calculate the Q (excess runoff)
P = 2 inches rainfall
Q (forest) = $[(2 – 0.2(1.81))^2] / (2 + 0.8(1.81)) = 0.78$
Q (townhouses) = $[(2 – 0.2(0.38))^2] / (2 + 0.8(0.38)) = 1.61$

3) Calculate volume
Area = 4 acre
Excess rainfall (forest) = 0.78 inch (1 ft / 12 inch) = 0.065 ft
Excess rainfall (townhouses) = 1.61 inch (1 ft / 12 inch) = 0.134 ft
Volume (forest) = 4 acre (0.065 ft) = 0.26 acre ft
Volume (townhouses) = 4 acre (0.134 ft) = 0.536 acre ft
Volume (forest) = 0.26 acre ft (43,560 ft^2 / 1 acre) = 11,326 ft^3
Volume (townhouses) = 0.536 acre ft (43,560 ft^2 / 1 acre) = 23,348 ft^3

Thus volume of runoff will increase 12,022 ft^3 which is the equivalent to a 49% increase in runoff.

Curve Numbers for Antecedent Soil Moisture Condition II

	Hydrologic Soil Group			
Land Use Description	**A**	**B**	**C**	**D**
Commercial, row houses and townhouses	80	85	90	95
Fallow, poor condition	77	86	91	94
Cultivated with conventional tillage	72	81	88	91
Cultivated with conservation tillage	62	71	78	81
Lawns, poor condition	58	74	82	86
Lawns, good condition	39	61	74	80
Pasture or range, poor condition	68	79	86	89
Pasture or range, good condition	39	61	74	80
Meadow	30	58	71	78
Pavement and roofs	100	100	100	100
Woods or forest thin stand, poor cover	45	66	77	83
Woods or forest, good cover	25	55	70	77
Farmsteads	59	74	82	86
Residential quarter-acre lot, poor condition	73	83	88	91
Residential quarter-acre lot, good condition	61	75	83	87
Residential half-acre lot, poor condition	67	80	86	89
Residential half-acre lot, good condition	53	70	80	85
Residential 2-acre lot, poor condition	63	77	84	87
Residential 2-acre lot, good condition	47	66	77	81
Roads	74	84	90	92

Adjustments to Runoff Curve Number (CN) for Dry or Wet Antecedent Soil Moisture Conditions

	Factors to Convert Curve Number for AMC II to AMC I or AMC III	
Curve Number (AMC II)	**AMC I (dry)**	**AMC III (wet)**
10	0.40	2.22
20	0.45	1.85
30	0.50	1.67
40	0.55	1.50
50	0.62	1.40
60	0.67	1.30
70	0.73	1.21
80	0.79	1.14
90	0.87	1.07
100	1.00	1.00

Source: From NRCS, 1984

References:

Bedient, P.B. and Huber. W.C. (1992): Hydrology and Floodplain Analysis. Massachusetts: Addison-Wesley Publishing Company

Ward, A.D and Trimble S. W. (2003): Environmental Hydrology, Second Edition. CRC Press