LOCAL SOURCES FOR RUNOFF CURVE NUMBERS[1]

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Setting: Design rainfall-runoff hydrology and environmental impact analysis draws heavily on the Curve Number method. The centerpiece of it is the coefficient "Curve Number", a measure of a watershed's hydrologic response potential, and usually selected from handbooks based on soils, cover, and land use. As used in the calculation of rainfall excess and the synthesis of composite hydrographs it is easily shown to be the most influential item on flood peaks and volume. This is especially grievous considering that the ground-truth origin of the handbook CNs used is unknown.

Limited comparisons elsewhere have suggested significant departures between handbook and data-defined CNs. In addition, the primary reference for the CN method, NEH-4, suggests that the soils-based table values are but guides, and that local values should be used if possible. This work illustrates the determination of CNs from local rainfall and runoff using data from southern Arizona.

Development: The runoff equation is $Q=(P-0.2S)^2/(P+0.8S)$ for $P>0.2S$, where Q and P are the direct runoff and rainfall depths, and S is a storage index, all in inches. CN is a transformation of S, or $CN=1000/(10+S)$. Also, the runoff equation can be solved via the quadratic formula to $S=5[P+2Q-\sqrt{(4Q^2+5PQ)}]$, and if values for Q and P are available from local watersheds, then S and CN can be calculated for every event of $0<Q<P$. CN may vary from 0 to 100, though most CNs are in the 55-95 range.

When this is done, often a strong secondary relationship between the found CN and P remains. For most cases, this relationship is well described by the function $CN(P)=CN_\infty+(100-CN_\infty)$**exp**$(-kP)$, where CN(P) is the CN at rainfall depth P, and CN_∞ and k are coefficients. A least squares procedure for fitting the above equation has been developed, and applied to data from several hundred watersheds nationally and across the world. Insofar as CN_∞ is the asymptotic stable value approached as P grows larger, it is more appropriate for large events, such as design storms, and thus CN_∞ is taken as the defining CN for the watershed.

Procedure: The above procedure works well using "ordered" P:Q data. That is, when P and Q are matched by rank order. This unnatural pairing matches the frequency of each, in keeping with the dominant usage of the method. That is, is to estimate the (say) 100-year runoff from the 100-year rainfall. In addition, while the intent and the original NEH4 descriptions would specify events for annual flood peaks only, this constraint restricts use only a small part of available data. Happily, experience indicates no significant departures using all the available rainfall-runoff events.

Examples: Using the above-described procedures, the following Table gives data sources, watershed information, fitted CN_∞ and k, and goodness-of-fit statistics for a number of urban and wildland watersheds in southern Arizona.

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Watersheds	fr	to	N	DA	CN_∞	k	R^2	yr	y
U.S. Geological Survey									
Alamo Wash	83	86	28	6118	52.1	0.23	98.90		
Cemetery Wash	83	88	42	749	78.6	0.66	83.52		
Cholla Wash	82	87	24	813	86.4	3.69	30.91		
Craycroft Trib	82	88	28	24.3	62.1	0.54	96.70		
Flowing Wells	83	88	34	2259	70.0	0.60	90.60		

Rob Wash	82	86	21	1331	73.7	0.96	79.90
Roller Coaster Wash	83	83	4	1120	46.6	0.33	99.92
University of Arizona							
Arcadia Wash	68	83	208	1741	87.9	3.50	84.10
Atterbury Wash	57	83	128	3180	72.8	1.36	87.80
High School Wash	70	83	295	589	86.8	2.34	96.58
Railroad Wash	68	83	99	1472	93.5	7.55	69.50
USDA-Agricultural Research Service							
Santa Rita #1	76	91	183	4.0	85.1	3.04	94.55
Santa Rita #2	76	91	141	4.4	83.9	3.55	95.36
Santa Rita #3	75	91	257	6.8	88.9	3.52	94.83
Santa Rita #4	75	91	292	4.9	86.0	1.90	83.87
Safford #1	39	69	118	519	86.3	4.71	92.83
Safford #2	41	69	104	682	89.0	4.19	89.54
Safford #3	39	68	87	764	64.2	1.02	98.62
Safford #4	40	69	120	723	70.5	1.39	97.13
Walnut Gulch LH101	68	76	70	3.2	92.0	9.13	34.53
Walnut Gulch LH102	65	77	132	3.6	92.2	7.86	80.74
Walnut Gulch LH103	68	77	94	8.3	89.0	6.19	79.91
Walnut Gulch LH104	65	76	83	11.2	91.1	6.48	88.00

Note: Least squares fits on CN to $CN(P)=CN_\infty+(100-CN_\infty)*\mathbf{exp}(-kP)$ for ordered (frequency matched) P:Q data.

References

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