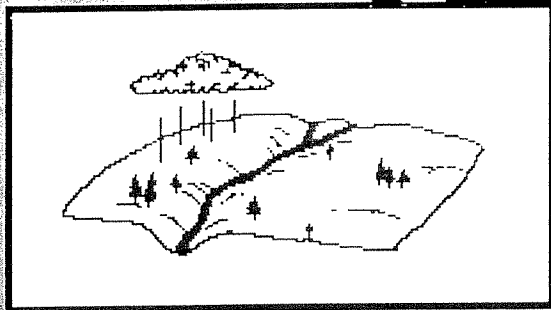
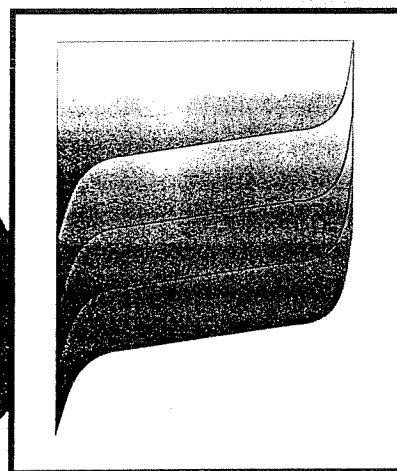
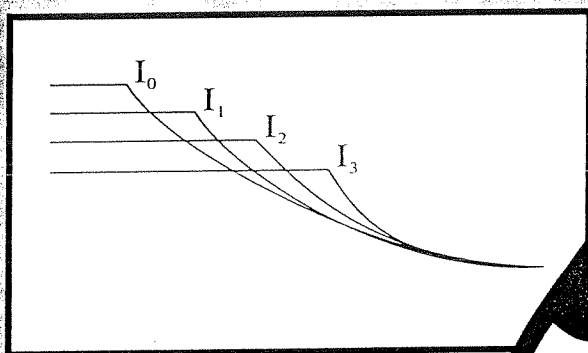


“REAL WORLD” INFILTRATION



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Infiltration - Scale Interactions

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It is crucial to understand infiltration phenomena over range of spatial scales to fully assess its impacts on both soil-plant-water interactions at the small scale and runoff and erosion at large scales. In particular, the field and small watershed scale is important as this is a typical area subject to management as well as the scale at which observed hydrographs and associated runoff water quality samples are available. These measurements are often our only realistic means to evaluate the impacts of management decisions on hydrologic response, and therefore indirectly, on infiltration behavior. Therefore a coupled understanding of runoff and infiltration processes is required. Two primary issues in obtaining accurate estimates of infiltration and runoff over a range of scales will be discussed. The first involves a very preliminary assessment of the comparability of infiltration estimates obtained from different techniques applied over a wide range of spatial scales. The second discusses the necessity of accurate temporal and spatial estimates of rainfall to obtain infiltration estimates at both small and large scales.

Infiltration Estimates Over a Range of Spatial Scales

A consistent set of economically feasible measurement or modeling procedures does not exist for obtaining accurate estimates of infiltration over a range of scales. At the small scale direct measures of infiltration fluxes can be obtained rapidly with disk permeameters. To obtain large scale infiltration estimates using this procedure, the daunting challenge of heterogeneity and the requisite large number of measurements must be faced. At larger scales, such as rainfall simulator plots or small watersheds, direct measures of infiltration flux cannot be obtained but must be calculated as a residual from measured rainfall less measured runoff. For rainfall simulators, this approach requires more elaborate instrumentation, and for small watershed, long-term monitoring of natural events. If a relatively small number of rapid disk permeameter measurements could provide comparable infiltration estimates to those obtained from the large scale residual approaches, a cost effective method would be available to provide large area estimates that could be used as initial infiltration parameters for simulation models. To assess the feasibility of this approach, steady-state infiltration estimates from unponded disk permeameter measurements, rainfall simulator measurements, and those estimated from a calibrated and verified rainfall-runoff model were obtained at the Lucky Hills catchments within the USDA-ARS Walnut Gulch Experimental Watershed in southeastern Arizona. Table 1 contains a summary of these preliminary estimates and the areas over which they apply. It is interesting to note the relative consistency over areas spanning seven orders of magnitude. For these watersheds, these results

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indicate that several disk permeameter measurements could provide the initial infiltration parameter estimates required to apply runoff models.

Table 1. Steady-State Infiltration Estimates for Lucky Hills from Three Different Methods

Method	Area (sq. m)	Steady-State Infil. Est. (mm/hr)
Unponded Disk Permeameter ¹	0.033	8.1
Rainfall Simulator ²	30	8.1
KINEROS R-R Model ³		
Catchment: LH-106	3,600	10.9
LH-102	14,000	8.1
LH-104	44,000	10.9

¹ Average of 2 measurements, -5 cm pressure head

² Average of 2 simulator runs (Green-Ampt Ks optimized using the IRIS-KW program)

³ Estimates are based on area weighted averages from multiple distributed model elements optimized over 10 calibration events (Smith-Parlange Ks)

The Importance of the Rainfall Boundary Condition for Infiltration Estimation

The importance of temporal rainfall variability for infiltration is well known and explicitly treated in most infiltration models. The importance of spatial variability at large scales is also well known. However, recent findings in the thunderstorm dominated Walnut Gulch environment indicate that spatial rainfall variability is significant even at the 50-100m scale where the spatially uniform rainfall assumption (single rain gauge) is commonly used. Faures et al. (1995) observed rainfall gradients up to 2.5 mm/100m within a 4.4 ha watershed. This spatial rainfall variation resulted in modeled peak runoff rates which varied by a factor of almost three (8 to 23 mm/hr) when two different recording rain gauges in the basin were used independently with the spatially uniform rainfall assumption. The dominance of rainfall variability was also pointed out by Goodrich et al. (1993). In this study it was found that far greater impacts on runoff model performance resulted from using one versus two rain gauges (spatially uniform rainfall assumption) than by simplifying the entire watershed geometry (and soils variability) from over 200 modeling elements to 1 element with uniform soil/infiltration parameters. The point is that for environments dominated by infiltration excess we must be able to properly define rainfall inputs in time and space. If this critical boundary condition cannot be specified, sophisticated small-scale analysis and treatment of spatial soil variability impacting infiltration variability may not be warranted.

References

Faurès, J. M., Goodrich, D. C., Woolhiser, D. A., and Sorooshian, S. Impact of small-scale spatial rainfall variability on runoff simulation. *J. of Hydrology*, 173(1995):309-326. 1995.

Goodrich, D. C., Stone, J. J., and Van der Zweep, R. Validation strategies based on model application objectives. Proc. Federal Interagency Workshop on Hydrologic Modeling Demands for the 90's, U.S.G.S. WRI. Report 93-4018, Ft. Collins, CO, p. 8-1 to 8-8, June 7-9. 1993.