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The effects of soil surface properties on infiltration and runoff

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A wide range of factors affects rainfall-runoff relationships, which therefore, take diversified forms. In the case of small, bare watersheds, infiltration is a very important factor. This can be seriously affected by (i) the formation of a sealing layer at the soil surface due to the raindrops impact and the soil and water chemical conditions, (ii) the spatial variability of the soil hydraulic properties within the watershed. A physically-based approach is suggested in this study to address these issues. First, rainfall physical properties are characterized. Then, the effect of the transfer of rainfall kinetic energy to the soil surface on soil hydraulic properties is modeled and imbedded in the solution of the flow equations to yield the infiltration curves. Also, the effect of spatial variability on infiltration is accounted for. Finally, a cell-model is used to compute the runoff hydrograph at the outlet of the catchment, and to express the combined effect of soil sealing and spatial variability on the runoff hydrogram.

With regard to infiltration, the results indicate that accounting for spatial variability of soil hydraulic properties, when soil sealing is considered, reduces the ponding time and increases the final infiltration rate.

The state of the soil surface seal was found to be a dominant factor with regard to runoff generation. Relative to the runoff produced in the homogeneous unsealed catchment, the runoff was augmented by a factor of 10 during soil surface sealing, and still more, by a factor of 20, when the soil surface was already sealed. On a relative basis, the impact of soil sealing on runoff is much more important than that of soil heterogeneity. The effect of areal heterogeneity on runoff seems to depend on both the soil surface condition and the rainfall intensity and duration. When the soil is unsealed, the total runoff and the discharge peak are higher for the heterogeneous catchment. When the soil surface undergoes a sealing process, the total runoff and the discharge peak

are higher for the heterogeneous catchment only for low rainfall intensity conditions.

The spatial pattern of the cells organization in the heterogeneous catchment is an additional factor affecting the hydrological response. The hydrographs corresponding to each of four patterns representing the same areal heterogeneity displayed differences regarding concentration time, timing of the peak runoff and the peak discharge, all being important engineering parameters required for the design of runoff-related hydraulic structures.