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Determination of watershed infiltration, runoff and erosion parameters: Turbulent or laminar flows?

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Key to modeling watershed runoff and erosion processes is estimation of infiltration/runoff rates or effective hydraulic conductivities (Km) and erosion rates, as they vary with soil cover/tilth/slope conditions, and seasonally with changing water contents. Portable rainfall simulators (RSs) are powerful tools for measuring infiltration, runoff and erosion under a variety of field conditions, and information from RS test plots can provide the infiltration/runoff parameterization required for watershed modeling. We apply a simultaneous solution of the time-to-ponding/runoff and Green–Ampt type infiltration equations to determine Km and compare these values with the simpler calculation of Km as the difference between steady rainfall and runoff rates. We also develop a laminar flow-based description of stream power to determine erodibilities and then apply both analyses to data from 423 RS plots across the Lake Tahoe Basin. For all practical purposes, calculation of Km from the steady rainfall and runoff rates was equivalent to that estimated from infiltration equations. When developing comparable "erodibilities", defined as the ratio of sediment detachment rates to stream power, the laminar-flow derived stream power results in a better fit between detachment rate and stream power than that derived from turbulent flow assumptions; thereby eliminating the restriction to <10% slopes and need to define 'n' associated with the Mannings equation. Applying the laminar flow stream power derivation to the determination of erodibilities enabled comparison of data from RS test plots having a wide range of slopes and runoff rates, as well as from RSs deploying different rainfall energies. Our overall goal is to develop a common assessment method, or approach, to evaluate field RS plot data for use in watershed modeling efforts.

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