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Hydrology without hillslopes: runoff controls and pathways on a near-level, engineered landscape

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Low relief, artificially drained landscapes like those of the Prairies in south-central Canada have received little consideration in hydrologic study. While topography is generally asserted as the main control of runoff generation, it is unknown whether this is also the case where relief is low, or if in the absence of high relief other landscape characteristics become relatively more influential. To address this knowledge gap, runoff behaviour was analysed via event rainfall-runoff hydrographs and perched water table level at 6 study sites to infer dominant runoff processes and their control factors. Instrumentation was deployed in the Catfish Creek watershed, a 642 km2 near-level, mixed land use and engineered Prairie watershed located 90 km northeast of Winnipeg, Manitoba, Canada. Specifically, surface water levels were measured at the outlet of six sub-watersheds while perched water table levels were monitored in riparian areas. At each site, rainfall events were delineated and rainfall-runoff parameters, perched water table maximum rise and antecedent rainfall variables (as surrogates for antecedent moisture conditions or AMCs) were calculated on an event basis. Landscape characteristics, including elevation, slope, and land use and land cover statistics, were also determined for each sub-watershed. Correlation analysis and principal component analysis were then carried out including all variables. Rainfall-runoff responses were highly variable across sites. Event hydrographs were generally characterized by short lag times and initial abstractions which correlated moderately to total event rainfall. However, sub-watersheds characteristics did not influence the different hydrograph characteristics recorded across sites. Threshold behaviour was observed only in the two study sub-watersheds of greatest relief. Runoff generation was hypothesized to occur predominantly as Hortonian overland flow, although the dominant runoff process shifted under certain moisture conditions, as inferred by a notable increase in the time of concentration associated with specific rainfall-runoff events. Antecedent and event rainfall totals explained the majority of the variability of event runoff magnitude. Runoff generation processes in near-level, engineered landscapes were therefore concluded to differ considerably from those of higher relief, humid, pristine landscapes and a conceptual model of hydrological behaviour for Prairie watersheds is proposed.