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# Hillslope-riparian-stream connectivity and flow directions at the Panola Mountain Research Watershed

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The question how water travels from rainfall to the stream network has engaged hydrologists for decades as it determines the streamflow response to rainfall and stream water quality. In order to obtain a better understanding of water's journey from the hillslope to the stream, and in particular the effects of rainfall amount, bedrock topography and variations in soil depth on hillslope subsurface flow pathways and hillslope-riparian zone-stream connectivity, we analyzed data from 26 groundwater wells in a hillslope-riparian study area in the Panola Mountain Research Watershed, Georgia, USA.

The water levels in the riparian zone were sustained throughout the wet winter period, while the wells on the hillslope showed very peaky and short-lived responses. Perched groundwater on the hillslope either developed across almost the entire hillslope or not at all, suggesting that either the majority of the hillslope became connected to the stream or that no connection was established. There were clear differences in the timing of the groundwater responses, with water levels near the stream and on the upper hillslope rising earlier than on the lower hillslope and midslope. The midslope with deep soils played a critical role in the establishment of hillslope-stream connectivity. A sharp increase in water level was measured at the lower hillslope wells and in some riparian wells when connectivity between the hillslope and the riparian zone was established. Sustained streamflow (more than 0.5 mm/h for more than 12 h) occurred only when the hillslope was connected to the stream.

The groundwater flow directions were highly variable across the midslope with deep soils: the flow directions followed the local bedrock topography when perched groundwater levels were low and the surface topography when groundwater levels were higher. The flow directions could even point in the general upslope direction but followed the local bedrock topography. This suggests that first the bedrock hollow filled but that once water levels were higher and saturation was more widespread, the flow directions followed the surface topography and were downslope. This competing influence of the surface and bedrock topography was not observed in the riparian zone, where the flow directions were either downslope or changed from a combined downslope and downstream direction towards a more downslope direction during events.