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Groundwater-surface water interactions in riparian ecosystems: implications for hyporheic zones and salmon embryo survival

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The spatial and temporal variability of riparian groundwater-surface water (GW-SW) interactions, and their influence on the hyporheic zone, were investigated at a range of scales in a semi-pristine upland salmon spawning catchment (Girnock Burn) in the Cairngorm Mountains, Northeast Scotland. Stream and hyporheic water quality (200-300mm depth) were monitored fortnightly at 16 spawning locations distributed throughout the catchment. Hydrochemical tracers were used to assess local GW-SW interactions. Stratified streambed incubators (50-300mm) provided information on salmon embryo mortality at a sub-set of 10 locations. Hyporheic water quality varied both temporally and spatially according to riparian GW-SW interactions. It was possible to categorise hyporheic zones into three broad typologies reflecting riparian stream-aquifer interactions: (1) groundwater dominated, (2) surface water dominated, and (3) sites exhibiting transient water table features. Groundwater upwelling occurred in areas where low permeability glacial moraine features caused substantive valley constriction. These locations were also conducive to accumulation of spawning grade gravels and consequently were utilised heavily by spawning salmon. Long residence groundwater was typically characterised by low dissolved oxygen (DO), of sufficiently low quality to be detrimental to salmon embryo survival. At sites dominated by surface water, hyporheic DO remained high throughout and rates of embryo survival were correspondingly high. Survival rates were also high at sites where hydrochemical characteristics indicated a transient water table. This is probably attributable to the hydrological conditions which resulted in increasing DO concentrations towards hatch time when embryo oxygen demand is at its maximum. It is suggested that future research should aim to integrate across spatial scales and disciplines to obtain a

better understanding of the ways in which hillslope and riparian zone hydrology affect GW-SW interactions, hyporheic zone processes and stream ecology.