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Utilize Tracer Tests with Numerical Simulation to Characterize Hyporheic Flux Exchanges beneath the First-order Stream at the Alpine Watershed in Taiwan

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The formosan land-locked salmon is one of the representative but endangered species in Taiwan and the first-order stream of Yushen Creek in Chichiawan Watershed, Taiwan is the major habitat for the salmons. Unfortunately, the intensive water exchanges beneath the streambed caused the creek to cease flow, and the fragmented creek could not provide a sustainable environment for the rehabilitation and the population of salmon was significantly reduced. To comprehensively understand the mechanisms of surface water and groundwater interaction and mitigate the effect of fragmentation on the salmon habitat, the tracer tests and numerical models were conducted to characteristic hyporheic flux exchanges beneath the stream. Seven observation wells and seven piezometers along the stream were installed to provide long-term water levels, temperatures, and electrical conductivities of surface water and groundwater. Five tracer tests from April, 2017 to May, 2018 were conducted at different sections of reach to delineate the horizontal and vertical hyporheic flow paths and seepage flow directions through the breakthrough curves. OTIS and VS2DT were selected to simulate the concentration variations in the stream and streambed, respectively and quantify the hydraulic characteristics of hyporheic zone. The estimated storage zones and exchange coefficients by the OTIS model were used to mimic the hyporheic cells and fed into the VS2DT model to identify the hyporheic and seepage flows. The simulated results revealed that the first-order stream has frequent flux exchanges beneath a high porosity gravel streambed but this intensive interaction reduces with the existence of confluences and the high level of baseflow. The results also demonstrated the effect of topography on the flow path that water flows out of the upstream wetted channel and back into downstream wetted channel to avoid the areas of step-riffle. Finally, the hydraulic characteristics of streambed, streamflow, and morphology of stream should be considered to mitigate the fragmentation when conducting the river restoration of the first-order stream in the alpine watershed.