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Verification of a Conceptual Model of Groundwater flow in a Poorly Productive Metasedimentary Bedrock Aquifer

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Poorly Productive Aquifers (PPA) underlie approximately two-thirds of the landmass of Ireland yet the behaviour of groundwater in these bedrock types remains poorly understood. Existing (unverified) conceptual models represent most groundwater as travelling through the uppermost metres of the bedrock and at the base of overlying unconsolidated deposits (transition zone), with a subordinate fraction flowing through the shallower bedrock (to 24m BGS) and the deeper rock (to 76m BGS). However, the hydrogeological properties of these units remain largely uninvestigated and thus any conceptual model of groundwater flow requires verification before application to meet the requirements of EU Water Framework Directive legislation. This study aimed to investigate and refine the current conceptual model of groundwater flow within a poorly productive shallow greenschist-grade metasedimentary (Dalradian) bedrock aquifer in the Gortinlieve Catchment, Co. Donegal. The final model will act as a basis for simulating groundwater flow in the uppermost 50 metres of bedrock in the area.
A programme of field-based characterisation involved outcrop measurements of fracture length, aperture, orientation and density. High resolution acoustic televiewer and caliper geophysical logs provided details of fracture frequency, orientation, and aperture at depth in six monitoring wells within the catchment, while differential temperature and differential conductivity logs permitted identification of hydraulically active fractures. Constant rate pumping tests conducted on all monitoring wells established the hydrogeological properties at different depths in the aquifer along a transect stretching from the catchment divide to the discharge zone (stream). A flow balance for the catchment provided an estimate of the groundwater contribution to stream flow.
Preliminary results identified two prominent conjugate fracture sets in outcropping, which were also encountered in the boreholes thus providing potential hydraulic connections between the transition zone, shallow and deep bedrock. Results from the resistivity logs indicate that the fractured bedrock aquifer is strongly heterogeneous. Analysis of pumping test, differential temperature and differential conductivity data demonstrated several of the fracture planes to be hydraulically active and facilitating the flow of groundwater. Average values of hydraulic conductivity obtained from pumping test analysis for the transition, shallow and deep bedrock are 1.83, 0.01 and 0.01 m/d respectively, suggesting that 85% of groundwater flow occurs within the heavily weathered transition zone and that the shallow and deep bedrock transmit a significantly lower proportion of the total groundwater flow per unit thickness. Pumping test and hydraulic gradient data also demonstrate the rate of groundwater flow increases with increasing saturated thickness. Overall, flow balance results suggest that only 20-30% of groundwater flow within the catchment contributes to flow in the nearby stream and the main component forms part of the deeper regional flow system. These preliminary findings provide an important basis for refining existing conceptual models of PPA.