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Stream temperature medelling and fibre optic distributed temperature sensing to quantify groundwater discharge in the Ngongotaha Stream, New Zealand

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To characterize stream/groundwater interaction, fibre optic distributed temperature sensing (FODTS) was deployed over a 1 km reach in the Ngongotaha Stream, Rotorua, New Zealand in January 2013. The cable was deployed at the streambed near the left and right banks as the groundwater fed springs discharge laterally at both banks. Temperature profiles measured by FODTS were used to identify the location of springs using a constant temperature method (20 min averaged temperature data) (Lowry et al., 2007; Matheswaran et al., 2014; Selker et al., 2006a) and a standard deviation of diurnal temperature method (Lowry et al., 2007; Matheswaran et al., 2014). Both methods identified 13 individual springs at the right and left banks in an approximately 115 m reach. The left and right bank temperature profiles showed that full mixing of the spring and stream water does not occur between most of the springs due to their close spacing.

Groundwater discharge quantification based on FODTS data is typically made using a simple steady state thermal mixing model (Briggs et al., 2012a; Selker et al.,2006a; Westhoff et al., 2007). This formula is not applicable in streams like the Ngongotaha where springs are closely spaced and groundwater and surface water are not well mixed between springs. To address this issue, a new approach was developed in this study in which a one dimensional heat transport model was fitted to the FODTS measurements, where the main calibration parameters of interest were the unknown spring discharges.

Datasets of measured temperatures at the left and right bank were transformed to a new single dataset using a weighted average where the weights reflect the degree of mixing downstream of a spring. Model calibration helped to find the optimum value of the weights in the springs section. For a spring on the left bank the weighted average was skewed towards the left bank data, and vice-versa for a right bank spring. Upstream of the spring section, a non-weighted average was applied. Streamflow gauging upstream and downstream of the study reach showed that the stream gains $\sim$ 500 L/s from groundwater which was used to find the mixing ratios of the left and right banks. The new model allowed the spring discharge to be quantified in the complex hydrogeological setting. The results showed consistency with the findings of previous study in the Ngongotaha Stream catchment (Kov′aˇcov′a et al., 2008).

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