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Towards understanding the spatial and temporal characteristics of stream, hillslope, and groundwater runoff processes in a Rocky Mountain headwater catchment in Alberta, Canada

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The eastern slopes of the Rocky Mountains produce the majority of the surface water supplies for much of Alberta's population. Groundwater inputs to rivers constitutes a large component of flow in this headwater region, however limited knowledge of the interaction of groundwater-surface water sources limits the ability to predict impacts of climate and disturbance in this critical source water region. The objectives of this study are to explore the spatial and temporal dynamics of surface, hillslope, and deeper groundwater runoff processes using coupled tracer approaches to characterize their interaction in regulating streamflow dynamics at stream reach and catchment scales.

The study was conducted in Star Creek (10.4 km^2), which is representative of small-medium sized, front-range Rocky Mountain catchments. A network of climate stations and 6 nested hydrometric-water quality sampling stations were used to collect 5 years (2009 - 2013) of meteorological, discharge (Q), and stream water quality data. Nested stream gauging stations enabled characterization of the spatial and temporal pattern of Q and water geochemistry (cations: Na^+, Mg^{2+}, Ca^{2+}, K^+, and anions: Cl^-, and SO_4^{2-}) along a gradient of very steep, bedrock entrenched alpine stream reaches down through lower gradient mid-montane alluvial stream reaches. The initial phase of this work uses the stream gauging network to determine the difference in Q between stations, hydrograph baseflow separation, and mixing model analyses of geochemical parameters. These analyses suggest the runoff process is dominated by longer, deeper runoff flow pathways (groundwater). Geologic information and a conceptual model of topographic controls on hillslope-stream connectedness (after Jensco *et al.* 2009 and others) was used to identify sites where concentrated hillslope flow may be connected with the stream to aid in interpreting the spatial and temporal variation in Q and stream geochemistry.

Strong longitudinal and seasonal patterns in Q were evident over 5 years showing that the alpine reaches contributed 20-40%, steep mid-elevation reaches contributed 2-9%, and the lowest elevation, alluvial reaches contributed 11-25% of total catchment Q. This was consistent with baseflow separation of the 6 nested gauging stations which showed baseflow comprised 67-70% in the alpine reaches, 70-71% in the steep mid-elevation reaches, and increased to 75-80% in the lowest alluvial stream reach. Preliminary analysis of distributed water geochemistry identified some parameters that displayed strong seasonal patterns with over-winter groundwater contributions. Results from an end member mixing analysis using these parameters were consistent with results from the hydrometric analysis suggesting large groundwater contributions in the steepest upper reaches and increased groundwater contributions in downstream reaches. Future work will focus on coupled tracing approaches using a broader suite of geochemical end-members, along with higher spatial resolution NaCl tracing studies, to better characterize groundwater-surface water interactions reflecting hillslope, hyporheic, and deeper groundwater sources.