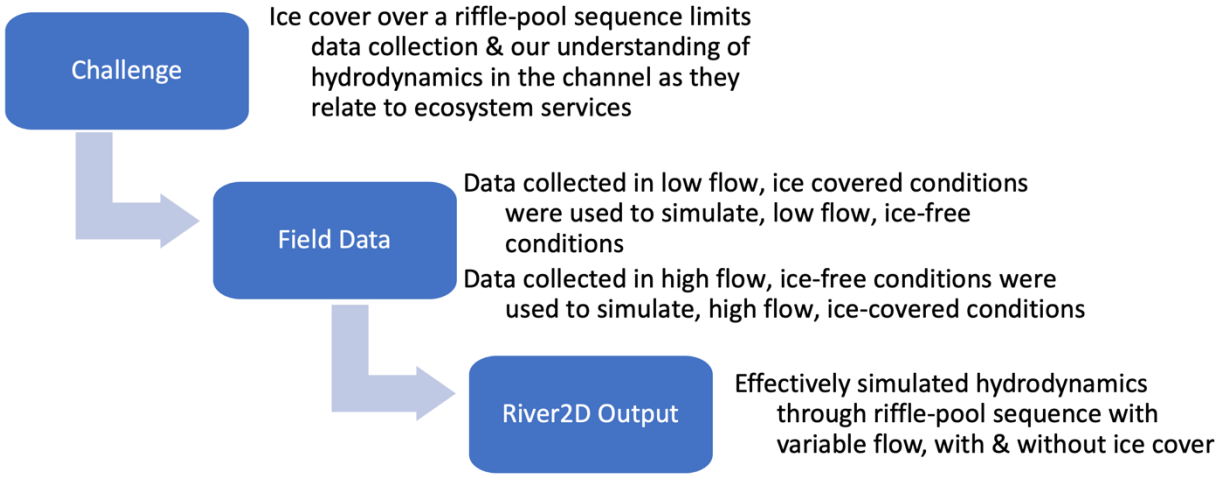
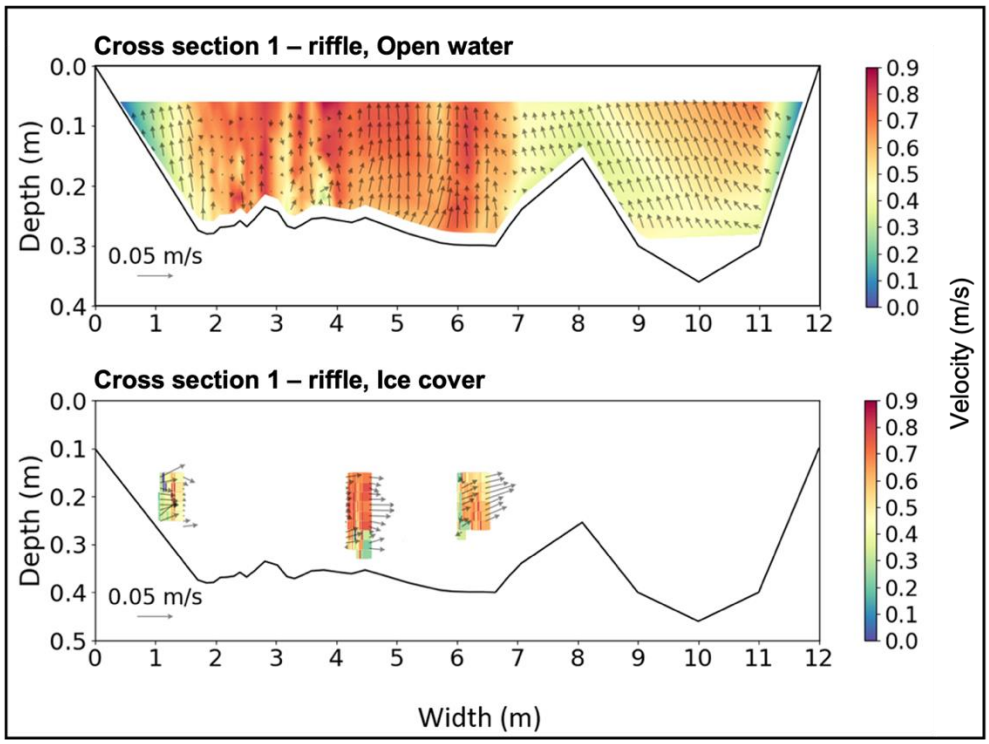
Supplementary Materials

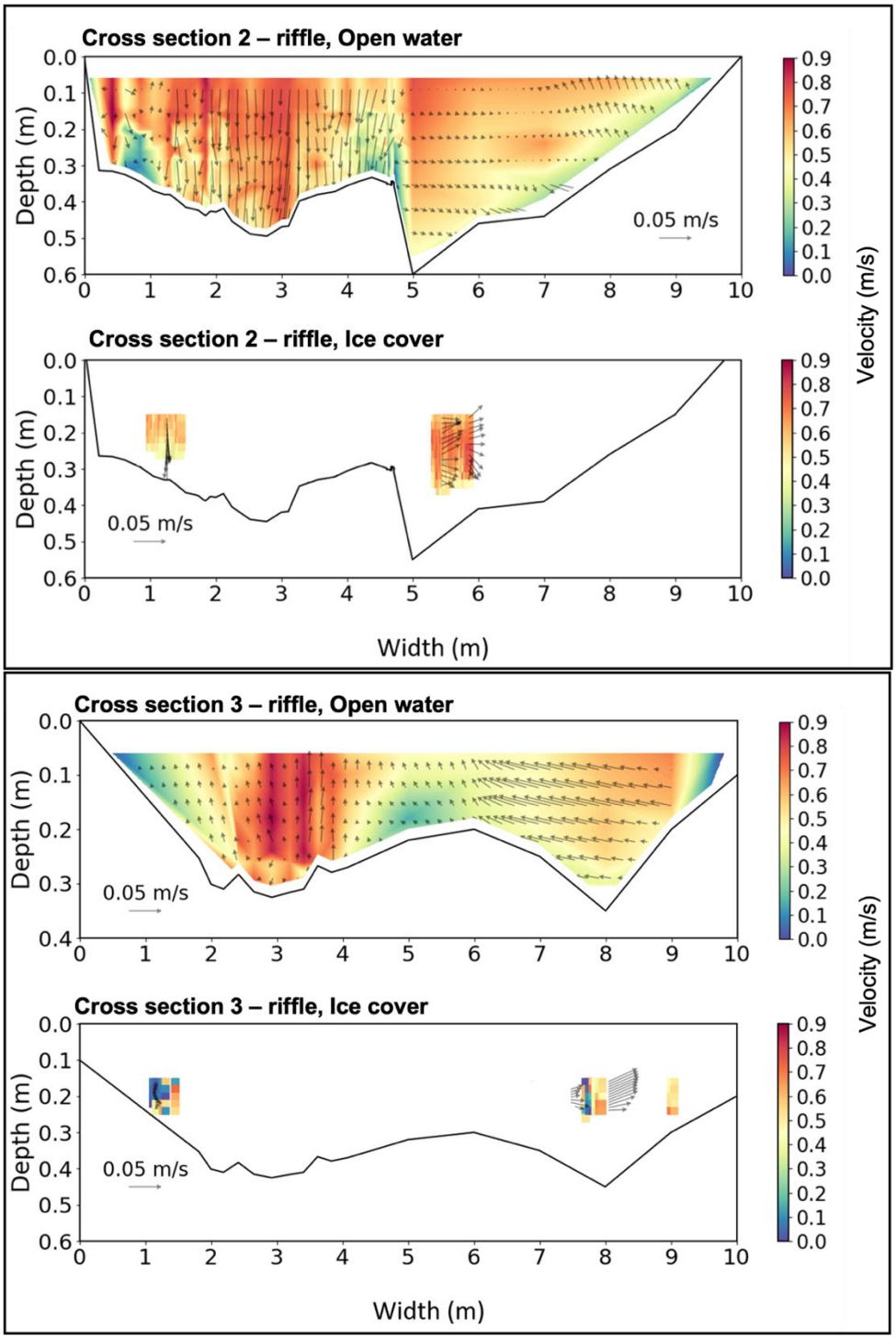
The research project schematic is shown in Supplementary Material Figure S1 to illustrate the challenge, where the field data and model outputs relate to each other (Supplementary Material Figure S1).



Supplementary Material Figure S1. Problem schematic.

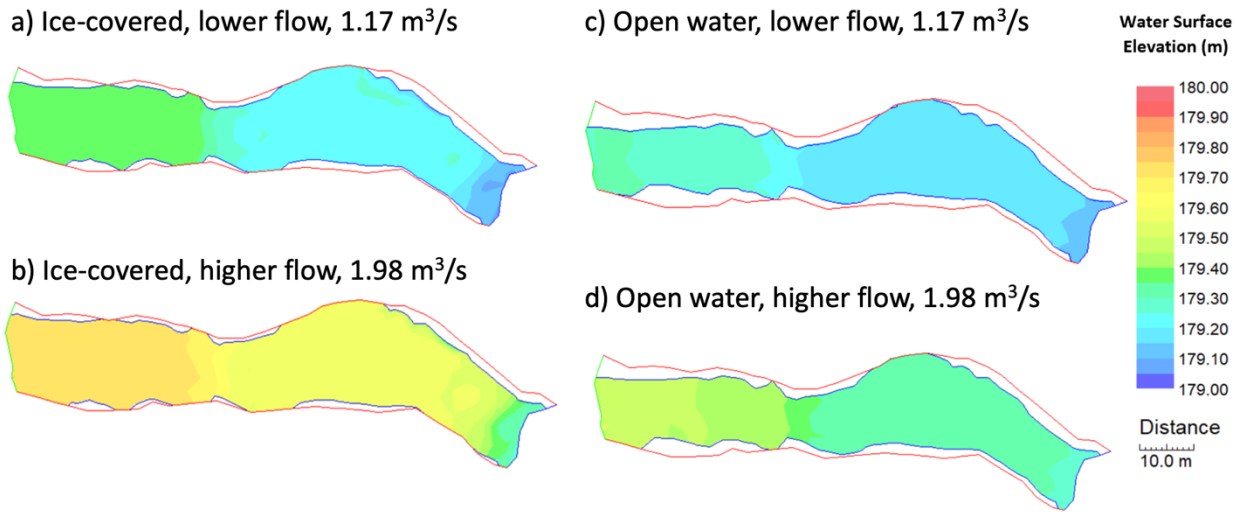
Cross-sectional geometries and the relationship to streamwise and secondary flow direction velocities were evaluated through the creation of a mesh grid with cross-section widths corresponding to x values, depths to y values, and streamwise velocities to z values. This grid was used to create maps of cross-sectional velocities at riffles (Supplementary Material Figure S2) and pools (Manuscript Figure 3), to visualize distributions along each cross-section. Lateral and vertical velocities were represented using a vector plot overlain on the cross-sectional contour, demonstrating the direction and magnitude of secondary velocities[1]. For ice-covered velocities, the intervals between measurement locations were left void to avoid errors caused by interpolation. The data collected on February 23, under ice-covered conditions, and on March 2 under open water conditions were used for this analysis as they provided the most information for each cross-section. ADV data collected on the same day were included to provide additional detail.





Supplementary Material Figure S2. Velocity distribution maps for each riffle cross-section (upper panel is cross-section 1; middle panel is cross-section 2; lower panel is cross-section 3; Figure 1) from left bank to right bank under open water conditions (top panel) and ice-covered conditions (bottom panel). Streamwise velocities are represented on a colour scale and secondary velocities are represented by arrows showing the direction and magnitude of the transverse and vertical velocity component. Data were collected using a Sontek S5 ADCP under ice-covered conditions on February 23, 2021, and open water conditions on March 2, 2021.

Under both higher and lower flow conditions, outflow water surface elevation was constant between ice-covered and open water trials (Supplementary Material Figure S3).



Supplementary Material Figure S3. Modelled water surface elevations for all four simulations. Water elevation decreases in the downstream direction according to the channel bed slope, and to simulated water depths.

Supplementary Material Reference (this aligns with reference number 28 in the main text)

1. Sontek RiverSuveyor Discharge, Bathymetry and Current Profiling. 2015. Available online: https://info.xylem.com/rs/240-UTB-146/images/riversurveyor-m9-s5-brochure.pdf?_ga=2.67666392.894680228.1648847751-199850675.1648847751 (accessed on 9 September 2021).