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Quantifying the effects of macrophyte growth on hydraulic parameters in New Zealand lowland streams

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Demand for water resources in New Zealand has increased pressure on river managers to monitor and set limits on water quality and quantity to maintain in-stream environmental values. Water quantity limits are usually set based on aquatic ecosystem habitat requirements (usually measured in terms of depth and velocity), and stream flow monitoring is typically carried out using continuous stage records and an established stage-discharge relationship. However, both setting and monitoring water quantity in New Zealand lowland streams is confounded by the effects of macrophytes. Introduced macrophytes have come to dominate many New Zealand lowland streams, due to their typically stable beds, low-gradient and open-canopy. Under these conditions macrophyte peak summer coverage can often exceed 70% of the stream bed. This dominance by macrophytes alters stream hydraulics by restricting flow to only a portion of the channel (or blocking the entire channel width) resulting in increased depths, reduced water velocities and fine sediment deposition. Quantitative relationships between flows, velocity and depth are basic tools that decision makers need to predict the outcomes of management and restoration actions. The complexity of these relationships is increased in lowland streams due to high seasonal variation in plant biomass and spatial heterogeneity of plant species and distribution within a section or reach. Most existing research on the effects of vegetation on hydraulic resistance has been laboratory based or has focused on individual macrophyte species. The aim of this paper was to study the natural seasonal growth of two common but contrasting types of macrophyte community (sprawling emergent and submerged macrophytes) and develop quantitative relationships between vegetative blockage and flow resistance as simple tools for river managers. Our findings demonstrate that hydraulic roughness (Manning's n) can vary considerably over time in lowland streams prone to macrophyte growth. This will limit the applicability of invariant stage-discharge relationships. However, our results suggest that if blockage can be estimated then stage-discharge relationships could potentially be adjusted using a blockage-Manning's correction factor. The macrophyte-enhanced Manning's n relationships could potentially then be used with hydraulic models to predict physical habitat variables dependent on flow and macrophyte cover and community type.