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Hydraulic Flow through a Channel Contraction: Multiple Steady States

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We have investigated shallow water flows through a channel with a contraction by experimental and theoretical means. The horizontal channel consists of a sluice gate and an upstream channel of constant width b_0 ending in a linear contraction of minimum width b_c . Experimentally, we observe upstream steady and moving bores/shocks, and oblique waves in the contraction, as single and multiple (steady) states, as well as a steady reservoir with a complex hydraulic jump in the contraction occurring in a small section of the b_c/b_0 and Froude number parameter plane. One-dimensional hydraulic theory provides a comprehensive leading-order approximation, in which a turbulent frictional parametrization is used to achieve quantitative agreement. An analytical and numerical analysis is given for two-dimensional supercritical shallow water flows. It shows that the one-dimensional hydraulic analysis for inviscid flows away from hydraulic jumps holds surprisingly well, even though the two-dimensional oblique hydraulic jump patterns can show large variations across the contraction channel.