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Removal of river embankments and the modelled effects on river-floodplain hydrodynamics

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The channelization and embankment of rivers has led to major ecological degradation of aquatic habitats worldwide. River restoration, which often includes the removal of previously constructed barriers between a river and its floodplain, is now being widely used to create favourable hydrological conditions for target species or processes. However the effects of river restoration on hydraulic and hydrological processes are complex, and are often difficult to determine due to the infrequency of long-term monitoring programmes before and after restoration works. To examine the hydrological impacts of embankment removal under a variety of possible hydrological conditions, we developed coupled hydrological/hydraulic models of pre-embankment and post-embankment conditions at a wet grassland meadow in Norfolk, UK using the MIKE-SHE/MIKE 11 system. Groundwater hydrology and climate were monitored between 2007 and 2010 with river inflows being provided from an upstream gauging station. The embanked model was calibrated and validated with observed groundwater data for two consecutive 12-month periods, after which the restored topography was applied to the model and validated for a subsequent 12-month period. The restored model was then run for the same period as the embanked model (i.e. with the same river inflow, precipitation, and potential evapotranspiration data) to remove interannual climate variability and enable a direct comparison between models. Modelled groundwater levels compared well with piezometer observations and reproduced the observed rapid groundwater response to high magnitude rainfall and river flow events. Removal of the embankments resulted in frequent localised flooding at the river edge, widespread floodplain inundation at flows greater than 1.9 m^3 sec^{-1}, as well as higher groundwater levels and greater subsurface storage. Restoration had only a minor effect on flood peak attenuation (maximum 5% flood peak reduction), likely due to the small size of the restored river reach (~400 m), and improved free drainage back to the river. Our results suggest that embankment removal can increase river–floodplain hydrological connectivity to form a more natural wetland ecotone driven by frequent flood disturbance. This has important implications for the planning and management of river restoration projects which aim to enhance floodwater storage, river water quality and floodplain species composition.