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Hydromorphic Classification of the Hanford Reach through Integration of Field Observations and Hydrodynamic Models

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This element of the PNNL SFA is developing a new approach for classifying and mapping hydromorphic features in large, dynamic river systems. The approach will be used in modeling hydrologic exchange flows (HEFs) and biogeochemistry at local, reach and watershed scales. It is well known that HEFs are strongly controlled by the interaction of surface water flow dynamics with river morphology (hydromorphic features). We hypothesize that classes of hydromorphic features will exhibit distinct distributions of HEFs, subsurface residence times, and biogeochemical reaction rates. If this hypothesis is correct, large-scale classification and mapping of these features combined with field observations and numerical simulations of HEF characteristics will provide a pathway to develop reach- and watershed-scale models of hydrologic exchange and biogeochemistry based on widely available information such as LIDAR-based river bathymetry.

As a first step toward testing this hypothesis, we have developed and tested a new quantitative approach for classifying and mapping hydromorphic features based on field observations of river bathymetry and two-dimensional (2D) river flow simulations. This approach extends and combines a number of methods recently published in the geomorphology literature. We extracted several attributes of river bathymetry and flow on a highly-resolved 2D grid of the Hanford Reach of the Columbia River. Measures of riverbed bathymetry include Fourier spectra of elevation, local slope and aspect, and concavity/convexity. Flow simulations are from the 2D Modular Aquatic Simulation System (MASS2) model applied to a historical time period, which has been previously calibrated and validated for the Hanford Reach. Statistical methods including principal components analysis, K-means and expectation- maximization clustering, and information criteria were combined to identify four controlling variables that defined seven classes of hydromorphic features. When applied to the Hanford Reach, this classification scheme resulted in the identification of well-defined spatially coherent features that are physically interpretable and consistent over the entire reach, as well as sub-domains within the reach. Field ground-truthing and observations of riverbed textural properties are underway to verify and extend this classification scheme, and to compare the results to existing hydromorphic classification schemes. The resulting feature maps are being used to guide selection of sub-domains for mechanistic modeling of hydrologic exchange (Bao et al. poster) and novel biogeochemical reaction processes (Graham et al. and Song et al. posters); to guide the selection of locations for field studies (Stegen et al. poster); and to support development and parameterization of reach- and watershed-scale reduced-order models (Zhang et al. poster).