Ecohydraulic Design of Salmonid Habitat Enhancement Projects in the Central Valley, California

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Abstract

In the last eleven years, concerted efforts led by agencies including the U.S. Bureau of Reclamation, U.S. Fish and Wildlife Service, California Department of Fish and Wildlife, NOAA Fisheries, Sacramento County Parks and the Sacramento Water Forum have resulted in a suite of aquatic habitat enhancement projects in the lower American River which runs through the greater metropolitan area of Sacramento, California. These projects have focused on the creation and enhancement of spawning and juvenile rearing habitats for Central Valley steelhead and Fall-run Chinook salmon. The ecohydraulic design approach employed incorporates topographic/bathymetric/hydraulic surveys, development and application of detailed multidimensional hydrodynamic models which are then combined with locally derived habitat suitability indices to estimate the amount of potential habitat and sediment mobility calculations to evaluate the potential longevity of project features.

The habitat enhancement projects are needed to support habitat that was lost due to the construction of Folsom and Nimbus Dams, which are components of the Federal Central Valley Project. These dams block access to the vast majority of the habitat once available to anadromous fishes in the American River watershed, as well as interrupt the transport and delivery of sediment to the lower American River, where it once replenished riffles used for the development of redds utilized for spawning. Though the vast majority of water originating in the watershed still flows down the lower American River, the sediment does not. This has led to a coarsening of the bed due to the winnowing of fine sediment. Habitat project features include the enhancement and/or creation of spawning riffles at locations where high amounts of spawning was historically documented, creation or reconnection of secondary and tertiary channels, gravel augmentation, construction of floodplain benches, and the placement of large woody material in the channel, banks and floodplains. In some cases, the projects include the placement of large cobble and boulder material in the main channel in an effort to raise water levels and re-wet previously disconnected side channels.

The ecohydraulic design process includes comprehensive bathymetric and topographic surveys, surface development, hydraulic surveys/measurements, and development of detailed two-dimensional hydrodynamic and habitat suitability models. Outputs from the hydrodynamic model for a wide variety of flow conditions are used to estimate salmonid spawning and rearing habitat suitability for proposed design configurations, as well as to assess the potential mobility of the placed sediment. The design process follows an iterative approach where the amount of

habitat created is optimized for a given amount of spawning sized material and excavation (set by the project budget) and the potential for mobility of the project features.

The material for the gravel augmentation efforts has been supplied from a variety of sources including purchase from nearby aggregate producers, excavation and onsite sorting from adjacent terraces distal from the current river channel, as well as material that is generated from the excavation of side channels and floodplain benches included in the project design. Many of the projects have been designed such that a cut-fill balance is achieved within the project footprint. When locally sourced, the material too fine to be used for gravel augmentation to riffles is used to improve the texture of floodplain surfaces to improve native plant recruitment, establishment and growth. The material that is too coarse to be used for gravel augmentation is used to fortify areas of the design that are expected to experience high shear stresses and subsequent transport of the placed appropriately size spawning gravels.

Extensive post-project physical and biological monitoring has occurred at these sites, which has documented the utilization of the sites by salmonids at various life stages in a variety of hydrologic conditions (i.e., critically dry through wet years), as well as the rate of degradation (i.e., erosion of sediment from the spawning areas). This post-project monitoring data has been used to enhance the design process and project complexity in subsequent years. Enhancements to the design process resulting from the post-project monitoring include refinement of habitat suitability curves, inclusion of increasing amounts of large wood, addition of secondary and tertiary channels for rearing and spawning habitat, and refinement of and experimentation with the size of the sediment placed in spawning areas.

The projects have substantially contributed to the limited amount of habitat used by anadromous salmonids at multiple freshwater life stages. As examples of the success of this ongoing project, the Nimbus Basin project was home to 926 documented redds (24% of all redds documented within the lower American River in that year) in the first spawning season following construction. 91% of these redds occurred in locations that were predicted to be medium or high-quality spawning habitat by the habitat suitability modeling effort. The Lower Sailor Bar project was home to 514 documented redds (14% of all redds documented within the lower American River in that year) in the first spawning season following construction. 79% of these redds occurred in locations that were predicted to be medium or high-quality spawning habitat by the habitat suitability modeling effort.