Columbia River Estuary Floodplain Wetted Area Model:

The Evaluation of Salmon Habitat Opportunity for Restoration Program Planning, Prioritization, Design, Assessment and Reporting and Other Operations Requirements

Problem: No hydraulic model presently exists to assess seasonal shallow-water habitat availability for out-migrating juvenile salmonids on the Columbia River estuary (CRE) for the purposes of ecological restoration and other operations project and program-level planning, prioritization, design, assessment and reporting. The CRE is here defined relative to juvenile salmon out-migration as the 235-km length of the river between Bonneville Dam and the mouth, and importantly includes the floodplain areas located lateral to the main stem river, with the perimeter delineated by the ordinary high water mark (Figure 1). Restoration is here defined as the removal of passage barriers and consequent hydrological reconnection of island areas or floodplain areas lateral to the main stem river and it also includes the creation of habitat in the main stem river using dredged material.

Needs:

- To prioritize restoration opportunities, the detailed topographic surface required as model input was a main recommendation in the most recent restoration prioritization framework funded by the Bonneville Power Administration (Evans et al. 2006).
- To identify large-scale habitat restoration and creation opportunities relative to the February 18, 2009 and February 25, 2009 letters sent by U.S. District Judge J.A. Redden to the Counsel of Record in Nat'l. Wildlife Fed'n v. Nat'l Marine Fisheries Serv.
- To measure the effects of existing salmon habitat restoration projects in the CRE by measuring key indicators – wetted area and inundation time – to estimate habitat availability at critical periods in the out-migration, based on recommendations from the Corps' cumulative effects project (Johnson and Diefenderfer 2008).
- To project the effects of existing and potential salmon habitat restoration projects under alternative restoration and flow scenarios, e.g. to evaluate environmental flows to these habitats under climate change (snow pack reduction) and other planning scenarios.
- Evaluate pile structure removal and/or enhancement in collaboration with the current program of the Lower Columbia River Estuary Partnership and Bonneville Power Administration.
- Assist Operations in District Regional Sediment Management (RSM) Program: identifying possible placement sites for elevation and volume estimating purposes, and additionally quantifying the long term results of such placements.
- Assist in site location planning for Habitat Creation Program.
- Assist in site location planning for Tribal fishing.
- Others…?

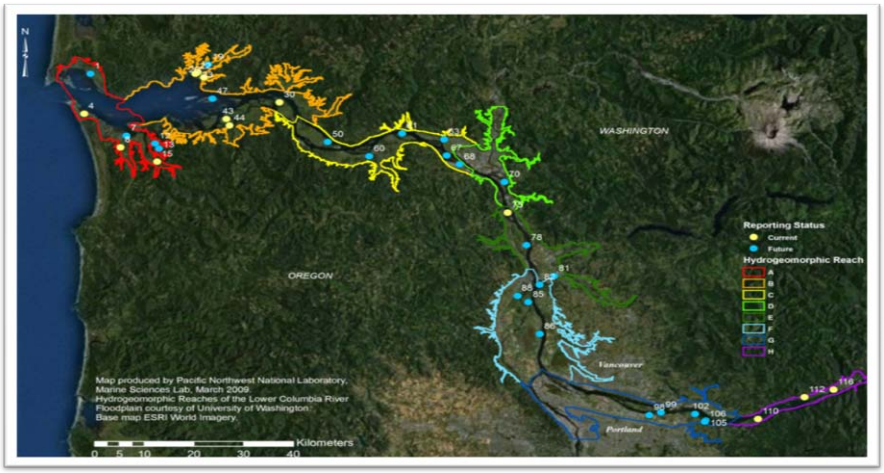

Figure 1. Map of the hydrogeomorphic reaches of the lower Columbia River and estuary showing reference sites where water level and land elevation data have been collected.

General Methods: These critical questions may be addressed by one-dimensional modeling of the CRE floodplain and main stem river, for example to assess the availability of tidal wetland channel and shallow-water salmon habitats under a range of scenarios with alternative flows, tides, and suites of habitat restoration projects (e.g., see Figure 2). However, the floodplain areas located laterally to the main stem river are most critical to the problem, while existing hydrodynamic models including the Corps Portland District models focus on the main stem river.

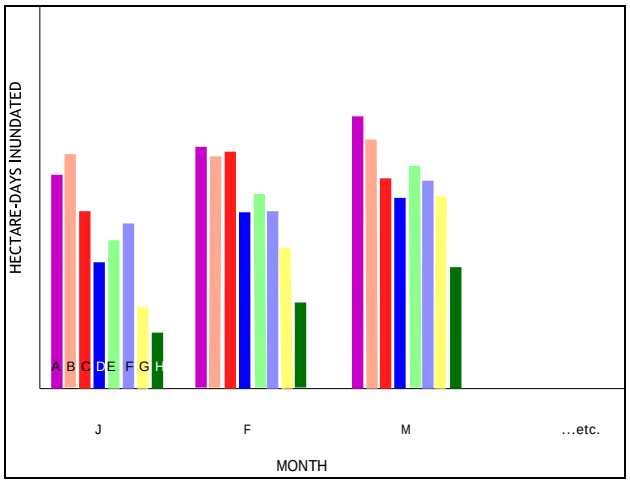

Figure 2. Hypothetical example chart of available floodplain and channel area in reaches A-H of the CRE, by month beginning with January (J), under typical flow scenario “A”.

Detailed Methods Proposed: Fact-finding meetings at the Corps Portland District in fall and winter of 2008-2009 and at the Corps Hydrologic Engineering Center in Davis, CA in April 2009 indicated that the Hydrologic Engineering Center’s River Analysis System

(HEC-RAS) used together with its GEO-RAS may be able to provide the outputs required for decision making. Furthermore, this approach may be the most efficient because *a HEC-RAS model of the main stem lower river already exists;* however, to be applicable for these purposes it requires a) lateral expansion to include the floodplain, and b) higher resolution input data sets for bathymetry, topography, and water surface elevation. (Additional available models that could provide alternative bases for expansion include DELFT at the Corps, MASS-2 at PNNL, and a National Weather Service model.)

Input Data Requirements: Bathymetry, Topography, and Water Surface Elevation.

Bathymetry: *Status.* Existing sources of bathymetry are incomplete. A bathymetry data gaps study has been completed for the main stem CRE (Marcoe and Burke 2008) but not for the tidal floodplain areas that are also areas of great concern for hydrological reconnection restoration. The Estuary Partnership contracted David Evans to fill some of the gaps identified (based on the EP's assessment of high priority gaps) and delivery is expected in November 2009 (the EP plans to stitch data with existing bathymetry). The Corps hydrosurvey unit may also have bathymetry data covering the main stem river and possibly the floodplain for the lower 40 miles of the study area. *Recommendation.* Extend the gap analysis to the remainder of the floodplain laterally to the ordinary high water mark. Evaluate options to fill these gaps including the Corps' Compact Hydrographic Airborne Rapid Total Survey (CHARTS) in-house survey capability that includes an Optech, Inc., SHOALS-3000 Lidar instrument integrated with an Itres CASI-1500 hyperspectral imager.

Topography: *Status.* Existing LiDAR of most of the study area has been flown (LiDAR Bare Earth DEM 2005), however, only small portions of it have been reprocessed into a continuous 1-m resolution dataset using a method that is sensitive to the low relief of the topographic surfaces e.g. the Hutchinson (1989; 1996) method used for tidal portions of the Grays and Deep rivers, tributaries to the CRE (Diefenderfer et al. 2008). *Recommendations.* If flying new LiDAR estuary-wide is infeasible or compromises the timeline, existing LiDAR requires reprocessing using a more data-sensitive method such as this one; results need to be verified using X,Y,Z survey data points on non-structured surfaces and a gap analysis is required to identify areas needing ground surveys. PNNL is currently automating its site-scale reprocessing method for larger-scale applications.

Water Surface Elevation. *Status.* In earlier years, water-level data collection and model input focused on the main stem river. In recent years, water-level data has been collected at restoration and reference sites in shallow-water areas and differences from the main stem hydrograph have been observed (e.g., 1-2 hour lag at tidal restoration sites on the Grays River, and impoundment by dikes). *Recommendation.* These current shallow water habitat area water level data, from both Corps and BPA-funded projects, are available for model set-up. PNNL

has provided example data and a map of the water-level data collection locations and times throughout the estuary to the Portland District.

Summary Proposal:

All raw input data required to extend the Corps' Portland District one-dimensional hydrodynamic HEC-RAS model of the estuary to the entire floodplain study area could be available by the end of calendar year 2009 provided that initial gap analysis is completed by mid-2009. In winter 2009-2010, if not sooner, these data could be compiled into ArcInfo TIN and raster files suitable for model set up. In spring-summer of 2010, wetted area estimates would be calculated using steady-state water surface elevations simulated by the HEC-RAS model; this model would incorporate improved topographic, bathymetric, and water level data from the existing version. The model would be set-up, calibrated, and run by the Portland District Hydrology Section. PNNL would work in collaboration with the Portland District to select the matrix of flow and tidal elevation scenarios to be run in model: an estimated 16 simulation scenarios would be required to meet the initial objectives for the cumulative effects project.

To complete the input and set-up data required in 2009, PNNL would build on the LiDAR post-processing currently underway by 1) verifying it using both Corps- and PNNL-collected data, and 2) working in close coordination with the Corps to integrate the following datasets into a digital terrain model of the floodplain and main stem river system in the ArcInfo TIN format:

1) TerraPoint Inc. LiDAR, post processed by PNNL
2) Portland District hydro surveys
3) Existing bathymetry data held by the Lower Columbia River Estuary Partnership (EP)
4) Bathymetry data to be collected by David Evans for the EP (due Nov. 2009)
5) Known remaining bathymetry gaps
6) The Ordinary High Water (OHW) Mark (by river mile) and the Columbia River Datum (CRD)

PNNL would provide TIN and raster files suitable for hydrological modeling to the Portland District (with 'circles' around areas of expected data from David Evans), and any additional gaps between the OHW and CRD would be identified by adding a water surface. On-the-ground or CHARTS surveys would need to be done in 2009 to fill in any substantial gaps. The 10-cm rule would be used to define "wetted area" to bring the biological component into the modeling. HEC-EFM may or may not be used.

Products Related to Salmon Habitat Restoration:

- Tables of wetted surface area, by flow scenario, for the eight hydrogeomorphic reaches.

- Maps and GIS data showing wetted area in eight hydrogeomorphic reaches for each flow scenario.
- Documentation of the calculation methods and results in the Cumulative Effects project year 2010 annual report.

Limitations and Other Options: It is recognized that an unsteady two-dimensional model would more accurately estimate the water surface elevations due to the complexity introduced by tidal effects. However, such a model would most likely be more expensive to develop depending on the computational resources available (data inputs would be similar). The trade-off is that using HEC-RAS for the purpose of salmon habitat modeling will require that downstream boundary conditions for specific tides be used and thus require a larger number of model runs.

Pilot-scale modeling to assess the suitability of the method for estuary-wide wetted area modeling could be conducted on a) the lower Grays River, where LiDAR has already been post-processed and an RMA-2 model is fully operational and could be utilized to verify the HEC-RAS outputs, or b) the lower 40 miles of the CRE, where the Corps has bathymetry data for the main stem and possibly the floodplain areas.

References:

CHARTS. http://shoals.sam.usace.army.mil/

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