

ECOSYSTEM FUNCTIONS STUDIES

The Comprehensive Study developed the Ecosystem Functions Model (EFM) to predict differences between without-project and with-project conditions in river reaches that would be affected by modifications to the flood management system. The functional relationships identified in the EFM are highly dependent on hydrologic and hydraulic characteristics of the river channel and floodplain. Using input variables such as stream flow, land use, soil type, vegetation, and topography, the EFM provides an indication of how potential floodway modifications could preserve, reduce, or enhance biological response. The EFM is described in detail in *Appendix G – Ecosystem Functions Model*.

Technical Approach

Unlike other models developed for the Comprehensive Study, the EFM is not a single computer program. Rather, the evaluation of ecosystem functions requires five major steps, shown **Figure 17**. Computer code has been developed to help automate portions of the EFM, but evaluation and interpretation are an important part of the EFM.

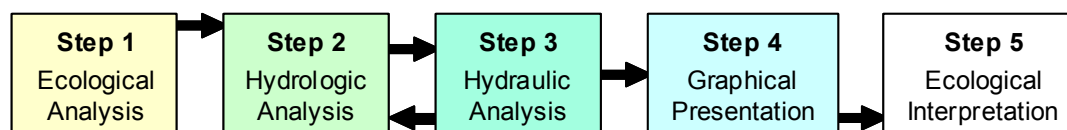


FIGURE 17 – ECOSYSTEM FUNCTION MODEL PROCESS

Step 1 - Ecological Analysis

The ecological analysis step identifies functional relationships between river hydrologic and hydraulic conditions and the riverine ecosystem/geomorphic system. These relationships reflect the different stream flow duration, flow frequency, and stage recession rate requirements of different types of habitats. The ecological analysis addresses two major elements: the aquatic ecosystem and the terrestrial ecosystem.

Aquatic ecosystem – The aquatic ecosystem consists of in-channel habitats, seasonally inundated floodplain, and flood bypass habitats. Relationships focus on factors that affect all the life stages of salmonids and Sacramento splittail, which are used as representatives of the entire aquatic community. The in-channel element includes relationships that reflect the dependence of suitable substrate, instream cover, and bank vegetation on changes in flow and morphologic parameters. The floodplain element incorporates conditions for suitable overbank flows to benefit floodplain spawning, rearing, and avoidance of stranding, and predicts spatial changes in the extent of suitable floodplain habitat.

Terrestrial ecosystem - The terrestrial ecosystem consists of existing riparian and wetland zones, rates of ecosystem change in these communities, and wildlife habitat values of these dynamic systems. Predicted changes in potential riparian/wetland zones would be inferred spatially by overlying suitability maps reflecting particular attributes, as identified in several relationships. Other relationships specify how several ecosystem processes would be temporally affected (such as fluctuations in the rates of change).

The ecological analysis has identified fifteen biological relationships to date, but others may be developed and added to the EFM in the future. Twelve of these relationships require a hydrologic analysis to provide stream discharges for subsequent hydraulic modeling, as described below in Step 2.

Step 2 - Hydrologic Analysis

A statistical analysis translates the ecosystem relationships developed in Step 1 into hydrologic discharges (stream flows) for specified durations, flow frequencies, and stage recession rates. The statistical analysis uses historical, existing, and/or with-project conditions (resulting from modification of reservoir operations, changes to levees, addition of transitory storage, or other proposed elements). The statistical analysis is conducted in a spreadsheet environment. The ecosystem requirements and statistical analysis are then coded into a computer software package for use in Step 3.

Step 3 - Hydraulic Analysis

Step 3 simulates the hydraulic response of the river system to the discharges (stream flows) estimated in the previous steps. Discharges developed in Step 2 are input to a HEC-RAS hydraulic model to obtain simulated stages and flood inundation areas. HEC-RAS is a river-system modeling package that is capable of simulating steady or unsteady flow in a network of open channels. HEC-GeoRAS, a geographic information system interface module developed for use with HEC-RAS, is used to create existing and/or with-project georeferenced river cross-sections of the study reaches for the HEC-RAS model, and export simulation results into a GIS environment for presentation and evaluation.

Step 4 - Graphical Presentation

A GIS tool (such as ArcView) is used to display the hydrologic and hydraulic simulation results together with other available geographic information, such as vegetative cover, soil types, land use, historic and existing topography, and ground water elevations. A sample is shown in **Figure 18**, which displays water depth in a study reach. The graphical presentation helps ecologists evaluate how proposed flood management and ecosystem restoration measures will impact existing terrestrial and aquatic habitat.

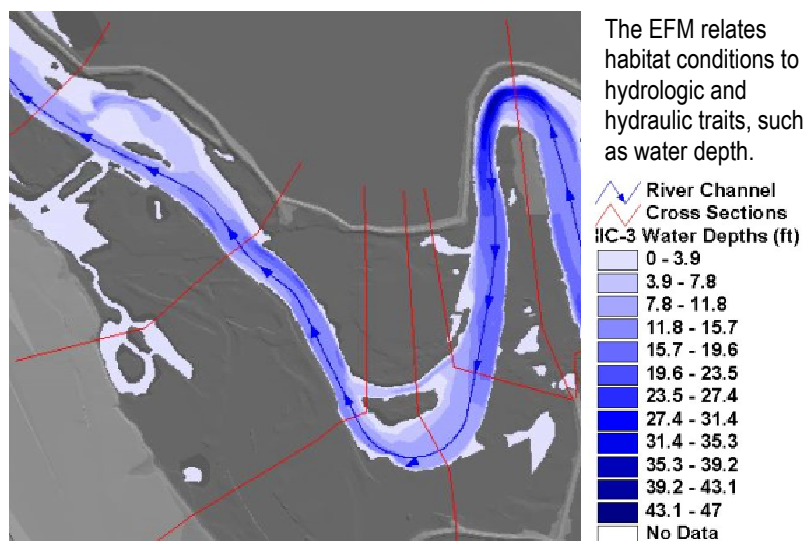


FIGURE 18 – GRAPHICAL PRESENTATION OF EFM RESULTS

Step 5 - Ecological Interpretation

The final step in the ecosystem function evaluation involves interpretation of the modeling results and various ecological and landform features by ecologists. Comments, conclusions, or recommendations are then made on the proposed flood management and/or ecosystem restoration measures.

EFM Pilot Studies

Two pilot studies have been completed using the EFM, one on the San Joaquin River near Vernalis and the other on the Sacramento River near Princeton. The Vernalis reach was selected because 1) there is no significant backwater effect in the reach; 2) the reach has a relatively wide floodplain confined by a levee on one side and a natural terrace and levee on the other side, making it easier to differentiate inundation areas for different flows; and 3) a nearby USGS gage provided a daily flow record of sufficient length for a statistical analysis. The Princeton site was selected because 1) there is no significant backwater effect in the reach; 2) the left bank levee constricts the river near the town of Princeton, offering a logical location to straighten the levee; 3) a nearby USGS gage provided a daily flow record of sufficient length for a statistical analysis.

Preliminary Results

Vernalis - A statistical analysis of the model algorithms and hydraulic data for the 1997 flood season was completed. Mapping of analysis results indicated that there were several locations in the pilot reach that should support riparian vegetation. These model outputs were field-verified for accuracy during a visit to the pilot reach. The areas projected to have riparian vegetation by the EFM did in fact have willow and cottonwood seedlings of the appropriate age class to have sprouted following the 1997 flood season.

Princeton – Mapped results indicate that a portion of the 480-acre floodplain reconnected to the river by a hypothetical levee realignment would be flooded about every 2 years. The realignment reduced the flow constriction such that water surface elevations in the reach were decreased by about 2.5 inches for an event with a 10% chance of occurrence in any year. A large portion of the new floodplain area would be suitable for floodplain fish-rearing habitat. The EFM suggests that the spatial extent of riparian vegetation will not increase as a result of the levee realignment because plant establishment flows remain in-channel and would not inundate the reconnected floodplain.

The two pilot studies demonstrate how the EFM can be used during planning and feasibility studies to indicate biological response to proposed changes to the flood management system and envision potential ecological improvements. As with other Comprehensive Study tools, the EFM is expected to evolve and develop additional capabilities as it is used in future studies.