CHAPTER C.14
MODEL EVALUATIONS BASED ON SIMULATIONS OF A VIRTUAL BASIN

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14.1 Introduction

The modules that were developed under the LCA were evaluated to assess uncertainty. There is conceptual uncertainty associated with the model structure and the assumptions on how driving forces influence the output parameters, and uncertainty in model response as a result of uncertainties in model input, which is described below as parameter uncertainty. The previous chapter discussed these uncertainties in the context of scientific rigor, providing an evaluation of the strengths and weaknesses of each of the models. However, to evaluate whether the models produced logical results, a virtual estuarine basin was developed and simulations of varying parameter values were used to test system behavior. Time has not allowed a full assessment of uncertainty, model sensitivity, verification, and empirical comparisons. These activities are on-going and will be continued during the refinement stage of the LCA modeling effort. The initial effort that has been conducted provides assurance that the models have been used consistently in the assessment of alternatives.

14.2 Sensitivity Analysis

In order to appraise model performance, sensitivity analysis is commonly employed to help verify that models will behave as intended under incremental change in the input variables (Waide and Webster 1976; Overton 1977; Schroeder and Haire 1993). To verify the logic of the habitat productivity and habitat use modules, a hypothetical dataset was developed and a sensitivity analysis was conducted. The major inputs to these models (i.e., salinity, inundation and wetland area) were incrementally varied one variable at a time to quantify the influence of each on model indices.

Salinity levels used in the hypothetical data set were: 0.0, 2.5, 5.0, 7.5, 10.0, 12.5, 15.0, 17.5, 20.0, 22.5, and 25.0 ppt. Inundation levels used were: 0, 25, 50, 75, and 100 percent of time flooded. Wetland area levels used were 0, 25, 50, 75, and 100 percent of a 1 km^2 cell. Habitat type followed salinity as follows: 0 ppt = fresh attached marsh, 2.5-5.0 ppt = intermediate marsh, 7.5-15.0 ppt = brackish marsh, and 17.5 ppt and greater = saline marsh.

Consistent with the conceptual model and consistent with the model output, brackish marsh is most productive of the attached habitat types with respect to emergent marsh productivity (Figure C.14-1) The productivity index does not reach 1, because the maximum productivity would be achieved in a fresh floating marsh, a habitat type that was not included in

this exercise. Productivity is highest at 50 percent flooding for all marsh types, which is consistent with the model assumptions. The higher sensitivity of brackish marsh to excessive flooding at 75 percent and 100 percent flooding is also captured by the model, as is the decrease in productivity with increasing salinity within a certain habitat type.

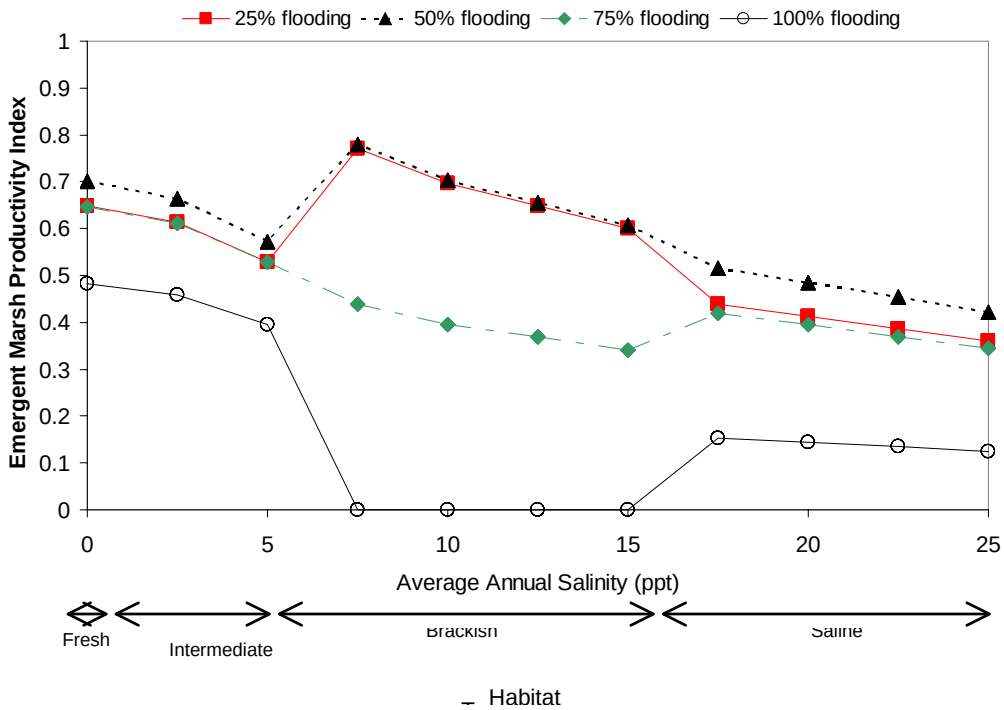

Figure C.14-1 Sensitivity of the Emergent Marsh Productivity Index to Salinity

Presented here are the results from the habitat use sensitivity analysis as the average HSI for species grouped by the part of the estuary most used (see E.3): lower salinity areas (otter, mink, alligators, dabbling ducks, and largemouth bass), moderate salinity areas (white shrimp, croaker, menhaden, and muskrat) and higher salinity areas (oyster, spotted seatrout, and brown shrimp). These results (Figure C.14-2) illustrate how producing a brackish marsh is optimal for moderate salinity species and sub-optimal for low and high salinity species. The results also show that the low salinity species are more sensitive to the percentage of the cell that is wetland. However, this is more likely a result from the choice of wetland area levels in this analysis. Most fish and shellfish species have optimum suitability indices for 20 to 80 percent wetland area, while wildlife suitability indices have a narrower range. Since four of the five low salinity species are wildlife species, it follows that the low salinity species show a higher sensitivity to wetland area.

Sensitivity analyses of the land change module and the water quality module are yet to be completed.

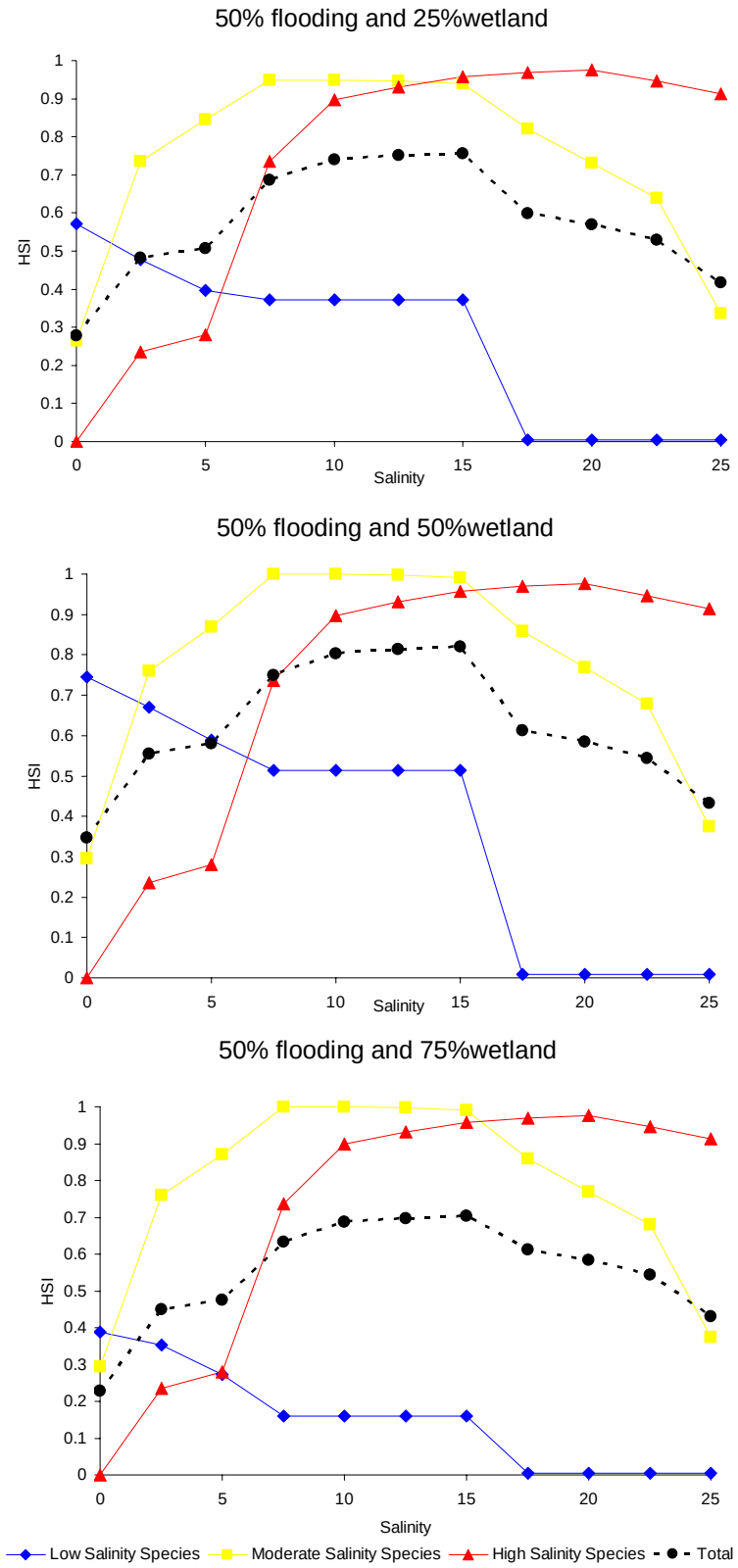

Figure C.14-2 Sensitivity of Habitat use Model to Salinity and Wetland Area Criteria

14.3 Verification

The models were repeatedly checked by the developers to insure that the mathematical relationships represented by the model were correct and properly translated into SAS code. Outputs from all of the models were also checked by the module teams and reviewed by an outside interagency group.

To address whether the models produced logical results, output from all of the different alternatives that utilized riverine freshwater inputs (subprovinces 1-3) were assembled. Each of the alternatives has a different total discharge ranging from 0 to nearly 300,000 cfs, and when ranked from lowest to highest, allows an evaluation of different indices relative to discharge (Figure C.14-3). Sediment load and discharge are directly proportional (Figure C.14-9) and deviations from this relationship are due to sediment enrichment associated with some of the alternatives. The relationship between sediment load and discharge is different in subprovince 3, because the Atchafalaya River (which consists of flows from the Mississippi and Red rivers) has slightly lower sediment loads than the Mississippi River. The high discharge scenarios in subprovince three combine Atchafalaya flows with Mississippi River diversions.

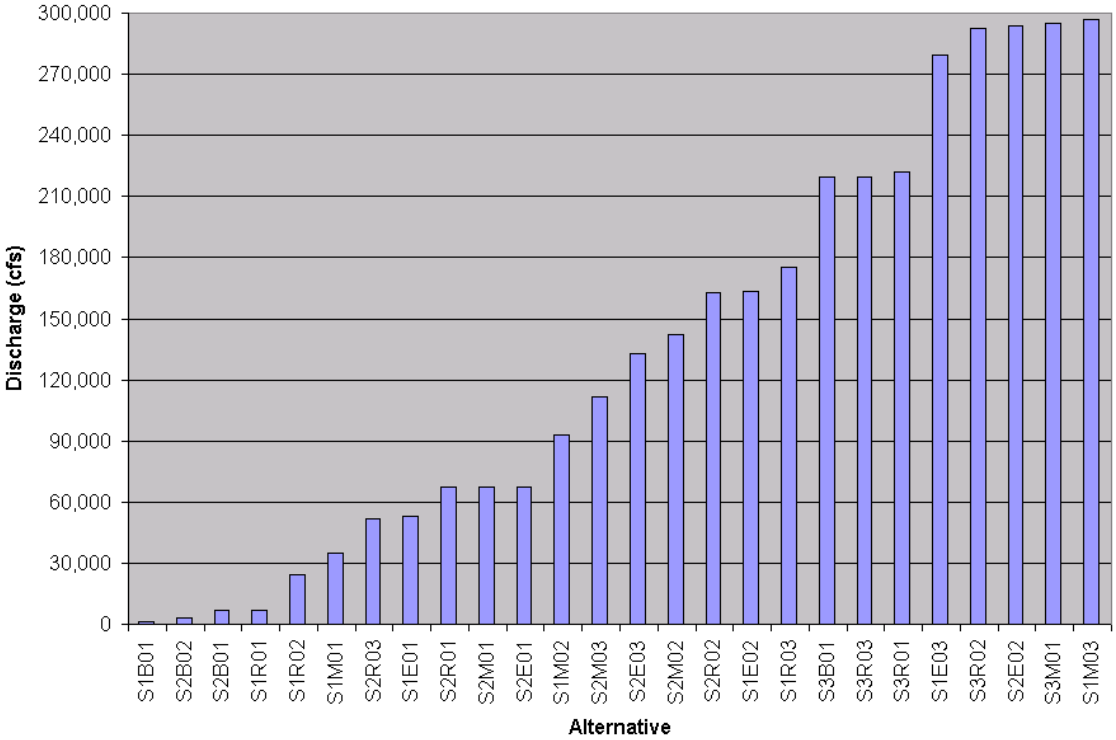

Figure C.14-3 LCA Alternatives from Subprovince's 1-3 Ranked by Total Discharge

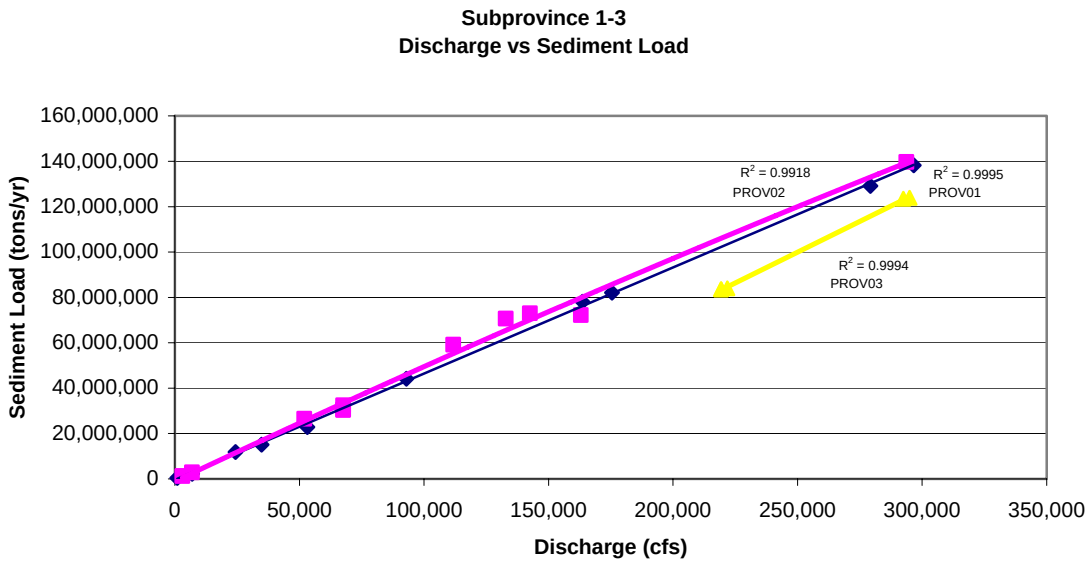

Figure C.14-4 Correlation Between Discharge and Sediment Load in Three Subprovinces

As sediment load increases with increased discharge, the total wetland area in each subprovince increases (Figure C.14-5). At low discharge rates, nourishment has a relatively high impact relative to direct land building. This explains the relatively rapid increase in wetland area at low discharge and the leveling out as nourishment becomes a small contribution relative to direct land building. The large increase in land area in subprovince 3 at approximately 220,000 cfs reflects the effect of distributing the same amount of discharge over a larger area and nourishing rapidly deteriorating marshes. The larger general increase in land area between 220,000 cfs and 300,000 cfs in sub province 3 is an artifact of fitting a logarithmic curve, the linear increase in land area with increased discharge has a similar slope. Deviations from the general trend in subprovince 1 and 2 are a result of the location and number of diversions, as well as land changes due to marsh creation.

Vegetative production for each subprovince shows a similar pattern to wetland area change (Figure C.14-6). This was expected since vegetative production is calculated as a function of wetland area and is reflected in the linear relationship between the vegetation productivity index and total land area (Figure C.14-7). Figure C.14-7 also shows that the same amount of area in prov 2 provides higher productivity. This represents the effect of salinity. Salinity is lower on average in subprovince 2, while the other subprovinces represent a wider array of habitat types.

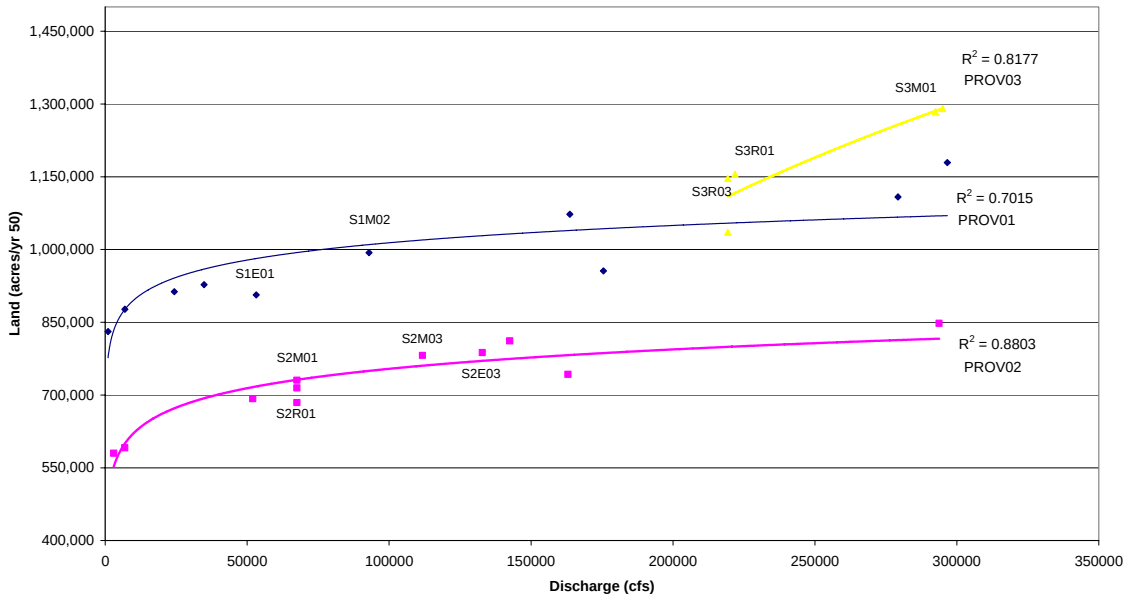

Figure C.14-5 LCA Alternatives from Subprovince's 1-3 Represented by Discharge and Land Acreage in Year 50

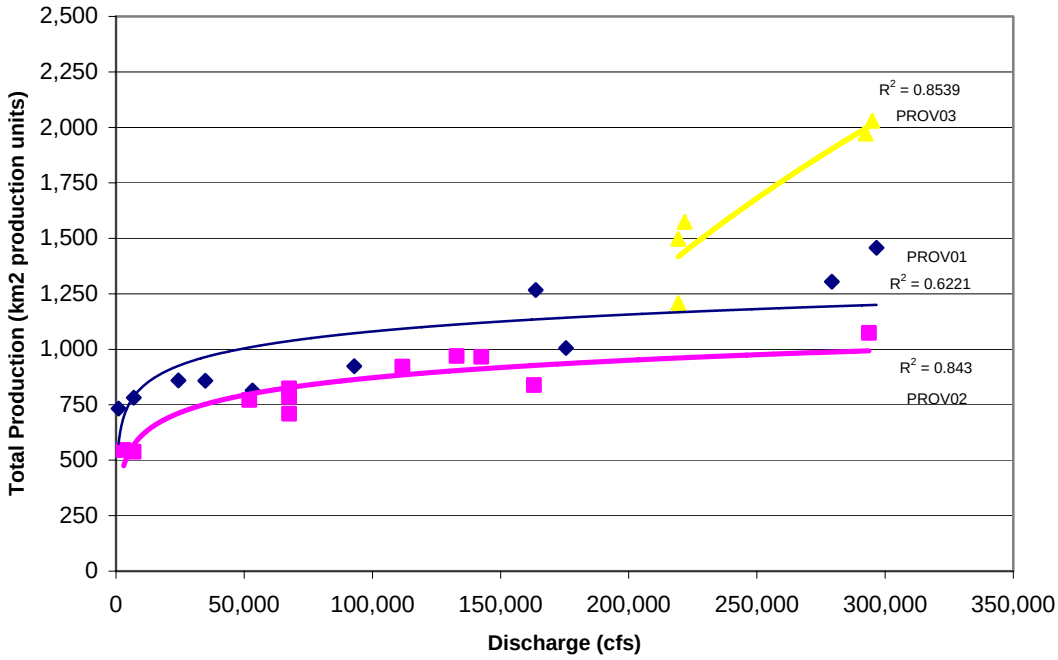

Figure C.14-6 Discharge Effect on Total Vegetative Production

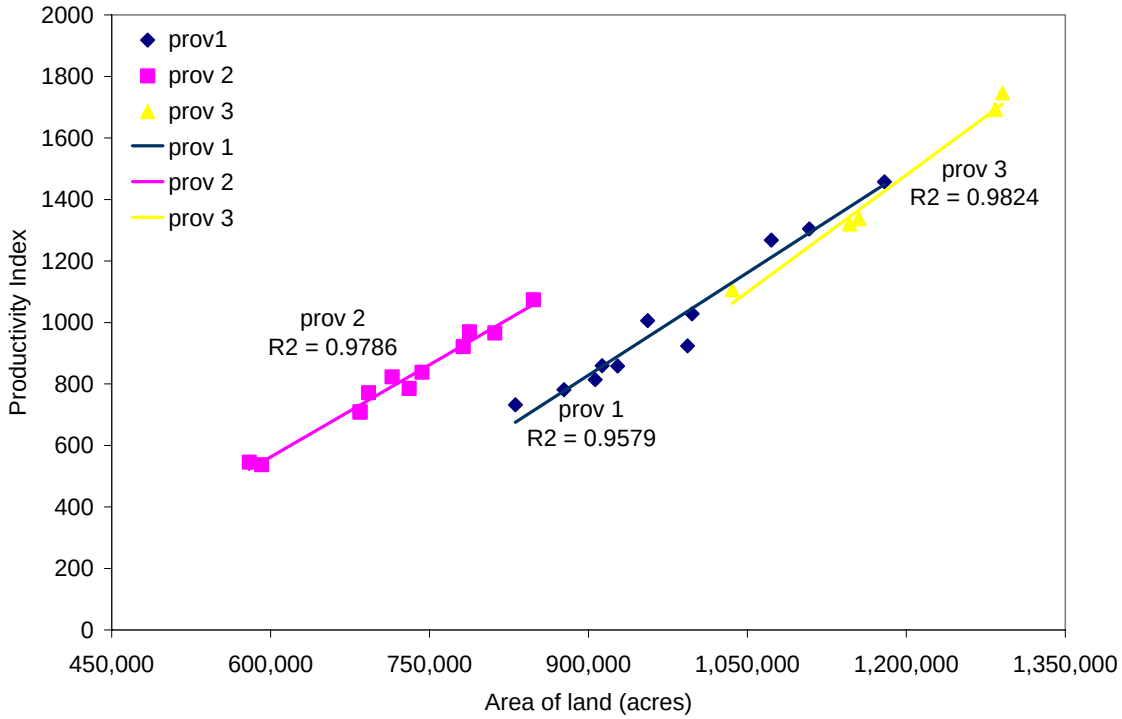

Figure C.14-7 Relationship between land acreage and total productivity index for Year 50

As expected, the HSI for high salinity species decreases with increased discharge and the associated decrease in salinity in each subprovince. Of the three high salinity species brown shrimp and spotted seatrout have a generally positive relationship with wetland area, while oyster has a negative relationship with wetland area. Therefore, the negative impact of decreased salinity to brown shrimp and spotted seatrout outweighs any positive impact from creating and restoring more wetland area.

14.4 Virtual Basin

Once an indication of the scale of inputs needed to optimize gains was identified, an assessment of the size and locations of diversion measures was needed. This was done by evaluating the land change module at 3 levels of freshwater diversion (1,000 cfs, 10,000 cfs and 100,000 cfs) and at 2 locations representing the upper basin and the lower basin, using the land-water configuration from subprovince 2. This analysis provided an assessment of how the number and location of diversion points influence total wetland area and change at year 50. Monthly hydrographs representing the low, medium, and high discharge in the upper and lower basin were used based on river levels available at those points (Figure C.14-9). Distributing the sediment load over three diversion locations instead of one location increases the wetland area remaining after 50 years (Figure C.14-10).

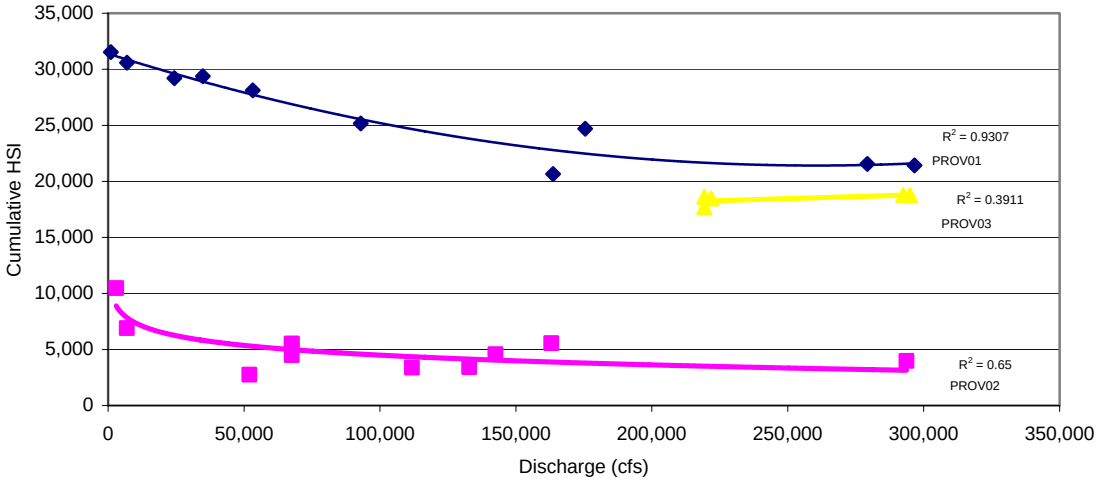

Figure C.14-8 Discharge Effects on Cumulative HSIs for High Salinity Species (Oyster, Brown Shrimp, Spotted Seatrout)

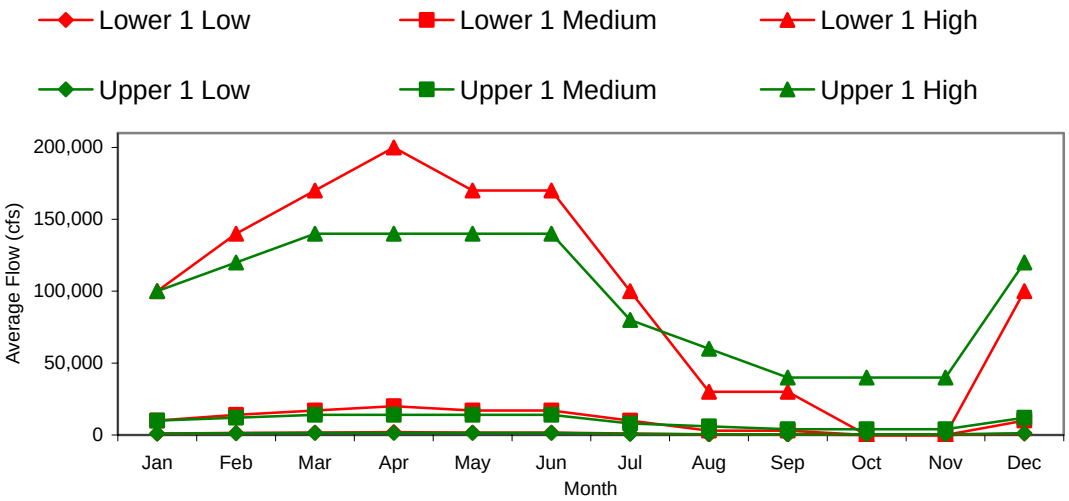

Figure C.14-9 Hydrographs of the Virtual Basin Representing 1,000 cfs, 10,000 cfs and 100,000 cfs Average Annual Discharge into the Upper and Lower Basin

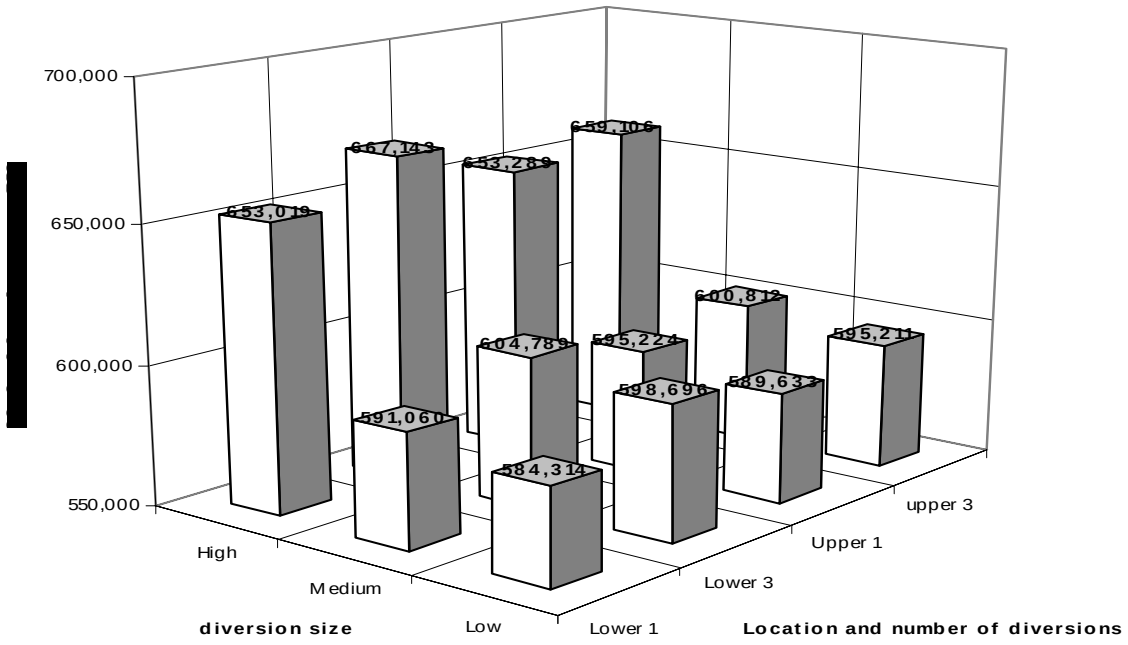

Figure C.14-10 Total Wetland Area at Year 50 in the Virtual Basin

This result is a direct effect of the nourishment component of the land change module and shows the importance of spreading fresh water and nutrients over a larger area to optimize land gains. The effect of spreading the diversion waters over more locations in the lower basin has a greater effect than spreading the diversions in the upper basin. This reflects the assumption that the freshening nourishment effect is absent in the upper basin that is already fresh. The slightly lower land area in 1 location in the upper basin versus 1 location in the lower basin reflect the slightly lower sediment load resulting from the difference in hydrograph between the upper and lower basin (Figure C.14-11).

14.5 Refinements

The initial assessment of uncertainty and sensitivity provided insight into each module's capabilities and limitations. It is understood that significant effort will be needed to improve risk assessment of restoration alternatives during the LCA implementation. To address uncertainty associated with the complex ecological processes operating at multiple spatial and temporal scales, both single and multi-criteria assessments will need to be conducted. Prior to conducting these assessments, improvements must be made in addressing parameter uncertainty. The quality of the available data used in assessing environmental drivers in section E.4.1 was low to moderate. Although a substantial amount of data on the dominant environmental drivers exists for coastal Louisiana, limited spatial extent, disparate collection methodologies, and limited collection time-periods minimize its usage in model development.

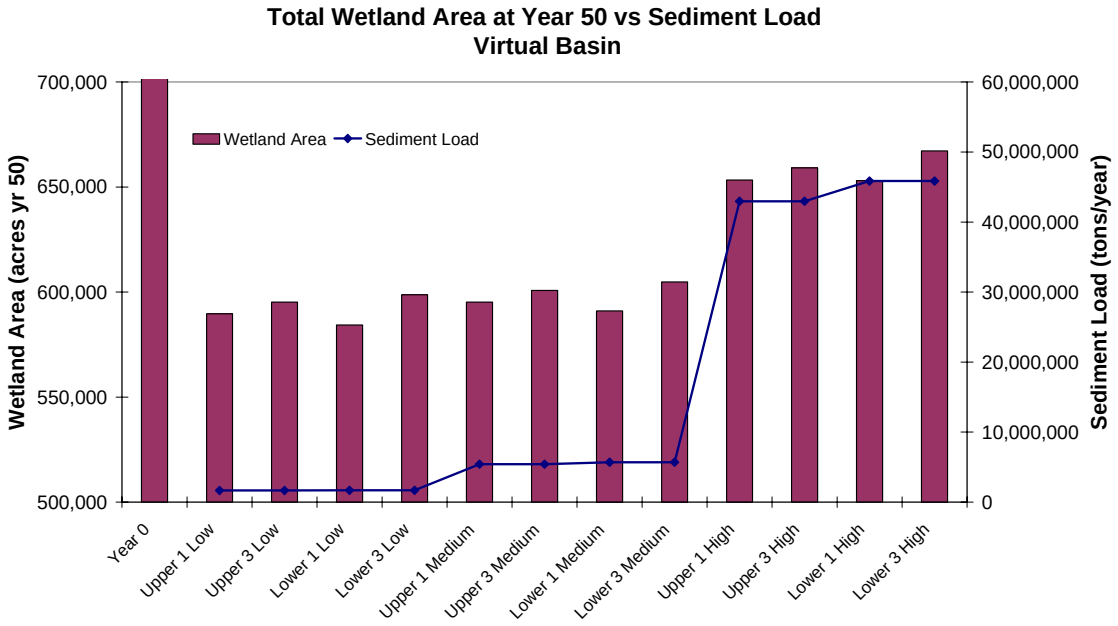

Figure C.14-11 Total Wetland Area at Year 50 and Annual Sediment Load in the Virtual Basin