**39-Compartment Model Analysis of Refuge TP response to Reduction in Inflow Concentration: Preliminary Analysis**

Mike Waldon, January 2012

The response of Refuge surface water TP concentration to reduction in inflow concentrations is simulated here using the 39-Compartment Refuge model (Bazgirkhoob 2011). This model aggregates the Refuge into 11 canal compartments (or cells) and 28 marsh compartments in a link-node representation (Figures 1 and 2). The version of the model used here has some known discrepancies in topography of a few cells. However, I do not believe that correction of these compartment properties would change the overall conclusions presented here. It is anticipated that a completed stable version of the 39-compartment model used for calibration and validation will be available in the spring 2012.

The 3 model runs used here represent the results of scaling all historic Refuge inflows by a factor (0.5, 0.2646, and 0.14) over calendar years 2004-2010 which was the current 39-compartment model simulation period for historical flows and concentrations at the time this model analysis was initiated. The simulation uses the LRI calibration set (k1= 0.192874, k2= 0.00860201, and k3= 0.294011) for TP which gives improved calibration performance at the low concentrations observed in the Refuge interior. The 39-compartment model (filename Lox\_39box\_2004\_2010-TPScale.mmd) returned concentrations values only when depths were above 10 cm. Below simulated depths of 10 cm, the concentration values returned are negative and are ignored in the calculation of mean, median, and geometric mean. Array formulas, a.k.a. CSE formulas, are used in the spreadsheet to calculate statistics. Statistics are calculated using the final 5-years of simulation, 2006-2010. This allows the model to “spin up” for 2 years. Initial storage is calculated as the steady-state value for 10 ppb TP surface water concentration.

**Results and Discussion:**

The 3 scaled inflow concentrations at cell C3 (STA-1W) were 21.90, 11.59, and 6.13 ppb. With an inflow TP geometric mean concentration (GM) into canal cell C3 (STA-1W) of 10 ppb, the canal GM TP in C3 is predicted to be 12.3 ppb.

Phosphorus enters the Refuge through inflow and both wet and dry aerial deposition. At very high TP inflow concentration the aerial loading is inconsequential, but at extremely low inflow concentration aerial loading is important. The model predicts that the ratio of GM canal TP to inflow GM in cell C3decreases as inflow concentration increases asymptotically approaching over 71% at high concentration. This is reasonable because with higher inflow concentrations the marsh runoff and mixing dilute canal water, while at lower inflow concentrations that are near the marsh concentration, mixing with marsh water has little effect on canal concentration. Further, in the extreme case of zero TP inflow concentration, the canal would still have measurable TP as marsh water loaded by aerial deposition mixes into the canal resulting in a predicted canal TP GM around 5 ppb.

Sensitivity of cells to changing inflow concentration is measured here by the change in cell GM divided by the change in C3 inflow GM expressed as a percentage (Table 1). Canal cell C3 is most sensitive to inflow TP concentration change, 71.6%. This predicts that a 1 ppb reduction in inflow GM into C3 will result in a 0.716 ppb reduction in the canal GM at this point. Marsh cell 16 (M16), the cell adjacent to canal cell C3 which receives STA-1W inflow, is the most sensitive marsh cell to inflow TP concentration change, 26.5%. The marsh cell least sensitive to inflow concentration is marsh cell M37 which has a sensitivity of 0.2%.

The model predicts that even under a very low inflow concentration scenario, much of the Refuge marsh will not achieve a long term GM of 10 ppb. The area predicted to have higher GM concentrations not meeting a 10 ppb criterion is in the northern and eastern marsh. The area achieving 10 ppb is restricted to the southern Refuge marsh corresponding to deeper water. In part, this prediction may be biased by constraining depth to a 10 cm cut off in statistical analysis. Field sampling is not allowed at clear water depth less than 10 cm, and this would correspond to deeper, but unpredicted, total water column depth. It is also important to remember that this analysis only uses 5 years of predictions, and these years are not representative of a longer time period.

The analysis presented here uses predicted surface water TP concentration. The marsh TP storage model variable may be a more meaningful ecological predictor of impact, and is more sensitive to changes in inflow TP load. However, because the TP criterion is based on surface water concentration, my analysis focused on this variable.

**Conclusions:**

This is a preliminary analysis. The purpose was to simply get a semi-quantitative estimate of expected response of the Refuge marsh and canal to proposed future inflow concentration reductions. A more complete analysis, if attempted, should run for more years simulating the planning period under current consideration, and using precipitation, ET, inflows and concentrations consistent with anticipated future operations used in current design modeling used in the SFWMM, RSM, or DMSTA models.

**Citation:**

Bazgirkhoob, H. (2011). "A.R.M. Loxahatchee National Wildlife Refuge Refuge 39-Box Model User’s Manual." Prepared for the U.S. Fish and Wildlife Service under a cooperative-agreement with the University of Louisiana-Lafayette.

**Table 1.** Predicted 5-year GM under the 3 scenarios of inflow concentration scaling.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **C3in GM** | | |  |  |
| **Compartment** | **21.90** | **11.59** | **6.13** | **Sensitivity** | **GMin=10** |
| 1 | 18.90 | 12.80 | 9.39 | 60.3% | 11.81 |
| 2 | 19.54 | 13.23 | 9.72 | 62.3% | 12.21 |
| 3 | 20.79 | 13.55 | 9.49 | 71.6% | 12.37 |
| 4 | 19.60 | 13.13 | 9.48 | 64.2% | 12.07 |
| 5 | 18.46 | 12.84 | 9.64 | 55.9% | 11.91 |
| 6 | 15.34 | 11.80 | 9.68 | 35.9% | 11.18 |
| 7 | 14.47 | 11.39 | 9.56 | 31.1% | 10.86 |
| 8 | 14.56 | 11.38 | 9.50 | 32.1% | 10.84 |
| 9 | 16.21 | 11.58 | 8.87 | 46.6% | 10.79 |
| 10 | 17.65 | 11.67 | 8.30 | 59.3% | 10.69 |
| 11 | 18.68 | 12.83 | 9.54 | 57.9% | 11.87 |
| 12 | 14.10 | 12.27 | 11.30 | 17.8% | 11.99 |
| 13 | 14.44 | 12.72 | 11.83 | 16.5% | 12.46 |
| 14 | 14.09 | 11.99 | 10.89 | 20.3% | 11.67 |
| 15 | 14.46 | 12.55 | 11.55 | 18.4% | 12.26 |
| 16 | 15.76 | 13.01 | 11.58 | 26.5% | 12.59 |
| 17 | 15.65 | 13.34 | 12.15 | 22.3% | 12.99 |
| 18 | 14.24 | 11.64 | 10.28 | 25.1% | 11.24 |
| 19 | 13.32 | 11.48 | 10.53 | 17.7% | 11.20 |
| 20 | 13.98 | 11.38 | 10.01 | 25.2% | 10.98 |
| 21 | 12.71 | 11.02 | 10.12 | 16.4% | 10.76 |
| 22 | 11.50 | 10.43 | 9.84 | 10.5% | 10.26 |
| 23 | 11.02 | 10.27 | 9.86 | 7.4% | 10.15 |
| 24 | 10.77 | 10.11 | 9.75 | 6.5% | 10.00 |
| 25 | 10.58 | 10.04 | 9.75 | 5.3% | 9.96 |
| 26 | 11.18 | 10.37 | 9.92 | 8.0% | 10.24 |
| 27 | 10.81 | 10.25 | 9.96 | 5.4% | 10.17 |
| 28 | 12.04 | 11.28 | 10.86 | 7.5% | 11.16 |
| 29 | 11.88 | 11.48 | 11.26 | 3.9% | 11.42 |
| 30 | 14.55 | 12.37 | 11.23 | 21.0% | 12.04 |
| 31 | 14.22 | 12.88 | 12.18 | 12.9% | 12.68 |
| 32 | 15.79 | 13.90 | 12.91 | 18.3% | 13.61 |
| 33 | 16.23 | 14.74 | 13.97 | 14.3% | 14.52 |
| 34 | 14.58 | 14.19 | 13.98 | 3.8% | 14.13 |
| 35 | 15.34 | 15.19 | 15.10 | 1.5% | 15.16 |
| 36 | 11.44 | 11.30 | 11.22 | 1.4% | 11.27 |
| 37 | 11.24 | 11.22 | 11.20 | 0.2% | 11.21 |
| 38 | 10.73 | 10.48 | 10.34 | 2.5% | 10.44 |
| 39 | 10.49 | 10.42 | 10.38 | 0.6% | 10.41 |



**Figure 1.** Compartmental structure of marsh compartments are shown here. Stage and inflow sites are also mapped (Bazgirkhoob 2011).



**Figure 2.** Link-Node model structure (Bazgirkhoob 2011).



**Figure 3.** Compartment C3 predicted GM plotted against GM of inflow to C3.



**Figure 4.** Compartment M16 predicted GM plotted against GM of inflow to C3.



**Figure 5.** Marsh minimum and maximum GM plotted against GM of inflow to C3.