APPENDIX 7D. WETLAND CONSTITUENT REDUCTION MODEL

INTRODUCTION

The Biogeochemistry Work Group also developed the Wetland Constituent Reduction Model, a Excel® spreadsheet-based model that calculates the fraction of constituent releases from the wetlands that do not reach the river due to uptake within the wetland. Reduction pathways include settling, sorption, chemical breakdown, biological uptake, and volatilization. Often multiple processes are occurring simultaneously. This reduction is represented by a removal coefficient that lumps all of the potential reduction pathways into a single variable. Our model used a first-order decay function with the background constituent concentration as the asymptote (Kadlec and Wallace 2008). Kadlec and Wallace (2008) favor a formulation that computes the result as if the water was passing through a series of continuously stirred tank reactors or a tanks-in-series model. The model is:

$$\frac{C_o - C^*}{C_i - C^*} = \frac{1}{\left(1 + (K/P \times q)\right)^P} \quad \textbf{[Eq. 7D–1]}$$

where C_o = Outflow concentration (g m^{-3})
C_i = Inflow concentration (g m^{-3})
K = Removal coefficient (m d^{-1})
P = Number of tanks in series; corrects for differential length flow path lengths and eddy diffusivity
q = Hydraulic loading (m d^{-1})

The removal coefficient is usually empirically derived. The hydraulic loading, q, is the volumetric water load divided by the area.

With the simplifying assumption of a background concentration of zero and some algebraic manipulations, an equation for calculating the load (i.e. the mass that remains after uptake) can be developed. Assuming a background concentration of zero is somewhat problematic, however, it does prevent predictions of extraction from the soils to bring lower concentrations up to the background, which could obscure differences between scenarios. It also reduces several sources of error, not the least of which is to define water depths over a range of elevations and across the season in order to convert mass into concentration. Whether the assumption increases or reduces error in the prediction is not known and there is insufficient data on this system to determine this. It may reduce overall error in the model predictions by reducing the number of estimated variables but, again, this cannot be determined.

Next, Inflow Concentration, C_i, times hydraulic loading, q, is equal to the input mass which in this case is equal to the mass released and is already calculated, M_i. The hydraulic load is defined as the rainfall during the rising limb period of the hydrograph: undoubtedly an underestimate because it doesn't account for flooding and drainage from the river or river flow through the wetland. However, it also assumes that the wetland evapotranspiration is supplied by the river, an assumption that reduces the tendency towards underestimation. Still, considering that rainfall and flooding releases to the river occur as short term events associated with storms, while ET is more or less continuous, we feel it is our best estimator of net effective hydraulic loading to the river in the absence of a 2-dimensional wetland model that could track water flows. This reduces the equation to:

$$L_r = M_i\left(\left(1 + \left(\frac{K}{P \times q}\right)\right)^{-p}\right) \quad \textbf{[Eq. 7D–2]}$$

where M_i = Mass released from wetland (g)
L_r = Load reaching river (g)

Because DOC removal coefficients are seldom calculated, we used the K for Biochemical Oxygen Demand (BOD) as a surrogate for DOC. This assumes most of the DOC released is reasonably labile, within five days, although DOC can have a larger range of values. Having the indication from an ongoing DOC inhibition study that the initial DOC flush is largely labile (Andrew Ogram, personal communication), our use of BOD as a surrogate seemed reasonable. We chose to use the BOD median value in our modeling.

Release values used are shown in Table E1. As recommended in Kadlec and Wallace (2008), the value for the number of tanks in series was set at one for BOD and three for all others constituents lacking any other information.

Table D1. Removal coefficients used for different constituents. Values are quartiles Form the Orlando Easterly Wetlands treatment wetland, previously known as Ironbridge. Detail of how we chose this site are in the main body of the chapter. Values for the 1st and 3rd quartiles were provided to give the reader a indication of the magnitude of the range of values encountered by the different constituents. TN median used BCMCA example described in Discussion and Appendix 7E

Constituent	20th	Median	80th
DOC/BOD[1]	0.03	2.72	6.79
TN		4.25	
TKN	1.21	3.69/	7.08
TP	-0.33	5.80	11.89

[1] The removal coefficient is actually for BOD because DOC is seldom regulated or reported in treatment wetlands. No values for SRP were provided by Ironbridge so dissolved TP values were used instead in modeling.

The load was apportioned over the five-month period that typically comprises the rising limb of the hydrograph as a flow-weighted average. This allowed the five month flow to be used to calculate potential increases in concentration.