

# *A Practical Tool For Modeling Wetland Nutrient Cycling*

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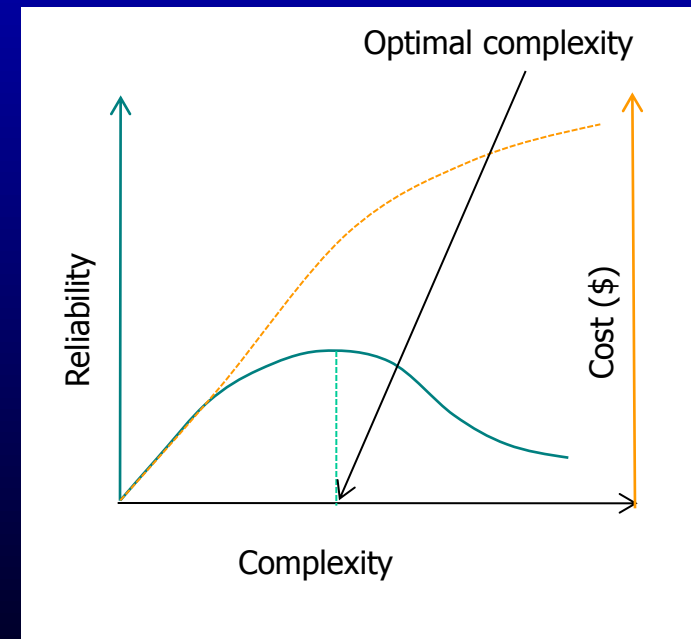
# *Wetlands*

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- Provide effective, free treatment for many types of water pollution (filtration, sedimentation, other assimilation processes)
- Natural flood control (store and slow the flow of floodwater)
- Provide habitats for biota and wildlife and maintain biodiversity
- Contribute to stabilizing shorelines and protecting them from wave-induced erosion
- Contribute recharge to ground water and sustain base flow in streams during dry periods

# Wetland Models

- Wetlands are valuable ecosystems and act as hydrologic and pollutants buffer between uplands and downstream water bodies
- Wetland models offer a tool to understand, quantify, and predict the behavior of these ecosystems (proper management tool)
- Relatively simple, reliable model
  - ◆ Relate nitrification, denitrification, and phosphorus precipitation and release to oxygen dynamics
  - ◆ Describe wetland free-water and soil processes in some details
- Integrate the module to a watershed model



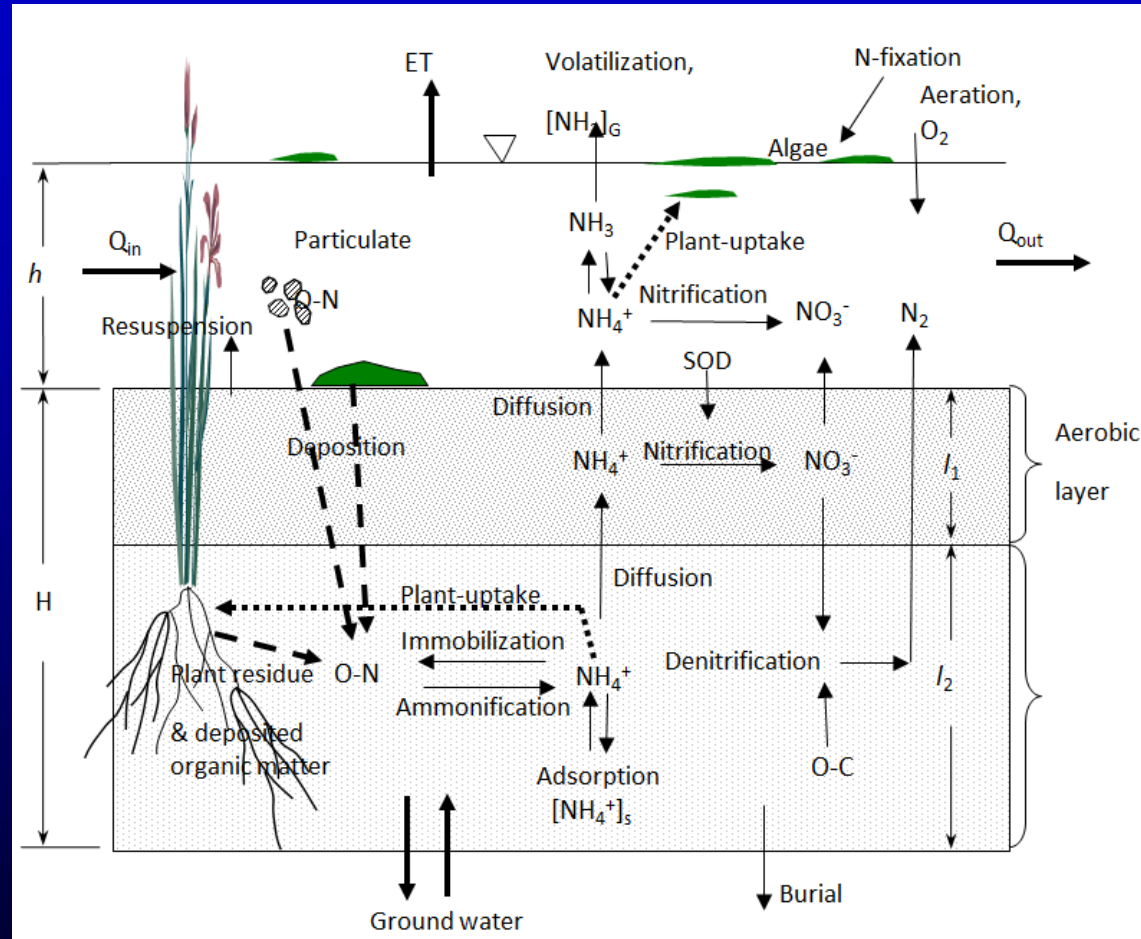
# *WetQual*

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- Lumped model
- Coding: Fortran
- Soil is partitioned into aerobic and anaerobic layers
- N, P, TSS and C cycle
- Plant Growth: Separated into rooted and floating plant
- Hydrology: Poned and dynamic version (wetting/drying cycles)
- Compartmental version

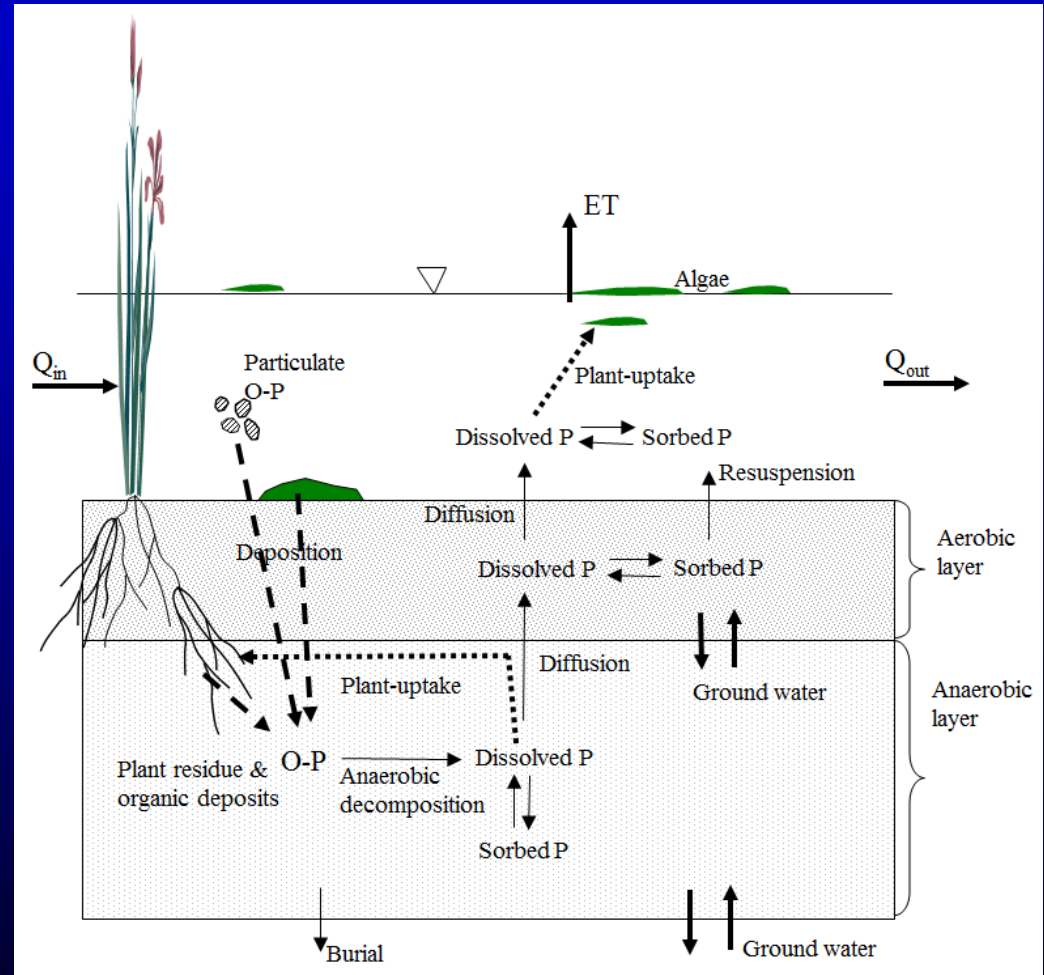
# WetQual: Nitrogen Cycle

- Aerobic and anaerobic layers
- Sedimentation, burial
- Mineralization
- Nitrification,
- Denitrification
- $\text{NH}_4^+$  adsorption
- $\text{NH}_3$  volatilization
- Aeration
- Diffusion, advection
- Plant uptake, growth, death
- Atmospheric deposition, microbial assimilation

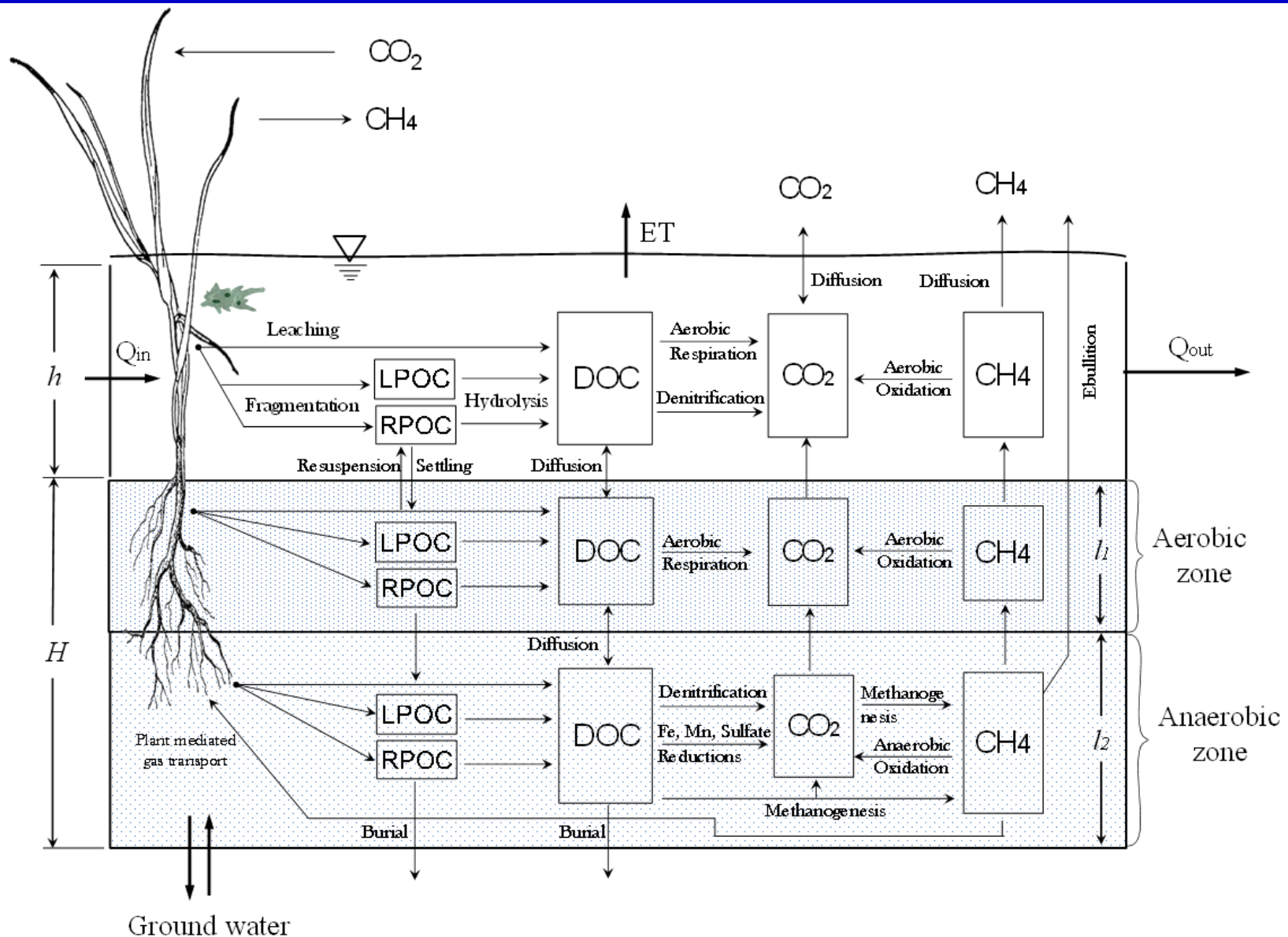


# WetQual: Phosphorous Cycle

- Aerobic and anaerobic layers
- Sedimentation, burial
- Mineralization
- Adsorption
- Precipitation/release
- Diffusion, advection
- Plant uptake, growth, death

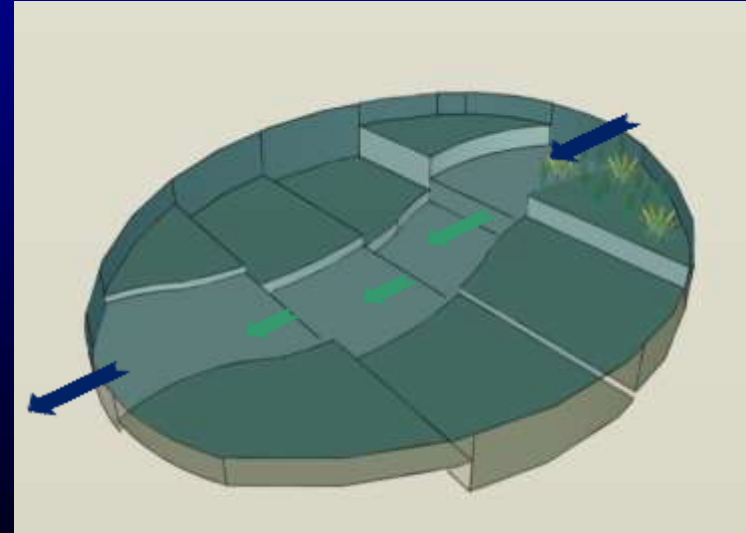
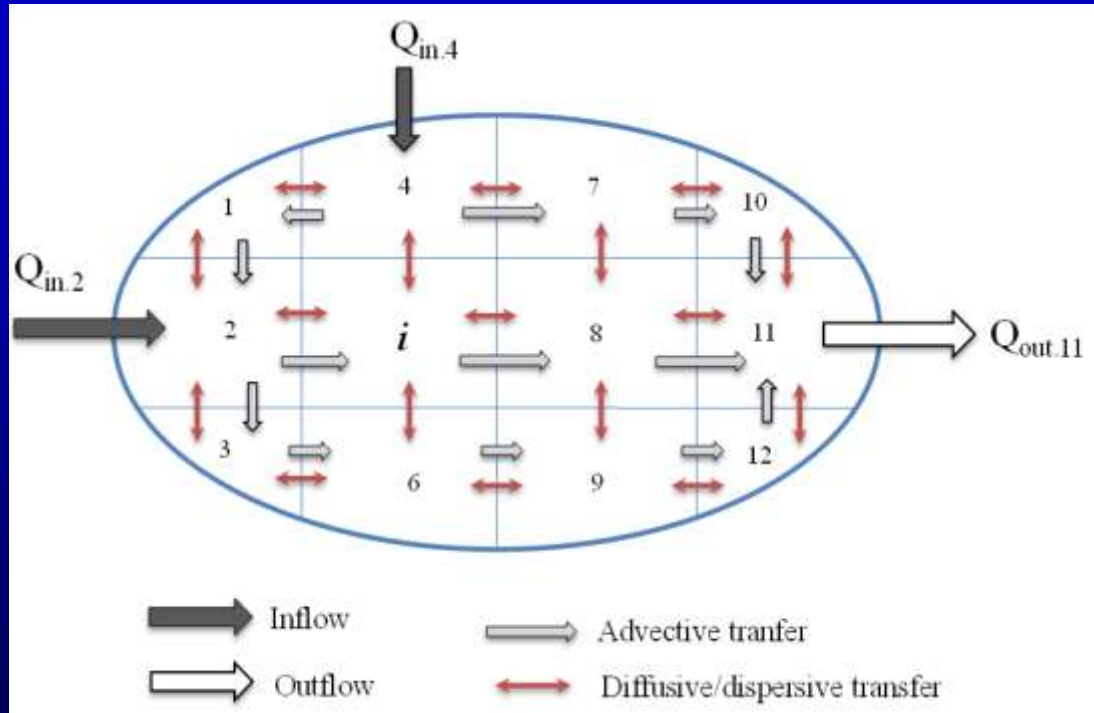


# WetQual: Carbon Cycle





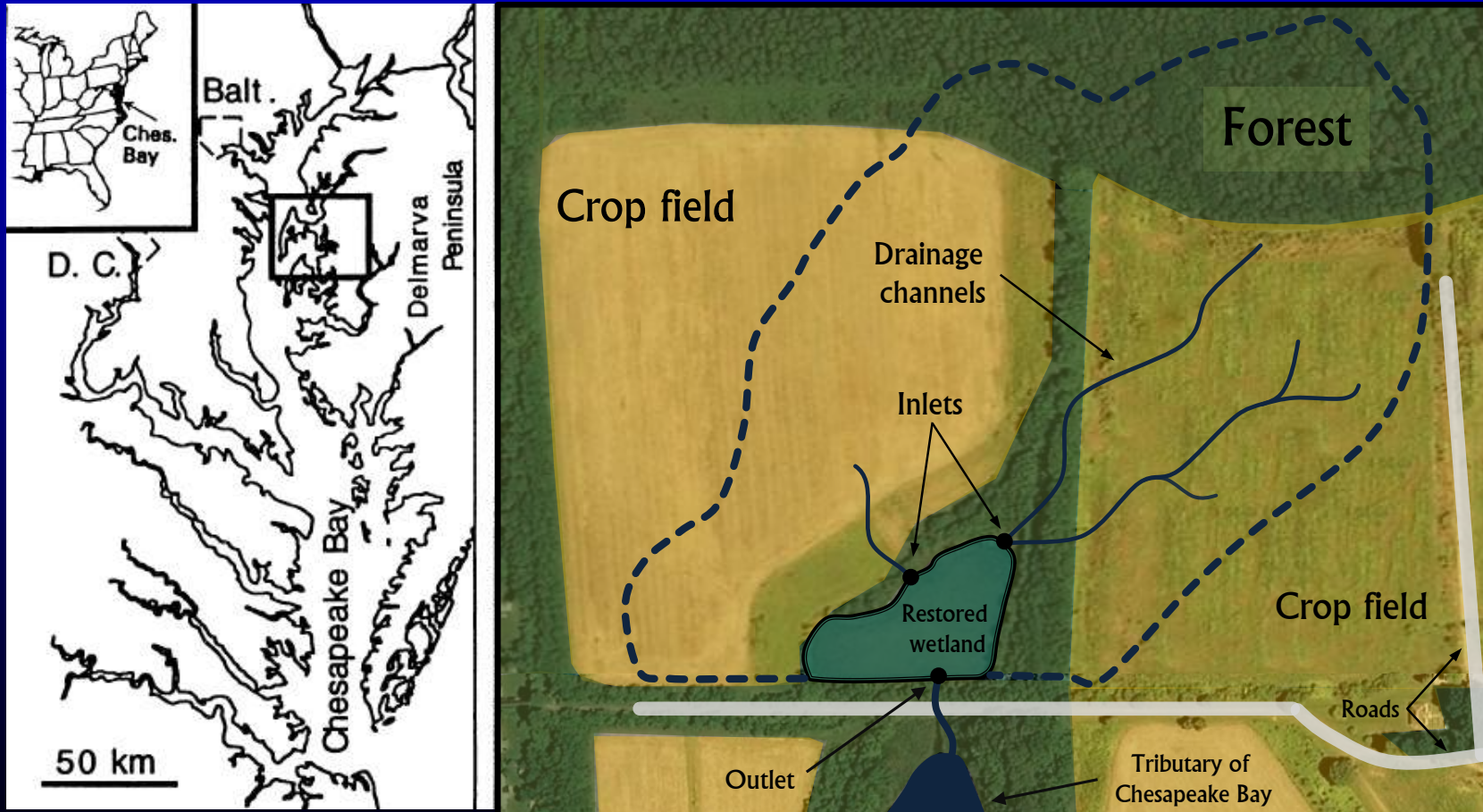
# WetQual: Compartmental Version



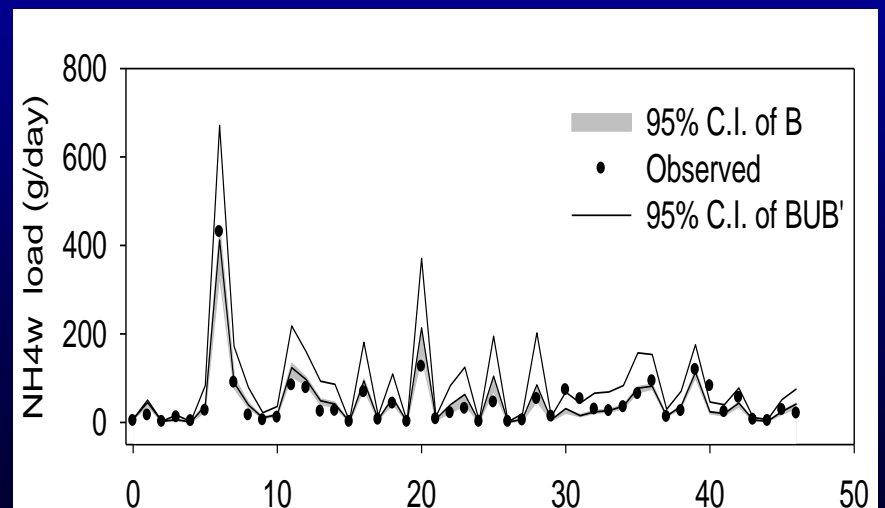
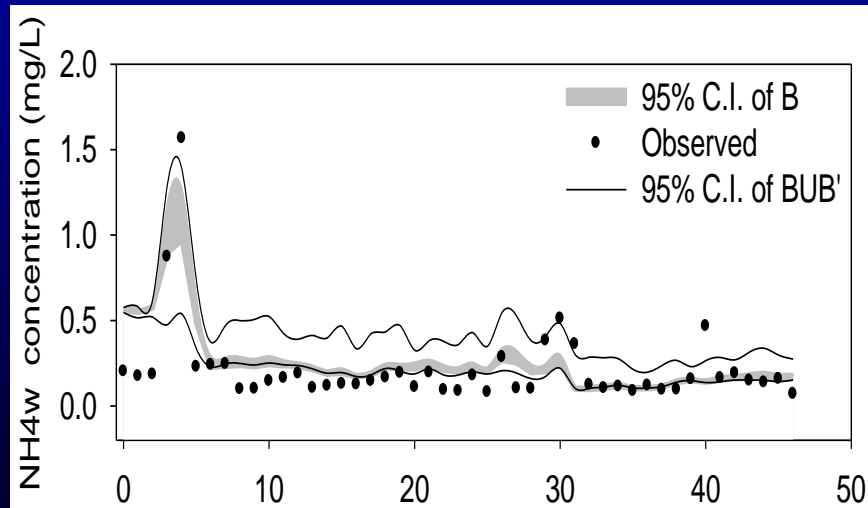
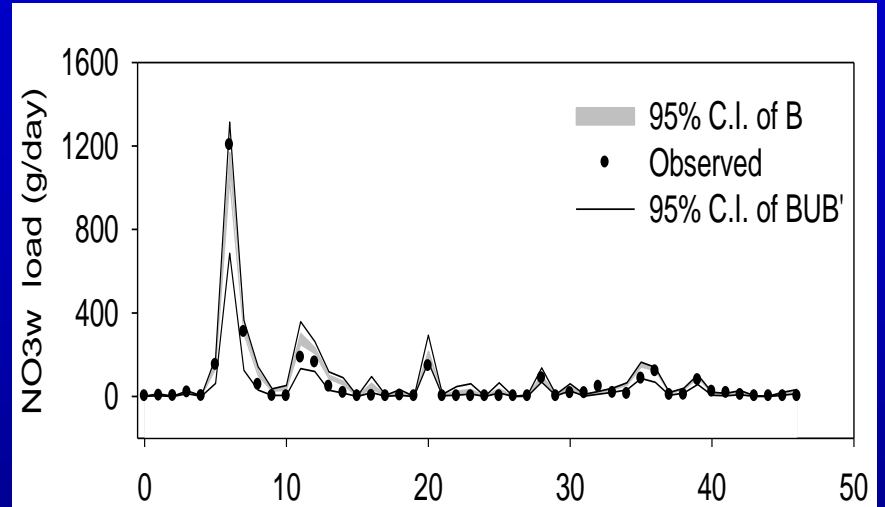
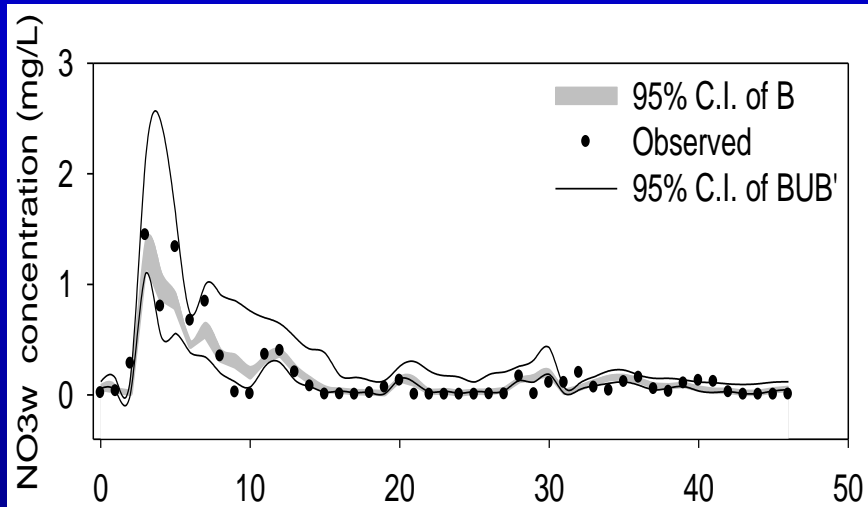


# Application

- One of the 12 restored wetlands in Eastern shores of Chesapeake Bay.
- All 12 sites had been ditched agricultural fields before restoration and restored as depressional wetlands. (Whigham et al. 2002, *Wetlands*)



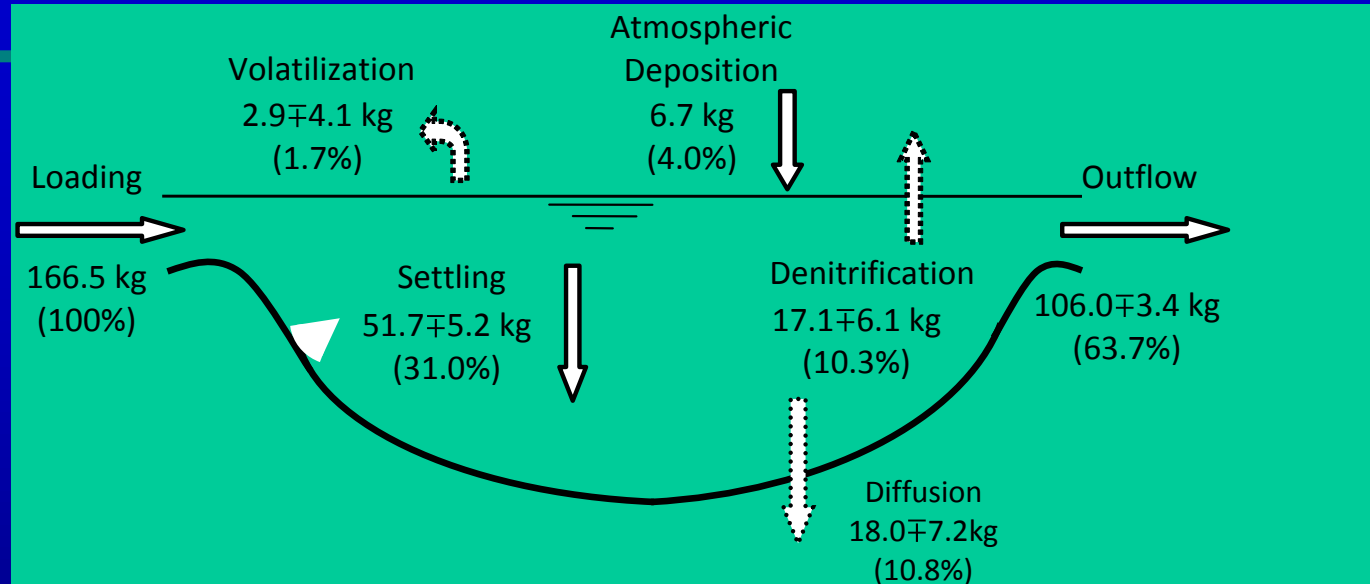
# Comparison



# Nitrogen Budget

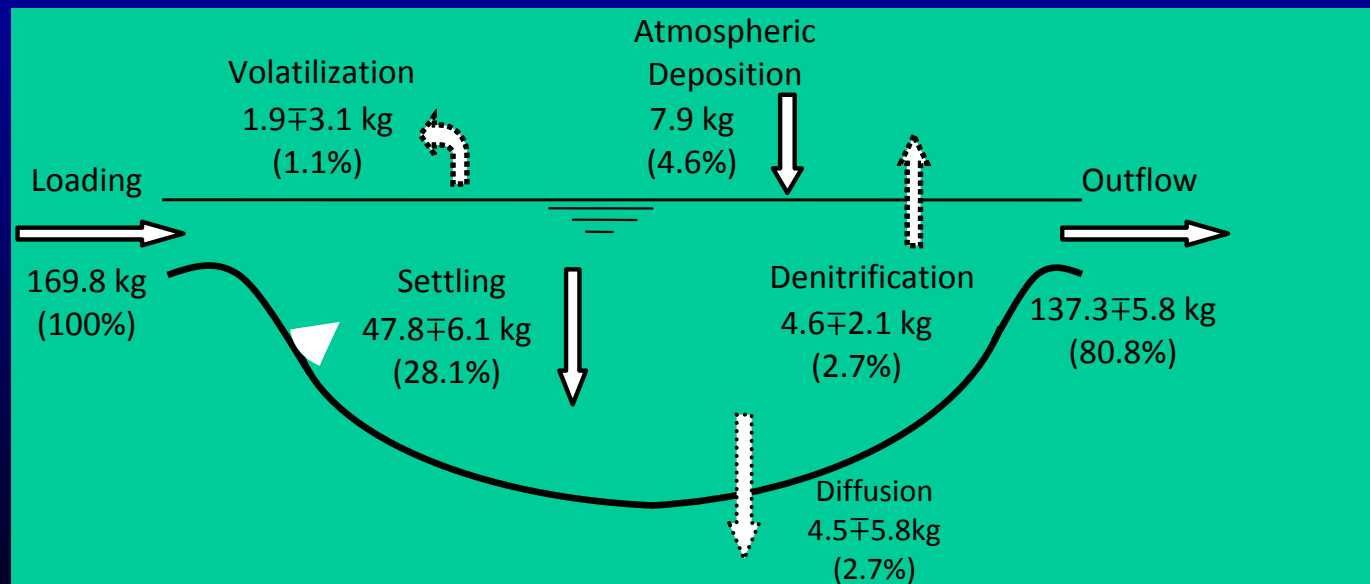
year-1

Org-N : 69%  
 $\text{NO}_3$  : 25%  
 $\text{NH}_4$  : 6%

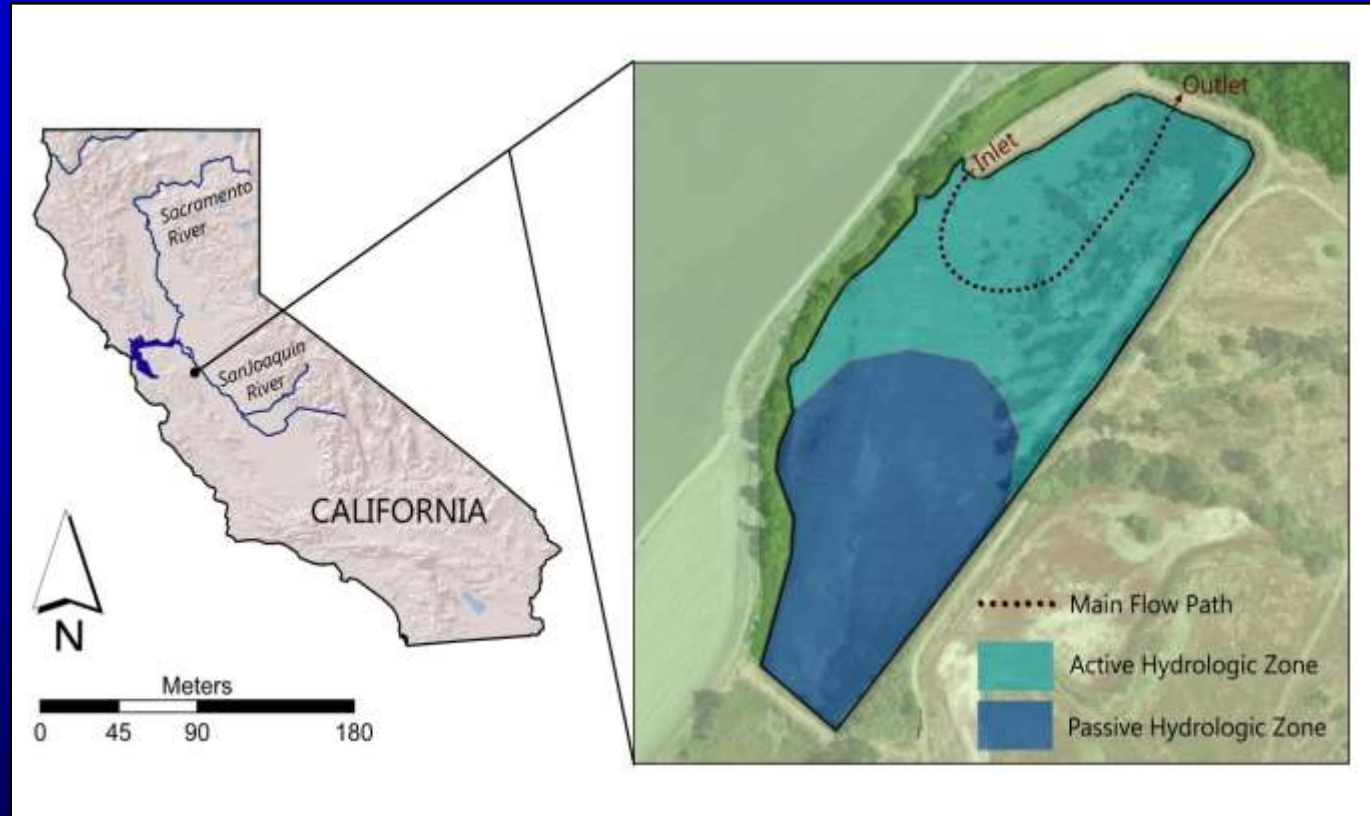


Year-2

Org-N : 86%  
 $\text{NO}_3$  : 7%  
 $\text{NH}_4$  : 7%



# Case study application: Compartmental Version

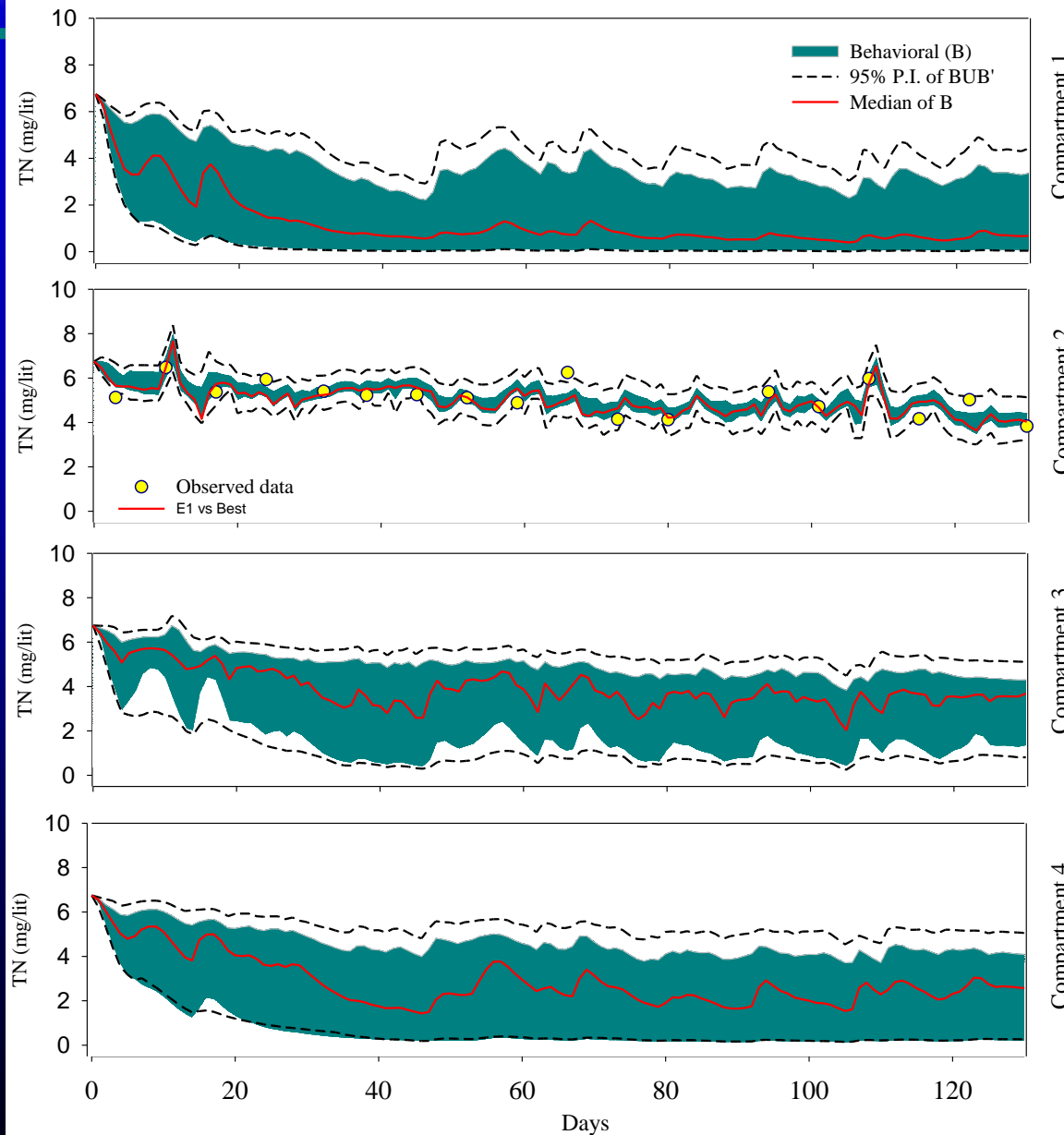


Study wetland located on west side of the San Joaquin River in California's Central Valley. Redrawn from Maynard et al. (2011)

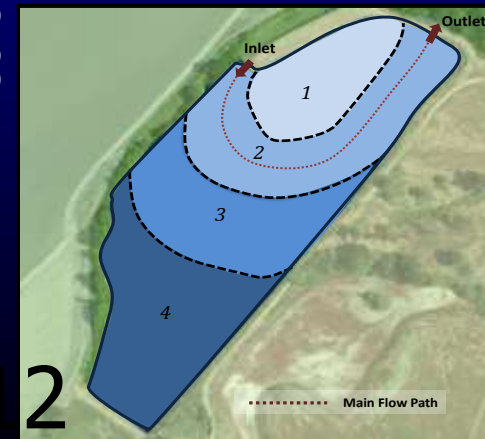
Area = 4.4 ha

Receives irrigation tail-water from about 2300 ha of upstream farmlands

# Uncertainty analysis -TN

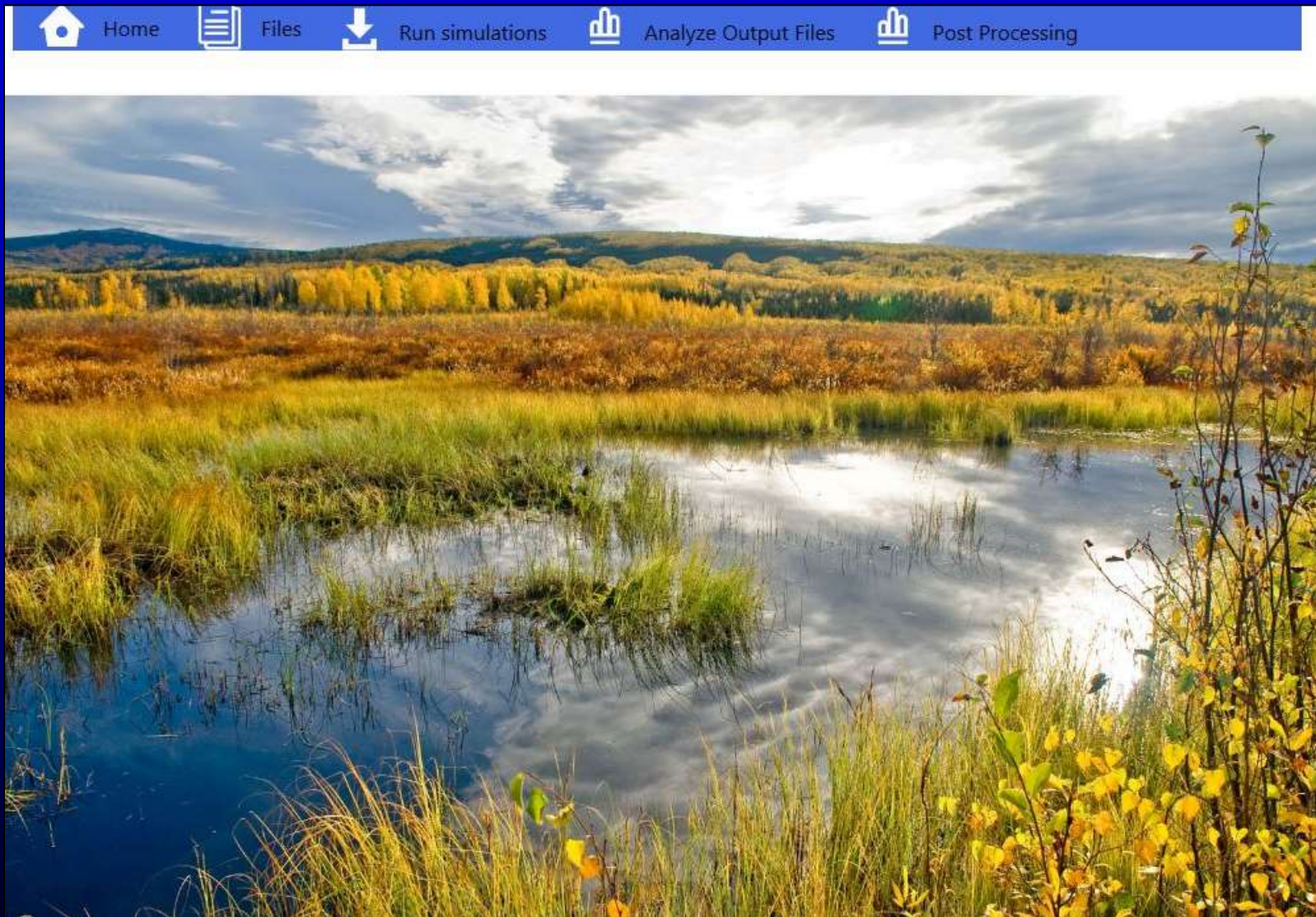


Decrease in concentration



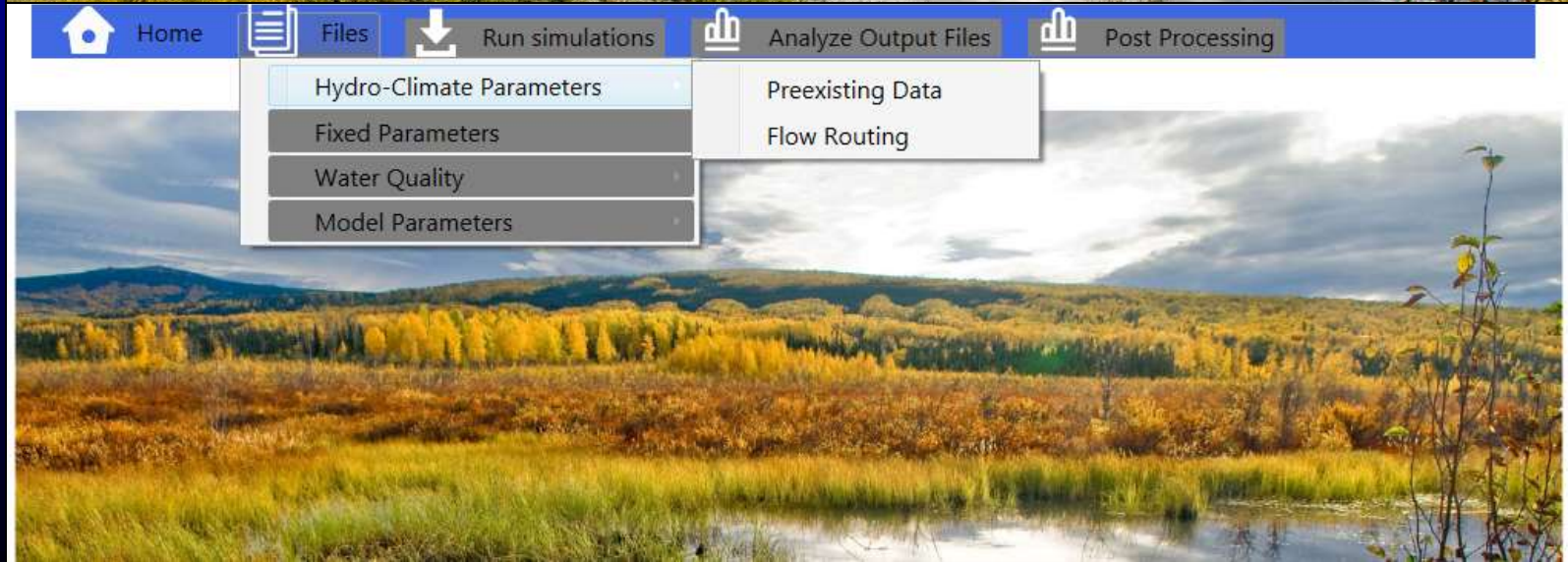
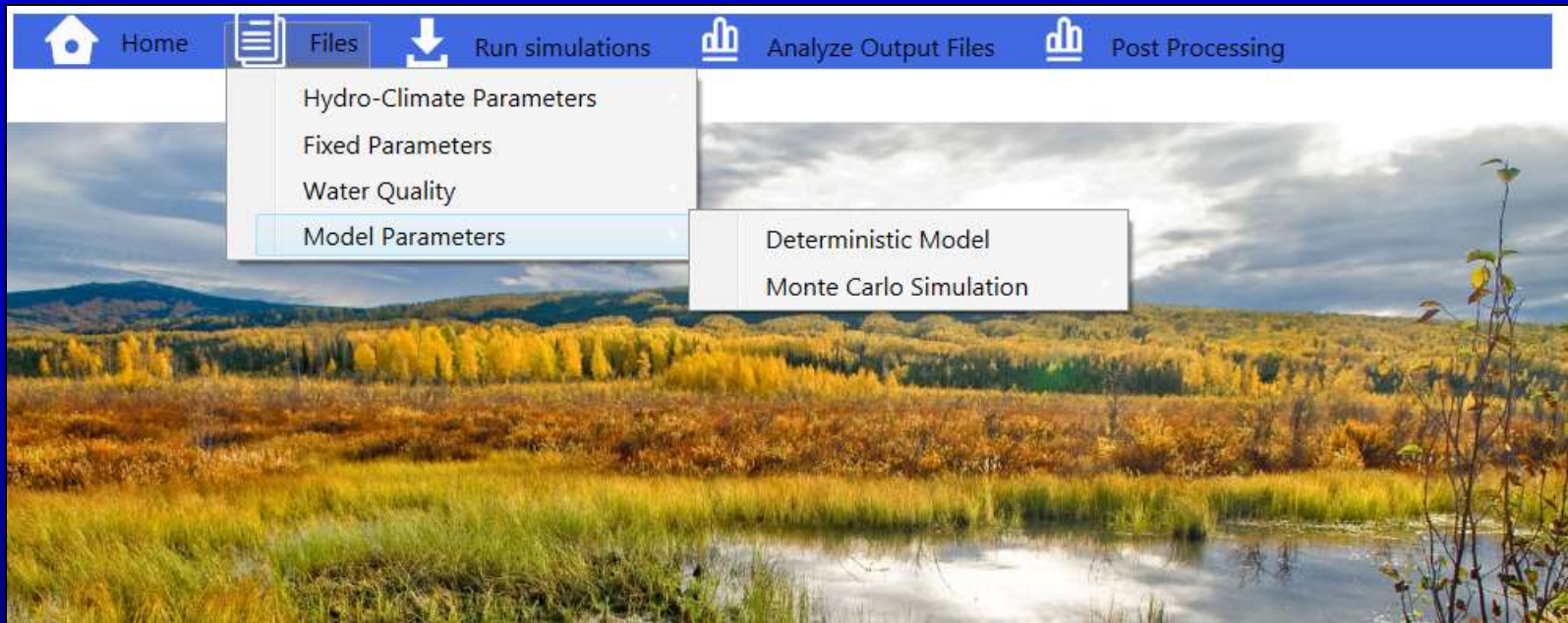


# *Graphical User Interface (GUI)*



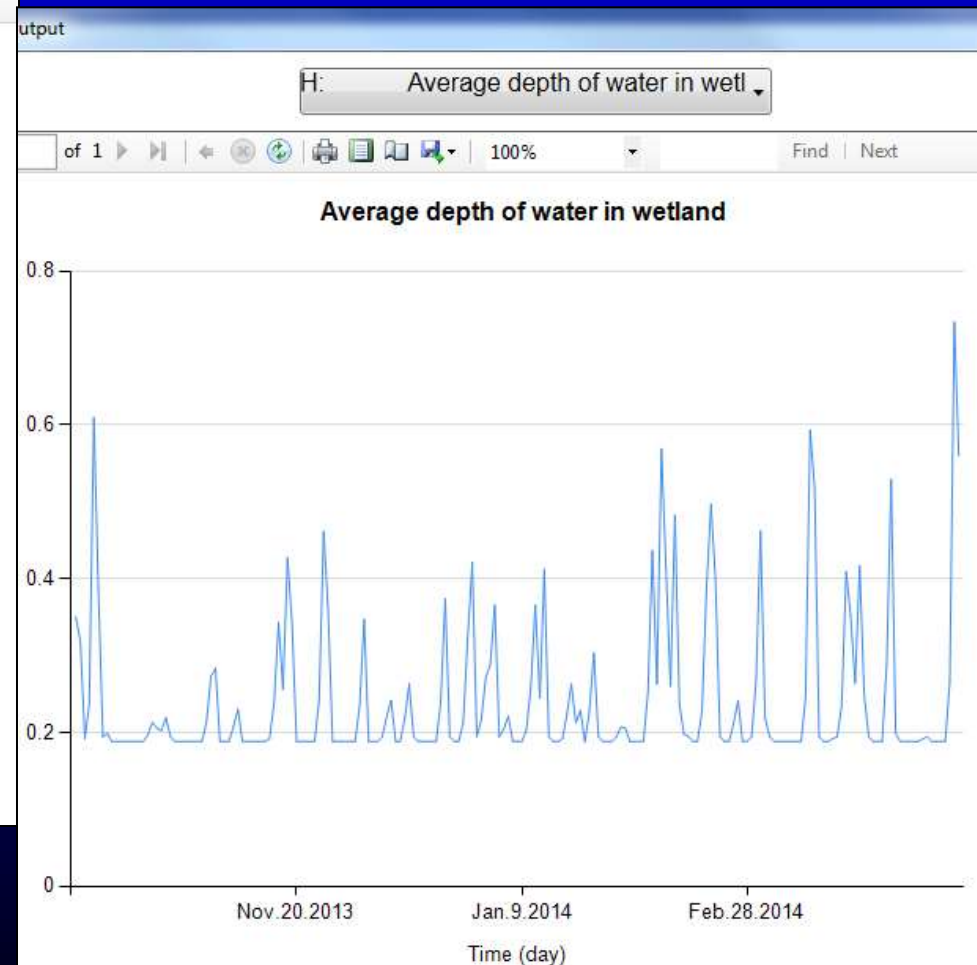
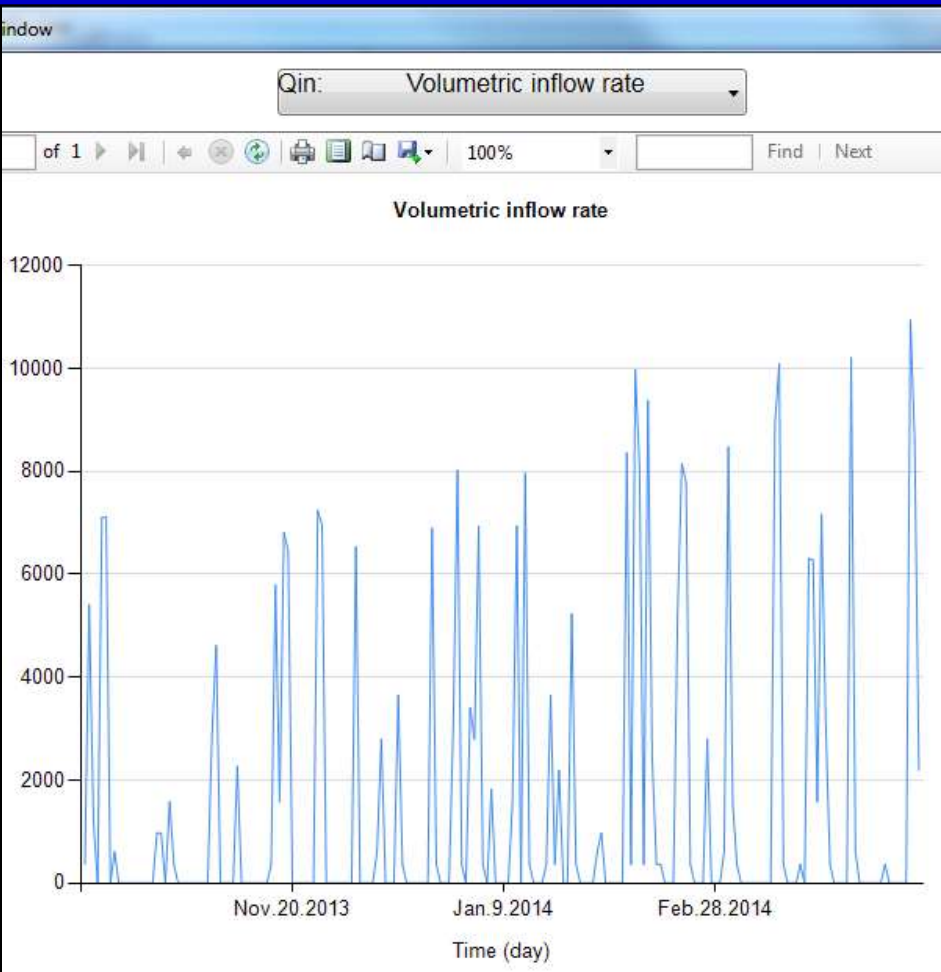


# Graphical User Interface (GUI)





# GUI: Visualization



# GUI: Deterministic

Default values for model parameters

### Nitrogen and phosphorus

$l_2$ (cm)	$\theta$	$l_s$ (ly/day)	$fN$		
27.63	1.25	248.58	0.335		
$k_d$ (mL/g)	$kep$ (1/m)	$kga$ (1/day)	$kgb$ (1/day)	$kmr$ (1/day)	$knw$ (1/day)
1.2	0.3	0.0014	0.0014	0.00003	0.0032
$kmw$ (1/day)	$kns$ (1/day)	$kdn$ (1/day)	$ps$	$vso$ (cm/day)	$vss$ (cm/day)
0.000032	0.32	1.29	2	0.8	299
$vb$ (cm/day)	$ana$ (cm/day)	$rc,chl$ (gC/gChl)	$Ss$ (g/L/day)	$Sw$ (gr/cm3/day)	$\alpha$
0.0034	10.56	60	0.0435	0	0.2155
$fr$	$c_1$	$c_2$	$pH$	$S$ (mg-N/m3/hr)	$Kw$ (cm3/g)
0.7514	0.09	2450	6.36	0.1266	31.54
$apa$ (grP/grChl)	$Dpw$ (cm2/day)	$Ksa$ (cm3/g)	$Ksb$ (cm3/g)	$Ran1$	$fw$
1.19	0.7452	31.73	317.46	0.5	0.75
$fact$	$Cro$	$Crs$	$\phi_w$		
140	0.0318	0.0032	0.8005		

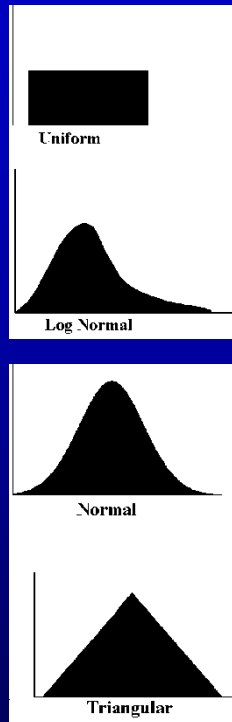
### Carbon

(gC/gChl)	$faD$	$faL$	$faR$	$fbD$	$fbL$
86.6	0.16	0.5	0.5	0.16	0.5
$fbR$	$kL$ (1/day)	$kR$ (1/day)	$KO$ (mg/lit)	$KinO$ (mg/lit)	$KN$ (mg/lit)
0.5	0.00001	0.000001	0.6	0.25	0.038
$KinN$ (mg/lit)	$K1DOC$ (1/day)	$K2DOC$ (1/day)	$K3DOC$ (1/day)	$K4DOC$ (1/day)	$cp1$
0.019	0.2	0.08	0.04	0.015	0.36
$cp2$	$cp3$	$fbw$ (1/day)	$k1CH4$ (1/day)	$k2CH4$ (1/day)	$Rv$ (cm/gr)
0.36	0.36	0.55	0.13	0.04	0.1

Edit Save

# GUI: Monte Carlo Simulation

Parameters	Distribution	Min (or mu)	Max (or sigma)	"c" in Triangular dist
l2 (cm)	Uniform	5	50	5
$\theta$	Uniform	1.15	1.35	1.15
ls (ly/day)	Uniform	100	400	100
fNup	Uniform	0.29	0.38	0.29
kd (mL/g)	Log-N(min max)	0.032	80	0.032
kep (1/m)	Uniform	0.15	0.45	0.15
kga0 (1/day)	Log-N(min max)	0.0009	0.002	0.0009
kgb0 (1/day)	Log-N(min max)	0.0009	0.002	0.01
kmin1s (1/day)	Log-N(min max)	0.000001	0.0031	0.000001
knw (1/day)	Log-N(min max)	0.0001	0.35	0.0001
kminw (1/day)	Log-N(min max)	0.000001	0.001	0.000001
kns (1/day)	Log-N(min max)	0.01	42	0.01
kden (1/day)	Uniform	0.004	0.15	0.004
rows (gr/cm3)	Uniform	1.5	2.2	1.5
vels_o (cm/day)	Log-N(min max)	0.025	138	0.025
vels_s (cm/day)	Log-N(min max)	8	6750	8
velb (cm/day)	Uniform	0.000274	0.006575	0.000274
ana (gN/gChl)	Uniform	3.5	17.6	3.5



# GUI: Output Analyzer

Home Files Run simulations Analyze Output Files Post Processing

## Select File To Analyse Data

Select File

--Select File--

Enter Simulation

--Select File--

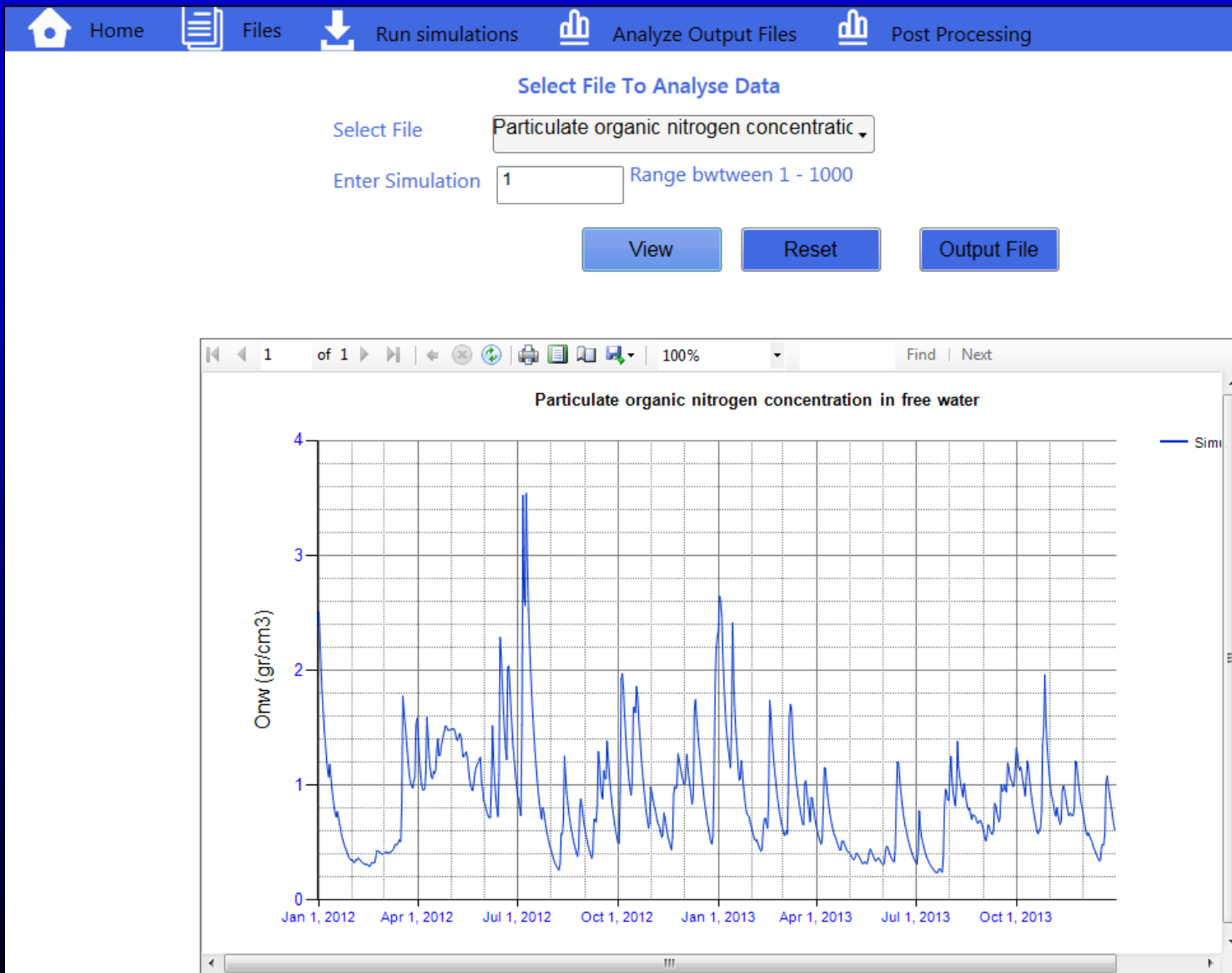
Particulate organic nitrogen concentration in free water (gr/cm3)  
Concentration of organic nitrogen in in anaerobic sediment layer (gr/cm3)  
Concentration of organic nitrogen in in aerobic sediment layer (gr/cm3)  
Total ammonia-nitrogen ( $[NH_4^+] + [NH_3]$ ) concentration in free water (gr/cm3)  
Total ammonia-nitrogen pore-water concentration in upper aerobic layer (gr/cm3)  
Total ammonia-nitrogen pore-water concentration in lower anaerobic layer (gr/cm3)  
Nitrate-nitrogen concentration in free water (gr/cm3)  
Nitrate-nitrogen pore-water concentration in upper aerobic layer (gr/cm3)  
Nitrate-nitrogen pore-water concentration in lower anaerobic layer (gr/cm3)  
Oxygen concentration in free water (gr/cm3)  
Mass of free floating plant (gr chlorophyll a)  
Mass of rooted plants (gr chlorophyll a)  
Total inorganic phosphorus concentration in free water (gr/cm3)  
Total phosphorus concentration in aerobic layer (gr/cm3)  
Total phosphorus concentration in anaerobic layer (gr/cm3)

Enter Simulation

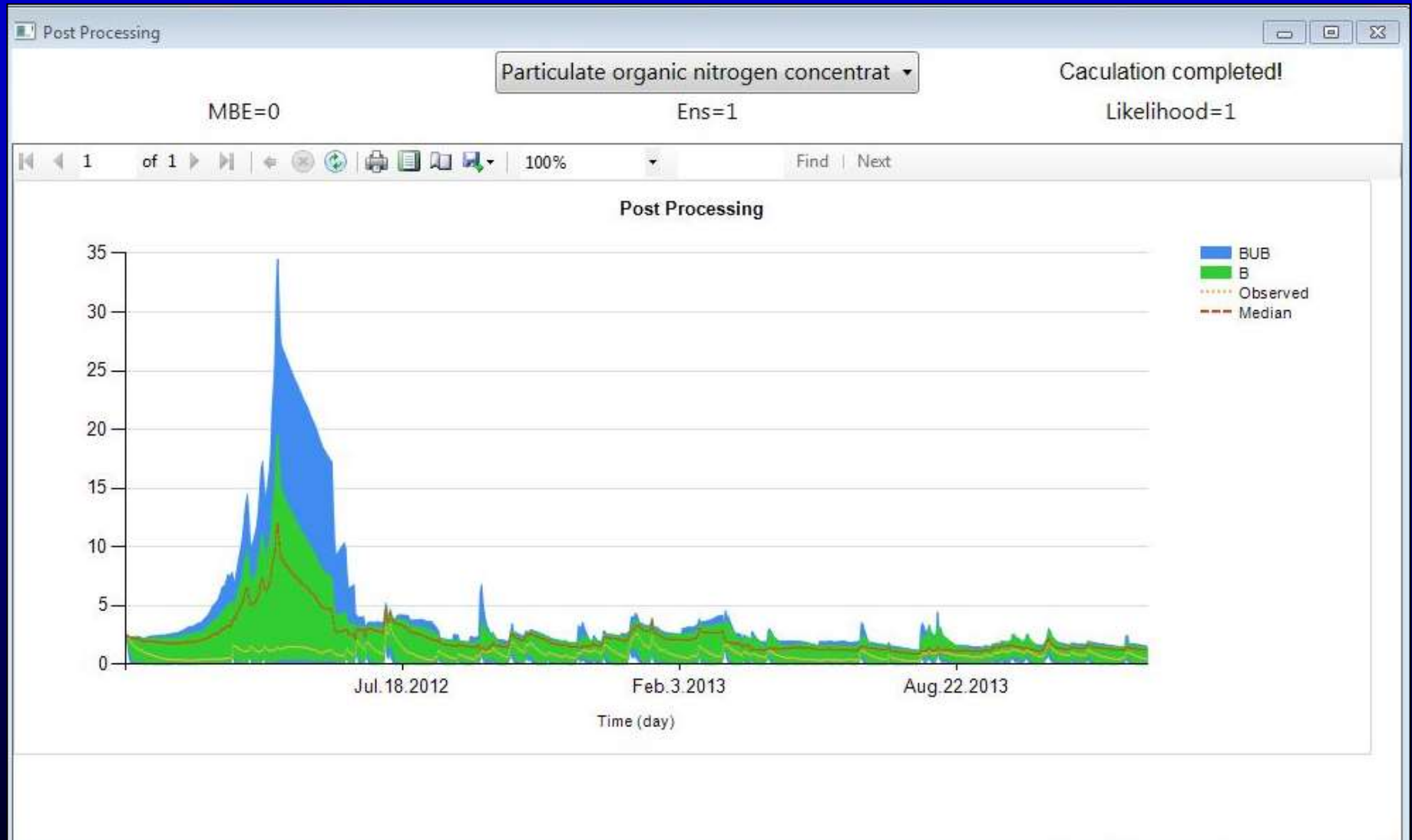
Total phosphorus concentration in aerobic layer (gr/cm3)

Total phosphorus concentration in anaerobic layer (gr/cm3)  
Sediment concentration in free water (gr/cm3)  
Concentrations of dissolved organic C in free water (gr/cm3)  
Concentrations of labile (fast reacting) particulate organic C in free water (gr/cm3)  
Concentrations of refractory (slow reacting) particulate organic C in free water (gr/cm3)  
Pore water concentrations of DOC in aerobic sediment layer (gr/cm3)  
Pore water concentrations of LPOC in aerobic sediment layer (gr/cm3)  
Pore water concentrations of RPOC in aerobic sediment layer (gr/cm3)  
Pore water concentrations of DOC in lower anaerobic sediment layer (gr/cm3)  
Pore water concentrations of LPOC in lower anaerobic sediment layer (gr/cm3)  
Pore water concentrations of RPOC in lower anaerobic sediment layer (gr/cm3)  
Concentrations of total organic C in free water (gr/cm3)  
Methane concentration in free water (gr/cm3)  
Methane concentration in aerobic sediment layer (gr/cm3)  
Methane concentration in anaerobic sediment layer (gr/cm3)

# GUI: Output Analyzer



# GUI: Output Analyzer



# Release

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- Oct '15: Internal Testing
- Nov '15: External Testing
- May '16: Final Release and Distribution on [www.epa.gov](http://www.epa.gov)

- ✓ Sharifi, A., L. Kalin, M.M. Hantush, A.T. O'Geen, R.A. Dahlgren, J.J. Maynard (2015), "Capturing Spatial Variability of Concentrations and Reaction Rates in Wetland Water and Soil through Model Compartmentalization", *Journal of Hydrologic Engineering*. DOI: 10.1061/(ASCE)HE.1943-5584.0001196.
- ✓ Sharifi, A., L. Kalin, M.M. Hantush, S. Isik\*, T. Jordan (2013), "Carbon Export and Dynamics from Flooded Wetlands: A Modeling Approach", *Ecological Modeling*, 263:196-210.
- ✓ Kalin, L., M.M. Hantush, S. Isik, A. Yucekaya, T. Jordan (2013), "Nutrient Dynamics in Flooded Wetlands: II. Model Application", *Journal of Hydrologic Engineering*, 18(12):1724-1738. [PDF]
- ✓ Hantush, M.M., L. Kalin, S. Isik, A. Yucekaya (2013), "Nutrient Dynamics in Flooded Wetlands: I. Model Development", *Journal of Hydrologic Engineering*, 18(12):1709-1723.