A Practical Tool For Modeling Wetland Nutrient Cycling

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

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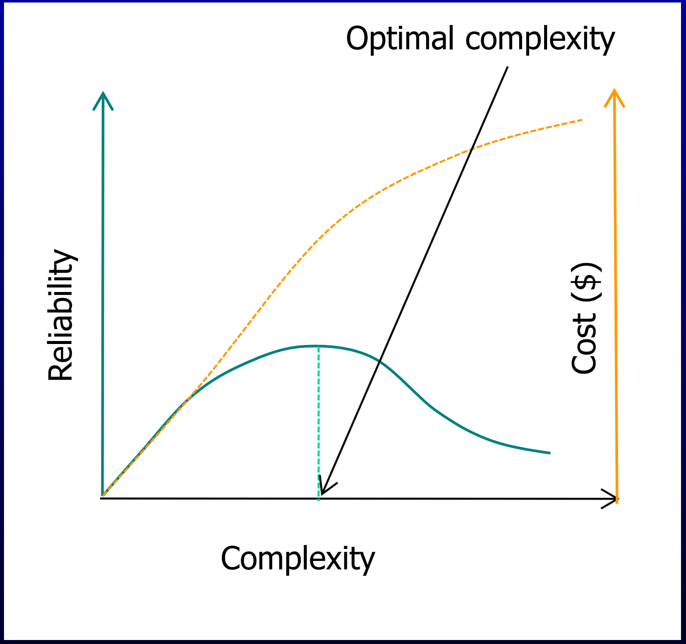
ENVIRONMENTAL STUDIES
- AT THE -
URBAN - RURAL INTERFACE

Wetlands

- 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

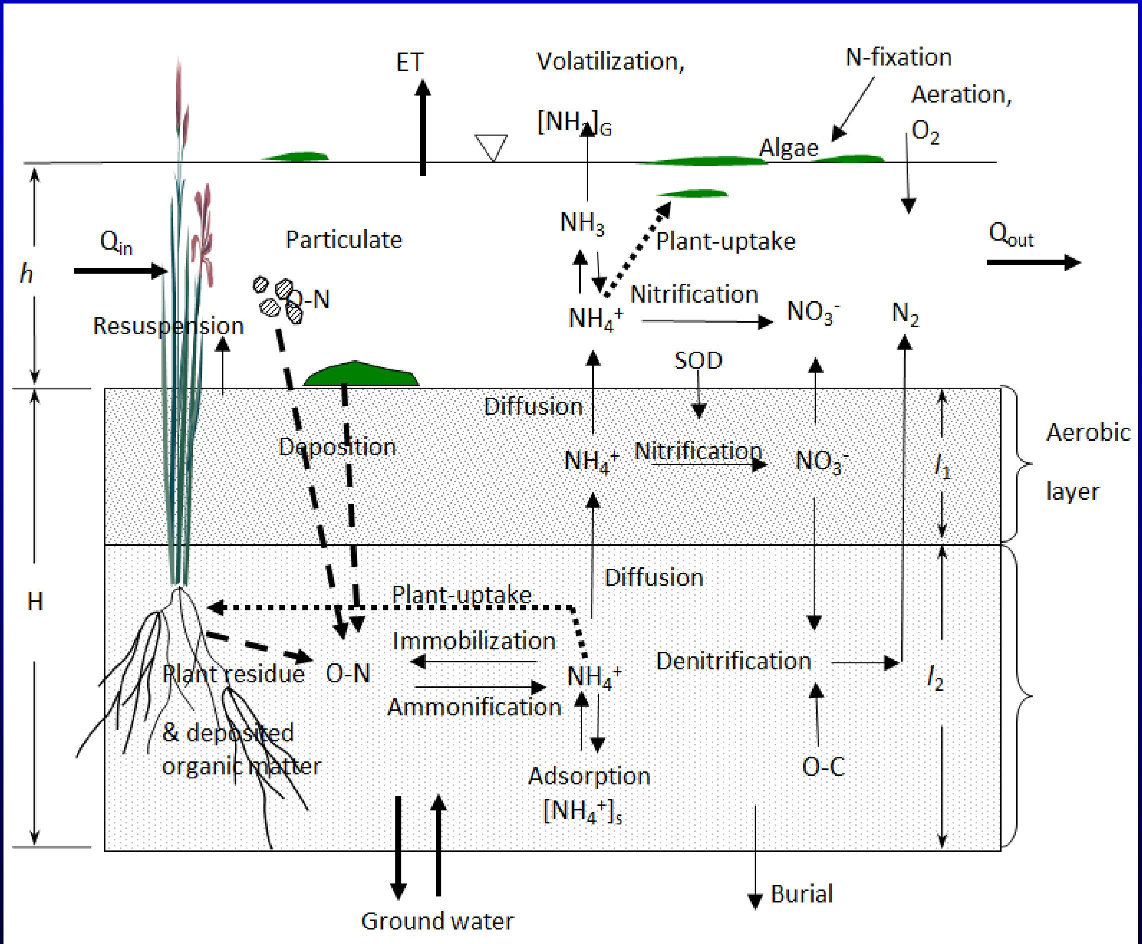


WetQual

- 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: Ponded and dynamic version (wetting/drying cycles)
- Compartmental version

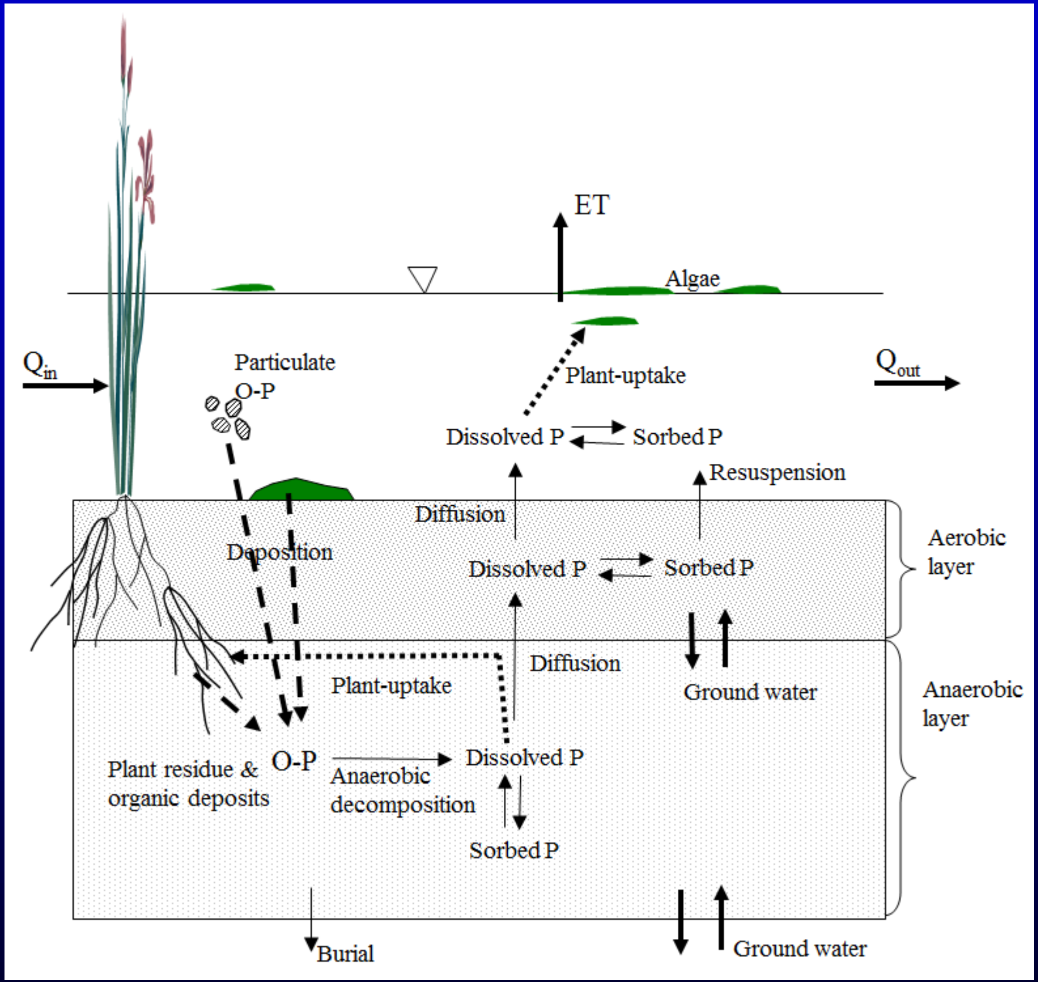
WetQual: Nitrogen Cycle

- Aerobic and anaerobic layers
- Sedimentation, burial
- Mineralization
- Nitrification,
- Denitrification
- NH4+ adsorption
- NH3 volatilization
- Aeration
- Diffusion, advection
- Plant uptake, growth, death
- Atmospheric deposition, microbial assimilation

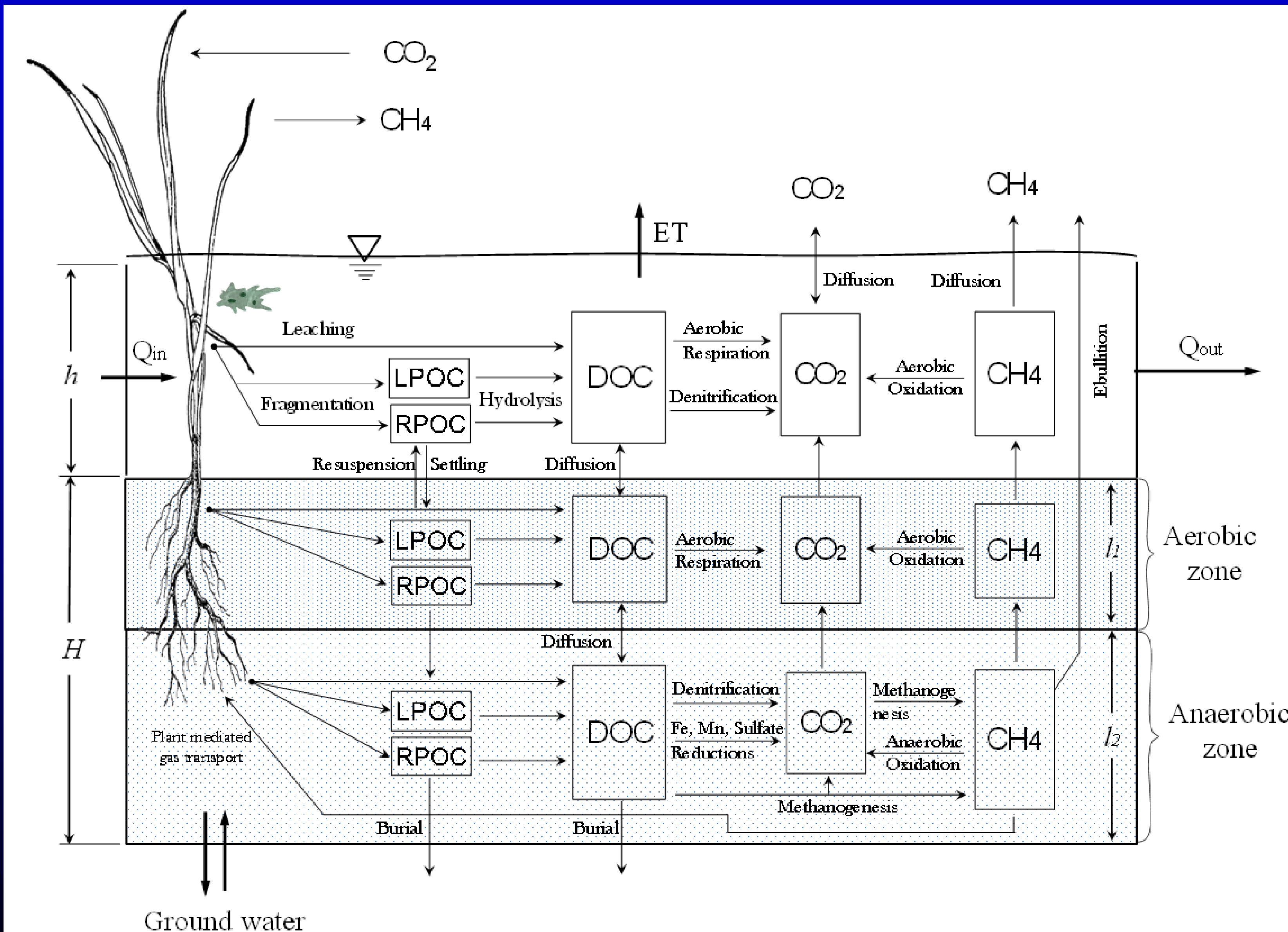


WetQual: Phosphorous Cycle

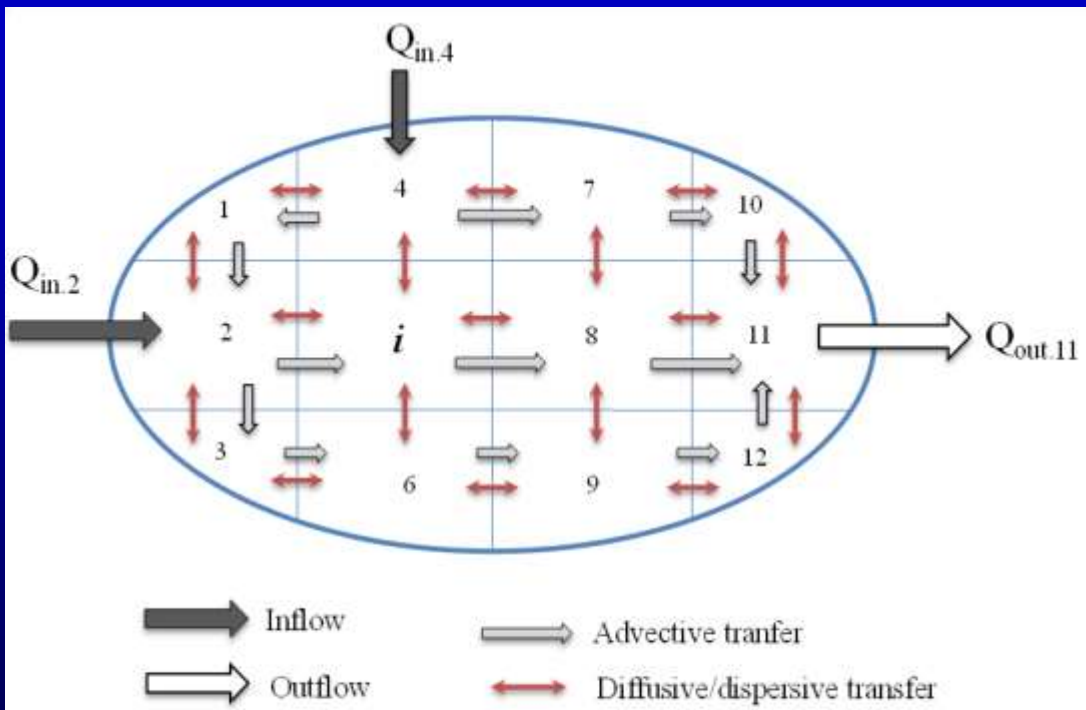
- Aerobic and anaerobic layers
- Sedimentation, burial
- Mineralization
- Adsorption
- Precipitation/release
- Diffusion, advection
- Plant uptake, growth, death

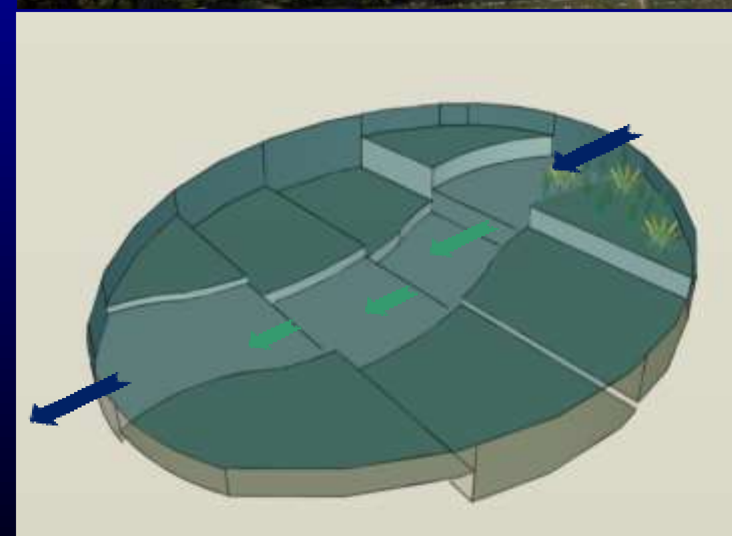


WetQual: Carbon Cycle



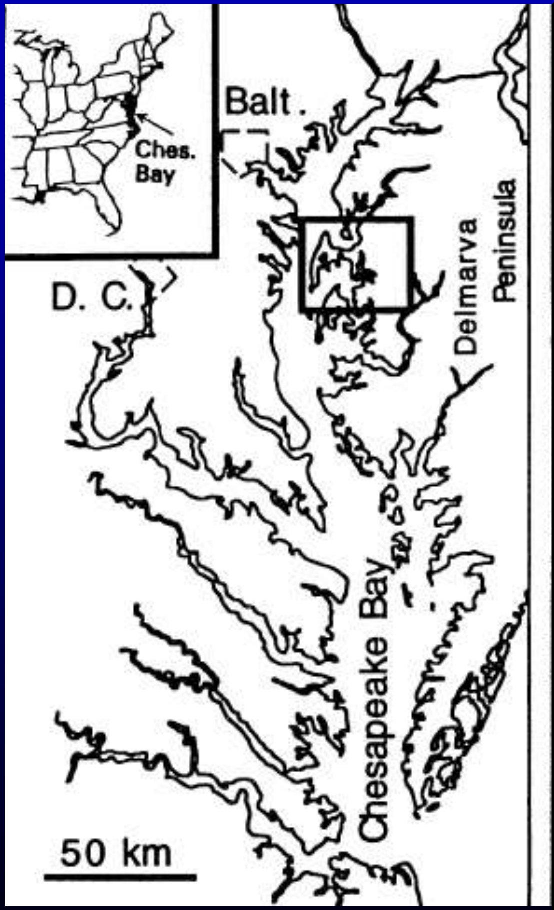
WetQual: Compartmental Version

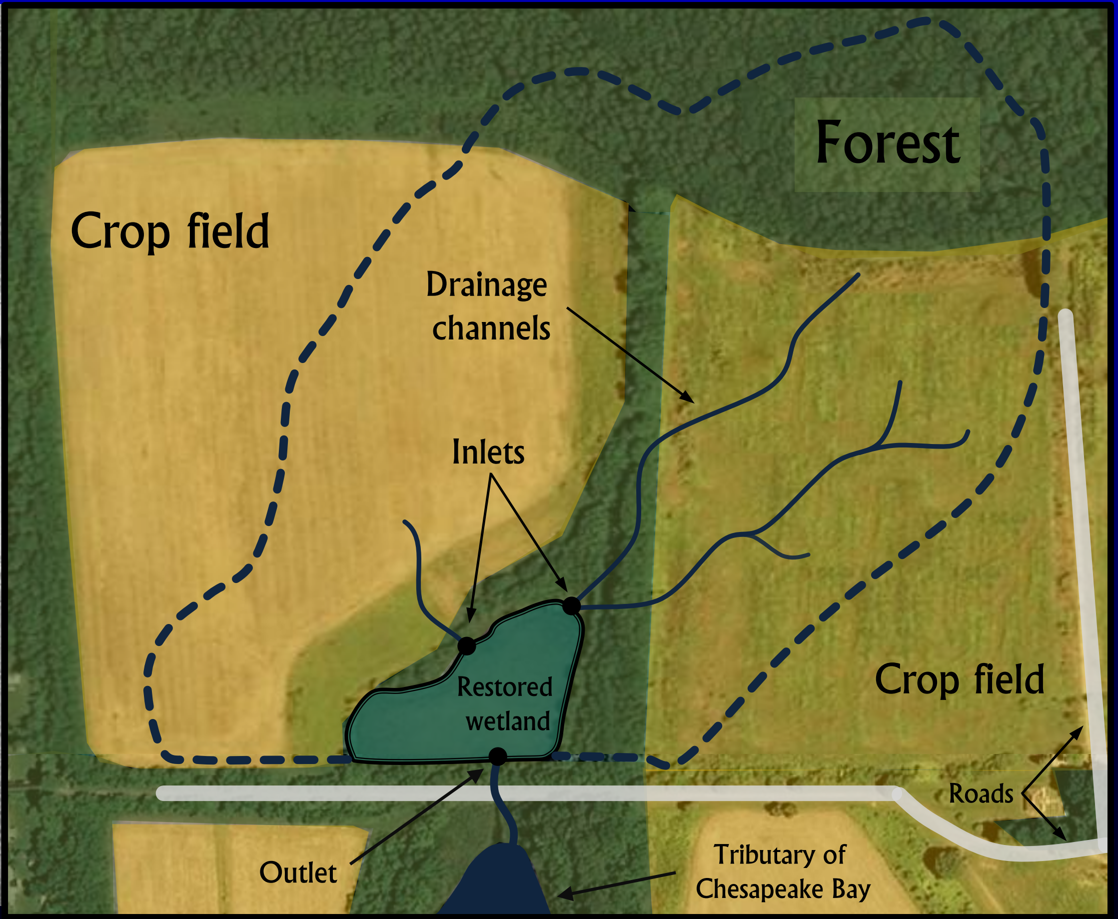




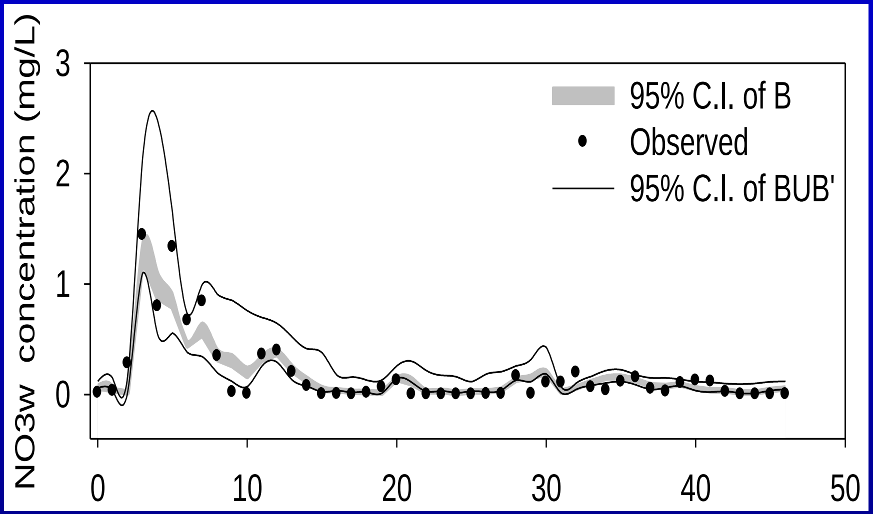
Application

- 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*)

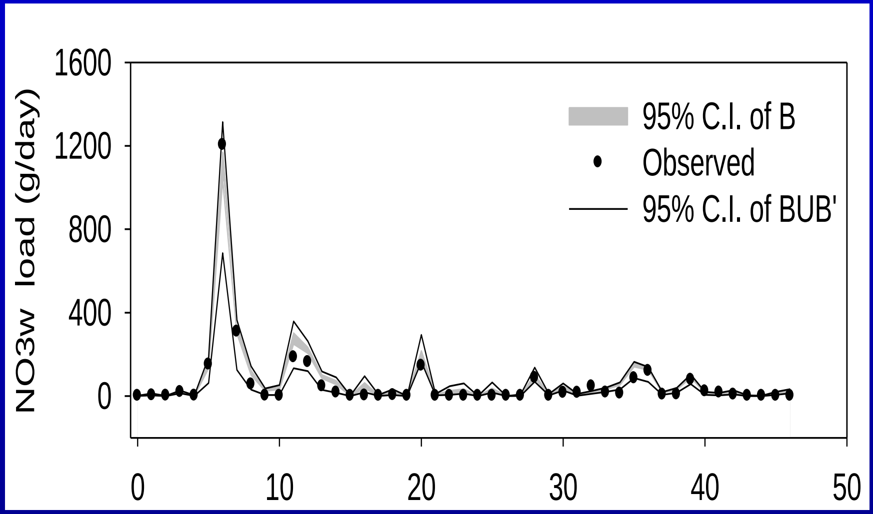




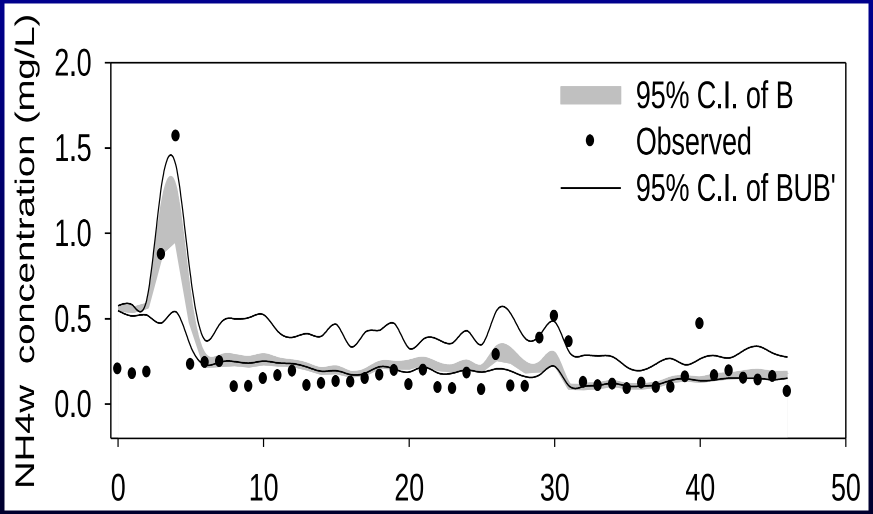
Comparison



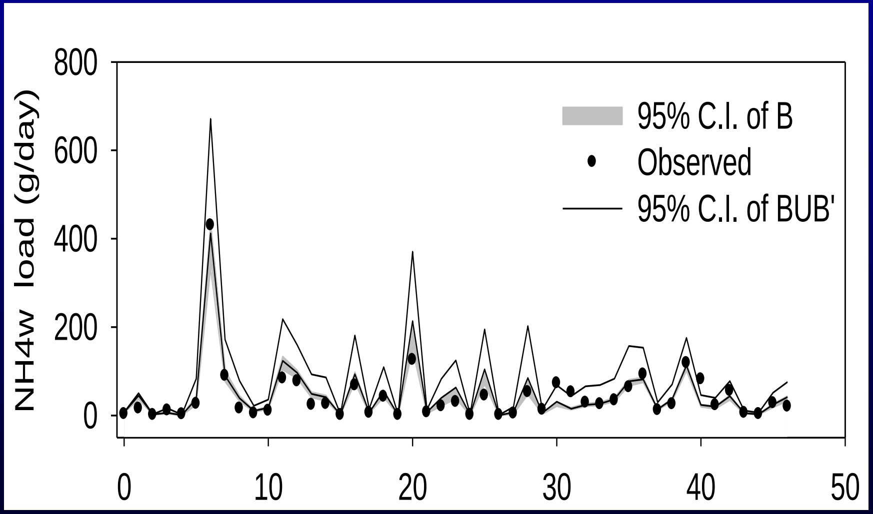
NO3w concentration (mg/L)
3
2
1
0
0
10
20
30
40
50
95% C.I. of B
Observed
95% C.I. of BUB'



NO3w load (g/day)
1600
1200
800
400
0
0
10
20
30
40
50
95% C.I. of B
Observed
95% C.I. of BUB'



NH4w concentration (mg/L)
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
95% C.I. of B
Observed
95% C.I. of BUB'

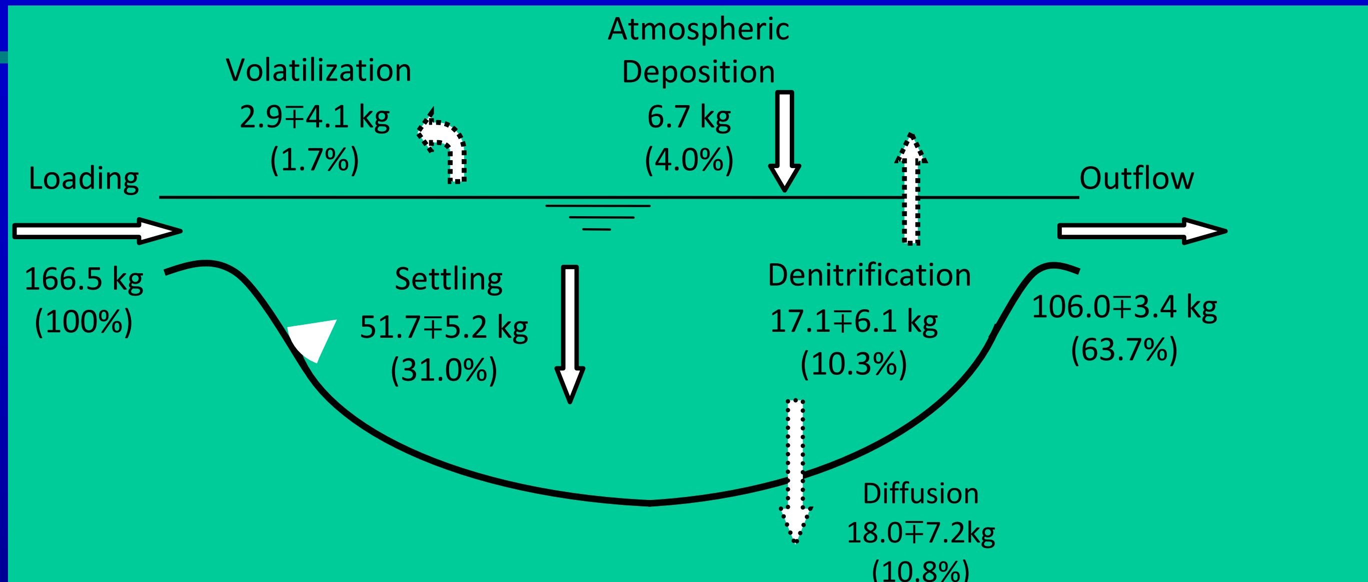


NH4w load (g/day)
800
600
400
200
0
0
10
20
30
40
50
95% C.I. of B
Observed
95% C.I. of BUB'

Nitrogen Budget

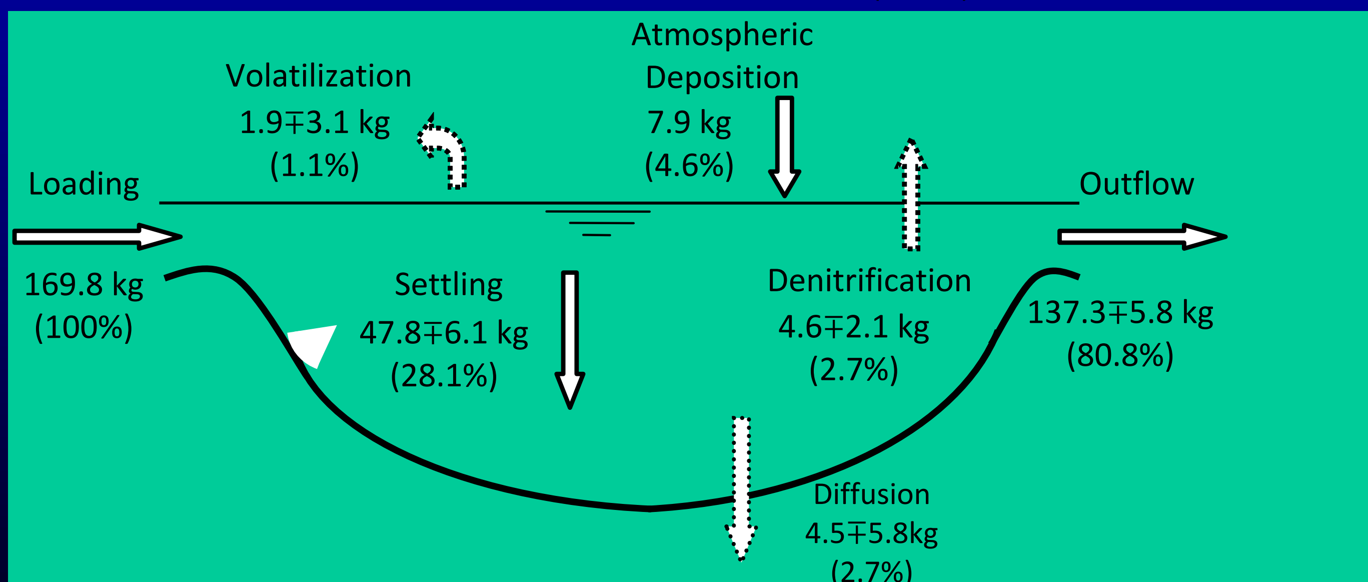
year-1

Org-N : 69%
NO_3 : 25%
NH_4 : 6%

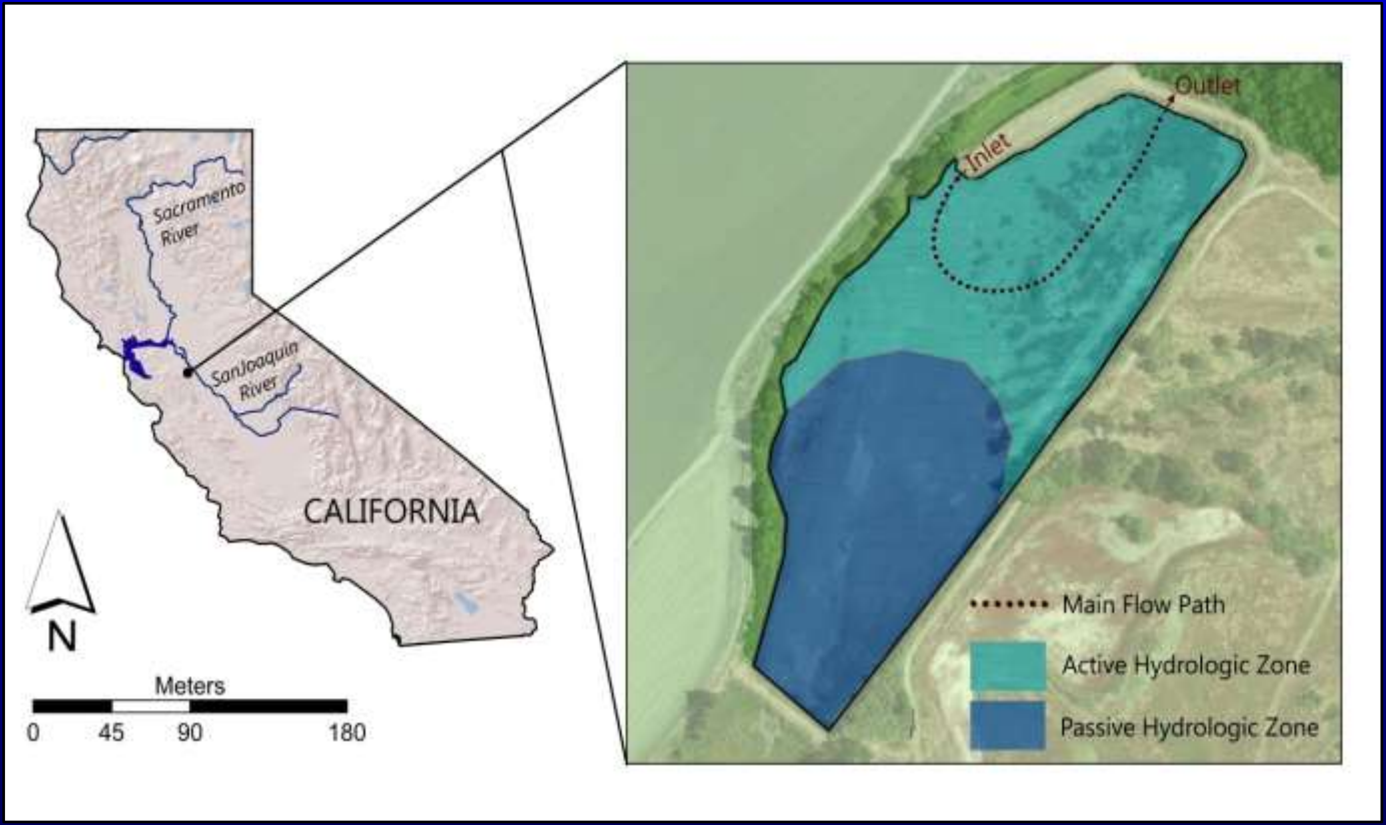


Year-2

Org-N : 86%
NO_3 : 7%
NH_4 : 7%



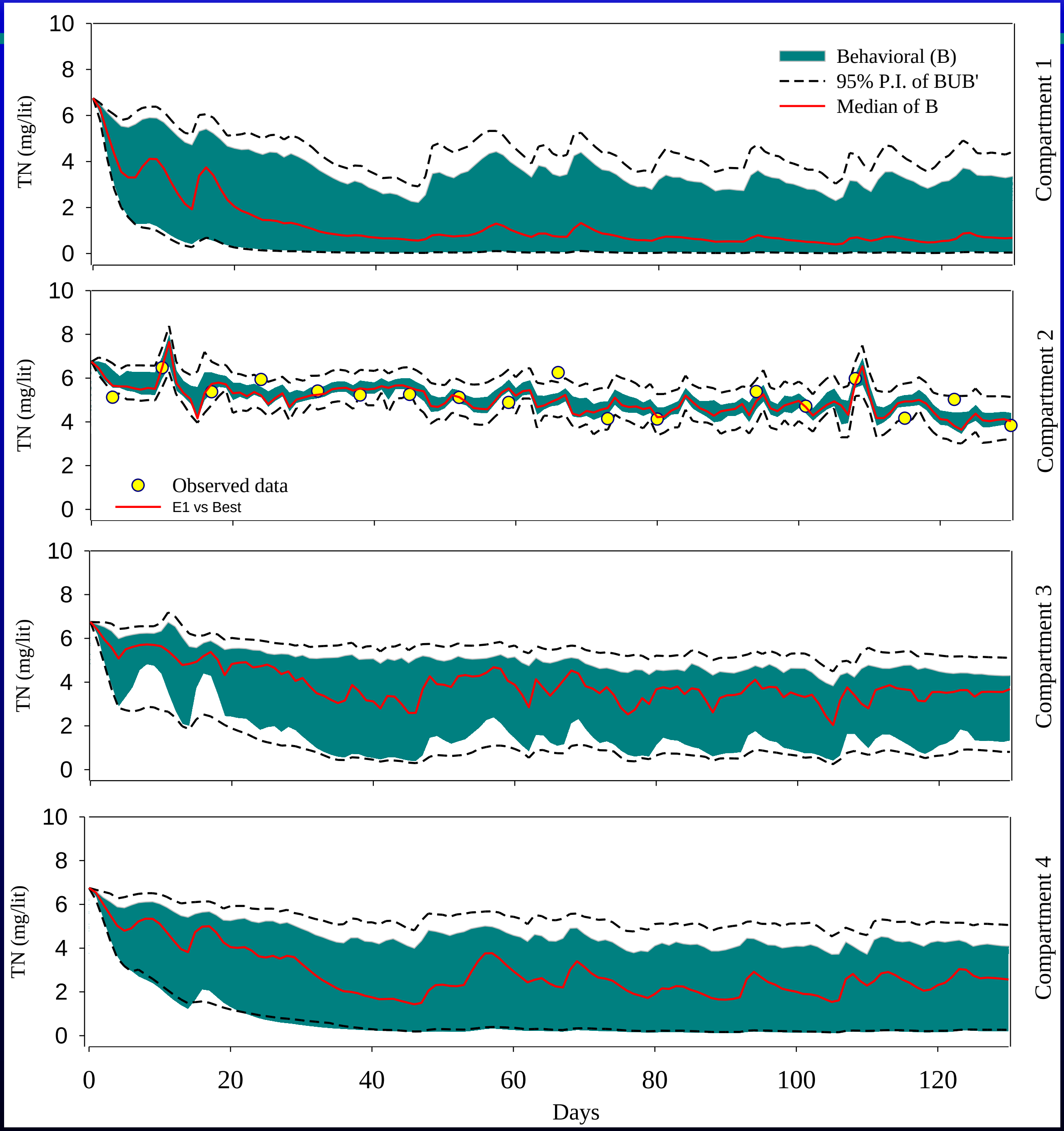
Case study application: Compartmental Version



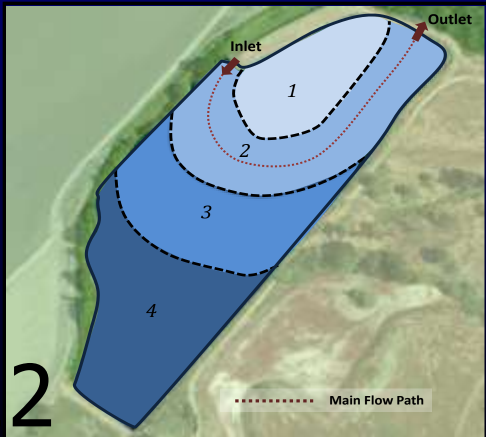
Study wetland located on west side of the San Joaquin River in California's Central Valley. Redrawn from Maynard et al. (2011)

Area = 4.4 ha
Receives irrigation tail-water from about 2300 ha of upstream farmlands

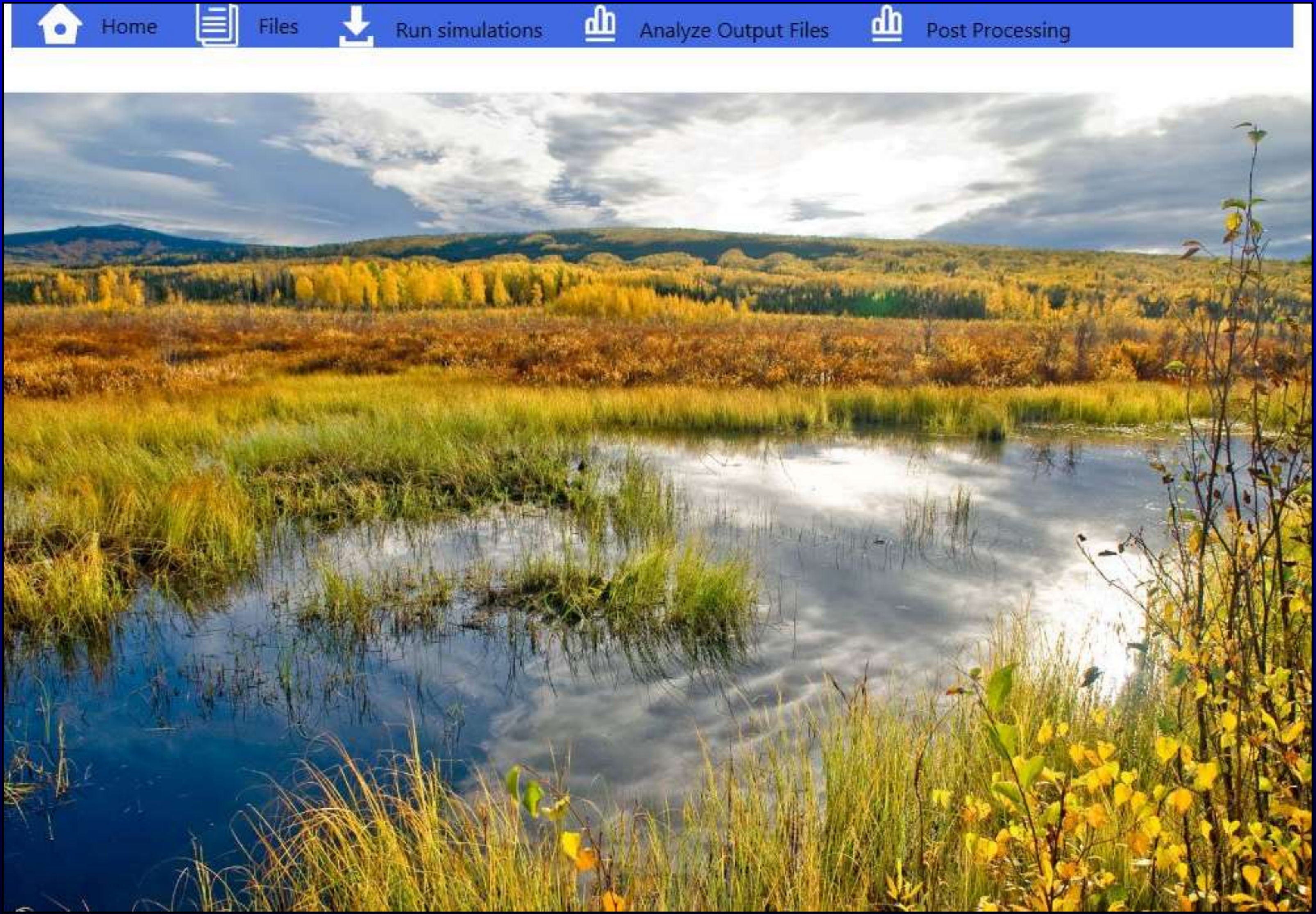
Uncertainty analysis -TN



Decrease in concentration



Graphical User Interface (GUI)



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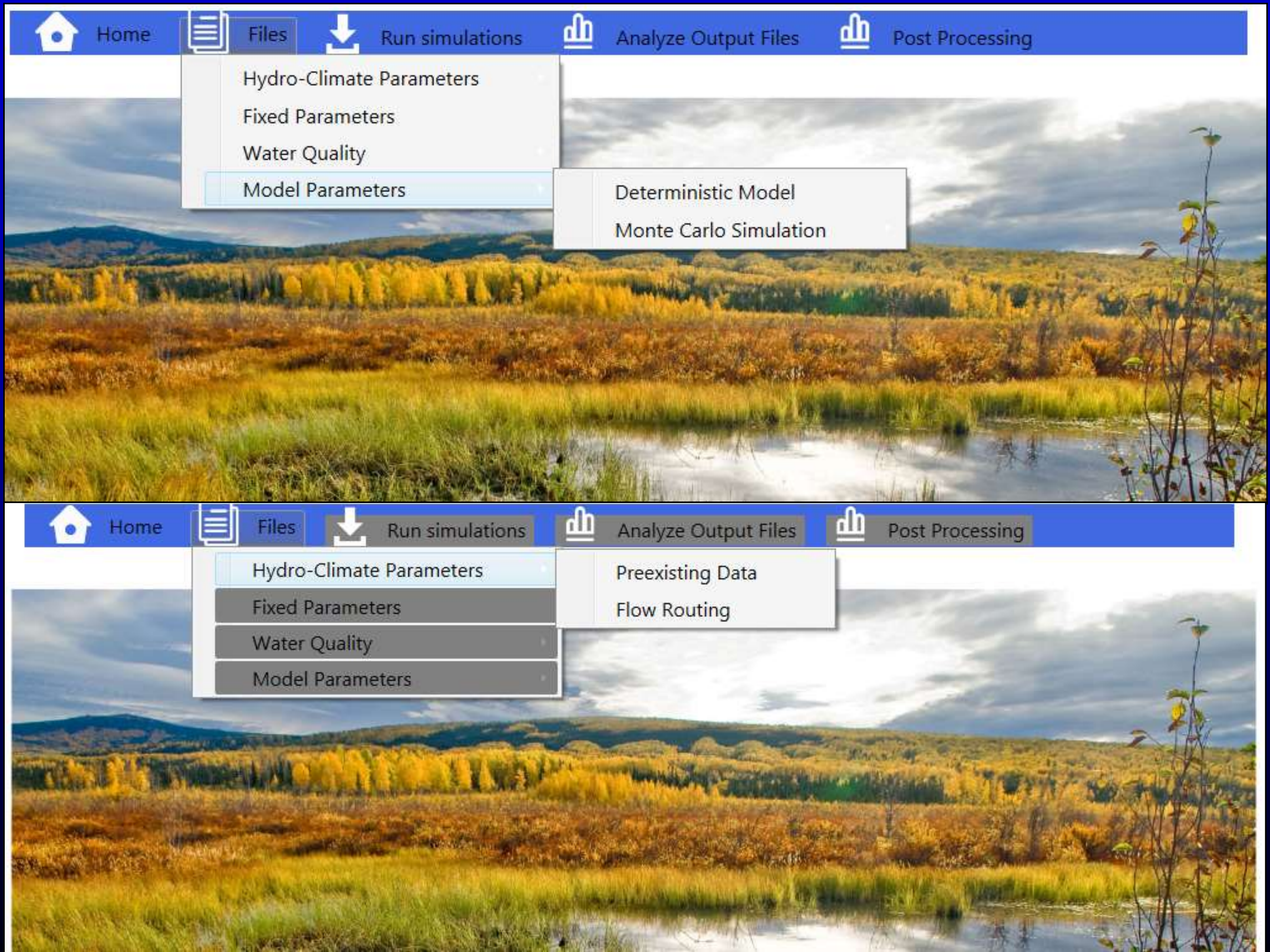
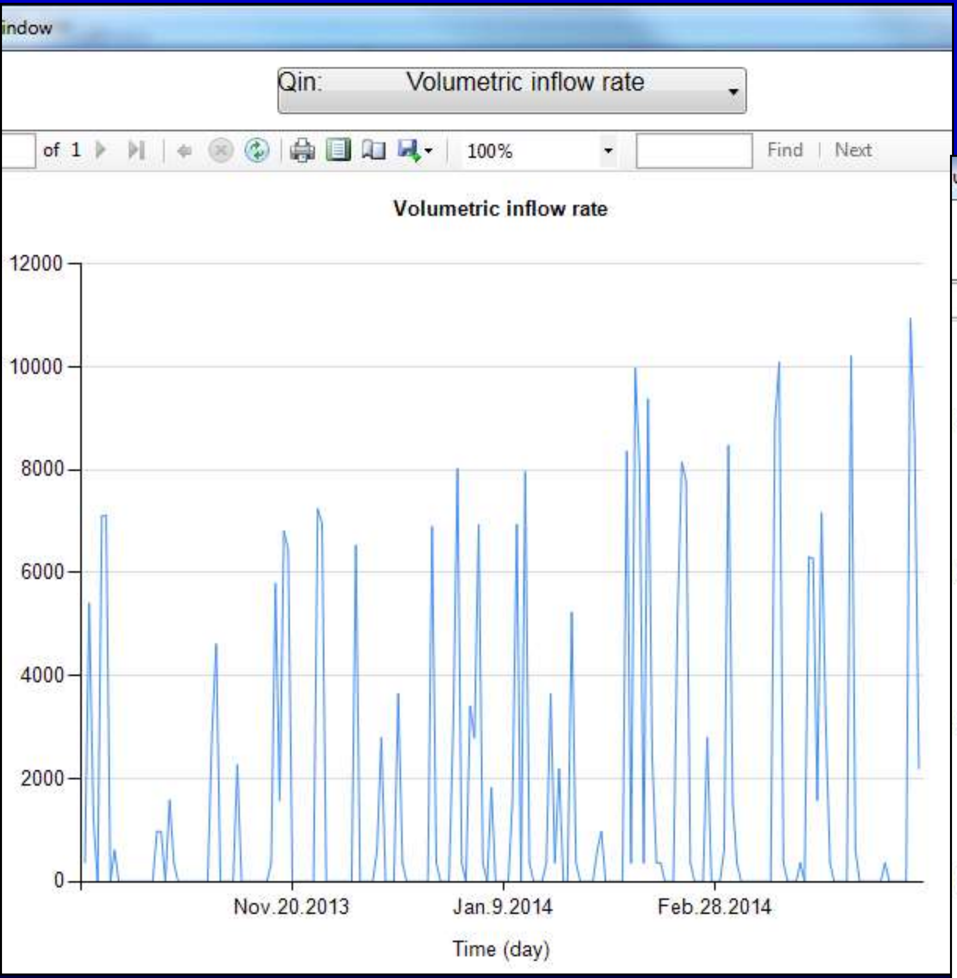
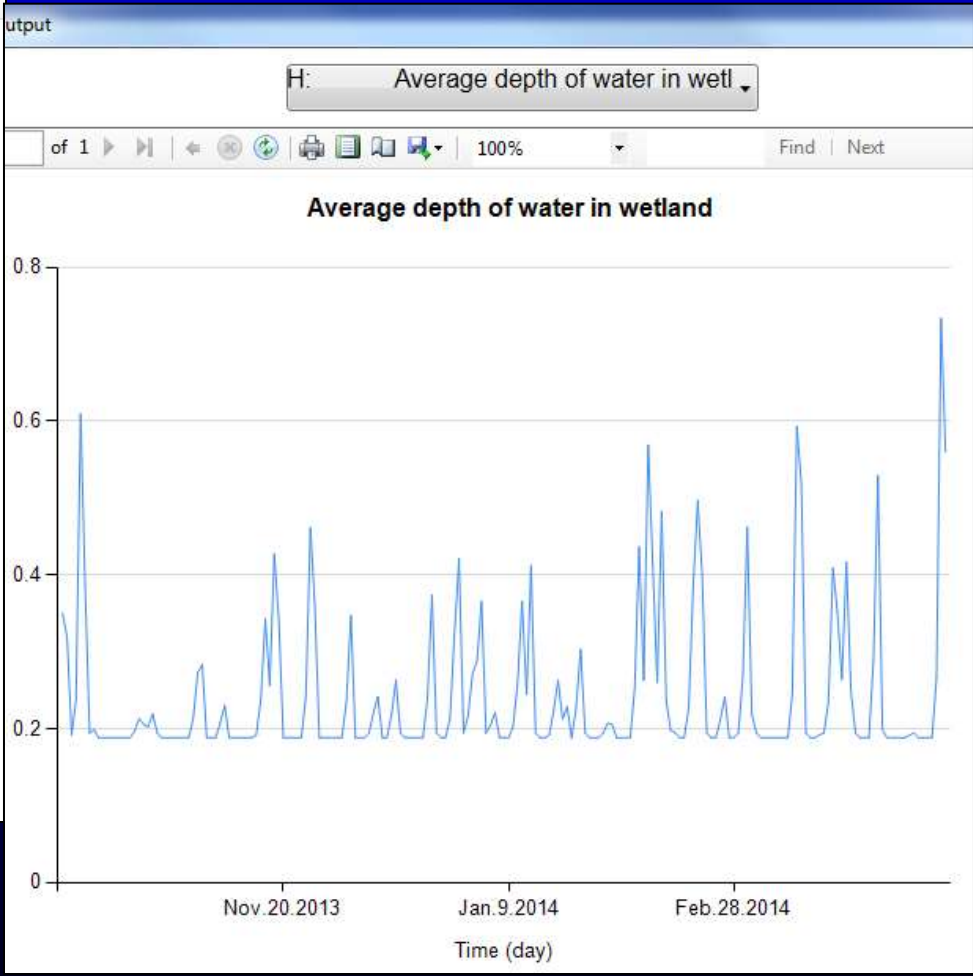
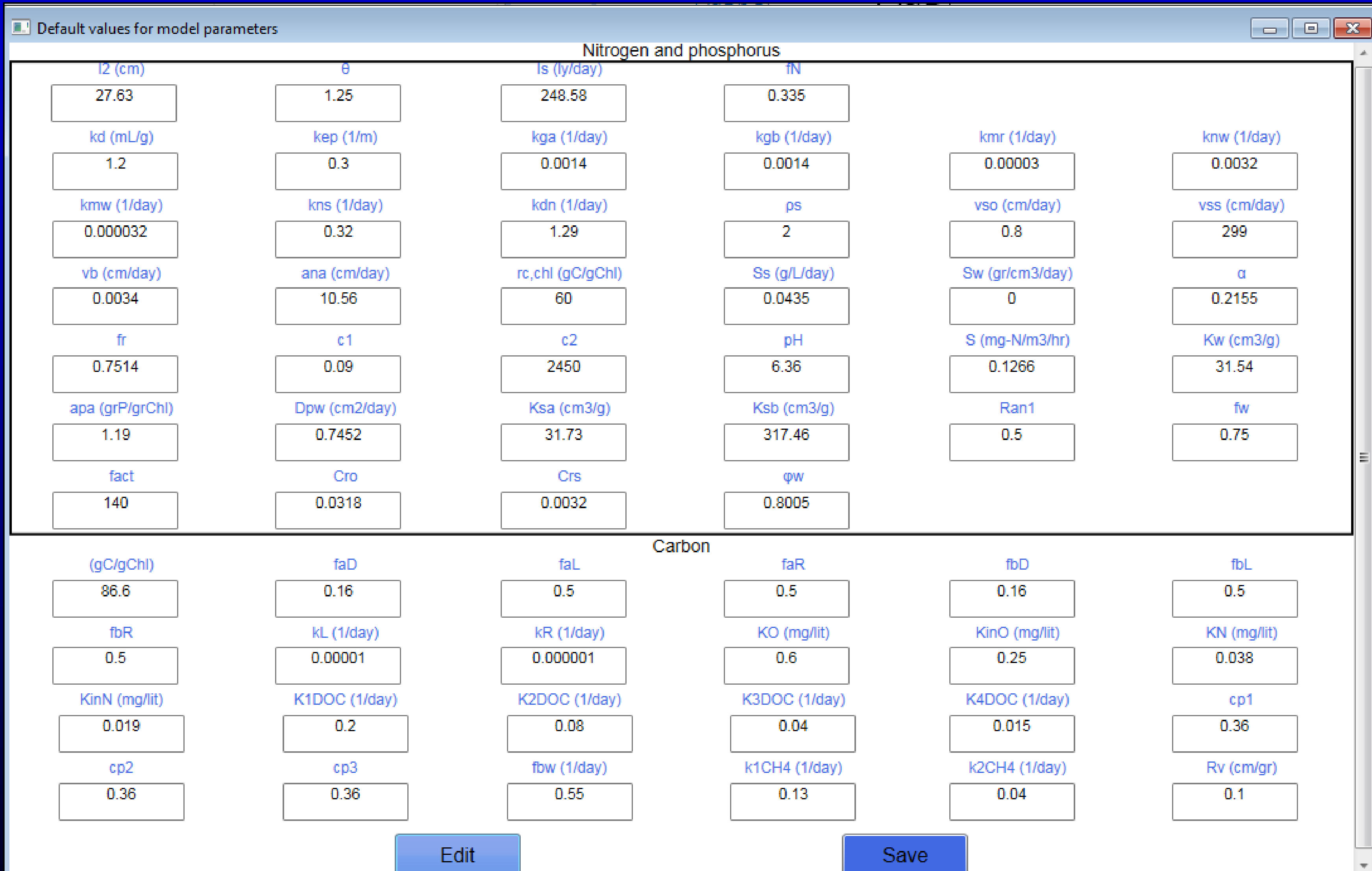


GUI: Visualization





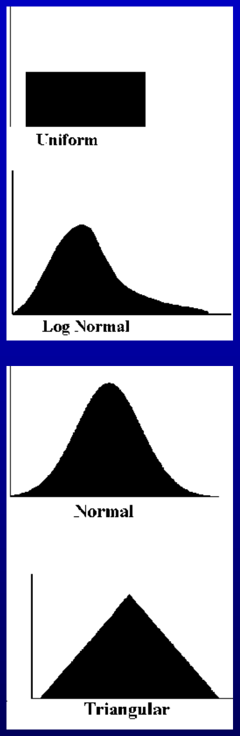
GUI: Deterministic



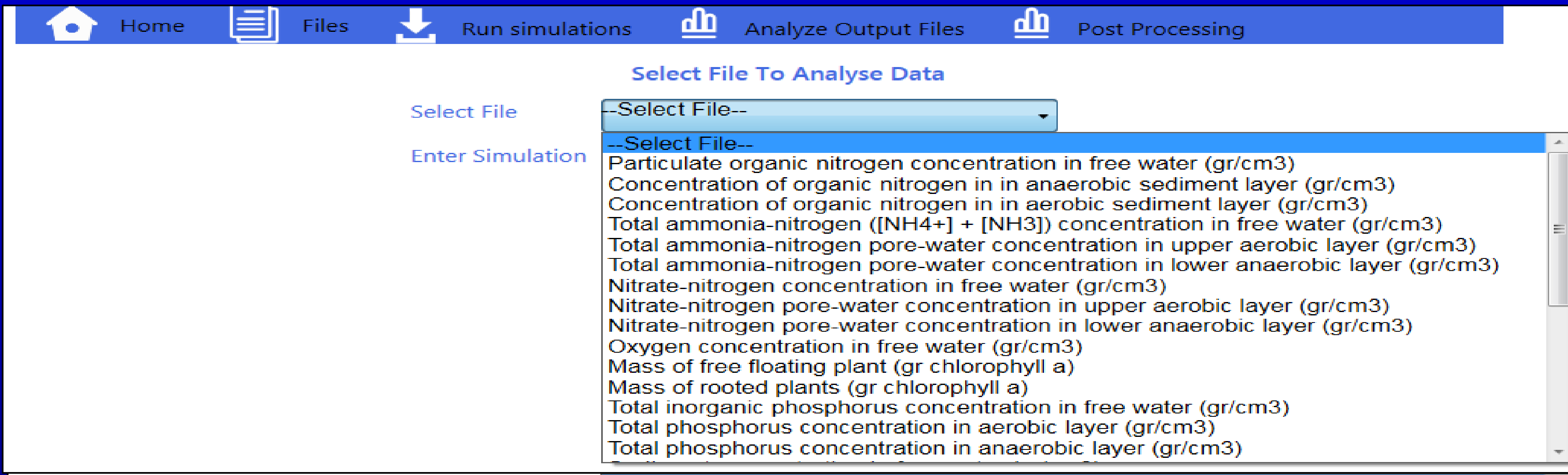
GUI: Monte Carlo Simulation

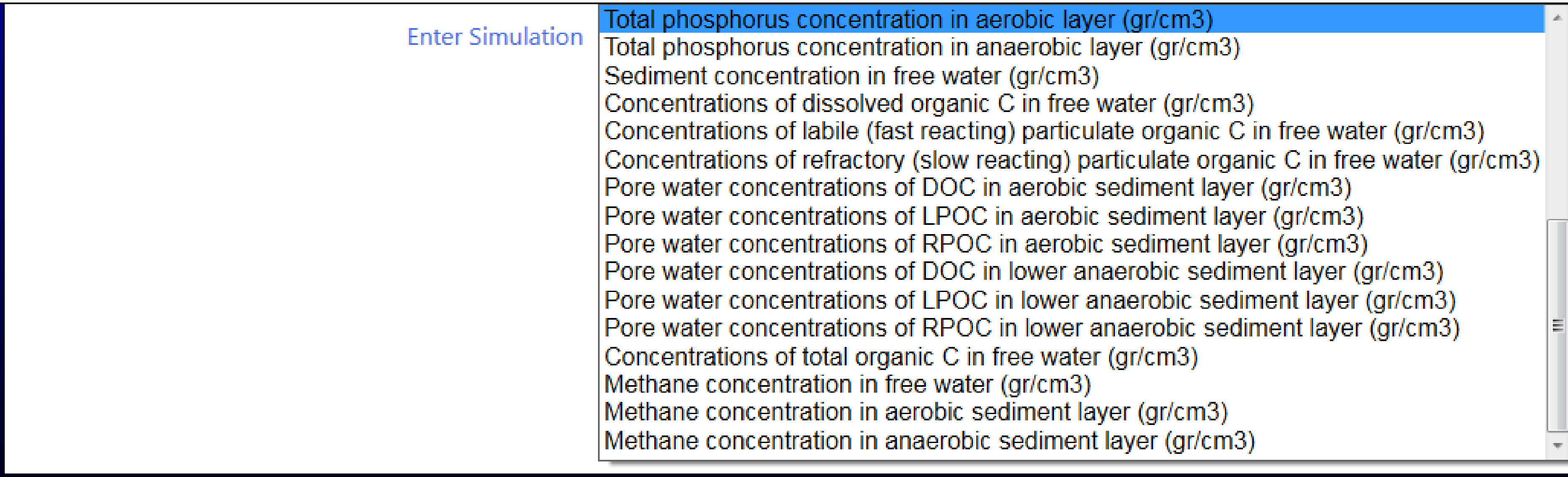
monte

Parameters	Distribution	Min (or mu)	Max (or sigma)	"c" in Triangular dist
l2 (cm)	Uniform	5	50	5
θ	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





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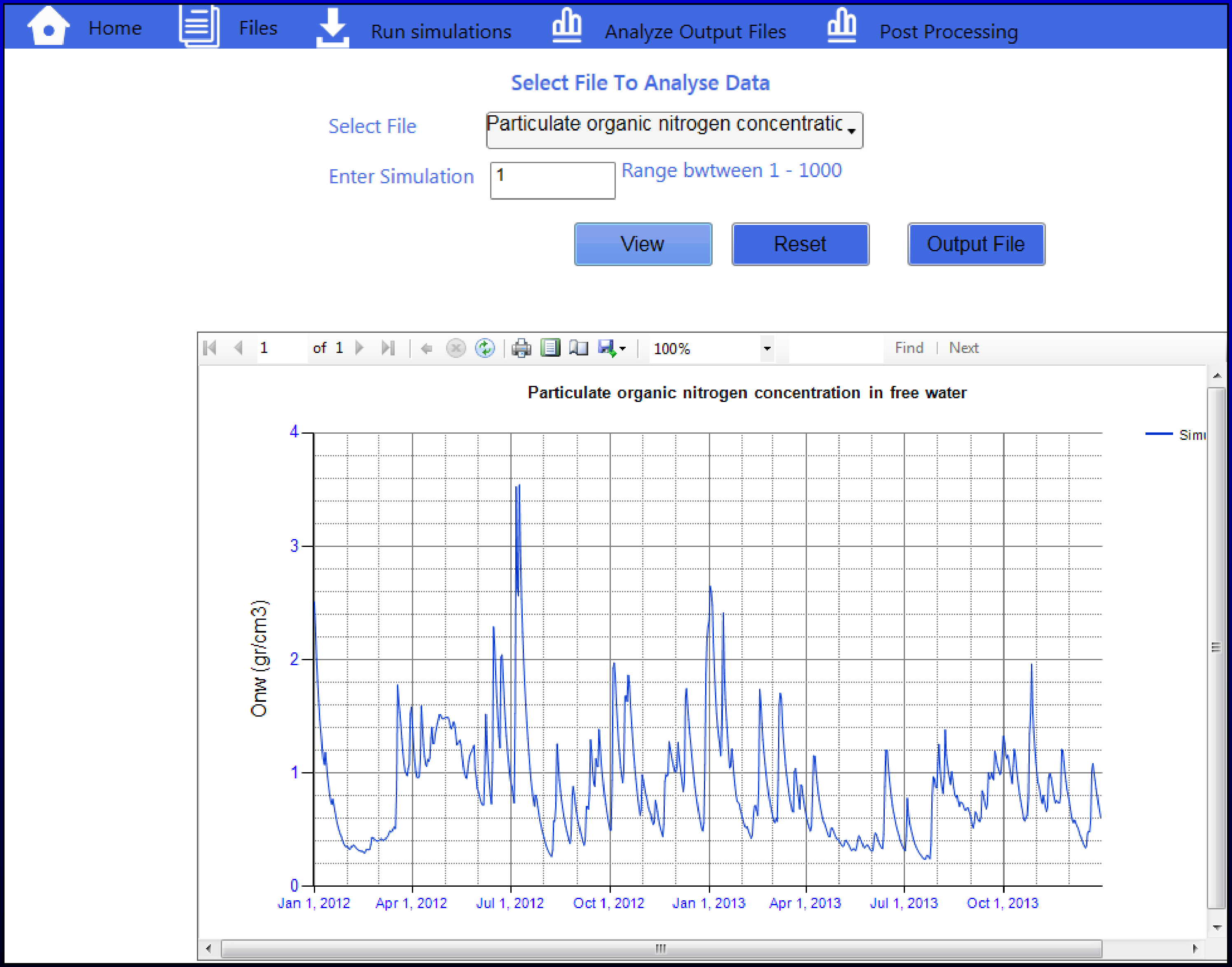

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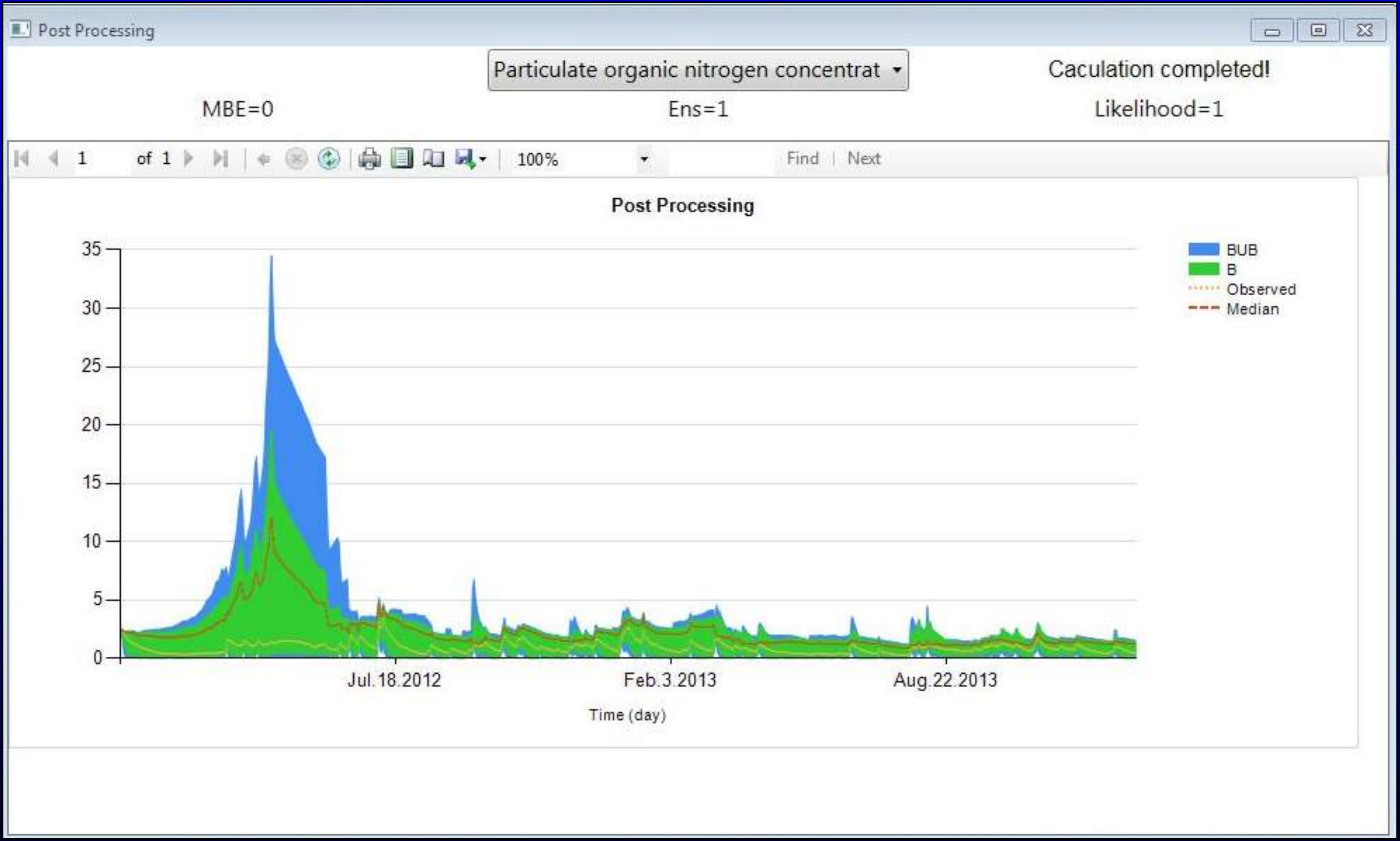

Release

- Oct ’15: Internal Testing
- Nov ‘15: External Testing
- May ‘16: Final Release and Distribution on 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.