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Arthur R. Marshall Loxahatchee National Wildlife Refuge

Hydrodynamic & Water Quality Model Selection Report

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Introduction

This report discusses the selection of a hydrodynamic-water quality model for the Arthur R. Marshall Loxahatchee National Wildlife Refuge. The refuge is composed of 147,392 acres of Everglades habitat. It is part of a large fresh water storage area connected by a series of canal and levees. According to the Comprehensive Conservation Plan for the refuge: "Water quality, quantity and delivery timing affect the welfare of fish, wildlife and plants…Because the Everglades is no longer a free-flowing system that relies on temporal weather patterns to sustain it, humans must now attempt to provide water when and where the system can most benefit". The refuge is impacted by elevated concentrations of nutrients, particularly phosphorous, in pumped stormwater. Such nutrients enhance the growth of non-indigenous and invasive species to the detriment of native species (Comprehensive Conservation Plan for the refuge). It is a priority for the refuge to better understand and minimize the impacts of this excessive nutrients loading. The use of detailed numerical model will provide a quantitative framework for management decisions related to refuge inflow and outflow of water and nutrients.

When fully calibrated and validated, the selected model should assist in answering questions and provide information such as those listed below

- What is the impact of different management scenarios on the water distribution inside the refuge?
- Which management scenarios will cause portions of the refuge to dry out and for how long? In other words what is the impact of the management scenarios on the hydro-period?
- Does the water depth (duration and frequency) satisfy the needs of plants and wildlife?
- What are the spatial and temporal distributions of phosphorus levels within the refuge?
- What are the impacts of management decisions and strategies on the water quality?
- What are the impacts of alternative regulation schedules on the water quantity and quality in the refuge?
- What are the effects of the surface-groundwater interactions on the refuge?
- How does the surface and ground water interact in the refuge?

Model Selection

Twenty-five models or combination of models were considered for this modeling effort. To be included in this list, available models had to meet one or more of the following criteria:

- The model has capabilities for simulating hydrodynamics and transport processes.
- The model has capabilities for simulating water quality processes.
- The model is available and documented through manuals, publications and/or user guides.

The 25 models or combination of models included in the evaluation are:

1. DMSTA
2. CE-QUAL-R1
3. CE-QUAL-W2
4. LOWQM
5. WQRRS
6. Mike 3
7. WASP 6 – DYNHYD5
8. Wetlands/WASP 6 _ EFDC
9. HSPF
10. H3D
11. TELEMAC
12. HEM -3D – EFDC
13. Mike Flood
14. RCA
15. ECOMSED
16. SSIIM
17. ELM
18. CCHE-2D, -3D, -WQ
19. GLEAMS
20. BLTM
21. SFRSM
22. MODHMS
23. Mike SHE
24. SWAT
25. FTLOADDS

Model Evaluation Sheet

A model evaluation sheet was designed in order to simplify and standardize the evaluation. Each of the identified models was reviewed, and the key information was summarized in the respective model sheet (see Attachment A: Model Evaluation Sheet, Model No. 1 through Model No. 25).

The model evaluation sheet divides the model information in three major components:

A) Hydrodynamics

Spatial Dimension: identifies the spatial dimension of the model, e.g., one dimensional (1D), two-dimensional (2D), or three-dimensional (3D)

Time Dimension: identifies whether or not the model simulates time-varying (unsteady) conditions, and what are the limitations, e.g., only daily variations, monthly variations, etc.

Model Characteristics: provides an overview of the hydrodynamic features in the models, e.g., what is the numerical method/scheme used in the model.

Wetting and Drying: identifies whether or not the model is able to simulate flooding and drying processes.

Ground Water Flow: identifies the ability of the model for simulating surface-groundwater interactions.

Additional Information: provides additional key information about hydrodynamics features in the model.

B) Water Quality

Components: identifies the main components of the water quality module in the model.

Vegetation: identifies the type of vegetation included in the water quality module. It indicates when the model is able to simulate nutrients plant uptake and plant growth.

Soil: identifies the ability of the model for simulating nutrients transformation in the soil, and soil –water column interactions.

Additional Information: provides additional key information about water quality features in the model.

C) General Information

Public Availability: identifies the availability of the model for use and distribution.

Run Time: identifies whether or not it is possible to run long-term simulations with a reasonable execution time. It should be emphasized that our judgment is somewhat subjective since we did not perform a true comparative testing for all the models in a single platform. Therefore, the information listed is based on either on our own experience or gathered from developers or users.

Acceptance: identifies the general acceptance of the model within the professional community based on factors such as: prior peer-reviewed publications, adopted by agencies, successful applications to similar projects.

Documentation: indicates the availability of model documentation through user manuals, publications and/or other technical documents.

Pre/Post Processor: indicates the availability of pre/post-processing modules.

Contact Information: identifies contact person and location information for model information, procurement, and technical support.

Platform: indicates the model platform, e.g., Windows, Linux, etc.

Technical Support: indicates the availability of technical support for the model.

Source Code: identifies whether or not the source code is available, and what programming language it is based on.

Other Model Features: provides any key information that was not included in the previous sections.

Other Capabilities: lists additional capabilities that may be important for the refuge application.

Limitations: summarizes the technical or practical limitations that were not explicitly indicated in the previous sections.

It should be emphasized that it was challenging to collect all the aforementioned information for each of the 25 models. For certain models, if the information was not readily available in published reports or papers, considerable effort was devoted to personally contact the developers to complete the forms as much as possible. We were unable to completely fill the forms for all the models. However, we believe the information gathered is sufficient and adequate to select a model (or two) for the proposed modeling effort.

Model Selection Criteria

It is crucial to ensure that the model selection is guided by the project objectives. A summary of the project objectives is provided below:

- Provide the best available technical support for management decisions related to refuge inflow and outflow quantity and quality.
- Provide projections of water movement and water quality resulting under alternative scenarios of structure operation, treatment performance, and structural changes within the refuge.
- Provide a quantitative platform for analysis of causes of elevated phosphorus events.

Based on these objectives, the research team designed the following system to evaluate the candidate models. It should be noted that a computer model that fully satisfy all the requirements might not be readily available. Therefore, some compromise among the selection criteria will almost certainly be required. It is anticipated that some customization and formulation improvements will be needed. However, due to time and budget constraints, it is highly desirable to minimize code development effort.

Based on the project objectives, we established essential and desirable features. The essential features must exist in the selected model(s). A summary of the essential and desirable features are listed below:

A) Essential Features

- The model must have at least a 2-D (depth averaged) fully dynamic surface flow module. A 1-D model is not suitable for this application. A 3-D model may not be needed but is not detrimental, unless it severely impacts the execution speed.
- The model must be able to simulate wetting and drying phenomena. This is a crucial component. Since it is challenging to develop and fully test a robust module for wetting and drying, any model that does not have such feature available should not be selected.
- The model must have either a water quality module, or at least user-defined reactive transport module.
- The model must have a groundwater module, preferably simulating both the vertical and horizontal movements.

B) Desirable Features

- The model should have good pre/post processing modules.
- The model should have documentation that includes theoretical background, input and output formats, and any pre and post processors.
- The investigators should have at least partial access to the source code to implement improvements to the formulation especially to the water quality module.
- The model should have availability of technical support from developers, experienced staff, or other users.

In summary, the most appropriate model for this project should have as many of essential and desirable features as possible in order to minimize the development effort.

Preliminary Evaluation Results

Table 1 shows a comparison for 24 models (the RCA and ECOMSED were considered as a combined model) relative to the essential and desirable features listed above. This table also indicates the number of essential and total criteria met by each model. The preliminary evaluation led to identifying the following models as primary candidates. Final decision on one or two models should be reached after the January 28th meeting.

- Model # 8: WASP 6 – EFDC
- Model # 10:H3D
- Model # 11:TELEMAC
- Model # 17:ELM
- Model # 13+23:MIKE SHE + MIKE FLOOD
- Model # 25:FTLOADDS

Table 1. Model Selection Matrix

Model (rows) / Criteria (columns)		Essential Features				Desirable Features				Summary			
		1	2	3	4	5	6	7	8	Number of Criteria Met		Consider Further?	Comments
		2D or 3D Hydrodynamics	Wetting and Drying	Water Quality/Transport Module	Ground Water Flow	Pre/Post Processing	Documentation	Open Source Code	Technical Support	Essential	Total		
1	DMSTA	X	⊖	●	⊖	●	●	●	?	2	5	No	1-D Model
2	CE-QUAL-R1	X	X	●	⊖	●	●	●	⊖	1.5	5	No	1-D Model
3	CE-QUAL-W2	X	?	●	?	⊖	●	●	⊖	1.5	4	No	2-D laterally average
4	LOWQM	X	?	●	?	●	⊖	?	?	1	----	No	The model is under development
5	WQRRS	X	X	●	?	⊖	●	?	?	1	----	No	1-D Model
6	MIKE 3	●	●	●	X	●	●	X	●	3	6	No	Proprietary model, the source code is not public and it does not include groundwater
7	WASP 6-DYNHYD5	X	X	●	X	●	●	●	●	1	5	No	1-D Model
8	Wetlands/WASP 6 - EFDC	●	●	●	⊖	⊖	●	●	⊖	3.5	6.5	Yes	WQ may need additional development for the application
9	HSPF	X	⊖	●	●	⊖	●	●	⊖	2.5	5.5	No	Surface flow is not fully dynamic
10	H3D	●	●	●	⊖	⊖	⊖	●	●	3.5	6.5	Yes	WQ needs additional development for the application. Fast model
11	TELEMAC	●	●	●	⊖	●	●	⊖	⊖	3.5	6.5	Yes	WQ may need additional development for the application. Unstructured grid
12	HEM -3D - EFDC	●	●	●	⊖	⊖	●	●	⊖	3.5	6.5	No	WQ module has not been fully tested, and may need additional development
13	MIKE FLOOD	●	●	●	X	●	●	X	●	3	6	No	Proprietary model, the source code is not public and it does not include groundwater
14-15	RCA - ECOMSED	●	X	●	⊖	⊖	●	●	●	2.5	6	No	wetting and drying is not implemented. Relatively slow model

● Criterion fully met (one point)
⊖ Criterion partially met (0.5 point)
X Criterion is not met (no point)
? No information

Cont. Table 1. Model Selection Matrix

Model		Essential Features				Desirable Features				Summary			
	Criteria	1	2	3	4	5	6	7	8	Number of Criteria Met		Consider Further?	Comments
		2D or 3D Hydrodynamics	Wetting and Drying	Water Quality/Transport Module	Ground Water Flow	Pre/Post Processing	Documentation	Open Source Code	Technical Support	Essential	Total		
16	SSIIM	●	●	●	?	●	●	●	X	3	6	No	There are relevant-new implemented algorithms that are not fully tested
17	ELM	⊖	●	●	●	●	⊖	●	⊖	3.5	6.5	Yes	The model has been applied to adjacent areas to the Loxahatchee Refuge
18	CCHE-2D,- 3D, -WQ	●	●	●	?	●	●	?	?	3	5	No	The CCHE-WQ module is currently being tested
19	GLEAMS	X	⊖	⊖	●	●	●	●	?	2	5	No	The WQ module is too limited for the application
20	BLTM	X	X	●	X	●	●	●	?	1	4	No	1-D Model
21	SFRSM	⊖	?	●	●	X	⊖	⊖	?	2.5	3.5	No	Diffusion flow approximation. The model is under development
22	MODHMS	⊖	●	?	●	●	●	X	●	2.5	5.5	No	Diffusion wave approximation of 2-D surface flow. Proprietary model
23	MIKE SHE	⊖	●	⊖	●	●	●	X	●	3	6	Yes*	Diffusion wave approximation of 2-D surface flow. Needs to be linked to WQ model. Proprietary model
24	SWAT	X	⊖	●	●	●	●	●	?	2.5	5.5	No	Surface flow is not fully dynamic. Complete WQ model
25	FTLOADDS	●	●	⊖	●	⊖	●	●	⊖	3.5	6.5	Yes	Requires development of the WQ module

* Will be consider in combination with MIKE FLOOD

● Criterion fully met (one point)

X Criterion is not met (no point)

⊖ Criterion partially met (0.5 point)

? No information

Attachment A: Model Evaluation Sheets

Model No. 1 to Model No. 25

Model Evaluation Sheet

Model No. 1: DMSTA (Dynamics Model for Stormwater Treatment Areas)

Component A: Hydrodynamics

Dimension	Spatial:	1D longitudinal	Time:	Daily variations
Model Characteristics	Simple Hydrodynamic Model; uses wetland treatment cells divided in CFSTRs for reaction. Includes simple reservoir model			
Wetting and Drying	Dry out frequency and supplemental water needs		Ground Water Flow	Seepage in - out
Additional Information	Can Simulate up to 6 cells			
Water Balance: In flow, bypass, rainfall, ET, outflow, seepage in-out				

Component B: Water Quality

Components	Phosphorus (P), P load reaction of wetlands
Vegetation	It is included. Parameter estimation for various types
Soil	
Additional Information	The phosphorus removal performance of stormwater treatment areas (STAs) have been evaluated using DMSTA
Can not model P removal by particle settling, biological uptake and net refractory biomass storage, or chemical precipitation. Can not model release of P from sediments.	

Component C: General

Public Availability	Available	Contact Information	William Walker; wwwalker.net/dmsta
Run Time	Computationally Efficient - Fast	Platform	Excel
Acceptance	Wide	Technical Support	No information
Documentation	Available - Complete	Source Code	Available
Pre Processor	Excel Spreadsheet/macros	Post Processor	Spreadsheet
Other Model Features	Currently used in the evaluation of STAs.		
Other Capabilities	Easy to use, simple dynamics with limited number of parameters		
	Calibrated to a very large number of wetland systems similar to the refuge		
Limitations	20% standard error for predicted outflow TP		

Model Evaluation Sheet

Model No. 2: <u>CE-QUAL-R1</u>

Component A: Hydrodynamics

Dimension	Spatial:	1D vertical	Time:	Varying
Model Characteristics	Simple hydrodynamic model. Flux model with vertical sequence of horizontal layer			
Wetting and Drying	It is not included		Ground Water Flow	Possible
Additional Information	Simulation of surface flows, interflows and underflow are possible			

Component B: Water Quality

Components	Can model up to 27 variables and 11 materials in sediments, including P, nitrogen (N) and dissolved oxygen (DO)
Vegetation	Phytoplankton and macrophytes
Soil	
Additional Information	Can simulate water quality (WQ) problems associated with reservoir eutrophication
Complete N & P Cycling models	

Component C: General

Public Availability	Available	Contact Information	Dorothy Tillman, http://smig.usgs.gov
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	Limited
Documentation	Available - Complete	Source Code	Available
Pre Processor	Available	Post Processor	Available – Graphics tool
Other Model Features	Good surface heat exchange and DO sub-models		
Other Capabilities	Includes anoxic-anaerobic conditions. Uptake-excretion kinetics and regeneration of P and N under both aerobic and anaerobic		
Limitations	It is strictly a reservoir model		

Model Evaluation Sheet

Model No. 3: CE-QUAL-W2

Component A: Hydrodynamics

Dimension	Spatial:	2D longitudinal - vertical	Time:	Varying
Model Characteristics	Implicit finite difference (FD) scheme, laterally averaged equations of momentum, continuity and transport			
Wetting and Drying	No information		Ground Water Flow	No information
Additional Information	The model predicts water surface elevations. Used in lakes, reservoirs, and estuaries			

Component B: Water Quality

Components	Can model up to 22 parameters, including P, nitrogen (N) and dissolved oxygen (DO)
Vegetation	Phytoplankton
Soil	
Additional Information	Can simulate water quality (WQ) problems associated with reservoir eutrophication
Complete N & P Cycling models	

Component C: General

Public Availability	Available	Contact Information	Thomas Cole; www.wes.army.mil/el/elmodels
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	Limited
Documentation	Available - Complete	Source Code	Available
Pre Processor	Beta Development	Post Processor	Needs to be developed for graphics
Other Model Features	Multi-branches is possible, variable grid spacing		
Other Capabilities	Surface wind stress, long-term simulations		
	Hotstart, autostepping		
Limitations	Does not include macrophytes		
	Requires knowledge of hydrodynamics, chemisty, aquatic biology		

Model Evaluation Sheet

Model No. 4 LOWQM (Lake Okeechobee Water Quality Model)

Component A: Hydrodynamics

Dimension	Spatial:	One stirred tank plus benthos	Time:	Dynamic
Model Characteristics	In-lake water movement can be simulated by a separate hydrodynamic model			
Wetting and Drying	No information		Ground Water Flow	No information
Additional Information				

Component B: Water Quality

Components	Uses WASP to simulate eutrophication in both water and sediments
Vegetation	Algae
Soil	Include sediment resuspension based on hydrodynamic model
Additional Information	Lake water model
Modified WASP by including three algae groups instead of one	

Component C: General

Public Availability	Under Development	Contact Information	Thomas James; tjames@sfwmd.gov http://www.sfwmd.gov/org/wrp/wrp_okee/projects/lowqm.html
Run Time	No information	Platform	Windows
Acceptance	No information	Technical Support	No information
Documentation	Partial	Source Code	No information
Pre Processor	WASP interface	Post Processor	Post-processing graphics routines
Other Model Features			
Other Capabilities	Same WASP capabilities		
	Models sediment resuspension		
Limitations	Model is currently under development		

Model Evaluation Sheet

Model No. 5: WQRRS (Water Quality for River-Reservoir Systems)

Component A: Hydrodynamics

Dimension	Spatial:	1D longitudinal	Time:	Steady and unsteady	
Model Characteristics	One-dimensional representation of reservoirs and the stream hydraulic module routes flow using different methods				
Wetting and Drying	It is not included			Ground Water Flow	No information
Additional Information	1D representation of well-mixed reservoir and longitudinal conditions in river networks				

Component B: Water Quality

Components	Reservoir and stream WQ modules; can simulate 18 different parameters, including P, N and O
Vegetation	Phytoplankton and benthic algae
Soil	
Additional Information	Can simulate water quality (WQ) problems associated with reservoir eutrophication
In the stream quality module the rate of transport of quality parameters can be represented for aerobic streams, and peak pollutant loads into the steady or unsteady hydraulic environment can be simulated.	

Component C: General

Public Availability	Available	Contact Information	HEC USACE
Run Time	No information	Platform	DOS
Acceptance	Wide	Technical Support	No information
Documentation	Available	Source Code	No information
Pre Processor	Available	Post Processor	No information
Other Model Features	Flow and WQ can be simulated for stream network, including branching channels and islands		
Other Capabilities	Includes weather data		
Limitations	Assumption of completely mixed for reservoirs, requires the assumption of instantaneous dispersion of all inflow quantities		
	Present minor errors in mass conservation		
	Limited to aerobic systems		

Model Evaluation Sheet

Model No. 6: Mike 3

Component A: Hydrodynamics

Dimension	Spatial:	3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic model, implicit ADI finite difference scheme of 2nd order accuracy			
Wetting and Drying	Flooding and drying is included		Ground Water Flow	It is not included
Additional Information	Includes different turbulence models			

Component B: Water Quality

Components	Nutrients and DO/BOD. Basic and extended eutrophication module
Vegetation	Algae, macro algae and benthic vegetation
Soil	Sediment nutrient flux model and sediment diagenesis
Additional Information	Complete N, P and phytoplankton cycles

Component C: General

Public Availability	Available	Contact Information	DHI; www.dhigroup.com
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	Available
Documentation	Available	Source Code	Not public
Pre Processor	Available - Included	Post Processor	Included – animated presentation
Other Model Features	Complete sediment transport module. Transport of suspended substance, including erosion, transport and deposition		
Other Capabilities	Modeling the transport of trace and dissolved substance, might include decay		
	Simulates heat exchange with the atmosphere, including evaporation and precipitation		
	Accepted by the US Federal Emergency Management Agency (FEMA)		
Limitations	Proprietary model		

Model Evaluation Sheet

Model No. 7: WASP 6 – DYNHYD5

Component A: Hydrodynamics

Dimension	Spatial:	DYNHYD5→1D	Time:	Unsteady
Model Characteristics	Simple hydrodynamic model, predicts water height and volumes			
Wetting and Drying	It is not included		Ground Water Flow	It is not included
Additional Information	The flow that defines advective transport can be supplied directly or calculated by a hydrodynamic model			
WASP6 might be linked to other 1D, 2D or 3D hydrodynamic models				

Component B: Water Quality

Components	WQ for aquatic systems including both the water column and the underlying benthos. Complete eutrophication module (WASP EUTRO module)
Vegetation	Benthos or benthic vegetation, algae
Soil	Benthic fluxes, accumulation in sediments. Sediment diagenesis
Additional Information	Complete N and P cycles, DO balance. Complete phytoplankton model
Used for WQ problems in ponds, streams, lakes, reservoirs, rivers, estuaries and coastal waters. Used for the development of TMDL	

Component C: General

Public Availability	Available	Contact Information	EPA; Wool.Tim@epamail.epa.gov
Run Time	Computationally Efficient - Fast	Platform	Windows
Acceptance	Wide	Technical Support	Available
Documentation	Available	Source Code	FORTRAN - Available
Pre Processor	Available - Included	Post Processor	Included – graphical presentation
Other Model Features	Used for the development of TMDL		
Other Capabilities	The eutrophication module can simulate some or all of the parameters		
	Includes flux for resuspension of heavy metals		
	Can be modified to include other reactions		
Limitations	Needs to be linked to a hydrodynamics model		
	The sediment diagenesis module is in development		

Model Evaluation Sheet

Model No. 8: Wetlands/WASP 6-EFDC (Environmental Fluid Dynamic Code)

Component A: Hydrodynamics

Dimension	Spatial:	EFDC→3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic model, finite difference Cartesian or curvilinear-orthogonal grid			
Wetting and Drying	EFDC can simulate wetting and drying		Ground Water Flow	Vertical Exchange
Additional Information	Computes changes in surface water elevation and horizontal movement that result from inflows and outflows to and from the wetland			
The hydrodynamics is affected by evaporation and precipitation, The model can include source/sink representing groundwater exchange or can include a soil moisture layer				

Component B: Water Quality

Components	Floating periphyton mat, water column, benthic periphyton mat, detrital litter layer, and a sediment layers. Eutrophication submodel
Vegetation	Uptake by periphyton and emergent vegetation
Soil	Sediment nutrient flux submodel and back flux
Additional Information	Complete N, P and DO cycles.
Dissolved and particulate nutrients. Includes temperature for WQ control	

Component C: General

Public Availability	Available	Contact Information	http://www.epa.gov/athens/wwqtsc/html/efdc.html John Hamrick, Tetra Tech
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	Partial
Documentation	Available	Source Code	EFDC is available
Pre Processor	EPA BASINS (in development)	Post Processor	EPA BASINS (in development)
Other Model Features			
Other Capabilities	Includes chemical and atmospheric precipitation for P and others (chemical sub-model)		
	The vegetation model considers above- and below-ground biomass. Models the interactions between sediment nutrients, plant growth and plant nutrient composition		
Limitations	Floating and benthic periphyton mats, the litter layer and the sediment layers are fixed in space, and are not influenced by horizontal transport, only by vertical diffusion		

Model Evaluation Sheet

Model No. 9: HSPF (Hydrological Simulation Program – FORTRAN)

Component A: Hydrodynamics

Dimension	Spatial:	lumped spatial 2 D	Time:	Varying	
Model Characteristics	Can simulate hydrologic and WQ processes on pervious and impervious surface and in streams and well-mixed impoundments				
Wetting and Drying	Partial			Ground Water Flow	Included
Additional Information	The model produces a time history of the runoff flow rate, sediment load, nutrients and pesticide concentrations				
Overland flow is treated as a turbulent flow process. It is simulated using the Chezy-Manning equation and an empirical expression which relates outflow depth to detention storage. The outflow from active groundwater storage is based on a simplified model, it assumes that the discharge of an aquifer is proportional to the product of the cross-sectional area and the energy gradient of the flow					

Component B: Water Quality

Components	Nutrients cycling in watershed
Vegetation	Allows and optional yield-based method for simulating nutrient uptake by plant
Soil	Land and soil contaminant runoff processes with in-stream hydraulics and sediment-chemical interactions
Additional Information	Includes atmospheric deposition as a mass flux or as concentration in rainfall
The reaction processes included are hydrolysis, oxidation, photolysis, biodegradation, volatilization and sorption	

Component C: General

Public Availability	Available	Contact Information	h2osoft@usgs.gov; EPA; epa.gov
Run Time	Computationally Efficient - Fast	Platform	Windows
Acceptance	Wide	Technical Support	Limited
Documentation	Available	Source Code	FORTRAN - Available
Pre Processor	Available	Post Processor	Available
Other Model Features	Includes resuspension of silts and clay		
Other Capabilities	Includes heat exchange and evapotranspiration modules		
	The stream channel simulation includes flow routing and oxygen and nutrients biochemical modeling (through phytoplankton)		
	Is able to simulate point and non-point sources, is integrated into the EPA BASINS GIS based modeling support system		
Limitations	Assumes that the receiving water body is well-mixed		

Model Evaluation Sheet

Model No. 10: H3D

Component A: Hydrodynamics

Dimension	Spatial:	3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic-free surface model. Finite difference model, second order accurate in time			
Wetting and Drying	Wetting and drying is included		Ground Water Flow	Vertical exchange
Additional Information	The model is semi-implicit, so that relatively large time steps can be used. H3D economizes in storage by storing only active cells			
The model can use Cartesian or curvilinear-orthogonal grids. The model conserves scalar quantities in flooding and drying process.				

Component B: Water Quality

Components	Dissolved/suspended substances with a source term for reaction.
Vegetation	Algae
Soil	
Additional Information	Eutrophication module

Component C: General

Public Availability	Available	Contact Information	J.A. Stronach; stronach@hayco.com. E. Meselhe, meselhe@louisiana.edu
Run Time	Computationally Efficient - Fast	Platform	Windows/DOS/ Linux/Unix
Acceptance	Wide	Technical Support	Available
Documentation	Partial	Source Code	FORTRAN - Available
Pre Processor	Partial	Post Processor	Tecplot output
Other Model Features	Complete sediment transport module and sediment settling module		
Other Capabilities	Simulates heat exchange with the atmosphere		
	Includes wind and density effects		
	Can include dry cells in the computational domain		
Note	Investigators are familiar with the model		
Limitations	Tecplot is a proprietary software, but it is not expensive		

Model Evaluation Sheet

Model No. 11: TELEMAC

Component A: Hydrodynamics

Dimension	Spatial:	2D, 3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic – free surface model. Finite element model			
Wetting and Drying	Flooding and drying is included		Ground Water Flow	Vertical exchange
Additional Information	Different turbulence models are available. The model has the flexibility of an unstructured grid of triangular elements, which			
means that it can be easily refined particularly in areas of special interest				

Component B: Water Quality

Components	Dissolved/suspended substances with a source term for reaction. Includes a eutrophication module
Vegetation	phytoplankton
Soil	Fluxes can be included: flux of erosion, and flux of deposition on benthic conditions
Additional Information	The model has been extended to include reactive processes

Component C: General

Public Availability	Available	Contact Information	CHC; www.telemacsystem.com
Run Time	Relatively slow/ Fully Parallelized	Platform	Windows
Acceptance	Wide	Technical Support	Available. The response time is slow
Documentation	Available	Source Code	Partial
Pre Processor	Available - Included	Post Processor	Included – animated presentation
Other Model Features	Complete sediment transport module and sediment settling module. Includes sediment consolidation		
Other Capabilities	Includes wind and density effects		
	Simulates heat exchange with the atmosphere		
	Can include dry cells in the computational domain		
Note	Investigators are familiar with the model		
Limitations	Proprietary model		

Model Evaluation Sheet

Model No. 12: HEM-3D - EFDC

Component A: Hydrodynamics

Dimension	Spatial:	EFDC→2D, 3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic – free surface model. Finite difference model.			
Wetting and Drying	Flooding and drying is included		Ground Water Flow	Vertical exchange
Additional Information	It's very computationally efficient, it economizes in storage by storing only active cells			
Sigma vertical coordinate system, and Cartesian or curvilinear-orthogonal grid				

Component B: Water Quality

Components	Complete eutrophication model
Vegetation	Algae
Soil	Sediment nutrient flux model and sediment diagenesis
Additional Information	Complete N, P, DO and phytoplankton cycles
Includes refractory particulate, labile particulate, and dissolved organic P and TPO4	

Component C: General

Public Availability	Available	Contact Information	Virginia Institute of Marine Sciences; boon@vims.edu
Run Time	No information	Platform	UNIX or DOS
Acceptance	Wide	Technical Support	Partial
Documentation	Available	Source Code	EFDC is Available
Pre Processor	EPA BASINS (in development)	Post Processor	EPA BASINS (in development)
Other Model Features	Complete sediment transport module. Transport of suspended substance, including erosion, transport and deposition		
Other Capabilities	Includes wind stresses and density effects. Includes transport equation for temperature		
	The HEM-3D model can be coupled with others hydrodynamic and sediment transport models		
Limitations	The WQ model has not been fully tested		

Model Evaluation Sheet

Model No. 13: <u>Mike Flood</u>

Component A: Hydrodynamics

Dimension	Spatial:	Dinamically couples Mike 11 (1D) with Mike 21 (2D)	Time:	Unsteady
Model Characteristics	Complete hydrodynamic model, implicit ADI finite difference scheme of 2nd order accuracy			
Wetting and Drying	Flooding and drying is included		Ground Water Flow	It is not included
Additional Information	Mike Flood uses Mike 11 for river hydraulics and Mike 21 for surface water modeling			

Component B: Water Quality

Components	Nutrients and DO/BOD. Basic and extended eutrophication module
Vegetation	Algae, macro algae and benthic vegetation
Soil	Sediment nutrient flux model and sediment diagenesis
Additional Information	Complete N, P and phytoplankton cycles

Component C: General

Public Availability	Available	Contact Information	DHI; www.dhigroup.com
Run Time		Platform	Windows
Acceptance	Wide	Technical Support	Available
Documentation	Available	Source Code	Not public
Pre Processor	Available - Included	Post Processor	Included – animated presentation
Other Model Features	GIS integration for spatial and temporal analysis		
Other Capabilities	Same as Mike 21		
	Accepted by the US Federal Emergency Management Agency (FEMA)		
Limitations	Proprietary model		

Model Evaluation Sheet

Model No. 14: <u>ECOMSED</u>

Component A: Hydrodynamics

Dimension	Spatial:	3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic – free surface model. Finite volume method second order accuracy			
Wetting and Drying	It is not included		Ground Water Flow	Vertical exchange
Additional Information	Good mass conservation properties associated with the discretization scheme.			
Sigma vertical coordinate system, and Cartesian or curvilinear-orthogonal grid				

Component B: Water Quality

Components	Dissolved tracer transport (conservative or first order decay)
Vegetation	
Soil	Deposition and resuspension of cohesive and non-cohesive sediments based on shear stress
Additional Information	Can be coupled to RCA for WQ simulations

Component C: General

Public Availability	Available	Contact Information	HydroQual, Inc.; Hydroqual.com
Run Time	Relatively slow	Platform	UNIX, LINUS and DOS
Acceptance	Wide	Technical Support	Available
Documentation	Available	Source Code	Available, FORTRAN
Pre Processor	Partial	Post Processor	Tecplot output
Other Model Features	Complete sediment transport module (cohesive and non-cohesive sediment transport)		
Other Capabilities	Includes wind stresses and density effects. Includes transport equation for temperature		
	Includes heat flux module (including precipitation and evaporation)		
Limitations	Tecplot is a proprietary software		

Model Evaluation Sheet

Model No. 15: RCA

Component A: Hydrodynamics

<table>
<tr><td>Dimension</td><td>Spatial:</td><td>Coupled with ECOMSED or EFDC</td><td>Time:</td><td>Unsteady</td></tr>
<tr><td>Model Characteristics</td><td colspan="4">WQ model that has been applied to rivers, lakes, estuaries and coastal systems</td></tr>
<tr><td>Wetting and Drying</td><td colspan="2">Depends on the hydrodynamic model used</td><td>Ground Water Flow</td><td>Depends on the hydrodynamic model used</td></tr>
<tr><td>Additional Information</td><td colspan="4">Uses finite difference</td></tr>
<tr><td colspan="5"></td></tr>
</table>

Component B: Water Quality

<table>
<tr><td>Components</td><td>Simple and advanced eutrophication, wetland systems</td></tr>
<tr><td>Vegetation</td><td>Algae (multiple algal groups)</td></tr>
<tr><td>Soil</td><td>Includes a sediment nutrient flux subroutine (deposition and resuspension)</td></tr>
<tr><td>Additional Information</td><td>Fully closed P and N cycles, complete DO/BOD dynamics</td></tr>
<tr><td colspan="2">The model is based on USEPA WASP</td></tr>
</table>

Component C: General

<table>
<tr><td>Public Availability</td><td>Available</td><td>Contact Information</td><td>HydroQual, Inc.; Hydroqual.com</td></tr>
<tr><td>Run Time</td><td>No information</td><td>Platform</td><td>UNIX, LINUS and Windows</td></tr>
<tr><td>Acceptance</td><td>New Model</td><td>Technical Support</td><td>No information</td></tr>
<tr><td>Documentation</td><td>Partial</td><td>Source Code</td><td>Available, FORTRAN</td></tr>
<tr><td>Pre Processor</td><td>No information</td><td>Post Processor</td><td>No information</td></tr>
<tr><td>Other Model Features</td><td colspan="3">Flexible input structure (different points and diffuse sources)</td></tr>
<tr><td rowspan="2">Other Capabilities</td><td colspan="3">Transport of dissolved and particulate substances</td></tr>
<tr><td colspan="3">Includes volatilization in the water-air interface</td></tr>
<tr><td></td><td colspan="3"></td></tr>
<tr><td rowspan="2">Limitations</td><td colspan="3">The model was recently release for public use; it has not been fully tested</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td></td><td colspan="3"></td></tr>
</table>

Model Evaluation Sheet

Model No. 16: SSIIM

Component A: Hydrodynamics

Dimension	Spatial:	3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic free surface model. Finite volume method			
Wetting and Drying	Wetting and drying is included		Ground Water Flow	No information
Additional Information	A control volume method is used for discretization with power law or 2nd order upwind schemes			
SIMPLE method is used for pressure coupling. Can use non-orthogonal grids. Complete turbulence model				

Component B: Water Quality

Components	Transport of up to 20 constituents with source terms for each one
Vegetation	Algae
Soil	Resuspension is included
Additional Information	The model has some prescribed functions for nutrient cycles, and allows flexible modifications

Component C: General

Public Availability	Available	Contact Information	Nils R. Olsen; Nils.R.Olsen@nhl.sintef.no
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	No
Documentation	Available	Source Code	Available
Pre Processor	Available - Included	Post Processor	Available - Included
Other Model Features	Includes a complete sediment transport module with movable bed		
Other Capabilities	Includes heat flux module and transport equation for temperature		
	Includes gas reaeration at the water surface		
Other Limitations	There are relevant-new implemented algorithms that are not fully tested		

Model Evaluation Sheet

Model No. 17: ELM (Everglades Landscape Model)

Component A: Hydrodynamics

Dimension	Spatial:	2D	Time:	Varying
Model Characteristics	The model captured the spatio- temporal dynamics of hydrology. Cell surface and groundwater flows are solved using a finite difference, Alternating Direction Explicit (ADE) technique, providing for propagation of water and water-borne constituents across space			
Wetting and Drying	It is included		Ground Water Flow	It is included
Additional Information	ELM divides the landscape into a uniform grid of square cells. The ELM supports user specified grid cell resolution			
The hydrology may be driven by daily flow data, using either historical observations, or output from the SFWMM for management scenarios				

Component B: Water Quality

Components	Phosphorus cycles included uptake, remineralization, sorption, diffusion, and organic soil loss/gain
Vegetation	Periphyton biomass and community type, macrophyte biomass and habitat type
Soil	Phosphorus accumulation in the soils
Additional Information	Growth of macrophyte and periphyton communities responds to available nutrients, water, sunlight and temperature

Component C: General

Public Availability	Available	Contact Information	SFWMD; www.sfwmd.gov/org/wrp/elm/
Run Time	Computationally Efficient - Fast	Platform	Unix, Linus
Acceptance	Wide	Technical Support	Limited
Documentation	Partial	Source Code	ANSI C
Pre Processor	Available	Post Processor	Available
Other Model Features	Canal/levee can be superimposed on the grid to define the hydrologic basins and provide for rapid flow of water through the system		
Other Capabilities	ELM has been applied with a finer grid to adjacent areas to the Loxahatchee Refuge		
	Rainfall and saturated hydraulic conductivity can be included for water budget purposes		
Limitations	The finite difference is first order accuracy, and dispersion is not simulated		

Model Evaluation Sheet

Model No. 18: <u>CCHE2D, CCHE3D, CCHE-WQ</u>

Component A: Hydrodynamics

Dimension	Spatial:	2D depth-averaged, 3D	Time:	Unsteady
Model Characteristics	Complete hydrodynamic – free surface model. It is based on Efficient Element Method, a collocation approach of the FEM			
Wetting and Drying	Flooding and drying is included		Ground Water Flow	No information
Additional Information	The model strictly enforces the mass conservation within the computational domain through the user of control volume approach			
The model includes different turbulence closure schemes. CCHE3D uses a structured quadrilateral mesh in the horizontal plane				

Component B: Water Quality

Components	Phosphorous and nitrogen cycles, dissolved oxygen balance.
Vegetation	Phytoplankton kinetics
Soil	
Additional Information	CCHE-WQ is a physical and bio-chemical process based module which simulates WQ variables and pollutant transport dynamically. CCHE-WQ considers the impacts of environmental factors such as temperature, pH, and salinity on the WQ processes.
Different sources can be simulated, e.g, multiple point and non-point, and time-varying flow conditions.	

Component C: General

Public Availability	Available	Contact Information	CCHE University of Mississippi http://hydra.cche.olemiss.edu/
Run Time	No information	Platform	Windows 95, 98, 2000 and XP
Acceptance	Wide	Technical Support	No information
Documentation	Available	Source Code	No information
Pre Processor	Mesh Generator – GUI	Post Processor	Graphical User Interface (GUI)
Other Model Features	Includes a complete sediment transport module with erodible and non-erodible sub-regions.		
Other Capabilities	The roughness of the moveable bed changes due to change in sediment size and change in bed form		
	The sediment module includes the curvature effects for sediment transport in bends		
Limitations	The CCHE-WQ module is currently being tested using field data		
	The GUI for CCHE3D is under development		
	CCHE-WQ and CCH3D are proprietary		

Model Evaluation Sheet

Model No. 19: GLEAMS (Groundwater Loading Effects of Agricultural Management Systems)

Component A: Hydrodynamics

Dimension	Spatial:	Field Scale	Time:	Daily variations	
Model Characteristics	The models simulates runoff and percolation				
Wetting and Drying	Partial			Ground Water Flow	Percolation-vertical movement
Additional Information	It consists of four major components: hydrology, erosion/sediment yield, pesticide transport, and nutrients				
The model tracks movement of pesticides with percolated water, runoff, and sediment					

Component B: Water Quality

Components	Conservative, erosion and sediments, pesticides, nutrients
Vegetation	Plant uptake of pesticide
Soil	Soil profile description and crop data are used to estimate effective rooting depth
Additional Information	Soils data are input by soil horizon, and the model distributes values of porosity, water retention characteristics, and organic matter
into the appropriate computational layers	

Component C: General

Public Availability	Available	Contact Information	Daren Harmel, USDA-ARS, Temple, TX http://www.cpes.peachnet.edu/sewrl/Gleams/gleams_y2k_update.htm
Run Time	Computationally Efficient -FAST	Platform	Windows
Acceptance	Wide	Technical Support	No longer supported by ARS
Documentation	Available - Complete	Source Code	FORTRAN
Pre Processor	Available in C code	Post Processor	Included
Other Model Features	Upward movement of pesticides and plant uptake are simulated with evaporation and transpiration		
Other Capabilities	Widely used to simulate nutrient nonpoint source impacts on water quality, nutrient dynamics may be incorporated into RSM		
	Nutrient dynamic formulation may provide ideas for implementation in other models		
Limitations	Assumes that a field has homogeneous land use, soils and precipitation		
	Field scale model		

Model Evaluation Sheet

Model No. 20: BLTM (Branched Lagrangian Transport Model)

Component A: Hydrodynamics

Dimension	Spatial:	1D with branches	Time:	Dynamic
Model Characteristics	Must be integrated with flow model (BRANCH and DAFLOW frequently used)			
Wetting and Drying	It is not included		Ground Water Flow	It is not included
Additional Information	The model solves the one-dimensional convective-diffusion equation with reaction kinetics			

Component B: Water Quality

Components	Two subroutines are available, one to route any number of independent constituents with first order decay, and one which duplicates the reactions kinetics in the EPA QUAL2E
Vegetation	Phytoplankton
Soil	
Additional Information	The model includes a subroutine to predict stream temperature

Component C: General

Public Availability	Available	Contact Information	Harvey E. Jobson, USGS http://water.usgs.gov/software/bltm.html
Run Time	No information	Platform	Windows, UNIX
Acceptance	Wide	Technical Support	No information
Documentation	Available - Complete	Source Code	FORTRAN 77
Pre Processor	Included	Post Processor	Included
Other Model Features	Specalized reaction kinetics can be easily developed by modifications to one of the existing kinetic subroutines		
Other Capabilities	Water quality model, easily modified by user. Lagrangian technique eliminates numerical dispersion		
Limitations			

Model Evaluation Sheet

Model No. 21: SFRSM (South Florida Regional Simulation Model)

Component A: Hydrodynamics

Dimension	Spatial:	2D	Time:	Dynamic
Model Characteristics	The Hydrologic Simulation Engine (HSE) simulates the hydrology in south Florida, including the canals, structures and levees. A weighted implicit finite volume method is used in the HSE to simulate diffusion flow in both overland and groundwater flow			
Wetting and Drying	No information		Ground Water Flow	Included
Additional Information	The model domain is discretized using triangular cells whose walls control the flow rates into the cells based on Manning's equation			
for overland flow and the Darcy's equation for ground water flow.				

Component B: Water Quality

Components	Under development, full mass transport not yet available
Vegetation	
Soil	
Additional Information	

Component C: General

Public Availability	Available	Contact Information	Randy Van Zee, Hydrologic Systems Modeling Department, SFWMD http://www.sfwmd.gov/org/pld/hsm/models/sfrsm/index.html
Run Time		Platform	UNIX
Acceptance	New Model	Technical Support	No information
Documentation	Partial	Source Code	C++
Pre Processor	Under development	Post Processor	Under development
Other Model Features	The processes modeled include overland and groundwater Flow, precipitation, evapotranspiration, infiltration, levee Seepage, canal and structure flow		
Other Capabilities			
Limitations	This model is currently 'under development'. Individual components are being developed independently and are in various stages of completion		
	This model is designed for regional, long-term applications. Although scalable, performance constraints may impose practical limits on the time and space scales. This model is not intended for local-scale decision-making support.		

Model Evaluation Sheet

Model No. 22: MODHMS

Component A: Hydrodynamics

Dimension	Spatial:	3D subsurface, 2D surface	Time:	Dynamic
Model Characteristics	A MODFLOW variant that fully integrates ground water with surface water modeling			
Wetting and Drying	Included		Ground Water Flow	Included
Additional Information	MODFLOW simulates three-dimensional ground-water flow through a porous medium by using a finite-difference method			
MODHMS includes interactions between overland flow, channel flow, and groundwater flow. Overland flow/runoff is characterized by the twodimensional diffusion wave approximation to the St.Venant equations governing shallow-water flow.				

Component B: Water Quality

Components	No information
Vegetation	
Soil	
Additional Information	

Component C: General

Public Availability	Available, proprietary, free to federal government	Contact Information	Sorab M.Panday, HydroGeoLogic, Inc. http://modhms.com/software/modhms.html
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	Available
Documentation	Complete	Source Code	Not public
Pre Processor	Available	Post Processor	Available
Other Model Features	The hydrologic cycle is viewed as a fully integrated system with dynamic interactions between all regimes of flow		
Other Capabilities	A curvilinear grid option is available to allow for flexible gridding		
Limitations	No information		

Model Evaluation Sheet

Model No. 23: MIKE SHE

Component A: Hydrodynamics

Dimension	Spatial:	3D subsurface, 2D surface	Time:	Dynamic
Model Characteristics	2D, diffusive wave, finite-difference overland flow and 3D, finite-difference groundwater flow			
Wetting and Drying	Included		Ground Water Flow	Included
Additional Information	Surface water simulation using flow-routing methods and water levels calculated by Manning's equation or specified relationships			
Includes drainage routing to surface water bodies. Can be coupled with Mike 11 for modeling open channel flow				

Component B: Water Quality

Components	Can be coupled with DAISY that is a single column model, which describes all the major processes related to water, carbon and nitrogen in an agricultural ecosystem.
Vegetation	Complete crop model
Soil	Plant uptake of nitrogen
Additional Information	DAISY calculates nitrate and pesticide leaching from agricultural areas
MIKE SHE can be used to simulate solute transport across the various hydrologic process boundaries	

Component C: General

Public Availability	Available	Contact Information	DHI; www.dhigroup.com
Run Time	No information	Platform	Windows
Acceptance	Wide	Technical Support	Available
Documentation	Complete	Source Code	DAISY is open source code
Pre Processor	Available	Post Processor	Included – animated presentation
Other Model Features	Precipitation, evapotranspiration, overland sheet and channel flow, unsaturated and saturated ground water flow are included		
Other Capabilities	GIS integration for spatial and temporal analysis		
	Weirs, culverts and spillways can be easily modeled using Mike 11		
Limitations	Proprietary model		
	DAISY does not include phosphorous process		
	MIS SHE/DAISY does not model crop and nitrogen processes under flooded conditions		

Model Evaluation Sheet

Model 24: SWAT (Soil and Water Assessment Tool)

Component A: Hydrodynamics

Dimension	Spatial:	Lumped 2D, Field Scale	Time:	Daily variations
Model Characteristics	The model includes surface runoff, base flow, transmission losses, pond and reservoir storage, reach routing and groundwater flow			
Wetting and Drying	Partial		Ground Water Flow	Included
Additional Information	Surface runoff volume is computed using a modification of the SCS curve number method or the Green @ Ampt infiltration method			
SWAT partitions groundwater into a shallow, unconfined aquifer and a deep-confined aquifer. Open channel flow is calculated using Manning's equation				

Component B: Water Quality

Components	Nitrogen and phosphorus cycling. Nutrients routing. Algae, DO and BOD models
Vegetation	Plant growth model. Nutrients plant uptake is simulated
Soil	Includes transformation of N and P in the soil. In addition to plant use, the nutrients may be removed via mass flow of water
Additional Information	SWAT tracks the movement and transformation of several forms of N and P in the watershed, and nutrient transformations in the
stream are controlled by the in-stream WQ model which is adapted from QUAL2E	

Component C: General

Public Availability	Available	Contact Information	www.brc.tamus.edu/swat/ Jeff Arnold; jgarnold@spa.ars.usda.gov
Run Time	Computationally efficient	Platform	DOS/Windows, UNIX
Acceptance	Wide	Technical Support	No information
Documentation	Available	Source Code	Available
Pre Processor	Included	Post Processor	Included
Other Model Features	Incorporates features of SWRRB, CREAMS, GLEAMS and EPIC. The model includes a SWAT/ArcView interface		
Other Capabilities	Enable users to study long-term impacts, e.g., several decades.		
	In addition to return flow, water stored in the shallow aquifer may replenish moisture in the soil profile in dry conditions		
	Model components also include weather, percolation, ET, crop growth, irrigation and water transfer from channels and reservoirs		
Limitations	SWAT is a continuous time model, i.e. a long-term yield model. It is not designed to simulate detailed, single-event flood routing.		

Model Evaluation Sheet

Model 25: FTLOADDS (Flow and Transport in a Linked Overland Aquifer Density Dependent System)

Component A: Hydrodynamics

Dimension	Spatial:	2D (surface flow), 3D (groundwater flow)	Time:	Unsteady
Model Characteristics	Fully dynamic 2D finite difference for surface water flow, and 3D finite difference for variable-density groundwater flow			
Wetting and Drying	Included		Ground Water Flow	Included
Additional Information	The main linkage between surface and groundwater flow is through a leakage quantity passed between the two models			
Leakage is calculated using a variable-density form of Darcy's law, the surface water stage, the groundwater head, and a leakage coefficient				

Component B: Water Quality

Components	Tracer mass transport model
Vegetation	
Soil	
Additional Information	

Component C: General

Public Availability	Available	Contact Information	langevin@usgs.gov
Run Time	Computationally Efficient - Fast	Platform	DOS
Acceptance	Wide	Technical Support	Available
Documentation	Available	Source Code	Available
Pre Processor	Partial	Post Processor	Partial
Other Model Features	The model combines SWIFT2D (for overland surface water flow) and SEAWAT (for groundwater flow)		
Other Capabilities	SWIFT2D was modified to include rainfall, ET and flow resistance of marsh vegetation		
	Recharge and ET are applied to the cells in the uppermost layer in the groundwater model		
	The model includes the capability for upward leakage to rewet a surface water cell		
Limitations	FTLOADDS has not be linked to a water quality model		