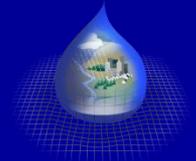


Introduction to the Water Quality Analysis Modeling System

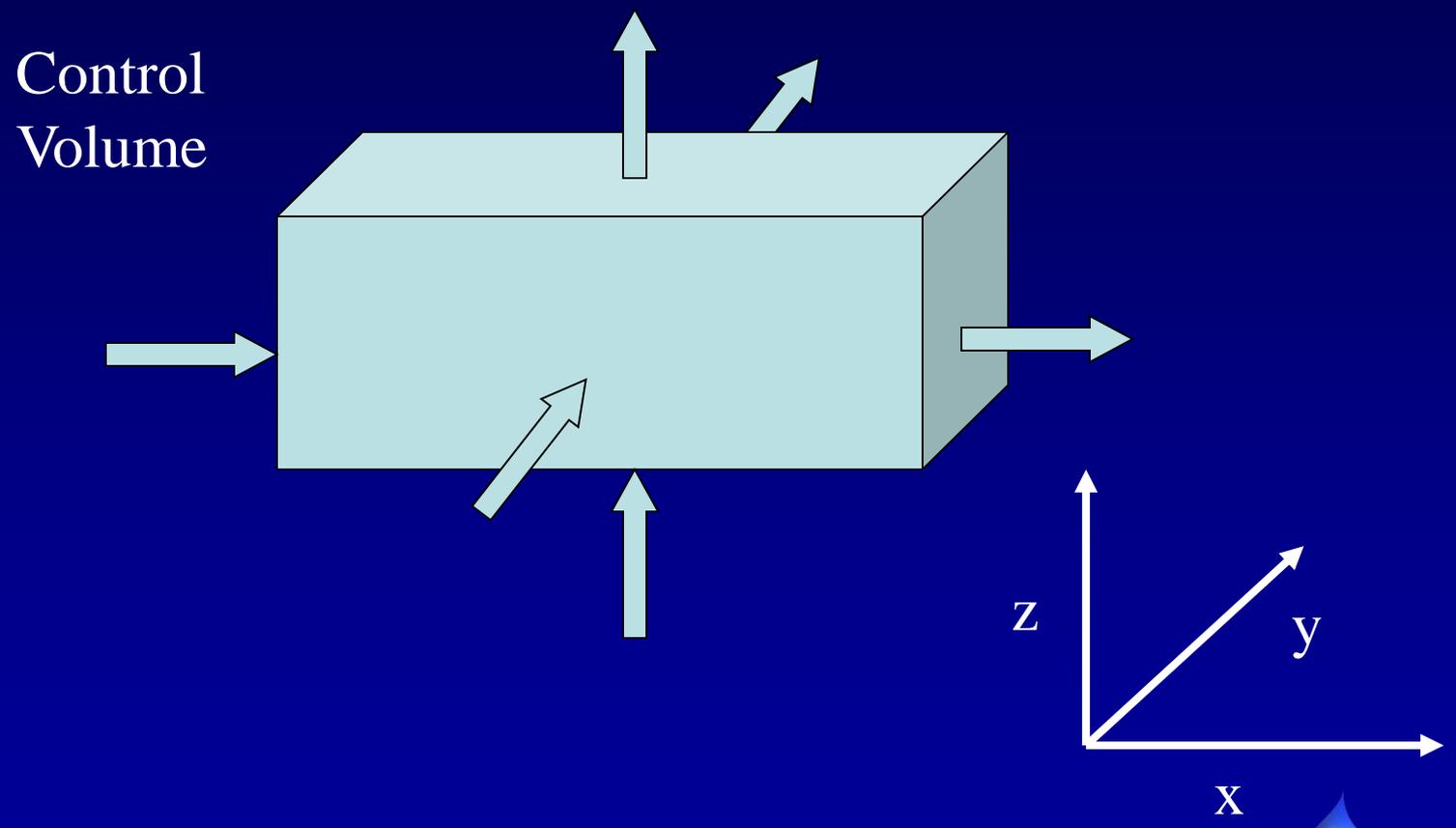
WASP

Version 7.0

April, 2005



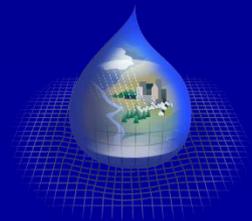
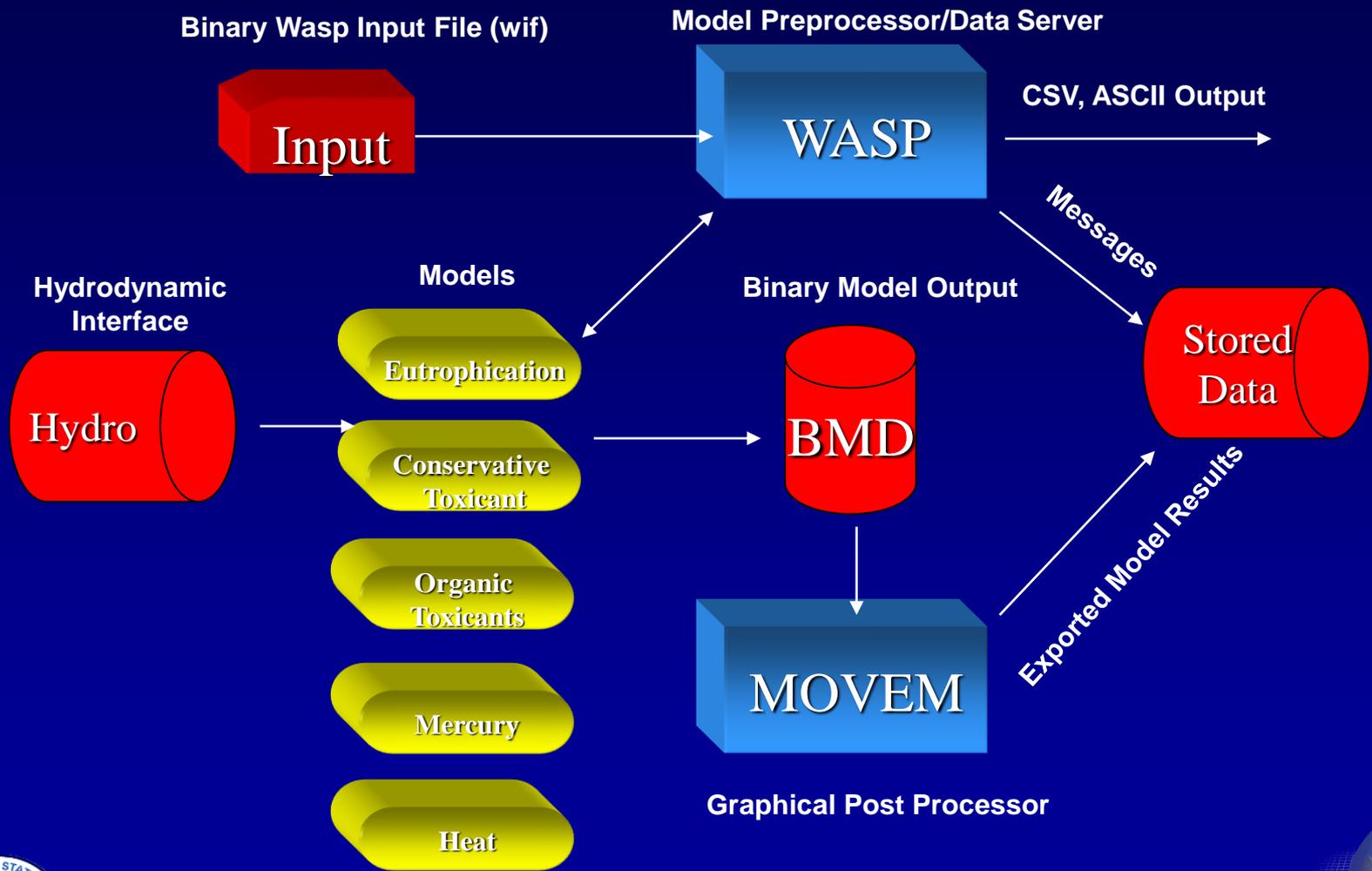
Three Dimensional Transport Equation



$$\frac{\partial C}{\partial t} = -\frac{\partial U_x C}{\partial x} + \frac{\partial}{\partial x} \left(E_x \frac{\partial C}{\partial x} \right) - \frac{\partial U_y C}{\partial y} + \frac{\partial}{\partial y} \left(E_y \frac{\partial C}{\partial y} \right) - \frac{\partial U_z C}{\partial z} + \frac{\partial}{\partial z} \left(E_z \frac{\partial C}{\partial z} \right) \pm \text{Sources and Sinks}$$

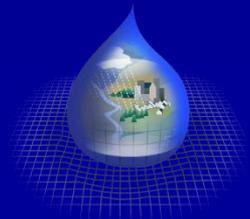
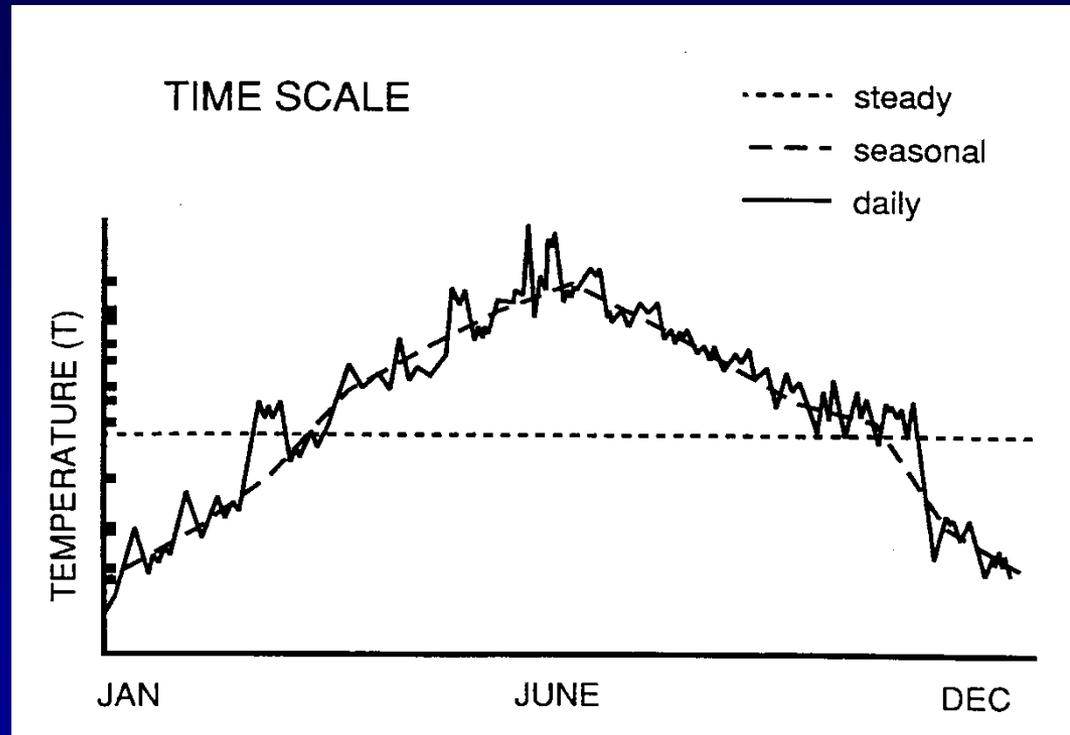


WASP Modeling Framework

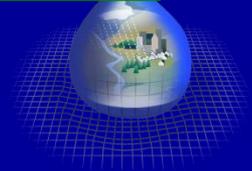
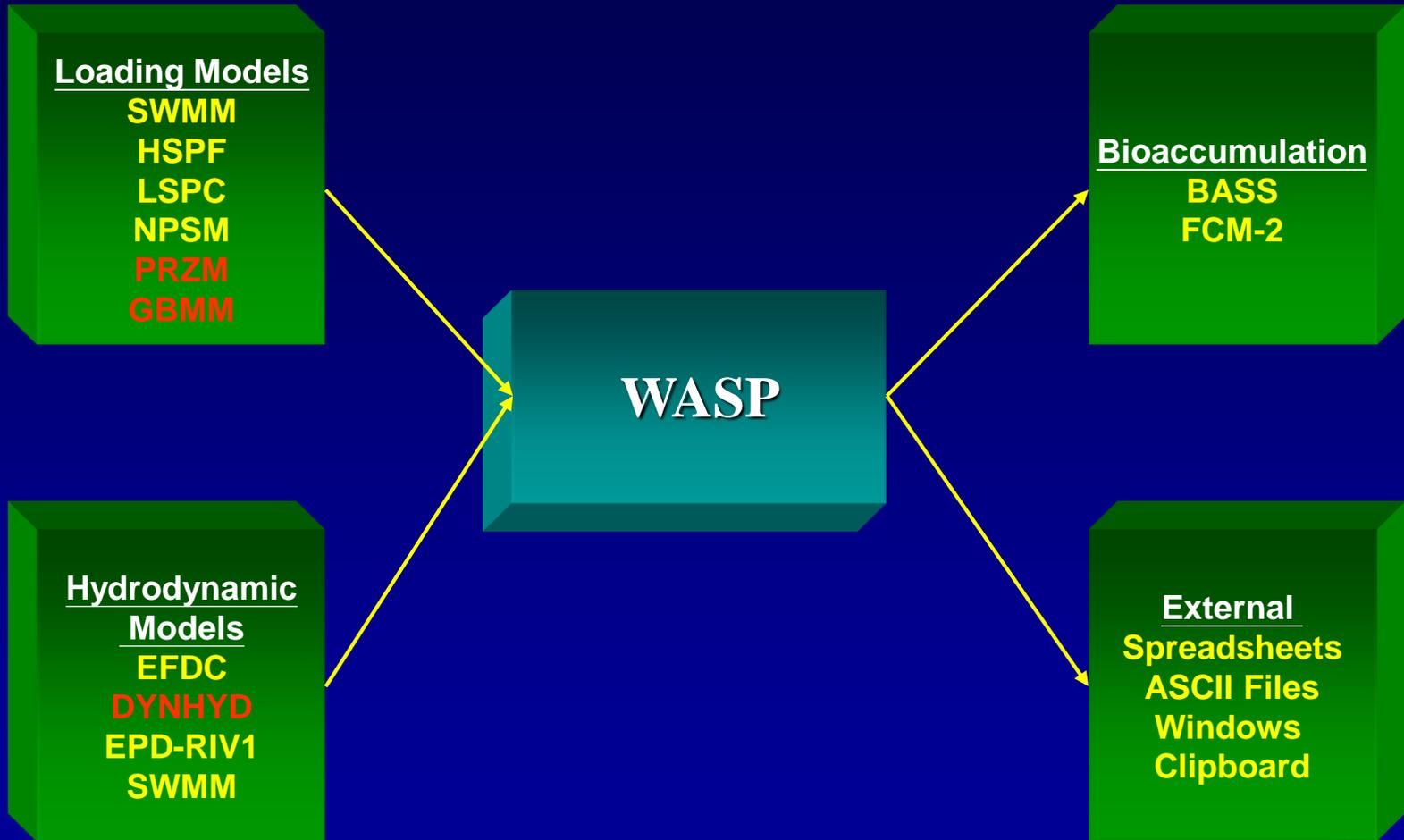


Potential WASP Time Scales

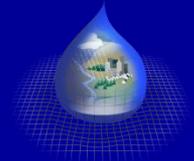
- Steady
- Seasonal
- Monthly
- Daily/Hourly



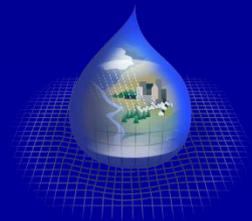
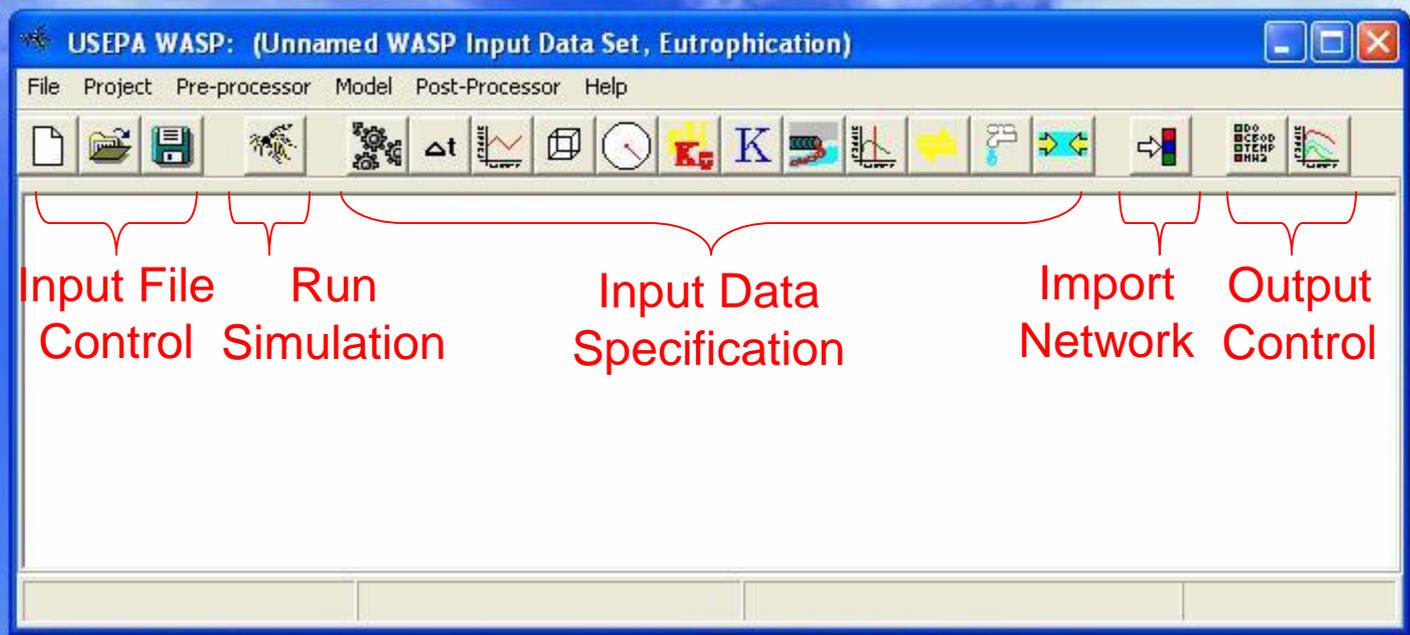
WASP External Linkages



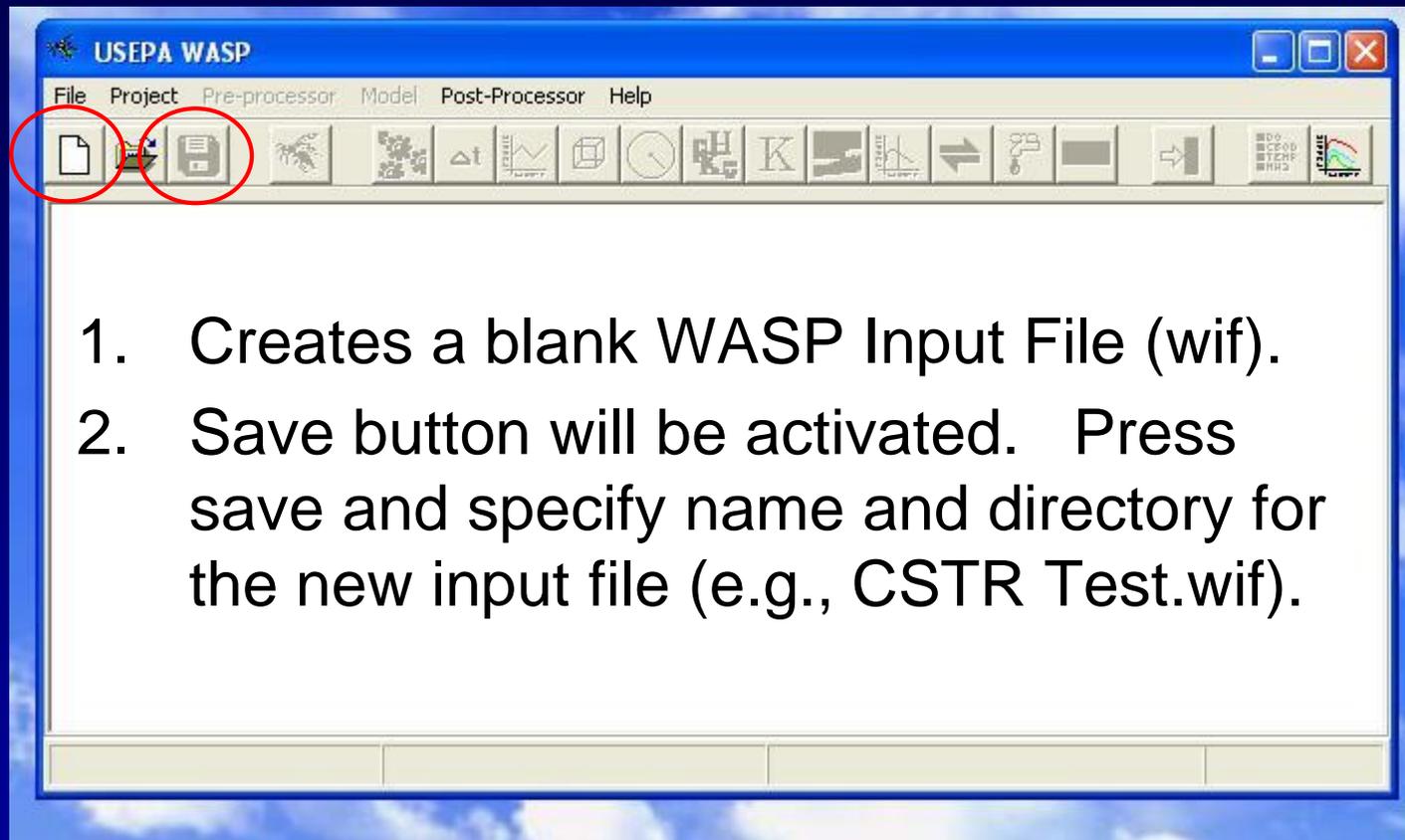
Introduction to the WASP Interface



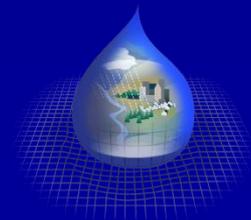
Introduction to WASP Interface



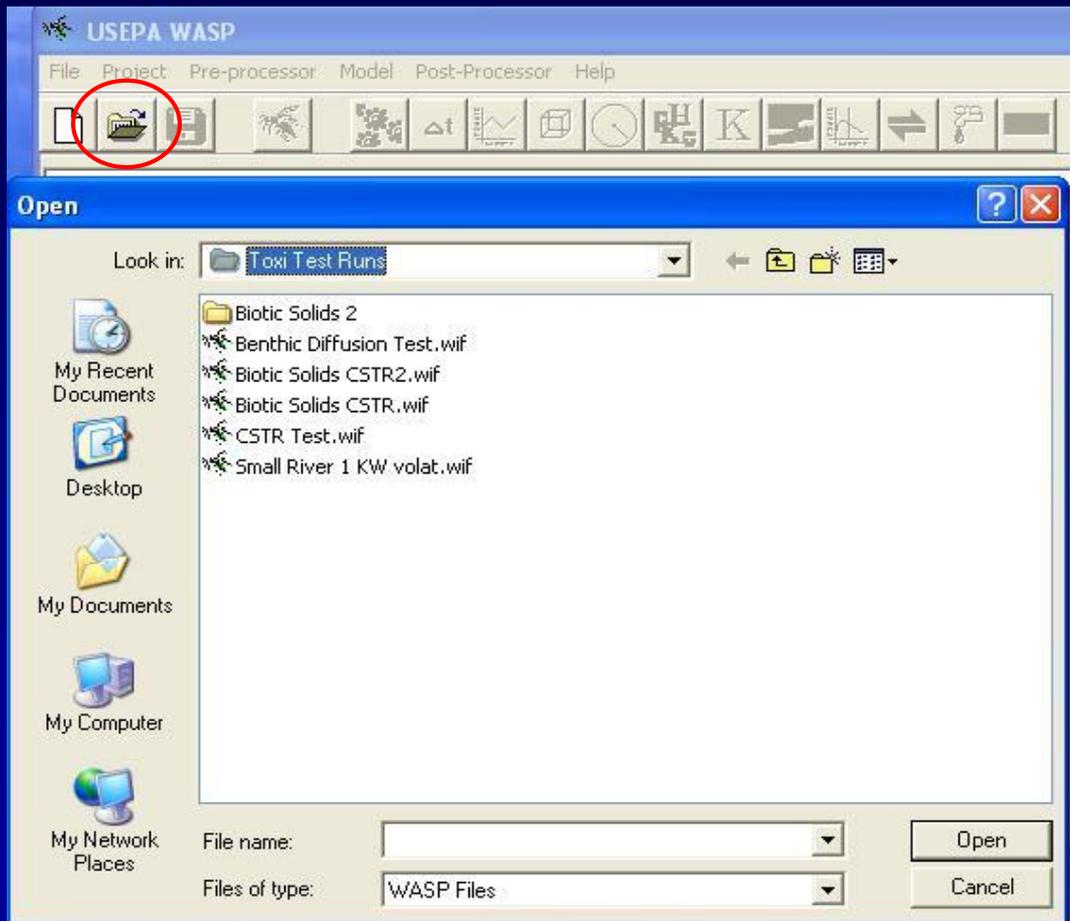
Create New WASP Input File



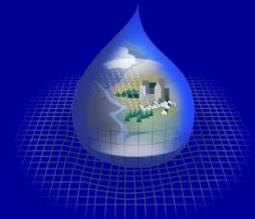
1. Creates a blank WASP Input File (wif).
2. Save button will be activated. Press save and specify name and directory for the new input file (e.g., CSTR Test.wif).



Open Existing WASP Input File



- ❖ Browse and select an existing Wasp Input File
- ❖ WASP provides a listing of *.wif in the current directory.



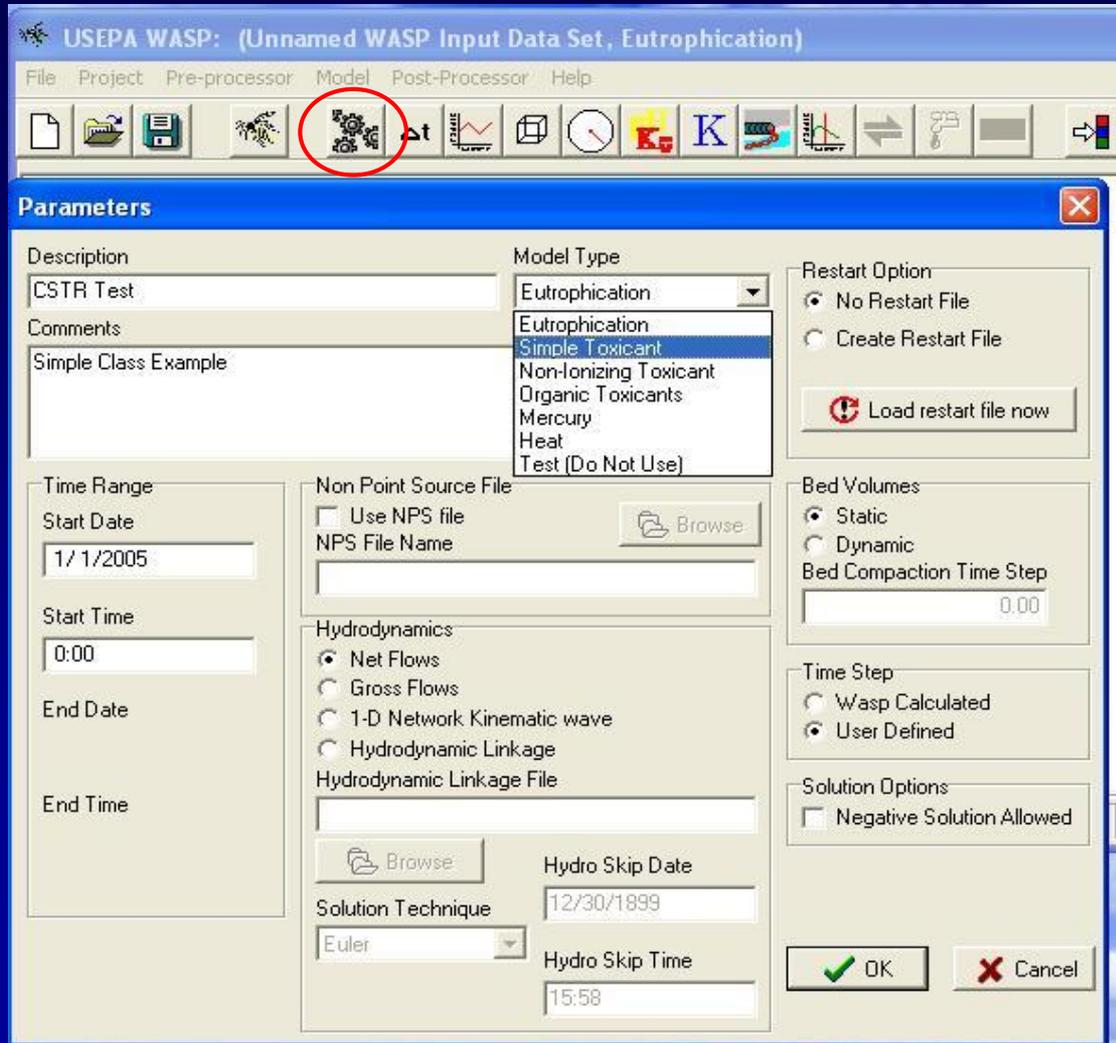
WASP Input Data Categories



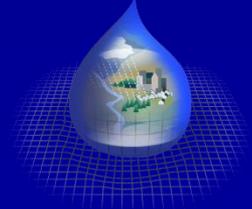
1. Simulation Control
2. Time Step
3. Print Interval
4. Segment Properties
5. System Properties
6. Parameter Switches
7. Constants
8. Loadings
9. Kinetic Time Functions
10. Dispersive Exchanges
11. Advective Flows
12. Boundary Concentrations



Simulation Control



- Description and Comments
- Model Type
- Simulation Start Date & Time
- Non Point Source Linkage
- Hydrodynamic Option and Linkage
- Restart Option
- Bed Volume Option
- Time Step Option
- Negative Solution Option



Segment Properties - Geometry

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

Segments

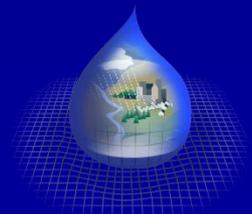
Segments Parameters Initial Concentrations Fraction Dissolved

Segment	Description	Volume	Velocity Multiplier	Velocity Exponent	Depth Multiplier	Depth Exponent	Segment Type	Bottom Segment	Length	Width	Slope	Bottom Roughness
1	Wasp Segment	1E+4	0.0000	0.0000	1.0000	0.0000	Surface Water	None	0.0000	0.0000	0.0000	0.0000

Volume Scale Factor: 1.0000000
Volume Conversion Factor: 1.0000000

Buttons: Fill/Calc, Copy, Paste, Insert, Delete, OK, Cancel

Segments Tab:
Spatially-Variable Physical Properties



Segment Properties - Parameters

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

Segments Parameters Initial Concentrations Fraction Dissolved

Segment	Dissolved Organic Carbon	Partition Coefficient to Silt	Partition Coefficient to Sand	Partition Coefficient to Organic	Decay Rate Constant (per day)
1	0	0	0	0	0

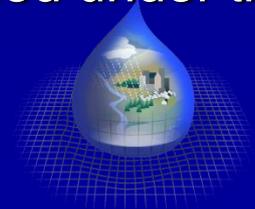
Fill/Calc Copy Paste

Insert Delete OK Cancel

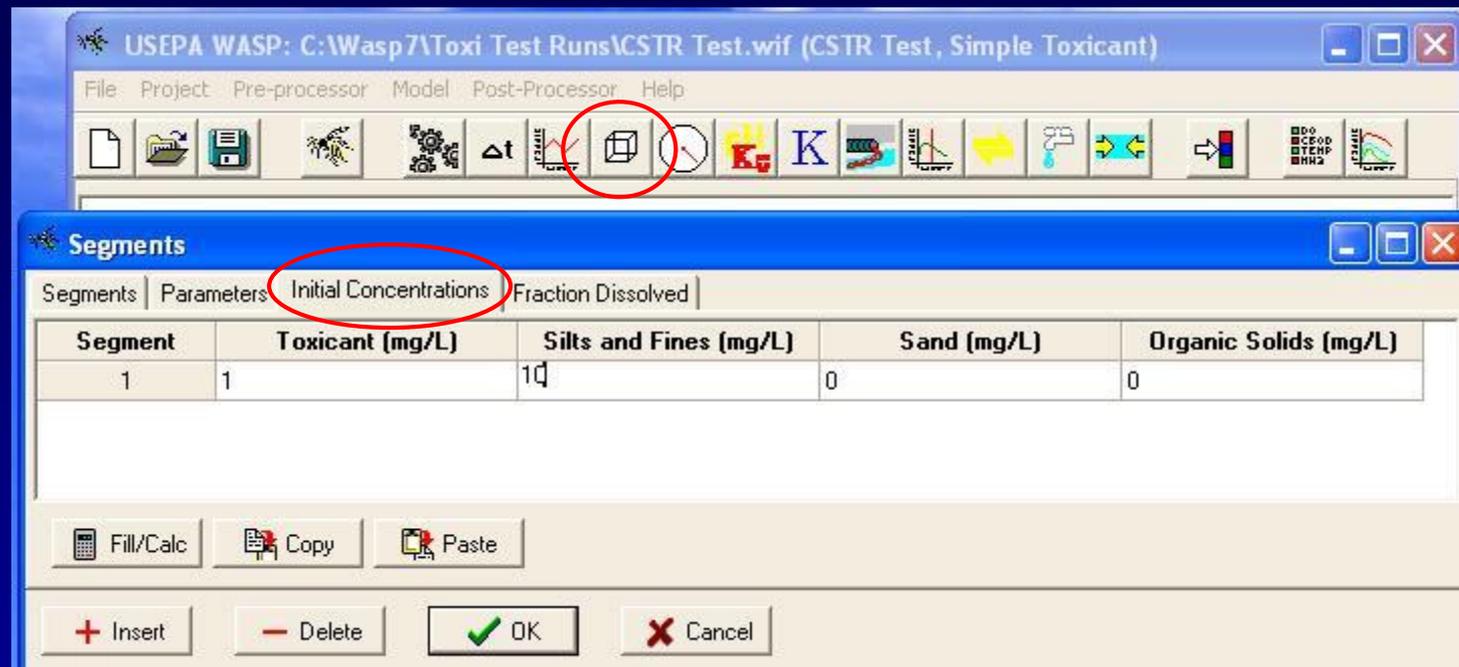
Parameters Tab:

Values for Spatially-VARIABLE Environmental Properties or Model Coefficients

Note – to be used in a simulation, parameters must be enabled under the Parameter Control button



Segment Properties – Initial Concentrations



Initial Concentrations Tab:

Concentrations of each state variable (system) at beginning of simulation



Segment Properties – Fraction Dissolved

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

Segments

Segments | Parameters | Initial Concentrations | **Fraction Dissolved**

Segment	Toxicant (mg/L)	Silts and Fines (mg/L)	Sand (mg/L)	Organic Solids (mg/L)
1	1.0000	0.0000	0.0000	0.0000

Fill/Calc Copy Paste

Insert Delete OK Cancel

Fraction Dissolved Tab:

- Fraction of total constituent concentration that is dissolved.
- Dissolved fractions for solids must be set to 0.
- Dissolved fractions for toxicants do not need to be reset.



Systems

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

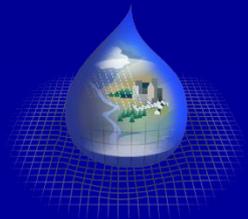
System Data

	System	Option	Particulate Transport Field	Mass Balance	Dispersion Bypass	Flow Bypass	Density	Maximum Concentration	Boundary Scale Factor	Boundary Conversion Factor	Loading Scale Factor	Loading Conversion Factor
1	Toxicant (mg/L)	Simulated	Solids 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	1.0000	100.0000	1.0000	1.0000	1.0000	1.0000
2	Silts and Fines (mg/L)	Simulated	Solids 1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.6500	2000000.000	1.0000	1.0000	1.0000	1.0000
3	Sand (mg/L)	Bypassed	Solids 2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.6500	2000000.000	1.0000	1.0000	1.0000	1.0000
4	Organic Solids (mg/L)	Bypassed	Solids 3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	2.6500	2000000.000	1.0000	1.0000	1.0000	1.0000

Copy Paste Fill/Calc OK Cancel

System (state variable) properties and controls:

- Switch to simulate or bypass state variables
- Switch to select particulate transport fields (for silt, sand, and organic solids)
- Solids particle densities (g/mL)
- Maximum allowable concentrations
- Boundary and loading scale factors



Parameter Control

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

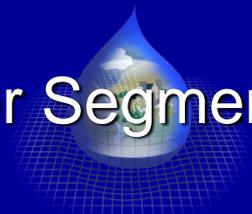
Parameter data

	Parameter	Used	Scale Factor
1	Dissolved Organic Carbon (mg/L)	<input type="checkbox"/>	1.0000
2	Partition Coefficient to Silts and Fines (L/kg)	<input checked="" type="checkbox"/>	1.0000
3	Partition Coefficient to Sand (L/kg)	<input type="checkbox"/>	1.0000
4	Partition Coefficient to Organic Solids (L/kg)	<input type="checkbox"/>	1.0000
5	Decay Rate Constant (per day)	<input type="checkbox"/>	1.0000

Copy Paste Fill/Calc OK Cancel

Parameter Controls:

- Switch to turn on parameters for the simulation
- Scale factors to adjust parameter values for all segments.
- **Note:** Parameter values are specified under Segments, but will not be used unless selected here



Constants

The screenshot shows the 'Constants Data' dialog box in the USEPA WASP software. The 'Constant Group' is set to 'Toxicant'. The table below lists various constants with their 'Used' status, 'Value', 'Minimum', and 'Maximum'.

		Used	Value	Minimum	Maximum
1	Log10 of Partition Coefficient to DOC (L/kg)	<input type="checkbox"/>	0	0.0000	7.0000
2	Partition Coefficient to Silts and Fines (L/kg)	<input checked="" type="checkbox"/>	1E+5	0.0000	0000000.0000
3	Partition Coefficient to Sands (L/kg)	<input type="checkbox"/>	0	0.0000	100000.0000
4	Partition Coefficient to Organic Solids (L/kg)	<input type="checkbox"/>	0	0.0000	0000000.0000
5	Volatilization loss rate constant, 1/day	<input type="checkbox"/>	0	0.0000	0.0000
6	Water column decay rate constant, 1/day	<input checked="" type="checkbox"/>	1E-1	0.0000	0.0000
7	Benthic decay rate constant, 1/day	<input type="checkbox"/>	0	0.0000	0.0000

Environmental and system properties or model settings that are constant in time and space



Direct Loads

PA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

Project Pre-processor Model Post-Processor Help

Loads

Loads | Scale and Conversion Factors

- Loads
 - Toxicant (mg/L)
 - Wasp Segment
 - Silts and Fines (mg/L)
 - Sand (mg/L)
 - Organic Solids (mg/L)

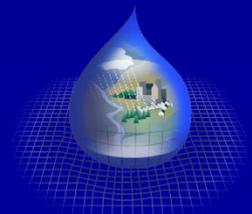
Time functions for segment 1 (Wasp Segment), Toxicant (mg/L)

Date	Time	Value
1/1/2005	0:00	0
2/1/2005	0:00	0

Buttons: + Insert, - Delete, Delete All, Graph, Copy, Paste, Fill/Calc, Import, OK, Cancel

External input of variable mass to segments.

Note: variables with concentration in mg/L require loading values in kg/day.



Dispersive Exchanges

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

Exchanges

Exchange Fields	Field	Used	Scale	Conversion
	Surface Water	<input type="checkbox"/>	1.0000000	1.0000000
	Pore Water	<input checked="" type="checkbox"/>	1.0000000	0.0001000

Pore Water functions

Function
Benthic Exchange

Segment pairs for Pore Water, Benthic Exchange

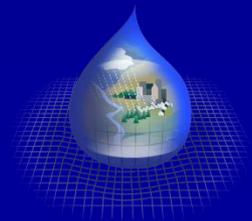
Segment one	Segment two	Area	Distance
Boundary	1: Wasp Segr	10000.00000	0.1000000

Time/value pairs for Pore Water, Benthic Exchange

Date	Time	Value
1/ 1/2005	0:00	1E-5
2/ 1/2005	0:00	1E-5

Buttons: + Insert, - Delete, Delete All, Graph, Copy, Paste, Fill/Calc, Import, OK

Bulk
dispersive
exchange
flows among
model
segments



Advective Flows

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

Flows

Flow Fields

Field	Used	Scale	Conversion
Surface Water	<input checked="" type="checkbox"/>	1.0000000	0.0000116
Pore Water	<input type="checkbox"/>	1.0000000	1.0000000
Solids 1	<input type="checkbox"/>	1.0000000	1.0000000
Solids 2	<input type="checkbox"/>	1.0000000	1.0000000
Solids 3	<input type="checkbox"/>	1.0000000	1.0000000
Evaporation/Precipitatio	<input type="checkbox"/>	1.0000000	1.0000000

Surface Water functions

Function
CSTR Throughflow

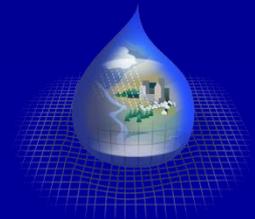
Segment pairs for Surface Water, CSTR Throughflow

From	To	Frac. of flo
Boundary	1: Wasp Segm	1.0000000
1: Wasp Segmer	Boundary	1.0000000

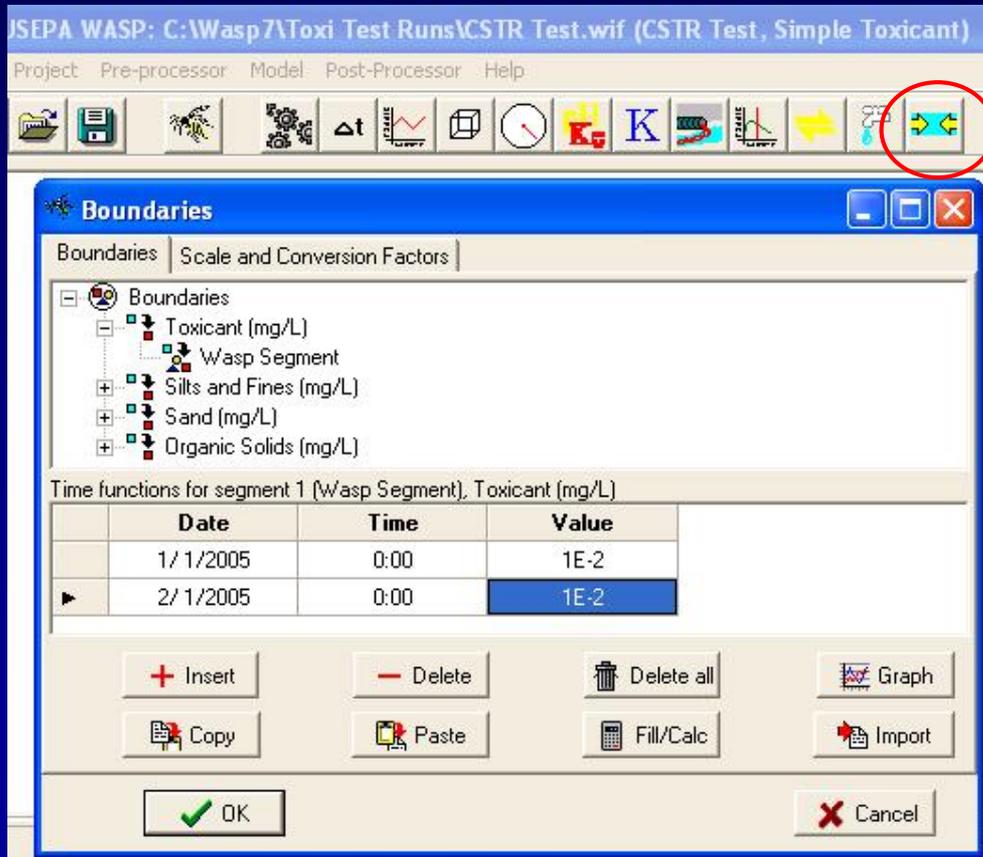
Time/value pairs for Surface Water, CSTR Throughflo

Date	Time	Value
1/ 1/2005	0:00	1E+3
2/ 1/2005	0:00	1E+3

Movement of water and solids among model segments

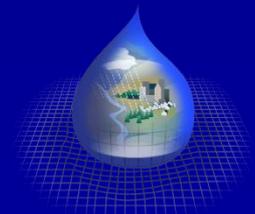


Boundaries



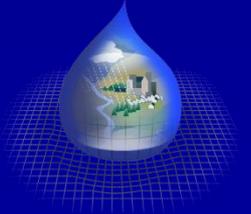
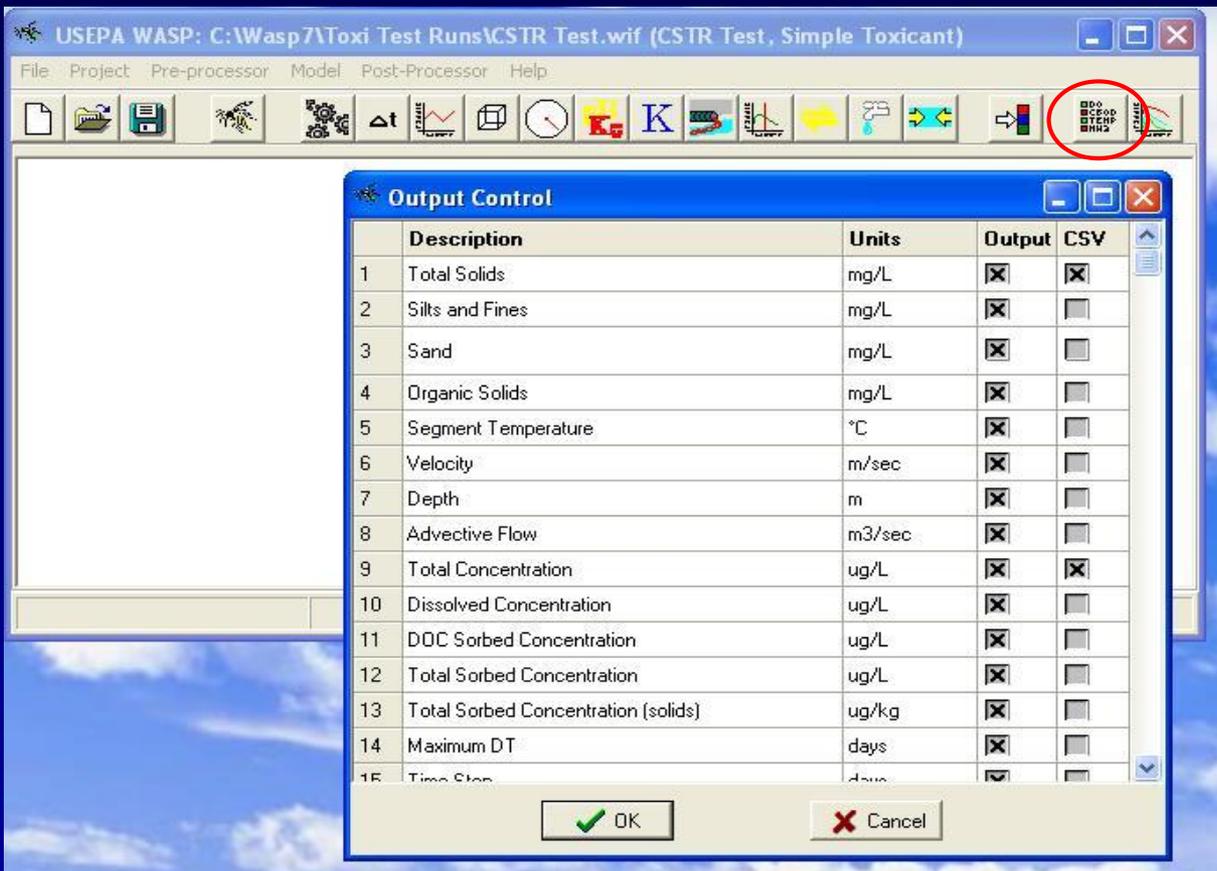
Concentration of each system in flows entering model network.

BCs must be specified for upstream and downstream advective flows and dispersive exchanges.

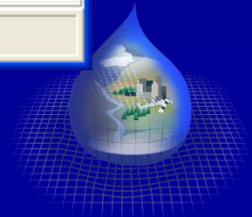
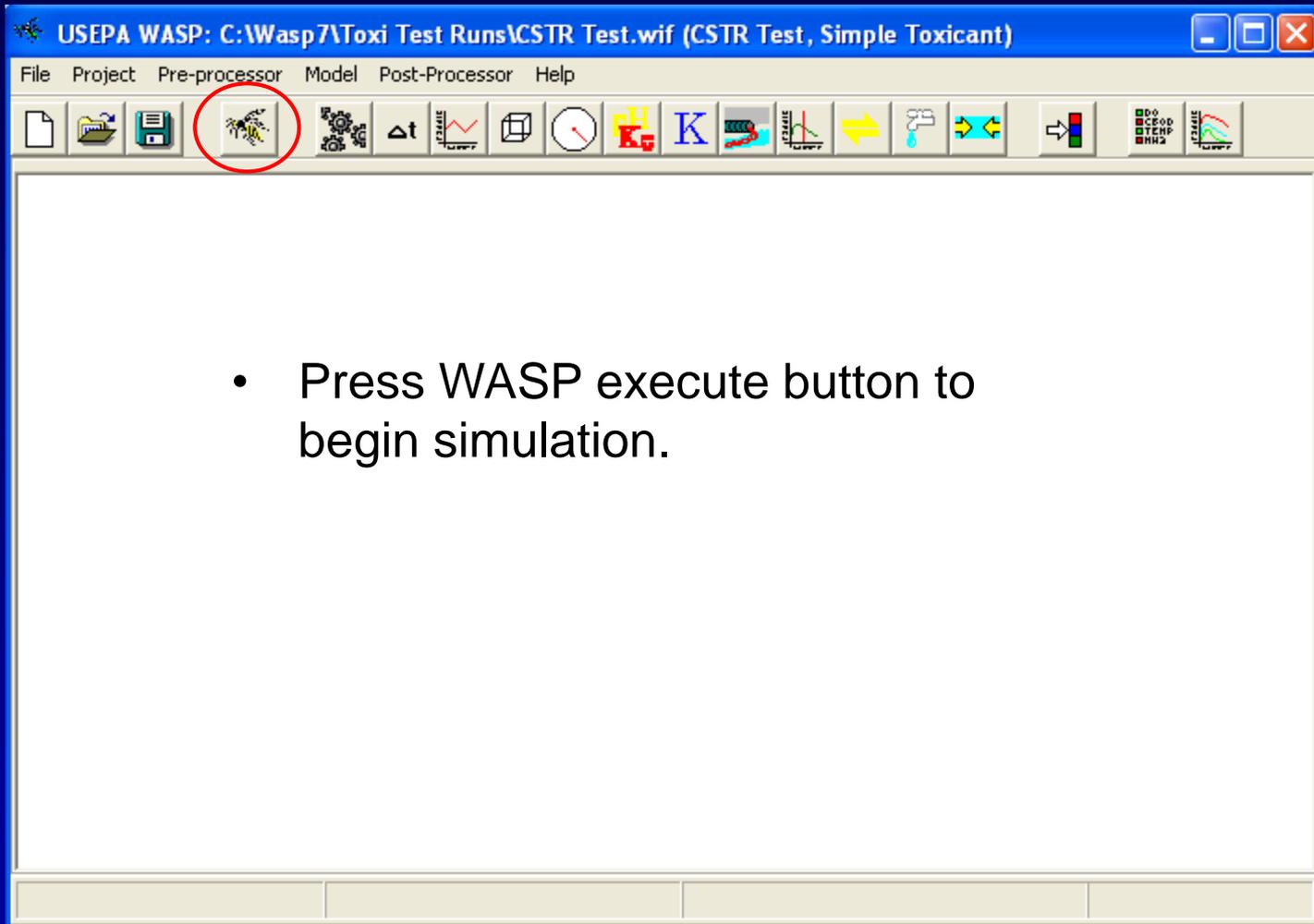


WASP Output Variable Selection

Selects variables that will be saved to the WASP output file (bmd), and variables that will be saved in a set of comma-delimited files (*.csv)



Execute Model Simulation -1



Execute Model Simulation - 2

USEPA WASP: C:\Wasp7\Toxi Test Runs\CSTR Test.wif (CSTR Test, Simple Toxicant)

File Project Pre-processor Model Post-Processor Help

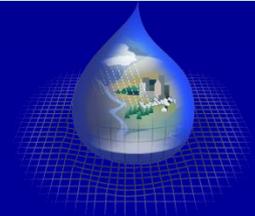
	Chemical	Chemical	Chemical	Solids 1	Solids 2	Solids 3	Total Soli	Flow	Volume
1	95.425156	0.000000	0.000000	3.014666	0.000000	0.000000	3.014666	0.011574	10000.0000

US EPA -- WASP Version 7.0
Organic Chemical Model Last Revised: 7/14/2004 2:52PM

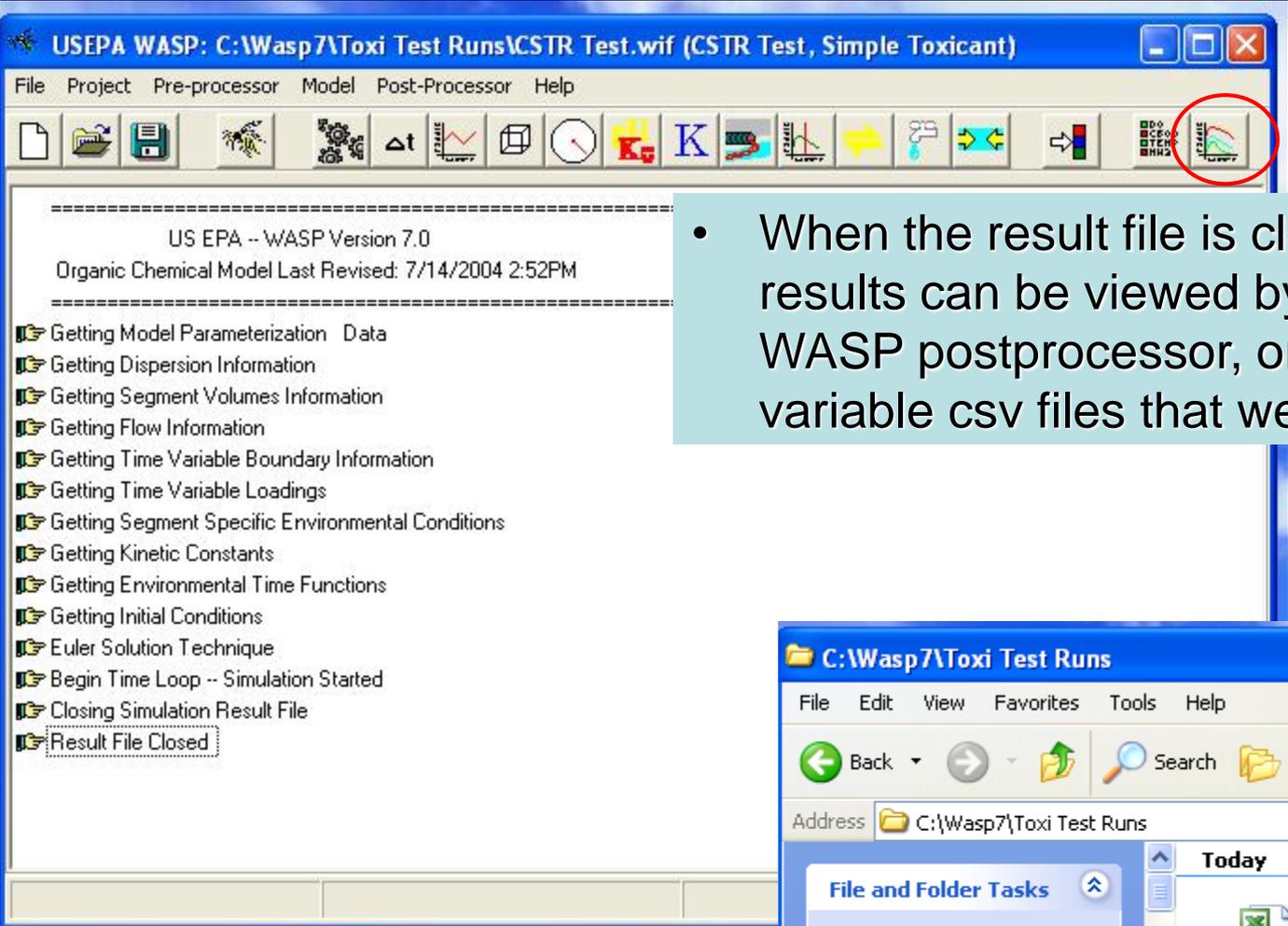
- Getting Model Parameterization Data
- Getting Dispersion Information
- Getting Segment Volumes Information
- Getting Flow Information
- Getting Time Variable Boundary Information
- Getting Time Variable Loadings
- Getting Segment Specific Environmental Conditions
- Getting Kinetic Constants
- Getting Environmental Time Functions
- Getting Initial Conditions
- Euler Solution Technique
- Begin Time Loop -- Simulation Started

Stop Turbo Simulation Time: 1/13/2005 0:00:01 Time remaining: 0:00:01

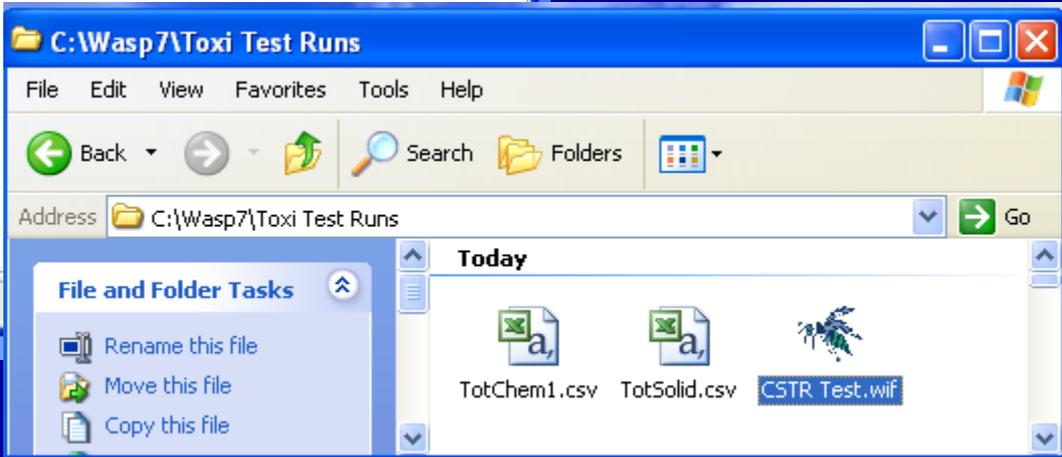
- A table of calculated concentrations will be displayed throughout the simulation.
- Status and error messages will be displayed.
- Progress through the simulation is summarized along the bottom bar. A control slide can be used to speed up, slow down, or freeze the simulation.
- The simulation can be aborted by pressing the stop button (circled above).



Execute Model Simulation - 3



- When the result file is closed, simulated results can be viewed by launching the WASP postprocessor, or by opening the variable csv files that were created.



WASP Output csv file

	A	B	C	D	E	F	G	H
1	Output Variable: Tot Conc ug/L Number of Segments 1							
2	0	1000						
3	1	817.9874						
4	2	669.2699						
5	3.1	536.9018						
6	4.1	439.6025						
7	5.1	360.1018						
8	6.1	295.144						
9	7.1	242.0688						
10	8.1	198.7025						
11	9.1	163.269						
12	10	136.9565						

	A	B	C	D	E	F	G	H
1	Output Variable: Tot Conc ug/L Number of Segments 1							
2	0	1000						
3	1	817.9874						
4	2	669.2699						
5	3.1	536.9018						
6	4.1	439.6025						
7	5.1	360.1018						
8	6.1	295.144						
9	7.1	242.0688						
10	8.1	198.7025						
11	9.1	163.269						
12	10	136.9565						
13	11	112.818						
14	12	93.0952						
15	13	76.9802						
16	14	63.813						
17	15	53.0545						
18	16	44.2641						
19	17	37.0816						
20	18	31.213						
21	19	26.4179						
22	20	22.5						
23	21	19.2988						
24	22	16.6831						
25	23.0001	14.546						
26	24.0001	12.7998						
27	25.0001	11.373						
28	26.0001	10.2072						
29	27.0001	9.2546						
30	28.0001	8.4764						
31	29.0001	7.8404						
32	30.0001	7.3208						
33	31.1501	6.8963						
34								

Time,
days

Output variable by segment in columns

