NUTRIENT TMDLs FOR THE LOWER CATAWBA RIVER BASIN: Current Status

UNIVERSITY OF SOUTH CAROLINA

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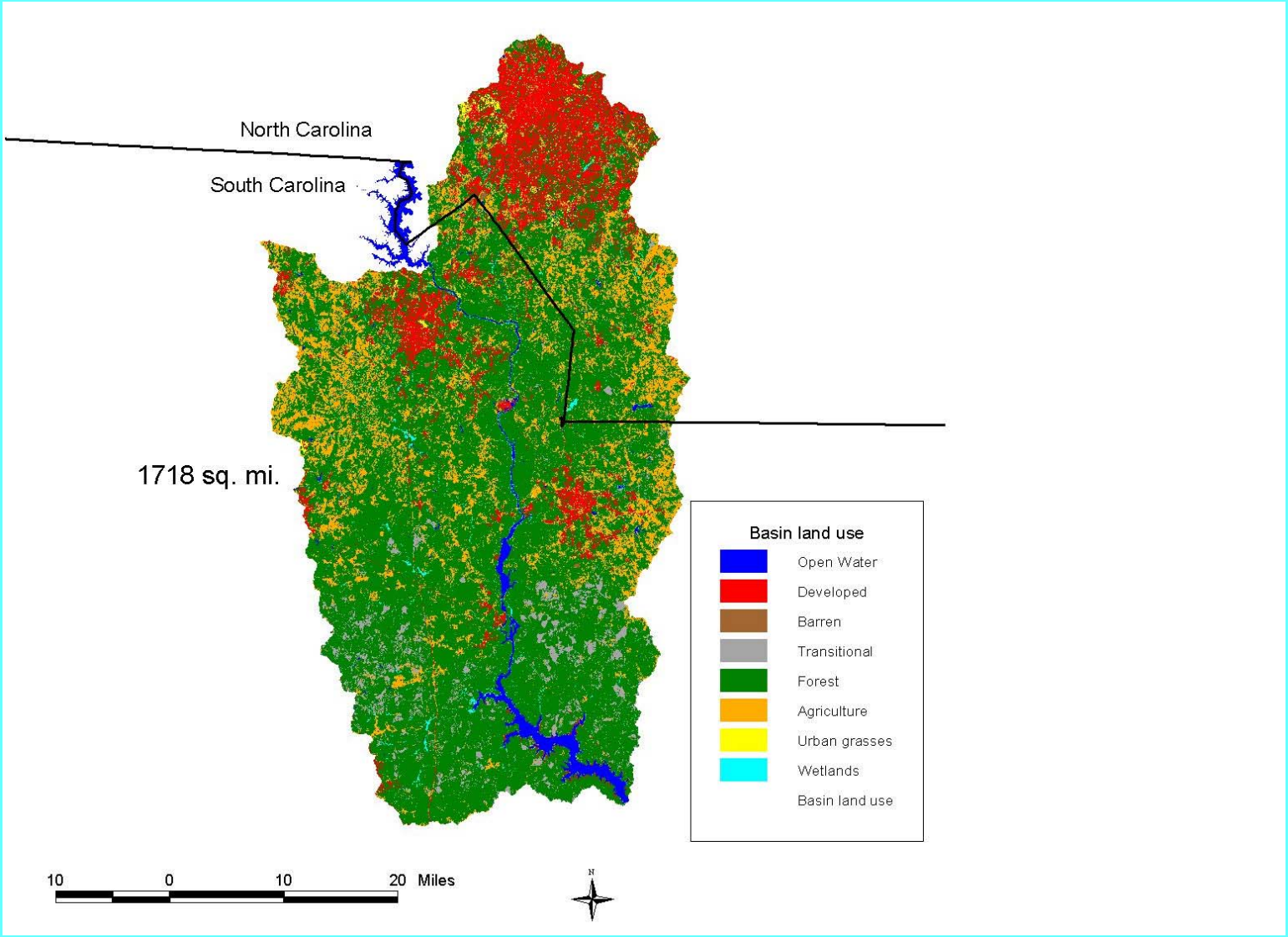
COLLABORATORS

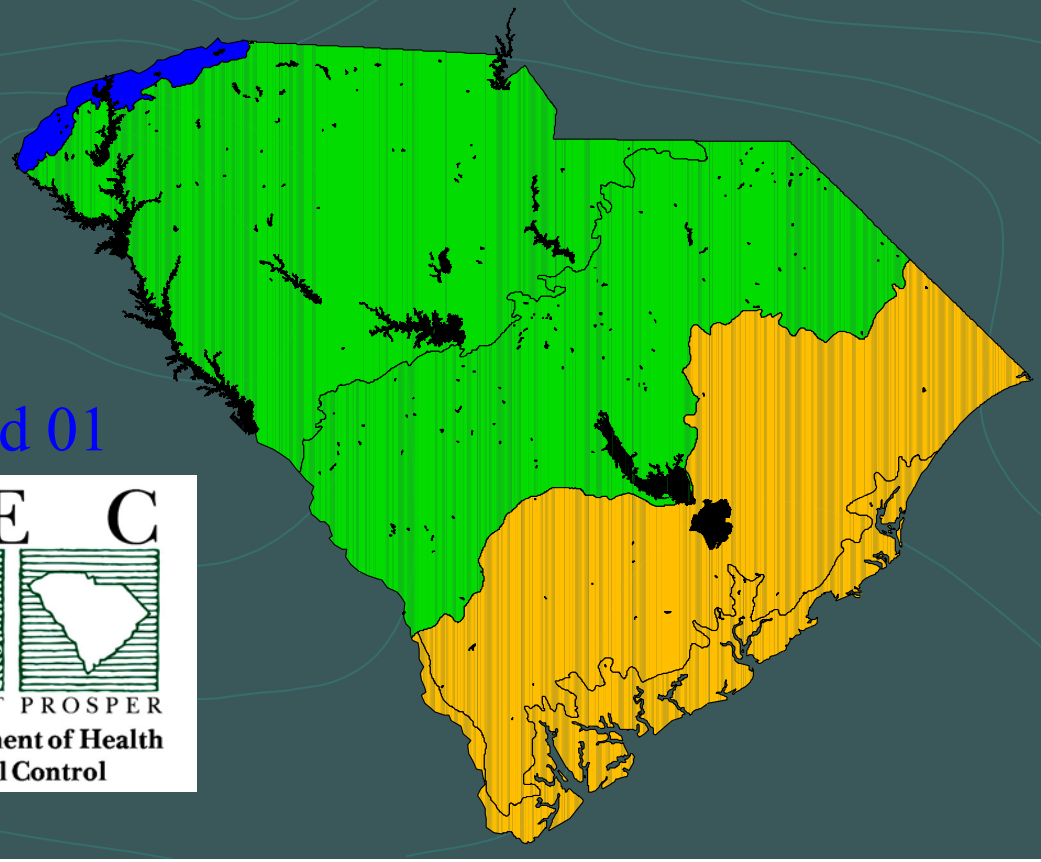
- Duke Energy
- Systech Engineering
- US Geological Survey
- NC DENR
- SC DHEC
- Wateree Homeowners Assoc.
- Catawba River Keeper
- City of York

Lower Catawba River watershed



Numeric nutrient criteria for lakes > 40 acres based on an ecoregional approach

	Phosphorus (mg/L)	Nitrogen (mg/L)	chl-a (µg/L)
Blue Ridge	0.02	0.35	10
Piedmont/Southeastern Plains	0.06	1.50	40
Middle Atlantic Coastal Plain	0.09	1.50	40

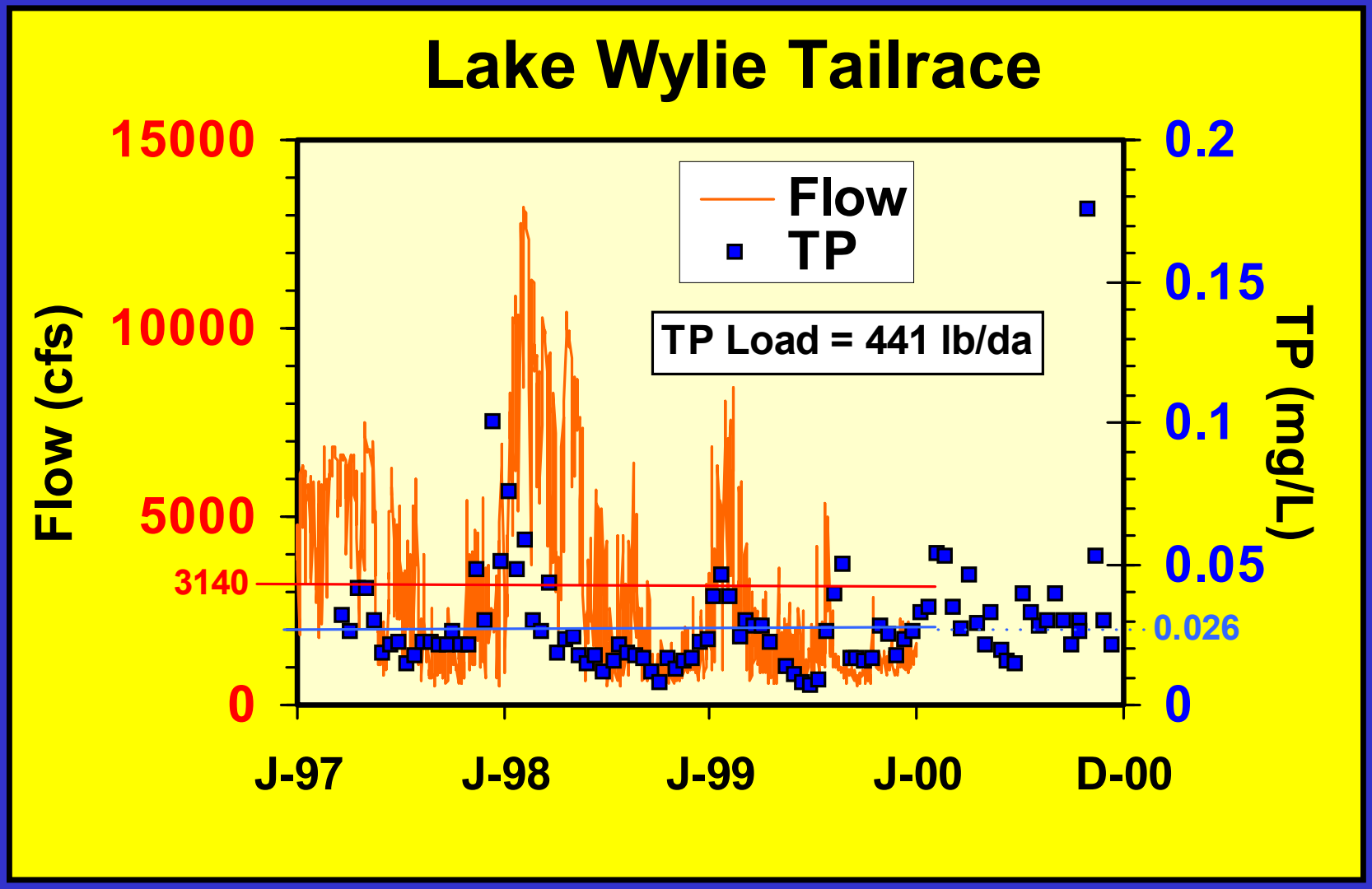


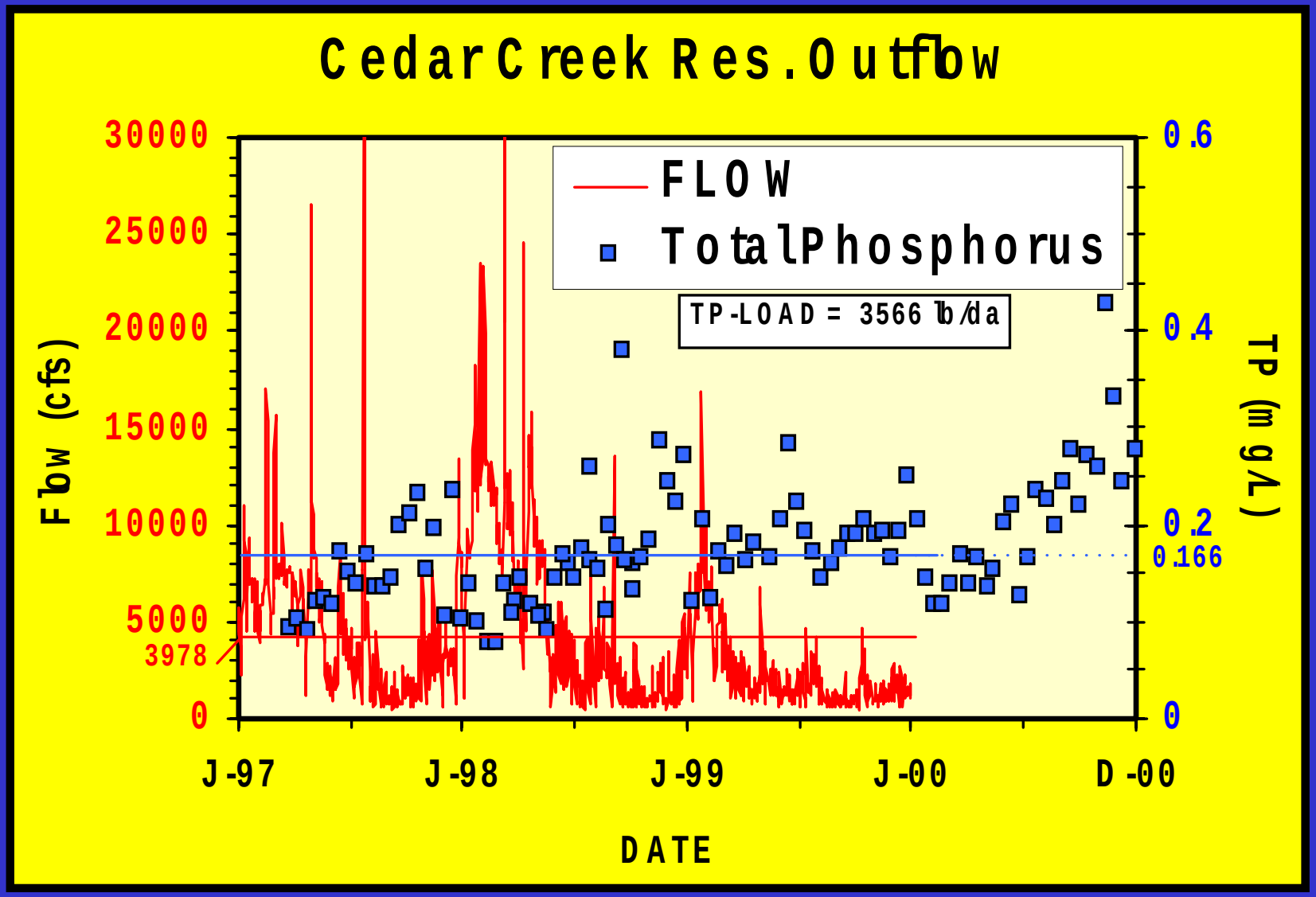
M. Alford 01

D H E C

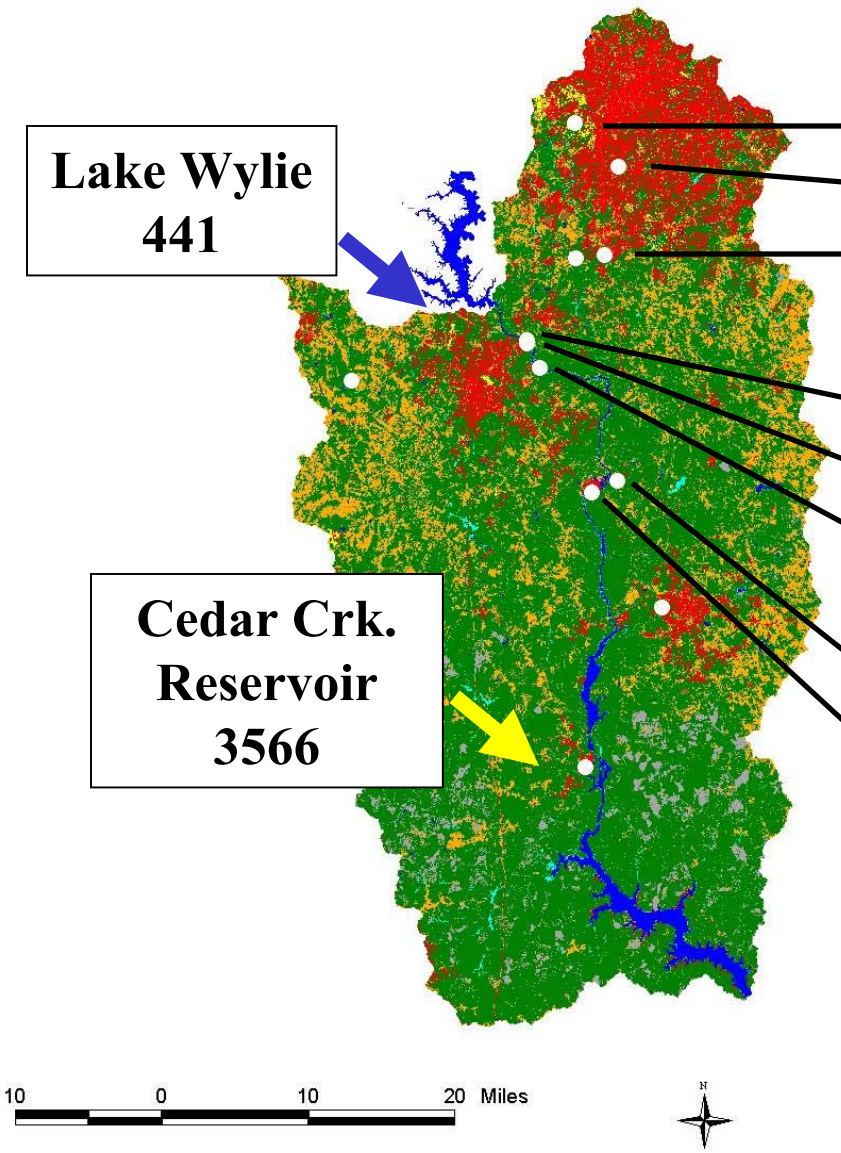
PROMOTE PROTECT PROSPER

South Carolina Department of Health and Environmental Control


Lake Wylie Tailrace
Flow
TP
TP Load = 441 lb/da
Flow (cfs)
TP (mg/L)
15000
10000
5000
3140
0
0.2
0.15
0.1
0.05
0.026
0
J-97
J-98
J-99
J-00
D-00


Cedar Creek Res. Outflow
FLOW
Total Phosphorus
TP-LOAD = 3566 lb/da
Flow (cfs)
TP (mg/L)
30000
25000
20000
15000
10000
5000
3978
0
0.6
0.4
0.2
0.166
0
J-97
J-98
J-99
J-00
D-00
DATE

MAJOR POINT SOURCES

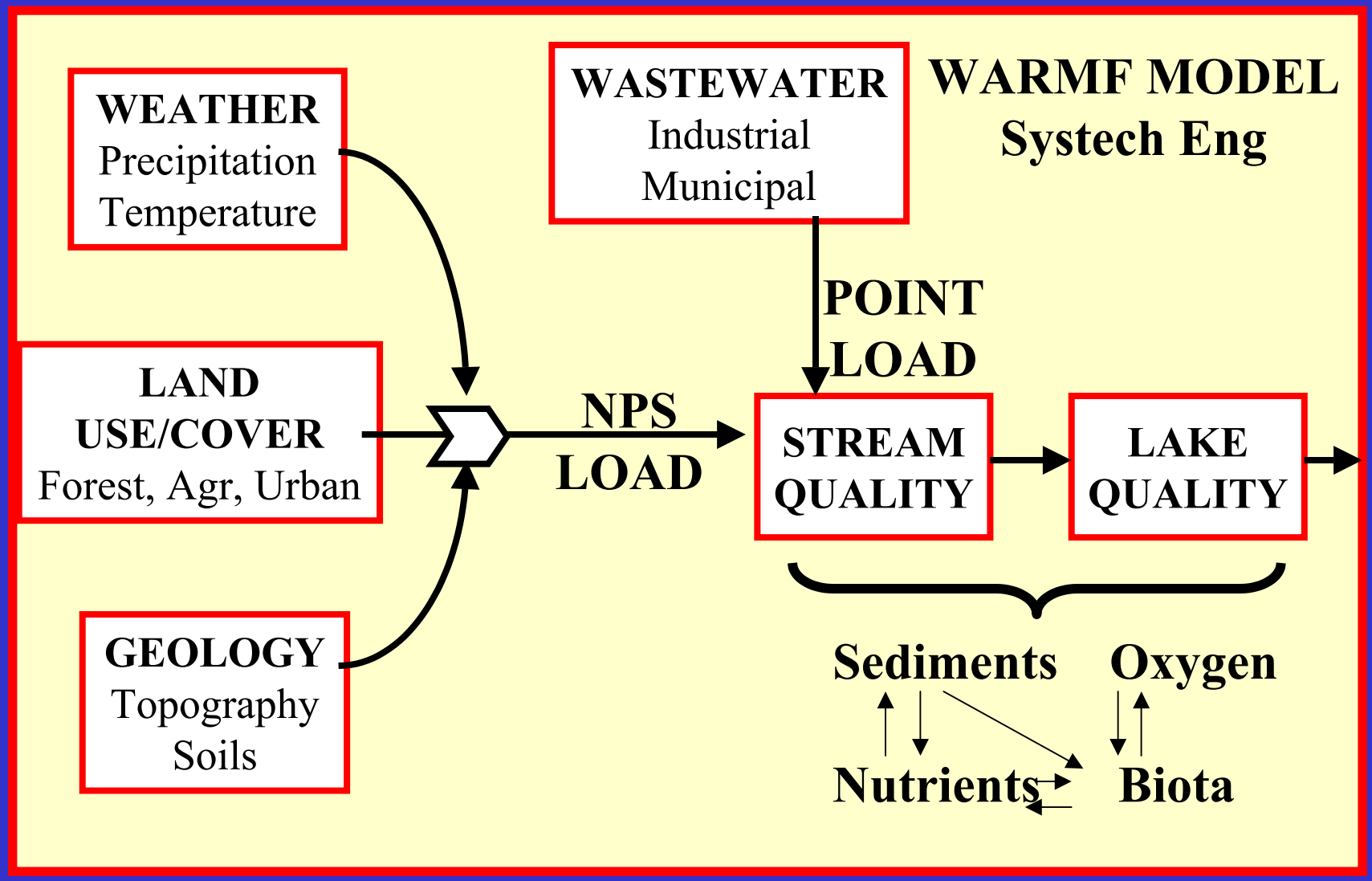


	Phosphorus Load (Lbs/Day)
CMU-Irwin Cr	156.8
CMU-Sugar Cr	580.9
CMU-McAlpine Cr	830.0
Town of Ft. Mill	12.7
Celanese-Acetate	108.8
Rock Hill	137.8
Lancaster-Catawba	30.8
Bowater	274.3
	2132.1

Total Maximum Daily Load (TMDL)

* Wasteload Allocation +
* Nonpoint Source Loading +
* Margin of Safety

WATERSHED ANALYSIS AND TMDLs



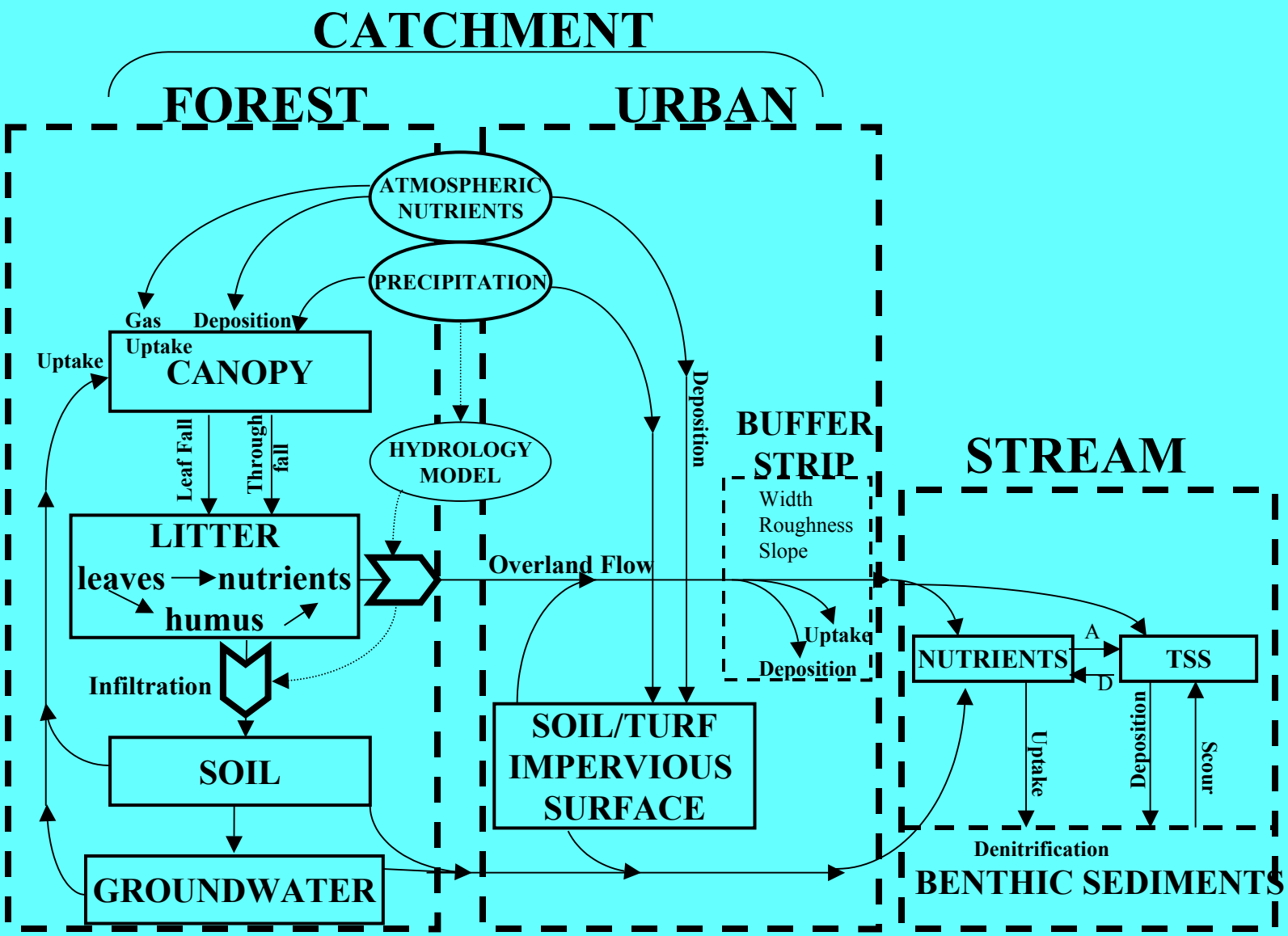
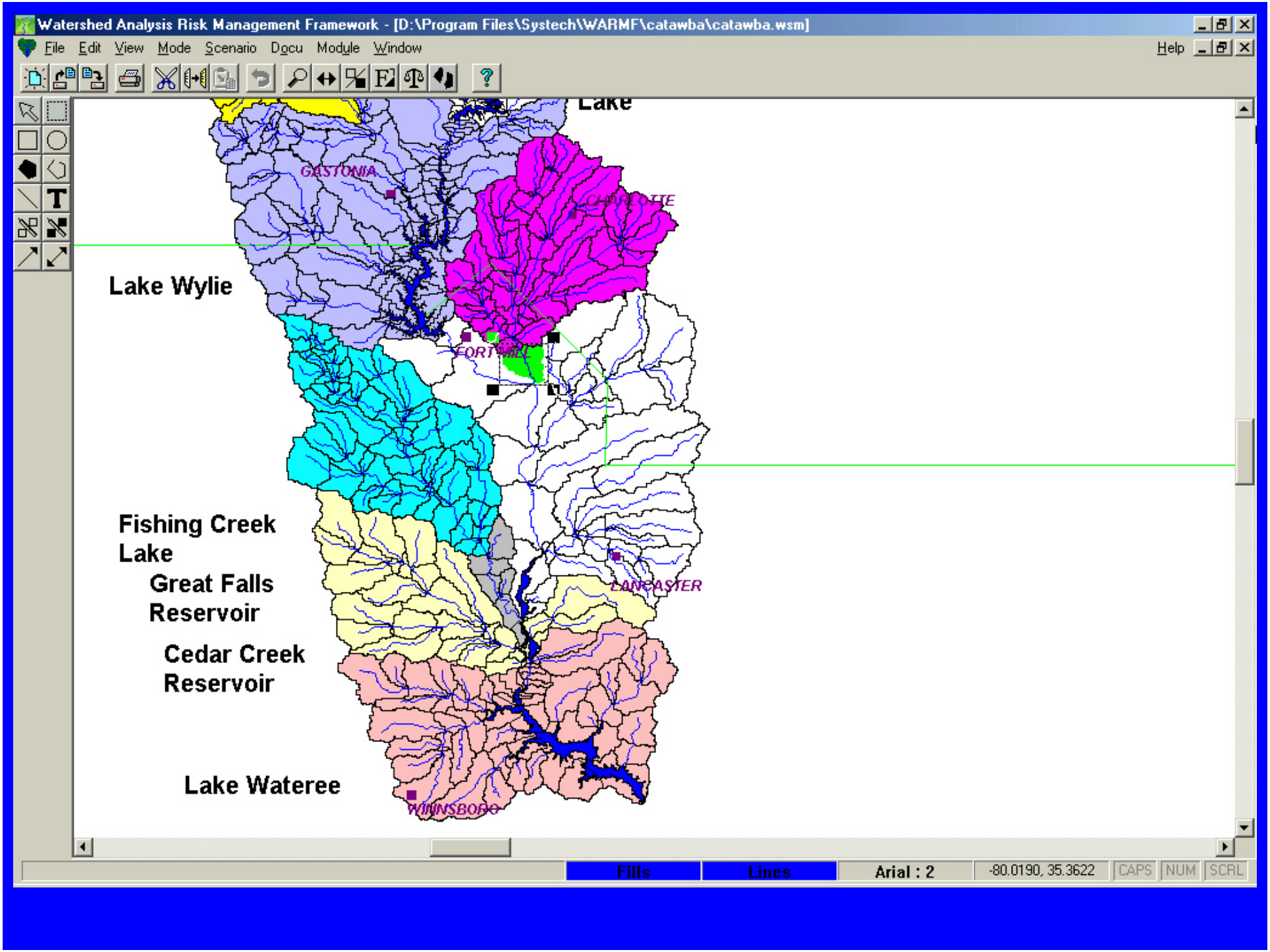


Figure . Basic pathways of watershed nutrient transformation and transport.


Watershed Analysis Risk Management Framework - [D:\Program Files\Systech\WARMF\catawba\catawba.wsm]
File Edit View Mode Scenario Docu Module Window
Help
Lake
GASTONIA
CHARLOTTE
Lake Wylie
FORT MILL
Fishing Creek Lake
Great Falls Reservoir
LANCASTER
Cedar Creek Reservoir
Lake Wateree
WINNSBORO
Fills
Lines
Arial : 2
-80.0190, 35.3622
CAPS
NUM
SCRL

Catchment 39

BMP's | Septic Sys. | Reactions | Soil Layers | Mining | CE-QUAL-W2

Physical Data | Meteorology | Land Uses | Land Application | Irrigation | Sediment

Name: Catchment 39

Subcatchment ID: 39

Size and Slope

Area (sq. m): 2.7695e+07

Use scale to calculate

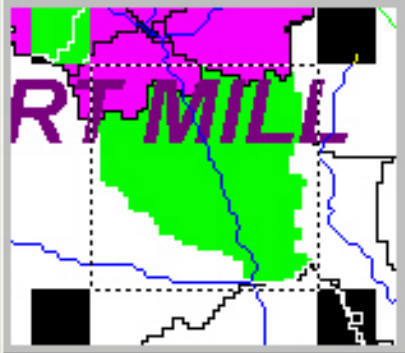
Aspect: 200.619

Slope: 0.035349

Width (m): 13324.5

Detention Storage (%): 10

Suface Roughness (Manning's n): 0.3



Apply Changes To Selected

Apply Changes To All

Write Output To File

OK | Cancel | Help

Catchment 39

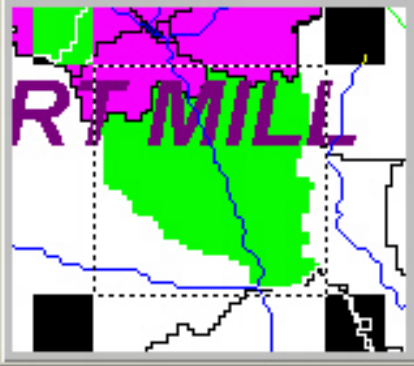
Physical Data | Meteorology | Land Uses | Land Application | Irrigation | Sediment
BMP's | Septic Sys. | Reactions | Soil Layers | Mining | CE-QUAL-W2

Number of Soil Layers: 4

Hydrology
- Hydrology
- Initial Concentrations
- Adsorption
- Mineral Composition
- Inorganic Carbon

Scroll for other parameters -->

Layer	Area m2	Thickness cm	Initial Moisture	Field Capacity	Sat. Moisture	Horizontal Cond. cm/d
1	27694000	55	0.267	0.1	0.316	10000
2	27694000	60	0.3	0.148	0.32	900
3	27694000	200	0.25	0.2	0.275	700
4	25857000	300	0.32	0.35	0.473	300



- [ ] Apply Changes To Selected
- [ ] Apply Changes To All
- [ ] Write Output To File

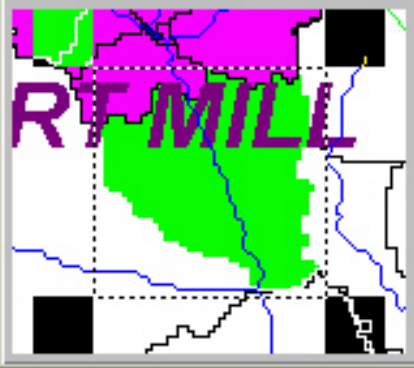
OK | Cancel | Help

Catchment 39

BMP's | Septic Sys. | Reactions | Soil Layers | Mining | CE-QUAL-W2

Physical Data | Meteorology | Land Uses | Land Application | Irrigation | Sediment

	%
Deciduous Forest	50.9
Evergreen Forest	16.92
Mixed Forest	13.85
Pasture	6.76
Cultivated	6.17
Recr. Grasses	0.22
Water	0.56
Barren	0.62
Low Int. Develop.	2.34
High Int. Develop.	0.02
Comm / Industrial	0.42
Wetlands	1.23
TOTAL	100



☐ Apply Changes To Selected

☐ Apply Changes To All

☐ Write Output To File

OK | Cancel | Help

Sugar Creek near Road 36

Sediment | Initial Conc. | Observed Data | CE-QUAL-W2

Physical Data | Stage-Width | Diversions | Point Sources | Reactions

Name: Sugar Creek near Road 36

Stream ID: 39

Bed Elevations (m)

Upstream: 165.514

Downstream: 147.865

Length and Depth

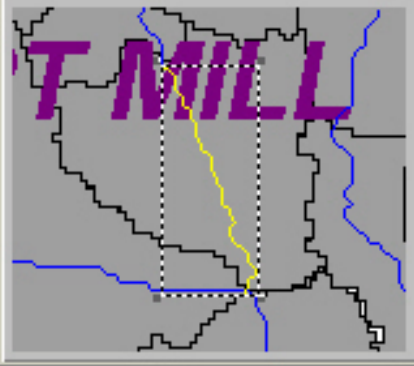
Length: 6670.41

Use scale to calculate.

Initial Depth (m): 1

Kinematic Wave Routing

Manning's N: 0.1



- [ ] Apply Changes To Selected
- [ ] Apply Changes To All
- [x] Write Output To File

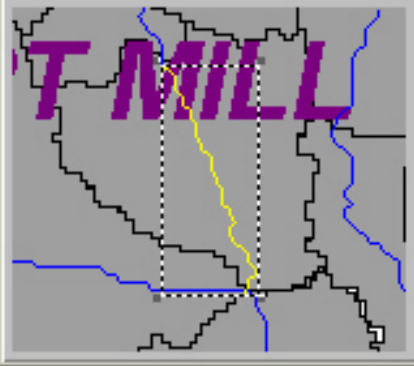
OK | Cancel | Help

Sugar Creek near Road 36

Physical Data | Stage-Width | Diversions | Point Sources | Reactions

Sediment | Initial Conc. | Observed Data | CE-QUAL-W2

Temperature, C	15
Ammonia, mg/l N	0.05
Aluminum, mg/l	0.1
Calcium, mg/l	3
Magnesium, mg/l	1
Potassium, mg/l	2
Sodium, mg/l	5
Sulfate, mg/l S	5
Nitrate, mg/l N	0.1
Chloride, mg/l	5
Phosphate, mg/l P	0.01
Org. Carbon, mg/l	2
Inorg. Carbon, mg/l	25
Silica, mg/l Si	4
Copper, mg/l Cu	0
Fec. Coli.. #/100 ml	100



☐ Apply Changes To Selected

☐ Apply Changes To All

☑ Write Output To File

OK | Cancel | Help

Sugar Creek near Road 36

Sediment | Initial Conc. | Observed Data | CE-QUAL-W2

Physical Data | Stage-Width | Diversions | Point Sources | Reactions

Aeration Factor	1
SOD, g/m2/day	1
Organic Carbon Decay, 1/day	0.1
Nitrification Rate, 1/day	0.25
Dentrification Rate, 1/day	0
Ferrous Oxidation Rate, (mol/l)^2/d	0
Sulfur Reduction, 1/day	0
Coliform Decay, 1/day	0.3
Convective Heat Factor	1e-08
Precipitate Settling, m/day	0

☑ Periphyton Growth

☐ Apply Changes To Selected

☐ Apply Changes To All

☑ Write Output To File

OK | Cancel | Help

Sugar Creek near Road 36

Sediment | Initial Conc. | Observed Data | CE-QUAL-W2

Physical Data | Stage-Width | Diversions | Point Sources | Reactions

SC0035033.PTS

Add

Remove

Specify temperature and total loading.

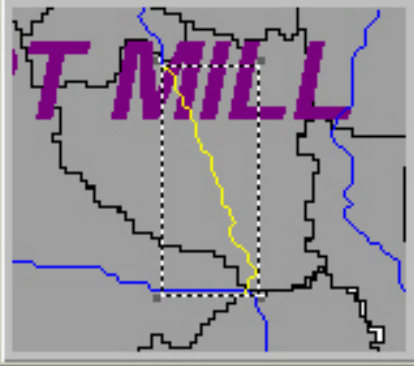
Water source

- Internal (from river)
- External

Unspecified Constituents

- Zero
- River Ambient

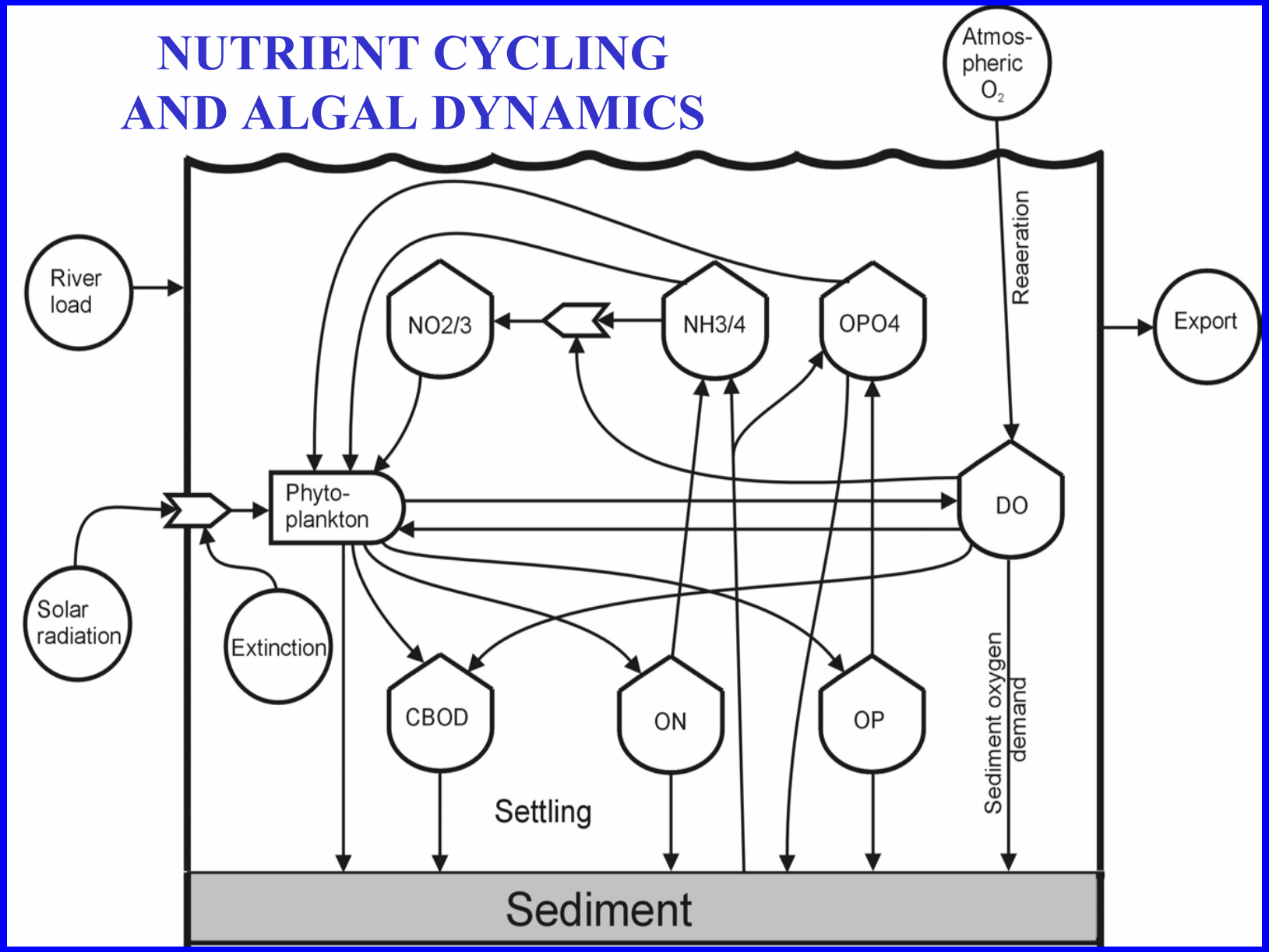
NPDES Permit SC0035033

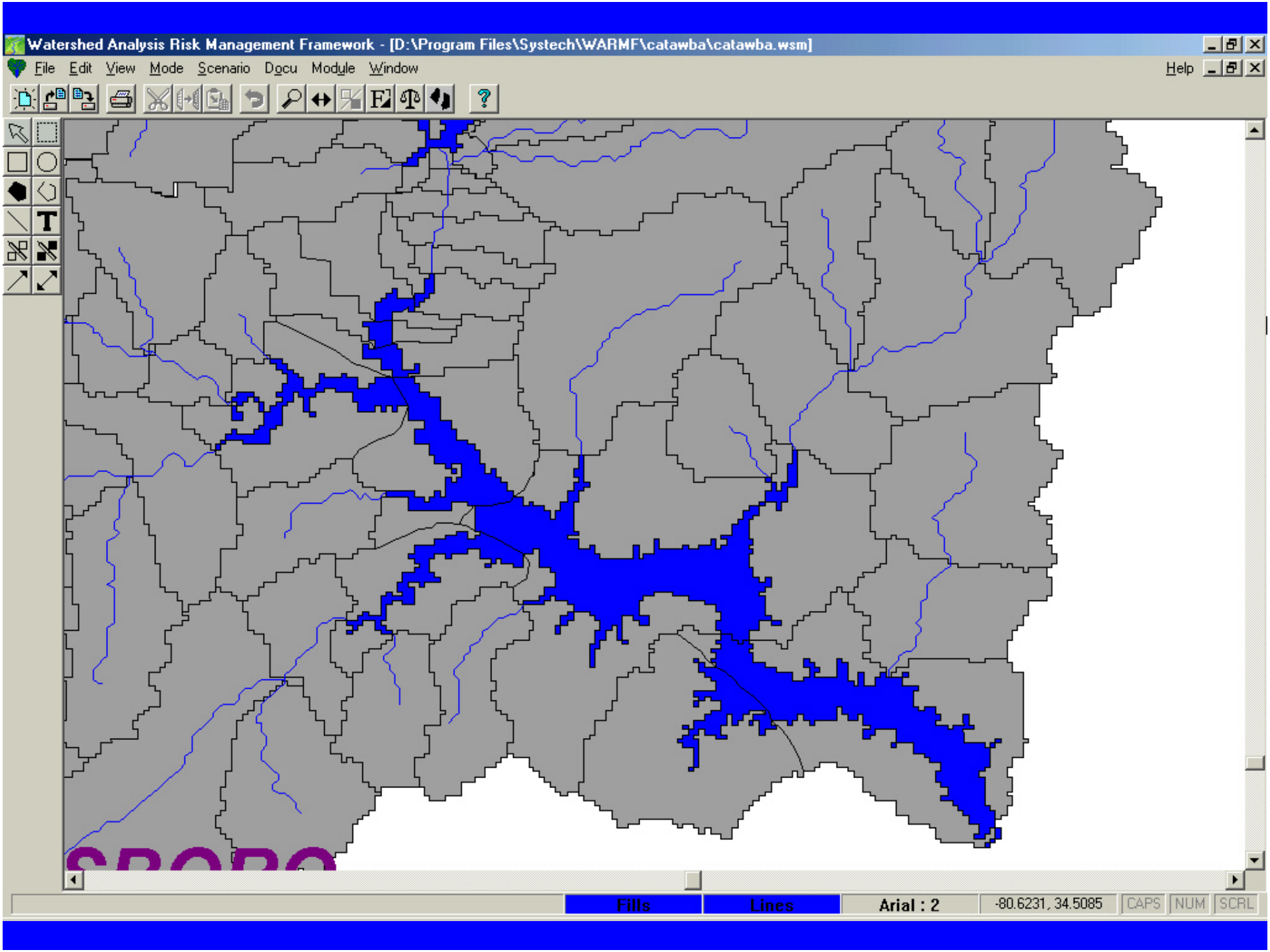


- [ ] Apply Changes To Selected
- [ ] Apply Changes To All
- [x] Write Output To File

OK | Cancel | Help

NUTRIENT CYCLING AND ALGAL DYNAMICS




Watershed Analysis Risk Management Framework - [D:\Program Files\Systech\WARMF\catawba\catawba.wsm]
File Edit View Mode Scenario Docu Module Window
Help
Fills
Lines
Arial : 2
-80.6231, 34.5085
CAPS
NUM
SCRL

Lake Wateree Seg 3

Outlets | Meteorology | Heat/Light | Diffusion | Sediment | Initial Temp. | Initial Conc.

Physical Data | Stage-Flow | Reactions | Point Sources | Observed Data | Stage-Area

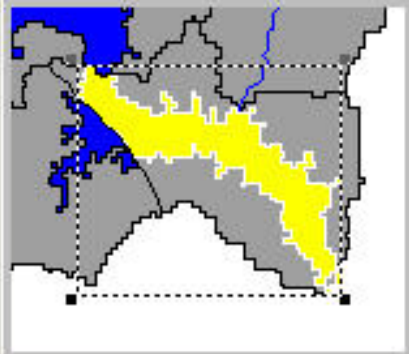
Name: Lake Wateree Seg 3

Reservoir Segment ID: 2292

Initial Water Surface Elevation, m: 67.8

Minimum Surface Elevation, m: 45.72

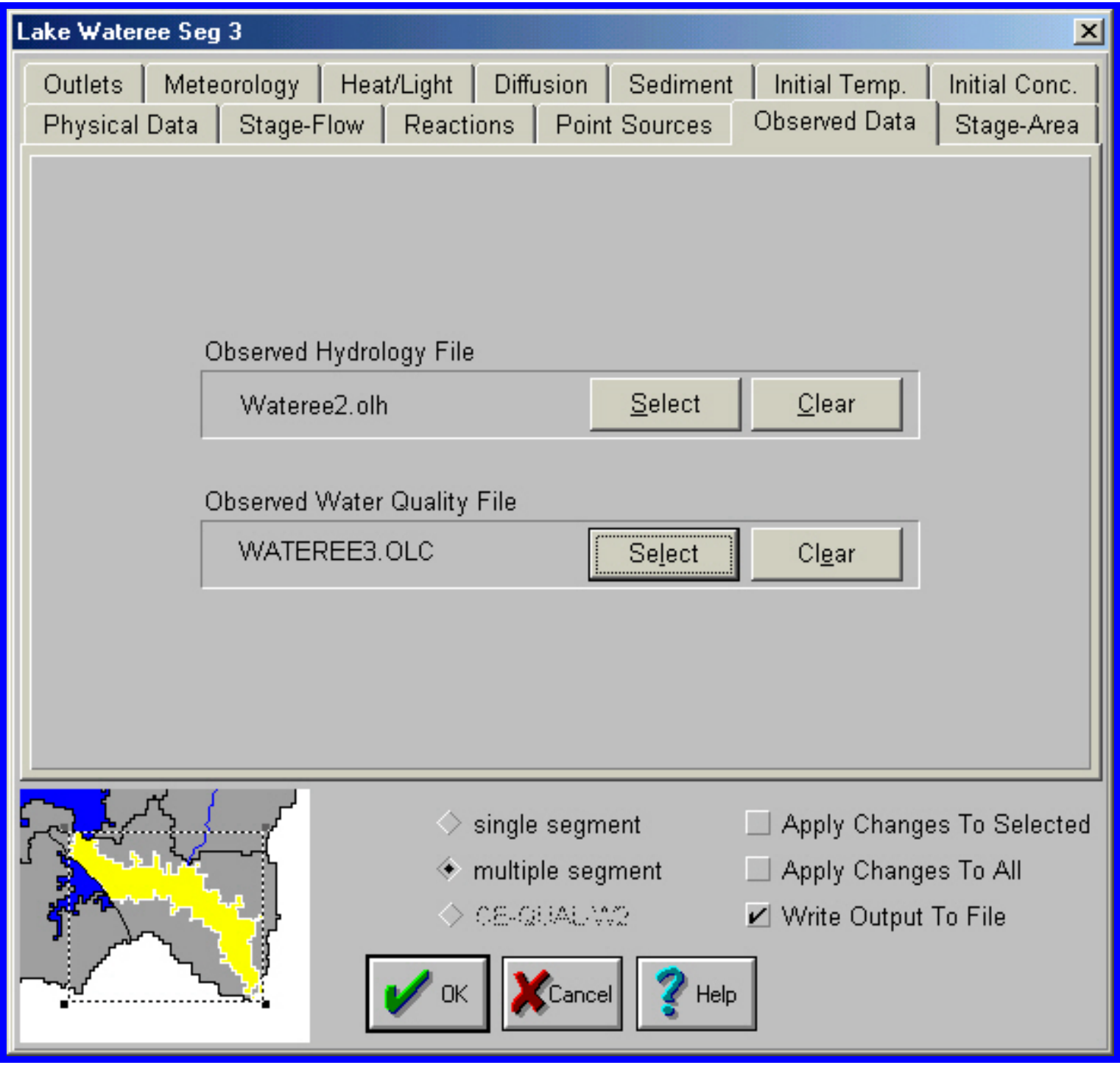
Maximum Surface Elevation, m: 79.25



- ◇ single segment
- ◆ multiple segment
- ◇ CE-QUAL-W2

- ☐ Apply Changes To Selected
- ☐ Apply Changes To All
- ☑ Write Output To File

OK | Cancel | Help

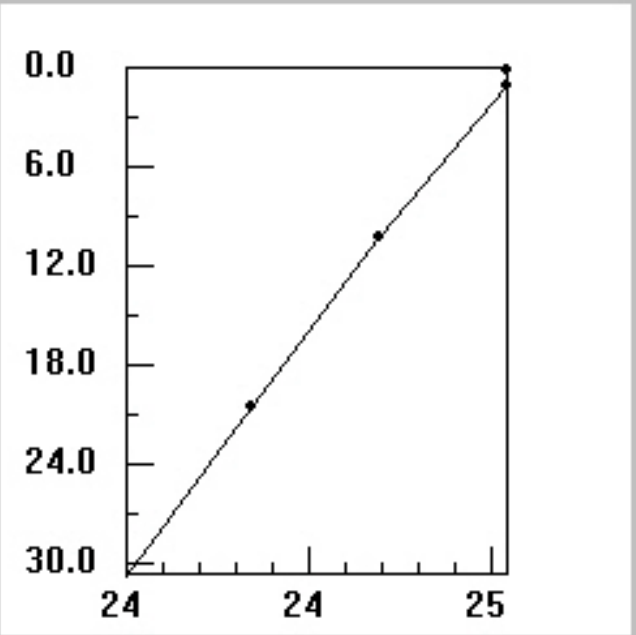

Lake Wateree Seg 3
Outlets
Meteorology
Heat/Light
Diffusion
Sediment
Initial Temp.
Initial Conc.
Physical Data
Stage-Flow
Reactions
Point Sources
Observed Data
Stage-Area
Observed Hydrology File
Wateree2.olh
Select
Clear
Observed Water Quality File
WATEREE3.OLC
Select
Clear
single segment
multiple segment
CE-QUAL-W2
Apply Changes To Selected
Apply Changes To All
Write Output To File
OK
Cancel
Help

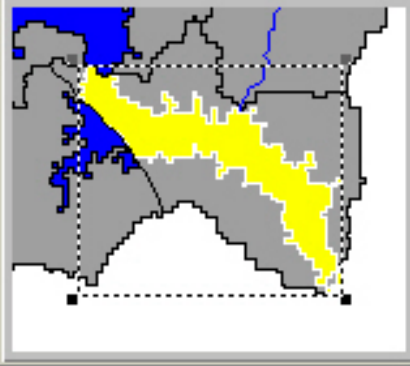
Lake Wateree Seg 3

Physical Data | Stage-Flow | Reactions | Point Sources | Observed Data | Stage-Area
Outlets | Meteorology | Heat/Light | Diffusion | Sediment | Initial Temp. | Initial Conc.

Enter up to 9 pairs of depth-temperature data

Depth (m)	Temperature
30.00	23.5
20.00	24.0
10.00	24.5
1.00	25.0
0.01	25.0
0.00	0.0
0.00	0.0
0.00	0.0
0.00	0.0





◇ single segment
◆ multiple segment
◇ CE-QUAL-W2

☐ Apply Changes To Selected
☐ Apply Changes To All
☑ Write Output To File

OK | Cancel | Help

System Coefficients

Minerals | Sediment | Pesticides | Phytoplankton | Periphyton | Detritus | Parameters

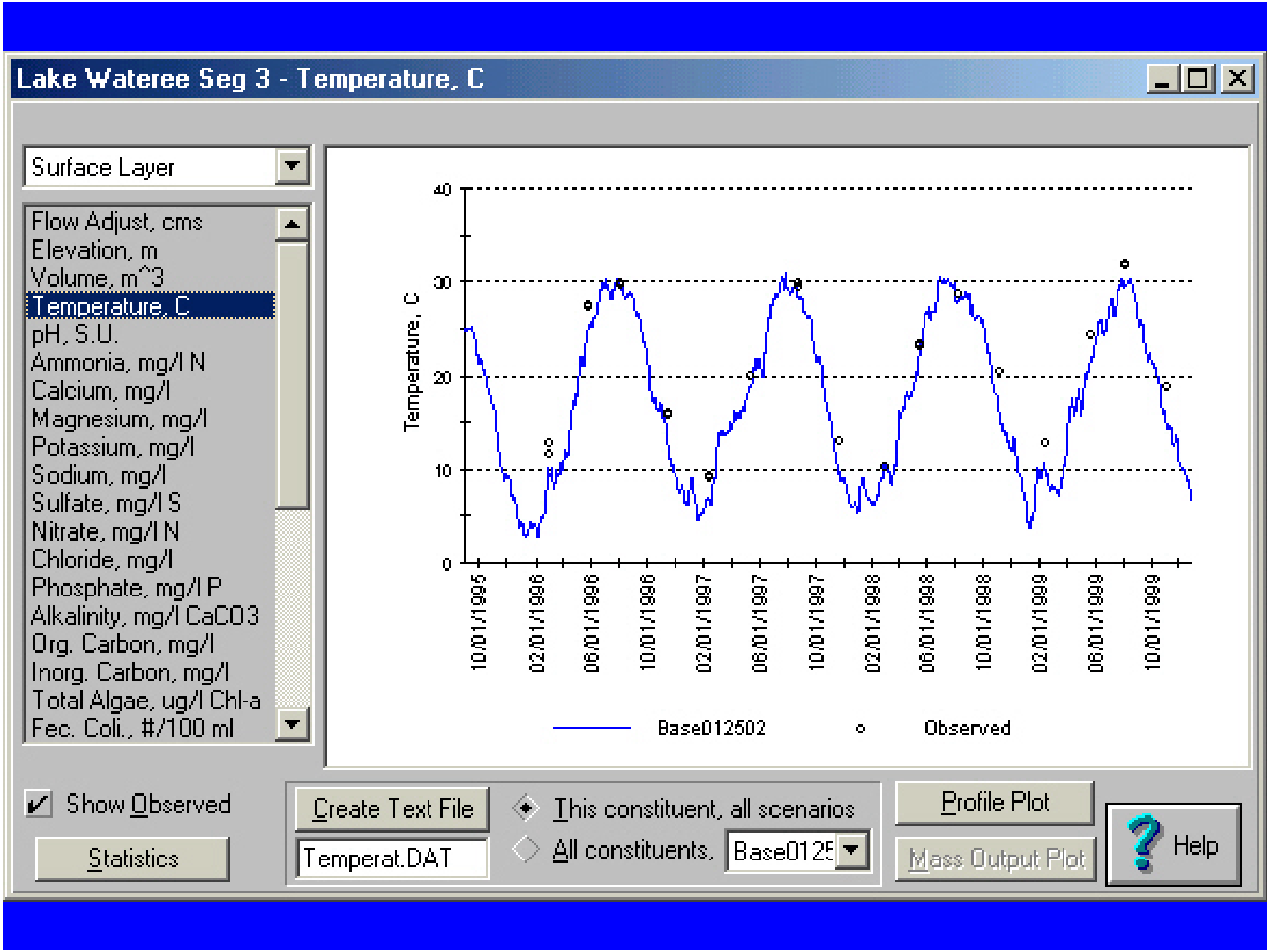
Physical Data | Land Uses | Snow/Ice | Heat/Light | Canopy | Litter | Reactions | Septic Sys.

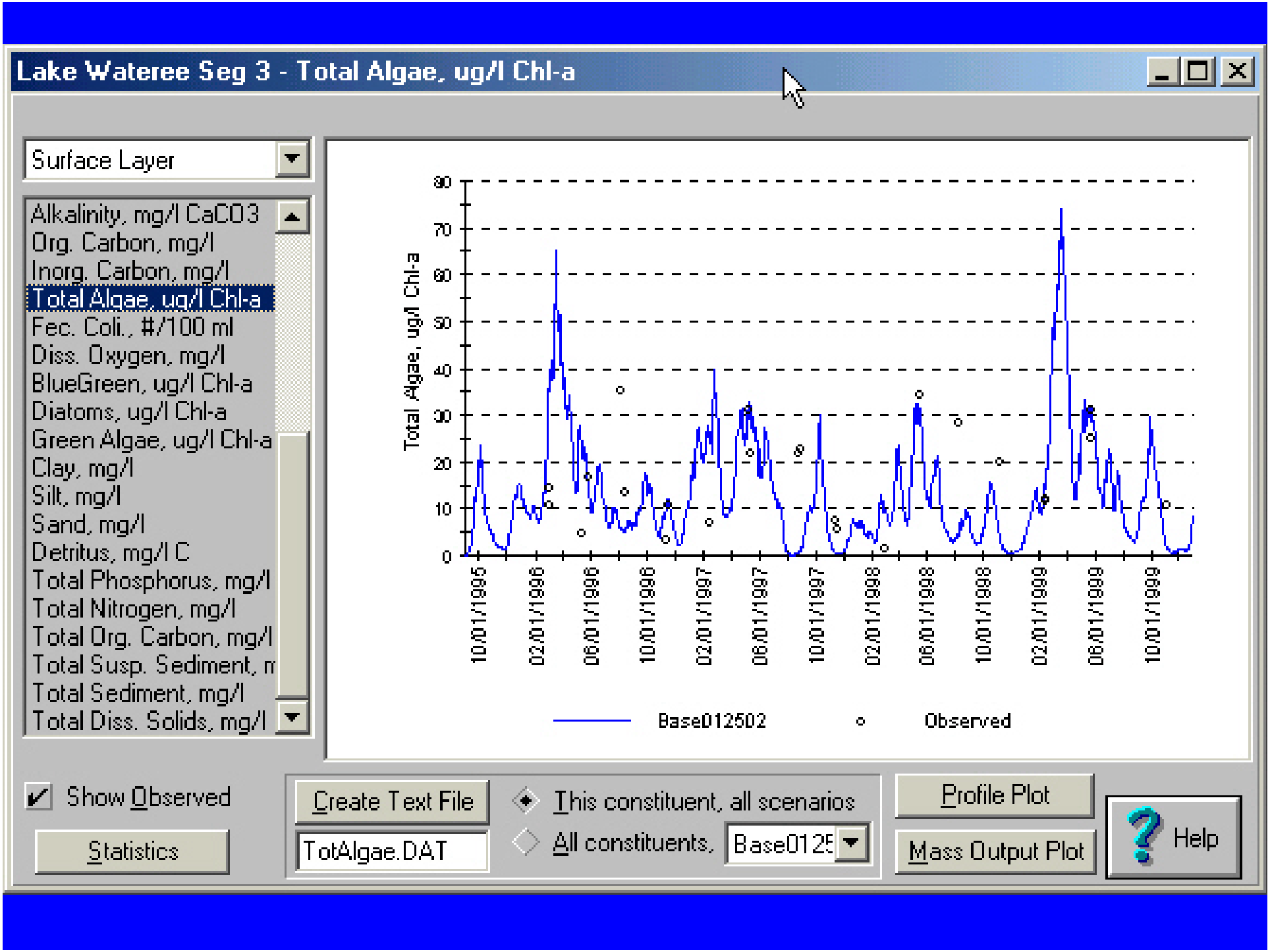
Parameter: Fraction Impervious

Edit List

Land Uses	Value
Deciduous Forest	0
Evergreen Forest	0
Mixed Forest	0
Pasture	0
Cultivated	0
Recr. Grasses	0
Water	1
Barren	0
Low Int. Develop.	0.5
High Int. Develop.	1
Comm / Industrial	1
Wetlands	0

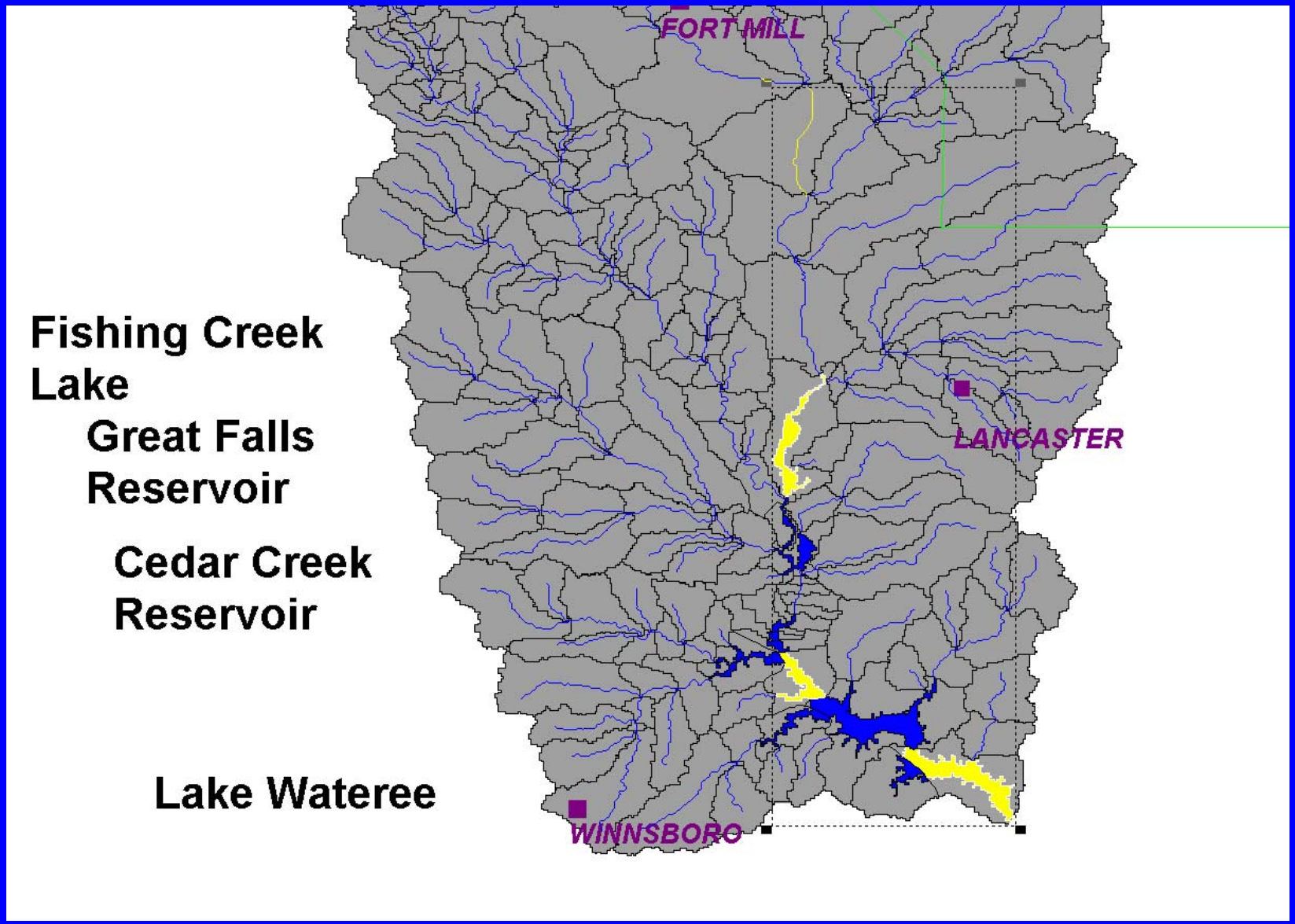
OK | Cancel | Help


Lake Wateree Seg 3 - Temperature, C
Surface Layer
Flow Adjust, cms
Elevation, m
Volume, m^3
Temperature, C
pH, S.U.
Ammonia, mg/l N
Calcium, mg/l
Magnesium, mg/l
Potassium, mg/l
Sodium, mg/l
Sulfate, mg/l S
Nitrate, mg/l N
Chloride, mg/l
Phosphate, mg/l P
Alkalinity, mg/l CaCO3
Org. Carbon, mg/l
Inorg. Carbon, mg/l
Total Algae, ug/l Chl-a
Fec. Coli., #/100 ml
Temperature, C
40
30
20
10
0
10/01/1995
02/01/1996
06/01/1996
10/01/1996
02/01/1997
06/01/1997
10/01/1997
02/01/1998
06/01/1998
10/01/1998
02/01/1999
06/01/1999
10/01/1999
Base012502
Observed
Show Observed
Statistics
Create Text File
Temperat.DAT
This constituent, all scenarios
All constituents,
Base0125
Profile Plot
Mass Output Plot
Help

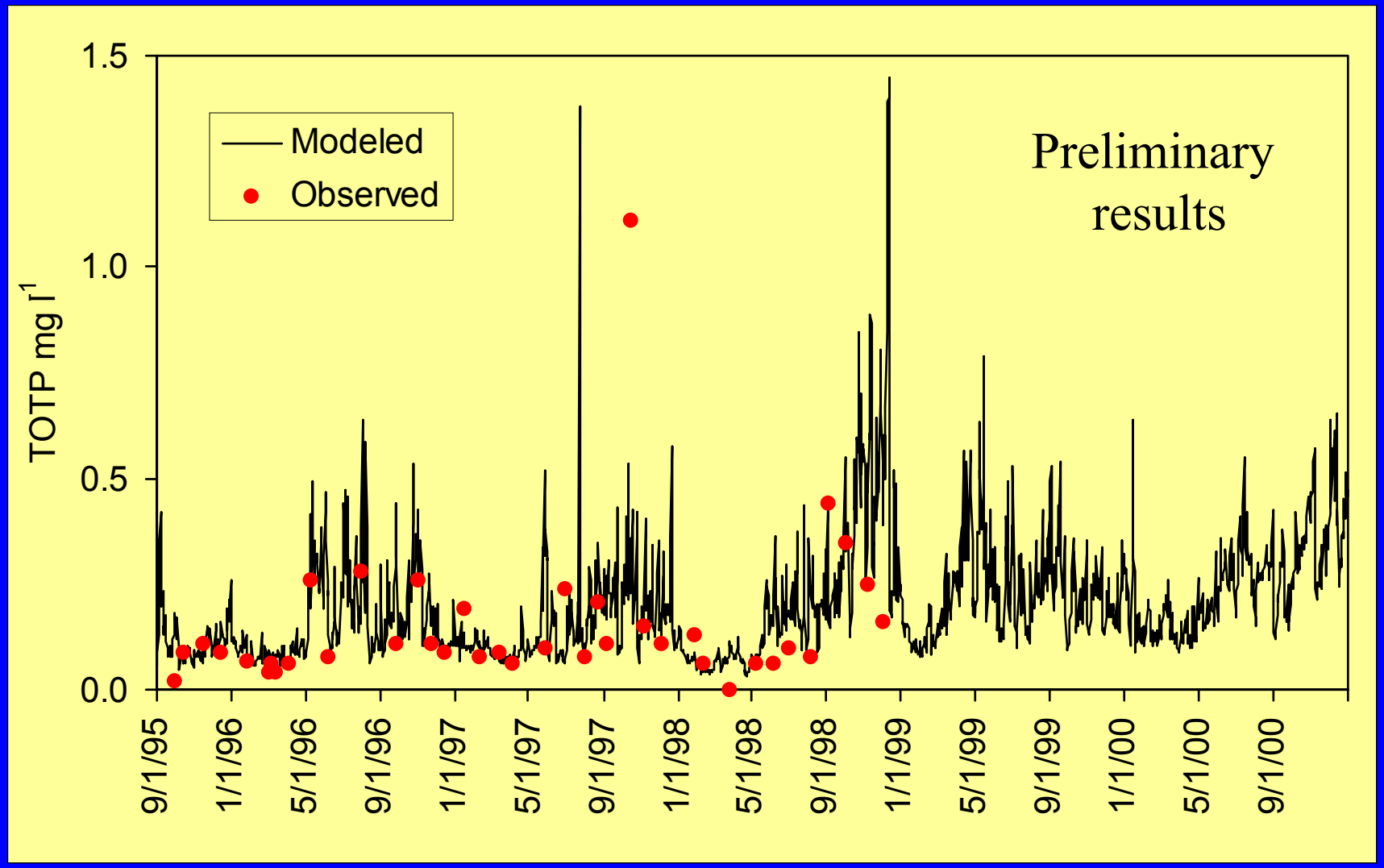

Lake Wateree Seg 3 - Total Algae, ug/l Chl-a
Surface Layer
Alkalinity, mg/l CaCO3
Org. Carbon, mg/l
Inorg. Carbon, mg/l
Total Algae, ug/l Chl-a
Fec. Coli., #/100 ml
Diss. Oxygen, mg/l
BlueGreen, ug/l Chl-a
Diatoms, ug/l Chl-a
Green Algae, ug/l Chl-a
Clay, mg/l
Silt, mg/l
Sand, mg/l
Detritus, mg/l C
Total Phosphorus, mg/l
Total Nitrogen, mg/l
Total Org. Carbon, mg/l
Total Susp. Sediment, m
Total Sediment, mg/l
Total Diss. Solids, mg/l
Total Algae, ug/l Chl-a
0
10
20
30
40
50
60
70
80
10/01/1995
02/01/1996
06/01/1996
10/01/1996
02/01/1997
06/01/1997
10/01/1997
02/01/1998
06/01/1998
10/01/1998
02/01/1999
06/01/1999
10/01/1999
Base012502
Observed
Show Observed
Statistics
Create Text File
TotAlgae.DAT
This constituent, all scenarios
All constituents,
Base0125
Profile Plot
Mass Output Plot
Help

Preliminary results

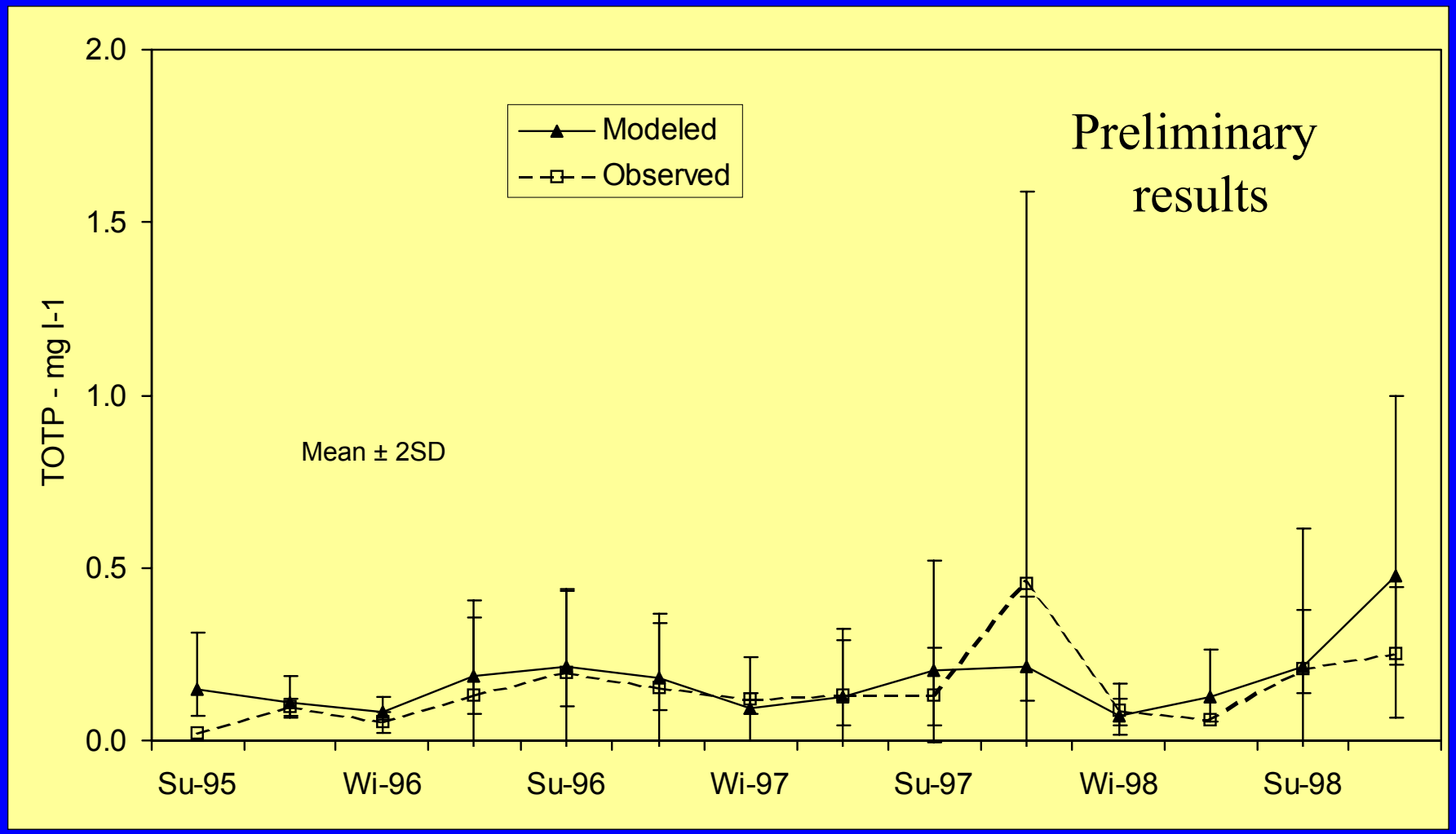
Model calibration and analysis



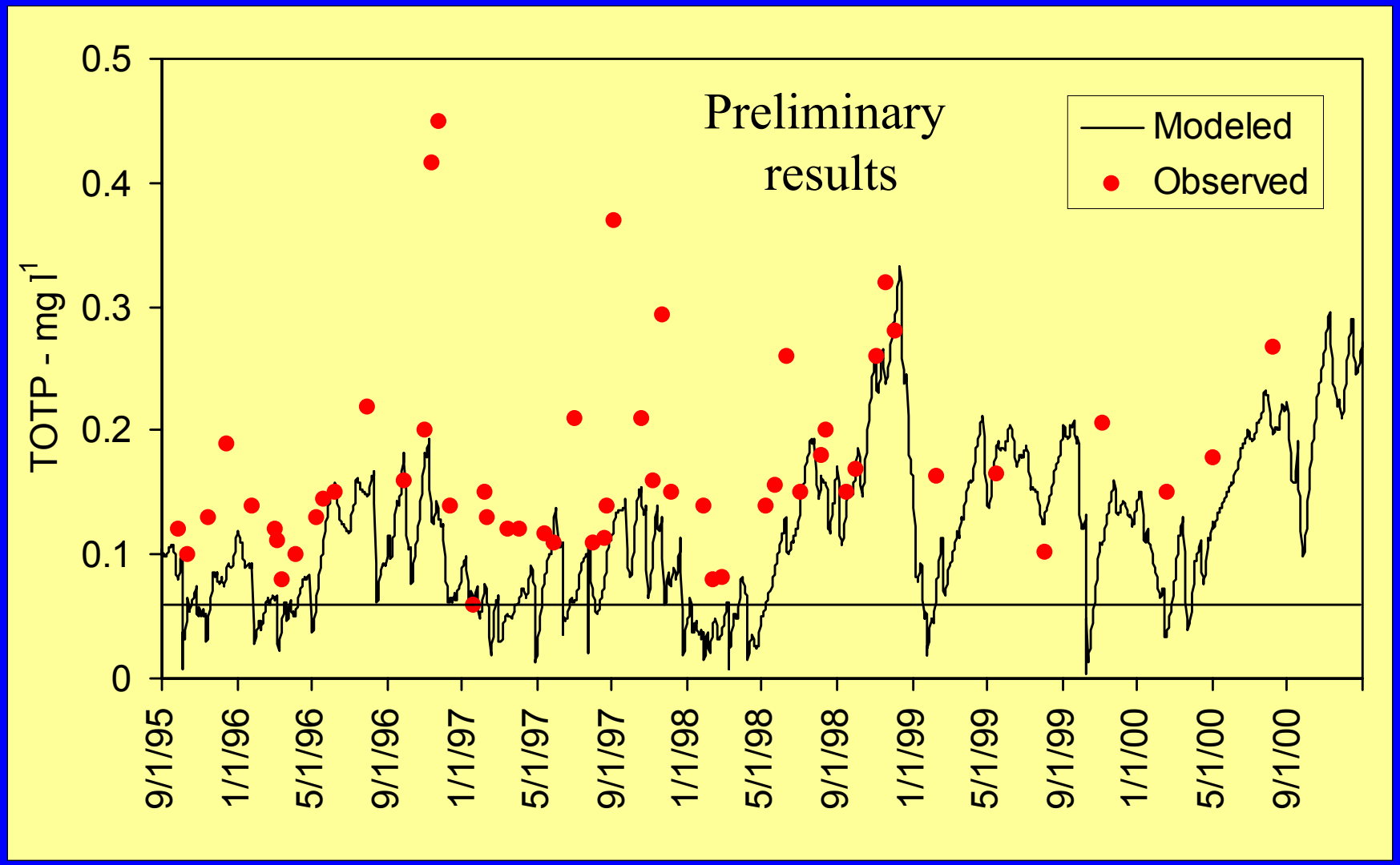
Catawba River below Sugar Creek



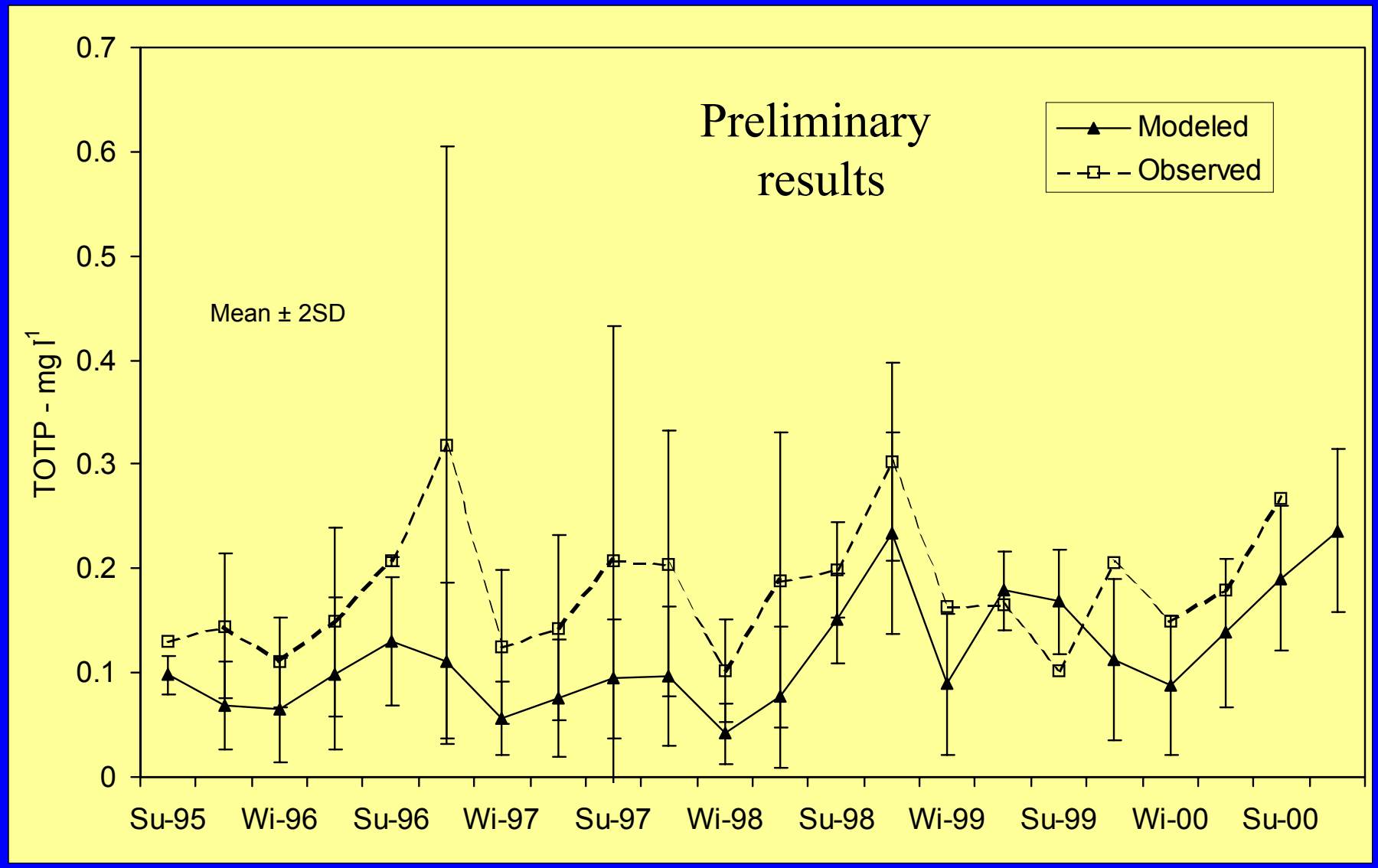
Catawba River below Sugar Creek



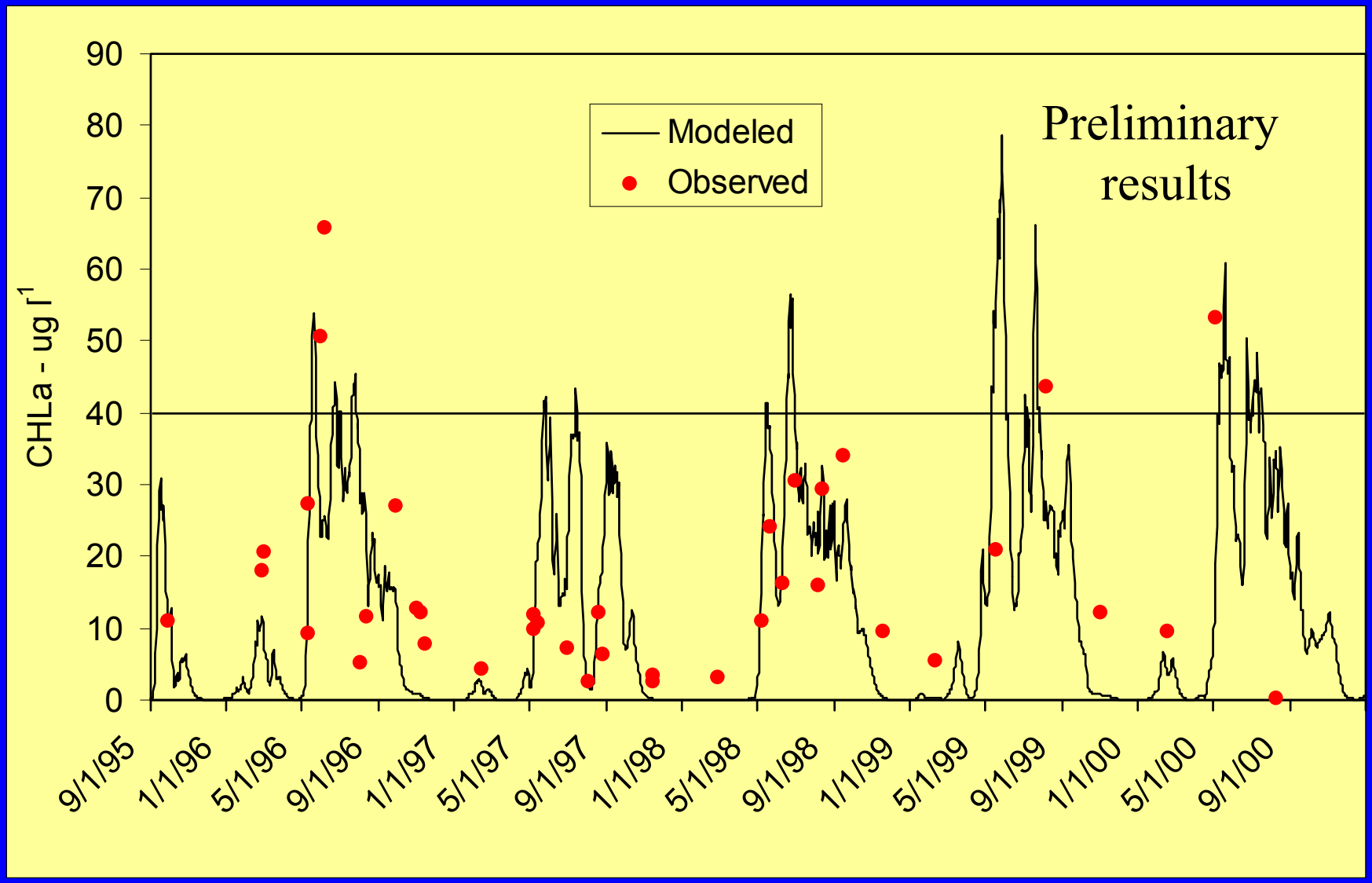
Fishing Creek Reservoir



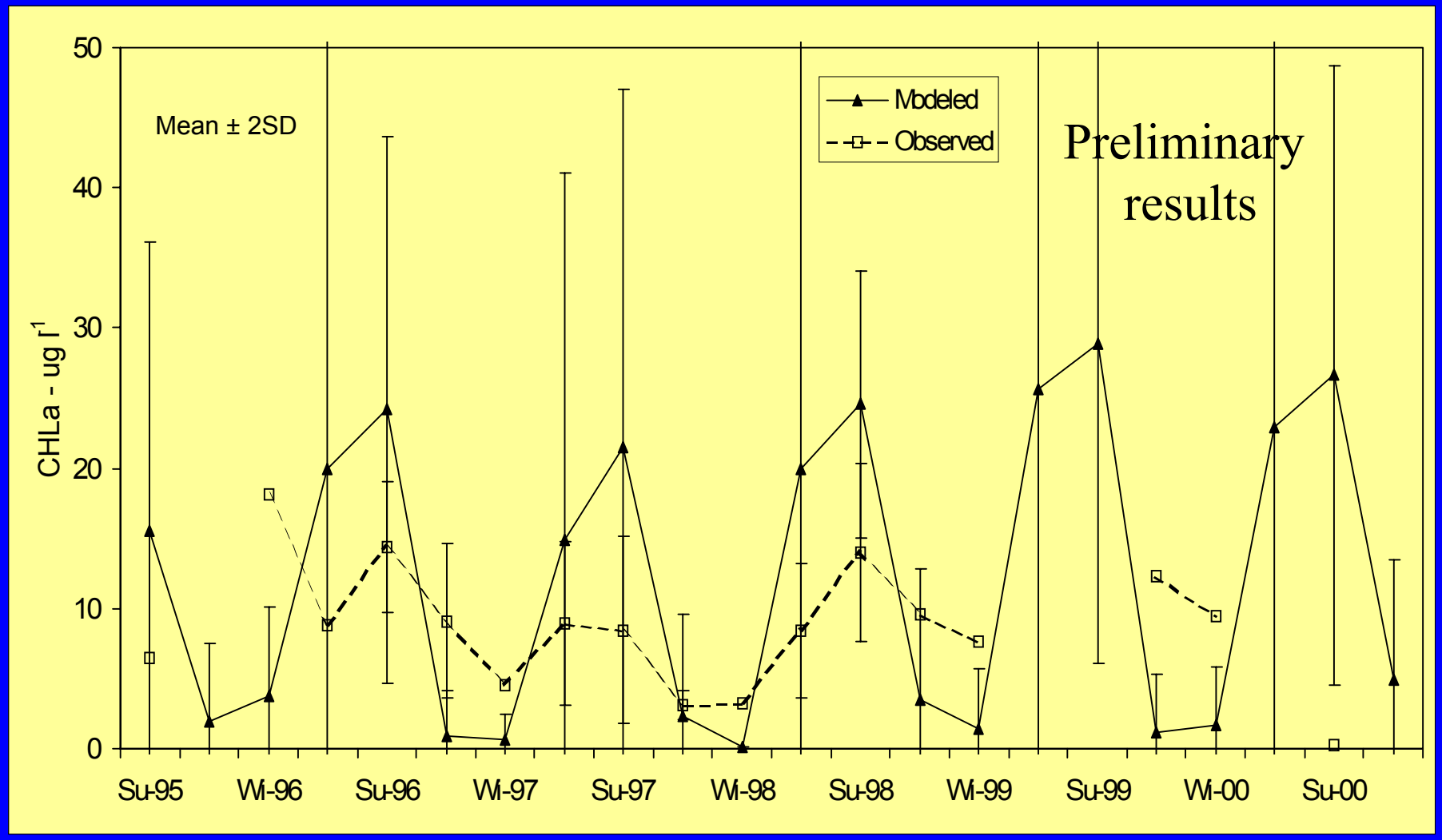
Fishing Creek Reservoir



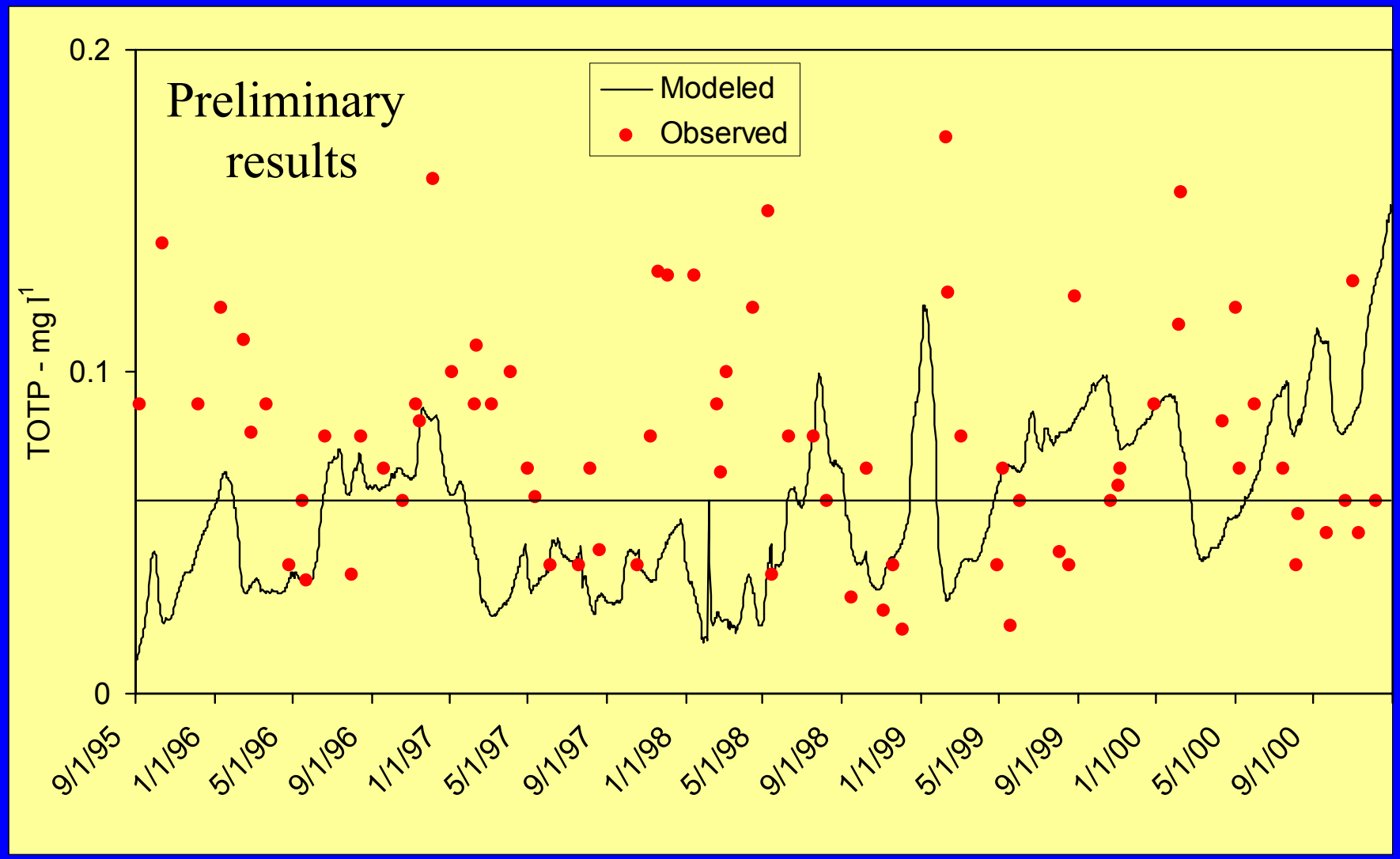
Fishing Creek Reservoir



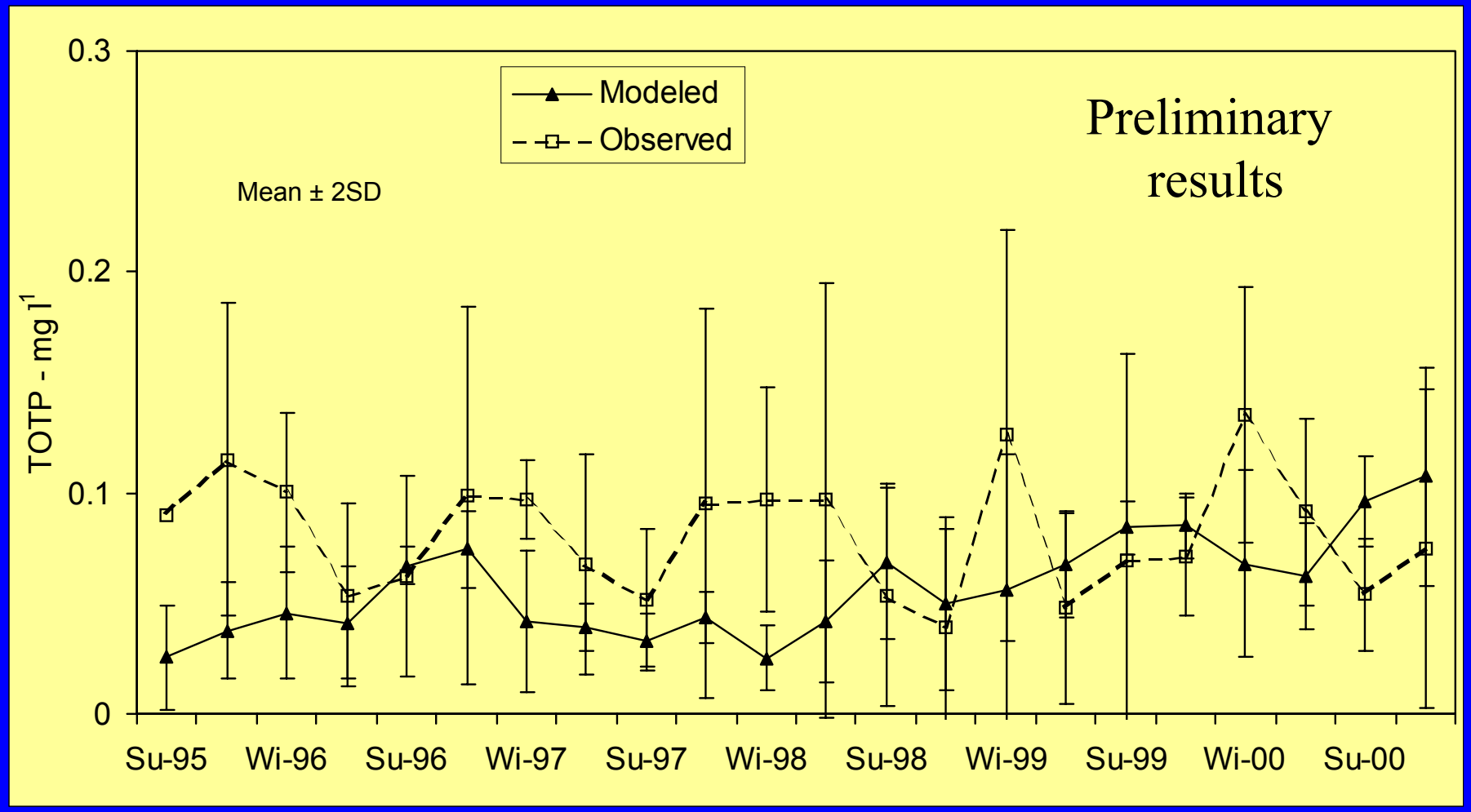
Fishing Creek Reservoir



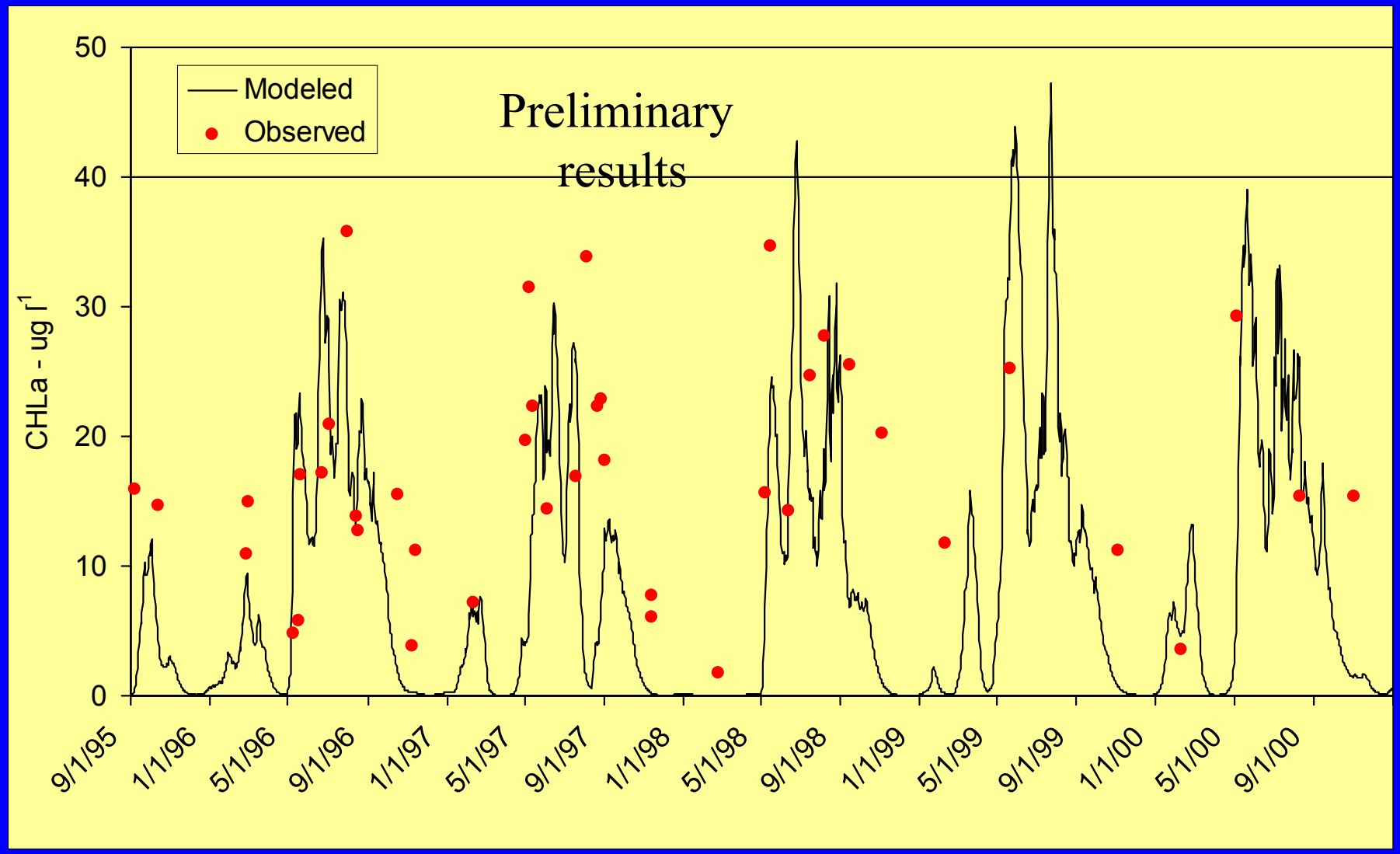
Lake Wateree - forebay



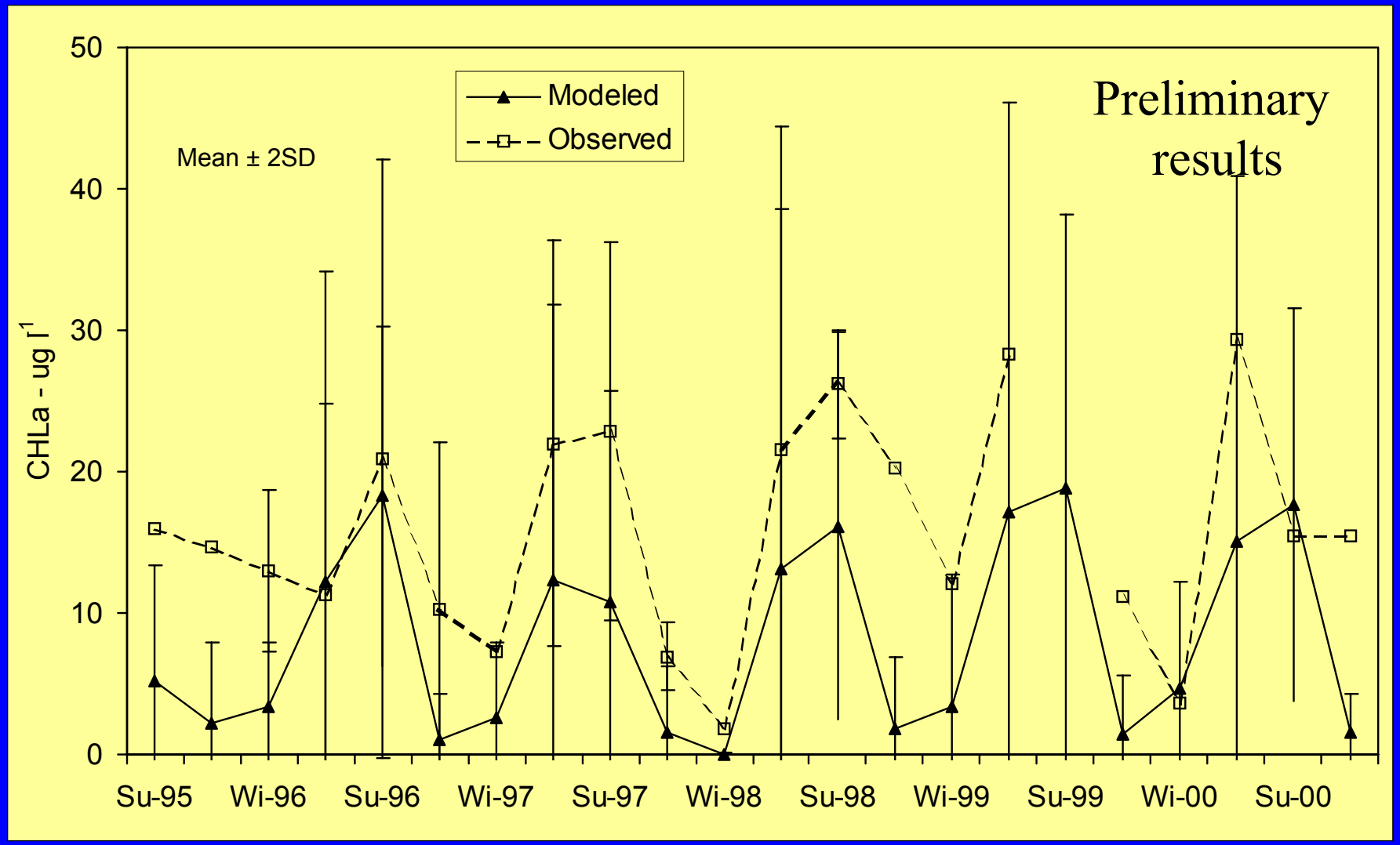
Lake Wateree - forebay



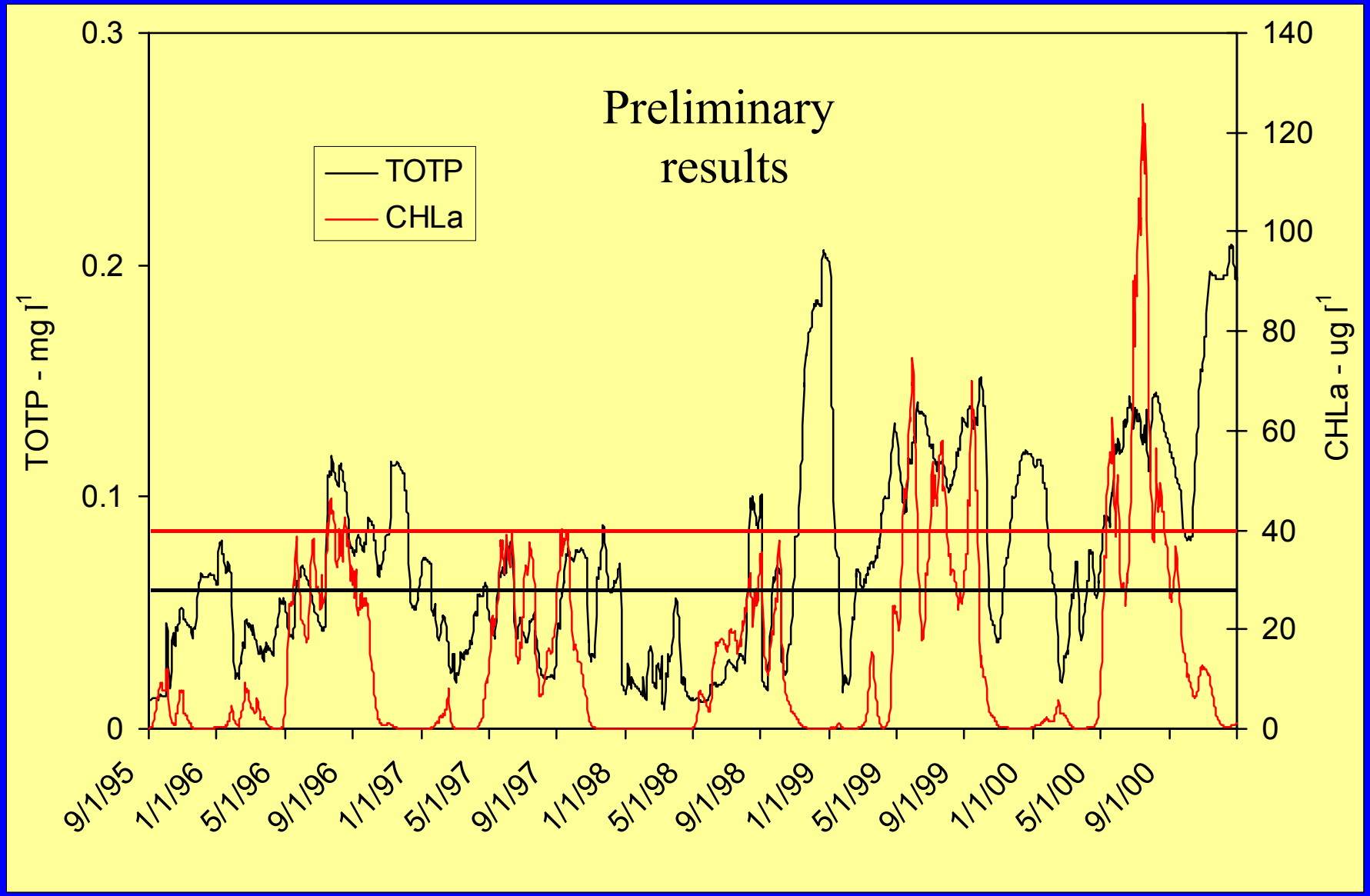
Lake Wateree - forebay



Lake Wateree - forebay



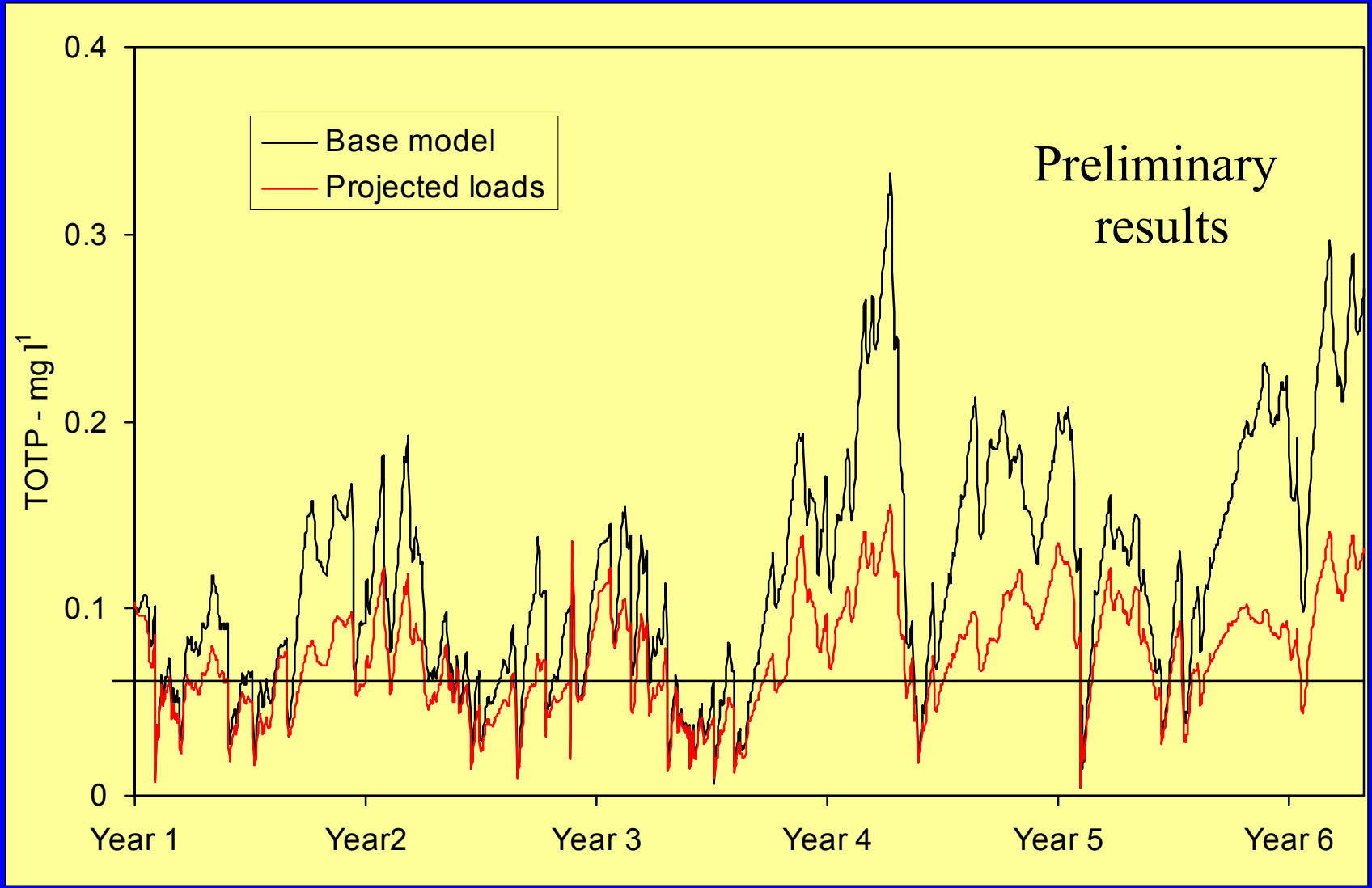
Lake Wateree – transition zone



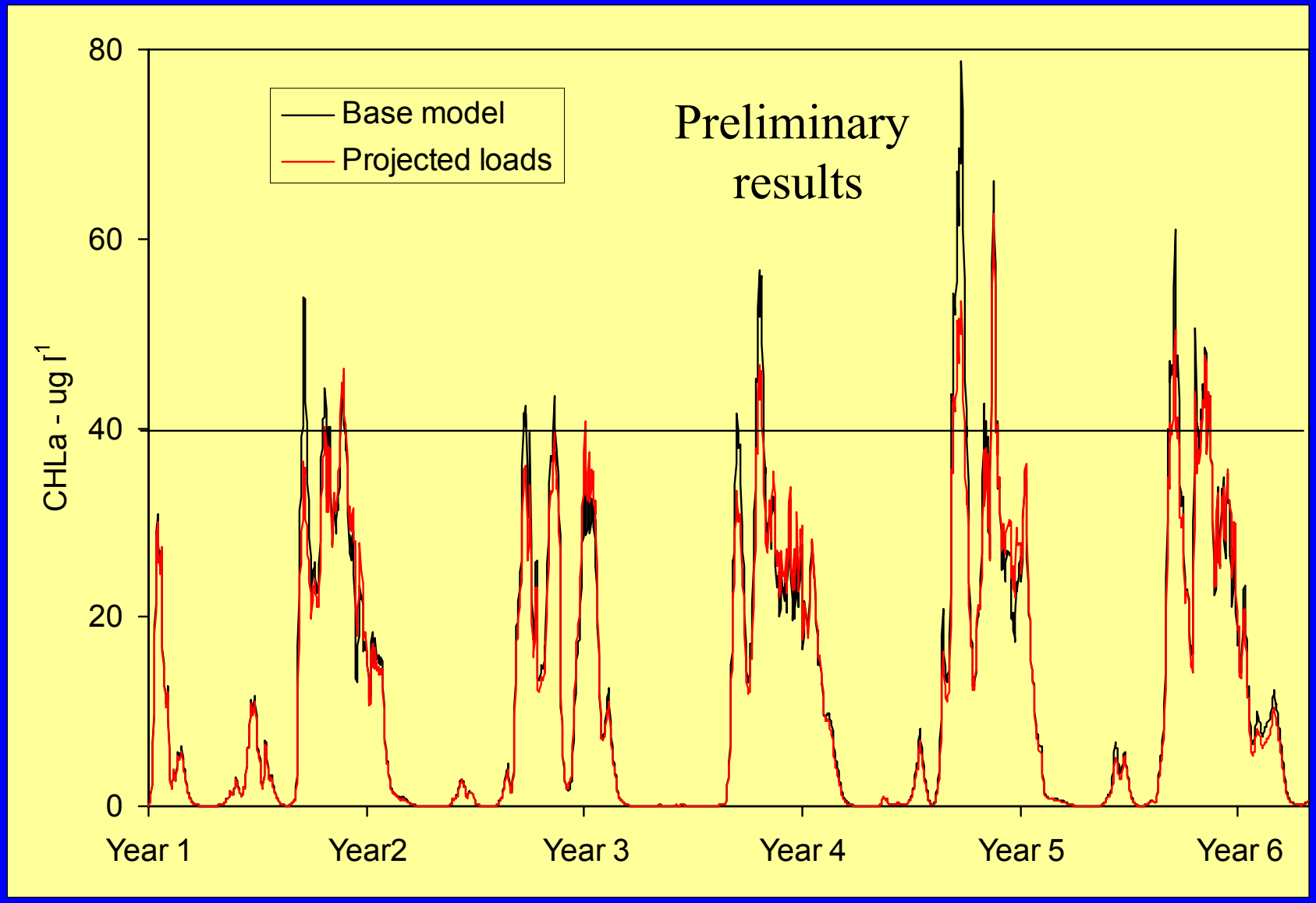
Phosphorus loading scenarios

Phosphorus loading scenarios		Base model		Projected loads	
Facility name		DMR data		Permited limits	
		MGD	lbs/da	MGD	lbs/da
CMU-McAlpine	Preliminary results	33.74	830.0	64.00	534.1
CMU-Sugar Creek		12.54	580.9	20.00	166.9
CMU-Irwin Creek		10.82	156.8	15.00	125.2
Celanse-Acetate LLC		3.08	108.8	-	108.8
Bowater Inc.		31.25	274.3	-	292.0
City of Rock Hill/Manchester Cr. Plant		8.32	137.8	20.00	124.7
City of Lancaster/Catawba River		2.52	30.8	5.75	48.0
City of York/Fishing Cr. Plant		1.02	6.5	2.00	17.0
Town of Fort Mill		0.87	12.7	2.00	12.5
City of Chester/Rocky Creek Plant		0.53	5.3	1.36	11.3
Town of Great Falls		0.26	4.0	1.40	12.0

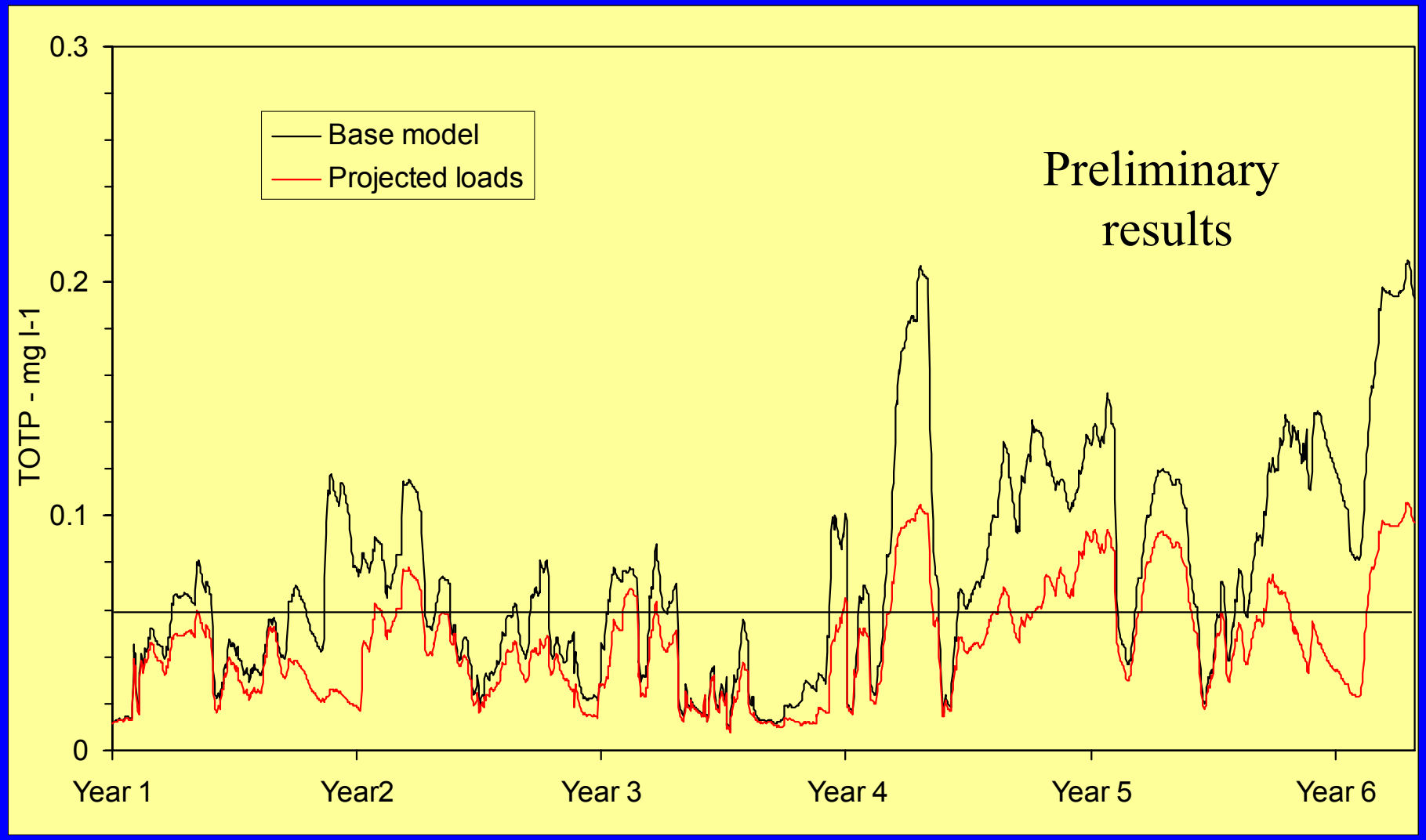
Fishing Creek Reservoir



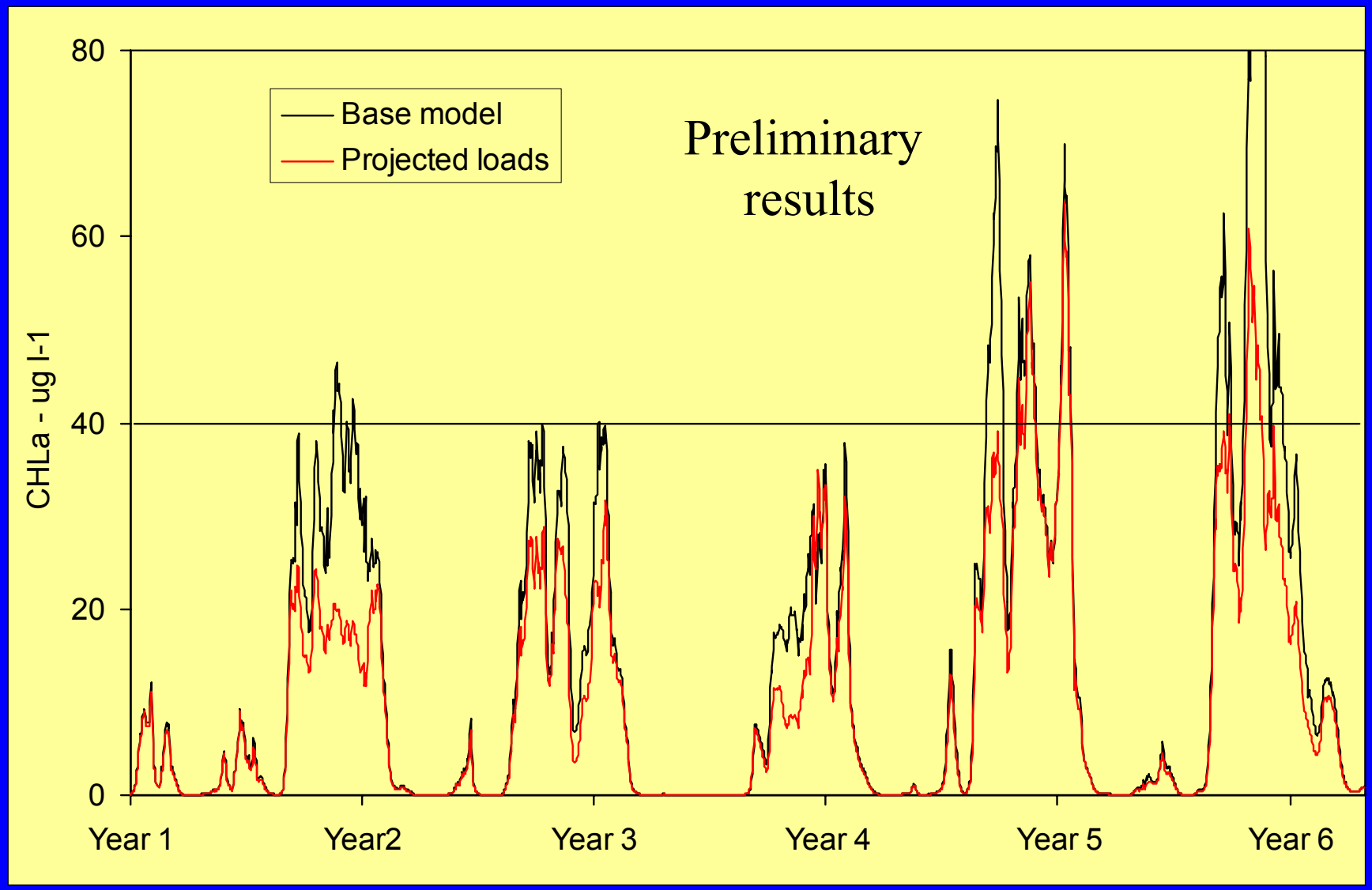
Fishing Creek Reservoir



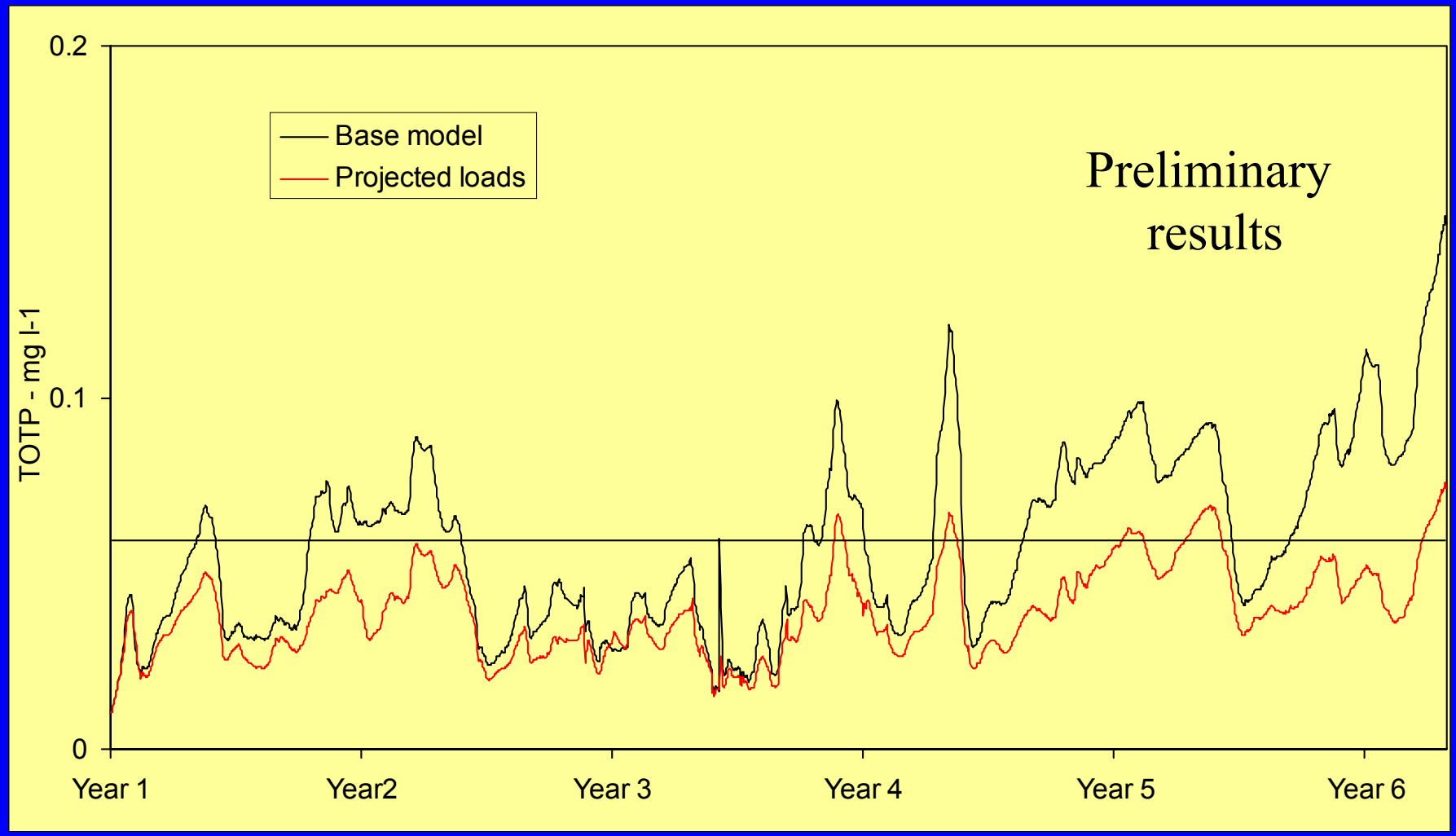
Lake Wateree – transition zone



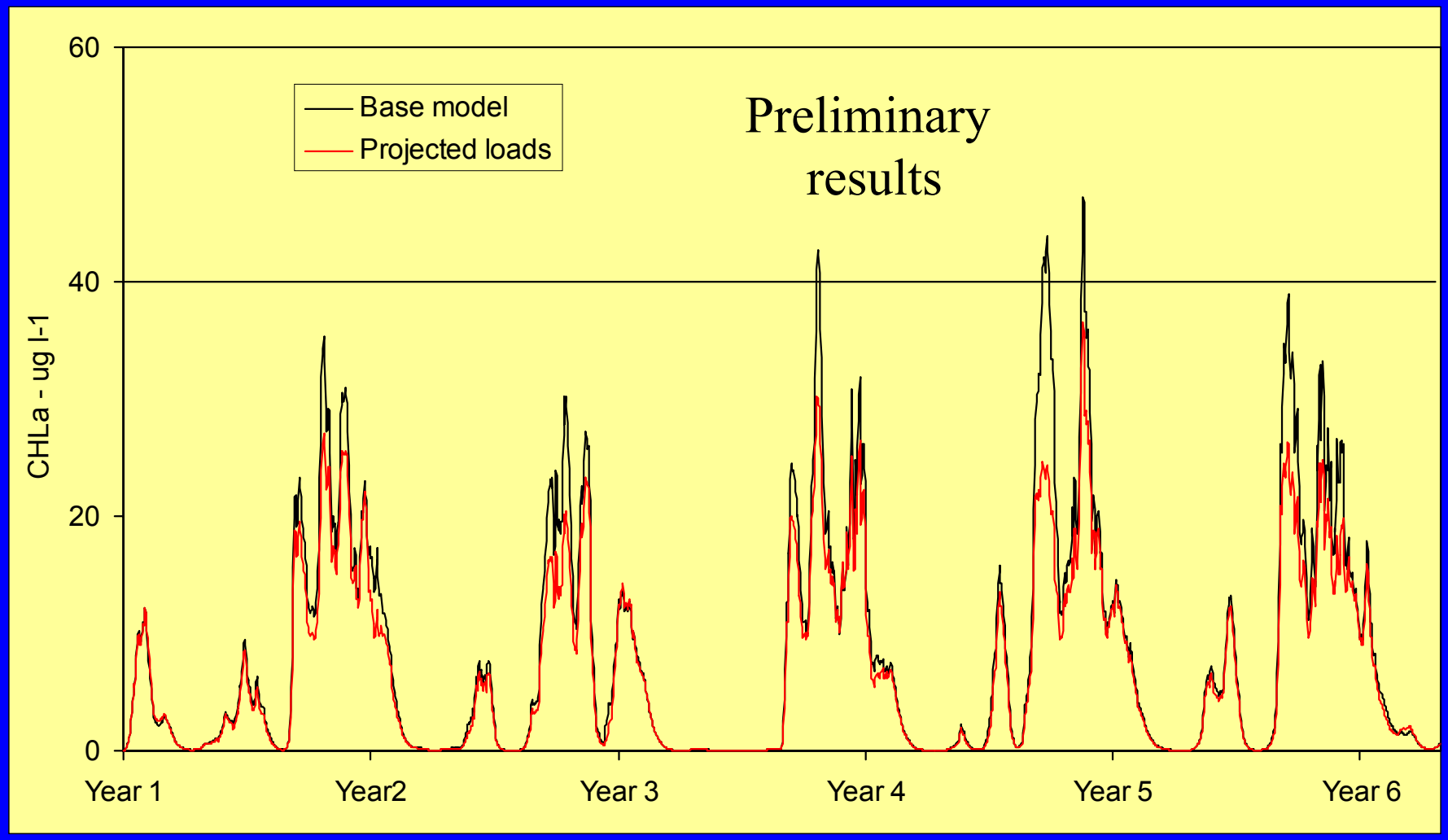
Lake Wateree – transition zone



Lake Wateree - forebay



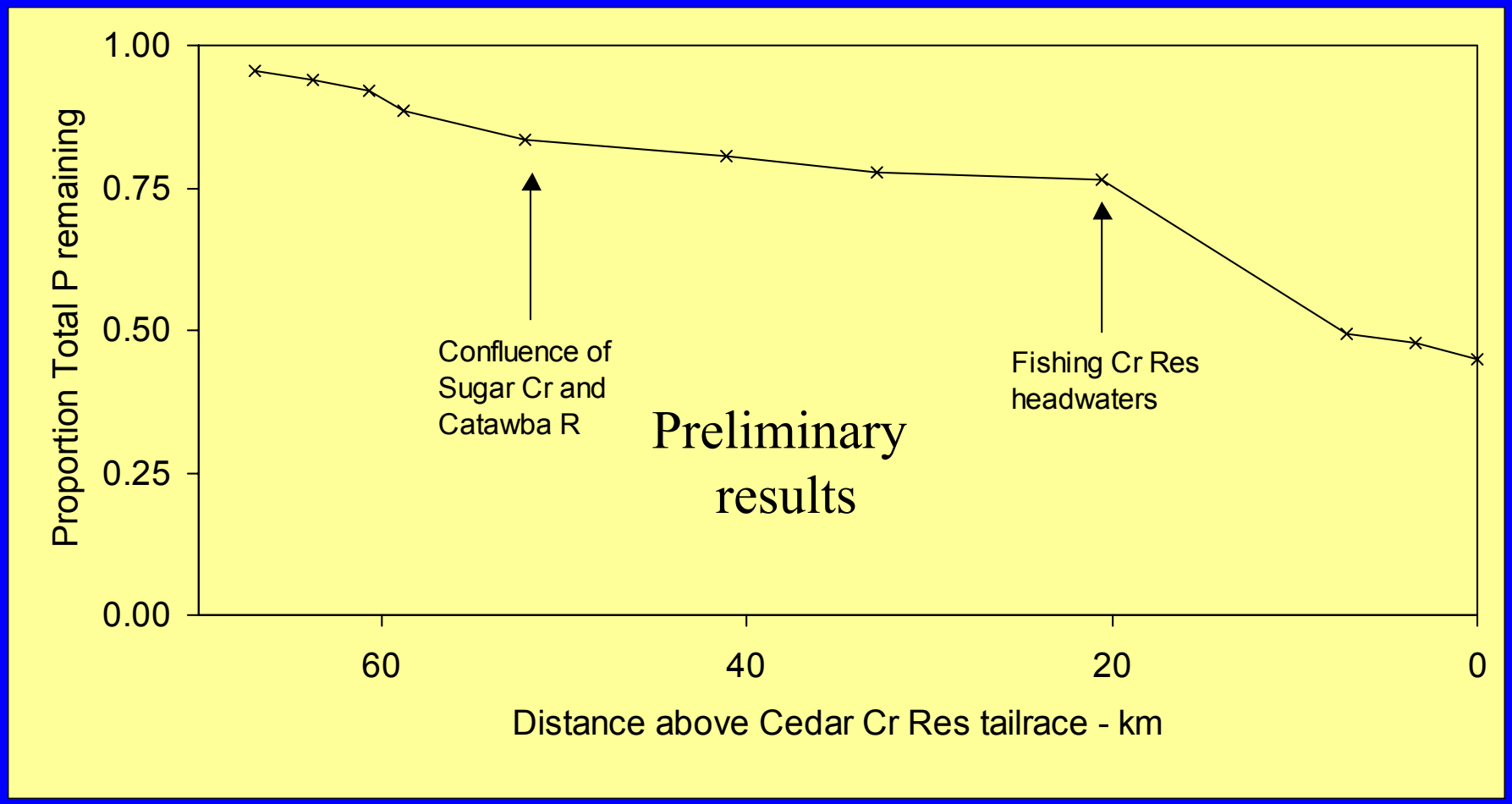
Lake Wateree - forebay



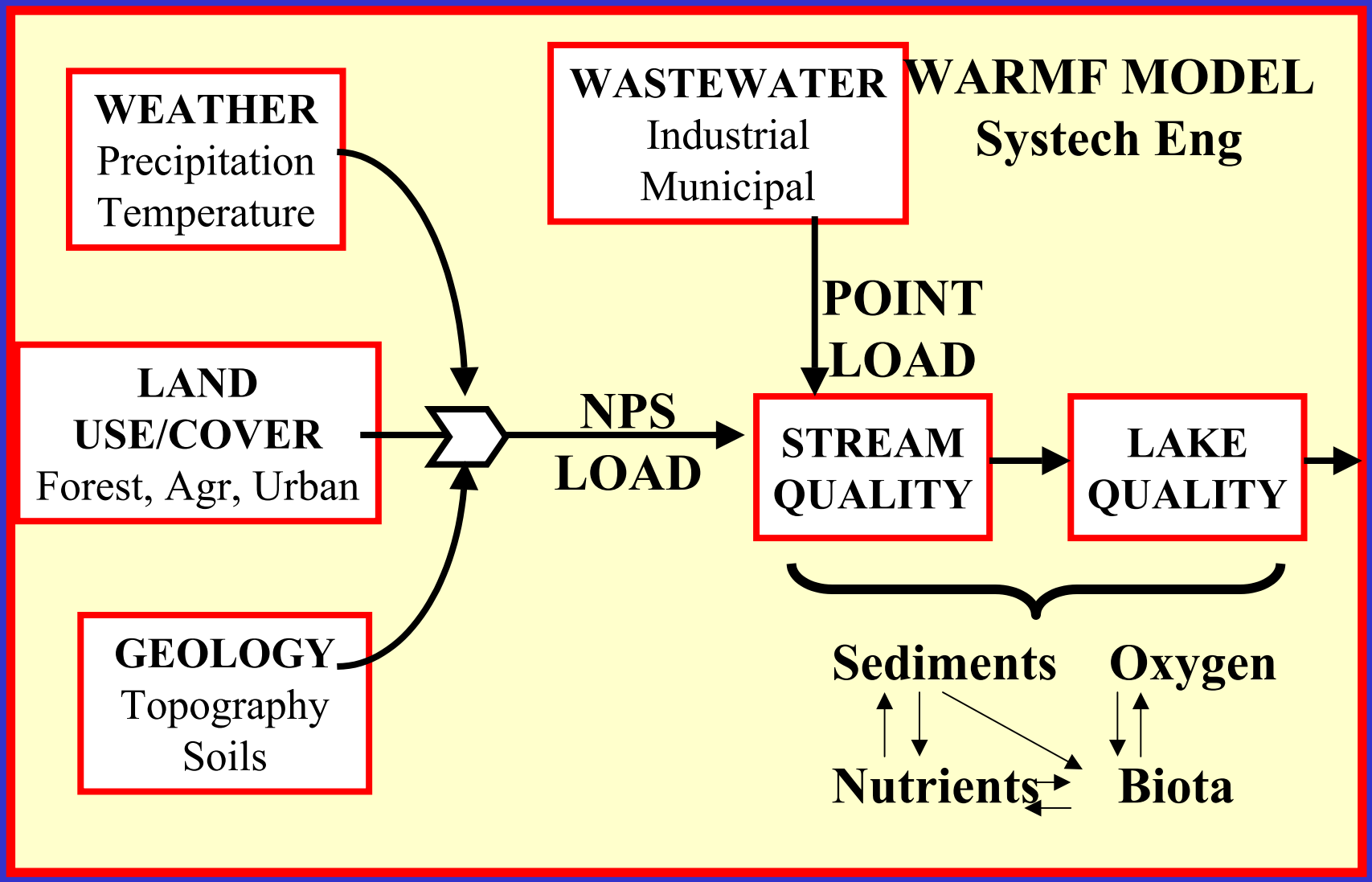
Progress towards the TMDL value

Simulated daily Total P loading		Fish.Cr.Res. Headwater	Cedar Cr. Tailrace
		lbs d^{-1}	lbs d^{-1}
Base model	Preliminary results	2607	1701
CMUD reductions		2032	1239
All new permits		2031	1246

Phosphorous transport



WATERSHED ANALYSIS AND TMDLs



Still to do:

1) Finish model calibration and verification
2) Nonpoint source loading analysis
3) Develop TMDL
4) Report to SCDHEC