Modeling and Regulatory Support Workgroup Meeting
In Person Meeting, October 4, 2022

Agenda

- Opening Comments, Agenda Review/Revisions
- Watershed Model Report Status
- WARMF Lake Modeling Status
- EFDC Lake Modeling Status
- Lake Reporting Status
- Statistical Model Development and Plan for Developing the Revised Strategy and Site-Specific Chlorophyll-a Water Quality Standard Proposal
- Communications Outreach and Preparation

Watershed Model Report Status

Watershed Model Report Status

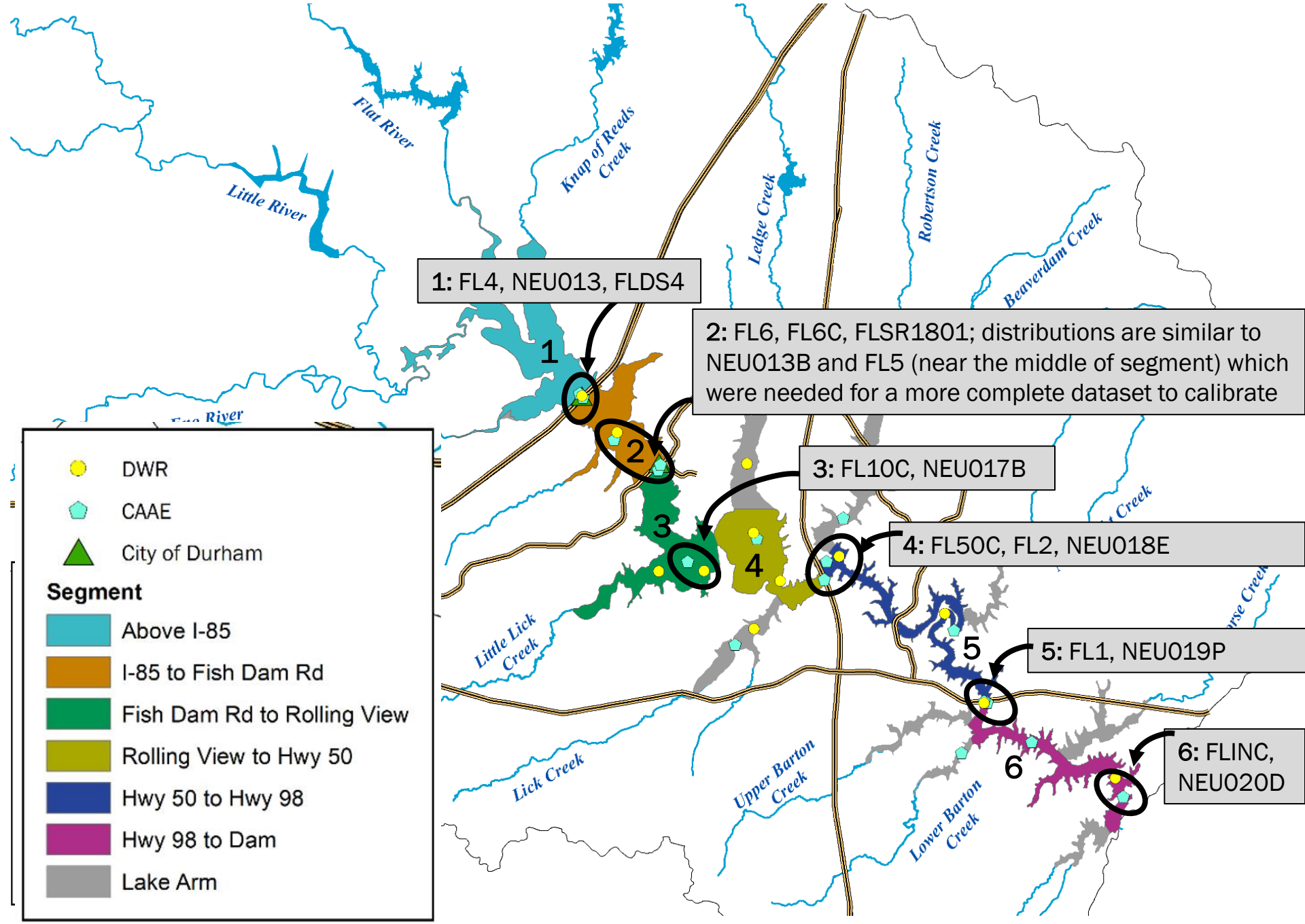
- The draft WARMF watershed modeling report was distributed to the MRSW on June 30, 2022.
- We have received comments from several MRSW members as well as DWR.
- The modeling team continues to compile and address comments in a revised report to be submitted to the Path Forward Committee (PFC).
- Following PFC review and input, the report will be finalized for submittal to DWR for their formal review along with the modeling files and executable.
- Prior to delivery of the watershed model files, the modeling team will conduct a training workshop with DWR and others interested in running the model.

WARMF Lake Development and Calibration Status

WARMF Lake Development and Calibration

- During the August MRSW meeting
  - The modeling team reviewed past decisions regarding WARMF Lake development
  - The MRSW reviewed draft WARMF Lake calibration
  - Third-party reviewers suggested applying uniform model coefficients when feasible
- The modeling team has revised the calibration to use uniform chemical and biological reaction rates throughout the lake and retained segment-specific net settling rates
- A summary of the revised model coefficients and performance statistics follow.
- The MRSW will have the opportunity to provide feedback on the calibration.

WARMF Lake Calibration Stations (approved 10/5/2021)



Performance Criteria

- WARMF Lake uses the same performance criteria as the watershed model for water quality evaluations in the six main stem segments
- Measurements in Falls Lake at each station selected for calibration are compared to the segment output for the 6-hour time step that contains the observation

Model Performance Targets

Parameter	Percent Bias Criteria		
	Very Good	Good	Fair
Sediment	< ± 20	± 20-30	± 30-45
Water Temperature	< ± 7	± 8-12	± 13-18
Water Quality/Nutrients	< ± 15	± 15-25	± 25-35

Initial Conditions – Sediment Depth by Segment

Segment	Segment Type	Average Sediment Depth (cm)
Above I-85	Main	1.43
I-85 to Fish Dam Rd	Main	2.75
Fish Dam Rd to Rolling View	Main	3.40
Rollingview to Hwy 50	Main	6.77
Hwy 50 to Hwy 98	Main	6.76
Hwy 98 to Dam	Main	13.55
Beaverdam Impoundment	Arm	8.82
Honeycutt Arm	Arm	12.37
Horse Creek Arm	Arm	6.30
Ledge Creek Arm	Arm	3.04
Lick Creek Arm	Arm	3.52
Lower Barton Creek Arm	Arm	5.99
New Light Creek Arm	Arm	5.68
Upper Barton Creek Arm	Arm	6.65

Based on UNRBA Sediment Depth Special Study

No change from August presentation

Adsorption Isotherms and Initial Sediment Bed Conditions – All Segments

N & P sediment adsorption isotherms set using sediment core and pore water concentration data:	
Phosphate	25000 L/kg
Ammonia	60 L/kg
N & P initial sediment concentrations set using sediment core data:	
Ammonia	0.7 mg/g N
Phosphate	0.9 mg/g P
Organic Carbon	25.6 mg/g
Initial concentration of detritus (provides a pool of organic matter to break down into N, P, Org. C, etc.)	
Detritus	3.7 mg/g C

Based on UNRBA Sediment Quality Special Study

No change from August presentation

Sediment Bed Reaction and Diffusion Rates – All Segments

Rate (applied to all segments)	Value
BOD Decay, 1/d	0.5
Denitrification, 1/d	0.5
Sulfate Reduction, 1/d	0.05
Organic Carbon Decay, 1/d*	**0.01**
Nitrification, 1/d*	0.01
Detritus Decay, 1/d*	0.01
Settled Detritus Decay, 1/d*	**0.01**
Bed Diffusion Rate (m^2/d)*	**8E-05**

Parameters marked with a "" indicate these were adjusted for model calibration. Bold rates were changed since August MRSW meeting (made uniform across segments).*

Reservoir Wide Parameters

Water Column Diffusion Parameters:			
Density Gradient Max (m^2/sec)	0.0005		
Wind Diffusion Max (m^2/sec)	0.0005		
Algae Growth Parameters:			
Parameter	**Blue-Green Algae**	**Diatoms**	**Other Algae (Greens, Prym., Eugl., etc.)**
Nitrogen Half-Saturation, mg/L*	0.005	0.005	0.005
Phosphorus Half-Saturation, mg/L	0.005	0.005	0.005
Silica Half-Saturation, mg/L	0.005	0.005	0.005
Light Half-Saturation, W/m^2 *	200	55	150
Lower Growth Temperature, C *	10	0	5
Upper Growth Temperature, C *	40	30	40
Optimum Growth Temperature, C *	31	8	17

Parameters marked with a "" indicate these were adjusted from model defaults.*

No change from
August presentation

Water Column Reaction Rates – All Segments

Reaction Rate	Value
BOD Decay, 1/d	0.5
Detritus Decay, 1/d*	0.01
Organic Carbon Decay, 1/d*	**0.01**
Nitrification, 1/d*	**0.015**
Denitrification, 1/d	0.5
Sulfate Reduction, 1/d	0.05
Periphyton Mortality, 1/d	0.05
Net Sand Settling/Resuspension, m/d*	1036.8
Blue-green, Diatom, Other Algae Respiration, 1/d*	0.01
Blue-green and Other Algae Mortality, 1/d*	0.02
Diatom Mortality, 1/d*	0.1
Blue-green and Other Algae Growth, 1/d*	**0.9**
Diatom Growth, 1/d*	**1.8**

Parameters marked with a "" indicate these were adjusted for model calibration.*
Bold rates were changed since August MRSW meeting (made uniform across segments).

Water Column Net Settling Rates – By Segment

Reaction Rate	Seg1	Seg2	Seg3	Seg4	Seg5	Seg6
Blue-green Settling, m/d	0.02	0.02	0.02	0.018	0.018	0.018
Diatom Settling, m/d	0.20	0.20	0.20	0.180	0.180	0.180
Other Algae Settling, m/d	0.06	0.06	0.06	0.054	0.054	0.054
Detritus Settling, m/d	0.25	0.25	0.25	0.25	0.5	0.5
Net Clay Settling, m/d	0.01	0.1	0.21	0.3	0.8	1
Net Silt Settling, m/d	0.01	3	3	3	3	3

Each of these parameters were adjusted for model calibration.

No change in values from August presentation (silt settling added to the table).

Revised Draft Performance Criteria, 1/2, September 30th

	Average of pBias:						Average of Observations by period (n), % below reporting limit (full period)					
Lake Segment:	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Ammonia Nitrogen as N, mg/l							64%	65%	11%	47%	23%	27%
Full Period	63	53	117	370	106	50	0.029 (232)	0.031 (215)	0.019 (54)	0.019 (139)	0.045 (56)	0.06 (57)
Calibration	46	34	61	278	82	72	0.029 (113)	0.03 (107)	0.022 (33)	0.022 (61)	0.046 (34)	0.051 (36)
Validation	80	69	270	480	133	37	0.029 (119)	0.033 (108)	0.013 (21)	0.015 (78)	0.043 (22)	0.069 (21)
Nitrate-Nitrite as N, mg/l							35%	37%	7%	46%	17%	28%
Full Period	50	-2	12	263	133	141	0.077 (234)	0.08 (218)	0.06 (54)	0.031 (139)	0.053 (56)	0.06 (57)
Calibration	104	18	-25	129	93	121	0.064 (115)	0.06 (109)	0.081 (33)	0.049 (61)	0.069 (34)	0.067 (36)
Validation	12	-14	181	612	217	163	0.091 (119)	0.101 (109)	0.027 (21)	0.014 (78)	0.034 (22)	0.053 (21)
Total Kjeldahl Nitrogen as N, mg/l							0%	0%	0%	0%	0%	0%
Full Period	-8	0	17	20	26	22	0.96 (204)	0.83 (190)	0.76 (54)	0.72 (139)	0.67 (56)	0.62 (57)
Calibration	-5	0	24	30	32	35	0.94 (115)	0.81 (109)	0.73 (33)	0.68 (61)	0.65 (34)	0.58 (36)
Validation	-11	1	5	13	20	12	0.98 (89)	0.85 (81)	0.8 (21)	0.76 (78)	0.68 (22)	0.65 (21)
Total N - calculated, mg/l					Calculated parameter							
Full Period	-4	0	16	30	34	33	1.03 (204)	0.9 (190)	0.82 (54)	0.75 (139)	0.72 (56)	0.68 (57)
Calibration	0	-1	19	36	38	43	1.01 (115)	0.87 (109)	0.81 (33)	0.73 (61)	0.72 (34)	0.65 (36)
Validation	-9	0	11	25	29	24	1.06 (89)	0.94 (81)	0.83 (21)	0.77 (78)	0.71 (22)	0.71 (21)

- Meeting the performance criteria is more difficult when concentrations are very low
- Values on the right side of the table in black font: average of the observations (number of samples)
- Values in blue font: percent of samples less than the reporting limit for the full period
- Different organizations sample different segments, and segments 1 and 2 have the most data
- Ammonia and nitrate are generally overpredicted (increased bed diffusion rate)
- Most of the total nitrogen is in the organic nitrogen form (TKN minus ammonia)
- TKN and TN are good to very good in segments 1 to 3 but over-estimated in segments 4 through 6

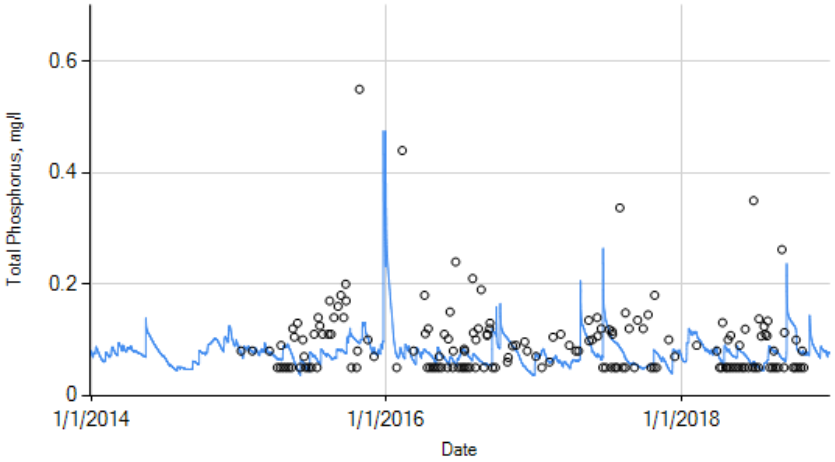
Final Draft Performance Criteria, 2/2, September 30th

	Average of pBias:						Average of Observations by period (n), % below reporting limit (full period)					
Lake Segment:	**1**	**2**	**3**	**4**	**5**	**6**	**1**	**2**	**3**	**4**	**5**	**6**
Chlorophyll-a, ug/l							0%	0%	0%	0%	0%	0%
Full Period, n=2	-4	-6	-6	-20	-8	6	42.2 (284)	36.5 (277)	35.3 (111)	32.3 (243)	27 (57)	20.6 (57)
Calibration, n=1	8	16	11	-5	21	16	39.6 (169)	31.2 (147)	31.4 (69)	28.6 (146)	21.3 (35)	18.2 (36)
Validation, n=1	-19	-25	-28	-37	-29	-10	45.8 (115)	42.4 (130)	41.1 (42)	37.6 (97)	33.4 (22)	24.5 (21)
Total Organic Carbon, mg/l							0%	0%	0%	0%	0%	0%
Full Period	5	1	13	3	3	-3	8.1 (235)	8.1 (219)	7.6 (54)	7.8 (139)	7.5 (57)	7.2 (57)
Calibration	3	0	15	9	9	4	8.5 (116)	8.3 (109)	7.8 (33)	7.6 (61)	7.5 (35)	7 (36)
Validation	6	3	10	-1	-3	-10	7.8 (119)	7.8 (110)	7.3 (21)	7.9 (78)	7.6 (22)	7.3 (21)
Total Phosphorus as P, mg/l							30%	47%	0%	0%	0%	0%
Full Period	-26	-13	-9	-11	-12	-2	0.097 (225)	0.053 (212)	0.06 (54)	0.048 (139)	0.04 (56)	0.031 (57)
Calibration	-28	-16	-12	-15	-4	2	0.1 (114)	0.05 (106)	0.064 (33)	0.052 (61)	0.039 (34)	0.033 (36)
Validation	-23	-9	-3	-7	-20	-7	0.093 (111)	0.057 (106)	0.054 (21)	0.045 (78)	0.042 (22)	0.03 (21)
Total Suspended Solids, mg/l					Calculated (TSS minus VSS)							
Full Period	-13	-37	2	58	-4	-3	19.5 (35)	13.9 (36)	6.2 (37)	5 (37)	3.1 (36)	2.2 (36)
Calibration	20	-30	-1	34	-17	-9	16.7 (15)	12.6 (16)	6.2 (16)	5.5 (16)	3.2 (14)	2.2 (15)
Validation	-32	-42	4	80	6	1	21.6 (20)	14.9 (20)	6.2 (21)	4.6 (21)	3.1 (22)	2.2 (21)
Water Temperature, C							0%	0%	0%	0%	0%	0%
Full Period	1	5	6	8	12	10	22 (60)	22.4 (54)	17.8 (53)	17.8 (57)	17.7 (57)	17.5 (56)
Calibration	2	4	4	9	13	11	21.5 (37)	22 (34)	17.4 (32)	17.4 (36)	16.9 (35)	17 (35)
Validation	0	6	8	7	10	9	22.6 (23)	22.8 (20)	18.5 (21)	18.6 (21)	19.2 (22)	18.3 (21)

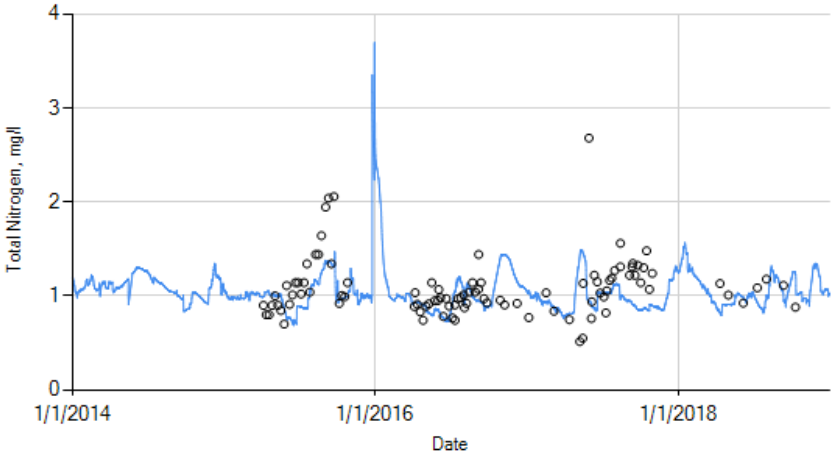
- Chlorophyll-a model performance is good to very good during calibration and validation at segments 1, 2, and 6. It is very good or good at segments 3, 4, and 5 during the calibration period and fair at both in the validation period at 3 and 5.
- Total organic carbon performance is very good range for each segment and period
- Total phosphorus model performance is good to very good during calibration and validation in segments 2 through 6. Model performance in segment 1 ranges from fair to very good.
- There are fewer TSS observations due to lack of VSS measurements for comparison to WARMF output [WARMF TSS (silt plus clay) corresponds to observed TSS minus observed VSS]. TSS model performance is fair to very good except in segment 4.
- Water temperature model performance is usually good to very good with one segment/period that is fair.

Falls Lake Water Quality – Segment 1 (above I-85)

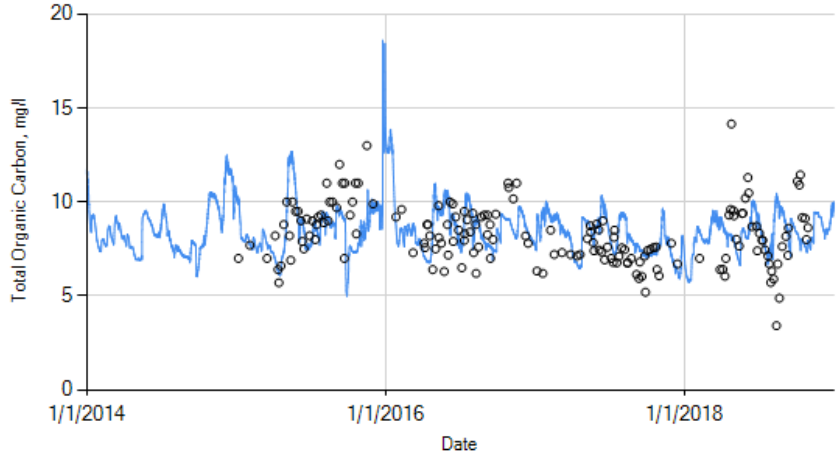
Total Phosphorus (mg/L)



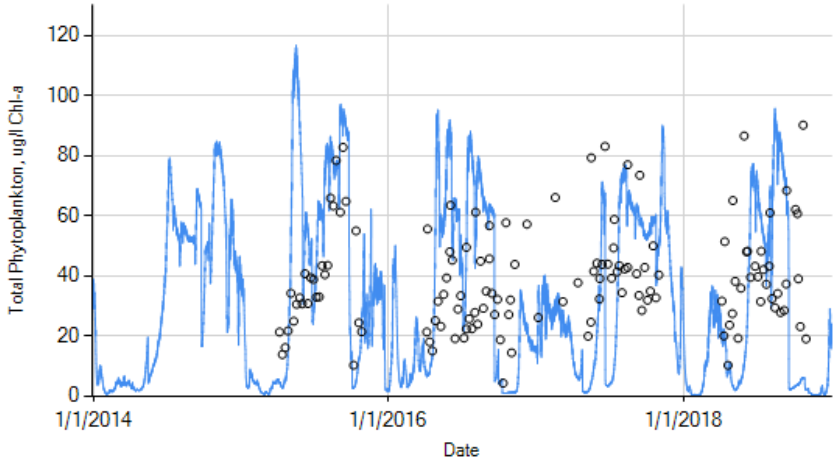
Total Nitrogen (mg/L)



Total Organic Carbon (mg/L)

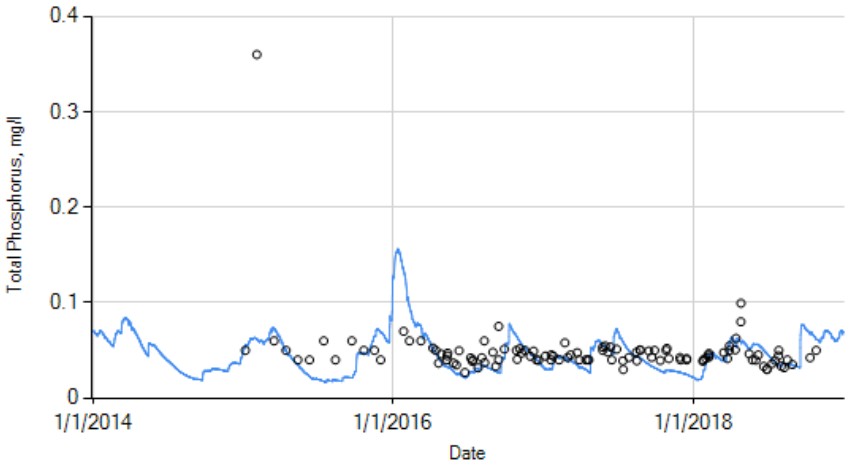


Chlorophyll-a (µg/L)

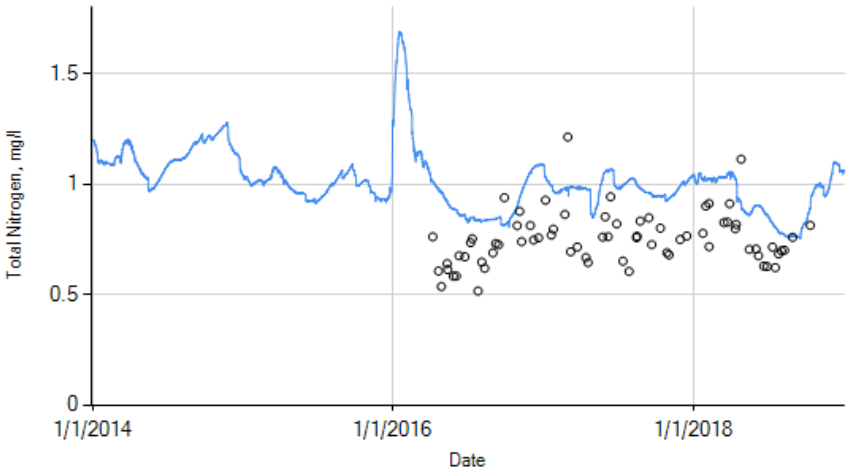


Falls Lake Water Quality – Segment 4 (Rolling View to Hwy. 50)

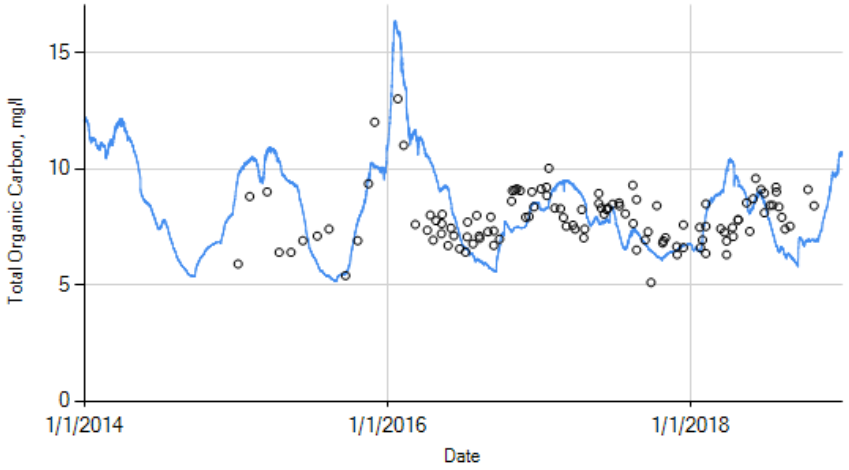
Total Phosphorus (mg/L)



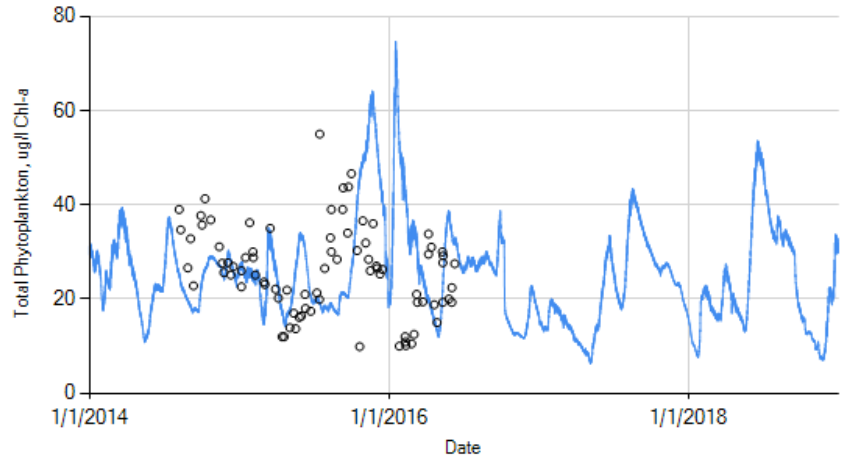
Total Nitrogen (mg/L)



Total Organic Carbon (mg/L)

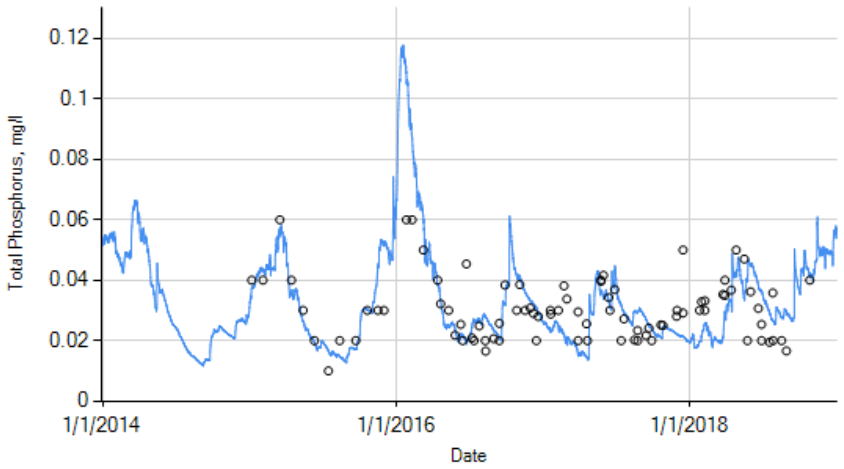


Chlorophyll-a (µg/L)

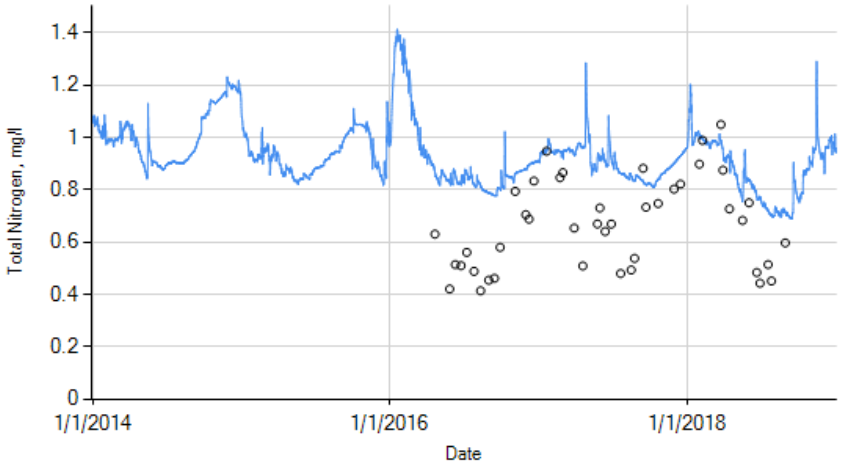


Falls Lake Water Quality – Segment 6 (Hwy. 98 to dam)

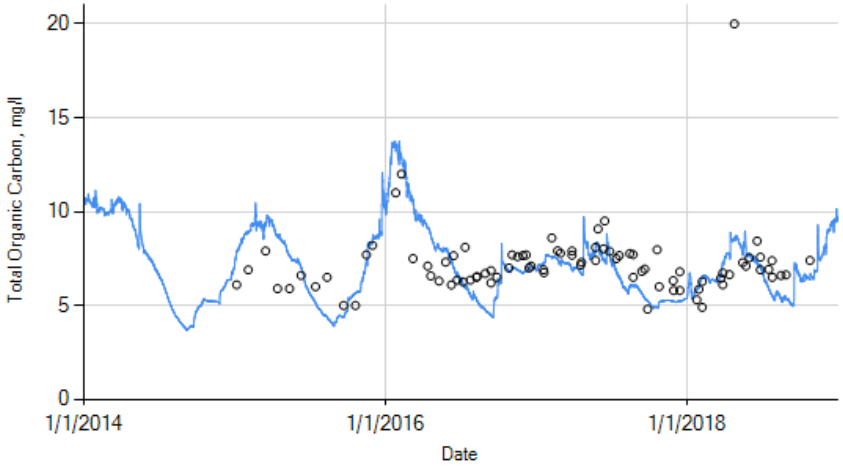
Total Phosphorus (mg/L)



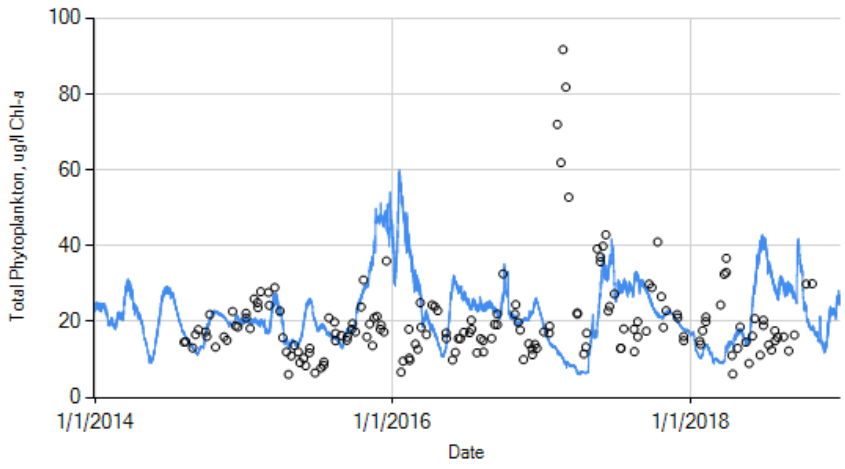
Total Nitrogen (mg/L)



Total Organic Carbon (mg/L)



Chlorophyll-a (µg/L)



Summary

- The latest calibration applies uniform chemical and biological model coefficients
- A few additional modifications are being tested to lower ammonia and nitrate and raise total phosphorus
- Revised slides will be distributed following the meeting for MRSW review
- MRSW Discussion

EFDC Lake Modeling Status

EFDC Lake Modeling Status

- During the May and August MRSW meetings, the modeling team presented comparisons of observed biovolume and chlorophyll-a data in Falls Lake and discussed calibration challenges
- Modeling team has continued to discuss model calibration with subject matter experts and DWR modeling staff with most recent meeting on September 26, 2022
- Further refinements are being made and sensitivity analyses being conducted; we hope to finalize the calibration soon

Lake Reporting Status

Lake Reporting Status

- The modeling team is continuing to draft sections and appendices of the lake modeling report.
- Will work with subject matter experts and DWR regarding time series comparisons to observed data
- Current focus is on responding to comments on the watershed modeling report

Statistical Model Development and Plan for Developing the Revised Strategy and Site-Specific Chlorophyll-a Water Quality Standard Proposal

Statistical Model Development and Plan for Developing the Revised Strategy and Site-Specific Chlorophyll-a Water Quality Standard Proposal

- The modeling team is continuing to develop the statistical/ Bayesian/decision support tool.
- The Executive Director will continue to coordinate with DWR on a collaborative approach for DWR and UNRBA to finalize the models, develop a revised nutrient management strategy, and develop a petition for site specific criteria.
- The UNRBA will continue to work with other stakeholders on these items as well.
- The UNRBA subject matter experts continue to evaluate other State's site-specific standards for chlorophyll-a and nutrient-related standards and continue to coordinate with Dr. Marty Lebo to integrate his work into the statistical modeling and regulatory support efforts

Communications Outreach and Preparation

Communications Outreach and Preparation

- Continued engagement with DWR including a workshop with DWR and UNRBA on how to run the revised WARMF Model with the new model interface and functionality *Fall 2022*
- UNRBA Technical Stakeholder Workshop – *Winter 2022/2023*
- Workshop with local government communications staff- *Winter 2022/2023*
- Workshop with DWR/NC Policy Collaboratory/NGOs – *Spring 2023*
- Joint symposium with NC Policy Collaboratory – *Summer 2023*
- UNRBA Stakeholders workshop to review final draft strategy – *Fall 2023*

Future Meeting Protocols

Future Meeting Protocols

- The Executive Director will continue to track conditions and coordinate changes as needed.

Closing Comments
Additional Discussion