Modeling and Regulatory Support Workgroup Meeting
January 3, 2023

Remote Access Options

Equipment Type	Access Information	Notes
Computers with microphones and speakers	Join Microsoft Teams Meeting **Please mute your microphone** unless you want to provide input.	Press control and click on this link to bring up Microsoft Teams through the internet. You can view the screen share and communicate through your computer's speakers and microphone
Computers without audio capabilities, or audio that is not working	Join Microsoft Teams Meeting (888) 404-2493 Passcode: 371 817 961# **Please mute your phone** unless you want to provide input.	Follow instructions above **Turn down your computer speakers, mute your computer microphone,** and dial the toll-free number through your phone and enter the passcode
Phone only	(888) 404-2493 Passcode: 371 817 961# **Please mute your phone** unless you want to provide input.	Dial the toll-free number and enter the passcode

Remote Access Guidelines

- This meeting will open 30 minutes prior to the official meeting start time to allow users to test equipment and ensure communication methods are working
- If you dial in through your phone, mute your microphone and turn down your speakers to avoid feedback
- Unless you are speaking, please mute your computer or device microphone and phone microphone to minimize background noise

Agenda

- Opening Comments, Agenda Review/Revisions
- Modeling and Regulatory Support Status
    - WARMF Watershed Model Report Status
    - WARMF Lake Model Code Modification and Updated Performance Statistics
    - EFDC Lake Calibration Status

Modeling and Regulatory Support Status

WARMF Watershed Model Report Status

Watershed Model Report Status

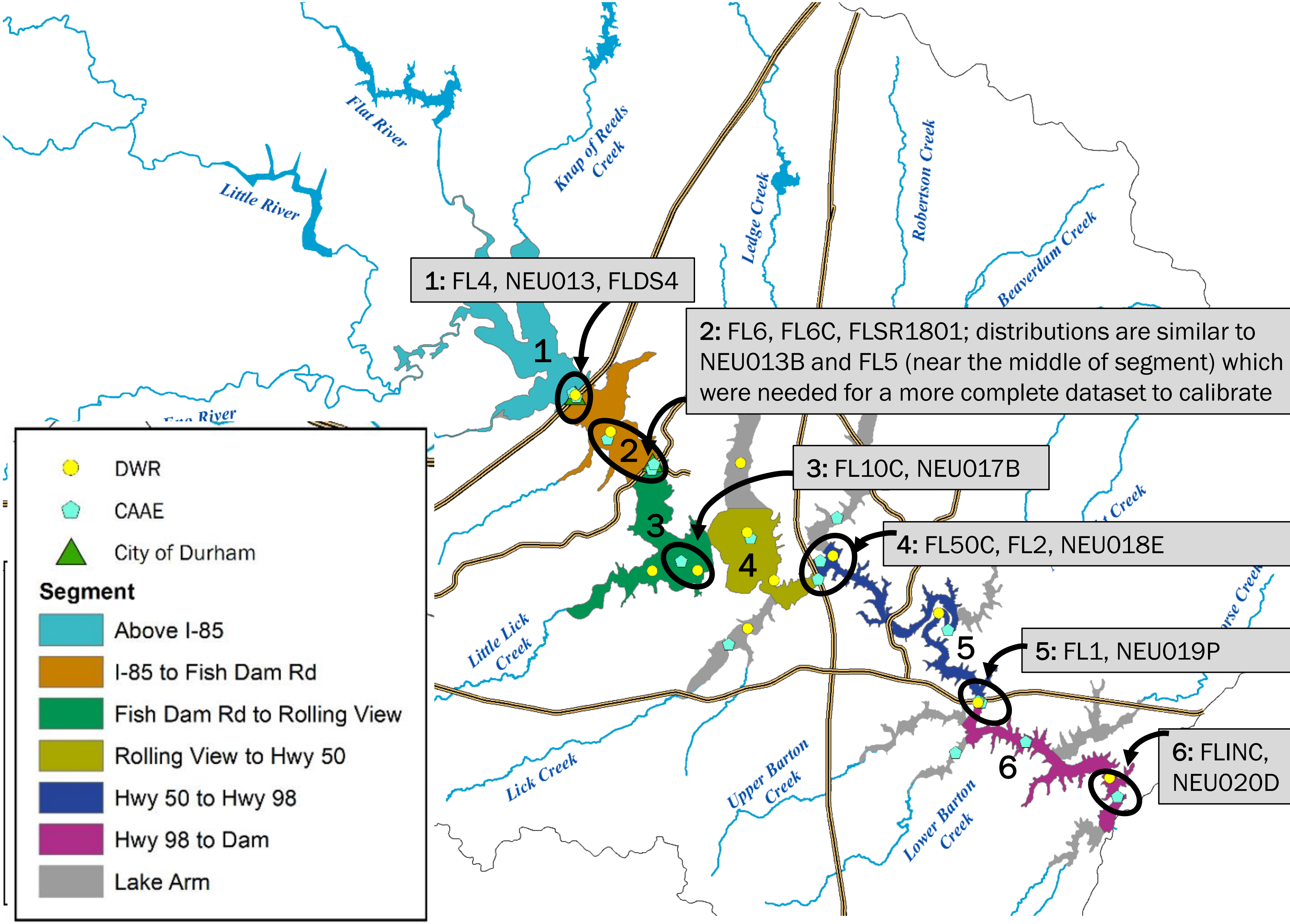
- The draft WARMF watershed modeling report was distributed to the MRSW on June 30, 2022.
- We have received comments from several MRSW members as well as DWR.
- The modeling team continues to compile and address comments in a revised report to be submitted to the Path Forward Committee (PFC).
- Following 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 Calibration Status

WARMF Lake Modeling

- At the November 1, 2022, meeting, the MRSW approved the WARMF Lake model calibration
- Because the lake model is embedded in the watershed model, both have to be run five times (25 years)
  - This is required to stabilize the soils in the watershed by land use
  - This has the effect of “washing” out the lake sediments as well, and the initial conditions based on the UNRBA sediment quality studies are “lost”
- To provide a more accurate starting point for the lake sediments for the 5th model run, a code modification was required to set lake sediments to initial conditions rather than using the warm start file generated by the 4th run
- Revised statistics will be presented today

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

Performance Criteria, Final WARMF Lake Calibration

	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	151	40	58	168	5	-29	0.029 (232)	0.031 (215)	0.019 (54)	0.019 (139)	0.045 (56)	0.06 (57
Calibration	146	26	11	131	2	-12	0.029 (113)	0.03 (107)	0.022 (33)	0.022 (61)	0.046 (34)	0.051 (36
Validation	155	52	185	212	9	-39	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	117	5	-9	96	6	-8	0.077 (234)	0.08 (218)	0.06 (54)	0.031 (139)	0.053 (56)	0.06 (57
Calibration	200	27	-47	32	0	12	0.064 (115)	0.06 (109)	0.081 (33)	0.049 (61)	0.069 (34)	0.067 (36
Validation	58	-8	166	264	19	-29	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	3	0	9	7	8	3	0.96 (204)	0.83 (190)	0.76 (54)	0.72 (139)	0.67 (56)	0.62 (57
Calibration	7	-2	13	13	11	11	0.94 (115)	0.81 (109)	0.73 (33)	0.68 (61)	0.65 (34)	0.58 (36
Validation	-1	2	2	3	5	-3	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	13	0	7	10	8	2	1.03 (204)	0.9 (190)	0.82 (54)	0.75 (139)	0.72 (56)	0.68 (57
Calibration	18	-1	7	14	10	11	1.01 (115)	0.87 (109)	0.81 (33)	0.73 (61)	0.72 (34)	0.65 (36
Validation	6	2	7	7	5	-5	1.06 (89)	0.94 (81)	0.83 (21)	0.77 (78)	0.71 (22)	0.71 (21

- 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
- Meeting the performance criteria (left side) is more difficult when concentrations are very low
- Ammonia and nitrate are generally overpredicted upstream of Highway 50
- Most of the total nitrogen is in the organic nitrogen form (TKN minus ammonia)
- TKN and TN are very good in all segments/periods except one (good)

Highway 50 is downstream of Segment 4

Performance Criteria, Final WARMF Lake Calibration

	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	3	-2	-6	-16	-2	13	42.2 (284)	36.5 (277)	35.3 (111)	32.3 (243)	27 (57)	20.6 (57)
Calibration, n=1	18	20	10	-3	23	19	39.6 (169)	31.2 (147)	31.4 (69)	28.6 (146)	21.3 (35)	18.2 (36)
Validation, n=1	-16	-21	-25	-31	-20	3	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	13	1	6	-6	-9	-15	8.1 (235)	8.1 (219)	7.6 (54)	7.8 (139)	7.5 (57)	7.2 (57)
Calibration	13	-1	5	-3	-6	-11	8.5 (116)	8.3 (109)	7.8 (33)	7.6 (61)	7.5 (35)	7 (36)
Validation	13	4	6	-8	-12	-18	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	-22	-7	-7	-3	-2	11	0.097 (225)	0.053 (212)	0.06 (54)	0.048 (139)	0.04 (56)	0.031 (57)
Calibration	-25	-15	-13	-11	1	8	0.1 (114)	0.05 (106)	0.064 (33)	0.052 (61)	0.039 (34)	0.033 (36)
Validation	-18	0	3	5	-4	15	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	7	-33	4	61	0	-2	19.5 (35)	13.9 (36)	6.2 (37)	5 (37)	3.1 (36)	2.2 (36)
Calibration	45	-27	1	36	-17	-9	16.7 (15)	12.6 (16)	6.2 (16)	5.5 (16)	3.2 (14)	2.2 (15)
Validation	-15	-36	7	84	14	3	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	3	6	7	9	12	10	22 (60)	22.4 (54)	17.8 (53)	17.8 (57)	17.7 (57)	17.5 (56)
Calibration	4	5	5	9	13	11	21.5 (37)	22 (34)	17.4 (32)	17.4 (36)	16.9 (35)	17 (35)
Validation	2	7	9	8	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, 5, and 6. It is very good at segments 3 and 4 during the calibration period and fair at both in the validation period.
- Total organic carbon model performance is very good in all segments/periods except one (good)
- Total phosphorus model performance is good to very good for each segment and period except one that is 0.2 over threshold
- 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.

Concentration Performance Criteria and Sediment Nutrient Fluxes

	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	151	40	58	168	5	-29	0.029 (232)	0.031 (215)	0.019 (54)	0.019 (139)	0.045 (56)	0.06 (57)
Calibration	146	26	11	131	2	-12	0.029 (113)	0.03 (107)	0.022 (33)	0.022 (61)	0.046 (34)	0.051 (36)
Validation	155	52	185	212	9	-39	0.029 (119)	0.033 (108)	0.013 (21)	0.015 (78)	0.043 (22)	0.069 (21)
Total Phosphorus as P, mg/l							30%	47%	0%	0%	0%	0%
Full Period	-22	-7	-7	-3	-2	11	0.097 (225)	0.053 (212)	0.06 (54)	0.048 (139)	0.04 (56)	0.031 (57)
Calibration	-25	-15	-13	-11	1	8	0.1 (114)	0.05 (106)	0.064 (33)	0.052 (61)	0.039 (34)	0.033 (36)
Validation	-18	0	3	5	-4	15	0.093 (111)	0.057 (106)	0.054 (21)	0.045 (78)	0.042 (22)	0.03 (21)

- Sediment nutrient fluxes are simulated by sediment diffusion rates and adsorption isotherms
- The model has been modified to apply initial conditions for the lake sediments for every model run
- Simulated ammonia and phosphorus concentrations in the lake have opposite trends in the upstream to downstream direction compared to observations
  - Ammonia concentrations are overestimated above Highway 50 and phosphorus concentrations are generally underestimated; both do well downstream of Highway 50
  - Refining the calibration may improve one parameter but make the other parameter worse.
- The annual WARMF Lake simulated flux rates are similar to previous estimates
  - The WARMF Lake model simulates approximately 190,000 pounds per year of ammonia released from the sediments compared to previous estimates by UNRBA/Alperin of approximately 207,000 pounds per year.
  - The WARMF Lake model simulates approximately 7,000 pounds per year of phosphate released from the sediments compared to previous UNRBA/Alperin estimates of approximately 14,000 pounds per year. Note that WARMF simulates the diffusion processes only; not the oxygen-based chemistry component.

EFDC Lake Calibration Status

EFDC Lake Model Configuration

- Output from the WARMF watershed model provides stream flow and nutrient concentrations to the EFDC lake model
- The EFDC lake model is comprised of the ~862 horizontal grid cells and 10 Sigma-Zed vertical layers*.
- Model takes ~ 35 hrs to run 2014 to 2018 (6 initialization and 4 calibration/validation years)
- Primary performance criteria is the RSR: normalized root mean square error (RMSE)
    - Expressed as a percentage (target is 100 percent)
    - Ratio of the RMSE to the standard deviation in the observed data for each hydrodynamic or water quality constituent
    - Abbreviated RSR (**R**MSE to **S**tandard deviation **R**atio)
- Other statistics are also evaluated for context (e.g., percent bias where <35% is fair, <25% is good, <15% is very good)

** Sigma-Zed allows for the number of layers to vary over the model domain. Each cell can use a different number of layers, though the number of layers for each cell is constant in time. The thickness of each layer varies in time to accommodate the time varying depths.*

EFDC Lake Modeling Status

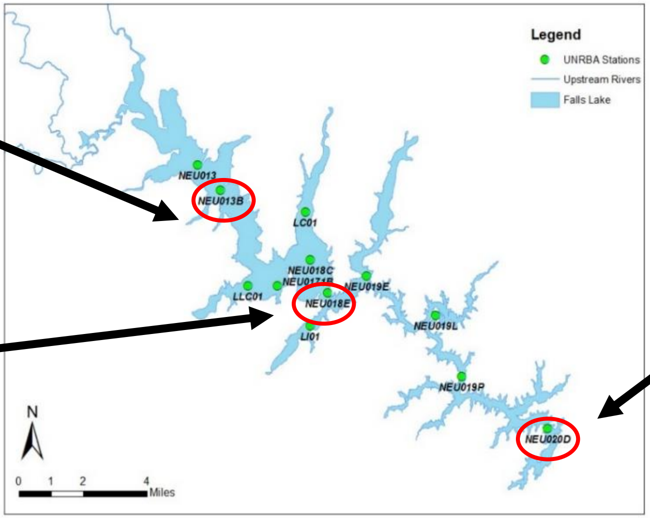
- During the May and August MRSW meetings, the modeling team presented comparisons of observed biovolume and chlorophyll-a data in Falls Lake and discussed calibration challenges
- Modeling team has continued to discuss model calibration with subject matter experts and DWR modeling staff
  - September 26, 2022 (with DWR and SMEs)
  - October 13, 2022 (with SMEs)
  - November 17, 2022 (with DWR and SMEs)
- Further refinements have been made and model performance has improved
- Today we will review the final calibration results for EFDC for approval by the MRSW

Water Quality Stations

- The model is being calibrated to the 12 DWR lake monitoring stations (UNRBA Modeling QAPP)
- Data from other organizations is used to inform model development
- Today we will show results for three stations (upper, middle, and lower lake)

Station NEU013B in the upper lake (photic layer is the top layer (10))

Station NEU018E in the middle lake (photic layer is the top layer (10))



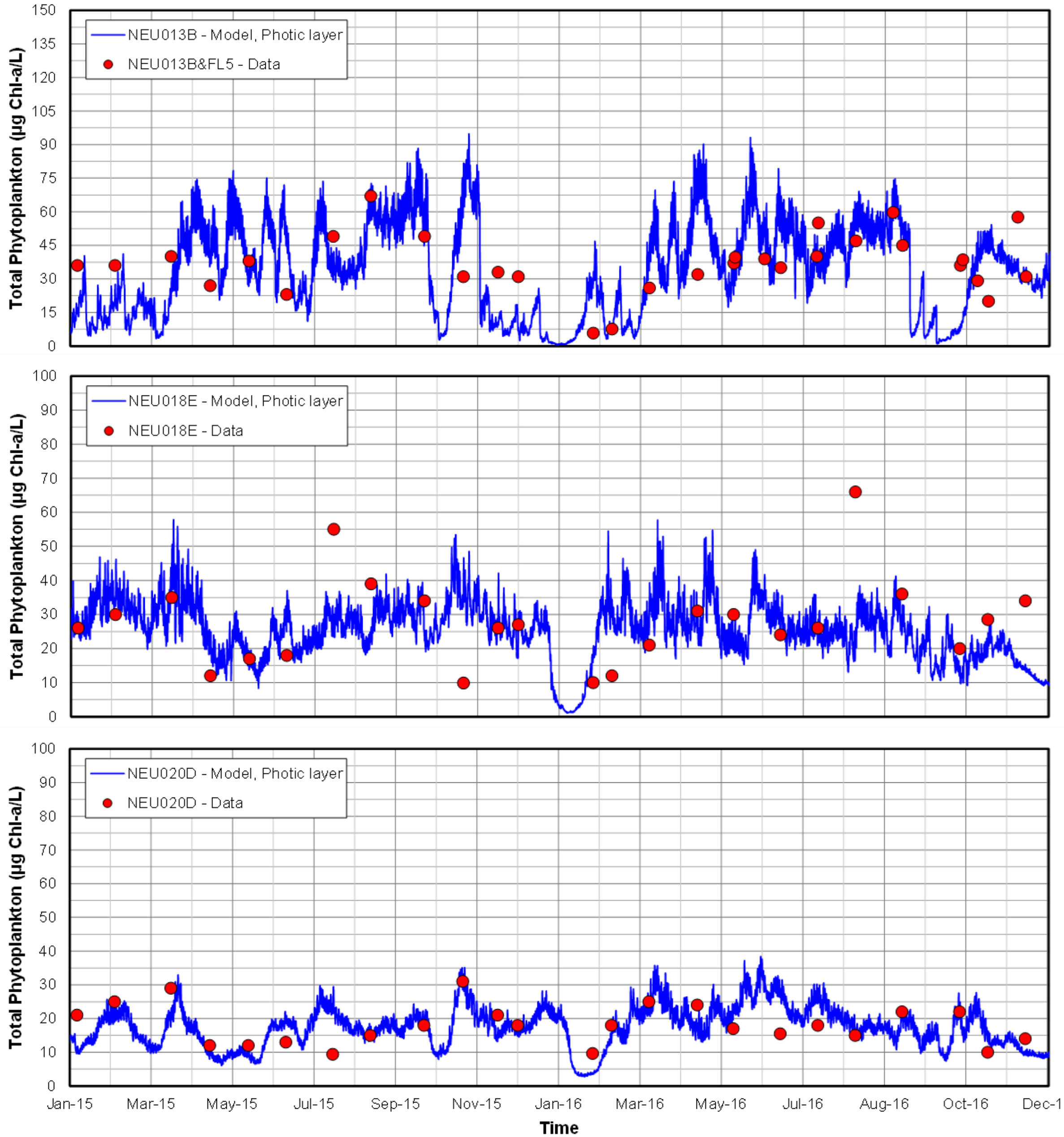
Station NEU020D in the lower lake photic layers include 10, 9, and 8 depending on the water level.

Chlorophyll-a Calibration Period

Upper Lake (13B&FL5)
RSR = 109
Percent bias = 1.7

Middle Lake (18E)
RSR = 116
Percent bias = -8.4

Lower Lake (20D)
RSR = 85
Percent bias = -2.2

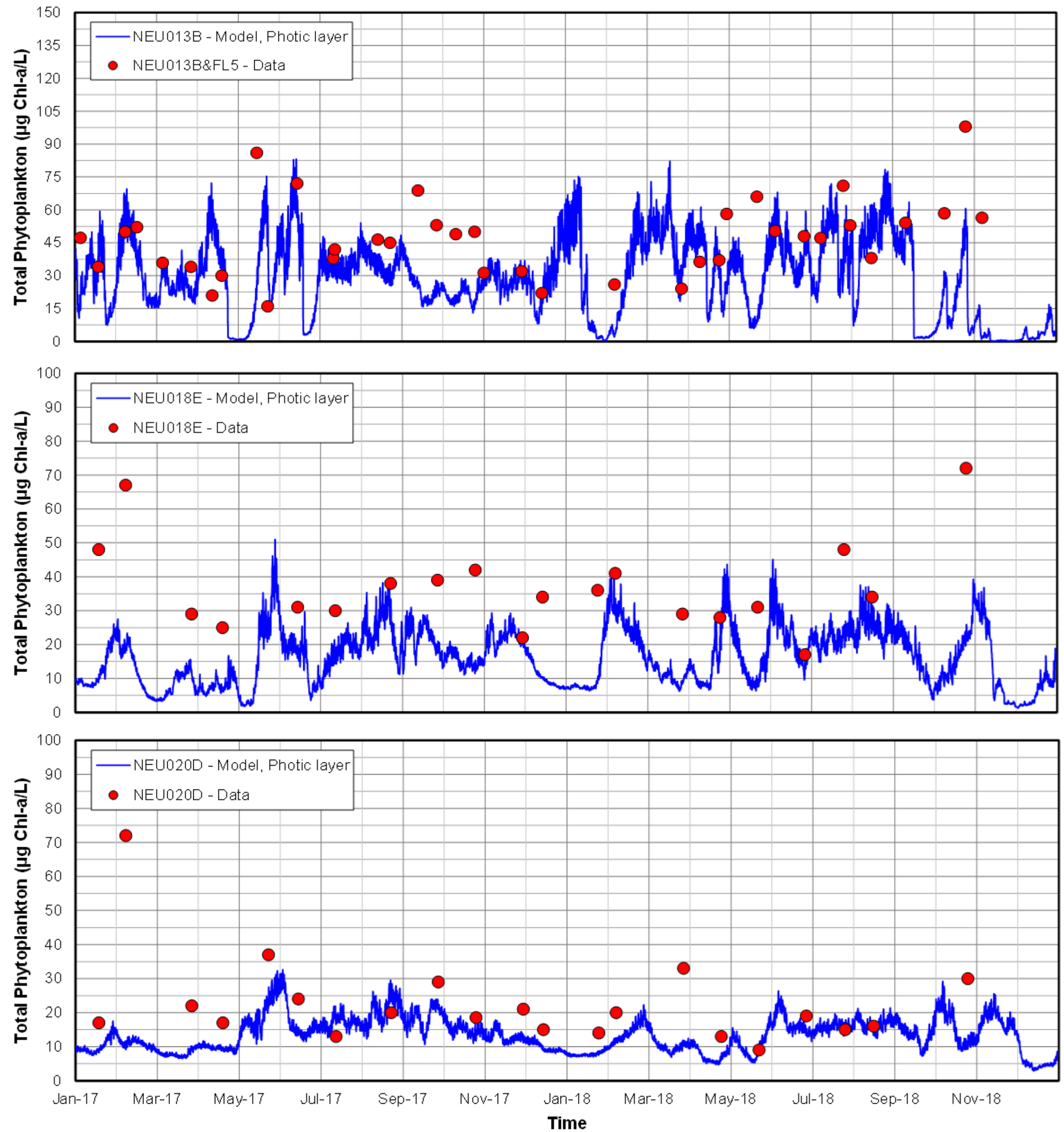


Chlorophyll-a Validation Period

Upper Lake (13B&FL5)
RSR = 154
Percent bias = -29.1

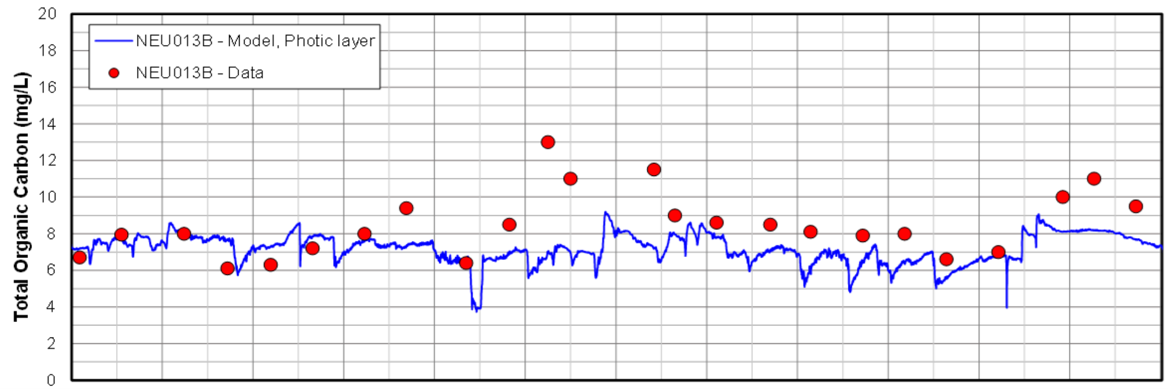
Middle Lake (18E)
RSR = 154
Percent bias = -55.8

Lower Lake (20D)
RSR = 121
Percent bias = -37.0

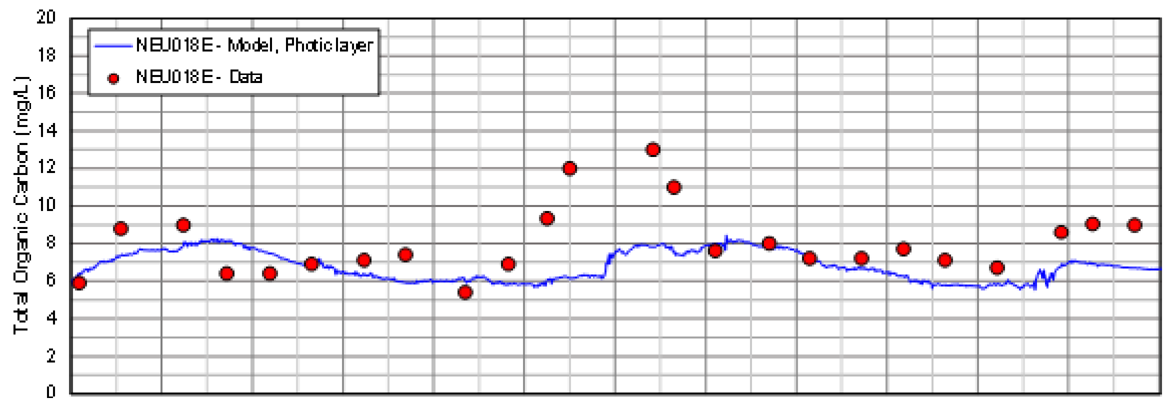


TOC
Calibration Period

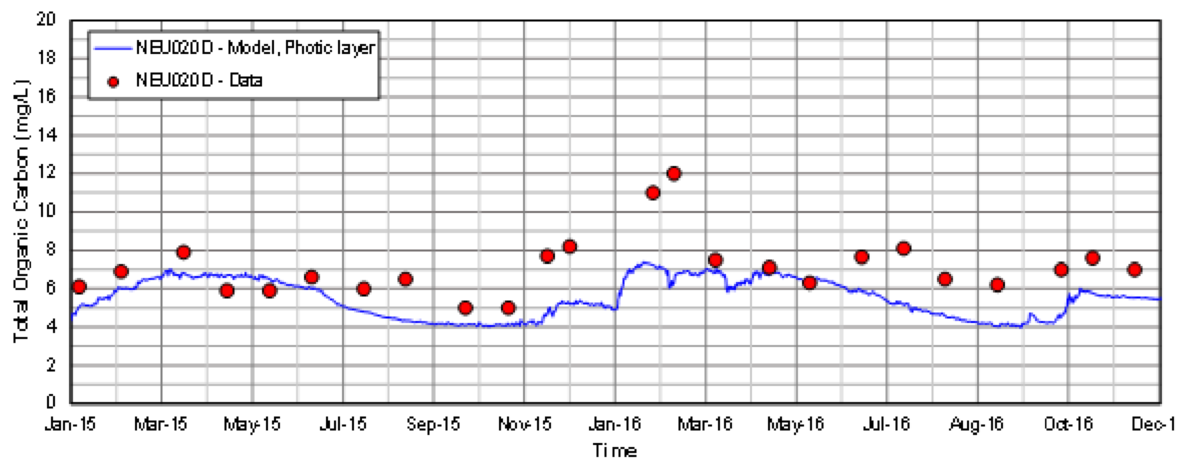
<u>Upper Lake (13B)</u>
RSR = 123
Percent bias = -15.3



<u>Middle Lake (18E)</u>
RSR = 115
Percent bias = -12.1



<u>Lower Lake (20D)</u>
RSR = 120
Percent bias = -17.1

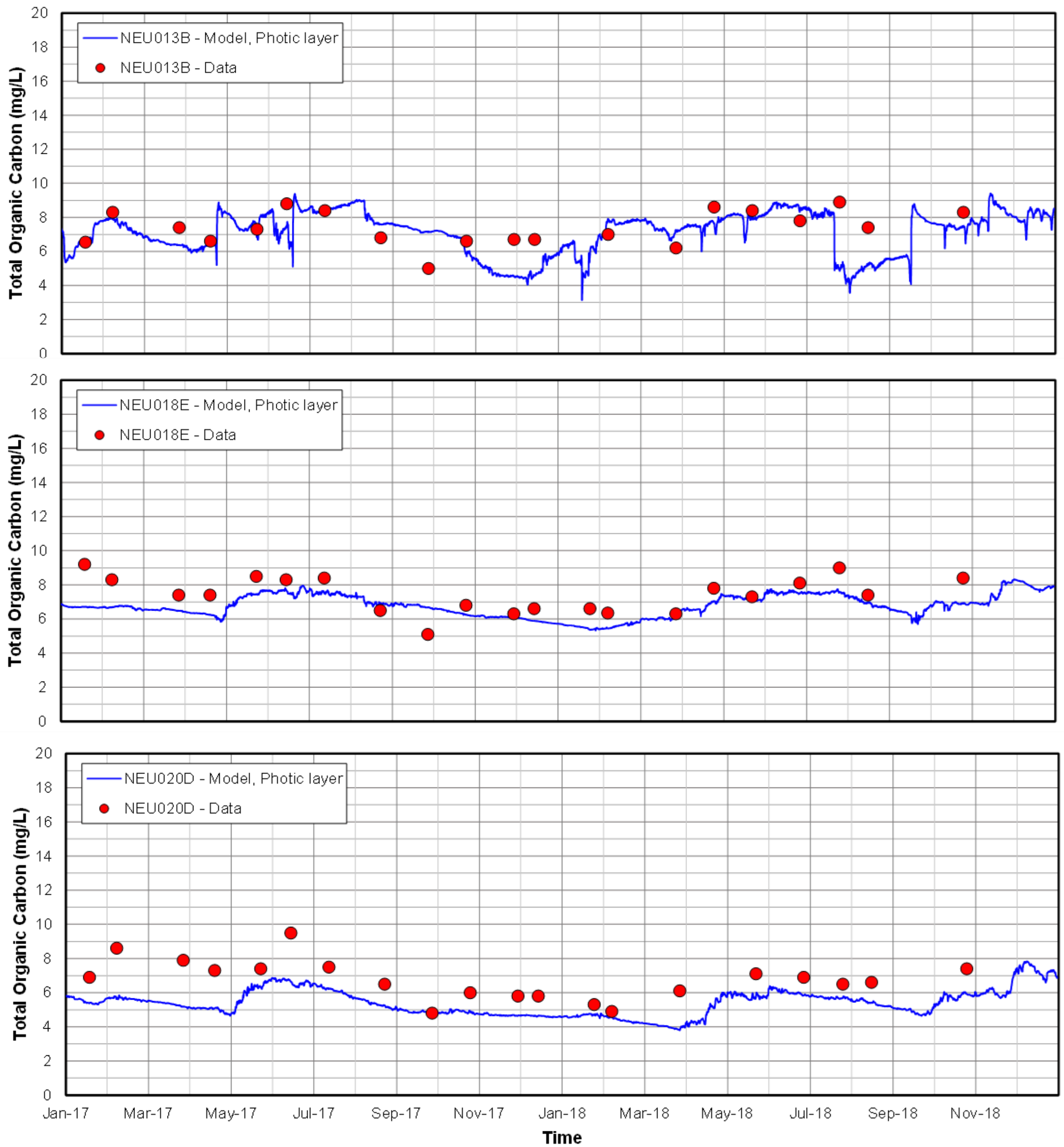


TOC
Validation Period

Upper Lake (13B)
RSR = 147
Percent bias = -7.6

Middle Lake (18E)
RSR = 104
Percent bias = -9.8

Lower Lake (20D)
RSR = 141
Percent bias = -20.9

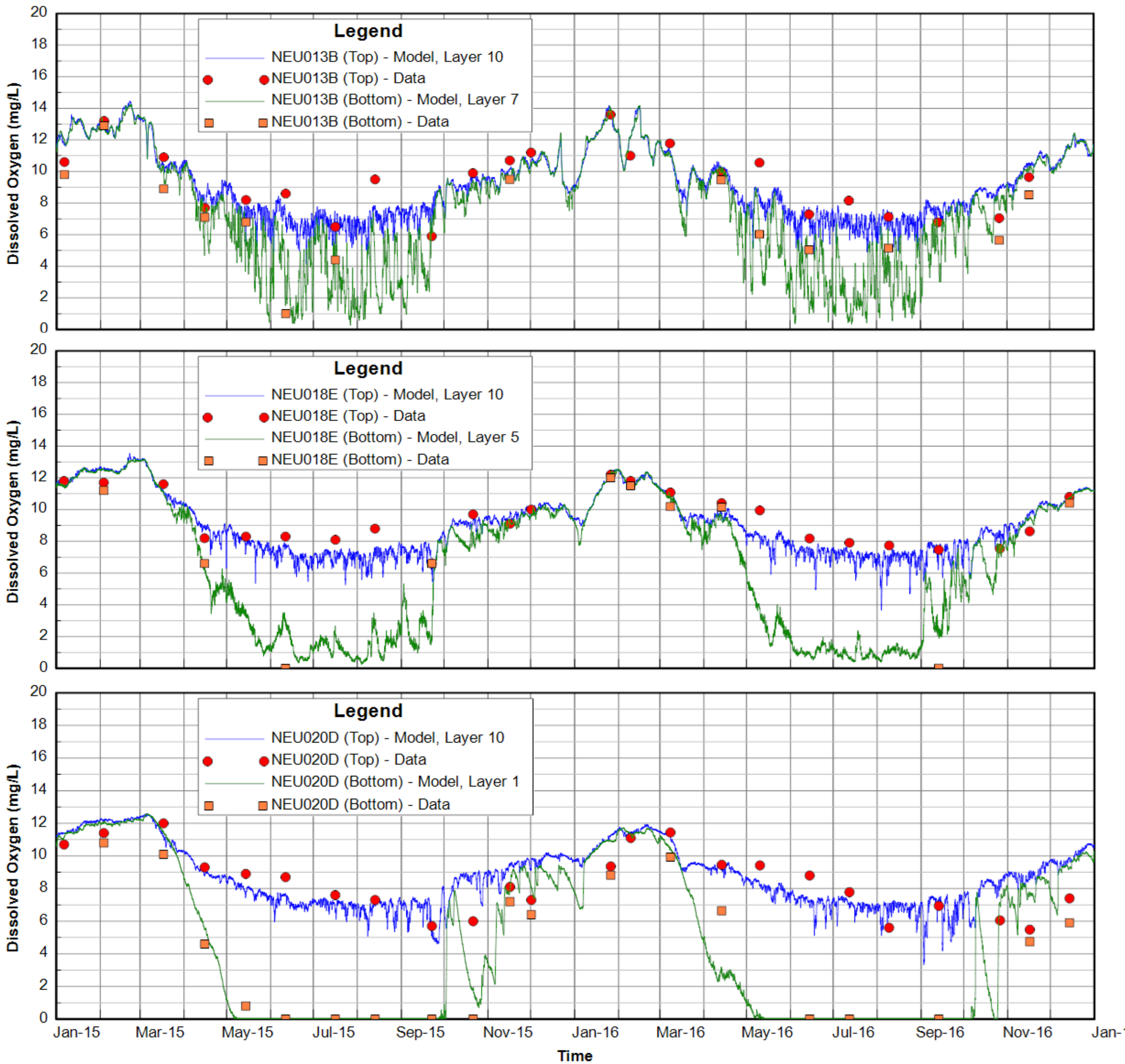


DO
Calibration Period

<u>Upper Lake (13B)</u>
RSR = 53 (T) 55 (B)
Percent bias = -2.3(T) 2.6 (B)

<u>Middle Lake (18E)</u>
RSR = 48 (T) 46 (B)
Percent bias = -2.8 (T) 2.6 (B)

<u>Lower Lake (20D)</u>
RSR = 76 (T) 41 (B)
Percent bias = 4.5 (T) 15.7 (B)

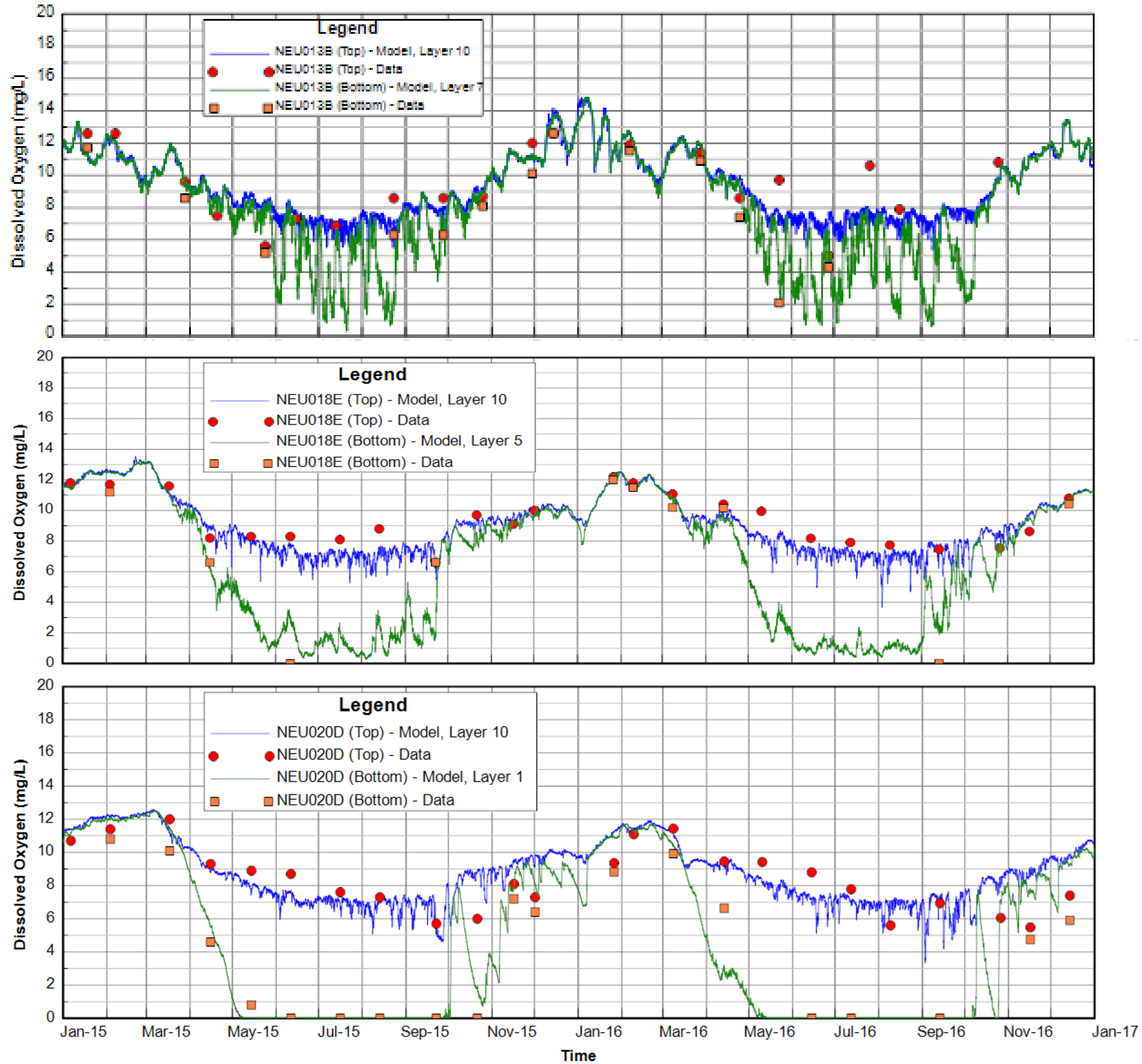


DO
Validation Period

Upper Lake (13B)
RSR = 68 (T) 52 (B)
Percent bias = -1.7 (T)
4.5 (B)

Middle Lake (18E)
RSR = 48 (T) 51 (B)
Percent bias = -0.1 (T)
14.0 (B)

Lower Lake (20D)
RSR = 77 (T) 39 (B)
Percent bias = 15.2 (T)
5.0 (B)

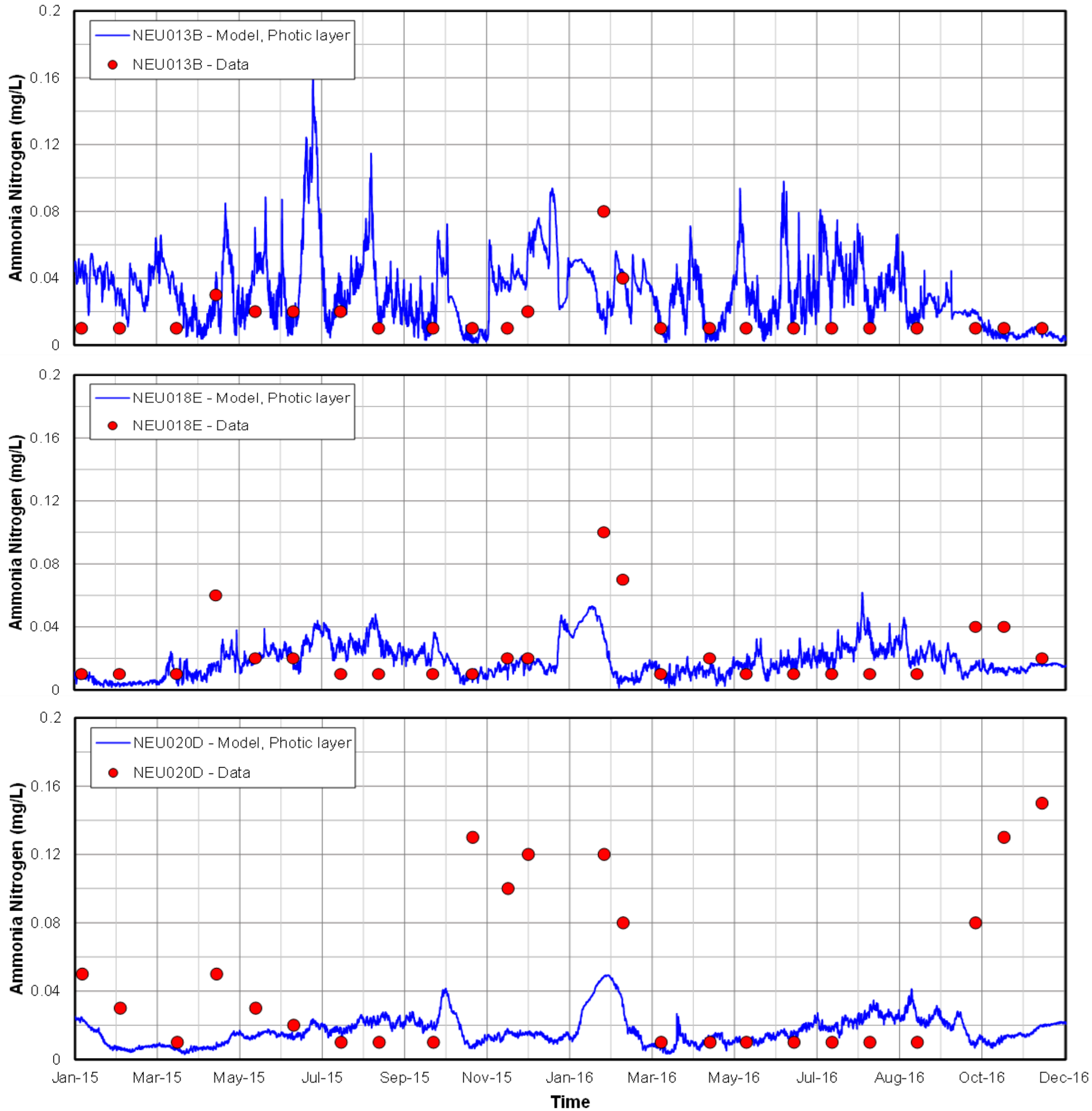


NH4 Calibration Period

<u>Upper Lake (13B)</u>
RSR = 151
Percent bias = 57.9

<u>Middle Lake (18E)</u>
RSR = 107
Percent bias = -24.8

<u>Lower Lake (20D)</u>
RSR = 122
Percent bias = -66.0

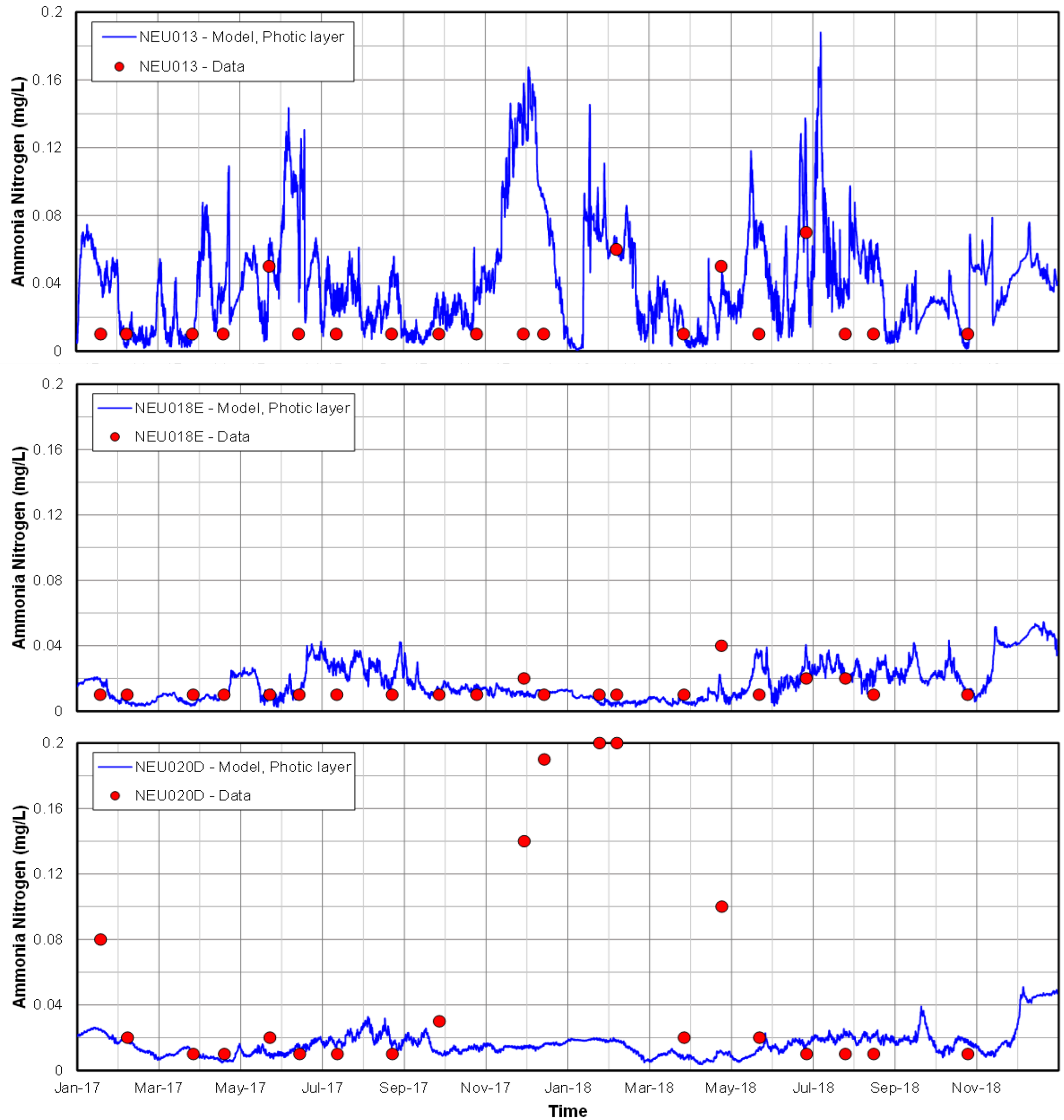


NH4
Validation Period

Upper Lake (13B)
RSR = 174
Percent bias = 87.8

Middle Lake (18E)
RSR = 153
Percent bias = 10.9

Lower Lake (20D)
RSR = 118
Percent bias = -78.3

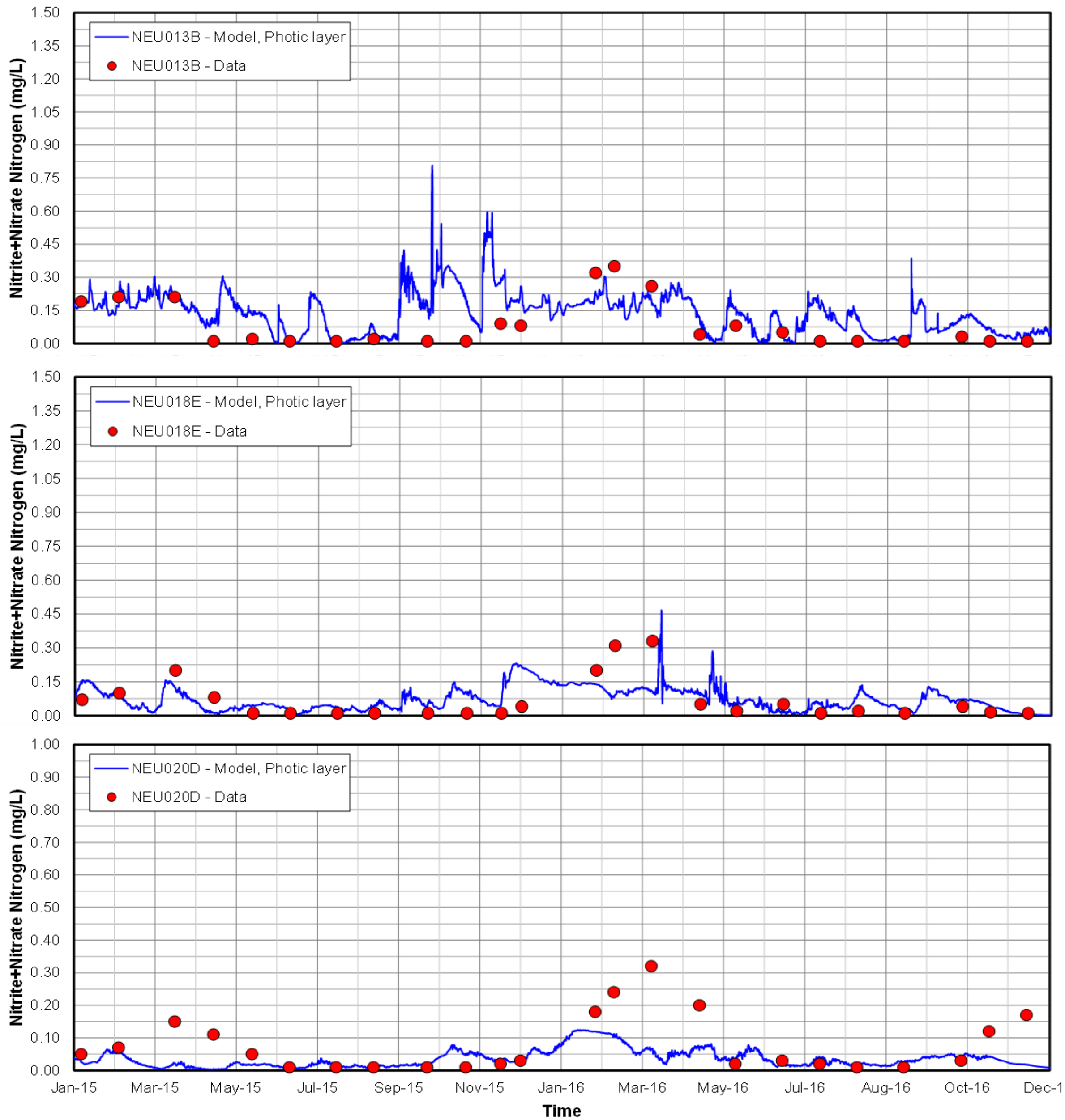


NO3 Calibration Period

Upper Lake (13B)
RSR = 98
Percent bias = 57.3

Middle Lake (18E)
RSR = 93
Percent bias = 7.4

Lower Lake (20D)
RSR = 102
Percent bias = -53.7



NO3
Validation Period

Upper Lake (13B&FL5)

RSR = 269

Percent bias = 163.7

Middle Lake (18E)

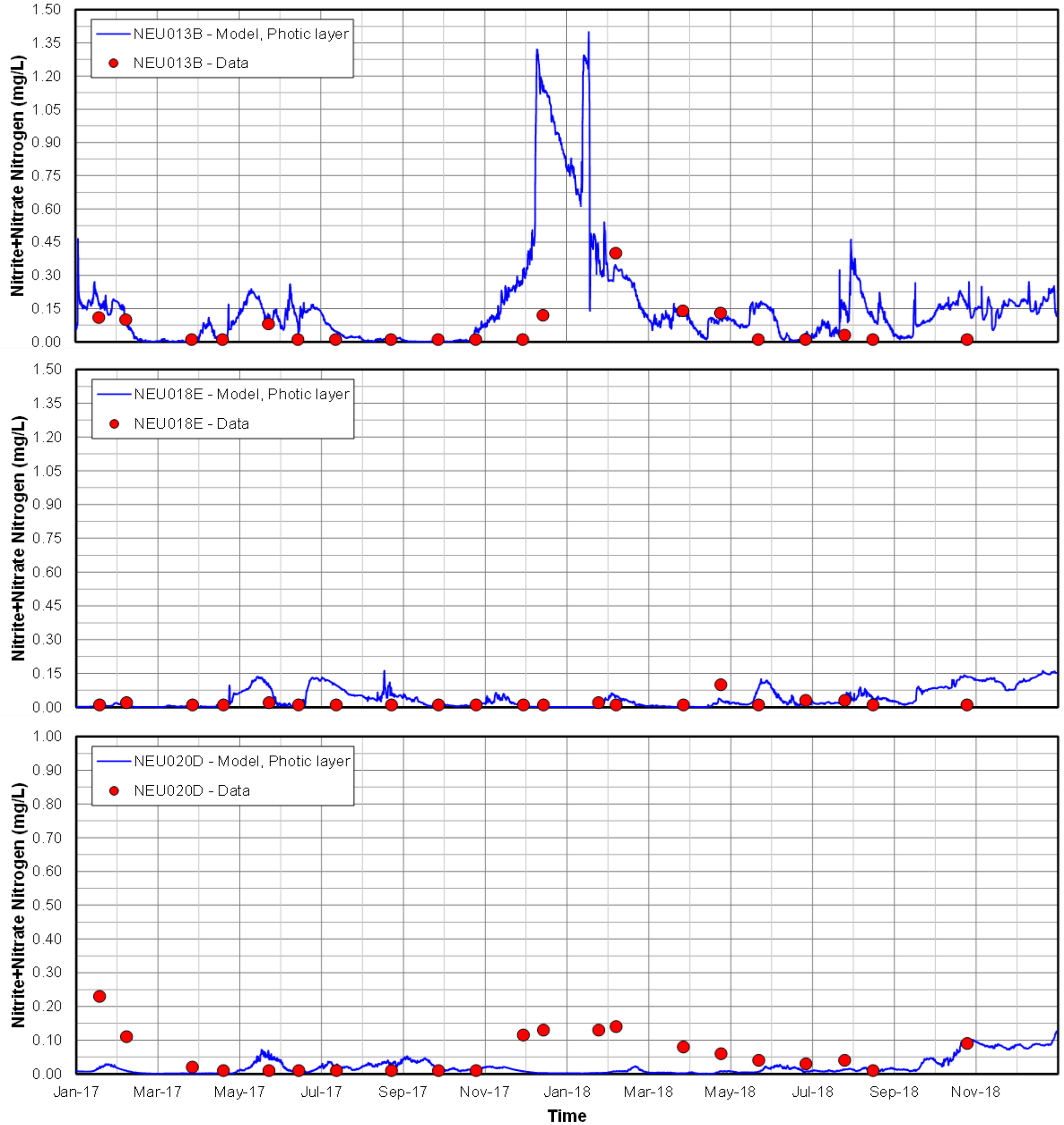
RSR = 245

Percent bias = 78.3

Lower Lake (20D)

RSR = 128

Percent bias = -73.5

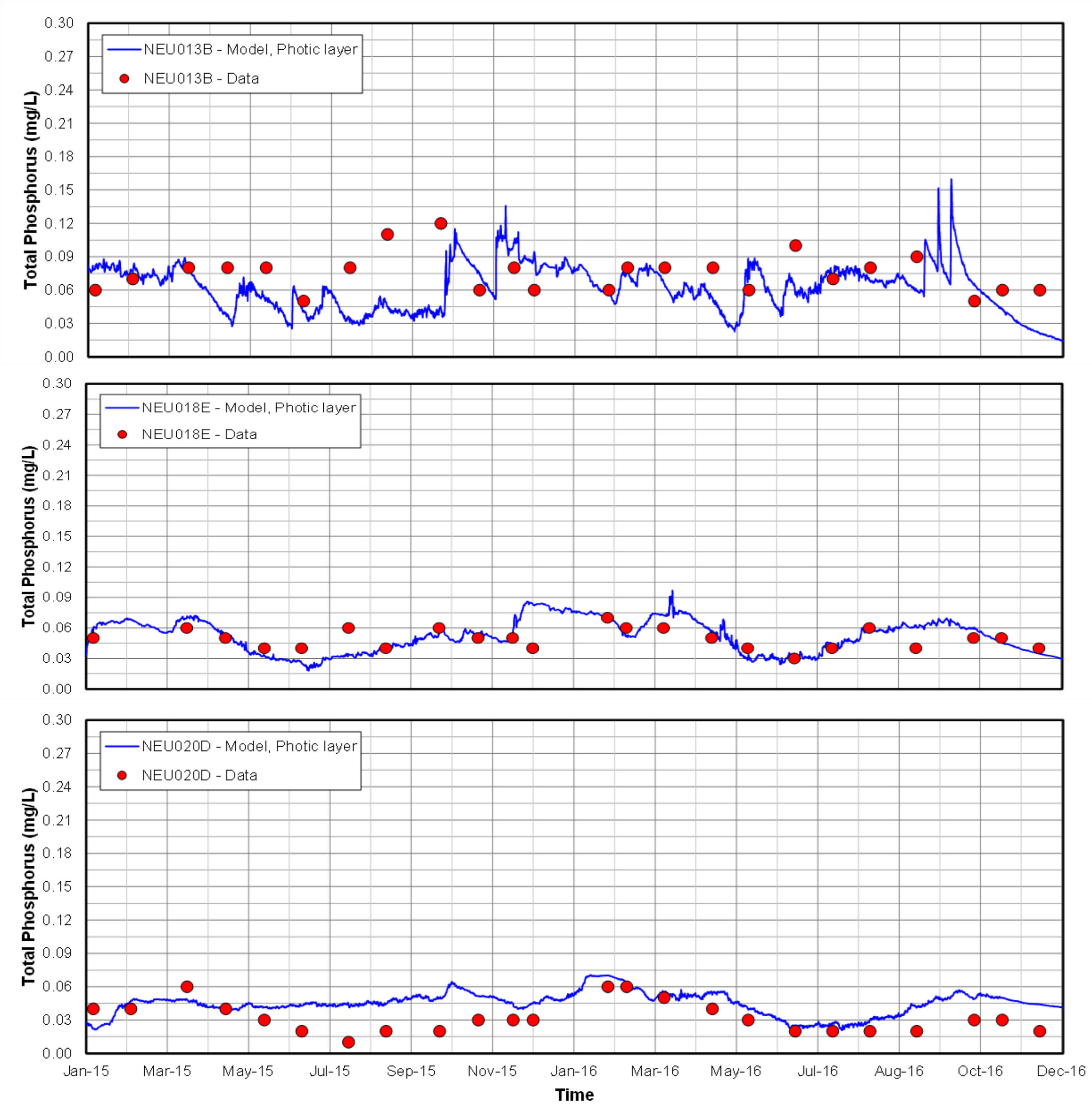


TP
Calibration Period

<u>Upper Lake (13B)</u>
RSR = 184
Percent bias = -18.2

<u>Middle Lake (18E)</u>
RSR = 133
Percent bias = 4.3

<u>Lower Lake (20D)</u>
RSR = 127
Percent bias = 39.0

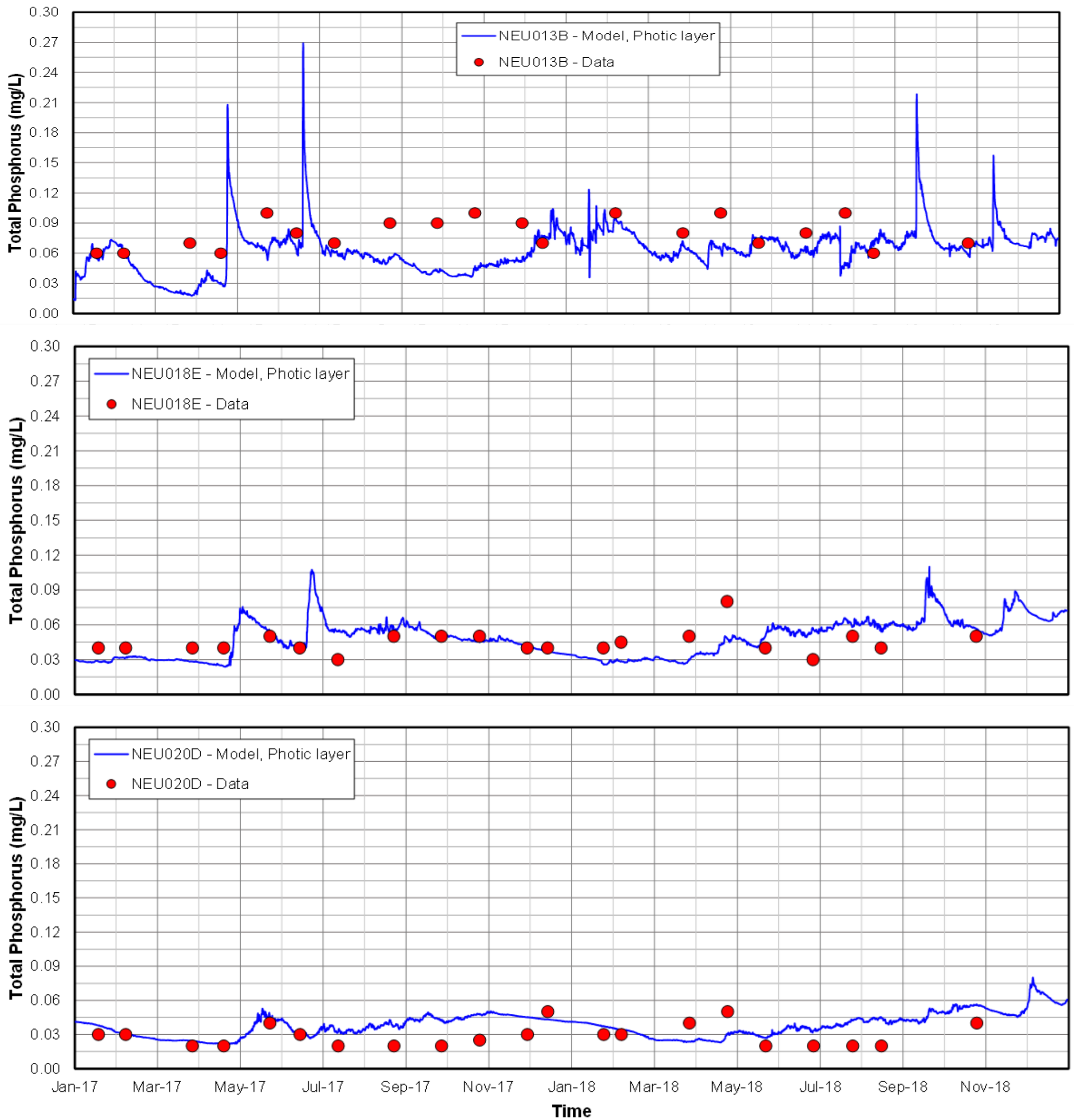


TP
Validation Period

<u>Upper Lake (13B)</u>
RSR = 199
Percent bias = -27.2

<u>Middle Lake (18E)</u>
RSR = 145
Percent bias = -3.5

<u>Lower Lake (20D)</u>
RSR = 135
Percent bias = 25.4

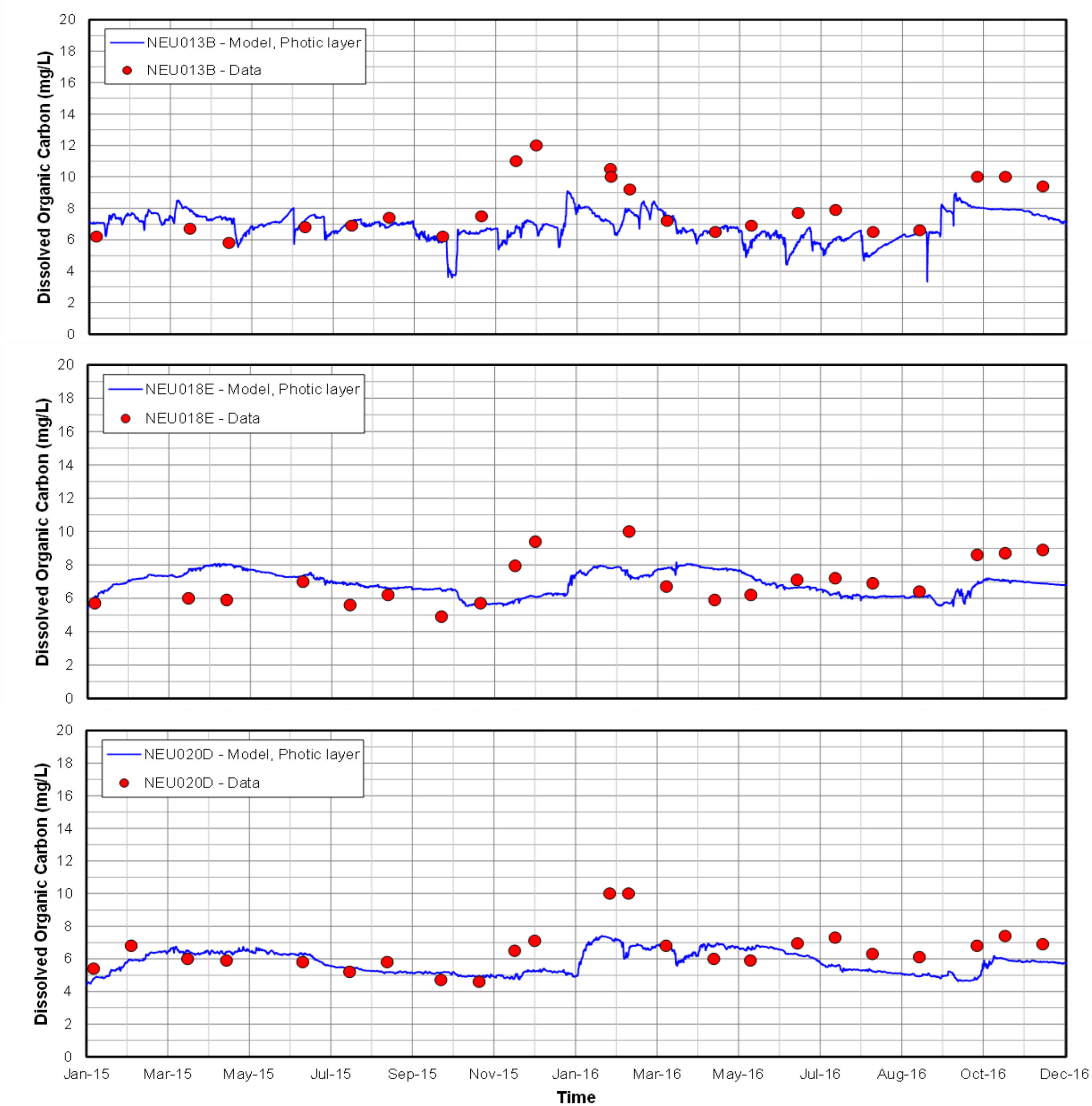


DOC
Calibration Period

<u>Upper Lake (13B)</u>
RSR = 115
Percent bias = -14.4

<u>Middle Lake (18E)</u>
RSR = 114
Percent bias = -2.9

<u>Lower Lake (20D)</u>
RSR = 107
Percent bias = -11.7



DOC
Validation Period

Upper Lake (13B)

RSR = 115

Percent bias = -4.8

Middle Lake (18E)

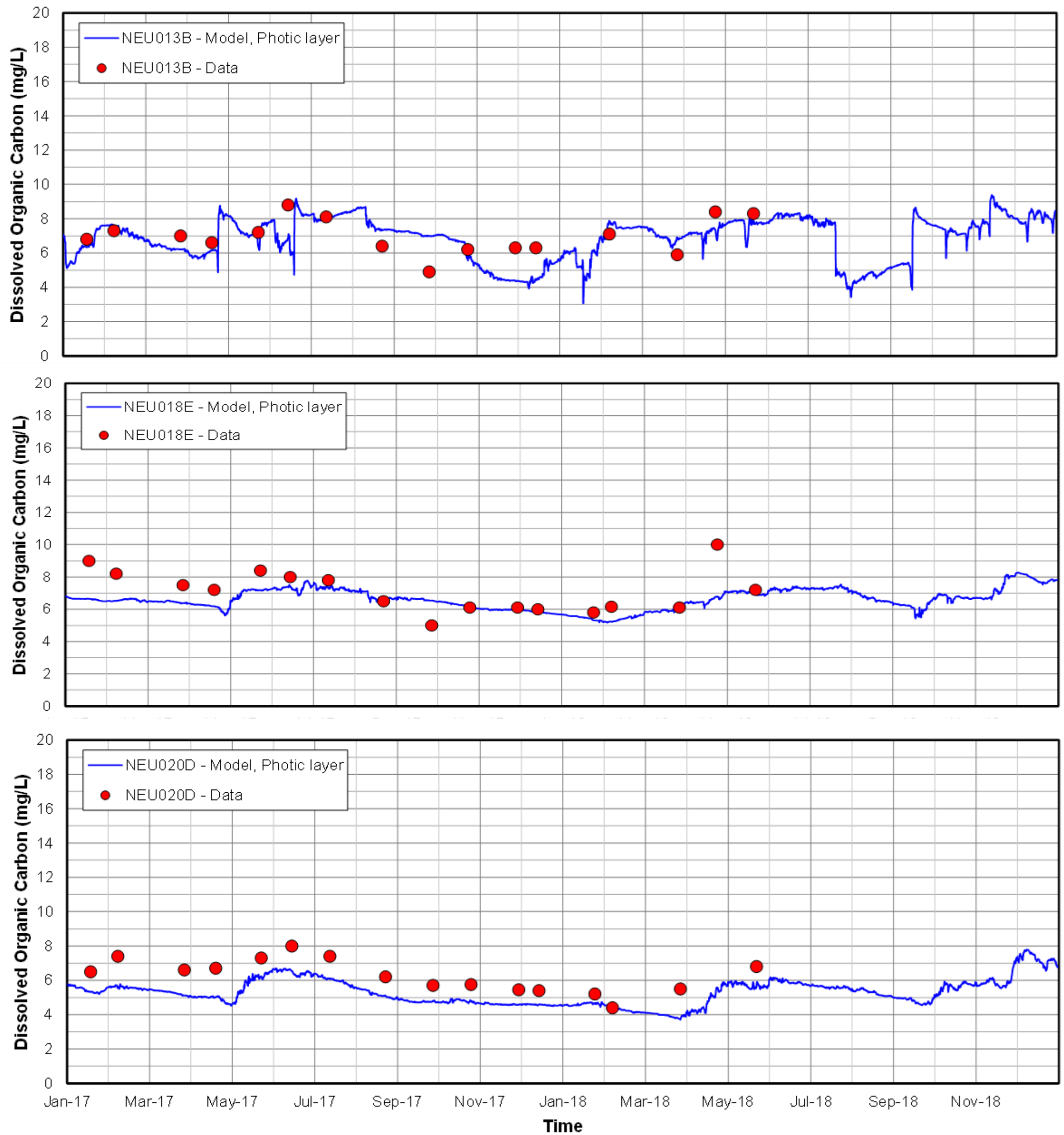
RSR = 98

Percent bias = -9.9

Lower Lake (20D)

RSR = 128

Percent bias = -18.0

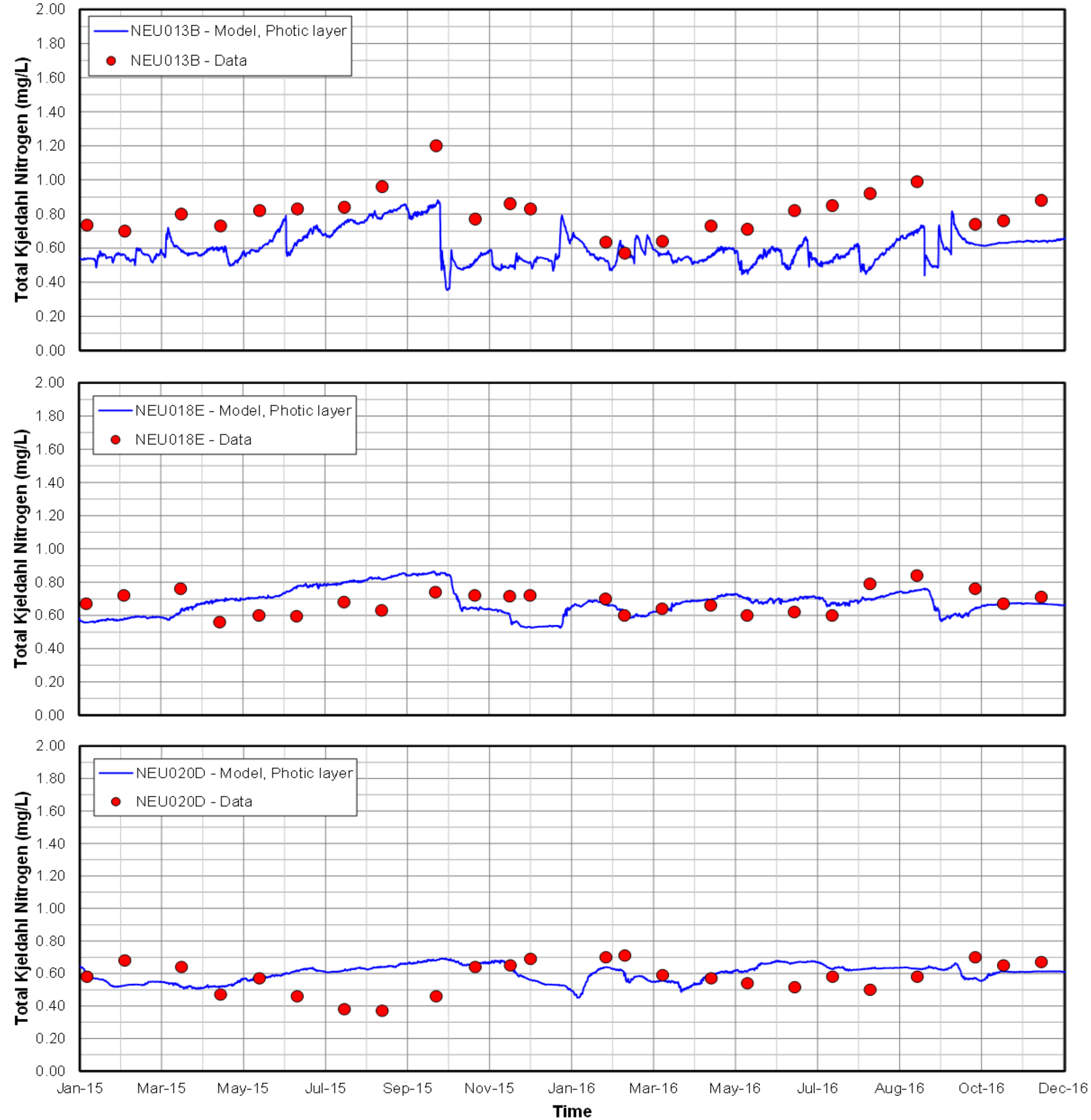


TKN
Calibration Period

Upper Lake (13B)
RSR = 170
Percent bias = -22.4

Middle Lake (18E)
RSR = 155
Percent bias = -0.3

Lower Lake (20D)
RSR = 131
Percent bias = 3.6

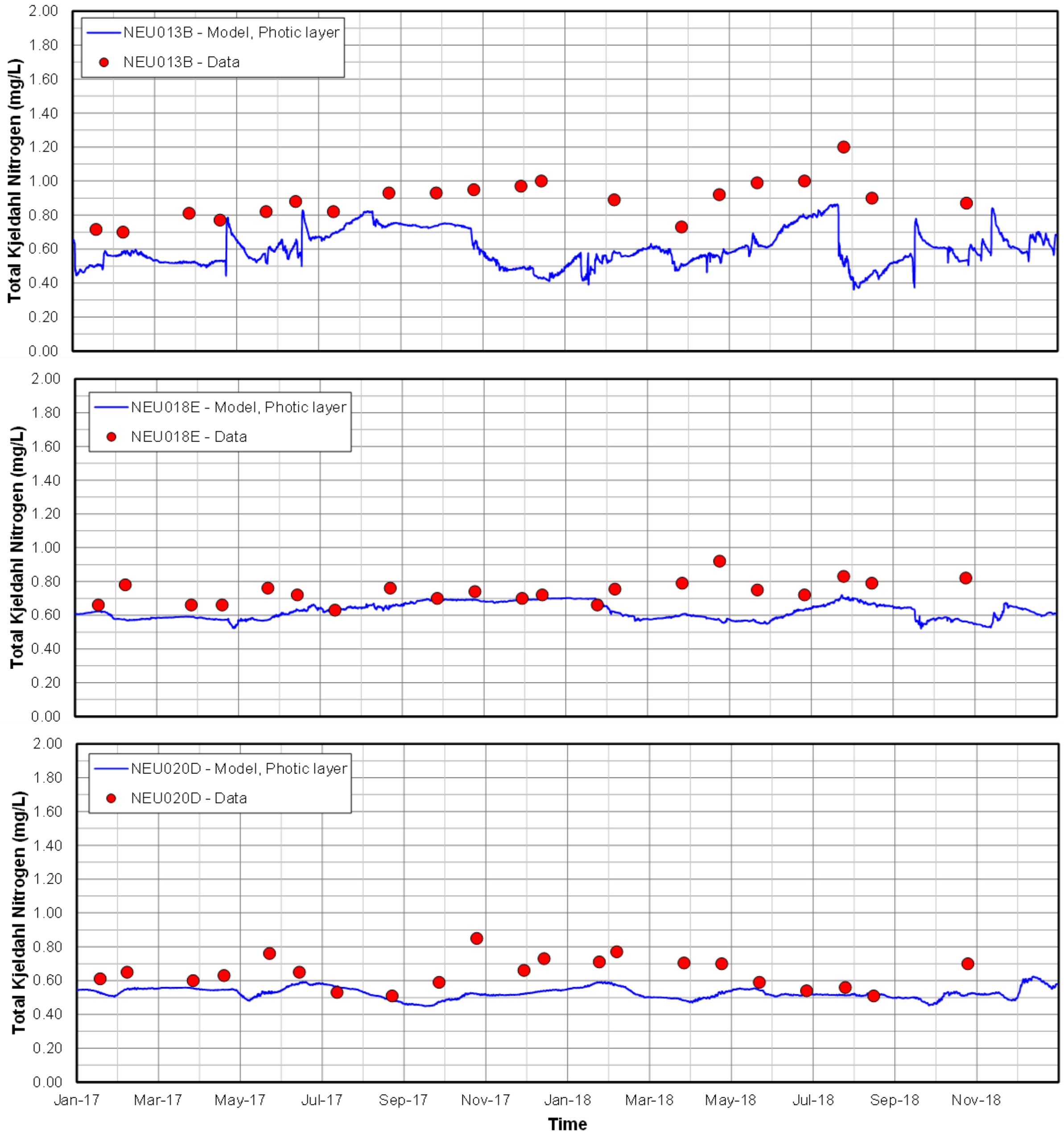


TKN
Validation Period

Upper Lake (13B)
RSR = 294
Percent bias = -32.7

Middle Lake (18E)
RSR = 182
Percent bias = -7.6

Lower Lake (20D)
RSR = 131
Percent bias = -9.6

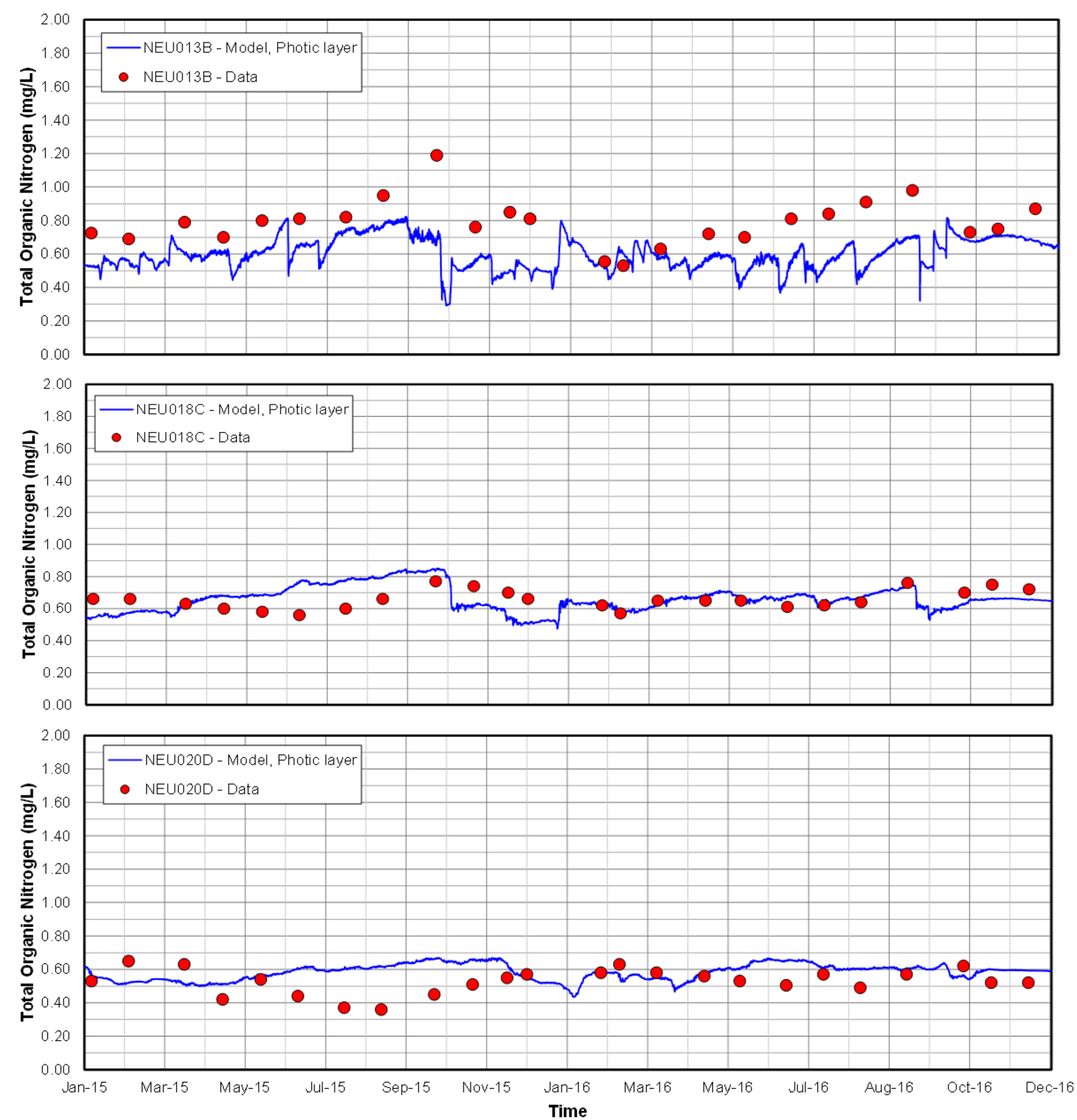


TON
Calibration Period

Upper Lake (13B)
RSR = 170
Percent bias = -24.1

Middle Lake (18E)
RSR = 140
Percent bias = 0.6

Lower Lake (20D)
RSR = 154
Percent bias = 10.2

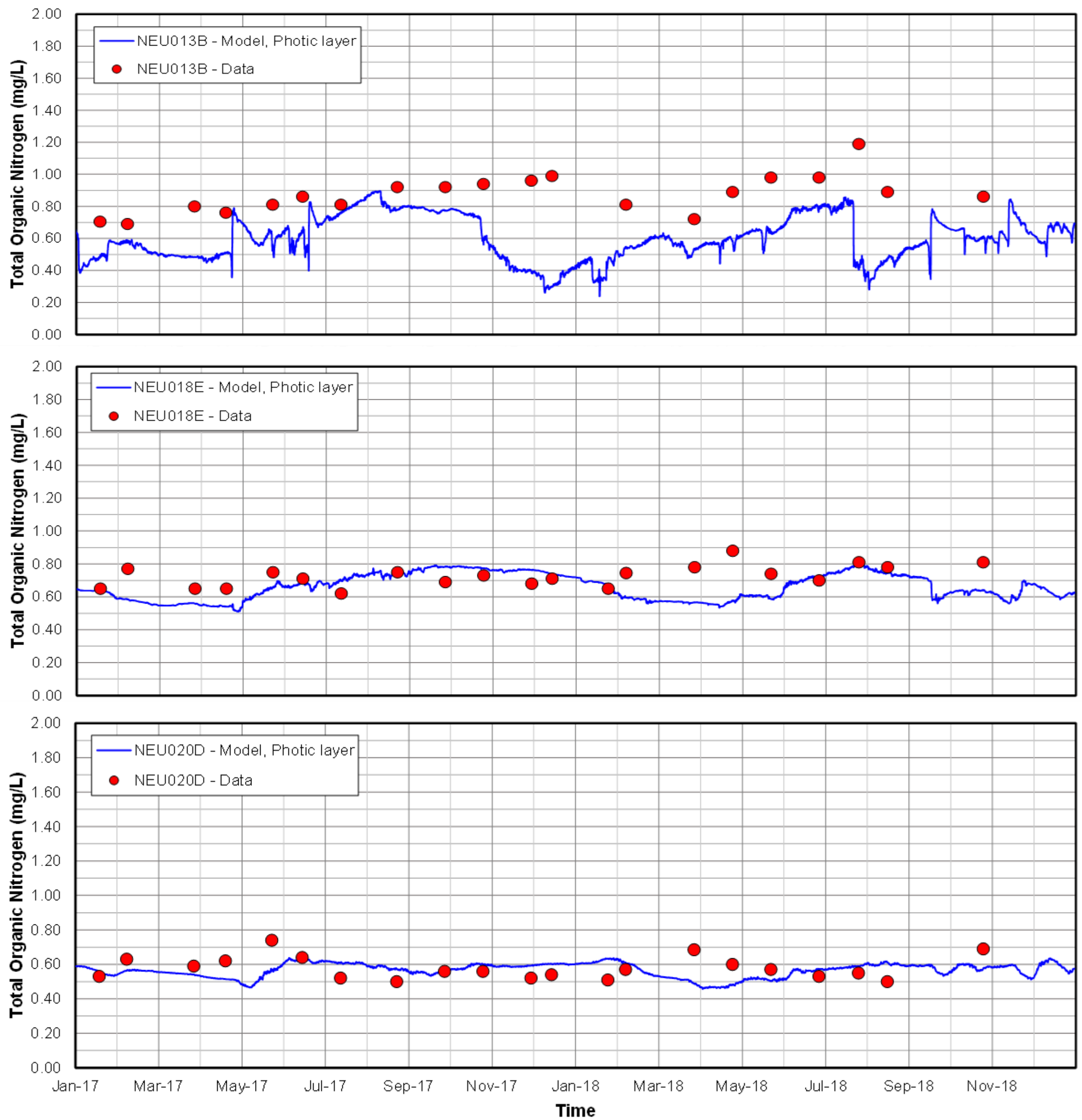


TON
Validation Period

Upper Lake (13B)
RSR = 307
Percent bias = -34.9

Middle Lake (18E)
RSR = 188
Percent bias = -8.0

Lower Lake (20D)
RSR = 141
Percent bias = -1.6

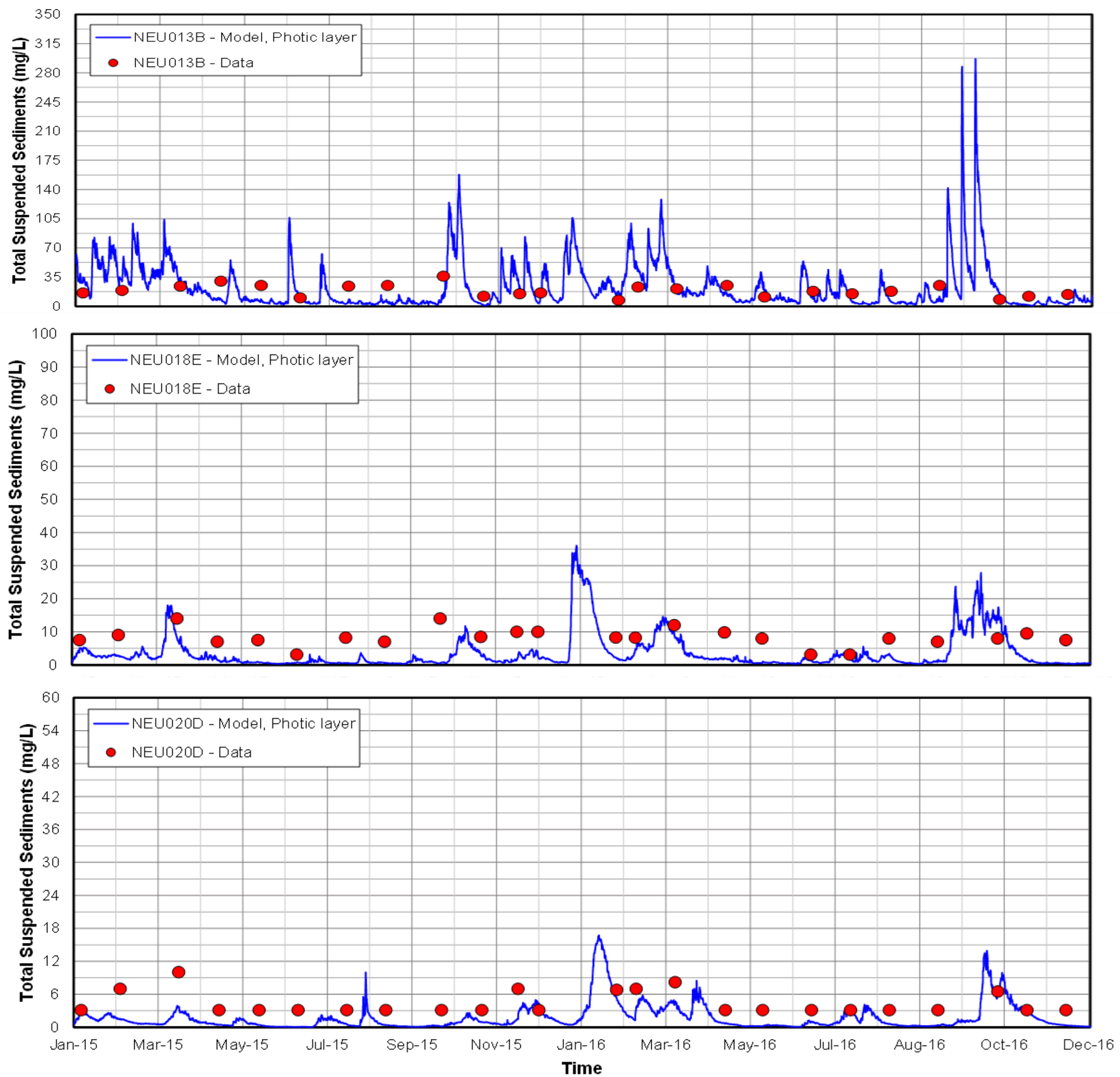


TSS
Calibration Period

Upper Lake (13B)
RSR = 186
Percent bias = -23.4

Middle Lake (18E)
RSR = 235
Percent bias = -64.8

Lower Lake (20D)
RSR = 153
Percent bias = -61.9

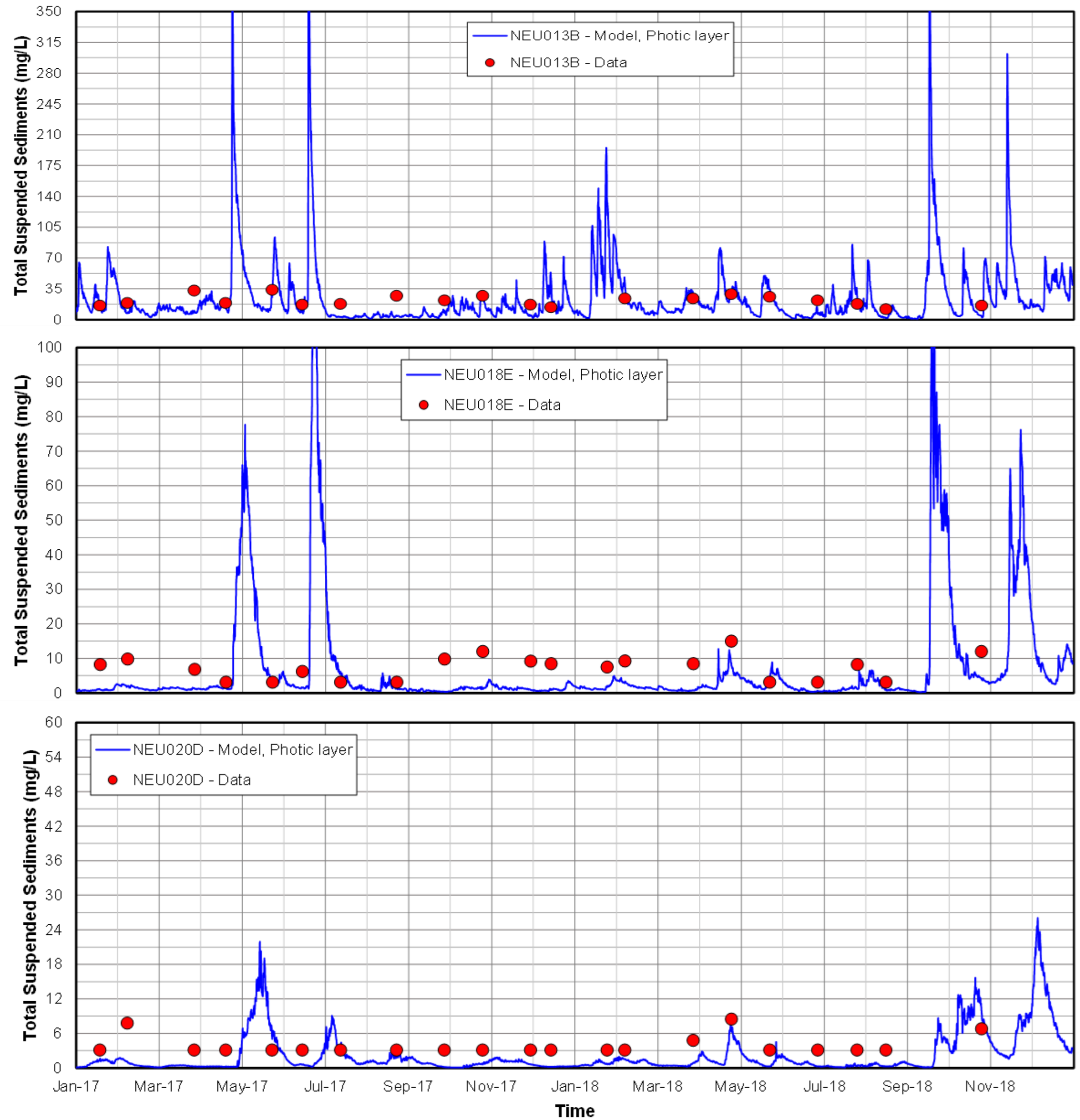


TSS
Validation Period

Upper Lake (13B)
RSR = 230
Percent bias = -16.6

Middle Lake (18E)
RSR = 180
Percent bias = -69.8

Lower Lake (20D)
RSR = 173
Percent bias = -63.8



Seasonal and Total NH4 Sediment Load

Years	NH_4 Load from Nov to Apr (lb/yr)	NH_4 Load from May to Oct (lb/yr)	NH_4 Total Annual Load (lb/yr)
2015	72,792	269,095	341,888
2016	83,690	294,175	377,865
2017	41,489	219,698	261,187
2018	31,968	240,004	271,972
EFDC Average	57,485	255,743	313,228
Alperin Estimate (UNRBA, 2019)			207,000
Piehler Estimate (personal communication to Alix Matos, November 30, 2022)			520,000

Seasonal and Total PO4 Sediment Load

Years	PO_4 Load from Nov to Apr (lb/yr)	PO_4 Load from May to Oct (lb/yr)	PO_4 Total Annual Load (lb/yr)
2015	8,505	46,164	54,668
2016	8,895	47,658	56,554
2017	6,753	40,667	47,419
2018	5,254	45,125	50,378
EFDC Average	7,351	44,903	52,255
Alperin Estimate (UNRBA, 2019)			14,000
Piehler Estimate (personal communication to Alix Matos, November 30, 2022)			10,500

Seasonal and Total NO3 Sediment Load

Years	NO_3 Load from Nov to Apr (lb/yr)	NO_3 Load from May to Oct (lb/yr)	NO_3 Total Annual Load (lb/yr)
2015	-20,548	-74,872	-95,420
2016	-32,989	-79,397	-112,386
2017	-13,911	-57,561	-71,472
2018	-14,896	-66,036	-80,933
EFDC Average	-20,586	-69,467	-90,053
Piehler Net Estimate (personal communication to Alix Matos, November 30, 2022)			-480,000
Hall Estimate (Hall and Paerl, 2021)			-59,500 to -68,300

Cohesive Sediment Key Parameters

Parameter	Unit	Definition	Value
$1/\rho$	m^3/g	Specific Volume	3.77E-07
SG	---	Specific gravity	2.65
V_S	m/s	Settling velocity	6.00E-06
τ_{cd}	m^2/s^2	Tau critical-deposition	1.00E-05
τ_{ce}	m^2/s^2	Tau critical-erosion	5.00E-05
J_r	$g/m^2/s$	Reference surface erosion rate	0.0001

Light Extinction Key Parameters

Definition	Value
Background Light Extinction Coefficient (1/m):	0.045
Light Extinction due to TSS (1/m per mg/L):	0.021
Light Extinction due to Chlorophyll (1/m per mg/L) (use Riley's eq. if < 0):	0.062
Chlorophyll Light Extinction Exponent (ignored if using Riley's eq.):	1
Light Extinction due to POC (POM) (1/m per mg/L):	0.078
Light Extinction due to DOC (DOM) (1/m per mg/L):	0.2

Kinetics Key Parameters

Parameter	Unit	Definition	Value
$IWQKA$	---	Reaeration Option	Constant - Owen & Gibbs
k_a	$1/d$	Reaeration Rate Constant	3.00 - 5.32
θ	---	Reaeration Temperature Rate Constant	1.024
R_{ea}	---	Reaeration Adjustment Factor	0.30 - 1.50
K_{DOC}	$1/d$	Minimum hydrolysis Rate of DOC	0.005
K_{CD}	$1/d$	COD Decay Rate	0.10
KH_{COD}	$mg\,O_2/L$	Oxygen Half-Saturation Constant for COD Decay	1.50
WS_{RP}	m/d	Settling Velocity for RPOM	0.2-0.5
WS_{LP}	m/d	Settling Velocity for LPOM	0.2-0.5

Nutrients Key Parameters

Parameter	Unit	Definition	Value
		PHOSPHORUS	
K_{RPOP}	$1/d$	Minimum Hydrolysis Rate of RPOP	0.005
K_{LPOP}	$1/d$	Minimum Hydrolysis Rate of LPOP	0.075
K_{DOP}	$1/d$	Minimum Mineralization Rate of DOP	0.1
K_{PO4p}	g/m^3	Partition Coefficient for Sorbed/Dissolved PO4 (to TSS or TAM):	0.04
		NITROGEN	
K_{NIT}	$1/d$	Maximum Nitrification Rate	0.25
K_{RPON}	$1/d$	Minimum Hydrolysis Rate of RPON	0.005
K_{LPON}	$1/d$	Minimum Hydrolysis Rate of LPON	0.075
K_{DON}	$1/d$	Minimum Mineralization Rate of DON	0.0022
KH_{NH4}	$g\ N/m^3$	NH_4 Half-Sat Constant for Nitrification	0.025
KH_{NO3}	$g\ N/m^3$	NO_3 Half-Sat Constant for Denitrification	0.1
TR_{NIT}	^0C	Reference temperature for Nitrification	21
$\theta_{sub,NIT}$	---	Suboptimal Temperature Coefficient for Nitrification	0.045
$\theta_{super,NIT}$	---	Superoptimal Temperature Coefficient for Nitrification	0.0045
		CARBON	
K_{RPOC}	$1/d$	Minimum Hydrolysis Rate of RPOC	0.005
K_{LPOC}	$1/d$	Minimum Hydrolysis Rate of LPOC	0.075
K_{DOC}	$1/d$	Minimum Heterotrophic Mineralization Rate of DOC	0.005

Algae General Key Parameters

Parameter	Unit	Definition	Value
Cyanobacteria			
WS_C	m/d	Settling velocity	0.2-0.26
$CChl_C$	$mg\,C/\mu g\,ChlA$	Carbon to ChlA ratio	0.005
N/C	$g\,N/g\,C$	Nitrogen to Carbon ratio	0.176
Diatom			
WS_D	m/d	Settling velocity	0.4
$CChl_D$	$mg\,C/\mu g\,ChlA$	Carbon to ChlA ratio	0.005
N/C	$g\,N/g\,C$	Nitrogen to Carbon ratio	0.176
Si/C	$g\,Si/g\,C$	Silica to Carbon ratio	0.8
Green			
WS_G	m/d	Settling velocity	0.3
$CChl_G$	$mg\,C/\mu g\,ChlA$	Carbon to ChlA ratio	0.007
N/C	$g\,N/g\,C$	Nitrogen to Carbon ratio	0.176

The “green” group is used to represent “other” algae that are not diatoms or cyanobacteria.

Algae Growth Key Parameters

Parameter	Unit	Definition	Value
		Cyanobacteria	
PM_C	$1/d$	Max growth rate	2.63-3.05
$D_{opt,C}$	m	Optimal depth for growth	1
$AOCR_{p,C}$	---	Photosynthesis Oxygen-to-Carbon Ratio	2.67
KHP_C	mg/L	P Half-Saturation	0.001
KHN_C	mg/L	N Half-Saturation	0.01
$TM1_C$	^0C	Optimal Temp lower bound	24
$TM2_C$	^0C	Optimal Temp upper bound	31
$KTG1_C$	---	Temp effect Coeff below optimal (1/DegC^2)	0.0025
$KTG2_C$	---	Temp effect Coeff above optimal (1/DegC^2)	0.002

Algae Growth Key Parameters

Diatom			
PM_D	$1/d$	Max growth rate	3.48- 4.17
$D_{opt,D}$	m	Optimal depth for growth	1
$AOCR_{p,D}$	---	Photosynthesis Oxygen-to-Carbon Ratio	2.67
KHP_D	mg/L	P Half-Saturation	0.001
KHN_D	mg/L	N Half-Saturation	0.01
KHS_D	mg/L	Silica Half-Saturation	0.05
$TM1_D$	^0C	Optimal Temp lower bound (Deg C)	15
$TM2_D$	^0C	Optimal Temp upper bound (Deg C)	18
$KTG1_D$	---	Temp effect Coeff below optimal (1/DegC^2)	0.001
$KTG2_D$	---	Temp effect Coeff above optimal (1/DegC^2)	0.006

Algae Growth Key Parameters

Green			
PM_G	$1/d$	Max growth rate	4
$D_{opt,G}$	m	Optimal depth for growth	1
$AOCR_{p,G}$	---	Photosynthesis Oxygen-to-Carbon Ratio	2.67
KHP_G	mg/L	P Half-Saturation	0.001
KHN_G	mg/L	N Half-Saturation	0.01
$TM1_G$	^0C	Optimal Temp lower bound (Deg C)	24
$TM2_G$	^0C	Optimal Temp upper bound (Deg C)	26
$KTG1_G$	---	Temp effect Coeff below optimal (1/DegC^2)	0.008
$KTG2_G$	---	Temp effect Coeff above optimal (1/DegC^2)	0.008

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Algae Metabolism Key Parameters

Parameter	Unit	Definition	Value
		Cyanobacteria	
BM_C	$1/d$	Basal metabolism rate	0.08
$AOCR_{r,C}$	---	Respiration Oxygen-to-Carbon Ratio	2.67
$FNR_{x,C}$	---	Fraction of N produced as RPON	0.075
$FNL_{x,C}$	---	Fraction of N produced as LPON	0.075
$FND_{x,C}$	---	Fraction of N produced as DON	0.65
$FNI_{x,C}$	---	Fraction of N produced as NH4	0.2
$FPR_{x,C}$	---	Fraction of P produced as RPOP	0.2
$FPL_{x,C}$	---	Fraction of P produced as LPOP	0.2
$FPD_{x,C}$	---	Fraction of P produced as DOP	0.2
$FPI_{x,C}$	---	Fraction of P produced as PO4	0.4
$FCD_{x,C}$	---	Fraction of Algal DOC excretion	1
$KHR_{x,C}$	---	Oxygen Half-Saturation Constant for DOC excretion	0.5
$TR_{BM,C}$	^0C	Reference temperature for basal metabolism	20
$KT_{BM,C}$	$1/^0C$	Effect of temperature on metabolism	0.069

Algae Metabolism Key Parameters

Parameter	Unit	Definition	Value
		Diatom	
BM_D	$1/d$	Basal metabolism rate	0.0735
$AOCR_{r,D}$	---	Respiration Oxygen-to-Carbon Ratio	2.67
$FNR_{x,D}$	---	Fraction of N produced as RPON	0.075
$FNL_{x,D}$	---	Fraction of N produced as LPON	0.075
$FND_{x,D}$	---	Fraction of N produced as DON	0.65
$FNI_{x,D}$	---	Fraction of N produced as NH4	0.2
$FPR_{x,D}$	---	Fraction of P produced as RPOP	0.2
$FPL_{x,D}$	---	Fraction of P produced as LPOP	0.2
$FPD_{x,D}$	---	Fraction of P produced as DOP	0.2
$FPI_{x,D}$	---	Fraction of P produced as PO4	0.4
$FSU_{x,D}$	---	Fraction of Silica produced as SU	0.5
$FSA_{x,D}$	---	Fraction of Silica produced as SA	0.5
$FCD_{x,D}$	---	Fraction of Algal DOC excretion	1
$KHR_{x,D}$		Oxygen Half-Saturation Constant for DOC excretion	0.5
$TR_{BM,G}$	^0C	Reference temperature for basal metabolism	20
$KT_{BM,G}$	$1/^0C$	Effect of temperature on metabolism	0.069

Algae Metabolism Key Parameters

Parameter	Unit	Definition	Value
		Green	
BM_G	$1/d$	Basal metabolism rate	0.0105
$AOCR_{r,G}$	---	Respiration Oxygen-to-Carbon Ratio	2.67
$FNR_{x,G}$	---	Fraction of N produced as RPON	0.075
$FNL_{x,G}$	---	Fraction of N produced as LPON	0.075
$FND_{x,G}$	---	Fraction of N produced as DON	0.65
$FNI_{x,G}$	---	Fraction of N produced as NH4	0.2
$FPR_{x,G}$	---	Fraction of P produced as RPOP	0.2
$FPL_{x,G}$	---	Fraction of P produced as LPOP	0.2
$FPD_{x,G}$	---	Fraction of P produced as DOP	0.2
$FPI_{x,G}$	---	Fraction of P produced as PO4	0.4
$FCD_{x,G}$	---	Fraction of Algal DOC excretion	1
$KHR_{x,C}$		Oxygen Half-Saturation Constant for DOC excretion	0.5
$TR_{BM,G}$	^0C	Reference temperature for basal metabolism	20
$KT_{BM,G}$	$1/^0C$	Effect of temperature on metabolism	0.069

The “green” group is used to represent “other” algae that are not diatoms or cyanobacteria.

Algae Predation Key Parameters

Parameter	Unit	Definition	Value
		Cyanobacteria	
PR_C	$1/d$	Max predation rate	0.08
$FCRP_C$	---	Fraction of C produced as RPOC	0.18
$FCLP_C$	---	Fraction of C produced as LPOC	0.12
$FCDP_C$	---	Fraction of C produced as DOC	0.7
$FNRP_C$	---	Fraction of N produced as RPON	0.33
$FNLP_C$	---	Fraction of N produced as LPON	0.17
$FNDP_C$	---	Fraction of N produced as DON	0.35
$FNIP_C$	---	Fraction of N produced as NH4	0.15
$FPRP_C$	---	Fraction of P produced as RPOP	0.36
$FPLP_C$	---	Fraction of P produced as LPOP	0.39
$FPDP_C$	---	Fraction of P produced as DOP	0.2
$FPIP_C$	---	Fraction of P produced as PO4	0.05

Algae Predation Key Parameters

Diatom			
PR_D	$1/d$	Max predation rate	0.288-0.3
$FCRP_D$	---	Fraction of C produced as RPOC	0.18
$FCLP_D$	---	Fraction of C produced as LPOC	0.12
$FCDP_D$	---	Fraction of C produced as DOC	0.7
$FNRP_D$	---	Fraction of N produced as RPON	0.33
$FNLP_D$	---	Fraction of N produced as LPON	0.17
$FNDP_D$	---	Fraction of N produced as DON	0.35
$FNIP_D$	---	Fraction of N produced as NH4	0.15
$FPRP_D$	---	Fraction of P produced as RPOP	0.36
$FPLP_D$	---	Fraction of P produced as LPOP	0.39
$FPDP_D$	---	Fraction of P produced as DOP	0.2
$FPIP_D$	---	Fraction of P produced as PO4	0.05
$FSUP_D$	---	Fraction of Silica produced as SU	0.5
$FSSP_D$	---	Fraction of Silica produced as SA	0.5

Algae Predation Key Parameters

Green			
PR_G	$1/d$	Max predation rate	0.258
$FCRP_G$	---	Fraction of C produced as RPOC	0.18
$FCLP_G$	---	Fraction of C produced as LPOC	0.12
$FCDP_G$	---	Fraction of C produced as DOC	0.7
$FNRP_G$	---	Fraction of N produced as RPON	0.33
$FNLP_G$	---	Fraction of N produced as LPON	0.17
$FNDP_G$	---	Fraction of N produced as DON	0.35
$FNIP_G$	---	Fraction of N produced as NH4	0.15
$FPRP_G$	---	Fraction of P produced as RPOP	0.36
$FPLP_G$	---	Fraction of P produced as LPOP	0.39
$FPDP_G$	---	Fraction of P produced as DOP	0.2
$FPIP_G$	---	Fraction of P produced as PO4	0.05

The “green” group is used to represent “other” algae that are not diatoms or cyanobacteria.

Diagenesis Rates

Parameter	Unit	Definition	Value
$k_{POC,N,P,1}$	$1/d$	Decay rate of POC, PON, and POP at 20^0C in layer 2 for 1st G class	0.035
$\theta_{POC,N,P,1}$	---	Constant for temperature adjustment for KPOC, N, and P for 1st G class	1.10
$k_{POC,N,P,2}$	$1/d$	Decay rate of POC, PON, and POP at 20^0C in layer 2 for 2nd G class	0.0018
$\theta_{POC,N,P,2}$	---	Constant for temperature adjustment for KPOC, N, and P for 2nd G class	1.15

Diagenesis Kinetics and Mixing

Parameter	Unit	Definition	Value
K_{M,D_p}	$mg\,O_2/L$	Particle mixing half-saturation constant for Oxygen	4.0
$[O_2]_{crit,PO_4}$	mg/L	Critical Dissolved Oxygen for PO_4 sorption	2.0
$\pi_{PO_4,2}$	L/kg	Partition coefficient for PO_4 in anaerobic condition	100
D_d	cm^2/d	Diffusion coefficient in porewater	24-50
D_p	cm^2/d	Particle mixing apparent diffusion coefficient	0.6
κ_{NH_4}	m/d	Optimal nitrification velocity at 20^0C	0.02
$\kappa_{NO_3,1}$	m/d	Denitrification velocity in 1^{st} layer at 20^0C	0.2
$\kappa_{NO_3,2}$	m/d	Denitrification velocity in 2^{nd} layer at 20^0C	0.5
$\Delta\pi_{PO_4,1}$	---	PO_4 sorption enhancement factor	1-60
SOD	---	Factor to enhance magnitude of sediment oxygen demand	10

Summary of EFDC Calibration

- The modeling team has worked with subject matter experts and DWR modeling staff to improve the model performance
- Simulated sediment bed nutrient fluxes are reasonably simulated compared to other studies conducted on Falls Lake
- Simulated water quality concentrations are well calibrated; further adjustments are unlikely to improve model fit
- The modeling team is seeking approval of the EFDC model calibration during today's meeting
- MRSW discussion

Lake Model Report Status

Lake Model Report Status

- Based on DWR comments on the watershed model report and since most of the lake data was not collected by UNRBA, we propose a simplified approach to establishing the bars for the lake observations compared to modeled time series to visualize uncertainty
- The two largest sources of lake data are DWR and CAAE
  - DWR data is the calibration dataset for EFDC
  - WARMF Lake uses both datasets as well as City of Durham
- The DWR quality assurance project plan (QAPP) provides “example” <u>targets</u> for relative percent difference
  - Most nutrients <=10 percent
  - TKN, TSS and TOC <=20 percent
  - Chlorophyll-a was not listed
- CAAE QAPP lists a <u>target</u> RDP of 15 percent for all parameters
- For visualization purposes we propose applying +-15% to each observation to illustrate the uncertainty associated with laboratory analyses

Closing Comments

Additional

Discussion