Bocaniov, S. A., & Scavia, D. (2018): Nutrient Loss Rates in Relation to Transport Time Scales in a Large Shallow Lake (Lake St. Clair, USA – Canada): Insights from a Three-Dimensional Model. Supporting Information, *Water Resources Research*, 54. https://doi.org/10.1029/2017WR021876.

AGU PUBLICATIONS

Water Resources Research

Supporting Information (SI) for

Nutrient Loss Rates in relation to Transport Time Scales in a Large Shallow Lake (Lake St. Clair, USA – Canada): Insights from a Three-dimensional Model.

Serghei A. Bocaniov[1,*], and Donald Scavia[2]

[1]Graham Sustainability Institute, University of Michigan, Ann Arbor, Michigan, USA; [2]School for Environment and Sustainability, University of Michigan, Ann Arbor, Michigan, USA.

Corresponding author: Serghei A. Bocaniov (sbocaniov@uwaterloo.ca , serghei.bocaniov@gmail.com)

*Current Address: Department of Earth and Environmental Sciences and Water Institute, University of Waterloo, Waterloo, Ontario, Canada.

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Table S1. Nomenclature of the often-used terms (abbreviations).

Terms	Definition	Units
A	Phytoplankton biomass concentration as C in water column	$mg\ C\ L^{-1}$
A_{SED}	Phytoplankton biomass concentration as C in sediments	$mg\ C\ L^{-1}$
Chl-a	Phytoplankton biomass concentration as Chlorophyll-a	$mg\ Chl\text{-}a\ m^{-3}$
AIN	Phytoplankton internal nitrogen concentration	$mg\ N\ L^{-1}$
AIP	Phytoplankton internal phosphorus concentration	$mg\ P\ L^{-1}$
a	Phytoplankton group index: a = 1 to 5	-
N_A	Number of phytoplankton groups being simulated: $N_A = 5$	-
DO	Dissolved oxygen concentration	$mg\ O_2\ L^{-1}$
DIC	Dissolved inorganic carbon concentration	$mg\ C\ L^{-1}$
DOC	Dissolved organic carbon concentration	$mg\ C\ L^{-1}$
POC	Detrital particulate organic carbon concentration	$mg\ C\ L^{-1}$
TOC	Total organic carbon concentration	$mg\ C\ L^{-1}$
CO_2	Carbon dioxide concentration	$mg\ C\ L^{-1}$
pCO_2	Partial pressure of carbon dioxide	*atm*
pH	Measure of hydrogen ion concentration, $[H^+]$	-
TN	Total nitrogen concentration	$mg\ N\ L^{-1}$
DON	Dissolved organic nitrogen concentration	$mg\ N\ L^{-1}$
PON	Detrital organic nitrogen concentration	$mg\ N\ L^{-1}$
PIN	Particulate inorganic nitrogen concentration	$mg\ N\ L^{-1}$
NH_4	Ammonium concentration	$mg\ N\ L^{-1}$
NO_3	Nitrate (NO_3) + Nitrite (NO_2) concentration	$mg\ N\ L^{-1}$
TKN	Total Kjeldahl nitrogen concentration	$mg\ N\ L^{-1}$
TP	Total phosphorus concentration	$mg\ P\ L^{-1}$
DOP	Dissolved organic phosphorus concentration	$mg\ P\ L^{-1}$
POP	Detrital particulate organic phosphorus concentration	$mg\ P\ L^{-1}$
DRP	Dissolved reactive phosphorus concentration	$mg\ P\ L^{-1}$
PIP	Particulate inorganic phosphorus concentration	$mg\ P\ L^{-1}$
s	Suspended solid group index: s = 1 to 2	-
N_S	Number of suspended solids groups being simulated: $N_S = 2$	-
SS	Suspended sediment concentration	$mg\ L^{-1}$
TSS	Total suspended sediment concentration ($TSS = SS_1 + SS_2$)	$mg\ L^{-1}$
RSi	Dissolved reactive silica (SiO_2) concentration	$mg\ Si\ L^{-1}$
ISi	Phytoplankton (diatom) internal silica concentration	$mg\ Si\ L^{-1}$
K_{TP}, K_{DRP}	Lake-scale loss rates for *TP* and *DRP* (defined in section 2.6)	day^{-1}
FT	Flushing time (defined in section 2.6)	*day*
WRT	Water residence time (defined in section 2.7)	*day*
$\overline{WA}_a$	Lake-averaged area-weighted water age (defined in section 2.7)	*day*
$\overline{WA}_v$	Lake-averaged volume-weighted water age (defined in section 2.7)	*day*
wa_i	Water age for water cell i	*day*
T	Water temperature	*°C*

Table S2. Mass balance equations for major state variables in CAEDYM[§,$]. All state variables also include sources via tributary and atmospheric loads and losses via outflows, and are subject to advection and mixing through the hydrodynamic model.

1. Light, *μmol photons m^{-2} s^{-1}* (intensity, *I*):

$$I(\eta, z) = f_{PAR} I_0 \exp(-\eta z) \quad \text{(s2.1.1)}$$

$$\eta(A_a, SS_s, DOC, POC) = \eta_w + \sum_a^{N_a} K_e^{A_a} A_a + \sum_s^{N_s} K_e^{SS_s} SS_s + \eta_{DOC} DOC + \eta_{POC} POC \quad \text{(s2.1.2)}$$

2. Inorganic Particles (s = 1 to 2 and denotes two size classes, SS1 and SS2, 1.8 and 3 μm diameter respectively, g m^{-3})

$$\frac{\partial SS_s}{\partial t} = \underbrace{f_{SS_s}^{RES}(\tau, SS_s)}_{\text{resuspension}} - \underbrace{f_{SS_s}^{SET}(SS_s)}_{\text{settling}} \quad \text{(s2.2.1)}$$

3. Oxygen, *mg O L^{-1}* (dissolved, *DO*):

$$\frac{\partial DO}{\partial t} = \underbrace{f_{O_2}^{ATM}(DO)}_{\text{atmospheric flux}} - \underbrace{\left[f_{CO_2}^{BUP}(A_a, DIC) - f_{CO_2}^{BRE}(A_a)\right] Y_{O_2:C}}_{\text{algal photosynthesis \& respiration}} - \underbrace{\mu_{NIT} f_{NIT}^{T2}(T) f_{NIT}^{DO1}(DO) NH_4 Y_{O_2:N}}_{\text{nitrification}} - \underbrace{k_{SOD} f_{SOD}^{T2}(T) f_{SOD}^{DO1}(DO) \frac{1}{\Delta z_{bot}}}_{\text{sediment oxygen demand}} \quad \text{(s2.3.1)}$$

4. Phytoplankton, *mg C L^{-1}* (biomass for group a, A_a, where a = 1 to 5 and denotes five phytoplankton groups):

$$\frac{\partial A_a}{\partial t} = \underbrace{\mu_a(A_a)}_{\text{photosynthesis}} - \underbrace{R_a(A_a)}_{\text{respiration}} - \underbrace{E_a(A_a) - M_a(M_a)}_{\text{excretion \& mortality}} - \underbrace{f_{A_a}^{SET}(A_a)}_{\text{settling}} + \underbrace{f_{A_a}^{RES}(\tau, A_a)}_{\text{resuspension}} \quad \text{(s2.4.1)}$$

5. Carbon, *mg C L^{-1}* (dissolved inorganic, *DIC*; dissolved organic, *DOC*; detrital particulate organic, *POC*; algal internal, A_a)

$$\frac{\partial DIC}{\partial t} = \underbrace{f_{DOC}^{MIN}(T, DO, DOC)}_{\text{DOC mineralization}} - \underbrace{f_{DIC}^{BUP}(A, DIC)}_{\text{biological uptake}} + \underbrace{f_{DIC}^{DSF}(T, DO)}_{\text{sediment flux}} + \underbrace{f_{DIC}^{BRE}(A)}_{\text{biological respiration}} + \underbrace{f_{DIC}^{ATM}(pCO_2)}_{\text{atmospheric flux}} \quad \text{(s2.5.1)}$$

$$\frac{\partial DOC}{\partial t} = \underbrace{f_{POC}^{DEC}(T, DO, POC)}_{\text{POC decomposition}} + \underbrace{f_{DOC}^{BME}(A)}_{\text{mortality / excretion}} + \underbrace{f_{DOC}^{DSF}(T, DO)}_{\text{sediment flux}} - \underbrace{f_{DOC}^{MIN}(T, DO, DOC)}_{\text{DOC mineralization}} \quad \text{(s2.5.2)}$$

$$\frac{\partial POC}{\partial t} = -\underbrace{f_{DOC}^{DEC}(T, DO, POC)}_{\text{POC decomposition}} - \underbrace{f_{POC}^{SET}(POC)}_{\text{settling}} + \underbrace{f_{POC}^{RES}(POC_{sed})}_{\text{resuspension}} + \underbrace{f_{POC}^{BME}(A)}_{\text{mortality \& excretion}} \quad \text{(s2.5.3)}$$

$$\frac{\partial A_a}{\partial t} = \underbrace{U_{DIC}(A_a)}_{\text{uptake}} - \underbrace{E_{DOC}(A_a) - E_{POC}(A_a)}_{\text{mortality \& excretion}} - \underbrace{R_{DIC}(A_a)}_{\text{respiration}} - \underbrace{f_{A_a}^{SET}(A_a)}_{\text{settling}} + \underbrace{f_{A_a}^{RES}(A_{sed})}_{\text{resuspension}} \quad \text{(s2.5.4)}$$

$$TOC = DOC + POC + \sum_a^{N_A} A_a \quad \text{(s2.5.5)}$$

$$TC = TOC + DIC \quad \text{(s2.5.6)}$$

Table S2. (*Continued*).

6. Nitrogen, $mg\ N\ L^{-1}$ (ammonium, NH_4; nitrate + nitrite, NO_3; dissolved organic, DON; detrital particulate organic, PON; particulate inorganic, PIN; algal internal, AIN_a, where a = 1 to 5 and denotes algal groups):

$$\frac{\partial NH_4}{\partial t} = \underbrace{f_{NH_4}^{MIN}(T, DO, DON)}_{\text{mineralization}} + \underbrace{f_{NH_4}^{DSF}(T, DO)}_{\text{sediment flux}} + \underbrace{f_{NH_4}^{BUP}(AIN, NH_4)}_{\text{biological uptake}} + \underbrace{\mu_{NIT} f_{NIT}^{T2}(T) f_{NIT}^{DO1}(DO) NH_4}_{\text{nitrification}} + \underbrace{f_{NH_4,\ PIN}^{ADD}(SS_1, SS_2, NH_4, PIN)}_{\text{adsorption / desorption}} \quad \text{(s2.6.1)}$$

$$\frac{\partial NO_3}{\partial t} = \underbrace{f_{NO_3}^{BUP}(A, NO_3)}_{\text{biological uptake}} + \underbrace{f_{NO_3}^{DSF}(T, DO)}_{\text{sediment flux}} + \underbrace{f_{NIT} f_{NIT}^{T2}(T) f_{NIT}^{DO1}(DO) NH_4}_{\text{nitrification}} + \underbrace{f_{DEN} f_{DEN}^{T2}(T) f_{DEN}^{DO2}(DO) NO_3}_{\text{denitrification}} \quad \text{(s2.6.2)}$$

$$\frac{\partial DON}{\partial t} = \underbrace{f_{PON}^{DEC}(T, DO, PON)}_{\text{decomposition}} + \underbrace{f_{DON}^{DSF}(T, DO)}_{\text{sediment flux}} + \underbrace{f_{DON}^{MIN}(T, DO, DON)}_{\text{mineralization}} + \underbrace{f_{DON}^{BME}(A)}_{\text{biolog mortal \& excretion}} \quad \text{(s2.6.3)}$$

$$\frac{\partial PON}{\partial t} = -\underbrace{f_{PON}^{DEC}(T, DO, PON)}_{\text{decomposition}} + \underbrace{f_{PON}^{BUP}(A)}_{\text{biolog mortal \& excretion}} - \underbrace{f_{PON}^{SET}(PON)}_{\text{settling}} + \underbrace{f_{PON}^{RES}(PON_{sed})}_{\text{resuspension}} \quad \text{(s2.6.4)}$$

$$\frac{\partial PIN}{\partial t} = -\underbrace{f_{NH_4,PIN}^{ADD}(SS_1, SS_2, NH_4, PIN)}_{\text{adsorption / desorption}} - \underbrace{f_{PIN}^{SET}(PIN)}_{\text{settling}} + \underbrace{f_{PIN}^{RES}(PIN_{sed})}_{\text{resuspension}} \quad \text{(s2.6.5)}$$

$$\frac{\partial AIN_a}{\partial t} = \underbrace{U_{NH_4}(A_a) + U_{NO_3}(A_a)}_{\text{uptake}} - \underbrace{E_{DON}(A_a) - E_{PON}(A_a)}_{\text{mortality \& excretion}} - \underbrace{f_{A_a}^{SET}(AIN_a)}_{\text{settling}} + \underbrace{f_{A_a}^{RES}(AIN_{sed})}_{\text{resuspension}} + \underbrace{f_{A_a}^{FIX}(A_a, NO_3, NH_4)}_{N_2\ \text{fixation}} \quad \text{(s2.6.6)}$$

$$TN = NH_4 + NO_3 + DON + PON + PIN + \sum_{a}^{N_A} A_a \quad \text{(s2.6.7)}$$

7. Silicon, $mg\ Si\ L^{-1}$ (algal, ISi; soluble reactive, RSi):

$$\frac{\partial RSi}{\partial t} = -\underbrace{f_{RSi}^{BUP}(A, RSi)}_{\text{diatom uptake}} + \underbrace{f_{RSi}^{DSF}(T, DO)}_{\text{sediment flux}} \quad \text{(s2.7.1)}$$

$$\frac{\partial ISi}{\partial t} = -\underbrace{f_{RSi}^{BUP}(A, RSi)}_{\text{diatom uptake}} - \underbrace{f_{RSi}^{BME}(A)}_{\text{diatom mortality \& excretion}} - \underbrace{f_{ISi}^{SET}(ISi)}_{\text{settling}} + \underbrace{f_{ISi}^{RES}(ISi_{sed})}_{\text{resuspension}} \quad \text{(s2.7.2)}$$

Table S2. (*Continued*).

8. Phosphorus, $mg\ P\ L^{-1}$ (soluble reactive, *DRP*; dissolved organic, *DOP*; detrital particulate organic, *POP*; particulate inorganic, *PIP*; algal internal, AIP_a, where a = 1 to 5 and denotes five simulated algal groups):

$$\frac{\partial DRP}{\partial t} = \underbrace{f_{DOP}^{MIN}(T, DO, DOP)}_{\text{mineralization}} - \underbrace{f_{DRP}^{BUP}(T, DO, DOP)}_{\text{biological uptake}} + \underbrace{f_{DRP}^{DSF}(T, DO)}_{\text{sediment flux}} \quad \text{(s2.8.1)}$$

$$\frac{\partial DOP}{\partial t} = \underbrace{f_{POP}^{DEC}(T, DO, POP)}_{\text{decomposition}} - \underbrace{f_{DOP}^{MIN}(T, DO, DOP)}_{\text{mineralization}} + \underbrace{f_{DOP}^{DSF}(T, DO)}_{\text{sediment flux}} + \underbrace{f_{DOP}^{BME}(A)}_{biological\ mort\ \&\ excr} \quad \text{(s2.8.2)}$$

$$\frac{\partial POP}{\partial t} = \underbrace{f_{POP}^{DEC}(T, DO, POP)}_{\text{decomposition}} - \underbrace{f_{POP}^{SET}(POP)}_{\text{settling}} + \underbrace{f_{POP}^{RES}(POP_{sed})}_{\text{resuspension}} + \underbrace{f_{DOP}^{BME}(A)}_{biological\ mort\ \&\ excr} \quad \text{(s2.8.3)}$$

$$\frac{\partial PIP}{\partial t} = \underbrace{f_{PIP,\ DRP}^{ADD}(SS_1, SS_2, DRP, PIP)}_{\text{adsorption / desorption}} - \underbrace{f_{PIP}^{SET}(PIP)}_{\text{settling}} + \underbrace{f_{PIP}^{RES}(PIP_{sed})}_{\text{resuspension}} \quad \text{(s2.8.4)}$$

$$\frac{\partial AIP_a}{\partial t} = \underbrace{U_{PO_4}(A_a)}_{\text{uptake}} - \underbrace{E_{DOP}(A_a) - E_{POP}(A_a)}_{\text{mortality \& excretion}} - \underbrace{f_{A_a}^{SET}(AIP_a)}_{\text{settling}} + \underbrace{f_{A_a}^{RES}(AIP_{sed})}_{\text{resuspension}} \quad \text{(s2.8.5)}$$

$$TP = DRP + DOP + POP + PIP + \sum_{a}^{N_A} AIP_a \quad \text{(s2.8.6)}$$

[§]For more details see Hipsey and Hamilton (2008), Hipsey (2008), Leon et al (2011), and Bocaniov et al (2016).
[$]In this Table S2, the removal of a given constituent from the water column due to settling is shown with a positive sign (+) to indicate that is the loss from the system. However, in CAEDYM, phytoplankton settling velocities are negative so the change in the concentration is indicated with a negative sign (-).

Table S3. Algal process descriptions in CAEDYM[§]. See Table S4 for parameter notation and values.

Algal growth rate: $\mu_a = \mu_{MAX_a} \cdot f_{A_a}^{T1} \cdot \min[f(I)_a, f(N)_a, f(P)_a, f(Si)_a]$	(S3.1)
N and P limitation functions, $f(N)_a$, $f(P)_a$: $f(X)_a = \frac{AIX_a}{AIX_{MAX_a} - AIX_{MIN_a}}\left[1 - \frac{AIX_{MIN_a}}{AIX_a}\right]$	(S3.2)
Silica limitation functions: $f(Si)_a = \frac{RSi - RSi_o}{(RSi - RSi_o) + K_{Si_a}}$	(S3.3)
Light limitation function: $f(I)_a = 1 - \exp\left(\frac{-I}{I_k}\right)$	(S3.4)
Phosphorus uptake: $U_{DRP}(A_a) = UP_{MAX_a} \cdot f_{A_a}^{T1}(T) \cdot \left[\frac{AIP_{MAX_a} - AIP_a}{AIP_{MAX_a} - AIP_{MIN_a}} \frac{DRP}{DRP + K_{P_a}}\right] \cdot A_a$	(S3.5)
NH_4 uptake: $U_{NH_4}(A_a) = UN_{MAX_a} \cdot f_{A_a}^{T1}(T) \cdot \left[\frac{AIN_{MAX_a} - AIN_a}{AIN_{MAX_a} - AIN_{MIN_a}} \frac{NH_4 + NO_3}{NH_4 + NO_3 + K_{N_a}}\right] \cdot A_a$	(S3.6)
NO_3 uptake: $U_{NO_3}(A_a) = (1 - P_{N_a}) \cdot UN_{MAX_a} \cdot f_{A_a}^{T1}(T) \cdot \left[\frac{AIN_{MAX_a} - AIN_a}{AIN_{MAX_a} - AIN_{MIN_a}} \frac{NH_4 + NO_3}{NH_4 + NO_3 + K_{N_a}}\right] \cdot A_a$	(S3.7)
Ammonium Preference: $P_{N_a} = \left[\frac{NH_4 \cdot NO_3}{(NH_4 + K_{N_a})(NO_3 + K_{N_a})}\right] \cdot \left[\frac{NH_4 \cdot K_{N_a}}{(NH_4 + NO_3)(NO_3 + K_{N_a})}\right]$	(S3.8)
Algal losses (respiration, excretion, mortality): $R_a = k_{R_a} \cdot \vartheta_{R_a}^{(T-20)}$	(S3.9)
Temperature dependence: $f_a^{T1}(T) = \vartheta_{A_a}^{T-20} + \vartheta_{A_a}^{C1(T-C2)} + C3$, where C1, C2 and C3 are constants (see Leon et al., 2011)	(S3.10)
Settling: $f_{A_a}^{SET} = \frac{V_{s_{Aa}}}{\Delta z}$	(S3.11)
Resuspension: $f_{A_a}^{RES} = \alpha_{A_a}\left[\frac{\tau - \tau_{c_{Aa}}}{\tau_{ref}}\right]\left[\frac{A_{a_{SED}}}{K_{T_{Aa}} + A_{a_{SED}}}\right]$	(S3.12)

[§]As Appendix B in Leon et al (2011) and Table S2 in Bocaniov et al (2016). For more details, see Hipsey and Hamilton (2008) and Leon et al (2011).

Table S4. Parameter values for phytoplankton processes in CAEDYM§: parameter definitions and values for phytoplankton characteristics and processes. For more details, see Leon et al. (2011).

Parameter	CYANO	OTHER	FLAG.	Early DIAT	Late DIAT	References	Description
$Y_{C:Chla}$	50	40	180	50	50	1, 2, 3, 4	*Ratio of C to Chl-a (mg C (mg Chl-a)$^{-1}$)*
μ_{max}	0.8	0.8	1.0	1.7	1.9	5, 6, 7, 8, 9, 10	*Maximum growth rates of algae (d^{-1})*
ϑ	1.09	1.06	1.06	1.048	1.075	Optimized	*Temperature multiplier for growth (-)*
R	0.17	0.11	0.20	0.13	0.15	11, 10, 12	*Algal respiration, mortality, and excretion (d^{-1})*
ϑ_{Ri}	1.06	1.08	1.08	1.09	1.035	Optimized	*Temperature multiplier for respiration (-)*
f_{dom}	0.7	0.2	0.4	0.4	0.4	23	*Fraction of mortality & excretion that is DOM (remainder is POM)*
f_{resp}	0.5	0.2	0.2	0.3	0.3	23	*Fraction of algal losses that is respiration (remainder is mortality and excretion)*
UP_{MAX}	1.0	2.0	0.7	0.4	1.0	8, 13	*Maximum phosphorus uptake rate (mg P (mg Chl-a)$^{-1}$ d^{-1})*
K_P	0.009	0.003	0.003	0.009	0.006	2, 13, 14, 19	*Half saturation constant for phosphorus uptake (mg P L^{-1})*
AIP_{MAX}	1.0	2.0	1.0	1.8	1.3	8, 13, 14, 15	*Maximum internal phosphorus concentration (mg P (mg Chl-a)$^{-1}$)*
AIP_{MIN}	0.1	0.3	0.1	0.18	0.13	8, 14, 9, 15	*Minimum internal phosphorus concentration (mg P (mg Chl-a)$^{-1}$)*
UN_{MAX}	1.5	1.5	1.5	1.5	1.5	1, 8	*Maximum nitrogen uptake rate (mg N (mg Chl-a)$^{-1}$ d^{-1})*
K_N	0.045	0.06	0.045	0.045	0.045	3, 8, 11, 19	*Half saturation constant for nitrogen uptake (mg N L^{-1})*
AIN_{MAX}	4.0	9.0	4.0	4.0	4.0	1, 8	*Maximum internal nitrogen concentration (mg N (mg Chl-a)$^{-1}$)*
AIN_{MIN}	2.0	3.0	2.0	2.0	2.0	1, 8	*Minimum internal nitrogen concentration (mg N (mg Chl-a)$^{-1}$)*
I_k	130	100	40	60	60	23	*Onset of light saturation of photosynthesis (μE m^{-2} s^{-1})*
η_A	0.02	0.014	0.014	0.02	0.02	16	*Algal effect on the extinction coefficient ((g Chl-a m^{-3})$^{-1}$ m^{-1})*
K_{Si}	N/A	N/A	N/A	0.150	0.055	8, 14, 17, 18	*Si ½ saturation constant for algal uptake of dissolved reactive silica (mg Si L^{-1})*
RSi_O	N/A	N/A	N/A	0.100	0.020	22	*Low concentration of Si at which uptake ceases (mg Si L^{-1})*
T_{STD_A}	24.0	24.0	19.0	7.0	19.0	23	*Standard temperature for algal growth (°C) where f^{T1} = 1.0*

Table S4. (*Continued*).

T_{OPT_A}	30.0	29.0	21.0	9.8	23.0	23	*Optimum temperature for algal growth (°C) where f^{T1} = maximum*
T_{MAX_A}	39.0	35.0	27.5	18.5	31.0	23	*Maximum temperature for algal growth (°C) where f^{T1} = 0*
v_s	0.07	0.02	0.02	0.09	0.09	8, 19, 20, 21	*Settling velocity at 20 °C (m day^{-1})*

§As Appendix C in Leon et al. (2011) or Table S3 in Bocaniov et al. (2016).

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Table S5. Lake St. Clair water surface levels, major morphometric characteristics, and water storage capacity for 2009 and 2010.

Dimension	2009	2010
Mean water surface elevation (m) ±SD	175.077 ±0.138	174.854 ±0.197
5-day min water surface elevation[a] (m)	174.781	174.242
5-day max water surface elevation[a] (m)	175.311	175.124
Area (km^2)	1115	1115
Mean volume (km^3)	4.375	4.126
Mean depth (m)	3.9	3.7
Water Storage Capacity [b] (days)	9.2	9.1

Note: [a] Calculated as an average of any observed five days minimum and maximum water levels during the entire year. [b]Calculated as the ratio of annually averaged daily lake volume to annually averaged daily flow of the Detroit River (lake outflow); water storage capacity is similar to flushing time (*FT*) defined in section 2.6 in the text.

Table S6. Stream gauging stations and drainage areas for tributaries and the outlet of Lake St Clair.

#	River name	Agency	Station ID	Latitude; Longitude	Notes	Drainage Area (km^2)	
						Site	Entire
Tributaries:							
1	St. Clair River, including:						3387.0
1.1	St. Clair River [USA/Canada]	USGS	04159130	42.987; 82.425	N1	576013	0.0
1.2	Black River [USA]:						1843.0
1.2.1.	Black River [USA]	USGS	04159492	43.151; 82.625	N2	1202	1427.0
1.2.2.	Mill Creek [USA]	USGS	04159900	42.880; 82.568	N3	350	416.0
1.3	Belle River [USA]	USGS	04160600	42.901; 82.769	N4	378	589.0
1.4	Pine River [USA]				N5		487.0
1.5	St. Clair River (*other catchment*) [USA/Canada]				N6		468.0
2	Thames River [Canada]	WSC	02GE003	42.545; 81.967	N7	4370	5827.0
3	Sydenham River, including:						3169.0
3.1	Sydenham River [Canada]	WSC	02GG003	42.651; 82.008	N8	1149	
3.2	Bear Creek [Canada}	WSC	02GG009	42.812; 82.298	N9	536	
3.3	Black Creek [Canada]	WSC	02GG013	42.762; 82.259	N10	213	
4	Clinton River [USA]	USGS	04165500	42.596; 82.909	N11	1813	1919.0
5	Ruscom River [Canada]	WSC	02GH002	42.211; 82.629	N12	95	178.0
6	Belle River [Canada]				N13		117.0
7	Pike Creek [Canada]				N13		100.0
8	Salt River [USA]				N5		95.0
9	Puce River [Canada]				N13		77.0
10	Little River [Canada]	WSC	02GH011	42.310; 82.928	N13	55	72.0
11	Swan Creek [USA]				N5		70.0
12	Beaubien Creek [USA]				N5		69.0
13	Little Creek [Canada]				N13		54.6
14	Moison Creek [Canada]				N13		25.4
15	Marsac Creek [USA]				N5		21.8
16	Duck Creek [Canada]				N13		21.8
17	Crapaud Creek [USA]				N5		20.3
Lake Outflow:							
18	Detroit River [USA/Canada]	USGS	04165710	42.298; 83.093	N14		

Note: N1: St Clair River at Port Huron (St Clair River at the source); N2: Black River near Jeddo; N3: Mill Creek near Avoca; N4: Belle River at Memphis; N5: Unmonitored catchment area: daily flows for this river were calculated as the river's catchment area multiplied by the daily areal mean runoff from the nearest USGS gauging station at the Belle River (station ID: 04160600); N6: Unmonitored catchment area: daily flows for this river were calculated as the catchment area multiplied by the daily areal mean runoff from the upstream part of the catchment; N7: Thames River at Thamesville; N8: Sydenham River at Florence; N9: Bear Creek below Brigden; N10: Black Creek near Bradshaw; N11: Clinton River at the Moravian Drive at Mt. Clemens; N12: Ruscom River near Ruscom station; N13: Unmonitored rivers: daily flows for these rivers are calculated as the rivers' catchment areas multiplied by the daily areal mean runoff from the nearest gauging station at the Ruscom River (station ID: 02GH002); N14: Detroit River at Fort Wayne at Detroit.

Table S7. Water quality parameters for two stations, 209 and 210, with contrasting trophic statuses in northern (station 210) and southern (station 209) parts of the lake.

Parameter	Southern part (station 209)				Northern part (station 210)			
	Total	Spring[a]	Summer[b]	Fall[c]	Total	Spring[a]	Summer[b]	Fall[c]
	N = 58	N = 20	N = 18	N = 20	N = 57	N = 20	N = 19	N = 20
TP,	0.0250	0.0294	0.0161	0.0285	0.0073	0.0048	0.0057	0.0119
mg L^{-1}	±0.0132	±0.0138	±0.0076	±0.0131	±0.0059	±0.0019	±0.0037	±0.0079
	(0.0220)	(0.0235)	(0.0110)	(0.0225)	(0.0050)	(0.0045)	(0.0050)	(0.0110)
DRP,	0.0045	0.0060	0.0019	0.0052	0.0014	0.0010	0.0012	0.0014
mg L^{-1}	±0.0048	±0.0071	±0.0018	±0.0029	±0.0009	±0.0005	±0.0008	±0.0009
	(0.0030)	(0.0030)	(0.0015)	(0.0053)	(0.0011)	(0.0008)	(0.0001)	(0.0011)
NO_3+NO_2,	1.1027	2.7068	0.1065	0.3953	0.3177	0.3547	0.2892	0.3067
mg L^{-1}	±1.3011	±0.9373	±0.1079	±0.1193	±0.0400	±0.0171	±0.0234	±0.0421
	(0.4025)	(2.5450)	(0.0565)	0.3950)	(0.3060)	(0.3605)	(0.2940)	(0.2995)
NH_3,	0.0237	0.0203	0.0217	0.0291	0.0163	0.0154	0.0201	0.0134
mg L^{-1}	±0.0182	±0.0207	±0.0173	±0.0159	±0.0134	±0.0104	±0.0181	±0.0099
	(0.0220)	(0.0150)	(0.0215)	(0.0265)	(0.0110)	(0.0210)	(0.0110)	(0.0105)
TKN,	0.3724	0.5010	0.2822	0.3250	0.1710	0.1870	0.1447	0.1806
mg L^{-1}	±0.1438	±0.1201	±0.1324	±0.0667	±0.0670	±0.1043	±0.0227	±0.0267
	(0.3600)	(0.4850)	(0.2100)	(0.3150)	(0.1600)	(0.1600)	(0.1400)	(0.1900)
TN,	1.225	3.167	0.2425	0.750	0.565	0.565	0.420	0.368
mg L^{-1}	±1.276	±0.311	±0.013	±0.047	±0.091	±0.044	±0.008	±0.019
	(0.730)	(3.200)	(0.240)	(0.745)	(0.420)	(0.580)	(0.420)	(0.375)
	N = 11	N = 3	N = 4	N = 4	N = 12	N = 4	N = 4	N = 4
RSi (SiO_2)	0.643	0.635	0.653	0.693	0.715	0.704	0.538	0.914
mg L^{-1}	±0.264	±0.209	±0.323	±0.174	±0.498	±0.169	±0.194	±0.816
	(0.620)	(0.630)	(0.680)	(0.610)	(0.680)	(0.780)	(0.600)	(0.750)
Chl-a,	4.93	7.1	5.17	2.55	1.24	1.0	1.12	1.65
µg L^{-1}	±3.74	±15.2	±8.64	±9.55	±0.58	±0.01	±0.33	±0.86
	(3.00)	(7.5)	(3.0)	(3.0)	(1.0)	(1.0)	(1.0)	(1.0)
TSS,	13.31	12.54	6.78	19.98	5.01	2.52	3.94	8.92
mg L^{-1}	±8.14	±5.70	±5.41	±7.23	±4.12	±0.46	±0.93	±5.48
	(13.75)	(13.15)	(4.45)	(16.90)	(3.40)	(2.50)	(3.70)	(6.25)

Note: The results are based on the observations in five different years (2001, 2004, 2007, 2010 and 2014). The numbers indicate mean values ±SD, with values in brackets indicating the median values. For the definition of water quality parameters see Table S1, and for the locations of the sampling stations see Figure S3d and Table S10. [a]Spring: from mid-April to late May. [b] Summer: from early August to early September. [c]Fall: from mid-October to early November.

Table S7. (*Continued*).

Parameter	Southern part (station 209)				Northern part (station 210)			
	Total	Spring[a]	Summer[b]	Fall[c]	Total	Spring[a]	Summer[b]	Fall[c]
	N = 58	*N* = 20	*N* = 18	*N* = 20	*N* =57	*N* = 20	*N* = 19	*N* = 18
DIC	23.39	29.8	17.73	22.06	18.33	18.40	18.65	17.80
mg L^{-1}	±5.71	±3.64	±2.05	±2.23	±0.38	±0.14	±0.13	±0.20
	(22.5)	(29.8)	(17.85)	(22.35)	(18.5)	(18.45)	18.65	(17.8)
DOC	2.54	3.13	2.36	2.14	1.54	1.49	1.55	1.59
mg L^{-1}	±0.64	±0.55	±0.56	±0.28	±0.30	±0.49	±0.13	±0.09
	(2.40)	(3.15)	(2.15)	2.05	(1.60)	(1.25)	(1.60)	(1.60)
Chloride,	15.65	22.4	11.54	12.61	7.14	7.07	7.35	7.0
mg L^{-1}	±7.36	±5.98	±4.62	±5.84	±0.42	±0.44	±0.50	±0.19
	(12.05)	(24.45)	(9.10)	(11.1)	(7.1)	(7.1)	(7.4)	(7.0)
Secchi depth,	1.1	0.9	1.76	0.56	2.28	3.08	2.3	1.46
m	±0.74	±0.48	±0.84	±0.09	±0.88	±0.68	±0.38	±0.66
	(0.7)	(0.6)	(1.8)	(0.5)	(2.2)	(3.0)	(2.3)	(1.8)
	N = 15	*N* = 5	*N* = 5	*N* = 5	*N* = 15	*N* = 5	*N* = 5	*N* = 5

Note: The results are based on the observations in five different years (2001, 2004, 2007, 2010 and 2014). The numbers indicate mean values ±SD, with values in brackets indicating the median values. For the definition of water quality parameters see Table S1, and for the locations of the sampling stations see Figure S3d and Table S10. [a]Spring: from mid-April to late May. [b]Summer: from early August to early September. [c]Fall: from mid-October to early November.

Table S8. Tributary and atmospheric inputs of water (mean flows for tributaries and direct over-lake precipitation), total phosphorus (TP), and dissolved reactive phosphorus (DRP), to Lake St Clair for March 15 to November 10, 2009.

#	Tributary Name or atmospheric input [country]	Total TP load (MT)	Total DRP load (MT)	Daily flow ($m^3 s^{-1}$)	As % of Total TP (%)	As % of Total DRP (%)	As % of Total inflow* (%)
1	St. Clair River [USA/Canada]	1030.89	389.82	5379.425	73.76	70.55	97.883
2	Thames River [Canada]	135.10	45.61	58.742	9.67	8.25	1.069
3	Sydenham River [Canada]	41.40	14.32	19.802	2.96	2.59	0.360
4	Clinton River [USA]	136.23	76.63	31.324	9.75	13.87	0.570
5	Ruscom River [Canada]	2.97	1.66	0.684	0.21	0.30	0.012
6	Belle River [Canada]	1.95	1.09	0.449	0.14	0.20	0.008
7	Pike Creek [Canada]	1.67	0.94	0.384	0.12	0.17	0.007
8	Salt River [USA]	5.26	4.32	1.325	0.38	0.78	0.024
9	Puce River [Canada]	1.29	0.72	0.296	0.09	0.13	0.005
10	Little River [Canada]	2.36	1.32	0.542	0.17	0.24	0.010
11	Swan Creek [USA]	1.25	0.97	0.976	0.09	0.18	0.018
12	Beaubien Creek [USA]	2.39	2.08	0.762	0.17	0.38	0.014
13	Little Creek [Canada]	1.15	0.65	0.265	0.08	0.12	0.005
14	Moison Creek [Canada]	0.42	0.24	0.098	0.03	0.04	0.002
15	Marsac Creek [USA]	0.80	0.65	0.304	0.06	0.12	0.005
16	Duck Creek [Canada]	0.36	0.20	0.084	0.03	0.04	0.002
17	Crapaud Creek [USA]	0.74	0.61	0.283	0.05	0.11	0.005
	Atmospheric input [USA-Canada]	31.40	10.73	35.253	2.25	1.94	-
	TOTAL	1397.63	552.56	5495.626	100	100	100

Note: *As % of total inflow from all tributaries (precipitation is not included).

Table S9. Tributary and over-lake atmospheric inputs of water (mean flows for tributaries and direct over-lake precipitation), total phosphorus (TP), and dissolved reactive phosphorus (DRP), to Lake St Clair for March 15 to November 10, 2010.

#	Tributary Name [country] and atmospheric input [country]	Total TP load (MT)	Total DRP Load (MT)	Average inflow ($m^3 s^{-1}$)	As % of Total TP (%)	As % of Total DRP (%)	As % of Total inflow* (%)
1	St. Clair River [USA/Canada]	1020.29	389.42	5169.587	82.75	81.41	98.324
2	Thames River [Canada]	74.60	25.75	48.217	6.05	5.38	0.917
3	Sydenham River [Canada]	35.11	12.60	18.680	2.85	2.63	0.355
4	Clinton River [USA]	60.60	30.63	15.925	4.91	6.40	0.303
5	Ruscom River [Canada]	4.60	2.58	1.058	0.37	0.54	0.020
6	Belle River [Canada]	3.02	1.69	0.695	0.24	0.35	0.013
7	Pike Creek [Canada]	2.58	1.45	0.594	0.21	0.30	0.011
8	Salt River [USA]	2.12	1.74	0.533	0.17	0.36	0.010
9	Puce River [Canada]	1.99	1.11	0.458	0.16	0.23	0.009
10	Little River [Canada]	2.47	1.39	0.569	0.20	0.29	0.011
11	Swan Creek [USA]	0.50	0.39	0.393	0.04	0.08	0.007
12	Beaubien Creek [USA]	0.96	0.84	0.306	0.08	0.18	0.006
13	Little Creek [Canada]	0.87	0.49	0.199	0.07	0.10	0.004
14	Moison Creek [Canada]	0.30	0.25	0.151	0.02	0.05	0.003
15	Marsac Creek [USA]	0.32	0.26	0.122	0.03	0.05	0.002
16	Duck Creek [Canada]	0.56	0.32	0.130	0.05	0.07	0.002
17	Crapaud Creek [USA]	0.30	0.25	0.114	0.02	0.05	0.002
	Atmospheric input [USA-Canada]	21.86	7.19	34.390	1.77	1.50	-
	TOTAL	1233.05	478.35	5257.735	100	100	100

Note: *As % of total inflow from all tributaries (precipitation is not included).

Table S10. Monitoring and sampling stations used for validation and comparison purposes.

#	Station Name - additional name	Project/Agency	Latitude (N)	Longitude (W)	Data Source
1	O1 - New Baltimore WTP Intake	MCHD - LSCA	42.6726	-82.7295	A1
2	O2 - Crapeau Creek	MCHD - LSCA	42.6690	-82.7416	A1
3	O3 - Salt River	MCHD - LSCA	42.6507	-82.7882	A1
4	O4 - Irwin Branch Relief Drain	MCHD - LSCA	42.6297	-82.8146	A1
5	O5 - Clinton River	MCHD - LSCA	42.5944	-82.7663	A1
6	O6 - Metropolitan Beach	MCHD - LSCA	42.5673	-82.7960	A1
7	O7 - Mt. Clemens WTP Intake	MCHD - LSCA	42.5590	-82.8291	A1
8	O8 - Clinton River Spillway	MCHD - LSCA	42.5583	-82.8425	A1
9	O9 - Memorial Park	MCHD - LSCA	42.5233	-82.8672	A1
10	O10 - Coast Guard Station	MCHD - LSCA	42.4731	-82.8751	A1
11	O11 - Milk River	MCHD - LSCA	42.4600	-82.8698	A1
12	O12 - N. Channel	MCHD - LSCA	42.6267	-82.7164	A1
13	O13 - S. Channel	MCHD - LSCA	42.5127	-82.6989	A1
14	N23 - Clinton River	MCHD - LSCA	42.5943	-82.7706	A1
15	1n - nearshore	ECCC - WQ	42.5264	-82.8689	A2
16	2n - nearshore	ECCC - WQ	42.5264	-82.8700	A2
17	3n - nearshore	ECCC - WQ	42.5264	-82.8706	A2
18	4n - nearshore	ECCC - WQ	42.5683	-82.7944	A2
19	5n - nearshore	ECCC - WQ	42.5692	-82.7947	A2
20	6n - nearshore	ECCC - WQ	42.5700	-82.7947	A2
21	1o - offshore	ECCC - WQ	42.4553	-82.8256	A2
22	2o - offshore	ECCC - WQ	42.4206	-82.7106	A2
23	3o - offshore	ECCC - WQ	42.4697	-82.6983	A2
24	209	BW - LTSS	42.3726	-82.4326	A3
25	210	BW - LTSS	42.5016	-82.7026	A3
26	45147	CHMBD	42.4300	-82.6800	A4
27	820414	EPA STORET	42.3524	-82. 9272	A5
28	11965 – Belle River	DFO	42.3000	-82.7167	A6
29	9034052 – St. Clair Shores	NOAA – T&C	42.4733	-82.8800	A7
30	Town of Lakeshore	DWSP	*	*	A8
31	Town of Lakeshore – Stoney Point	DWSP	*	*	A8
32	Ira Township	WIMS	*	*	A1
33	New Baltimore	WIMS	*	*	A1

Table S10. (*Continued*).

#	Station Name - additional name	Project/Agency	Latitude (N)	Longitude (W)	Data Source
34	Mt. Clemens	WIMS	*	*	A1
35	Grosse Pointe Farms	WIMS	*	*	A1
33	Water Works Park (Belle Isle)	WIMS	*	*	A1

Note: Abbreviation used for projects: MCHD-LSCA, The Macomb County Health Department (MCHD) – the Lake St. Clair Assessment Regional Monitoring Project (LSCA); ECCC – WQ, Environment and Climate Change Canada (ECCC) – Water Quality in Lake St. Clair (WQ); BW – LTSS, Basin Wide (BW) – Long Term Sensing Sites (LTSS); DWSP, Ontario Drinking Water Surveillance Program; WIMS, Water Intake Monitoring System, Huron to Erie Drinking Water Monitoring Network.

Abbreviation used for data sources: A1 - Huron to Erie Drinking Water Monitoring Network, online database: <http://hetestweb.azurewebsites.net/OtherProjects.aspx>; A2 – STAR database (maintained and distributed by ECCC); A3 – dataset maintained and distributed by OMECC; A4 – USEPA STORET online database: <https://www.epa.gov/waterdata/storage-and-retrieval-and-water-quality-exchange>, A6 – Division of Fisheries and Ocean (DFO) online database: <http://www.tides.gc.ca>; A7 – NOAA Tides & Currents (NOAA – T&C) online database: <https://tidesandcurrents.noaa.gov>; A8 – Huron to Erie Drinking Water Monitoring Network, available online at <http://hetestweb.azurewebsites.net/WaterIntakeMonitoring.aspx>.

Latitude and longitude coordinates were rounded to the forth decimal digit.

The coordinates of the stations used as public water intakes are marked with asterisk (*). The locations of these stations are shown in Figure S3a, d.

Figure legends

Figure S1. Overview of the applied biogeochemical model (CAEDYM) with state variables showing the water column and sediment components (modified from Hipsey and Hamilton, 2008). For the terms (abbreviations) of water quality parameters see Table S1.

Figure S2. Schematic diagram of phosphorus cycle in the biogeochemical model applied to Lake St. Clair (modified from Hipsey and Hamilton, 2008). For the definitions of the terms (abbreviations) see Table S1.

Figure S3. Map of stations used for validation and comparison purposes. For the coordinates of the stations see Table S10.

Figure S4. Model-data comparisons of total phosphorus (TP; mg L^{-1}) in 2010. Part I. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S5. Model-data comparisons of total phosphorus (TP; mg L^{-1}) in 2010. Part II. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S6. Model-data comparisons of nitrate + nitrite (NO_3 + NO_2; mg L^{-1}) in 2010. Part I. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S7. Model-data comparisons of nitrate + nitrite (NO_3 + NO_2; mg L^{-1}) in 2010. Part II. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S8. Model-data comparisons of total ammonia (NH_3; mg L^{-1}) in 2010. Part I. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S9. Model-data comparisons of total ammonia (NH_3; mg L^{-1}) in 2010. Part II. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S10. Model-data comparisons of dissolved reactive silica (RSi; mg L^{-1}) in 2010. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

Figure S11. The relationship between within-lake total and dissolved reactive phosphorus loss rates (K_{TP}, K_{DRP}) and transport time scales: flushing time (*FT*; a – b), water residence time (*WRT*; c – d); area-weighted water age ($\overline{\boldsymbol{WA}}_{\boldsymbol{a}}$; e – f), and volume-weighted water age ($\overline{\boldsymbol{WA}}_{\boldsymbol{v}}$; g – h).

Figure S12. Satellite image of Lake St. Clair taken on 28-July-2015 showing algal bloom.

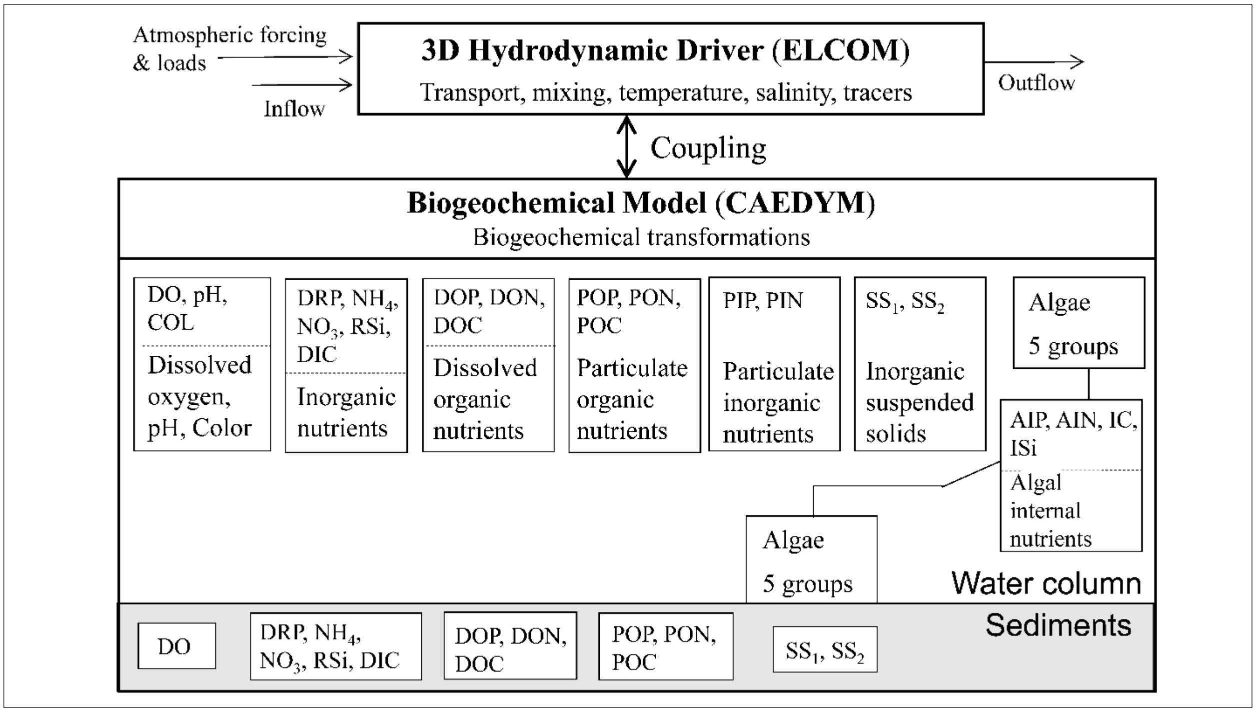

Figure S1. Overview of the applied biogeochemical model (CAEDYM) with state variables showing the water column and sediment components (modified from Hipsey and Hamilton, 2008). For the terms (abbreviations) of water quality parameters see Table S1.

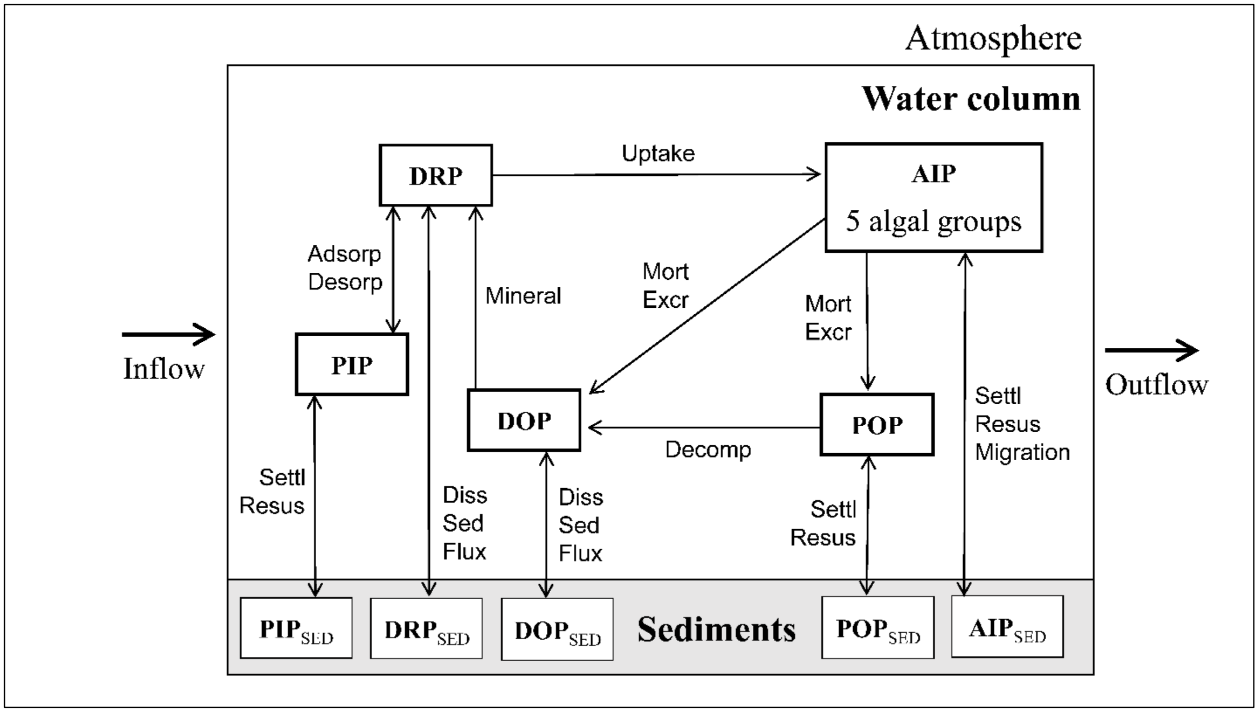

Figure S2. Schematic diagram of phosphorus cycle in the biogeochemical model applied to Lake St. Clair (modified from Hipsey and Hamilton, 2008). For the definitions of the terms (abbreviations) see Table S1.

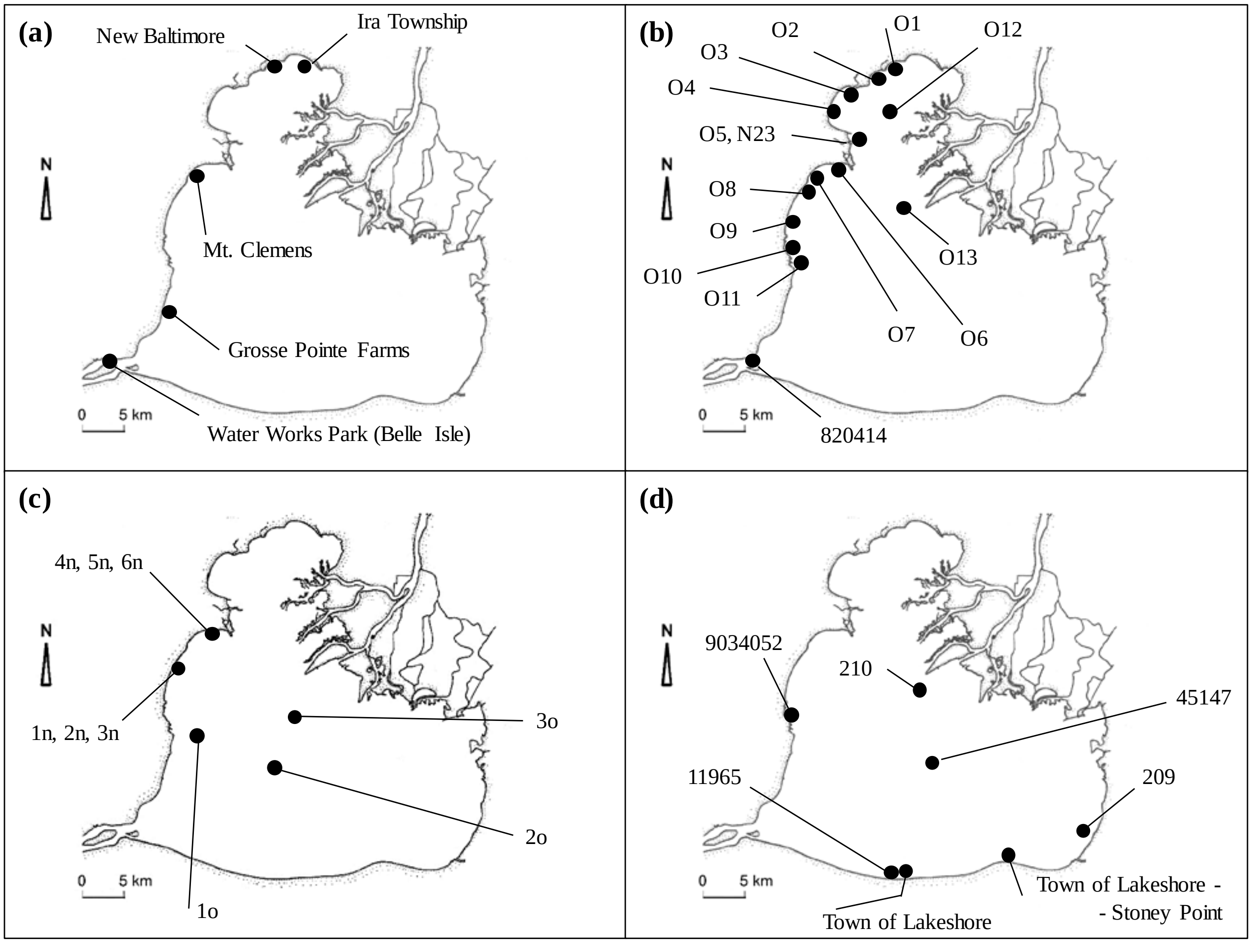

Figure S3. Map of stations used for validation and comparison purposes. For the coordinates of the stations see Table S10.

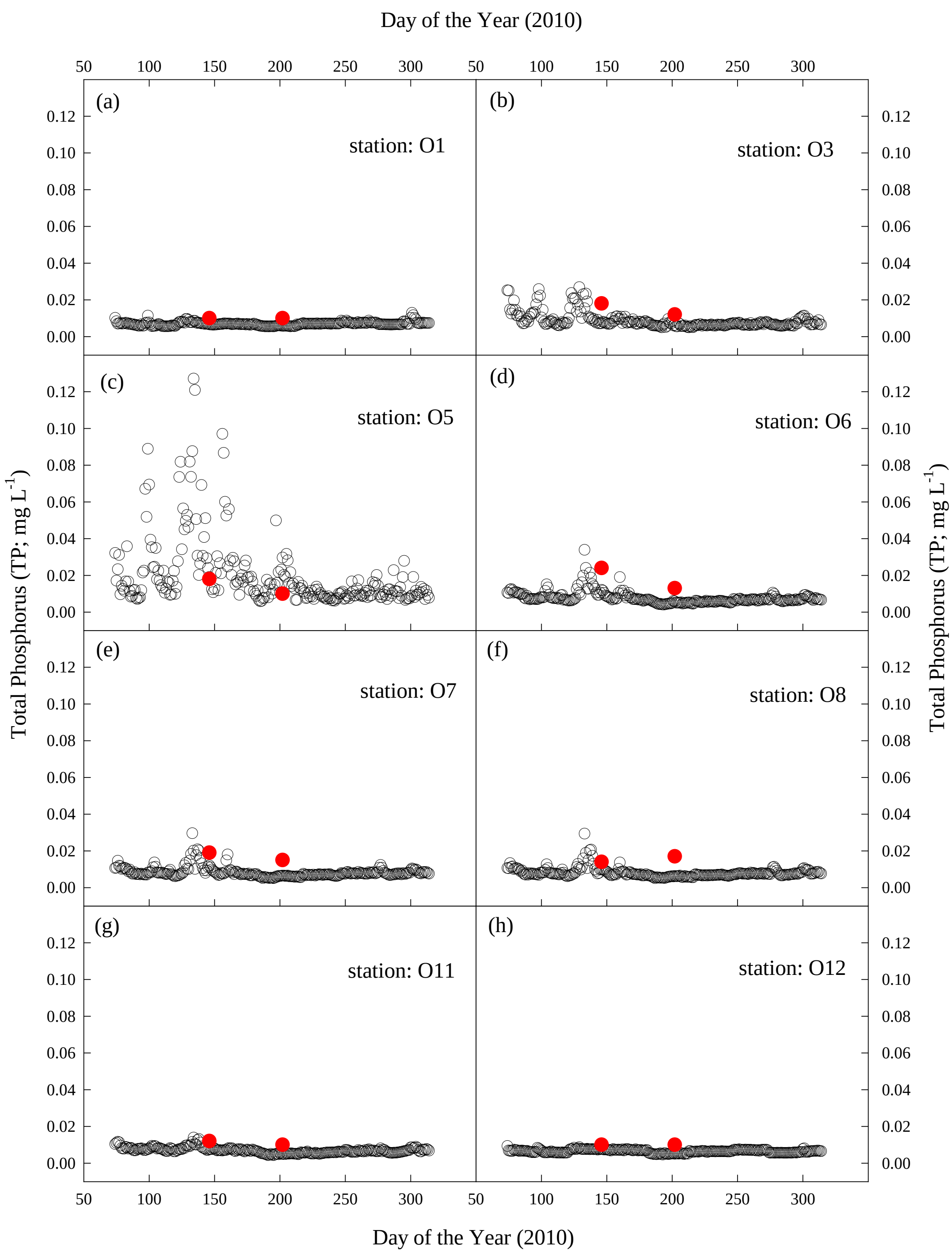

Figure S4. Model-data comparisons of total phosphorus (TP; mg L^{-1}) in 2010. Part I. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

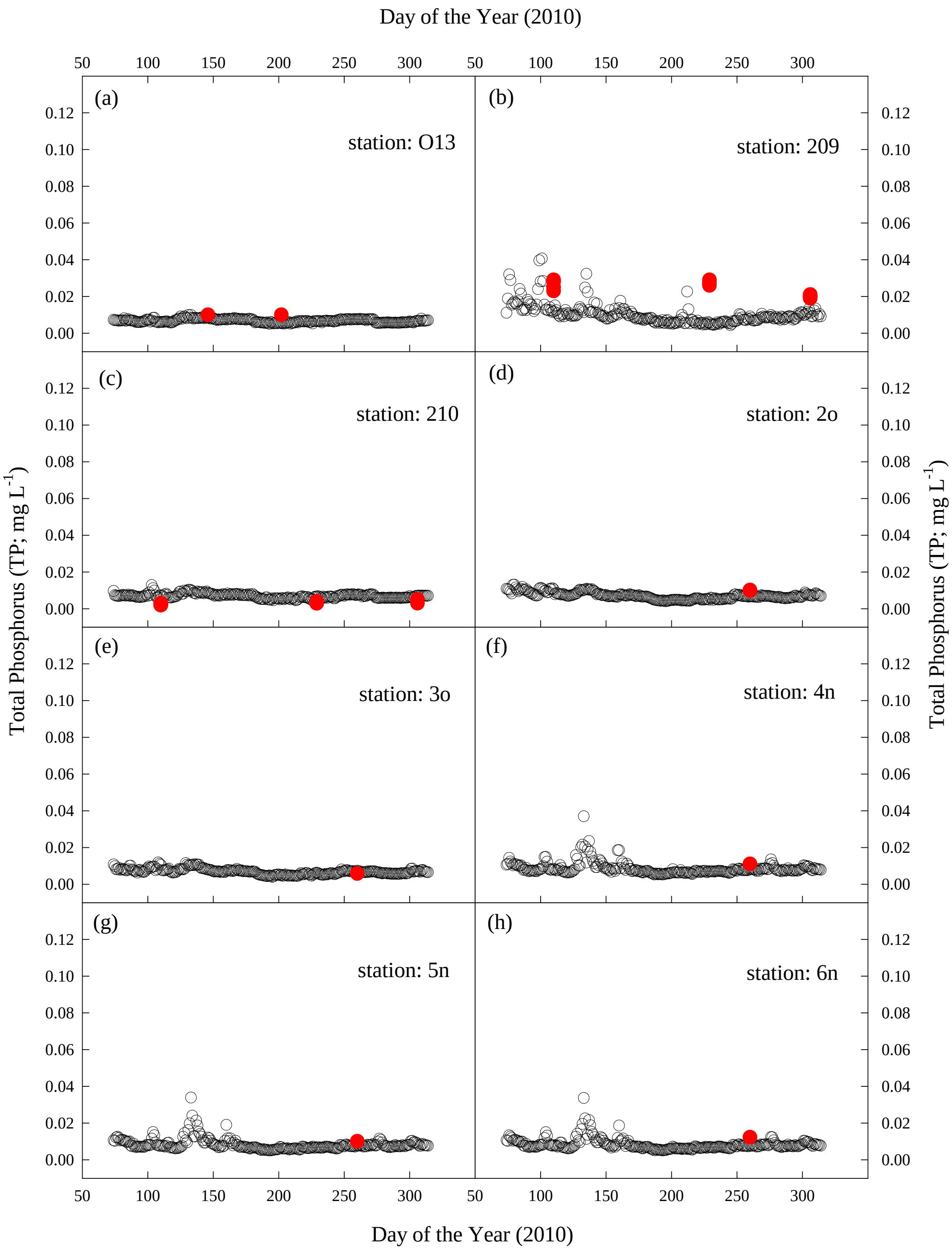

Figure S5. Model-data comparisons of total phosphorus (TP; mg L^{-1}) in 2010. Part II. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

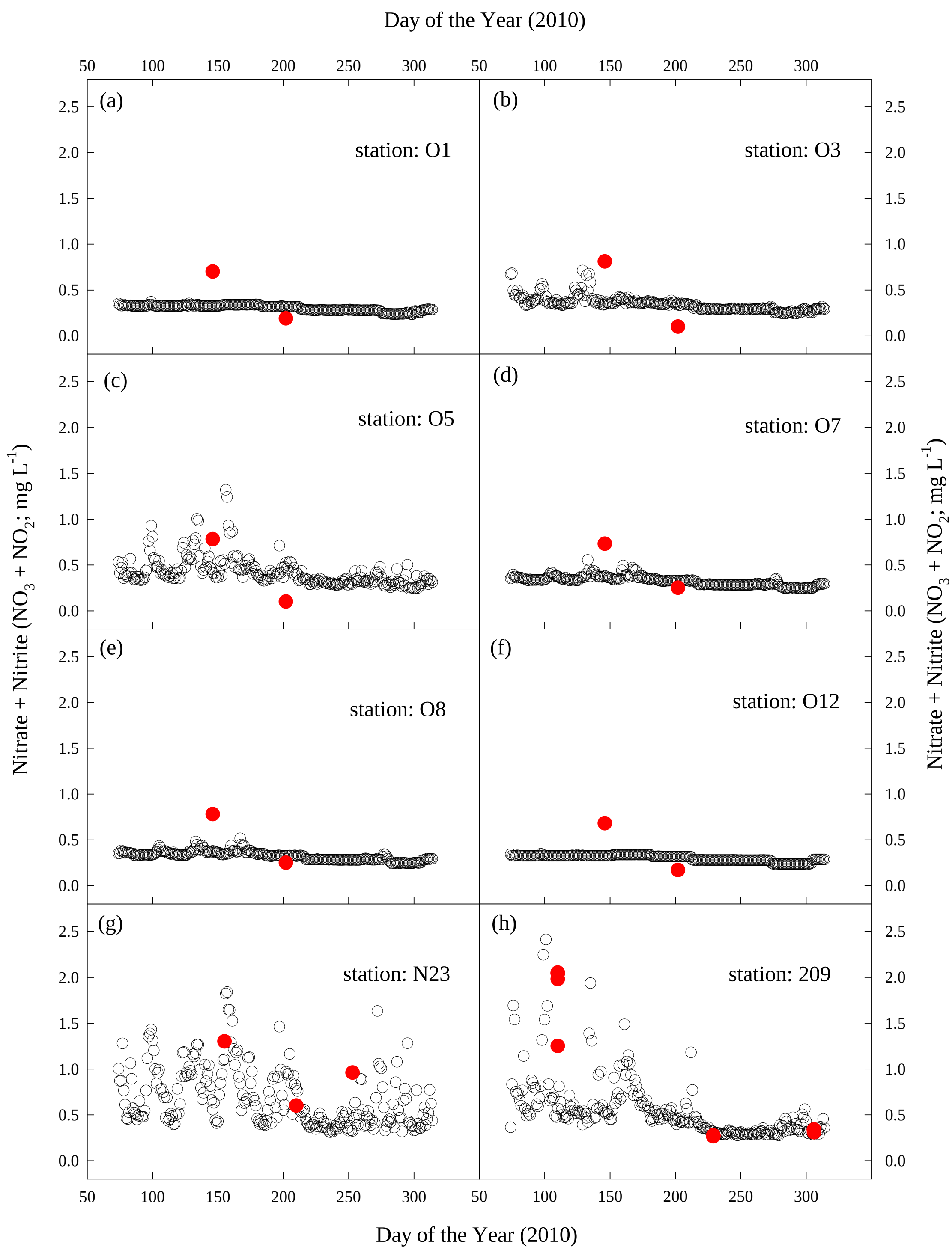

Figure S6. Model-data comparisons of nitrate + nitrite (NO_3 + NO_2; mg L^{-1}) in 2010. Part I. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

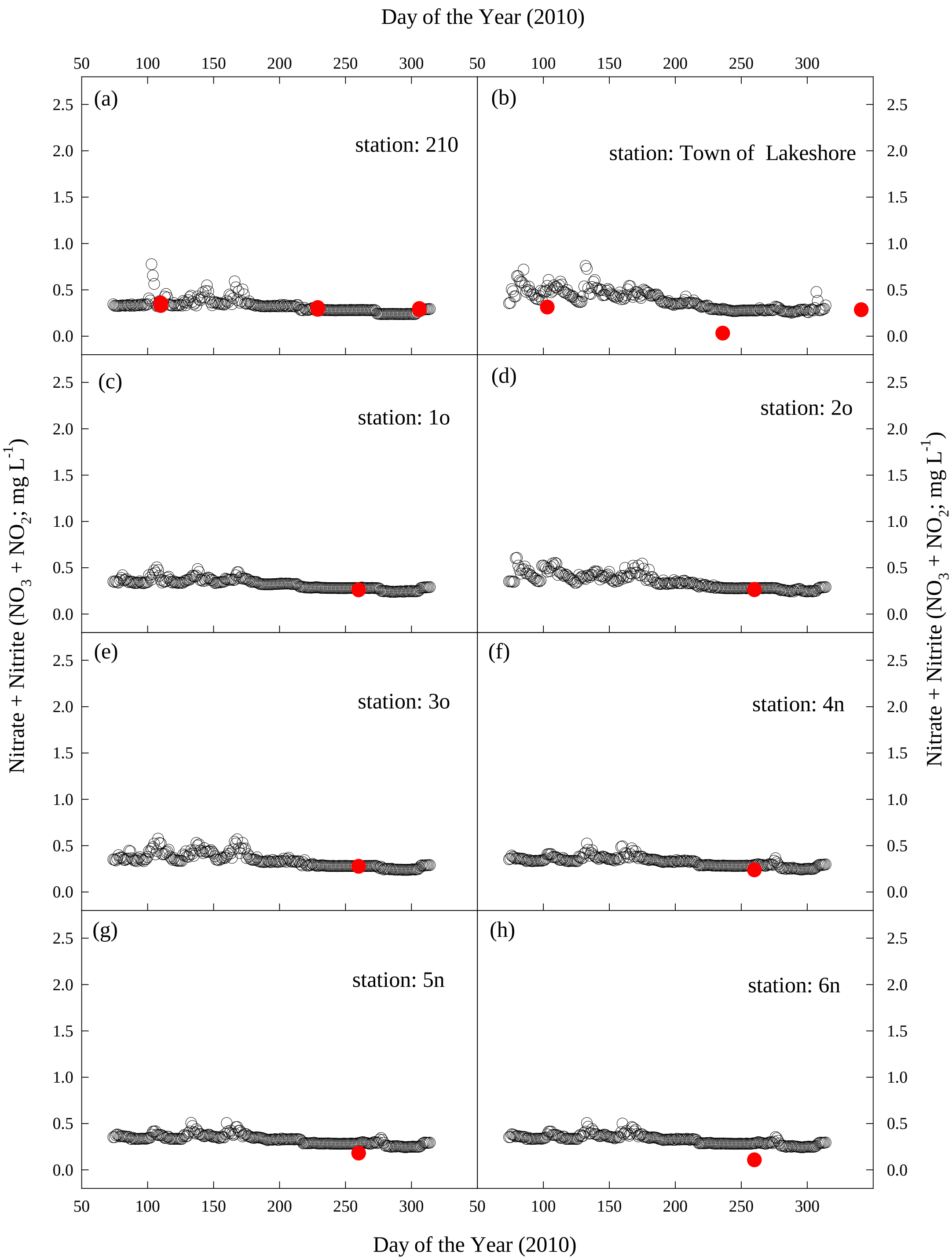

Figure S7. Model-data comparisons of nitrate + nitrite ($NO_3 + NO_2$; mg L^{-1}) in 2010. Part II. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

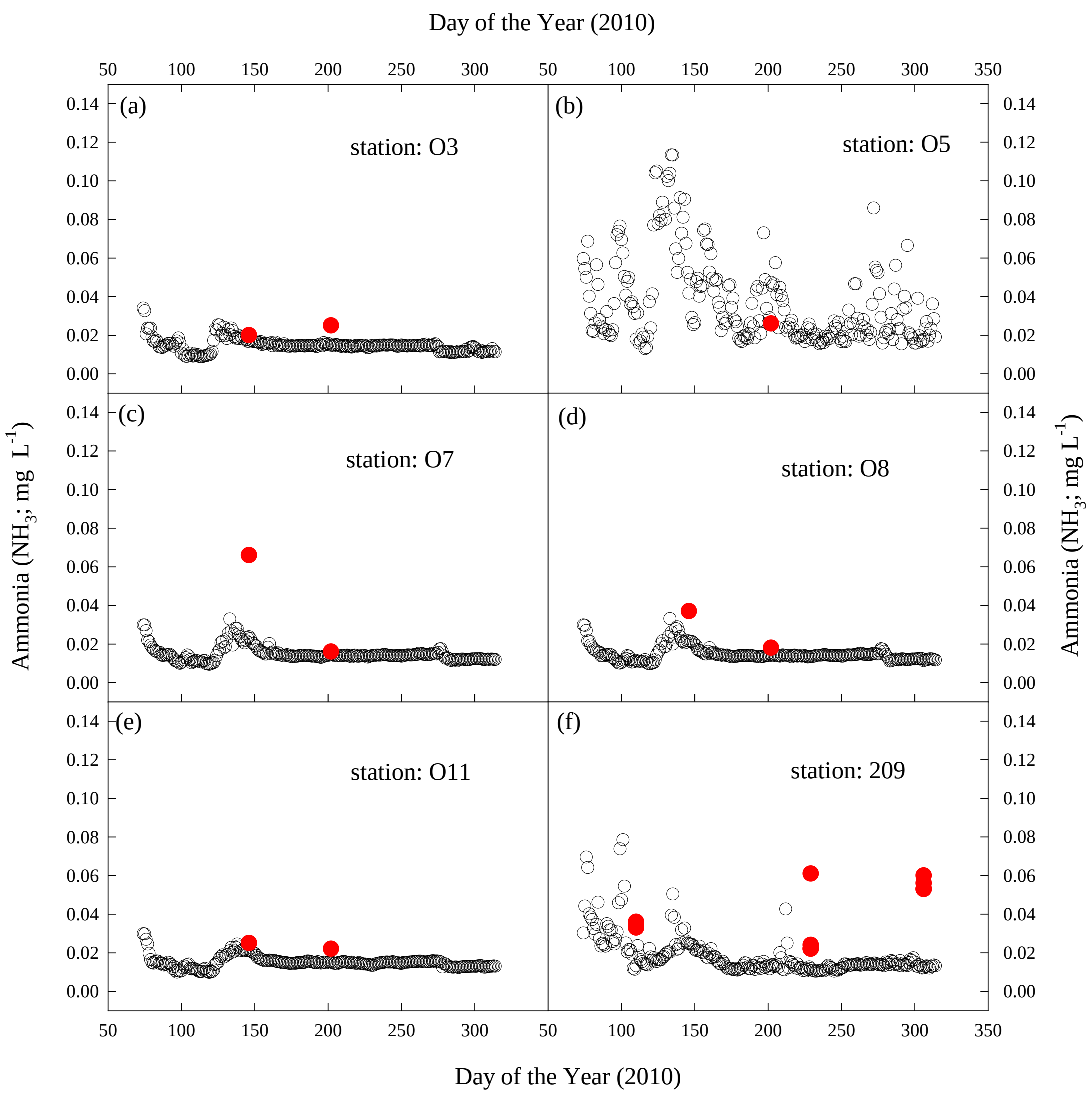

Figure S8. Model-data comparisons of total ammonia (NH_3; mg L^{-1}) in 2010. Part I. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

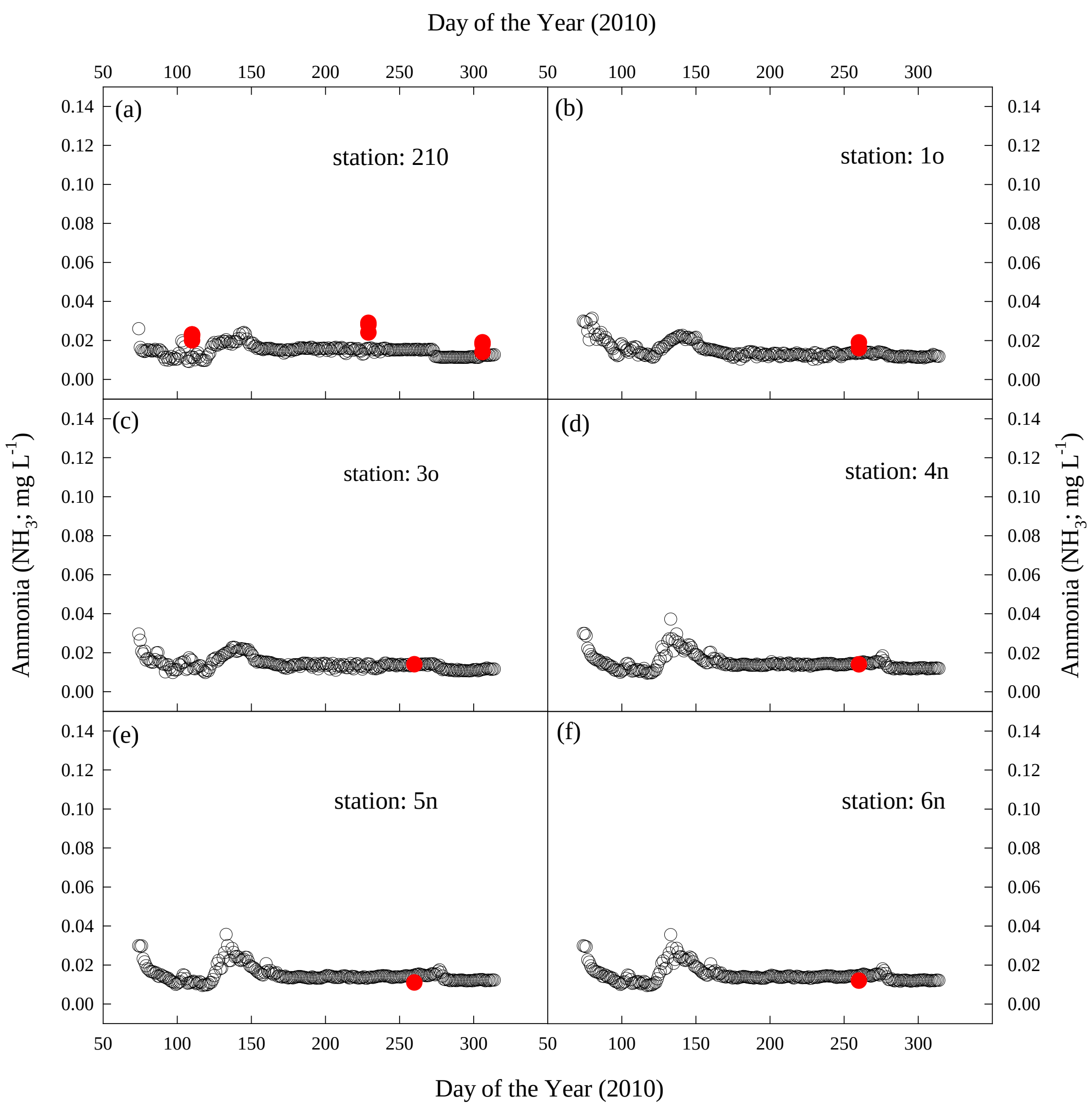

Figure S9. Model-data comparisons of total ammonia (NH_3; mg L^{-1}) in 2010. Part II. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

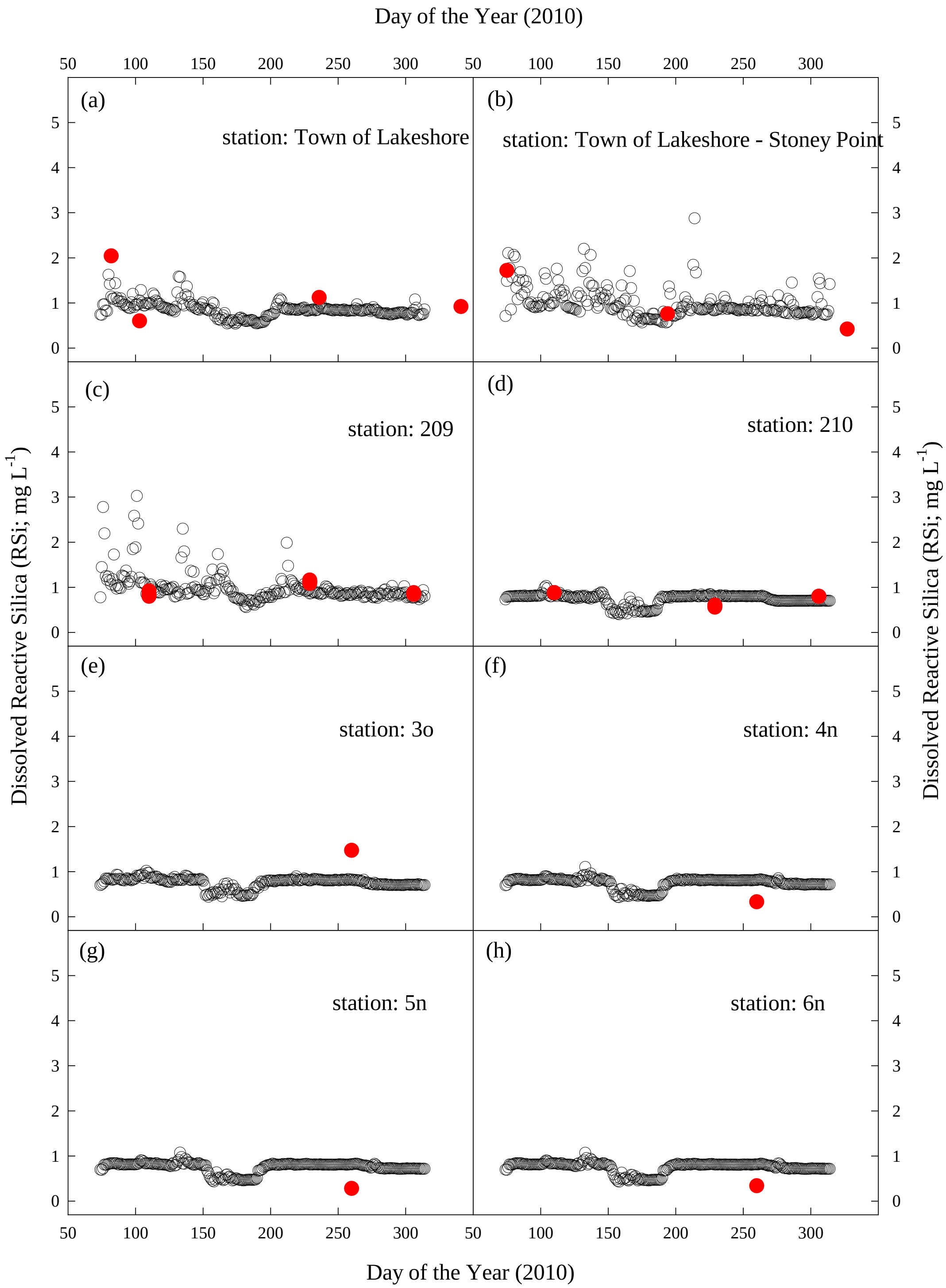

Figure S10. Model-data comparisons of dissolved reactive silica (RSi; mg L^{-1}) in 2010. Open black circles = modeled daily-averaged values, solid red circles = measured instantaneous data. For the locations of the stations see Figure S3.

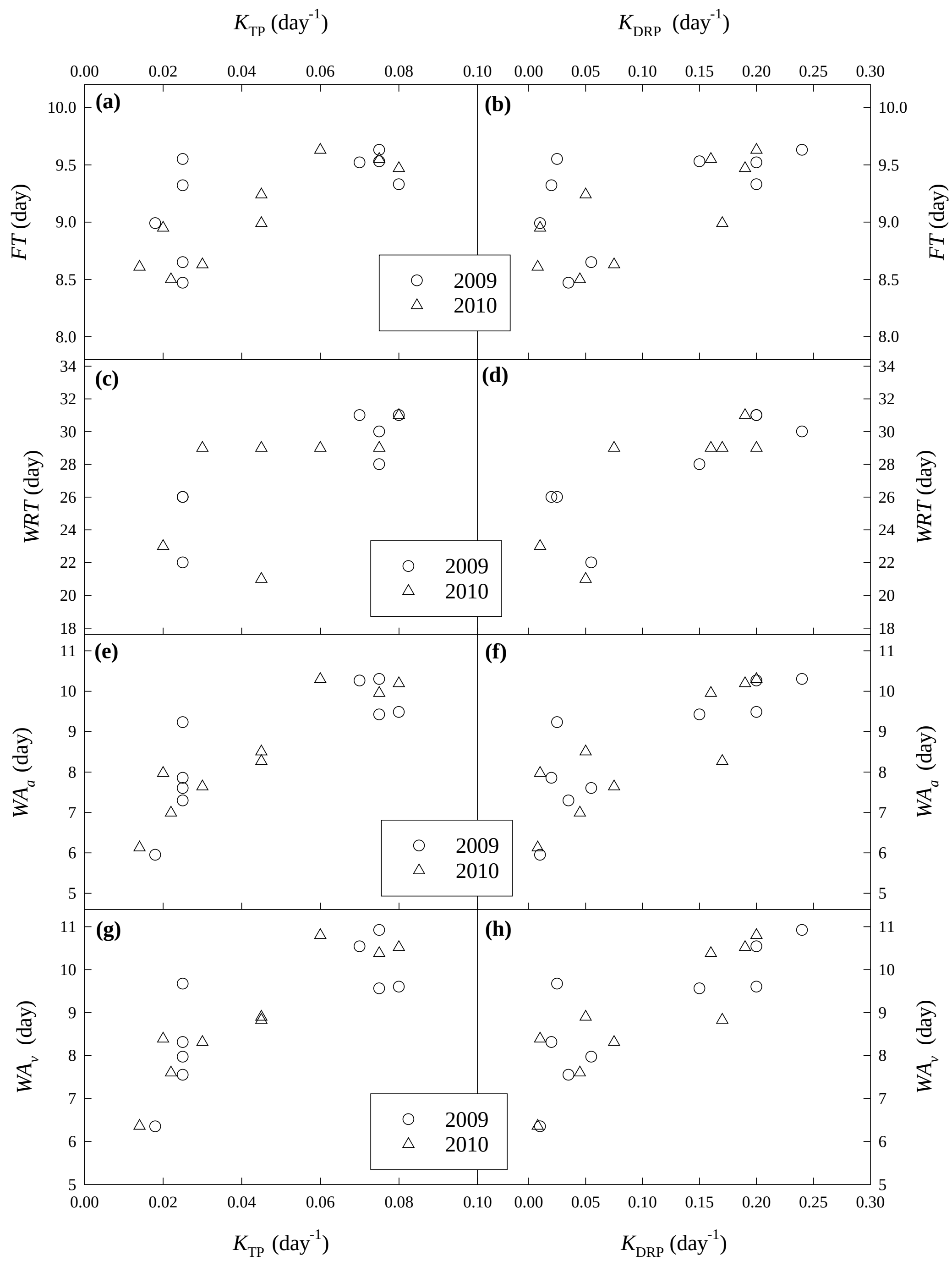

Figure S11. The relationship between within-lake total and dissolved reactive phosphorus loss rates (K_{TP}, K_{DRP}) and transport time scales: flushing time (*FT*; a – b), water residence time (*WRT*; c – d); area-weighted water age ($\overline{WA}_a$; e – f), and volume-weighted water age ($\overline{WA}_v$; g – h).

Figure S12. Satellite image of Lake St. Clair taken on 28-July-2015 showing algal bloom indicated as visible swirls of green color along the southern shore of the lake. The image was taken by the Operational Land Imager (OLI) on the Landsat 8 satellite as part of a joint effort between NASA, USEPA, NOAA, and USGS to transform satellite data designed to probe ocean biology into information that will help protect the public from harmful freshwater algal blooms.