Modeling Water Quantity and Quality in the Devils Lake Watershed Using SWAT

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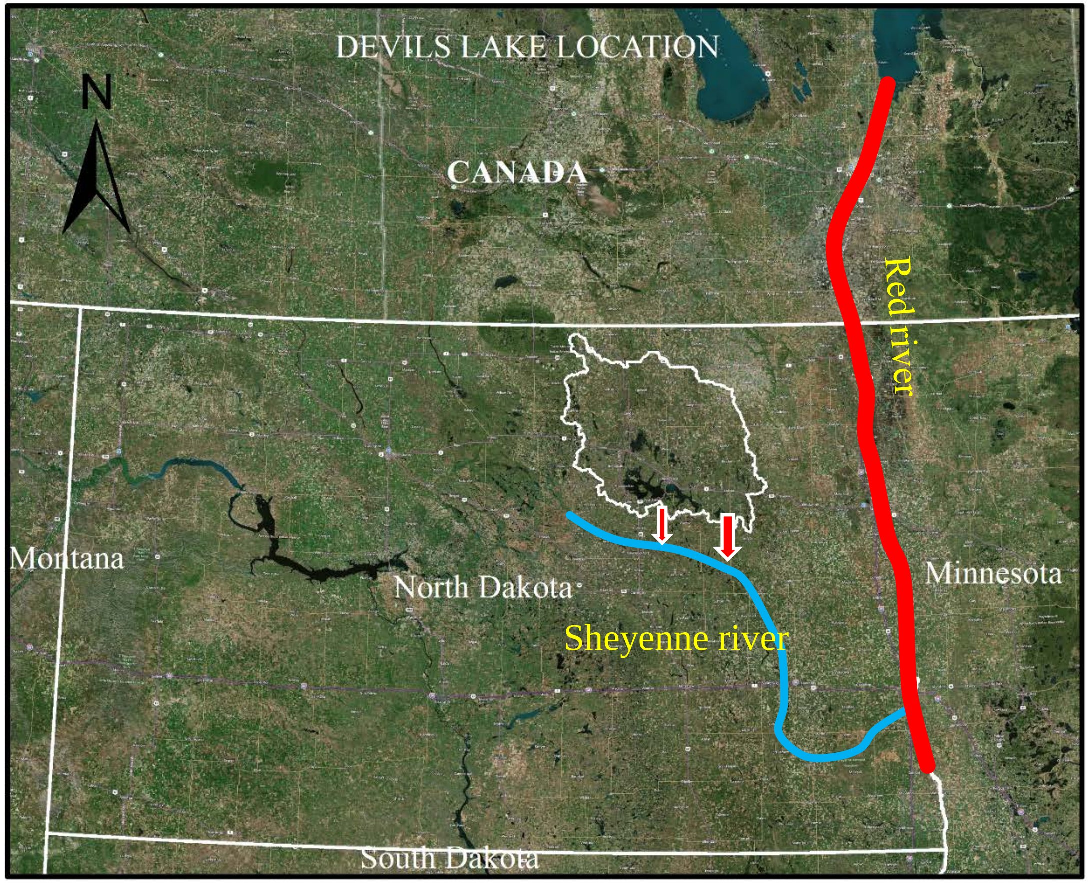
Devils Lake Watershed



Method

$$R^2 = \frac{\left[\sum_{i=1}^{N}(q_{obs,i} - \bar{q}_{obs})(q_{sim,i} - \bar{q}_{sim})\right]^2}{\left[\sum_{i=1}^{N}(q_{obs,i} - \bar{q}_{obs})^2\right]\left[\sum_{i=1}^{N}(q_{sim,i} - \bar{q}_{sim})^2\right]}$$

$$E_{NS} = 1 - \frac{\left[\sum_{i=1}^{N}(q_{obs,i} - q_{sim,i})^2\right]}{\left[\sum_{i=1}^{N}(q_{osb,i} - \bar{q}_{obs})^2\right]}$$

$$PBIAS = \frac{\sum_{i=1}^{N}(q_{obs,i} - q_{sim,i})}{\sum_{i=1}^{N} q_{obs,i}} \times 100$$

Watershed Delineation

Revised using USGS Data

HRU Definition

Flow Calibration-validation

Lake Elevation Simulation

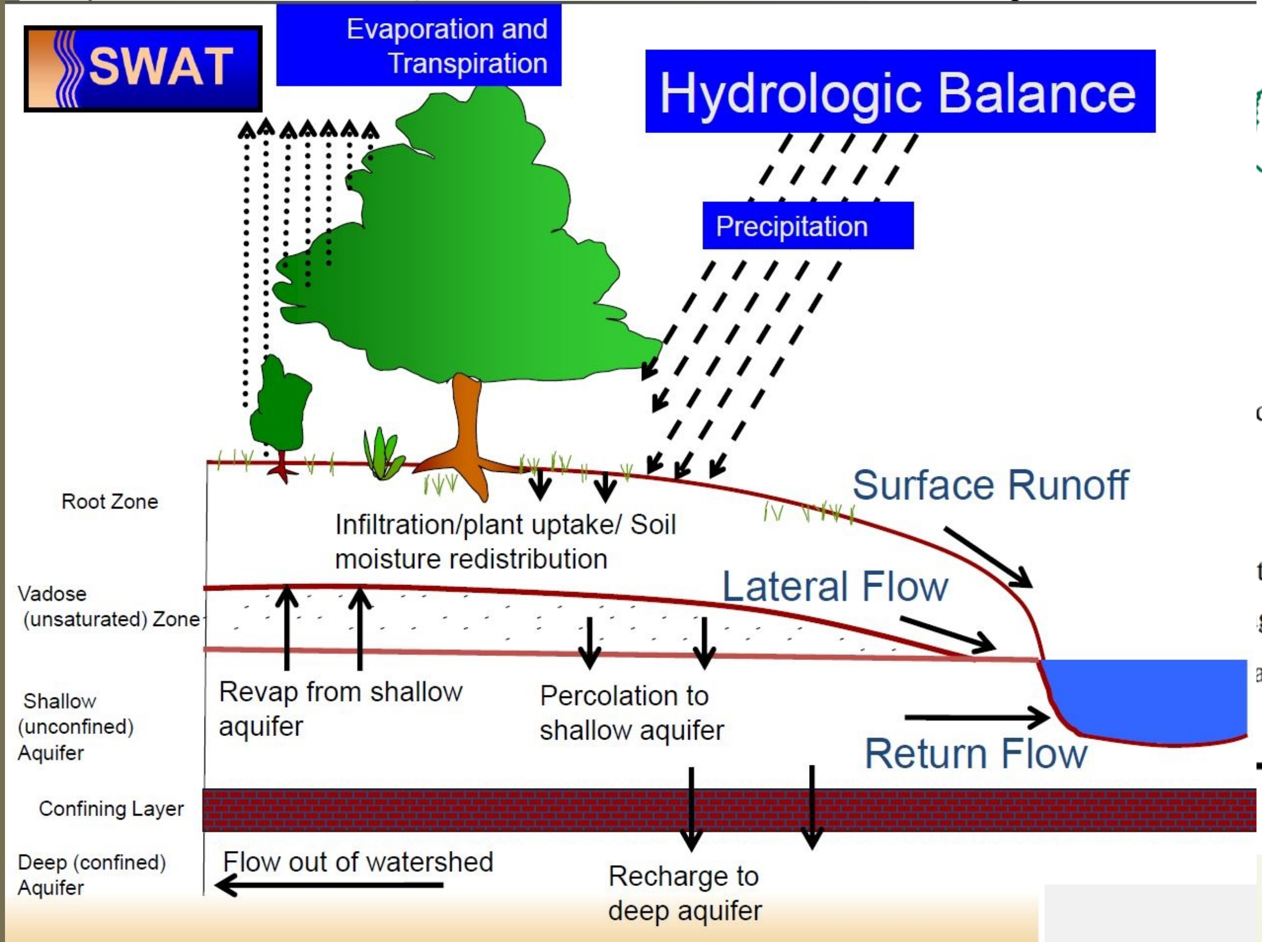
Sediment Calibration-validation

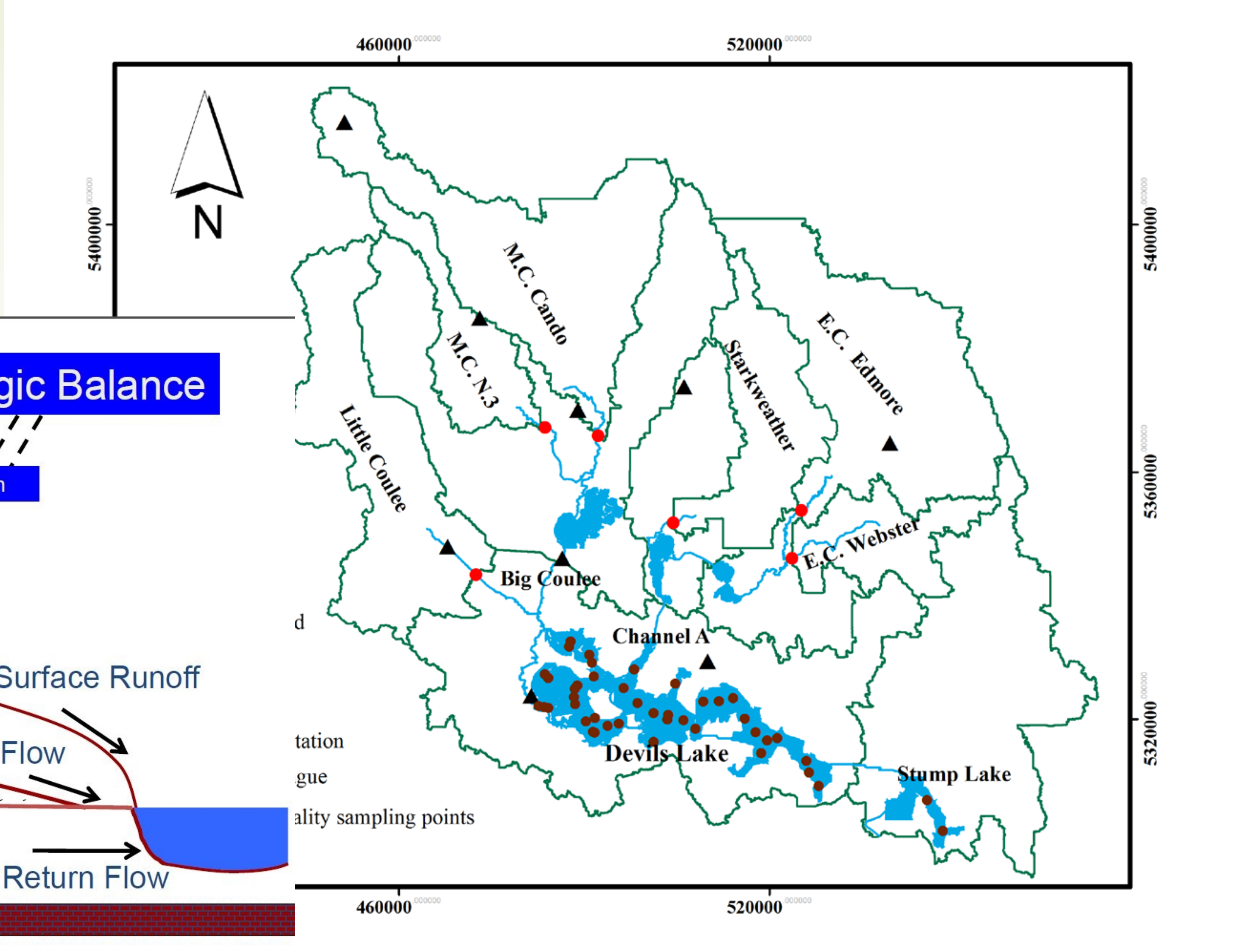
TP and TN Calibration-validation

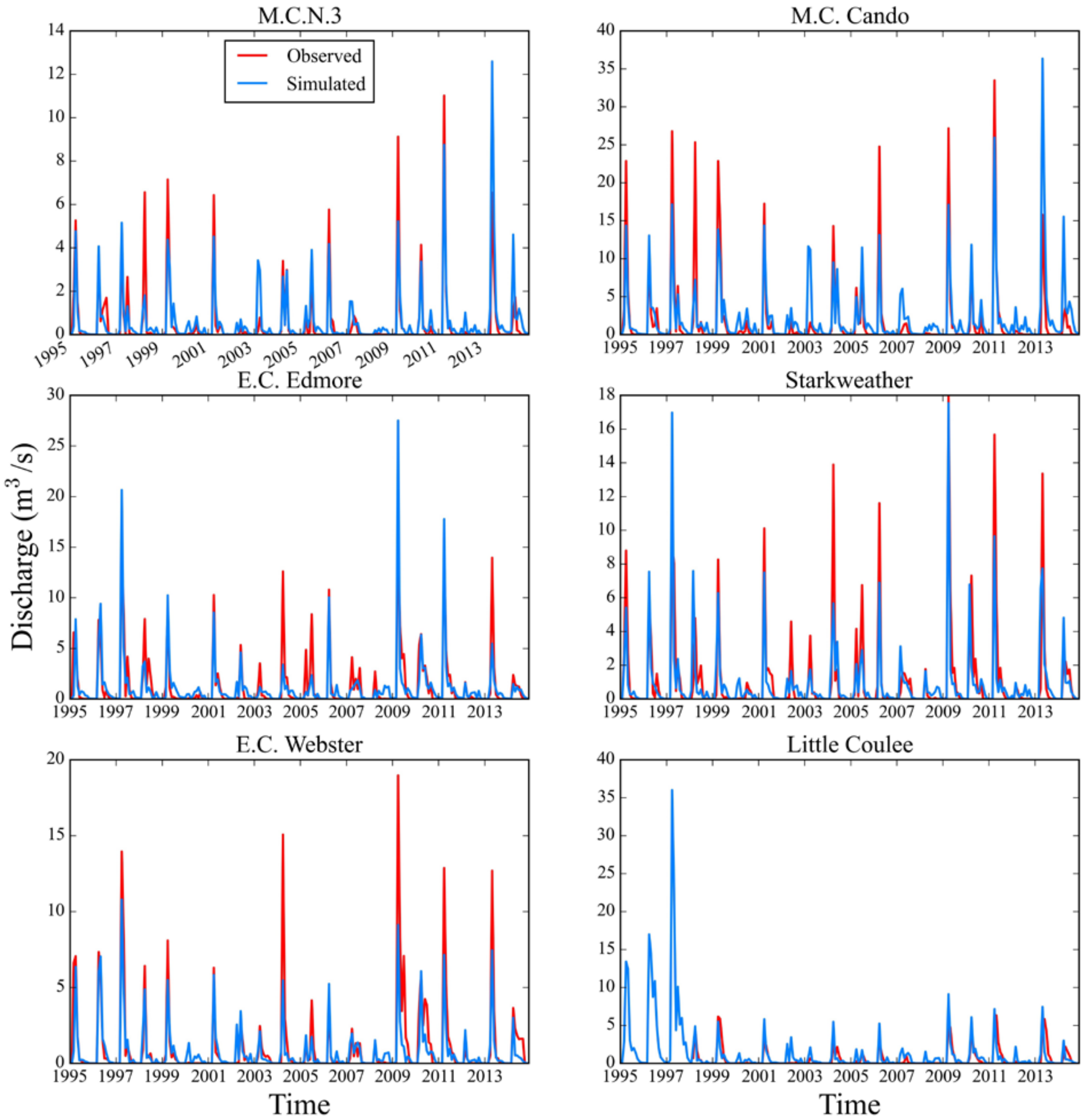
Lake Nutrient Simulation

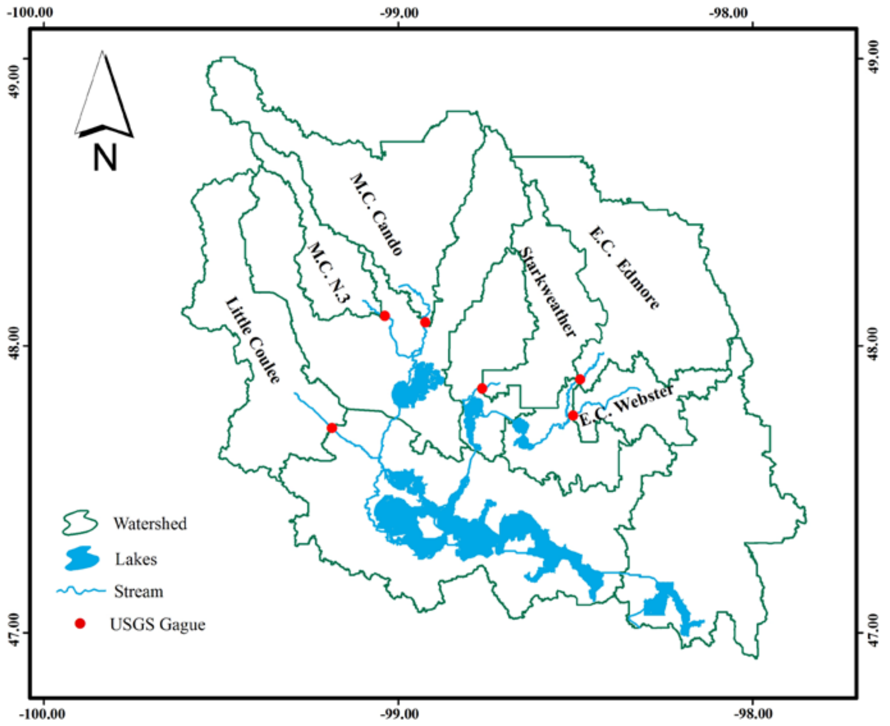
Flow

- Calibration 1993-2003
- Validation 2004-2014
- Using USGS data









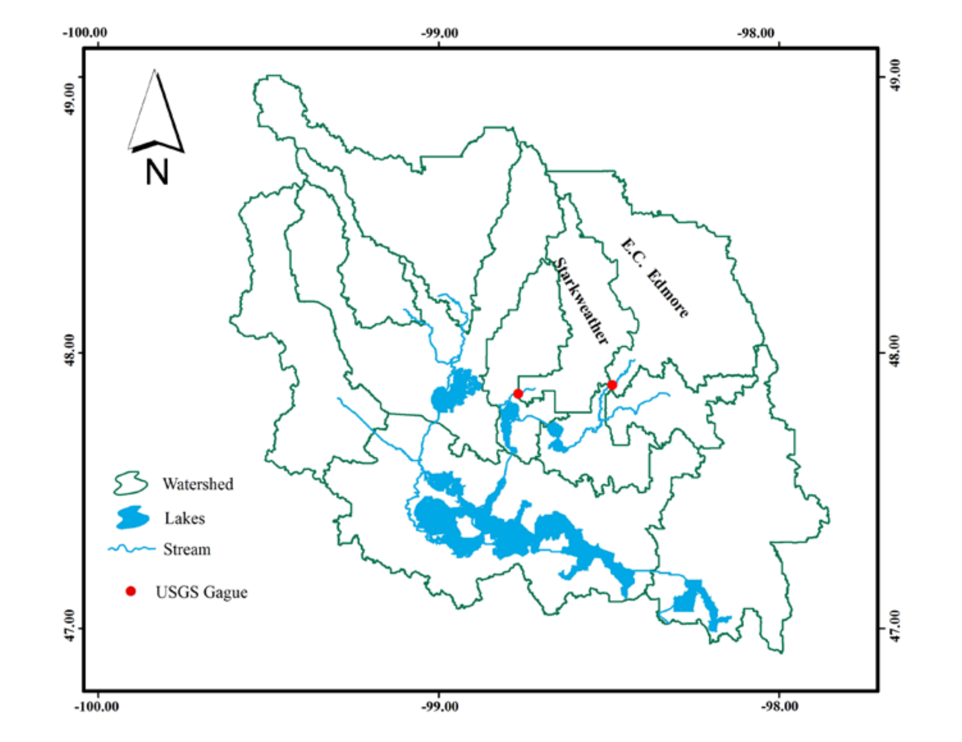
$R^2 > 0.55$

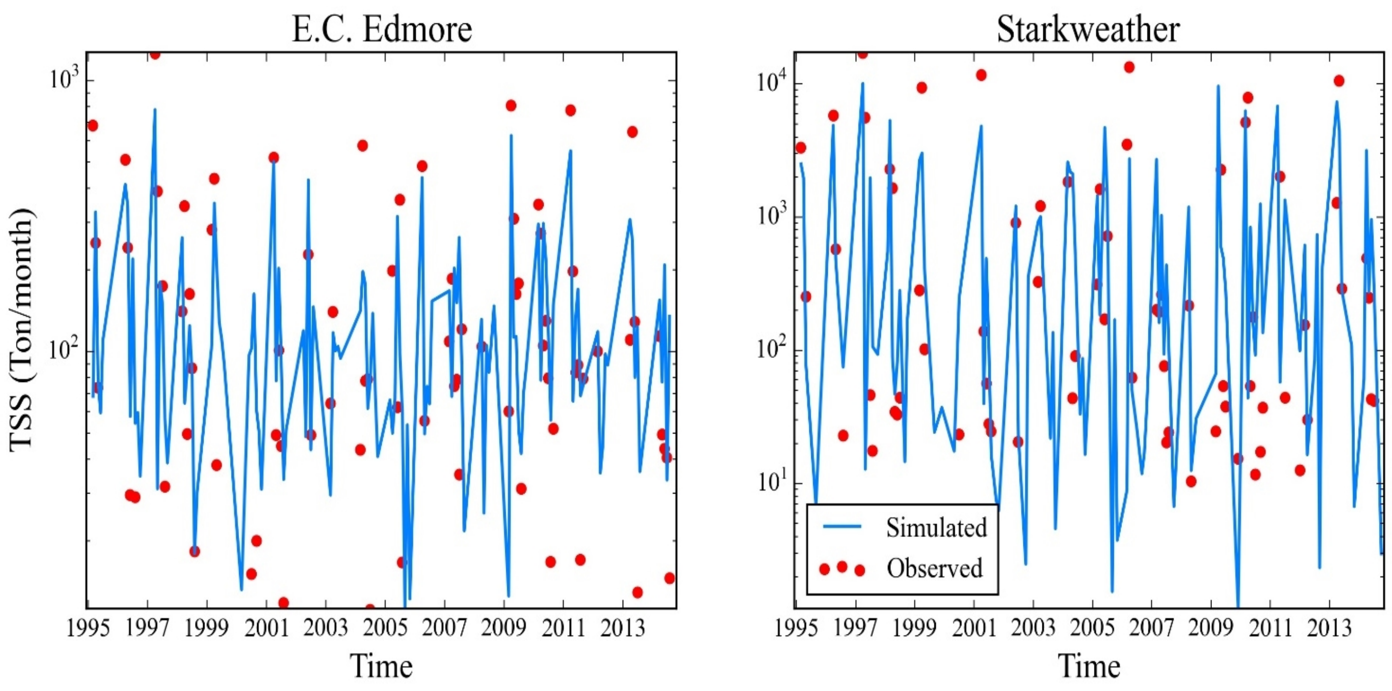
PBIAS < ± 20%

$E_{NS} > 0.51$

Sediment

Average 0.05 ton/ha





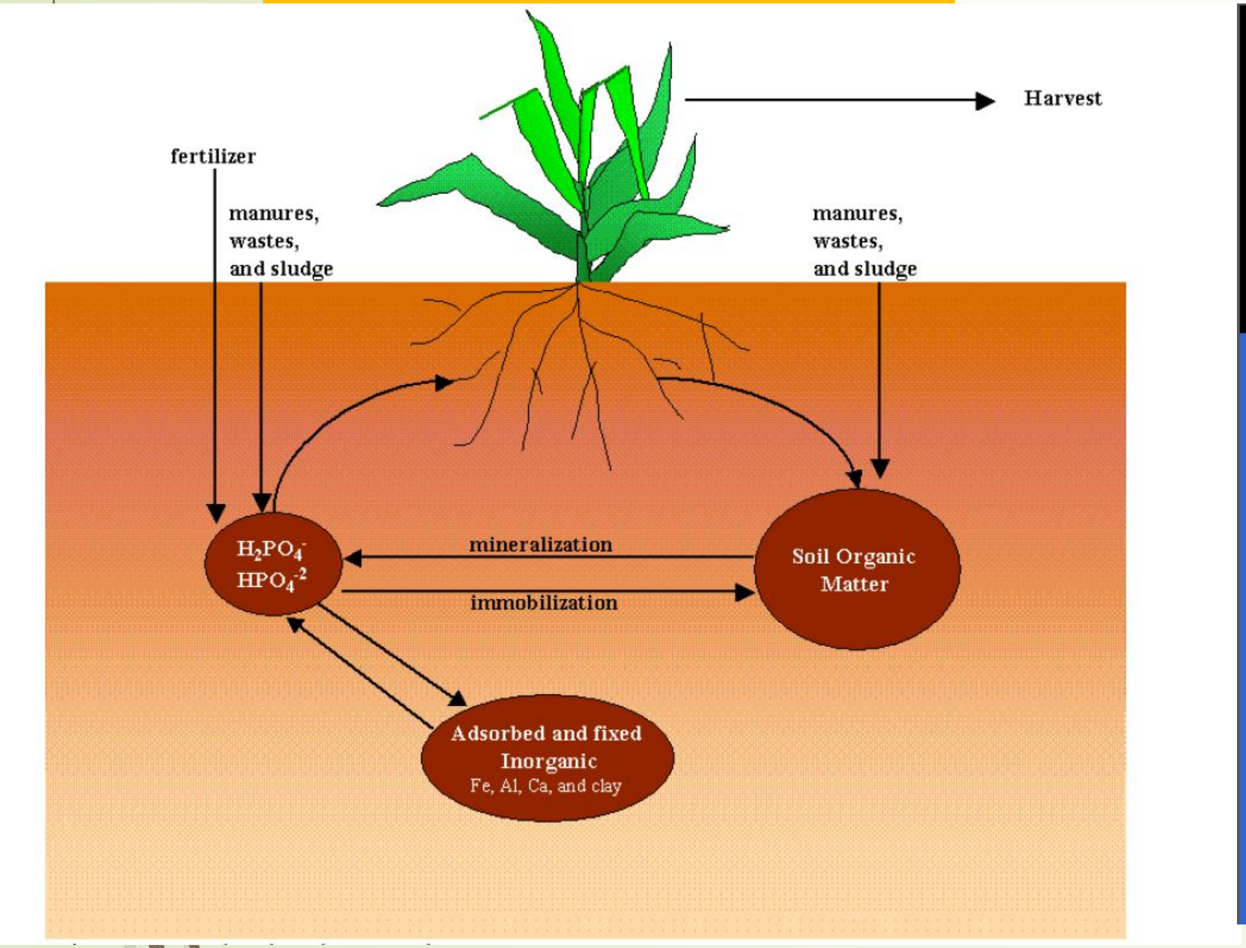
$R^2 > 0.55$

$E_{NS} > 0.51$

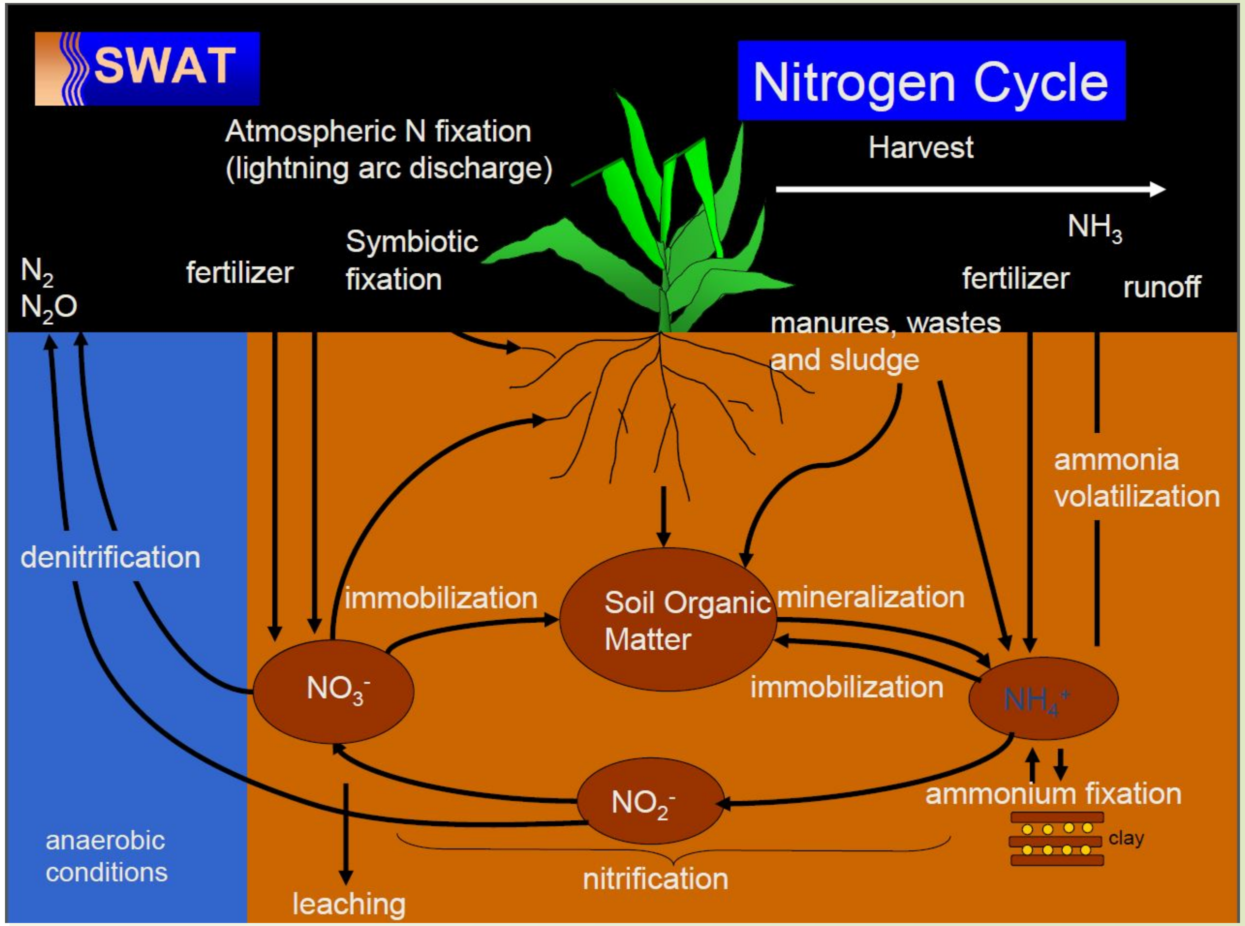
PBIAS < ± 20%

Phosphorus and Nitrogen

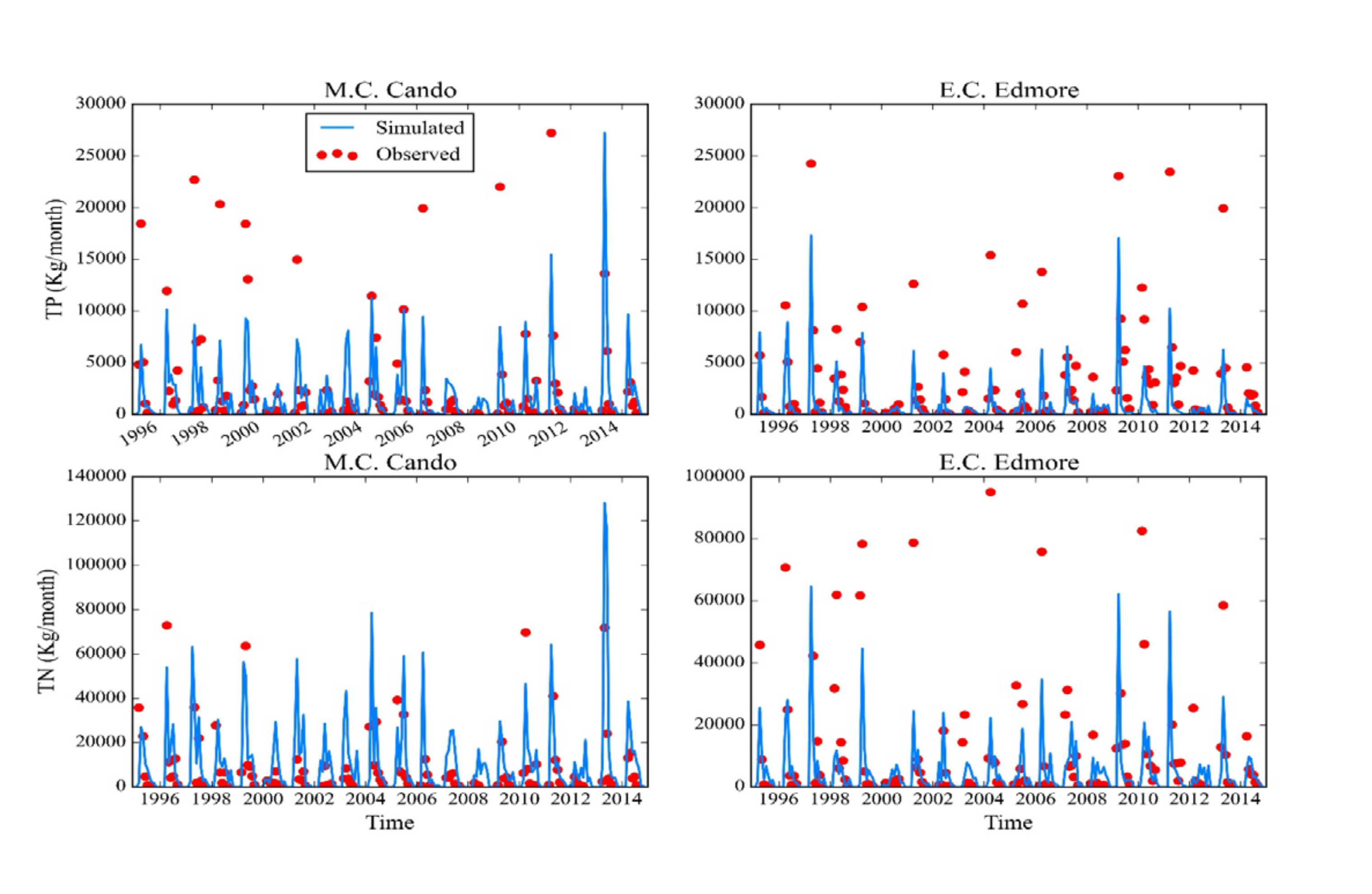
Phosphorus Cycle

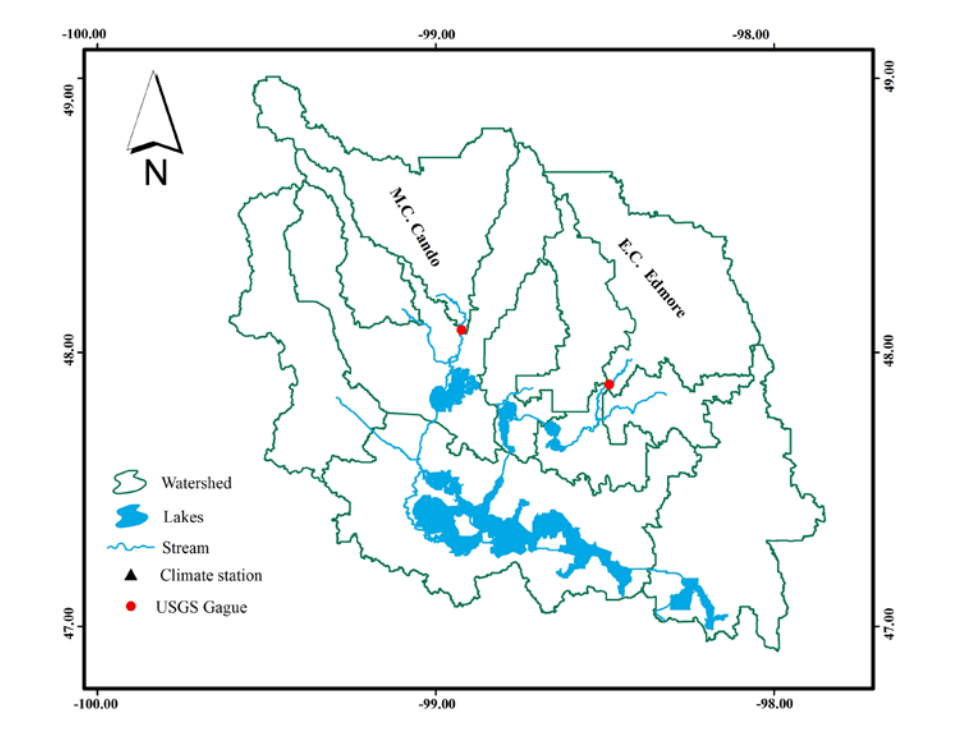


Nitrogen Cycle



Phosphorus and Nitrogen





$0.36 \leq R^2 \leq 0.71$

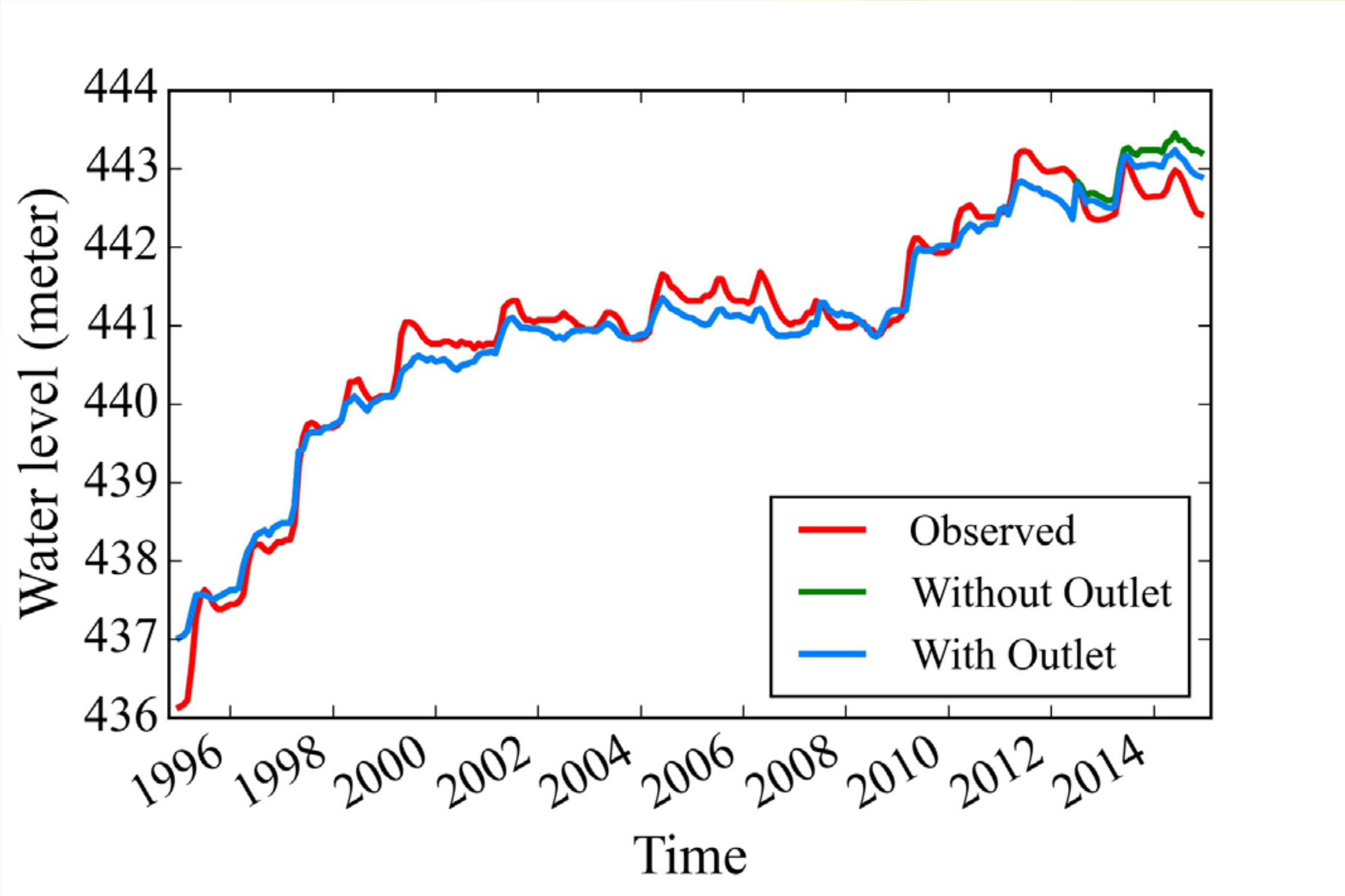
PBIAS < ± 47%

Devils Lake Water Level

R^2=0.97

RMSE=0.26 Meter

Outlet decreased water level by
~ 0.30 meter

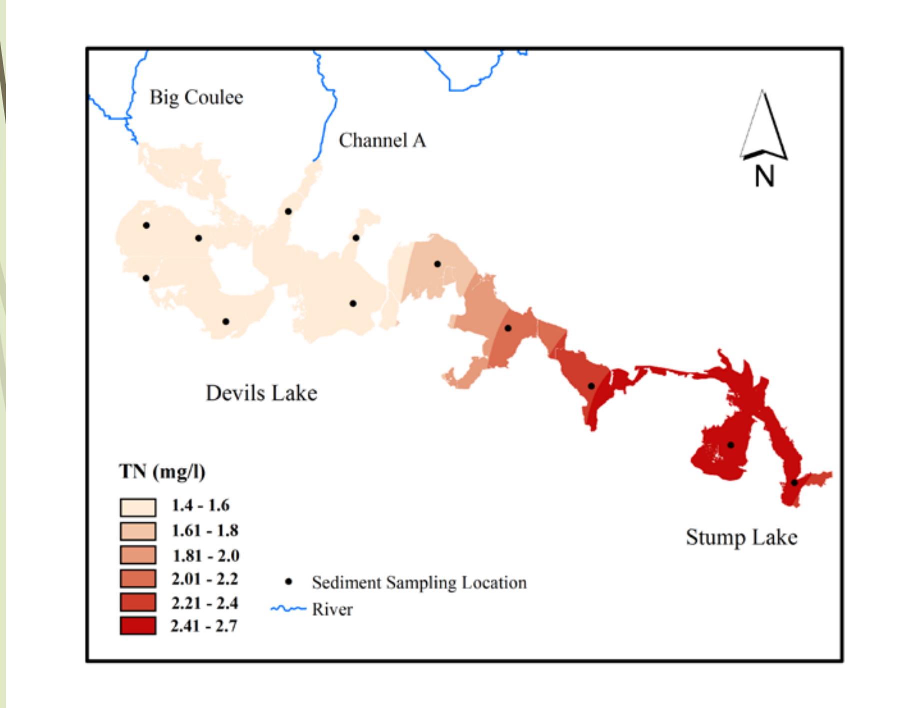


Using GSM data to predict lake elevation by 2030.

Evaluation feasible scenarios to prevent flood (Like change in land use).

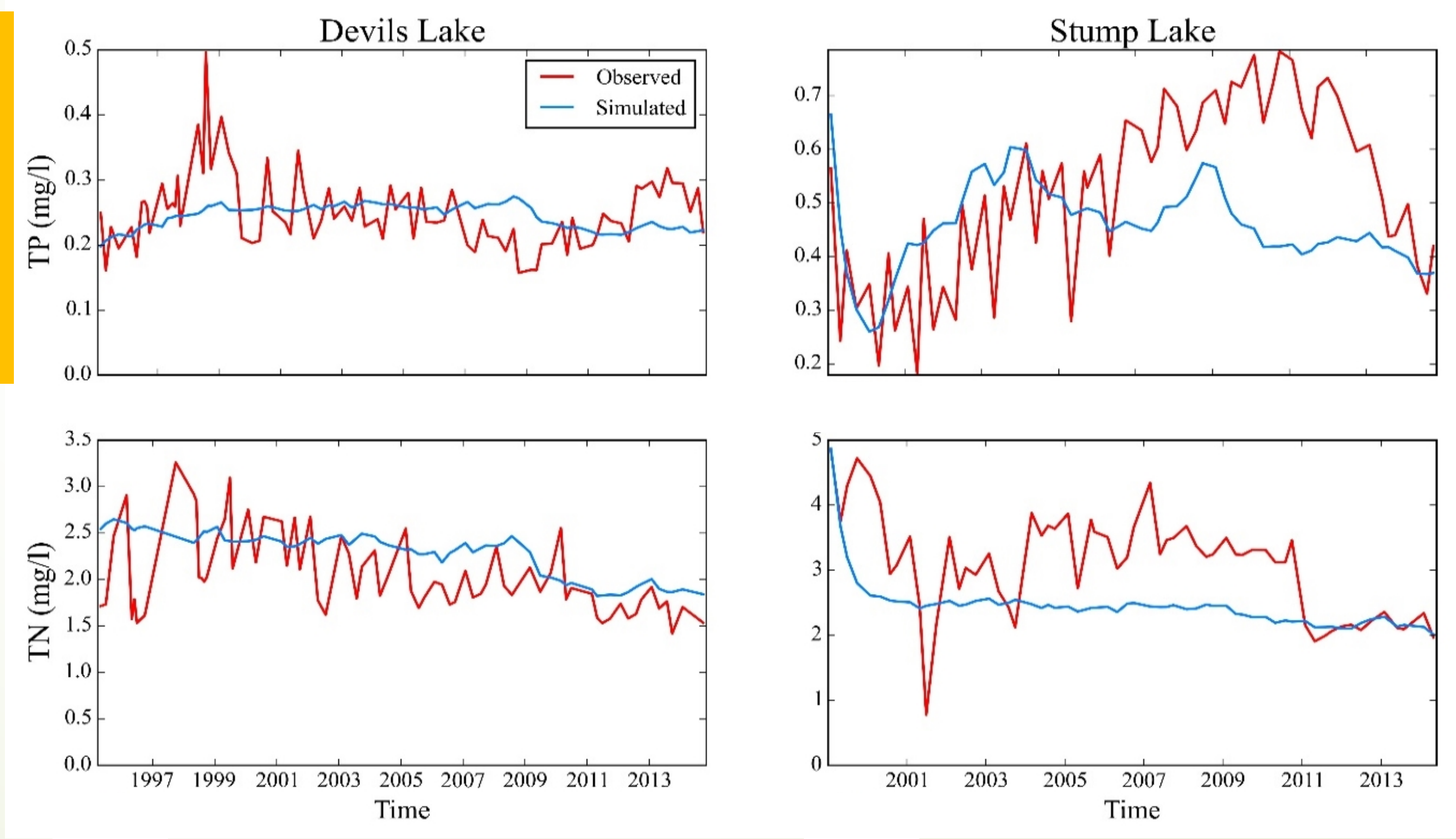
Devils Lake Nutrients

Average TP and TN agreeing within 20% and 15% with the measured concentrations



Phosphorus

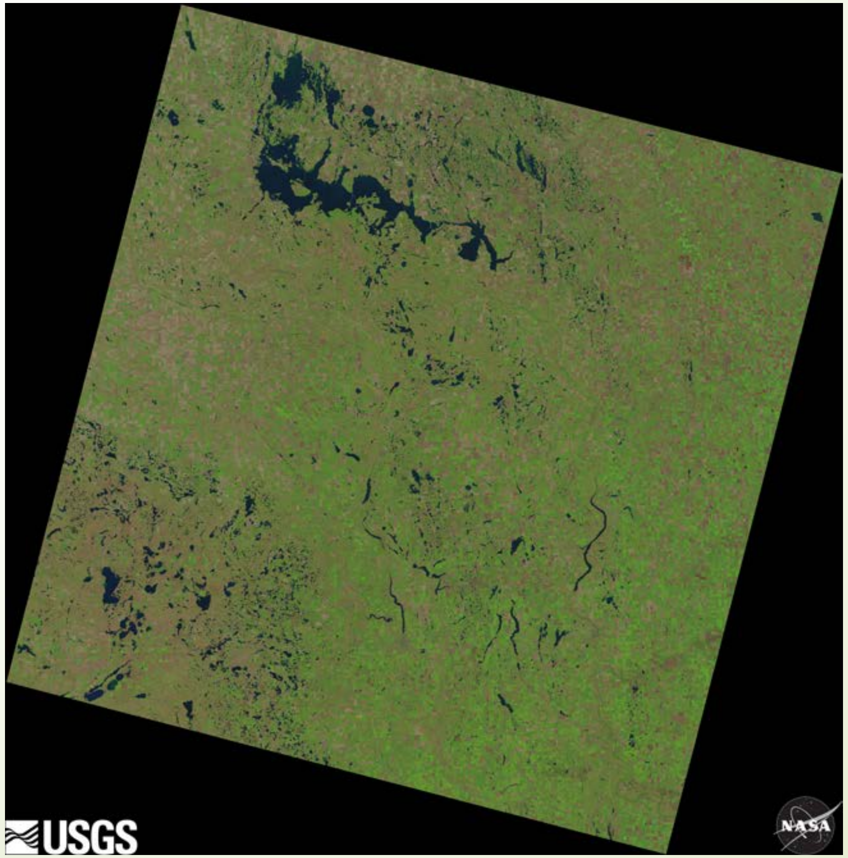
Nitrogen

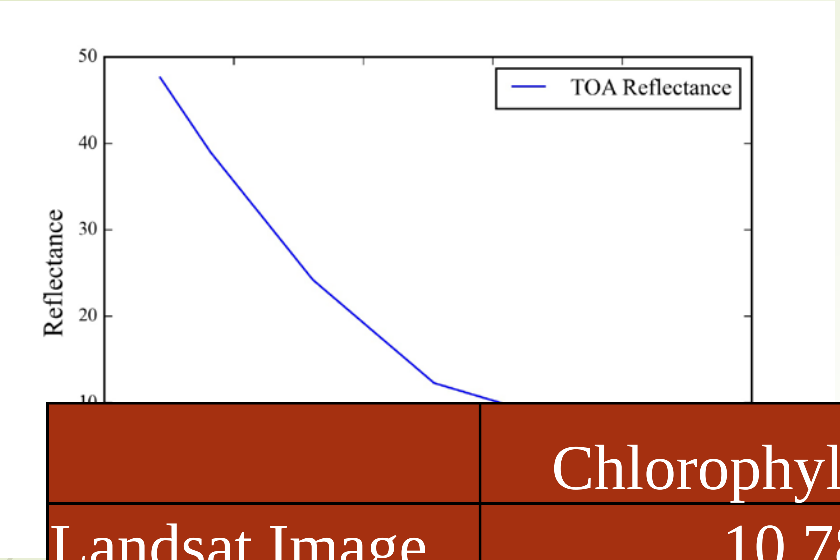


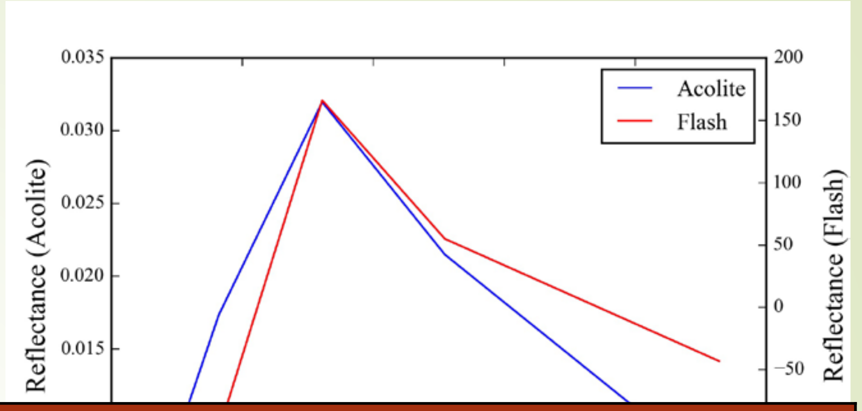
Conclusion

	Upstream	Lakes		Sheyenne River
		Devils Lake	Stump Lake	
TSS (mg/l)	20-105	----	-----	21-95
TP (mg/l)	0.4	0.25	0.52	0.25
TN (mg/l)	1.9	2.0	3.0	1.4

Buoy and Satellite Image

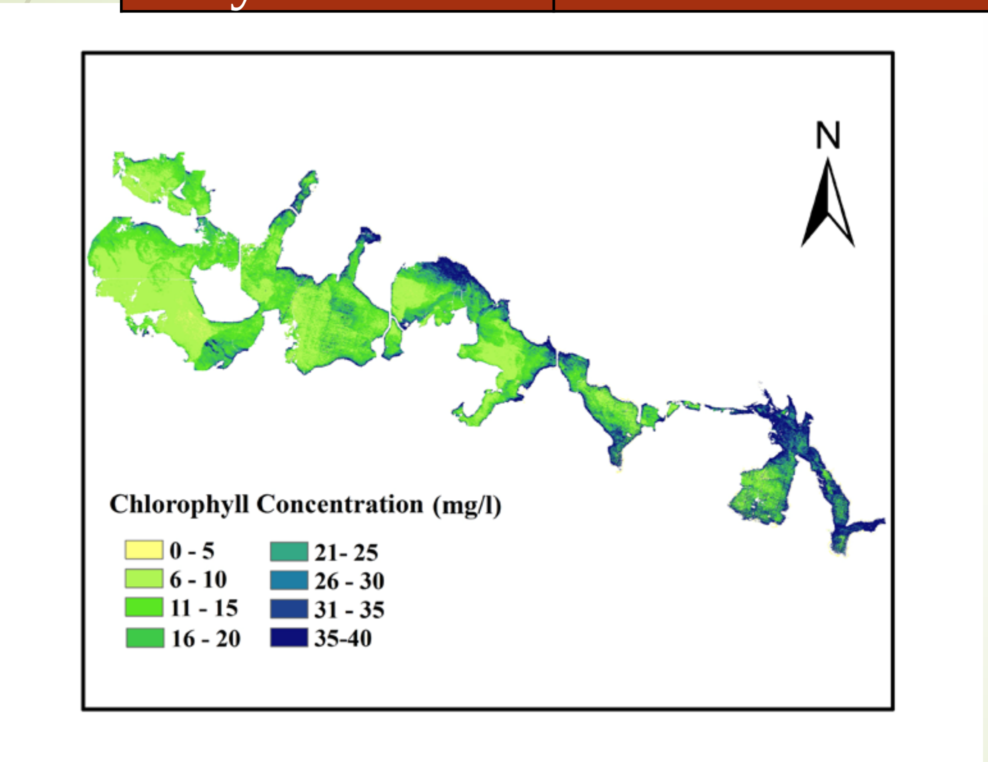


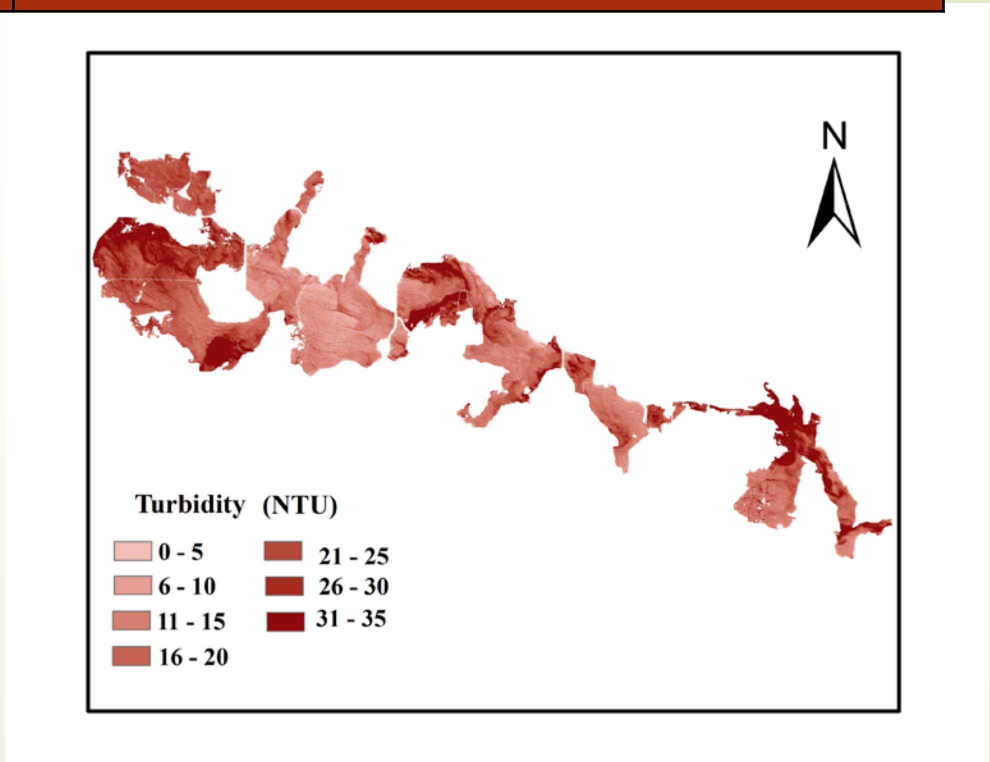




	Chlorophyll (mg/l)	Turbidity (NTU)
Landsat Image	10.78	7.9
Buoy	3.7	7.2

Tc ... nce





Acknowledgment

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Thanks to

Ms. Rochelle Nustad
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Dr.Gehendra Kharel

Thank you

	Flow Parameters	Initial	Fitted
1	Moisture condition II curve number (CN_2)	#	R (-0.097)
2	Available water capacity (SOL_AWC)	#	R (-0.038)
3	Saturated hydraulic conductivity (mm/hr) (SOL_K)	#	R (-0.286)
4	Soil Albedo (SOL_ALB)	#	-0.099
5	Baseflow recession constant (ALPHA_BF)	0.048	0.10
6	Delay time for aquifer recharge (days)	31	242
7	Threshold water level in shallow aquifer for revap (mm H_2O) (REVAPMN)	750	94
8	Revap coefficient (GW_REVAP)	0.02	0.36
9	Initial depth of water in shallow aquifer (mm) (SHALLST)	1000	748
10	Aquifer percolation coefficient (RCHRG_DP)	0.05	0.33
11	Plant uptake compensation factor (EPCO)	1.0	0.99
12	Soil evaporation compensation coefficient (ESCO)	0.95	1.0
13	Manning's value for overland flow (OV_N)	0.14	0.01
14	Manning's value for main channel (CH_N2)	0.014	0.069
15	Effective hydraulic conductivity in main channel (mm/hr) (CH-K2)	2.0	116.79
16	Surface runoff lag coefficient (SURLAG)	1.0	4.51
17	Mean air temperature at which precipitation is equally likely to be rain as snow/freezing rain (° C) (SFTMP)	0.5	1.13
18	Threshold temperature for snow melt (° C) (SMTMP)	4.5	5.00
19	Melt factor on June 21 (mm H_2O/day-°C) (SMFMX)	4.5	7.39
20	Melt factor on December 21 (mm H_2O/day-°C)	1.0	5.53
21	Snow temperature lag factor (TIMP)	2.0	0.91

Flow

		Calibration period			Validation period		
Sub-watersheds	Number of Observation	R^2	E_{NS}	PBIAS (%)	R^2	E_{NS}	PBIAS (%)
M.C-N.3	240	0.67	0.67**	-6.8***	0.75	0.70**	-33
M.C-CANDO	240	0.69	0.67**	-7.3***	0.66	0.60*	-46.3
E.C-EDMORE	240	0.77	0.74**	-7.6***	0.68	0.64*	13*
STARK WEAHTHER	240	0.60	0.51*	1.9***	0.74	0.72**	17.5*
E.C.WEBSTER	240	0.86	0.85***	3.7***	0.81	0.64**	4.0***
LITTLE COULEE	202	0.76	0.63**	-90	0.55	0.43	-13*

***** Very good simulation: $0.75 < E_{NS} \leq 1.0$, PBIAS < ±10%**

**** Good simulation: $0.65 < E_{NS} \leq 0.75$, ±10% ≤ PBIAS < ±15%**

*** Satisfactory simulation: $0.50 < E_{NS} \leq 0.65$, ±15% ≤ PBIAS < ±25%**

Unsatisfactory simulation: $E_{NS} \leq 0.50$, PBIAS > ±25% (Moriasi et al., 2007)

Sediment

Subwatershed	Number of observation	Calibration period			Validation period		
		R^2	E_{NS}	PBIAS (%)	R^2	E_{NS}	PBIAS (%)
E.C. Edmore	155	0.57	056*	18**	0.53	0.52*	-16**
Starkweather	69	0.70	0.70**	-5.5***	0.2	0.15	6.0***

***** Very good simulation: 0.75 < E_{NS} ≤ 1.0 , PBIAS < ±15%**
**** Good simulation: 0.65 < E_{NS} ≤ 0.75 , ±15% ≤ PBIAS < ±30%**
*** Satisfactory simulation: 0.50 < E_{NS} ≤ 0.65 , ±30% ≤ PBIAS < ±55%**
Unsatisfactory simulation: E_{NS} ≤ 0.50 , PBIAS > ±55% (Moriasi et al., 2007)

Parameter	Initial	Fitted
Channel erodibility factor (CH_COV1)	0.0	0.03
Channel cover factor (CH_COV2)	0.0	0.4
Exponent in sediment transport equation (SPEXP)	1.0	1.4
Sediment transport cofficient (SPCON)	0.0001	0.01
USLE support practice factor (USLE_P)	1.0	0.01
Concentration of sediment in lateral and ground water flow (mg/l) (LAT_SED)	0.0	89.0
USLE soil erodibility factor (0.013 metric ton $m^2hr/(m^3$ metric ton cm)) (USLE _K)	#	R (-0.28)

Nutrients

Parameter	Initial	Fitted
Local rate constant for organic phosphorus mineralization 20° C (day $^{-1}$) (BC4)	0.35	0.133
Local settling rate for organic phosphorus at 20° C (day $^{-1}$) (RS5)	0.05	0.014
Benthos (sediment) source rate for soluble phosphorus 20° C (mg P/m^2-day) (RS2)	0.05	0.095
Organic P in baseflow (mg/l) (LAT_ORGP)	0.0	190.3
Soluble phosphorus concentration in ground water flow (mg P/l) (GWSLOP)	0.0	924.0
Or		
Ph		
Ph		
Ph		
Ph		
Ph		

Subwatershed		Number of observation	Calibration period			Validation period		
			R^2	E_{NS}	PBIAS (%)	R^2	E_{NS}	PBIAS (%)
Phosphorus	M.C. Cando	117	0.62	0.63*	0.17***	0.71	0.73**	-13*
	E.C. Edmore	126	0.61	0.65*	28**	0.62	0.47	0.5***
Nitrogen	M.C. Cando	118	0.4	0.32	-42*	0.36	0.32	-47*
	E.C. Edmore	126	0.71	0.74**	-17***	0.55	0.12	-10***

***** Very good simulation: $0.75 < E_{NS} \leq 1.0$, PBIAS < ±25%**

**** Good simulation: $0.65 < E_{NS} \leq 0.75$, ±25% ≤ PBIAS < ±40%**

*** Satisfactory simulation: $0.50 < E_{NS} \leq 0.65$, ±40%≤ PBIAS < ±70%**

Unsatisfactory simulation: $E_{NS} \leq 0.50$, PBIAS > ±70% (Moriasi et al., 2007)

	CH_OC2 (mg/l)	CH_OC3 (mg/l)	DOGLIOTTI (NTU)	DOGLIOTTI_NIR (NTU)	DOGLIOTI_RED (NTU)	GARABA (NTU)	NECHAD (NTU)
Image	11.38	10.78	2.40	7.95	2.40	2.36	2.40
Buoy	3.7	3.7	7.2	7.2	7.2	7.2	7.2