Water Quality Model for Brewster Lake

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COMSOL CONFERENCE
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Study Goal

Develop a dynamic water quality model for Brewster lake using explicit “process-oriented” mechanistic basis that includes the chemical and biological interactions that take place in the lake.

Why This Study:

Most lake water quality models (studies) use steady-state input-output “data-oriented” mass balance equations.

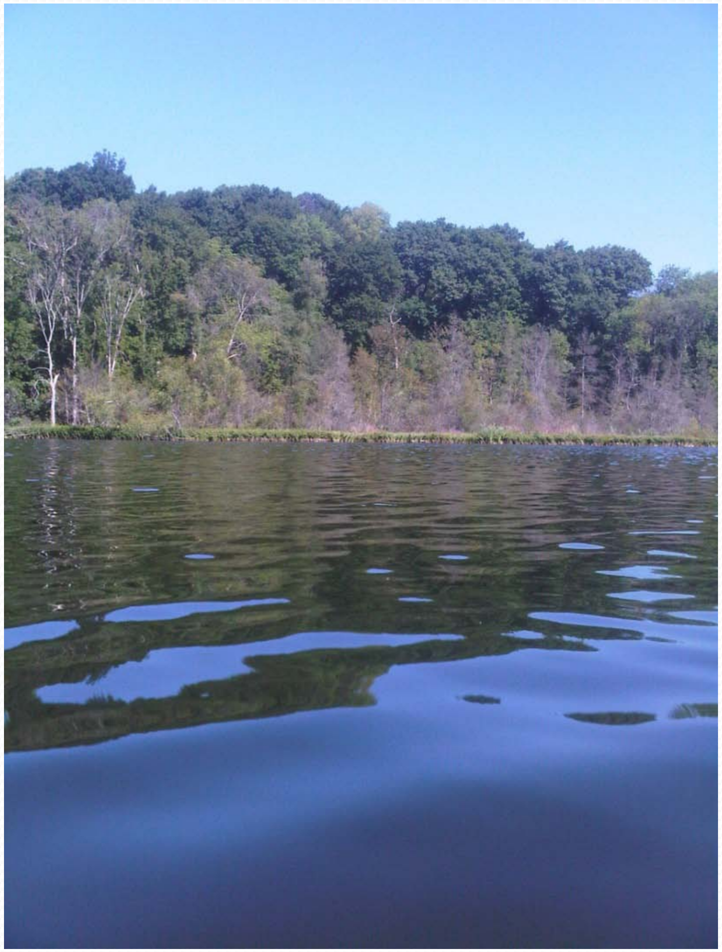
Objectives

- Collect/obtain physical data of the lake.
- Develop a graphical model of the lake.
- Perform hydrodynamic analysis of the lake's watershed - water budget.
- Collect and analyze water samples for a set of water quality variables.
- Obtain atmospheric/weather data.
- Develop/derive a mathematical model for the lake's water quality.
- Develop a numerical model.
- Perform water quality simulations using COMSOL Multiphysics®.

Study Location

Pierce Cedar Creek Biological Field Station, Barry County, Southwest MI

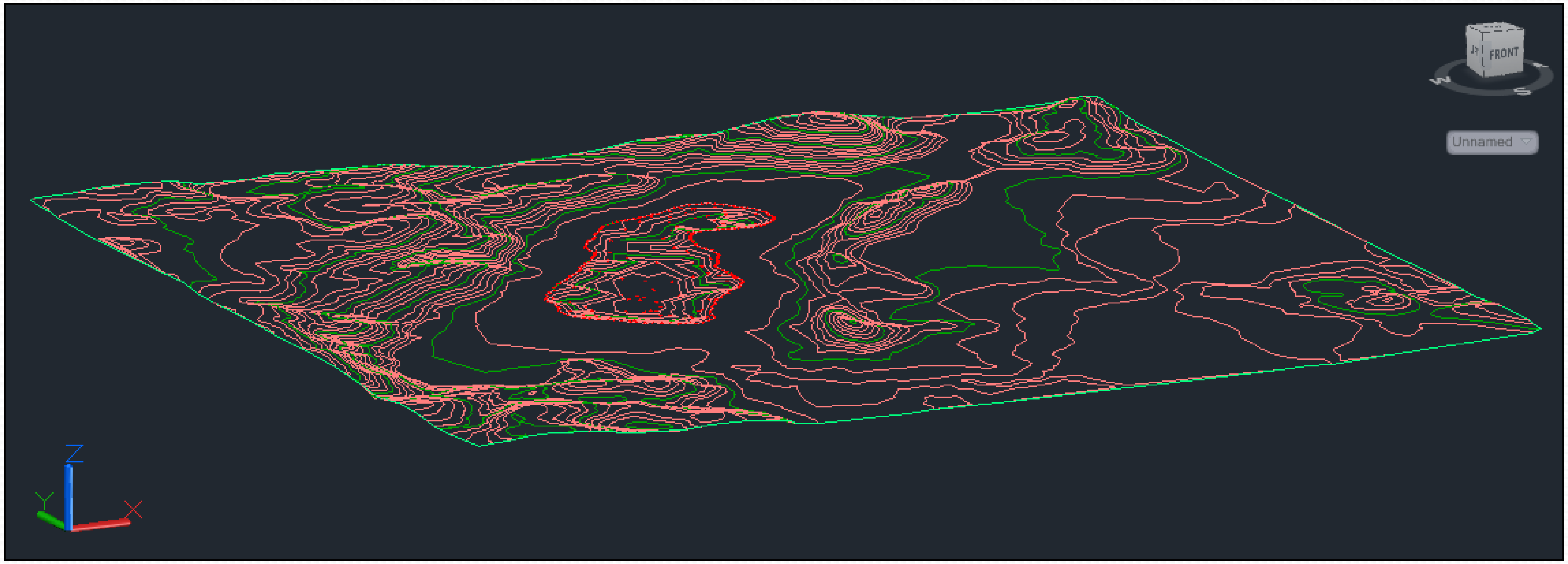
Brewster Lake



Physical Data Collected

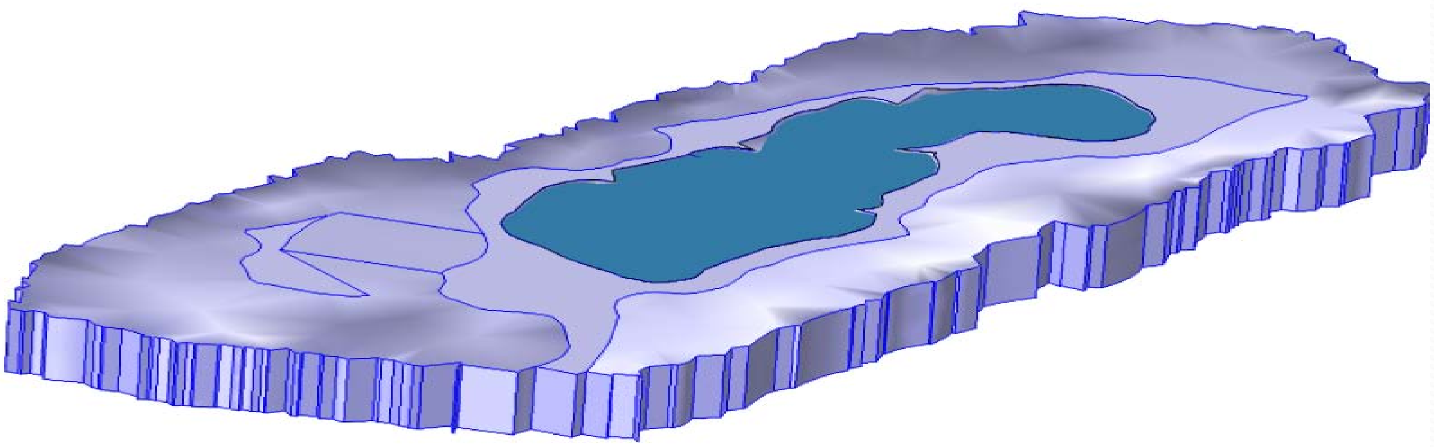
- Bathymetric data – lake depth
- USGS topographic data – watershed delineation
- GPS data
- Field dimensional measurements
- Google areal images
- Lake elevations
- Outlet flow rate measurements

Graphical Model – Brewster Lake



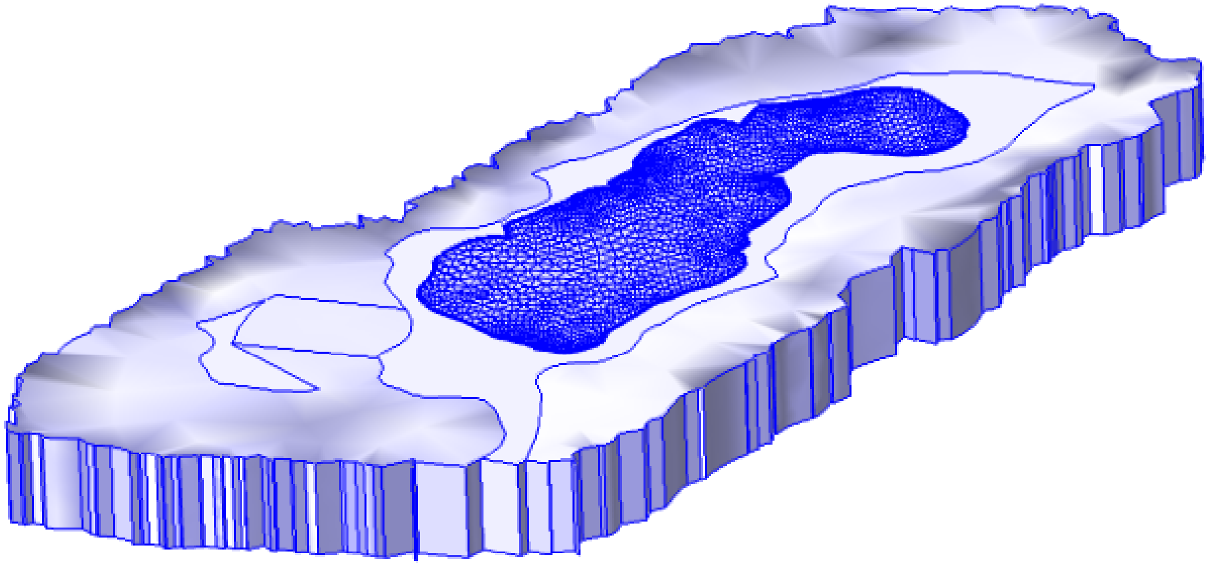
AutoCAD Civil 3D 2013

Graphical Model – Brewster Lake



COMSOL Multiphysics®

Graphical Model – Brewster Lake



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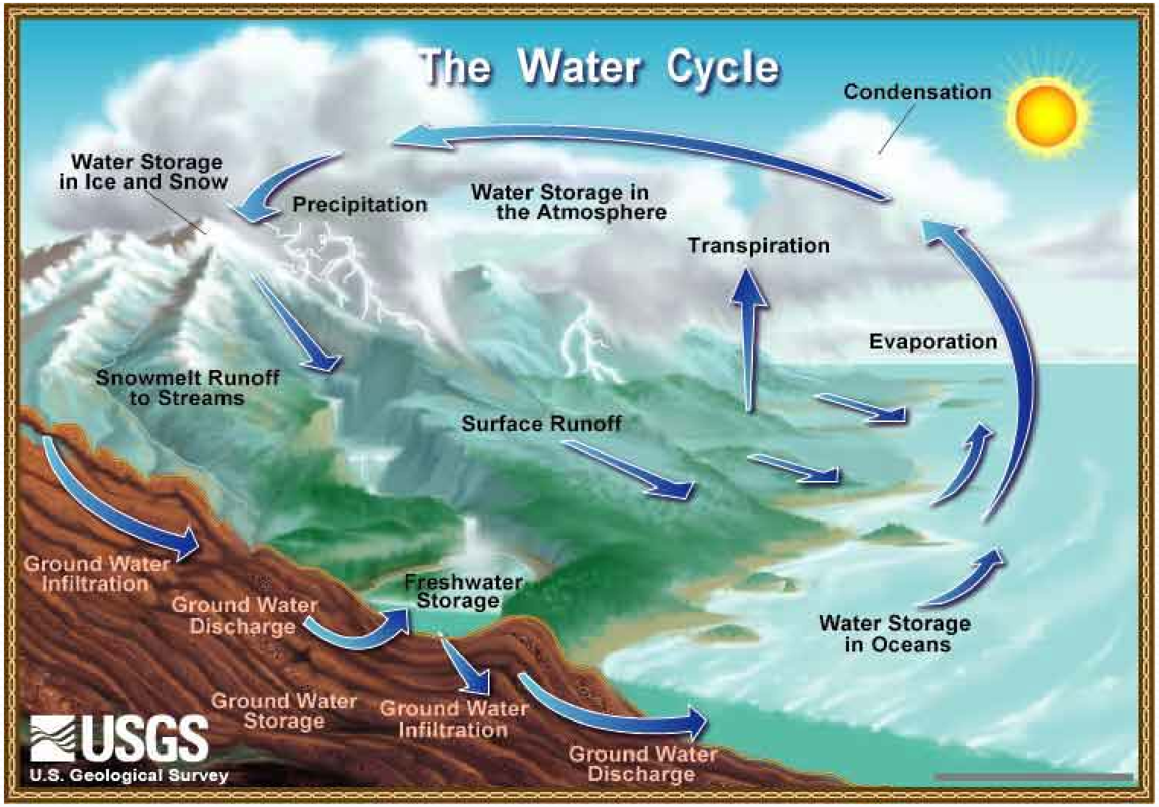
Hydrodynamic Analysis – Water Budget

Used the USGS conceptual model to perform the hydrodynamic analysis

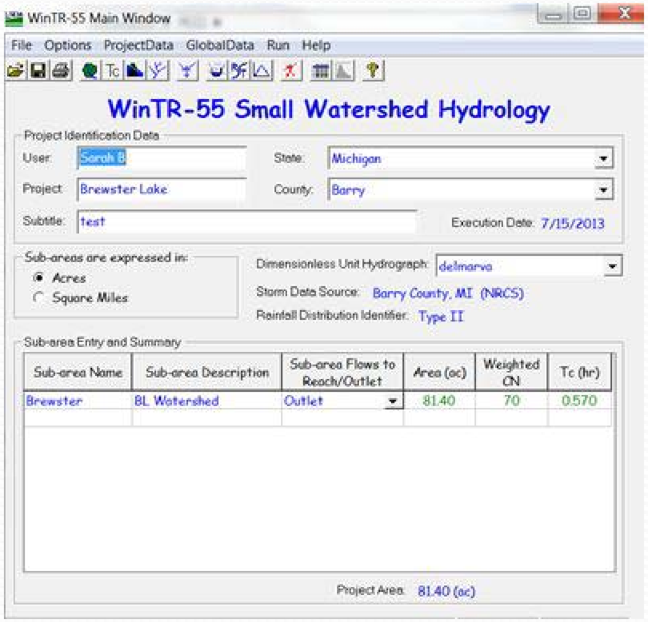


4 main components

- Runoff
- Groundwater
- Evaporation
- Precipitation

Hydrodynamic Analysis – Water Budget

- Runoff and Precipitation was calculated using TR-55

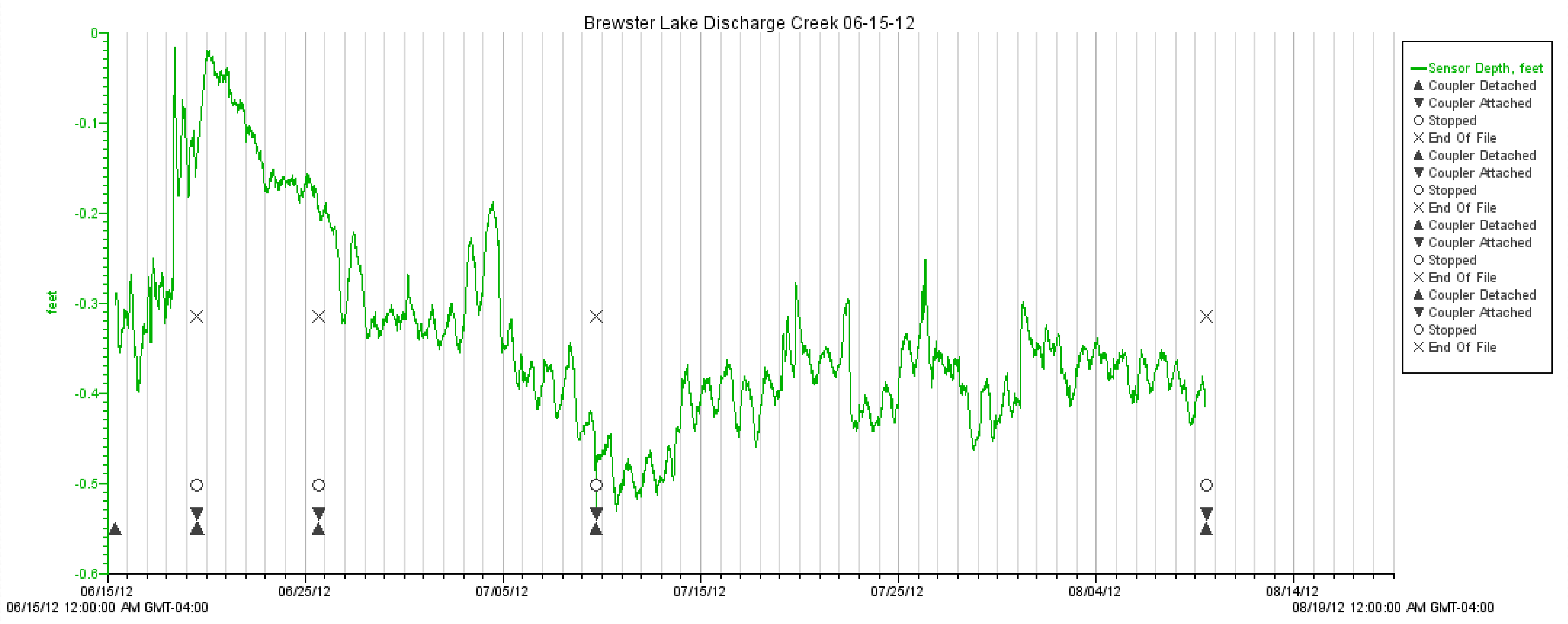


- Evaporation was estimated using a mathematical model
- Groundwater was estimated by using a water budget balance

Hydrodynamic Analysis – Water Budget

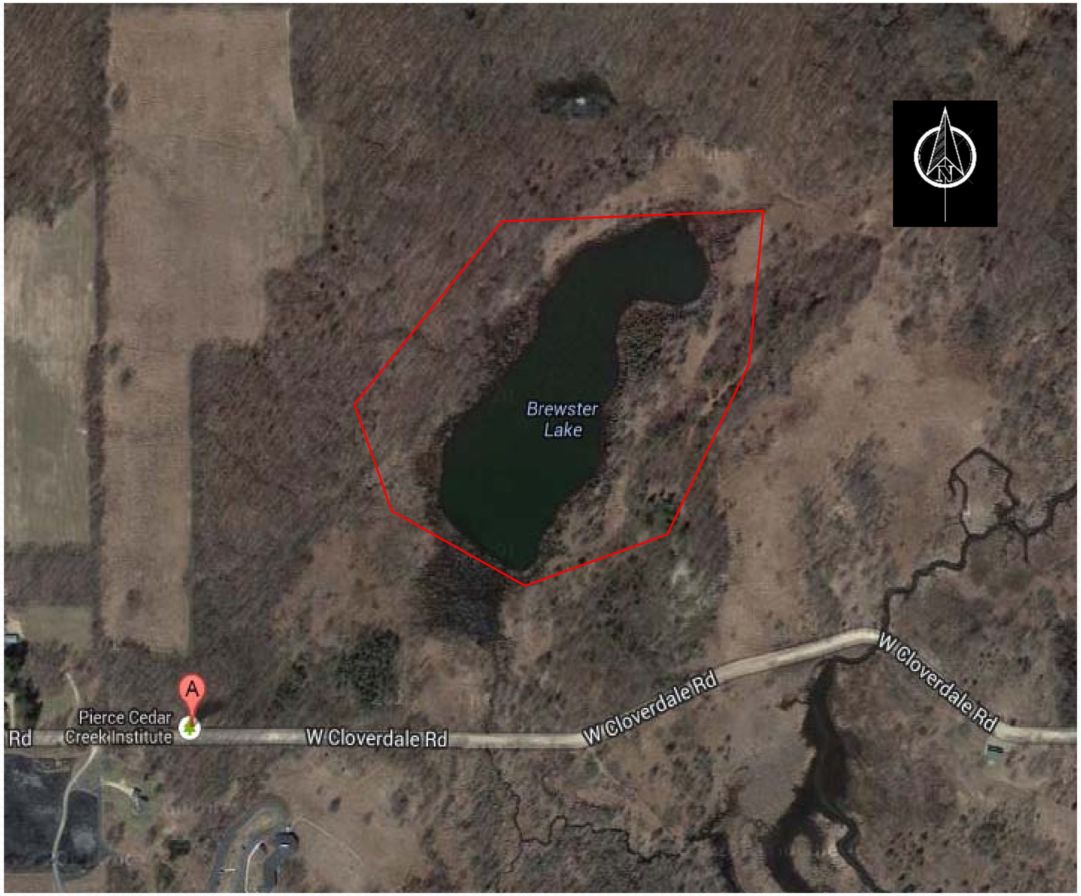
Lake Water Level Monitoring

Hydrodynamic Analysis – Water Budget



Outlet flow rate measurements

Hydrodynamic Analysis – Water Budget



L-THIA 2.0 web-based watershed software – Purdue University

Watershed Analysis

Hydrodynamic Analysis – Water Budget

L-THIA Basic Input

- **Name to identify output:** wdcjy22636
- **State :** Michigan
- **County :** Barry
- **Area in :** acres

LAND USE	HYD. SOIL GROUP	1	2	3
		SCENARIO 1	SCENARIO 2	SCENARIO 3
Water/Wetlands	B	7.4		
Agricultural	B	7.1		
Grass/Pasture	B	22.2		
Forest	B	61.7		
SELECT LANDUSE	A			
SELECT LANDUSE	A			
SELECT LANDUSE	A			
SELECT LANDUSE	A			
	Total Area	98.5	0	0

Hydrodynamic Analysis – Water Budget

L-THIA OUTPUT

Scenario Name : wdcjy22636
Total area : 98.5 acres
State : Michigan
County : Barry

Link To GIS RAINFALL DATA Text File

Average Annual Runoff Volume for SCENARIO 1			
Land Use	**Hydrologic Soil Group**	**Area (acres)**	**Average Annual Runoff Volume (acre-ft)**
Water/Wetlands	B	7.4	0
Agricultural	B	7.1	1.07
Grass/Pasture	B	22.2	1.01
Forest	B	61.7	1.68
	Total Annual Volume (acre-ft)		3.77
	Average Annual Runoff Depth (in)		0.46

Average Runoff Depth For Hydrologic Soil Group And Landuse Combination			
Land Use	**Hydrologic Soil Group**	**Curve Number**	**Runoff Depth (in)**
Water/Wetlands	B	0	0
Agricultural	B	75	1.82
Grass/Pasture	B	61	0.55
Forest	B	55	0.33
Average Annual Rainfall Depth (in)			32.06

Hydrodynamic Analysis – Water Budget

Weeks	Rainfall total (in)	Rainfall Average (in/day)	Runoff (cfs)	Evaporation (in)	Temperature (F)	Relative Humidity (%)	Wind Speed (kt)
May 26 -June 1	0.99	0.14	0	1.13	66.7	70.9	9.1
June 2 - June 8	0	0.00	0	1.25	60.2	61.5	6.9
June 9 - June 15	1.19	0.17	0	1.25	68.3	73.6	7.2
June 16 – June 22	0.18	0.03	0	1.25	70.9	59.9	7
June 23 - June 29	11.67	1.67	2	1.25	73.8	74.2	7.4
June 30 - July 6	10.92	1.56	1.36	1.44	69.7	69.6	6.2
July 7 -July 13	6.59	0.94	0	1.44	73.1	72.8	6.4
July 14 - July 20	18.29	2.61	14.99	1.44	80.8	70.4	6.6
July 21 - July 27	10.14	1.45	0.83	1.44	68.1	70.5	6.8
July 28 - August 3	20.54	2.93	21.52	1.13	64.4	77.8	6.7

Weekly Weather Averages

Hydrodynamic Analysis – Water Budget

Weeks	Average discharge (cfs)	Volume of Discharge (m^3)	Volume of evaporation (m^3)
June 16 – 22	2.133	36529.8	1682.8
June 23- 29	1.69	28943.0	1682.8
June 30 – July 6	1.117	19129.8	1935.2
July 7 - 13	1.214	20791.0	1935.2
July 14 - 20	1.366	23394.2	1935.2
July 21 – 27	1.188	20345.7	1935.2
July 28 – August 3	1.099	18821.5	1514.5

Weekly Water Budget

Hydrodynamic Analysis – Water Budget

Weeks	Volume of Runoff (m³)	Average Delta height (m)	Change in Volume (m³)	Groundwater Volume (m³)
June 16 – 22	0.0	0.143	7579	45791.6
June 23- 29	34252.1	0.122	6466	2839.7
June 30 – July 6	23291.4	-0.239	-12667	-14893.5
July 7 - 13	0.0	-0.314	-16642	6084.2
July 14 - 20	256719.2	-0.2	-10600	-241989.9
July 21 – 27	14214.6	-0.148	-7844	222.3
July 28 – August 3	368552.1	-0.028	-1484	-349700.2

Weekly Water Budget – Groundwater Flow Rate

Nutrient Loading to the Lake from Watershed

Scenario Name : wdcjy22636
Total area : 98.5
State : Michigan
County : Barry

NPS Nitrogen losses

Land Use	SCENARIO 1 (lbs)
Water/Wetlands	0
Agricultural	13
Grass/Pasture	1
Forest	3
Total/Scenario	17

Avg Annual Concentration (ppm)	1.681

Scenario Name : wdcjy22636
Total area : 98.5
State : Michigan
County : Barry

NPS Phosphorous losses

Land Use	SCENARIO 1 (lbs)
Water/Wetlands	0
Agricultural	3
Grass/Pasture	0.027
Forest	0.046
Total/Scenario	3.073

Avg Annual Concentration (ppm)	0.304

Scenario Name : wdcjy22636
Total area : 98.5
State : Michigan
County : Barry

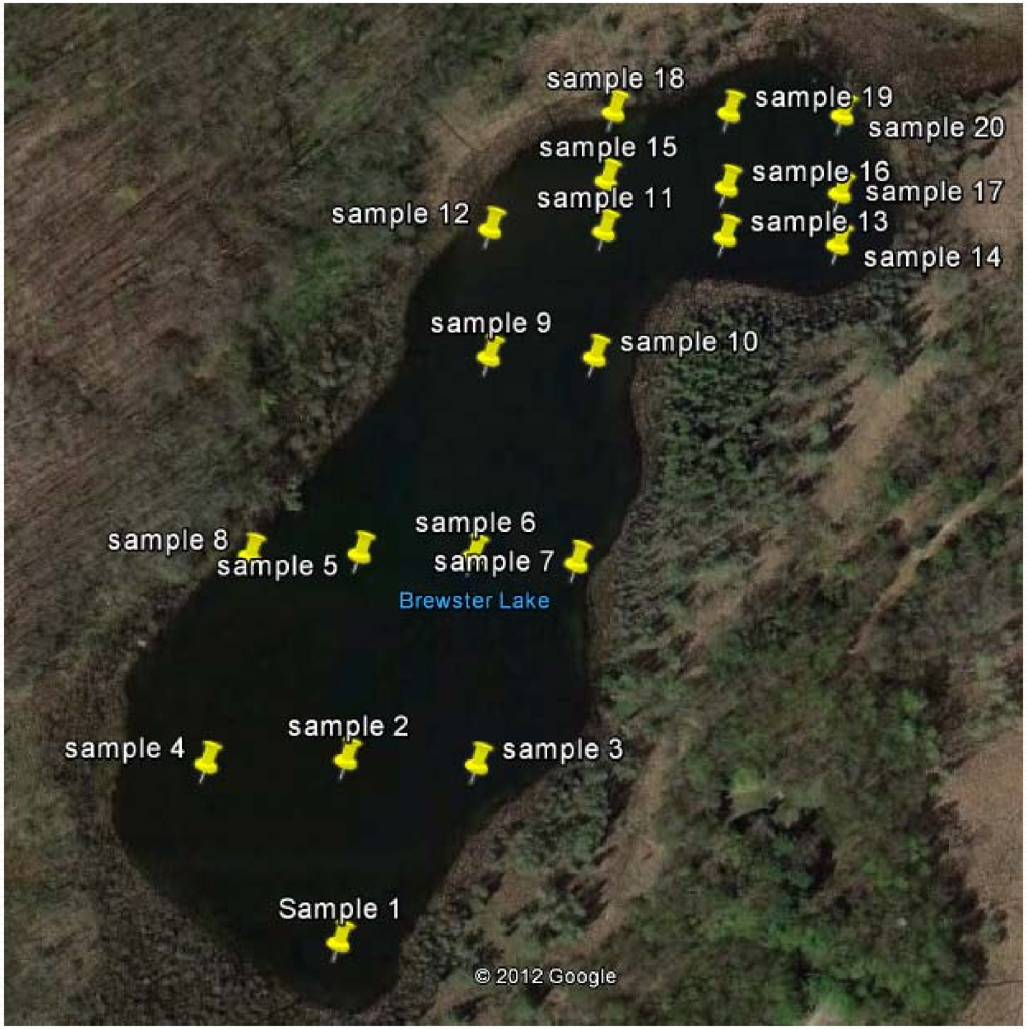
NPS BOD losses

Land Use	SCENARIO 1 (lbs)
Water/Wetlands	0
Agricultural	11
Grass/Pasture	1
Forest	2
Total/Scenario	14

Avg Annual Concentration (ppm)	1.385

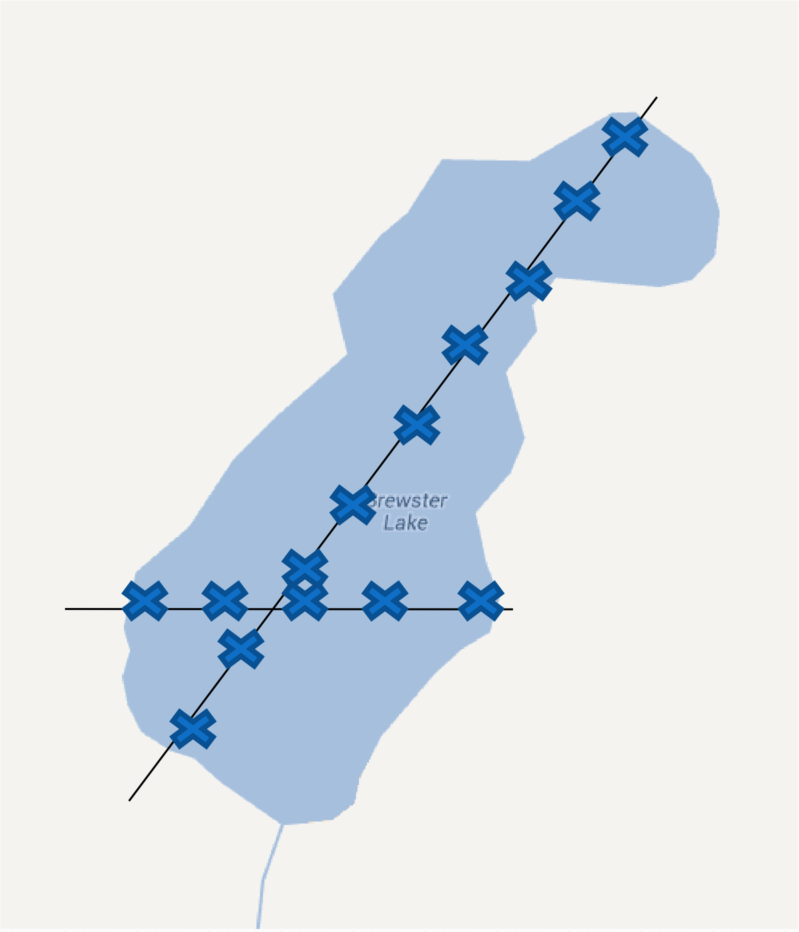
Monitoring Plan/Design

Monitoring Plan/Design



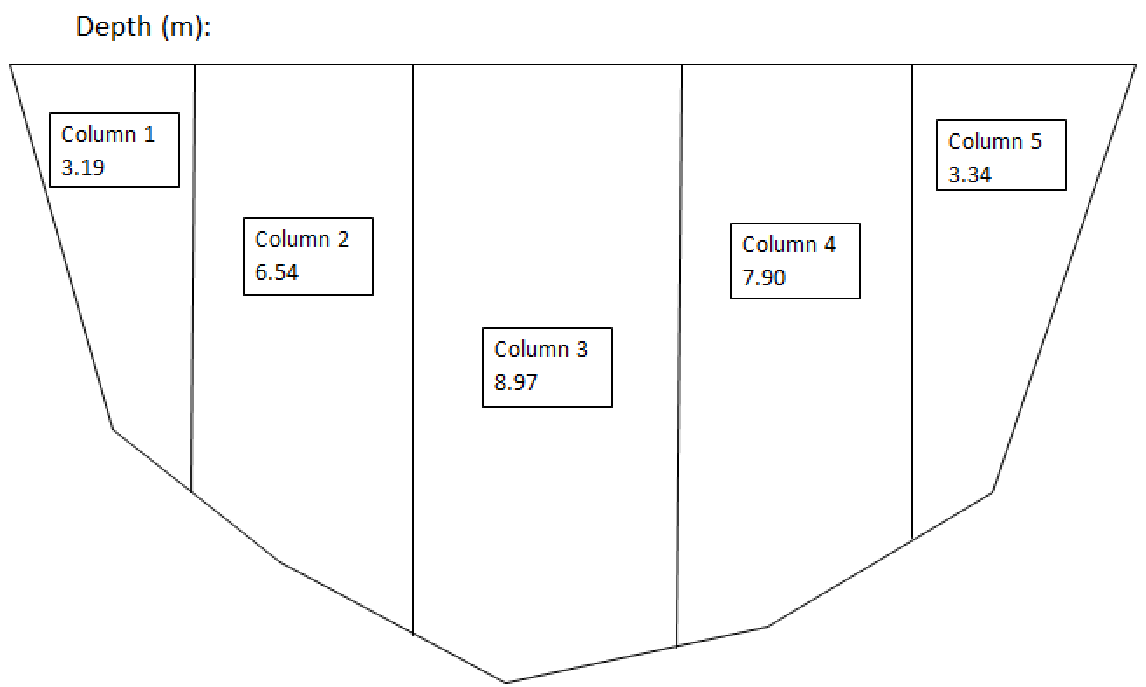
Monitoring Plan

- 2 cross sections
- 14 water columns
- 3 sampling depths



Monitoring Plan

E-W Cross Section

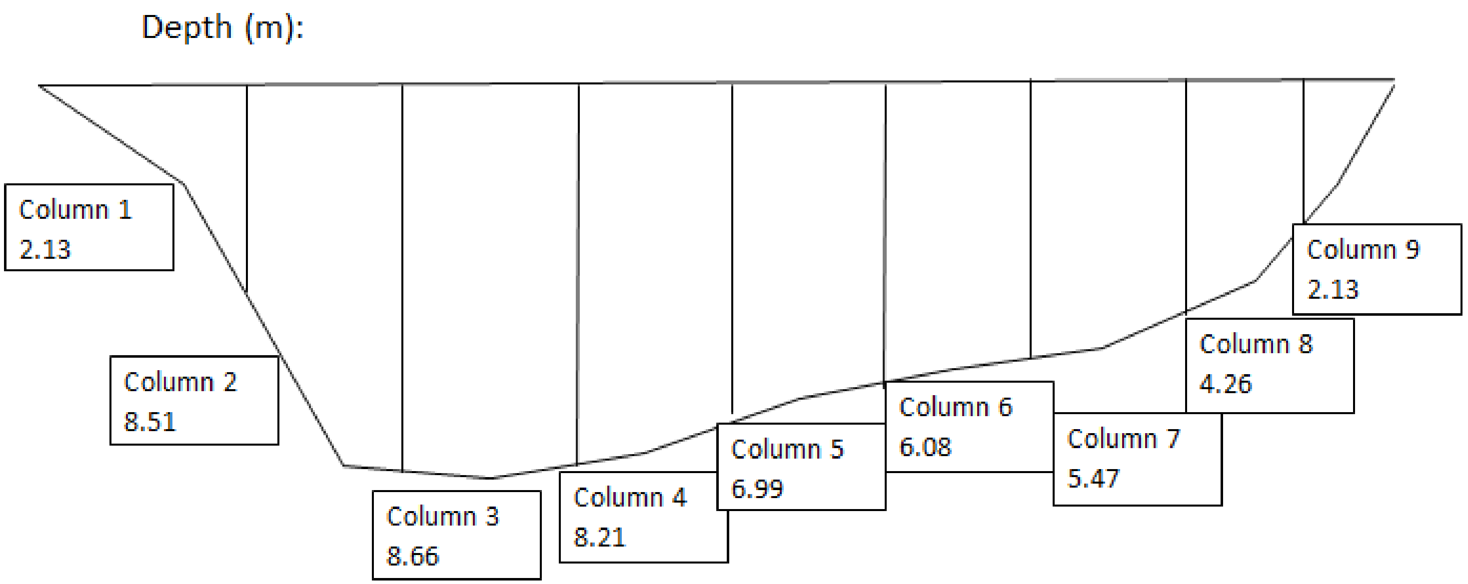


EW cross-section

1 16639866 E 4711109 N	2 16639837 E 4711126 N	3 16639807 E 4711144 N	4 16639778 E 4711162 N	5 16639749 E 4711179 N

Monitoring Plan

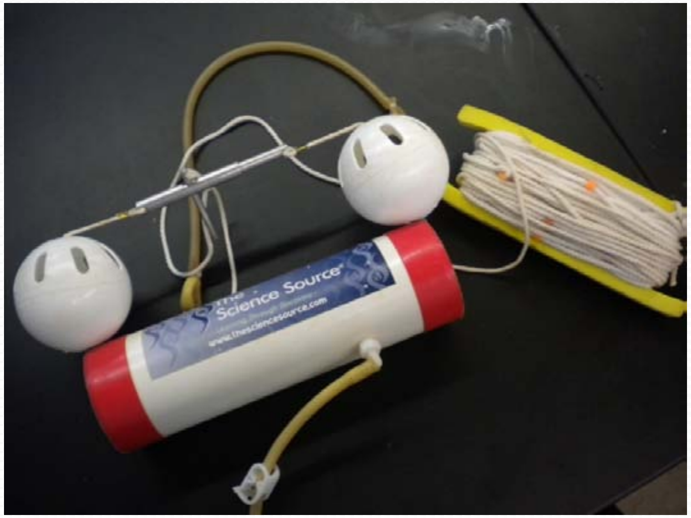
NE-SW Cross Section

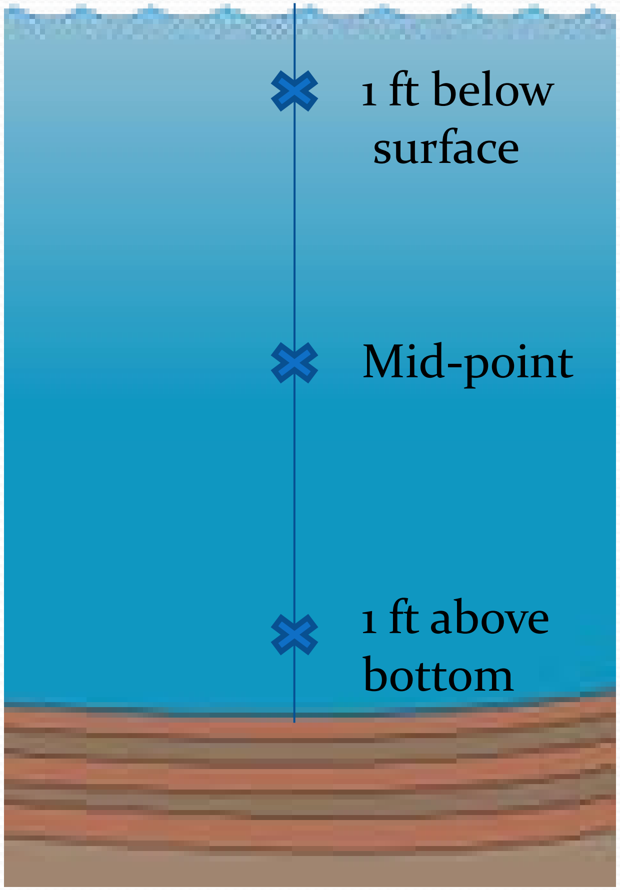


NS cross-section

1 16639718 E 4711041 N	2 16639745 E 4711081 N	3 16639772 E 4711121 N	4 16639799 E 4711161 N	5 16639826 E 4711201 N	6 16639854 E 4711241 N	7 16639881 E 4711281 N	8 16639908 E 4711321 N	9 16639935 E 4711361 N

Monitoring and Sampling





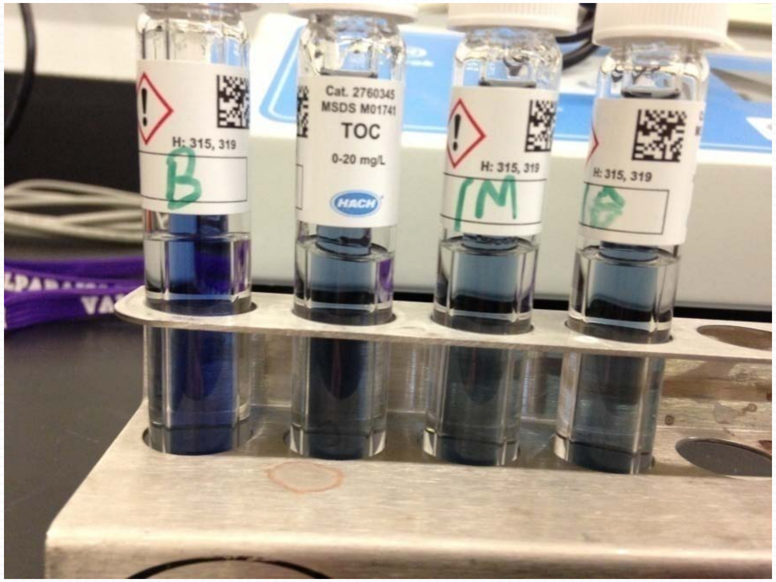
Monitoring and Sampling

- 14 water columns
- 3 sampling depths

- YSI Unit In-lake measurements
  - Dissolved Oxygen
  - Temperature
  - pH
  - Conductivity
- Water Sampler

Lab Analyses

- 8 Parameters
  - Total Nitrogen
  - Total Phosphorus
  - Reactive Phosphorus
  - Ammonia
  - Nitrates
  - Chemical Oxygen Demand
  - Biochemical Oxygen Demand
  - Total Organic Content



Modeling Process

Variable Notation Concentration Units:

C_1 = Ammonia Nitrogen NH_3, mg N/L
C_2 = Nitrate Nitrogen NO_3, mg N/L
C_3 = Inorganic Phosphorus PO_4, mg P/L
C_4 = Phytoplankton Carbon PHYT, mg C/L
C_5 = Carbonaceous BOD CBOD, mg O_2/L
C_6 = Dissolved Oxygen DO, mg O_2/L
C_7 = Organic Nitrogen ON, mg N/L
C_8 = Organic Phosphorus OP, mg P/L

Modeling Process

Wool, et al., 2006 (WASP6 Manual):

Dissolved Oxygen DO, mg O_2/L

$$\frac{dC_6}{dt} = k_2(C_S - C_6) - k_d 1.047^{(T-20)}\frac{C_6}{k_{BOD} + C_6}C_5 - \frac{64}{14}k_{12}1.08^{(T-20)}\frac{C_6}{k_{NIT} + C_6}C_1 - \frac{SOD}{D}1.08^{(T-20)} + G_P\left(\frac{32}{12} + \frac{12}{14}(1 - P_{NH_3})\right)C_4 - \frac{32}{12}k_{1R}1.045^{(T-20)}C_4$$

$$\ln C_s = -139.34 + (1.5757x10^5)T_K^{-1} - (6.6423x10^7)T_K^{-2} + (1.2438x10^{10})T_K^{-3} - (8.6219x10^{11})T_K^{-4} - 0.5535\,S\,(0.031929 - 19.428T_K^{-1} + 3867.3T_K^{-2}$$

$$\frac{dC_5}{dt} = (\frac{32}{12})k_{1d}C_{PHYT} - k_d 1.047^{(T-20)}\frac{C_6}{k_{BOD} + C_6}C_5 - \frac{V_{s3}}{2D}C_5 - (\frac{5}{4})(\frac{32}{14})k_{2d}1.08^{(T-20)}\left(\frac{k_{NO_3}}{k_{NO_3} + C_6}\right)C_2$$

Modeling Process

Ammonia Nitrogen

$$\frac{\partial C_1}{\partial t} = D_{pl} a_{NC} (1 - f_{on}) C_4 + k_{71} \Theta_{71}^{(T-20)} \left(\frac{C_4}{K_{mPc} + C_4} \right) C_7 - G_{pl} a_{NC} P_{NH3} C_4$$

Nitrate Nitrogen

$$\frac{\partial C_2}{\partial t} = k_{12} \Theta_{12}^{(T-20)} \left(\frac{C_6}{K_{NIT} + C_6} \right) C_1 - G_{pl} a_{NC} (1 - P_{NH3}) C_4 - k_{2D} \Theta_{12}^{(T-20)} \left(\frac{K_{NO3}}{K_{NO3} + C_6} \right) C_2$$

$$P_{NH3} = C_1 \left(\frac{C_2}{(K_{m14} + C_2)(K_{m14} + C_2)} \right) + C_1 \left(\frac{K_{m14}}{(C_1 + C_2)(K_{m14} + C_2)} \right)$$

Modeling Process

Phytoplankton Nitrogen

$$\frac{\partial(C_4 a_{NC})}{\partial t} = G_{pl} a_{NC} C_4 - D_{pl} a_{NC} C_4 - \frac{V_{s4}}{D} a_{NC} C_4$$

Organic Nitrogen

$$\frac{\partial C_7}{\partial t} = D_{pl} a_{NC} f_{on} C_4 - k_{71} \Theta_{71}^{(T-20)} \left(\frac{C_4}{K_{mPc} + C_4} \right) C_1 - \frac{V_{s3}(1 - f_{D7})}{D} C_1$$

Modeling Process

Inorganic Phosphorus

$$\frac{\partial C_3}{\partial t} = D_{Pl}\partial_{pc}\left(1 - f_{op}\right)C_4 + k_{83}\Theta_{83}^{(T-20)}\left(\frac{C_4}{K_{mPc} + C_4}\right)C_8 - G_{Pl}a_{pc}C_4$$

Phytoplankton Phosphorus

$$\frac{\partial(C_4 a_{pc})}{\partial t} = G_{Pl}a_{pc}C_4 - D_{Pl}a_{pc}C_4 - \frac{V_{S4}}{D}a_{pc}C_4$$

Organic Phosphorus

$$\frac{\partial C_8}{\partial t} = D_{Pl}a_{pc}f_{op}C_4 - k_{83}\Theta_{83}^{(T-20)}\left(\frac{C_4}{K_{mPc} + C_4}\right)C_8 - \frac{V_{s3}\left(1 - f_{DB}\right)}{D}C_4$$

Modeling Process

Rearation:

Flow-Induced

Dependent on depth

$d < 2$ ft

$2 < d < 20$ ft

$d > 20$ ft

Wind Induced

Wind velocity

$W < 6$ m/s

$6 < w < 20$ m/s

$w > 20$ m/s

Modeling Process

Rearation:

Flow-Induced

Dependent on depth

d < 2 ft

$$k_{qj}(20°C) = 5.349\, v_j^{0.67}\, D_j^{-1.85}$$

2 < d < 20 ft

$$k_{qj}(20°C) = 5.049\, v_j^{0.97}\, D_j^{-1.67}$$

d > 20 ft

$$k_{qj}(20°C) = 3.93\, v_j^{0.50}\, D_j^{-1.50}$$

Modeling Process

Rearation:

Wind Induced - Wind velocity

W < 6 m/s

$$k_{wj} = \frac{86400}{100\, D_j} \left(\frac{D_{OW}}{\nu_W} \right)^{2/3} \left(\frac{\rho_a}{\rho_W} \right)^{1/2} \frac{\kappa^{1/3}}{\Gamma} \sqrt{C_d}\, (100 \bullet W)$$

6 < w < 20 m/s

$$k_{wj} = \frac{86400}{100\, D_j} \left[(TERM1 \bullet 100\, W\,)^{-1} + (TERM2\, \sqrt{100\, W}\,)^{-1} \right]^{1}$$

w > 20 m/s

$$k_{wj} = \frac{86400}{100\, D_j} \left(\frac{D_{OW}}{\kappa\, z_e} \frac{\rho_a\, \nu_a}{\rho_W\, \nu_W} \sqrt{C_d} \right)^{1/2} \sqrt{100\, W}$$

Acknowledgements

- Pierce Cedar Creek Institute
- Valparaiso University

Q & A

References

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First Round Results

Water Column		Dissolve Oxygen (mg/L)	pH	Temperature (°C)	Conductivity (mS/cm)
	Surface	8.95	8.41	20.18	0.345
1	Middle	8.44	8.04	18.41	0.348
	Bottom	4.10	7.30	17.70	0.423
	S	8.62	8.61	20.01	0.345
2	M	12.94	8.28	15.83	0.363
	B	0.45	6.69	7.58	0.410
	S	8.32	8.47	20.11	0.345
3	M	13.27	7.66	10.70	0.372
	B	0.67	7.05	6.40	0.545
	S	8.65	8.47	20.08	0.345
4	M	14.86	8.33	12.26	0.366
	B	0.55	7.43	6.68	0.474
	S	8.65	8.55	20.35	0.343
5	M	7.75	8.24	18.97	0.328
	B	1.02	7.47	17.29	0.328

First Round Results

Water Column		Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	Ammonia (mg/L)	Nitrates (mg/L)	TOC (mg/L)
	Surface	0.39	0.0	-	-	0.1	7.1
1	Middle	0.34	0.1	-	0.006	0.0	7.3
	Bottom	0.40	0.5	0.03	0.012	0.3	5.9
	S	0.32	0.3	-	-	0.1	6.6
2	M	0.45	1.1	0.01	0.006	0.1	5.2
	B	0.44	1.4	0.13	0.052	0.1	7.1
	S	0.30	1.7	0.07	-	0.1	5.4
3	M	0.37	-	0.001	0.001	0.1	5.0
	B	3.25	5.0	2.29	3	-	15.2
	S	0.40	0.9	0.07	-	0.1	6.8
4	M	0.36	1.8	0.013	0.013	0.1	5.5
	B	1.10	2.0	0.65	1.608	-	7.7
	S	0.29	0.0	-	0.007	0.1	6.6
5	M	0.31	3.4	0.007	0.007	0.1	5.9
	B	0.63	1.2	0.11	0.127	0.1	7.5

Second Round Results

Water Column		Dissolve Oxygen (mg/L)	pH	Temperature (°C)	Conductivity (mS/cm)
1	Surface	7.45	8.12	26.37	0.321
	Middle	7.29	8.20	26.36	0.322
	Bottom	4.62	6.88	26.09	0.334
2	S	7.07	8.33	26.45	0.322
	M	0.40	7.35	15.46	0.393
	B	0.00	6.60	7.64	0.523
3	S	7.47	8.35	26.47	0.323
	M	0.25	7.16	13.88	0.404
	B	0.34	6.55	7.08	0.667
4	S	6.48	8.34	26.47	0.322
	M	0.85	7.37	18.06	0.38
	B	0.40	5.84	8.44	0.482
5	S	6.65	8.41	26.58	0.320
	M	6.62	8.37	26.49	0.321
	B	6.06	8.17	26.33	0.321

Second Round Results

Water Column		Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	Ammonia (mg/L)	Nitrates (mg/L)	TOC (mg/L)	COD (mg/L)	BOD (mg/L)
	Surface	0.440	1.700	0.150	0.006	0.133	5.2	10.900	-
1	Middle	0.393	0.700	0.090	0.003	0.100	5.3	8.500	-
	Bottom	0.330	1.950	0.110	0.004	0.100	4.6	2.700	-
	S	0.297	0.000	0.130	0.020	0.100	4.6	4.633	2.87
2	M	0.247	0.600	0.113	0.007	0.100	2.5	15.567	0.33
	B	2.143	3.500	3.163	4.781	0.700	5.0	5.667	0.51
	S	0.240	0.200	0.097	0.018	0.100	2.7	16.000	-
3	M	0.187	0.000	0.150	0.021	0.100	1.9	3.650	-
	B	6.333	4.900	4.550	6.849	0.667	13.3	24.367	-
	S	0.287	0.600	0.103	0.013	0.100	2.5	5.767	2.34
4	M	0.210	0.600	0.223	0.018	0.133	2.8	10.300	0.22
	B	0.737	2.200	0.710	2.948	0.300	1.6	5.900	0.45
	S	0.243	0.500	0.133	0.021	0.200	2.5	8.233	-
5	M	0.203	0.450	0.110	0.003	0.100	2.6	9.150	-
	B	0.213	0.900	0.110	0.009	0.133	2.5	10.433	-

First Round Results

Water Column		Dissolve Oxygen (mg/L)	pH	Temperature (°C)	Conductivity (mS/cm)
1	Surface	8.51	8.21	22.45	0.343
	Middle	9.69	8.27	21.42	0.341
	Bottom	6.73	8.33	20.98	0.349
2	S	8.22	8.95	22.16	0.343
	M	17.13	8.04	10.93	0.372
	B	0.81	7.54	6.42	0.540
3	S	7.95	9.02	22.80	0.344
	M	15.69	8.94	10.84	0.373
	B	0.87	8.34	6.64	0.548
4	S	7.93	9.02	22.20	0.343
	M	15.92	9.04	11.83	0.371
	B	0.65	8.20	6.50	0.500
5	S	9.62	8.43	23.75	0.323
	M	13.67	8.15	16.04	0.366
	B	0.90	7.52	8.77	0.446
6	S	9.13	8.74	23.81	0.325
	M	10.37	8.25	18.42	0.356
	B	0.67	7.51	9.73	0.425
7	S	8.88	8.58	23.72	0.327
	M	9.20	8.30	20.14	0.335
	B	0.64	7.80	10.17	0.405
8	S	9.64	8.66	23.76	0.322
	M	8.86	8.32	22.15	0.324
	B	0.51	8.35	15.17	0.419
9	S	8.34	8.37	23.82	0.325
	M	8.65	8.38	23.25	0.325
	B	1.10	7.59	22.99	0.367

First Round Results

Water Column		Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	Ammonia (mg/L)	Nitrates (mg/L)	TOC (mg/L)
	Surface	0.22	1.3	0.05	0.005	0.1	6.7
1	Middle	0.25	1.8	0.06	0.019	0.1	6.9
	Bottom	0.26	0.6	0.08	-	0.1	7.8
	S	0.27	0.9	0.07	0.005	0.1	6.6
2	M	0.31	0.8	0.06	0.01	0.2	6.5
	B	2.05	4.1	1.64	2.806	-	7.9
	S	0.25	0.3	0.06	-	0.1	7.2
3	M	0.29	-	0.08	-	0.1	5.5
	B	2.29	6.4	1.96	2.943	-	7.1
	S	0.25	1.8	0.05	-	0.1	5.7
4	M	0.23	-	0.07	-	0.2	6.2
	B	0.68	1.2	0.17	0.444	-	6.7
	S	0.29	-	0.06	-	0.2	6.2
5	M	0.29	0.9	0.05	-	0.1	6.1
	B	0.65	-	0.10	0.371	-	8.5
	S	0.26	-	0.12	-	0.1	6.0
6	M	0.30	-	0.05	-	0.1	6.0
	B	0.45	-	0.20	0.308	0.1	6.7
	S	0.27	-	0.07	-	0.2	6.5
7	M	0.24	-	0.05	-	0.1	8.1
	B	0.98	-	0.12	0.021	0.1	8.5
	S	0.28	-	0.05	-	0.1	6.2
8	M	0.24	-	0.06	-	0.1	6.1
	B	0.54	0.8	0.05	0.122	1.9	8.2
	S	0.32	-	0.05	-	0.1	6.2
9	M	0.34	-	0.07	-	0.1	17.6
	B	0.39	-	0.08	-	0.2	7.3

Second Round Results

Water Column		Dissolve Oxygen (mg/L)	pH	Temperature (°C)	Conductivity (mS/cm)
	Surface	7.11	8.40	26.54	0.322
1	Middle	7.06	8.38	26.55	0.322
	Bottom	5.68	8.00	26.01	0.325
	S	7.66	8.44	26.59	0.322
2	M	0.52	7.40	15.52	0.397
	B	0.58	7.15	7.94	0.522
	S	8.08	8.49	24.14	0.326
3	M	0.50	8.10	14.40	0.400
	B	0.50	7.67	7.17	0.616
	S	7.78	8.87	24.14	0.327
4	M	0.38	8.89	15.84	0.399
	B	0.37	8.00	8.17	0.505
	S	7.22	8.59	24.11	0.327
5	M	1.91	8.13	20.81	0.376
	B	0.39	8.16	10.71	0.448
	S	7.22	8.87	24.18	0.327
6	M	6.70	8.74	23.94	0.327
	B	0.66	8.85	12.11	0.501
	S	6.91	8.68	24.22	0.326
7	M	7.37	8.78	24.16	0.326
	B	0.41	8.45	12.85	0.453
	S	6.26	8.52	24.33	0.324
8	M	7.38	8.65	24.15	0.323
	B	0.48	7.85	18.96	0.567
	S	6.78	8.47	24.33	0.325
9	M	6.69	8.53	24.33	0.325
	B	5.42	8.43	23.75	0.325

Second Round Results

Water Column		Total Phosphorus (mg/L)	Total Nitrogen (mg/L)	Reactive Phosphorus (mg/L)	Ammonia (mg/L)	Nitrates (mg/L)	TOC (mg/L)	COD (mg/L)	BOD (mg/L)
	Surface	0.086	9.63	0.11	0.026	0.10	2.3	13.2	-
1	Middle	0.043	0.70	0.11	0.020	0.10	3.0	16.6	-
	Bottom	0.060	3.86	0.16	0.112	0.10	3.1	16.2	-
	S	0.300	0.50	0.10	0.015	0.10	2.3	7.1	2.48
2	M	0.240	0.10	0.13	0.012	0.13	1.9	12.5	0.08
	B	2.523	8.83	2.84	4.182	0.73	3.9	19.3	0.48
	S	0.653	0.30	0.13	0.034	0.10	2.3	6.9	-
3	M	0.323	0.87	0.11	0.014	0.13	2.8	7.3	-
	B	5.013	11.33	4.22	6.591	0.87	6.5	15.9	-
	S	0.520	0.00	0.09	0.130	0.10	7.6	5.5	-
4	M	0.427	0.40	0.14	0.014	0.17	6.9	6.5	-
	B	1.873	4.13	2.36	4.388	0.60	9.6	4.3	-
	S	0.340	0.30	0.18	0.143	0.20	7.4	5.2	1.68
5	M	0.267	2.03	0.18	0.008	0.10	7.3	5.3	0.06
	B	0.950	0.70	1.31	2.245	0.33	8.7	3.6	0.39
	S	0.283	3.55	0.13	0.121	0.10	6.8	6.2	-
6	M	0.330	1.43	0.16	0.192	0.10	6.0	2.7	-
	B	0.660	1.00	0.46	0.809	0.20	6.2	3.7	-
	S	0.280	0.00	0.10	0.162	0.10	7.1	4.7	-
7	M	0.247	2.00	0.09	0.002	0.13	6.7	3.7	-
	B	0.587	1.07	0.54	1.368	0.20	7.2	4.8	-
	S	0.287	0.05	0.04	0.231	0.10	7.5	7.0	1.34
8	M	0.317	0.73	0.09	0.000	0.13	6.6	1.9	1.17
	B	0.357	0.00	0.12	0.484	0.20	7.1	5.5	0.21
	S	0.310	0.20	0.07	0.181	0.13	7.1	4.4	-
9	M	0.287	0.70	0.08	0.005	0.10	6.5	2.2	-
	B	0.277	0.40	0.11	0.217	0.13	6.5	1.1	-