Appendix 10-A

METHODOLOGY FOR CALCULATING MINIMUM DIURNAL DO

Methodology and Instructions for Determining Minimum Diurnal DO (see worksheet on next page):

This worksheet computes the theoretical difference between the Ave DO and Min DO in mg/L as a function of chlor a and the rearation rate Ka (1/day). This value is then subtracted from the QUAL2E modeled AVE DO to obtain the modeled Min DO for comparison to the 5 mg/L instantaneous minimum DO standard.

1. The worksheet first uses QUAL2E model input to compute the average photosynthetic oxygen production in mg O2/L-day (Pave). This is done as follows:

Input "Oxygen produced by algae" (phytoplankton) in mg O2/ mg A from Data Type 1A (usually 1.6) in cell J3.

Input chlorophyll a to phytoplankton biomass ratio in mg chlor a/g A (= ug chlor a/ mg A) from Data Type 6B (usually around 10) in cell J4.

Input "Oxygen produced by periphyton" in mg O2/ mg Ap from Data Type 1A (usually 1.6)in cell J5

Input chlorophyll a to periphyton biomass ratio in mg chlor a/g A (= ug chlor a/ mg A) from Data Type 6B (usually around 10) in cell J6

Input "Number of daylight hours" from Data Type 1A (usually around 14 hours for summer) in cell J7.

Pave (Phyto) in mg O2/L = Cell J3 / Cell J4 * chlor a (phytoplankton) in ug/L from Model Plot File worksheet or

(phyto chlor a in ug/L) * (mg 02/mg A phyto) / (ug chlor a/ mg A phyto) = mg O2/L.

Pave (Peri) = (Cell J5 / Cell J6) * (Periphyton chlor a in mg chlor a/ ft2) * (Bottom area in ft2) * (fraction of bottom covered by periphyton) / volume in ft3 * Conversion Factor

where the Periphyton chlor a, fraction of bottom coverage and volume are from the Model Plot file worksheet.

(mg 02/mg A peri) / (ug peri chlor a/ mg A peri) * (oeri chlor a in mg/ft2) (Bottom area in ft2)*Fraction of bottom covered by peri) * Conversion Factor = mg O2/L.

Total Pave = Pave Phyto + Pave Peri

2. Total Pave is then input into the following formula developed by DiToro (1975) to compute the theoretical diurnal change in DO due to phtyoplankton and periphyton.

$$Cmax-Cmin= \frac{Pave * [1-exp(-Ka *f*T)] *[1-exp(-Ka*T*(1-f))]}{f * Ka*[1- exp(-Ka*T)]}$$

where, Cmax is maximum daily DO concentration in mg/L
Cmin is the minimum daily DO concentration in mg/L
Ka is reaeration rate (1/day) from the Model Plot File worksheet
f is the fraction of day light is available for photosynthesis (ie, the photoperiod) which is equal to (cell J7)/24.
T = diurnal period = 1.0 day

3. (Cmax-Cmin) was then divided by 2 to get the theoretical difference between Ave DO and Min DO. This value was then compared to the observed Ave DO- Min DO and a correction factor (see J8) was added or subtracted where deemed appropriate. The Corrected Theoretical Ave DO-Min DO equation

was then used compute the modeled min DO in the Supp Plotting Data Worksheet by subtracting the Corrected Theoretical Ave DO - Min DO from the modeled Ave DO.

Reference:

DiToro (1975); Algae and Dissolved Oxygen. Summer Inst. Water Pollution Control Notes. Manhattan College, Bronx, NY.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2				***Worksheet for Determining Min Modeled DO for comparison to the 5 mg/L water quality standard.***						**INPUT**					
3				**Input "Oxygen produced by algae" (phytoplankton) in mg O/ mg A from Data Type 1A (usually 1.6)**						1.6					
4				**Input chlorophyll a to phytoplankton biomass ratio in mg chlor a/g A (= ug chlor a/ mg A) from Data Type 6B (usually around 10)**						10					
5				**Input "Oxygen produced by periphyton" in mg O/ mg Ap from Data Type 1A (usually 1.6)**						1.6					
6				**Input chlorophyll a to periphyton biomass ratio in mg chlor a/g A (= ug chlor a/ mg A) from Data Type 6B (usually around 10)**						10					
7				**Input "Number of daylight hours" from Data Type 1A (usually around 14 hours for summer)**						14					
8	Reach	ELE BGN LOC	**Temperature (deg C)**	**Fraction of day algae are producing Oxygen (ie, the photoperiod)**	**Chlor a Phyto (ug/L)**	**Chlor a Periphyton in mg chlor a / ft2**	**Chlor a Periphyton (ug/L)**	**Pave = daily average algae photosynthic production (mgO2/L - day)**	**Theoretical DO Ave - DO Min due to chlor a in phyto and periphyton (mg/L)**	**Input Diurnal Correction Factor to account for other factors influencing Diurnal swing (ie, macrophytes, SOD,CBOD,etc).**	**Corrected Theoretical DO Ave - DO Min for determining Min Model DO**	**Obs Ave DO - Min DO**	**Sampling Station**	**Notes**	
9	1	68.20	25.1	0.58	3.06	2.40	1.67	0.76	0.12	0.85	0.97	0.97	34-CTC		
10	1	68.10	25.1	0.58	3.05	2.38	1.64	0.75	0.12	0.27	0.39			use 32-CTC	
11	1	68.00	25.1	0.58	3.03	2.35	1.62	0.74	0.12	0.27	0.39			use 32-CTC	
12	1	67.90	25.1	0.58	3.02	2.33	1.60	0.74	0.12	0.27	0.39			use 32-CTC	
13	1	67.80	25.1	0.58	3.00	2.30	1.57	0.73	0.11	0.27	0.38	0	32T-CTC		
14	1	67.70	25.1	0.58	2.99	2.28	1.55	0.73	0.11	0.27	0.38			use 32T-CTC	
15	1	67.60	25.1	0.58	2.97	2.25	1.53	0.72	0.11	0.27	0.38			use 32T-CTC	
16	2	67.50	24.5	0.58	2.51	2.46	7.50	1.60	0.20	0.33	0.53			use 32M-CTC	
17	2	67.40	24.5	0.58	2.18	2.52	7.25	1.51	0.15	0.33	0.48			use 32M-CTC	
18	2	67.30	24.5	0.58	1.93	2.57	6.99	1.43	0.15	0.33	0.48	0.48	32M-CTC		
19	3	67.20	24.2	0.58	5.10	4.10	9.86	2.39	0.29	0.21	0.62			Jaffrey WWTF use 32-CTC	
20	3	67.10	24.2	0.58	5.03	4.08	9.72	2.36	0.32	0.21	0.53			use 32-CTC	
21	3	67.00	24.2	0.58	4.97	4.07	9.58	2.33	0.31	0.21	0.52			use 32-CTC	
22	4	66.90	24.0	0.58	4.82	4.05	1.59	1.03	0.15	0.21	0.36			use 32-CTC	
23	4	66.80	24.0	0.58	4.69	4.03	1.56	1.00	0.16	0.21	0.37			use 32-CTC	
24	4	66.70	24.0	0.58	4.56	4.01	1.52	0.97	0.16	0.21	0.37	0.37	32-CTC		
25	4	66.60	24.0	0.58	4.45	3.98	1.49	0.95	0.15	0.21	0.36			use 32-CTC	
26	5	66.50	24.1	0.58	4.58	3.80	0.89	0.88	0.16	0.08	0.24			use 31B-CTC	
27	5	66.40	24.1	0.58	4.77	3.79	0.89	0.90	0.18	0.08	0.26			use 31B-CTC	
28	6	66.30	23.7	0.58	4.93	3.84	3.08	1.28	0.26	0.00	0.26	0	31C-CTC	use 31B-CTC	
29	6	66.20	23.7	0.58	5.10	3.82	3.07	1.31	0.27	0.00	0.27			use 31B-CTC	
30	6	66.10	23.7	0.58	5.26	3.81	3.07	1.33	0.27	0.00	0.27			use 31B-CTC	
31	6	66.00	23.7	0.58	5.43	3.80	3.07	1.36	0.28	0.00	0.28			use 31B-CTC	
32	6	65.90	23.7	0.58	5.61	3.78	3.06	1.39	0.28	0.00	0.28			use 31B-CTC	
33	6	65.80	23.7	0.58	5.79	3.77	3.06	1.42	0.29	0.00	0.29			use 31B-CTC	
34	6	65.70	23.7	0.58	5.97	3.75	3.06	1.44	0.29	0.00	0.29			use 31B-CTC	
35	7	65.60	23.0	0.58	6.10	3.93	4.22	1.65	0.32	0.00	0.32	0	31B-CTC		
36	7	65.50	23.0	0.58	5.85	3.87	3.99	1.57	0.29	0.00	0.29			Town Farm Bk use 31AT-CTC	
37	7	65.40	23.0	0.58	5.95	3.86	3.98	1.59	0.30	0.00	0.30	0	31AT-CTC		
38	8	65.30	23.2	0.58	6.25	3.73	6.05	1.97	0.37	0.00	0.37			Gridley Bk	
39	8	65.20	23.2	0.58	6.36	3.72	6.03	1.98	0.37	0.00	0.37	7.12	31AF-CTC		
40	8	65.10	23.2	0.58	6.47	3.70	6.01	2.00	0.38	0.00	0.38			Use 31AF-CTC	
41	8	65.00	23.2	0.58	6.59	3.69	5.99	2.01	0.38	0.00	0.38			Use 31AF-CTC	
42	9	64.90	22.1	0.58	6.63	3.75	5.51	1.94	0.37	0.00	0.37			Use 31AF-CTC	
43	9	64.80	22.1	0.58	6.68	3.73	5.45	1.94	0.38	0.00	0.38			Use 31AF-CTC	
44	9	64.70	22.1	0.58	6.73	3.71	5.40	1.94	0.38	0.00	0.38			Use 31AF-CTC	
45	9	64.60	22.1	0.58	6.78	3.69	5.35	1.94	0.38	0.00	0.38			Use 31AF-CTC	
46	9	64.50	22.1	0.58	6.17	3.61	4.95	1.78	0.35	0.00	0.35			Meadow Bk	
47	10	64.40	22.3	0.58	6.27	3.55	0.87	1.14	0.23	0.00	0.23			Use 31-CTC	
48	10	64.30	22.3	0.58	6.37	3.53	0.87	1.16	0.23	0.00	0.23		31-CTC	Use 30M-CTC	
49	10	64.20	22.3	0.58	6.48	3.51	0.86	1.17	0.23	0.00	0.23			Use 30M-CTC	
50	10	64.10	22.3	0.58	6.58	3.49	0.86	1.19	0.24	0.00	0.24			Use 30M-CTC	
51	10	64.00	22.3	0.58	6.69	3.47	0.85	1.21	0.24	0.00	0.24			Use 30M-CTC	
52	10	63.90	22.3	0.58	6.80	3.45	0.85	1.22	0.24	0.00	0.24			Use 30M-CTC	
53	10	63.80	22.3	0.58	6.90	3.43	0.84	1.24	0.25	0.00	0.25			Use 30M-CTC	
54	10	63.70	22.3	0.58	7.01	3.41	0.83	1.26	0.25	0.00	0.25	7.72	30M-CTC		
55	11	63.60	22.1	0.58	7.60	0.00	0.00	1.22	0.25	0.34	0.59			Use 30-CTC	
56	11	63.50	22.1	0.58	8.23	0.00	0.00	1.32	0.27	0.34	0.61			Use 30-CTC	
57	11	63.40	22.1	0.58	8.88	0.00	0.00	1.42	0.30	0.34	0.64			Use 30-CTC	
58	11	63.30	22.1	0.58	9.53	0.00	0.00	1.53	0.32	0.34	0.66			Use 30-CTC	
59	11	63.20	22.1	0.58	10.17	0.00	0.00	1.63	0.34	0.34	0.68			Use 30-CTC	
60	11	63.10	22.1	0.58	10.75	0.00	0.00	1.72	0.36	0.34	0.70			Use 30-CTC	
61	11	63.00	22.1	0.58	11.22	0.00	0.00	1.79	0.37	0.34	0.71	0.71	30-CTC		
62	12	62.90	22.1	0.58	11.39	2.54	2.40	2.21	0.45	0.00	0.45			Dam	
63	13	62.80	23.4	0.58	11.49	2.25	1.73	2.12	0.42	0.00	0.42			Use 29-CTC	
64	13	62.70	23.4	0.58	11.61	2.15	1.64	2.12	0.43	0.00	0.43			Use 29-CTC	
65	13	62.60	23.4	0.58	11.72	2.04	1.56	2.12	0.43	0.00	0.43			Use 29-CTC	
66	13	62.50	23.4	0.58	11.81	1.92	1.46	2.12	0.43	0.00	0.43			Use 29-CTC	
67	13	62.40	23.4	0.58	11.89	1.80	1.37	2.12	0.43	0.00	0.43			Use 29-CTC	
68	13	62.30	23.4	0.58	11.94	1.68	1.27	2.11	0.43	0.00	0.43			Use 29-CTC	
69	13	62.20	23.4	0.58	11.97	1.55	1.17	2.10	0.43	0.00	0.43			Use 29-CTC	
70	13	62.10	23.4	0.58	11.98	1.42	1.07	2.09	0.43	0.00	0.43			Use 29-CTC	
71	13	62.00	23.4	0.58	11.98	1.28	0.96	2.07	0.42	0.00	0.42			Use 29-CTC	
72	13	61.90	23.4	0.58	11.95	1.14	0.86	2.05	0.42	0.00	0.42	0	29-CTC		
73	13	61.80	23.4	0.58	11.89	1.00	0.75	2.02	0.41	0.00	0.41			Use 29-CTC	
74	13	61.70	23.4	0.58	11.74	0.89	0.66	1.98	0.41	0.00	0.41			Use 29-CTC	
75	13	61.60	23.4	0.58	10.99	0.95	0.71	1.87	0.38	0.00	0.38			Use 29-CTC	
76	14	61.50	24.4	0.58	4.93	0.00	0.00	0.79	0.16	0.17	0.33		#REF!	Use 28-CTC	
77	14	61.40	24.4	0.58	4.96	0.00	0.00	0.79	0.16	0.17	0.33			Nubanusit - Use 28-CTC	
78	15	61.30	23.4	0.58	4.99	1.95	0.34	0.85	0.17	0.17	0.34	0.34	28-CTC	Dam	
79	15	61.20	23.4	0.58	5.02	1.93	0.34	0.86	0.17	0.17	0.34			Use 27M-CTC	
80	15	61.10	23.4	0.58	5.06	1.90	0.34	0.86	0.18	0.17	0.35			Use 27M-CTC	
81	15	61.00	23.4	0.58	5.09	1.88	0.33	0.87	0.18	0.17	0.35			Use 27M-CTC	
82	15	60.90	23.4	0.58	5.12	1.85	0.33	0.87	0.18	0.17	0.35			Use 27M-CTC	
83	15	60.80	23.4	0.58	5.16	1.83	0.32	0.88	0.18	0.17	0.35			Use 27M-CTC	
84	15	60.70	23.4	0.58	5.19	1.80	0.32	0.88	0.18	0.17	0.35	0.35	27M-CTC		
85	16	60.60	24.4	0.58	5.25	0.00	0.00	0.84	0.17	0.44	0.61			Use 27-CTC	
86	16	60.50	24.4	0.58	5.33	0.00	0.00	0.85	0.18	0.44	0.62			Use 27-CTC	
87	16	60.40	24.4	0.58	5.40	0.00	0.00	0.86	0.18	0.44	0.62			Use 27-CTC	
88	16	60.30	24.4	0.58	5.48	0.00	0.00	0.88	0.18	0.44	0.62			Use 27-CTC	
89	16	60.20	24.4	0.58	5.55	0.00	0.00	0.89	0.18	0.44	0.62			Use 27-CTC	
90	16	60.10	24.4	0.58	5.61	0.00	0.00	0.90	0.19	0.44	0.63			Use 27-CTC	
91	16	60.00	24.4	0.58	5.68	0.00	0.00	0.91	0.19	0.44	0.63			Use 27-CTC	
92	16	59.90	24.4	0.58	5.74	0.00	0.00	0.92	0.19	0.44	0.63			Use 27-CTC	
93	16	59.80	24.4	0.58	5.80	0.00	0.00	0.93	0.19	0.44	0.63			Use 27-CTC	
94	16	59.70	24.4	0.58	5.86	0.00	0.00	0.94	0.19	0.44	0.63			Use 27-CTC	
95	16	59.60	24.4	0.58	5.91	0.00	0.00	0.94	0.20	0.44	0.64		#REF!	Use 27-CTC	
96	17	59.50	24.2	0.58	5.89	1.22	0.34	1.00	0.19	0.44	0.63	0.63	27-CTC	Dam	
97	17	59.40	24.2	0.58	5.88	1.20	0.33	0.99	0.16	0.44	0.60			Use 25Y-CTC	
98	17	59.30	24.2	0.58	5.87	1.18	0.33	0.99	0.16	0.44	0.60			Use 25Y-CTC	
99	17	59.20	24.2	0.58	5.85	1.16	0.32	0.99	0.16	0.44	0.60			Use 25Y-CTC	
100	17	59.10	24.2	0.58	5.84	1.14	0.32	0.99	0.16	0.44	0.60			Use 25Y-CTC	
101	17	59.00	24.2	0.58	5.83	1.12	0.31	0.98	0.16	0.44	0.60			Use 25Y-CTC	
102	17	58.90	24.2	0.58	5.82	1.10	0.30	0.98	0.16	0.44	0.60			Use 25Y-CTC	
103	17	58.80	24.2	0.58	5.81	1.09	0.30	0.98	0.16	0.44	0.60	0	25Y-CTC		
104															
105															