Loon Environmental LLC
41 Rhodes Ave
Riverside, RI 02915
1-401-433-2684
www.loonenvironmental.com

December 17, 2012

Dr. Robert Duncanson, Director
Department of Health and Environment
Town of Chatham
549 Main St.
Chatham, MA 02633

Dear Dr. Duncanson,

Loon Environmental LLC ("Loon') is pleased to submit this letter report as a summary of the additional monitoring work completed on Lovers Lake and Stillwater Pond in 2012 and as an addendum to the *Lovers Lake and Stillwater Pond Nutrient Inactivation Final Report* (the "*Final Report*"; Loon, 2012). The goal of this additional monitoring was to further document the water chemistry and physiochemical characteristics within the two waterbodies after the alum treatment in October 2010. The 2012 monitoring provided additional data to better evaluate the overall effectiveness of the alum treatment in nutrient inactivation in the two ponds.

Monitoring was conducted on May 21, 2012 and August 21, 2012. Water quality samples were collected at the previously established deep stations in Lovers Lake (both North and South basins) and Stillwater Pond and analyzed for total phosphorus (TP) and orthophosphorus (which represents the dissolved phosphorus (DP) fraction). In addition, Secchi disk transparency and depth profiles for temperature, specific conductivity, pH and dissolved oxygen were also collected at each location. The results of the phosphorus analyses are presented below (Table 1), with accompanying graphics exhibiting the TP levels in the deep basins of each pond (Exhibits 1-3). Pre-treatment values (e.g., October 2010) are indicated within the blue box.

For 2012, TP values within Stillwater Pond continue to remain low throughout the watercolumn (Table 1; Exhibit 3); most noticeably in the waters below the thermocline, where sediment phosphorus release previously led to high TP concentrations in late summer. TP values in Lovers Lake (Table 1; Exhibits 1 and 2) do not exhibit the same pattern of decline observed in Stillwater Pond. While the precise reason for this difference is not known, it is likely that the more complex bathymetry of Lovers Lake (i.e., two deep basins set along axes at a 90^{o} angle, separated by a shallow area) lends itself to more episodic internal mixing due to wind and wave action.

Of greater significance with regard to the nutrient inactivation are the levels of DP found in the bottom waters of both ponds (Table 1). Where sediment nutrient release is

Loon Environmental LLC
41 Rhodes Ave
Riverside, RI 02915
1-401-433-2684
www.loonenvironmental.com

active, the dissolved fraction will be a large percentage of the TP concentrations. As can be seen by the data, DP concentrations are uniformly at or below the detection limit of 0.002 for all samples, regardless of TP levels. This indicates that, while particulate TP may be present in some cases, there is very little of the more bioavailable DP present to mix into upper waters where it can fuel late summer algal blooms. These reductions in DP concentrations are directly attributable to the alum treatment.

Field observations including Secchi disk transparency (SDT) depths are provided in Table 2 with accompanying graphics (Exhibits 4 and 5) displaying SDT values (in meters) over the monitoring period. Pre-treatment values are indicated by the values within the blue box. The two year trend in SDT for Lovers Lake (Exhibit 4) indicates most values were greater than pre-treatment levels. There were seasonal differences in 2011 (the October 2011 value was likely due to storm-related wave action) and very good transparency in 2012. Stillwater Pond (Exhibit 5) exhibits a trend of increasing clarity and SDT values over the monitoring period.

We incorporated the 2011-2012 data to update and extend the comparison of pre- and post-implementation trophic state indicators, as described in the *Final Report* (Loon, 2012). In this comparison, the upper water concentrations of TP and SDT in late summer (usually the period of poorest water quality during the season) at each of the three sampling stations are used to generate TSI scores, using the methods of Carlson (1977), to evaluate overall changes in general pond conditions. The results of these comparisons are exhibited in Table 3.

In Table 3, pre-implementation late summer values are provided for 2001-2006 data from the Ponds and Lakes Sampling (PALS) volunteering monitoring overseen by the Cape Cod Commission as well as for 2007 data collected during the more comprehensive diagnostic study (see ENSR Corporation, 2008). The post-implementation data are the pooled (averaged) 2011-2012 August data.

The two pre-implementation datasets are very comparable and indicate both Lovers Lake and Stillwater to have elevated TP concentrations (range of 28 -43ug/L) and poor water clarity (i.e., 3.0-5.2 ft). The post-implementation TP conditions (6-13 ug/L) shows a 3-4 fold reduction with a similar magnitude of increase for SDT depth (12.2-13 ft).

Converting this raw data using regression equations into TSI scores according to the lake quality classifications of Carlson (1977) shows a dramatic improvement in the general trophic state of both ponds due to the nutrient inactivation. Lovers Lake and Stillwater Pond in the mid-2000s were considered eutrophic ponds, whose ecosystems and biota were heavily impacted by over-fertilization with nutrients. Following the alum

Loon Environmental LLC
41 Rhodes Ave
Riverside, RI 02915
1-401-433-2684
www.loonenvironmental.com

treatments, both ponds have significantly improved with their trophic states shifted into mesotrophic (or better) conditions.

In conclusion, the data from the 2012 monitoring demonstrates a continuing pattern of significant reductions in nutrient availability and improving water clarity due to the reduction in algal blooms that formerly impacted the recreational and ecologic functions of the Ponds. Further information and evaluation of the nutrient inactivation is contained in the *Final Report*.

Please review this letter and let us know if you have any questions or comments regarding the data or our interpretation of the results.

Sincerely,

Marie Evans Esten, CLM
President
Loon Environmental LLC

David F. Mitchell, Ph.D., CLM
Lake Consultant

Table 1. Phosphorus data

		5/21/2012		8/21/2012	
Lovers Lake North Basin					
Parameter	**Unit**	**Surface**	**Deep**	**Surface**	**Deep**
PO4-P	mg/L	<0.002**	<0.002**	<0.002**	<0.002**
TP	mg/L	0.014	0.020	0.008	0.050
Lovers Lake South Basin					
Parameter	**Unit**	**Surface**	**Deep**	**Surface**	**Deep**
PO4-P	mg/L	<0.002**	<0.002**	<0.002**	<0.002**
TP	mg/L	0.014	0.019	0.011	0.020
Stillwater Pond					
Parameter	**Unit**	**Surface**	**Deep**	**Surface**	**Deep**
PO4-P	mg/L	0.002	0.002	<0.002**	<0.002**
TP	mg/L	0.067	0.024	<0.003**	0.028

**Method detection limit

Exhibit 1. Total phosphorus trend in Lovers Lake North Basin

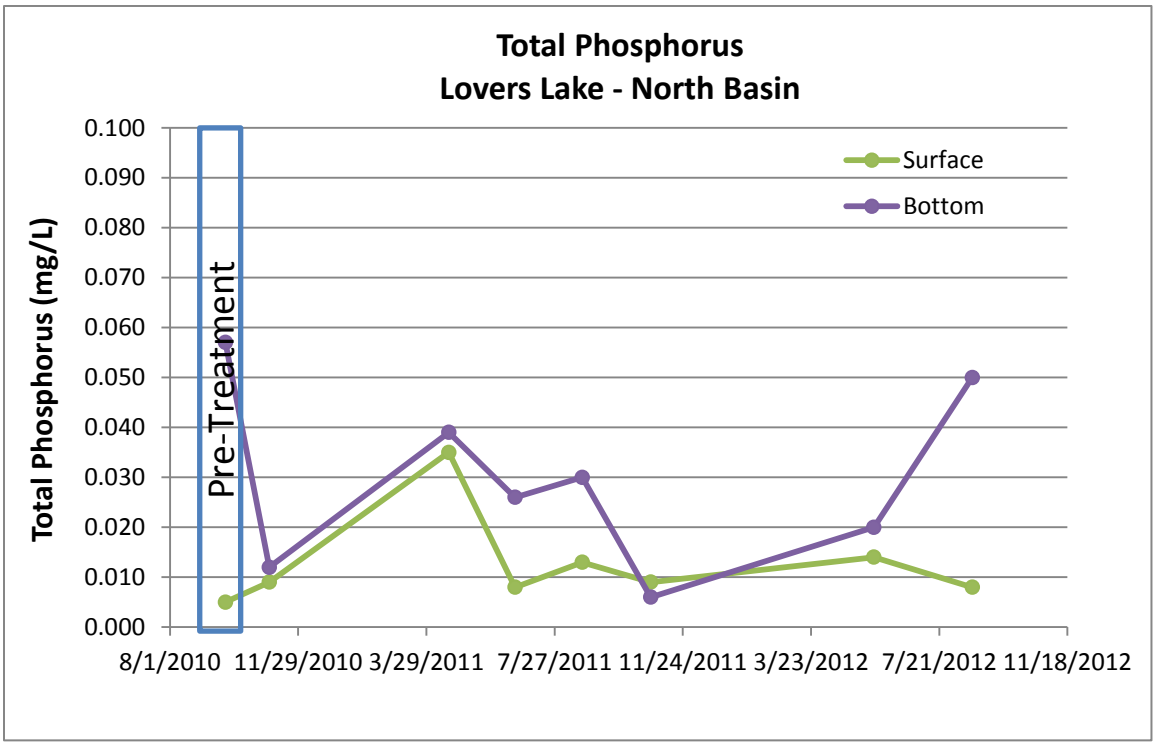

Exhibit 2. Total phosphorus trend in Lovers Lake South Basin

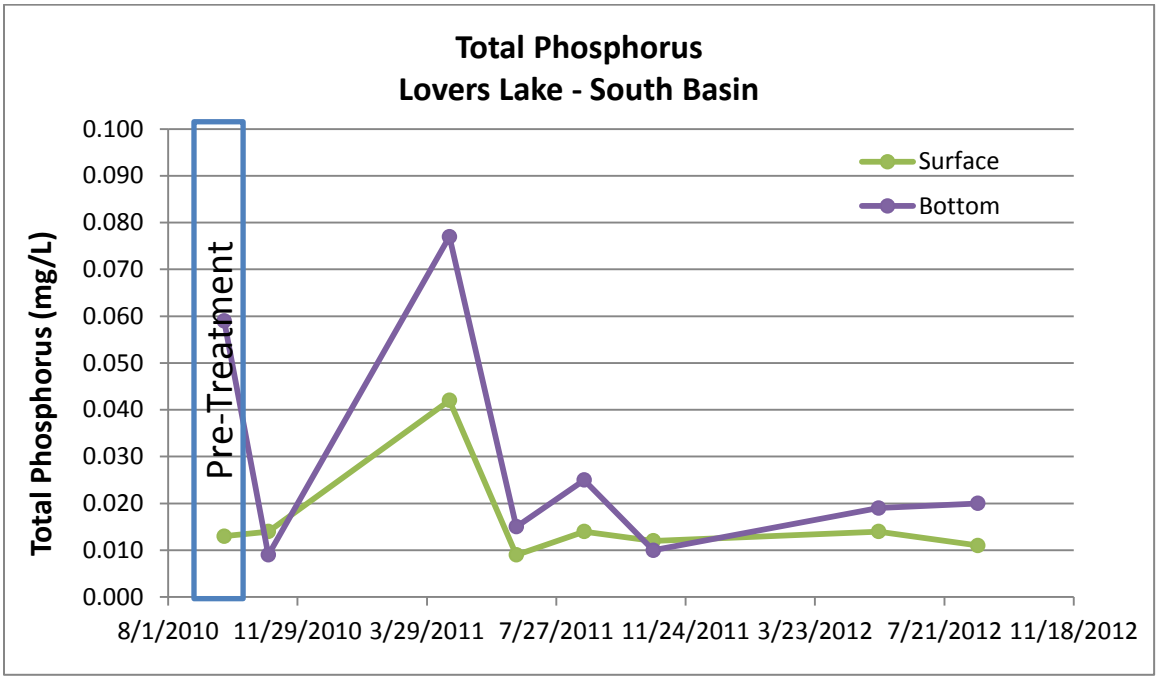

Exhibit 3. Total phosphorus trend in Stillwater Pond

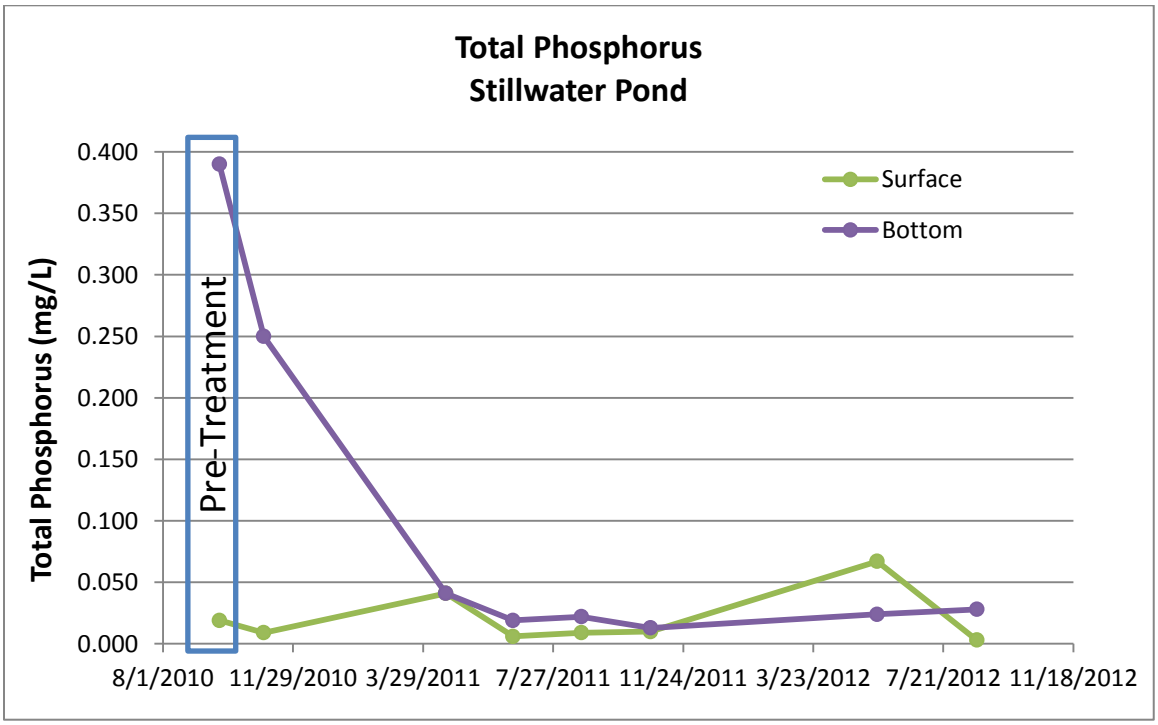

Table 2. Field data

Monitoring day: May 21, 2012
Lovers Lake - North Basin

Depth (m)	Temp (C)	pH	DO (mg/L)**	DO (%)**	Cond (mS/cm)
0	18.84	6.46	9.86	106.0	0.191
1	18.84	6.56	9.89	106.2	0.191
2	18.83	6.64	9.88	106.1	0.191
3	18.28	6.73	9.91	105.4	0.191
4	17.56	6.82	10.07	105.4	0.190
4.5	16.94	6.85	10.17	105.1	0.191
5	15.96	6.87	10.05	101.9	0.192
6	14.66	6.82	8.73	86.4	0.193
7	13.99	6.65	5.88	57.4	0.194
8	12.80	6.36	2.99	28.6	0.196
9	10.77	6.19	0.35	3.1	0.204
10	9.93	6.27	0.19	1.7	0.237
Secchi:	3.35	m			

Lovers Lake - South Basin

Depth (m)	Temp (C)	pH	DO (mg/L)**	DO (%)**	Cond (mS/cm)
0	18.72	7.00	10.16	108.9	0.191
1	18.73	7.08	10.17	109.1	0.191
2	18.68	7.14	10.16	108.9	0.191
3	18.11	7.16	10.08	107.3	0.191
4	17.02	7.03	8.23	85.4	0.192
4.5	15.54	6.95	9.25	93.0	0.193
5	14.61	6.84	7.47	73.3	0.193
6	13.16	6.64	1.64	16.2	0.196
7	12.12	6.61	0.38	3.8	0.241
Secchi:	3.35	m			

Monitoring day: August 21, 2012
Lovers Lake - North Basin

Depth (m)	Temp (C)	pH	DO (mg/L)	DO (%)	Cond (mS/cm)
0	25.61	8.40	7.90	96.7	0.214
1	25.61	8.19	7.89	96.4	0.214
2	25.60	8.07	7.87	96.3	0.214
3	25.54	7.93	7.72	94.5	0.214
4	25.42	7.87	7.72	94.0	0.214
4.5	25.19	7.65	7.27	88.3	0.214
5	23.06	7.47	6.38	73.5	0.212
6	19.12	7.16	2.78	30.0	0.212
7	15.94	6.94	0.58	5.8	0.212
8	13.64	6.93	0.16	1.6	0.259
9	11.84	6.95	0.14	1.3	0.291
10	11.05	6.97	0.12	1.1	0.372
Secchi:	4.15	m			

Lovers Lake - South Basin

Depth (m)	Temp (C)	pH	DO (mg/L)	DO (%)	Cond (mS/cm)
0	25.60	7.33	7.38	90.4	0.212
1	25.53	7.32	7.40	90.4	0.212
2	25.49	7.30	7.35	89.8	0.212
3	25.45	7.29	7.25	88.5	0.212
4	25.41	7.28	7.31	89.0	0.212
4.5	24.20	6.77	1.81	21.7	0.212
5	21.10	6.69	3.05	34.2	0.209
6	16.34	6.62	3.79	38.4	0.249
6.5	14.38	6.67	0.30	3.3	0.374
Secchi:	4.35	m			

Monitoring day: May 21, 2012
Stillwater Pond

Depth (m)	Temp (C)	pH	DO (mg/L)**	DO (%)**	Cond (mS/cm)
0	19.17	6.92	8.71	94.2	0.188
1	19.14	6.96	8.67	93.8	0.188
2	19.13	6.96	8.71	94.1	0.187
3	18.04	6.91	8.27	87.3	0.187
3.5	17.36	6.89	8.35	86.9	0.188
4	16.35	6.88	8.6	87.7	0.188
5	14.09	6.90	9.82	95.7	0.189
6	11.46	6.90	10.39	95.5	0.190
7	9.05	6.82	8.51	72.7	0.190
8	7.71	6.66	4.52	37.4	0.190
9	6.93	6.53	3.30	26.3	0.192
10	6.56	6.43	1.80	14.7	0.193
11	6.40	6.34	1.33	10.8	0.193
12	6.27	6.24	0.84	6.4	0.193
13	6.22	6.17	0.46	3.8	0.195
14	6.21	6.17	0.29	2.2	0.196
15	6.18	6.19	0.21	1.7	0.201
Secchi:	3.70	m			

**No post calibration because instrument stopped working after last profile

Key:
Temp – Temperature in °C
DO – Dissolved oxygen
Cond – Specific Conductance

Monitoring day: August 21, 2012
Stillwater Pond

Depth (m)	Temp (C)	pH	DO (mg/L)	DO (%)	Cond (mS/cm)
0	26.08	7.28	7.81	96.4	0.208
1	25.81	7.26	7.86	96.6	0.208
2	25.70	7.23	7.78	95.4	0.208
3	25.66	7.21	7.75	94.9	0.208
4	25.44	7.15	7.39	90.2	0.208
5	22.42	6.74	5.84	67.4	0.203
5.5	19.98	6.63	5.09	56.0	0.202
6	17.82	6.52	4.96	52.2	0.202
7	13.65	6.48	6.71	64.5	0.200
8	10.30	6.44	6.24	55.8	0.199
9	8.30	6.36	1.35	11.7	0.205
10	7.33	6.38	0.28	2.3	0.220
11	6.92	6.43	0.17	1.4	0.228
12	6.74	6.50	0.13	1.0	0.233
13	6.66	6.56	0.11	0.9	0.238
14	6.62	6.57	0.10	0.8	0.242
14.5	6.62	6.57	0.08	0.7	0.264
Secchi:	4.05	m			

Exhibit 4. Lovers Lake Secchi disk transparency

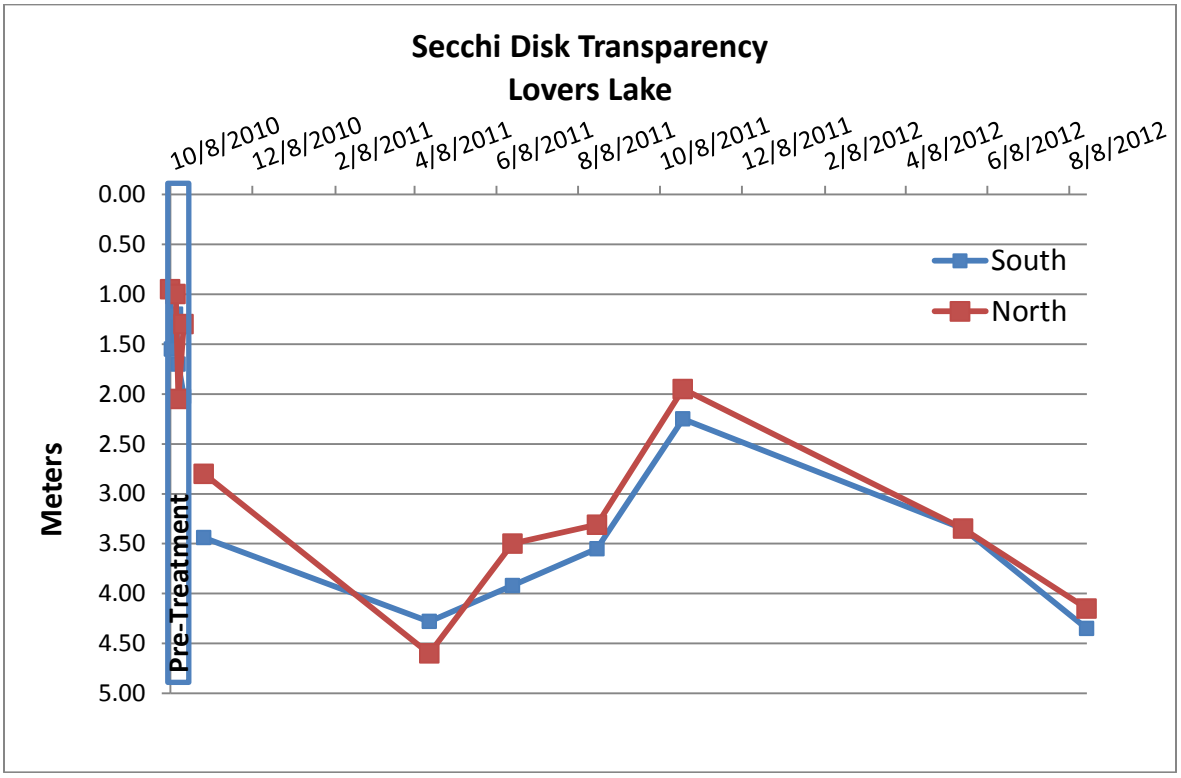

Exhibit 5. Stillwater Pond Secchi disk transparency

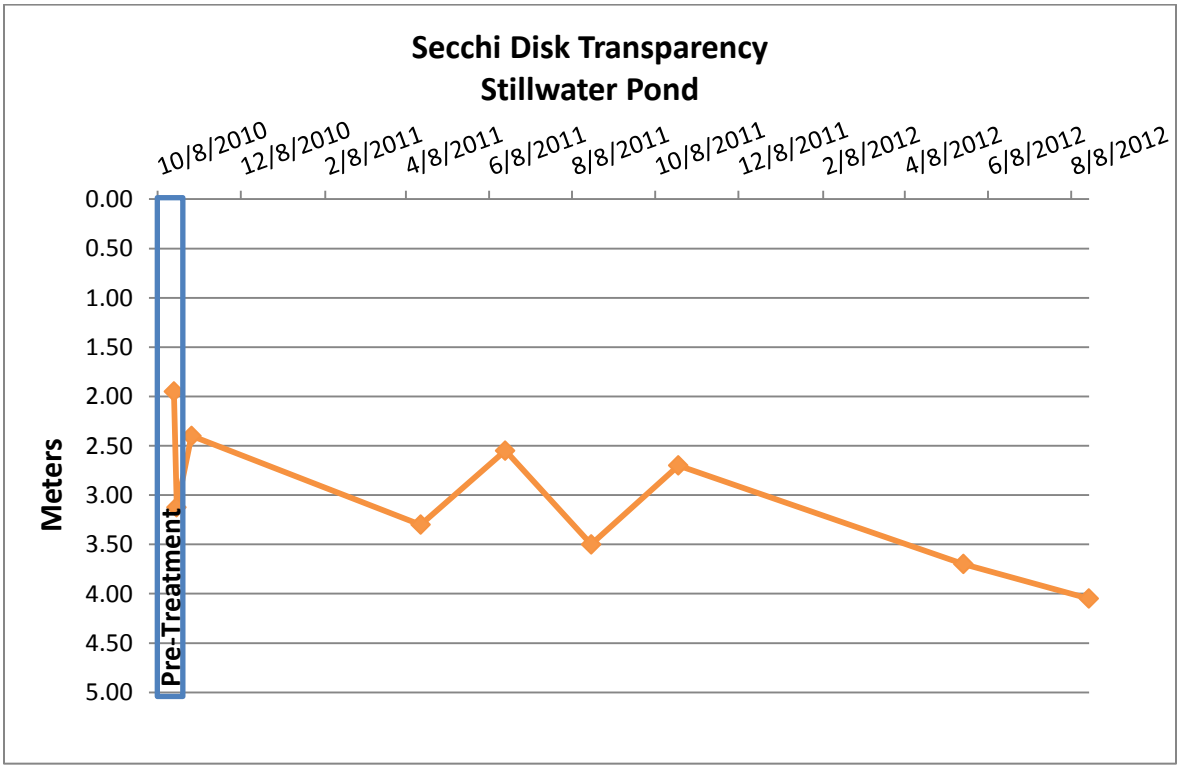

Table 3-Trophic State Index (TSI) Summary

2001-2006 TSI Values	SDT (m)	TP (ug/L)	TSI-SDT	TSI-TP	Mean TSI Value	Trophic State
Lovers Lake	1.1	32.2	58	54	56	**Eutrophic**
Stillwater Pond	1.6	27.5	53	52	53	**Eutrophic**

2007 TSI Values	SDT (m)	TP (ug/L)	TSI-SDT	TSI-TP	Mean TSI Value	Trophic State
Lovers Lake North Basin	0.9	42.5	61	58	60	**Eutrophic**
Lovers Lake South Basin	1.0	36.5	60	56	58	**Eutrophic**
Stillwater Pond	1.0	35.5	61	56	58	**Eutrophic**

2011-2012 TSI Values	SDT (m)	TP (ug/L)	TSI-SDT	TSI-TP	Mean TSI Value	Trophic State
Lovers Lake North Basin	3.7	10.5	41	38	40	**Mesotrophic**
Lovers Lake South Basin	4.0	12.5	40	41	40	**Mesotrophic**
Stillwater Pond	3.8	6	41	30	35	**Oligo-Mesotrophic**

TSI Score & Trophic Classifications based on Carlson (1977).
Oligotrophic= < 38 (poorly fertilized)
Mesotrophic = 38-47 (moderately fertilized)
Eutrophic = 48-66 (well fertilized)
Hypereutrophic = > 66 (extremely fertilized)