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MEMORANDUM

To:	The Lake Hopatcong Commission
From:	F.S. Lubnow, Ph.D., Princeton Hydro, LLC
Date:	18 October 2010
Subject:	**Mid-year 2010 water quality monitoring for Lake Hopatcong Revised from 20 September 2010**
# of Pages:	eight

[*Please note this memo is a revision to the original mid-year report which was submitted at the 20 September 2010 Commission meeting. An error was found in the original September memo and was corrected; shown in bolded red and underlined on page 3. In addition, the water quality data collected at the five near-shore sampling stations (two stations representing sites near the 319 projects from the SFY05 grant and the remaining three representing sites near the 319 projects from the SFY10 grant) were added to this memo. A detailed analysis of these near-shore data, as well as all of the2010 in-lake data will be provided in the year-end report.*]

This memorandum is a concise summary of the water quality conditions of Lake Hopatcong during the 25 May, 28 June, 28 July and 25 August 2010 monitoring events. It should be noted that discrete water samples were collected during each sampling event but only the May through July data were available at the time this memo was written. A more comprehensive analysis of the 2010 water quality database will be conducted in the year-end report, after the September sampling event and all of the laboratory results have been received.

For the Lake Hopatcong monitoring program, a variety of physical, chemical, and biological data were collected from 11 sampling stations throughout the lake:

Station	Location
1	Woodport Bay
2	Mid-Lake
3	Crescent Cove/River Styx
4	Point Pleasant/King Cove
5	Outlet
6	Henderson Cove
7	Inlet from Lake Shawnee
8*	Great Cove
9*	Byram Cove
10	Northern Woodport Bay
11	Jefferson Canals

* *In-situ* data only

It should be noted that all field protocol and laboratory methodology have been described in detail and have been accepted by NJDEP through an approved QAPP. Also, Princeton Hydro is State-certified for the collection of *in-situ* data and discrete samples (State ID # 10006).

A calibrated Eureka Amphibian with Manta multi-probe or similar instrument was used to collect *in-situ* data from all 11 stations and included dissolved oxygen (DO), pH, conductivity, and temperature. The *in-situ* data were collected at 0.5 to 1.0 meter intervals from surface to bottom. In addition, sub-surface discrete water samples were collected and analyzed for ammonia-N, nitrate-N, total phosphorus (TP), total suspended solids (TSS), and chlorophyll *a*. Vertical net tows were conducted for phytoplankton (free-floating algae) and zooplankton (micro-animals, some of which feed on phytoplankton) at the mid-lake sampling station (Station #2).

The table below provides data on water clarity, as measured with a Secchi disk, for Lake Hopatcong during the May through August sampling events. Typically, a lake is perceived by a layperson as being “dirty” or “scummy” when the Secchi depth is less than 1.0 meter (3.3 feet). Please note that a “b” after a Secchi value indicates that the disk reached the bottom. While all Secchi depth values were at or greater than the 1.0 meter threshold from May through June, two of the eleven stations during the July and August events had Secchi depths less than 1.0 meter (in bolded red). Station #3 (River Styx / Crescent Cove) had Secchi depths less than 1.0 meters during both mid-summer sampling events (see table below).

In spite of the lower Secchi depths at Station #3, Secchi depth values overall were generally higher in 2010 relative to 2009. This was attributed to the low frequency of storm events in 2010, relative to the higher frequency of storm events in 2009. This is a relationship that is generally well established in Lake Hopatcong, particularly in the deeper, mid-lake stations; during dry years, Secchi depths are generally higher due to lower watershed-based inputs of nutrients and suspended solids. In contrast, during wetter years, Secchi depths are generally lower due to elevated pollutant loads.

Station	May Secchi depth (meters)	June Secchi depth (meters)	July Secchi depth (meters)	August Secchi depth (meters)
1	1.5	1.1	1.0	1.0
2	2.5	2.75	2.2	2.8
3	2.3	1.9	**0.8**	**0.7**
4	2.1	2.25	1.2	1.5
5	2.0	1.0	**0.8**	1.6
6	2.5	1.6	1.4	2.2b
7	1.6b	2.0	1.4b	1.5b
8	2.2	2.7	2.3	2.8
9	2.2	2.3	2.0	2.8
10	1.7b	1.0	1.0	1.4
11	1.1b	1.1b	1.0b	**0.9b**

Temperature changes greater than $1^{o}C$ over 1 meter (3.3 feet) through the water column indicate that the lake is thermally stratified, which has a profound impact on the physical, chemical, and biological components of a lake ecosystem. Based on the collected *in-situ* data, Station #2 was thermally stratified between 4 and 5 meters below the surface in May, was strongly thermally stratified between 4 and 9 meters in June, strongly thermally stratified between 5 and 9 meters in July and strongly thermally stratified between 8 and 11 meters in August.

Overall, Lake Hopatcong was well oxygenated (DO > 6 mg/L) from surface to bottom during the May 2010 monitoring event and oxygenated (DO > 2 mg/L) during the June, July and August monitoring events.

Through the May to August monitoring events, pH values typically varied from the mid 6.0's to the mid 8.0's. Since optimum range for pH for most aquatic organisms is between 6.0 and 8.5, the water quality of Lake Hopatcong was generally acceptable relative to pH. The exception to this was during the May 2010 monitoring event, when surface water pH values were greater than 9.4 at Stations #3; however, by the June 2010 event the pH value at this station was below 8.5 and remained so during the July and August 2010 events.

Conductivity is a measure of the capacity of water to carry an electrical charge, based on the amount of dissolved ions (i.e. nutrients and salts) in the water. A waterbody with an extremely low level of productivity will tend to have a conductivity less than 0.1 mmhos / cm, while a highly productive waterbody can have conductivity values greater than 0.5 mmhos / cm. The conductivity through most of Lake Hopatcong in May – August 2010 varied from the upper 0.3's to the lower 0.4's with some exceptions. For example, during the May monitoring event the conductivity at Station #3 (River Styx) varied between 0.49 and 0.66 mmhos / cm, which is indicative of more productive conditions. In addition, the Canal stations in the northern end of the lake (Stations #7 and #11) had lower conductivities, varying between 0.13 and 0.14 mmhos / cm, which are indicative of lower amounts of productivity. However, by the summer season, conductivities values were more consistent over the whole lake, varying between 0.3 and the upper 0.4's mmhos / cm. It should also be noted that due to equipment malfunctions, the conductivity during the July event were approximated.

During the 25 May 2010 sampling event, total phosphorus (TP) concentrations varied from 0.01 to 0.04 mg/L (average 0.03 mg/L; same as the May 2008 and 2009 events). The highest TP concentration on 25 May 2010 was 0.04 mg/L in the Canals (#11). During the 28 June 2010 sampling event TP concentrations varied from <0.01 to 0.03 mg/L, while during the 28 July 2010 sampling event TP concentrations varied from 0.01 to **0.05 mg/L** with the River Styx station (#3) having the highest TP concentration.

The targeted average in-lake TP concentration is 0.03 mg/L, as stated in the TMDL Restoration Plan for Lake Hopatcong. Thus, all of the in-lake and watershed-based projects that are and will be implemented at Lake Hopatcong are designed to attain this targeted in-lake TP concentration. During the May and June 2009 sampling events, the surface water TP concentrations were at or below 0.03 mg/L for all collected samples (100%). In contrast, during the July 2010 event, 33% of the collected samples were above the targeted in-lake TP threshold of 0.03 mg/L. In contrast, during the July 2009 event, approximately half of the TP samples exceeded the targeted in-lake TP threshold of 0.03 mg/L. These results indicate two points:

1. In general, surface water TP concentrations are generally lower in Lake Hopatcong during dry growing seasons when compared to those that experience a high frequency of storm events.
2. Exceedances over the targeted in-lake TP threshold of 0.03 mg/L tends to occur during the summer season; thus, watershed-based restoration activities need to continue in order to protect the water quality, ecological and recreational value of Lake Hopatcong and comply with its TMDL.

TSS is essentially a measurement of the amount of particulate matter or "dirt" in the water. For most lakes and ponds, TSS concentrations during baseline (non-storm event) conditions are typically less than 25 mg/L. Thus, TSS concentrations greater than 25 mg/L are typically perceived by the layperson as being "dirty" or "muddy". TSS concentrations were low during the May through July sampling events, varying between < 3 to 9 mg/L.

Measuring the amount of chlorophyll *a* in is an excellent means of measuring algal biomass. Based on our in-house database of Mid-Atlantic waterbodies, when chlorophyll *a* concentrations exceed 30 mg/m^3, the general perception by the layperson is that the water is "scummy" or "dirty" relative to recreational use. The lake-wide mean chlorophyll *a* concentrations in May 2010 varied between 2.1 and 9.6 mg/m^3, while concentrations in June 2010 varied between 1.4 and 11.9 mg/m^3. By July 2010 Station #3 exceeded the chlorophyll *a* concentration threshold of 30 mg/m^3, and two other stations had concentrations greater than 25 mg/m^3; Stations #1 (Woodport Bay) and #10 (Northern Woodport Bay). In recent years nuisance algal blooms appear to be more frequent in the northern part of the lake.

In May 2010 the dominant algae were the "brown" alga (a diatom) *Tabellaria* and the blue-green alga *Coelosphaerium*. The blue-green alga *Coelosphaerium* continued to be the dominant alga in Lake Hoaptcong during the June 2010 sampling event, however, the green alga *Pediastrum* was relatively abundant and several diatoms were also common at this time. By July 2010 the blue-green alga *Anabaena*, the green alga *Pediastrum* and several diatoms (*Tabellaria* and *Melosira*) were the most common algae. Given the moderate algal blooms observed in the northern end of the lake during the July 2010 event, some additional plankton samples were collected. The majority of the algae producing the nuisance blooms in the northern end of the lake were the blue-green algae *Anabaena* and *Aphanizomenon*.

As has been identified during pervious monitoring years, the most abundant zooplankton in Lake Hoaptcong were the small-bodied cladoceran *Bosmina*, which feeds primarily on bacteria and detritus, and the predaceous copepod *Cyclops*. However, the moderately herbivorous (algae-eating) cladoceran *Ceriodaphnia* was the dominant zooplankton during the June 2010 event, which is at least partially responsible for the lower chlorophyll *a* concentrations measured in that month. These data support the idea that larger, more herbivores zooplankton in the lake would provide a natural means of contributing toward algal control in Lake Hopatcong.

Near-Shore (319-grant) *In-Situ* Data for Lake Hopatcong

In-Situ Monitoring for Hopatcong 319 Stations 5/25/10								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH	Dissolved Oxygen
	Total	Secchi	Sample	(⁰C)	(mmhos/cm)	(mg/L)	(units)	(%)
NPS 1	1.5	1.5	Surface	24.96	0.652	17.69	9.34	214.72
			1.00	20.66	0.787	19.53	9.34	218.45
			1.50	20.43	0.881	24.84	9.66	276.65
NPS 2	1.2	1.2	Surface	21.53	0.322	14.62	7.98	166.13
			1.00	20.58	0.314	14.25	8.12	158.93
NPS 3	0.75	0.75	Surface	23	0.279	14.85	7.62	173.52
			0.80	21.59	0.275	14.61	7.61	166.19
NPS 4	1.4	1.4	Surface	20.64	0.34	10.43	8.03	116.5
			1.00	20.49	0.34	10.48	8.03	116.72
			1.25	20.45	0.34	10.43	8.05	116.03
NPS 5	2.5	2	Surface	21.22	0.338	9.91	7.96	111.93
			1.00	20.28	0.337	9.92	7.94	109.99
			2.00	19.58	0.338	9.17	7.7	100.32
			2.50	18.81	0.339	6.23	7.19	67.08

In-Situ Monitoring for Hopatcong 319 Stations 6/28/10								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH	Dissolved Oxygen
	Total	Secchi	Sample	(⁰C)	(mmhos/cm)	(mg/L)	(units)	(%)
NPS 1	1.2	0.9	Surface	27.27	0.591	10.21	7.94	130.93
			1.00	27.23	0.592	10.08	7.96	129.19
NPS 2	1.2	1.2	Surface	26.59	0.319	8.71	8.62	110.26
			1.00	26.56	0.317	9.01	8.77	114.09
NPS 3	1.1	1.1	Surface	28.04	0.276	9.89	8.06	128.55
			0.80	26.95	0.278	10.31	8.3	131.42
NPS 4	1.2	1.2	Surface	28.37	0.349	12.72	7.93	166.31
			1.00	27.66	0.348	13.37	8.34	172.58
NPS 5	2.2	1.1	Surface	26.83	0.331	7.55	7.56	96.04
			1.00	26.64	0.331	7.61	7.52	96.41
			2.00	26.45	0.331	7.05	7.41	89.12

In-Situ Monitoring for Hopatcong 319 Stations 7/28/10								
Station	DEPTH (meters)			Temperature	Conductivity*	Dissolved Oxygen	pH	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)	(%)
NPS 1	1.2	0.4	Surface	26.17	0.619	9.7	8.36	120.59
			1.00	26.18	0.6175	9.43	8.34	117.22
NPS 2	1	0.8	Surface	26.37	0.3935	10.26	8.66	127.78
			1.00	26.22	0.3945	8.95	8.34	111.22
NPS 3	0.5	0.5	Surface	26.22	0.355	10.64	8.74	132.1
			0.50	26.24	0.354	10.49	8.76	130.34
NPS 4	1.2	1	Surface	26.9	0.403	9.78	8.31	123
			1.00	26.78	0.4015	9.99	8.65	125.35
NPS 5	1.7	1	Surface	26.47	0.4235	7.33	7.76	91.52
			1.00	26.4	0.42	7.3	7.88	91.03
			1.50	26.36	0.419	7.04	7.84	87.75

* = 28 July Conductivity values are approximate due to possible meter malfunction

In-Situ Monitoring for Hopatcong 319 Stations 8/25/10								
Station	DEPTH (meters)			Temperature	Conductivity	Dissolved Oxygen	pH	Dissolved Oxygen
	Total	Secchi	Sample	(^{0}C)	(mmhos/cm)	(mg/L)	(units)	(%)
NPS 1	1.3	0.5	Surface	21.14	0.451	9.41	8.02	109.52
			1.00	20.73	0.439	9.22	7.95	106.46
NPS 2	1	1.0+	Surface	20.85	0.36	8.88	7.2	102.73
			1.00	20.68	0.359	8.5	7.26	98.02
NPS 3	0.8	0.8+	Surface	20.04	0.329	10.31	7.3	117.39
			0.50	19.85	0.328	10.31	7.41	116.95
NPS 4	1.1	1.1+	Surface	20.49	0.377	8.03	7.06	92.31
			1.00	20.47	0.377	7.96	7.15	91.43
NPS 5	1.7	1.5	Surface	21.1	0.376	8.25	7.06	95.96
			1.00	21.08	0.376	8.31	7.19	96.62
			1.50	20.77	0.371	8.42	7.28	97.32

In-Situ Monitoring for Hopatcong 319 Stations 9/22/10								
Station	**DEPTH (meters)**			**Temperature**	**Conductivity**	**Dissolved Oxygen**	**pH**	**Dissolved Oxygen**
	Total	**Secchi**	**Sample**	**(^{0}C)**	**(mmhos/cm)**	**(mg/L)**	**(units)**	**(%)**
NPS 1	**1.1**	**0.6**	**Surface**	20.93	0.481	9.95	8.08	113.3
			1.00	19.59	0.474	9.54	8.14	105.79
NPS 2	**0.8**	**0.8**	**Surface**	19.94	0.375	9.28	7.94	103.63
			1.00	19.94	0.375	9.1	7.96	101.68
NPS 3	**0.75**	**0.75**	**Surface**	21	0.352	10.22	8.34	116.52
			0.50	19.77	0.351	11.55	8.86	128.55
NPS 4	**1.5**	**1.5**	**Surface**	19.35	0.387	9.9	8.34	109.25
			1.00	19.34	0.386	9.98	8.44	110.16
NPS 5	**2**	**1.2**	**Surface**	20.07	0.384	9.58	8.19	107.28
			1.00	19.31	0.383	9.92	8.42	109.35
			2.00	19.1	0.383	9.28	8.24	101.92

Near-Shore (319-grant) Discrete Water Quality Data for Lake Hopatcong (May through August 2010)

5/25/2010

Station	TP (mg/L)	TSS (mg/L)	CHL *a* (mg/m^3)
NPS 1	0.02	ND <2	NS
NPS 2	0.01	ND <2	
NPS 3	0.02	ND <2	8.7
NPS 4	0.01	ND <2	8.7
NPS 5	0.01	ND <2	7

6/28/2010

Station	TP (mg/L)	TSS (mg/L)	CHL *a* (mg/m^3)
NPS 1	0.07	4	
NPS 2	0.03	ND <2	
NPS 3	0.02	2	4.8
NPS 4	0.03	5	3.1
NPS 5	0.03	5	13.1

7/28/2010

Station	TP (mg/L)	TSS (mg/L)	CHL *a* (mg/m^3)
NPS 1	0.09	15	
NPS 2	0.02	29	
NPS 3	0.04	12	14.1
NPS 4	0.02	ND <2	5.1
NPS 5	0.03	6	11.3

8/25/2010

Station	TP (mg/L)	TSS (mg/L)	CHL *a* (mg/m^3)
NPS 1	0.08	12	
NPS 2	0.02	ND <2	
NPS 3	0.04	9	20.4
NPS 4	0.02	ND <2	6.6
NPS 5	0.02	2	7.9

As always, if you have any questions or comments, please feel free to contact Princeton Hydro at 610-524-4220 or by e-mail (flubnow@princetonhydro.com). Thank you for your time.