Fresh Pond Reservation

Cambridge, Massachusetts

Evaluation of Black's Nook for In-Pond Restoration Opportunities

January 2021

HATCH

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SECTION 1
INTRODUCTION AND BACKGROUND

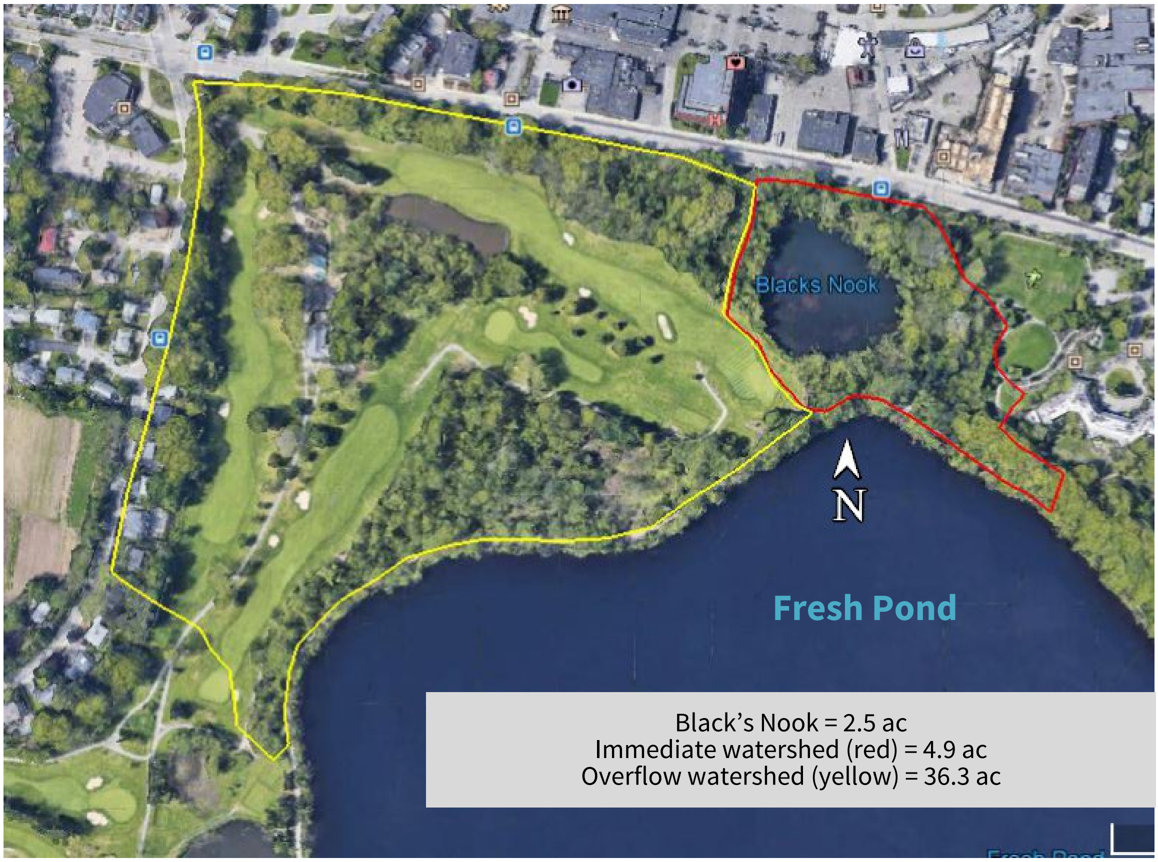
Black's Nook Pond within the Fresh Pond Reservation in Cambridge, Massachusetts, covers 2.5 acres off Concord Avenue at the north end of the reservation. A former cove of Fresh Pond, it has been cut off for over 150 years and has only a small (4.9 acre) direct drainage watershed (Figure 1) with a larger (36.3 acre) overflow watershed that drains the golf course and normally bypasses Black's Nook. However, during wet weather with higher flows and possible restriction of flow under Concord Avenue, water can back up into Black's Nook through what is normally the outlet of the pond. Except during such overflow periods, Black's Nook gets most of its water from precipitation and the much smaller direct drainage watershed. The Whitman and Howard diagnostic/feasibility study from 1987 found a similar situation; Black's Nook hydrology appears to have been relatively stable for the last 30+ years.

The shoreline of Black's Nook is largely wooded with shrub and ground vegetation layers also dense in some areas. Work along the margin with the golf course (Fresh Pond Golf Course) sought to enlarge the buffer zone along that border and improve its habitat and stormwater mitigation value, but mowing and golf course enhancement have kept that buffer zone narrow and Canada geese access Black's Nook from that side of the pond. The pond itself has limited open water during summer as aquatic plants grow densely. Shifts in species composition have occurred over time and plant growths have gotten denser since the 1987 Whitman and Howard report. Nutrient levels have been reported as variable but generally high and algae blooms, including cyanobacteria, have occurred over the last thirty (30) years on an intermittent basis.

Black's Nook has become, by design and ecological rehabilitation, a wildlife refuge within the Fresh Pond Reservation. Invasive and non-native species have been minimized on land, fencing and rules limit use by people and pets, and constructed access promotes wildlife viewing and education functions. The Black's Nook area is accessible off Concord Avenue or from the path that rings Fresh Pond (Perimeter Road), but there is no nearby parking or any visitor facilities other than an access boardwalk. Work to rehabilitate Black's Nook and its immediate surroundings to better serve as natural habitat is ongoing.

This assessment was performed and prepared by Water Resource Services Inc. (WRS) and Normandeau Associates in partnership with Hatch in the planning and implementation of further improvements to Fresh Pond Reservation in general and Black's Nook specifically. WRS evaluated water and sediment features in Black's Nook with additional effort devoted to algae and rooted plant assessment. Normandeau Associates evaluated the benthic community and developed a baseline for wildlife. Consideration of watershed features and related hydrology and nutrient loading was also provided. The Hatch team, in conjunction with the Cambridge Water Department Watershed Management group and its stakeholders, will assist in the review and selection of long-term management options.

Figure 1. Black's Nook Pond and it's Watershed



SECTION 2
WATER QUALITY APPROACH

WRS assessed water depth over a series of GPS points blanketing Black's Nook (Figure 2). Water quality and plankton sampling was conducted on three dates in fall 2019, spring 2020, and summer 2020 at GPS points 061 (BN1) and 062 (BN2), with 061 representing the deepest point located in the pond and having surface and bottom locations for sampling. Water quality was assessed in the field with a multi-probe sonde calibrated prior to use and in the lab by standard methods.

Sediment probings for depth of soft sediment were conducted at another set of GPS points (Figure 3) with sediment cores collected at GPS points 080 (Sed1), 081 (Sed2) and 082 (Sed3) with a universal corer on an extendable pole. Sediment samples were tested by labs certified for the chosen parameters.

Phytoplankton were collected as whole water samples while zooplankton were collected with net tows amounting to 380 liters of water being filtered per sample. Samples were preserved with glutaraldehyde in the field and examined by WRS staff under a microscope to identify and enumerate algae and zooplankton.

A Marcum underwater video system was used to examine the pond below the surface. Sediment probing was accomplished with 10-ft metal rods that can be attached sequentially when the combined water and sediment depth is greater than ten feet (>10 feet). Groundwater elevation was assessed by comparing water depth in two wells near Black's Nook to the elevation of the pond.

Figure 2. Black's Nook Water Assessment Locations

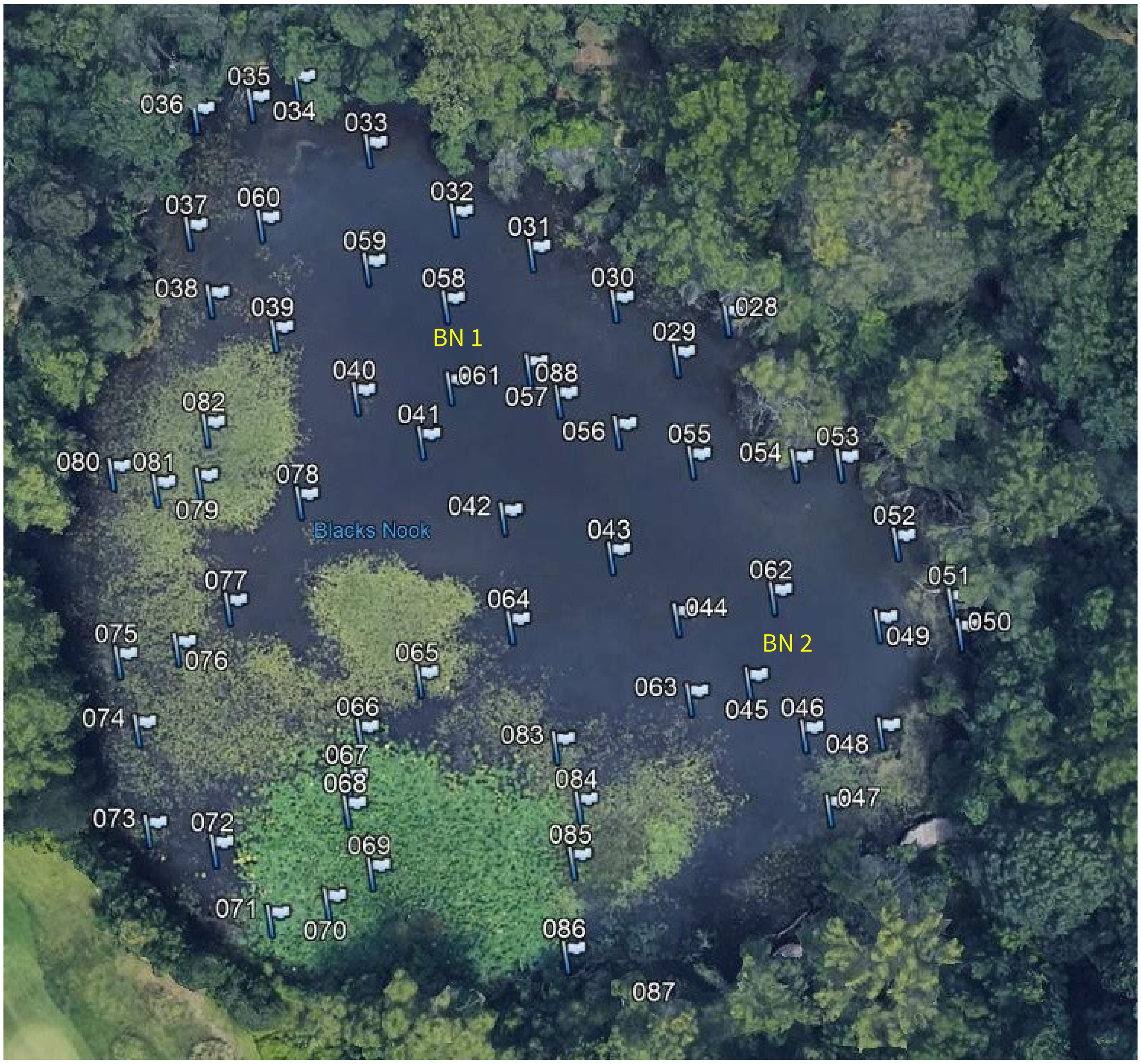
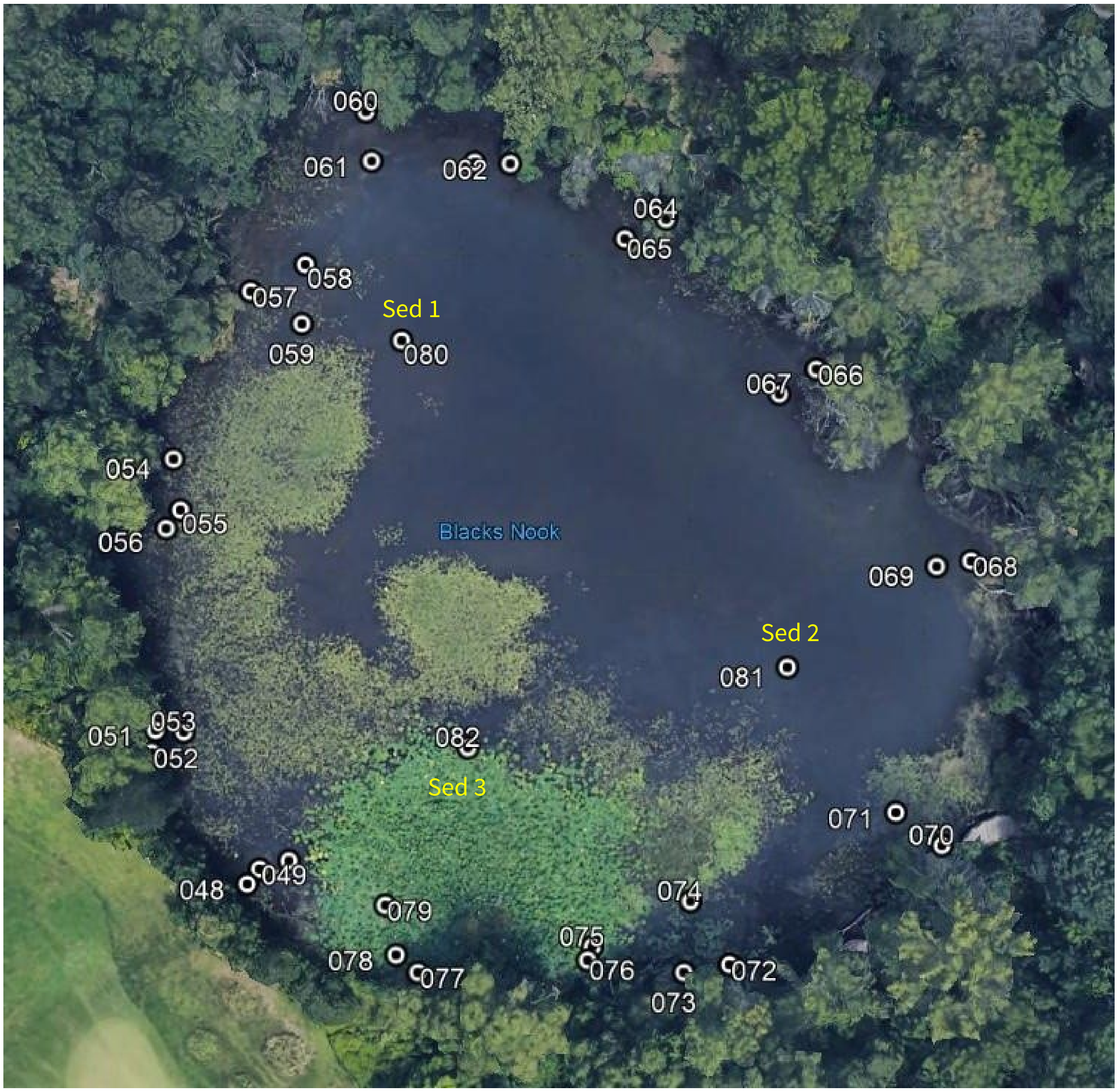


Figure 3. Black's Nook Sediment Assessment Locations



SECTION 3
WATER QUALITY RESULTS

PHYSICAL FEATURES

Water depth measurements allowed contours to be drawn at 1-foot increments (Figure 4). Maximum depth is just over 6 feet while average depth is 3.7 feet. The total water volume is 9.3 acre-feet (Table 1), or 405,000 cubic feet or 11,500 cubic meters. The bathymetric map differs slightly from that in the 1987 Whitman and Howard report, but not greatly. Water level can vary by almost 2 feet over the course of a year, with high levels most often encountered in spring and low levels occurring in late summer or early fall. The values in Figure 4 and Table 1 are based on the normal full pool elevation.

Sediment probing was only possible to a combined water and sediment depth approaching 20 feet, given the difficulty in pushing the probe into the peaty sediment. However, the probing that was conducted allowed a map of soft sediment contours to be drawn for sediment up to 15 feet deep (Figure 5). Maximum sediment depth exceeded 15 feet over at least an acre of the pond and the total volume of soft sediment <15 feet deep was 28 ac-ft (Table 2), or 1.22 million cubic feet or 34,600 cubic meters. The sediment turned to peat within 2 feet of the sediment-water interface and extended to an unknown depth. Reports of the borings collected in 2010 made when planning the observation platform off the boardwalk suggest that the depth might be as much as 30 feet. The peat is very old, suggesting that Black's Nook has been a shallow water feature even when it was attached to Fresh Pond, but that at some point not long after the last glaciation it was considerably deeper.

The non-peat portion of the sediment, functionally the upper 1-2 feet, represents a volume of 2.4 to 4.6 ac-ft or 3,872 to 7,420 cubic yards. The physical difference in the soft sediment in roughly 1-foot increments to a depth of 3 feet was striking (Figure 6), with loose, fine organic sediment at the top and a firm fibrous peat from 2 feet down, with a gradation between the two states in the 1-2 foot range of the core samples.

Measurement of the water level in two wells relative to the water level elevation in Black's Nook in mid-August 2020, a time of relatively low water level in the pond, revealed that the groundwater table was lower than the surface of the pond (Figure 7). The groundwater table may rise in the spring to meet the low water level, but at that time the water level is usually much higher. Given the dense peat layer under the pond, it appears that Black's Nook is a perched water feature, dependent largely on the balance of precipitation and evaporation for its depth. Groundwater will not move quickly through the peat layer and will only enter the pond in any significant quantity if the groundwater table rises enough to access the sandier to cobbly sediment near the pond edge. However, the peat layer is thick more than 30 feet from the pond edge all the way around, so this pathway will be limited.

Figure 4. Black's Nook Bathymetry

Table 1. Black's Nook Water Volume

Water Depth (ft)	Area (ac)	Water Vol (ac-ft)
0	2.5	9.3
1	2.3	6.9
2	2.0	4.7
3	1.7	2.9
4	1.2	1.4
5	0.6	0.5
6	0.2	0.1

Figure 5. Black's Nook Sediment Depth

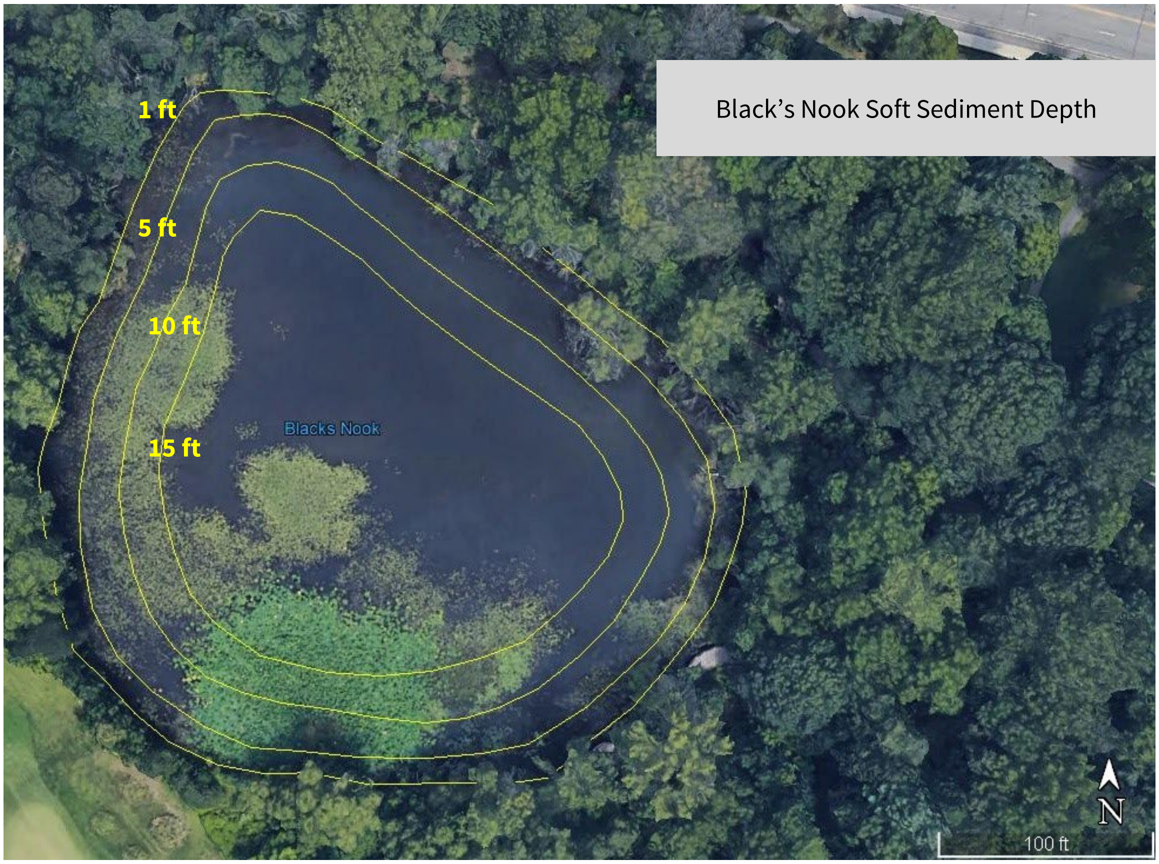
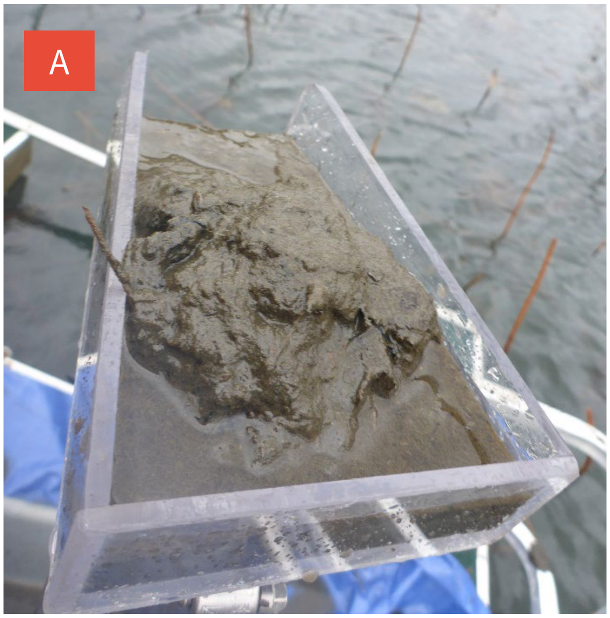


Table 2. Black's Nook Sediment Volume

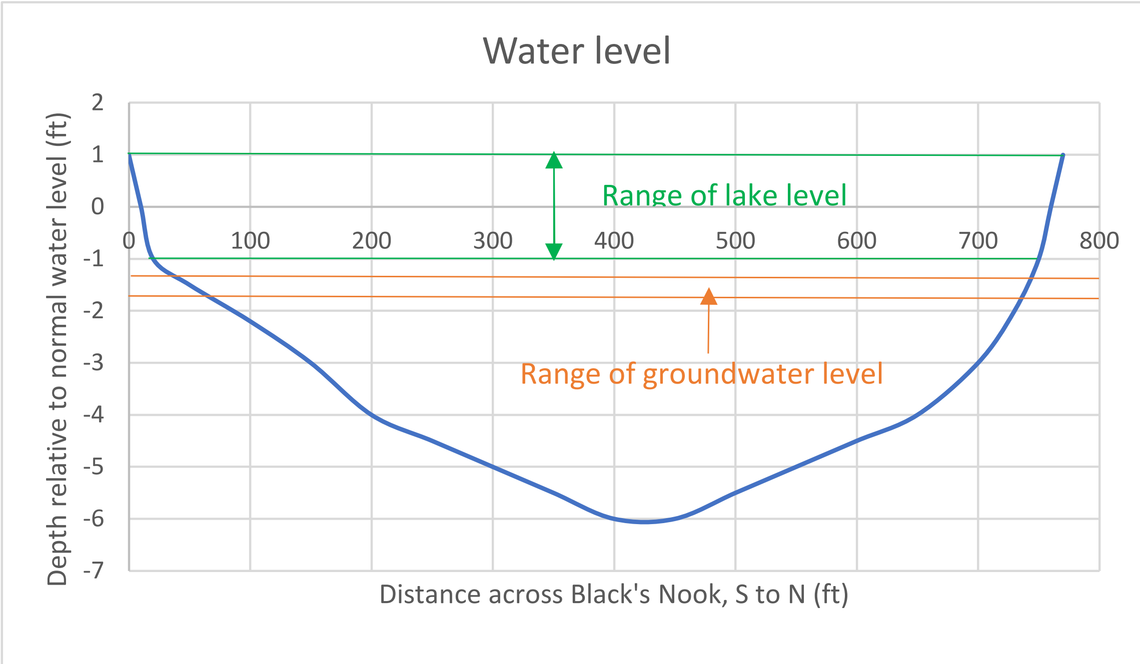
Sediment Depth (ft)	Area (ac)	Sediment Layer Vol (ac-ft)	Cum. Sediment Vol (ac-ft)
0	2.5	0.0	28.0
1	2.4	2.4	25.6
5	2.0	8.6	17.0
10	1.4	8.5	8.5
15	1.0	6.0	2.5
>15	1.0	2.5	-
1 ft deep over 2.4 ac = 2.4 ac-ft			
1.5 ft deep over 2.35 ac = 3.5 ac-ft			
2 ft deep over 2.3 ac = 4.6 ac-ft			

Figure 6. Black's Nook Sediment Core Features



Soft sediment cores representing the upper foot (A), middle foot (B) and lower foot (C) of a 3-ft core in Blacks Nook. Note the transition from typical pond muck to highly cohesive peat.

Figure 7. Groundwater Table Relative to Black's Nook Water Level



CHEMICAL FEATURES

Black's Nook was the subject of a diagnostic/feasibility study by Whitman and Howard in 1986-87 and that report noted issues with elevated nutrients and fluctuating oxygen and pH. Runoff from the golf course was perceived as a major influence, entering through the normal Black's Nook outlet during larger storms as the culvert under Concord Avenue restricts flow at that point. Possible issues with sediment interacting with the overlying water in this shallow system were also noted.

Monitoring from 2001-2009 by the Cambridge Water Department is summarized here (Table 3) and a more complete listing is provided in the Appendix. Water quality from the three WRS/CWD samplings of fall 2019 into summer 2020 (Tables 4 and 5) provide comparison. In general, water quality has not varied greatly over the last two decades although there are seasonal patterns that repeat and are typical of waterbodies in this region. There are issues with elevated phosphorus and nitrogen (especially the ammonium fraction), fluctuating pH and oxygen, and occasionally with fecal bacteria. The bacteria are undoubtedly from wildlife, most likely birds, and no human inputs are suspected. The elevated nutrients and fluctuating pH and oxygen are likely related to interactions between the organic sediment and the overlying water. A lot of the observed vertical gradients during summer are fostered by dense aquatic vegetation that limits mixing. Even the temperature exhibited a strong gradient between the top and bottom in only 6 feet of water during summer.

Table 3. Black's Nook Historic Water Quality Summary

Date	Depth (feet)	Water temp. (°C)	Sp. Cond. (µS/cm)	pH	DO (mg/L)	DO (%Sat)	Turbidity (NTU)	Ammonium N (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ortho Phos. (mg/L)	Chl-a (ug/L)	FC(CFU /100 ml)	Alkalinity (mg/L CaCO3)	Na (mg/L)	NO3 (mg/L)
Maximum	6.0	30.2	522	9.1	11.5	128.2	611.2	1.750	5.100	0.670	0.033	110.0	1070	87	20.7	0.290
Minimum	0.0	0.8	127	3.0	0.1	1.2	0.5	0.038	0.100	0.010	0.003	0.8	0	40	7.0	0.005
Median	2.0	16.6	227	7.1	5.0	42.2	13.1	0.038	0.700	0.046	0.003	14.0	40	60	14.2	0.025
Average	1.9	15.3	232	7.0	4.8	46.3	52.0	0.147	0.979	0.076	0.005	20.9	121	62	14.2	0.031

Table 4. Black's Nook Field Water Quality from 2019-2020 for Station BN1

Date	Time	Latitude	Longitude	Depth (ft)	Depth (m)	Temp (C)	DO (mg/l)	DO (%Sat)	Conductivity (uS/cm)	pH (units)	TDS (mg/L)	Chl (ug/L)	Alkalinity (mg/L)	Secchi (m)
10/3/2019	10:56:42	42.39	-71.16	0.0	0.0	17.7	4.9	51.4	144	7.3	91.9	3.9	48	To plants
10/3/2019	10:57:44	42.39	-71.16	1.1	0.3	17.7	2.5	26.5	144	7.1	91.8	7.1		
10/3/2019	10:58:36	42.39	-71.16	2.1	0.6	17.7	2.0	20.8	146	7.0	93.3	13.4		
10/3/2019	11:00:04	42.39	-71.16	3.0	0.9	17.7	1.8	18.5	151	6.9	96.3	75.9		
10/3/2019	11:01:19	42.39	-71.16	4.0	1.2	17.6	1.5	16.0	137	6.8	87.8	20.8		
10/3/2019	11:02:37	42.39	-71.16	5.1	1.5	17.6	1.0	10.6	151	6.6	96.4	74.2		
10/3/2019	11:03:09	42.39	-71.16	5.9	1.8	17.4	0.9	9.0	305	6.4	195.4	67.5		
											Turb. (NTU)			
3/12/2020	10:55:19	42.39	-71.16	0.6	0.2	9.5	10.9	96.6	107	7.3	4.0	3.1	41	To plants
3/12/2020	10:55:57	42.39	-71.16	1.7	0.5	9.5	10.9	96.6	107	7.4	3.8	4.0		
3/12/2020	10:56:23	42.39	-71.16	3.3	1.0	9.5	10.7	95.0	107	7.4	3.8	5.5		
3/12/2020	10:58:05	42.39	-71.16	5.0	1.5	8.9	6.9	60.0	110	7.0	12.8	46.3		
3/12/2020	11:00:07	42.39	-71.16	6.0	1.8	8.7	2.8	24.0	132	6.6	21.5	88.3		
7/9/2020	10:43:44	42.39	-71.16	0.3	0.1	27.4	9.9	126.7	105	9.5	4.2	13.1	45	To plants
7/9/2020	10:44:15	42.39	-71.16	1.7	0.5	24.3	3.2	38.7	107	8.9	6.0	14.7		
7/9/2020	10:44:55	42.39	-71.16	3.4	1.0	21.7	0.0	0.0	153	7.7	5.3	3.6		
7/9/2020	10:46:11	42.39	-71.16	5.0	1.5	20.8	0.0	0.2	220	6.7	65.6	32.0		

Table 5. Black's Nook Laboratory Water Quality from 2019-2020

Collect Date	Site	Ammonium as Nitrogen	Nitrate as Nitrogen	Nitrite as Nitrogen	Total Kjeldahl Nitrogen	Total Phosphorus	Lab Conductivity	Lab pH	Lab Total Alkalinity	Lab Turbidity	Total Organic Carbon	Color	UV254
Units		mg/L	mg/L	mg/L	mg/L	mg/L	uS/cm	Std Units	mg/L	NTU	mg/L	CU	Abs
03-Oct-19	BN 1S	0.082	<0.01	<0.05	0.500	0.329	116	7.16	47.5	2.2	4.4	28	0.122
03-Oct-19	BN 1B	0.148	<0.05	<0.01	0.730	0.055	119	6.96	46.0	3.9	1.4	42	0.146
03-Oct-19	BN 2S	0.106	<0.01	<0.05	0.440	0.033	121	7.22	46.0	2.0	1.9	27	0.124
12-Mar-20	BN1 B	0.106			0.338	0.029	126	7.53	46.5	1.8	4.4	14	0.092
12-Mar-20	BN2	0.201			0.377	0.075	131	7.49	46.0	1.6	4.4	14	0.090
12-Mar-20	BN1 S	0.136			0.372	0.053	127	7.54	47.0	1.8	4.3	14	0.090
09-Jul-20	BN 1S	0.150	0.071	<0.01	0.925	0.079	148	9.22	46.0	2.0	5.4	26	0.126
09-Jul-20	BN 1B	0.522	0.051	0.021	2.380	0.266	146	7.08	54.0	7.5	5.9	110	0.304
09-Jul-20	BN 2S	0.244	0.071	<0.01	0.574	0.045	136	9.88	44.5	3.9	5.2	28	0.114

Collect Date	Site	Aluminum	Antimony	Arsenic	Barium	Berylium	Cadmium	Calcium	Chloride	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Sodium	Sulfate	Thallium
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
03-Oct-19	BN 1S	<0.010						13.9	13.4			0.84			0.147				7		
03-Oct-19	BN 1B	0.060						15.1	13.1			2.42			0.640				8		
03-Oct-19	BN 2S	<0.010						13.5	13.0			0.75			0.132				7		
12-Mar-20	BN1 B	0.010						14.5	19.1			0.23			0.026				7	6.6	
12-Mar-20	BN2	0.020						13.9	16.6			0.25			0.032				7	7.1	
12-Mar-20	BN1 S	0.010						14.4	16.5			0.27			0.026				7	7.0	
09-Jul-20	BN 1S	<0.010						14.4	14.1			0.61			0.213				7		
09-Jul-20	BN 1B	0.030						17.7	13.5			3.77			1.110				8		
09-Jul-20	BN 2S	<0.010	< 0.001	< 0.001	0.020	< 0.001	< 0.001		11.9	< 0.0020	< 0.0020		< 0.0010	3.0		< 0.0005	< 0.0050	< 0.0010			< 0.0010

The pH does indeed vary greatly, with values >9 observed at the surface during summer as a consequence of intense photosynthesis by rooted plants (which removes carbon dioxide from the water and raises pH). Values are much lower (typically 6.4 to 7.1) near the bottom of the pond where light restricts photosynthesis and decomposition of organic matter releases acids that depress the pH.

Oxygen exhibits a similar pattern with supersaturation near the surface and depletion at times near the bottom. The influence of photosynthesis and decomposition are again evident. Oxygen was lower than the state standard for support of fish and wildlife throughout the water column during the October 2019 sampling, a function of reduced photosynthesis at that time of year and continued high decomposition with limited mixing among dense plants. Oxygen did not meet the standard even 2 feet from the surface during the July 2020 sampling.

Conductivity (dissolved solids), turbidity/suspended solids, and chlorophyll-a (an algal pigment) also exhibited a gradient from lowest near the surface to highest near the bottom. The high chlorophyll-a values may be a function of organic matter fluorescing at the same wavelength as chlorophyll-a, as algae were not very abundant in the 2019-2020 samples. But the conductivity and turbidity gradients are expected under the circumstances, with substances being released or resuspended from the loose organic bottom. Color is also sometimes higher at the bottom for the same reason, and the effect is much more pronounced during summer when metabolism by plants and microbes is higher.

Other aspects of water quality were generally acceptable, with no indications of problems due to salt or metals. A lack of influence by urban stormwater or groundwater on a regular basis is suggested. The golf course may add nutrient-rich runoff at times, but salt and metals would not be expected to be high in such runoff. Salt (sodium and chloride) are known to be high in the water supply source, further suggesting that groundwater flow from Fresh Pond into Black's Nook is very limited.

Sediment samples proved to be minimally contaminated (Table 6) other than high organic content (yielding elevated oxygen demand) and moderate to elevated available phosphorus (Fe-P and biogenic P), neither of which are regulated as potentially hazardous material. The only potential exceedances of sediment standards for Massachusetts were for arsenic, lead, three forms of polyaromatic hydrocarbons and one pesticide. The lead in the upper 1 foot of two of three cores was slightly above the most stringent standard. All the other possible exceedances were a matter of the detection limits attainable by the lab for those sediment samples being higher than the most stringent standard. This happens frequently with organic sediments of relatively low solids content.

It is unlikely that the hydrocarbons or pesticide actually exceed any standard. Arsenic is sometimes high in relation to past use in orchard pesticides, but there is no reason to believe that is a factor in this case and the detection limit for only 4 of 9 samples slightly exceeded the most stringent standard. If dredged, some additional testing will be needed, and it may be that the material cannot simply be used anywhere, but it is probable that any dredged sediment could be placed within the reservation (or golf course) with some cover on top of it.

Table 6. Black's Nook Sediment Quality from April 2020

Parameter	Method	Units	MA DEP Background Soil Data Set 90th Percentile	Typical Natural Concentration in Soil by MCP	MCP Reportable Concentration for Soil Level 1	BN Sed 1a	BN Sed 1b	BN Sed 1c	BN Sed 2a	BN Sed 2b	BN Sed 2c	BN Sed 3a	BN Sed 3b	BN Sed 3c
						04/24/20	04/24/20	04/24/20	04/24/20	04/24/20	04/24/20	04/24/20	04/24/20	04/24/20
Total Metals														
Arsenic	6010B, SW-846	mg/kg	11-16.7	20	20	<21.7	<26.6	<26.0	<23.8	<14.2	<16.6	<15.7	<14.7	<16.4
Cadmium	6010B, SW-846	mg/kg	1.63-3.0	2	70	<3.62	<4.43	<4.33	<3.96	<2.37	<2.77	<2.61	<2.45	<2.74
Chromium (total)	6010B, SW-846	mg/kg	28.6-43.9	30	100	33.9	16.2	16.9	29.5	37.1	17.6	25.9	16.8	18.2
Copper	6010B, SW-846	mg/kg	37.7-47.5	40	1000	62.1	19.7	<17.3	54.1	52.8	18.5	40.8	17	15.1
Lead	6010B, SW-846	mg/kg	78.9-640	100	200	236	28.4	15.9	227	110	34.2	184	37.1	<8.22
Mercury	7471, EPA 1986	mg/kg	0.28-1.4	0.3	20	0.567	<0.622	<0.605	0.523	<0.394	<0.382	<0.455	<0.418	<0.428
Nickel	6010B, SW-846	mg/kg	16.6-67.5	20	600	31.9	12.9	12.6	31.3	31.8	14.2	24.3	14.8	14.5
Zinc	6010, EPA 1987	mg/kg	103-340	100	1000	279	47.2	34.7	253	183	36.4	147	75.4	33.8
Extractable Petroleum Hydrocarbons														
C9-C18 Aliphatics	EPH	mg/kg			1000	<50	<59	<55	<49	<36	<36	<42	<37	<40
C19-C36 Aliphatics	EPH	mg/kg			3000	<99	<120	<110	<97	<72	<73	<83	<74	<79
C11-C22 Aromatics	EPH	mg/kg			1000	<99	<120	<110	<97	<72	<73	<83	<74	<79
Polynuclear Aromatic Hyrdocarbons														
Acenaphthene	EPA 8270	mg/kg	1.9	0.5	4	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Acenaphthylene	EPA 8270	mg/kg	1	0.5	1	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Anthracene	EPA 8270	mg/kg	3.8	1	1000	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Benzo(a)anthracene	EPA 8270	mg/kg	2.39-17.6	2	7	0.210	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Benzo(a)pyrene	EPA 8270	mg/kg	2.02-15.3	2	2	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Benzo(b)fluoranthene	EPA 8270	mg/kg	6.78-11.0	2	7	0.270	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Benzo(k)fluoranthene	EPA 8270	mg/kg	3.35-11.4	1	70	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Benzo(g,h,i)perylene	EPA 8270	mg/kg	1.2-3.1	1	1000	0.170	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Chrysene	EPA 8270	mg/kg	2.1-20.3	2	70	0.230	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Dibenzo(a,h)anthracene	EPA 8270	mg/kg	0.49-1.1	0.5	0.7	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Fluoranthene	EPA 8270	mg/kg	4.2-14.0	4	1000	0.330	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Fluorene	EPA 8270	mg/kg	2.3	1	1000	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Indeno(1,2,3-cd)pyrene	EPA 8270	mg/kg	1.5-6.3	1	7	0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
1-Methylnaphthalene	EPA 8270	mg/kg	0.96	0.5	0.7	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
2-Methylnaphthalene	EPA 8270	mg/kg	0.96	0.5	0.7	<0.280	<1.700	<1.600	<1.400	<1.000	<1.000	<1.200	<1.000	<1.100
Naphthalene	EPA 8270	mg/kg	1.4	0.5	4	<0.140	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Phenanthrene	EPA 8270	mg/kg	2.7-15.0	3	10	0.200	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570
Pyrene	EPA 8270	mg/kg	4.29-16.0	4	1000	0.350	<0.830	<0.790	<0.700	<0.510	<0.510	<0.580	<0.520	<0.570

Table 6. Black's Nook Sediment Quality from April 2020 (Continued)

Parameter	Method	Units	MA DEP Background Soil Data Set 90th Percentile	Typical Natural Concentration in Soil by MCP	MCP Reportable Concentration for Soil Level 1	BN Sed 1a	BN Sed 1b	BN Sed 1c	BN Sed 2a	BN Sed 2b	BN Sed 2c	BN Sed 3a	BN Sed 3b	BN Sed 3c
Solids														
Total Solids	2540B SM	%				12	10.5	10.8	12	16.7	15.3	15	15.9	14.9
Total Volatile Solids	2540G SM	%				32.8	61.6	60.1	31.9	28.1	38.1	26.9	36.7	43.4
Grain Size														
% larger than 4.75 mm (Sieve Size 4)		%				100	100	77	100	100	100	100	100	100
% between 4.75 and 2.00 mm (Sieve Size 10)		%				98	81	51	98	98	95	99	96	33
% between 2.00 and 0.850 mm (Sieve Size 20)		%				96	65	34	94	93	88	92	91	17
% between 0.850 and 0.425 mm (Sieve Size 40)		%				93	56	25	91	88	81	85	86	11
% between 0.425 and 0.250 mm (Sieve Size 60)		%				91	48	20	89	84	75	81	83	8
% between 0.250 and 0.150 mm (Sieve Size 100)		%				88	39	15	86	81	68	76	79	6
% between 0.150 and 0.110 mm (Sieve Size 140)		%				86	33	11	84	77	61	70	77	4
% between 0.110 and 0.075 mm (Sieve Size 200)		%				84	28	7.7	81	72	51	62	72	2.9
% finer than 0.075 mm (Sieve Size 230)		%				82	25	5	79	68	47	56	69	2
Phosphorus availability testing														
Solids content		%				11.2	10.4		12.3	18.7		12	15.8	
Total P		mg/kg				1395	825		1205	1004		1059	1010	
Loosely sorbed P		mg/kg				<2	<2		<2	<2		<2	<2	
Fe-P		mg/kg				335	183		289	128		223	107	
Biogenic P		mg/kg				210	41.3		169	143		214	164	
Al-P		mg/kg				340	253		273	232		178	127	
Ca-P		mg/kg				372	242		339	389		312	193	
Organic P		mg/kg				348	148		303	255		346	583	
Al		mg/kg				16156	5748		13946	13881		11852	8511	
Fe		mg/kg				46254	14176		33160	25780		21527	14774	
Ca		mg/kg				6689	12652		8598	6814		5105	6627	
Available P		mg/kg				1730	1008		1494	1132		1282	1117	
Mass of available P		g/m2-10 cm				21.3	11.5		20.2	23.3		16.9	19.4	

Notes: Red highlight indicates exceedance of the most stringent MA standard for sediment disposal. Yellow highlight indicates that the detection limit achieved for this testing was higher than the most stringent MA standard. Sediment sampling locations are shown in Figure 3. For each core, a=0-1 ft, b=1-2 ft, and c=2-3 ft.

BIOLOGICAL FEATURES

Plankton samples were collected on each of three sampling visits to assess that aspect of the aquatic community. The phytoplankton, or floating algae, form the base of the food web and are essential to a functioning pond ecosystem. However, where nutrients are excessive and grazing on algae is limited, blooms may occur that impair pond conditions for both human and non-human users. Blooms have been reported in the past for Black's Nook, including by cyanobacteria that can be toxic, and qualitative data from the CWD for past samples indicates a range of possible bloom-forming species in the pond. However, samples collected in fall of 2019, spring of 2020, and summer of 2020 did not suggest abundant algae (Figure 8).

Several problem species of algae were detected but not at problem levels (Appendix). Biomass <1000 ug/L is generally considered low while biomass >3000 ug/L may be an issue depending on the algae present. The only sample to exceed 3000 ug/L was dominated by the golden alga Dinobryon, not a species of concern for a pond like Black's Nook. More frequent sampling might help define algae issues better, but the dominance by rooted plants, apparently increasing in recent years, may be depressing algal abundance.

Zooplankton were scarce in Black's Nook in the 2019-2020 samples (Figure 9). Biomass <25 ug/L is considered very low for zooplankton and values did not exceed that threshold. At biomass <100 ug/L there is not enough grazing pressure to keep algae in check, so the lack of abundant algae in Black's Nook is not a function of zooplankton feeding. Cladocerans, especially large-bodied Daphnia, are the most effective grazers and are preferred as food for small fish; Daphnia were absent in the Black's Nook samples and cladocerans of any genus were almost absent (Appendix).

Most biomass was comprised of small copepods, less efficient grazers and harder for small fish to catch. Mean length for zooplankton did exceed the 0.4 mm threshold below which the zooplankton community is ineffective as a grazing force or food source but was well below the 0.9 mm threshold indicative of dominance by larger predatory fish (Figure 10). The Normandeau fish survey of spring 2020 found no larger predatory fish but did find many smaller fish that consume zooplankton.

Figure 8. Black's Nook Phytoplankton Summary

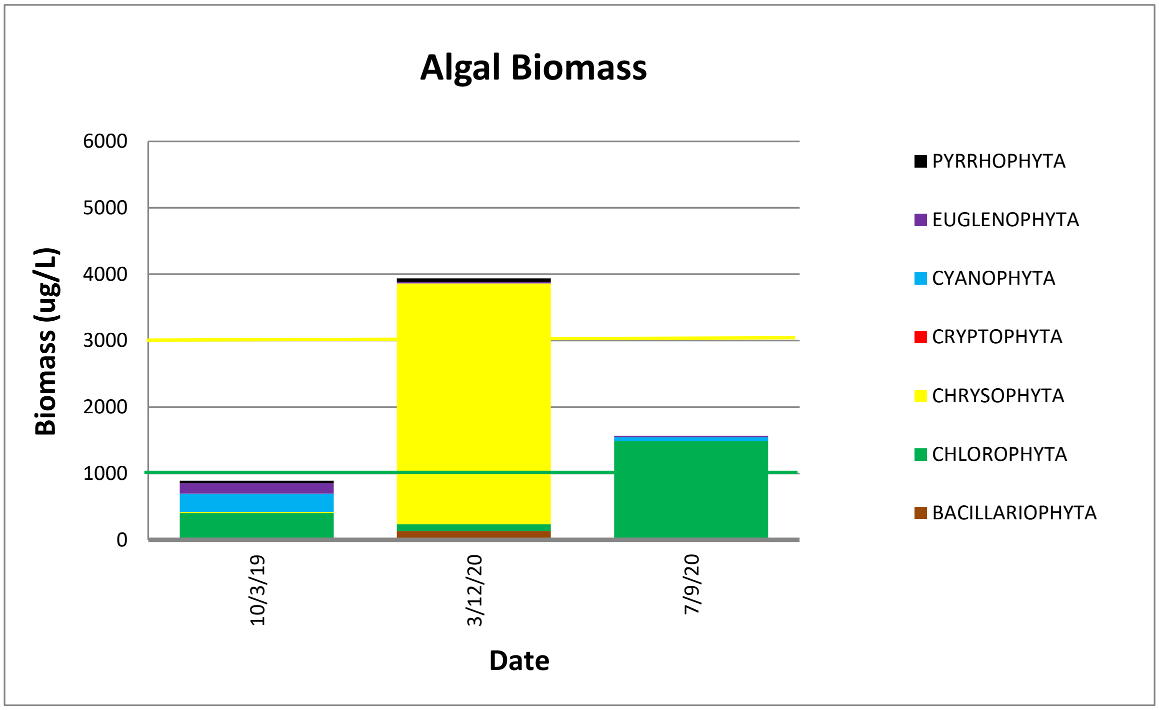


Figure 9. Black's Nook Zooplankton Biomass

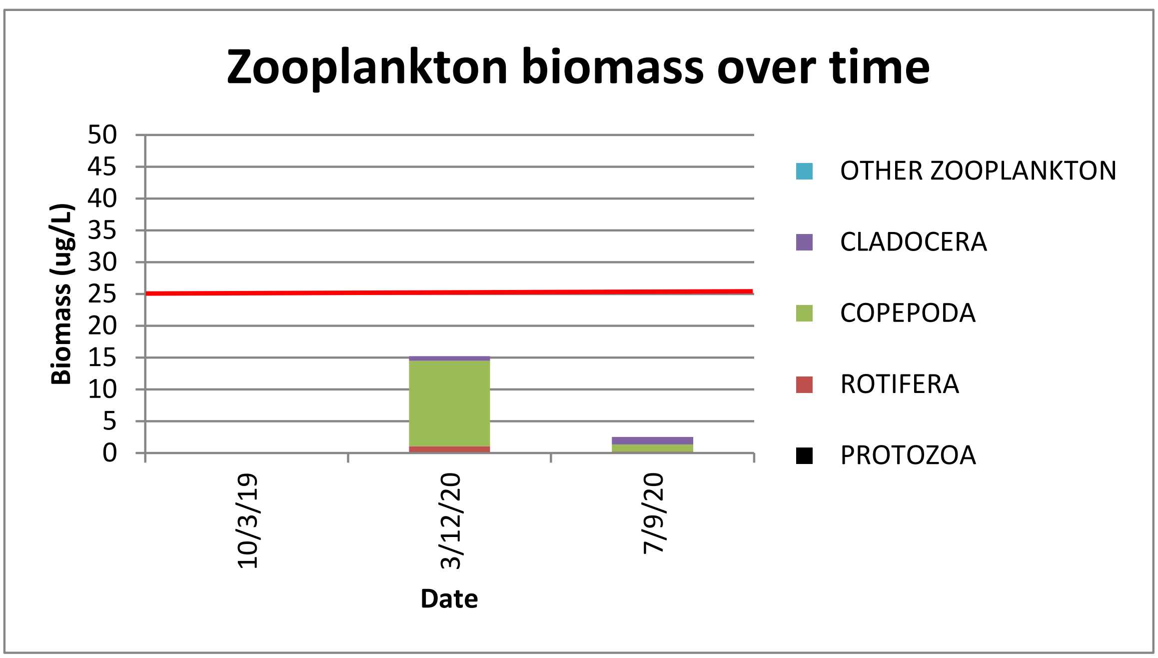
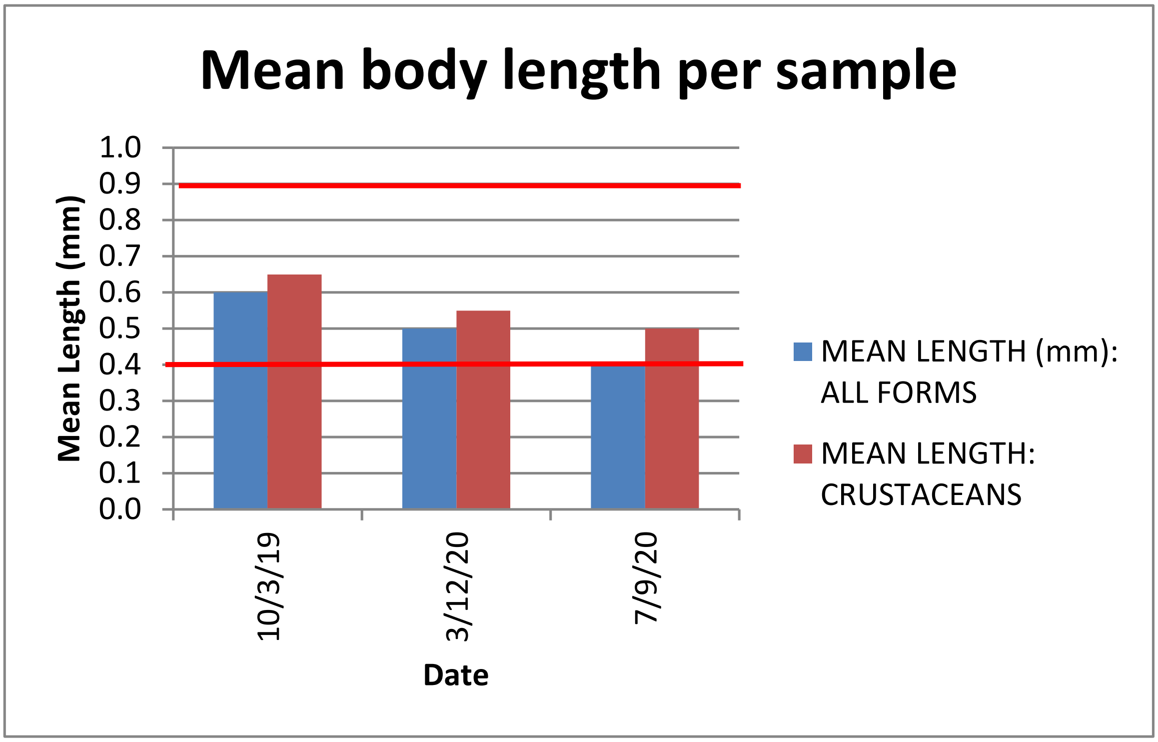


Figure 10. Black's Nook Zooplankton Mean Length



Aquatic plants are extremely abundant in Black's Nook. Native coontail fills the water column during summer in the deeper part of the pond while a mix of native water smartweed and non-native Indian lotus cover the surface in shallower water (Table 7). Invasive water chestnut has been abundant in the past but has been kept below nuisance levels through a volunteer hand-pulling effort. Yellow and white water lily and duckweed can be found in scattered growths; each is capable of covering the surface of this pond but is outcompeted by other aquatic plants. The lotus was reportedly introduced to the pond only a few years ago by unknown sources and has expanded greatly over time. It can be expected to cover most of the pond within less than a decade if not controlled.

The 1987 Whitman and Howard report listed coontail and waterweed (*Elodea canadensis*) as abundant. The more recent Normandeau survey in 2019 noted some Brazilian waterweed (*Egeria densa*), which is often confused with waterweed, but neither was abundant. It appears that the lotus and smartweed are gaining dominance in the pond and other species are being relegated to minor status, although coontail is still dominant in water greater than four feet (>4 ft) deep.

Aquatic plants in Black's Nook have a major influence on all aspects of the pond. The dense growths inhibit vertical mixing during the summer, fostering chemical gradients from surface to bottom. High photosynthesis is also responsible for gradients of pH and oxygen. Low oxygen at the sediment-water interface is causing the release of phosphorus from sediment and leading to overfertilization. Algae blooms can be expected when vascular plants die back in the fall. Habitat for some water-dependent species may be enhanced by the dense plant growth, but fish and wading birds will have trouble foraging. The invertebrate fauna found by Normandeau was found to be tolerant of low oxygen and included mostly small species with limited food value to fish and wildlife. With habitat suitability for a range of desirable species as a goal for Black's Nook, control of aquatic vascular plants is an obvious need.

Table 7. Black's Nook Plant Community from WRS Observation

Scientific Name	Common Name	Status	Abundance in Blacks Nook
Ceratophyllum demersum	Coontail	Native	Dense submergent growth over about 0.75 ac (4-6 ft depth contour)
Lemna minor	Duckweed	Native	Scattered surface growths, not abundant in 2019-20
Nelumbo nucifera	Indian lotus	Exotic	Dense emergent growth over 0.25 ac on S side of pond, scattered growth over 0.75 ac, expanding at up to 5 ft water depth
Nuphar advena	Yellow water lily	Native	Scattered surface growths mostly on S side of pond, outcompeted by lotus and smartweed
Nymphaea odorata	White water lily	Native	Scattered surface growths mostly on S side of pond, outcompeted by lotus and smartweed
Persicaria amphibia	Water smartweed	Native	Dense surface growth over 0.5 ac, scattered growths over another 0.25 ac, out to about 5 ft water depth
Trapa natans	Water chestnut	Exotic	Scattered growths throughout pond, much reduced by hand pulling
Note: Expansion of Indian lotus apparent in 2020; covering more like 1.25 ac (half of pond) in total			

SECTION 4
HABITAT APPROACH

BENTHIC SURVEY

Collection

The macroinvertebrate samples were collected from three different areas of the pond, spread out to include the entire perimeter. This to obtain data representative of as much of the pond area as possible from a limited amount of sampling. Collections were made utilizing two gear types, one quantitative and one qualitative. Quantitative samples were collected from Stations A, B, and C, with a Petite Ponar grab that encompasses a bottom area of 0.023 square meters. The Ponar is a selective device used to target soft sediments. Qualitative samples were collected from Stations D, E, and F with a Kick Net fitted with a 500 micron mesh. The Kick Net was used to target the vegetated areas that covered most of the pond surface.

Photo 1. Ponar sample collection

The Ponar samples were collected by abruptly dropping the sampler to the bottom, utilizing the weight of the device to insert itself into the mud to a depth of one or two inches. A "grab" was considered usable if a good portion of the sampler (e.g., one-half) was filled with sediment upon retrieval. Kick sampling was conducted from vegetated areas by collecting a series of "sweeps" and "jabs" to produce a composite sample. Samples from both gear-types were sieved in the field, preserved with alcohol, and transported as a mixture of specimens and matrix to the laboratory for analysis.

Laboratory Analysis

At the lab, the sample matrices were placed into sorting trays partially filled with water. Using forceps, invertebrate specimens were removed from small aliquots of the matrices under magnification and placed by type into glass vials. Each matrix was processed in entirety. Subsampling was limited to only the most abundant (> 100) taxonomic groups present in each sample. This was accomplished by first removing all non-abundant forms from the entire volume of matrix, while leaving abundant taxa unprocessed. Following this, the matrices were placed in a Folsom Splitter and divided into one-quarter fractions. A fraction was then selected at random and reprocessed to remove abundant forms. Counts were estimated for abundant taxa according to the amount of matrix reprocessed. The specimens were identified to the genus/species taxonomic endpoints as their age and condition allowed.

Metric Analysis

A Tolerance Value was assigned to each taxon, taken from a list published by NYS DEC (2018), ranging from 0 to 10, where low values indicate invertebrates sensitive to water or sediment quality degradation. The Tolerance Values can be interpreted as follows: 0–3 (sensitive); 4-6 (facultative); and 7-10 (tolerant).

To aid description of the invertebrate community the data were reduced to measures of Richness, Population and Community Density (for the Ponar samples), and Diversity. Richness is simply a count of all of the invertebrate taxa identified in a sample, so communities with a large number of taxa are described as rich. Density is an estimate of the number of specimens per square meter from the quantitative Ponar samples. Exceedingly low densities occur when most of the invertebrates are eliminated due to pollution. Abnormally high densities can occur when many of the more sensitive forms are eliminated, placing a few tolerants at a selective advantage. Shannon Diversity (H') is a summary statistic, a measure of distribution according to the formula: H' (base e) = Σ Pi lnPi; where: Pi is the proportion if invertebrates belonging to the ith taxon. Simply put, it is a measure of how evenly distributed an invertebrate community is among those taxa present. Maximum diversity is attained when all taxa are present in equal number.

FISHERIES SURVEY


Photo 2. Electrofishing in Blacks Nook.

The fisheries investigation was conducted using a john-boat electro-fishing system powered by a generator that establishes a continuous DC-field of approximately 5-amperes between boat-mounted cathode and anode arrays. This method is particularly effective in depths up to six feet. The electric field temporarily immobilizes any fish and sometimes amphibians and reptiles encountering it, so they can be netted and placed in a live well for processing and metrics collection (taxonomic identification, measurements, condition, etc.), and then released unharmed. For this project, the perimeter of the pond (the littoral zone) was traversed in a sine-wave (sinuous) pattern as a single-pass effort. Captured fish were identified, measured to the nearest 1-mm total length, observed for disease or parasitism, and released.

TERRESTRIAL WILDLIFE SURVEYS

Bird Survey

Breeding songbirds were surveyed three times in the spring of 2020, using standardized census methods to detect birds, and Breeding Bird Atlas (BBA) criteria to confirm the breeding status of the birds detected. Surveys were conducted on June 2, June 14, and June 23. Because Black's Nook is only about 100 meters in diameter and point count methodologies require points be located at least 150 meters apart, an area-census method has been selected to completely characterize avifauna within 100 feet of the pond. Species recorded on at least two of three survey dates per site were assumed to be breeders at that site. Other behaviors, including carrying of nesting material, fecal material, or food, as well as begging young will also be considered evidence of breeding. Each survey consisted of a surveyor walking the perimeter of the pond slowly and locating individual birds found within the study area. The surveyor spent a minimum of two hours on site and remained on site until no new species were detected for at least 10 minutes. The starting point and direction of travel along the pond shore varied such that no location was surveyed at the same time of day during subsequent visits.

Anuran Survey

Following the North American Amphibian Monitoring Program1 survey protocols, surveys for breeding frogs and toads were conducted in May to verify their presence at Black's Nook. These surveys consisted of a three-minute listening period at each listening location, conducted within three hours after sunset under conditions with minimal wind, and an appropriate air temperature, based on the sampling period. Light rain that does not interfere with listening is also a suitable survey condition. The survey locations were visited three times from late May through June. Survey locations were established at two locations on Black's Nook and two nearby locations: on the north shore of Fresh Pond, and on Little Fresh Pond. All species of amphibian heard calling were recorded.

For each species of amphibian heard, calls were coded as:

1. non-overlapping calls;
2. intermittently overlapping calls; or
3. continuously overlapping calls, for that species.

BAT SURVEY

Detector Deployment

Photo 3. A bat acoustic detector similar to those used at Blacks Nook.

Normandeau conducted surveys using equipment from Binary Acoustic Technology. This included 1) IFR-V Field Recorders, full-spectrum ultrasonic acoustic detectors; and 2) AR125-EXT Ultrasonic receivers, microphones designed specifically for ultrasonic monitoring and analysis. The microphones were attached to the inside of a 45 degree angle PVC elbow to protect them from precipitation.

As defined by the USFWS' 2020 Range-wide Indiana Bat Survey Guidelines , the Project was categorized as a non-linear project, and required eight detector nights (two detectors deployed for four nights) of survey effort per 0.5 kilometer squared of project area. Due to weather and logistical considerations for detector retrieval, detectors were in place for nine nights at each location.

The sampling locations were selected based on a combination of factors including access, proximity/opportunity for minimal human disturbance, an open cone of detection for the microphones to sample, and apparent bat habitat quality (e.g., mature trees, snags, hollows and crevices, and wetland habitat). The detector set-up adhered to specifications detailed in the 2020 Guidelines.

To ensure that the detectors were functioning correctly during every survey period, settings were checked upon retrieval of the detector in a similar fashion as to when they are deployed: 1) the microphones were checked for proper recording of sounds and archiving of data onto the internal drive/USB; and 2) the program recording times and acoustic range were verified.

Call Analysis

The entire call analysis process was managed via Normandeau's ReBAT® data management system, which tracks each acoustic recording file after upload throughout the call analysis process and stores all results in a MySQL database. Each acoustic file was processed as required by the 2020 Guidelines using Kaleidoscope Pro version 5.1.9i, which is one of the USFWS-approved automated bat call classification software packages. The software analyzes bat calls and determines the probability (or "likelihood of presence p (probability) value") that they were made by a certain bat species. Any probability less than 0.05 is statistically interpreted to mean that the call belongs to that species.[1]

[1]https://www.fws.gov/midwest/endangered/mammals/inba/surveys/pdf/FINAL%20Range-wide%20IBat%20Survey%20Guidelines%203.23.20.pdf

SECTION 5
HABITAT RESULTS

BENTHIC SURVEY

Ponar Grabs (Pond Sediments)

A cumulative total (Stations A, B, and C combined) of 382 specimens (Appendix A) was collected using the Ponar. Thirty taxa were identified, indicating a moderately rich invertebrate community. Community Density was 5,536 per square meter, indicating a moderately dense community. The most common species are detailed in Table 8.

Table 8. The most abundant species identified during ponar grab surveys at Black's Nook

Taxon	Common Name	Tolerance	Density	Percent
Chironomus sp.	midge	10	1,425	25.9%
Dero sp.	naiad worm	10	957	17.3%
Dero nivea	naiad worm	10	594	10.7%
Dicrotendipes sp.	midge	8	406	7.3%
Paranytarsus sp.	midge	6	362	6.5%

Thus, the four most abundant taxa in the community were tolerant forms (Tol. = 7 - 10). No sensitive (Tol. = 0 – 3) taxa were present. Collectively, facultative taxa (Tol. = 4 – 6) represented 16.5 percent of the total and tolerants were 83.5 percent.

For this gear-type and analytical procedure, Diversity values (in base e) greater than 2.00 may be interpreted to indicate a diverse community. Shannon Diversity for the three Ponar samples was 2.57 (Table 9).

Table 9. Summary of results from Ponar sampling in Black's Nook

	Sta. A	**Sta. B**	**Sta. C**	**Total**
Total Specimens	176	56	150	382
Total Taxa (Richness)	18	8	15	**30**
Total Density (no. sq. m.)	5,536			
Shannon Diversity (base e)	2.57			

Kick Net (aquatic vegetation)

Cumulative totals (Stations D, E, and F) of 1,289 specimens and 51 taxa (Appendix A) were collected using the Kick Net, indicating a rich community. Dominant species are detailed in Table 10.

Table 10. The most abundant species identified during kick net surveys at Black's Nook

Taxon	Common Name	Tolerance	Total	Percent
Dero nivea	naiad worm	10	582	45.2%
Caenis sp.	mayfly	6	107	8.3%
Corynoneura sp	midge	4	88	6.8%
Enallagma sp.	damselfly	8	76	5.9%

Just two sensitive taxa were identified, which represented 4.3 percent of the cumulative total. Facultative taxa represented 32.0 percent and tolerant forms 63.6 percent.

Kick Net sampling tends to collect a greater variety of invertebrates than normally seen from the Ponar, so for this data set diversity values of 2.50 or more can be considered high. The Shannon Diversity calculation produced a result of 2.39 (Table 11).

Table 11. Summary of results from kick net sampling in Black's Nook

	Sta. A	Sta. B	Sta. C	Total
Total Specimens	374	179	736	1,289
Total Taxa (Richness)	27	35	27	51
Shannon Diversity (base e)	2.39			

Pond habitat can be divided into two general groupings: 1) soft sediments, typically found in both deep and shallow areas, and 2) aquatic vegetation, most often found in the shallow littoral margins near the banks.

Soft sediments tend to be naturally anoxic, providing poor habitat for invertebrates that require a well oxygenated environment to persist. In lakes and larger ponds wave action created by wind can aid the oxygenation process but in small and more stagnant ponds there is little aerative mixing. Hence, a boundary layer at the water/substrate interface forms (particularly in the summertime) consisting of poorly oxygenated sediments overlain by a more oxygenated water column. Thus, investigations from benthic habitats tend to reveal communities consisting largely of burrowing forms with multiple adaptations to eutrophic low oxygen environments.

Submerged aquatic vegetation (SAV) normally creates a more preferred substrate for colonization. There, invertebrates can perch on plant surfaces in areas relatively well oxygenated through photosynthetic activity. SAV also provides forage in the form of a film of algae that grows on the leaf and stem surfaces, that is utilized by grazing invertebrates. SAV provides refuge from predators as well. However, when pond systems are brought out of balance by too much vegetative growth, sunlight tends to be blocked at the water surface limiting photosynthetic activity in the deeper regions. Bacteriological decay of dead plant tissue at the bottom further depletes oxygen concentrations. If this occurs at night when photosynthesis ceases or in the wintertime when the pond is frozen-over, severe anoxia can occur causing fish kills. Photos of Black's Nook show vegetative growth that extends across nearly the entire surface area of the pond.

Thus, collections from both habitat types are best to produce data sufficient to fully describe small pond communities.

As anticipated, the Ponar samples produced invertebrate taxa well adapted to low oxygen environments.

Midges are one of the largest of the aquatic insect families, inhabiting a wide variety of environments. Chironomus and Dicrotendipes are burrowing forms, within a subgroup called the blood-red midges; an indicator of eutrophication. Both have a hemoglobin-like compound in their circulatory systems that allows them to more efficiently metabolize oxygen. In addition, Chironomus possess a pair of caudal gills. Some mud-inhabiting genera such as Paratanytarsus construct silken tubes and utilize a filter-feeding mechanism that also aids oxygenation. A silken net is spun across the entrance of the tube and the Paratanytarsus undulates its' body within to create a current of water. Food items are captured on the net and a stream of oxygenated water is supplied.

The naiad worm Dero is common in both benthic and littoral habitats and are also an indicator of eutrophication. Carbon dioxide and oxygen exchange occurs mostly through the body wall. Water is also taken in at the posterior end - and through peristalsis and ciliary action passed forward to create an accessory respiratory mechanism. Dero also have a set of posterior gills supplied with blood vessels. The data from the Kick Net samples indicated a shift in community composition from that observed in the pond sediments.

Dero was clearly the dominant in the Kick Net samples as well. They, like many naiads, are often found in dense concentrations associated with filamentous algae and SAV.

The mayfly Caenis is one of the few members of the insect Order Ephemeroptera commonly found in small ponds. Like most mayflies they reside mostly in the shallows. Referred to by habit as "sprawlers", they are a facultative genus, adapted to live on bottom muds - but almost certainly utilize SAV stratum on which to forage.

Corynoneura is a midge associated with filamentous algae and SAV. These represent a second facultative genus common at Black's Nook.

A tolerant damselfly in the genus Enallagma was also common. Enallagma, as is the case with most damselflies, are predators strongly associated with SAV where they lay their eggs. Known by habit as "climbers" these are ambush feeders that move about slowly on dense vegetation in search of prey. Oxygen is taken in through the body surface and through a set of posterior gills. Enallagma have the capacity to avoid anoxia by residing on SAV near the surface of the pond.

To summarize, the invertebrate community of Black's Nook Pond can be described as: 1) moderately rich to rich; 2) moderately dense; and 3) taxonomically diverse. Most of the taxa found are tolerant forms adapted to eutrophic low oxygen conditions - but may be considered to be fairly typical of small pond ecosystems. Although typical, the diversity and abundance within the community could be greatly improved with more oxygen and fewer plants.

FISHERIES SURVEY

A total of 78 individuals of four (4) fish species were identified (Table 12). Over 70 (92.3%) of these individuals belonged to two of the species: Pumpkinseed and Goldfish. Age distribution was generally skewed towards younger individuals, with over half of all observed fish less than one year old (Table 13).

Table 12. Fish captured during electrofishing surveys at Black's Nook

Species	Scientific Name	Count (# individuals)	Min Length (mm TL)	Max Length (mm TL)	Average Length (mm TL)	CPUE (fish/ minute)	Relative Abundance
Spottail Shiner	Notropis hudsonius	1	51	51		0.04	1.3%
Golden Shiner	Notemigonus crysoleucas	5	78	126	99.8	0.2	6.4%
Goldfish	Carassius auratus	29	85	210	155.0	1.16	37.2%
Pumpkinseed	Lepomis gibbosus	43	49	116	59.9	1.72	55.1%

Table 13. Age distribution of fish captured at Black's Nook

Count of Fish in Each Age Class (approximate length distribution)						
Species	1 year	2 years	3 years	4 years	5 years	6 years
Goldfish	range of 85 mm to 210 mm indicating multiple age classes - no literature on growth at age for fish in US					
Golden Shiner	2 (up to 76 mm)	2 (77-102 mm)	1 (103-114 mm)	0 (115-140 mm)		
Pumpkinseed	42 (up to 89 mm)	0 (89-104 mm)	0 (105-124 mm)	1 (115-140 mm)		

All four species identified are common in warm water bodies in the Northeast (Table 14). These species are typically moderately tolerant of degraded habitat and two of the species identified on site are introduced. Nearly all pumpkinseeds identified on site were immature (estimated <1 year old), while other species exhibited a wider age distribution. The age distribution of pumpkinseeds on site is indicative of low survivorship of the species. Although fish diversity on site is limited to species moderately tolerant of degraded habitat, these species support terrestrial species present on site.

Photo 4. Four species of fish detected at Blacks Nook. Top Left: Pumpkinseed, Top Right: Golden Shiner, Bottom Left: Goldfish, Bottom Right: Spottail Shiner.

Table 14. Status of fish species detected at Black's Nook

Species	Native Distribution (in relation to Northeast)	Occurrence in Northeast (common to rare)	Water Class (General Habitat preference)	Water temperature preference	Trophic Class	Tolerance to degraded habitat
Spottail Shiner	Native/ Introduced[1]	common	Rivers to Lakes	warmwater	Water Column	Intermediate
Golden Shiner	Native	common	Streams to Lakes	warmwater	Generalist Feeder	Tolerant
Goldfish	introduced	common	Rivers to Lakes	warmwater	Generalist Feeder	Tolerant
Pumpkinseed	Native	common	Streams to Lakes	warmwater	Generalist Feeder	Intermediate

TERRESTRIAL WILDLIFE SURVEYS

Bird Survey

A total of 34 species of birds were identified on site (Table 15). Of these, nine were confirmed nesting and seven were probable breeders. The remaining 18 species were possible breeders or observed outside of breeding habitat. Thirteen species observed on site were native residents, ten were long-distance migrants, nine were short-distance migrants, and two were non-native residents.

Table 15. Bird species detected during surveys at Black's Nook

Species	Scientific Name	Breeding Status	Regional Status
American Goldfinch	*Spinus tristis*	Confirmed	Resident
American Redstart	*Setophaga ruticilla*	Probable	Long-distance Migrant
American Robin	*Turdus migratorius*	Confirmed	Resident
Baltimore Oriole	*Icterus galbula*	Confirmed	Long-distance Migrant
Black-capped Chickadee	*Poecile atricapilla*	Observed	Resident
Black-crowned Night-Heron	*Nycticorax nycticorax*	Observed	Short-distance Migrant
Blue Jay	*Cyancitta cristata*	Observed	Resident
Brown-headed Cowbird	*Molothrus ater*	Probable	Short-distance Migrant
Canada Goose	*Branta Canadensis*	Confirmed	Resident
Cedar Waxwing	*Bombycilla cedrorum*	Possible	Resident
Chimney Swift	*Chaetura pelagica*	Observed	Long-distance Migrant
Common Grackle	*Quiscalus quiscula*	Confirmed	Short-distance Migrant
Downy Woodpecker	*Dryobates pubescens*	Probable	Resident
Eastern Kingbird	*Tyrannus tyrannus*	Possible	Long-distance Migrant
European Starling	*Sturnus vulgaris*	Confirmed	Non-native Resident
Gray Catbird	*Dumatella carolinensis*	Confirmed	Short-distance Migrant
Great Blue Heron	*Ardea Herodias*	Observed	Short-distance Migrant
Great Crested Flycatcher	*Myiarchus crinitus*	Probable	Long-distance Migrant
Green Heron	*Butorides virescens*	Observed	Short-distance Migrant
Herring Gull	*Larus argentatus*	Observed	Resident
House Sparrow	*Passer domesticus*	Observed	Non-native Resident
House Wren	*Troglodytes aedon*	Possible	Short-distance Migrant
Least Flycatcher	*Empidonax minimus*	Possible	Long-distance Migrant

Species	Scientific Name	Breeding Status	Regional Status
Mallard	*Anas platyrhynchos*	Confirmed	Resident
Mourning Dove	*Zenaida macroura*	Observed	Resident
Northern Cardinal	*Cardinalis*	Probable	Resident
Northern Flicker	*Colaptes aura*	Observed	Short-distance Migrant
Orchard Oriole	*Icterus spurius*	Probable	Long-distance Migrant
Red-bellied-Woodpecker	*Melanerpes carolinus*	Observed	Resident
Red-winged Blackbird	*Agelius phoeniceus*	Probable	Short-distance Migrant
Ring-billed gull	*Larus delawarensis*	Observed	Resident
Tree Swallow	*Tachycineta bicolor*	Observed	Short-distance Migrant
Warbling Vireo	*Vireo gilvus*	Confirmed	Long-distance Migrant
Yellow Warbler	*Setophaga petechia*	Probable	Long-distance Migrant

Of the 34 species identified on site, eighteen species are reliant directly on the pond, either as a source of food or as breeding habitat (Table 16). Species identified as using the pond for breeding habitat are identified based on their preference for either emergent aquatic vegetation or riparian-associated tree habitat. Aquatic insect species either forage on emerging insects aerially or may forage the shoreline and shallows for emergent insect species. Species reliant on aquatic vegetation are generalists and will typically return to the site.

Table 16. Pond-dependent species identified during the bird survey at Black's Nook.

Aquatic Insects	Aquatic Vertebrates	Aquatic Vegetation	Breeding Habitat
American Redstart	Black-crowned Night-Heron	Canada Goose	Common Grackle
Cedar Waxwing	Green Heron	Mallard	Eastern Kingbird
Chimney Swift	Great Blue Heron		Great Crested Flycatcher
Common Grackle			Orchard Oriole
Eastern Kingbird			Baltimore Oriole
Gray Catbird			Red-winged Blackbird
Great Crested Flycatcher			Warbling Vireo
Red-winged Blackbird			Yellow Warbler
Tree Swallow			

Photo 6 Male Orchard Oriole, a species dependent on riparian habitats for nesting.

Photo 5. Gray catbird was found breeding at the site and feeds primarily on aquatic invertebrates in the pond.

Non-native species detected on site are associated with adjacent urban areas and are not typical of the forested habitat present in the vicinity of the pond. The relatively mature trees surrounding the pond provide breeding habitat for many of the species present on site and have created a diverse community in a small, relatively isolated patch of natural habitat.

Anuran Survey

Photo 7. Bullfrog was the most commonly detected species at Black's Nook Pond.

Three species of frogs were identified during the anuran survey (Table 17). Bullfrog was the most common species recorded during all three surveys with spring peeper and green frog also recorded during the first survey at Black's Nook. Bullfrog was identified at both Black's Nook sites during all three surveys with multiple overlapping calls. No anurans were identified from adjacent Fresh Pond, while only Bullfrogs were observed at Little Fresh Pond. Two of the species were only detected on a single survey, while Bullfrogs were detected on all surveys. Bullfrogs were also noted to be abundant during diurnal surveys on site. Bullfrogs are aggressive towards other pond species and will eat fish, birds, and other amphibians in addition to insects. They are often abundant in ponds with dense floating-leaved vegetation such as Black Nook; however, the high densities currently present on site may be limiting other amphibian diversity. Removal of the extensive Indian lotus (Nelumbo nucifera) on site may result in a decline in the bullfrog population, in turn allowing for the eventual recolonization of other species of anuran on site.

Table 17. Frog call densities at two locations on Black's Nook, one location on Fresh Pond and one location on Little Fresh Pond. Call densities are coded as follows: 0 = Not Detected; 1 = Single calls; 2= Multiple non-overlapping calls; 3 =Overlapping calls

Species	Scientific Name	Black's Nook (N)	Black's Nook (S)	Fresh Pond	Little Fresh Pond
Bullfrog	*Lithobates catesbeianus*	3	3	0	3
Green Frog	*Lithobates clamitans*	1	1	0	0
Spring Peeper	*Pseudacris crucifer*	2	0	0	0

Bat Survey

A total of six species of bats were recorded during the bat survey. The most commonly identified species was the big brown bat, with hoary bat and silver-haired bat also commonly identified. Other species were identified by 10 or fewer calls. Species identified can be found in Table 18.

Table 18. Bat species and call counts at each location on Black's Nook. Bold numbers indicate spectrographic analysis of calls was statistically significant (p<0.05) for correct specific assignment

Species	Scientific Name	Calls at Location 1	Calls at Location 2
Big Brown Bat	*Eptesicus fuscus*	**87**	**479**

Eastern Red Bat	*Lasiurus borealis*	3	1
Hoary Bat	*Lasiurus cinereus*	**7**	**476**
Silver-haired Bat	*Lasionycterus noctivagans*	11	**639**
Little Brown Bat	*Myotis lucifugus*	2	1
Northern Long-eared Bat	*Myotis septentrionalis*	1	**9**

Two of the bat species identified on site are state listed, including the federally listed northern long-eared bat (Table 12). Primary threats to these species include winter mortality as a result of White Nose Syndrome. Other species present on site included three migratory species, and big brown bat, which is solitary. Bats on site rely on the pond primarily as a source of aquatic insects. Although some species, particularly northern long-eared bat, forage in the canopy, they are still reliant on nearby waterbodies as a source of food insects. Additionally, the presence of mature trees surrounding the water is critical for maintaining bat roosting habitat. Any tree clearing needed for restoration should take place during the winter to avoid unintended impacts to bat species on site.

Table 19. Endangered Species Status of bats identified at Black's Nook.

Species	Winter Strategy	State Status	Federal Status
Big Brown Bat	Solitary Hiberation	-	-
Eastern Red Bat	Migration	-	-
Hoary Bat	Migration	-	-
Silver-haired Bat	Migration	-	-
Little Brown Bat	Communal Hibernation	Endangered	-
Northern Long-eared Bat	Communal Hibernation	Endangered	Threatened

Photo 8. Federally-listed Northern Long-eared Bat calls were detected during acoustic surveys.

SECTION 6
CONCLUSIONS

The direct watershed of Black's Nook is small and mostly an engineered "natural area" that has been altered in recent years to enhance habitat value and serve as an urban oasis and outdoor educational facility. It is not a major contributor of nutrients, sediment, or other contaminants, having no stormwater conveyance system and largely excluding sources that would be considered a threat to the pond. There is a larger potential drainage area that includes mainly golf course that can contribute runoff to Black's Nook during significant rain events by virtue of water backing up at the culvert under Concord Avenue and entering Black's Nook via its normal outlet, but this was not an observed phenomenon during the field phase of this investigation. Such runoff would likely have a lot of nutrients and possibly pesticides but does not appear to be a regular influence on Black's Nook. Episodic inputs may be responsible for the build-up of nutrient-rich sediment in the pond, but it appears that internal recycling of nutrients from the sediment is the main productivity issue for Black's Nook now.

The primary water source to Black's Nook is precipitation. Some runoff will enter from the direct watershed and larger inputs are possible from the extended (golf course) watershed, but on an annual basis these are not likely to be major inputs. The thick peat layer under the pond greatly limits groundwater flow. Black's Nook is functionally a deep puddle over an organic base with an overflow outlet that can become an inlet under very wet conditions. Water level will be determined largely by the balance between precipitation and evaporation, with higher water levels in spring and lower levels in late summer and early fall. The detention time for water in the pond may be as much as a year, further emphasizing the importance of internal processes to water quality.

The organic sediment exhibits a gradient of features, with the top 1 foot being loose organic muck of more recent origin and higher nutrient content, with sediment more than 2 feet below the sediment surface being very old peat. The 1-2 foot depth interval for sediment is a transition zone between the more recent material and the much older peat. Rumors of deliberate filling of Black's Nook do not seem to be completely accurate; there is debris in the pond, but the layer of sediment accumulated since prior to human settlement is not all that thick.

The quality of the sediment under Black's Nook is not poor. Decayable organic content in the upper foot or so is high, leading to high oxygen demand, and available phosphorus in the form of iron-bound or biogenic (easily decayed) phosphorus is moderately elevated, leading to release from sediments exposed to low oxygen and elevated phosphorus concentrations in the pond. Those are problems leading to suboptimal habitat in the pond, but contamination by hydrocarbons, pesticides and metals is very limited to minimal, particularly considering the urban setting. If the upper 1 to 2 feet of sediment were removed, nearly pure peat would be exposed and would have much less negative influence on water quality and habitat value.

Black's Nook is shallow and has been shallow for many years. Plants can grow over its entire area and currently become dense throughout the pond. Invasive, non-native, and native species with nuisance potential are all abundant, but the recently introduced Indian lotus appears to be taking over the pond and eliminating open water. Where lotus is not dense, water smartweed and coontail fill the water column during summer. The related gradient and fluctuations of pH and oxygen are critical stressors for fish and invertebrates, and both communities can be characterized as poor. The loss of oxygen near the bottom fuels phosphorus release from sediment, and while algae blooms were not observed during the field phase of this investigation, such blooms have been reported in the past and would be expected in the absence of such a dense vascular plant community.

Black's Nook provides a diverse aquatic habitat, supporting an equally diverse terrestrial community. Two elements of the community are particularly critical to maintaining diversity on site: aquatic invertebrates and riparian vegetation. The aquatic invertebrate community will likely rapidly rebound from alteration to habitat; however, there may be an initial decrease in diversity as a result in the loss of submerged aquatic vegetation. This will be mitigated in the long term by the ability of the pond to support a greater diversity of aquatic species. Maintaining some submerged aquatic vegetation will be critical to the repopulation of the pond by invertebrate species. Of particular importance are aquatic insects, which only spend part of their life cycle in the water and provide important forage for bats and birds.

Limiting clearing along the pond shore is critical to providing breeding habitat to the bird species using the pond, as well as providing habitat for roosting bats. Shoreline trees also provide shade for aquatic invertebrates and fish.

Anurans exhibit a low diversity on site and are dominated by aggressive bullfrogs that may be limiting the ability of other species to colonize the site. Reduction in the density of floating leaved vegetation may allow for a greater diversity of anurans on site.

While the accumulation of nutrient-rich, organic sediment is a key factor in pond condition, it is the abundance of vascular plants that is controlling water quality and habitat value at this time in Black's Nook. Reduction of vegetation density and coverage and some action to limit sediment influence on water quality should be the main thrust of rehabilitation of Black's Nook.

SECTION 7
NEXT STEPS

With an understanding of the physical, chemical, and biological features of Black's Nook through the surveys conducted by WRS, Normandeau, and the CWD with input from Hatch, we can proceed to matching management options with stated goals for the pond and its immediate watershed. This will be a separate effort from this assessment activity, but it is appropriate to note the major needs and possible options to be considered.

There is a need to reduce the density of rooted vascular plants in Black's Nook and to manage the types of species present to both enhance habitat for target fish and wildlife species and limit future problems to keep maintenance at a reasonable level. For rooted plant control, there are over a dozen possible options for reducing the density of vascular plants in Black's Nook, but only a few are highly applicable. Use of herbicides will work but would have to be practiced on an annual to every other year basis and is generally not favored in Cambridge. There are no biological agents that are both legal in Massachusetts and effective on the range of plants present. This leaves physical techniques as the likely mainstay of plant management for Black's Nook.

Hand pulling has been effective for the control of water chestnut but is not a suitable approach for the dominant species now in the pond. Use of benthic barriers, which are covers laid on the bottom or over plants to maintain open water, could be effective but will also restrict habitat use by fish, wildlife and invertebrates. On a localized scale (a few thousand square feet) this could be helpful in opening areas among dense plant growths but covering most of the pond bottom is not a realistic option given impacts and maintenance needs. Mechanical harvesting could work but will require creation of access for a suitable cutting and collection barge. With access, however, harvesting could occur in a day or two. Two cuts per year may be needed. Hydroraking, whereby root systems are removed along with the stems and leaves, could be conducted with access provision for suitable equipment and would provide results that should last several years for most but not all (coontail would be the main exception) species in the pond. Dredging would more completely rehabilitate the pond and could put it into the desired condition for many years.

Dredging is a complicated approach to pond management, with many considerations relating to permitting and implementation. It constitutes a major structural reworking of the aquatic environment and while not all areas must be dredged, it will represent a major disruption to the ecology of the pond during its conduct. It would, however, provide the means to create the desired conditions in Black's Nook with limited future maintenance. A thorough dredging feasibility analysis is needed to allow decision-makers to fully understand the impacts, both positive and negative.

If rooted plants are controlled, some of the negative influence of the surficial sediment under Black's Nook on its water quality will be reduced. Oxygen should be moderated, although it will still likely be low near the sediment-water interface and phosphorus release may still be excessive. Fluctuations in pH should decrease, although the potential for algal blooms may increase and those could cause pH swings much like those currently caused by rooted plants. Some action to manage the surficial sediment of Black's Nook is likely to be needed to achieve desired water quality conditions.

One option for addressing sediment interactions with the overlying water is to treat it with a phosphorus inactivator that binds phosphorus and will keep it from moving into solution. This is now commonly done in lakes that have problems with internal recycling of nutrients and has been successful in improving lake condition in nearly all cases. Another option is to cap the sediments, adding a more benign layer over the existing sediment. A combination of the two approaches is possible, using materials that include phosphorus inactivators.

The most effective approach would involve dredging. Removing the loose organic muck sediment down to the older, firmer, fibrous peat layer would minimize nutrient recycling and create a substrate much more favorable from both physical habitat and water quality perspectives. If dredging were employed to control rooted plants, both objectives could be accomplished with one technique. As noted above, this is a complicated approach subject to more regulation than most lake management techniques and requiring more planning and engineering than other techniques. Given its potential to solve multiple problems however, it is worth strongly considering.

If (shallow) dredging is considered to be the best option for the City, there are techniques to promote healthy aquatic vegetation growth while minimizing the cost of new plantings. One is to propose dredging approximately 15-20 ft from the existing shoreline and leave aquatic vegetation along the shoreline. Invasive aquatic species (i.e. water lotus) would be manually removed in this zone. Unvegetated areas could be planted with native emergent and high marsh species. Table 20 on page 7-3 summarized the four major alternatives discussed above, and includes special considerations, as well as, a 20-year life cycle cost for each alternative.

The one other issue that may require attention is input of runoff from Stream A that normally bypasses Black's Nook and serves as its outlet path but can become a source of water and contaminants during wet weather. No such overflow events were observed during this assessment phase but have been documented in the past and the 1987 Whitman and Howard report included a diagram of an outlet structure that would also serve to block inflows during high water events in Stream A. The current low concrete structure at the outlet of Black's Nook may or may not be adequate and further evaluation of hydrologic management options is advisable.

Table 20. Alternatives Decision Making Matrix

No.	ALTERNATIVE	WATER QUALITY IMPROVEMENTS			HABITAT IMPROVEMENTS					Special Considerations	20-Year Life Cycle Cost
		Returns BN to Open Water Body	Meet Class B Water Quality Standards	Address Category 5 Impaired Water Body Status	Benthic Community	Fishery	(Avian) Birds	(Anuran) Amphibians	Bats		
1	**Hydro Rake and Benthic Barriers**	Y	**P**	**P**	**P**	**P**	**P**	**P**	**P**	Will limit plants where applied but would not cover whole pond due to impacts on benthic community; requires maintenance.	**$170,000**
2	**Chemical Treatment and Phosphorus Inactivation**	Y	**P**	**P**	**P**	**P**	**P**	**P**	**P**	Would need more than one herbicide for range of species present.	**$80,000**
3	**Shallow Dredging (2')**	Y	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	Affects all aspects of the pond, allows for overall restoration and enhancement.	**>$300,000**
4	**Deeper Dredging (4')**	Y	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	Same as for shallow dredging but provides longer benefits and will expand habitat for some species and limit regrowth of plants.	**>$600,000**

KEY:
Y = YES
P = PARTIAL

Appendix
Water Quality Data

Historic Water Quality Data

Date	Field Data							Alpha Analytical Laboratories					CWD Lab Data			
	Depth (feet)	Water temp. (°C)	SpC (μS/cm)	pH	DO (mg/L)	DO (%Sat)	Turbidity (NTU)	Ammonium N (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ortho Phos. (mg/L)	Chl-a (ug/L)	FC(CFU /100 ml)	Alkalinity (mg/L CaCO3)	Na (mg/L)	NO3 (mg/L)
4/13/2001	0	11.7	189	7.3	10.1	93.0	11.0	0.038	0.170	0.030	0.003	3.2		55	14.0	0.025
4/13/2001	2	11.1	189	7.3	9.4	86.0	10.8									
4/13/2001	4	9.6	204	7.1	9.0	80.0	12.8									
4/13/2001	6	8.5	215	7.0	5.5	50.0	16.0									
5/16/2001	0	16.8	211	7.5	4.2	42.0	8.0	0.038	0.440	0.030	0.017	2.8	30	59	18.0	0.025
5/16/2001	2	16.8	210	7.2	3.4	37.3	20.7									
5/16/2001	4	16.4	221	6.9	1.3	13.0	415.4									
5/16/2001	3	16.7	210	7.0	3.3	33.3	13.7									
5/16/2001	4	16.6	254	6.8	1.2	11.9	611.2									
6/28/2001	0	26.4	237	7.6	5.1	62.6	8.8	0.038	0.690	0.030	0.003	9.4		54	16.0	0.025
6/28/2001	2	24.7	239	7.3	3.3	39.5	9.4									
6/28/2001	4	22.2	283	6.9	0.8	9.1	24.8									
6/28/2001	5	19.4	434	6.9	0.3	2.9	22.7	1.750	4.600	0.420	0.003			87	17.0	0.025
6/28/2001	5.26	18.6	522	6.9	0.1	1.2	18.4									
8/28/2001	0	23.4	230	6.5	3.3	38.8	10.2									
8/28/2001	2	23.0	231	6.7	2.3	29.8	21.0									
8/28/2001	4	22.4	239	6.6	0.6	8.3	17.2									
8/28/2001	0	23.6	230	7.0	3.6	42.4	13.9	0.038	0.630	0.030	0.003	8.5		66	17.0	0.025
8/28/2001	2	22.9	230	7.0	2.8	32.1	13.1									
8/28/2001	4	22.9	230	7.0	2.8	32.1	13.1	1.090	5.100	0.670	0.008			82	14.0	0.025
8/28/2001	4.9	21.5	385	6.4	0.1	1.2	93.5									

	Field Data							Alpha Analytical Laboratories					CWD Lab Data			
Date	Depth (feet)	Water temp. (°C)	SpC (µS/cm)	pH	DO (mg/L)	DO (%Sat)	Turbidity (NTU)	Ammonium N (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ortho Phos. (mg/L)	Chl-a (ug/L)	FC(CFU /100 ml)	Alkalinity (mg/L CaCO3)	Na (mg/L)	NO3 (mg/L)
11/8/2001	0	9.3	266	7.3	5.3	46.3	9.0	0.115	0.580	0.020	0.003	3.2	64	78	18.0	0.025
11/8/2001	2	8.3	265	7.3	5.5	46.7	7.6									
11/8/2001	4	8.0	265	7.3	5.5	46.7	7.6									
11/8/2001	4.7	8.2	271	7.3	5.2	44.8	80.4									
5/15/2002	0	13.5	233	6.6	7.3	70.3	6.0	0.038	0.100	0.026	0.003	1.3		63	14.4	0.025
5/15/2002	2	13.4	233	6.7	7.2	69.7	5.9									
5/15/2002	4	13.3	233	6.8	7.4	70.8	6.0									
5/15/2002	6	13.4	243	6.7	5.9	56.2	432.1									
7/10/2002	0	29.1	190	9.1	9.8	128.2	1.1	0.038	0.700	0.026	0.003	0.8	66	49	13.8	0.290
7/10/2002	2	23.4	205	8.5	1.7	18.9	8.2									
7/10/2002	4	21.6	263	8.0	0.4	4.1	19.4									
7/10/2002	4.8	19.0	364	7.7	0.2	2.4	273.4									
8/5/2002	0	30.2	214	7.8	8.2	111.3	4.0	0.038	1.000	0.070	0.011	110.0	368	65	15.0	0.025
8/5/2002	2	25.0	236	7.8	1.6	18.2	56.3									
8/5/2002	2.7	24.1	358	7.3	0.4	4.2	22.5									
5/6/2003	0	16.8	238	7.1	6.9	70.4		0.038	0.380	0.020	0.003	4.0	42		20.7	
5/6/2003	4	16.6	252	6.9	3.6	37.0										
7/23/2003	0	24.2	186	7.6	4.4	53.0		0.038	0.630	0.050	0.003	23.6				0.007
7/23/2003	bottom	22.5	227	7.0	1.1	12.0										
9/8/2003	0	20.3	229	7.3	5.2	56.9		0.132	0.720	0.050	0.003	26.7	16	68		0.025
9/8/2003	bottom	19.9	275	6.7	2.3	25.0										

Date	Field Data							Alpha Analytical Laboratories					CWD Lab Data			
	Depth (feet)	Water temp. (°C)	SpC (µS/cm)	pH	DO (mg/L)	DO (%Sat)	Turbidity (NTU)	Ammonium N (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ortho Phos. (mg/L)	Chl-a (ug/L)	FC(CFU /100 ml)	Alkalinity (mg/L CaCO3)	Na (mg/L)	NO3 (mg/L)
11/8/2001	0	9.3	266	7.3	5.3	46.3	9.0	0.115	0.580	0.020	0.003	3.2	64	78	18.0	0.025
11/8/2001	2	8.3	265	7.3	5.5	46.7	7.6									
11/8/2001	4	8.0	265	7.3	5.5	46.7	7.6									
11/8/2001	4.7	8.2	271	7.3	5.2	44.8	80.4									
5/15/2002	0	13.5	233	6.6	7.3	70.3	6.0	0.038	0.100	0.026	0.003	1.3		63	14.4	0.025
5/15/2002	2	13.4	233	6.7	7.2	69.7	5.9									
5/15/2002	4	13.3	233	6.8	7.4	70.8	6.0									
5/15/2002	6	13.4	243	6.7	5.9	56.2	432.1									
7/10/2002	0	29.1	190	9.1	9.8	128.2	1.1	0.038	0.700	0.026	0.003	0.8	66	49	13.8	0.290
7/10/2002	2	23.4	205	8.5	1.7	18.9	8.2									
7/10/2002	4	21.6	263	8.0	0.4	4.1	19.4									
7/10/2002	4.8	19.0	364	7.7	0.2	2.4	273.4									
8/5/2002	0	30.2	214	7.8	8.2	111.3	4.0	0.038	1.000	0.070	0.011	110.0	368	65	15.0	0.025
8/5/2002	2	25.0	236	7.8	1.6	18.2	56.3									
8/5/2002	2.7	24.1	358	7.3	0.4	4.2	22.5									
5/6/2003	0	16.8	238	7.1	6.9	70.4		0.038	0.380	0.020	0.003	4.0	42		20.7	
5/6/2003	4	16.6	252	6.9	3.6	37.0										
7/23/2003	0	24.2	186	7.6	4.4	53.0		0.038	0.630	0.050	0.003	23.6				0.007
7/23/2003	bottom	22.5	227	7.0	1.1	12.0										
9/8/2003	0	20.3	229	7.3	5.2	56.9		0.132	0.720	0.050	0.003	26.7	16	68		0.025
9/8/2003	bottom	19.9	275	6.7	2.3	25.0										

Date	Field Data							Alpha Analytical Laboratories					CWD Lab Data			
	Depth (feet)	Water temp. (°C)	SpC (µS/cm)	pH	DO (mg/L)	DO (%Sat)	Turbidity (NTU)	Ammonium N (mg/L)	TKN (mg/L)	Total Phos. (mg/L)	Ortho Phos. (mg/L)	Chl-a (ug/L)	FC(CFU /100 ml)	Alkalinity (mg/L CaCO3)	Na (mg/L)	NO3 (mg/L)
7/13/2005	0	23.5	169	8.3	6.5	76.2	16.9	0.038	1.000	0.010	0.003	65.6	15	61	11.4	0.025
7/13/2005	2.8	22.6	191	7.1	0.6	6.7	TNC									
10/20/2005	0	12.7	198	6.7	6.0	56.6	13.1	0.038	0.690	0.030	0.033	21.5	50	62	13.8	0.062
1/19/2006	0	1.4	169	6.7	10.9	76.6	25.6	0.038	1.400	0.130	0.011	43.2	7	57	15.7	0.035
1/19/2006	1.5	2.6	173	6.7	10.5	77.2	21.0									
6/22/2006	0	24.7	145	7.4	6.4	74.6	12.9	0.038	1.100	0.060	0.003	50.3	360	51	11.9	
6/22/2006	QA/QC							0.038	0.990	0.050	0.003					
8/10/2006	0	24.8	162	7.2	5.5	65.7	5.9	0.106	0.980	0.060	0.003	33.2	10	58	9.1	0.013
8/10/2006	bottom	24.5	163	7.3	3.1	36.3	16.3									
10/17/2006	0	12.4	164	7.4	7.0	64.7	8.4	0.139	0.780	0.050	0.003	16.5	18	55		0.025
10/17/2006	3	12.3	164	7.5	5.7	52.3	30.7									
1/22/2007	0	3.6	157	7.5	11.5	88.0	12.8	0.038	0.730	0.050	0.003	25.1				0.005
4/25/2007	bottom	15.8	127	7.6	6.7	67.1	20.6	0.200	0.590	0.040	0.003	12.0	0	40		0.005
8/2/2007	0	25.5	146	7.0	6.1	77.0	1.1	0.038	0.900	0.060	0.006	18.2	56			0.005
9/18/2007												24.2	1070	83	9.1	
3/4/2008	0.77	3.3	201	7.0			1.0	0.200	1.000	0.090	0.006		10	62	8.2	0.005
7/29/2008	0.88	24.9	207	7.2	5.9	71.2	2.1						20	62	7.0	0.005
4/16/2009	Surface	11.6	164	7.4	11.3	103.9	1.1	0.038	0.100	0.042	0.006	14.0			11.8	
7/9/2009	0.4	19.6	159	7.2	3.2	35.4	3.3	0.038	0.700	0.024	0.003	21.6			13.7	

Date	Depth (ft)	Al (mg/L)	Ca (mg/L)	Cl (mg/L)	Color (CU)	Fe (mg/L)	Mn (mg/L)	TOC (mg/L	Total coliform (MPN)	E-coli (MPN)
1/19/2006	1.5	0.340	24.2	15.5		1.70	0.22	9.36		
6/22/2006	0.1	0.059	23.7	12.0		0.79	0.11	17.90	2400	308
8/10/2006	0.1	0.120	27.0	11.0		1.27	0.19	10.60	2200	2
9/18/2007	0.1	0.120	27.0	11.0	38	1.27	0.19	10.60	2200	2
3/4/2008	0.8	0.369	24.2	11.4	39	0.98	0.21		770	4
7/29/2008	0.9	0.020	15.7	10.4	31	0.54	0.07	6.60	9	1
7/29/2008	Bottom	0.026	13.3	8.6	29	0.49	0.09	5.74	120	1
4/16/2009	0.1	0.105	17.4	8.7	24	1.08	0.11		9700	34
4/16/2009	Bottom	0.078	47.6	99.6		11.40	3.57	3.41	>2419	800
7/9/2009	0.4	0.009	23.6		43	1.24	0.66		50	21
7/9/2009	Bottom	0.014	20.9	22.6	27	0.83	0.09	6.39		

Phytoplankton Data

	PHYTOPLANKTON DENSITY (CELLS/ML)		
	Black's Nook	Blacks Nook	Black's Nook
TAXON	10/03/19	03/12/20	07/09/20
Araphid Pennate Diatoms			
Fragilaria/related taxa	0	0	62
Synedra	0	141	0
Biraphid Pennate Diatoms			
Gomphonema/related taxa	0	24	0
Coccoid/Colonial Chlorophytes			
Ankistrodesmus	0	0	25
Closteriopsis	0	94	0
Crucigenia	71	0	0
Dictyosphaerium	214	0	149
Elakatothrix	0	47	0
Kirchneriella	0	0	74
Pediastrum	0	0	50
Scenedesmus	142	0	25
Selenastrum	0	0	0
Sphaerocystis	0	0	546
Filamentous Chlorophytes			
Ulothrix	0	0	25
Desmids			
Closterium	18	0	0
Cosmarium	36	0	50
Desmidium	0	0	124
Mougeotia/Debarya	53	47	0
Staurastrum	0	0	6
Staurodesmus	18	0	12
Teilingia/related taxa	36	0	0
CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon	0	1175	0
Mallomonas	0	94	0
Synura	18	71	0
CYANOPHYTA			
Unicellular and Colonial Forms			
Aphanocapsa	0	0	248
Microcystis	0	0	620
Filamentous Nitrogen Fixers			
Dolichospermum	1335	0	198
Nodularia	0	0	620
Filamentous Non-Nitrogen Fixers			
Pseudanabaena	1068	0	0
EUGLENOPHYTA			
Euglena	36	0	0
Lepocinclis	27	0	0
Phacus	80	0	0
Trachelomonas	89	24	25
PYRRHOPHYTA			
Peridinium	18	24	0
DENSITY (CELLS/ML) SUMMARY			
BACILLARIOPHYTA	**0**	**164.5**	**62**
Centric Diatoms	0	0	0
Araphid Pennate Diatoms	0	141	62
Monoraphid Pennate Diatoms	0	0	0
Biraphid Pennate Diatoms	0	23.5	0
CHLOROPHYTA	**587.4**	**188**	**1085**
Flagellated Chlorophytes	0	0	0
Coccoid/Colonial Chlorophytes	427.2	141	868
Filamentous Chlorophytes	0	0	24.8
Desmids	160.2	47	192.2
CHRYSOPHYTA	**17.8**	**1339.5**	**0**
Flagellated Classic Chrysophytes	17.8	1339.5	0
Non-Motile Classic Chrysophytes	0	0	0
Haptophytes	0	0	0
Tribophytes/Eustigmatophytes	0	0	0
Raphidophytes	0	0	0
CRYPTOPHYTA	**0**	**0**	**0**
CYANOPHYTA	**2403**	**0**	**1686.4**
Unicellular and Colonial Forms	0	0	868
Filamentous Nitrogen Fixers	1335	0	818.4
Filamentous Non-Nitrogen Fixers	1068	0	0
EUGLENOPHYTA	**231.4**	**23.5**	**24.8**
PYRRHOPHYTA	**17.8**	**23.5**	**0**
TOTAL	**3257.4**	**1739**	**2858.2**
CELL DIVERSITY	**0.73**	**0.56**	**0.95**
CELL EVENNESS	**0.61**	**0.56**	**0.77**

	PHYTOPLANKTON BIOMASS (UG/L)		
	Black's Nook	Blacks Nook	Black's Nook
TAXON	10/03/19	03/12/20	07/09/20
Araphid Pennate Diatoms			
Fragilaria/related taxa	0.0	0.0	18.6
Synedra	0.0	112.8	0.0
Biraphid Pennate Diatoms			
Gomphonema/related taxa	0.0	23.5	0.0
Coccoid/Colonial Chlorophytes			
Ankistrodesmus	0.0	0.0	2.5
Closteriopsis	0.0	47.0	0.0
Crucigenia	7.1	0.0	0.0
Dictyosphaerium	21.4	0.0	14.9
Elakatothrix	0.0	4.7	0.0
Kirchneriella	0.0	0.0	7.4
Pediastrum	0.0	0.0	9.9
Scenedesmus	14.2	0.0	2.5
Selenastrum	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	109.1
Filamentous Chlorophytes			
Ulothrix	0.0	0.0	5.0
Desmids			
Closterium	71.2	0.0	0.0
Cosmarium	156.6	0.0	129.0
Desmidium	0.0	0.0	1178.0
Mougeotia/Debarya	53.4	47.0	0.0
Staurastrum	0.0	0.0	5.0
Staurodesmus	10.7	0.0	7.4
Teilingia/related taxa	71.2	0.0	0.0
CHRYSOPHYTA			
Flagellated Classic Chrysophytes			
Dinobryon	0.0	3525.0	0.0
Mallomonas	0.0	47.0	0.0
Synura	14.2	56.4	0.0
CYANOPHYTA			
Unicellular and Colonial Forms			
Aphanocapsa	0.0	0.0	2.5
Microcystis	0.0	0.0	6.2
Filamentous Nitrogen Fixers			
Dolichospermum	267.0	0.0	39.7
Nodularia	0.0	0.0	6.2
Filamentous Non-Nitrogen Fixers			
Pseudanabaena	10.7	0.0	0.0
EUGLENOPHYTA			
Euglena	17.8	0.0	0.0
Lepocinclis	26.7	0.0	0.0
Phacus	24.0	0.0	0.0
Trachelomonas	89.0	23.5	24.8
PYRRHOPHYTA			
Peridinium	37.4	49.4	0.0
DENSITY (UG/ML) SUMMARY			
BACILLARIOPHYTA	**0.0**	**136.3**	**18.6**
Centric Diatoms	0.0	0.0	0.0
Araphid Pennate Diatoms	0.0	112.8	18.6
Monoraphid Pennate Diatoms	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	23.5	0.0
CHLOROPHYTA	**405.8**	**98.7**	**1470.6**
Flagellated Chlorophytes	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	42.7	51.7	146.3
Filamentous Chlorophytes	0.0	0.0	5.0
Desmids	363.1	47.0	1319.4
CHRYSOPHYTA	**14.2**	**3628.4**	**0.0**
Flagellated Classic Chrysophytes	14.2	3628.4	0.0
Non-Motile Classic Chrysophytes	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0
CRYPTOPHYTA	**0.0**	**0.0**	**0.0**
CYANOPHYTA	**277.7**	**0.0**	**54.6**
Unicellular and Colonial Forms	0.0	0.0	8.7
Filamentous Nitrogen Fixers	267.0	0.0	45.9
Filamentous Non-Nitrogen Fixers	10.7	0.0	0.0
EUGLENOPHYTA	**157.5**	**23.5**	**24.8**
PYRRHOPHYTA	**37.4**	**49.4**	**0.0**
TOTAL	**892.7**	**3936.3**	**1568.6**
BIOMASS DIVERSITY	**0.98**	**0.24**	**0.46**
BIOMASS EVENNESS	**0.81**	**0.24**	**0.37**

Zooplankton Data

	ZOOPLANKTON DENSITY (#/L)				ZOOPLANKTON BIOMASS (UG/L)		
TAXON	**Blacks Nook 10/3/19**	**Blacks Nook 3/12/20**	**Blacks Nook 7/9/20**	**TAXON**	**Blacks Nook 10/3/19**	**Blacks Nook 3/12/20**	**Blacks Nook 7/9/20**
PROTOZOA				**PROTOZOA**			
Ciliophora	0.0	0.0	0.0	**Ciliophora**	0.00	0.00	0.00
Mastigophora	0.0	0.0	0.0	**Mastigophora**	0.00	0.00	0.00
Sarcodina	0.0	0.0	0.0	**Sarcodina**	0.00	0.00	0.00
ROTIFERA				**ROTIFERA**			
Anuraeopsis	0.3	0.0	0.0	*Anuraeopsis*	0.01	0.00	0.00
Asplanchna	0.0	0.7	0.1	*Asplanchna*	0.00	0.73	0.10
Brachionus	0.0	1.5	0.0	*Brachionus*	0.00	0.13	0.00
Conochilus	0.0	0.7	0.0	*Conochilus*	0.00	0.03	0.00
Keratella	0.0	2.2	0.0	*Keratella*	0.00	0.20	0.00
Lepadella	0.0	0.0	0.3	*Lepadella*	0.00	0.00	0.12
Polyarthra	0.3	0.0	0.0	*Polyarthra*	0.03	0.00	0.00
COPEPODA				**COPEPODA**			
Copepoda-Cyclopoida				**Copepoda-Cyclopoida**			
Cyclops	0.0	2.2	0.2	*Cyclops*	0.00	5.34	0.49
Mesocyclops	0.0	0.0	0.1	*Mesocyclops*	0.00	0.00	0.13
Copepoda-Calanoida				**Copepoda-Calanoida**			
Diaptomus	0.0	0.7	0.0	*Diaptomus*	0.00	0.35	0.00
Other Copepoda-Nauplii	0.0	2.9	0.2	**Other Copepoda-Nauplii**	0.00	7.74	0.53
CLADOCERA				**CLADOCERA**			
Alona	0.0	0.0	0.1	*Alona*	0.00	0.00	0.30
Chydorus	0.0	0.7	0.8	*Chydorus*	0.00	0.72	0.78
Diaphanosoma	0.0	0.0	0.1	*Diaphanosoma*	0.00	0.00	0.10
OTHER ZOOPLANKTON				**OTHER ZOOPLANKTON**			
SUMMARY STATISTICS				**SUMMARY STATISTICS**			
DENSITY				**BIOMASS**	**10/3/19**	**3/12/20**	**7/9/20**
PROTOZOA	0.0	0.0	0.0	**PROTOZOA**	0.00	0.00	0.00
ROTIFERA	0.6	5.1	0.4	**ROTIFERA**	0.03	1.09	0.22
COPEPODA	0.0	5.8	0.5	**COPEPODA**	0.00	13.43	1.14
CLADOCERA	0.0	0.7	1.0	**CLADOCERA**	0.00	0.72	1.18
OTHER ZOOPLANKTON	0.0	0.0	0.0	**OTHER ZOOPLANKTON**	0.00	0.00	0.00
TOTAL ZOOPLANKTON	0.6	11.7	1.9	**TOTAL ZOOPLANKTON**	0.03	15.24	2.54
TAXONOMIC RICHNESS							
PROTOZOA	0	0	0				
ROTIFERA	2	4	2				
COPEPODA	0	3	3				
CLADOCERA	0	1	3				
OTHER ZOOPLANKTON	0	0	0				
TOTAL ZOOPLANKTON	2	8	8				
S-W DIVERSITY INDEX	0.30	0.84	0.76				
EVENNESS INDEX	1.00	0.93	0.84				
MEAN LENGTH (mm): ALL FORMS	0.08	0.33	0.37				
MEAN LENGTH: CRUSTACEANS	0.00	0.48	0.41				