A Biological and Chemical Survey of Selected Surface Waters in the Lye Brook Wilderness Area, Vermont

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For
The United States Forest Service - Green Mountain National Forest

Vermont Agency of Natural Resources
Department of Environmental Conservation
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March, 1994

A cooperative project between the State of Vermont and the United States Forest Service under the auspices of the Vermont Monitoring Cooperative

This project was partially funded with a grant from the USDA Forest Service, Green Mountain National Forest

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INTRODUCTION

In 1993, the Vermont Monitoring Cooperative (VMC), working in close cooperation with the Green Mountain National Forest (GMNF) and the State of Vermont, established a southern Vermont monitoring site in the Lye Brook Wilderness (LBW) area. The Vermont Department of Environmental Conservation (VT DEC) and the GMNF subsequently entered into a cooperative agreement that would permit an expansion of monitoring activities within the LBW. Funding was provided by the GMNF in response to mandates under the Clean Air Act to protect Air Quality Related Values (AQRV) in LBW, a Class 1 Wilderness Area. Inventorying and monitoring hydrogeochemical and biological characteristics of lakes and streams within and adjacent to LBW were identified by GMNF through their planning process as essential tasks contributing to the determination of current and future effects of air quality on AQRV's in LBW.

The VT DEC has monitored water quality in and around the LBW since 1980 in an effort to document the effects of acid deposition on sensitive lakes. The VT DEC has established a biological (Fiske, 1987) and chemical (Burnham and Kellogg, 1989) data base for long-term trends in both Bourn and Branch Ponds. In addition, several other lakes within the GMNF have been intensively monitored. These include: Beebe, Big Mud, Griffith, Grout, Haystack, Little (Winhall), Little (Woodford), Little Rock, Moses, Somerset and Stratton. Between 1982 and 1984, fish and chemical surveys were conducted on several lakes and rivers which were within or adjacent to GMNF (Langdon 1982, 1983, 1984, 1985).

The field element of this project was carried out cooperatively by the GMNF and the VT DEC. The GMNF was responsible for:

1. The sampling of the fish community characteristics and water chemistry at one site on Branch Pond Brook and the Winhall River.

The VT DEC was responsible for:

1. The sampling of Bourn, Branch and Little Mud Ponds for littoral and profundal macroinvertebrates, with emphasis on documenting populations from groups known to be sensitive to acid precipitation (Crustacea, Mollusca, Ephemeroptera).

2. The sampling of Bourn, Branch and Little Mud Ponds for water chemistry.

3. Analysis of one representative deep site surficial sediment from both Bourn and Branch Ponds for priority pollutant metals, polynuclear aromatic hydrocarbons (PAH), PCBs and chlorinated pesticides.

4. The sampling of macroinvertebrate and fish community characteristics and water chemistry at two sites in both Bourn and Lye Brooks documenting the effects of elevation, drainage area and bedrock geology on stream biota and chemistry.

This report fulfills VT DEC's obligations to the GMNF by providing a summary and assessment of the biology and chemistry of the major waterbodies within or adjacent to LBW. A recommended long-term biological and chemical monitoring plan is also provided.

STUDY AREA AND METHODS

Study Area

All three lakes and most of the river sites were located within the LBW (**Figure 1**). Refer to **Tables 1 and 2** for a description of the physical characteristics of the study streams and lakes.

The LBW area is highly susceptible to surface water acidification primarily due to the fact that the waterbodies are situated in geologic areas resistant to chemical weathering that permits neutralization of acidic surface and ground waters. This susceptibility has been documented by the ongoing Vermont Long-Term Lake Monitoring Program and past river studies conducted by the VT DEC.

A classification of geologic terrain was conducted by Norton and was based on the acid neutralizing capacity (ANC) or buffering capacity of bedrock formations (Hendrey et al, 1979). The classification consisted of four bedrock types as outlined below:

Type I: Low to no buffering capacity -- Granite-Syenite or metamorphic equivalent; granitic gneisses; quartz sandstone or metamorphic equivalent.

Type II: Medium to low buffering capacity -- sandstone, shales, conglomerates or their metamorphic equivalent (no free carbonate phase present), high grade metamorphic felsic to intermediate volcanic rocks; intermediate igneous rocks; calc-silicate gneisses with no free carbonate phases.

Type III: Medium to high buffering capacity -- slightly calcareous rocks, low grade intermediate mafic volcanic rocks; ultramafic rocks; glossy volcanic rocks.

Type IV: Infinite buffering capacity -- highly fossiliferious sediments or metamorphic equivalents, limestone or dolostones.

Much of the GMNF east of US Route 7 is described as Type I or II. All three study lakes are underlain by Type I bedrock as are the streams with the exception of the lower

stations on Bourn and Lye Brooks. The lower stations on these streams have Type II bedrock. This is readily apparent by comparing the single chemical sampling event results between the upper and lower stations of the brooks. Refer to **Table 7** for a comparison of these sites.

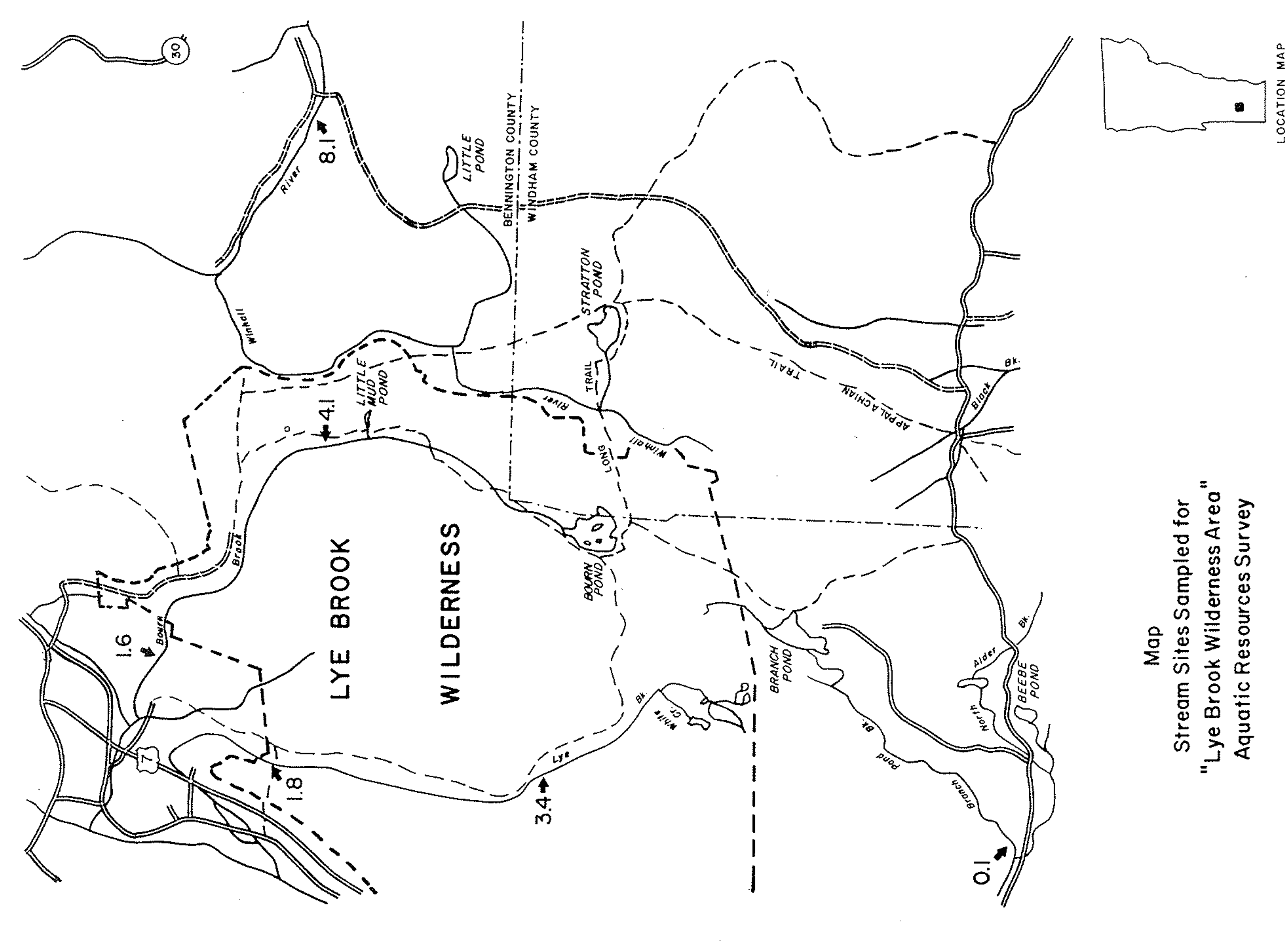
The soil associations for Bourn and Branch Pond have been determined (Kellogg, 1985). These ponds occur in soils that formed in glacial till on uplands and mountains. These soils can be shallow to deep, depending on the depth of bedrock or hardpan. They tend to be loamy and low in lime. Often, there is hardpan or bedrock within three feet of the surface. The three soil associations are:

BPT Berkshire-Peru-Tunbridge Association: Moderately deep to deep, dominantly well drained, loamy soils low in lime, and with a hardpan or bedrock within three feet. Located on steep slopes along the western edge of the Lye Brook Wilderness.

MHW Mundal-Houghtonville-Wilmington Association: Moderately well to well drained soils interspersed with smaller areas of poorly drained soils. Soils are loamy, high in surface organic matter, low in lime and have a hardpan within three feet. Located on the upland flats, depressions, and sideslopes in the eastern half of the Wilderness.

RMH Rawsonville-Mundal-Houghtonville Association: Moderately well to well drained loamy soils, high in surface organic matter, low in lime, and have a hardpan or bedrock within three feet. Located on the upland flats, sideslopes and ridgetops in areas with greater local relief than the MHW Association.

Figure 1.



Map
Stream Sites Sampled for
"Lye Brook Wilderness Area"
Aquatic Resources Survey

Table 1. Physical Characteristics of Lye Brook Wilderness Study Streams

Stream	Site ID	Station (Stream Mile)	Town	Latitude	Longitude	Elev. (feet)	Drainage Area (km^2)	Topography[1]	Bedrock[2] Type	Location Description
Bourn Bk. (upper)	592600000041	4.1	Winhall	430825	725922	2161	11.1	SL-Mod	I	1/4 mile below confluence with Little Mud Pond and 1/4 mile above lean-to.
Bourn Bk. (lower)	592600000016	1.6	Winhall	430934	730135	900	18.3	High	II	1/4 mile above O.M. Pleisner Homestead.
Branch Pond Bk.	591410000001	0.1	Sunderland	430314	730316	2160	6.3	Mod	I	Immediately above confluence of Roaring Bk.
Lye Bk. (Upper)	592500000034	3.4	Manchester	430758	730229	1300	14.8	High	I	50 feet below confluence of Lye Brook Falls Tributary.
Lye Bk. (Lower)	592500000018	1.8	Manchester	430912	730223	840	19.1	Mod	II	Immediately inside LBW boundary above first small tributary.
Winhall River	033500000081	8.1	Winhall	430818	725555	1470	46.6	SL-Mod	I	At site of IPCO bridge off Kendall Farm Road.

[1] SL = slight relief. Mod = moderate relief. High = high relief.

[2] Type I = low to no buffering capacity; granite/syenite/granitic gneisses, quartz sandstones or metamorphic equivalents. Impacts from acid precipitation expected.
Type II = medium to low buffering capacity; sandstones, shales, conglomerates, high-grade metamorphic site to intermediate igneous rock, calcsilicate gneisses (no free carbonates). Impacts from acid precipitation restricted to first and second order streams and small lakes.

Table 2. Physical Characteristics of Lye Brook Wilderness Study Lakes

Lake	Site ID	Station	Town	Latitude	Longitude	Elev. (feet)	Drainage Area (ha)	Surface Area (ha)	Drainage Area / Surface Area (ha)	Maximum Depth (m)	Topography[1]	Bedrock[2] Type
Bourn Pond	592600000075	7.5	Sunderland	430625	730018	2552	166	19	9	9	Mod	I
Branch Pond	591410000033	3.2	Sunderland	430458	730105	2632	134	14	10	12	SL	I
Little Mud Pond	59L000500533	0.3	Winhall	430802	735901	2303	34	2	17	1.3	SL	I

[1] SL = slight relief, Mod = moderate relief.

[2] Type I = all lakes have low to no buffering capacity and are expected to have been impacted from acid precipitation.

The Calcite Saturation Index (CSI) is computed using pH, alkalinity and calcium measurements. This index is used to determine a waterbodies' sensitivity to acid deposition (Conroy et al, 1974). **Tables 4 and 5** present the values for the streams and lakes. The equation for CSI is:

$$CSI = -\log \frac{Ca\ (mg/l)}{40{,}000} - \log \frac{Alk\ (mg/l)}{50{,}000} - pH + 2$$

The CSI values cannot be accurately calculated for waterbodies with alkalinities below zero. For those lakes with alkalinity values below zero the alkalinity was assumed to be 0.01 mg/l and a greater than (>) value is assigned to the calculated CSI.

The following table summarizes the CSI values and the rivers classification based on a mean value.

Table 3. Streams Found in Each CSI Classification.

CSI	Description of Values	Rivers*
≥6	acidified	Branch Pond Brook
≥4 <6	unstable to acid loading	Bourn, Lye, Winhall
≥3 <4	susceptible to acid loading	
≥0 - <3	in equilibrium with $CaCO_3$	
≤0	saturated with $CaCO_3$	

* lower stations only

The upper Bourn station had a CSI value of 5.70 in the fall and it is likely that this site can be categorized as acidified during the acidic runoff period. The upper Lye station had a CSI value of >8.55 and probably remains acidified year-round. All stream sites had CSI's in the acidified range during the mid-April sample. Bourn and Branch Ponds are usually acidified in the epilimnion based on the CSI values, regardless of the season that the sample was taken. Past CSI values for Bourn and Branch Ponds have consistently been within the acidified range. Little Mud Pond had never been sampled before and this current data documents it is an acidified lake. These CSI values confirm the susceptibility of the area to acidification.

Table 4. Lye Brook Wilderness Study CSI Index for Streams

Date	Bourn Bk. (Upper)	Bourn Bk. (Lower)	Branch Pond Bk.	Lye Bk. (Upper)	Lye Bk. (Lower)	Winhall R.
Mar-30-93			>8.60			
Apr-5-93			>8.43			5.86
Apr-8-93		3.99			5.13	
Apr-13-93			>8.67			6.49
Apr-14-93		4.49			6.30	
Apr-20-93			>8.82			6.89
Apr-22-93		>8.33			>8.76	
Apr-26-93			>8.76			6.84
Apr-28-93		6.91			7.05	
May-4-93			>8.60			5.52
May-6-93					4.94	
Aug-4-93			>8.36			4.61
Aug-5-93		3.74			3.62	
Sep-21-93	5.70	3.63		>8.55	4.20	
Oct-6-93		6.46				
Oct-19-93			>8.25			
Oct-21-93		4.11			4.42	4.35

Table 5. Lye Brook Wilderness Study CSI Index for Lakes

Month	Bourn (Epi)	Bourn (Hypo)	Branch (Epi)	Branch (Hypo)	Little Mud
May	6.84	6.58	>8.60	>8.59	>8.64
August	6.34	5.38	>8.69	>8.52	>8.40
October		6.46		>8.48	

Epi = Epilimnion
Hypo = Hypolimnion

Water Chemistry

Branch Pond was sampled three times on a seasonal basis (May 19, August 12 and October 6) and was found to be stratified during the spring and summer. The maximum depth is 12 meters. Samples were collected from the epilimnion and hypolimnion from a canoe (see map, **Appendix 4**).

Bourn Pond was sampled three times on a seasonal basis (May 27, August 12 and October 7) and was found to be stratified during the spring and summer. The maximum depth is approximately 9.0 meters. Samples were collected (see map, **Appendix 5**) during the spring and summer using an inflatable raft and in the fall with a 15′ aluminum canoe.

Little Mud Pond was sampled twice (May 18 and August 11). The shallow maximum depth of approximately 1.3 meters does not allow for stratification. The pond was sampled at what was suspected to have been the "deep" hole (see map, **Appendix 6**) by using a small inflatable two-person raft.

All lake samples were collected with a 1.2ℓ acrylic Kemmerer bottle at one meter and, if found to be stratified, approximately one to two meters from the bottom. Water was transferred into two - 1.0ℓ Nalgene high density polyethylene (HDPE) bottles and upon return to the vehicle, placed in coolers with ice for transport to the field laboratory or VT DEC Laboratory in Waterbury, Vermont. In-situ measurements include Secchi Disk transparency and temperature profiles from surface to bottom at 1.0m intervals. A field sheet was filled out to record in-situ measurements, weather conditions and other observations.

The lower stream stations were sampled 7 or 8 times during 1993. More intensive weekly sampling was undertaken during spring runoff to track water chemistry changes during spring snowmelt. Branch Pond Brook was sampled on March 30 prior to initiating the runoff sampling to demonstrate technique to all field samplers. Bourn, Lye and the Winhall were initially sampled during the first week of April. By May 6, the last day of runoff sampling, the water levels had dropped considerably from maximum stage conditions and stream pH and alkalinity had already begun to increase.

Bourn and Lye Brooks were sampled by the VT DEC and Branch Pond Brook and the Winhall River were sampled by the GMNF. The samples were collected at, or near the centroid of flow directly into two - 1.0ℓ Nalgene HDPE bottles. The samples collected by the GMNF were brought to the Manchester District office in coolers and refrigerated. These samples were picked up on a weekly basis by VT DEC staff for transport to the field laboratory or VT DEC Laboratory. In-situ pH (Beckman 21 meter) and conductivity (Hanna HI 8633) were measured only at Bourn and Lye Brooks and temperature (mercury thermometer) was recorded from all streams. A field sheet was filled out to record snowmelt and runoff conditions, weather and additional observations.

The streams were also sampled once during the summer (August 4 and 5) and the fall (October 19 and 21). Bourn and Lye Brooks were sampled on September 21 and 22 at two sites each to determine the effects of elevational differences, drainage area and bedrock on water chemistry. Additional water chemistry sampling was proposed if warranted by extreme precipitation events. No events of a magnitude large enough to generate high flow conditions were observed, and thus no additional samples were collected.

If an overnight sampling trip was planned, a field laboratory was set-up in a nearby motel so the samples could be processed as soon as possible following collection.

One of the two liter bottles collected was filtered through a Gelman Supor-450 0.45μm filter into a 1ℓ side-arm flask using a Doerr electric vacuum pump. Prior to filtration, all filtration apparatus, including the filters, were thoroughly rinsed with deionized water. Filters were soaked, then pre-rinsed with approximately 25ml of sample. Stringent rinsing protocols with both deionized water and filtered sample all but eliminate the possibility of contamination. The filtered liter is split into aliquots for dissolved organic carbon (DOC), base cations, aluminum and anions. The remaining one liter bottle is used for pH, alkalinity, colors and conductance. pH and alkalinity are determined in the field laboratory and colors and conductance are analyzed in the VT DEC Laboratory upon return.

All field and laboratory procedures are consistent with the "Vermont Field Methods Manual" (VT DEC, 1989) and the "Vermont Quality Assurance Plan" (VT DEC, 1992). The analytical procedures are presented in **Appendix 1** along with the reference source. These methods are also consistent with the U.S. EPA Quality Assurance Plan for the Long-Term Monitoring Project (Morrison, 1991). The VT DEC is a participant of this project whose objectives are to detect and measure trends in the chemistry of low alkalinity surface waters over gradients of H^+ and SO_4^{2-} deposition in different geographic regions. Bourn and Branch Ponds have been examined under this project since 1982.

Sediments

Sediments were collected from Bourn and Branch Ponds on August 11 and 12 at or near the area of maximum depth.

A six inch Ekman dredge was used to collect one representative sample. The sediment sample was emptied into a plastic sieve bucket where the center portion (≈1500mls) was placed in a new Ziploc plastic freezer bag. This bag was placed in a second bag to prevent accidental spillage while in the backpack. Upon returning to the laboratory the sediment was transferred to the appropriate containers: two 500ml Nalgene plastic bottles were used for the 13 priority pollutant metals and a 500ml amber glass bottle was used for PAHs, PCBs and pesticides. The samples were kept on ice while in transit and refrigerated until analyzed.

For mercury analyses, a 1-2 grams dry weight subsample of well mixed sediment was digested in Aqua Regia (3:1 HCl/HNO_3), oxidized with Potassium Permanganate, and analyzed by cold vapor methods (Method 7471, VT DEC, 1992).

For other metals analyses, 1-2 grams dry weight subsample of well-mixed sediment was digested in nitric acid and hydrogen peroxide, filtered, and analyzed by flame - Cadmium, Chromium, Copper, Lead, Nickel, Zinc (Perkin-Elmer Model 3030 Atomic Absorption Spectrophotometer) or graphite furnace - Silver, Arsenic, Beryllium, Antimony, Selenium, Thallium (Perkin-Elmer Model HGA-600 graphite furnace). Percent moisture was determined on separate subsamples (Method 3050, VT DEC, 1992).

For organic analyses, 8-10 gram wet weight subsamples of well mixed sediment were subject to Soxhlet extraction with 1:1 acetone/hexane (Method 8080, VT DEC, 1992). Both semi-volatiles and organochlorines were extracted using method 3540 (VT DEC, 1992). Samples for semi-volatile compounds were analyzed by GC/MS methodologies using a Finnegan instrument Model INCOS 50 GC/MS (Method 8027, VT DEC, 1992). Organochlorine compounds were analyzed with a Hewlett-Packard 5890 GC/Electron Capture Detection using method 8080 (VT DEC, 1992). Separate subsamples were used for percent moisture determinations.

All sediment results are reported on a dry weight basis in ppb ($\mu g/kg$) for organic contaminants and ppm (mg/kg) for metals.

Macroinvertebrates - Lakes

The lakes were primarily surveyed for populations of "pH-sensitive" Crustacea, Mollusca and Ephemeroptera. Two collection methods were employed to cover all habitats within each pond. Ekman dredge (6 inch) samples were collected from the profundal zone and sublittoral areas in early spring (VT DEC Field Method 4.4.5, 1989). Three replicate dredge samples were collected from each pond and depth zone. The littoral zones were qualitatively sampled twice, once in May and once in August. A large 12 x 18 inch kick net was used to sweep through vegetation and bottom muck, while forceps and small sieves were used to collect animals from the surfaces of rocks and snags. All sieves and nets used were equipped with 560 micron mesh netting or smaller. Qualitative sampling was done for two hours at each pond covering all habitat types offered along the shoreline. The sampling locations for both the Ekman dredge and the littoral shoreline sampling are shown on the lake maps in **Appendices 4-6.** The specific areas along the shoreline where populations of Mollusca (Bivalvia and Gastropoda), and Ephemeroptera are located were also marked on these maps.

All animals collected were preserved in the field using 75 percent ethyl alcohol (ETOH), brought back to the laboratory, picked and identified to the lowest possible taxonomic level, usually genus or species. While the targeted taxa were the Crustacea, Mollusca, and Ephemeroptera, an effort was made to collect as many taxa as encountered during each two hour survey.

Macroinvertebrates - Streams

The stream macroinvertebrate communities were sampled at four sites; two sites on Bourn Brook and two sites on Lye Brook (**Figure 1**). The sites represent different elevations, drainage areas and bedrock geology on each stream. The samples were collected from riffle habitats using the two minute kick net technique (VT DEC Field Method 4.4.1, 1989). Samples were preserved in the field with 75 percent ETOH and returned to the laboratory for processing. Samples were processed following the VT DEC Field Method 4.6.1-4, 1989, using a gridded tray, 2X magnifier light and forceps. The protocol requires that at least one quarter of each sample is picked. Picking then continues one grid at a time until 300 animals have been removed or the entire sample is picked.

Fish

Six sections (sites) on four streams in the GMNF were surveyed in August and September 1993. Stream sections were selected which were representative of the physical habitat in the overall stream reach sampled. General physical characteristics were recorded at each site. A more quantitative habitat assessment evaluation (Green Mtn. National Forest Basin-Wide Survey Method) was employed at two sites with the remaining four sites to be evaluated in 1994. Water temperature and specific conductance were taken during each sampling event.

Fish populations were sampled using pulsed-DC backpack electroshockers. Fish were sampled in an upstream direction using block nets at some sites. At sites where no nets were used, the upper end of the section was located at the foot of a cascade which acted as a barrier to escaping fish. Two to three electrofishing passes were completed at all but one site. When no fish were collected or spotted at the Lye Brook - 3.4 site after the first pass it was decided not to conduct any further efforts.

All individuals were identified to species and salmonids measured for total length. At two sites all species were weighed in groups of two to twelve fish. Population estimates were expressed in numbers/mile for trout and numbers/100m^2 for salmon (per salmon unit) and non-game species. The removal method of Carle and Strub (1978) was used to generate estimates. A relative density measure, based on raw numbers from run one/100m^2, was also used to facilitate comparison to the state-wide VT DEC database. The Vermont Index of Biotic Integrity (VTIBI) was applied to characterize fish population health and to relate that measure to the Vermont Water Quality Standards at the Winhall River site.

RESULTS AND DISCUSSION

Lake Chemistry

Branch and Bourn Ponds have been monitored on a seasonal basis since 1981 and 1982 respectively as part of the Vermont Long-Term Monitoring Program (VLTMP). VLTMP data suggest a clear Statewide trend of decreasing calcium, magnesium, and sulfate concentrations in surface waters, in response to lower inputs of sulfate from atmospheric deposition. The decrease in calcium and magnesium (base cations) is due to declining base cation deposition and reduced cation leaching from the watershed soils. A lake-specific trend of decreasing sulfate concentrations has been described for Bourn Pond (Stoddard and Kellogg, 1993). Refer to **Appendix 2** for a presentation of the lake results from 1993. Means and ranges are presented in **Table 6.**

Both lakes are dystrophic and highly "stained" a tea color due to dissolved organic matter. This organic "humic" matter originates from the breakdown of terrestrial plant growth. Dissolved organic carbonaceous matter readily binds with inorganic monomeric aluminum (IMAL), the form of aluminum most toxic to aquatic biota, to form organic monomeric aluminum (OMAL) complexes, a much less toxic form of aluminum. Recent *in situ* studies in the Adirondacks have shown that Brook Trout and Blacknose Dace mortality in low-pH streams is directly correlated with IMAL concentration and exposure duration with an inverse correlation to DOC (Simonen et al, 1993). IMAL concentrations greater than 150-200 μg/l have been shown to be toxic to some species of aquatic biota within the pH range 4.5-5.5 (Baker et al, 1982). The levels of IMAL in Bourn Pond are not considered an immediate threat because the concentrations are quite low (37-57μg/l during 1993) and the dissolved organic carbon (DOC) levels observed (4.09-5.40mg/l) will likely mitigate toxicity. IMAL concentrations in Branch Pond (114-124μg/l) are in a range indicating potential toxicity at DOC concentrations similar to those found in Bourn Pond. Aluminum is most toxic in the pH level 5.2 to 5.4 range (Baker et al, 1982). Bourn Pond is often found in this pH range while Branch Pond has pH values consistently below 5. It does appear that, in both ponds, the DOC component may be alleviating the symptoms of aluminum toxicity that are observed in clearwater systems. Dissolved aluminum concentrations in both ponds were at potentially toxic levels if the aluminum was to occur as IMAL. Acidification may remove DOC from a waterbody and can cause a conversion, over time, from a brown water acid pond to a clearwater acid pond (Bailey, 1987). If this were to happen, both fisheries would be potentially jeopardized by the conversion of aluminum to toxic (IMAL) forms.

It is recommended that these lakes, as part of the VLTMP, continue to be monitored on a regular basis to determine water quality trends in dystrophic waterbodies.

Little Mud Pond was surveyed for the first time during this study. Refer to **Table 2** for a description of its physical characteristics and **Appendix 2** for a presentation of the results from 1993. The means and ranges are presented in **Table 6**. It has many of the characteristics of a bog in that it is shallow, acidic, and a sphagnum mat does appear to be encroaching over much of the open water. This pond will, in time become a sphagnum bog. The chemistry is different from the other study lakes in that although the pH, alkalinity and color are similar, the total ionic composition is lower in concentration for both anions and cations. It is recommended that this lake be re-evaluated every five years.

Table 6. Means and Ranges for Lye Brook Wilderness Study Lakes During 1993.*

Ponds and # of Observations	pH Std. U.	Alk mg/l	Cond[0] µs/cm	DC_2[1] Pt-Co	DCL[2] mg/l	DNO_3[3] mg/l	DSO_4[4] mg/l	DCA[5] mg/l	DMG[6] mg/l	DNA[7] mg/l	DK[8] mg/l	DAL[9] µg/l	IMAL[10] µg/l	OMAL[11] µg/l	DOC[12] mg/l
Bourn (3) Epilimnion	5.39 5.34-5.43	0.34 .18-.49	14.8 13.1-17.2	38 22-55	0.26 .25-.28	0.02 <.01-.03	3.55 3.12-3.80	0.75 .71-.81	0.34 .31-.38	0.51 .46-.55	0.34 .31-.36	133 97-173	46 37-55	32 28-37	4.22 4.09-4.35
Bourn (2) Hypolimnion	5.44 5.19,5.68	1.29 .44,2.14	14.6 13.1,17.2	76 67,86	0.42 .28,.55	0.07 .04,.10	3.40 2.95,3.84	0.80 .78,.81	0.31 .31,.31	0.46 .44,.49	0.35 .33,.37	224 213,235	57	42	5.40
Branch (3) Epilimnion	4.86 4.78-4.95	-0.38 -.15- -.63	17.8 15.1-19.3	66 46-83	0.30 .25-.34	0.03 <.01-.06	3.89 3.56-4.09	0.69 .67-.74	0.24 .23-.26	0.47 .45-.49	0.35 .30-.39	266 248-300	117 114-121	46 45-46	5.01 4.94-5.08
Branch (2) Hypolimnion	4.89 4.87,4.91	-0.26 -.06,-.45	17.5 15.7,19.3	100 94,105	0.32 .30,.34	0.04 <.01,.08	3.29 3.00,3.58	0.72 .70,.74	0.26 .25,.26	0.46 .45,.48	0.40 .39,.40	292 280,303	124	66	5.27
Little Mud(2) Epilimnion	4.95 4.85,5.04	-0.36 -.02,.11	15.2	79 78,80	0.06 .02,.10	<0.01	2.38 1.93,2.84	0.68 .65,.72	0.21 .18,.24	0.30 .19,.42	0.10 .03,.16	117 94,140	32	41	8.05

* All DNO_3 <0.01 values were assumed to be 0.01 for statistical purposes.

[0] Cond = conductivity
[1] DC_2 = filtered color
[2] DCL = dissolved chloride
[3] DNO_3 = dissolved nitrate
[4] DSO_4 = dissolved sulfate
[5] DCA = dissolved calcium
[6] DMG = dissolved magnesium
[7] DNA = dissolved sodium
[8] DK = dissolved potassium
[9] DAL = dissolved aluminum
[10] IMAL = inorganic monomeric aluminum
[11] OMAL = organic monomeric aluminum
[12] DOC = dissolved organic carbon

Stream Chemistry

Refer to **Appendix 3** for a presentation of the stream results from 1993. The means and ranges are presented in **Table 8.**

Much of what was stated pertaining to color and aluminum in the lakes is true for the streams. The streams do have significant chemical differences from the lakes, most notably higher concentrations of aluminum, DOC, and base cations. Whereas no lakes had calcium levels exceeding 1 mg/l, calcium concentrations greater than 1 mg/l were often observed on Bourn and Lye Brooks and the Winhall River and occasionally noted on the most acidic stream, Branch Pond Brook.

All streams underwent a reduction of pH, alkalinity and calcium between mid to late April when spring runoff was at its highest stage. Bourn experienced the greatest decline in these parameters with a 1.31 pH unit decrease, a 2.22mg/l alkalinity decrease (this resulted in a negative alkalinity) and a 0.79mg/l decrease in calcium. This trend was observed to a lesser degree in all the streams. It is realistic to assume that our monitoring may not have observed the lowest pH, alkalinity and calcium conditions because of the limited frequency of sampling.

Branch Pond Brook was the only stream to consistently experience negative alkalinities and only once did the pH go above 5. This stream is chemically similar to its headwaters, Branch Pond.

The mean DOC (Bourn and Lye upper stations not included) of the study streams ranged from 6.45 to 9.39 mg/l in the following gradient: Winhall < Bourn < Branch Pond Brook < Lye. These DOC levels have a positive biological effect by allowing the humic particulates to bind with the toxic IMAL. The mean IMAL (Bourn and Lye upper stations included) ranged from 26 to 89µg/l in the following gradient: Winhall < Bourn (lower) < Lye (lower) < Bourn (upper) < Branch Pond Brook < Lye (upper). No monomeric aluminum or DOC data were collected during the Spring runoff period. However, given observed ratios of dissolved to monomeric aluminum species, it is **highly** likely that potentially toxic thresholds for IMAL were exceeded in Lye Brook, and likely that toxic thresholds were exceeded in both Bourn and Branch Pond Brooks. Actual in-stream impacts would be dependent upon the duration of elevated concentrations in the stream water. These observations may account for the absence of fish in the upper Lye Brook station. The pH of 4.96 observed on September 22, 1993 is near the reported 5.2-5.4 range when IMAL is most lethal.

One of the secondary objectives of this study was to document the effects of elevation on water chemistry. Bourn and Lye Brook had upper stations selected for this purpose, but unfortunately the single sampling prevents the use of statistical tests. It can be noted that, for the date sampled, a difference was observed between the sites for a number of parameters, including both pH and alkalinity.

Table 7 shows significant differences in pH and alkalinity at these stations. This is probably due to higher levels of chemical weathering products in the lower reaches (Bailey, 1987). This phenomena can be better illustrated by additional sampling several times/year at both stations.

Table 7. Comparison of pH and Alkalinity from Fall Sampling at Two Sites on Bourn and Lye Brooks.

	BOURN BROOK			LYE BROOK		
Site # (mile)	**Upper 4.1**	**Lower 1.6**	**Diff.**	**Upper 3.4**	**Lower 1.8**	**Diff.**
pH (Std. U)	5.69	6.78	1.09	4.96	6.69	1.73
Alkalinity (mg/l)	0.62	3.94	3.32	-0.02	2.30	2.32

These streams are recommended for continued monitoring because of the variable "flashy" nature of their discharge and resultant effects on water chemistry.

Fish Tissue

Vermont DEC is participating in the International Toxics Monitoring Program (ITMB), a joint effort of the Canadian Eastern Provinces, the New England States, and New York. Fish, snowpack, and sphagnum moss are collected from seventeen watersheds along a south-west to north-east gradient across the participating states/provinces. Samples are analyzed for mercury, arsenic, lead, and cadmium. Bourn Pond is included in the seventeen watersheds in the program.

In August, 1992 the VT DEC collected three Brook Trout from Bourn Pond. The results (mg/kg wet wt) follow: silver <0.21, cadmium <0.003, lead <0.02 and mercury 0.35. Snowpack samples were collected during the winter. Mercury levels in the snowpack were 108 ng/l, the third highest concentration found among the seventeen sites. Bourn Pond was resampled in October 1993, when five Brook Trout plus sphagnum moss were collected. The snowpack was resampled in March, 1994, but are not yet analyzed.

Table 8. Means and Ranges for Lye Brook Wilderness Study Streams During 1993*

River Mile and # of Observations	pH Std. U.	Alk mg/l	Cond[0] µs/cm	DC_2[1] Pt-Co	DCL[2] mg/l	DNO_3[3] mg/l	DSO_4[4] mg/l	DCA[5] mg/l	DMG[6] mg/l	DNA[7] mg/l	DK[8] mg/l	DAL[9] µg/l	IMAL[10] µg/l	OMAL[11] µg/l	DOC[12] mg/l
Bourn Bk. (1) (Upper-4.1)	5.69	0.62	21.9	85	0.27	0.02	3.83	1.40	0.59	0.92	0.39	299	58	147	9.69
Bourn Bk. (8) (Lower-1.6)	6.08 4.94-6.78	1.93 -.28-3.94	19.7 17-22.9	99 73-135	0.33 .24-.48	0.09 <.01-.20	4.20 3.23-4.84	1.80 1.07-2.24	0.65 .33-.95	0.65 .38-.89	0.51 .36-.65	272 175-299	32 30-33	102 83-120	6.89 5.83-7.80
Branch Pd. Bk. (8) 0.1	4.78 4.61-5.06	-0.75 -1.34- -.04	21.4 16.4-27.2	88 71-130	0.28 .20-.40	0.14 <.01-.38	3.80 3.06-4.53	0.94 .67-1.17	0.30 .24-.36	0.58 .45-.86	0.42 .33-.54	305 224-382	76 70-83	121 90-152	7.83 5.60-10.0
Lye Bk. (1) (Upper-3.4)	4.96	-0.02	20.4	142	0.45	0.04	3.56	1.09	0.46	0.82	0.41	365	89	155	11.67
Lye Bk. (8) (Lower-1.8)	5.78 4.67-6.69	1.48 -1.21-2.78	20.2 17.8-23.2	141 111-161	0.32 .21-.39	0.32 .21-.51	3.95 2.97-4.74	1.56 .75-2.32	0.78 .30-1.52	0.55 .33-.76	0.47 .37-.69	323 140-411	57 51-66	147 123-173	9.39 8.67-10.2
Winhall R. (7) (8.1)	5.63 5.16-6.44	0.87 .14-2.14	18.2 13.4-21.1	65 55-84	0.32 .27-.50	0.11 <.01-.22	3.89 3.37-4.68	1.54 1.14-2.26	0.43 .31-.66	0.67 .45-.89	0.50 .42-.59	208 154-246	26 24-27	91 73-109	6.45 5.21-7.68

* All DNO_3 <0.01 values were assumed to be 0.01 for statistical purposes.

[0] Cond = conductivity
[1] DC_2 = filtered color
[2] DCL = dissolved chloride
[3] DNO_3 = dissolved nitrate
[4] DSO_4 = dissolved sulfate
[5] DCA = dissolved calcium
[6] DMG = dissolved magnesium
[7] DNA = dissolved sodium
[8] DK = dissolved potassium
[9] DAL = dissolved aluminum
[10] IMAL = inorganic monomeric aluminum
[11] OMAL = organic monomeric aluminum
[12] DOC = dissolved organic carbon

Sediments

A representative surficial sediment sample was collected from Bourn and Branch Ponds in August, 1993. These samples represent a continuation of a 1992 sediment characterization study of other VLTMP lakes. The VLTMP lakes were chosen for this study because their remote, high elevation locations tend to isolate atmospheric deposition as the primary source of toxic pollutants. Sediments from six lakes within the GMNF have now been examined for toxic substances.

Refer to **Tables 9 and 10** for the results of the PAHs, PCBs, pesticides and priority pollutant metals found in the two target lakes in LBW. Since this was the first time these lake sediments have been analyzed by the VT DEC there is no historical data on these waterbodies for trend analysis. Charles and Norton have analyzed sediment cores from Branch Pond for diatom remains and changes in inferred pH. Results suggest that the pH of Branch Pond has not changed significantly from background conditions, although minor increases in acidity since 1930 are indicated. It is unknown whether these cores were analyzed for atmospheric contaminants (Charles and Norton, 1986). Nine of the metals were found below the minimum detection level (MDL). Arsenic and zinc were found in levels comparable to the other VLTMP lakes and well below the low level environmental risk (ER-L) guidelines proposed by NOAA (NOAA, 1990). Lead was found in both lake sediments at levels slightly above twice the ER-L guidelines of 35mg/kg dry weight (dw). The VLTMP lakes surveyed had lead values ranging from <25 to 83mg/kg dw with a mean value of 44mg/kg dw.

Sediment mercury was also found in both lakes in exceedance of the ER-L guidelines of 0.15mg/kg dw. Bourn and Branch each had levels of more than twice the ER-L with concentrations of 0.34 and 0.51mg/kg dw, respectively. The VLTMP lakes surveyed had mercury values ranging from <0.10 to 0.24mg/kg dw with a mean of 0.14mg/kg dw. Two other GMNF lakes, Big Mud and Little Rock Ponds, had values of 0.24mg/kg dw. Though our sediment data base is limited, it clearly suggests that of the lakes sampled, the GMNF region in southern Vermont has the highest levels of sediment mercury compared to other remote undisturbed Vermont lakes. Both lead and mercury have been implicated as metals subject to atmospheric transport. Lead sources are predominantly automotive emissions, while mercury like the major precursors to acid deposition (sulfur and nitrogen oxides) originates from coal burning utilities and smelters.

Table 10 presents the organic results for Bourn and Branch Ponds where some levels did exceed the practical quantitation limits (PQL). The PAHs fluoranthene and pyrene were found in both ponds and phenanthrene was found in Branch. The values did not greatly exceed the PQLs, if at all, and do not pose a threat to the aquatic biota. PCBs and pesticides were not detected in these ponds. The survey of 16 VLTMP lakes reported no lakes with PAHs, PCBs, or pesticides found in levels above the PQLs.

Table 9. Sediment Metals Analysis from Two Lye Brook Wilderness Lakes. All metals reported in mg/kg dry weight (ppb). **Bold** values indicate a value in exceedance of the low level environmental risk guidelines proposed by NOAA.

Pond	Arsenic	Beryllium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Bourn	5.20	.51	<5	<25	<25	**79**	**.34**	<25	<2.5	<.50	102
Branch	3.70	<.50	<5	<25	<25	**80**	**.51**	<25	<2.5	<.50	96

Table 10 PAHs, PCBs and Chlorinated Pesticides from Two Lye Brook Wilderness Lakes Sediments. All organics reported in µg/kg Dry Weight (ppb). The Practical Quantitative Limits (PQL) varies with percent moisture of the sample.

BOURN			BRANCH		
Parameter - PAHs	PQL	Result	Parameter - PAHs	PQL	Result
Napthalene	10	N.D.	Naphthalene	50	N.D.
2-Methylnaphthalene	10	N.D.	2-Methylnaphthalene	50	N.D.
1-Methylnaphthalene	10	N.D.	1-Methylnaphthalene	50	N.D.
Acenaphthylene	10	N.D.	Acenaphthylene	50	N.D.
Acenaphthene	10	N.D.	Acenaphthene	50	N.D.
Dibenzofuran	10	N.D.	Dibenzofuran	50	N.D.
Fluorene	10	N.D.	Fluorene	50	N.D.
Phenanthrene	10	N.D.	Phenanthrene	50	46
Anthracene	10	N.D.	Anthracene	50	N.D.
Fluoranthene	10	17	Fluoranthene	50	79
Pyrene	10	<14	Pyrene	50	58
Benzo[a]anthracene	20	N.D.	Benzo[a]anthracene	90	N.D.
Chrysene	20	N.D.	Chrysene	90	N.D.
Benzo[b]fluoranthene	20	N.D.	Benzo[b]fluoranthene	90	N.D.
Benzo[k]fluoranthene	20	N.D.	Benzo[k]fluoranthene	90	N.D.
Benzo[a]pyrene	20	N.D.	Benzo[a]pyrene	90	N.D.
Indeno[1,2,3,cd]pyrene	40	N.D.	Indeno[1,2,3,cd]pyrene	200	N.D.
Dibenz[a,h]anthracene	40	N.D.	Dibenz[a,h]anthracene	200	N.D.
Benzo[g,h,i]perylene	40	N.D.	Benzo[g,h,i]perylene	200	N.D.
Dichlorobiphenyl congeners	30	N.D.	Dichlorobiphenyl congeners	90	N.D.

BOURN			BRANCH		
Parameter - PAHs	PQL	Result	Parameter - PAHs	PQL	Result
Trichlorobiphenyl congeners	30	N.D.	Trichlorobiphenyl congeners	90	N.D.
Tetrachlorobiphenyl congeners	30	N.D.	Tetrachlorobiphenyl congeners	90	N.D.
Pentachlorobiphenyl congeners	30	N.D.	Pentachlorobiphenyl congeners	90	N.D.
Hexachlorobiphenyl congeners	30	N.D.	Hexachlorobiphenyl congeners	90	N.D.
Heptachlorobiphenyl congeners	60	N.D.	Heptachlorobiphenyl congeners	200	N.D.
Total PCBs (done with ECD)	300	N.D.	Total PCBs (done with ECD)	900	N.D.
Aldrin	30	N.D.	Aldrin	90	N.D.
Heptachlor epoxide	30	N.D.	Heptachlor epoxide	90	N.D.
Chlordane	100	N.D.	Chlordane	400	N.D.
4,4'-DDE	30	N.D.	4,4'-DDE	90	N.D.
Dieldrin	30	N.D.	Dieldrin	90	N.D.
Endrin	30	N.D.	Endrin	90	N.D.
4,4'-DDD	30	N.D.	4,4'-DDD	90	N.D.
4,4'-DDT	30	N.D.	4,4'-DDT	90	N.D.
Methoxychlor	30	N.D.	Methoxychlor	90	N.D.

ND = not detected

Macroinvertebrates

Lakes

The biometrics of density/m^2, mean richness, total richness, diversity, and the number of dominant taxa (≥3.5%) for the Ekman dredge data are reported in **Table 11.** The data represents the mean of three Ekman dredge samples taken within each depth zone (sublittoral and profundal). Density ranged from a low of 367 organisms/m^2 in the profundal zone of Branch Pond to a high of 6967/m^2 at one meter depth in Little Mud Pond. The density in Branch Pond within the sublittoral zone (three to four meters) is very close to that collected by the VT DEC in 1983. In Bourn Pond, the density within the sublittoral zone is seven times higher than found in 1983.

Taxa richness (mean and total) ranged from a low in the Branch Pond profundal zone (2.7 and 6.0 taxa) to a high in Little Mud Pond (12.3 and 18.0 taxa). Since Little Mud Pond was only one meter in depth, the dredge samples cannot be directly compared to the sublittoral samples from Bourn and Branch Ponds. Both Bourn and Branch Ponds had very similar numbers of taxa from both sublittoral and profundal zones. Taxa richness decreased significantly from the sublittoral to the profundal zone areas of both ponds, from about seven taxa in the sublittoral to three - four taxa in the profundal. The sublittoral zone taxa richness values collected here are very similar to those reported in 1983 by the VT DEC. The diversity of the macroinvertebrate community and the number of dominant taxa also decreased in the profundal zones of both Branch and Bourn Ponds.

The percent composition by major taxanomic groups is presented in **Table 12** and by species in **Table 13.** Little Mud Pond is dominated by the Chironomidae (84%) and Tubificidae (9%). Branch Pond is dominated by the Chironomidae (69%), Chaoboridae (13%) and Trichoptera (7%) in the sublittoral zone. In the profundal zone the Chironomidae (50%) and Chaoboridae (45%) are co-dominant, with the Ceratopogonidae at 5% as the only other group present. Bourn Pond is dominated by the Tubificidae (44%), Chaoboridae (37%), and the Chironomidae (18%) in the sublittoral zone. The profundal zone is dominated by the Chaoboridae (96%).

The dominance of Chaoboridae in the profundal zone of Bourn Pond indicates it is a severely dissolved oxygen (D.O.)-stressed environment. The macroinvertebrate community composition within the sublittoral zone of Bourn Pond also indicates that D.O. is becoming a significant environmental stress within that zone of the pond. Compared to the 1983 VT DEC data there has been a compositional shift in the sublittoral zone community composition toward more D.O. tolerant taxa. The Trichoptera have disappeared, and the D.O. tolerant Chironomidae Chironomus sp. has moved in and become the dominant Chironomid. At the same time the D.O. tolerant taxa Chaoboridae and Tubificidae have increased in their dominance. Dissolved Oxygen measurements will be performed on both Bourn and Branch Ponds in the summer of 1994.

Table 11. Macroinvertebrate Community Biometrics from Sublittoral and Profundal Zones of Little Mud Pond, Branch Pond and Bourn Pond. Samples collected with 6" Ekman dredge in May 1993. Data represents the mean values from three samples.

Pond	Little Mud	Branch Pond		Bourn Pond	
Depth (m)	1	3	9	4	8
Density/m^2	6967	1117	367	6500	7217
Mean Richness	12.3	7.3	2.7	7	3.7
Total Richness	18	12	6	9	6
Diversity	3.10	2.34	1.09	1.70	.29
# Dominant Taxa (≥3.5%)	9	9	4	4	1

Table 12. Percent Composition of Major Taxa Groups from Sublittoral and Profundal Zones of Little Mud Pond, Branch Pond, and Bourn Pond. Samples collected with 6" Ekman dredge in May 1993. Data represents the mean values from three samples.

Pond	Little Mud	Branch Pond		Bourn Pond	
Depth (m)	2	3	9	4	8
Chironomidae	84	69	50	18	3
Ceratopogoniae	2	4	5	1	0
Chaoboridae	3	13	45	37	96
Trichoptera	0	7	0	0	<1
Odonata	0	1	0	0	0
Megaloptera	0	4	0	0	0
Oligocheata	9	0	0	44	1
Other	2	0	0	<1	0

Table 13. Percent Composition of the Taxa From Sublittoral and Profundal Zones of Little Mud Pond, Branch Pond, and Bourn Pond. Chironomidae taxa in **bold** print. The dominant taxa (≥3.5%) for each pond is marked with an asterisk (*).

Pond	Little Mud	Branch Pond		Bourn Pond	
Depth (m)	1	3	9	4	8
Taxa					
Bezzia	2	0	5	1	0
Ceratopogon	0	4*	0	0	0
Chaoborus	3	13*	45*	37*	96*
Ablabesmyia	4*	0	0	0	0
Chironomus	18*	0	27*	13*	1
Cladotanytarsus	1	0	0	0	0
Cladopelma	13*	0	5*	0	0
Cryptochironomus	0	0	0	0	<1
Dicrotendipes	11*	7*	0	0	0
Heterotrissocladius	0	3	0	<1	0
Orthocladius	0	17*	0	0	0
Paratanytarsus	1	0	0	0	0
Pagastiella	<1	7*	0	1	0
Polypedilum	4*	0	0	0	0
Procladius	9*	30*	0	4*	0
Psectrocladius	12*	0	14*	0	0
Telopelopia	<1	0	0	0	0
Tanytarsus	10*	1	0	1	0
Zalutschia	0	18*	0	0	0
Nematocera	2	0	0	0	0
Oxyethira	0	0	0	0	<1
Phylocentropus	0	7*	0	0	0
Libellula	0	1	0	0	0
Sialis	0	4*	0	0	0
Hydracarina	0	0	0	<1	0
Tubificidae	8*	0	0	44*	1
Naididae	1	0	0	0	0

The profundal zone community of Branch Pond is also dominated by the taxa Chaoboridae and Chironomus sp., indicating that low D.O. also exist in the Branch Pond deep water habitat. The sublittoral zone community in Branch Pond has a more diverse community than that of the Bourn Pond sublittoral zone, with nine species among the dominant taxa (≥3.5%). Of these the species Zalutschia sp. is one of the more dominant taxa at 18%. It is typically found in very dystrophic lakes. The order Trichoptera is represented by the taxa Phylocentropus sp. and the order Megaloptera by Sialis sp.. The presence of these taxa as well as the diversity present indicates that D.O. is not limiting in the sublittoral zone of Branch Pond.

The bottom community of Little Mud Pond contains a diverse number of Diptera and Oligocheata. The species diversity indicates that D.O. stress is not a problem in Little Mud Pond. The lack of Trichoptera, Megaloptera, and Ephemeroptera in the lake may be attributable to the bottom substrate being made up of mostly peat, and to the low pH.

Finally no "pH sensitive" Crustacea, Mollusca or Ephemeroptera species were found in Ekman dredge samples from the three ponds. The VT DEC samples collected in the winter of 1983 also did not contain any of these taxa. The probable limiting environmental factors to these taxa are the low pH (pH 4.87-5.68) and calcium levels (0.65-0.81 mg/l) recorded from these ponds (**Table 6**). Also, low dissolved oxygen conditions in the profundal zones of Branch and Bourn Ponds are likely limiting factors. A complete list of lake macroinvertebrates collected by Ekman dredge is found in **Appendix 8.**

A list of the taxa recorded from the qualitative shoreline surveys is presented in **Appendix 9** for all three ponds. The pH sensitive Mollusca and Ephemeroptera taxa found are listed first and highlighted in bold print. No Crustacea taxa were found in any of the ponds.

Little Mud Pond contained only one "pH sensitive" taxon, a mayfly (Ephemeroptera) Arthroplea bipunctata. This mayfly was also found in Branch and Bourn Ponds. Two additional mayfly species, Eurylophella temporalis and Leptophlebia sp., were found in both Branch and Bourn Ponds. Arthroplea bipunctata was not previously listed in the 1983 VT DEC biosurvey of Branch and Bourn Ponds. In fact, in the 1983 biosurvey of 26 acid sensitive lakes, it was only found in two lakes, both with pHs over 6.0. The present study indicates that it is a more pH tolerant mayfly than supposed from the results of the 1983 study. Leptophlebia sp. was reported as present in 1983 but was identified as Paraleptophlebia sp. These are closely related taxa that are difficult to tell apart as immature larvae. Eurylophella temporalis was not reported in 1983 in Bourn Pond but was found in Branch Pond.

Only three Mollusca taxa were found in the study lakes. The fingernail clam Pisidium casertanum was found in both Branch and Bourn Ponds. Bourn Pond contained an additional species, Musculium securis. These same taxa were reported in the ponds in 1983.

Branch Pond contained the only Gastropod species found in any of the ponds. The species Ferrissia fragilis was found in two chemically similar lakes in 1983 (Beebe and Forester Ponds) both nearby in southern Vermont. It was not, however, found in Branch Pond and may be a new addition to the Mollusca community.

The Chironomidae, Odonata, Coleoptera, Trichoptera and Hemiptera groups were all represented by six or more species. These taxa are generally accepted as being tolerant toward low pHs. The Coleoptera family Dytiscidae (predacious diving beetles) was represented by eight species. In the order Trichoptera the families Limniphilidae and Phryganidae were represented by several species.

The list of taxa presented here is by no means complete for each lake, but it does show that the lakes are dominated by acid tolerant macroinvertebrate groups. No Crustacea species were found in the three ponds. It is important to note that a few taxa from the typically "acid sensitive" groups (Ephemeroptera and Mollusca) still manage to exist in these lakes. Alterations to the populations of the species within these "acid sensitive" groups should reflect any future environmental change to these lakes resulting from atmospheric deposition.

Streams

The macroinvertebrate community biometrics are presented in **Table 14** for all four stream sites. The lower Bourn Brook site (1.6) is both the most productive at 1,704 (density/kick net (KN) and contains the most species 46.5, (25.5 as Ephemeroptera, Plecoptera, Trichoptera (EPT) species). The upper Lye Brook site (3.4) is the least productive at 166 (density/KN), and contains the least number of species at 21.5, and has the fewest EPT species at 14.5. The site also had a Bio Index value of 0.64, considerably lower than the other sites.

Compared to data from the VT DEC statewide database collected from similar habitat types, the two Bourn Brook sites and the lower Lye Brook site compare favorably, showing good-excellent biological integrity in all the biometric categories (see **Appendix 7**). The upper Lye Brook community, however, is in poor-fair biological condition compared to similar habitats around the state. The site is poor in density and species richness and fair in EPT richness.

Table 15 presents the percent composition of the major macroinvertebrate orders and the functional guild composition of the stream sites. The two upper sites are dominated (60%) by a few species of the order Plecoptera. Due to these high numbers, other major orders comprise low proportions of the total. Both of the lower sites are dominated by the order Trichoptera (>50%) but to a lesser extent than does the Plecoptera dominate the upper sites. The order Coleoptera is poorly represented (1%) at both Lye Brook sites.

Table 14. The Macroinvertebrate Community Biometrics from Four Stream Sites Within the Lye Brook Wilderness Area.

Stream	**Bourn Brook**		**Lye Brook**	
Site # (mi)	**1.6**	**4.1**	**1.8**	**3.4**
Biometrics				
Density/Unit	1704	756	460	166
Species Richness	46.5	27.5	34.0	21.5
EPT Richness	25.5	19.0	21.0	14.5
EPT/Species	0.55	0.69	0.58	0.67
Bio Index	1.31	1.05	1.10	0.64
Diversity	4.60	3.79	4.08	3.44
Dominance %	16	22	24	28
# E/P/T	8/7/14	4/6/12	5/9/12	1/5/3

Table 15. The Percent Composition of the Major Orders and Functional Guilds, of the Macroinvertebrate Community from Four Stream Sites Within the Lye Brook Wilderness Area.

Stream	Bourn Brook		Lye Brook	
Site # (mi)	**1.6**	**4.1**	**1.8**	**3.4**
Major Orders				
Coleoptera	4	13	1	1
Diptera	12	5	10	6
Ephemeroptera	22	4	21	11
Trichoptera	54	16	50	17
Plecoptera	8	60	18	62
Oligocheata	1	0	0	1
Other	0	1	0	2
Functional Guilds				
Collector Gatherer	21	2	24	16
Collector Filterer	29	12	36	6
Predator	11	21	25	46
Shredder Detritus	12	43	12	29
Shredder Herbivore	3	7	1	<1
Scraper	17	14	1	2

The functional guild composition of the lower Bourn Brook site is the most evenly spread of the study streams. The two Bourn Brook sites have a significant percent composition of scrapers, while the two Lye Brook sites are very low in scraper composition. The upper Bourn Brook site contains a higher percent of leaf shredders than all the other sites, and both upper sites have higher percentages of leaf shredders than the lower sites. The upper Lye Brook site is significantly higher than the other sites in percent predators. The upper Lye Brook site is almost exclusively dominated by predators and leaf shredders, and is the least evenly distributed in functional guild composition of all the sites.

The percent composition of the dominant taxa (those taxa which makeup ≥3.5%) from each site is presented in **Table 17.** The Pinkham Pearson Coefficient of Similarity (PPCS) was used to compare the similarity between the dominant taxa of the sites (**Table 16**). The PPCS shows that the upper and lower sites on both streams are highly dissimilar to one another (PPCS = 0.16 and 0.17). The two high elevation sites Bourn (4.1) and Lye (3.4) are also highly dissimilar from one another (PPCS = 0.20). The lower two sites are the most similar to one another (PPCS = 0.44) but are still less than 50% similar **Table 16.**

Table 16. PPCS Showing the Similarity of the Macroinvertebrate Community Between Stream Sites. The values range from 0 (total dissimilarity) to 1 (total similarity).

Stream Sites	Bourn Brook (1.6 - Lower)	Bourn Brook (4.1 - Upper)	Lye Brook (3.4 - Upper)	Lye Brook (1.6 - Lower)
Bourn Brook (1.6 - Lower)	1			
Bourn Brook (4.1 - Upper)	0.16	1		
Lye Brook (3.4 - Upper)		0.20	1	
Lye Brook (1.6 - Lower)	0.44		0.17	1

Table 17. The Percent Composition of the Dominant Macroinvertebrate Taxa (≥ 3.5%) Collected from Four Stream Sites Within the Lye Brook Wilderness Area. The dominant taxa ≥3.5% at each site are shown in **bold** print.

Stream	Bourn Brook		Lye Brook	
Site #	1.6	4.1	1.8	3.4
Dominant Taxa				
Oulimnius	3	**8**	0	0
Promoresia	<1	**6**	0	0
Baetis	**10**	1	**18**	0
Ephemerellidae	**6**	<1	1	0
Ameletus	0	0	0	**11**
Glossosoma	**10**	0	0	0
Symphitopsyche	**16**	**10**	**11**	<1
Lepidostoma	**9**	<1	**7**	0
Dolophilodes	**11**	<1	**24**	0
Rhyacophila	2	3	**7**	**7**
Parapsyche	0	0	<1	**4**
Chloroperlidae	**5**	**11**	**9**	**28**
Capniidae	<1	**22**	1	**16**
Malirekus	0	0	<1	**5**
Leuctridae	2	**18**	2	**10**
Taeniopteryx	0	**6**	0	0

The high dissimilarity between the upper and lower sites on each stream appears to be in part related to the natural longitudinal change that occurs in functional guilds and therefore genera. The upper sites are more dominated by the leaf shredder and predator genera Taeniopteryx sp., Capniidae, Leuctridae and Chloroperlidae. Another factor contributing to the difference between the upper and lower sites on Bourn Brook is the differences in habitat characteristics (**Table 18**). The upper Bourn Brook site is more dominated by smaller-sized cobble and gravel substrates and mosses, both of which are preferred by the riffle beetles Promoresia sp. and Oulimnius sp.. The pH differences (especially on Lye Brook) between the upper and lower sites (**Table 7**) is also a contributing factor in the taxonomic dissimilarity between the sites. The upper Lye Brook site is devoid of several taxa that are dominant in either the lower Lye Brook site or upper Bourn Brook site that one would expect to otherwise find in the upper Lye Brook community. Those pH sensitive taxa absent at the upper Lye Brook site, include Baetis sp. (replaced in upper Lye Brook functionally by the pH tolerant Ameletus sp.), Lepidostoma sp., Dolophilodes sp., and Taeniopteryx sp..

A list of all the taxa collected at each stream site is presented in **Appendix 10.** The crayfish Decapoda Cambarus bartoni interestingly is present in both upper sites. This species of crayfish is apparently highly tolerant to low pH and low calcium levels. The upper Lye Brook site also contains another crustacean (the Amphipod Hyalella azteca) and the Gastropod (snail) Physidae. Both of these may be contributed to the community by the extensive wetland in the upper Lye Brook watershed.

It is also interesting to note the presence of several insect species that are somewhat uncommon. These include the Trichoptera (caddisfly) Palaegapetus celsus, Symphitopsyche macleodi, and the Ephemeroptera (mayfly) Ameletus sp.. Finally the upper Lye Brook site has seven species of Rhyacophilid Trichopterans Rhyacophila: fuscula, carolina, carpenteri, torva, fenestra, minora, fuscula, invaria. This high diversity of Rhyacophila has also been noted around the State in other high elevation, low pH streams.

Table 18. Physical Habitat Characteristics of the Four Stream Sites in Lye Brook Wilderness Area.

Stream	Bourn Brook		Lye Brook	
Site # (mi)	**1.6**	**4.1**	**1.8**	**3.4**
Substrate % Composition				
Bedrock	0	0	0	0
Boulder >10"	60	25	30	60
Cobble 2.5-10"	30	30	40	25
Coarse Gravel .5-2.5"	10	15	20	10
Gravel .05-.15"	0	15	10	5
Sand .002-.05"	0	5	0	0
Organic Floc	--	+	+	--
% Embeddedness	0-5	25-35	0-5	0-5
% Canopy Cover	40	80	80	100
% Periphyton Cover				
Diatom	100	100	100	100
Filamentous Green	0	0	0	0
Blue Green	5	0	5	10
Moss	10	80	30	60
Width (m)	6	4	6	10

FISH

All four study streams can be classified as cold-water streams. All drain watersheds which originate at elevations of greater than 2500 ft. Bourn, Lye and Branch Pond Brook sites are of moderate to high gradient, contain a mix of riffles and pools, and a substrate composed primarily of gravel, cobble and boulder. Canopy cover is extensive on these relatively small streams (site drainages: 6-19km^2). The Winhall River site exhibits similar gradient and substrate composition as the other sites but drains a larger area (47km^2) and has little canopy cover. Results from the five sites on the three smaller streams will be discussed separately from the Winhall River site.

Small, coldwater streams in Vermont generally support relatively few fish species and contain low population densities. These streams generally support brook and sometimes brown trout, most often with slimy sculpin and sometimes with one or two dace species. Bourn, Branch Pond and lower Lye Brooks typify this description. These sites support four, three and one species respectively. First run total densities were 0.7-16.8/100m^2 **(Table 19).** Numbers of trout per mile based on population estimates ranged from 107 to 339 **(Table 20). Appendices 11 and 12** present length and weight data. Raw catch data appears in **Appendix 13.**

Records from the VT DEC streams database show that small higher elevation sites (over 800 ft. elevation and drainage area less than 20km^2) have a mean species richness of 2.5 and first run density of 11.4/100m^2 (n=39). The VTIBI could not be computed for these sites because too few species were present.

The upper Lye Brook site collection yielded no fish. None were observed during the sampling. It is likely that episodic depressions in pH levels combine concurrently with elevated aluminum concentrations to limit fish occurrence at this elevation on Lye Brook. The pH at the upper station was 4.71 during the September fish sampling. Although the IMAL concentration was the highest of the five sites at 89 μg/l, it was not considered acutely toxic. At low pH's, IMAL concentrations exceeding 200μg/l produce measurable lethal and sub-lethal effects (Baker and Schofield 1981; Haines 1981; Fiss and Carline 1993). Since aluminum concentrations are likely to increase and pH is likely to decrease during runoff events and the present value was observed during baseflow conditions, it is probable that, given observed monomeric aluminum species ratios, concentrations of IMAL could reach potentially toxic levels during periods of high runoff. Fish were recorded at the other sites in varying densities where pH and aluminum levels were not considered as limiting.

Fish population data from the Winhall River site compared favorably with the existing VT DEC database sites of similar elevation and drainage area. Mean richness and first run densities from database sites are 4.0 and 15.6/100m^2 respectively. Richness for the Winhall site was 6 with a first run density of 32.6/100m^2. The VTIBI score was 43 (out of a possible 45) indicating excellent population integrity.

Table 19. Fish Population Parameters for the Six Sites. Population estimates and total densities are expressed in numbers /100m2. Population estimates are given with 95% confidence estimates.

	Richness	VTIBI	Run-1 Density	Atlantic Salmon	Brook Trout	Brown Trout	Blacknose Dace	Longnose Dace	Slimy Sculpin	White Sucker
Bourn Bk. (4.1)	1	-	0.7		1.2 + 0.2 -0.0					
Bourn Bk. (1.6)	4	-	16.8		3.0 + 0.8 -0.2	0.3 +0.3 -0.0	0.5 + 0.3 -0.0		27.7 + 6.5 -6.1	
Lye Bk (3.4)	0	-	0							
Lye Bk. (1.8)	3	-	3.5		3.1 + 0.4 -0.1	0.5 + 0.4 -0.0			1.1 + 0.2 -0.0	
Winhall R.	6	43	32.5	15.3 + 0.2 -0.1	2.9 + 0.1 -0.0		9.1 + 2.2 -1.8	16.6 + 25 -25	13.5 + 1.3 -1.3	-
Branch Pond Bk.	1	-	1.9		2.0 + 0.1 -0.0					

General Observations

1. Small, coldwater streams in Vermont like these generally support relatively few fish species and contains low population densities.
2. These streams generally support brook and sometimes brown trout, most often with slimy sculpin and occasionally with one or two dace species.
3. Upper Lye yield no fish. It is likely that episodic depression in pH levels combined with elevated IMAL limit fish occurrence here. pH and aluminum were not considered as limiting at other sites.
4. Winhall has excellent population integrity (VTIBI of 41). IBI's could not be calculated at other sites because too few species.

Table 20. Population Estimates of Salmonids in Numbers/mile with 95% Confidence Limits.

Bourn Bk. (1.6)	268 + 78, - 16
Bourn Bk. (4.1)	107 + 20, - 0
Lye Bk. (1.8)	322 + 46, - 13
Winhall R. (8.1)	339 + 12, - 0
Branch Pond Bk. (0.1)	148 + 6, - 0

The same site was sampled by the VT DEC in 1984. At that time the VTIBI was also 43 (excellent). In 1993 Wagner, Heindel and Noyes sampled three sites within 1/4 mile of this present site. The VTIBI calculated from these three sites was again excellent with a mean of 40.

RECOMMENDATIONS

This study was a good opportunity for the State of Vermont to survey remote surface waters to document their present biological and chemical status. The Lye Brook Wilderness area is an important resource that needs ongoing monitoring to assure that its integrity remains undisturbed.

The State has been fortunate to have been part of the U.S. EPA/VT DEC Long-Term Monitoring Program. It would be beneficial to the GMNF, the State and its citizenry if this study continues along with the VT DEC's stream Ambient Biomonitoring Network.

The following recommendations direct a continued monitoring effort for the surface waters of LBW:

Lakes:

1. The chemical monitoring of Branch and Bourn Ponds should continue indefinitely as part of the ongoing U.S. EPA/VT DEC's Long-Term Monitoring Program. Sampling should occur three times per year during the spring, summer (both epilimnion and hypolimnion) and fall.

2. Little Mud Pond should be sampled for water chemistry every five years. The next sampling should occur in the summer of 1998.

3. Surficial sediments of Branch and Bourn Ponds should be examined every five years after the 1994 sampling for priority pollutant metals, PCBs, PAHs and chlorinated pesticides. The next sampling would be in the summer of 1998.

4. Fish tissue analysis on brook trout in Branch and Bourn Ponds for metals and organics should be undertaken every five years. Fish should be collected by rod and reel.

5. Fish population density determinations need to be conducted at some regular interval to be determined by the GMNF Fishery Biologist.

6. Macroinvertebrate monitoring of Branch and Bourn Ponds should be conducted every five years unless a change in the water chemistry would warrant more frequent analysis. The sensitive mayflies and crustacean communities can be examined on a qualitative informal basis as part of the present VT DEC Long-Term Monitoring Program by using non-destructive sampling techniques. No benthic samples need to be collected until the summer of 1998.

Rivers:

1. It is recommended that a minimum of three to five years of intensive biological and chemical monitoring be undertaken. This would document annual variability within the populations and water chemistry to establish the necessary baseline. The VT DEC should continue to sample Bourn and Lye Brooks and the GMNF should continue sampling Branch Pond Brook and the Winhall River. A subset (if not all) of these rivers should be part of the VT DEC's Ambient Biomonitoring Network.

2. During the next two years the upper stations of Bourn and Lye should be monitored seasonally to better define the observed water chemistry gradient. Additional chemical sampling during spring runoff or high flow events may help explain the absence of fish from upper Lye Brook.

ACKNOWLEDGEMENTS

This study was effective in terms of reaching its goals mainly due to the cooperative spirit between the State of Vermont (VT DEC) and the United States Forest Service (GMNF). This would not have been possible with out the concerted efforts of Wayne Kingsley (USFS), Project Officer; Steve Roy (USFS), Fishery Biologist; Cindy Boyce (USFS) and Frank Thompson (USFS).

Camilla Schamaun (VT DEC) assisted with all stages of chemical sampling and Rick Levey (VT DEC) assisted with biological sampling. Jim Pease (VT DEC) did much of the initial picking and sorting of macroinvertebrate samples. The diverse amount of macroinvertebrate identification required for this study was made possible due to the taxonomic expertise of the Vt. Biomonitoring and Aquatic Studies Unit. This includes Alan Quackenbush - Plecoptera and Odonata, Rick Levey - Trichoptera and Megaloptera, Rich Langdon - Ephemeroptera, James Kellogg - Coleoptera, Hemiptera, Crustacea, Molluska (Gastropoda), Steve Fiske - Diptera, Oligocheata, Hirudinidae, Molluska (Bivalvia) and other groups. The VT DEC's Reginald A. LaRosa Laboratory under the direction of Dr. Gerald DiVincenzo and the University of Maine's Environmental Chemistry Laboratory under the direction of Dr. Donald Verault, II deserve special thanks for the analytical testing.

Alison Farnsworth was responsible for the typing of this report.

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Appendix 1. Analytical Methods for the Lye Brook Wilderness Study.

Parameter	Method/Equipment	Method Reference	Reference Number
pH, field	Beckman 21 meter with temperature compensation. Sample placed in 30ml plastic beaker and analyzed.	U.S. EPA, 1983 Method 150.1	1
pH, lab (stirred)	Cole Palmer DigipHase meter, Ross combination electrode model 81-02.	U.S. EPA, 1983 Method 150.1	1
Gran Alkalinity	Titration with 0.020 N H_2SO_4 to pH 3.5, with a minimum of 17 points used for Gran plot calculation.	Pfeiffer and Festa, 1980	3
Conductivity	YSI model 32 with two cells, one for samples <20 µmhos, another for samples >20 µmhos.	U.S. EPA, 1983 Method 120.1	1
Cl^-, SO_4^{2-}, NO_3^-	Dionex Ion Chromatograph 2000 with integrator; manual injection, 3 to 6 calibration standards with an independent check sample run after every 10 samples.	Pfaff, Brockhoff and O'Dell U.S. EPA, 1989 Method 300.0	4
Ca, Mg, Na, K	Perkin Elmer 3030B; 5 calibration standards; acetylene flame for Mg, Na and K, nitrous oxide flame for Ca, 1 out of every 10 samples is a duplicate or spike. Lanthanum added to base cations.	U.S. EPA 1983 Method 215.1 (Ca) Method 242.1 (Mg) Method 273.1 (Na) Method 258.1 (K)	1
Al, total dissolved	Perkin Elmer 3030B, Perkin Elmer 5100 PC and OHGA 600 furnace with autosampler.	U.S. EPA, 1983 Method 202.1	1
*Total Monomeric and Organic Al	Pyrocatechol violet - manual injection with 5cm flow cell Milton-Roy Spectronic 601.	U.S. EPA, 1987 Section 8.0	2
*Dissolved Organic Carbon	Oceanographic Institutes Model 700 Spectrophotometer. Persulfate oxidation, Infra-red dispersion 2 point calibration.	U.S. EPA, 1987 Section 14.0	2
Color	True color is filtered through 0.45-µm filter and measured at 420 nm on a spectrophotometer. Bauch and Lomb Spectronic 100	Black & Christman, 1963.	5
	Apparent color is unfiltered and measured on a Taylor color comparator.	U.S. EPA, 1983 Method 110.2	1
Temperature	Cole-Parmer thermistor (Model 8402-00) with weighted cable.	APHA, 1992 Section 2550B	6
Secchi Disk Transparency	Secchi Disk with calibrated line.	U.S. EPA, 1989 Section 11.0	7

* These parameters are analyzed by the Environmental Chemistry Laboratory at the University of Maine in Orono.

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Appendix 2. Chemistry of Lye Brook Wilderness Study Lakes.

Lake	Depth (m)	Date	TEMP °C	pH Std. U.	ALK mg/l	COND[0] us/cm	DC2[1] Pt-Co	TC[2] Pt-Co	DCL[3] mg/l	DNO3[4] mg/l	DSO4[5] mg/l	DCA[6] mg/l	DMG[7] mg/l	DNA[8] mg/l	DK[9] mg/l	DAL[10] µg/l	IMAL[11] µg/l	OMAL[12] µg/l	DOC[13] mg/l
Bourn	1	27-May-93	14.3	5.34	0.18	14.1	55	40	0.25	0.02	3.12	0.74	0.31	0.46	0.34	173	--	--	--
Bourn	6	27-May-93	6.2	5.19	0.44	16.1	67	65	0.28	0.07	2.95	0.78	0.31	0.44	0.33	235	--	--	--
Bourn	1	12-Aug-93	21.2	5.43	0.49	13.1	22	45	0.26	<0.01	3.80	0.70	0.34	0.51	0.31	97	55	28	4.09
Bourn	6.5	12-Aug-93	9.6	5.68	2.14	13.0	86	>70	0.55	0.04	3.84	0.81	0.31	0.49	0.37	213	57	42	5.40
Bourn	1	07-Oct-93	9.8	5.39	0.35	17.2	36	45	0.28	0.03	3.74	0.81	0.38	0.55	0.36	129	37	37	4.35
Branch	1	19-May-93	14.1	4.87	-0.63	19.0	83	>70	0.32	0.06	3.56	0.67	0.23	0.45	0.39	250	--	--	--
Branch	9	19-May-93	5.2	4.87	-0.45	19.3	94	>70	0.34	0.08	3.58	0.70	0.25	0.45	0.40	280	--	--	--
Branch	1	12-Aug-93	20.2	4.78	-0.35	15.1	46	55	0.25	<0.01	4.09	0.67	0.23	0.49	0.30	300	121	46	4.94
Branch	7.5	12-Aug-93	5.3	4.91	-0.06	15.7	105	>70	0.30	<0.01	3.00	0.74	0.24	0.48	0.39	303	124	66	5.27
Branch	1	06-Oct-93	9.7	4.95	-0.15	19.3	69	>70	0.34	0.02	4.01	0.74	0.26	0.49	0.36	248	114	45	5.08
Little Mud	1	18-May-93	16.0	4.85	-0.62	15.2	80	>70	0.10	<0.01	2.84	0.65	0.24	0.42	0.16	--	--	--	--
Little Mud	1	11-Aug-93	21.0	5.04	-0.11	--	78	55	0.02	<0.01	1.93	0.72	0.18	0.19	0.03	94	32	41	8.05

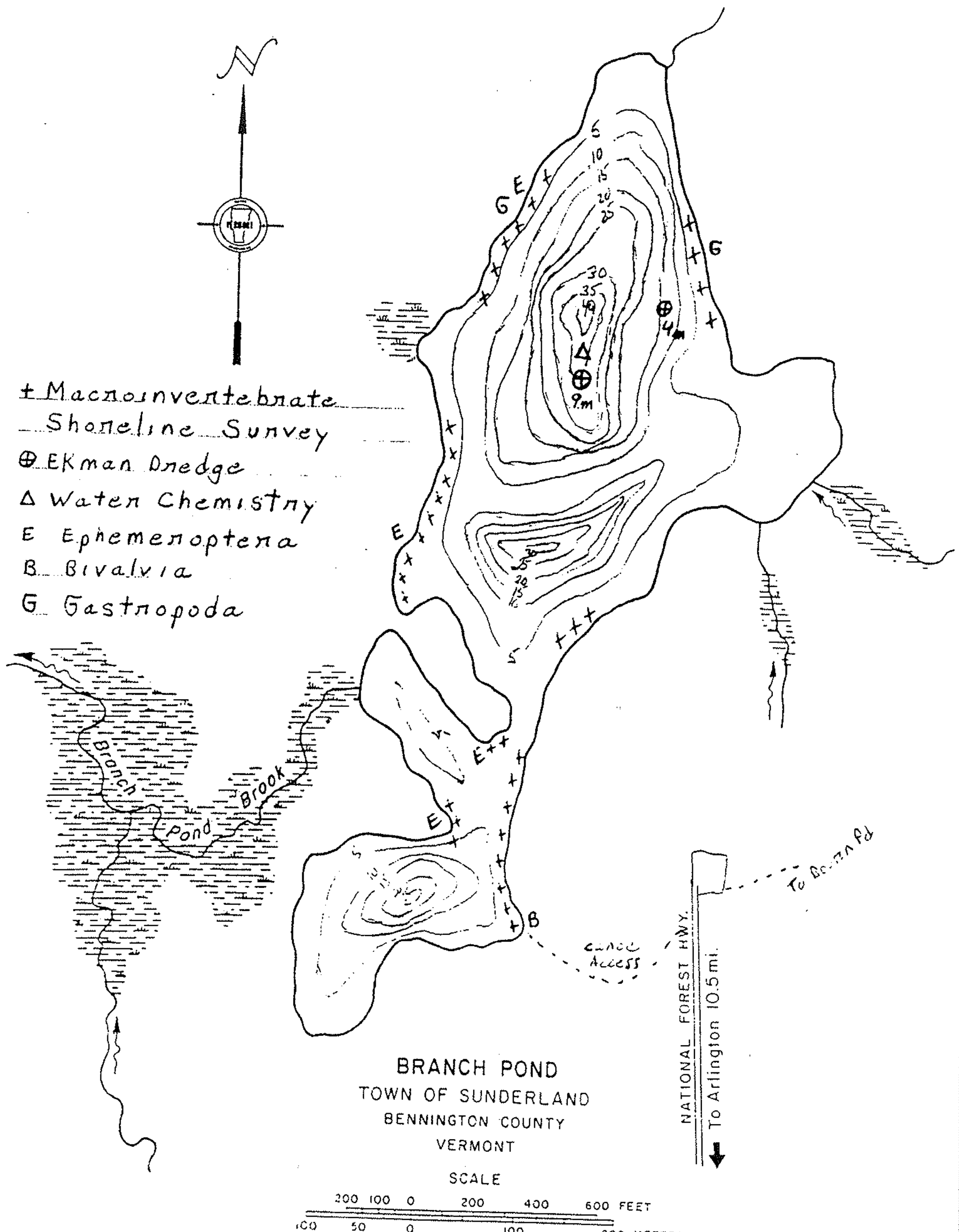
Parameter:
[0]Cond = conductivity
[1]DC2 = Filtered Color
[2]TC = Unfiltered Color
[3]DCL = Dissolved Chloride
[4]DNO_3 = Dissolved Nitrate
[5]DSO_4 = Dissolved Sulfate
[6]DCA = Dissolved Calcium
[7]DMG = Dissolved Magnesium
[8]DNA = Dissolved Sodium
[9]DK = Dissolved Potassium
[10]DAL = Dissolved Aluminum
[11]IMAL = Inorganic Monomeric Aluminum
[12]OMAL = Organic Monomeric Aluminum
[13]DOC = Dissolved Organic Carbon

River	Date	TEMP °C	pH Std. U.	ALK mg/l	COND[0] µs/cm	DC2[1] Pt-Co	TC[2] Pt-Co	DCL[3] mg/l	DNO3[4] mg/l	DSO4[5] mg/l	DCA[6] mg/l	DMG[7] mg/l	DNA[8] mg/l	DK[9] mg/l	DAL[10] µg/l	IMAL[11] µg/l	OMAL[12] µg/l	DOC[13] mg/l
Bourn (Upper)	21-Sep-93	7	5.69	0.62	21.9	85	65	0.27	0.02	3.83	1.40	0.59	0.92	0.39	299	58	147	9.69
Bourn (Lower)	08-Apr-93	1.5	6.51	3.08	22.9	56	45	0.29	0.20	4.40	2.05	0.80	0.61	0.56	210			
Bourn (Lower)	14-Apr-93	3	6.25	1.94	21.4	72	55	0.27	0.16	4.18	1.86	0.66	0.54	0.49	237			
Bourn (Lower)	22-Apr-93	3	4.94	-0.28	18.0	86	60	0.22	0.12	3.23	1.07	0.33	0.38	0.36	297			
Bourn (Lower)	28-Apr-93	5.5	5.21	0.12	16.7	77	55	0.24	0.08	3.66	1.25	0.39	0.49	0.41	261			
Bourn (Lower)	06-May-93	11	5.67	0.82	17.0	110	>70	0.24	0.08	3.26	2.15	0.57	0.78	0.46	286			
Bourn (Lower)	05-Aug-93	15.5	6.67	3.49	22.2	96	70	0.35	0.14	4.89	2.24	0.95	0.82	0.62	213	31	120	7.80
Bourn (Lower)	21-Sep-93	8.5	6.78	3.94	17.8	135	65	0.27	0.04	4.36	2.16	0.86	0.89	0.50	197	33	104	7.04
Bourn (Lower)	21-Oct-93	7	6.62	2.31	21.9	73	65	0.48	<0.01	4.84	1.62	0.64	0.74	0.65	175	30	83	5.83
Branch Pond Bk.	30-Mar-93	1	4.69	-0.81	27.2	68	55	0.32	0.38	3.84	1.02	0.33	0.55	0.50	382			
Branch Pond Bk.	05-Apr-93	1	4.86	-0.73	23.9	72	55	0.33	0.26	4.39	1.12	0.34	0.54	0.54	279			
Branch Pond Bk.	13-Apr-93	2	4.64	-1.07	22.8	82	65	0.26	0.21	3.84	0.97	0.30	0.54	0.47	315			
Branch Pond Bk.	20-Apr-93	2	4.61	-1.34	22.1	86	60	0.25	0.14	3.42	0.75	0.25	0.45	0.34	328			
Branch Pond Bk.	26-Apr-93	4	4.62	-1.16	20.3	98	70	0.20	0.10	3.06	0.84	0.24	0.45	0.34	288			
Branch Pond Bk.	04-May-93	10	4.87	-0.58	19.2	97	70	0.23	0.03	3.22	0.67	0.24	0.50	0.37	313			
Branch Pond Bk.	04-Aug-93	16	4.87	-0.24	16.4	130	>70	0.23	0.02	4.13	1.17	0.35	0.77	0.33	312	83	152	10.0
Branch Pond Bk.	19-Oct-93	8.5	5.06	-0.04	19.1	71	70	0.40	<0.01	4.53	0.98	0.36	0.86	0.45	224	70	90	5.66
Lye (Upper)	22-Sep-93	9	4.96	-0.02	20.4	142	>70	0.45	0.04	3.56	1.09	0.46	0.82	0.41	365	89	155	11.67
Lye (Lower)	08-Apr-93	1	5.74	1.37	21.4	111	>70	0.37	0.15	4.66	1.56	0.68	0.55	0.60	411			
Lye (Lower)	14-Apr-93	2.5	5.25	0.45	19.5	135	>70	0.28	0.10	4.02	1.26	0.55	0.46	0.48	140			
Lye (Lower)	22-Apr-93	2	4.67	-1.21	20.5	170	>70	0.22	0.08	2.97	0.75	0.30	0.33	0.37	396			
Lye (Lower)	28-Apr-93	4.5	5.08	0.14	18.0	140	>70	0.21	0.05	3.53	1.05	0.46	0.35	0.39	387			
Lye (Lower)	06-May-93	11.5	5.92	1.76	17.8	161	>70	0.22	0.08	3.12	1.56	0.61	0.50	0.42	391			
Lye (Lower)	05-Aug-93	16	6.68	4.31	23.2	140	>70	0.39	0.10	4.56	2.32	1.52	0.69	0.44	291	51	173	10.20
Lye (Lower)	22-Sep-93	10	6.69	2.30	18.3	157	>70	0.39	0.06	3.97	2.16	1.14	0.76	0.40	289	55	144	9.30
Lye (Lower)	21-Oct-93	7	6.19	2.78	22.8	116	70	0.51	<0.01	4.74	1.78	0.96	0.76	0.69	276	66	123	8.67

River	Date	TEMP °C	pH Std. U.	ALK mg/l	COND[0] µs/cm	DC2[1] Pt-Co	TC[2] Pt-Co	DCL[3] mg/l	DNO3[4] mg/l	DSO4[5] mg/l	DCA[6] mg/l	DMG[7] mg/l	DNA[8] mg/l	DK[9] mg/l	DAL[10] µg/l	IMAL[11] µg/l	OMAL[12] µg/l	DOC[13] mg/l
Winhall	05-Apr-93	4.5	5.61	0.50	19.2	56	50	0.35	0.22	4.19	1.35	0.40	0.61	0.57	223			
Winhall	13-Apr-93	4	5.32	0.25	18.0	57	50	0.27	0.17	3.80	1.24	0.34	0.52	0.46	225			
Winhall	20-Apr-93	5	5.21	0.14	17.3	58	35	0.27	0.14	3.37	1.14	0.31	0.45	0.42	212			
Winhall	26-Apr-93	7	5.16	0.14	13.4	71	70	0.23	0.09	3.37	1.42	0.36	0.58	0.43	246			
Winhall	04-May-93	9	5.67	0.74	19.2	72	40	0.32	0.06	3.43	1.75	0.42	0.77	0.47	204			
Winhall	04-Aug-93	17.5	6.00	2.15	19.3	84	70	0.27	0.06	4.37	2.26	0.66	0.88	0.54	189	24	109	7.68
Winhall	19-Oct-93	8.5	6.44	2.15	21.1	55	50	0.50	<0.01	4.68	1.62	0.55	0.90	0.59	154	27	73	5.21

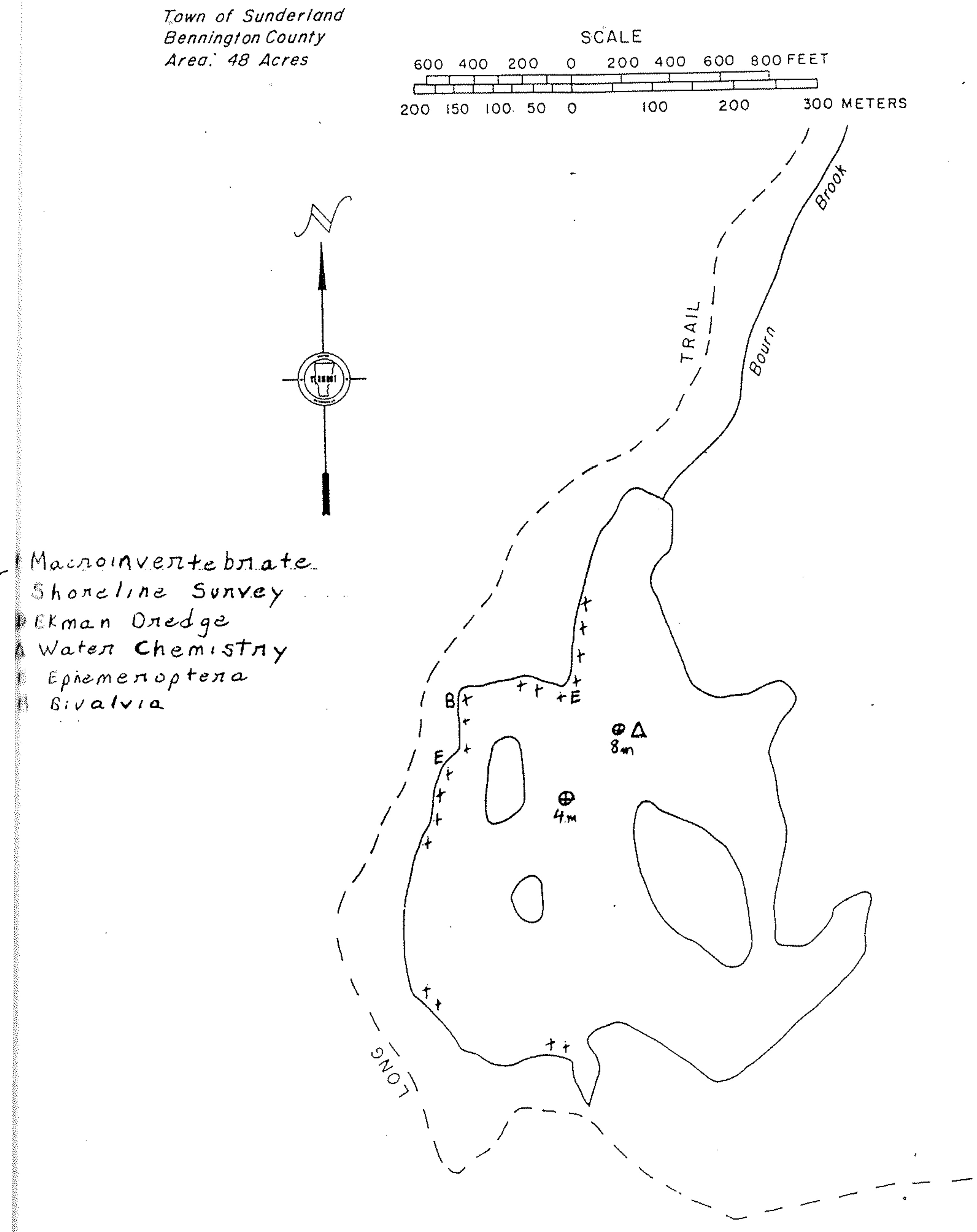
Parameter:
[0]Cond = Conductivity
[1]DC2 = Filtered Color
[2]TC = Unfiltered Color
[3]DCL = Dissolved Chloride
[4]DNO_3 = Dissolved Nitrate
[5]DSO_4 = Dissolved Sulfate
[6]DCA = Dissolved Calcium
[7]DMG = Dissolved Magnesium
[8]DNA = Dissolved Sodium
[9]DK = Dissolved Potassium
[10]DAL = Dissolved Aluminum
[11]IMAL = Inorganic Monomeric Aluminum
[12]OMAL = Organic Monomeric Aluminum
[13]DOC = Dissolved Organic Carbon

Appendix 4. Map of Branch Pond.

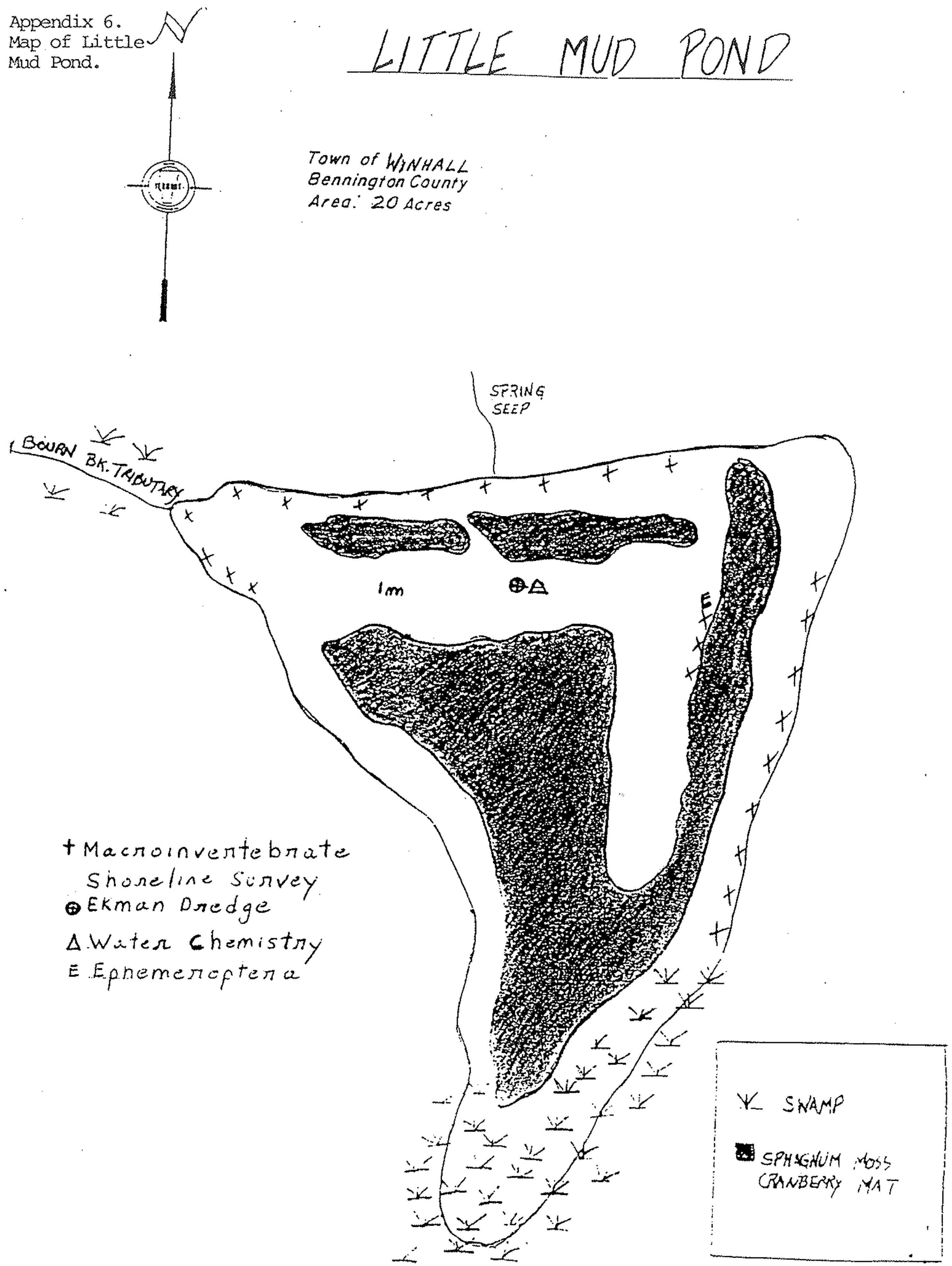


Appendix 5. Map of Bourn Pond.

BOURN POND



Appendix 6. Map of Little Mud Pond.



Appendix 7. Macroinvertebrate Biocriteria.

MACROINVERTEBRATE BIOCRITERIA

Biocriteria used for determining the biological integrity of the aquatic biota for wadeable streams and rivers in Vermont. Method used 2 min. kick net sample and 300 organism subsample. Identifications in laboratory to the genus - species level. The overall biological integrity of a stream is made by the degree a metric is rated and the number of metrics which are found to be acceptable or unacceptable.

Metric Rating	Mean Richness	Mean EPT	Bio Index	Diversity
Very Poor	<15	<8	≥3.50	<1.50
Poor	15-19	8-12	3.01-3.49	1.51- 2.24
Fair	20-29	13-17	2.75-3.00	2.25 -2.99
		Unacceptable		
		Acceptable		
Good	30-39	18-22	2.01-2.74	3.00-3.99
Very Good	40-49	23-25	1.51-2.00	4.00-4.49
Excellent	≥50	>25	≤1.50	>4.50

	% Dominant Genera		# EPT/# Chiro	
Poor	>55-60%		<.75	Poor
Fair	≥40%	Unacceptable	.75-1.99	Fair
Good-Excellent	<40%	Acceptable	>2.0	Good

OTHER METRICS TO BE EVALUATED

Scraper/Filterer Ratios
Spec/Generalist Ratio
Community Loss Index
#4% Genera

*Generated using ABN Data 1984-1989

Appendix-8 Lake Macroinvertebrate Ekman dredge data by replicate for each lake and depth
Data are raw counts from each .02m2 dredge sample.

A:Little Mud Pond at 1m depth

Order	Genera	Species	Count 1	Count 2	Count 3
DIPTERA	ABLABESMYIA	sp	17	0	1
DIPTERA	BEZZIA	sp	1	4	4
DIPTERA	CHAOBORUS	punctipennis	1	12	0
DIPTERA	CHIRONOMUS	sp	22	54	1
DIPTERA	CLADOPELMA	sp	5	47	2
DIPTERA	CLADOTANYTARSUS	sp	0	2	2
DIPTERA	DICROTENDIPES	sp	3	38	4
DIPTERA	NEMATOCERA	unid	0	9	0
DIPTERA	PAGASTIELLA	sp	1	0	0
DIPTERA	PARATANYTARSUS	sp	0	3	0
DIPTERA	POLYPEDILUM	halterale	0	6	1
DIPTERA	POLYPEDILUM	sp	0	11	0
DIPTERA	PROCLADIUS	sp	10	24	3
DIPTERA	PSECTROCLADIUS	sp	19	20	11
DIPTERA	TANYTARSUS	sp	7	30	5
DIPTERA	TELOPELOPIA	sp	2	0	0
OLIGOCHAETA	NAIDIDAE	unid	0	0	4
OLIGOCHAETA	TUBIFICIDAE	unid	1	31	0

B:Branch Pond at 9m depth.

Order	Genera	Species	Count 1	Count 2	Count 3
DIPTERA	CLADOPELMA	sp	0	0	1
DIPTERA	ZALUTSCHIA	sp	0	0	1
DIPTERA	CHIRONOMUS	sp	0	0	6
DIPTERA	BEZZIA	sp	1	0	0
DIPTERA	PSECTROCLADIUS	sp	1	2	0
DIPTERA	CHAOBORUS	punctipennis	2	8	0

C:Branch Pond at 3.5m depth.

Order	Genera	Species	Count 1	Count 2	Count 3
DIPTERA	CERATOPOGON	sp	2	1	0
DIPTERA	CHAOBORUS	punctipennis	0	1	8
DIPTERA	DICROTENDIPES	sp	2	3	0
DIPTERA	HETEROTRISSOCLADIUS	sp	1	0	1
DIPTERA	ORTHOCLADIUS	sp	1	0	0
DIPTERA	PAGASTIELLA	sp	4	1	0
DIPTERA	PROCLADIUS	sp	7	10	3
DIPTERA	TANYTARSUS	sp	0	1	0
DIPTERA	ZALUTSCHIA	sp	0	1	11
MEGALOPTERA	SIALIS	sp	2	1	0
ODONATA	LIBELLULA	sp	1	0	0
TRICHOPTERA	PHYLOCENTROPUS	sp	1	0	4

D:Bourn Pond at 8m depth

Order	Genera	Species	Count 1	Count 2	Count 3
DIPTERA	CHAOBORUS	punctipennis	95	201	120
DIPTERA	CHIRONOMUS	sp	3	2	1
DIPTERA	CRYPTOCHIRONOMUS	sp	0	0	1
DIPTERA	PROCLADIUS	sp	0	5	0
OLIGOCHAETA	TUBIFICIDAE	unid	2	2	0
TRICHOPTERA	OXYETHIRA	sp	1	0	0

E:Bourn Pond at 4m depth.

Order	Genera	Species	Count 1	Count 2	Count 3
DIPTERA	BEZZIA	sp	1	1	0
DIPTERA	CHAOBORUS	punctipennis	83	20	42
DIPTERA	CHIRONOMUS	sp	22	18	9
DIPTERA	HETEROTRISSOCLADIUS	sp	0	0	1
DIPTERA	PAGASTIELLA	sp	0	1	1
DIPTERA	PROCLADIUS	sp	3	3	9
DIPTERA	TANYTARSUS	sp	1	1	1
HYDRACARINA	UID		0	0	1
OLIGOCHAETA	TUBIFICIDAE	unid	51	60	61

Appendix 9. The Presence (x) of Macroinvertebrate Taxa Collected from Shoreline Qualitative Sampling for Little Mud, Branch, and Bourn Pond in Spring and Summer 1993. pH sensitive taxa in **bold** print. The number of taxa within an order is listed for each lake.

	Little Mud	**Branch**	**Bourn**
Bivalvia	0	1	2
Pisidium casertanum		x	x
Musculium securis			x
Gastropoda	0	1	0
Ferrissia fragilis		x	
Ephemeroptera	1	3	3
Eurylophella temporalis		x	x
Arthroplea bipunctata	x	x	x
Leptophlebia sp.		x	x
Coleoptera	9	6	2
Haliplus sp.			x
Peltodytes sp.		x	
Donacia sp.		x	
Hydroporus sp.	x	x	x
Coptotomus sp.		x	
Dytiscus sp.	x	x	
Graphoderus sp.	x	x	
Dineutes sp.	x		
Enochrus sp.	x		
Desmopachria sp.	x		
Illybius sp.	x		
Cyphon sp.	x		

	Little Mud	Branch	Bourn
Trichoptera	6	6	6
Glyphopsyche sp.			x
Limnephilus sp.	x	x	x
Molanna uniophila		x	x
Triaenodes sp.	x		
Banksiola smithi	x	x	x
Ptilostomis ocellifera	x	x	x
Nyctiophylax sp.		x	
Polycentropus sp.	x	x	x
Oxyethira sp.	x		
Megaloptera	1	2	1
Chauliodes sp.	x	x	
Sialis sp.		x	x
Lepidoptera	1	0	0
Pyralidae sp.	x		
Neuroptera	0	1	0
Climacia sp.		x	
Diptera	12	14	16
Chironomidae	10	13	15
Orthocladiinae uid	x		
Ablabesmyia sp.	x	x	x
Corynoneura sp.		x	x
Chironomus sp.		x	
Cricotopus sp.		x	x
Cryptochironomus sp.			x
Dicrotendipes sp.	x		x

	Little Mud	Branch	Bourn
Dorocricotopus sp.	x		
Endochironomus sp.	x	x	x
Heterotanytarsus sp.		x	
Lapposmittia sp.			x
Maeropelopia sp.		x	
Microtendipes sp.			x
Polypedilum illionoense	x	x	x
Procladius sp.	x	x	x
Psectrocladius sp.	x	x	x
Tarytarsus sp.	x	x	x
Telopelopia sp.	x		
Thienemanniella sp.			x
Tribelos sp.		x	x
Tvetenia discoloripes			x
Xenochironomus sp.		x	
Ceratopogonidae	1	1	1
Bezzia sp.	x	x	x
Tipulidae	1	0	0
Rhabdomastix sp.	x		
Odonata	12	8	5
Aeshna sp.	x	x	x
Boyeria uinosa	x	x	x
Coenagrion sp.	x		
Arigomphus sp.	x		
Sympetrum sp.	x		
Erythemis sp.	x	x	

	Little Mud	Branch	Bourn
Leucorrhinia sp.	x	x	x
Libellula sp.	x	x	
Ladona sp.	x	x	x
Lestes sp.	x		
Neurocordulia sp.			x
Tetraogeneuria sp.			x
Enallagma sp.	x	x	
Anomalagrion sp.			x
Chromagrion sp.		x	
Coenagrion sp.	x		
Hemiptera	6	5	4
Corixidae	x	x	x
Belostomatidae	x		
Notonecta sp.	x	x	x
Gerris sp.	x		
Hesperocorixa sp.	x	x	x
Trichorixa sp.	x	x	
Microvelia sp.		x	
Mesovelia sp.			x
Hydracarina			x
Hirudinea	1	0	1
Oligobdella biannulata	x		x
Oligocheata	2	3	1
Lumbriculidae	x	x	x
Naididae	x	x	
Tubificidea		x	

Appendix 1C. The raw macroinvertebrate count by replicate for each stream site.

A: Bourn Brook 4.1

Order	Genera	Species	Count1	Count2
COLEOPTERA	OPTIOSERVUS	ovalis	0.00	2.40
COLEOPTERA	OULIMNIUS	latiusculus	41.40	69.60
COLEOPTERA	PROMORESIA	tardella	39.60	48.00
DECAPODA	CAMBARUS	bartoni	0.00	2.40
DIPTERA	ATHERIX	sp	7.20	16.80
DIPTERA	DICRANOTA	sp	16.20	19.20
DIPTERA	EUKIEFFERIELLA	claripennis	1.80	0.00
DIPTERA	HEXATOMA	sp	1.80	0.00
DIPTERA	MICROPSECTRA	sp	1.80	0.00
DIPTERA	SIMULIUM	tubersom	0.00	4.80
DIPTERA	THIENEMANNEMYIA	sp	3.60	0.00
DIPTERA	TIPULA	sp	0.00	4.80
EPHEMEROPTERA	BAETIDAE	imm	16.20	2.40
EPHEMEROPTERA	BAETIS	tricaudatus	1.80	0.00
EPHEMEROPTERA	EPHEMERELLIDAE	imm	0.00	2.40
EPHEMEROPTERA	EURYLOPHELLA	funeralis	9.00	16.80
EPHEMEROPTERA	EURYLOPHELLA	sp	1.80	0.00
EPHEMEROPTERA	HEPTAGENIA	sp	3.60	2.40
EPHEMEROPTERA	HEPTAGENIIDAE	imm	1.80	0.00
HYDRACARINA	UID		0.00	4.80
ODONATA	GOMPHIDAE	imm	5.40	0.00
PLECOPTERA	ACRONEURIA	carolinesis	5.40	12.00
PLECOPTERA	ACRONEURIA	sp	3.60	9.60
PLECOPTERA	CAPNIIDAE	unid	109.80	218.40
PLECOPTERA	CHLOROPERLIDAE	unid	48.60	110.40
PLECOPTERA	LEUCTRIDAE	unid	144.00	120.00
PLECOPTERA	PELTOPERLA	sp	21.60	12.00
PLECOPTERA	TAENIOPTERYX	sp	25.20	60.00
TRICHOPTERA	APATANIA	sp	0.00	0.00
TRICHOPTERA	DOLOPHILODES	sp	0.00	14.40
TRICHOPTERA	LEPIDOSTOMA	sp	1.80	0.00
TRICHOPTERA	LYPE	sp	5.40	0.00
TRICHOPTERA	PALAEGAPETUS	sp	1.80	7.20
TRICHOPTERA	POLYCENTROPUS	sp	9.00	9.60
TRICHOPTERA	RHYACOPHILA	carpenteri	3.60	4.80
TRICHOPTERA	RHYACOPHILA	fenestra	5.40	2.40
TRICHOPTERA	RHYACOPHILA	fuscula	14.40	12.00
TRICHOPTERA	SYMPHITOPSYCHE	alhedra	16.20	19.20
TRICHOPTERA	SYMPHITOPSYCHE	macleodi	37.80	21.60
TRICHOPTERA	SYMPHITOPSYCHE	sparna	30.60	28.80

Appendix 10. The raw macroinvertebrate count by replicate for each stream site.

B: Bourn Brook 1.6

Order	Genera	Species	Count1	Count2
COLEOPTERA	ELMIDAE	imm	4.00	0.00
COLEOPTERA	OPTIOSERVUS	ovalis	0.00	16.00
COLEOPTERA	OULIMNIUS	latiusculus	32.00	56.00
COLEOPTERA	PROMORESIA	tardella	4.00	16.00
DIPTERA	ANTOCHA	sp	0.00	4.00
DIPTERA	ATHERIX	sp	8.00	20.00
DIPTERA	BEZZIA	sp	0.00	4.00
DIPTERA	CARDIOCLADIUS	sp	4.00	4.00
DIPTERA	CRICOTOPUS	bisinctus	24.00	8.00
DIPTERA	CRICOTOPUS	tremulus	4.00	4.00
DIPTERA	DIAMESA	sp	4.00	0.00
DIPTERA	DICRANOTA	sp	8.00	16.00
DIPTERA	EMPIDIDAE	unid	4.00	4.00
DIPTERA	EUKIEFFERIELLA	brehmi	0.00	16.00
DIPTERA	EUKIEFFERIELLA	claripennis	52.00	20.00
DIPTERA	HEXATOMA	sp	4.00	4.00
DIPTERA	MUSCIDAE	unid	4.00	20.00
DIPTERA	PARACHAETOCLADIUS	sp	0.00	4.00
DIPTERA	PARAMETRIOCNEMUS	sp	36.00	40.00
DIPTERA	POLYPEDILUM	aviceps	4.00	16.00
DIPTERA	SIMULIUM	tubersom	20.00	8.00
DIPTERA	SYNORTHOCLADIUS	sp	4.00	0.00
DIPTERA	THIENEMANNEMYIA	sp	4.00	4.00
DIPTERA	THIENEMANNIELLA	sp	4.00	8.00
EPHEMEROPTERA	BAETIDAE	imm	0.00	20.00
EPHEMEROPTERA	BAETIS	flavistriga	80.00	96.00
EPHEMEROPTERA	BAETIS	sp	16.00	4.00
EPHEMEROPTERA	BAETIS	tricaudatus	76.00	68.00
EPHEMEROPTERA	EPEORUS	sp	48.00	52.00
EPHEMEROPTERA	EPHEMERELLIDAE	imm	108.00	104.00
EPHEMEROPTERA	HEPTAGENIA	sp	8.00	4.00
EPHEMEROPTERA	HEPTAGENIIDAE	imm	12.00	12.00
EPHEMEROPTERA	LEPTOPHLEBIIDAE	unid	0.00	16.00
EPHEMEROPTERA	PSEUDOCLOEON	carolina	4.00	8.00
EPHEMEROPTERA	PSEUDOCLOEON	sp	4.00	0.00
EPHEMEROPTERA	STENONEMA	luteum	0.00	4.00
EPHEMEROPTERA	STENONEMA	sp	0.00	12.00
MEGALOPTERA	NIGRONIA	sp	0.00	0.00
OLIGOCHAETA	LUMBRICULIDAE	unid	12.00	20.00
PLECOPTERA	ACRONEURIA	carolinesis	0.00	4.00
PLECOPTERA	ACRONEURIA	sp	4.00	8.00
PLECOPTERA	AGNETINA	capitata	8.00	4.00
PLECOPTERA	CAPNIIDAE	imm	8.00	8.00
PLECOPTERA	CHLOROPERLIDAE	imm	76.00	80.00
PLECOPTERA	ISOPERLA	sp	0.00	4.00
PLECOPTERA	LEUCTRIDAE	imm	20.00	44.00
PLECOPTERA	PELTOPERLA	sp	0.00	8.00
TRICHOPTERA	APATANIA	sp	36.00	32.00
TRICHOPTERA	BRACHYCENTRUS	americanus	12.00	0.00
TRICHOPTERA	BRACHYCENTRUS	numerosus	4.00	12.00
TRICHOPTERA	DIPLECTRONA	sp	16.00	12.00
TRICHOPTERA	DOLOPHILODES	sp	188.00	172.00
TRICHOPTERA	GLOSSOSOMA	sp	152.00	196.00
TRICHOPTERA	LEPIDOSTOMA	sp	136.00	176.00
TRICHOPTERA	MICRASEMA	rusticum	28.00	20.00
TRICHOPTERA	RHYACOPHILA	carolina	0.00	4.00
TRICHOPTERA	RHYACOPHILA	fenestra	0.00	8.00
TRICHOPTERA	RHYACOPHILA	fuscula	36.00	32.00
TRICHOPTERA	SYMPHITOPSYCHE	macleodi	4.00	4.00
TRICHOPTERA	SYMPHITOPSYCHE	slossonae	124.00	80.00
TRICHOPTERA	SYMPHITOPSYCHE	sparna	196.00	144.00

Appendix 10. The raw macroinvertebrate count by replicate for each stream site.

C: Lye Brook 3.4

Order	Genera	Species	Count 1	Count 2
AMPHIPODA	HYALLELA	azteca	2.00	0.00
COLEOPTERA	CURCULIONIDAE	unid	1.00	0.00
COLEOPTERA	HYDROPORUS	sp	0.00	1.00
COLEOPTERA	PSEPHENUS	herricki	1.00	0.00
DECAPODA	CAMBARUS	bartoni	1.00	2.00
DIPTERA	DIAMESA	sp	1.00	2.00
DIPTERA	DICRANOTA	sp	3.00	4.00
DIPTERA	EUKIEFFERIELLA	claripennis	0.00	4.00
DIPTERA	PARACHAETOCLADIUS	sp	0.00	1.00
DIPTERA	SIMULIUM	tubersom	0.00	4.00
DIPTERA	THIENEMANNEMYIA	sp	0.00	2.00
EPHEMEROPTERA	AMELETUS	sp	1.00	34.00
GASTROPODA	PHYSIDAE	unid	1.00	0.00
HYDRACARINA	UID		1.00	0.00
OLIGOCHAETA	ENCHYTRAEIDAE	unid	0.00	3.00
PLECOPTERA	CAPNIIDAE	unid	20.00	34.00
PLECOPTERA	CHLOROPERLIDAE	unid	30.00	62.00
PLECOPTERA	LEUCTRIDAE	unid	7.00	25.00
PLECOPTERA	MALIREKUS	hastatus	10.00	8.00
PLECOPTERA	TAENIONEMA	sp	5.00	4.00
TRICHOPTERA	HELICOPSYCHE	borealis	5.00	0.00
TRICHOPTERA	OECETIS	sp	1.00	0.00
TRICHOPTERA	PALAEGAPETUS	celsus	0.00	2.00
TRICHOPTERA	PARAPSYCHE	apicalis	8.00	7.00
TRICHOPTERA	POLYCENTROPUS	sp	0.00	8.00
TRICHOPTERA	RHYACOPHILA	carolina	0.00	2.00
TRICHOPTERA	RHYACOPHILA	carpenteri	1.00	3.00
TRICHOPTERA	RHYACOPHILA	fenestra	0.00	2.00
TRICHOPTERA	RHYACOPHILA	fuscula	4.00	8.00
TRICHOPTERA	RHYACOPHILA	invaria	0.00	2.00
TRICHOPTERA	RHYACOPHILA	minora	1.00	1.00
TRICHOPTERA	RHYACOPHILA	torva	1.00	0.00
TRICHOPTERA	SYMPHITOPSYCHE	macleodi	0.00	1.00

Appendix 10. The raw macroinvertebrate count by replicate for each stream site.

D: Lye Brook 1.8

Order	Genera	Species	Count1	Count2
COLEOPTERA	OPTIOSERVUS	ovalis	3.60	1.40
COLEOPTERA	OPTIOSERVUS	trivittatus	0.00	1.40
DIPTERA	ANTOCHA	sp	0.00	1.40
DIPTERA	ATHERIX	sp	7.20	9.80
DIPTERA	BEZZIA	sp	1.80	4.20
DIPTERA	DIAMESA	sp	1.80	5.60
DIPTERA	DICRANOTA	sp	3.60	7.00
DIPTERA	EUKIEFFERIELLA	brehmi	5.40	2.80
DIPTERA	HEXATOMA	sp	7.20	7.00
DIPTERA	MICROPSECTRA	sp	9.00	4.20
DIPTERA	PARAMETRIOCNEMUS	sp	0.00	1.40
DIPTERA	POLYPEDILUM	aviceps	1.80	1.40
DIPTERA	SIMULIUM	tubersom	3.60	1.40
DIPTERA	THIENEMANNIELLA	sp	3.60	1.40
DIPTERA	TIPULA	sp	1.80	0.00
EPHEMEROPTERA	BAETIDAE	imm	30.60	46.20
EPHEMEROPTERA	BAETIS	flavistriga	9.00	16.80
EPHEMEROPTERA	BAETIS	tricaudatus	39.60	25.20
EPHEMEROPTERA	CAENIS	sp	1.80	0.00
EPHEMEROPTERA	EPEORUS	sp	1.80	9.80
EPHEMEROPTERA	EPHEMERELLIDAE	imm	3.60	5.60
PLECOPTERA	ACRONEURIA	carolinesis	1.80	0.00
PLECOPTERA	CAPNIIDAE	unid	5.40	5.60
PLECOPTERA	CHLOROPERLIDAE	unid	57.60	26.60
PLECOPTERA	ISOGENOIDES	sp	0.00	4.20
PLECOPTERA	ISOPERLA	sp	5.40	12.60
PLECOPTERA	LEUCTRIDAE	unid	14.40	2.80
PLECOPTERA	MALIREKUS	hastatus	3.60	1.40
PLECOPTERA	PELTOPERLA	sp	10.80	7.00
PLECOPTERA	UTAPERLA	sp	1.80	0.00
TRICHOPTERA	APATANIA	sp	0.00	0.00
TRICHOPTERA	DIPLECTRONA	sp	1.80	2.80
TRICHOPTERA	DOLOPHILODES	sp	147.60	67.20
TRICHOPTERA	LEPIDOSTOMA	sp	27.00	33.60
TRICHOPTERA	MICRASEMA	rusticum	0.00	8.40
TRICHOPTERA	PARAPSYCHE	apicalis	0.00	0.00
TRICHOPTERA	POLYCENTROPUS	sp	1.80	0.00
TRICHOPTERA	RHYACOPHILA	carpenteri	10.80	9.80
TRICHOPTERA	RHYACOPHILA	fenestra	3.60	1.40
TRICHOPTERA	RHYACOPHILA	fuscula	21.60	15.40
TRICHOPTERA	SYMPHITOPSYCHE	alhedra	18.00	22.40
TRICHOPTERA	SYMPHITOPSYCHE	sparna	21.60	37.80

Appendix 11. Total Lengths and Pooled Weights for Trout Species.

<table>
<tr><th>SPECIES</th><th>Bourn Brook 1.6</th><th>Bourn Brook 4.1[1]</th></tr>
<tr><td>Brook Trout</td><td>66 134
82 136
86 137
89 139
112 141
120 144
122 145
134 150 mean= 121.0mm</td><td>71 139
97 145
116 149
122 150
123 156
126 176
126
129 mean = 130.4mm</td></tr>
<tr><td>Brown Trout</td><td>225mm</td><td>192mm</td></tr>
<tr><td></td><td>Lye Brook 1.8</td><td>Lye Brook 3.4</td></tr>
<tr><td>Brook Trout</td><td>87 106 145
91 108 146
93 112 147
96 122 188
97 128 191
98 129 195
100 130 196
100 138 mean = 128.0mm</td><td></td></tr>
<tr><td>Brown Trout</td><td>109 167
146 231 mean = 163.3mm</td><td></td></tr>
</table>

1. included fish outside of sampled section

Appendix 11 (Continued).

SPECIES	Winhall River	Branch Pond Brook
Brook Trout	65 112 120 135 (624g) 69 112 120 140 97 112 121 145 101 114 123 145 104 115 125 154 110 115 127 156 111 116 128 182 112 116 130 250 mean = 124.4mm	61 153 (371g) 69 153 75 155 76 157 98 161 107 173 140 140 mean = 125.2mm
Atlantic Salmon	65 74 80 82 85 90 139 (554g) 65 74 80 82 86 91 146 66 75 80 83 86 91 146 66 75 81 83 86 92 147 67 75 81 83 86 92 152 68 75 81 83 86 92 155 69 76 81 84 87 94 155 71 76 81 84 87 95 165 71 78 82 85 88 95 71 78 82 85 88 130 73 78 82 85 88 130 73 79 82 85 90 136 74 80 82 85 90 137 74 80 82 85 90 137 grand mean = 90.2mm parr mean = 80.0mm	

Appendix 12. Total Lengths(mm.) and Pooled Weight by Species in Grams for Non-Game Species.

Blacknose Dace	35 61 64 66 70 72 76 (53g) 37 61 64 66 70 72 76 51 61 64 67 70 72 76 56 61 65 67 70 72 77 56 62 65 67 70 74 78 59 62 65 68 70 74 80 59 62 66 69 71 75 80 60 62 66 69 71 75 80 60 62 66 69 71 75 80 60 62 66 69 71 75 81 60 63 66 70 71 75 60 63 66 70 72 76 mean = 67.2mm
Longnose Dace	57 70 74 76 78 80 82 86 91 100 (596g) 59 70 74 76 78 80 82 86 92 100 60 70 74 76 79 80 82 86 93 100 61 71 75 76 79 80 82 86 93 100 62 72 75 76 79 80 83 87 94 100 63 72 75 76 79 80 84 87 95 102 64 72 75 76 79 81 84 89 95 102 65 72 75 76 79 81 85 89 95 104 65 72 75 76 79 81 85 90 95 105 65 72 75 76 79 81 85 90 95 106 66 72 75 76 80 81 85 90 95 106 69 72 75 76 80 81 85 90 95 110 70 73 75 77 80 81 85 90 96 110 70 73 75 78 80 82 86 90 96 118 70 74 75 78 80 82 86 90 96 mean = 82.5mm
Slimy Sculpin	29 35 52 60 65 66 70 72 76 86 30 35 52 60 65 66 70 72 76 30 35 55 61 65 66 70 72 76 (317g) 30 37 55 62 65 66 70 72 77 31 38 55 62 65 67 70 72 77 31 39 55 62 65 67 71 73 79 31 39 59 63 65 67 71 74 79 31 40 59 63 65 69 71 74 80 32 40 60 63 65 69 71 74 80 33 40 60 63 65 69 71 74 80 33 41 60 64 66 70 71 75 80 34 41 60 64 66 70 71 75 80 34 41 60 65 66 70 71 75 81 35 41 60 65 66 70 72 75 81 35 41 60 65 66 70 72 75 85 mean = 61.1mm
White Sucker	130 (23g)

Appendix 13. Raw Catch Data for all Sites by Electrofishing Run.

RUN NUMBER	1	2	3	TOTAL
Brook Trout				
Bourn Brook 4.1	5	2	1	8
Bourn Brook 1.6	11	5		16
Lye Brook 1.8	19	5		24
Winhall River	24	8	0	32
Branch Pond Brook	13	1		14
Brown Trout				
Bourn Brook 1.6	1	1		2
Lye Brook 1.8	2	2		4
Winhall River				
Atlantic Salmon				
Winhall River	138	24	7	169
White Sucker				
Winhall River	0	1	0	1

	1	2	3	TOTAL
Blacknose Dace				
Bourn Brook 1.6	2	1		3
Winhall River	46	14	21	81
Longnose Dace				
Winhall River	73	59	20	152
Slimy Sculpin				
Winhall River	80	35	20	135
Bourn Brook 1.6	**82**	**41**		**123**
Lye Brook 1.8	7	2		9