Fineout and Schoof's Creek Monitoring Study 2013

By Tip of the Mitt Watershed Council

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INTRODUCTION

Walloon Lake is a 4600-acre oligotrophic lake in the Northern Lower Peninsula of Michigan that drains into Lake Michigan at Little Traverse Bay via the Bear River. The Walloon Lake Association (WLA) and Walloon Lake Trust and Conservancy (WLTC) have worked for decades to protect the lake and its watershed. In 2011, WLTC contracted with Tip of the Mitt Watershed Council (TOMWC) to perform a comprehensive assessment of the watershed's largest wetland complexes and associated inlet tributaries, as well as a watershed-wide ecological evaluation of individual properties. Based on recommendations from this assessment, WLA and WLTC again contracted with TOMWC to conduct a water quality monitoring study of the two largest tributaries of Walloon Lake: Fineout Creek (also known as South Arm Creek) and Schoof's Creeks. The Fineout and Schoof's Creek Monitoring Study was carried out in 2012 and 2013. It consisted of physical, chemical, and biological water quality monitoring at multiple sites in each creek's watershed. This report provides the results of monitoring activities, a discussion of those results, and comparisons with water quality data from past studies.

Study Area

Fineout Creek is located in Evangeline and Melrose Townships of Charlevoix County at the southern tip of Walloon Lake's Foot Basin (Figure 1). The main branch flows from south to north through extensive wetland complexes, crisscrossing M75 and flowing under Shadow Trails before draining into Walloon Lake. The west branch of the creek originates in the vicinity of a small lake encircled by wetlands and flows from west to east along Fineout Road. The main branch drops over 70' throughout 3 miles of channel length, whereas the west branch drops approximately 80' over the course of 1.25 miles.

Schoof's Creek is located in Resort and Bear Creek Townships of Emmet County at the northern tip of Walloon Lake's North Arm (Figure 1). The main branch flows over 4 miles from north to south, roughly following Resort Pike to Williams Road, where it then flows southeast through a large wetland complex before draining into Walloon Lake. Another tributary of Schoof's Creek, which originates in the Little Traverse Conservancy Bubbling Spring Preserve at Intertown Road, flows approximately 2 miles before it converges with the main branch to the south of Williams Road. The main branch drop approximately 70' throughout its length.

Fineout Creek and Schoof's Creek, at 4,100 and 4,400 acres respectively, are the largest sub-watersheds of the Walloon Lake Watershed. Land cover data from 2006 show a higher percentage of both urban and agricultural land cover in the Schoof's Creek Watershed as compared to that of Fineout Creek and the larger Walloon Lake Watershed (Table 1). Fineout and Schoof's Creeks' Watersheds also possess the largest wetland complexes (Figure 1).

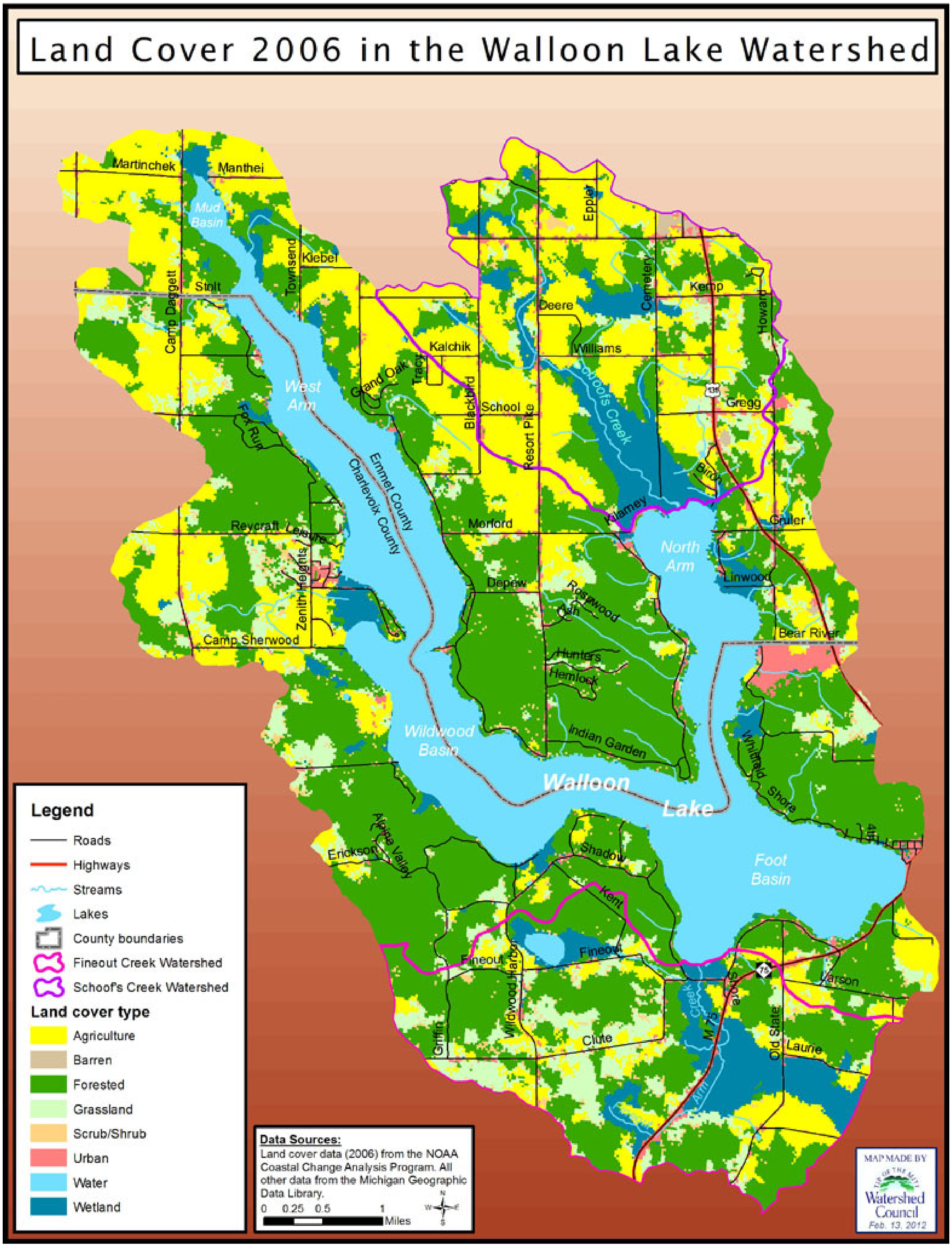

Figure 1: Land cover 2006 in the Walloon Lake Watershed.

Table 1: Fineout Creek, Schoof's Creek, and Walloon Lake Watersheds' land cover in 2006.

Land Cover Type	Fineout Creek (acres)	Fineout Creek (percent)	Schoof's Creek (acres)	Schoof's Creek (percent)	Walloon Lake (acres)	Walloon Lake (percent)
Agriculture	643	15.68	2062	46.81	5835	21.99
Barren	0	0.00	35	0.81	48	0.18
Forested	1773	43.21	1045	23.72	10468	39.46
Grassland	684	16.68	257	5.83	1975	7.44
Scrub/Shrub	137	3.33	112	2.55	620	2.34
Urban	129	3.13	235	5.33	927	3.5
Water	40	0.98	1	0.02	4699	17.71
Wetland	697	16.98	657	14.93	1958	7.38
TOTAL	4103	100.00	4404	100.00	26531	100.00

Both Fineout and Schoof's Creek are managed as cold-water trout streams by the Michigan Department of Natural Resources. As of 2012, no information was available regarding specific fish species in these streams (H. Seites-Hettinger, personal communication, 2012).

Prior Monitoring and Studies

TOMWC performed an extensive literature and data search as part of the *Walloon Lake Wetlands and Tributary Assessment* (TOMWC 2012). Relevant findings include the *Project CLEAR Technical Report* (Gold 1978) and *Project Vigilant* (Rodgers 1987).

Project CLEAR was undertaken by University of Michigan Biological Station researchers to examine nutrient management in the Walloon Lake Watershed, which included water quality monitoring for both Fineout and Schoof's Creek. The results of nutrient and chloride monitoring from Project CLEAR show levels that are within typical ranges for non-impacted, high quality streams of Northern Michigan (Table 2).

Project Vigilant was a water quality monitoring study carried out by Limno-Tech Inc., a consulting firm from Ann Arbor. Monitoring was performed near the mouths of Fineout and Schoof's Creek multiple times throughout 1986 and 1987. Averages and ranges for the parameters monitored are presented in Table 3 (complete data set available in Appendix A). Project Vigilant also included discharge (flow) measurements, which were collected multiple times during 1986 and 1987 at five locations on Schoof's Creek and two on Finout Creek. All discharge data are included in Appendix A. The Project Vigilant report indicated that the tributaries were found to have high quality water, but that phosphorus concentrations and loads increased dramatically during wet weather events. Phosphorus concentrations were found to reach levels up to ten times higher than typical for dry weather, and phosphorus loads were approximately two times higher during wet weather.

Table 2: Project CLEAR water quality data for three Walloon Lake tributaries (1977).

Stream Name	**Location**	**Date**	**TP*** *(ppb)*	**NO3-N*** *(ppb)*	**NH3-N*** *(ppb)*	**Cl*** *(ppm)*
Fineout Creek	outlet	7/7/1977	32.0	13.0	16.0	3.1
Fineout Creek	outlet	7/30/1977	21.0	42.0	27.0	4.2
Schoof's Creek	outlet	5/5/1977	6.6	ND	8.6	3.4
Schoof's Creek	outlet	7/7/1977	43.0	43.0	153.0	12.0
Skornia Creek (Lily Pad Bay)	outlet	7/7/1977	27.0	40.0	17.0	3.6

**TP=total phosphorus, NO3-N=nitrate nitrogen, NH3-N=ammonia nitrogen, Cl=chloride, ppb=parts per billion, ppm=parts per million.*

Table 3: Project Vigilant water quality data for Schoof's and Fineout Creeks (1987).

Parameter*	**Average (Schoof's[ǂ])**	**Low (Schoof's[ǂ])**	**High (Schoof's[ǂ])**	**Average (Fineout[ǂ])**	**Low (Fineout[ǂ])**	**High (Fineout[ǂ])**
TP *(ppb)*	8.2	2.9	14.6	13.4	4.6	21.8
SRP *(ppb)*	2.1	1	5.2	4	1	15.5
TKN *(ppb)*	670	420	1100	546	350	800
NH3-N *(ppb)*	400	400	400	60	60	60
NO3-N *(ppb)*	60	60	60	320	320	320
Cl *(ppm)*	7.3	5	9.3	7.3	6	9
Alk *(ppm)*	217	166	252	174	144	220
Ca *(ppm)*	69	39	83.5	55	42	64
Fecal *(#/100mL)*	0	430	95	72	0	300
Chl-a *(ppb)*	0.49	0.49	0.49	ND	ND	ND

[ǂ]Data collected from locations near the mouth of both creeks.

**TP=total phosphorus, SRP=soluble reactive phosphorus, TKN=total Kjeldahl nitrogen, NH3-N=ammonia nitrogen, NO3-N=nitrate nitrogen, Cl=chloride, Alk=alkalinity, Ca=calcium, Fecal=fecal coliforms, Chl-a=chlorophyll-a, ppb=parts per billion, ppm=parts per million, #/100mL=number of organisms per 100 mLs.*

METHODS

Physical and Chemical Monitoring

Water quality and discharge data were collected from four sites on Fineout Creek and five sites on Schoof's Creek (Figure 2). Fineout Creek sites are:

FIN001: the furthest upstream road crossing on M75 near 01658 M75,

FIN002: the furthest downstream site on M75,

FIN003: the Clute Road crossing near the intersection of Shadow Trails,

FIN004: the mouth at Walloon Lake.

Identification labels and locations for the Schoof's Creek sites are:

SHF001: the Intertown Road crossing,

SHF002: the Little Traverse Conservancy Bubbling Spring Preserve,

SHF003: the mid-stream site on Resort Pike (2939 Resort Pike),

SHF004: the Williams Road crossing,

SHF005: the mouth at Walloon Lake.

Four sites were monitored in the fall of 2012 (Williams Rd and mouth on Schoof's; M75 upstream and mouth on Fineout). The Bubbling Spring Preserve was monitored in February of 2013. Eight sites (all but Bubbling Spring) were monitored in the spring and summer of 2013. All sample events, except for the February event, occurred in wet weather conditions.

At each site, surface grab samples were collected in the middle of the stream with three separate bottles for chemical, suspended solids, and bacteriological analyses. Acid-rinsed 250 mL (milliliters) Nalgene bottles were used to collect water samples for chemical analysis and were rinsed three times with stream water (both bottle and cap) prior to collecting the sample. Clean 1000 mL Nalgene bottles were used to collect water samples for total suspended solids measurements, which were also rinsed with stream water at the site prior to collecting the water sample. Sterilized bottles acquired from the Emmet County Health Department were

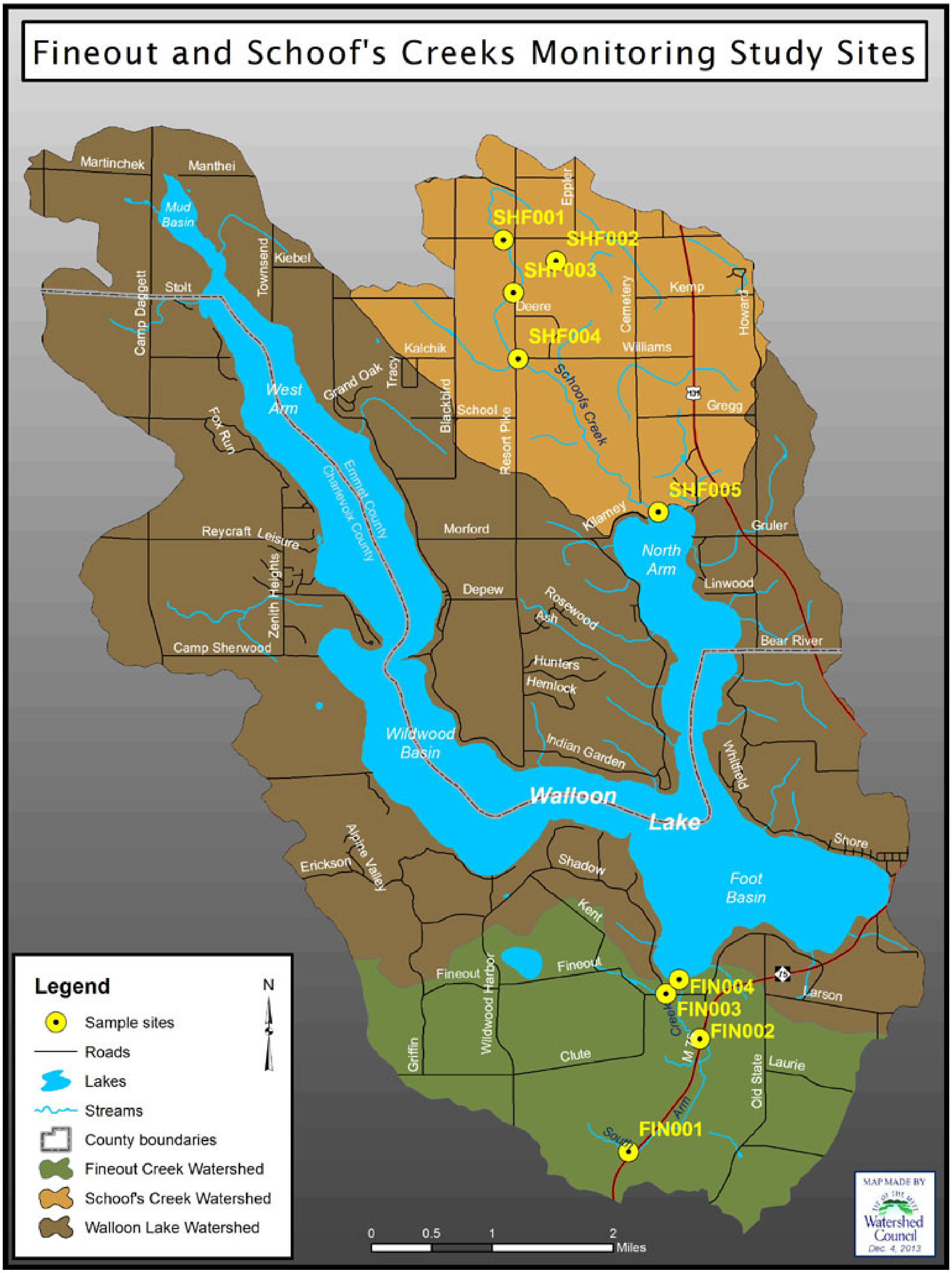

Figure 2: Fineout and Schoof's Creeks monitoring study sites.

used to collect water samples for bacteriological analysis, filling once and capping per instructions provided by the Health Department. All water samples were immediately placed in a cooler containing ice.

Water samples collected for bacteriological analysis were delivered directly to the Health Department Laboratory in Gaylord, where they were analyzed to determine the number of *Escherichia coli* (*E. coli*) per 100 mLs. Water samples collected for chemical analysis were frozen upon returning to the Watershed Council office while samples collected for total suspended solids measurements were refrigerated; both were transported to the University of Michigan Biological Station (UMBS) within a week of collecting the samples. The UMBS laboratory analyzed samples to determine concentrations of orthophosphates ($PO4^-$), total phosphorus (TP), nitrate-nitrogen ($NO3^-$), total nitrogen (TN), dissolved organic carbon (DOC), chloride (CL^-), and total suspended solids (TSS).

Physical parameters, including dissolved oxygen, specific conductivity, pH, and water temperature, were measured using a Hydrolab MiniSonde®. The MiniSonde® was calibrated prior to field work using methods detailed in the manual; dissolved oxygen was calibrated with the percent saturation method using current barometric pressure; specific conductivity was calibrated using a standard solution of 447 microSiemens/cm; and pH was calibrated using standard buffer solutions of 7 and 10 units pH. At each monitoring site the MiniSonde® was placed in the water in the middle of the stream and allowed to stabilize for several minutes before saving readings to the memory in the Surveyor4a handheld unit. Readings from the MiniSonde® were also recorded on a field datasheet. Upon returning to the office, data were transferred from the Surveyor4a to a computer and consolidated in a Microsoft Excel® workbook.

After collecting water samples and physical parameter data, stream discharge was measured at each site. The stream channel in the immediate area was examined to determine the best location for measuring discharge. The ideal area was without upstream or downstream obstructions (e.g., woody debris, aquatic plants), without undercut banks, and with at least two inches of water depth. A transect for measuring discharge was established by affixing a nylon measuring tape to stakes on each side of the stream and suspending the tape across the stream channel perpendicular to the direction of flow. A Marsh McBirney digital current meter and wading rod were used to measure flow velocity and water depth at intervals across the stream channel. Intervals across the transect were selected based on changes in depth and current velocity. Prior to recording flow velocity, the velocity sensor of the current meter was adjusted to six tenths the depth at each location across the channel. All data were recorded on a field datasheet and later entered into a Microsoft Excel® workbook.

Biological Monitoring

At all sample sites, an assessment of the aquatic macroinvertebrate community was conducted using methods from the Tip of the Mitt Volunteer Stream Monitoring Program. The mouths of both streams - Schoof's Creek at Williams Road and Fineout Creek at the M75 upstream site - were sampled in the October of 2012. The Bubbling Spring Preserve site was sampled in February of 2013 and all other sites were sampled in July of 2013.

The assessment consisted of a thorough search at each site to document the aquatic macroinvertebrate community composition, which entailed two to three hours of sampling by experienced field staff. D-frame nets were used to sample all available habitat types in a 300' stream reach, including riffles, runs, pools, stream margins, undercut banks, aquatic vegetation, overhanging vegetation, leaf packs, and cobble. Aquatic macroinvertebrate specimens representing the total diversity were preserved at the site in 70% ethanol. Specimens were identified in the laboratory to the lowest taxonomic level possibleusing microscopes and taxonomic keys (usually to the family level).

Biological data from sample sites were used to assess stream ecosystem health in terms of aquatic macroinvertebrate diversity using three biotic indices: total taxa, EPT taxa, and sensitive taxa. As implied by the name, the total taxa index is the summation of the total number of macroinvertebrate families found at a site. The EPT taxa index is the sum of taxa belonging to *Ephemeroptera*, *Plecoptera*, and *Tricoptera* (mayflies, stoneflies, and caddisflies, respectively), which are considered the most pollution-sensitive insect orders. The sensitive taxa index is the sum of taxa at the site rated as 0, 1, or 2 in Hilsenhoff's family-level biotic index, which rates aquatic macroinvertebrate sensitivity to nonpoint source pollution (Hilsenhoff 1988).

Pollutant loading calculations

Pollutant loadings were calculated for each sample event at all sites using discharge and pollutant concentration values. The total stream discharge was calculated by multiplying the width, average depth and average current velocity for each transect section, and then summing the calculated discharge of all sections. Pollutant loads were calculated by multiplying discharge (in cubic meters per second), the pollutant's measured concentration, and a conversion factor (190.48 for parameters measured in parts per million or 0.1905 for those in parts per billion).

RESULTS

Bacteria

In terms of regulation for small streams, Rule 62 (R 323.1062) of DEQ Part 4 Water Quality Standards states that "All waters of the state protected for partial body contact recreation shall not contain more than a maximum of 1000 *E. coli* per 100 mLs. Compliance shall be based on the geometric mean of 3 or more samples, taken during the same sampling event, at representative locations within a defined sampling area." Pertinent to sample sites near Walloon Lake where full-body contact does occur, Rule 62 states that "All waters of the state protected for total body contact recreation shall not contain more than 130 *Escherichia coli* (*E. coli*) per 100 mLs, as a 30-day geometric mean" and that, "At no time shall the waters of the state protected for total body contact recreation contain more than a maximum of 300 *E. coli* per 100 mLs."

Bacteriological analyses found as little as 8.6 to over 2419.6 *E. coli* bacteria per 100 mLs (Tables 4 and 5). Samples exceeded State of Michigan standards at the mouth on Fineout Creek and at all sites on Schoof's Creek except Bubbling Springs Preserve (for which there are no data). In two instances, at Intertown and Williams Roads, concentrations were above what could be quantified by the Health Department laboratory (i.e., >2419.6).

Table 4: Bacteria concentrations in Fineout Creek.

Site ID	Location	Date	*E. coli**
FIN001	M75 Upstream	10/16/2012	8.6
FIN001	M75 Upstream	5/21/2013	95.9
FIN001	M75 Upstream	7/8/2013	365.4
FIN002	M75 Downstream	5/21/2013	435.2
FIN002	M75 Downstream	7/8/2013	307.6
FIN003	Clute Road	5/21/2013	579.4
FIN003	Clute Road	7/8/2013	307.6
FIN004	Mouth	10/16/2012	816.4
FIN004	Mouth	5/21/2013	1986.3†
FIN004	Mouth	7/8/2013	1299.7†

**Reported in units of E. coli bacteria per 100 mLs.*
†Exceeding State of Michigan water quality standards.

Table 5: Bacteria concentrations in Schoof's Creek.

Site ID	Location	Date	*E. coli**
SHF001	Intertown Rd	5/21/2013	135.4
SHF001	Intertown Rd	7/8/2013	>2419.6†
SHF002	Bubbling Spring	2/16/2013	No data
SHF003	Resort Pike	5/21/2013	167.0
SHF003	Resort Pike	7/8/2013	1553.1†
SHF004	Williams Rd	10/17/2012	248.1
SHF004	Williams Rd	5/21/2013	613.1
SHF004	Williams Rd	7/8/2013	>2416.6†
SHF005	Mouth	10/17/2012	101.7
SHF005	Mouth	5/21/2013	1299.7†
SHF005	Mouth	7/8/2013	1046.2†

**Reported in units of E. coli bacteria per 100 mLs.*

†Exceeding State of Michigan water quality standards.

Nutrients

Total phosphorus, which is a measure of all phosphorus types in the water sample, was found in low concentrations in the Fineout and Schoof's Creeks; all readings were less than 30 µg/L (micrograms per liter or parts per billion) and nearly half were less than 10 µg/L (Table 6 and 7). The highest total phosphorus concentrations occurred at the downstream site of M75 on Fineout Creek and at the Resort Pike site on Schoof's Creek. Soluble reactive phosphorus, the portion of total phosphorus that is readily available for uptake by algae and higher aquatic plants, was found on average to be 44% of the total phosphorus in Fineout Creek and 51% in Schoof's Creek.

DEQ Part 4 Water Quality Standards do not include a numerical standard for nutrient concentration limits for surface waters. Regulation for surface waters is limited to the following narrative standard from Rule 60 (323.1060): "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi or bacteria which are or may become injurious to the designated uses of the waters of the state." A total phosphorus concentration of 12 µg/L or less for streams in the Northern Michigan ecoregion is considered the reference condition by the United States Environmental Protection Agency (USEPA) "because it is likely associated with minimally impacted conditions, will be protective of designated uses, and provides management flexibility" (USEPA, 2001). Total phosphorus concentrations were found in excess of the 12 µg/L reference condition six times on Fineout Creek and five times on Schoof's Creek.

Table 6: Nutrient concentrations in Fineout Creek.

Site ID	Location	Date	SRP*	TP*	NO3-N*	TN*	DOC*
FIN001	M75 Upstream	10/16/2012	2.6	5.1	181	393	7.20
FIN001	M75 Upstream	5/21/2013	1.6	4.7	64	337	12.21
FIN001	M75 Upstream	7/8/2013	3.0	4.5	154	340	5.14
FIN002	M75 Downstream	5/21/2013	1.3	7.7	3	390	16.95
FIN002	M75 Downstream	7/8/2013	16.4	26.1	8	400	12.78
FIN003	Clute Road	5/21/2013	2.9	13.1	15	479	18.32
FIN003	Clute Road	7/8/2013	5.2	7.4	46	197	5.11
FIN004	Mouth	10/16/2012	5.9	18.0	1	410	16.40
FIN004	Mouth	5/21/2013	2.6	14.0	5	449	12.21
FIN004	Mouth	7/8/2013	13.7	21.1	92	464	10.11
Average	Mouth		7.4	17.7	33	441	12.91
Average	All sites		5.5	12.2	57	386	11.64

**SRP=soluble reactive phosphorus, TP=total phosphorus, NO3-N=nitrate nitrogen, TN=total nitrogen, DOC=dissolved organic carbon. All data reported in µg/L (micrograms per liter or parts per billion).*

Table 7: Nutrient concentrations in Schoof's Creek.

Site ID	Location	Date	SRP*	TP*	NO3-N*	TN*	DOC*
SHF001	Intertown Rd	5/21/2013	2.5	14.3	88	531	10.46
SHF001	Intertown Rd	7/8/2013	7.4	11.4	488	776	8.22
SHF002	Bubbling Spring	2/16/2013	1.4	18.1	2119	2816	1.06
SHF003	Resort Pike	5/21/2013	15.2	24.5	353	732	10.46
SHF003	Resort Pike	7/8/2013	20.3	23.5	390	690	8.91
SHF004	Williams Rd	10/17/2012	6.2	8.3	1156	1482	7.10
SHF004	Williams Rd	5/21/2013	3.9	14.2	478	822	10.08
SHF004	Williams Rd	7/8/2013	6.6	8.0	1879	2390	4.36
SHF005	Mouth	10/17/2012	4.0	9.9	272	703	10.30
SHF005	Mouth	5/21/2013	1.8	7.7	681	1018	5.67
SHF005	Mouth	7/8/2013	7.5	9.6	1315	1652	4.70
Average	Mouth		4.4	9.1	756	1124	6.89
Average	All sites		7.0	13.6	838	982	7.39

**SRP=soluble reactive phosphorus, TP=total phosphorus, NO3-N=nitrate nitrogen, TN=total nitrogen, DOC=dissolved organic carbon. All data reported in µg/L (micrograms per liter or parts per billion).*

Total nitrogen is a measure of all nitrogen types in a water sample. The USEPA total nitrogen reference condition of 440 ppb for minimally impacted conditions for Northern Michigan streams was exceeded in five samples (USEPA, 2001). Total nitrogen concentrations were less than 500 µg/L in Fineout Creek, whereas concentrations in Schoof's Creek reached 2816 µg/L (Table 6 and 7). The highest total nitrogen concentrations were found on Schoof's Creek at the Bubbling Spring Preserve and at Williams Road. Nitrate-nitrogen is the water soluble form that is readily available for uptake by plants, which, on average, accounted for 16.1% of total nitrogen in Fineout Creek and 60% in Schoof's Creek.

Organic matter in lakes and streams originating from sources throughout the watershed can be measured by analyzing water samples for dissolved organic carbon (DOC). DOC concentrations in streams range from less than one to 50 mg/L (Mulholland, 2003) and from studies of other Midwest streams have been found in the range of 1-18 mg/L (Royer and David 2003, and Volk et. al 2002). DOC concentrations documented at all sites in this study fell within this range (Tables 6 and 7).

Chloride, Conductivity, and Total Solids

Chloride, a component of salt, is naturally present at low levels in Northern Michigan surface waters due to the marine origin of the underlying bedrock (typically < 5 mg/L). Although Michigan has not set limits for chloride in surface waters, the USEPA recommends that 230 mg/L be established for chronic toxicity and 860 mg/L for acute toxicity (USEPA, 2012). Although current chloride levels in Northern Michigan are generally far below the USEPA toxicity thresholds, increases are indicative of other pollutants reaching our waterways (e.g., automotive fluids from roads; nutrients/bacteria from septic systems). Chloride concentrations in Fineout and Schoof's Creek were well below toxicity thresholds recommended by the USEPA. The range of chloride concentrations was similar in both creeks, though on average higher in Schoof's Creek (Table 8).

Conductivity is a measure of the ability of water to conduct an electric current resulting from the concentration of charged particles (ions) dissolved in the water. Conductivity is not addressed in

DEQ Part 4 Water Quality Standards, though Rule 51 (323.1051) provides a framework for regulating total dissolved solid (TDS) concentrations from point source discharge. TDS in mg/L can be estimated from specific conductivity readings by using the widely applied multiplication factor of 0.67. Estimated TDS concentrations for conductivity measurements from all sites on Fineout and Schoof's Creeks were below the Rule 51 TDS maximum of 750 mg/L. On average, conductivity readings were highest on Schoof's Creek (Table 8).

Total suspended solids is a measure of the amount of sediment and other particles in water bodies, which is done by filtering, drying, and weighing the particles in a given volume of water. State of Michigan water quality standards do not have numerical limits for suspended solids, but rather a narrative standard that states "that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits." Water is generally considered to be clear when total suspended solids measure 20 mg/L or less, cloudy between 40 and 80 mg/L, and dirty when over 150 mg/L. Most of the total suspended solid measurements from Fineout and Schoof's Creeks were less than 20 mg/L, indicating clear water (Table 8). There were three readings on Schoof's Creek above 40 mg/L, but none above 150 mg/L.

Table 8: Chloride, conductivity, and total solids in Fineout Creek.

Site ID	Location	Date	Chloride*	Conductivity*	Total Dissolved Solids*	Total Suspended Solids*
FIN001	M75 Upstream	10/16/2012	11.0	311.0	208.4	1.0
FIN001	M75 Upstream	5/21/2013	11.1	269.0	180.3	8.4
FIN001	M75 Upstream	7/8/2013	30.0	468.2	313.7	18.2
FIN002	M75 Downstream	5/21/2013	13.8	268.8	180.1	1.3
FIN002	M75 Downstream	7/8/2013	17.1	521.8	349.6	3.2
FIN003	Clute Road	5/21/2013	4.5	202.0	135.3	10.3
FIN003	Clute Road	7/8/2013	26.9	341.8	229.0	27.1
FIN004	Mouth	10/16/2012	13.0	227.0	152.1	1.2
FIN004	Mouth	5/21/2013	13.4	267.3	179.1	3.9
FIN004	Mouth	7/8/2013	24.8	480.6	322.0	2.8
Average	Mouth		17.1	325.0	217.7	2.6
Average	All sites		16.6	335.7	225.0	7.7

**Chloride, total dissolved solids, and total suspended solids reported in mg/L (milligrams per liter or parts per million), conductivity in microsiemens. Total dissolved solids estimated from conductivity using coefficient of 0.67.*

Table 9: Chloride, conductivity, and total solids in Schoof's Creek.

Site ID	Location	Date	Chloride*	Conductivity*	Total Dissolved Solids*	Total Suspended Solids*
SHF001	Intertown Rd	5/21/2013	7.4	363.0	243.2	2.4
SHF001	Intertown Rd	7/8/2013	33.5	666.0	446.2	55.7
SHF002	Bubbling Spring	2/16/2013	20.2	475.0	No data	No data
SHF003	Resort Pike	5/21/2013	27.4	470.8	315.4	2.4
SHF003	Resort Pike	7/8/2013	41.8	700.1	469.0	44.9
SHF004	Williams Rd	10/17/2012	27.0	506.5	339.4	4.0
SHF004	Williams Rd	5/21/2013	24.3	456.7	306.0	29.5
SHF004	Williams Rd	7/8/2013	23.9	630.0	422.1	101.9
SHF005	Mouth	10/17/2012	8.7	325.5	218.1	1.0
SHF005	Mouth	5/21/2013	13.5	388.8	260.5	2.3
SHF005	Mouth	7/8/2013	24.6	547.5	366.8	4.1
Average	Mouth		15.6	420.6	281.8	2.5
Average	All sites		22.9	502.7	338.7	24.8

**Chloride, total dissolved solids, and total suspended solids reported in mg/L (milligrams per liter or parts per million), conductivity in microsiemens. Total dissolved solids estimated from conductivity using coefficient of 0.67.*

Dissolved Oxygen, Temperature, and pH

Dissolved oxygen concentrations in the Fineout and Schoof's Creeks ranged from 0.15 to 13.05 mg/L (Table 10 and 11). The DEQ Part 4 Water Quality Standards minimum dissolved oxygen concentration for sustaining a cold-water fishery is 7 mg/L. Levels were below the 7 mg/L standard on five occasions on Fineout Creek and three times on Schoof's Creek.

Water temperatures ranged from 7.18° to 21.26° Celsius and were, on average, higher in Fineout Creek (Table 10 and 11). According to DEQ Part 4 Water Quality Standards, monthly maximum temperatures for streams supporting cold-water fish are set at 65° Fahrenheit (18.3° Celsius) for May, 68° Fahrenheit (20.0° Celsius) for July, and 56° Fahrenheit (13.3° Celsius) for October. Water temperatures exceeded State Water Quality Standards at two sites on Fineout Creek and at one site on Schoof's Creek.

Hydrogen ion concentration, expressed as pH, ranged from 7.47 to 8.21 in Fineout and Schoof's Creeks (Table 10 and 11). All pH readings fell within the range of 6.5 to 9.0 required for all Michigan surface waters according to DEQ Part 4 Water Quality Standards, Rule 53 (323.1053).

Table 10: Dissolved oxygen, temperature, and pH in Fineout Creek.

Site ID	Location	Date	Dissolved Oxygen*	Temperature*	pH*
FIN001	M75 Upstream	10/16/2012	9.54	8.71	7.84
FIN001	M75 Upstream	5/21/2013	7.41	13.13	7.77
FIN001	M75 Upstream	7/8/2013	8.17	14.86	8.05
FIN002	M75 Downstream	5/21/2013	4.57†	18.95†	7.52
FIN002	M75 Downstream	7/8/2013	0.15†	20.89†	7.47
FIN003	Clute Road	5/21/2013	7.32	18.08	7.73
FIN003	Clute Road	7/8/2013	8.26	18.75	8.21
FIN004	Mouth	10/16/2012	6.28†	7.18	7.76
FIN004	Mouth	5/21/2013	5.42†	20.31†	7.77
FIN004	Mouth	7/8/2013	4.03†	19.93	7.79
Average	All sites		6.11	16.08	7.79

**Temperature in °Celsius, dissolved oxygen in mg/L or parts per million.*
† Non-conforming with State of Michigan water quality standards.

Table 11: Dissolved oxygen, temperature, and pH in Schoof's Creek.

Site ID	Location	Date	Dissolved Oxygen*	Temperature*	pH*
SHF001	Intertown Rd	5/21/2013	9.93	7.82	8.09
SHF001	Intertown Rd	7/8/2013	5.94†	16.77	7.64
SHF002	Bubbling Spring	2/16/2013	13.05	8.91	8.09
SHF003	Resort Pike	5/21/2013	9.11	8.84	8.13
SHF003	Resort Pike	7/8/2013	6.02†	16.91	7.89
SHF004	Williams Rd	10/17/2012	9.20	7.72	7.75
SHF004	Williams Rd	5/21/2013	9.06	8.75	8.10
SHF004	Williams Rd	7/8/2013	7.75	15.49	7.96
SHF005	Mouth	10/17/2012	9.10	8.16	7.70
SHF005	Mouth	5/21/2013	9.80	9.69	8.20
SHF005	Mouth	7/8/2013	5.99†	21.26†	7.91
Average	All sites		8.63	11.85	7.95

**Temperature in °Celsius, dissolved oxygen in mg/L or parts per million.*
† Non-conforming with State of Michigan water quality standards.

Discharge and Loads

Discharge was accurately measured at the mouths of the creeks during two monitoring events. Based on the average of the two discharge measurements, Fineout Creek discharged 8.21 cubic feet per second (cfs) into Walloon Lake while Schoof's Creek discharged 16.98 cfs (Table 12 and 13). As would be expected, discharge generally increased in a downstream direction, though there was a slight (<0.05 cfs) decrease between upstream and downstream sites on three occasions.

Total phosphorus loads coming into Walloon Lake at the mouths of Fineout and Schoof's Creeks were approximately the same, whereas nitrogen loads were much higher in Schoof's Creek (Table 12 and 13). Nutrient loads increased steadily from upstream to downstream during all sample events on Fineout Creek. In Schoof's Creek, there were instances where phosphorus or nitrogen loads decreased between sites in a downstream direction.

The total suspended solid loads discharged into Walloon Lake at the creek mouths were on average higher from Schoof's than Fineout (Table 12 and 13). There was considerable variability in terms of suspended solid load accrual or loss between sites in a downstream direction.

Table 12: Discharge and loads from Fineout Creek.

Site ID	Location	Date	Discharge* (cfs)	TP Load* (lbs/day)	TN Load* (lbs/day)	TSS Load* (lbs/day)
FIN001	M75 Upstream	10/16/2012	0.4889	0.013	1.04	2.64
FIN001	M75 Upstream	5/21/2013	1.7107	0.043	3.11	77.51
FIN001	M75 Upstream	7/8/2013	0.8432	0.020	1.55	82.78
FIN002	M75 Downstream	5/21/2013	8.9210	0.371	18.77	62.55
FIN002	M75 Downstream	7/8/2013	0.7983	0.112	1.72	13.78
FIN003	Clute Road	5/21/2013	0.9954	0.070	2.57	55.27
FIN003	Clute Road	7/8/2013	0.3591	0.014	0.38	52.49
FIN004	Mouth	10/16/2012	5.3261	0.517	11.78	34.47
FIN004	Mouth	5/21/2013	11.0984	0.838	26.88	233.46
FIN004	Mouth	7/8/2013	1.4703	0.167	3.68	22.21
Average	Mouth (all events)		5.96	0.51	14.11	96.71
Average	Mouth (1st two events)†		8.21	0.68	19.33	133.97

**cfs=cubic feet per second, TP=total phosphorus, TN=total nitrogen, TSS=total suspended solids.*
†Averaged for first two events to facilitate comparisons with Schoof's Creek.

Table 13: Discharge and loads from Schoof's Creek.

Site ID	Location	Date	Discharge* (cfs)	TP Load* (lbs/day)	TN Load* (lbs/day)	TSS Load* (lbs/day)
SHF001	Intertown Rd	5/21/2013	1.7173	0.132	4.92	22.23
SHF001	Intertown Rd	7/8/2013	0.0252	0.002	0.11	7.56
SHF002	Bubbling Spring	2/16/2013	0.0447	0.004	0.68	No data
SHF003	Resort Pike	5/21/2013	3.7483	0.495	14.80	48.52
SHF003	Resort Pike	7/8/2013	0.1033	0.013	0.38	25.01
SHF004	Williams Rd	10/17/2012	1.1303	0.051	9.04	24.39
SHF004	Williams Rd	5/21/2013	3.7108	0.284	16.45	590.46
SHF004	Williams Rd	7/8/2013	0.5886	0.025	7.59	323.49
SHF005	Mouth	10/17/2012	10.2701	0.548	38.94	55.39
SHF005	Mouth	5/21/2013	23.6910	0.984	130.08	293.90
SHF005	Mouth	7/8/2013	ND†	ND†	ND†	ND†
Average	At mouth		16.98	0.77	84.51	174.65

**cfs=cubic feet per second, TP=total phosphorus, TN=total nitrogen, TSS=total suspended solids, ND=no data.*
†Due to slow flow and south wind pushing lake water into creek mouth, flow velocities were undetectable at most stations and therefore, discharge and loading data considered invalid.

Aquatic Macroinvertebrates

In general, the total diversity of the aquatic macroinvertebrate community in Fineout Creek increased in a downstream direction while sensitive taxa diversity decreased. In Fineout Creek, 28 taxa were found at the mouth and only 18 found at the upstream site on M75 (Table 14). Conversely, EPT and sensitive taxa were much higher upstream than at the mouth. Only two EPT taxa and no sensitive taxa were found where a small tributary stream crosses M75 and flows into Fineout Creek between upstream and downstream sites on M75.

Biological data from Schoof's Creek also show an increase in total diversity moving downstream, with less than 20 taxa found at the headwater sites (i.e., Bubbling Spring Preserve and Intertown Road) while over 20 taxa were found at the downstream sites (Table 15). Sensitive taxa were found in higher numbers in the headwaters than at the mouth. However, both EPT and sensitive taxa diversity were found to be as high or higher at Williams Road than at upstream sites.

Table 14: Aquatic macroinvertebrate data from Fineout Creek.

Sample Site	Date	Total Taxa	EPT Taxa	Sensitive Taxa
M75, upstream	10/17/2012	18	9	4
M75, midstream tributary†	7/1/2013	21	2	0
Clute Road	7/1/2013	19	6	3
Mouth	10/17/2012	28	3	1

**Total Taxa=total number of taxa found at the site, EPT Taxa=number of taxa found at site belonging to Ephemeroptera, Plecoptera, and Trichoptera insect orders; Sensitive Taxa=number of taxa rated as 0, 1, or 2 in Hilsenhoff's family-level biotic index.*

†the midstream tributary on M75 was mistakenly sampled on 7/1/2013 instead of the downstream M75 site, so there is no biological data for the latter.

Table 15: Aquatic macroinvertebrate data from Schoof's Creek.

Sample Site	Date	Total Taxa	EPT Taxa	Sensitive Taxa
Bubbling Spring Preserve	2/16/2013	13	8	5
Intertown Rd	6/11/2013	17	3	2
Resort Pike	6/11/2013	23	7	2
Williams Rd	10/17/2012	25	9	5
Mouth, Walloon Lake	10/17/2012	23	4	1

**Total Taxa=total number of taxa found at the site, EPT Taxa=number of taxa found at site belonging to Ephemeroptera, Plecoptera, and Trichoptera insect orders; Sensitive Taxa=number of taxa rated as 0, 1, or 2 in Hilsenhoff's family-level biotic index.*

DISCUSSION

Bacteria

E. coli is a species of fecal coliform bacteria that is specific to fecal material from humans and other warm-blooded animals. *E. coli* is commonly used to monitor surface waters because it is considered a good indicator of health risk from body contact in recreational waters.

Bacteria concentrations exceeded State of Michigan partial-body contact limits (1000 *E. coli* per 100 mLs) at four sites on Schoof's Creek during the July 8, 2013 sample event. Although field notes indicate that it did rain during the morning, discharge measurements at all sites on Schoof's Creek on July 8th were lower than during other sample periods. There are a variety of circumstances that could explain the high concentrations throughout the stream system on July 8th. The most probable explanations are: 1) the July 8th sampling event captured high bacteria concentrations associated with the first flush of a storm event; 2) elevated bacteria concentrations typical during base-flow were diluted during the other sampling events; or 3) the high bacteria concentrations were caused by poor waste management practices (e.g., manure spilling from a storage lagoon, manure washing directly into the creek, or livestock being allowed access to the creek).

The longitudinal patterns in bacteria concentrations from headwater sites to the creek mouths was probably the result of seasonal differences in water temperature. Research shows that water temperature may be the most important factor in in predicting fecal coliform survival and that survival of E. coli is negatively correlated with increasing water temperature (Faust et al, 1975). This provides an explanation for the steady increase in E. coli concentrations in a downstream direction in both creeks during the cool weather of May, as compared to the decreases that occurred between some sample sites during the warmer summer weather of July.

Five of the six samples collected at the mouths of the two creeks exceeded State of Michigan full-body contact limits (300 *E. coli* per 100 mLs). Although the samples were collected at stream sites regulated for partial-body contact limits, there are potential threats to public health due to the proximity of the sample sites to swimming areas in the receiving waters of Walloon Lake.

Nutrients

Nutrients are necessary to sustain a healthy aquatic ecosystem. However, elevated levels, particularly phosphorus, can result in problematic algae and plant growth. An increase in algal blooms has the potential to become a recreational nuisance due to algal mats and scum that form on the lake's surface. Additionally, some species produce toxins that can threaten public health, including hepatotoxins (toxins that cause liver damage) and neurotoxins (toxins that affect the nervous system). Increased abundance of aquatic macrophytes (higher or vascular plants) can become a nuisance to recreation in shallow areas (typically less than 20 feet of depth). In addition, excess growth of both macrophytes and algae has the potential to degrade water quality by depleting the ecosystem's dissolved oxygen stores. Plants compete with other organisms for a limited oxygen supply during nighttime respiration and, furthermore, the decomposition of dead algae and plant material has the potential to deplete dissolved oxygen supplies due to the aerobic activity of decomposers, particularly in the deeper waters of stratified lakes.

Total phosphorus increased in a downstream direction in Fineout Creek, though concentrations remained relatively low at the mouth (<=21 ug/l, Table 6). The increase was probably a result of allochthonous inputs as opposed to anthropogenic sources considering the sparse residential/urban and limited agricultural land cover in the watershed (Table 1). Uptake by soils and plants in the expansive wetlands buffer between agricultural or residential/urban areas and the creek probably contributed to the relatively low phosphorus concentrations in the creek (Figure 1).

Phosphorus concentrations increased between the first two sites in Schoof's Creek (from Intertown Road to Resort Pike) and then decreased markedly downstream of Resort Pike (Table 7). Total phosphorus loads also decreased during one sample event between Resort Pike and Williams Road (Table 13). The observed decreases in phosphorus could be the result of uptake by algae and higher aquatic plants living in the creeks since phosphorus was consistently found to be the limiting nutrient (N:P ratio > 16:1).

Phosphorus concentrations at the mouths of both streams varied little from findings in the 1987 Project Vigilant study (Tables 3, 6, and 7) and were slightly lower than values reported in the 1977 Project Clear data. Relative to Tip of the Mitt Watershed Council's Comprehensive Water Quality Monitoring (CWQM) program river data, phosphorus concentrations in the creeks were high. However, this was not surprising as a number of the rivers monitored in the CWQM program drain large oligotrophic lakes that naturally possess low nutrient levels (Table 16). Considering total phosphorus concentrations at the creek mouths were within or just slightly above the range of what has been found in the largely nutrient-poor rivers monitored in the CWQM program, it is unlikely that phosphorus from the creeks will negatively impact the lake ecosystem.

Table 16: Nutrient, chloride, and conductivity data from the CWQM program.

WATER BODIES	TP*	$NO3^{-}$*†	TN*†	CL^{-} *	SpCond*
All rivers – Low	1.0	8	202	2.9	222
All rivers – High	16.2	390	626	14.5	405
All rivers – Average	5.2	164	356	9.1	301
Walloon North Arm – Low	2.2	90	252	6.5	266
Walloon North Arm – High	15.3	329	700	17.1	326
Walloon North Arm – Average	7.2	243	504	11.0	292
Walloon Foot Basin – Low	1.0	67	195	5.4	241
Walloon Foot Basin – High	9.0	125	450	13.7	295
Walloon Foot Basin – Average	4.9	94	342	9.3	265

**TP = total phosphorus, $NO3^{-}$ = nitrate-nitrogen, TN = total nitrogen, CL^{-} = chloride, SpCond = specific conductivity. Chloride reported in mg/L (parts per million), specific conductivity in microsiemens per centimeter^2, all other units in ug/l (parts per billion).*

†Rivers data do not include NO3- and TN data from the Jordan River due to atypically high levels (>1000 ug/l) suspected of being associated with agriculture.

Total nitrogen concentrations increased in Fineout Creek between the headwaters at the M75 upstream site and the mouth, whereas nitrate-nitrogen decreased (Table 6). The extensive riparian wetland complexes between these sites offer a plausible explanation for these changes in nitrogen levels. Wetlands effectively remove nitrate-nitrogen through the denitrification process, but yet have the potential to increase organic nitrogen and thus, total nitrogen levels, through allochthonous inputs (i.e. inputs of leaves, branches and other plant matter). However, agricultural and residential land use in the watershed could also contribute to in-stream nutrient enrichment (Figure 1). Data also indicate that nitrogen concentrations at the mouth were likely influenced by inputs from the west branch on Clute Road.

Nitrogen concentrations generally increased in a downstream direction in Schoof's Creek, though levels decreased between Williams Road and the mouth on two occasions (Table 7). Total nitrogen loads increased consistently moving downstream (Table 13). The increase in both nitrate-nitrogen and total nitrogen concentrations was most pronounced between the sites on Resort Pike and Williams Road, which indicates that nutrient pollution is likely occurring somewhere in this stretch. Agricultural operations in this section are suspected of contributing to elevated nitrogen levels, though residential development along Resort Pike could also be a source (Figure 1). The decreases noted between Williams Road and the mouth are probably the result of uptake, settling, and denitrification in the large wetland complex buffering both sides of the creek throughout this section.

Comparisons of nitrogen between the current and historic studies were problematic due to different forms measured and the number of measurements made for some forms. Total Kjedahl nitrogen was measured in the Project Vigilant study while total nitrogen was measured in this study. Total nitrogen varies from total Kjeldahl nitrogen in that Kjedahl does not include the nitrate and nitrite forms of nitrogen. Nitrate concentrations were measured for just a few samples from the Project Vigilant study. A comparison of the sum of total Kjedahl nitrogen and nitrate-nitrogen from the Project Vigilant study with total nitrogen from the current study shows that levels were higher in Fineout Creek and lower in Schoof's Creek in 1987 (Tables 3, 6, and 7).

Total nitrogen levels in Schoof's Creek were found to be much higher than what is typically found in rivers of Northern Michigan (Table 16). Similar to the Jordan River, agricultural activity in the watershed is suspected of contributing to the high nitrogen concentrations that were found in this study (see footnote under Table 16). Furthermore, the apparent nutrient pollution occurring in the Schoof's Creek Watershed may be contributing to the abnormally high nitrogen concentrations found in the open water of the North Arm of Walloon Lake (Table 16).

Dissolved organic carbon (DOC) is influenced by wetlands in that research has shown that in-stream DOC concentrations increase as the amount of wetlands increase (Echardt and Moore 1990). Although the percentage difference was small (~2%), the higher DOC concentrations in Fineout Creek as compared to Schoof's Creek may be indicative of the greater percentage of wetlands in the Fineout Creek Watershed (Table 1).

Chloride and Conductivity

Chloride is an excellent indicator of human disturbance in a watershed because many products associated with human activities contain chloride (e.g., de-icing salts, water softener salts, fertilizers, and bleach) and it is a "mobile ion," meaning it is not removed by chemical or biological processes in soil or water. Research by Herlihy et al. (1998) found that "chloride concentration is a good surrogate indicator for general human disturbance in the watershed". Research shows that conductivity is also a good indicator of human impacts on aquatic ecosystems because levels usually increase as urbanization of a watershed increases (Jones and Clark 1987, Lenat and Crawford 1992). Chloride is related to conductivity in that it is a major inorganic anion in water.

The majority of the chloride and conductivity data from Fineout Creek show typical levels for streams in this region, though elevated concentrations were found on a handful of occasions (Tables 8 and 16). Chloride and conductivity levels were higher in Schoof's Creek than in Fineout and higher than what is typical for the region's streams (Tables 9 and 16), which is likely due to the extensive agricultural land use in the watershed. Land cover data from 2006 show higher percentages of both agriculture and urban/residential in the Schoof's Creek Watershed as compared to Fineout Creek, as well as the greater Walloon Lake Watershed (Table 1).

Relatively high chloride and conductivity levels were found throughout Fineout and Schoof's Creeks during the July 8th monitoring event (Table 8 and 9). Similar to inferences made regarding bacteriological results, the high levels recorded on July 8th may indicate that sampling captured higher concentrations of pollutants associated with the first flush following a rain event. Although there are many potential sources of chlorides and other charged particles contributing to the elevated conductivity levels, residual de-icing salts in roadside ditches are suspected.

Differing from nutrient trends in Schoof's Creek, chloride and conductivity levels increased between the most upstream site at Intertown Road and the next site down at Resort Pike, followed by steady decreases to the mouth. Considering that chloride is a mobile ion and therefore, not removed by biological or chemical processes in water, the reductions that occurred between Resort Pike and the mouth may be the result of dilution resulting from surface and groundwater accrual. However, the extensive wetland complexes in the riparian areas of these lower sections also serve as a sink for salts.

Chloride concentrations were much higher in the current study compared with data from the 1977 Project Clear and 1987 Project Vigilant studies (Tables 2, 3, 8, and 9). In addition, averaged data show that chloride concentrations at the mouths of both creeks were higher than those documented in the open water of Walloon Lake and the CWQM rivers (Table 16). However, chloride concentrations were far below levels that adversely impact aquatic life.

Dissolved Oxygen, Temperature, pH, and Total Suspended Solids

Dissolved oxygen, temperature, and pH are very influential parameters in terms of a stream's water quality. Low dissolved oxygen levels, high water temperatures, or highly acidic or alkaline waters can rapidly degrade a stream ecosystem. Results show that pH levels at all sites in both tributaries were in an acceptable range typical of Northern Michigan streams. Dissolved oxygen and temperature data, however, show that the streams may not be attaining standards required to maintain healthy cold-water fisheries.

Dissolved oxygen and temperature monitoring results indicate that much of the main branch of Fineout Creek may not be attaining State of Michigan water quality standards. Dissolved oxygen concentrations were low at the M75 downstream and mouth sites during all sample events, and water temperatures were high during most events. The elevated temperatures and low oxygen levels are probably a result of the creek meandering through vast wetland complexes throughout much of its length. Sluggish flow resulting from the flat terrain, lack of shading and subsequent exposure of much of the water surface to direct sunlight, as well as allochthonous inputs from riparian vegetation all contribute to high water temperatures and low oxygen levels. Although perhaps due to natural conditions, the data indicate that only the west branch of Fineout Creek and the most upstream areas of the main branch may be capable of supporting a cold-water fishery throughout the year.

Dissolved oxygen and water temperature data indicate that large stretches of Schoof's Creek may not be attaining State of Michigan water quality standards during the warm summer months. Data show that dissolved oxygen concentrations were lower than state standards at all sites but Williams Road during the July monitoring event. Similar to Fineout Creek, sections of Schoof's Creek may not be capable of sustaining a cold-water fishery, at least during portions of the year.

Sediments in surface waters can have a variety of negative impacts on aquatic ecosystems. Large amounts of sediment in water can degrade aquatic habitat, interfere with navigation, harm aquatic life, and impair water quality. Sediments are commonly measured in terms of total suspended solids and total dissolve solids. Suspended and dissolved solids were generally found to be low in Fineout and Schoof's Creeks. Total solids were higher in Schoof's Creek than Fineout Creek and, similar to findings regarding other parameters in this study, the elevated solids concentrations mostly occurred during the July 8th sampling event (Tables 8 and 9). However, concentrations never reached what is considered to give the water a "dirty" appearance (>150 mg/L) by State of Michigan water quality standards.

Total suspended solids loads were higher on average in Fineout Creek than Schoof's Creek in spite of higher water discharge rates from Schoof's. This could be due to greater sediment inputs in Fineout Creek or high rates of solids settling in the lower section of Schoof's Creek. The limited dataset of just two observations should also be considered.

Biological Assessment

Biological data from the M75 upstream and Clute Road sites of Fineout Creek show a diverse aquatic macroinvertebrate community indicative of a healthy stream ecosystem. Taxa diversity at these sites was comparable to high quality trout streams, such as the Boyne and Maple Rivers, that are monitored as part of the Tip of the Mitt Volunteer Stream Monitoring Program (Table 17). While still possessing high total diversity, the midstream M75 and mouth sites had considerably less EPT taxa diversity and little to no sensitive taxa diversity (Table 14). The low sensitive taxa diversity is typical for stream sites like these where slow flow slow through large wetland complexes results in higher water temperatures, lower dissolved oxygen concentrations and less habitat variability. Unfortunately, there are no historical biological data for making examining changes over time.

Table 17: Data from the Tip of the Mitt Volunteer Stream Monitoring program, 2005 to 2012.

Stream Name	Total Taxa Average	EPT Taxa Average	Sensitive Taxa Average
Bear River	17.4	7.2	2.7
Boyne River	16.3	9.2	5.0
Eastport Creek	20.7	7.3	3.0
Horton Creek	17.3	7.8	3.6
Jordan River	20.1	11.8	7.0
Kimberly Creek	20.9	7.7	3.8
Maple River	22.9	9.4	3.4
Milligan Creek	19.6	9.6	6.3
Mullett Creek	21.9	8.4	3.3
Pigeon River	19.4	9.2	5.6
Stover Creek	16.1	4.6	1.9
Sturgeon River	20.3	10.8	6.7
Tannery Creek	14.7	5.4	1.9
ALL STREAMS	19.0	8.3	4.2

Schoof's Creek showed a trend of increasing total taxa diversity moving from the headwaters to the mouth, which is typical for stream ecosystems. Similar to Fineout Creek, biological data show that the Schoof's Creek system is comparable to high quality trout streams monitored as part of the Tip of the Mitt Volunteer Stream Monitoring Program (Tables 15 and 17). The site at the mouth of Schoof's Creek had lower sensitive taxa diversity than the other sites, which likely results from the same conditions noted at the mouth of Fineout Creek.

RECOMMENDATIONS

Results from this study provided the means to assess the current status of the Fineout and Schoof's Creeks' ecosystems, to compare them with past studies and determine any changes or trends that have occurred over time. Based on these assessments and comparisons, recommendations have been developed to guide follow-up actions that will address problems identified by this study, as well as further efforts to monitor and study the creeks and their watersheds.

Specific recommendations are as follow:

1. Share study results and report with appropriate organizations, agencies, and people, including the Little Traverse Bay Watershed Plan Advisory Committee, Emmet County Conservation District, Charlevoix County Conservation District, Natural Resources Conservation Service (USDA), Michigan Department of Environmental Quality (MDEQ), Michigan Department of Natural Resources (MDNR), Little Traverse Bay Bands of Odawa (LTBB), Health Department of Northwest Michigan, Bear Creek Township, Resort Township, Evangeline Township, and Melrose Township.
2. Identify all potential sources of nutrient pollution and bacteriological contamination in the watersheds of both creeks.
3. Work with appropriate organizations to address sources of nutrient pollution and bacteria in the creeks' watersheds, with particular focus on Schoof's Creek.
4. Examine historical land cover changes and project future landscape development trends in both watersheds. Based on this analysis, determine actions needed to protect and improve the stream ecosystems (e.g., permanent land protection priorities, appropriate planning and zoning, and ordinance development).

5. Determine how stream channels have changed over time, particularly near the mouths, using historical aerial imagery or other data (e.g., determine if channel widths or sinuosity have changed over time). Fill in gaps in stream channel mapping with GPS and on-the ground reconnaissance.
6. Continue to monitor water quality of the creeks to fill in gaps and track changes. Request that MDEQ and LTBB assist with monitoring. Form a volunteer team to assist with regular aquatic macroinvertebrate monitoring in the streams as part of the TOMWC Volunteer Stream Monitoring Program. Develop a regular monitoring schedule.
7. Assess sediment and nutrient pollution from agricultural and urban activity in the watershed to the wetlands, streams, and lakes by building a SWAT (Surface Water Assessment Tool) or other appropriate model. Use model results to identify problematic areas that could be addressed to help protect and improve the water quality of the tributaries, wetlands, and open water of Walloon Lake. Governmental agencies, academic researchers, or consulting firms could help develop a SWAT model.
8. Request that MDNR perform fish surveys to determine which species and communities inhabit the creeks. Fish surveys will also help determine if the creeks or sections of the creeks no longer support cold-water fisheries.

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Appendix A. Stream Data from 1987 Project Vigilant

Water Quality Data for Walloon Tributary Stations

Sub-Watershed	Trib Station	Sampling Date	Julian Day	Total Phosphorus (ug/L)	Soluble Reactive Phosphorus (ug/L)	TKN (ug/L)	Chloride (mg/L)	Alkalinity (mg/L)	Fecal Coliform (/100mL)	Calcium (mg/L)	Chloro phyll-a (ug/L)	Ammonia-Nitrogen (ug/L)	Nitrate-Nitrogen (ug/L)	Total Dissolved Phosphorus (ug/L)
Schoofs Ck	R25	4/13/1986	103	6.8	2.5	635	5	166	5	57				
Schoofs Ck	R25	5/6/1986	126	8.2	4.4	920	6	222	62	71				
Schoofs Ck	R25	5/28/1986	148	2.9	2.7	1100	8	200	16	78				
Schoofs Ck	R25	6/19/1986	170	11.8	1	800	6	224	20	77.6				
Schoofs Ck	R25	6/30/1986	181	8.8	2.6	900	7	222		39				
Schoofs Ck	R25	7/13/1986	194	14.6	5.2	800	6	180	430	56				
Schoofs Ck	R25	7/29/1986	210	9.6	1.1	620	7	252	95	83.5				
Schoofs Ck	R25	8/12/1986	224	9.8	2.9	650	7	235	180	79				
Schoofs Ck	R25	8/27/1986	239	10	1	460	8	248	31	80				
Schoofs Ck	R25	9/17/1986	260	9.6	1.5	500	7	222	180	71				
Schoofs Ck	R25	10/16/1986	289	4.4	1	600	8	217	0	72	0.49	400	60	
Schoofs Ck	R25	11/20/1986	324	6.4	1	420	8	224		68				
Schoofs Ck	R25	2/5/1987	401	6.8	1.4	520	9.3	228		71				
Schoofs Ck	R25	3/12/1987	436	8	2.2	450	8	220		76				5.9
Schoofs Ck	R25	4/9/1987	464	5.7	1		9	200	23	55				4.9
S. Arm Ck	M18C	4/13/1986	103	4.6	2.5	450	6	152	0	48		25	320	
S. Arm Ck	M18C	5/6/1986	126	15.1	6.8	750	6	172	28	60				
S. Arm Ck	M18C	5/28/1986	148	18	15.5	580	9	164	16	57				
S. Arm Ck	M18C	6/19/1986	170	21.2	1.8	800	6	166	208	51				
S. Arm Ck	M18C	8/30/1986	181	21.2	4.9	680	8	186	52	58				
S. Arm Ck	M18C	7/13/1986	194	21.8	9	600	6.5	179	300	60				
S. Arm Ck	M18C	8/1/1986	213	13	5.6	430	7	193	73	60				
S. Arm Ck	M18C	8/12/1986	224	13.1	6.4	520	7.9	196	86	62.6				
S. Arm Ck	M18C	8/27/1986	239	12.3	1	620	7	204	74	64				
S. Arm Ck	M18C	9/16/1986	259	14	2.4	800	7	150	60	56				
S. Arm Ck	M18C	10/13/1986	286	10	1	480	8	144	33	43				
S. Arm Ck	M18C	11/19/1986	323	7.9	1.3	380	7	162	4					
S. Arm Ck	M18C	12/16/1986	350	9.7	1	460	8	152						
S. Arm Ck	M18C	2/3/1987	399	11	2.8	350	8	180		57				
S. Arm Ck	M18C	3/12/1987	436	11	1	450	8	220						5.9
S. Arm Ck	M18C	4/8/1987	463	11.1	1	390	8	160	2	42				7.8

Walloon Tributary Flows (cfs)			* indicates wet weather during sampling												
Sub-	**Julian Day->**	**99**	**103**	**113**	**119**	**126**	**135**	**138***	**138***	**142**	**148**	**161**	**163***	**163***	**164***
Watershed	**Trib Station**	**4/9/1986**	**4/13/1986**	**4/23/1986**	**4/29/1986**	**5/6/1986**	**5/15/1986**	**5/18/86***	**5/18/86***	**5/22/1986**	**5/28/1986**	**6/10/1986**	**6/12/86***	**6/12/86***	**6/13/86***
Schoofs Ck	R23b			0.43	0.38	0.27	0.35	1.39	0.78	0.43	0.2	0.17	6*	2.5	0.69
Schoofs Ck	R23a	3.51	2.81	2.05	1.62	1.13	1.67	6.58	3.71	1.49	0.55	0.48	18.6	15.1	2.9
Schoofs Ck	R24	1.89	1.49	1.38*	1.26	1.08	1.39	4.71	2.71	1.43	0.8	0.67	13.4*	7.2	2.1
Schoofs Ck	R19				0.04							0			
Schoofs Ck	BC30	0.55	0.72		0.56	0.4	0.41	1.16	0.7		0.3	0.26	2	0.58	0.36
Jones Lan-	BC31a		0.19		0.15	0.13	0.14				0.04				
Jones Lan-	BC31b		0.2		0.17	0.14	0.15				0.13	0.12			
S. Arm Ck	M18a		1.24		1.02	0.77	1.01	2.21	1.44	0.91	0.53	0.44	5.33	4	2
S. Arm Ck	M18b		3.81	2.22	2.49	1.59	3.07	8.11	7.68	2.99	1.7	1*	19*	23.4	15.7

Sub-	**Julian Day->**	**167**	**170***	**181**	**194***	**213**	**224**	**239**	**259**	**273***	**286***	**301**	**323**	**350**	**399**
Watershed	**Trib Station**	**6/16/1986**	**6/19/1986**	**6/30/1986**	**7/13/1986**	**8/1/1986**	**8/12/1986**	**8/27/1986**	**9/16/1986**	**9/30/1986**	**10/13/1986**	**10/28/1986**	**11/19/1986**	**12/16/1986**	**2/3/1987**
Schoofs Ck	R23b	0.27	0.74	0.4	>6.5*	0.19	0.2	0.2	0.61	0.56	1.34	0.4	0.36	0.44	0.3
Schoofs Ck	R23a	0.89	2.6	0.6	24.7	1.11	1	0.63	1.92	1.63	3.83	1.26	1	1.38	1
Schoofs Ck	R24	0.85	3.15	0.78	12.7	0.93	1.06	0.69	1.58	1.43	2.62	1.14	0.97	1.15	0.95
Schoofs Ck	R19		0.09												
Schoofs Ck	BC30		0.61	0.36	0.58	0.18	0.23	0.24	0.38	0.77	0.64		0.51	0.36	0.3
Jones Lan-	BC31a		0.33	0.17	0.54	0.02	0.12	0.07	0.19	0.18	0.26		0.07	0.14	.09*
Jones Lan-	BC31b		0.33	0.12	0.19	0.13	0.04	0.12	0.13	0.13	0.18		0.12	0.14	0.12
S. Arm Ck	M18a		1.4	0.51	0.96	0.39	0.57	0.45	1.85	1.21	1.94		0.91	1.1	0.58
S. Arm Ck	M18b		3.51	1.56	2.9	1.33	2.2	1.95	4.61	5.7	6.96		2.2	2.3	1.5

			Snowmelt			Snowmelt							
Sub-	**Julian Day->**	**431**	**432**	**436**	**443**	**444**	**463**			**Standard**	**Maximum**	**Minimum**	**# of Data**
	Trib Station	**3/7/1986**	**3/8/1986**	**3/12/1986**	**3/19/1986**	**3/20/1986**	**4/8/1986**		**Average**				
Schoofs Ck	R23b	0.92	2.5	0.3	0.51	0.51	0.31						
Schoofs Ck	R23a	2.51	4.79	1.12	1.84	1.55	1.37						
Schoofs Ck	R24	1.84	2.99	0.91	1.25	1.3	1.19						
Schoofs Ck	R19	.5*	.1*	.02*	.04*	.04*	.03*						
Schoofs Ck	BC30	1.58	1.32	0.27			0.31		0.59	0.42	2	0.18	28
Jones Lan-	BC31a			.07*			.11*		0.14	0.13	0.54	0	0.19
Jones Lan-	BC31b			0.11			.11*		0.14	0.05	0.33	0.04	20
S. Arm Ck	M18a	2.41	1.82	0.79	0.8	0.72	0.94						
S. Arm Ck	M18b	2.41	1.82	0.79	0.8	0.72	0.94						

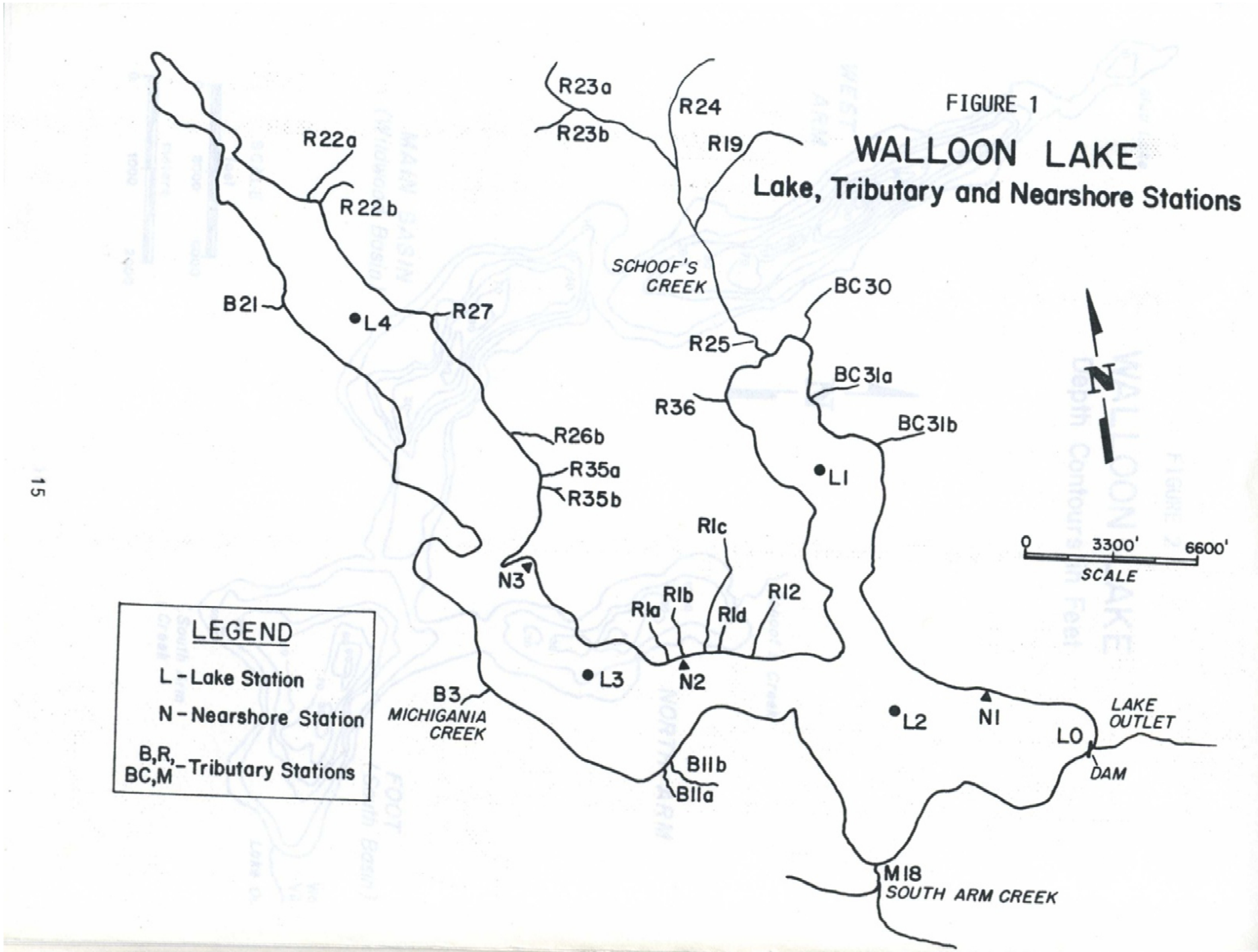
FIGURE 1
WALLOON LAKE
Lake, Tributary and Nearshore Stations
R23a
R23b
R24
R19
R22a
R22b
B21
L4
R27
SCHOOF'S CREEK
BC30
R25
BC31a
R36
BC31b
R26b
R35a
R35b
L1
R1c
N3
R1b
R1a
R1d
R12
N
0
3300'
6600'
SCALE
LEGEND
L - Lake Station
N - Nearshore Station
B,R, BC,M - Tributary Stations
B3
MICHIGANIA CREEK
L3
N2
L2
N1
LAKE OUTLET
LO
DAM
B11b
B11a
M18
SOUTH ARM CREEK