Fineout and Schoof's Creek Monitoring Study 2018

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 it's Watershed. Past assessments performed by Tip of the Mitt Watershed Council include:

- 2011-- comprehensive assessment of the Watershed's largest wetland complexes and associated inlet tributaries, as well as a watershed-wide ecological evaluation of individual properties
- 2013-- physical, chemical, and biological water quality monitoring at multiple sites in each Schoof's and Fineout Creeks' watersheds

In 2018, the Watershed Council was contracted with again to collect water quality, discharge, and habitat data at two sites each on Fineout and Schoof's Creeks.

This report provides the results of 2018 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 (

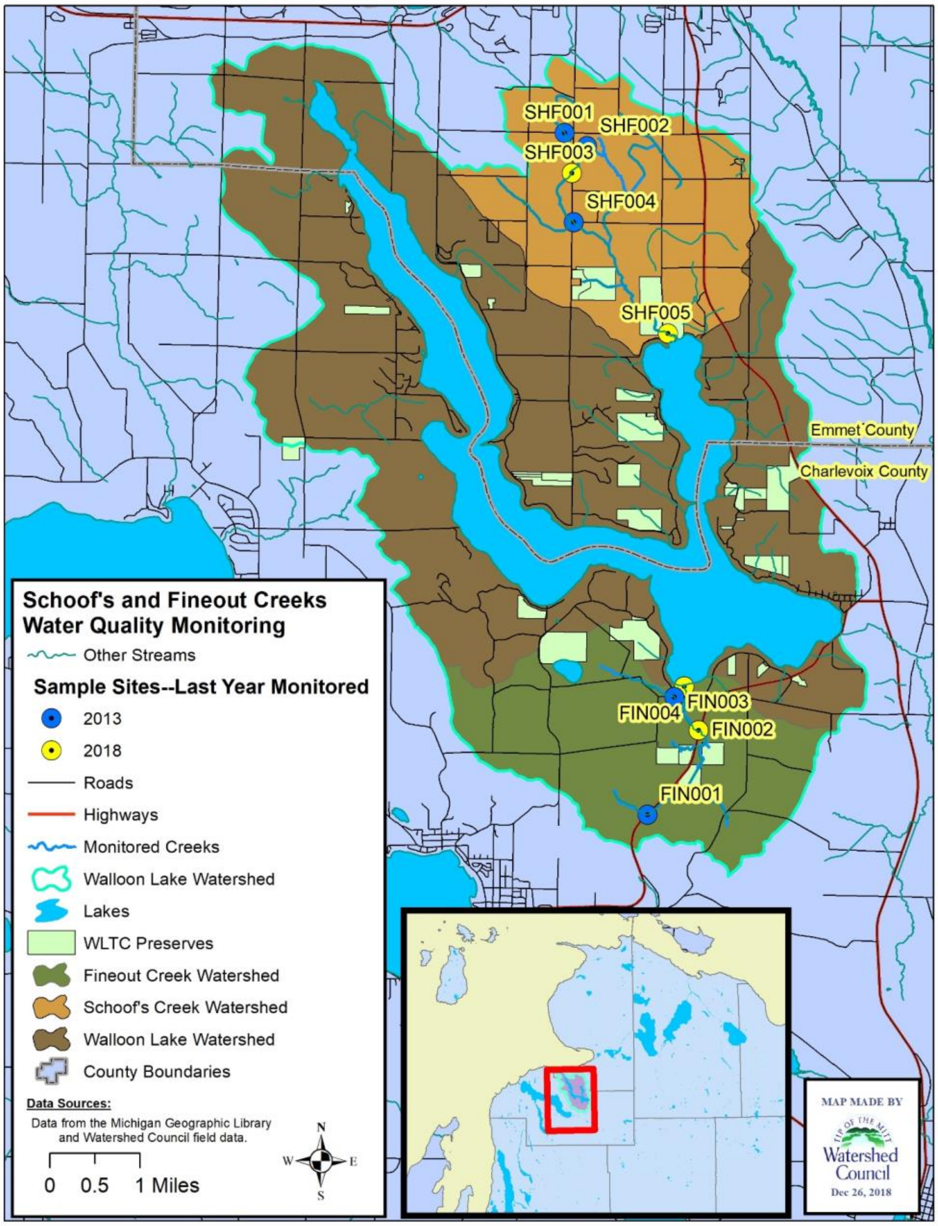
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Figure 1). The main branch flows from south to north through extensive wetland complexes, crisscrossing M-75 and flowing under Shadow Trails before draining into Walloon Lake. The west branch of the Creek originates in the vicinity of a small lake 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 (

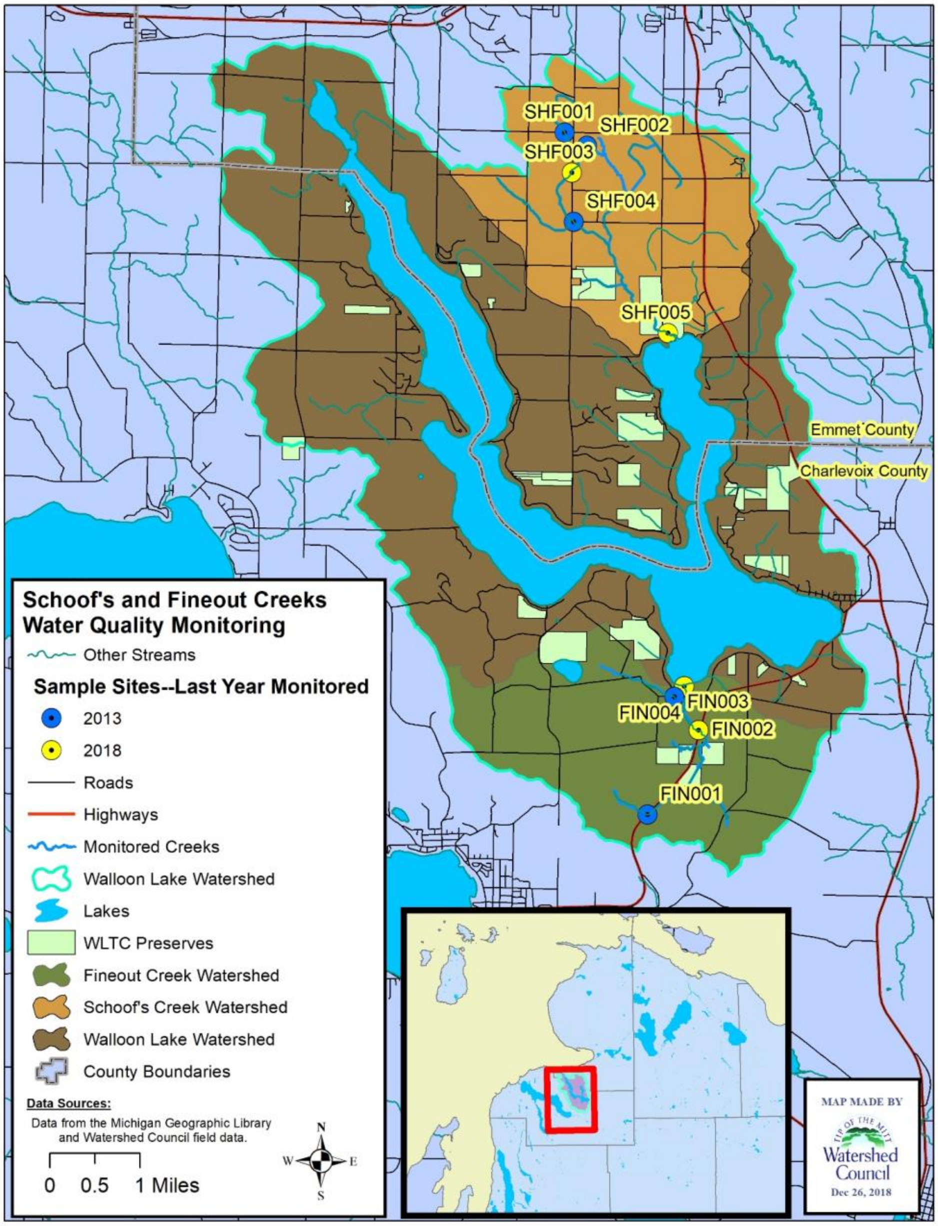
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Figure 1). The main branch flows over 4 miles from north to south, roughly following Resort Pike to Williams Road, where it then flows southeast through a large wetland complex before draining into Walloon Lake. Another tributary of Schoof's Creek, 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.

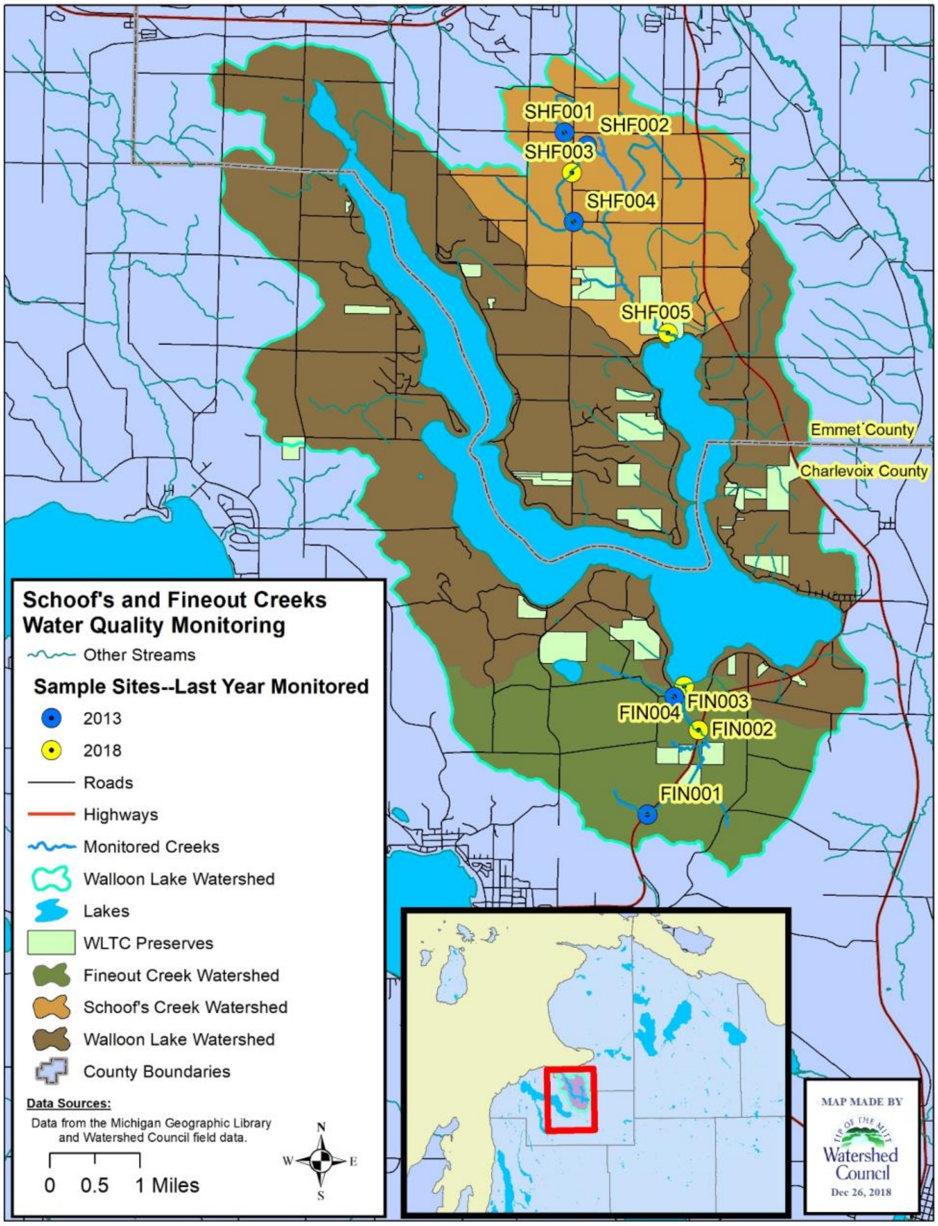

Figure 1. Study area for Schoof's and Fineout Creek Water Quality Monitoring

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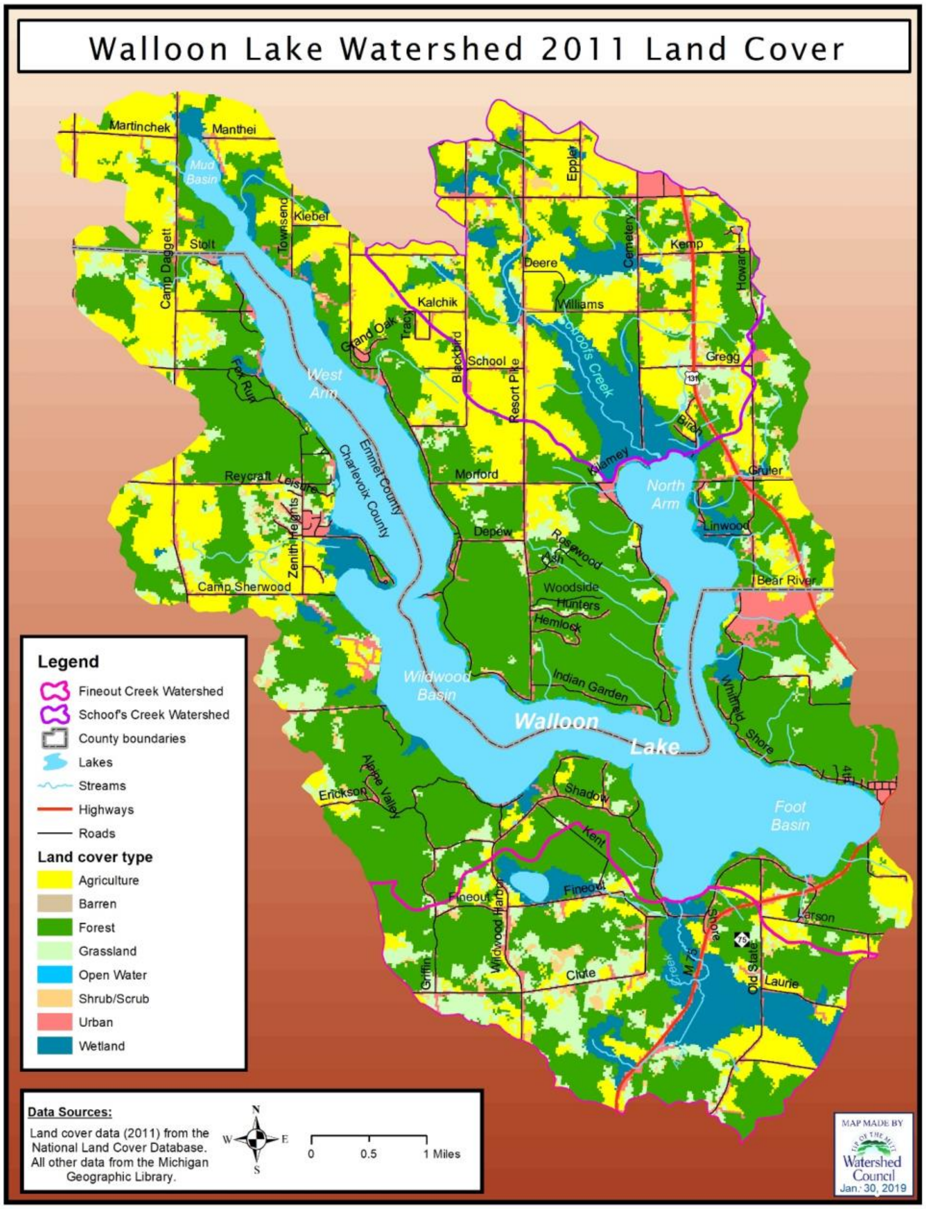

Figure 2. Land cover in the Walloon Lake Watershed (2011 National Land Cover Database)

Table 1. Walloon Lake Watershed's land cover in 2011 and changes since 2006.

Land Cover Type	Fineout Creek (acres)	Fineout Creek (percent)	Fineout Creek (percent change since 2006)	Schoof's Creek (acres)	Schoof's Creek (percent)	Schoof's Creek (percent change since 2006)	Walloon Lake (acres)	Walloon Lake (percent)	Walloon Lake (percent change since 2006)
Agriculture	562	13.71	-12.60	1948	44.28	-5.53	5446	20.54	-6.67
Barren	0	0.00	0	9	0.20	-74.29	18	0.07	-62.50
Forested	1802	43.96	1.64	1029	23.39	-1.53	10339	39.00	-1.23
Grassland	649	15.83	-5.12	279	6.34	8.56	1951	7.36	-1.22
Scrub/Shrub	83	2.02	-39.42	40	0.91	-64.29	278	1.05	-55.16
Urban	279	6.81	116.28	443	10.07	88.51	1913	7.22	106.36
Water	40	0.98	0.00	1	0.02	0.00	4749	17.91	1.06
Wetland	684	16.69	-1.87	650	14.78	-1.07	1819	6.86	-7.10
TOTAL	4099	100.00		4399	100.00		26513	100.00	

Land cover data from 2011 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. Fineout and Schoof's Creeks' Watersheds also possess the largest wetland complexes (Figure 2). Since the 2006 Land Cover Dataset reported in the 2013 tributary study, there have been some changes—notably the percentage of urban land cover has increased in both Watersheds, with Fineout Creek having the larger increase. The largest overall decrease was in barren areas. Scrub/shrub declined the most in the Schoof's Creek Watershed. 2011 data shows more urban land cover concentrated around roads than in 2006.

Prior Monitoring and Studies

In 2013, five sites were monitored for water quality on Schoof's Creek and four on Fineout Creek. The 2013 data is compared with the results of this 2018 study. Additional parameters in the 2013 study include *E. coli* and dissolved organic carbon. Those parameters are not discussed in this report.

Tip of the Mitt Watershed Council performed an extensive literature and data search as part of the *Walloon Lake Wetlands and Tributary Assessment* (Watershed Council 2012). Relevant findings include the *Project Community and Lakes Environmental Awareness and Research (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, Michigan. 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 Fineout 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[ƚ])	Low (Schoof's[ƚ])	High (Schoof's[ƚ])	Average (Fineout[ƚ])	Low (Fineout[ƚ])	High (Fineout[ƚ])
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

[ƚ]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, discharge, and habitat data were collected from two sites on Fineout Creek and two sites on Schoof's Creek (Table 4,

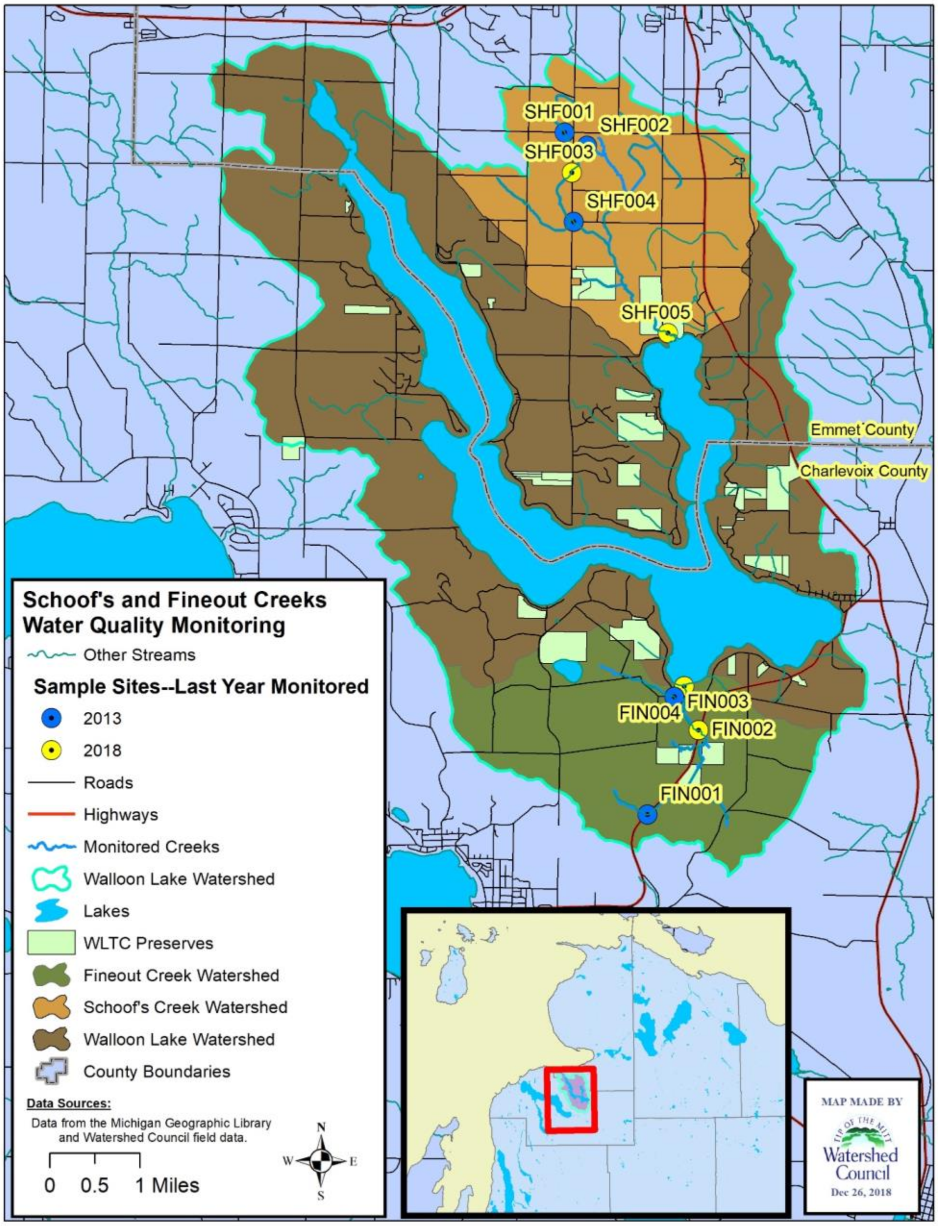
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Figure 1).

Table 4. 2018 Tributary Monitoring

Stream Name	Site ID	Site Description	Spring	Summer	Summer	Fall	Habitat Assessment
Schoof's Creek	SHF005	Mouth--Schoof's Creek Nature Preserve	5/31/2018**	7/25/2018	9/12/2018*	10/5/2018	8/7/2018
	SHF003	Resort Pike--north of Deere Rd.	5/31/2018**	7/26/2018	9/12/2018*	10/5/2018	8/13/2018
Fineout Creek	FIN004	Mouth-South Arm Creek Preserve	6/12/2018	7/26/2018	9/12/2018*	10/4/2018**	8/2/18--8/6/18
	FIN002	M-75 Downstream	6/11/2018	7/26/2018	9/12/2018*	10/4/2018**	8/6/2018

*Dry conditions

**Wet conditions

At each site, surface water grab samples were collected in the middle of the stream with two separate bottles for chemical and suspended solids. Acid-rinsed 250 milliliters (mL)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 1,000 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.

All water samples were immediately placed in a cooler containing ice.

Water samples collected were frozen upon returning to the Watershed Council office and transported to the University of Michigan Biological Station (UMBS). The UMBS laboratory analyzed samples to determine concentrations of fluoride (Fl-), chloride (Cl-), nitrite (NO_2-), nitrate (NO_3-), sulfate ($SO_{4\text{-}2}$), phosphate (PO^4-P), nitrate-nitrogen (NO_3N), total nitrogen (TN), total phosphorus (TP), 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 writing down readings on a datasheet. Readings from the MiniSonde® were also recorded on a field datasheet. Upon returning to the office, data were 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. The spring discharge was measured using a Marsh McBirney digital current meter using the USGS Mid-Section Method. Intervals across the transect were selected based on changes in depth and current velocity. All data were recorded on a field datasheet and later entered into a Microsoft Excel® workbook. All following discharge events were measured using a SonTek FlowTracker using the USGS Mid-Section Method. Data from the FlowTracker were stored in the FlowTracker and downloaded onto a computer. Total discharge was also written down on a datasheet. Discharge measurements at the mouth of Schoof's Creek are unreliable—conditions proved to be very challenging for staff to collect measurements in the spring due to high water levels, a mucky bottom, and overall non-wadable characteristics. Further attempts to use the FlowTracker at subsequent monitoring events were futile, and thus the discharge data at Schoof's Creek mouth is lacking.

Biological Monitoring

One assessment of the aquatic macroinvertebrate community on Schoof's Creek was conducted using methods from the Tip of the Mitt Watershed Council's Volunteer Stream Monitoring Program. While not part of the contract with Walloon Lake Trust and Conservancy, the data will be included here as to be as comprehensive as possible. Macroinvertebrates were collected between Resort Pike and Williams Rds., in between the sites in this assessments at Resort Pike Rd. and the mouth.

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 possible using microscopes and taxonomic keys (usually to the family level).

Biological data from the sample site 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 *Trichoptera* (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). After adding scores for total diversity, EPT, and sensitive taxa, a letter grade is assigned to streams according to the following rating system:

Total Score	Grade
115-120	A++
101-114	A+
70-100	A
50-69	B
30-49	C
20-29	D
10-19	E
<10	F

Pollutant Loading

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 (cubic meters per second), the pollutant's measured concentration, and a conversion factor (190.48 for parameters measured in parts per million (ppm) or 0.1905 for those in parts per billion (ppb).

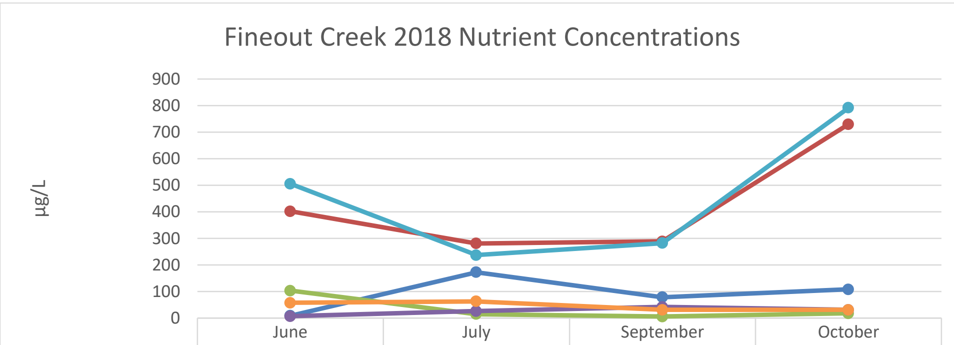
Habitat Assessments

Using a 1993 United States Department of Agriculture Forest Service study protocol by Dolloff et. al, each site was surveyed for habitat conditions. While the original intent was to assess habitat along the entirety of each stream, a more efficient approach was to survey strategically near road/stream crossings and Walloon Lake Trust and Conservancy preserves. These data can be used in future for road/stream crossing and preserve improvements. 900 feet were surveyed at the mouth of Fineout Creek to include the Walloon South Bay Association Preserve, Noel Preserve, and E. Shadow Trail road/stream crossing, which failed recently and was improved with a new concrete box culvert. An additional 400 feet were surveyed where M-75 crosses Fineout Creek (260 ft. upstream, 150 ft. downstream.). The M-75 location is just downstream of the Frog Hollow Preserve. 970 ft. were surveyed at Schoof's mouth to help assess conditions in the Schoof's Creek Nature Area. Another 400 ft. were surveyed downstream of where Schoof's crosses Resort Pike Rd. The upstream portion was not assessed due to the summer's dry conditions as instream habitat could not be identified without surface water.

GIS layers were created by using the measuring tool to draw individual bedform units sized to the wetted width of the stream and actual length of the unit. Spatial data was joined to survey data. Calculations were added to define large wood debris per mile, and riparian buffer vegetation widths. Where widths were unknown or could not be measured, spatial data was digitized to align with aerials or known measurements/observations were used to make assumptions. Metadata included in each layer explains this process.

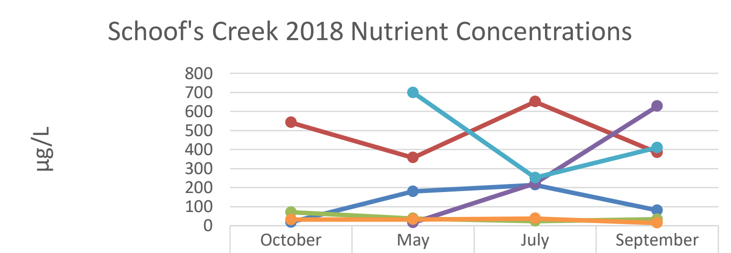
RESULTS

Nutrients



	June	July	September	October
M-75 NO3-N	9	172.85868	78.52284	108.432
M-75 TN	401.954	281.26	288.64	730.027
M-75 TP	103.1844	14.827	5.828	17.5
Mouth NO3-N	7	25.95591	41.88186	30.9483
Mouth TN	505.584	237.21	282.2533333	791.617
Mouth TP	57.7313	62.844	31.28033333	30.922

Figure 3. Fineout Creek 2018 Nutrient Concentrations



	October	May	July	September
Resort Pike NO3-N	19	180.22302	214.33392	80.8722
Resort Pike TN	541.923	357.44	651.18	383.991
Resort Pike TP	70.9687	37.606	24.737	33.884
Mouth NO3-N		16	221.74344	628.34085
Mouth TN		699.853	252.38	410.75
Mouth TP	32.07566667	33.2981	37.876	14.401

Figure 4. Schoof's Creek 2018 Nutrient Concentrations

Total phosphorus (TP), which is a measure of all phosphorus types in the water sample, reached a maximum of nearly 71 micrograms per liter (µg/L) (nearly twice the normal amount of TP) at Schoof's Creek/Resort Pike Rd. during a wet-weather monitoring event in May (Figure 4). The TP at Schoof's mouth was less reactive to the wet weather event and closer to the average for that site. The average was 41.80 µg/L for Resort Pike and 27.80 µg/L at the Mouth.

Michigan Department of Environmental Quality (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 Plant Nutrients (R 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 TP 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). TP concentrations were found in excess of the 12 µg/L reference condition at every monitoring event on both Creeks. A more local standard is used by the Little Traverse Bay Bands of Odawa Indians (LTBB), located in Emmet and Charlevoix counties. LTBB uses 50 µg/L as monthly average in their assessments of water quality. The value is derived from local water quality, numeric criteria for Minnesota high quality northern lakes fisheries, and mid-upper range ecoregion values from the USEPA. Fineout Creek exceeded 50 µg/L during three monitoring events and Schoof's at one event (Figure 3 and Figure 4).

Total nitrogen (TN) is a measure of all nitrogen types in a water sample. The USEPA TN reference condition of 440 µg/L for minimally impacted conditions for Northern Michigan streams was exceeded in six samples on Schoof's Creek and four on Fineout Creek (USEPA, 2001). Using LTBB's assessment criteria of 1,000 µg/L, which is derived similarly to TP with local water quality and state and federal criteria, there were no exceedances. Total nitrogen concentrations ranged from 237.21 µg/L at the mouth to 791.617 µg/L at the mouth in October on Fineout Creek. Both sites followed nearly the same trend line with a medium concentration of TN in the spring, the lowest concentrations in summer, and the highest concentrations of TN in October, correlating with the wet-weather event. Schoof's Creek TN ranged from 252.38 µg/L at the mouth in July to nearly 700 µg/L in May. The high concentration correlates with the wet-weather event on May 31. Schoof's Creek follows the same seasonal progression as Fineout Creek, except the TN at Resort Pike Road did not increase from September to October.

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). LTBB assesses water quality with data that shows high quality surface waters in Northern Michigan have less than 50 mg/L chloride (Figure 5). 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 and high water quality criteria from LTBB. The range of chloride concentrations was similar in both creeks, though on average higher in Schoof's Creek

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 5 and Table 6).

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, solids that settle, 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 1 mg/L (Table 5 and Table 6). The highest was in May at Fineout Creek (4.29 mg/L).

Table 5. Fineout Creek anions and solids

Date	Site ID	Location	Fluoride	Chloride	Total Suspended Solids	Conductivity	Total Dissolved Solids
			mg/L	mg/L	mg/L	µS/cm	
6/11/2018	FIN002	Fineout Creek-M75 Downstream		21.95	0.57	345.20	231.28
7/26/2018	FIN002	Fineout Creek-M75 Downstream	0.05	16.61	0.09	421.10	282.14
9/12/2018	FIN002	Fineout Creek-M75 Downstream	0.03	5.06	0.05	386.70	259.09
10/4/2018	FIN002	Fineout Creek-M75 Downstream	0.05	10.72	0.00	244.30	163.68
6/12/2018	FIN004	Fineout Creek Mouth	0.06	18.68	3.20	420.40	281.67
7/26/2018	FIN004	Fineout Creek-Mouth	0.05	16.13	0.09	462.20	309.67
9/12/2018	FIN004	Fineout Creek-Mouth	0.04	15.00	0.03	372.60	249.64
10/4/2018	FIN004	Fineout Creek-Mouth	0.04	10.28	0.01	224.00	150.08
Average			0.05	14.30	0.50	359.56	240.91

Table 6. Schoof's Creek anions and solids

Date	Site ID	Location	Fluoride	Chloride	Total Suspended Solids	Conductivity	Total Dissolved Solids
			mg/L	mg/L	mg/L	µS/cm	
5/31/2018	SHF003	Schoof's Creek-Resort Pike	0.16	19.78	2.12	473.80	317.45
7/26/2018	SHF003	Schoof's Creek-Resort Pike	0.16	38.48	0.15	698.00	467.66
9/12/2018	SHF003	Schoof's Creek-Resort Pike	0.19	27.88	0.07	589.00	394.63
10/5/2018	SHF003	Schoof's Creek-Resort Pike	0.11	32.68	0.09	558.00	373.86
5/31/2018	SHF005	Schoof's Creek-Mouth	0.13	14.03	4.29	532.10	356.51

Date	Site ID	Location	Fluoride	Chloride	Total Suspended Solids	Conductivity	Total Dissolved Solids
7/25/2018	SHF005	Schoof's Creek Mouth	0.09	14.18	0.13	551.40	369.44
9/12/2018	SHF005	Schoof's Creek Mouth	0.15	15.31	0.08	483.10	323.68
10/5/2018	SHF005	Schoof's Creek-Mouth	0.09	10.20	0.03	365.30	244.75
Average			0.09	17.94	0.69	531.34	356.00

Dissolved Oxygen, Temperature, and pH

Dissolved oxygen concentrations in the Fineout and Schoof's Creeks ranged from 3.62 to 8.97 mg/L (Table 7 and Table 8). The DEQ Part 4 Water Quality Standards minimum dissolved oxygen concentration for sustaining a cold-water fishery is 7 mg/L. Levels were too low to meet the 7 mg/L standard at every monitoring event at Fineout Creek's mouth, July and September at Schoof's Creek/Resort Pike Rd., and May at Schoof's Mouth.

Both Fineout and Schoof's Creek are managed as a coldwater fishery by the Michigan Department of Natural Resources. Water temperatures, which ranged from 9.23° to 22.83°C, were, on average, higher in Fineout Creek (Table 7 and Table 8). According to DEQ Part 4 Water Quality Standards, monthly maximum temperatures for streams supporting coldwater 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 in July at Fineout Creek's mouth and at both sites on Schoof's Creek in May and July.

Hydrogen ion concentration, expressed as pH, ranged from 7.47 to 8.21 in Fineout and Schoof's Creeks (Table 7 and Table 8). 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 7. Fineout Creek Hydrolab parameters

Date	Site ID	Location	Depth (m)	Water Temp	DO	Cond	pH
6/11/2018	FIN002	Fineout Creek-M75 Downstream	0.1	14.51	ND	345.2	7.76
7/26/2018	FIN002	Fineout Creek-M75 Downstream	0.3	19.88	8.21	421.1	7.76
9/12/2018	FIN002	Fineout Creek-M75 Downstream	0.24	15.3	8.04	386.7	7.48
10/4/2018	FIN002	Fineout Creek-M75 Downstream	0.737	12.923	4.95	244.3	7.42

6/12/2018	FIN004	Fineout Creek Mouth	0.4	19.66	3.75	420.4	7.3
7/26/2018	FIN004	Fineout Creek-Mouth	0.3	20.72	3.82	462.2	7.53
9/12/2018	FIN004	Fineout Creek-Mouth	0.4572	15.4	3.65	372.6	7.16
10/4/2018	FIN004	Fineout Creek-Mouth	0.555	12.783	4.9	224	7.36

Table 8. Schoof's Creek Hydrolab parameters

Date	Site ID	Location	Depth (m)	Water Temp	DO	Cond	pH
5/31/2018	SHF003	Schoof's Creek-Resort Pike	0.8	20.57	6.88	473.8	7.71
7/26/2018	SHF003	Schoof's Creek-Resort Pike	0.1	21.33	4.8	698	7.61
9/12/2018	SHF003	Schoof's Creek-Resort Pike	0.06096	17.1	5.22	589	7.37
10/5/2018	SHF003	Schoof's Creek-Resort Pike	0.129	9.256	8.97	558	7.82
5/31/2018	SHF005	Schoof's Creek-Mouth	0.4	21.11	3.62	532.1	7.54
7/25/2018	SHF005	Schoof's Creek Mouth	0.6	22.83	9.57	551.4	7.23
9/12/2018	SHF005	Schoof's Creek Mouth	0.7239	17.2	8.47	483.1	7.63
10/5/2018	SHF005	Schoof's Creek-Mouth	0.718	9.229	8.16	365.3	7.7

Discharge and Loads

Discharge was accurately measured at the mouths of the Creeks during nearly all monitoring events. Each recorded discharge was used to calculate a load for that site at each monitoring event.

Fineout Creek

Comparing the discharge between both Fineout Creek sites, there is little to no difference between sites (Figure 6, Table 9). There is also little to no difference between 2013 and 2018 discharge. The TSS load was always higher at M-75, perhaps because of the road/stream crossing. The TN load was relatively consistent from one site to the next, although more often higher upstream. The TP load was usually higher downstream. The total sulfate load was almost always higher upstream except for the spring monitoring event. Throughout the season, nutrients increased while TSS decreased.

Table 9. Fineout Creek discharge and pollutant loads

Date	Site ID	Location	Discharge (cms)	TSS Load	TN Load	TP Load	Total Sulfate Load
6/11/2018	FIN002	M75 Downstream	0.50	54.23	38.54	9.89	92.14
6/12/2018	FIN004	Mouth	0.41	252.35	39.87	4.55	25.71
7/26/2018	FIN002	M75 Downstream	0.61	10.33	32.60	1.72	609.44
7/26/2018	FIN004	Mouth	0.61	9.90	27.35	7.25	422.78
9/12/2018	FIN002	M75 Downstream	0.55	5.07	30.49	0.62	353.15
9/12/2018	FIN004	Mouth	0.55	3.36	29.55	3.27	1152.25
10/4/2018	FIN002	M75 Downstream	12.51	5.78	1740.31	41.72	9003.96
10/4/2018	FIN004	Mouth	10.66	15.36	1608.12	62.82	4322.91

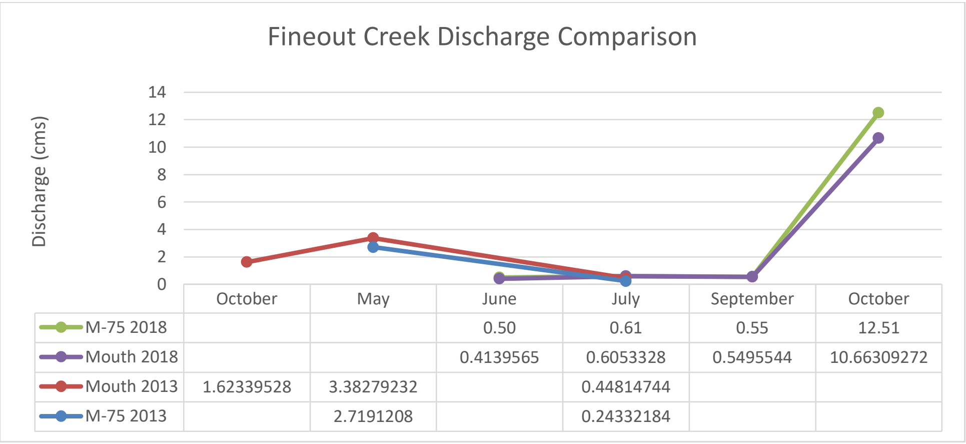


Figure 5. Fineout Creek comparison of discharge between 2013 and 2018

Schoof's Creek

More data is needed to understand the discharge rates in Schoof's Creek. Currently the mouth is non-wadeable, which means a remotely operated device is needed to monitor safely and accurately.

As spring was the only time discharge was captured at Schoof's mouth, it is the only set of data points we can use to infer nutrient loading from upstream to downstream (Figure 5 and Table 10). The measurements show that nutrient loading was higher downstream than upstream.

Table 10. Schoof's Creek discharge and pollutant loads

Date	Site ID	Location	Discharge (cms)	TSS Load	TN Load	TP Load	Total Sulfate Load
5/31/2018	SHF003	Resort Pike	0.50	203.30	52.00	6.81	27.92
5/31/2018	SHF005	Mouth	2.69	2194.68	358.27	17.05	871.30
7/25/2018	SHF005	Mouth	ND	ND	ND	ND	ND
7/26/2018	SHF003	Resort Pike	0.03	0.82	1.93	0.20	19.40
9/12/2018	SHF003	Resort Pike	0.02	0.34	3.01	0.11	32.59
9/12/2018	SHF005	Mouth	ND	ND	ND	ND	ND
10/5/2018	SHF003	Resort Pike	0.26	4.21	18.75	1.65	531.78
10/5/2018	SHF005	Mouth	ND	ND	ND	ND	ND

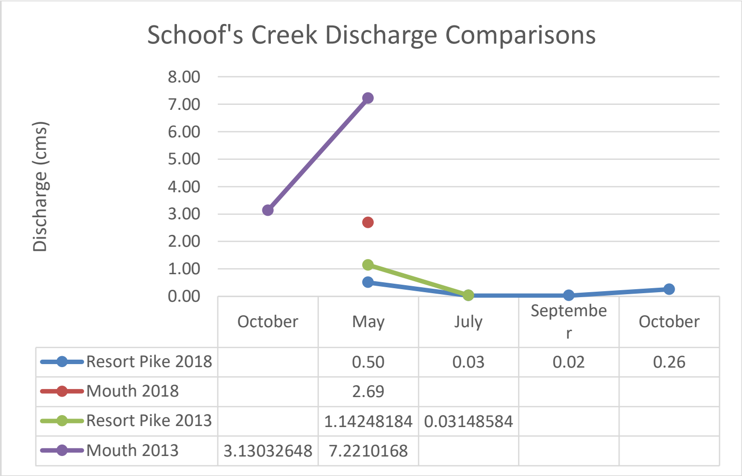


Figure 6. Schoof's Creek comparison of discharge between 2013 and 2018

Aquatic Macroinvertebrates

At Schoof's Creek at Resort Pike Rd./Williams Rd., 23 taxa were found (Table 11). 11 of the taxa were in the high quality EPT group. Five families were sensitive to pollution. Overall, the site was graded "A."

As only one site was assessed this year, we cannot compare upstream to downstream, but we can compare to previous datasets, which can be found in the discussion section.

Table 11. Aquatic macroinvertebrate data from Schoof's Creek

Sample Site	Date	Total Taxa	EPT Taxa	Sensitive Taxa
Williams Rd	5/23/18	23	11	5

**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.*

Habitat Assessments

Diversity of Bedform Units

A bedform is a feature on the stream bottom that is created when substrate is moved by water. Although different stream conditions can affect the distribution of aquatic life forms, bedform unit type is the most determinant variable. Bedform unit type is so determinant that in similar studies, it is referred to simply as "habitat type." Bedform unit type often influences stream conditions related to water velocity, and as a result, influences substrate particle size. Faster waters will carry away small particles, leaving larger particles such as gravel, and cobble. These small particulates tend to settle in areas of slower current, such as pools. Through this natural variability, streams provide living organisms with the different living conditions necessary for biological diversity. Pools, where water slows and deepens, provide trout with cover. They can rest here without expending energy fighting a strong current, and the depth afforded by pools maintains volume over the winter months when runs and riffles may be choked with ice. The riffle just upstream from the pool does not do much to aid in trout overwintering, but provides the necessary turbulence to mix atmospheric oxygen with the water, maintaining dissolved oxygen levels in the stream. Riffles are often the predominate places in streams where fine particulate does not settle. This gives trout an opportunity to spawn, since their eggs cannot survive in the presence of fine particulates. Likewise, the vulnerable, exposed gills of the stonefly require high levels of dissolved oxygen and absence of fine particulates for survival. Stoneflies and certain other sensitive macroinvertebrates are found exclusively in riffles, and serve as an important part of the greater food web of the stream. Through these relationships, and many more, the habitat variability afforded by bedform unit diversity supports a healthy stream ecosystem.

Four different types of bedform units were found in this inventory: pool, riffle, run, and glide. The most diverse area assessed was Schoof's Creek downstream of Resort Pike (the crossing north of Deere Rd.) (Figure 7). The upstream reach was not assessed as there was no water in it during the time of assessment--this would make identifying whether features were in-stream or not difficult. Schoof's Creek at Resort Pike had a plunge pool after the perched culvert under a private driveway (Figure 8). The private driveway crossing (LTB-162), was rated "severe" with zero fish passability on www.NorthernMichiganStreams.org). After a glide into another pool, the Creek is mostly run, except for a few riffles.

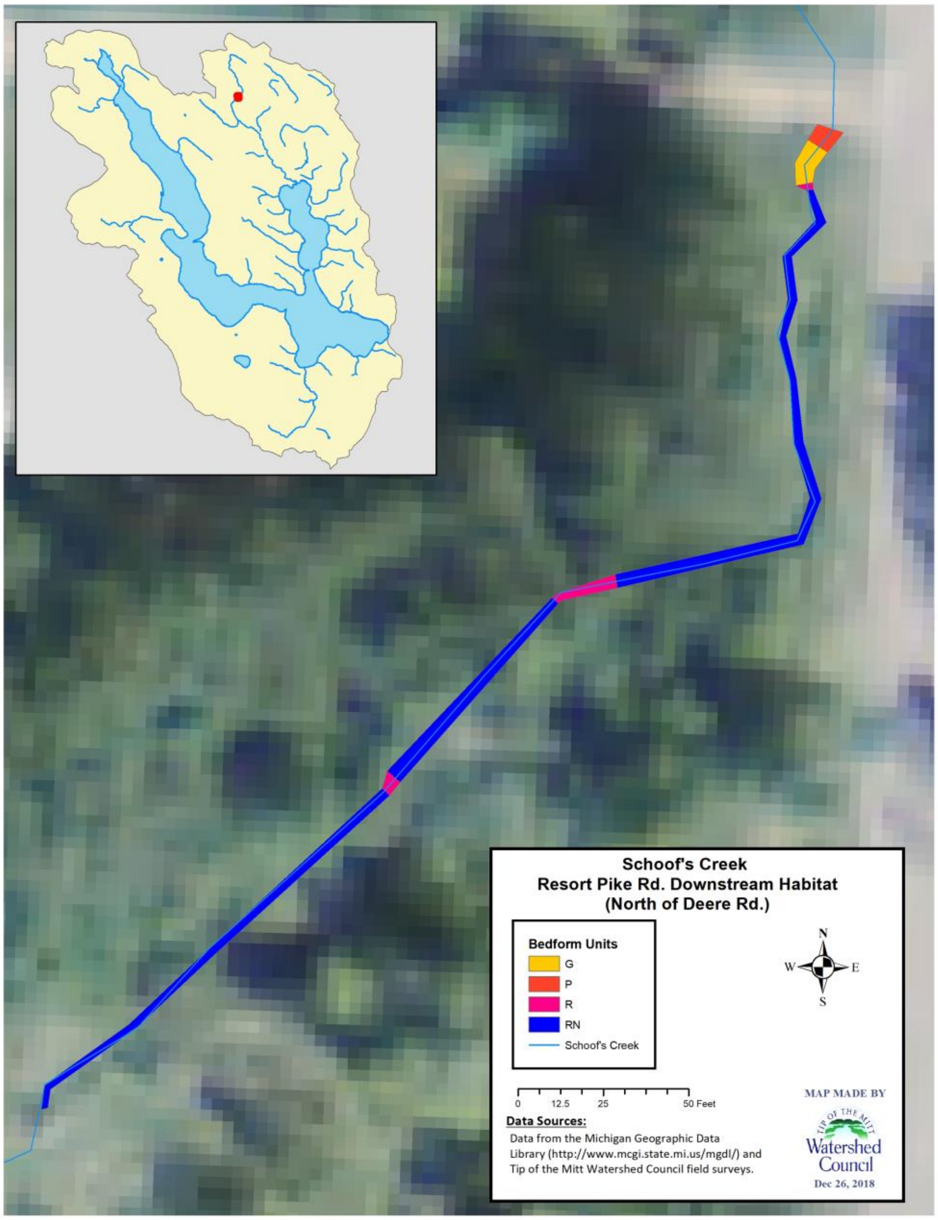


Figure 7. Schoof's Creek Habitat at Resort Pike Rd.

Figure 8. The culvert crossing of Schoof's Creek and a private driveway near Resort Pike Rd.

The mouth of Schoof's Creek had only pools and runs (Figure 9) as did both locations on Fineout Creek (Figure 10, Figure 11). The road/stream crossings included in the habitat assessment on Fineout Creek were nearly surrounded by pools. The crossing at E. Shadow Trails (LTB-208) was last assessed in 2014. However, in 2017, the concrete culvert collapsed when a passenger van crossed it. It was replaced with a box culvert in June the same year (Figure 12). It is believed that fish can still pass through, as that was the case before the replacement, although a downstream beaver dam slows overall discharge and contributes to a pool upstream of the culvert (Figure 13.)

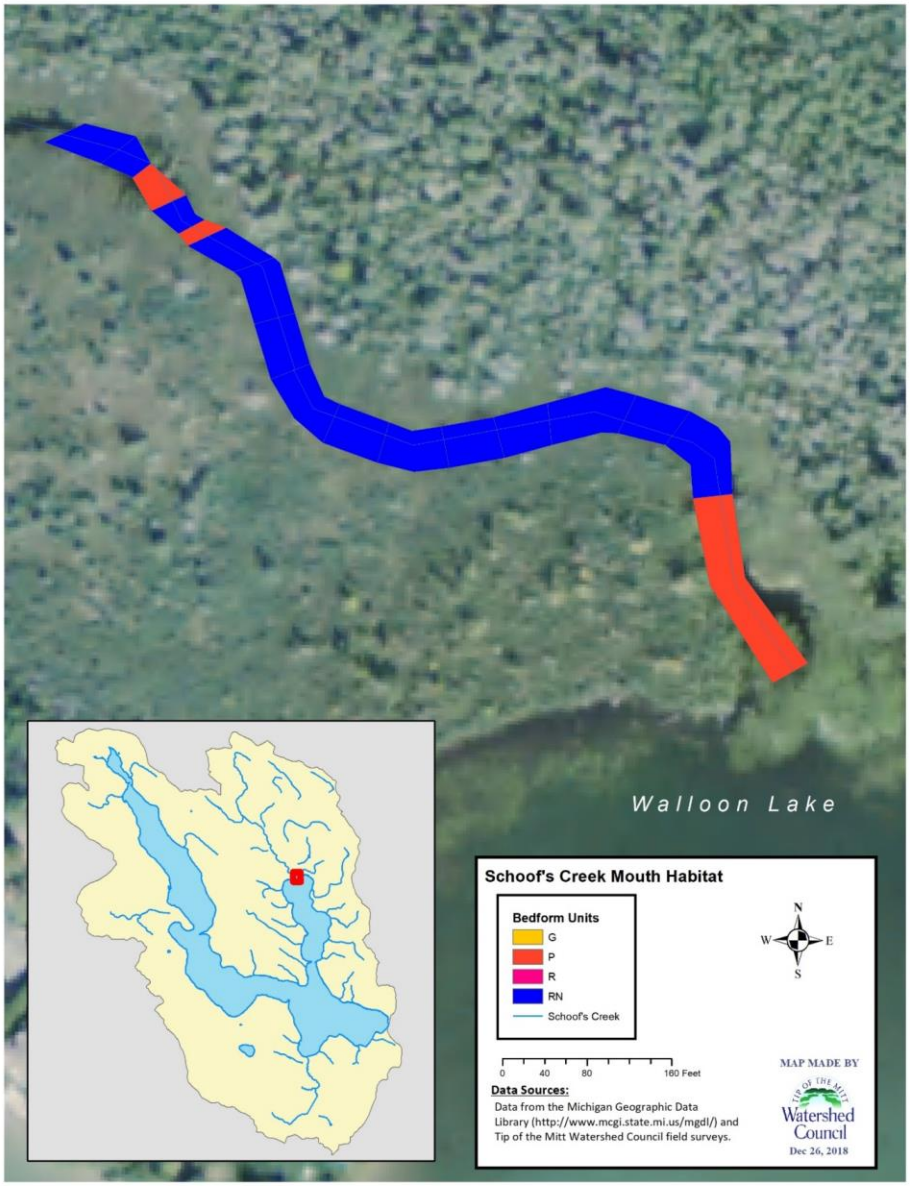


Figure 9. Schoof's Creek Habitat at the Mouth

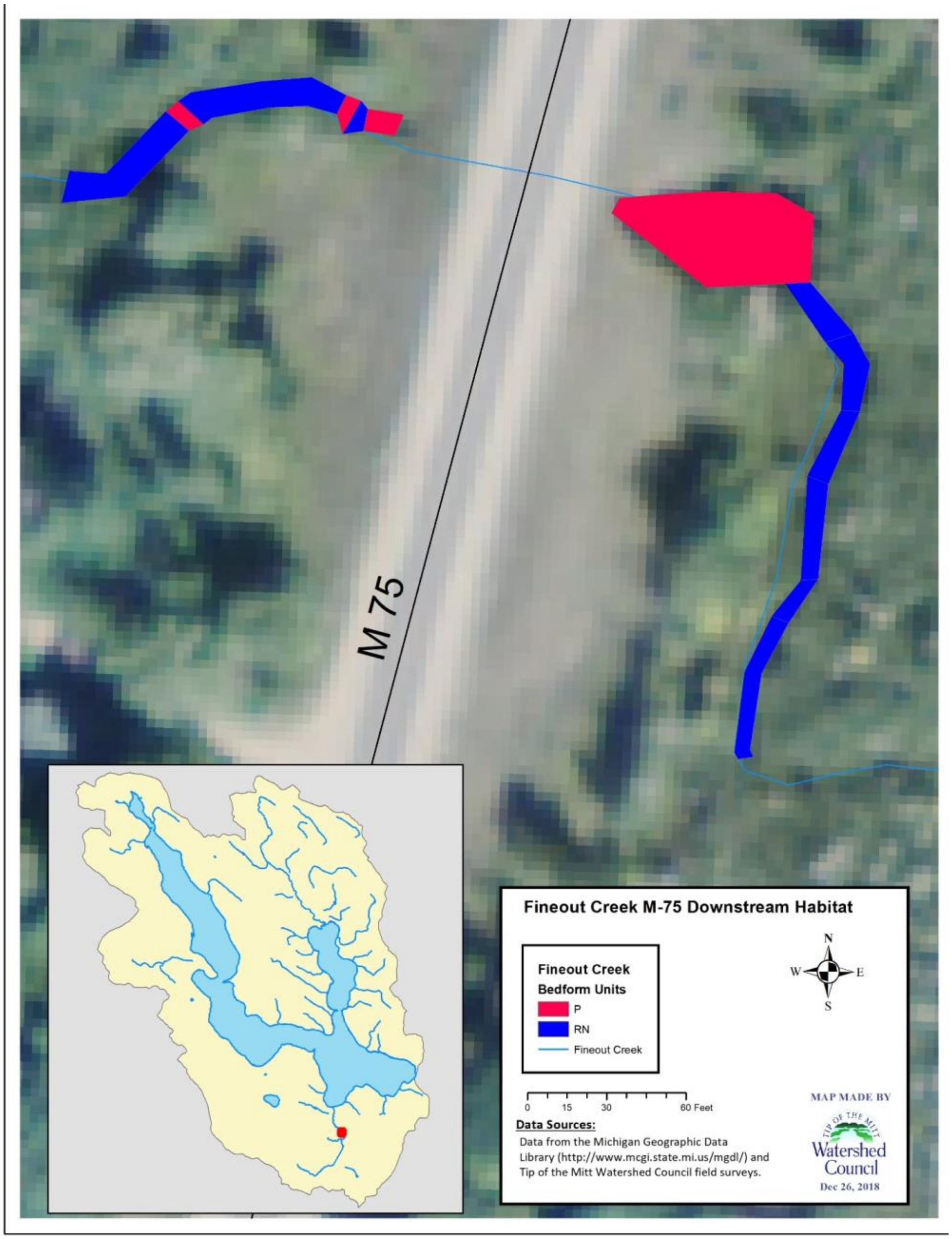


Figure 10. Fineout Creek Habitat at M-75

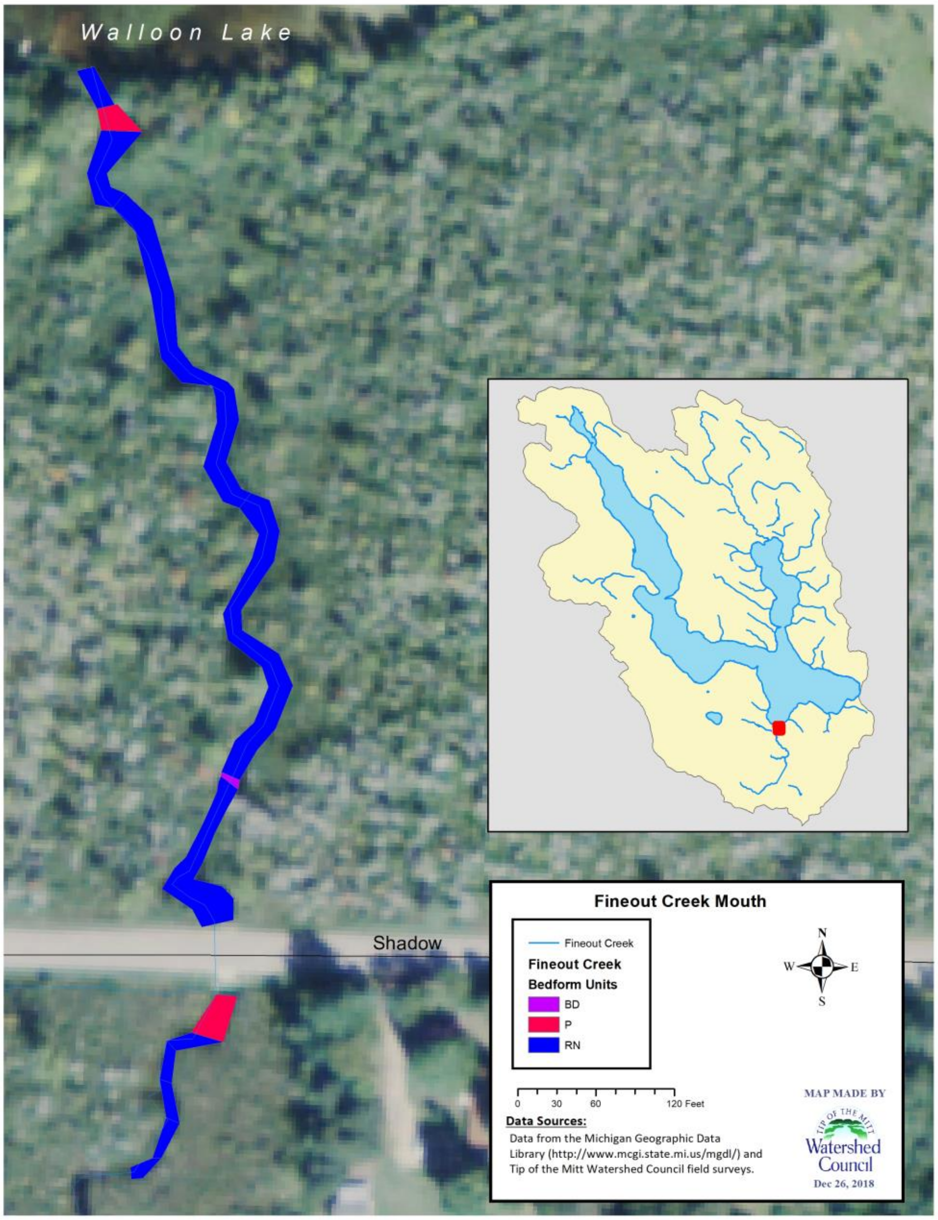


Figure 11. Fineout Creek Habitat at the Mouth

Figure 12. The new concrete box culvert on Fineout Creek/E. Shadow Trail

Figure 13. The beaver dam downstream of E. Shadow Trail/Fineout Creek

M-75 (LTB-223) had a pool on either side of the culvert, but was rated minor and allows for fish passability on www.NortherMichiganStreams.org. A few other pools were recorded, but no riffles or runs.

The overall small amounts of pool and riffle habitat types in both creeks falls far below the reference condition provided in the US Fish and Wildlife Service report: *Habitat Suitability Index Models: Brook Trout.* According to this document, optimal brook trout riverine habitat is characterized by a 1:1 pool-riffle ratio.

Large Woody Debris

Runs may provide brook trout habitat if they have gravel, large woody debris, small plunge pools, slow areas, and undercut banks. Since most of the reaches assessed in this study were dominated by runs, large woody debris (LWD) becomes especially important.

For the purposes of this study, the Watershed Council defines LWD as any piece of wood within the bankfull channel of the stream. The bankfull channel is the water level at which a stream is at the top of its banks, before it rises further and spills into the floodplain. To be counted, pieces had to be greater than four inches in diameter, and at least half of the bankfull width of the bedform unit in which it was found. If a piece of LWD failed to meet these conditions based on length, it could still be counted if greater than six inches in diameter.

Numerous studies have shown the importance of LWD in stream systems for both macroinvertebrates and fish. A 2007 study by the MDNR confirmed a positive relationship between the abundance of age class 0 – 2 brown and brook trout and the amount of LWD found within different reaches of the Au Sable River. Studies of smaller, higher gradient streams in the pacific northwest have also shown the importance of LWD inputs related to sustainable logging practices and their influence on salmonid populations.

LWD provides surface area within the stream channel for macroinvertebrates to live on, cling to, and even build cases and nets on (in the case of the caddisfly). Macroinvertebrates belonging to the scrapper-shredder functional feeding group often rely on LWD for sustenance, not by eating the wood directly, but by eating the biofilm that forms on LWD. Through additional nutrients resulting from log decomposition and formation of biofilm, the base of the stream food chain is sustained. Macroinvertebrate abundance is a product of this, and is an important food source for fish populations.

LWD in a stream not only acts to augment the food chain, but plays an important role in the morphology of a stream channel. Dave Rosgen, in his 1996 book *Applied River Morphology*, identified that at the watershed scale, streams are shaped by geology, water flow, and sediment deposition. On a local scale of stream morphology, the channel is shaped by slope, bed and bank material, riparian vegetation, and local hydrology. LWD plays a role in these factors as bed and bank material, altering flow patterns of water to create plunge pools, meanders, zones of deposition, and other small-scale channel variations. By altering stream flow, LWD actually increases the amount of time water spends in a given portion of stream, and prevents high water velocities from scouring away banks and bottom substrates.

LWD abundance in Schoof's Creek at the mouth was overall less than 200 pieces per mile, at minimum zero (Figure 13). At Resort Pike Road, Schoof's Creek had 0-100 LWD per mile (Figure 15). The amount of woody debris in both sections is well below the reference condition for upper Midwestern streams of 525 or more pieces of LWD per mile (Cordova et. al 2006).

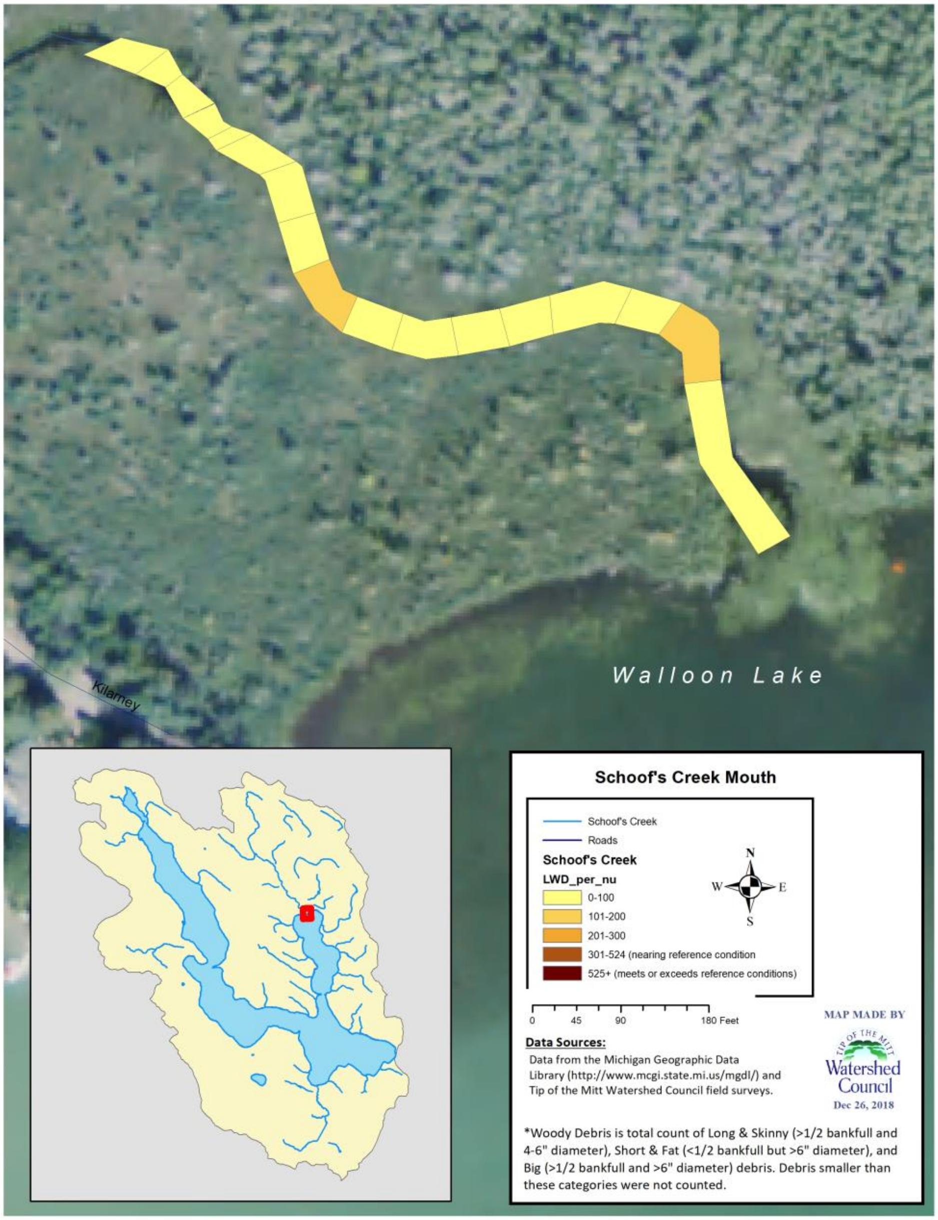


Figure 14. Schoof's Creek Large Woody Debris at the Mouth

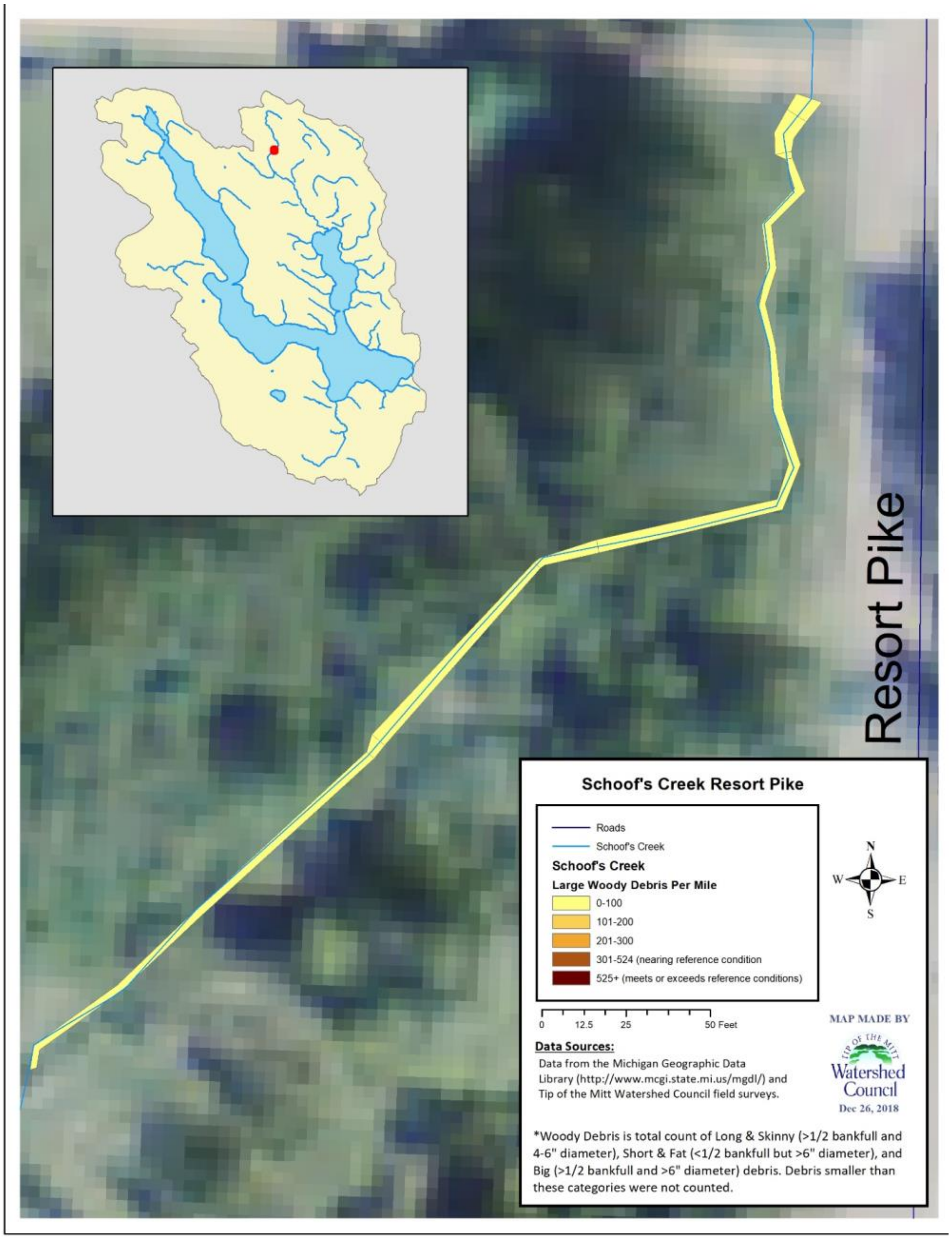


Figure 15. Schoof's Creek Large Woody Debris at Resort Pike Rd.

LWD abundance in Fineout Creek at the mouth and M-75 was 0-100 except for a small section upstream of M-75 that approached 101-200 and 201-300 ranges. The amount of woody debris in both sections is well below the reference condition for upper Midwestern streams of 525 or more pieces of LWD per mile (Cordova et. al 2006).

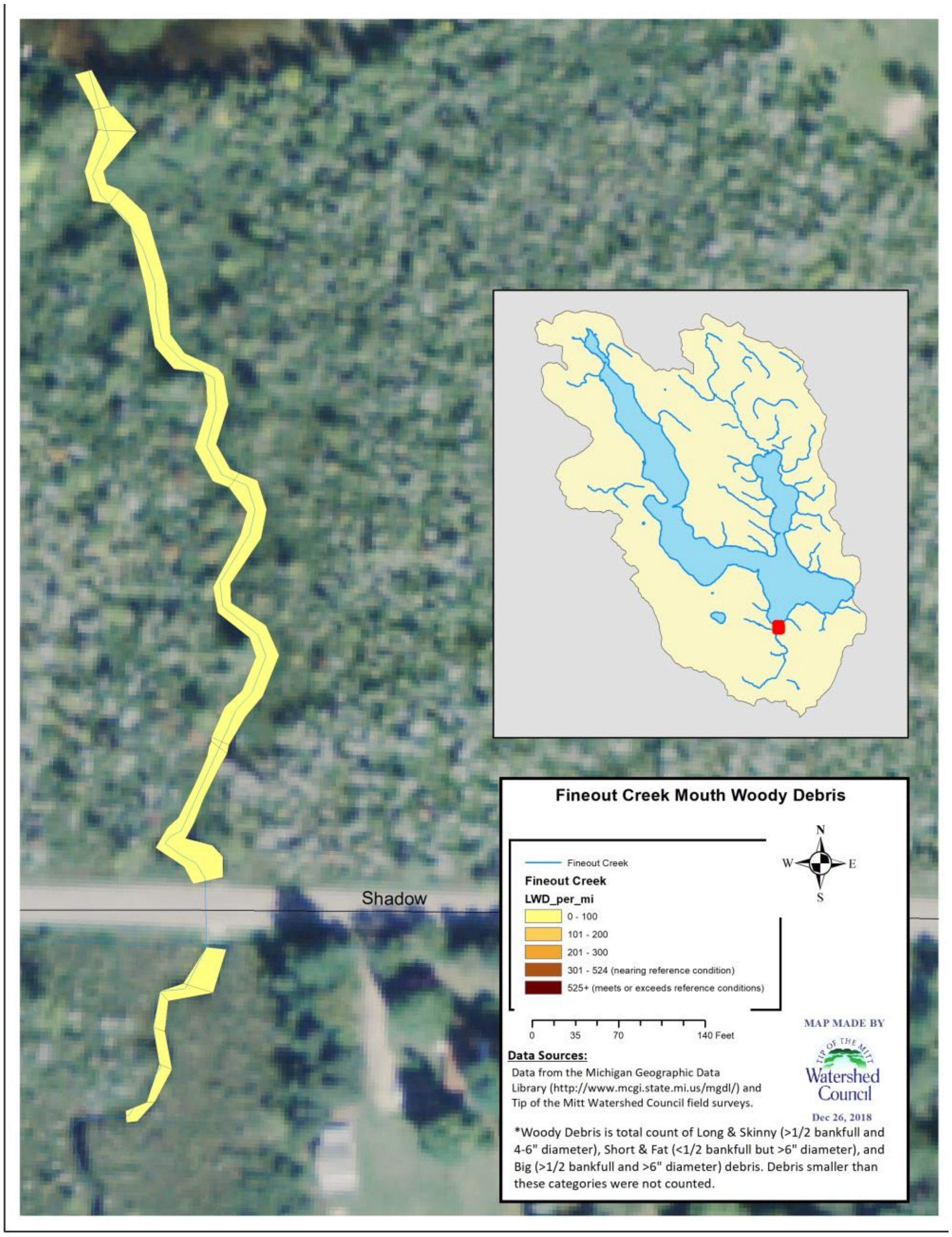


Figure 16. Fineout Creek Large Woody Debris at E. Shadow Trail

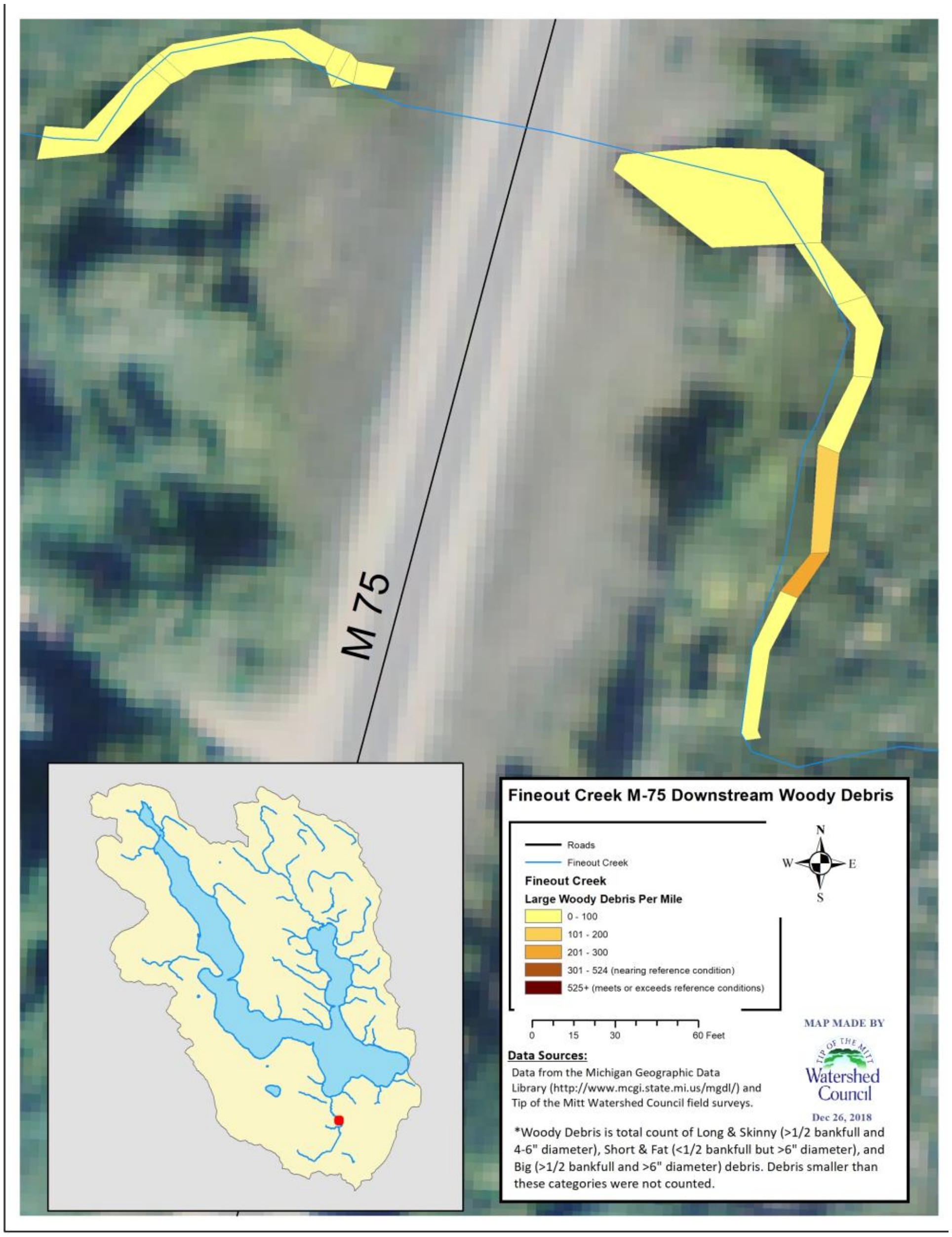


Figure 17. Fineout Creek Large Woody Debris at M-75

Stream Substrate

Stream substrate is a product of water velocity and how it moves the stream's sediment load down the channel. The sediment load of a channel is determined by the parent material of the stream bed, and also through external inputs such as bank erosion and stormwater. In a stream with stable banks and few sediment inputs, fine particulate is trapped in depositional areas of slow current, and transported away in areas of fast current. This process generates variability in substrate, which is generally desirable and encourages stream biodiversity. Gravel is necessary (as mentioned above) for trout spawning and sensitive macroinvertebrate populations. Depositional areas of organic material provide habitat for burrowing fauna and provide substrate for aquatic vegetation. When this balance is disrupted, biodiversity suffers.

There was little variability in substrate in both creeks. Schoof's Mouth was entirely organic (

Figure 18). The upper site at Resort Pike Rd. had a decent mix of gravel and cobble, but half of it was silt (Figure 19). Much of Schoof's Creek was deep and the nebulous bottom did not allow us to touch or see the substrate, which is why "no data" appears in the maps. Sand was the only other substrate observed near the mouth of Fineout Creek (Figure 20) and 1-46% was recorded downstream of M-75 (Figure 21) .

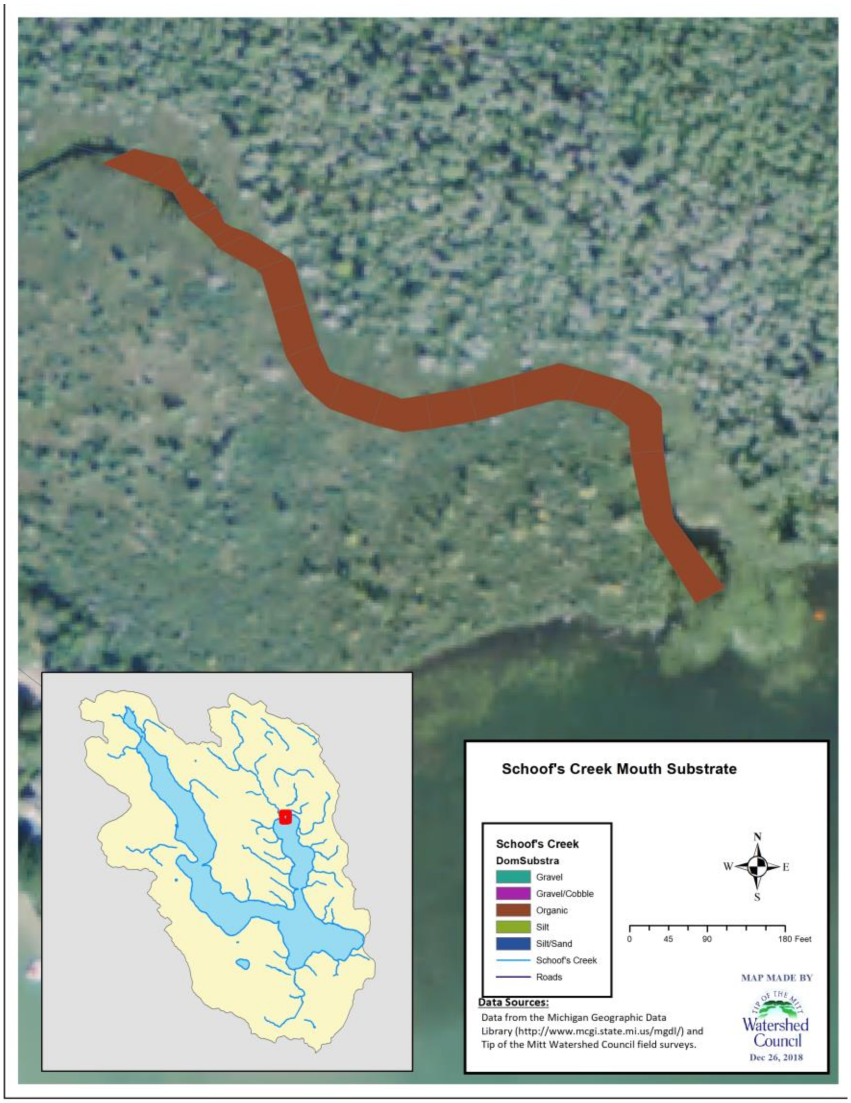


Figure 18. Schoof's Creek Substrate at the Mouth

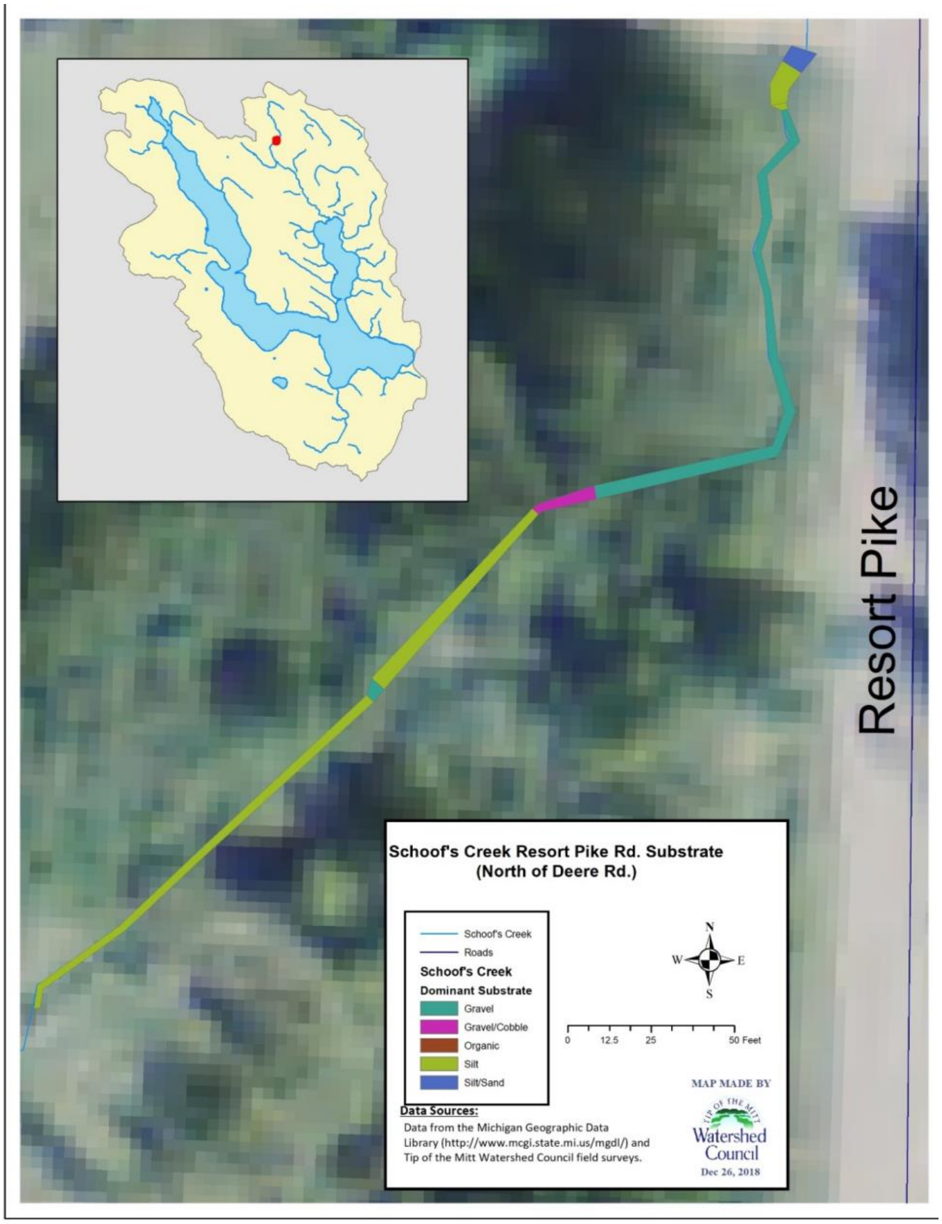


Figure 19. Schoof's Creek Substrate at Resort Pike Rd.

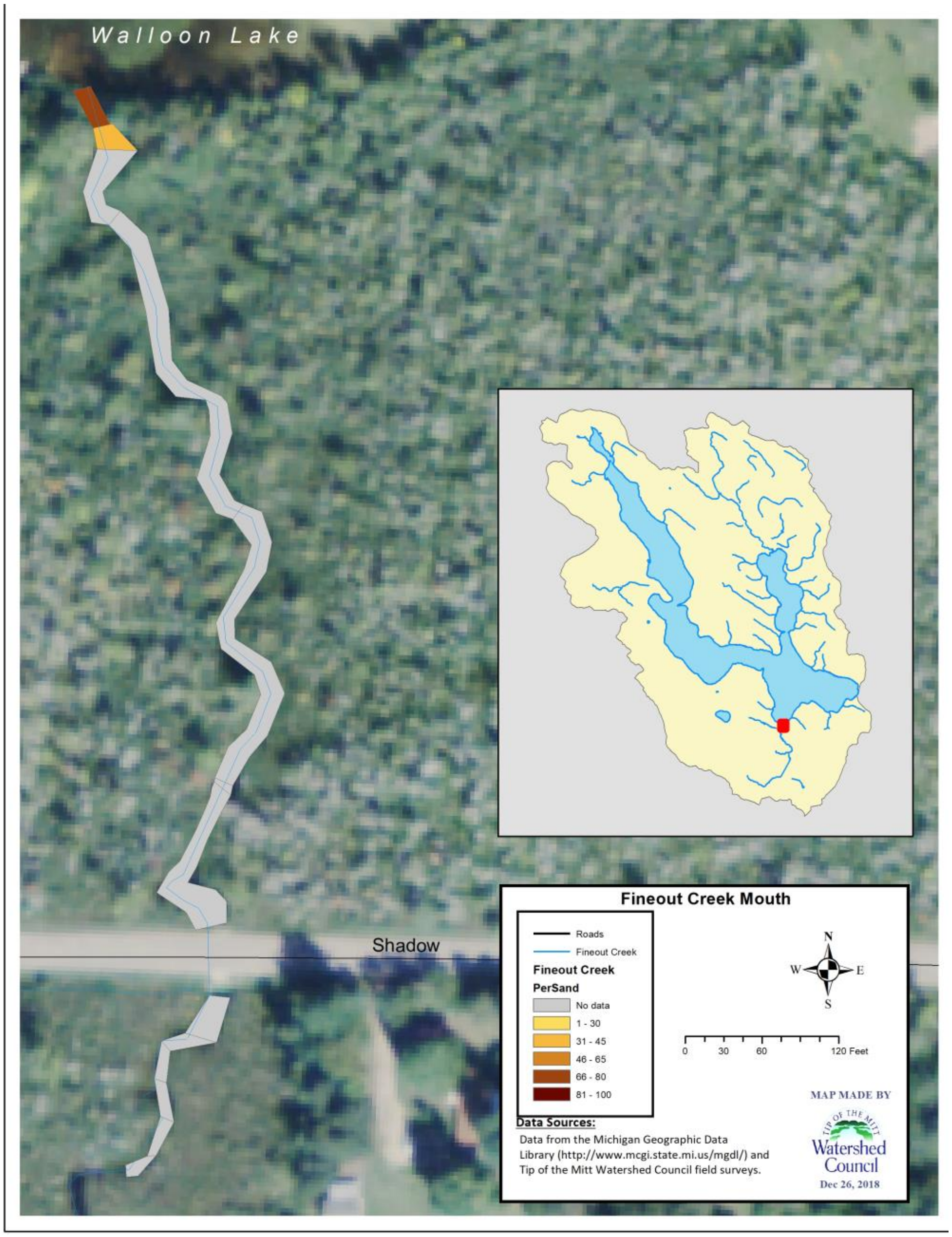


Figure 20. Fineout Creek Substrate at the Mouth

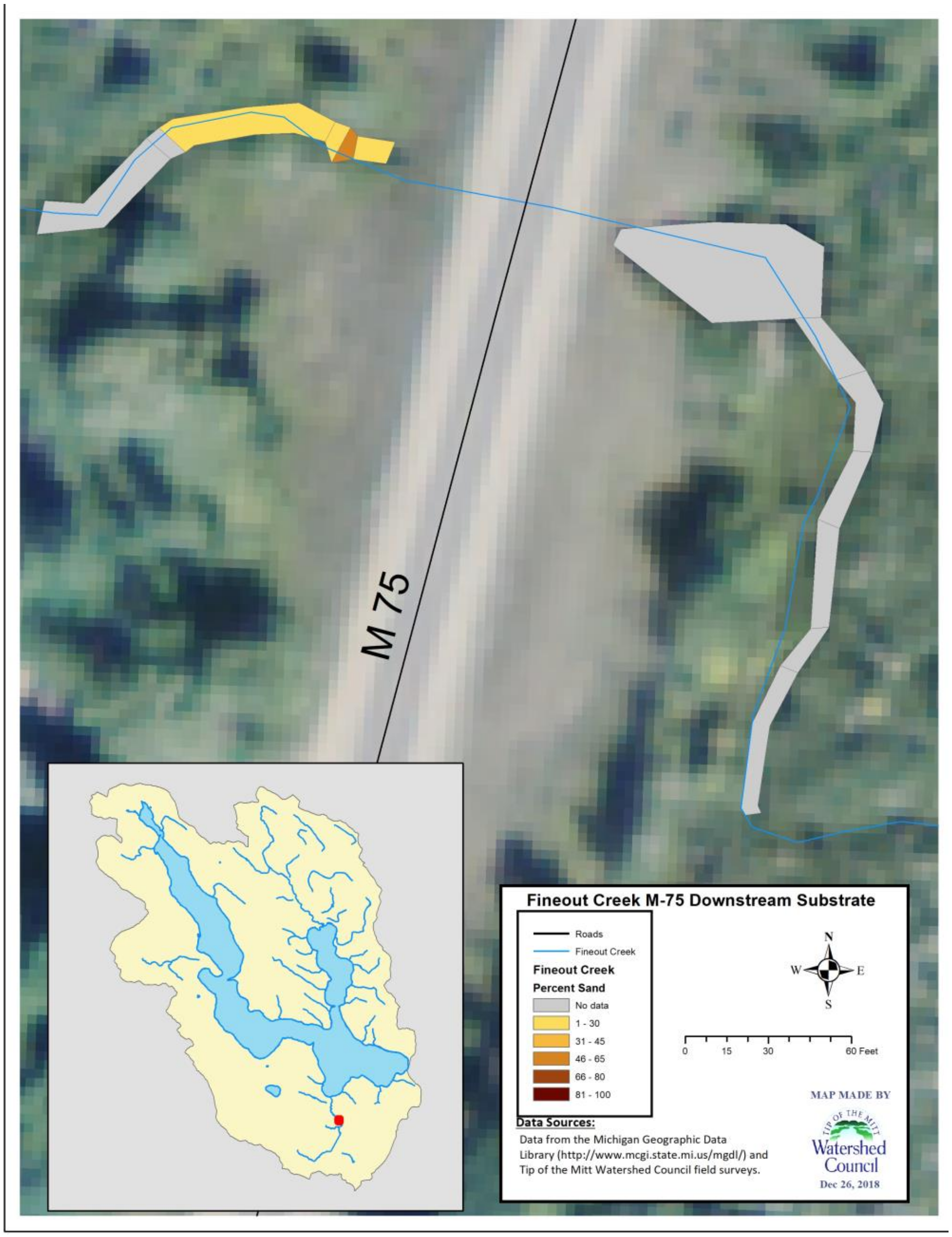


Figure 21. Fineout Creek Substrate at M-75

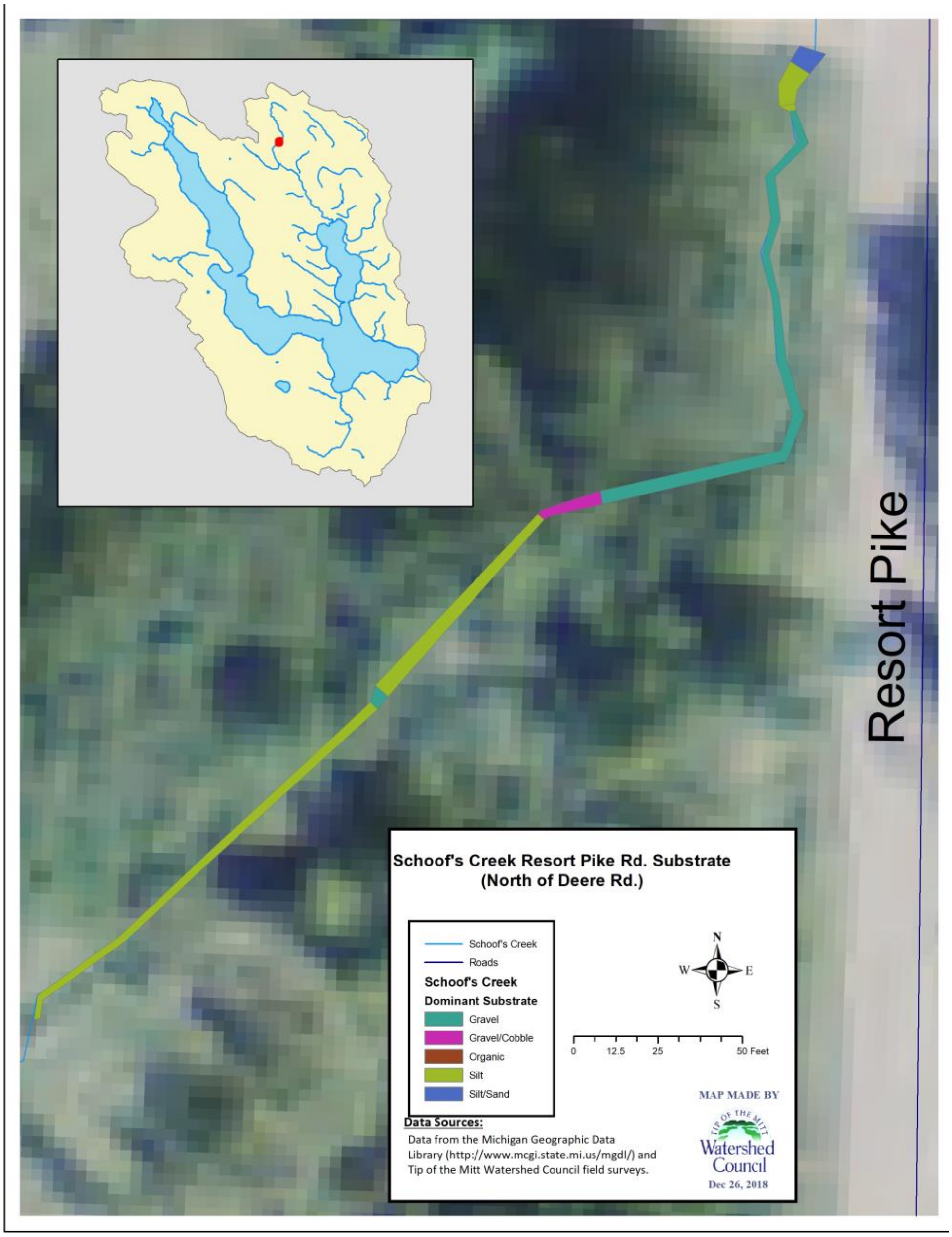


Figure 22. Substrate at Schoof's Creek/Resort Pike Rd.

Riparian Vegetation

The vegetation growing around a stream widely influences conditions within. Allochthonous inputs (material originating outside of the stream) such as sticks and leaves supplement water with nutrients as they decay. Large allochthonous inputs are considered LWD (covered above), and offer the stream many benefits. Vegetation above the steam provides shade, intercepting the warming energy of direct sunlight. Roots from vegetation prevent erosion to stream banks by holding the soil in place, and can even aid in the formation of undercut banks. Animals that use the stream for water and food benefit from the cover.

The US Fish and Wildlife Service gives the guideline: “A buffer 30 m deep, 80% of which is either well vegetated or has stable rocky stream banks, will provide adequate erosion control and maintain undercut stream banks characteristic of good trout habitat.” The vegetative cover on both Schoof's and Fineout Creeks is excellent. Schoof's at Resort Pike has an open canopy with grass/sedges in the inner zone (bankfull width) and conifer/hardwoods in the outer zone (Figure 23). Schoof's mouth also has an open canopy with grass/sedges right at the mouth and alders farther upstream (Figure 24). Its outer zone has hardwoods nearer to Walloon Lake and conifers farther upstream. Fineout Creek at M-75 has an open canopy near the road with partial to fully closed canopies of shrubs farther up and downstream (Figure 25). The inner zone is mostly grass/sedge with alders more frequent upstream. In the outer zone, conifers are more common downstream and hardwoods more common upstream. Fineout Creek's mouth is open at the crossing of E. Shadow Trail, and partial shrub the rest of the way downstream to Walloon Lake (Figure 26). The inner zone is very narrow from the canopy as the creek was at bankfull during assessment. The inner zone consists of alders associated with the partial shrub canopy and grass/sedge near the open canopy areas. The outer has alders upstream of the E. Shadow Trail and hardwoods downstream.

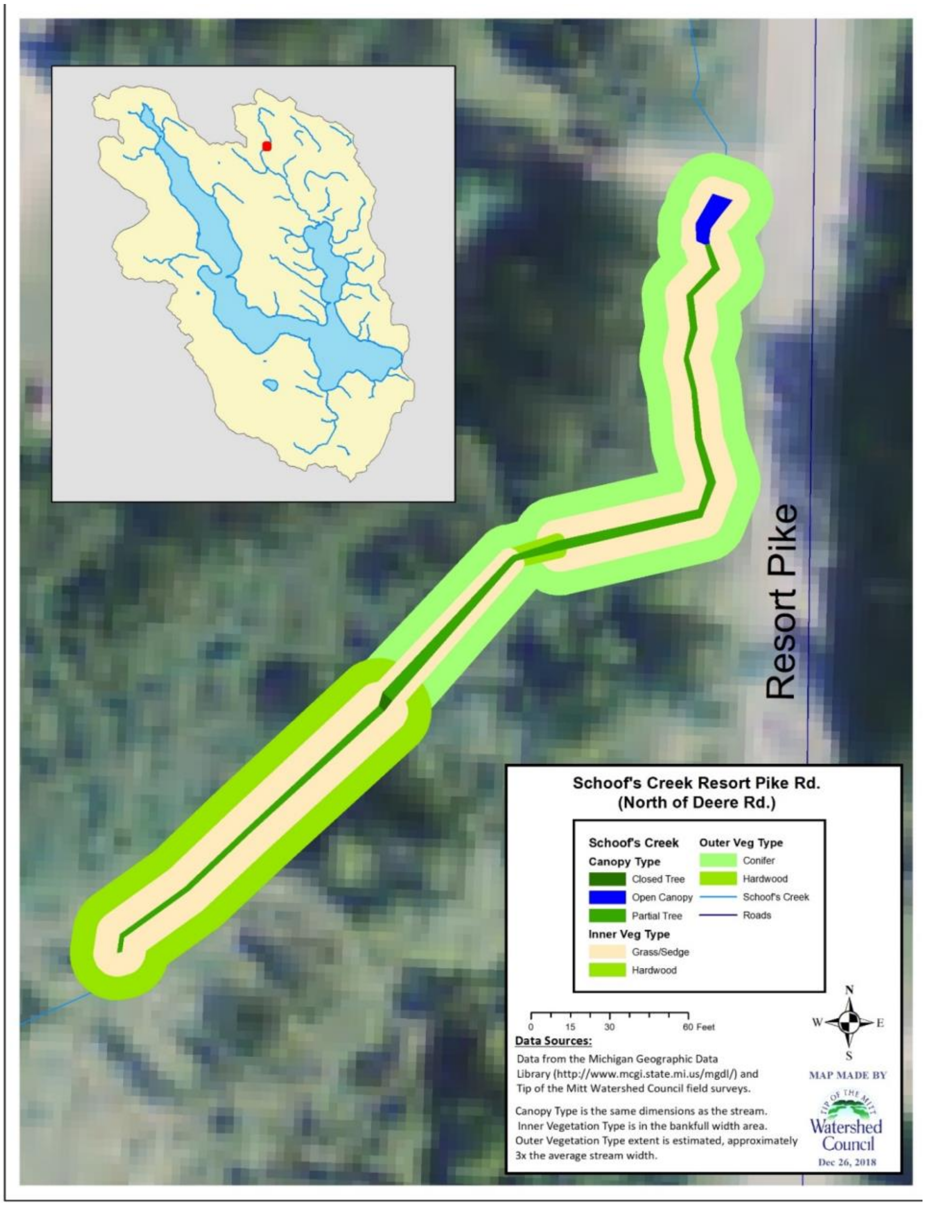


Figure 23. Canopy and riparian vegetation at Schoof's Creek/Resort Pike Rd.

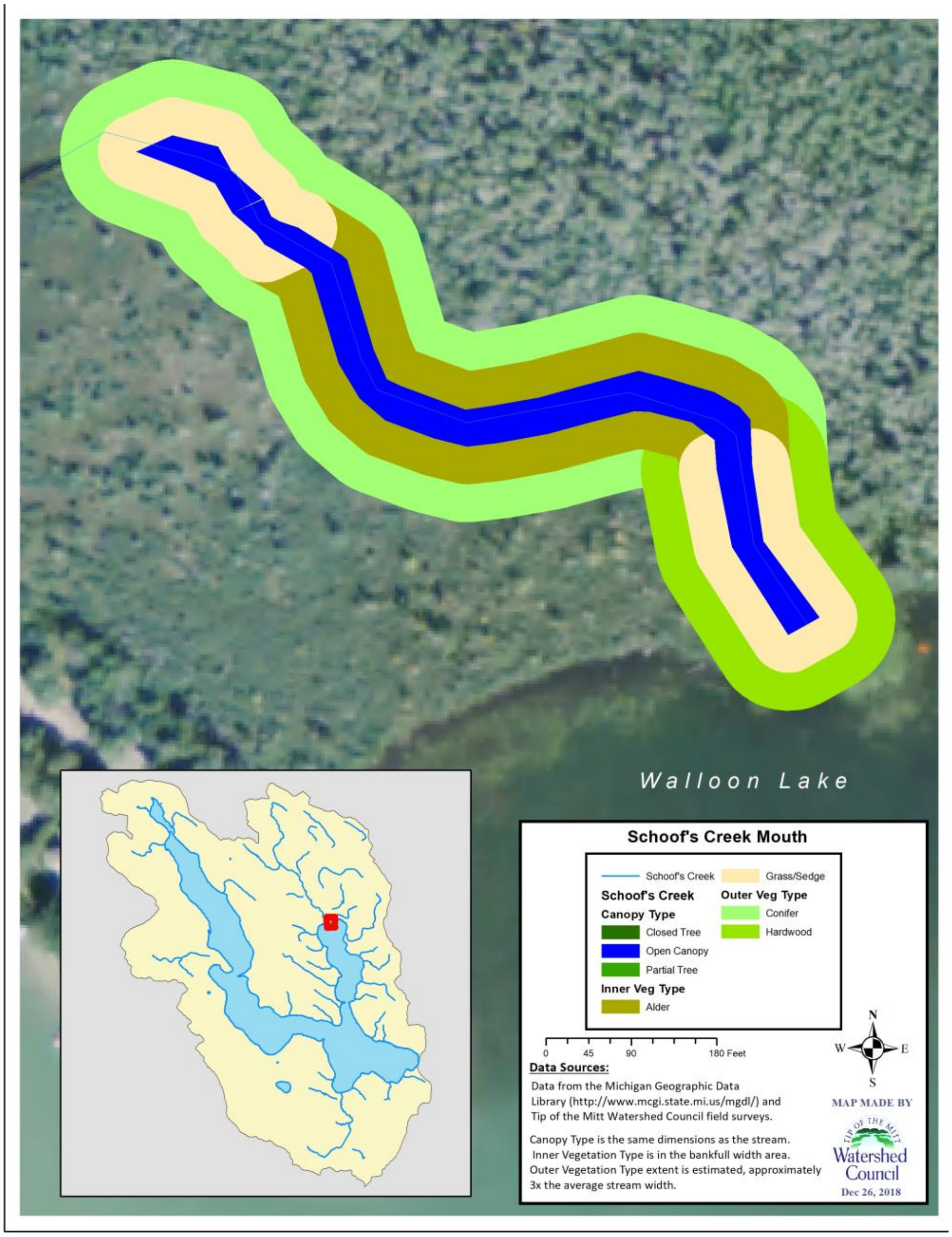


Figure 24. Canopy and riparian vegetation at Schoof's Creek Mouth

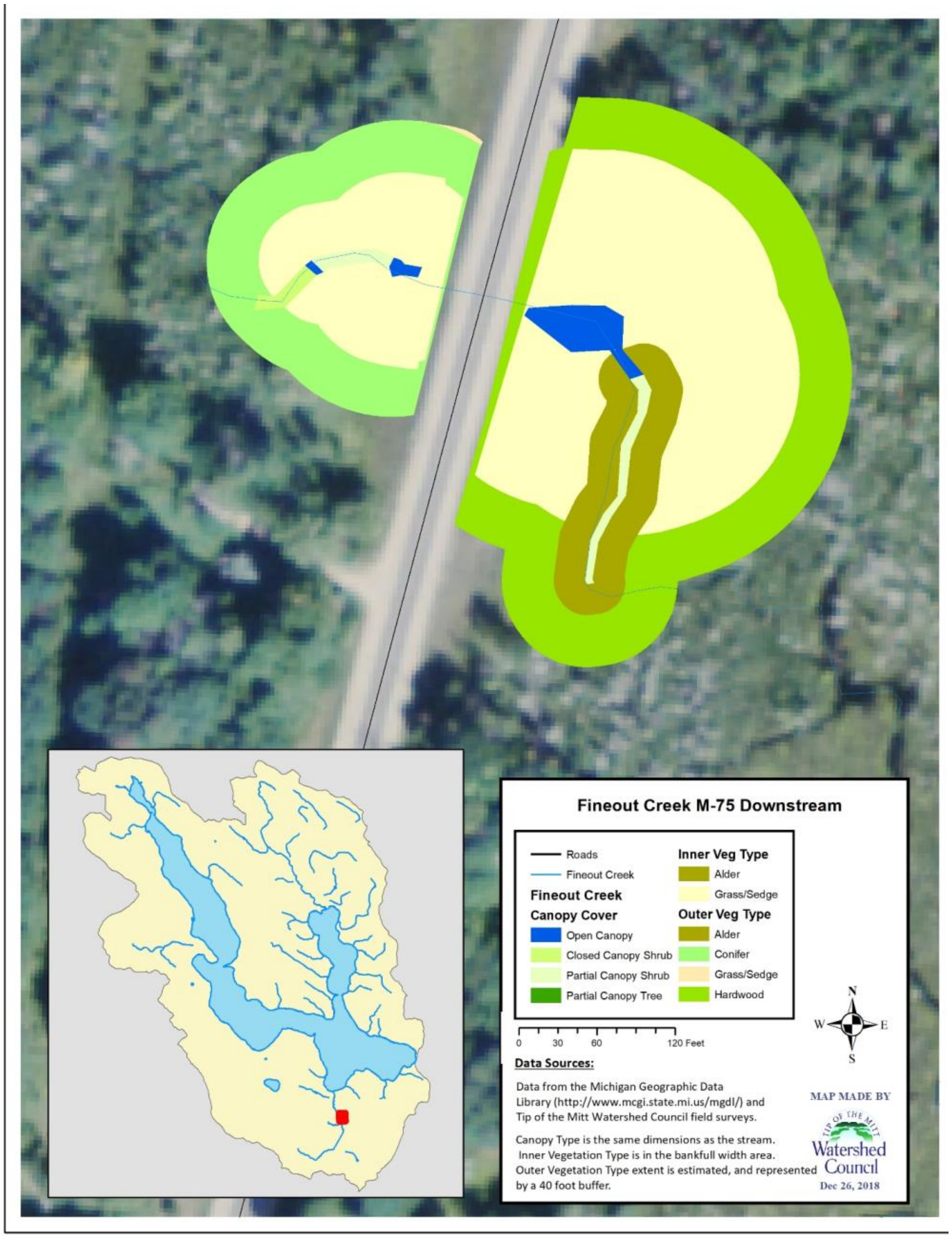


Figure 25. Canopy and riparian vegetation at Fineout Creek/M-75

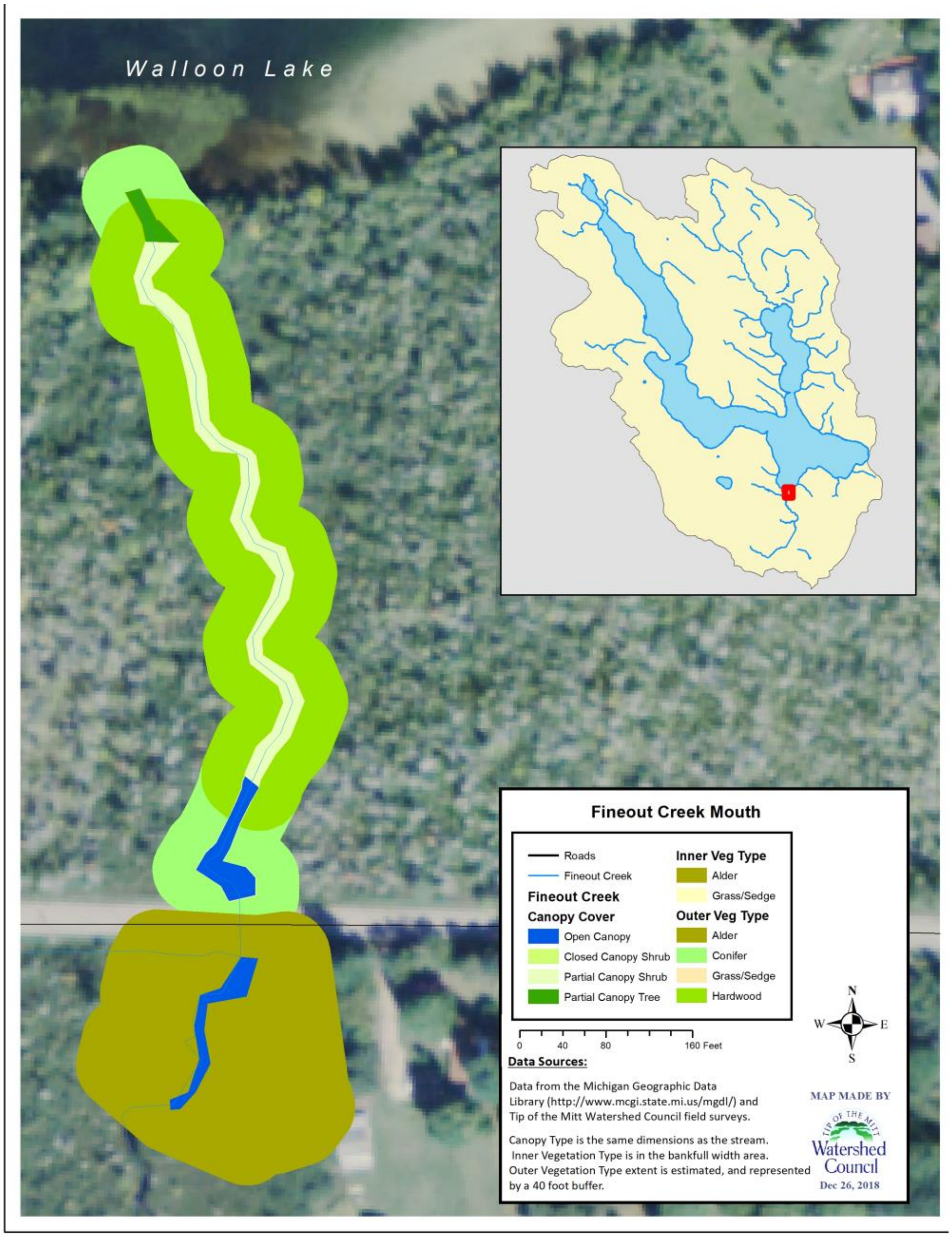
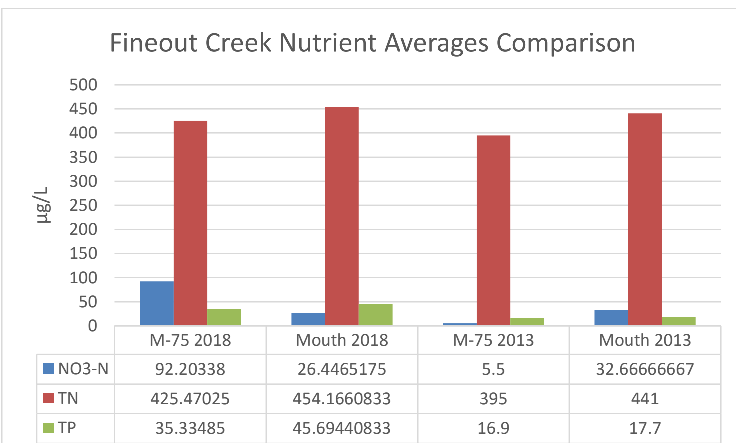


Figure 26. Canopy and riparian vegetation at Fineout Creek mouth

DISCUSSION

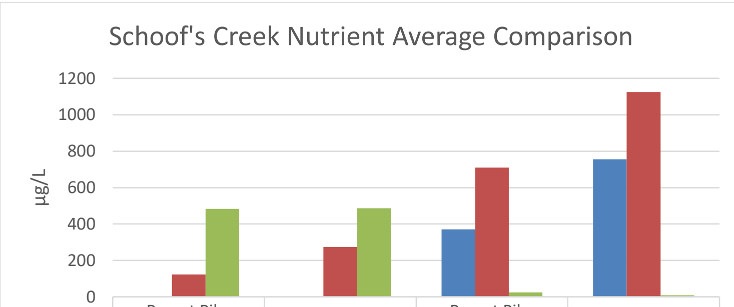
Nutrients

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 and ecological 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.



	M-75 2018	Mouth 2018	M-75 2013	Mouth 2013
NO3-N	92.20338	26.4465175	5.5	32.66666667
TN	425.47025	454.1660833	395	441
TP	35.33485	45.69440833	16.9	17.7

Figure 27. Fineout Creek Nutrient Averages Comparison from 2013 to 2018



	Resort Pike 2018	Mouth 2018	Resort Pike 2013	Mouth 2013
NO3-N	0.123607285	0.274238523	371.5	756
TN	123.607285	274.2385225	711	1124.333333
TP	483.6335	486.65475	24	9.066666667

Figure 28. Schoof's Creek Nutrient Averages Comparisons between 2013 and 2018

Nutrients were, on average, higher in Fineout Creek in 2018 than 2013 (Figure 27).

Nutrient levels between sites at Schoof's Creek in 2018 were mostly the same, except for higher TN at the mouth (Figure 28). The increase downstream is probably due to the large wetland complex's ability to increase organic nitrogen with allochthonous inputs of leaves, branches, and other plant matter. In the 2013 study, TN increased moving downstream, with a pronounced increase between Resort Pike and Williams Rd. 2018 concentrations were much lower than in 2013. While the exact cause is unknown, pollution due to agriculture may have been mitigated by best management practices. Nitrate-nitrogen was also less in 2018 than 2013, but total phosphorus increased.

Chloride, Conductivity, and Total Dissolved Solids

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 both Creeks show typical levels for streams in this region (Table 5-Table 6). Schoof's Creeks averages are higher than Fineout's, which is likely due to the fact that there is over three times the amount of agriculture in the

Schoof Creek's Watershed. This difference was also observed in data from 2013. Schoof's Creek July total dissolved solids nearly exceeded DEQ standard (Table 6).

Schoof's Creek average conductivity in 2018 was higher than in 2013. Fineout's was as well, but to a lesser extent. Chloride remained consistent from 2013 to 2018. Conductivity should be monitored in the future to ensure there is not an exceedance.

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 concentrations at Fineout Creek's mouth were low at all monitoring events (Table 7). Water temperatures were more likely to meet standards than in 2013, as there was only one temperature exceedance at the month in July. The elevated temperatures and low oxygen levels are probably due to ponding at beaver dams and undersized culverts. Additionally, 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. The crossing at M-75 seems to have enough oxygen and cold temperature to support a cold-water fishery.

The open canopy of Schoof's Creek may be contributing to warmer temperatures and low dissolved oxygen (Table 8, Figure 23, and Figure 24). 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 dissolved solids. Suspended and dissolved solids were generally found to be low in Fineout and Schoof's Creeks (Table 5 and Table 6). Total suspended solids were higher in Schoof's Creek than Fineout Creek. Total suspended solid loads were highest in both creeks in the spring. While Schoof's Creek's highest total suspended solids load correlated with a wet weather event (Table 10), Fineout Creek's highest total suspended solids load correlated with spring monitoring, which was neither wet nor dry (Table 9). The total suspended solids load may be caused more by seasonal inputs rather than discharge. Since 2013, the total suspended solids average has decreased.

Biological Assessment

The “A” grade for 2018 was similar to the 2013 score (Table 12). It is unknown what caused macroinvertebrate scores to be so low in 2017, but that year brought Schoof Creek’s overall average (including other monitoring sites) to a grade “C” (Table 13). Since 2017, total taxa, EPT taxa, and sensitive taxa increased. Future biological data would help examine changes over time and determine if 2017 was an anomaly. The “A” grade is a good sign that Schoof’s creek at Williams Road has good aquatic life habitat and high water quality.

Table 12. Macroinvertebrate score comparisons

Sample Site	Date	Total Taxa	EPT Taxa	Sensitive Taxa	Score
Williams Rd	5/23/18	23	11	5	A
Williams Road	9/27/2017	6	2	1	E
Williams Rd	2013	25	9	5	A

Table 13. Average scores of all Watershed Council streams of all time

Stream	Total Taxa Average	EPT Taxa Avg.	Sensitive Taxa Avg.	
Bear River	17.49	7.19	3.24	B
Bessey Creek	16.00	4.00	3.00	B
Boyne River	17.23	9.32	5.31	A
Carp River	18.30	7.20	4.10	A
Cedar River	20.50	8.75	5.25	A
Eastport Creek	19.26	7.08	2.85	B
Horton Creek	17.46	7.88	3.62	B
Jordan River	21.24	11.53	6.83	A
Kimberly Creek	20.82	7.64	3.73	B
Maple River	21.89	9.60	4.00	A
Minnehaha Creek	15.75	9.50	4.25	A
Milligan Creek	19.89	10.04	6.54	A
Mullett Creek	20.14	7.68	3.47	B
Pigeon River	21.54	10.65	6.54	A
Russian Creek	15.29	4.79	1.86	C
Schoofs Creek	10.67	3.67	1.50	C
Stover Creek	14.90	4.63	1.69	C
Sturgeon River	20.95	10.74	6.98	A
Tannery Creek	14.89	6.00	2.35	C

Habitat Assessments

Abundances of large woody debris were lower than reference conditions. However, undercut banks and root wads in both streams would provide fish cover. Low amounts of large woody debris may be caused by an absence of large trees due to the surrounding wetlands. Another reason may be that an abundance of runs keeps organic matter moving out of a stream, rather than having large woody debris settle into pools. No riffles were found on Fineout Creek. The mouth of Schoof's Creek had no riffles, but the Resort Pike Rd. crossing had a 1:4 pool to riffle ratio. The optimal brook trout riverine habitat is characterized by the US Fish and Wildlife Habitat Suitability Index as 1:1 pool to riffle and Resort Pike Rd./Schoof's Creek meets that. The absence of pools in both systems could be why temperatures were not consistently meeting cold-fishery standards, as pools provide depth and colder water exists at the bottom of pools.

The substrate of Schoof's creek is unlikely to support a cold-water fishery because of its mainly organic composition. Cold-water fish need gravel to spawn. The deep bottom of Fineout Creek is likely also organic. Neither creek had good variability to support greater biodiversity.

Both creeks had well-vegetated banks and buffers which benefits animals and provides shade. However, temperatures were still too high to support cold-water fisheries in some sections without shade.

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 follows:

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), Bear Creek Township, Resort Township, Evangeline Township, and Melrose Township.
2. Identify all potential sources of nutrient pollution in the watersheds of both creeks.
3. Work with appropriate organizations to address sources of nutrient pollution 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. Continue to monitor water quality of the creeks to fill in gaps and track changes. Conductivity is of priority at Schoof's Creek because it is trending towards an eventual exceedance of State standards. Continue to engage volunteer team to assist with regular aquatic macroinvertebrate monitoring in the streams as part of the Tip of the Mitt Watershed Council Volunteer Stream Monitoring Program. Develop a regular monitoring schedule.
6. 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.
7. Request that MDNR or LTBB 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. It may be helpful to consider assessment criteria for meeting wetland uses as well.
8. Consider incorporating some kind of wetland assessment to adjacent wetlands such as the Michigan Rapid Assessment Method or Floristic Quality Inventory.
9. Improve road/stream crossings and continue periodic inventories.
10. Consider if there is a need or want to remove beavers or beaver dams. Neighbors stopped by multiple times during monitoring events to discuss beaver dam removal.
11. Provide local education on the benefits of wetlands and small streams in a watershed context.
12. Conduct a historical assessment of uses of the river, especially fishing. Neighbors explained how they perceived a decrease in water quality and found that it could not support a coldwater fishery anymore. They used to catch 13" brook trout in the Creek and now they see only minnows and creek chubs.
13. Sample deep stretches of creeks using an Eckman bottom dredge for more accurate substrate analysis.
14. Sample discharge at Schoof's Creek using a deployable or remotely operated discharge meter.

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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								