Water Quality in Orbeton Stream, Madrid, Maine

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Introduction

Despite the restoration efforts of numerous groups since the 1970s, the population size of Atlantic salmon (*Salmo salar*) in Maine has remained low (USASAC 2020). Although the main stem of the Kennebec River has dams blocking access for sea-run fish, the Sandy River watershed remains highly productive for salmon, largely due to the trap-and-truck translocation of adults by the Maine Department of Marine Resources (MDMR). Within the Sandy River watershed, tributaries like Orbeton Stream have good quality spawning and rearing habitat, however salmon productivity is lower than expected. Many streams in the watershed are oligotrophic, which may result in nutrient limitation. This study investigated the hypothesis that water quality in Orbeton Stream exceeds stress thresholds or contains levels of nutrients too low for optimal salmon growth.

Methods

Study Location

Orbeton Stream is within the homeland of the Nanrantsouak (Norridgewock) Tribe of Abenakis. It has a large, primarily forested (87%) watershed of 151 km^2, with 32% conserved land, including the Appalachian National Scenic Trail corridor (National Park Service), Maine Bureau of Parks and Land, Maine Appalachian Trail Land Trust, and the Mount Abraham State Ecological Reserve (Maine Department of Environmental Protection, MDEP 2021). The watershed is primarily natural, with less than 1% development (MDEP 2021). The stream and its tributaries are assigned the Statutory Class of A under Maine's Water Classification Program (38 M.R.S.§§ 464). The area has a history of industrial logging. The bedrock geology in the upper Orbeton watershed is predominantly granite, while the lower portion is marine sandstone, slate, and shales (Maine Geological Survey - MGS 1985). Surficial geology is primarily glacially deposited sand, silt, clay and stones, till with some glaciofluvial deposits and eskers. In 2020, 53 adult salmon returned to the Kennebec River (MDMR data) and were relocated to the Sandy River watershed. Orbeton Stream had 22 redds in 2020, second only to the Sandy River mainstem, which had 59 redds (MDMR data). MDMR has regularly stocked Orbeton Stream since 2010, and the median relative abundance of parr from 2018-2020 was 1.25 catch per unit effort (CPUE; MDMR data).

Two locations in Orbeton Stream were monitored for water quality (Fig. 1): KSDOB70 upstream of the Potato Hill Rd crossing, and upstream of the confluence with Hardy Brook, and KSDOB39 upstream of Reeds Mill. Results were compared with data collected in Mt. Blue Stream, KSDMB11, one of the most productive salmon streams in the Sandy River watershed according to MDMR (median relative abundance of parr 1.82 CPUE, with the largest and likely healthiest juveniles in the watershed). Mt. Blue Stream has a primarily forested (89%) watershed of 31.6 km^2, with only 1% development (MDEP 2021), underlain by marine sandstone and slate and some granite bedrock (MGS 1985). No redds were observed in 2020 in Mt. Blue Stream, however this is not surprising due to an alluvial fan that constricts passage at low flows, such as occurred in 2020.

Water Quality

At the two Orbeton Stream locations and at Mt. Blue Stream, continuous monitoring devices were deployed May 27, 2020, as in Zimmermann (2018a). Technical issues in Mt. Blue Stream prevented data recording until June 24, 2020. Measurements of temperature, specific

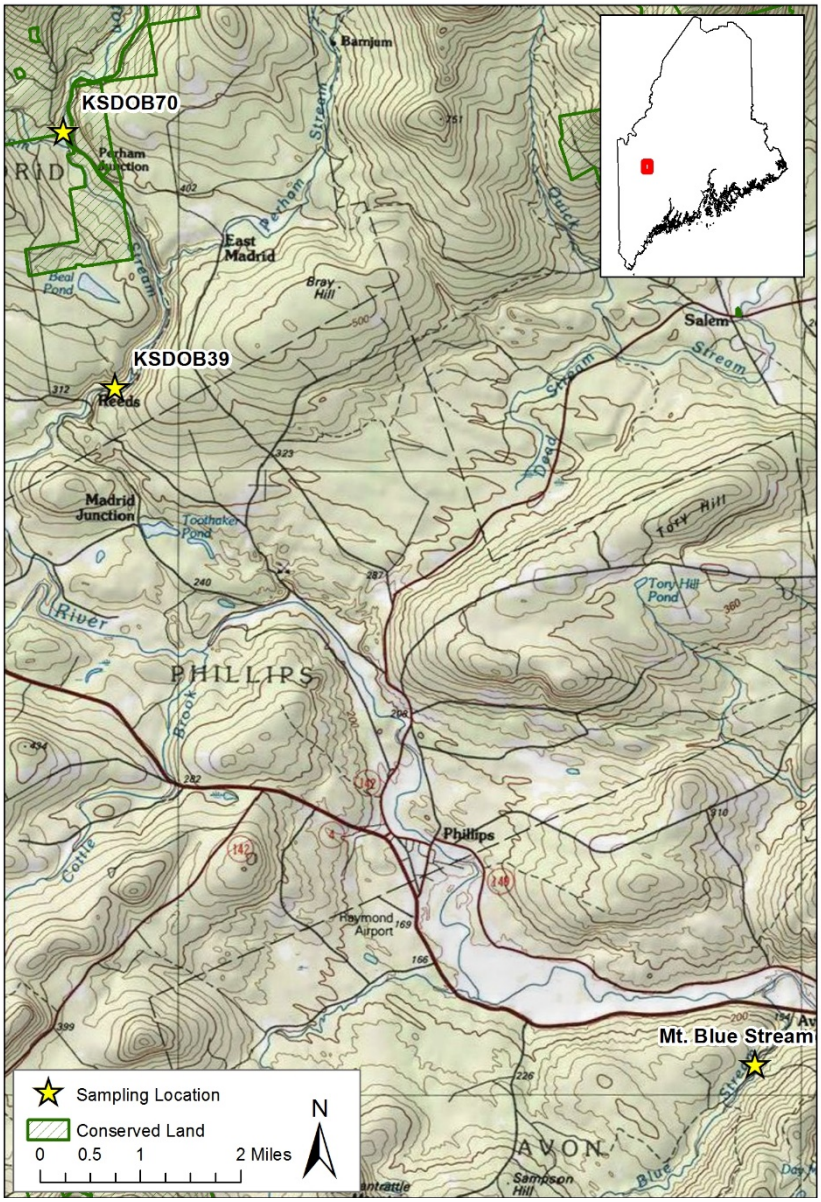

Figure 1. Map of the study sites on Orbeton Stream (KSDOB70 and KSDOB39) and Mt. Blue Stream.

conductance, pH, and dissolved oxygen (DO) were collected every 30 minutes using YSI 6000 EDS sondes in Orbeton Stream, and a Eureka Manta+ 20 sonde in Mt. Blue Stream. Sondes were cleaned and calibrated every four weeks until retrieval on October 14, 2020. Continuous data were corrected as needed based on quality control procedures as described in MDEP (2016) and using a Eureka Manta2 Sub2 sonde as a field meter. Grab samples for calcium, dissolved organic carbon (DOC), acid neutralization capacity (ANC), and closed-cell pH were collected in June, August, and October from each sample location, following the methods in Zimmermann (2018a). Grab samples for total phosphorus, total Kjeldahl nitrogen (TKN), and nitrate + nitrite as nitrogen were also collected in June and October.

Macroinvertebrates

Rock bags were deployed at Mt. Blue Stream in July 2020 and retrieved in August 2020, following MDEP's Biological Monitoring Program's sampling methods (MDEP 2014). The same methods were used by the MDEP's Biological Monitoring Program to collect data from the lower Orbeton Stream location in 2017.

Data visualization

Water quality data were analyzed using the Water Resources Database 6.1.0.71 (Wilson Engineering 2020) and R 3.5.2 (R Core Team 2018). Figure 3 was created using *ggplot2* (Wickham 2009). All data are presented as mean ± standard deviation, unless otherwise stated. Quality control issues caused 21% of all pH data combined across all sites to be rejected. Equipment malfunction caused 16% of data from each parameter to be rejected combined across all sites. Results from prior

sampling efforts in the study area were queried from the MDEP Environmental and Geographic Analysis Database (EGAD) for comparison purposes (MDEP 2021).

Results and Discussion

Weather

Maine experienced a mild winter followed by cold, wet weather in late spring 2020 (NOAA 2020a). Drought developed in June and lasted throughout the record-breaking warm summer (U.S. Drought Monitor, 2020; NOAA 2020b; Weather Underground 2020). Low flows and hot air temperatures may have contributed to stressful conditions for salmonids and other fishes by preventing access to cold water refuges.

pH

The impacts of acidity depend on 1.) duration, magnitude, and frequency of the episode, 2.) the ability of the fish to avoid adverse water quality conditions, 3.) the concentration of exchangeable aluminum (Alx), and 4.) the buffering capacity of the water (i.e., ANC and calcium; see Zimmermann 2018a for overview). pH thresholds used in this analysis are estimates of anticipated impacts to salmon populations and do not include a detailed analysis of the impact of other factors.

Orbeton Stream stayed above the threshold of 6.5, an optimal minimum pH for the protection of the most sensitive salmon life stages (alevins and smolts), for the majority of the study duration (93%; Fig. 2; Kroglund and Staurnes 1999; Kroglund et al. 2008). The upstream location fell below 6.5 for 2% of the study. Rain caused the pH to remain below 6.5 for approximately one day in July (following three days of more than 30 mm of rain), and for 13 hours in October (following more than 60 mm of rain; Weather Underground 2020). The downstream location fell below 6.5 for 13% of the study, lasting for an average of 11 hours (ranging from 30 minutes to 3.5 days). The July storm resulted in a pH decrease of around 0.6

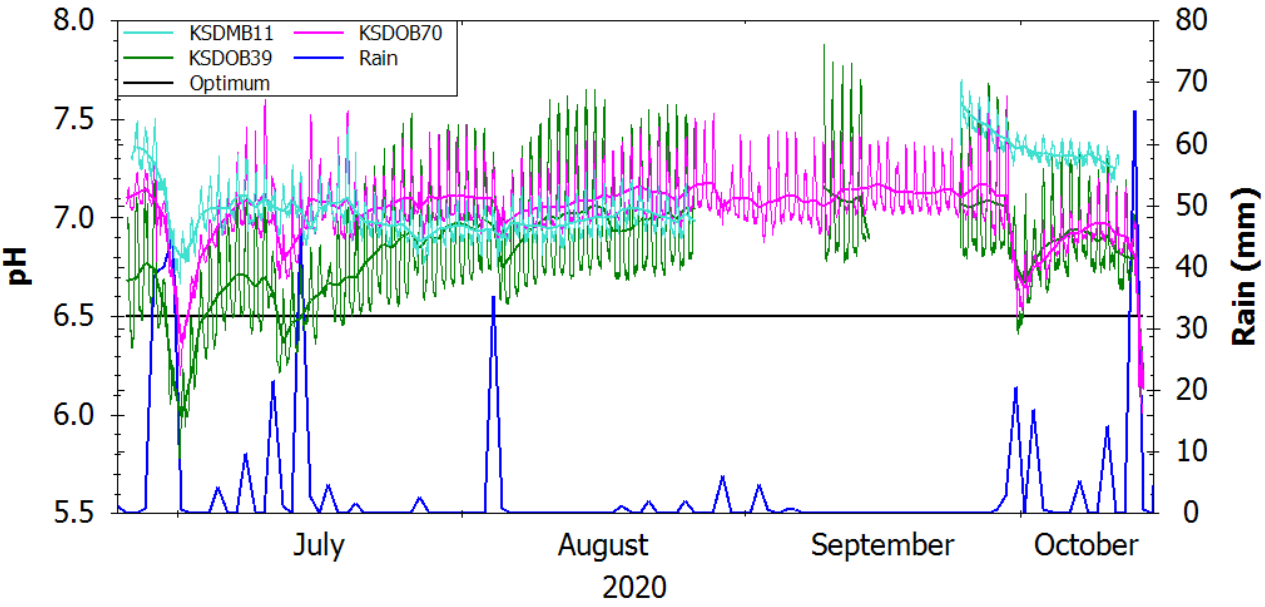

Figure 2. Continuous pH and local rainfall. The pH record for Mt. Blue Stream from late September to October is suspect and was excluded from analyses. Rainfall data from Weather Underground station KMEPHILL3.

units at all sites, with recovery to pre-storm pH within 6 days. The minimum pH value observed was 0.28 units above the critical stress threshold of 5.5, above which no adverse impacts to salmon populations are expected (Haines et al. 1990; Stanley and Trial 1995). Mean pH in Orbeton Stream (both sites combined) was 6.94 ± 0.28, and the pH was on average 0.2 units higher upstream compared to downstream. Similar mean values were observed in the summers of 2007 and 2012, with higher pH minima of 6.5 in 2007 and 7.2 in 2012 (n = 6 each year; MDEP 2021). The mean diel range in pH was 0.5 units, with the largest fluctuations (up to 1 unit) occurring at the downstream site. Rain events had a significant impact on pH when rainfall amounts exceeded 30 mm, especially after prolonged dry weather. A steep decline was observed following a large rain event (65 mm) in mid-October just before the sondes were retrieved. Mean pH in Mt. Blue Stream was similar, 7.01 ± 0.12, with a smaller diel range of 0.2 units. No significant negative impacts to salmon are expected from pH in the study area, despite rainfall driven declines.

Stream Temperature

Salmon prefer cold waters. Temperature was similar at all three sites, remaining above the threshold for optimal growth of 20°C for 17% of the study duration (Fig. 3; Jonsson et al. 2001; USEPA 1986). The stress threshold of 22°C, when salmon start to exhibit stress physiologically and behaviorally (e.g., stop feeding, seek cold water refuges), was exceeded only 6% of the time during the summer, similar to observations from the summers of 2007 and 2012 (Cunjak et al. 2005; Elliott and Elliott 2010; Lund et al. 2002; MDEP 2021). The summer of 2017 only saw 0.5% exceedances of the stress threshold, indicating a significantly cooler summer (MDEP 2021). Maximum temperatures for survival (26-27°C for adults, 28-29°C for parr) were never exceeded in 2020, despite the hot, dry summer (Elliott 1991 as cited in Stanley and Trial 1995; Garside 1973 as cited in Lund et al. 2002; Grande and Andersen 1991 as cited in Elliott and Elliott 2010; Shepard 1995 as cited in Frechette et al. 2018). It is possible that thermal stress occurred in 2020 during the warmest months (July to August), when temperatures remained above 22°C for 5.3 hours on average, with a maximum duration of 10.5 hours. Mean diel fluctuations were 4.23 ± 1.83°C, which likely provided daily thermal refugia for salmon during thermally stressful periods. In the study area, high temperatures may cause brief sublethal stress and reduced growth in salmon during the warmest months of July and August, however nightly temperature refugia may help mitigate any impacts.

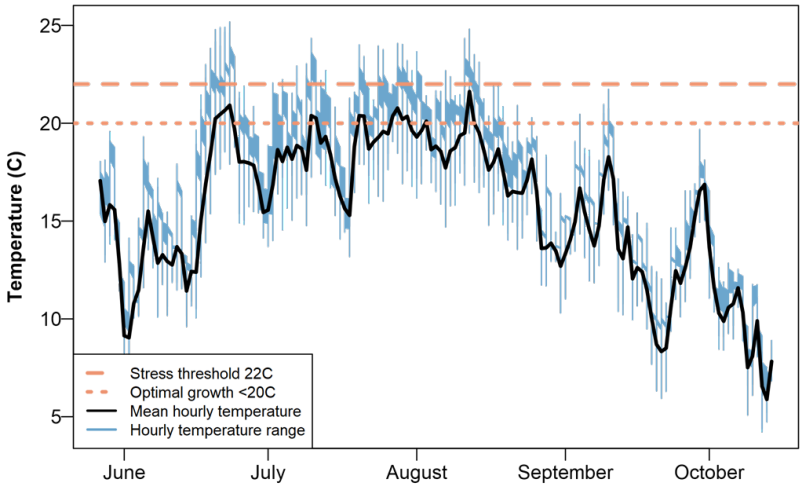

Figure 3. Mean hourly temperature at all study sites, May through October. Optimal growth limit from USEPA 1986. Stress threshold from Cunjak et al. 2005; Elliott and Elliott 2010; Lund et al. 2002.

Dissolved Oxygen (DO)

Salmon prefer well oxygenated waters. DO levels were within a healthy range for fish and aquatic life and remained above the Maine Water Quality Standard minimum criterion value

of 7 mg/L, which is also the preferred threshold for salmon (38 MRS Section 465.2.B; Stanley and Trial 1995). Mean DO for the study period was 9.6 ± 0.9 mg/L across all study sites (Appendix II, Table 1), reaching a minimum of 7.8 mg/L. Similar DO levels were observed in the summers of 2007 and 2012 (n = 5 and 6, respectively; MDEP 2021). No adverse impacts due to DO are expected.

Specific Conductance

Specific conductance is a measure of the concentration of ions in the water, or the ability of water to conduct electricity. Mean specific conductance was 27 ± 6 µS/cm (Appendix II, Table 1). Similar levels were observed in Orbeton Stream and its tributaries in the summers of 2007 and 2012 (n = 6 for each year; MDEP 2021). In comparison, specific conductance in two large, pristine river systems, Wassataquoik Stream and the East Branch Penobscot River, were very similar to the study streams (Zimmermann 2018b; Zimmermann 2019). No adverse impacts due to specific conductance are expected.

Acid Neutralization Capacity (ANC)

Streams with higher ANC have a higher capacity to buffer against changes in acidity. ANC was higher by about 50 µeq/L at Mt. Blue Stream (209.7 ± 52.4 µeq/L, 10.5 mg/L alkalinity) compared with the two Orbeton Stream sites (138.6 ± 64.2 µeq/L, 6.9 mg/L alkalinity). Values at both sites were above the threshold of acid sensitivity of 50 µeq/L (Driscoll et al. 2001), and the Norwegian 20-30 µeq/L critical limits for salmon (Baker et al. 1990; Lien et al. 1996; Kroglund et al. 2002). ANC minima (<100 µeq/L) occurred in Orbeton Stream in October after heavy rain (65 mm). ANC >100 µeq/L is necessary for maintenance of sufficient calcium concentrations (>2 mg/l; Brocksen et al. 1992). Higher ANC also provides greater buffering capacity and correlates with higher pH (lower acidity) and less volatile swings in pH (Potter 1982). Mt. Blue had the highest ANC and the smallest pH diel range, as compared with the Orbeton Stream sites. No samples at Orbeton or Mt. Blue Streams were above USEPA's recommended ambient water quality criteria (AWQC) for alkalinity of 20 mg/L, however this threshold does not apply where values are naturally lower (USEPA 1986). Based on ANC values, Orbeton Stream has reduced buffering capacity following autumn rain events, which could allow for sublethal stress to fish during episodic acidification. No stressful acidity events were observed during the 2020 study in Orbeton Stream, however larger rain events in the fall or rain-on-snow events in the spring may reduce pH to a stressful level (<5.5).

Calcium

Higher calcium values enable more growth in fish. Calcium buffers the detrimental impacts of exchangeable aluminum (Alx) by increasing the efficiency of ion regulation (Baldigo and Murdoch 2007; MacDonald et al. 1980). Orbeton Stream calcium levels (1.9 ± 0.3 mg/L) were near the survival threshold for salmon of 2 mg/L (Baker et al. 1990; Baldigo and Murdoch 2007). Buffering capacity is reduced when calcium concentrations are around 2 mg/L and when pH is <6.5 (Baker et al. 1990; Baldigo and Murdoch 2007). In Orbeton Stream, Alx buffering capacity may be lost following rain events, especially at pH less than 6.0 when the solubility (and therefore toxicity) of aluminum is increased (USEPA 2018). No aluminum data were collected in 2020, so it is unknown if aluminum levels in the study streams are at stressful levels, however the primarily circumneutral pH values observed suggest aluminum toxicity was not an issue during the study period. If episodic acidity events with pH <6.0 occur in Orbeton Stream,

such as in the fall or spring, sampling of aluminum species is recommended. In comparison, Mt. Blue Stream maintains calcium levels that allow for buffering. Mt. Blue Stream had higher calcium (3.5 ± 0.3 mg/L), with baseflow levels approaching the suggested threshold of 4 mg/L to prevent deformities and other stress (Marcus et al. 1986, as cited in Brocksen et al. 1992).

Dissolved Organic Carbon (DOC)

DOC has been shown to be a strong determinant of fish mortality (for brook trout, Baldigo and Murdoch 2007) due to its buffering capacity and can be used as an indicator of organic acidity to determine the role of anthropogenic activity in acidic streams (Monteith et al. 2007; Schiff et al. 1998 as cited in Clair and Hindar 2005). DOC can buffer against the toxic impacts of exchangeable aluminum, by binding the aluminum into inert organic complexes when the concentration o fDOC is greater than 2.0-5.0 mg/L and pH is above 5.5 (Baldigo and Murdoch 2007; Kroglund et al. 2008; Tipping et al. 1991). Baseflow DOC was similar at all study sites, averaging 3.1 ± 1.0 mg/L across all study sites, with highest values (13.5 ± 0.7 mg/L) observed in October after heavy rain (65 mm). Baseflow values were similar to the clear waters of Wassataquoik Stream (3.2 ± 0.6 mg/L; Zimmermann 2019). In the study sites, buffering capacity from DOC is potentially available when the risk of negative impacts from Alx are highest, following rainfall when pH and calcium values are lowest.

Nutrients

In Orbeton Stream, biologically available nitrogen (nitrate + nitrite as nitrogen) was 0.031 ± 0.007 mg/L. During baseflow, this was less than half compared with Mt. Blue Stream (0.091 mg/L), but levels were similar in the autumn at all sites. TKN was similar at all sites, averaging 0.32 ± 0.22 mg/L, however several values were below the reporting limit, so values should be treated as approximations. In Orbeton Stream, TKN increased in the autumn following a large rain event, likely due to leaf drop and other natural sources, however the increase was larger at the upstream site than the downstream site. This may be due to more intensive forest harvest or soil disturbance in the upper watershed, or dilution at the downstream location due to increased stream size. Total phosphorus was 10.5 ± 5.3 µg/L, averaged across all study sites, with values more than twice as high in the autumn following a large rain event compared with baseflow. Baseflow nutrients in Orbeton Stream were similar to observations in the summers of 2007 and 2012 (n = 2 per year; MDEP 2021). Baseflow biologically available nitrogen in Orbeton Stream was similar to Wassataquoik Stream, an oligotrophic system (Zimmermann 2019), with values 66% lower than in Mt. Blue Stream. Although biologically available nitrogen in Orbeton Stream was similar to oligotrophic systems, nutrients at both Orbeton and Mt. Blue streams were typical of natural, minimally disturbed streams in Maine.

Macroinvertebrates

The water quality of Orbeton and Mt. Blue Streams supports a robust macroinvertebrate community that attains Maine's highest aquatic life water quality classification (Appendix III, 38 M.R.S.§§ 465; Davies et al. 2016). In 2020, Mount Blue Stream had higher total mean abundance (315) and generic richness (66) compared with Orbeton Stream (176 and 39 respectively in 2017; Appendix II, Table 3), however Orbeton Stream was still comparable with other Class A waterbodies in the state. EPT taxa (mayflies, stoneflies, and caddisflies) represented 37% and 23% of the community at Mount Blue and Orbeton Streams, respectively. The dominant taxa in Orbeton Stream were filter feeding caddisflies (*Hydropsyche*), however

both Orbeton and Mount Blue Streams also had mayflies (*Baetis*) as a dominant species. The lack of a singular dominant taxon in Mount Blue Stream is indicative of a more balanced community, as evidenced by the high Shannon-Wiener diversity index (4.50, as compared to 3.61 in Orbeton Stream in 2017). In addition, the presence in Mt. Blue Stream of taxa that require multiple years for their life cycles, including hellgrammites and dragonflies, indicates long-term good water quality. The macroinvertebrate assemblage in both study streams contains a variety of sensitive taxa typical of clear, oligotrophic-mesotrophic systems. Mount Blue Stream is exceptional in terms of diversity and EPT relative abundance. Salmon are thought to be opportunistic feeders, changing their diet to the most abundant prey available, which often includes the larvae of mayflies, chironomids, caddisflies, blackflies, stoneflies, annelids, and mollusks (Scott and Crossman 1973 as cited in Stanley and Trial 1995). Although of lower abundance and diversity in Orbeton Stream, macroinvertebrates are not likely a limiting factor to salmon productivity.

Conclusion

The water quality in Orbeton and Mt. Blue Streams is good for salmon growth and development. Both Orbeton and Mt. Blue Streams experienced rainfall-driven episodic pH depressions, but these depressions were of short duration and likely did not have a significant impact on salmon growth due to the overall high pH. Buffering capacity (based on ANC and calcium) is lower in Orbeton Stream, which could result in detrimental pH depressions. If future episodic acidity events occur in Orbeton Stream, it is recommended to sample for aluminum species, ANC, calcium, and DOC to determine if toxic aluminum is a factor in the low productivity of salmon. In both study streams, high summer water temperatures could lead to sub-lethal stress or avoidance behavior in salmon. The most sensitive life stages of salmon (from hatch to swim up and smolts) are not present during the summer when most of the temperature maxima occur. However, sub-lethal stresses, such as thermal stress, are cumulative and can cause detrimental impacts to growth and survival. Water temperature may be the most stressful aspect of water quality for salmon growth in Orbeton and Mt. Blue Streams, especially during drought conditions like those observed in 2020. In both study streams, nitrogen and phosphorus levels are typical of natural, undisturbed Maine streams. Macroinvertebrate abundance in Orbeton Stream is similar to other oligotrophic systems such as Wassataquoik Stream, and lower than in Mt. Blue Stream. Despite lower abundances of macroinvertebrates, salmon growth is not expected to be impacted. Other factors may be reducing salmon productivity in Orbeton Stream, such as predation or competition for resources such as food and optimum habitat.

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Appendix I – Stream Characteristics

Table 1. Study site locations and watershed characteristics. Watershed area and percent wetlands calculated from MEGIS 2006 and 2020.

Stream Name	Site Code	Town	Watershed Area (km^2)	Percent Forested (%)	Percent Developed (%)
Orbeton Stream	KSDOB70	Madrid	151	87	0.7
Orbeton Stream	KSDOB39	Madrid			
Mt. Blue Stream	KSDMB11	Avon	31.6	89	1.2

Table 2. Study site physical characteristics. Mean stream depth was measured every three weeks while sondes were deployed in 2020.

Stream Name	Bankfull stream width (m)	Mean stream depth (cm)	Substrate (%)				
			Bedrock	Boulder	Cobble	Gravel	Sand/Silt
Orbeton Stream – KSDOB70	14	53	5	15	50	25	5
Orbeton Stream – KSDOB39	48	36	-	75	15	5	5
Mt. Blue Stream – KSDMB11	13.7	48	-	45	5	25	25

Appendix II – Summary Data Tables

Table 1. Continuous Data Summary. Summary statistics (mean, standard deviation (SD), minimum and maximum) of measurements from YSI 6000 EDS sondes (Orbeton) and Eureka Manta+ 20 sonde (Mt. Blue Stream), May to Oct. 2020 (n ~ 5,500, except for Mt. Blue Stream where n ~ 3,000).

Stream Name	pH				Temperature (°C)				Specific Conductance (µS/cm)				Dissolved Oxygen (mg/L)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
KSDOB70	7.03	0.19	6.01	7.62	15.76	4.05	4.37	25.18	26	6	12	38	9.49	0.86	7.83	12.19
KSDOB39	6.83	0.33	5.78	7.88	16.04	3.93	4.22	24.89	26	5	14	36	9.82	0.88	8.27	13.07
Mt. Blue Stream	7.01	0.12	6.66	7.50	17.40	3.56	6.57	23.78	29	6	13	42	9.27	0.76	8.11	12.14

Table 2. Discrete Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected June 25, Aug. 17, and Oct. 14. n = 3*.

Stream Name	Calcium (mg/L)				Dissolved Organic Carbon (mg/L)				ANC (µeq/L)				pH (closed-cell)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
KSDOB70	1.8	0.5	1.4	2.3	7.0	6.2	2.5	14	125.0	68.2	59.5	195.6	6.63	0.37	6.22	6.93
KSDOB39	2.0	0.2	1.8	2.2	6.2	5.9	2.1	13	152.3	71.3	78.6	220.9	6.82	0.44	6.33	7.19
Mt. Blue Stream	3.5	0.3	3.3	3.9	5.1	5.1	2.2	11	209.7	52.4	151.3	252.5	7.06	0.22	6.81	7.22

Table 3. Macroinvertebrate Summary. Samples were collected in August at Orbeton Stream (2017), Mt. Blue Stream (2020), and West Branch Sheepscot (2020) using rock bags following the DEP protocol (2014) and analyzed by a certified taxonomist to the lowest possible level (species). EPT taxa include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera).

Stream Name	Station ID	Log #	Year Sampled	Total Mean Abundance	Generic Richness	EPT Generic Richness	Relative Ephemeroptera Abundance	Dominant Taxa
Orbeton Stream	840	2579	2017	176	39	24	23%	*Hydropsyche* *Baetis*
Mt. Blue Stream	1182	2814	2020	315	66	37	37%	*Baetis* *Hydropsyche*

Appendix III – Biomonitoring Key Reports

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: S-1182
Waterbody: Mount Blue Stream - Station 1182
Town: Avon
Directions: UPSTREAM OF ROUTE 4

River Basin: Kennebec
HUC8 Name: Lower Kennebec
Latitude: 44 47 34.19 N
Longitude: 70 16 20.71 W
Stream Order: 2

Sample Information

Log Number: 2814 Type of Sample: ROCK BAG Date Deployed: 7/6/2020
Subsample Factor: X1 Replicates: 3 Date Retrieved: 8/6/2020

Classification Attainment

Statutory Class: B **Final Determination: A** Date: 2/17/2021
Model Result with P≥0.6: A **Reason for Determination: Model**
Date Last Calculated: 2/15/2021 Comments:

Model Probabilities

First Stage Model			
Class A	0.93	Class C	0.00
Class B	0.07	NA	0.00

C or Better Model	
Class A, B, or C	1.00
Non-Attainment	0.00

B or Better Model	
Class A or B	1.00
Class C or Non-Attainment	0.00

A Model	
Class A	1.00
Class B or C or Non-Attainment	0.00

Model Variables

01 Total Mean Abundance	315.00
02 Generic Richness	66.00
03 Plecoptera Mean Abundance	17.67
04 Ephemeroptera Mean Abundance	116.67
05 Shannon-Wiener Generic Diversity	4.50
06 Hilsenhoff Biotic Index	3.73
07 Relative Abundance - Chironomidae	0.25
08 Relative Generic Richness Diptera	0.30
09 *Hydropsyche* Abundance	48.33
11 *Cheumatopsyche* Abundance	6.00
12 EPT Generic Richness/ Diptera Generic Richness	1.85
13 Relative Abundance - Oligochaeta	0.00
15 Perlidae Mean Abundance (Family Functional Group)	14.00
16 Tanypodinae Mean Abundance (Family Functional Group)	9.67
17 Chironomini Abundance (Family Functional Group)	23.33
18 Relative Abundance Ephemeroptera	0.37
19 EPT Generic Richness	37.00
21 Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	2.33
23 Relative Generic Richness- Plecoptera	0.11
25 Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	8.33
26 Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	20.00
28 EP Generic Richness/14	1.64
30 Presence of Class A Indicator Taxa/7	1.00

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Baetis*	18.31
2	*Hydropsyche*	15.34
3	*Rheotanytarsus*	8.68
4	*Polypedilum*	7.20
5	*Maccaffertium*	5.61

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: **S-1182** Town: Avon Date Deployed: 7/6/2020
Log Number: **2814** Waterbody: Mount Blue Stream - Station 1182 Date Retrieved: 8/6/2020

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT Taxonomist: MICHAEL COLE

Waterbody Information - Deployment			Waterbody Information - Retrieval		
Temperature:	19.9	deg C	Temperature:	18.6	deg C
Dissolved Oxygen:	9.39	mg/l	Dissolved Oxygen:	9.74	mg/l
Dissolved Oxygen Saturation:	104.7	%	Dissolved Oxygen Saturation:	106.2	%
Specific Conductance:	30.7	uS/cm	Specific Conductance:	32.4	uS/cm
Velocity:	30.5	cm/s	Velocity:	15.2	cm/s
pH:	7.19		pH:	7.15	
Wetted Width:			Wetted Width:	6.8	m
Bankfull Width:			Bankfull Width:	9.3	m
Depth:	38	cm	Depth:	38	cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain	
Upland Hardwood	Open	Hilly	
Potential Stressor	**Location**	**Substrate**	
Logging	Minimally Disturbed	Boulder	50 %
		Gravel	20 %
		Rubble/Cobble	30 %

Landcover Summary - 2004 Data

Sample Comments

Maine Department of Environmental Protection
Biological Monitoring Program

Aquatic Life Taxonomic Inventory Report

Station Number: S-1182 Waterbody: Mount Blue Stream - Station 1182 Town: Avon

Log Number: 2814 Subsample Factor: X1 Replicates: 3 Calculated: 2/15/2021

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Nematomorpha	06	0.33	0.33		--	0.1	0.1
Leuctra	09020204020	1.33	1.33	0	SH	0.4	0.4
Pteronarcys	09020205023		0.33	0	SH		0.1
Pteronarcys biloba	09020205023061	0.33			--	0.1	
Perlodidae	09020207	1.67	1.67		--	0.5	0.5
Chloroperlidae	09020208	0.33	0.33		--	0.1	0.1
Acroneuria	09020209042	1.00	2.33	0	PR	0.3	0.7
Acroneuria abnormis	09020209042121	1.33		0	PR	0.4	
Paragnetina	09020209049	6.33	6.33	1	PR	2.0	2.0
Agnetina	09020209050		5.33	2	PR		1.7
Agnetina capitata	09020209050152	5.33		2	PR	1.7	
Boyeria	09020301004		0.33	2	PR		0.1
Boyeria grafiana	09020301004011	0.33			--	0.1	
Corduliidae	09020305	0.33	0.33		--	0.1	0.1
Baetis	09020401001	1.67	57.67	4	CG	0.5	18.3
Baetis flavistriga	09020401001004	17.00			--	5.4	
Baetis intercalaris	09020401001008	14.00			--	4.4	
Baetis pluto	09020401001009	25.00			--	7.9	
Acerpenna	09020401007	0.67	2.00	5	CG	0.2	0.6
Acerpenna macdunnoughi	09020401007001	1.33			--	0.4	
Procloeon	09020401010	0.33	0.33		CG	0.1	0.1
Plauditus	09020401012	3.33	3.33		CG	1.1	1.1
Diphetor	09020401013		2.67		--		0.8
Diphetor hageni	09020401013001	2.67			--	0.8	
Epeorus	09020402009	3.33	3.33	0	SC	1.1	1.1
Heptagenia	09020402010	1.33	1.33	2	SC	0.4	0.4
Leucrocuta	09020402011	8.67	8.67	1	SC	2.8	2.8
Maccaffertium	09020402015	15.00	17.67	4	SC	4.8	5.6
Maccaffertium vicarium	09020402015055	2.67			--	0.8	
Leptophlebiidae	09020406	1.33	1.33		--	0.4	0.4
Neoleptophlebia	09020406027	0.67	0.67		--	0.2	0.2
Ephemerella	09020410035	7.00	7.00	1	CG	2.2	2.2
Eurylophella	09020410036		0.67	3	CG		0.2
Eurylophella funeralis	09020410036115	0.67			SH	0.2	
Serratella	09020410037		7.67	2	CG		2.4
Serratella deficiens (Teloganopsis deficiens)	09020410037121	1.00			--	0.3	
Serratella serratoides	09020410037124	6.67			--	2.1	

Station Number: S-1182 Waterbody: Mount Blue Stream - Station 1182 Town: Avon

Log Number: 2814 Subsample Factor: X1 Replicates: 3 Calculated: 2/15/2021

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Tricorythodes	09020411038	0.33	0.33	4	CG	0.1	0.1
Caenis	09020412040	2.00	2.00	7	CG	0.6	0.6
Neureclipsis	09020603008	3.00	3.00	7	CF	1.0	1.0
Polycentropus	09020603010	1.33	1.33	6	PR	0.4	0.4
Diplectrona	09020604014		1.00	0	CF		0.3
Diplectrona modesta	09020604014025	1.00			--	0.3	
Cheumatopsyche	09020604015	6.00	6.00	5	CF	1.9	1.9
Hydropsyche	09020604016	25.00	48.33	4	CF	7.9	15.3
Hydropsyche morosa	09020604016030	0.33			--	0.1	
Hydropsyche slossonae	09020604016031	1.67			--	0.5	
Hydropsyche sparna	09020604016032	21.33			--	6.8	
Rhyacophila	09020605019	1.67	6.00	2	PR	0.5	1.9
Rhyacophila acutiloba	09020605019056	1.67			PR	0.5	
Rhyacophila fuscula	09020605019060	2.00			PR	0.6	
Rhyacophila minora	09020605019063	0.67			PR	0.2	
Glossosoma	09020606020	2.33	2.33	0	SC	0.7	0.7
Hydroptila	09020607026	0.33	0.33	6	P	0.1	0.1
Brachycentrus	09020609043		14.00	0	CF		4.4
Brachycentrus appalachia	09020609043096	14.00			--	4.4	
Pycnopsyche	09020610049	0.67	0.67	4	SH	0.2	0.2
Lepidostoma	09020611064	4.00	4.00	1	SH	1.3	1.3
Psilotreta	09020614068	0.33	0.33	0	SC	0.1	0.1
Helicopsyche	09020616070		0.67	3	SC		0.2
Helicopsyche borealis	09020616070137	0.67			--	0.2	
Apatania	09020619061	0.33	0.33		SC	0.1	0.1
Nigronia	09020701003		1.67	0	PR		0.5
Nigronia serricornis	09020701003003	1.67			--	0.5	
Ceratopogonidae	09021010	0.33	0.33		--	0.1	0.1
Chironomidae	09021011				--		
Nilotanypus	09021011012		0.67	6	PR		0.2
Nilotanypus fimbriatus	09021011012027	0.67			--	0.2	
Thienemannimyia	09021011020		9.00	3	PR		2.9
Thienemannimyia group	09021011020041	9.00			--	2.9	
Pagastia	09021011025	1.00	1.00	1	--	0.3	0.3
Sympotthastia	09021011029	0.33	0.33	2	CG	0.1	0.1
Corynoneura	09021011036	5.00	5.00	7	CG	1.6	1.6
Cricotopus	09021011037	0.33	1.00	7	SH	0.1	0.3
Cricotopus bicinctus	09021011037057	0.67			--	0.2	

Maine Department of Environmental Protection
Biological Monitoring Program

Aquatic Life Taxonomic Inventory Report

Station Number: S-1182 Waterbody: Mount Blue Stream - Station 1182 Town: Avon

Log Number: 2814 Subsample Factor: X1 Replicates: 3 Calculated: 2/15/2021

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Nanocladius	09021011049	0.33	0.33	3	CG	0.1	0.1
Orthocladius	09021011050	0.67	1.67	6	CG	0.2	0.5
Orthocladius lignicola	09021011050100	1.00			--	0.3	
Parametriocnemus	09021011053	2.00	2.00	5	CG	0.6	0.6
Thienemanniella	09021011062	0.33	0.33	6	CG	0.1	0.1
Tvetenia	09021011065		3.00	5	CG		1.0
Tvetenia vitracies	09021011065113	1.67			--	0.5	
Tvetenia paucunca	09021011065114	1.33			--	0.4	
Micropsectra	09021011070	2.33	2.33	7	CG	0.7	0.7
Rheotanytarsus	09021011072		27.33	6	CF		8.7
Rheotanytarsus exiguus group	09021011072127	18.33			CF	5.8	
Rheotanytarsus pellucidus	09021011072128	9.00			CF	2.9	
Tanytarsus	09021011076	1.33	1.33	6	CF	0.4	0.4
Microtendipes	09021011094		0.67	6	CF		0.2
Microtendipes pedellus group	09021011094166	0.67			--	0.2	
Polypedilum	09021011102		22.67	6	SH		7.2
Polypedilum aviceps	09021011102181	17.67			--	5.6	
Polypedilum flavum	09021011102182	3.67			--	1.2	
Polypedilum tritum	09021011102191	1.33			--	0.4	
Simulium	09021012047	1.67	1.67	4	CF	0.5	0.5
Simulium venustum/verecundum complex	09021012047072				CF		
Hemerodromia	09021016057	0.33	0.33	3	PR	0.1	0.1
Neoplasta	09021016064	1.00	1.00		PR	0.3	0.3
Dubiraphia	09021113064	0.33	0.33	6	--	0.1	0.1
Optioservus	09021113067		6.00	3	SC		1.9
Optioservus trivittatus	09021113067048	0.33			--	0.1	
Optioservus tardella	09021113067052	5.67			--	1.8	
Oulimnius	09021113068	0.33	0.67		--	0.1	0.2
Oulimnius latiusculus	09021113068049	0.33			--	0.1	
Promoresia	09021113069	0.33	0.33		--	0.1	0.1
Stenelmis	09021113070		0.33	5	SC		0.1
Stenelmis crenata	09021113070055	0.33			--	0.1	

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Information

Station Number: **S-840**
Waterbody: Orbeton Stream - Station 840
Town: Madrid Twp
Directions: ~500M UPSTREAM OF REEDS MILL ROAD (FOLLOW OBERTON RECREATIONAL PARK TRAIL TO SITE)

River Basin: Kennebec
HUC8 Name: Lower Kennebec
Latitude: 44 53 20.02 N
Longitude: 70 24 23.42 W
Stream Order: 4

Sample Information

Log Number: **2579** Type of Sample: ROCK BASKET Date Deployed: 7/24/2017
Subsample Factor: X1 Replicates: 3 Date Retrieved: 8/21/2017

Classification Attainment

Statutory Class: **A** **Final Determination:** **A** Date: 3/16/2018
Model Result with P≥0.6: A **Reason for Determination:** **Model**
Date Last Calculated: 3/15/2018 Comments:

Model Probabilities

First Stage Model				C or Better Model	
Class A	0.84	Class C	0.00	Class A, B, or C	1.00
Class B	0.16	NA	0.00	Non-Attainment	0.00

B or Better Model		A Model	
Class A or B	1.00	Class A	1.00
Class C or Non-Attainment	0.00	Class B or C or Non-Attainment	0.00

Model Variables

01 Total Mean Abundance	176.00
02 Generic Richness	39.00
03 Plecoptera Mean Abundance	23.33
04 Ephemeroptera Mean Abundance	40.33
05 Shannon-Wiener Generic Diversity	3.61
06 Hilsenhoff Biotic Index	3.65
07 Relative Abundance - Chironomidae	0.16
08 Relative Generic Richness Diptera	0.36
09 *Hydropsyche* Abundance	59.33
11 *Cheumatopsyche* Abundance	1.00
12 EPT Generic Richness/ Diptera Generic Richness	1.71
13 Relative Abundance - Oligochaeta	0.00
15 Perlidae Mean Abundance (Family Functional Group)	20.67
16 Tanypodinae Mean Abundance (Family Functional Group)	0.67
17 Chironomini Abundance (Family Functional Group)	6.00
18 Relative Abundance Ephemeroptera	0.23
19 EPT Generic Richness	24.00
21 Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.67
23 Relative Generic Richness- Plecoptera	0.15
25 Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	9.00
26 Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	3.67
28 EP Generic Richness/14	1.14
30 Presence of Class A Indicator Taxa/7	0.71

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Hydropsyche*	33.71
2	*Baetis*	15.15
3	*Paragnetina*	7.77
4	*Brachycentrus*	6.82
5	*Cricotopus*	4.55

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Classification Attainment Report

Station Number: S-840 Town: Madrid Twp Date Deployed: 7/24/2017

Log Number: 2579 Waterbody: Orbeton Stream - Station 840 Date Retrieved: 8/21/2017

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL COLE

Waterbody Information - Deployment			Waterbody Information - Retrieval		
Temperature:	16.3	deg C	Temperature:	18.7	deg C
Dissolved Oxygen:	10.99	mg/l	Dissolved Oxygen:	10.62	mg/l
Dissolved Oxygen Saturation:	114	%	Dissolved Oxygen Saturation:	115.6	%
Specific Conductance:	28.7	uS/cm	Specific Conductance:	30.3	uS/cm
Velocity:	30.5	cm/s	Velocity:	51.8	cm/s
pH:	7.78		pH:	6.7	
Wetted Width:	11	m	Wetted Width:	8.2	m
Bankfull Width:	18	m	Bankfull Width:	18	m
Depth:	64	cm	Depth:	63	cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Upland Conifer	Open	Hilly
Upland Hardwood		

Potential Stressor	Location	Substrate	
Logging		Boulder	85 %
		Gravel	5 %
		Rubble/Cobble	10 %

Landcover Summary - 2004 Data

Total Area (ac)	27007	High Int. Dev. %	0.0	Water %	0.2	Non-vegetated %	0.1
		Med Int. Dev. %	0.0	Wetland %	0.4	Tilled Agriculture %	0.1
		Low Int. Dev. %	0.6	Upland Woody %	97.9	Grassland %	0.2
		Development %	0.7	Natural %	98.8	Human Altered %	1.0
						Impervious %	0.2

Sample Comments

8/21/17: BASKETS DISTURBED BY FLOW.

Maine Department of Environmental Protection
Biological Monitoring Program

Aquatic Life Taxonomic Inventory Report

Station Number: S-840 Waterbody: Orbeton Stream - Station 840 Town: Madrid Twp

Log Number: 2579 Subsample Factor: X1 Replicates: 3 Calculated: 3/15/2018

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Girardia	03010102002	0.33	0.33		--	0.2	0.2
Paracapnia	09020203018	0.33	0.33	1	SH	0.2	0.2
Perlodidae	09020207	1.33	1.33		--	0.8	0.8
Isogenoides	09020207033	0.67	0.67	0	PR	0.4	0.4
Sweltsa	09020208040	0.33	0.33		PR	0.2	0.2
Paragnetina	09020209049	13.33	13.67	1	PR	7.6	7.8
Paragnetina immarginata	09020209049149	0.33			--	0.2	
Agnetina	09020209050	1.00	7.00	2	PR	0.6	4.0
Agnetina capitata	09020209050152	6.00		2	PR	3.4	
Baetis	09020401001	2.00	26.67	4	CG	1.1	15.2
Baetis flavistriga	09020401001004	10.67			--	6.1	
Baetis intercalaris	09020401001008	7.00			--	4.0	
Baetis pluto	09020401001009	4.33			--	2.5	
Baetis tricaudatus	09020401001012	2.67			--	1.5	
Plauditus	09020401012	4.33	4.33		CG	2.5	2.5
Epeorus	09020402009		2.33	0	SC		1.3
Epeorus vitreus	09020402009033	2.33			--	1.3	
Leucrocuta	09020402011	1.00	1.00	1	SC	0.6	0.6
Maccaffertium	09020402015	3.67	3.67	4	SC	2.1	2.1
Isonychia	09020404018	0.33	0.33	2	CF	0.2	0.2
Paraleptophlebia	09020406026		0.33	1	CG		0.2
Paraleptophlebia adoptiva	09020406026078	0.33		1	CG	0.2	
Ephemerella	09020410035	1.00	1.00	1	CG	0.6	0.6
Serratella	09020410037		0.33	2	CG		0.2
Serratella serratoides	09020410037124	0.33			--	0.2	
Tricorythodes	09020411038	0.33	0.33	4	CG	0.2	0.2
Neureclipsis	09020603008	5.00	5.00	7	CF	2.8	2.8
Cheumatopsyche	09020604015	1.00	1.00	5	CF	0.6	0.6
Hydropsyche	09020604016	47.33	59.33	4	CF	26.9	33.7
Hydropsyche morosa	09020604016030	0.33			--	0.2	
Hydropsyche slossonae	09020604016031	8.33			--	4.7	
Hydropsyche sparna	09020604016032	3.33			--	1.9	
Rhyacophila	09020605019	0.33	0.67	2	PR	0.2	0.4
Rhyacophila fuscula	09020605019060	0.33			PR	0.2	
Glossosoma	09020606020	1.67	1.67	0	SC	0.9	0.9
Hydroptila	09020607026	0.33	0.33	6	P	0.2	0.2
Brachycentrus	09020609043		12.00	0	CF		6.8

Maine Department of Environmental Protection
Biological Monitoring Program

Aquatic Life Taxonomic Inventory Report

Station Number: S-840 Waterbody: Orbeton Stream - Station 840 Town: Madrid Twp

Log Number: 2579 Subsample Factor: X1 Replicates: 3 Calculated: 3/15/2018

Taxon	Maine Taxonomic Code	Count (Mean of Samplers) Actual	Count (Mean of Samplers) Adjusted	Hilsenhoff Biotic Index	Functional Feeding Group	Relative Abundance % Actual	Relative Abundance % Adjusted
Brachycentrus appalachia	09020609043096	12.00			--	6.8	
Lepidostoma	09020611064	0.67	0.67	1	SH	0.4	0.4
Chironomidae	09021011				--		
Thienemannimyia	09021011020		0.67	3	PR		0.4
Thienemannimyia group	09021011020041	0.67			--	0.4	
Pagastia	09021011025	0.67	0.67	1	--	0.4	0.4
Cardiocladius	09021011034	0.33	0.33	5	PR	0.2	0.2
Corynoneura	09021011036	1.67	1.67	7	CG	0.9	0.9
Cricotopus	09021011037	6.33	8.00	7	SH	3.6	4.5
Cricotopus bicinctus	09021011037057	1.67			--	0.9	
Orthocladius	09021011050	0.67	1.33	6	CG	0.4	0.8
Orthocladius dubitatus	09021011050103	0.67			--	0.4	
Thienemanniella	09021011062	0.33	0.33	6	CG	0.2	0.2
Tvetenia	09021011065		1.67	5	CG		0.9
Tvetenia vitracies	09021011065113	1.33			--	0.8	
Tvetenia paucunca	09021011065114	0.33			--	0.2	
Micropsectra	09021011070	0.67	0.67	7	CG	0.4	0.4
Rheotanytarsus	09021011072		6.33	6	CF		3.6
Rheotanytarsus exiguus group	09021011072127	1.67			CF	0.9	
Rheotanytarsus pellucidus	09021011072128	4.67			CF	2.7	
Polypedilum	09021011102		6.00	6	SH		3.4
Polypedilum aviceps	09021011102181	5.33			--	3.0	
Polypedilum flavum	09021011102182	0.67			--	0.4	
Simulium	09021012047	2.67	2.67	4	CF	1.5	1.5
Hemerodromia	09021016057	0.67	0.67	3	PR	0.4	0.4
Dolichopodidae	09021017	0.33	0.33	4	--	0.2	0.2