Water Quality in Temple Stream, Farmington, Maine

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Walton's Mill Dam

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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). According to the 2018 recovery plan for Gulf of Maine Atlantic salmon, habitat connectivity is the primary action needed to restore populations (USFWS and NMFS 2018). 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). In 2022, the Atlantic Salmon Federation (ASF) plans to remove Walton's Mill Dam (see photo on cover page), the only dam on Temple Stream, a tributary to the Sandy River in Farmington. The 6 m tall dam blocks all fish passage and impounds approximately one mile of stream. Removal of small, surface-spill dams typically result in increased resiliency to the effects of climate change, including improvements in water quality such as decreased temperatures and increased dissolved oxygen concentrations (Paukert et al. 2021; Zaidel 2018; Zaidel et al. 2021). Environmental monitoring of the stream before and after dam removal is being conducted as a multi-partner collaboration between the University of Maine at Farmington, US Fish and Wildlife Service, MDMR, ASF, and MDEP. This report characterizes baseline stream water quality prior to dam removal.

Methods

Study Location

Temple Stream is within the homeland of the Nanrantsouak (Norridgewock) Tribe of Abenakis. The 89 km^2 watershed is predominantly forested (94%), with only 0.8% developed land (Appendix I Table I-1; MEGIS 2006 and 2019). The stream and its tributaries are assigned the Statutory Class of B under Maine's Water Classification Program (38 M.R.S.§§ 464). The area has a history of industrial logging and agriculture. The bedrock geology in the watershed is predominantly marine sandstone and slate, topped with glacially deposited till (Maine Geological Survey - MGS 1985). MDMR has been planting salmon eggs upstream of the dam for 12 years. Average relative abundance of salmon in Temple Stream is 0.68 parr/minute (with the majority of the samples collected above the dam; MDMR data from 2012-2021), which is higher than the average for the entire Sandy River drainage (0.59 parr/minute; MDMR data). Four locations in Temple Stream were monitored for water quality (Fig. 1): upstream of the Rt.43 crossing, in a deep section of the impoundment approximately 380 m above the dam, approximately 500 m downstream of the dam, and a biological monitoring site approximately 320 m further downstream.

Water Quality

All water quality monitoring activities followed the EPA-approved Salmon Habitat Monitoring Program Quality Assurance Project Plan (MDEP 2021). Continuous monitoring devices were deployed April 26, 2021, as in Zimmermann (2018). Measurements of temperature, specific conductance, pH, and dissolved oxygen (DO) were collected every 30 minutes using YSI 6000 EDS sondes at the upstream and downstream sites. A vertical line was deployed between an anchor and buoy in the thalweg of the impoundment, with two Onset Hobo U26 DO loggers (0.5m from the surface and 1m from the bottom) and a Hobo U20L water level logger 1.5m from the bottom. Measurements of temperature, DO, and depth were collected every 15 minutes. Sondes and loggers were cleaned and calibrated every three weeks until retrieval on

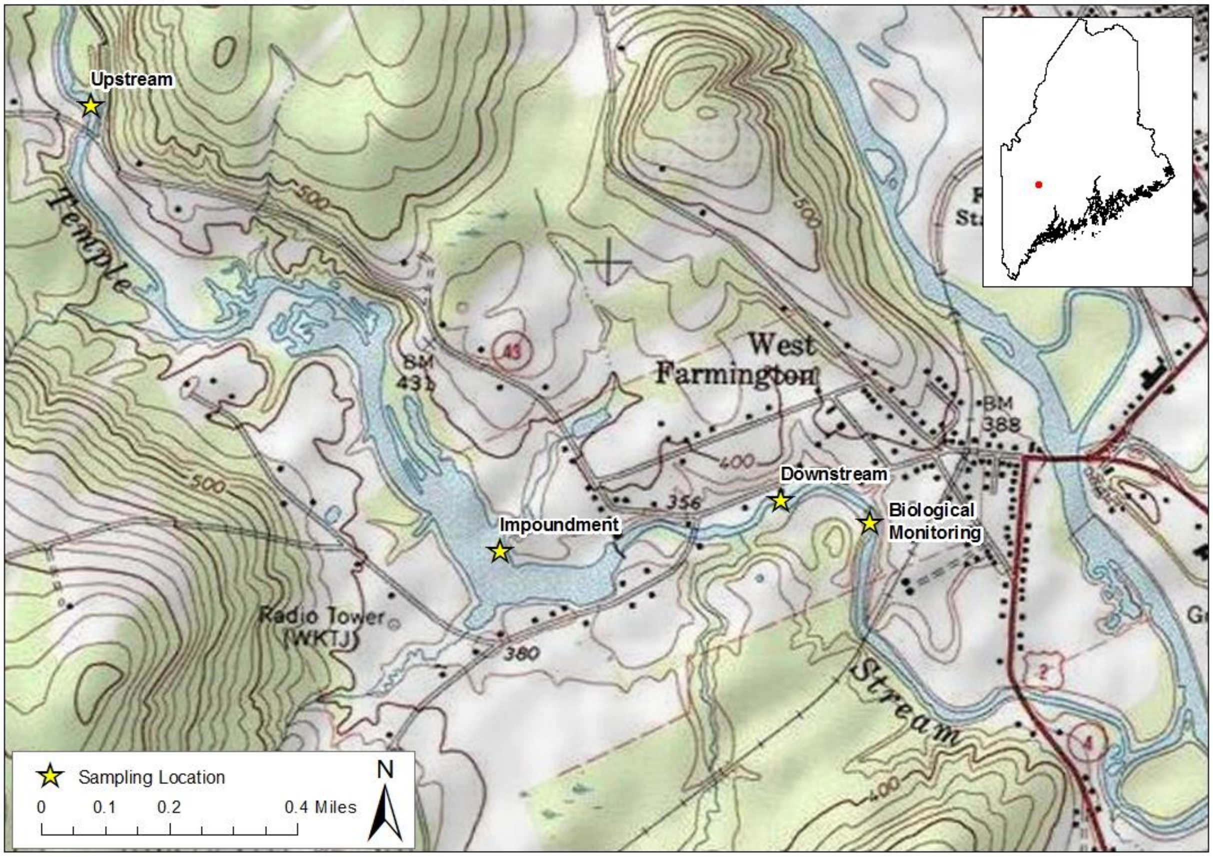

Figure 1. Map of the study sites on Temple Stream.

October 19, 2021. 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. Surface grab samples for calcium, dissolved organic carbon (DOC), total phosphorus, total Kjeldahl nitrogen (TKN), and nitrate + nitrite as nitrogen were collected in April, August, and October from each sample location except for the biological monitoring site, following the methods in Zimmermann (2018).

Water Surface Elevation

Water surface elevation was measured three times per week April 29 – August 27 by ASF by recording the length in inches from the top of the concrete dam abutment (river left adjacent to the existing gate) to the water surface of the impoundment upstream of the abutment. The recording was then subtracted from the known benchmark established along the top of the concrete dam abutment (112.12 m, 367.85 ft), established with a Leica TS06 total station by Plisga and Day Land Surveyors on August 1, 2017, for Acadia Civil Works.

Biological Monitoring

Rock bags were deployed July 10, 2020 at the site furthest downstream and retrieved on August 6, 2020, following the MDEP Biological Monitoring Program's sampling methods

(MDEP 2014). Epilithic algae samples were also collected on July 10, 2020 (MDEP 2014).

Data Visualization

Water quality data were analyzed using the Water Resources Database (WRDB) 6.1.0.101 (Wilson Engineering 2021) and R 4.1.2 (R Core Team 2021). Figures 4 and 6 were created in WRDB. All other figures were created in R using the *ggplot2* package (Wickham 2009). All data are presented as mean ± standard deviation (SD), unless otherwise stated. Quality control issues caused 6% of specific conductance data (20 cumulative days), 4% of DO data (19 days), and <1% of pH data (11 hours) to be rejected. On average, 9% of data from each of these parameters were flagged due to corrections. Non-detects were analyzed using the reporting limits. At the bottom of the impoundment, 60% of DO measurements were less than the reporting limit of 0.01 mg/L.

Results and Discussion

Weather

In 2021, Maine experienced an unusually warm winter with low snowpack followed by a warm, dry spring and summer (NOAA 2021; U.S. Drought Monitor 2021). Abnormally dry conditions persisted from June through September, escalating to severe drought for most of July and August (NOAA 2021). 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

Salmon prefer pH values that are circumneutral (6.5-7.5), rather than acidic (<6.5; Kroglund and Staurnes 1999; Kroglund et al. 2008). 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 (Al_x), and 4.) the buffering capacity of the water (i.e., ANC and calcium; see Zimmermann 2018 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.

Temple 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 (99%; Fig. 2; Appendix II Table II-1; Kroglund and Staurnes 1999; Kroglund et al. 2008). Both the upstream and downstream locations fell below 6.5 for <0.2% of the study, following large (>20 mm) rain events in July and September (Weather Underground 2021). These rain-driven depressions lasted on average 2.4 hours (maximum duration 4.5 hours). When the impoundment stratified (May-September), pH was <6.5 at depths greater than 2 m (29% of impoundment data), with minimum values observed at 3-4 m (Fig. 3). The minimum pH value observed in the impoundment was 6.06 (at 3 and 3.5 m depth), well 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).

Temple Stream had neutral pH (grand mean 7.02 ± 0.18). The pH upstream was on average 0.2 units higher (maximum 1.13 units higher) compared to downstream, with larger diel fluctuations (up to 1.2 units, compared to 0.5 units at the downstream site). Diel fluctuations in pH are primarily driven by the consumption and production of carbon dioxide during photosynthesis and respiration by aquatic plants and microbes (Nimick et al. 2011). Larger diel fluctuations at the upstream site may be driven by increased productivity compared to the downstream site. Carbon dioxide produced as a result of anaerobic respiration at the bottom

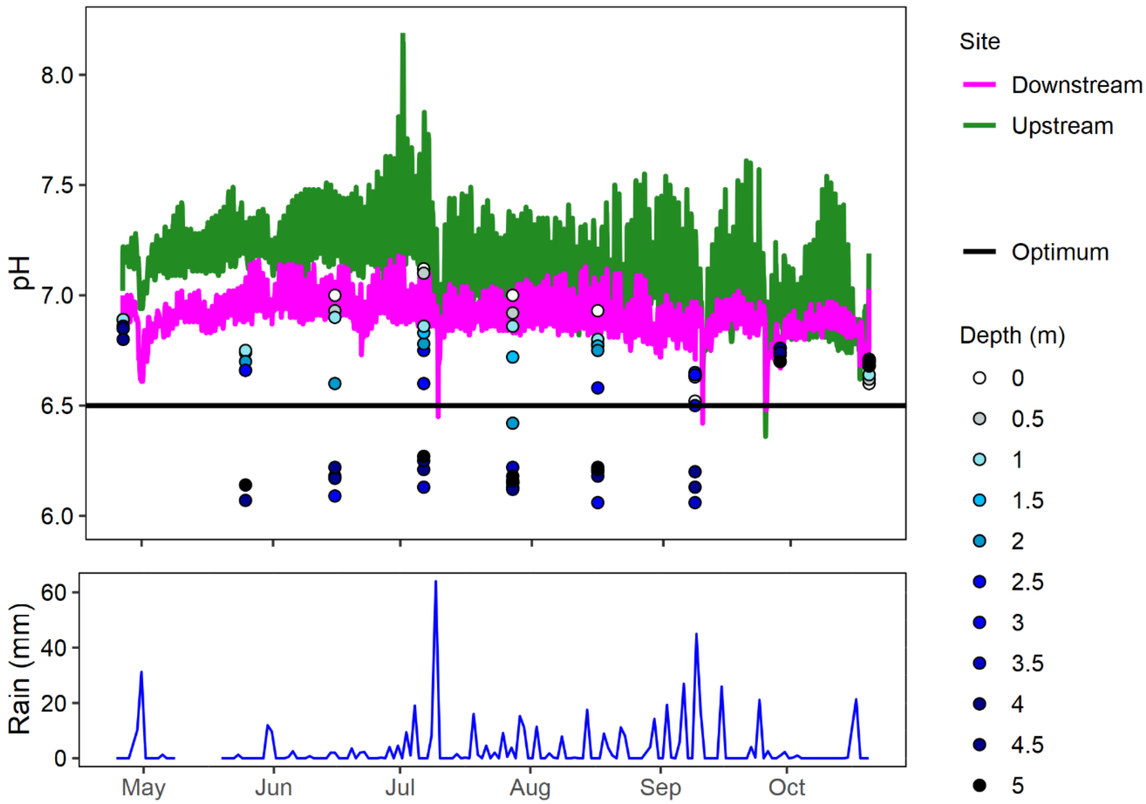

Figure 2. Continuous and discrete pH and local rainfall. Optimum pH from Kroglund and Staurnes 1999 and Kroglund et al. 2008. Rainfall data from Weather Underground station KMEFARMI35 and KMEWILTO2.

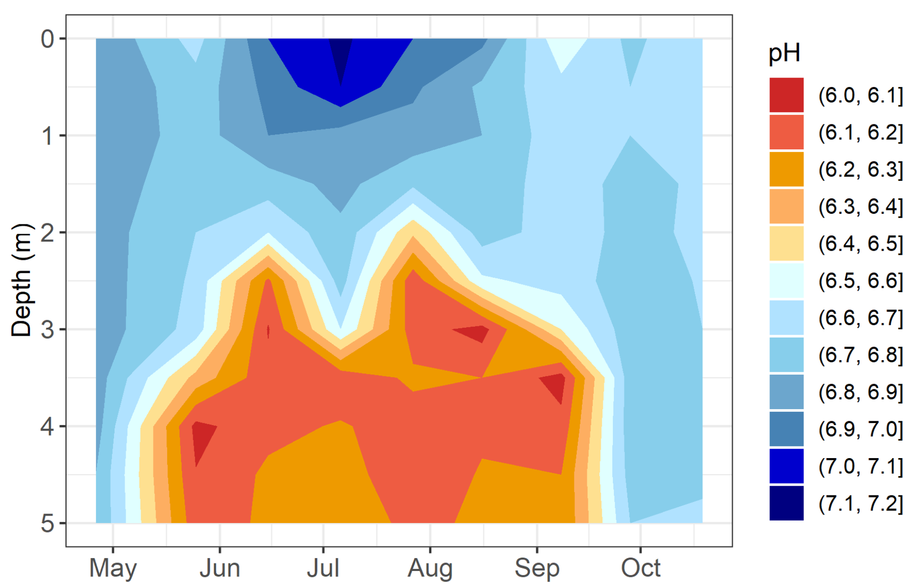

Figure 3. Impoundment pH depth profiles collected every three weeks April through October. Red to yellow represents potentially stressful pH (<6.5). Blue represents optimal pH (>6.5, from Kroglund and Staurnes 1999; Kroglund et al. 2008).

of the stratified impoundment waters may be causing the low pH at depth (Fig. 3). No significant negative impacts to salmon are expected from pH in the study area, however when the impoundment is stratified, conditions at depth may be less than optimal, particularly for alevins and smolts (Kroglund and Staurnes 1999; Kroglund et al. 2008). With the planned dam removal, the current impoundment will revert to more stream-like conditions with well-mixed water, increasing pH minimum values.

<u>Stream Temperature</u>

Salmon prefer cold waters (Stanley and Trial 1995). The temperature threshold for optimal growth is less than 20°C (Jonsson et al. 2001; USEPA 1986). Salmon experience physiological stress (e.g., stop feeding) and seek cold water refuge when temperatures are above 22°C (Cunjak et al. 2005; Elliott and Elliott 2010; Lund et al. 2002). Maximum temperature for the survival of adults occurs at 26-27°C (Shepard 1995 as cited in Frechette et al. 2018) and for parr at 28-29°C (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).

Temperature was highest at the impoundment surface and downstream, slightly cooler at the upstream site (on average 1.5°C cooler), and coldest at the bottom of the impoundment (Fig. 4, Appendix II Table II-1). Mean June-August water temperature at the upstream site was 20.7°C, within the transition zone between the coldwater and warmwater classes for fish communities, whereas the downstream mean of 22.4°C was within the warmwater class (Beauchene et al. 2014). Excluding the bottom of the impoundment, which never exceeded the threshold for optimal growth of 20°C, conditions were less than optimal for 56% of the study duration. The stress threshold of 22°C was exceeded 25% of the time. Maximum temperature for survival of adults (26-27°C) was exceeded only 1% of the time, and for parr (28-29°C) <0.1% of the time, occurring mostly in late June after a period of severe drought (U.S. Drought Monitor 2021). Thermal stress likely occurred during the summer when temperatures remained above 22°C for 25 hours on average, with a maximum duration of 11 days downstream and at the surface of the impoundment. Stream temperatures at the upstream site were less stressful, exceeding 22°C for 12 hours on average, with a maximum duration of 4 days. At all sites combined, mean diel fluctuations were 2.9 ± 1.7°C, which may have provided some daily

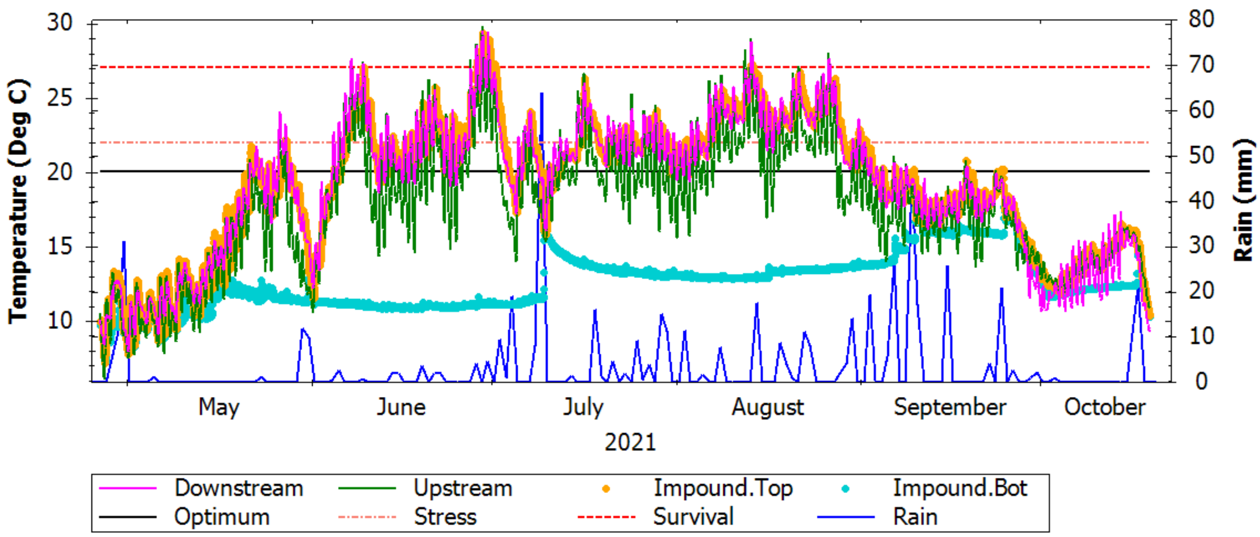

Figure 4. Water temperature and local rainfall May through October. Impound.Top was 0.5 m from the surface of the impoundment; Impound.Bot was 1 m above the impoundment bottom. Optimal growth limit from Jonsson et al. 2001 and USEPA 1986. Stress threshold from Cunjak et al. 2005; Elliott and Elliott 2010; Lund et al. 2002. Survival limit for adult salmon from Shepard 1995 as cited in Frechette et al. 2018). Rainfall data from Weather Underground station KMEFARMI35 and KMEWILTO2.

thermal refugia for salmon during thermally stressful periods, especially at the upstream site (diel fluctuations of 4.2 ± 2.0°C).

The impoundment experienced thermal stratification May-September, with the thermocline ranging from 1 m in early June to 3.5 m in early September (Fig. 5). The impoundment waters became fully mixed after a large rain event in July, with bottom temperatures matching surface temperatures for 13 hours following the rain event (Fig. 4). Smaller rain events also resulted in water column mixing, resulting in temporary slight warming of bottom temperatures. The abnormally dry summer conditions likely contributed to the stratification of the impoundment.

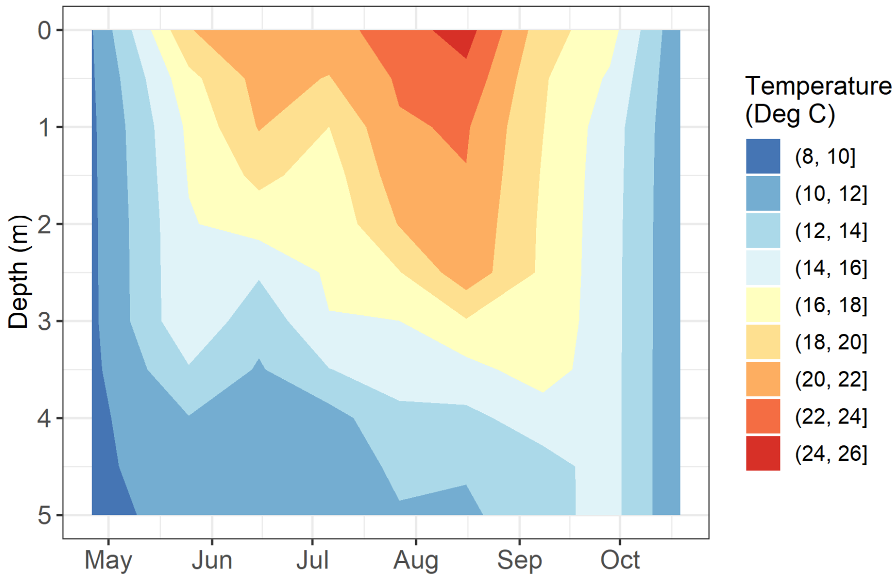

Figure 5. Impoundment temperature-depth profiles collected every three weeks April through October. Blue to yellow represents optimal growth for salmon (<20°C; Jonsson et al. 2001; USEPA 1986). Orange to red represents stressful conditions (>22°C; Cunjak et al. 2005; Elliott and Elliott 2010; Lund et al. 2002).

In the study area, high temperatures likely cause sublethal stress and reduced growth in salmon during the warmest months, however nightly temperature refugia may help mitigate some of those impacts. The downstream site is influenced by the warm, stable surface waters of the impoundment, as observed at many other small dams (Dripps and Granger 2013; Maxted et al. 2005; Zaidel et al. 2021). With the planned dam removal, temperatures at the downstream site may decrease, increasing the amount of cool-water habitat available for fish in Temple Stream (Beauchene et al. 2014; Zaidel et al. 2021; but see Zwieniecki and Newton 1999). Dam removal may also increase diel fluctuations at the downstream site, providing a greater chance for daily thermal refugia (Dripps and Granger 2013). Maximum temperature reduction may not occur until the former impoundment has revegetated with a resilient riparian zone that provides shade from solar radiation, which may take years (Lawrence et al. 2014; Zaidel et al. 2021). The cold waters at the bottom of the impoundment will likely be lost with the conversion to more stream-like conditions with well-mixed water, however it is unlikely this area served as a thermal refuge for aquatic biota during the summer due to the low pH and hypoxic conditions.

Water Surface Elevation

Walton's Mill Dam was opened on April 29, 2021 and by mid-June water levels had decreased by one meter, to approximately half of the full drawdown height. A minimum elevation of 110.3 m occurred June 23. Debris accumulation in the spillway, likely caused by beaver activity, caused water levels to rise to normal impoundment elevation by the end of June (Fig. 6). During the measurement period, water surface elevation was on average 111.1 ± 0.3 m.

Dissolved Oxygen (DO)

Salmon prefer well oxygenated waters with dissolved oxygen concentrations above the Maine Water Quality Standard minimum criterion value of 7 mg/L (38 M.R.S. §§ 465.2.B; Stanley and Trail 1995). Salmon experience acute physiological and behavioral stress below 5 mg/L (USEPA 1986).

DO levels were within a healthy range for fish (>7 mg/L) at the upstream site for the entire study period and at the downstream site for 99% of the study period (Fig. 6). DO at the upstream site was on average 0.6 ± 0.4 mg/L higher than at the downstream site, based on paired measurements (Appendix II Table II-1). The impoundment surface waters remained above 7 mg/L for 86% of the study period, dropping below this threshold for on average 4 hours at a time but lasting up to 74 hours in late August. Surface waters dropped below 5 mg/L for <1% of the study period, lasting on average 1.5 hours with a maximum duration of 13 hours (Fig. 6). The surface waters experienced exceedances in duration, frequency, magnitude, and diurnal swing of MDEP's consolidated assessment and listing methodology associated with the Integrated Water Quality Monitoring and Assessment Report (MDEP 2022, p. 53-55). This assessment methodology is used by MDEP to determine if streams are impaired for aquatic life criteria. As is typical in similar impoundments, bottom waters had even lower DO (Zaidel 2018), with only 25% of the study period above 7 mg/L. Bottom waters were below the acute stress threshold 71% of the study period, lasting for almost 2 days on average, with a maximum duration of two

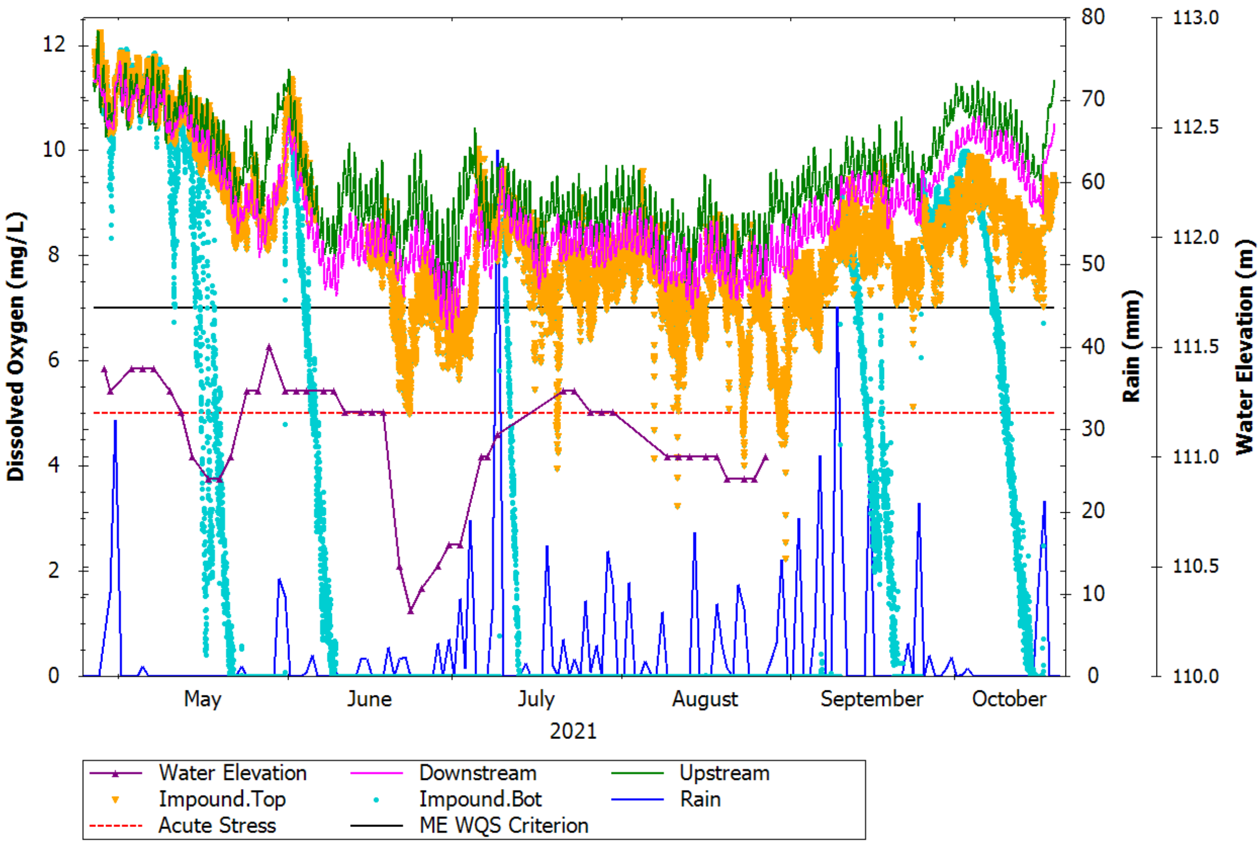

Figure 6. Dissolved oxygen and local rainfall May through October. Impound.Top was 0.5 m from the surface of the impoundment; Impound.Bot was 1 m above the impoundment bottom. Water surface elevation (m) collected by ASF. Maine Water Quality Standard (ME WQS) criterion from 38 M.R.S. §§ 465.2.B. Stress threshold from USEPA 1986. Rainfall data from Weather Underground station KMEFARMI35 and KMEWILTO2.

months (Fig. 6). Bottom waters experienced hypoxic conditions (<2 mg/L, Rounds et al. 2013) for 65% of the study period, lasting on average 2.2 days.

DO stratification occurred primarily in conjunction with thermal stratification May-September, with DO concentrations decreasing dramatically below 1-3 meters, depending on the month (Fig. 7). The impoundment waters became fully mixed after large rain events, lasting for 1.75 days before DO in bottom waters declined to near zero (Fig. 6). Following a rain event in September, DO was homogenous top to bottom for 11.5 days as temperatures decreased, before DO in bottom waters again declined to near zero. Periods of low DO in the surface waters of the impoundment, coupled with warm water, likely cause stress to salmon and other aquatic life. During summer hypoxia, the bottom waters of the impoundment likely do not support aquatic life below 3 meters and may contribute to lower pH downstream due to anaerobic respiration. With the planned dam removal, the current impoundment will revert to more stream-like conditions with well-mixed water, improving DO concentrations as seen in other studies (Zaidel 2018), however no significant changes are expected at the downstream site.

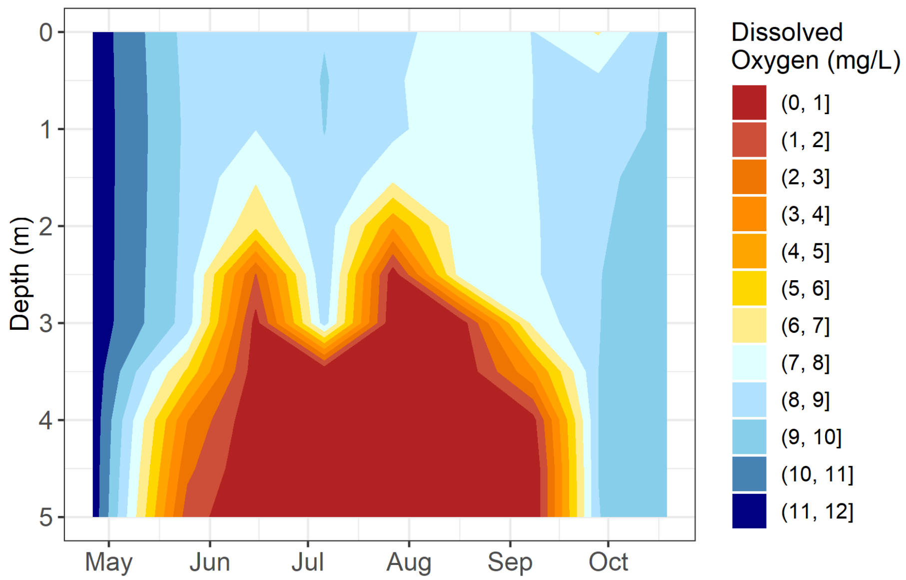

Figure 7. Impoundment dissolved oxygen-depth profiles collected every three weeks April through October. Red represents hypoxic conditions (<2 mg/L); orange acute stressful conditions (<5 mg/L; USEPA 1986); yellow suboptimal conditions (<7 mg/L); and blue optimal conditions (>7 mg/L; 38 M.R.S. §§ 465.2.B; Stanley and Trail 1995).

Specific Conductance

Specific conductance is a measure of the concentration of ions in the water, or the ability of water to conduct electricity. Specific conductance at the upstream and downstream sites had a grand mean of 58 ± 10 µS/cm (Fig. 8; Appendix II Table II-1), almost double the average observed in other tributaries to the Sandy River in 2020 (Orbeton and Mt. Blue Streams; Zimmermann 2021). In comparison, specific conductance was slightly lower at the surface of the impoundment, with an average of 37 ± 7 µS/cm (Figs. 8 and 9; Appendix II Table II-1). Higher specific conductance downstream may be due to the influence of winter de-icing salts washed off roads. Ions are released from the sediment under anoxic conditions, such as observed at the bottom of the impoundment, which likely impacted the average specific conductance measured near the bottom (159 ± 101 µS/cm; Fig. 9; Appendix II Table II-1). In addition, the substrate in the impoundment is fine sediment and organics that are easily stirred up, typical of impoundments. No adverse impacts due to specific conductance are expected at any of the study sites.

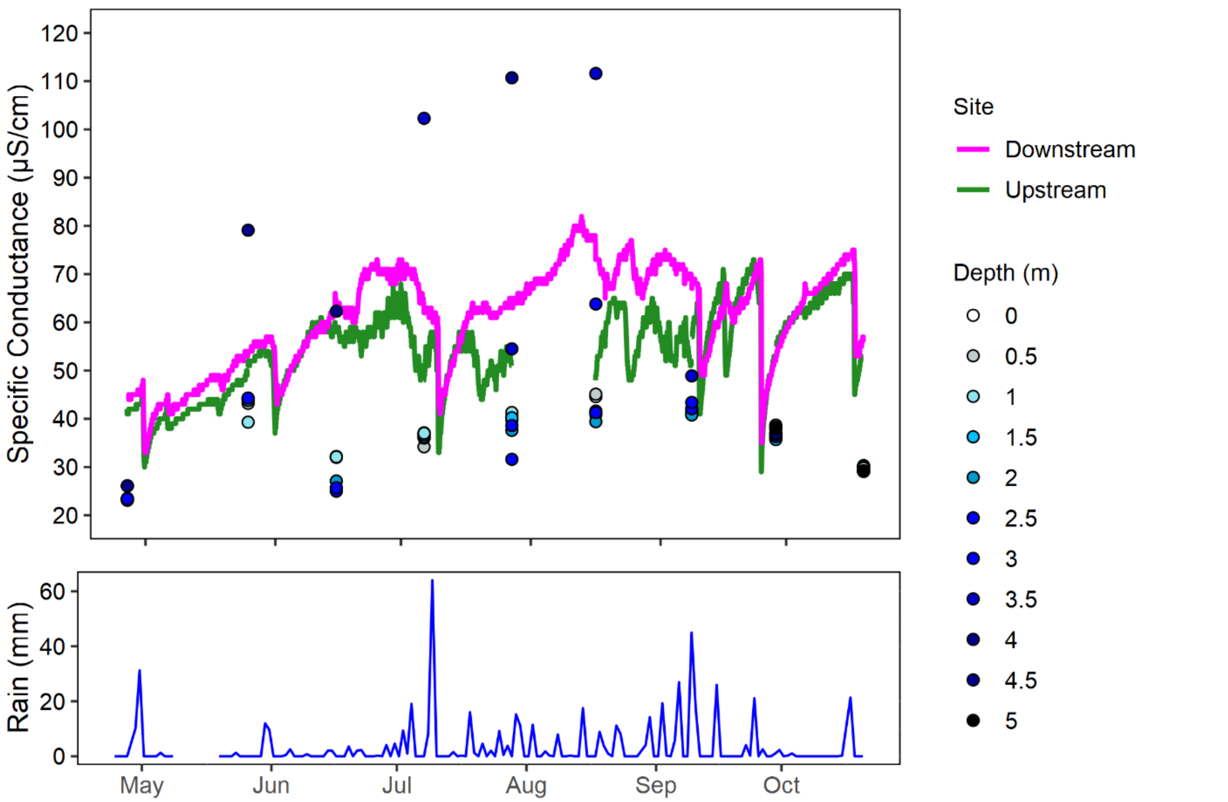

Figure 8. Continuous and discrete specific conductance and local rainfall. Specific conductance maxima, which occurred at depth in the impoundment, are not plotted on this graph. Rainfall data from Weather Underground station KMEFARMI35 and KMEWILTO2.

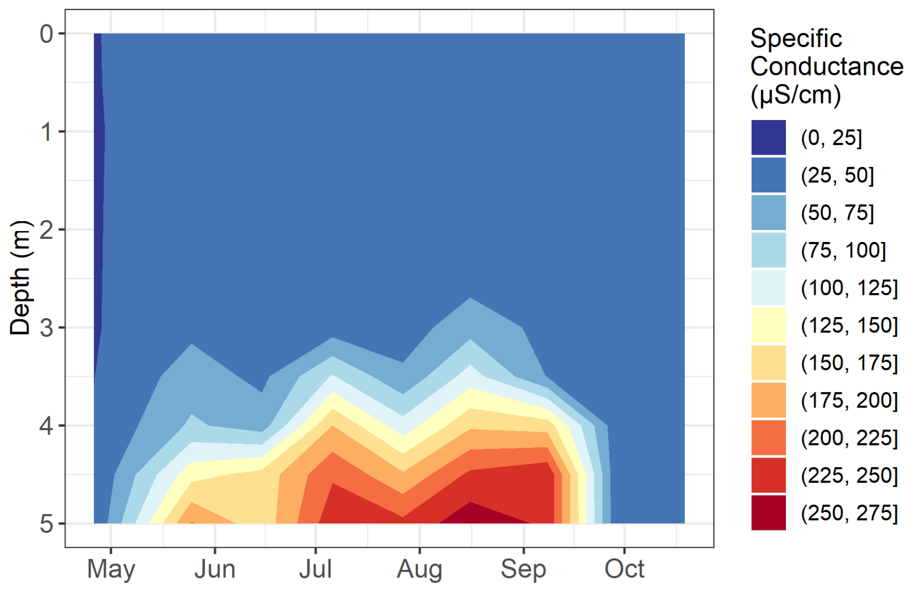

Figure 9. Impoundment specific conductance-depth profiles collected every three weeks April through October.

<u>Calcium</u>

Higher calcium values enable faster growth and higher survival in fish. Salmon survival is at risk when calcium concentrations are below 2 mg/L (Baker et al. 1990; Baldigo and Murdoch 2007). Calcium concentration above 4 mg/L prevent deformities and other stress (Marcus et al. 1986, as cited in Brocksen et al. 1992). At all study sites, average calcium concentrations were well above the survival threshold of 2 mg/L, with a grand mean of 4.8 ± 0.9 mg/L (Appendix II Table II-2). Minimum values in April were below the stress threshold of 4 mg/L. Mean calcium concentration was slightly lower at the upstream site than at the other two sites (by 0.4 mg/L). With the planned dam removal, calcium at the downstream site may decrease slightly to match the upstream site, however no adverse impacts to aquatic life are expected.

Dissolved Organic Carbon (DOC)

DOC has been shown to be a strong determinant of fish mortality in brook trout due to its buffering capacity (Baldigo and Murdoch 2007) 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). The grand mean of DOC across all study sites was 4.0 ± 2.2 mg/L, with highest values (6.7 ± 1.4 mg/L) observed in October after a rain event and leaf drop (Appendix II Table II-2). Baseflow values were similar to other streams with clear water, including Orbeton Stream, a tributary to the Sandy River (Zimmermann 2021). Temple Stream has very low organic content and high pH, indicating a well-buffered system. No changes in DOC concentration are expected with the planned dam removal.

Nutrients

Biologically available nitrogen (nitrate + nitrite as nitrogen) was extremely low in Temple Stream, with a grand mean of 0.013 ± 0.009 mg/L (Appendix II Table II-2). Compared to other tributaries to the Sandy River (Mt. Blue and Orbeton Streams), Temple Stream baseflow concentrations of biologically available nitrogen at the two stream sites were lower (0.025 ± 0.07 mg/L), including less than half of observed concentrations at Orbeton Stream (Zimmermann 2021). Concentrations were slightly higher at the upstream site (0.017 ± 0.014 mg/L) than at the downstream site (0.013 ± 0.008 mg/L), and even lower (0.009 ± 0.005 mg/L) in the impoundment, as expected based on the potential for denitrification at the sediment-water interface in low oxygen waters (Stanley and Doyle 2002). Total Kjeldahl nitrogen (TKN) was similar at all sites, averaging 0.24 ± 0.10 mg/L, similar to values observed at Mt. Blue Stream (Appendix II Table II-2; Zimmermann 2021). In the autumn, TKN decreased at the upstream site while increasing at the other two study sites. Total phosphorus had a grand mean of 13.9 ± 6.3 µg/L, with a summer baseflow average of 7.3 ± 2.1 µg/L, lower than values observed at other Sandy River tributaries (Appendix II Table II-2; Zimmermann 2021). Concentrations were lowest upstream (10.0 ± 5.0 µg/L) and highest downstream (16.3 ± 8.0 µg/L), indicating there is no net-retention of phosphorus in the impoundment (Stanley and Doyle 2002). Nutrient levels were typical of natural, minimally disturbed streams in Maine. The planned dam removal will reduce the potential for denitrification as oxygen levels increase in the former impoundment area, potentially increasing biologically available nitrogen levels downstream. Downstream total phosphorus levels may decrease slightly, based on the upstream concentrations, as phosphorus retention decreases in the free-flowing former impoundment.

Biological Data

The water quality of Temple Stream 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, Temple Stream had high total mean abundance (429) and generic richness (49) (Appendix II Table II-3), comparable with other Class A waterbodies in the state. EPT taxa (mayflies, stoneflies, and caddisflies) represented 47% of the community, comparable to reference sites in Baxter State Park. The dominant taxa were sensitive mayflies (*Maccaffertium* and *Isonychia*), net-spinning caddisflies (*Cheumatopsyche* and *Chimarra*) and a non-biting midge (*Rheotanytarsus*), with relatively low abundance of stoneflies. The Shannon-

Wiener diversity index was quite high (3.8, compared to a max of 4.6), indicating a stable, natural community. The Hilsenhoff Index was relatively low compared to reference streams, indicating higher tolerance of nutrients, although the macroinvertebrate assemblage contained a variety of sensitive taxa typical of mesotrophic systems. Taxonomic results for algae were not available for analysis in time for this report. Small surface-spill dams can have a negative impact on macroinvertebrates up to 1.5 km downstream (Bellucci et al. 2011). Biological samples will be collected the year after the planned dam removal, to assess any changes to the macroinvertebrate and algae communities.

Conclusion

The water quality in Temple Stream is more suitable for salmon and other aquatic life above the impoundment in comparison to below the dam. The impoundment contributed to downstream water temperatures 1.5°C warmer than upstream, as has been observed at other small dams (Dripps and Granger 2013; Maxted et al. 2005; Zaidel et al. 2021), however some of this temperature increase may be the natural warming trend with distance downstream (Zwieniecki and Newton 1999). At all study sites, high summer water temperatures, which were likely exacerbated by summer drought conditions, 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 temperature maxima occur. However, sub-lethal stresses, such as thermal stress, are cumulative and can cause detrimental impacts to growth and survival. The impoundment stratified during the warmest months, resulting in hypoxic conditions that likely do not support aquatic life. The macroinvertebrate community downstream of the dam contained a healthy mix of sensitive taxa, however nutrient tolerance may be slightly higher than in undisturbed reference streams. With the predicted 2°C increase in air temperatures in Maine by 2040 (Fernandez et al. 2020), protecting and enhancing cool water habitat, such as limiting the influence of dammed impoundments, is essential for the protection of aquatic life (Paukert et al. 2021). Removal of small dams helps buffer the negative effects of climate change on streams, such as warming temperatures, by increasing flow through the former impounded area, narrowing the channel, and increasing shade from restored riparian vegetation (Lawrence et al. 2014; Zaidel et al. 2021). As conditions in the impoundment return to stream-like conditions following the planned dam removal in summer 2022, water quality both in the former impoundment and downstream is expected to improve due to decreased water temperatures and elimination of the stratified hypoxic waters of the impoundment, creating more resilient aquatic habitat for Atlantic salmon.

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Appendix I – Stream Characteristics

Table I-1. Study site locations and watershed characteristics. Watershed area and percent land use calculated from MEGIS 2006 and 2020.

Site	Site Code	Latitude	Longitude	Watershed Area (km^2)	Percent Forested (%)	Percent Developed (%)
Upstream	KSDTE29	44.67001	-70.18253	89	94	0.8
Impoundment	KSDTE17	44.66005	-70.16934			
Downstream	KSDTE12	44.66127	-70.16044			
Biological monitoring	S-1183	44.66046	-70.15982			

Table I-2. Study site physical characteristics. Wetted stream width measured for channel sampled, with full multichannel width in parentheses. Mean stream depth was measured every three weeks while sondes were deployed in 2021.

Site	Wetted stream width (m)	Mean stream depth (cm)	Substrate (%)					
			Bedrock	Boulder	Cobble	Gravel	Sand/Silt	Fines
Upstream	3.4 (15.5)	26	-	2	70	10	18	-
Impoundment	27.2 (122)	480	-	-	-	-	-	100
Downstream	10.7 (25)	36	5	-	80	15	-	-
Biological Monitoring	13.6	32	-	20	40	30	10	-

Appendix II – Summary Data Tables

Table II-1. Continuous Data Summary. Summary statistics (mean, standard deviation (SD), minimum and maximum) of measurements from YSI 6000 EDS sondes and Onset Hobo U26 Dissolved Oxygen loggers (KSDTE17), May to October 2021 (n ~ 8,400, except for KSDTE17 where n ~ 16,900 due to 15 minutes sampling interval). pH and specific conductance at KSDTE17 from Eureka Manta2 Sub2 field meter (n = 9).

Site	Site Code	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
Upstream	KSDTE29	7.12	0.20	6.36	8.27	17.71	4.38	6.07	29.79	54	9	29	73	9.43	0.98	7.15	12.27
Impoundment	KSDTE17 - TOP	6.83	0.21	6.52	7.12	19.08	4.46	7.12	29.34	37	7	23.5	44.6	8.36	1.41	2.23	12.24
	KSDTE17 - BOTTOM	6.38	0.27	6.14	6.8	12.59	1.81	7.10	18.82	159	101	26	266	2.93	4.19	0	12.14
Downstream	KSDTE12	6.91	0.09	6.42	7.18	19.18	4.50	7.86	29.51	61	10	33	82	8.85	1.06	6.52	11.69

Table II-2. Discrete Data Summary. Summary statistics (mean, SD, minimum and maximum) from grab samples collected April 26, Aug. 16, and Oct. 19. n = 3. Samples in the impoundment (KSDTE17) were collected from surface waters.

Site Code	Calcium (mg/L)				Dissolved Organic Carbon (mg/L)				Nitrate + Nitrite as Nitrogen (N+N; mg/L)				Total Kjeldahl Nitrogen (TKN; mg/L)				Total Phosphorus (µg/L)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
KSDTE29	4.5	1.0	3.5	5.4	3.5	1.6	2.1	5.2	0.017	0.014	0.003	0.030	0.22	0.09	0.12	0.29	10	5	5	15
KSDTE17	4.9	0.9	3.9	5.5	4.1	2.6	2.2	7.1	0.009	0.005	0.004	0.014	0.27	0.13	0.14	0.4	15	6	9	20
KSDTE12	4.9	1.1	3.8	6	4.4	3.0	2.2	7.6	0.013	0.008	0.004	0.020	0.30	0.05	0.25	0.34	16	8	8	24

Table II-3. Macroinvertebrate Summary. Samples at biological monitoring station 1183 were collected in August 2020 using rock bags following the DEP protocol and analyzed by a certified taxonomist to the lowest possible level (species). EPT taxa include mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera).

Station ID	Log #	Year Sampled	Total Mean Abundance	Generic Richness	EPT Generic Richness	Relative Ephemeroptera Abundance	Dominant Taxa
1183	2816	2020	429	49	23	54%	*Maccaffertium* *Isonychia*

Appendix III – Biomonitoring Key Reports

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

Station Information

Station Number: S-1183
Waterbody: Temple Stream - Station 1183
Town: Farmington
Directions: FOLLOW AN ATV TRAIL TO THE SW OF OAKES STREET TO A PARKING AREA. PARK IN ALONG THE WESTERN EDGE AND THEN HIKE DOWN THE HILL

River Basin: Kennebec
HUC8 Name: Lower Kennebec
Latitude: 44 39 37.66 N
Longitude: 70 9 35.35 W
Stream Order: 3

Sample Information

Log Number: 2816
Subsample Factor: X1
Type of Sample: ROCK BAG
Replicates: 3
Date Deployed: 7/10/2020
Date Retrieved: 8/6/2020

Classification Attainment

Statutory Class: B
Model Result with P≥0.6: A
Date Last Calculated: 4/2/2021
Final Determination: A
Reason for Determination: Model
Comments:
Date: 4/6/2021

Model Probabilities

First Stage Model

Class A	0.63	Class C	0.01
Class B	0.36	NA	0.00

B or Better Model

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

C or Better Model

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

A Model

Class A	0.81
Class B or C or Non-Attainment	0.19

Model Variables

01	Total Mean Abundance	429.33
02	Generic Richness	49.00
03	Plecoptera Mean Abundance	3.00
04	Ephemeroptera Mean Abundance	231.00
05	Shannon-Wiener Generic Diversity	3.83
06	Hilsenhoff Biotic Index	4.23
07	Relative Abundance - Chironomidae	0.16
08	Relative Generic Richness Diptera	0.24
09	*Hydropsyche* Abundance	16.23
11	*Cheumatopsyche* Abundance	30.10
12	EPT Generic Richness/ Diptera Generic Richness	1.92
13	Relative Abundance - Oligochaeta	0.00
15	Perlidae Mean Abundance (Family Functional Group)	2.67
16	Tanypodinae Mean Abundance (Family Functional Group)	5.33
17	Chironomini Abundance (Family Functional Group)	27.00
18	Relative Abundance Ephemeroptera	0.54
19	EPT Generic Richness	23.00
21	Sum of Abundances: *Dicrotendipes, Micropsectra, Parachironomus, Helobdella*	0.00
23	Relative Generic Richness- Plecoptera	0.04
25	Sum of Abundances: *Cheumatopsyche, Cricotopus, Tanytarsus, Ablabesmyia*	37.43
26	Sum of Abundances: *Acroneuria, Maccaffertium, Stenonema*	135.33
28	EP Generic Richness/14	0.93
30	Presence of Class A Indicator Taxa/7	0.14

Five Most Dominant Taxa

Rank	Taxon Name	Percent
1	*Maccaffertium*	30.90
2	*Isonychia*	11.57
3	*Cheumatopsyche*	7.01
4	*Rheotanytarsus*	6.83
5	*Chimarra*	5.12

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

Station Number:	**S-1183**	Town: Farmington	Date Deployed: 7/10/2020
Log Number:	**2816**	Waterbody: Temple Stream - Station 1183	Date Retrieved: 8/6/2020

Sample Collection and Processing Information

Sampling Organization: BIOMONITORING UNIT

Taxonomist: MICHAEL COLE

Waterbody Information - Deployment		
Temperature:	24.1	deg C
Dissolved Oxygen:	9	mg/l
Dissolved Oxygen Saturation:	107.6	%
Specific Conductance:	61	uS/cm
Velocity:	15.2	cm/s
pH:	7.19	
Wetted Width:	14.7	m
Bankfull Width:	16.9	m
Depth:	30	cm

Waterbody Information - Retrieval		
Temperature:	21.5	deg C
Dissolved Oxygen:	8.85	mg/l
Dissolved Oxygen Saturation:	100.5	%
Specific Conductance:	61.1	uS/cm
Velocity:	15.2	cm/s
pH:	6.95	
Wetted Width:	12.5	m
Bankfull Width:	16.9	m
Depth:	33	cm

Water Chemistry

Summary of Habitat Characteristics

Landuse Name	Canopy Cover	Terrain
Cultivated	Partly Open	Rolling
Upland Hardwood		
Urban		

Potential Stressor	Location	Substrate	
Nps Pollution	Below Agriculture NPS	Boulder	20 %
	Below Urban NPS	Gravel	30 %
		Rubble/Cobble	40 %
		Sand	10 %

Landcover Summary - 2004 Data

Sample Comments

Maine Department of Environmental Protection
Biological Monitoring Program
Aquatic Life Taxonomic Inventory Report

Station Number: S-1183 Waterbody: Temple Stream - Station 1183 Town: Farmington

Log Number: 2816 Subsample Factor: X1 Replicates: 3 Calculated: 4/2/2021

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
Placobdella	08030101006	0.33	0.33		--	0.1	0.1
Hyalella	09010203006	0.33	0.33	8	CG	0.1	0.1
Cambaridae	09010301	0.33	0.33		--	0.1	0.1
Leuctra	09020204020	0.33	0.33	0	SH	0.1	0.1
Acroneuria	09020209042	1.00	2.67	0	PR	0.2	0.6
Acroneuria abnormis	09020209042121	1.67		0	PR	0.4	
Boyeria	09020301004	0.33	0.33	2	PR	0.1	0.1
Gomphidae	09020302	0.67	0.67		--	0.2	0.2
Corduliidae	09020305	0.33	0.33		--	0.1	0.1
Coenagrionidae	09020309	1.33	1.33		--	0.3	0.3
Baetis	09020401001	0.33	6.33	4	CG	0.1	1.5
Baetis flavistriga	09020401001004	1.00			--	0.2	
Baetis intercalaris	09020401001008	4.67			--	1.1	
Baetis pluto	09020401001009	0.33			--	0.1	
Acerpenna	09020401007	2.00	12.67	5	CG	0.5	3.0
Acerpenna pygmaea	09020401007011	10.67			--	2.5	
Procloeon	09020401010	0.33	0.33		CG	0.1	0.1
Iswaeon	09020401015	0.33	0.33		--	0.1	0.1
Epeorus	09020402009	1.33	1.33	0	SC	0.3	0.3
Leucrocuta	09020402011	8.00	8.00	1	SC	1.9	1.9
Stenacron	09020402014	17.00	17.00	7	SC	4.0	4.0
Maccaffertium	09020402015	128.00	132.67	4	SC	29.8	30.9
Maccaffertium modestum	09020402015051	1.67			--	0.4	
Maccaffertium vicarium	09020402015055	3.00			--	0.7	
Isonychia	09020404018	49.67	49.67	2	CF	11.6	11.6
Paraleptophlebia	09020406026	1.00	1.00	1	CG	0.2	0.2
Tricorythodes	09020411038	1.67	1.67	4	CG	0.4	0.4
Chimarra	09020601003	0.67	22.00	2	CF	0.2	5.1
Chimarra aterrima	09020601003002	1.33			--	0.3	
Chimarra obscura	09020601003003	2.33			--	0.5	
Chimarra socia	09020601003004	17.67			--	4.1	
Polycentropodidae	09020603	0.67			--	0.2	
Neureclipsis	09020603008	5.67	6.21	7	CF	1.3	1.4
Polycentropus	09020603010	1.33	1.46	6	PR	0.3	0.3
Hydropsychidae	09020604	0.67			--	0.2	
Cheumatopsyche	09020604015	29.67	30.10	5	CF	6.9	7.0
Hydropsyche	09020604016	8.67	16.23	4	CF	2.0	3.8

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
Hydropsyche morosa	09020604016030	3.33			--	0.8	
Hydropsyche sparna	09020604016032	0.67			--	0.2	
Hydropsyche betteni	09020604016037	3.33			--	0.8	
Rhyacophila	09020605019		0.33	2	PR		0.1
Rhyacophila minora	09020605019063	0.33			PR	0.1	
Oxyethira	09020607028	0.33	0.33	3	P	0.1	0.1
Neotrichia	09020607034	1.33	1.33	2	SC	0.3	0.3
Pycnopsyche	09020610049	0.33	0.33	4	SH	0.1	0.1
Oecetis	09020618078	9.67	9.67	8	PR	2.3	2.3
Corydalus	09020701002		0.33	6	PR		0.1
Corydalus cornutus	09020701002002	0.33			--	0.1	
Chironomidae	09021011				--		
Ablabesmyia	09021011001	0.33	0.33	8	PR	0.1	0.1
Thienemannimyia	09021011020		5.00	3	PR		1.2
Thienemannimyia group	09021011020041	5.00			--	1.2	
Thienemanniella	09021011062	0.67	0.67	6	CG	0.2	0.2
Rheotanytarsus	09021011072		29.33	6	CF		6.8
Rheotanytarsus exiguus group	09021011072127	28.00			CF	6.5	
Rheotanytarsus pellucidus	09021011072128	1.33			CF	0.3	
Stempellinella	09021011074	0.67	0.67	2	--	0.2	0.2
Tanytarsus	09021011076	7.00	7.00	6	CF	1.6	1.6
Microtendipes	09021011094		8.00	6	CF		1.9
Microtendipes rydalensis group	09021011094168	8.00			--	1.9	
Phaenopsectra	09021011101		0.67	7	SC		0.2
Phaenopsectra obediens group	09021011101180	0.67			--	0.2	
Polypedilum	09021011102		18.33	6	SH		4.3
Polypedilum aviceps	09021011102181	0.33			--	0.1	
Polypedilum flavum	09021011102182	18.00			--	4.2	
Simulium	09021012047	16.33	16.33	4	CF	3.8	3.8
Atherix	09021015055	1.00	1.00	2	PR	0.2	0.2
Empididae	09021016			6	--		
Hemerodromia	09021016057	1.33	1.33	3	PR	0.3	0.3
Psephenus	09021108058		0.33	4	SC		0.1
Psephenus herricki	09021108058028	0.33			--	0.1	
Helichus	09021112062	0.33	0.33	5	SH	0.1	0.1
Dubiraphia	09021113064	1.67	1.67	6	--	0.4	0.4
Optioservus	09021113067		1.00	3	SC		0.2
Optioservus elegans	09021113067051	0.67			--	0.2	

Aquatic Life Taxonomic Inventory Report

Station Number: S-1183 Waterbody: Temple Stream - Station 1183 Town: Farmington

Log Number: 2816 Subsample Factor: X1 Replicates: 3 Calculated: 4/2/2021

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
Optioservus tardella	09021113067052	0.33			--	0.1	
Oulimnius	09021113068		0.33		--		0.1
Oulimnius latiusculus	09021113068049	0.33			--	0.1	
Stenelmis	09021113070	11.00	11.00	5	SC	2.6	2.6