Mill Lake Stream (Charlotte County, New Brunswick): environmental conditions during the summer of 2016

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ABSTRACT

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The present study presents hydrological and meteorological data during the summer 2016 for Mill Lake Stream, which is a 220 m stretch of stream that joins Mill Lake and Lake Utopia near St. George (New Brunswick). Mill Lake Stream has a unique population of Rainbow Smelt (*Osmerus mordax*) that was designated as Threatened in 2008 by the Committee of the Status of Endangered Wildlife in Canada (COSEWIC). Rainbow Smelt inhabiting Lake Utopia and associated waters consists of two co-existing morphologically, ecologically, and genetically differentiated populations that are referred as Lake Utopia Rainbow Smelt. During the summer of 2016, hourly water temperatures, air temperatures and water levels were monitored between May 18 and October 13. River discharge was also monitored during site visits as well as water velocities within a culvert located at the mouth of the stream. Maximum recorded temperature over the summer period was 28°C in Mill Lake stream and the maximum recorded velocity in the culvert was 1.1 m/s.

RÉSUMÉ

Caissie, D., F. Savoie. 2017. Mill Lake Stream (Charlotte County, New Brunswick): environmental conditions during the summer of 2016. Can. Data Rep. Fish. Aquat. Sci. 1278: vi + 18p.

Cette étude présente des données hydrologiques et météorologiques du ruisseau Mill Lake pendant l'été 2016, soit un tronçon de 220 m qui relie le lac Mill au lac Utopia près de St. George (Nouveau-Brunswick). Le ruisseau Mill Lake possède une population unique d'éperlan arc-en-ciel (*Osmerus mordax*) qui a été désignée comme menacée en 2008 par le Comité sur la situation des espèces en péril au Canada (COSEPAC). L'éperlan arc-en-ciel qui habite le lac Utopia et les eaux environnantes se compose de deux populations coexistantes morphologiquement, écologiquement et génétiquement différenciées qui sont appelées l'éperlan arc-en-ciel du lac Utopia. Au cours de l'été 2016, les températures de l'eau, températures de l'air et les niveaux d'eau ont été mesurés (données horaires) entre le 18 mai et le 13 octobre. Le débit du cours d'eau a également été mesuré durant chaque visite sur le terrain et des vitesses d'écoulement de l'eau dans un ponceau situé à l'embouchure du ruisseau ont aussi été mesurées. La température maximale enregistrée pendant la période estivale au ruisseau Mill Lake était de 28°C et la vitesse maximale enregistrée dans le ponceau était de 1.1 m/s.

1.0 INTRODUCTION

This study was conducted in Mill Lake Stream which is located approximately 5 km north of Saint George (New Brunswick; Figure 1). Mill Lake Stream joins two lakes, Mill Lake and Lake Utopia, and supports a unique population of Rainbow Smelt (*Osmerus mordax*) that was designated as Threatened in 2008 by the Committee of the Status of Endangered Wildelife in Canada (COSEWIC). Rainbow Smelt inhabiting Lake Utopia and associated waters consists of two co-existing morphologically, ecologically, and genetically differentiated populations (Bradbury *et al.* 2011). Together the two populations are referred as Lake Utopia Rainbow Smelt (LURS). In order to better understand conditions influencing this population of smelt, meteorological and hydrological data were collected during the summer of 2016. Air temperature, water temperature and water level data were collected on a continuous basis over the summer period whereas stream discharge and velocities were monitored at specific location during site visits. The objective of the present data report is to outline environmental conditions over the summer period at the study site in order to assist development of aquatic and fisheries management strategies.

2.0 MATERIALS AND METHODS

2.1 Study area

The study site consists of the Mill Lake Stream (45°12’19.27”N; 66°46’42.53”W), which is a small stream that drains Mill Lake to Lake Utopia (Figure 1). The stream width is approximately 5.5 m. The length of the Mill Lake Stream is approximately 220 m. Lake Utopia is the larger of the two lakes with a surface area of 14.0 km^2 and a corresponding drainage basin area of 82 km^2. Mill Lake has a surface area of 1.6 km^2. The total basin drainage area for Mill Lake is 21.1 km^2 (Figure 2). Mill Lake Stream has a mean annual flow of approximately 0.49 m^3/s based on

provincial runoff characteristics and a median flow (Q_{50}) of 0.12 m^3/s (Caissie and Robichaud 2009). The 2-year flood is estimated at 6.1 m^3/s (Aucoin *et al.*, 2011) and the 2-year flood is also reflective of the bankfull discharge. A dam is present at the upstream end of the stream (at the Mill Lake) and a road crossing with culvert is present at the downstream end.

2.1 Data collection

Air temperatures, water temperatures and water levels were recorded on an hourly basis from May 18, 2016 (day 139) to October 13, 2016 (day 287). Water levels and water temperatures were measured using a HOBO Onset water level logger (Model U20; 0 to 9m; Typical error ±0.5cm). These units measure temperature in the range of -20°C to 50°C (±0.44°C). A second HOBO water level / water temperature logger was attached to a tree in the nearby forest (shaded location) to measure air temperature and to correct for atmospheric (barometric) pressure for the logger in the river. Discharge data were recorded for Mill Lake Stream during site visits (i.e., on May 18, June 30 and Oct. 13). During site visits, water velocities were measured inside the culvert located at the mouth of the brook, i.e., on Route 785 (Figure 2). This culvert is 1.65 m in diameter and is approximately 21 m in length. Velocities were taken at 5-8 points over the length of the culvert. At each location, water velocity was taken at a single point (in the middle of the culvert to represent maximum velocity) at a depth of 0.6 of the total column depth (to represent the mean water column velocity). These velocities should represent maximum velocities experienced by fish moving upstream (or downstream) within the culvert. However, if fish are moving at a depth closer to the bottom of the culvert, then velocities could be slightly lower (also influenced by the corrugation of the culvert or any debris within the culvert, if present).

Stream discharge was calculated using the velocity - surface area method where over 20 points were taken at a river cross section (outside the culvert). At each point

along the cross section, distance from the bank, river depth and the mean water column velocity (using a Marsh-McBirney - Model 2000 current meter) were measured. Then unit-area discharges are calculated and the summation of all unit-area discharges provided the river discharge (representing a volume of water over time, expressed in m^3/s).

3.0 DATA SUMMARY

Figure 3 plots hourly air temperatures, water temperatures and water levels between day 140 (May 19) and day 287 (Oct. 13). Air temperatures show significant seasonal and diel variability over this time period (Figure 3a). Mean summer air temperature (July and August) was 19.2°C, and air temperatures exceeded 30°C on 6 days, of which three occurred in June (day 171, June 19; 30.6°C; day 174, June 22; 31.1°C and day 178, June 26; 32.9°C; Table 1; Figure 3a). After this warm period in June, only a few days exceeded air temperature of 30°C, i.e., one day late July (day 206, July 24; 31.5°C) and one day in early September (day 253, Sept. 9; 30.5°C). Diel air temperature variability was typically around 11°C (early morning to mid-afternoon temperatures) but some days (e.g., day 170, June 18) experienced as much as 23°C diel temperature variation (min = 6.4°C and max = 29.9°C; Table 1). Water temperatures showed a seasonal cycle (similar to air temperature), but with less diel variability (mean diel variability = 2.5°C; Figure 3b). As such, diel variability was much less for water temperatures than air temperatures. The mean summer water temperature (July-August) was 23.4°C (Table 1), which was slightly higher than the corresponding mean summer air temperature (see above). Water temperatures exceeded 25°C in late June with corresponding higher air temperatures; however, as experienced in most rivers (e.g., Maritime Provinces), water temperatures generally peaked in late July and early August (between day 205 and day 220 in 2016; Figure 3b). During this period, water temperatures reached a summer maximum value of 27.9°C (day 206, July 24; Table 1).

In total during the study period, 6 days showed maximum water temperatures exceeding 27°C.

Water levels were also monitored in Mill Lake Stream (Figure 3c). Water levels were generally low towards the end of May and early June (day 140 to day 160; 0.25 m to 0.35 m); however, a high flow event occurred on June 8 (day 160) where water level reached a maximum value 0.44 m (daily mean of 0.368 m; Table 1). At the St. Stephen meteorological station (37 km from the study site), 33 mm of rain were recorded between June 5 and June 8, 2016. Water levels then declined in late June (day 175-180), but increased again in early July and remained relatively high (0.4 m) during mid-July (day 195-205). Water levels were lowest of the time series after day 255 (Sept. 11) with values close to 0.2 m and remained low until the end of the study period (i.e., Oct. 13; day 287).

During three site visits (May 18, June 30 and Oct. 13), both river discharge and velocities within the culvert were measured. Figure 4 shows the velocities vs. depths at different locations along the culvert. Velocities can be important for migratory fish at different times of year. Results show that on May 18 the depth of water varied between 0.36 m and 0.44 m with a mean of 0.41 m, with corresponding velocities between 0.58 m/s and 0.75 m/s (mean of 0.64 m/s; n = 5). The river discharge on this day was 0.23 m^3/s (see Appendix A for river discharge calculations). On June 30, depths of water within the culvert were shallower and higher velocities were observed. Depths were between 0.26 m and 0.33 m (mean of 0.30 m) with corresponding velocities between 0.78 m/s and 1.11 m/s (mean of 1.02 m/s; n = 8). The river discharge on June 30 was 0.22 m^3/s and this discharge was very similar to that observed on May 18. The higher velocities within the culvert on June 30 were most likely due to a lower level of Lake Utopia compared to May 18 (i.e., higher lake level on May 18 would have backed water into the culvert resulting in lower velocities). On October 13, water depths within the culvert were between 0.20 m and 0.28 m (mean of 0.24 m) and velocities were between

0.16 m/s and 0.33 m/s (mean of 0.25 m/s; n = 6). Stream discharge on Oct. 13 was the lowest of the site visits at only 0.05 m^3/s.

4.0 CONCLUSIONS

Observed water temperatures in Mill Lake Stream reached ≈ 28°C, most likely due the surface water heating within Mill Lake. These high water temperatures were observed towards the end of July and into August. Generally, the maximum daily water temperatures did not reach 25°C until day 195 (July 13), and temperatures were mostly below 20°C up to day 169 (June 17; Figure 3b). Mean daily water levels were generally between 0.19 m and 0.42 m with lower values towards the end of the study period (Table 1; Figure 3c). Velocities measured within the culvert reached values of 1.1 m/s on June 30 when stream water levels were relatively low (0.29 m; Table 1). It is expected that water velocities within the culvert would be much higher during high flow events, such as those experienced in late May and mid-July when water levels reached 0.4 m.

5.0 ACKNOWLEDGEMENTS

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6.0 REFERENCES

Aucoin, F., D. Caissie, N. El-Jabi and N. Turkkan. 2011. Flood frequency analyses for New Brunswick rivers. Can. Tech. Rep. Fish. Aquat. Sci. 2920: xi + 77p.

Bradbury, I., R. Bradford, and P. Bentzen. 2011. Genetic and phenotypic diversity and divergence in sympatric Lake Utopia rainbow smelt, *Osmerus mordax*. DFO Canadian Scientific Advisory Secretariat Research Document 2011/008. vi + 28 p.

Caissie, D. and S. Robichaud. 2009. Towards a better understanding of the natural flow regimes and streamflow characteristics of rivers of the Maritime Provinces. Can. Tech. Rep. Fish. Aquat. Sci. 2843: viii + 53p.

Table 1. Daily air temperature, water temperature and water level for Mill Lake Stream

	Air temperature (°C)			Water temperture (°C)			Water
DOY[1]	Min	Max	Mean	Min	Max	Mean	level (m)[2]
139	9.7	21.3	16.1	13.8	15.0	14.5	0.312
140	5.2	24.3	12.8	12.9	17.1	14.7	0.312
141	7.6	25.3	14.2	14.2	17.6	15.9	0.302
142	7.7	30.6	16.8	15.3	19.2	17.1	0.296
143	9.6	17.5	13.8	16.0	18.1	17.1	0.290
144	11.1	21.6	14.6	16.1	18.1	17.2	0.268
145	12.1	22.2	15.5	16.6	19.9	18.1	0.258
146	10.9	19.7	14.0	17.4	19.0	18.1	0.266
147	9.9	21.1	15.0	17.2	19.9	18.4	0.262
148	6.9	13.3	10.6	16.9	18.7	17.5	0.261
149	9.5	28.6	15.9	16.5	20.8	18.3	0.259
150	10.0	13.8	11.4	17.1	19.2	17.8	0.255
151	9.0	15.8	11.7	16.3	17.4	16.8	0.254
152	10.9	28.1	17.6	16.3	19.9	18.0	0.258
153	12.0	26.2	17.6	18.0	21.7	19.7	0.257
154	8.3	24.4	13.6	18.1	21.4	19.6	0.250
155	9.9	16.9	13.0	18.0	19.5	18.7	0.249
156	10.9	17.9	13.8	17.7	19.0	18.3	0.248
157	10.6	20.5	14.6	17.6	20.3	18.8	0.248
158	11.3	15.1	13.2	16.8	19.0	17.8	0.247
159	10.3	19.5	13.4	16.9	20.0	18.3	0.250
160	11.6	21.1	15.4	17.7	20.2	18.8	0.368
161	10.1	13.9	12.0	17.6	18.7	18.1	0.418
162	8.3	18.9	12.8	17.1	18.1	17.5	0.379
163	9.2	21.3	14.2	16.8	19.2	17.9	0.350
164	11.0	14.8	12.7	16.6	18.0	17.1	0.321
165	9.6	13.5	11.7	16.1	16.9	16.5	0.310
166	9.2	15.1	11.5	15.7	16.7	16.2	0.300
167	7.2	17.9	11.9	15.4	16.8	16.2	0.291
168	8.3	19.2	13.8	15.5	18.3	16.9	0.280
169	6.8	29.6	15.5	15.8	20.1	17.8	0.271
170	6.4	29.9	16.0	16.6	20.1	18.3	0.260
171	10.6	30.6	17.8	17.3	21.7	19.2	0.258
172	12.3	22.6	16.7	18.3	21.9	19.9	0.255
173	11.5	26.9	16.6	18.6	21.7	19.9	0.256
174	10.8	31.1	16.9	19.2	22.7	20.6	0.256
175	11.9	26.3	17.5	19.6	22.6	20.9	0.259
176	11.3	28.7	17.8	19.2	23.3	21.1	0.258
177	10.7	28.8	18.3	20.2	23.9	22.0	0.271
178	12.0	32.9	19.8	21.0	24.4	22.5	0.276
179	12.6	28.6	18.3	21.3	25.2	23.1	0.281

[1] DOY = day of year (Jan. 1 = 1 and Dec. 31 = 365); [2] mean daily water level (m)

Table 1. Daily air temperature, water temperature and water level for Mill Lake Stream (Continued)

	Air temperature (°C)			Water temperture (°C)			Water
DOY[1]	Min	Max	Mean	Min	Max	Mean	level (m)[2]
180	14.2	26.6	17.5	21.5	23.6	22.5	0.286
181	14.3	17.6	15.9	21.1	22.5	21.6	0.290
182	14.5	24.4	18.2	20.5	23.2	21.7	0.294
183	14.3	27.1	19.0	21.1	25.2	23.0	0.304
184	14.6	19.8	16.5	21.5	23.5	22.2	0.325
185	13.2	24.9	18.5	20.6	22.9	21.8	0.335
186	14.1	29.7	20.8	21.1	24.1	22.4	0.342
187	15.8	27.0	19.8	21.2	24.9	22.9	0.344
188	16.5	23.9	19.1	22.5	24.3	23.4	0.342
189	12.9	17.1	14.1	20.4	23.4	21.6	0.345
190	13.1	16.1	14.5	19.8	20.3	20.1	0.349
191	13.0	16.6	14.5	19.1	19.7	19.4	0.344
192	12.7	16.2	14.6	18.8	19.5	19.2	0.341
193	11.6	25.4	15.9	18.1	21.0	19.3	0.364
194	13.5	26.1	18.2	19.4	22.2	20.7	0.378
195	14.7	26.2	19.0	20.7	24.8	22.5	0.387
196	15.5	25.8	19.1	22.1	24.9	23.5	0.392
197	17.1	27.1	20.7	22.7	25.7	24.1	0.394
198	16.4	26.2	20.7	23.7	25.9	24.8	0.393
199	17.0	22.0	19.0	24.1	25.1	24.6	0.394
200	16.6	22.0	18.1	23.4	24.7	23.8	0.397
201	14.9	24.3	18.0	22.6	24.8	23.6	0.398
202	12.7	26.7	18.9	22.0	24.5	23.2	0.395
203	14.6	28.3	20.3	22.0	25.3	23.6	0.384
204	15.7	29.7	20.4	22.5	26.0	24.1	0.378
205	16.7	26.9	20.4	23.7	26.4	24.9	0.367
206	16.8	31.5	22.1	24.1	27.9	25.7	0.357
207	17.8	29.5	22.1	24.7	27.4	26.0	0.348
208	16.9	26.6	20.0	24.5	26.4	25.4	0.343
209	18.0	29.9	22.2	24.4	27.5	25.9	0.339
210	16.7	27.6	20.7	24.9	27.6	26.1	0.342
211	17.7	24.6	20.6	25.0	26.7	25.9	0.339
212	16.9	30.0	21.7	24.5	27.6	25.9	0.333
213	14.5	27.5	20.0	24.3	26.8	25.5	0.308
214	13.8	29.4	20.2	23.9	26.9	25.4	0.283
215	16.5	27.5	20.9	24.4	26.7	25.5	0.280
216	14.1	27.9	20.1	24.0	27.2	25.5	0.282
217	15.3	27.4	20.1	24.0	26.8	25.3	0.280
218	15.9	28.2	20.4	23.9	27.0	25.3	0.283
219	17.5	27.7	19.8	24.0	26.3	24.9	0.280
220	15.4	28.9	20.0	23.5	26.6	24.9	0.277

Table 1. Daily air temperature, water temperature and water level for Mill Lake Stream (Continued)

	Air temperature (°C)			Water temperture (°C)			Water
DOY[1]	Min	Max	Mean	Min	Max	Mean	level (m)[2]
221	14.6	28.1	19.9	23.1	25.9	24.4	0.271
222	10.6	27.3	18.1	22.0	24.9	23.5	0.264
223	13.7	28.9	19.5	22.0	25.2	23.6	0.250
224	18.4	28.7	21.4	23.3	25.7	24.3	0.250
225	17.0	22.7	19.4	23.2	24.4	23.7	0.249
226	15.7	23.0	18.3	22.1	24.0	23.0	0.247
227	15.4	19.8	17.4	21.7	23.0	22.2	0.248
228	16.7	23.6	19.0	21.8	23.6	22.5	0.247
229	13.6	25.4	18.7	21.3	24.4	22.8	0.249
230	15.3	19.9	17.4	21.3	23.3	22.0	0.251
231	14.7	25.9	19.5	20.8	24.1	22.2	0.252
232	14.8	23.2	18.8	21.4	24.1	22.7	0.266
233	13.3	25.4	18.3	21.5	24.3	22.7	0.268
234	15.1	26.1	18.8	22.0	23.9	22.7	0.268
235	15.1	19.8	18.5	21.8	22.9	22.4	0.272
236	12.1	26.1	18.1	20.3	23.6	21.8	0.280
237	14.9	28.7	20.2	20.9	24.2	22.4	0.292
238	16.0	25.1	19.9	21.8	24.3	23.0	0.294
239	17.2	27.7	20.5	22.5	24.2	23.3	0.293
240	15.7	28.5	20.5	22.1	24.8	23.4	0.288
241	13.6	25.2	18.5	22.2	24.5	23.3	0.288
242	16.0	26.3	19.5	22.0	24.4	23.0	0.285
243	13.1	26.1	18.5	21.0	23.8	22.3	0.245
244	14.7	24.9	18.3	21.2	22.8	22.0	0.236
245	15.9	24.8	19.1	21.3	23.4	22.2	0.230
246	14.5	22.0	17.4	20.5	22.2	21.5	0.222
247	10.7	26.5	16.5	19.6	22.8	21.1	0.218
248	12.0	26.5	17.3	19.9	22.8	21.2	0.210
249	12.2	23.1	16.7	19.7	22.5	21.1	0.197
250	15.9	24.9	19.6	20.7	22.6	21.5	0.195
251	17.0	27.7	20.7	21.2	23.8	22.3	0.190
252	18.3	23.4	20.0	22.1	23.4	22.7	0.194
253	17.5	30.5	21.3	21.9	24.3	22.8	0.193
254	15.3	28.4	20.2	21.2	24.6	22.8	0.193
255	14.2	21.9	18.5	21.1	23.2	22.3	0.197
256	9.4	25.0	16.3	18.7	22.0	20.4	0.189
257	11.6	26.5	17.9	19.2	22.3	20.6	0.191
258	12.1	20.2	16.2	19.6	20.8	20.2	0.191
259	7.4	21.7	13.0	17.6	20.6	19.1	0.196
260	5.9	22.2	13.2	16.9	20.2	18.6	0.202
261	11.6	22.0	15.9	17.6	20.7	19.0	0.201

Table 1. Daily air temperature, water temperature and water level for Mill Lake Stream (Continued)

	Air temperature (°C)			Water temperture (°C)			Water
DOY[1]	Min	Max	Mean	Min	Max	Mean	level (m)[2]
262	15.8	19.2	17.4	19.0	19.6	19.2	0.204
263	15.1	18.6	16.7	18.7	19.3	19.0	0.204
264	15.2	18.9	16.8	18.6	19.6	19.0	0.206
265	14.7	25.7	18.6	18.9	21.5	19.8	0.208
266	10.9	22.3	15.6	18.0	20.8	19.3	0.207
267	9.1	15.9	13.3	17.3	19.5	18.5	0.207
268	5.3	16.2	9.0	15.6	17.4	16.5	0.212
269	3.8	15.7	8.2	14.1	16.0	15.1	0.204
270	4.1	18.0	9.7	13.3	16.3	14.7	0.203
271	9.0	14.0	11.2	14.4	15.2	14.8	0.200
272	7.6	15.0	11.0	13.4	15.4	14.3	0.191
273	7.8	16.8	10.9	12.8	15.1	13.8	0.193
274	2.9	18.7	9.8	12.1	15.1	13.6	0.199
275	7.5	17.2	11.8	13.2	15.2	14.2	0.201
276	11.2	13.7	12.2	14.2	15.2	14.7	0.210
277	6.8	16.3	12.3	14.2	15.6	14.9	0.205
278	1.7	17.0	8.1	12.6	15.1	13.9	0.212
279	2.2	19.9	9.4	12.2	15.4	13.8	0.220
280	4.8	22.0	11.8	12.9	15.9	14.3	0.213
281	7.3	23.8	13.8	13.7	16.8	15.1	0.217
282	8.2	19.4	13.2	14.3	16.6	15.5	0.215
283	9.2	15.1	12.8	14.4	16.0	15.5	0.206
284	5.1	10.5	7.7	12.0	14.3	13.0	0.216
285	1.8	17.0	7.6	10.7	13.7	12.1	0.224
286	4.8	16.4	9.9	11.6	13.8	12.7	0.229
287	9.6	13.7	11.2	12.7	13.1	12.8	0.231
		Mean (all) =	16.5		**Mean (all) =**	20.3	
		Mean (July-Aug) =	19.2		**Mean (July-Aug) =**	23.4	
					Max water temp. =	27.9	

[1] DOY = day of year (Jan. 1 = 1 and Dec. 31 = 365); [2] mean daily water level (m)

Figure 1. Location of the Mill Lake Stream study site in relation to Lake Utopia and Mill Lake

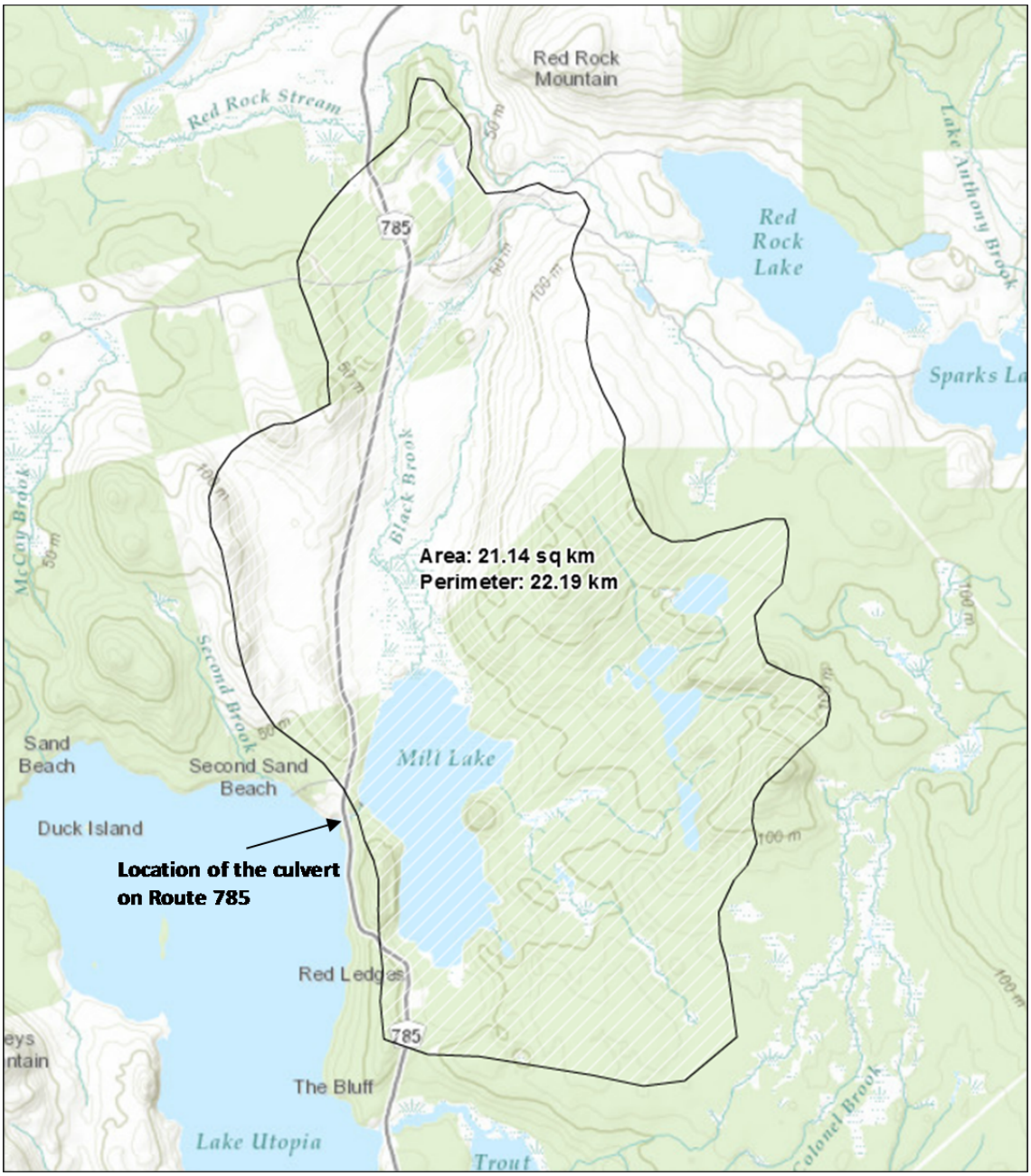

Figure 2. Mill Lake and Mill Lake Stream drainage basin area and perimeter (Topo map 1: 50 000), as well as the location of the culvert on Route 785

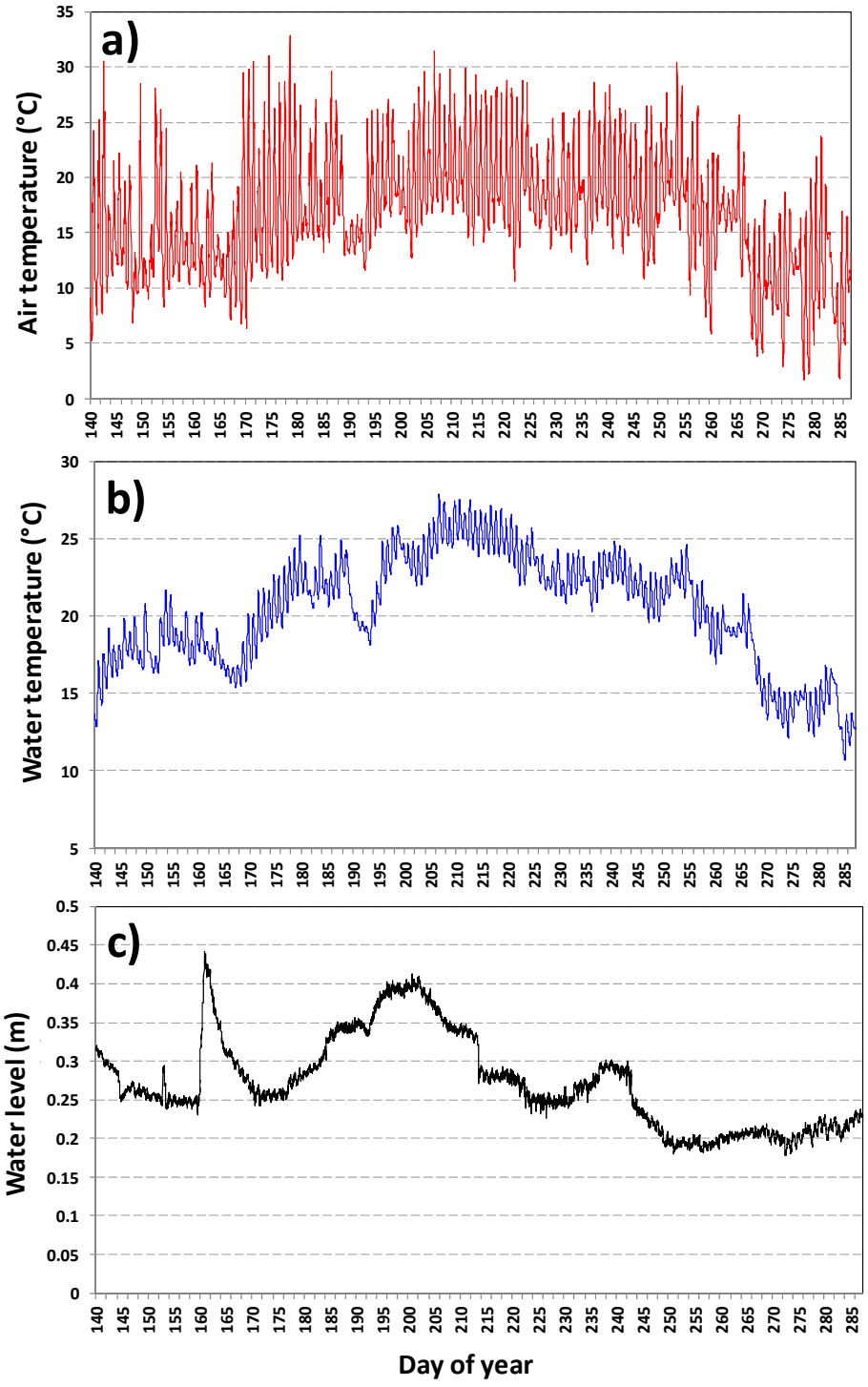

Figure 3. Hourly a) air temperature, b) water temperature and c) water level in Mill Lake Stream between day 140 (May 19, 2016) and day 287 (Oct. 13, 2016)

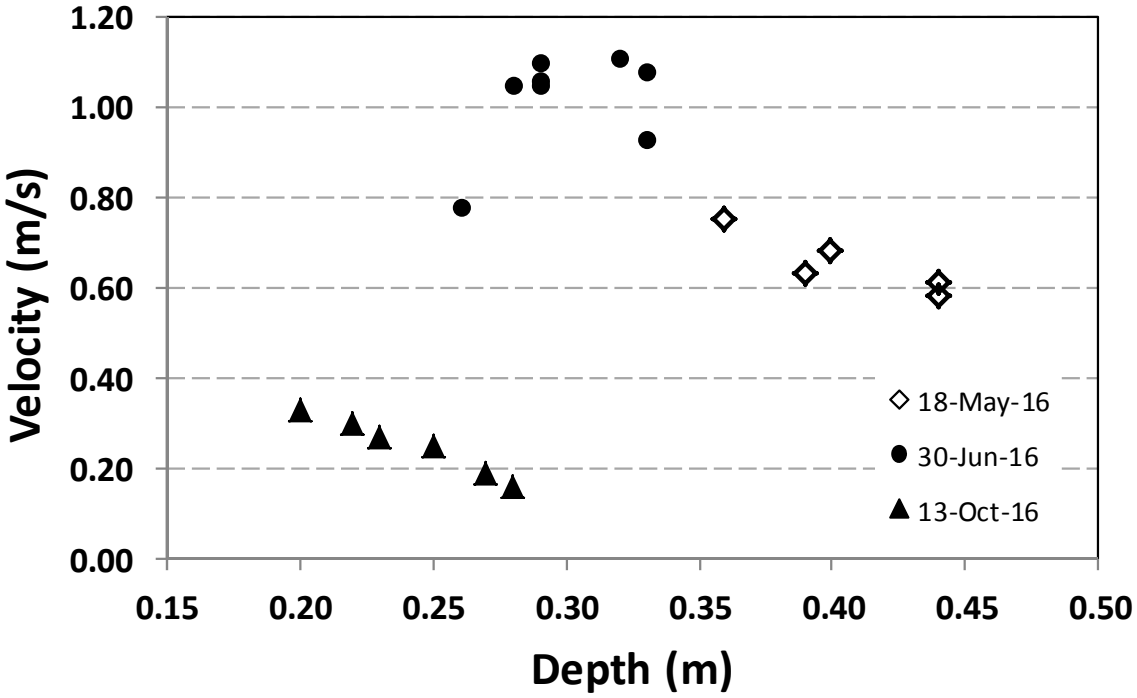

Figure 4. Velocity vs. depth at different locations within the culvert (velocities taken at a depth of 0.6 of the total depth to represent mean column velocity). The velocities were measured mid-section, i.e., at the maximum depth for each cross section

APPENDIX A

Discharge Measurements

Discharge calculation

Project:	**Lake Utopia (St-Gerorge, NB)**
Date:	18-May-16
Crew:	Daniel and Fernand
Equipment:	Marsh-McBirney, Model 2000
Met condition:	Sunny, ≈ 20 deg C
Time:	Started at around 13:00

Sta	Dist	Depth	V	Qi	
1	2.60	0	0.00	0.0000	
2	2.90	12	0.00	0.0000	
3	3.20	13	0.01	0.0004	
4	3.50	24	0.00	0.0000	
5	3.80	35.5	0.03	0.0032	
6	4.10	31	0.06	0.0056	
7	4.40	35	0.11	0.0116	
8	4.70	36.5	0.14	0.0153	
9	5.00	38	0.16	0.0182	
10	5.30	30.5	0.19	0.0174	
11	5.60	33	0.24	0.0238	
12	5.90	31	0.24	0.0223	
13	6.20	34.5	0.27	0.0279	
14	6.50	28	0.27	0.0227	
15	6.80	31	0.28	0.0260	
16	7.10	27	0.22	0.0178	
17	7.40	20	0.18	0.0108	
18	7.70	21	0.13	0.0082	
19	8.00	12	0.07	0.0025	
20	8.30	4	0.05	0.0004	
21	8.40	0	0.00	0.0000	
		Total discharge =		**0.2341**	**m^3/s**

Discharge calculation

Project:	**Lake Utopia (St-Gerorge, NB)**
Date:	30-Jun-16
Crew:	Daniel and Fernand
Equipment:	Marsh-McBirney, Model 2000
Met condition:	Sunny, ≈ 22 deg C
Time:	Started at around 12:00
D (rebar):	79.5 cm
Depth of wate	32 cm

Sta	Dist	Depth	V	Qi	
1	1.00	0	0.00	0.0000	
2	1.25	4	0.05	0.0005	
3	1.50	7	0.14	0.0025	
4	1.75	8	0.30	0.0060	
5	2.00	14	0.26	0.0091	
6	2.25	18	0.29	0.0131	
7	2.50	17	0.32	0.0136	
8	2.75	17	0.35	0.0149	
9	3.00	20.5	0.33	0.0169	
10	3.25	20	0.33	0.0165	
11	3.50	21	0.36	0.0189	
12	3.75	23	0.33	0.0190	
13	4.00	24	0.27	0.0162	
14	4.25	27	0.24	0.0162	
15	4.50	26	0.25	0.0163	
16	4.75	23	0.26	0.0150	
17	5.00	23	0.21	0.0121	
18	5.25	20	0.13	0.0065	
19	5.50	15	0.10	0.0038	
20	5.75	10	0.11	0.0028	
21	6.00	6	0.07	0.0008	
22	6.15	0	0.00	0.0000	
		Total discharge =		**0.2204**	**m^3/s**

Discharge calculation

Project:	**Lake Utopia (St-Gerorge, NB)**
Date:	13-Oct-16
Crew:	Daniel and Fernand
Equipement:	Marsh-McBirney, Model 2000
Met condition:	Overcast, ≈ 12 deg C
Time:	Started at around 12:00

Sta	Dist	Depth	V	Qi	
1	0.40	10	0.01	0.0001	
2	0.60	9	0.00	0.0000	
3	1.30	40	0.00	0.0000	
4	1.40	42	0.07	0.0029	
5	1.50	48	0.23	0.0110	
6	1.60	48	0.22	0.0106	
7	1.70	47	0.14	0.0066	
8	1.80	47	0.13	0.0061	
9	1.90	47	0.12	0.0056	
10	2.00	42	0.07	0.0029	
11	2.10	43	0.02	0.0009	
12	2.20	43	0.04	0.0017	
13	2.30	43	0.01	0.0009	
14	2.60	23	0.01	0.0003	
		Total discharge =		**0.0497**	**m^3/s**