Assessing the Freshwater of Eastern Charlotte

Eastern Charlotte WATERWAYS

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Acknowledgements

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Introduction

In 1993, Eastern Charlotte Waterways (ECW) was established. Its first action was to assess the freshwater of eastern Charlotte County, New Brunswick. For two years beginning in the summer of 1994, the organization's members visited ten watersheds between June and November, monitoring an upstream and downstream site for water temperature, pH, dissolved oxygen, and turbidity. They also monitored four popular swim locations for fecal coliform bacteria. The results of this study were published in "The watersheds of eastern Charlotte: Environmental quality assessment". Twenty years later, in 2014-2015 the assessment has been replicated by ECW staff to identify any changes in water quality.

The original assessment provided stakeholders in eastern Charlotte County with an overview of the area's freshwater health. Following the assessment, it was declared the watersheds were in 'reasonably good condition', determining that 'the effect of urban development, industry, acid rain, and general misuse is more evident in some locations than others'.

ECW's primary goal of this reassessment has been to identify areas of concern that can be addressed in the coming years. By utilizing a baseline established twenty years previous, this project will enhance the ability of all stakeholders in eastern Charlotte County to identify and respond to environmental change in the area's freshwater resources. Understanding those changes will facilitate environmental management that ensures our natural resources can continue to support the health of our community.

Methods

Monitoring of eastern Charlotte watersheds

A total of 20 sites were sampled biweekly from June to November in 2014 and 2015 to monitor the freshwater quality of 10 watersheds within eastern Charlotte County. Upper and lower sites were sampled on Lepreau River, New River, Pocologan River, Cripp's Stream, Buckman's Creek, Mill Stream, Linton Stream, Magaguadavic River, Digdeguash River, and Big Meadow Outflow (Table 1; Figure 1). Sites chosen were identical to those assessed during the 1994-1996 study to accurately reflect any significant changes in water quality that may have occurred in the last twenty years.

Water temperature (°C), dissolved oxygen (mg/L), and pH were measured on site using a YSI multi-meter. The YSI multi-meter also provided measurements of conductivity (µS/cm), total dissolved solids (mg/L), and salinity (ppt); therefore these parameters were recorded as well. Water samples were collected and tested for turbidity (NTU) in the field with a LaMotte 2020we turbidity meter. Additional parameters including air temperature, weather, water-surface conditions, time-of-day, and general comments were also noted. This information was used as an overview in situations where other test parameters may be affected (i.e. rain in amounts that may increase water flow and affect turbidity).

Monitoring of recreational waters of eastern Charlotte

In 1996, four popular swimming locations were sampled for E. coli bacteria during the peak period of recreational activity (July – September). These four swimming locations, Day Adventure Centre, Canal Beach, McLean's Beach, McDougall Lake, and control site, Lake Stream, were sampled again in 2014 and 2015 during the summer season. A fifth swimming location, Backside of the River, was also added in because of its growing popularity.

According to the Guidelines for Canadian Recreational Water Quality, a single water sample should not exceed a concentration of 400 E. coli per 100ml or a mean concentration of 200 E. coli per 100ml using a minimum of five samples. In this study, a single sample was collected from each location on a biweekly basis. Samples were immediately refrigerated in portable coolers, and transported to ECW's ISO/IEC 17025:2005 accredited microbiology laboratory to be analyzed.

Table 1: Coordinates for upstream (U) and downstream (D) watershed sample sites.

Site	Latitude	Longitude
Lep-U	45.230164	-66.466341
Lep-D	45.123571	-66.469481
New-U	45.179435	-66.54619
New-D	45.138007	-66.533277
Poc-U	45.190842	-66.632416
Poc-D	45.116842	-66.588048
Crip-U	45.109191	-66.66964
Crip-D	45.083579	-66.708643
Buck-U	45.097514	-66.726865
Buck-D	45.094212	-66.726854
Mill-U	45.134083	-66.736508
Mill-D	45.127918	-66.754375
Lin-U	45.214828	-66.891602
Lin-D	45.189641	-66.871373
Mag-U	45.266063	-66.810767
Mag-D	45.223768	-66.845564
Dig-U	45.2277	-67.006285
Dig-D	45.184848	-66.912683
BMO-U	44.970312	-66.967456
BMO-D	44.931868	-66.985137

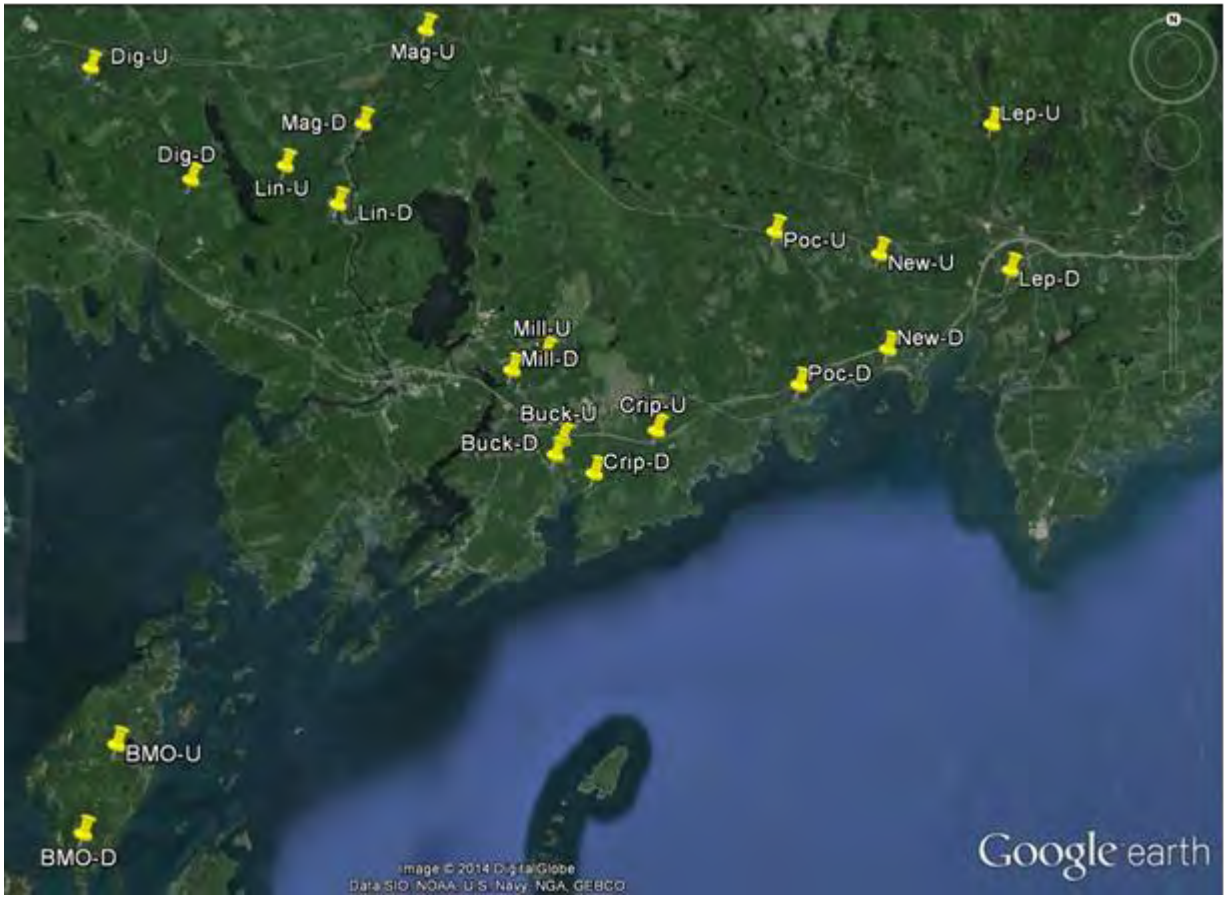


Figure 1: Map of upstream (U) and downstream (D) watershed sample sites.

Table 2: Coordinates for recreational waters sample sites.

Site	Latitude	Longitude
Backside of the River	45.174552	-66.843551
MacDougall Lake	45.338037	-66.779444
Lake Stream	45.303684	-66.844789
McLeans Beach	45.183055	-66.774719
Day Adventure Camp	45.135176	-66.823952
Canal Beach	45.160566	-66.810996

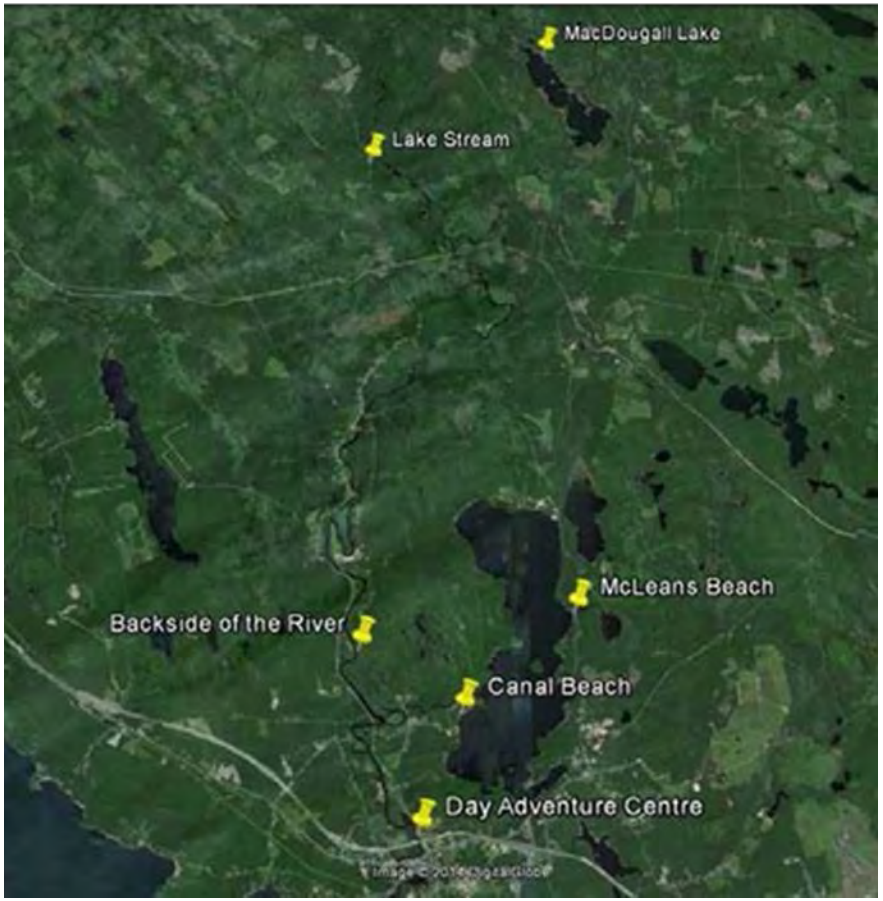


Figure 2: Map of recreational waters sample sites.

Results – Monitoring of eastern Charlotte watersheds

Lepreau River

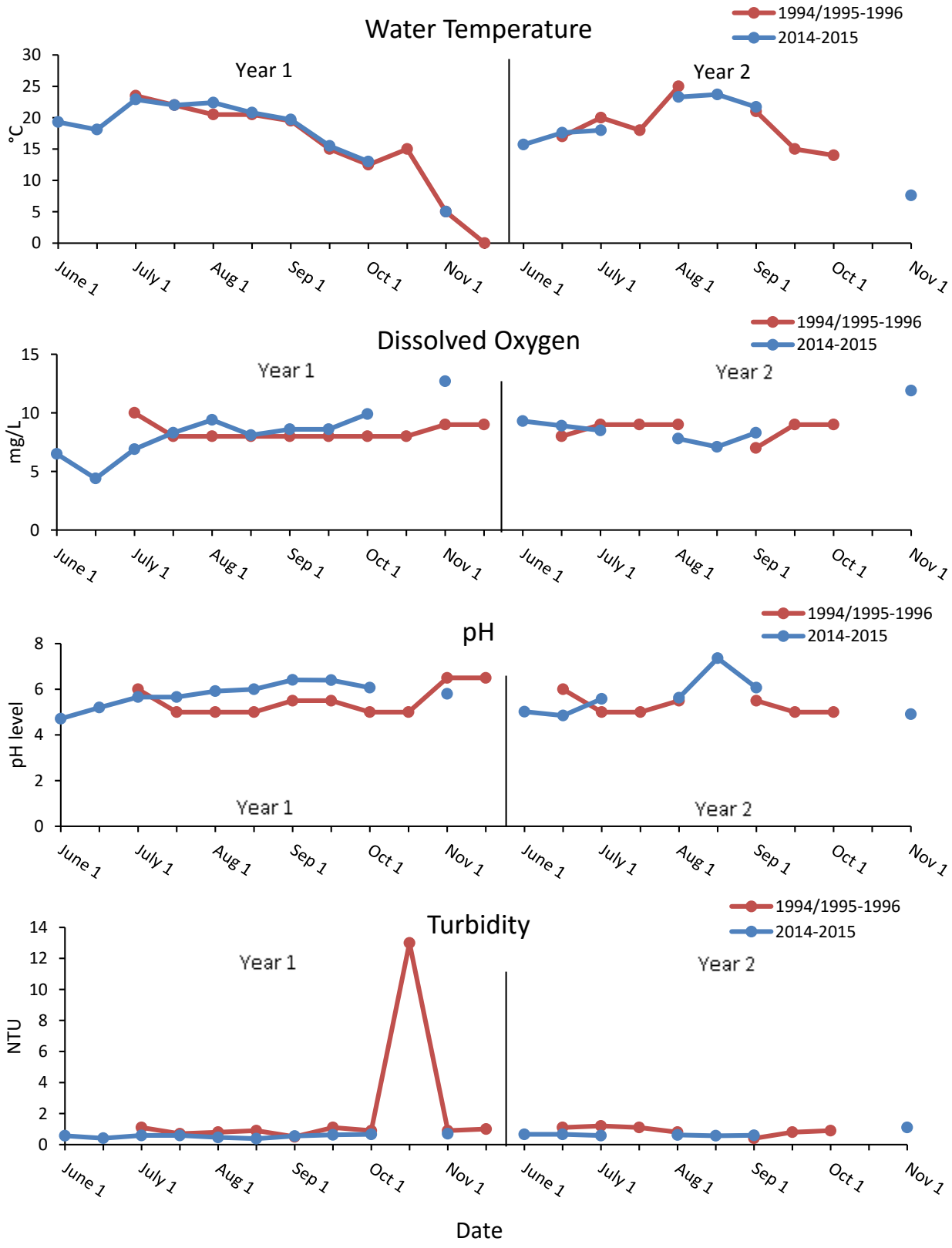
The Lepreau River is located 20 minutes outside the city of Saint John, and runs south through the Fundy coastal region where it empties into the Passamaquoddy Bay. This watershed is home to a number of natural wetlands, most of which tend to be acidic and high in iron and other minerals, which gives the water its rustic colour. The watershed is dense with vegetation and rock, as the area is home to many Triassic red beds. High gradients found along the river create many waterfalls, including the iconic Lepreau Falls that consists of a series of ledges, creating an 8 meter high drop into the Bay of Fundy.

The area gets its name from the Passamaquoddy language, which translates to "Little Rabbit". In addition, the river has been used as a control site for studies because of its lack of human influence. Historically, the area was used for log running and bootlegging during the 19th and 20th century, and in recent years has become the home of the Point Lepreau Nuclear Generating Station.

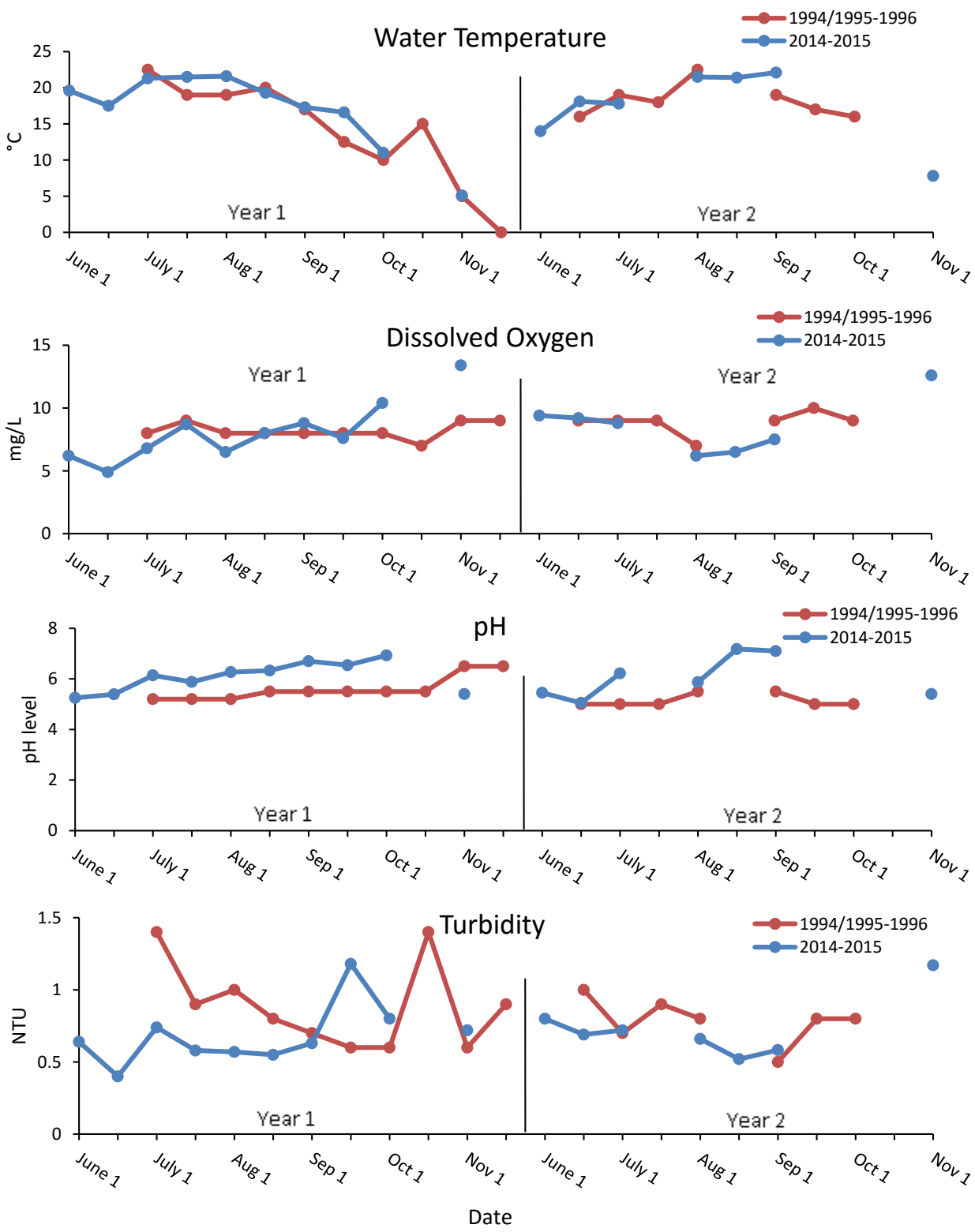
Water temperatures in the Lepreau River were very similar to those reported in 1994 to 1996, and did not exceed 24°C. Dissolved oxygen content was sufficient to sustain aquatic life ranging from 6.2 to 13.4 mg/L, with the exception of low levels recorded at both sites in mid-June of 2014; possibly associated with equipment calibration issues. Overall, pH levels improved slightly compared to 20 years ago (Table 2), but remain low ranging between 4.7 and 7.4 upstream and 5.0 and 7.2 downstream. These low pH levels sustained throughout most of the sampling period are of concern for aquatic life but most likely a result of the area's geology. Turbidity levels were low at both sites throughout the sampling period and did not exceed 1.2 NTU. Aside from improvements in pH levels, the Lepreau River appears to have had little change in water quality in the last 20 years.

Figure 3: Lepreau sample sites (uptream on left).

Lepreau River, Upstream



Lepreau River, Downstream



New River

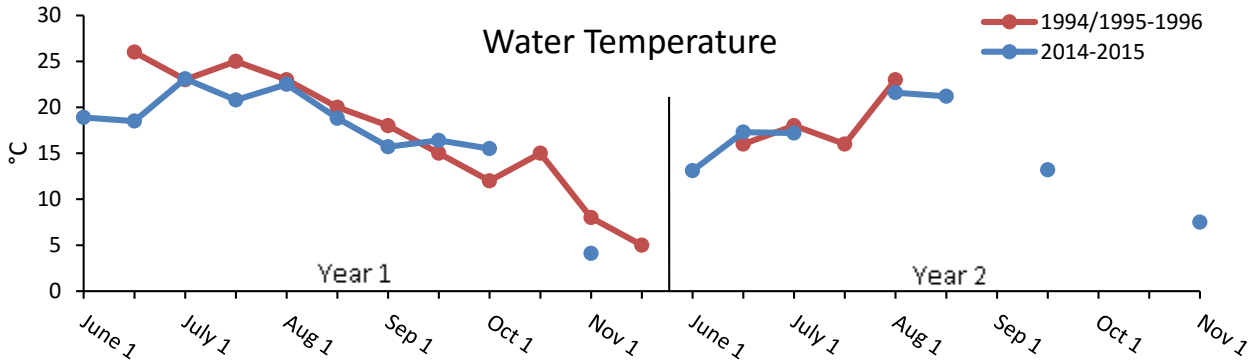
Located thirty minutes outside of the city of Saint John, the New River system flows along the Fundy coastal region before emptying into the Bay of Fundy. The river is typically rocky with fast water velocities and is mostly devoid of overhanging vegetation. This area is noted for being prone to fog throughout the day, particularly in the morning.

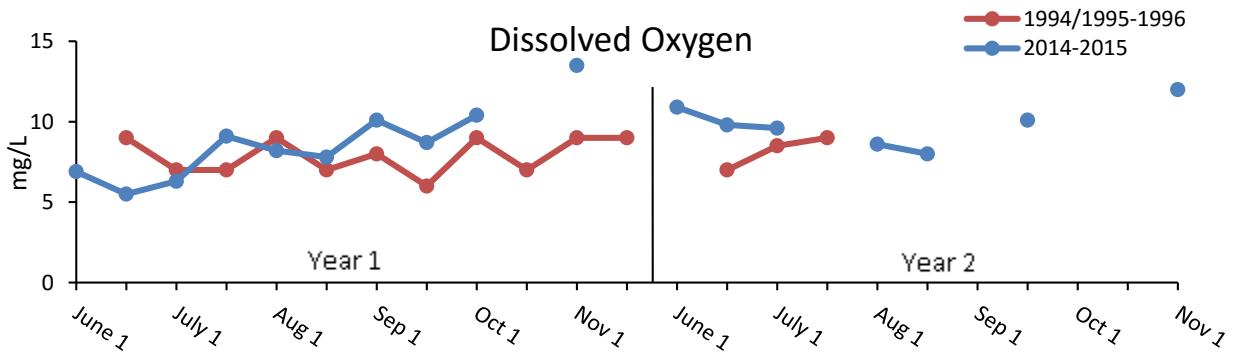
The primary use of this area is recreational. It is home to New River Beach, a campsite, a five kilometer walking trail and many other recreational areas. In the past the area was an important salmon spawning site, and in 1995 a permit was granted which allowed for the alteration of the river's natural course. It appears at this time that the alteration has not had an impact on the aquatic life in the area.

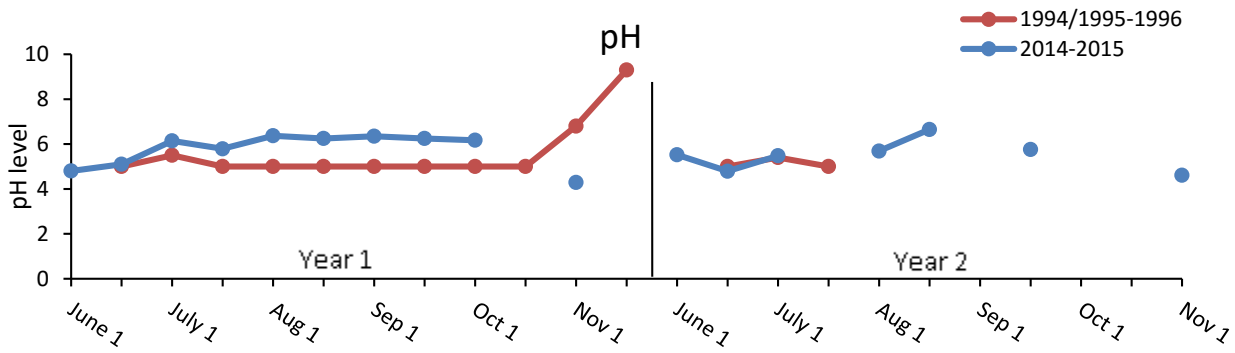
Water temperatures at both sites were consistent with 1994-1996 recordings and did not exceed 23.1°C. Dissolved oxygen levels significantly improved since 1994-1996 (Table 2), and when considering all sampling years (1994-1996 and 2014-2015), DO levels were lower during the early summer months. The pH levels remained the same as in 1994-1996, still dangerously low at times, especially at the upstream site which ranged from 4.3 to 6.7. Turbidity levels remained low, as was seen in 1994-1996, and only exceeded 1 NTU following precipitation events in mid-September 2014 and late October 2015.

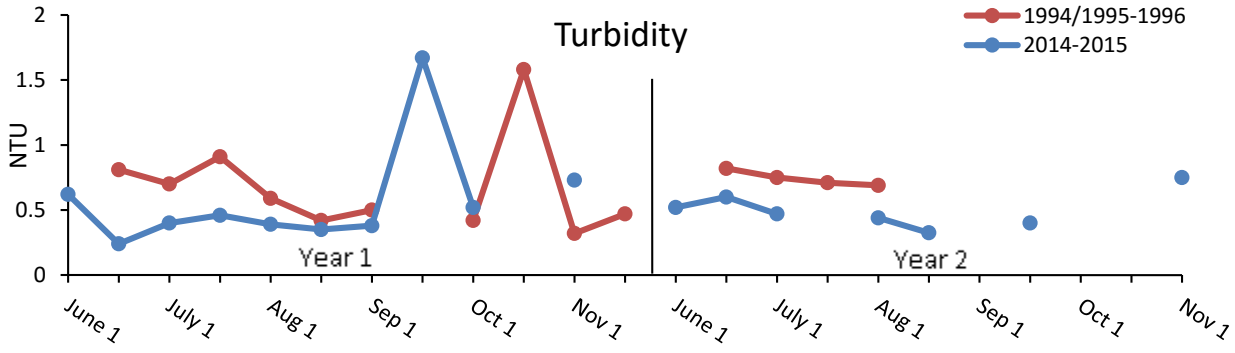
Figure 4: New River sample sites (upstream on left).

New River, Upstream



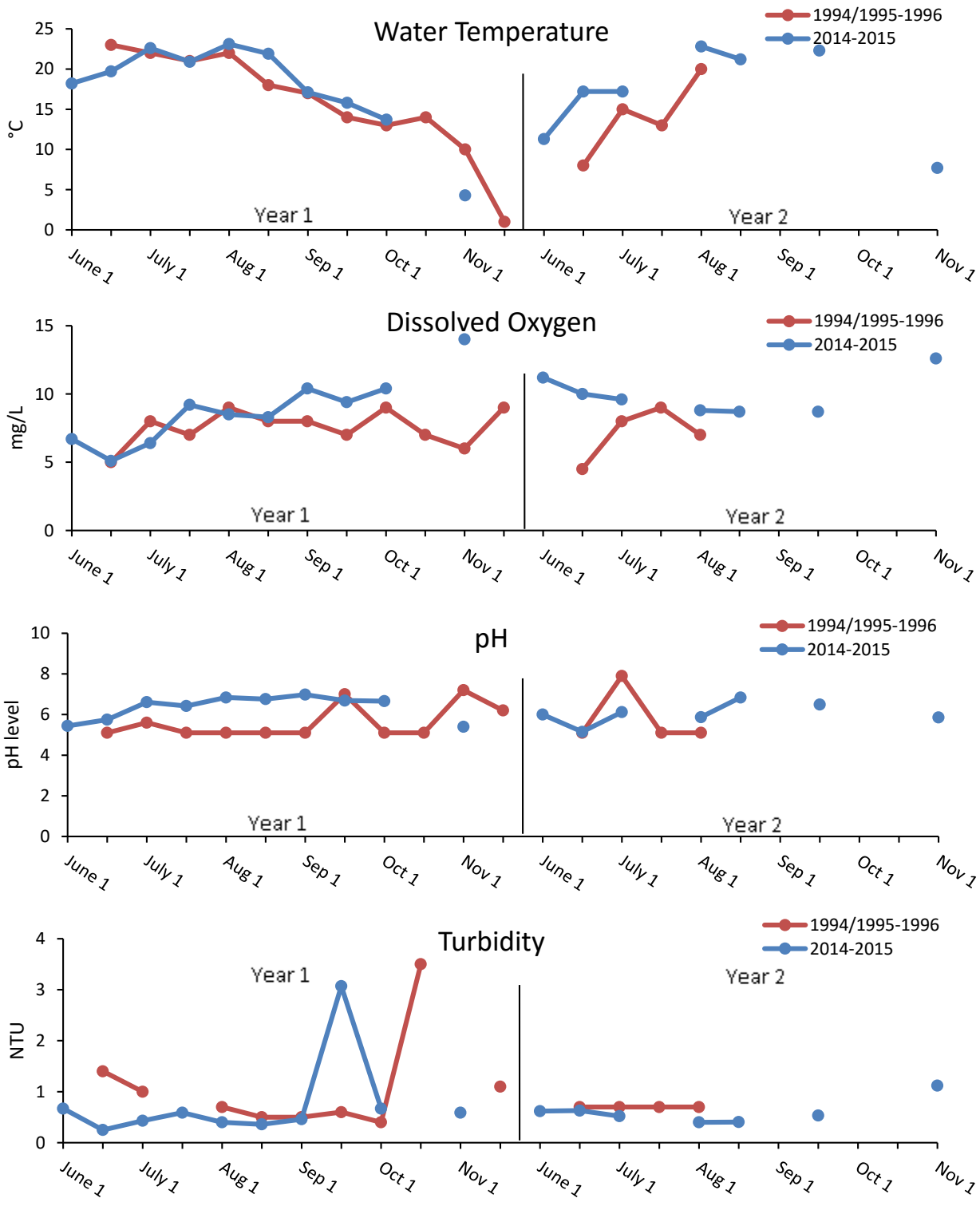






Date

New River, Downstream



Pocologan River

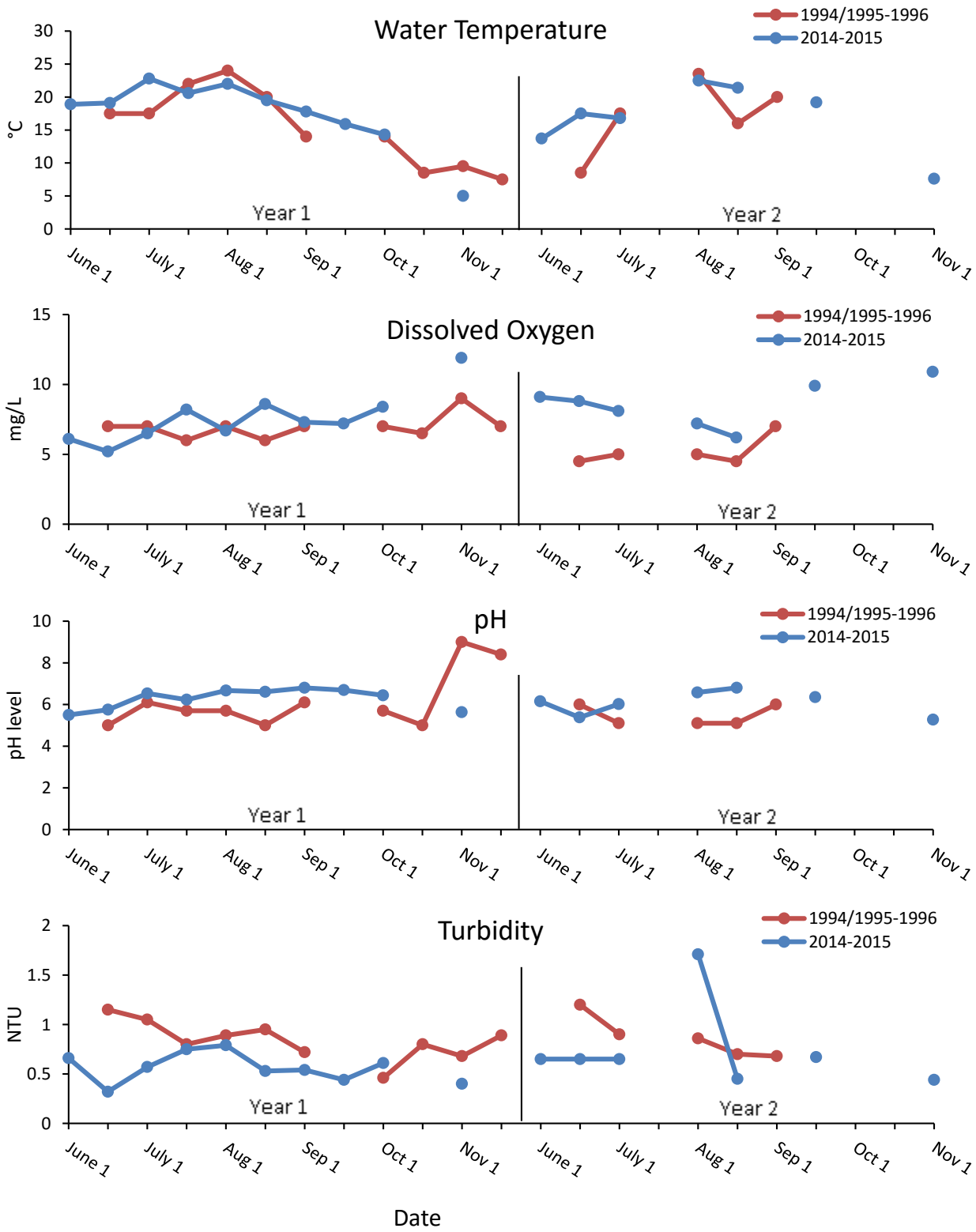
Located 30 minutes outside the city of Saint John, the Pocologan River runs along the Fundy coastal region, eventually emptying into the Bay of Fundy. The water is an off-brown colour and naturally acidic due to the surrounding area being high in mineral content. There are many small waterfalls throughout the course of the river, but the most notable is Pocologan Falls, which reaches a height of 6 meters. There are numerous inlets along this river's jagged shoreline.

The small community of Pocologan gets its name from the Passamaquoddy language, which translates to "Enclosed Harbour". Many of its residents enjoy the fishing that the area provides. In fact, the Pocologan River was once a salmon spawning site, but a steady decline in the salmon population has resulted in little to no use of the river as a spawning ground.

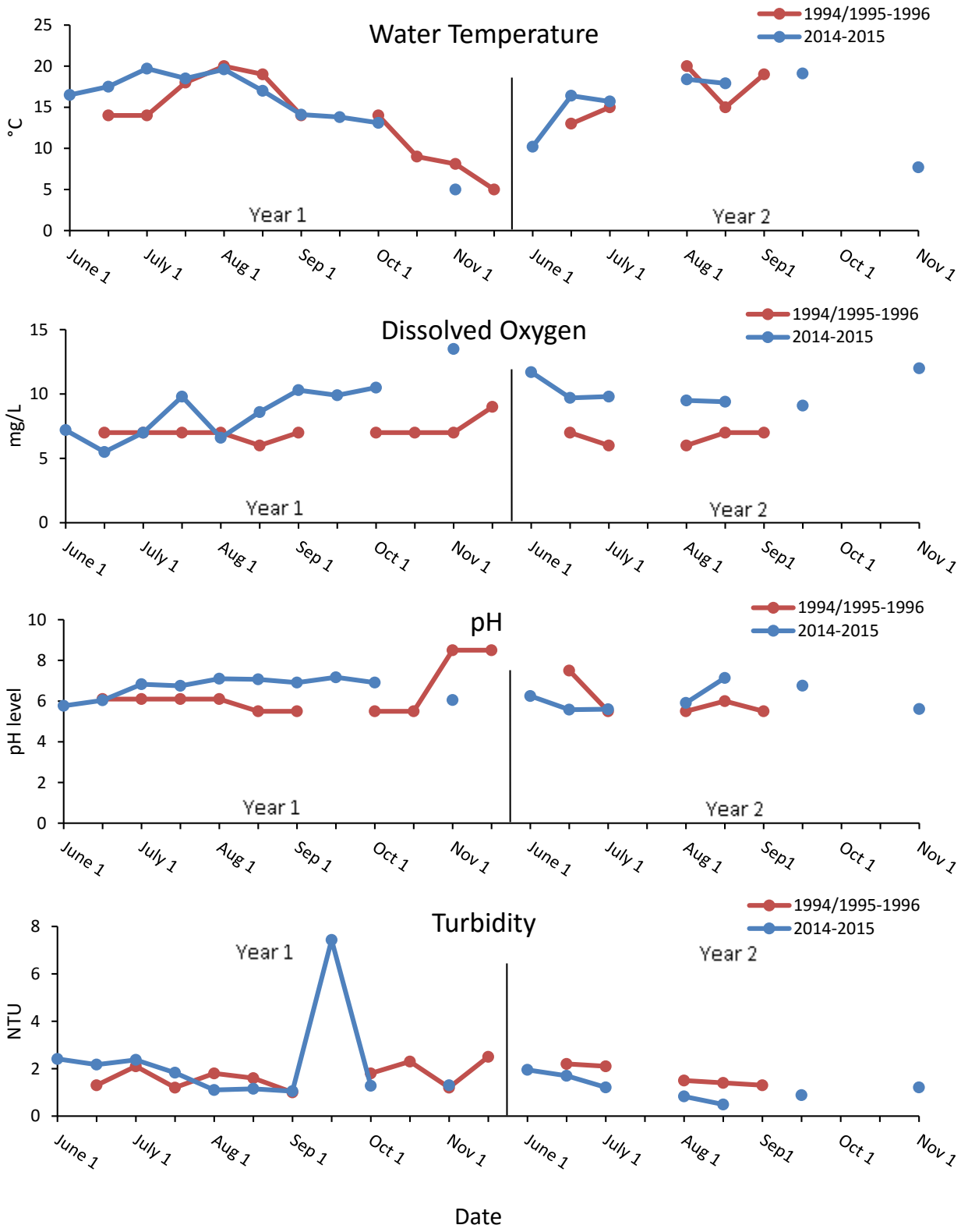
Water temperatures at the up and downstream sites of the Pocologan River were similar to those recorded in 1994-1996 and well within comfortable limits for aquatic life, although they were higher upstream in 2014 during the early summer months. Dissolved oxygen has improved since 1994-1996 (Table 2); 8.0 mg/L upstream and 9.4 mg/L downstream, with less favorable levels recorded in mid-June. Overall, pH levels remain relatively the same since the 1994-1996 study. During early summer and late fall of 2014/2015, especially at the upstream site, pH levels were found to be below optimum. Turbidity levels were consistent with those recorded 20 years. Turbidity remained below 2.5 NTU with the exception of a sample in mid-September at the downstream site which reached 7.4 NTU following a precipitation event.

Figure 5: Pocologan sample sites (upstream on left).

Pocologan River, Upstream



Pocologan River, Downstream



Cripp's Stream

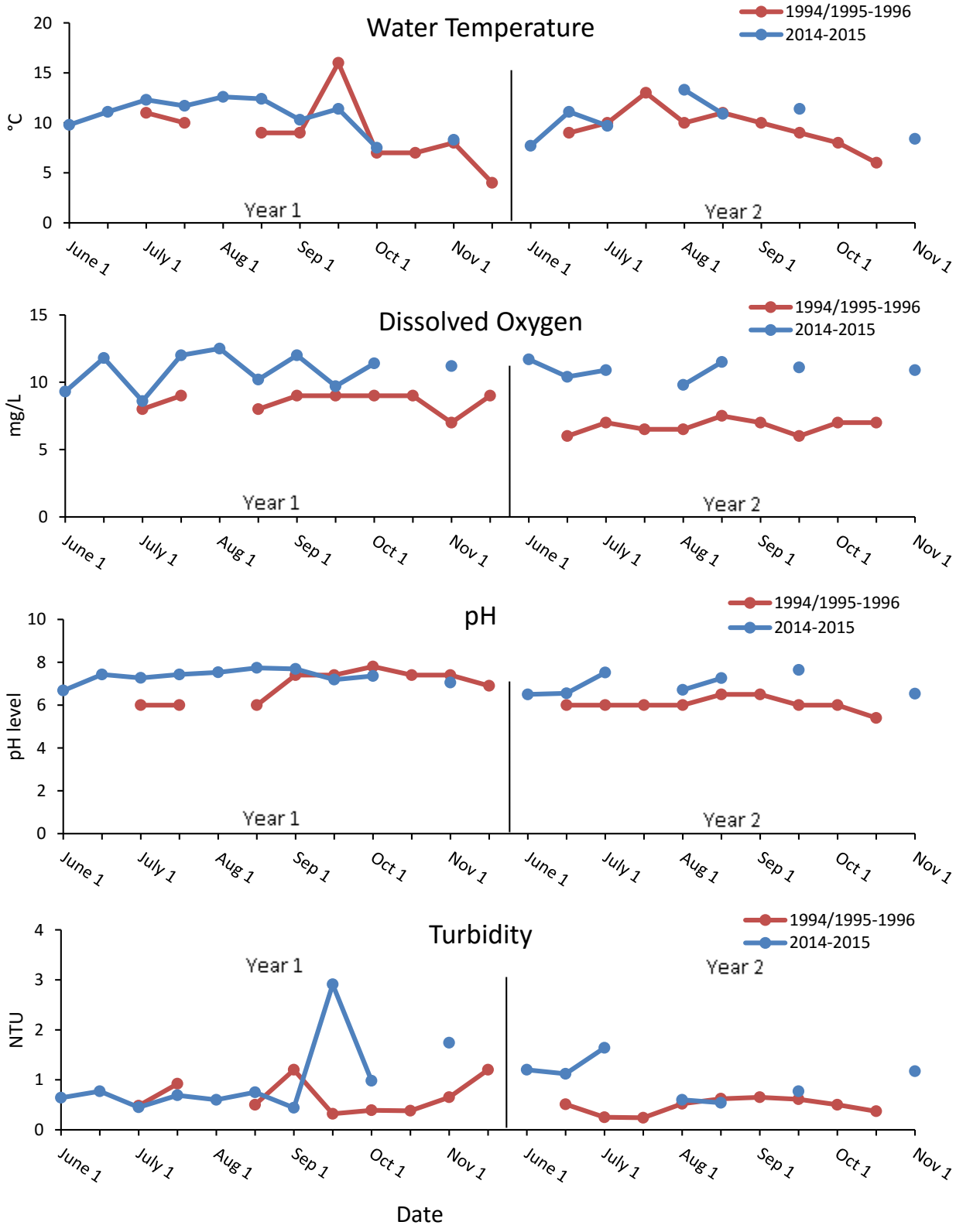
Located between Blacks Harbour and Pocologan, Cripp's Stream runs southwest along the Fundy coastal region and empties into the Passamaquoddy Bay. The body of water has a steady and slow water flow, with exception to an area known as the Cripp's Stream Fall. The stream is essentially free from any overhanging vegetation and is instead heavily congested with grasses and weeds. The stream varies in width, with the most notable change being as it empties into the harbor where it widens considerably.

Recreational opportunities in this watershed are mainly restricted to hiking and other similar activities, as the stream itself is typically too narrow and shallow for boating or swimming. The Cripp's Stream Fall does attract some photographers and other nature lovers, but the area is essentially unused.

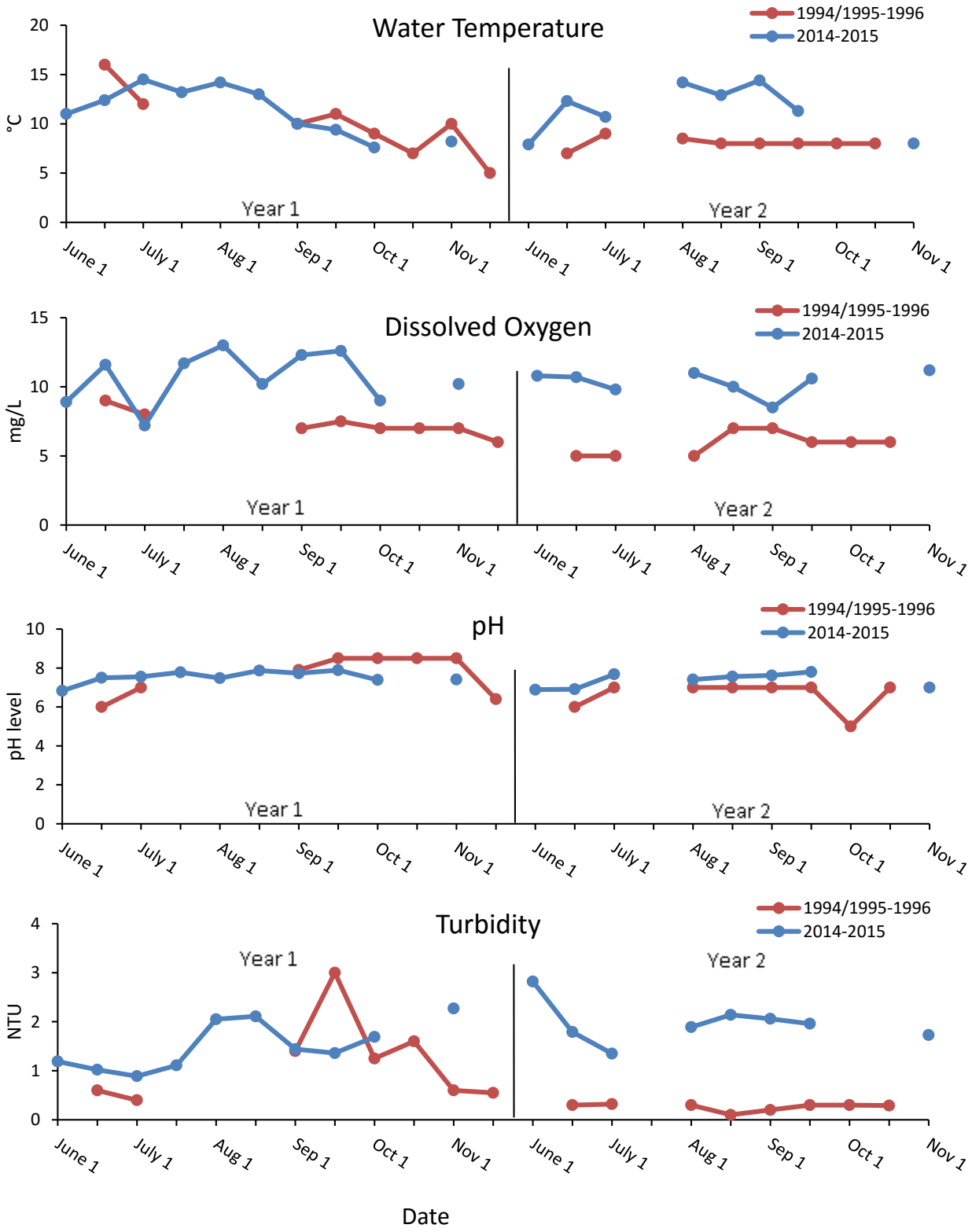
Cripp's Stream continues to be a very cool stable aquatic environment as was reported in 1997 and has seen improvements in conditions. Although water temperatures increased by approximately 2°C since 1994-1996 (Table 2), they remain low, ranging between 7.5°C and 14.5°C. Cool water temperatures kept dissolved oxygen levels high throughout the sampling period – averaging 10.7 mg/L – and were significantly higher compared to levels seen in 1994-1996 (Table 2). The pH levels slightly improved from 1994-1996, remaining near neutral throughout the sampling period. Overall, turbidity was generally higher in 2014/2015; however, these levels remained (1.38NTU) well within the recommended long term turbidity guideline of 2NTU (Canadian Council of Ministers of the Environment, 2002).

Figure 6: Cripp's Stream sample sites (upstream on left).

Cripp's Stream, Upstream



Cripp's Stream, Downstream



Buckman's Creek

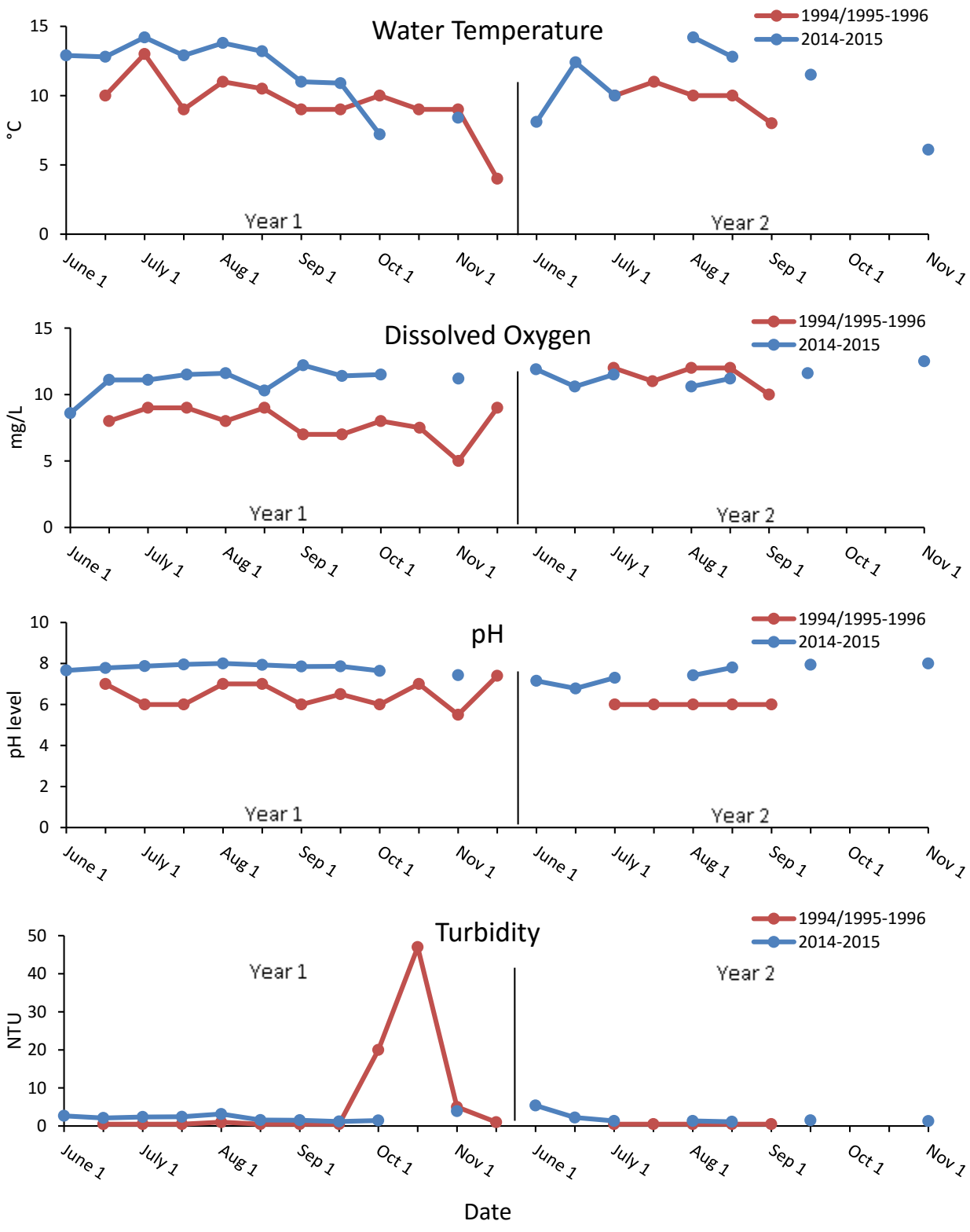
Located almost exclusively in Beaver Harbour, Buckman's Creek runs southwest, parallel to Cripp's Stream, and empties into the Bay of Fundy. Similar to Cripp's Stream, the water itself is very stable and cold, making it suitable for both aquatic life and cold water plants. The creek is heavily forested in its uppermost areas and completely devoid of vegetation further downstream as it empties into the ocean. Salinity levels tend to be high in the lower areas due to tidal fluctuations. The creek is both narrow and shallow in parts, particularly in the areas upstream, but widens as it empties into the bay.

The area itself is known for its high jagged cliffs, as well as two fossils from the Devonian Age which were discovered there. These factors make it an attractive place for hikers and nature enthusiasts; however, the narrowness and cool temperatures of the stream make it less desirable for swimming and boating purposes.

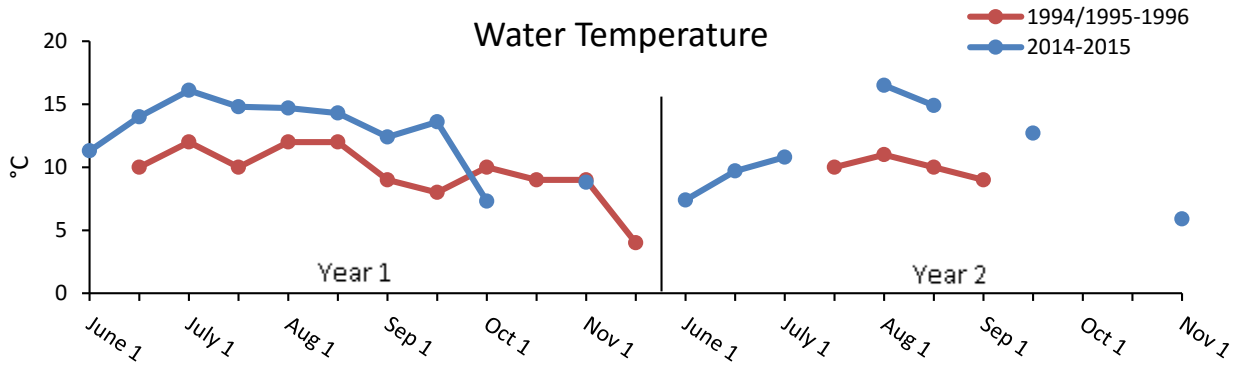
The results for the up and downstream sites for this small waterway were very similar and suggest a steady environment for aquatic life. The downstream site serves as a tidal inlet to Beaver Harbour and is periodically affected by increased salinity. The rise and fall of the tides have left the banks at this site muddy and exposed with little buffer zone, though this does not appear to significantly affect the results of the parameters tested. Water temperatures ranged from 5.9°C to 16.2°C throughout the sampling period and were on average 2.1°C higher than in 1994-1996 (Table 2). Despite slightly higher water temperatures in 2014, dissolved oxygen levels were greater compared to the previous study averaging 11.0 mg/L (Table 2). The pH levels were slightly higher in 2014 (Table 2), with both sites being near neutral throughout the sampling period. Turbidity levels at both sites remained within the acceptable range, with the exception of a sample in November 2014 at the downstream site that reached 8.79 NTU following a precipitation event the previous night. This was also the only sample taken at the downstream site during mid tide as the water flushed out of the inlet suspending sediment from the muddy banks upstream.

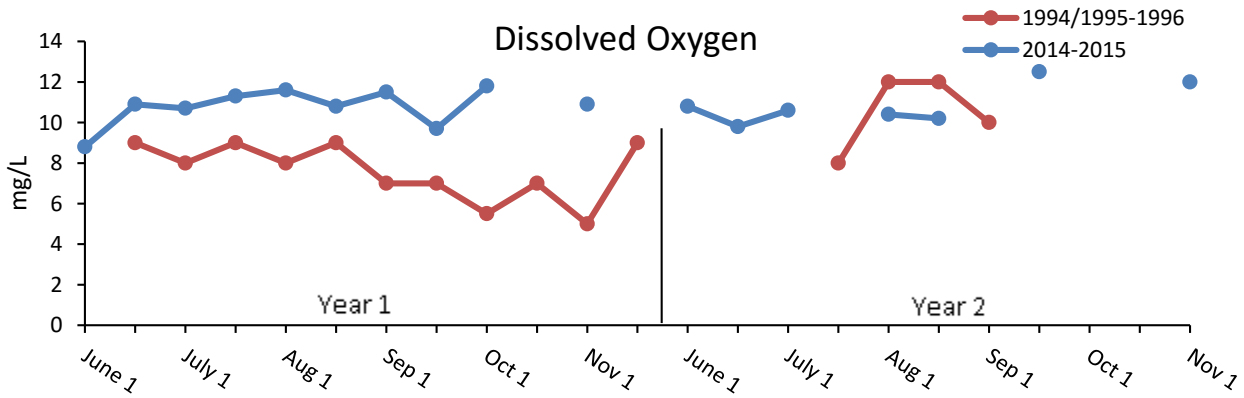
Figure 7: Buckman's Creek sample sites (upstream on left).

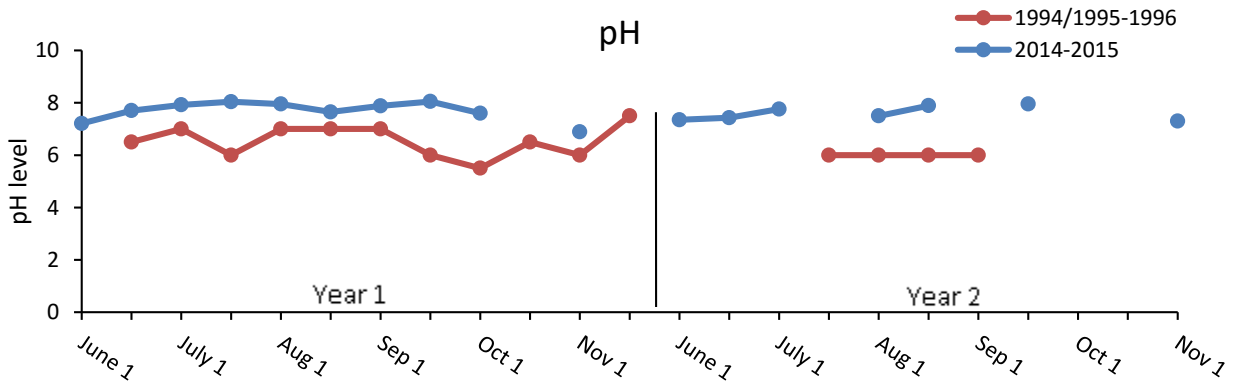
Buckman's Creek, Upstream

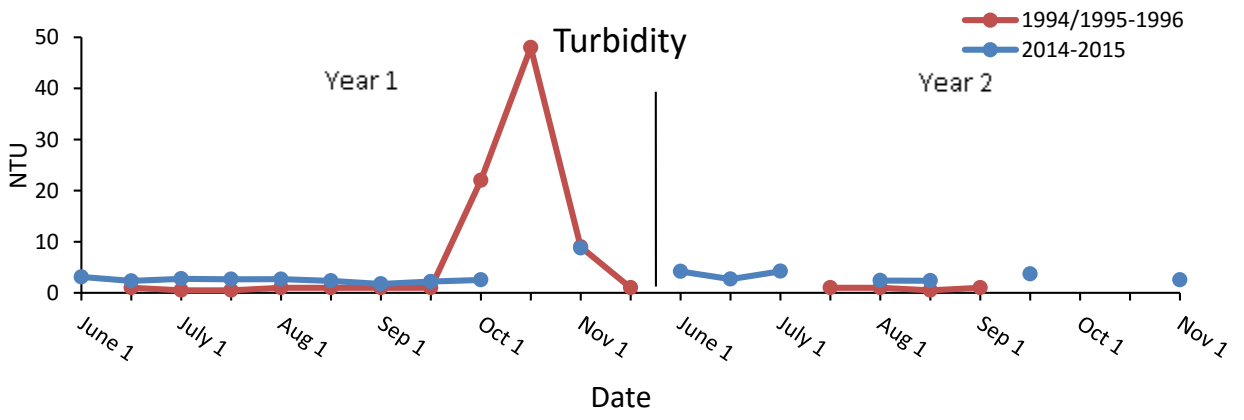


Buckman's Creek, Downstream









Mill Stream

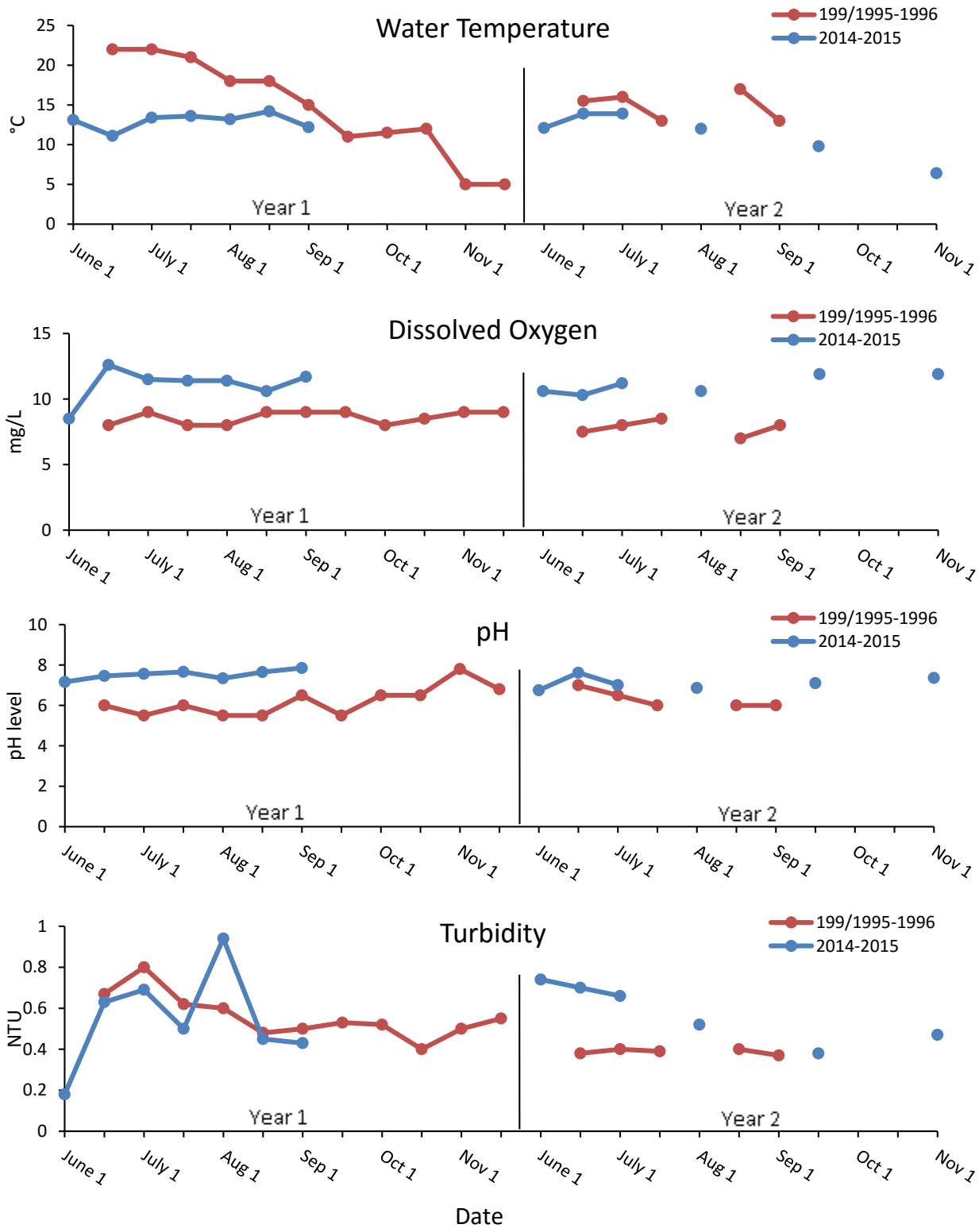
Located between Pennfield and Lake Utopia, Mill Stream runs through the Fundy Coastal Region and empties into the Bay of Fundy. Water velocities remain slow throughout the stream, although there are exceptions. The stream varies in the amount of vegetation and has few rock beds throughout. Although parts of the stream can reach considerable depths, for the most part, the body of water is shallow and maintains moderate temperatures throughout. Dissolved oxygen, pH, and turbidity are normally found at optimal levels, making this area not only ideal for recreational use and aquatic life, but also considered as one of the healthiest watersheds in the eastern Charlotte area.

The stream gets its name from the many mills which have operated in the area. Even though this location is known for its industrial use, there are many hiking trails and privately owned camps in the surrounding area. Despite both recreational and industrial use, the stream remains very healthy.

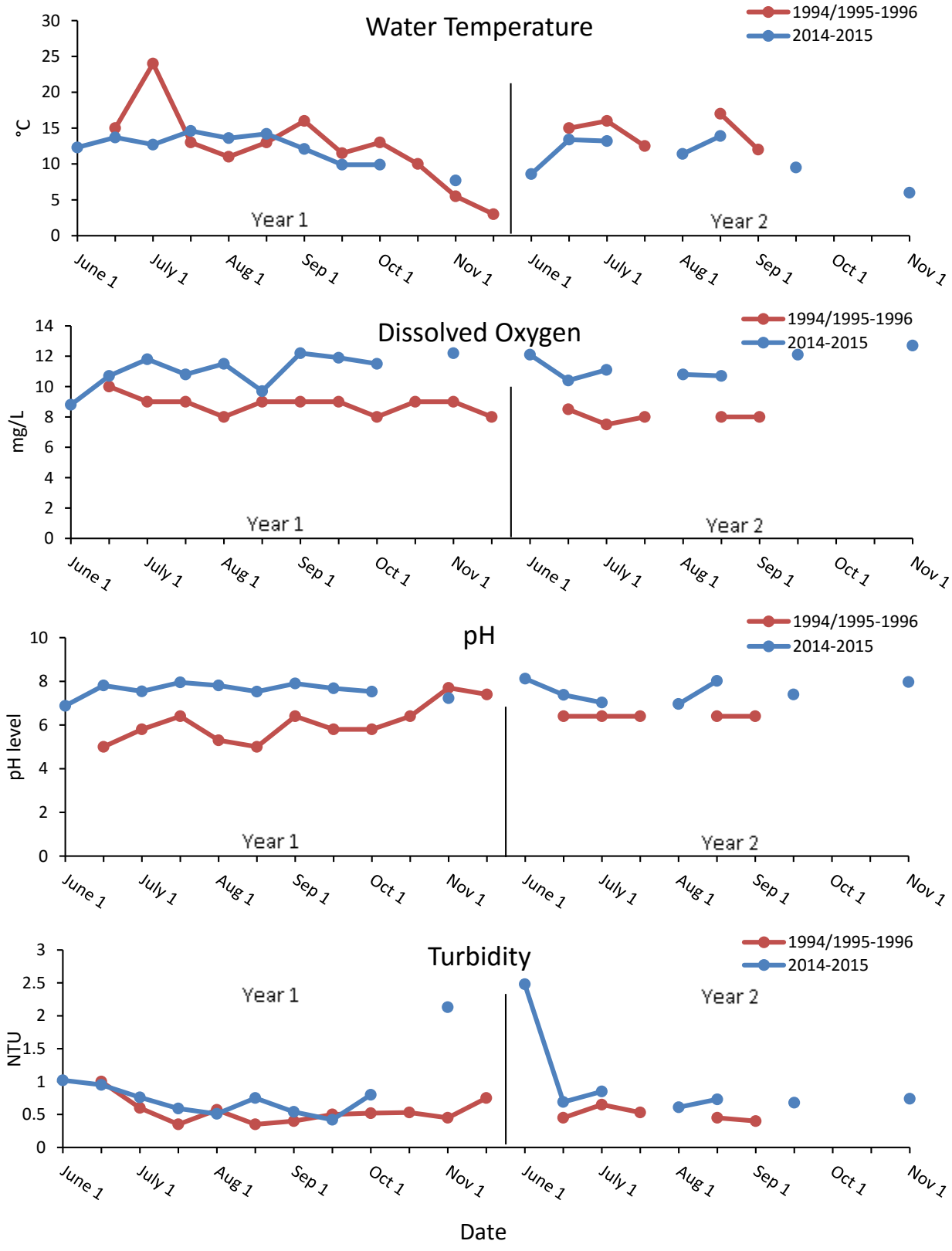
Compared to 1994-1996, Mill Stream water temperatures were lower during the 2014-2015 portion of this study, ranging between 11.1°C and 14.6°C. This resulted in higher dissolved oxygen levels, averaging 11.2 mg/L (Table 2). The pH levels were consistently higher, and closer to neutral, at both sites compared to 1994-1996 (Table 2). Although turbidity levels were slightly higher than those reported in 1994-1996 (Table 2), they remained below 1 NTU throughout the sampling period, with the exception of the downstream site in November 2014 and June 2015 where levels hit 2.1 and 2.48, respectively; these values remain well within the acceptable range. Overall, this stream appears to be in excellent conditions for all usage as previously stated in the 1997 report. In 2014 samples were not collected from the upstream site of Mill Stream after early September because of the site's remote location and a personal injury sustained by the project's field staff.

Figure 8: Mill Stream upstream sample site

Mill Stream, Upstream



Mill Stream, Downstream



Magaguadavic River

This historic Magaguadavic River has a meander length of 129km, making it the longest waterway in this study and sixth longest in New Brunswick. The river flows from the Magaguadavic Lake in York County through the low mountain range known as the St. Croix Highlands, where it eventually empties into the Passamaquoddy Bay. The river drains into an area known as "The Canal", and connects it to Lake Utopia. The watershed has an approximate area of 1800km^2, with 103 tributaries and 57 lakes in its boundaries. With such a large area, the Magaguadavic is home to many wetlands and heavily forested areas. Water temperature and quality vary throughout the entire river, but is, overall, adequate for sustaining aquatic life.

The river gets its name from the Passamaquoddy language which translates to "River of Eels". True to its name, the Magaguadavic is home to a number of American eels, as well as sculpin, smelt, creek chub and many other species. Because the river runs through many inhabited areas, most notably the town of St. George, residents have found many uses for the Magaguadavic. The river is home to a hydro-electric dam, fish hatcheries, a yarn factory, and an abandoned mine. It is also used heavily for recreational activities. These factors are likely the explanation for the variation in water quality.

Water temperatures at both up and downstream sites peaked in July of 2014, reaching dangerously high levels of over 25°C; however, warm water temperatures during the summer months cooled relatively quickly in September. Water levels during the summer of 2014 in the Magaguadavic River were lower than recently observed, which likely correlated with increased water temperatures. Water temperatures during the summer of 2015 remained relatively constant and did not exceed 22.5°C. Despite the aforementioned temperature peak in 2014, water temperatures remained similar to those recorded in 1994-1996. Dissolved oxygen levels were typically greater compared to 1994-1996 (Table 2) and remained above 7 mg/L throughout sampling. The pH levels were consistently close to neutral, which is an improvement since 1994-1996. Turbidity levels were low and coincide with those reported in 1994-1996, with the exception of an isolated spike in November 1995. Unfortunately, no data was collected for the up-stream section of the Magaguadavic River in 1996.

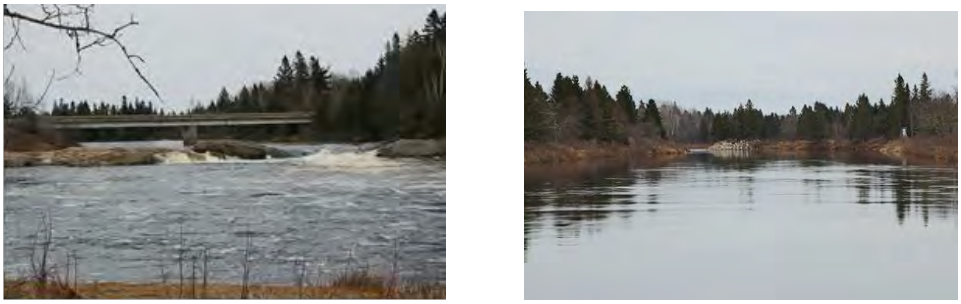
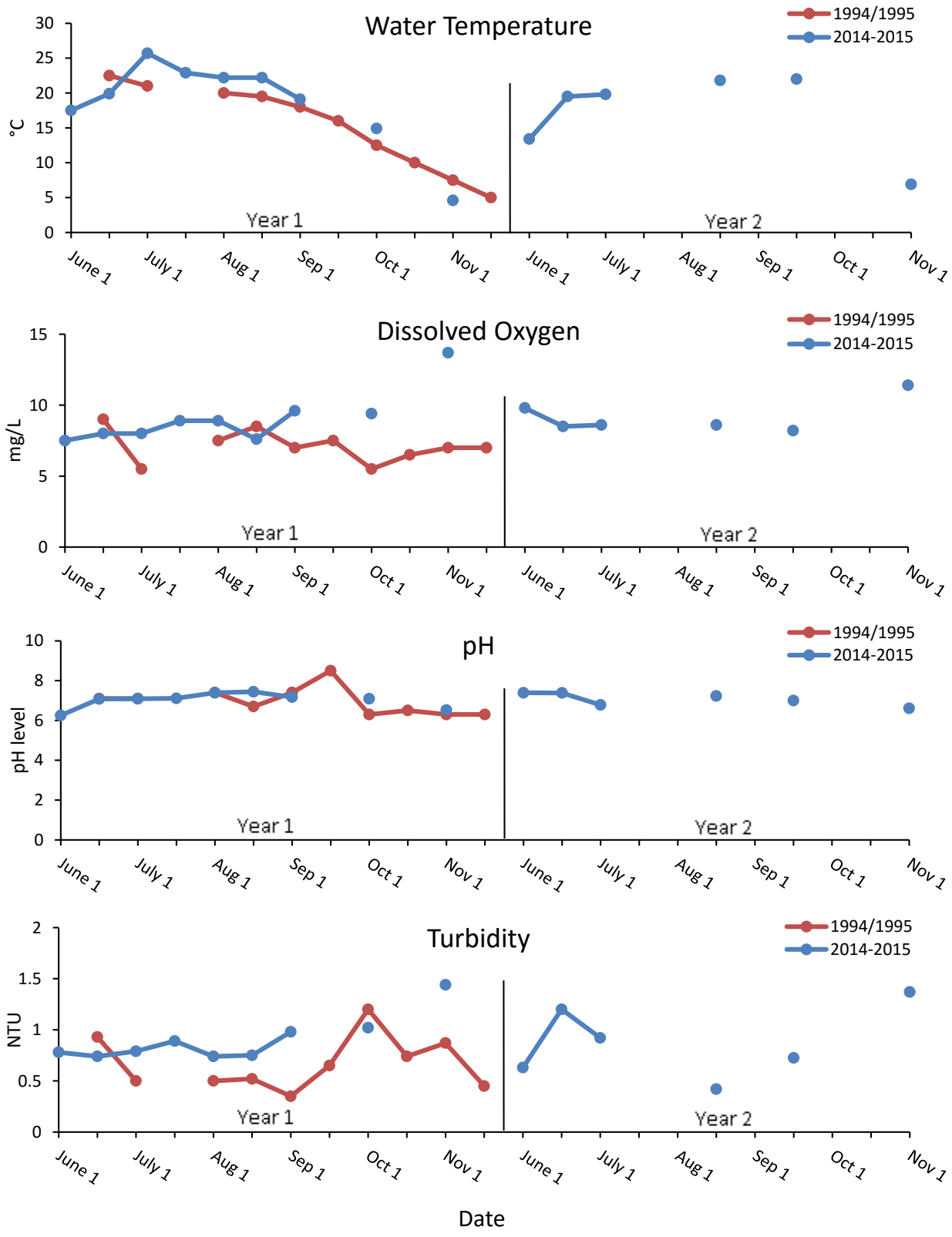
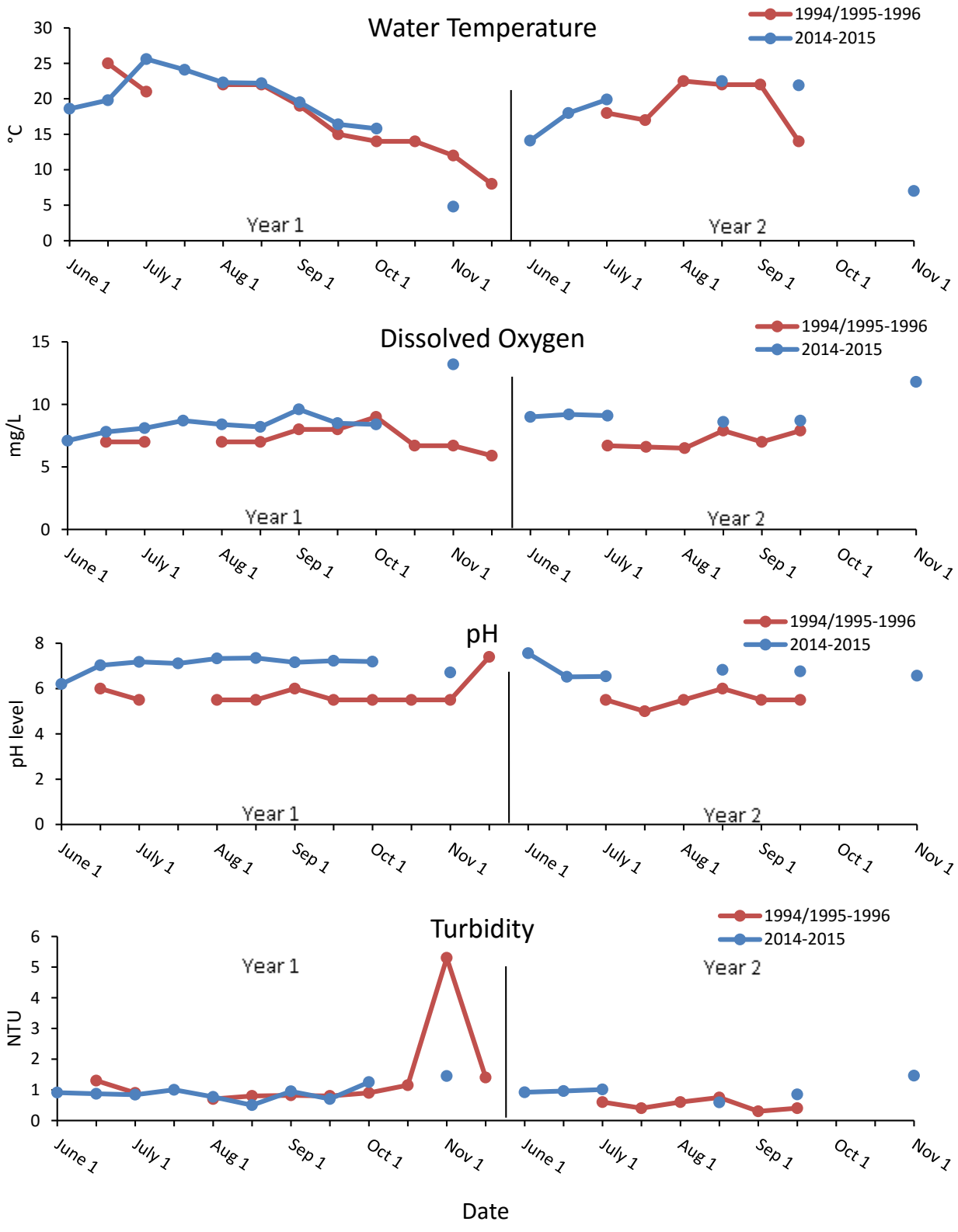


Figure 9: Magaguadavic sample sites (upstream on left).

Magaguadavic River, Upstream



Magaguadavic River, Downstream



Linton Stream

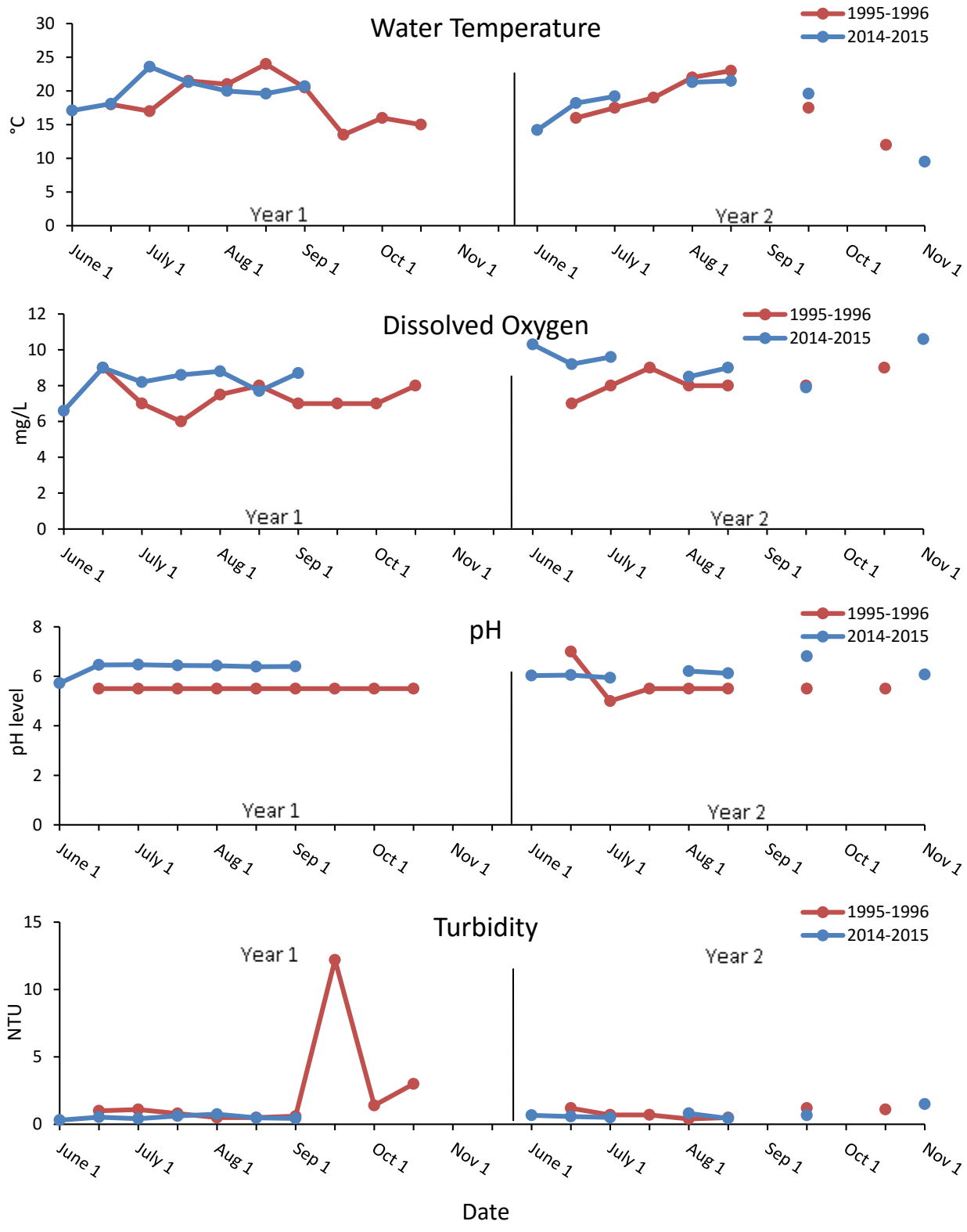
Linton stream empties from Digdeguash Lake into the Magaguadavic River, where it eventually drains into the Passamaquoddy Bay. The stream itself is rich with vegetation, including overhanging trees, small shrubs, and excessive plant and moss growth on the edges of the waterway. The stream itself experiences high water flow which has caused an accumulation of large exposed boulders. The stream, on average, is not exceptionally wide or deep.

Because of the rocks, the recreational use of this stream is mainly limited to hiking and fishing. The area is home to Stolt Sea Farms fish hatchery, which is found at the upper end of the stream. Signs of deforestation have also been noted over the past couple of decades, and when taken in consideration with the hatchery, these combined factors could explain the increased temperature in the upper sites.

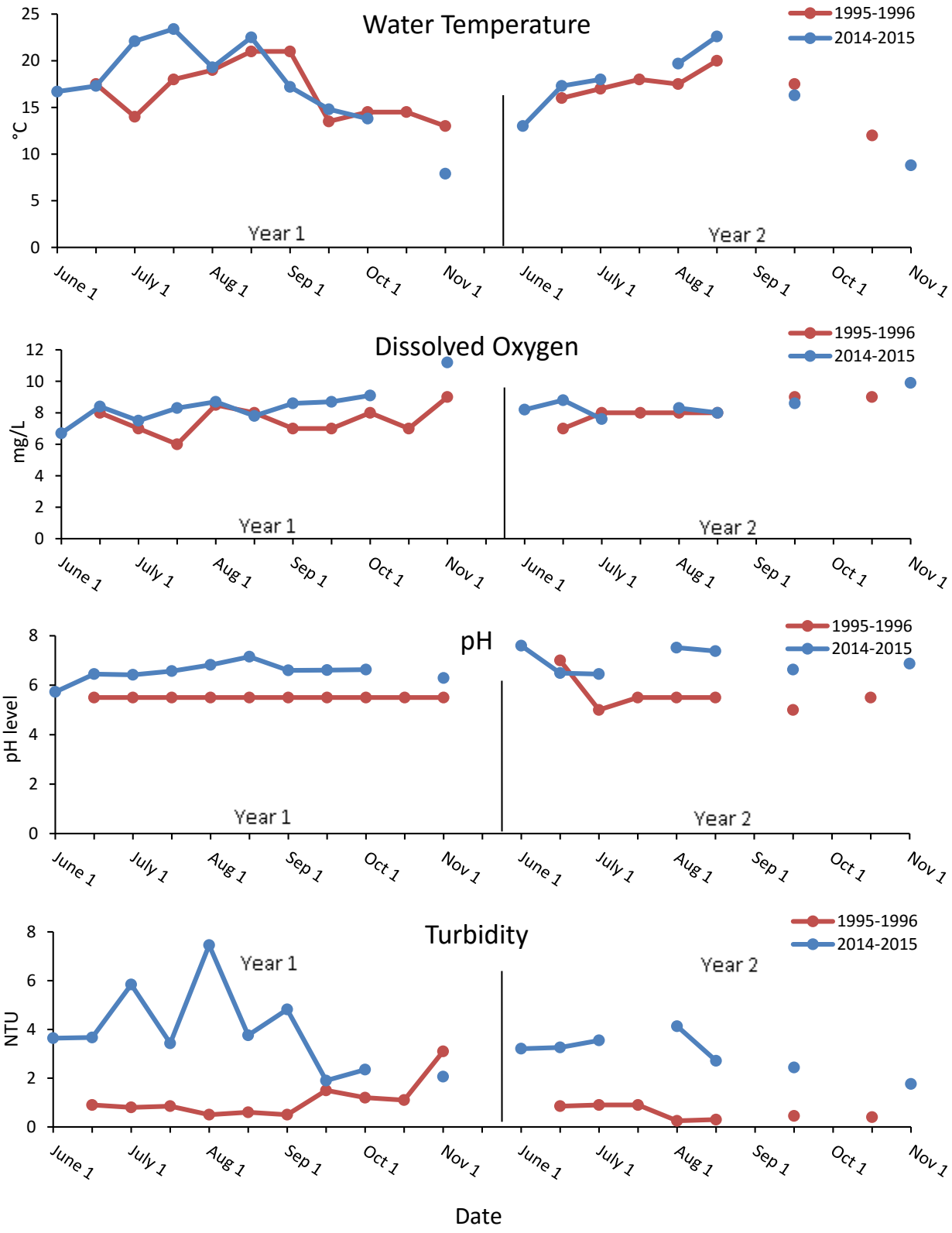
Water temperatures at the up and downstream sites peaked in July 2014 reaching close to 24°C, but settled to comfortable temperatures through the remainder of the sampling. Overall, water temperatures were consistent with 1995-1996 values. Dissolved oxygen levels were typically greater than those recorded in 1995-1996 (Table 2), though well within the acceptable limits for aquatic life, ranging between 6.6 and 11.2 mg/L. The pH levels were consistently greater and closer to neutral compared to 1995-1996 (Table 2). Overall, turbidity remained consistent with 1995-1996; however, at the down-stream site, turbidity was much higher than in 1995-1996. An odd “fishy” odor was regularly noted when collecting samples from the upstream site, which is not surprising considering the nearby fish hatchery. The average turbidity levels of 2014/2015 were 2.21NTU which is above the long term turbidity guidelines proposed by the Canadian Council of Ministers of the Environment. Samples were not collected from Linton upstream after early September 2014 due to difficulty accessing the site following a personal injury sustained by ECW field technician.

Figure 10: Linton Stream sample sites (upstream on left).

Linton Stream, Upstream



Linton Stream, Downstream



Digdeguash River

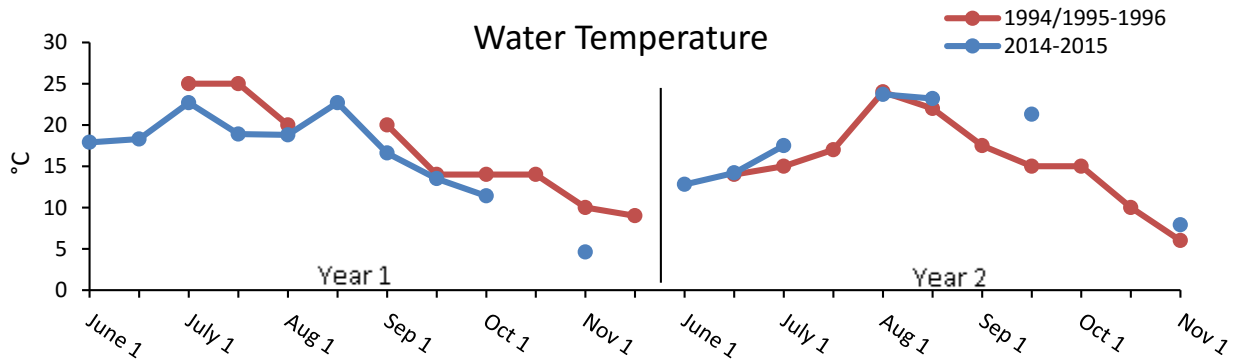
This watershed, which has an area of about 450km2, originates from a connecting series of streams and creeks located near the town of McAdam. The river flows southeast, where it eventually empties into the Passamaquoddy Bay. The watershed is forested in parts, and is home to many wetlands. The river has an average width of 20 feet, and has calm flowing water; however, some areas of high water velocities and waterfalls are present.

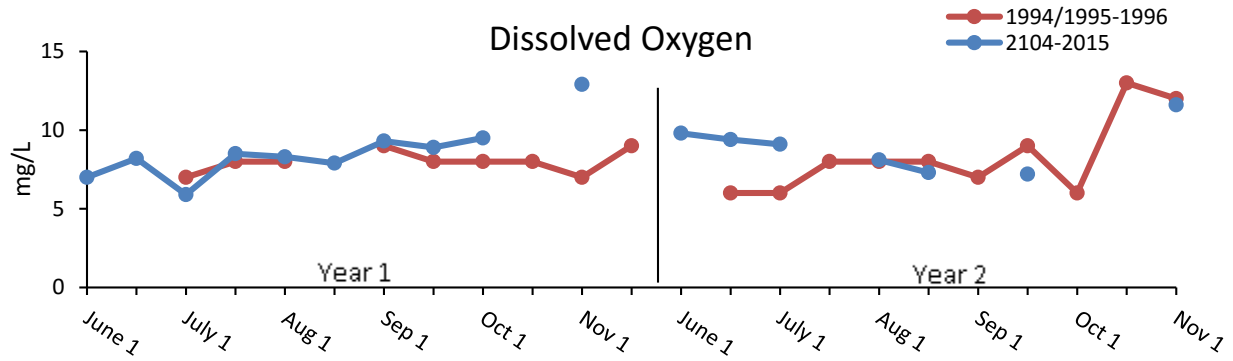
The river provides habitat for many fish species, which include brook trout, brown trout, and yellow perch. As a result, this area has become a popular recreational fishing site. Additionally, the area is commonly used for hiking, swimming, and boating. It is for these reasons that the river invites many campers, some of which own cabins along the edge of the Digdeguash.

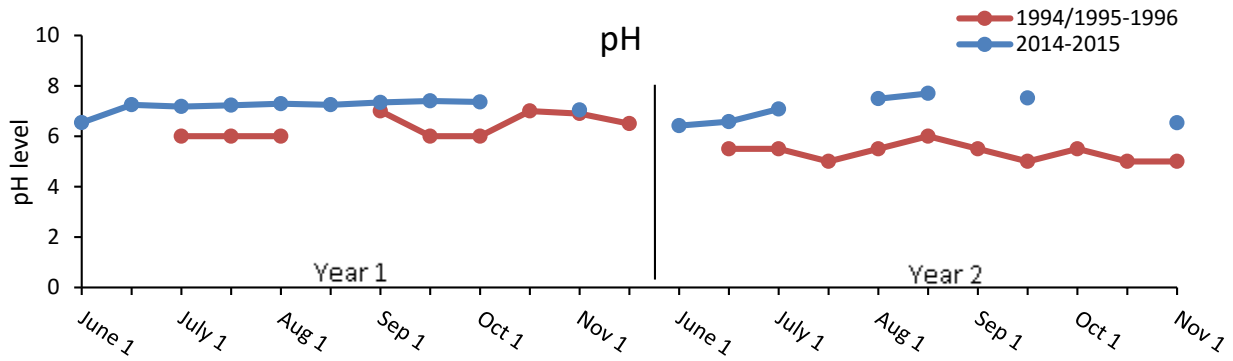
Water temperatures in the Digdeguash River were relatively the same as observed 20 years ago, and were generally higher downstream compared to upstream throughout the sampling period. Similar to the 1997 report, water temperatures rose in July and August before cooling with the fall weather. In July and August of 2014 and 2015, the downstream site reached close to 25°C. Dissolved oxygen levels were consistent with 1994-1996 levels and well within the acceptable limits for aquatic life, with the exception of two drops to 5.9 mg/L in July 2014 at the upstream site, and during September 2015 at the downstream site. The pH levels were higher and consistently closer to neutral compared to 1994-1996 levels that tended to be below 6 (Table 2). Turbidity levels were greatest at the downstream site but remained below the maximum optimal level of 5 NTU. Turbidity at the upstream site was more stable and did not exceed 1.0 NTU. Overall turbidity levels remained the same as in 1994-1996.

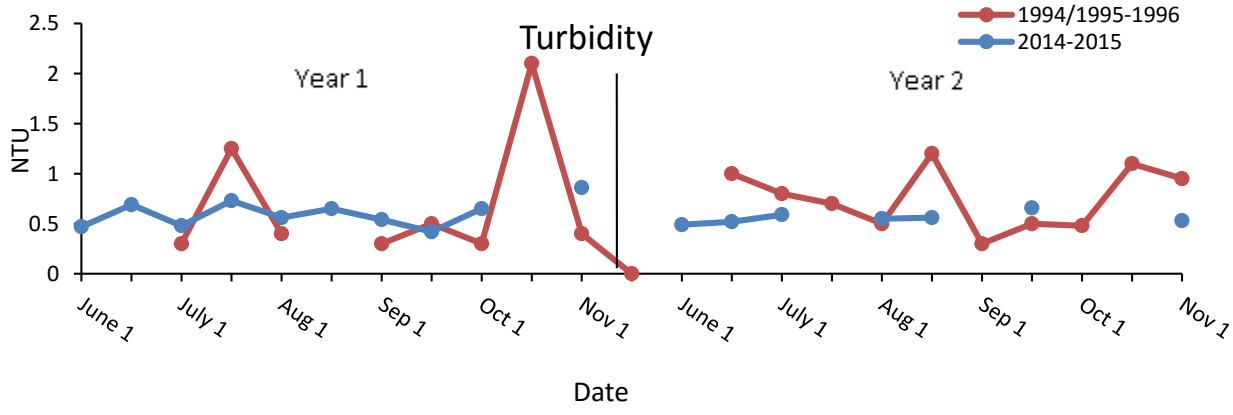
Figure 11: Digdeguash sample sites (upstream on left).

Digdeguash River, Upstream

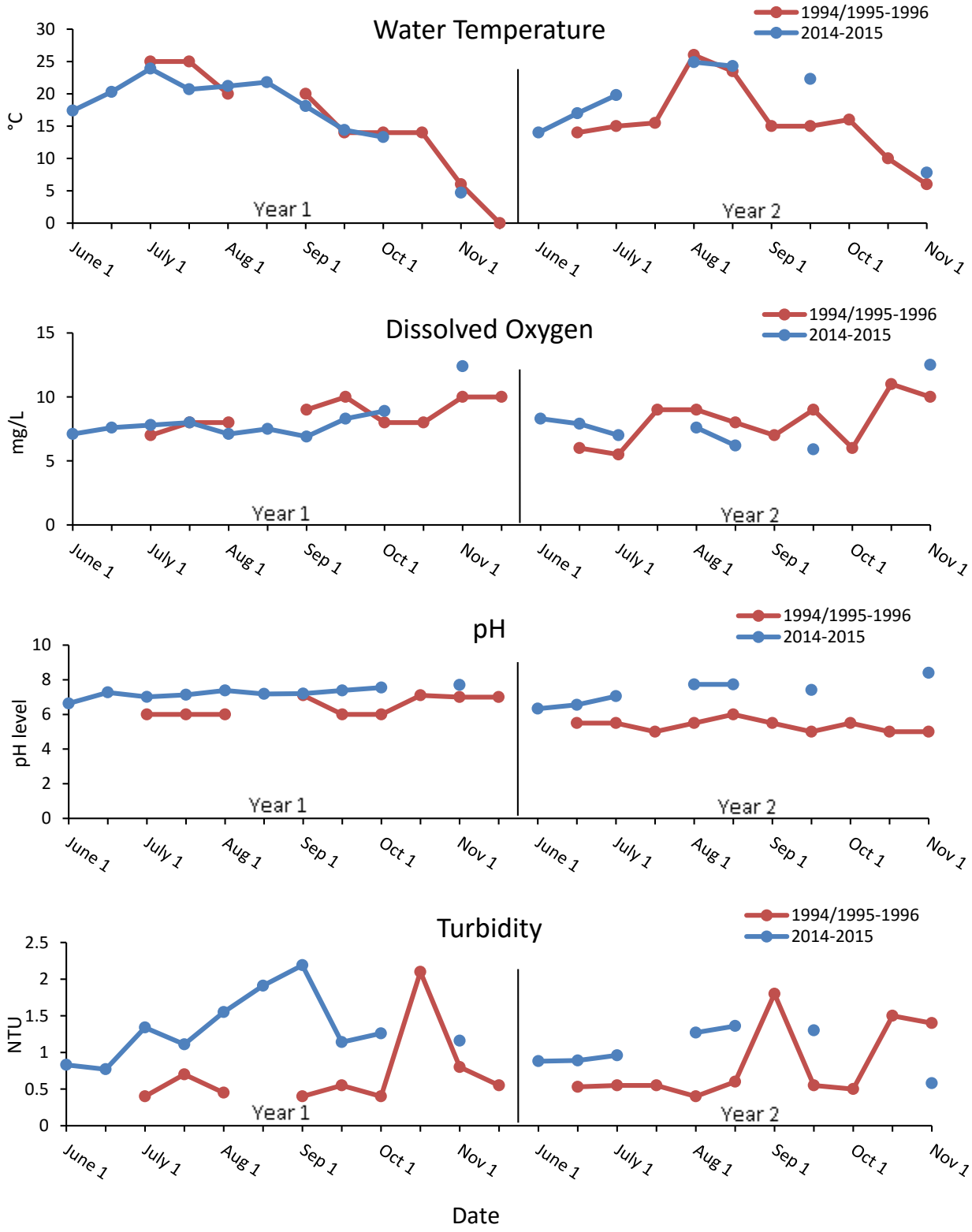








Digdeguash River, Downstream



Big Meadow Outflow

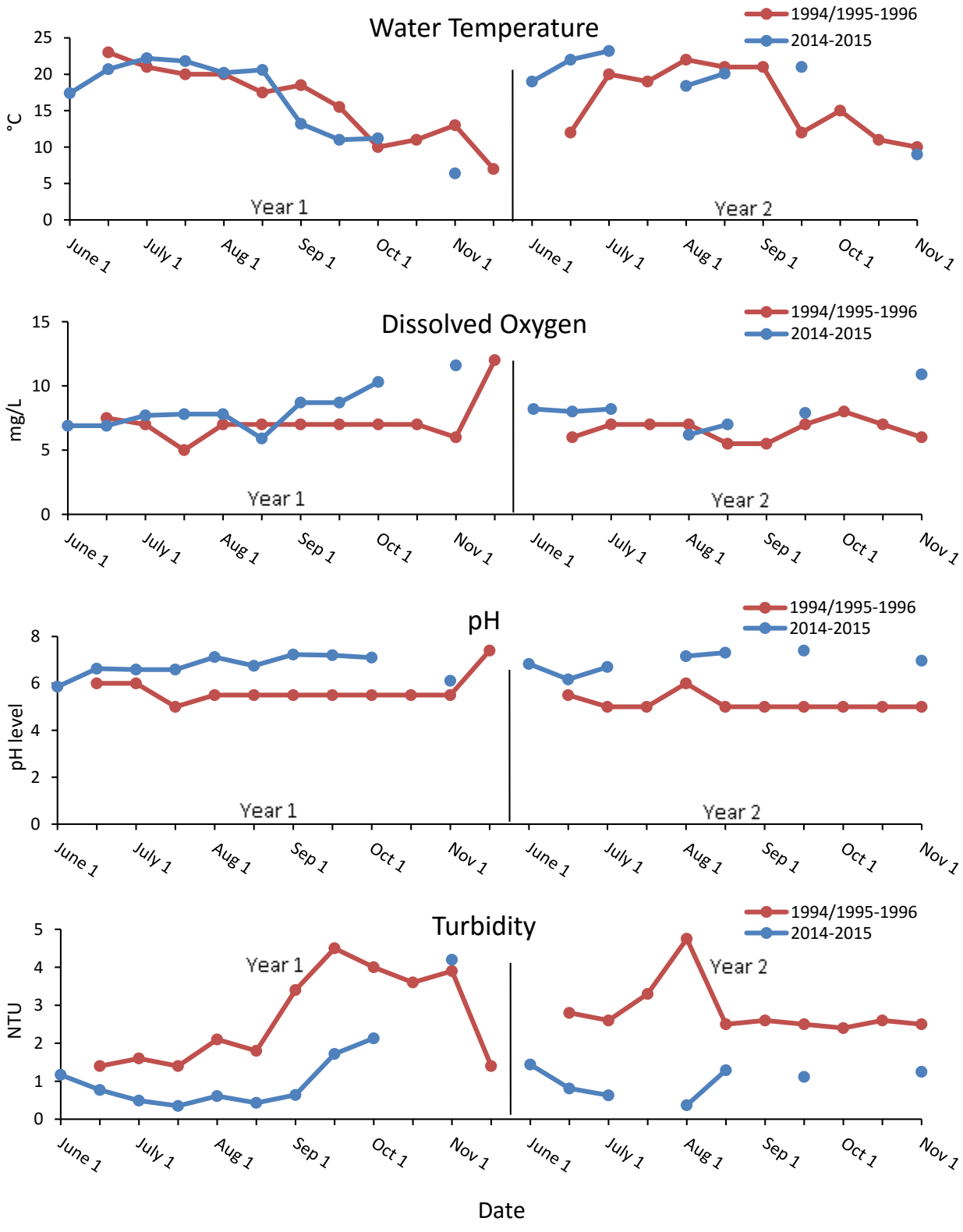
Located on Deer Island, this body of water is the primary waterway in the area. The meadow itself is found in the middle of the island, where its connecting streams run south through the lower villages of the island. These streams are mostly surrounded by dense vegetation, namely overhanging trees and bushes. Water flow is typically slow, and besides the meadow itself, the water does not reach considerable depths.

The water's primary use is recreational; throughout the spring and summer, it is used for trout fishing and swimming. Although only the meadow itself is used for such activities, the lower streams lie next to many off-road vehicle trails, some of which pass directly through the water. The Big Meadow also supplies water to a beaver pond located near the main body of water. In addition, Big Meadow Outflow serves as the Deer Island Fire Department's primary source of water.

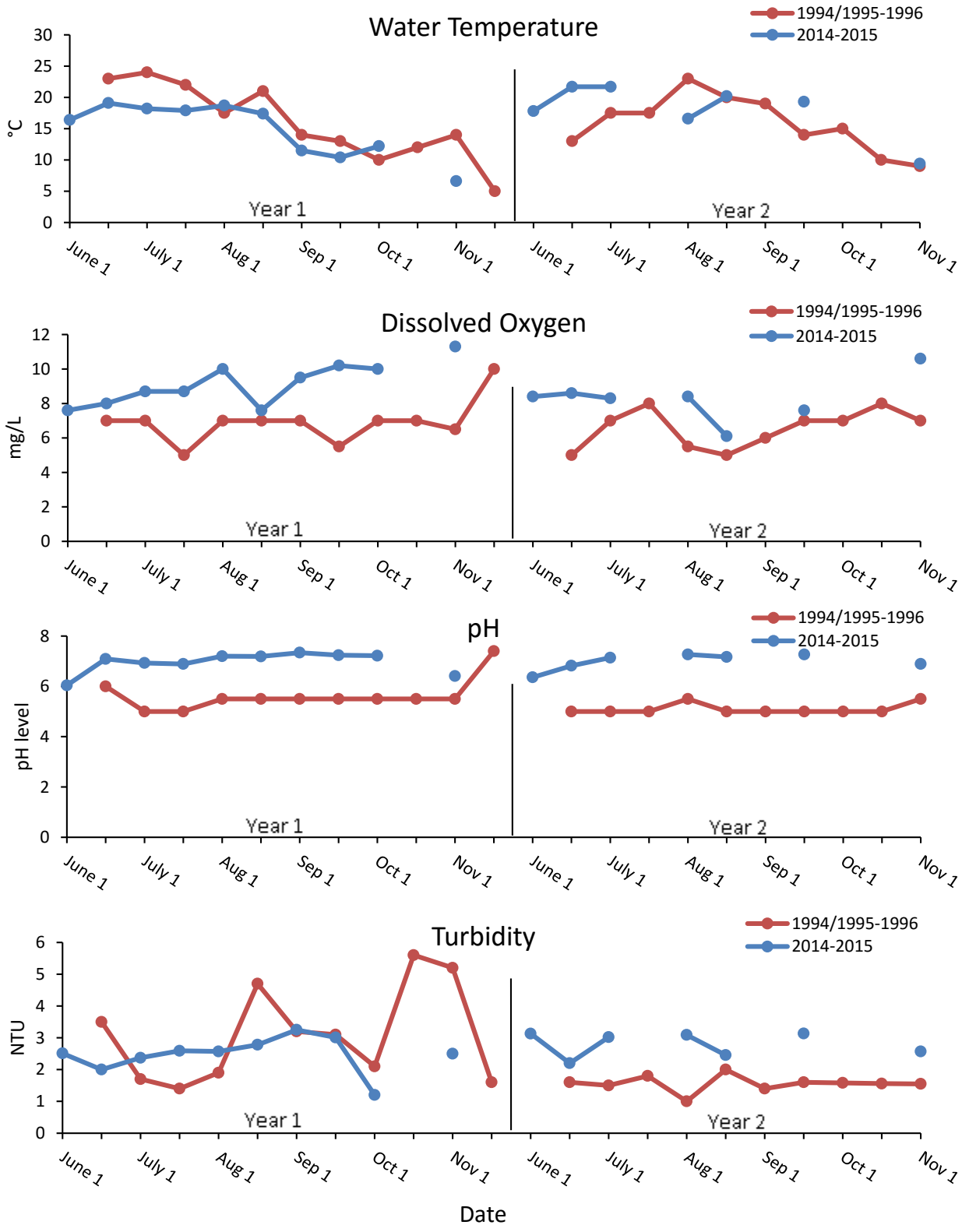
Water temperatures were generally higher upstream, which likely explains the lower dissolved oxygen levels recorded at the upstream site, which ranged from 5.9 to 11.6 mg/L. Dissolved oxygen levels improved since 1994-1996 (Table 2) averaging 8.2 and 8.8 mg/L at the up and downstream sites, respectively. Overall, pH levels improved since 1994-1996 (Table 2). The pH levels were higher and closer to neutral at both sites compared to 1994-1996 and remained near or within the acceptable range throughout the sampling period. Turbidity levels significantly decreased since 1994-1996 (Table 2). Turbidity levels were lower in the upstream site and relatively even downstream throughout the sampling period compared to 1994/1995, and remained within the recommended guideline for all water usage.

Figure 12: Big Meadow Outflow sample sites (upstream on left).

Big Meadow Outflow, Upstream



Big Meadow Outflow, Downstream



Comparative Analysis

For water quality comparisons we performed unpaired T-tests for 1994-1996 and 2014-2015. Analyses were performed on each river as a whole; therefore data from both up and down stream sites were pooled together. Comparisons were made between the initial study (1994-1996) and the present study's (2014-2015) results, and therefore data from all years within a study were pooled together. Habitat variables analyzed were temperature, pH, dissolved oxygen and turbidity.

Table 3: Results from T-tests on environmental variable changes from the first (1994-1996) and the second (2014-2015) assessment. Only significant values have been included (p value <0.05).

River/Stream	Variable	Year	Mean±SE	d.f	T-Value	p-Value
Lepreau River	pH	1994-1996	5.415±0.091	58.54	-3.509	<0.001
		2014-2015	5.922±0.114			
New River	D.O	1994-1996	7.69±0.166	56	-3.259	0.0029
		2014-2015	9.221±0.224			
Pocologan River	D.O	1994-1996	6.65±0.153	50.24	-5.289	<0.00001
		2014-2015	8.718±0.23			
Cripp's Stream	Turbidity	1994-1996	0.642±0.862	65.47	-4.938	<0.00001
		2014-2015	1.368±0.486			
Cripp's Stream	D.O	1994-1996	7.147±0.171	66.92	-11.674	<0.00001
		2014-2015	10.694±0.122			
Cripp's Stream	pH	1994-1996	6.794±0.136	45.1	-3.078	0.0035
		2014-2015	7.325±0.056			
Cripp's Stream	Temperature	1994-1996	9.162±0.278	64.4	-3.251	0.0018
		2014-2015	11.003±0.194			
Buckman's Creek	Temperature	1994-1996	9.597±0.198	57.37	-3.477	<0.001
		2014-2015	11.694±0.248			
Buckman's Creek	D.O	1994-1996	8.677±0.231	40.8	-5.988	<0.00001
		2014-2015	11.021±0.082			
Buckman's Creek	pH	1994-1996	6.368±0.087	48.1	-11.239	<0.00001
		2014-2015	7.66±0.043			

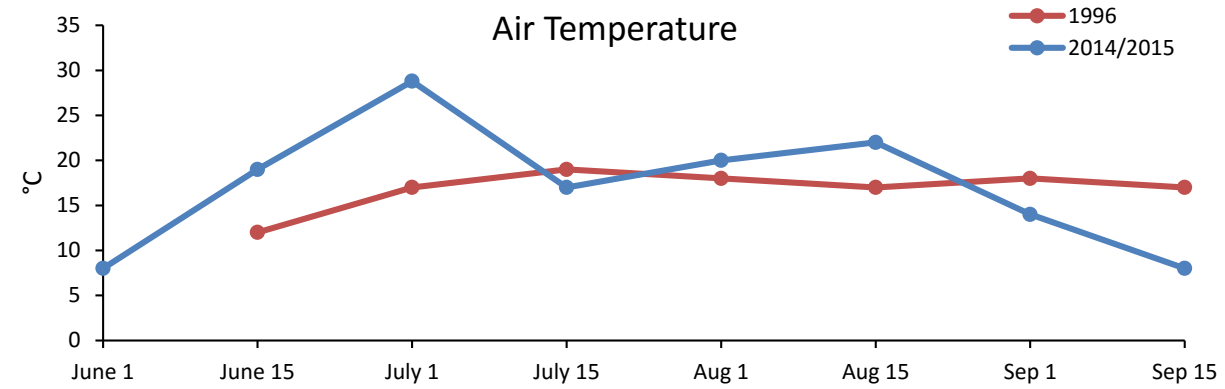
Mill Stream	Turbidity	1994-1996	0.519±0.275	34.18	-2.636	0.0125
		2014-2015	0.751±0.615			
Mill Stream	pH	1994-1996	6.206±0.109	49.22	-9.136	<0.00001
		2014-2015	7.471±0.051			
Mill Stream	D.O	1994-1996	8.453±0.076	48.85	-12.683	<0.00001
		2014-2015	11.173±0.089			
Mill Stream	Temperature	1994-1996	13.828±0.358	45.02	2.024	0.049
		2014-2015	11.853±0.199			
Magaguadavic River	D.O	1994-1996	7.144±0.124	49.21	-5.982	<0.00001
		2014-2015	9.068±0.169			
Magaguadavic River	pH	1994-1996	6.178±0.137	34.15	-4.663	<0.0001
		2014-2015	6.994±0.052			
Linton Stream	pH	1994-1996	5.545±0.073	59.82	-8.914	<0.00001
		2014-2015	6.508±0.070			
Linton Stream	D.O	1994-1996	7.758±0.108	58.72	-3.706	<0.001
		2014-2015	8.616±0.116			
Digdeguash River	pH	1994-1996	5.858±0.116	64.21	-9.998	<0.00001
		2014-2015	7.2±0.062			
Big Meadow Outflow	Turbidity	1994-1996	2.553±0.463	73.3	2.64	0.01
		2014-2015	1.876±0.560			
Big Meadow Outflow	pH	1994-1996	5.411±0.103	73.54	-13.267	<0.00001
		2014-2015	6.888±0.06			
Big Meadow Outflow	D.O	1994-1996	6.833±0.185	65.83	-5.203	<0.00001
		2014-2015	8.479±0.171			

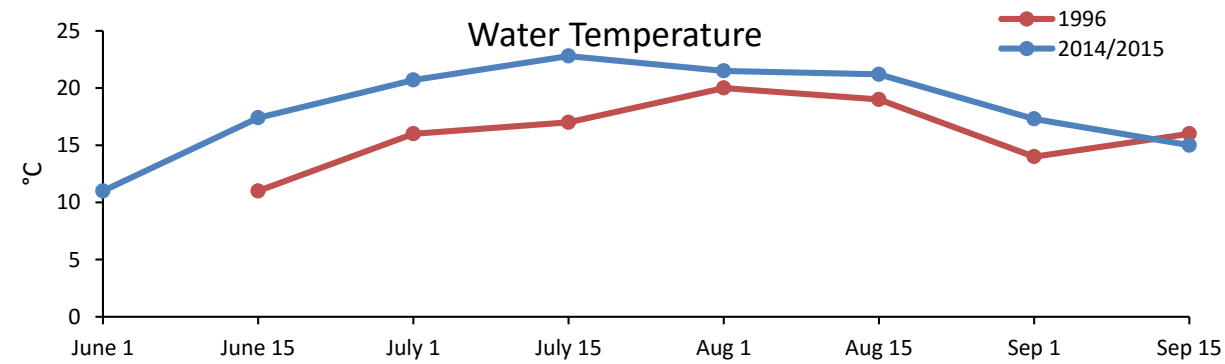
Results - Monitoring of eastern Charlotte recreational waters

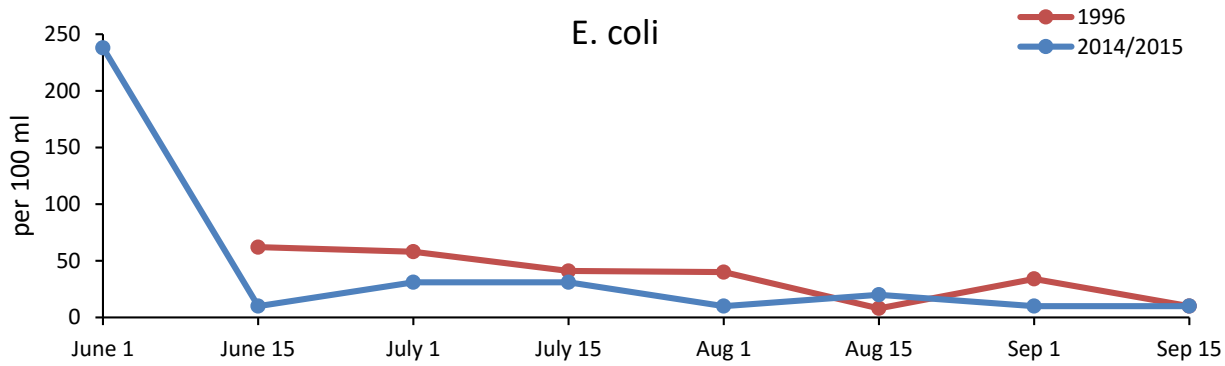
Each of the five swimming locations was sampled twice a month between July and September of 2014 and then again during June of 2015. There were two samples at McLean's Beach in July 2014 and one at Lake Stream in June 2015 that exceeded 200 E. coli/100 ml which is within the acceptable threshold. (Only single water samples with concentrations in excess of 400 E. coli per 100ml are considered unfit for recreational use.) In all other cases, E. coli present in these waters were similar to those reported in 1996 and well within the acceptable range for recreational use.

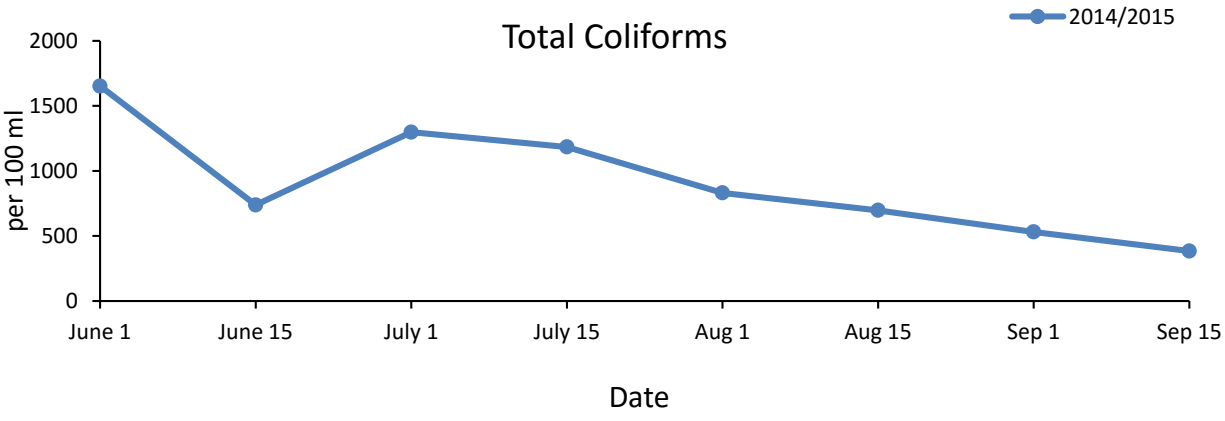
Figure 13: Map of recreational waters sample sites.

Lake Stream

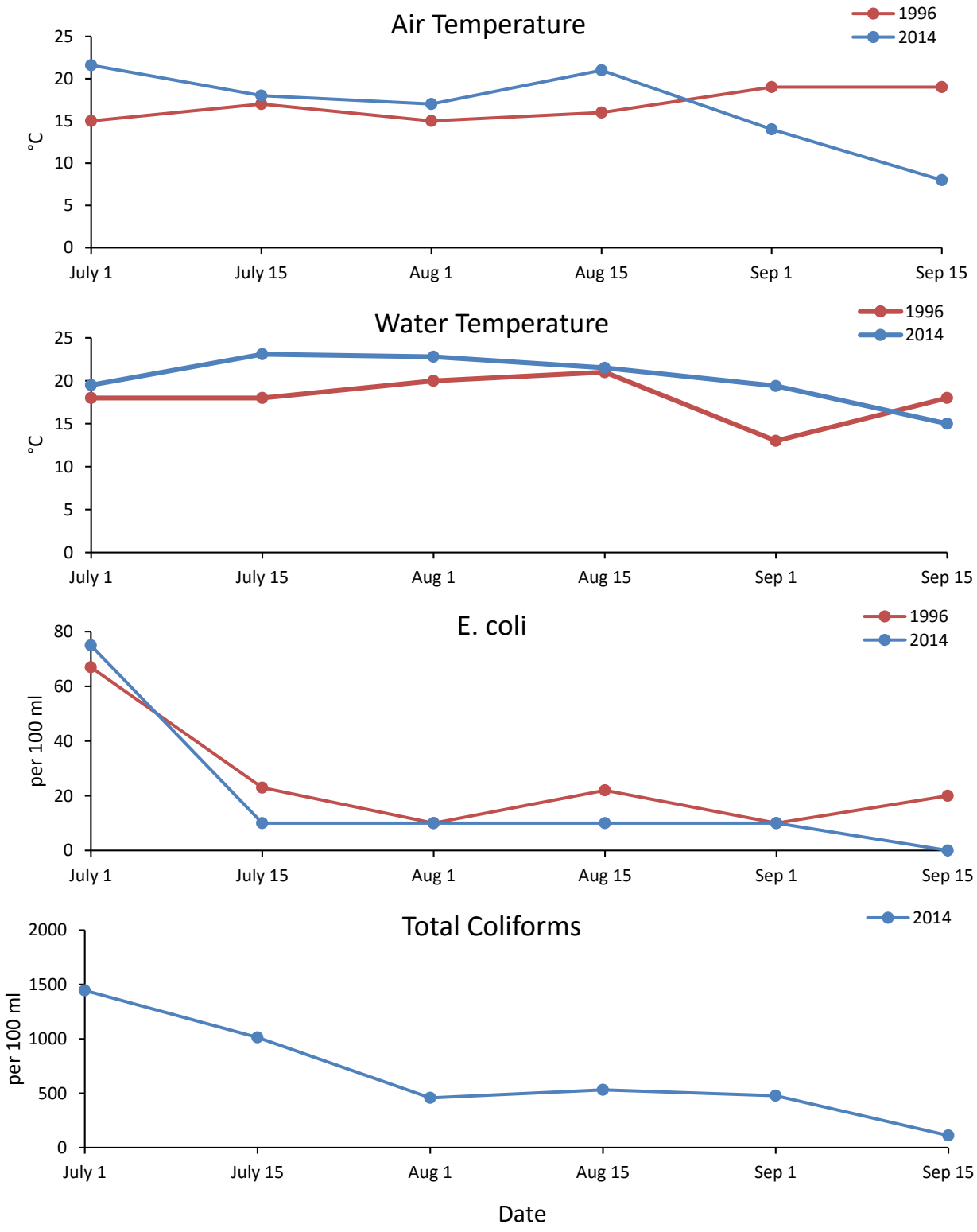

Air Temperature
1996
2014/2015
°C
35
30
25
20
15
10
5
0
June 1
June 15
July 1
July 15
Aug 1
Aug 15
Sep 1
Sep 15


Water Temperature
1996
2014/2015
°C
25
20
15
10
5
0
June 1
June 15
July 1
July 15
Aug 1
Aug 15
Sep 1
Sep 15

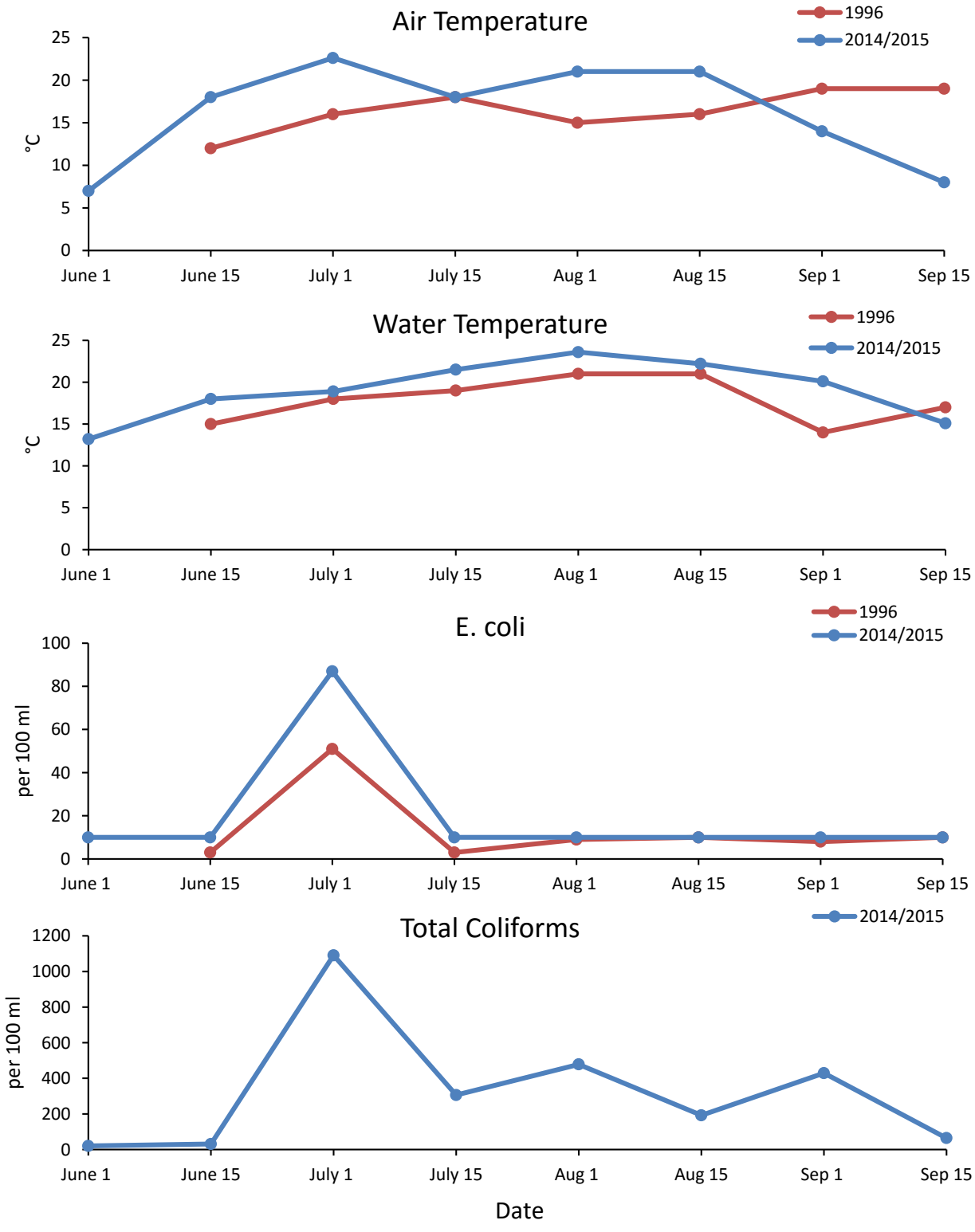

E. coli
1996
2014/2015
per 100 ml
250
200
150
100
50
0
June 1
June 15
July 1
July 15
Aug 1
Aug 15
Sep 1
Sep 15


Total Coliforms
2014/2015
per 100 ml
2000
1500
1000
500
0
June 1
June 15
July 1
July 15
Aug 1
Aug 15
Sep 1
Sep 15
Date

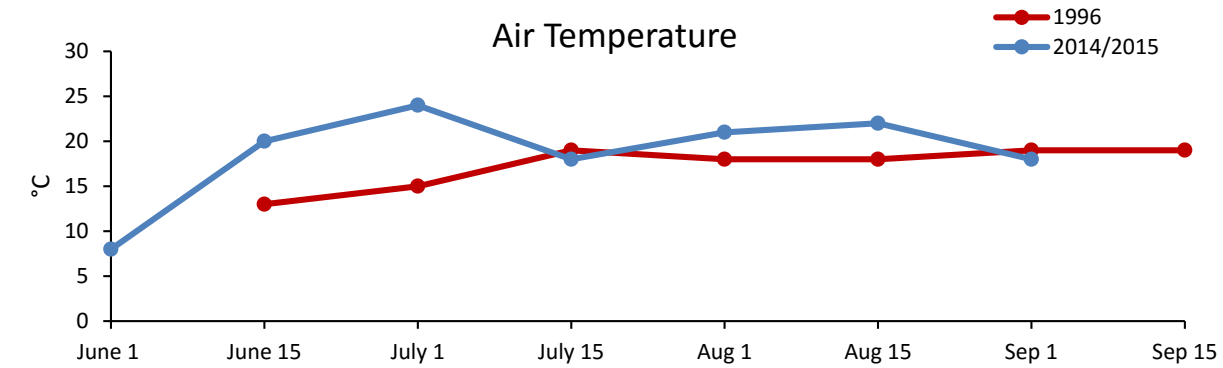
Day Adventure Centre, Magaguadavic River

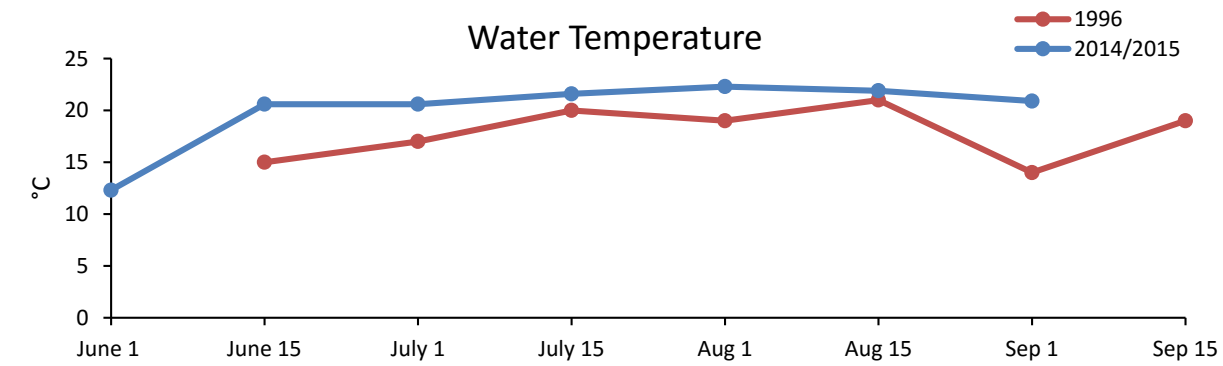


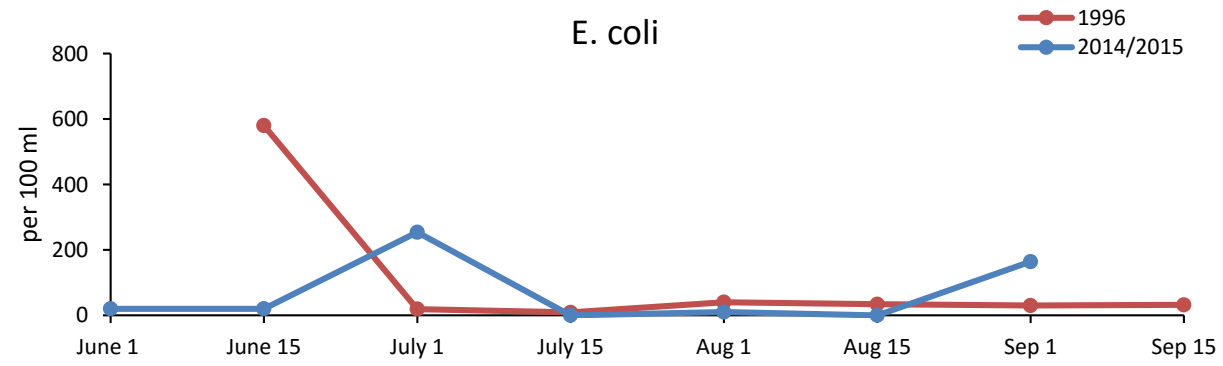
Canal Beach, Lake Utopia

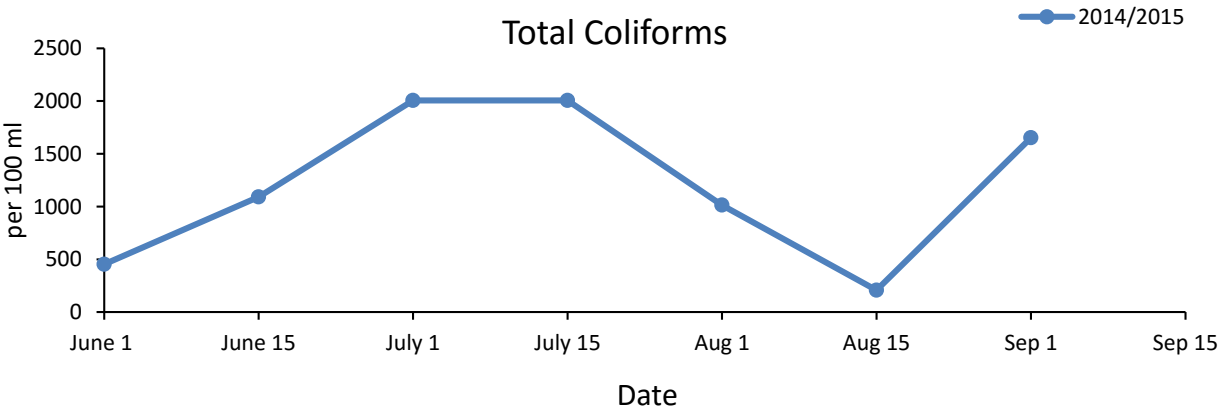


McLean's Beach, Lake Utopia

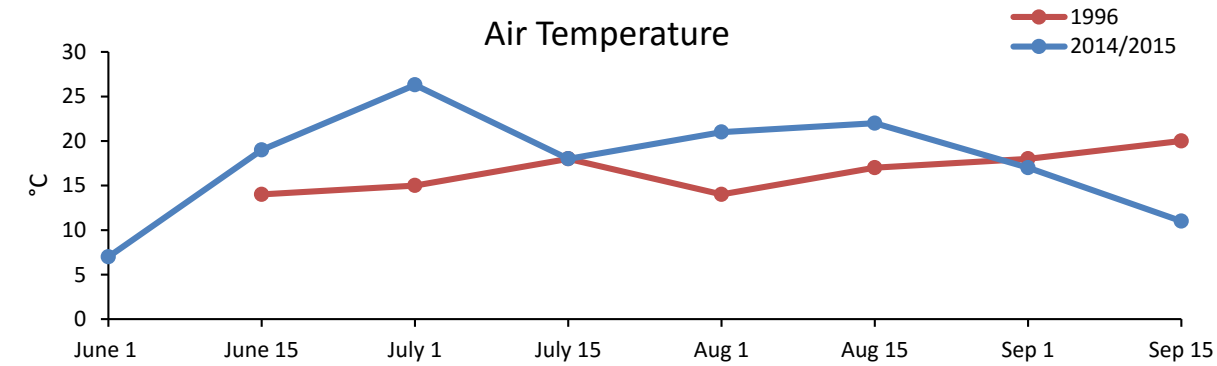


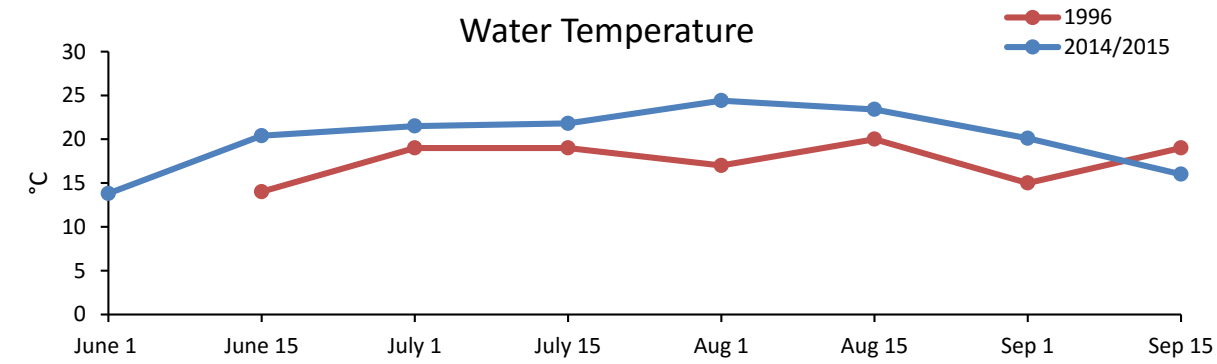


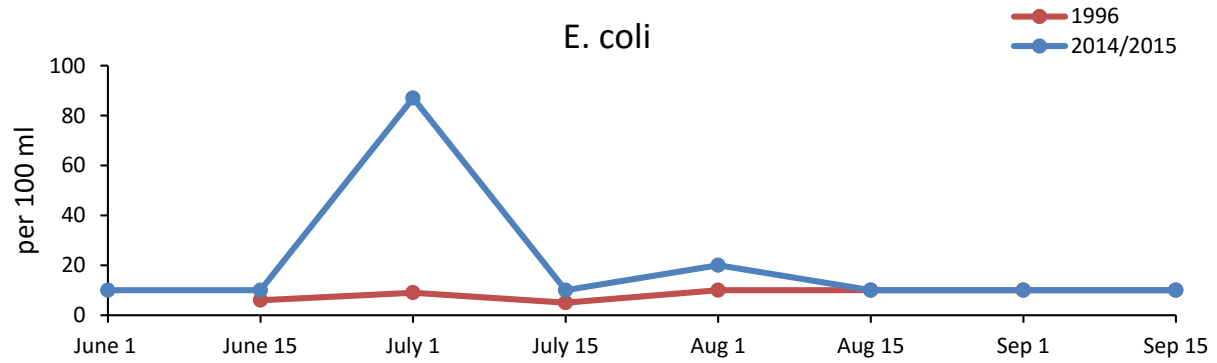


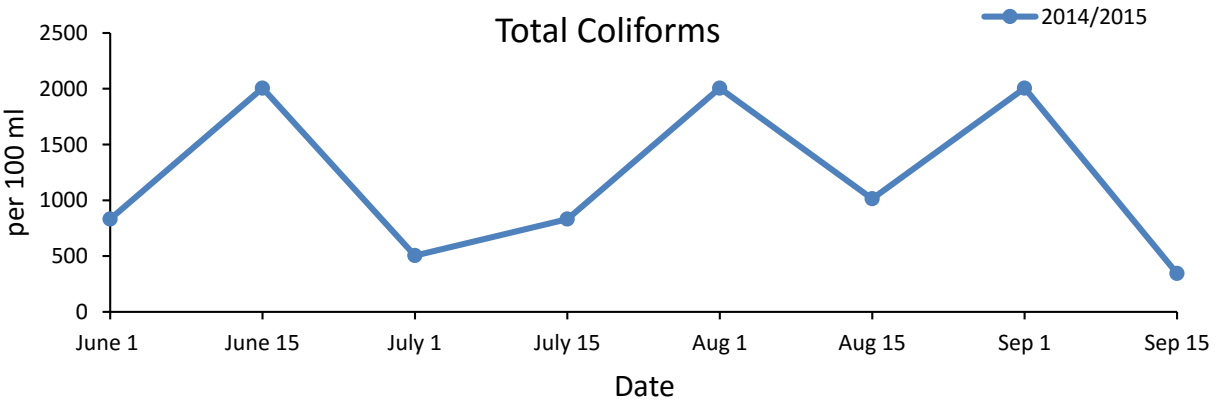


McDougall Lake

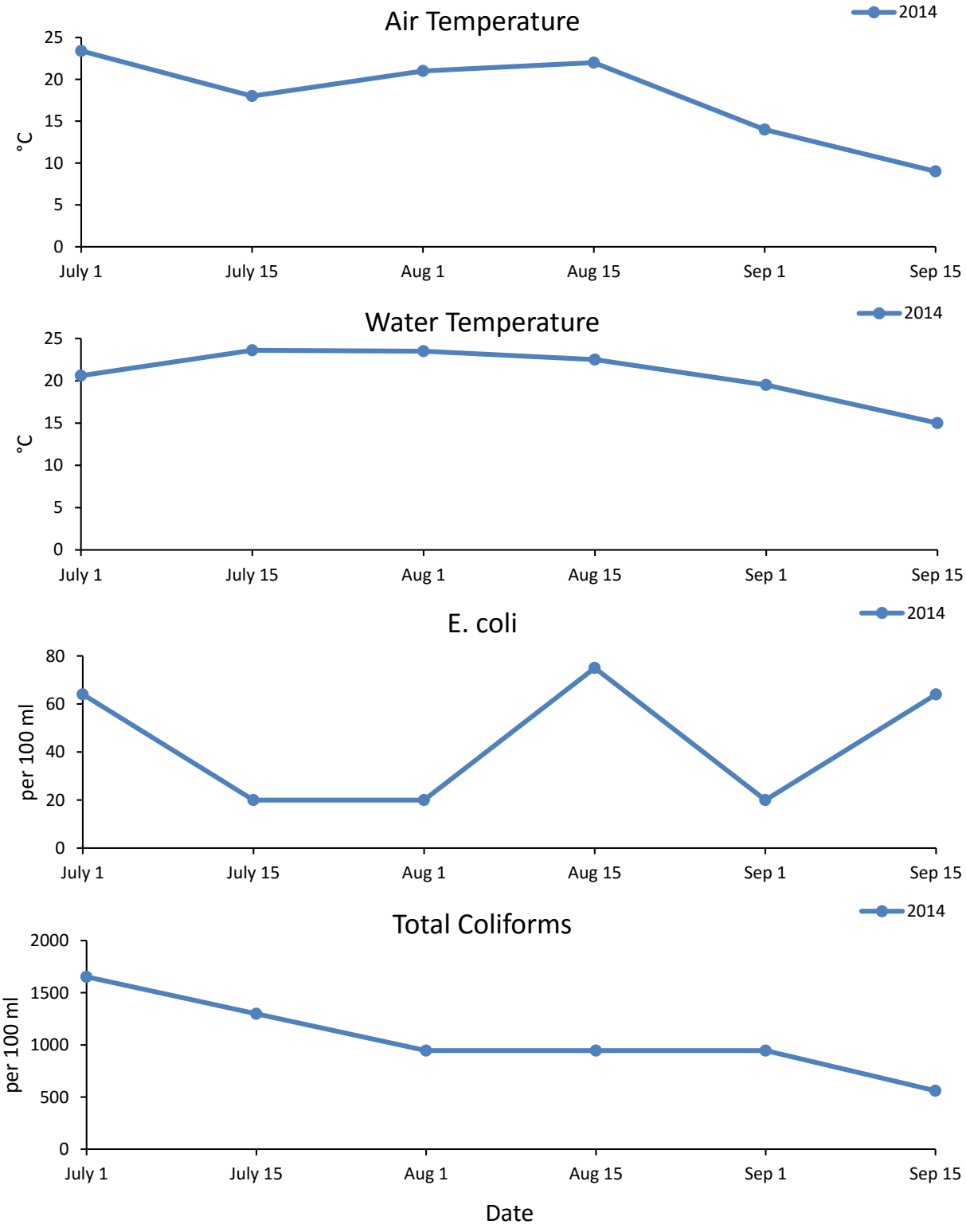








Backside of the River, Magaguadavic River



Discussion

Overall, the freshwater of Charlotte County remain in good condition. The majority of changes observed in freshwater quality over 20 years should be considered improvements, including both increased dissolved oxygen content and consistent pH levels near neutral in many of the re-visited waterways. The results from this study show stable and healthy watersheds.

Surprisingly, water temperatures remained relatively the same as 20 years ago aside from a slight decrease and increase in Mill Stream and Cripp's Stream, respectively. As climate change is expected to increase river temperatures (Cassie 2013), the present results infer that the watersheds of Charlotte County have yet to be severely impacted. This boasts for an optimistic future where mitigation strategies can begin before dramatic changes occur. However, further monitoring is needed to record temperatures in real time throughout the entire summer. Real time monitoring is important to record the amount, and duration, of temperature spikes throughout the summer which can cause high stress levels for aquatic life, such as salmonids. This is extremely important in the Magaguadavic River where temperatures hit 25°C and is home to a variety of fish species.

Dissolved Oxygen content increased in the vast majority of sites since 1994-1996, and remained the same in Digdeguash and Lepreau River. The lowest recorded DO content (5.9mg/L) was in Digdeguash River and occurred while temperatures were nearing 25°C and requires further monitoring as 6mg/L is the lowest concentration acceptable for early life stages of aquatic life (Canadian Water Quality Guidelines for the Protection of Aquatic Life). Although dissolved oxygen content remains within the healthy range, as temperatures are expected to continually rise, dissolved oxygen content will likely decrease and could pose a serious threat to aquatic life.

The only two rivers that did not improve to a more neutral range were Pocologan and New River. However, Pocologan, Lepreau and New River pH levels still remain below the optimal range. This is similar to findings 20 years ago and is most likely caused by the mineral content found in the surrounding soils and local geology. However, these three rivers require further monitoring to ensure pH levels remain stable and the waters remain healthy enough to support aquatic life.

Turbidity remained relatively the same as 20 years ago throughout Charlotte County Watersheds. Most high events that did occur were following rain events, as run off transports more sediment into the river, and increased water flow does not allow sediment to settle (Görransen et al. 2013). The only river that showed consistently high levels (average of 2.21NTU) was Linton Stream, and could perhaps be due to a fish hatchery located nearby, as a "fishy" odor was noted during sampling. Whether or not the high turbidity level is caused by the hatchery is unclear; as a result, this requires further attention as long term levels above

2NTU is deemed as harmful to aquatic species by the Canadian Council of Ministers of the Environment.

Results of monitoring the recreational waters in eastern Charlotte County suggest little change since the Swim Watch Program was introduced in 1996, with water remaining fit for recreational use. Only two samples studied had E. coli levels above 200 fecal coliforms per 100 ml, which is still well under the single sample 400 fecal coliforms per 100ml threshold. No evidence of high fecal densities was detected in 2014 and 2015.

Overall, the freshwater of eastern Charlotte County has only exhibited improvements in quality compared to 1994-1996. Aside from a few areas that require further monitoring, the region is more-than-well suited for supporting aquatic life and recreational use. The minimal change along with improvements in key variables is an excellent indication of an overall stable and healthy environment.

The results from this study use basic environmental parameters to show healthy and stable watersheds. To fully complete the picture of environmental quality it is recommended that a chemical analysis of the water is completed. This analysis would match that which was completed in 1997 as part of ECW's submission to the New Brunswick Department of Environment and Local Government for classification of the Outer Bay of Fundy complex of waterways under the Water Classification regulation and the Clean Water Act. As the 20th anniversary of this submission approaches, reassessing these chemical indicators will help further determine if there has been significant environmental change in the freshwater of southwestern New Brunswick. As well, there is an absence of biodiversity data for these freshwater resources, which should be addressed through the use of biodiversity measurement protocols such as the Canadian Aquatic Biomonitoring Network (CABIN). We also recommend as much as possible, real time monitoring of river temperatures during the summer to determine the amount, and duration, of spikes in temperatures that can be harmful to aquatic species. These future monitoring initiatives will ensure the continued stability and health of freshwater in Charlotte County.

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Eastern Charlotte
WATERWAYS