Freshwater and Estuarial Monitoring in the St. Croix Estuary Area of New Brunswick: October 2012 – March 2013

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Acknowledgements

The St. Croix Estuary Project (SCEP) gratefully acknowledges funding for this project from Environment Canada's Atlantic Coastal Action Program (ACAP). ACAP has consistently supported community-based environmental planning and monitoring in the St. Croix area since 1992. Much of the current knowledge of the estuary and the progress made in maintaining the health of its resources would not have been possible without this support.

SCEP particularly appreciates the participation and technical support of the Town of St. Stephen's Public Works Department and the N.B. Department of Environment & Local Government's Analytical Services Branch, Water & Wastewater Management Section and Water Quality & Quantity Section. These can consider and potentially act on the information that SCEP has been able to provide through this project, and we hope that they will.

SCEP also thanks the Bayside Port Corporation for allowing access to its wharf for estuary sampling, beside its busy commercial shipping schedule. Local partners are the key to the estuary's future and we hope that many more of these will get involved.

Project Synopsis

This project was designed to, in a limited period (October 2012 – March 2013), address three primary environmental information gaps:

1. Consolidate and expand data on select St. Stephen municipal stormwater and combined stormwater/sanitary outfalls that continue to impact the estuary, to provide information that will assist to address these. *New data was collected and old data was reviewed. Five outfalls continue to warrant further attention.*
2. Collect new data on pH variability in major freshwater tributaries and estuarine waters under dry and peak rainfall/snowmelt conditions, to support ocean acidification studies. *Preliminary data was collected and is reported: additional data is needed to substantiate early findings.*
3. Collect new data on major freshwater discharges into coastal waters, under seasonal and heavy rainfall/snowmelt conditions, to support future coastal planning and management. *New data was collected between October 2012 and March 2013 for five primary discharges and three coastal wharves; the former was entered into the province's water management database. Some findings warrant further study*.

Introduction

The St. Croix Estuary Project Inc. (SCEP) was founded in 1992 to allow St. Croix community-based interests – municipal, business, user group and others – to partner with Environment Canada in a long-term initiative to conserve coastal resources and economic opportunities under the federal Atlantic Coastal Action Program (ACAP). The St. Croix estuary, through SCEP, is one of just 14 Atlantic Canada sites to benefit from this initiative.

Since 2003, SCEP has collected water quality data for the St. Croix estuary and for up to 26 stormwater pipes that discharge to it, to assist in identifying and reducing the pollution sources that affect the estuary's ecosystem and the people who use it.

With the help of this monitoring effort, municipal and provincial programs have been able to eliminate or significantly reduce the impacts of all but a few discharge pipes identified in SCEP's earliest studies. Notably, the estuary's two New Brunswick municipalities (St. Stephen and St. Andrews) have constructed new wastewater treatment plants and separated many of the stormwater and sanitary sewer line interconnections that historically carried both flows straight to the estuary: a majority of the sanitary (i.e. sewage) outflow now goes to the new treatment plants.

During this study, SCEP collected new data on five stormwater outfalls in the Town of St. Stephen that have continued to show elevated bacteria counts in recent years. Tests were performed for bacteria, as in the past, but also for hydrocarbons and for a set of 31 other parameters (including metals and nutrients), to gain a better understanding of what these pipes are discharging to the river. The tests were made on two occasions – in dry weather and in wet weather (after a heavy rainfall and snow melt) – to see if the outfall water composition differed under these conditions, which it did.

The St.Croix estuary and nearby coastal waters are also affected by the outflows of the rivers and streams that lead to them. Aware of growing evidence that climate change is causing ocean water to become more acidic, which will over time affect many native marine species, and aware that little information on the freshwater inflows to the estuary area has been collected in the last decade, on five occasions SCEP collected stream samples that were analyzed for 32 parameters, (including the pH measure of acidity) and on all but one occasion also analyzed for bacteria. One of these samples (March 13-14, 2013) was taken on the high flows immediately following a heavy rainfall and snowmelt: snowmelt conditions have been shown to often produce a short period of low pH and high readings for some other parameters that affect certain fish and other aquatic populations. In all of these tests, pH remained near neutral (at 6-7 on a scale of 1-14) however variations in some other parameters were observed and are reported.

On these same five occasions, measurements of pH, conductivity, salinity, dissolved oxygen and temperature were collected at three wharves – in the upper, middle and lower estuary – to see if there was an indication that freshwater flows might be having an apparent effect on estuarine pH. This was not evident from the 2012-2013 samples however the baseline data will be useful for longer term studies.

Methods

Past SCEP studies have employed varied test methods and have relied on in-house data storage that, together, have limited the ability to measure and interpret results over time. This project has sought to consolidate key information from the previous studies, for areas of ongoing concern, and begin standardized testing and public data storage that will make it easier for interested parties to access and apply the findings

Stream samples

All field sampling was conducted under New Brunswick Department of Environment & Local Government (DELG) field protocols. Dissolved oxygen and temperature were recorded in the field with a calibrated YSI Model 57 meter. Water samples were collected, held and delivered within 24 hours, under DELG protocols, to the DELG analytical laboratory in Fredericton, NB, for analysis. This laboratory, performed standardized tests for its *B inorganic analysis package and for *E. coli* bacteria. See Appendix 5 for these test methods and limits of quantification.

The *B analysis package analyzes these parameters: alkalinity, aluminum, antimony, arsenic, cadmium, calcium, chloride, chromium, colour, conductivity, copper, fluoride, iron, lead, magnesium, manganese, nickel, nitrate-nitrogen, nitrate/nitrite, nitrite, pH, potassium, sodium, sulfate, total organic carbon, total phosphorus, total ammonia, total hardness, total nitrogen, turbidity and zinc. See Appendix 4 for a description of these and their role in the aquatic environment.

All of the above field and laboratory data have been entered into the province's longterm environmental database, ENVI, for future research access. They are also included in the appendices of this report.

Stormwater outfall samples

Stormwater outfalls received the same field data collection and *B sample collection and analysis as streams, following DELG protocols.

Samples were also collected and analyzed for DELG's Tier 1 hydrocarbon package (benzene, toluene, ethylbenzene, total xylenes, C6-C10 hydrocarbons, >C10-C16 hydrocarbons, >C16-C21 hydrocarbons, >C21-<C32 hydrocarbons and modified TPH) to provide some indication of possible oil and grease runoff from road surfaces.

Samples were also collected for analysis for total coliform bacteria and *E. coli* bacteria. Coliforms are a group of bacteria commonly found in soil, vegetation and water, and are universally present in the intestines (and feces) of warm-blooded animals. Most forms of coliform bacteria are benign, but their presence in high numbers can suggest that other more harmful pathogens might be present. *Escherichia coli* (*E. coli*) is the only member of the total coliform group of bacteria that is found exclusively in the intestines of mammals, including humans: it is a direct indicator of fecal pollution. While small numbers of *E. coli* are common in surface waters, from animal wastes, large numbers in municipal stormwater outfalls generally indicate that a sanitary sewer is still connected to one these and discharging to the river.

The 2012 Canadian Drinking Water Quality Guideline for both total coliforms and *E. coli* is 0 (zero) per 100ml of water. The recently-revised (2012) Guidelines for Canadian Recreational Water Quality give provide these: For primary contact recreation (ex: swimming): no more than 200 *E.coli*/100ml as an average for 5 water samples and no more than 400 *E.coli*/100ml for any one sample. For secondary contact recreation (ex: boating, fishing): no more than 1,000 *E.coli*/100ml of water.

All of the above field and laboratory data have been entered into the province's longterm environmental database, ENVI, for future research access. They are also included in this report.

Wharf samples

Field measurements of water temperature, conductivity, salinity, dissolved oxygen and pH were recorded using a calibrated YSI 556 MPS meter. These were collected at one meter intervals, between the water surface and one meter from the bottom, except at the Bayside wharf, where water depth exceeds the limit of the meter cable. Records were made of tide cycle, weather and other field conditions.

On one occasion (following the March 13 heavy rainfall), water samples were taken for bacteria at two of the wharves and analyzed by the DELG laboratory, following its protocols.

These data are on record with SCEP and are included in this report.

Differences in bacteria analyses, 2003-2013

Over the last 10 years, bacteria analyses for SCEP have been performed by different methods and providers, and to different limits of measurement, that do not permit direct comparison of results.

Two primary methods are used to measure bacteria numbers. The CFU (colony-forming unit) method was used by SCEP in 2003-2011. This involves placing a measured amount of water sample on an agar plate, incubating this to allow live bacteria colonies to grow and then counting their number. This usually includes a number of dilutions of a water sample to ensure a plating level where the colonies won't overcrowd each other into a mass that can only be recorded as (TNTC) "too numerous to count", or as a number beyond the dilution limit (recorded as "greater than" number). The MPN (most probable number) method is used starting in 2012: this now widely used for provincial and federal analyses and is less costly and labour-intensive. It involves diluting the water sample by orders of magnitude (ex: 2x or 10x), adding a growth media, apportioning the sample to a series of small chambers and using a count of the number of chambers that grow bacteria (presence/absence) to calculate a most probable number of the colonies.

While both methods typically report their results in bacteria colonies per 100ml of original water sample, there is no means to convert between CFU and MPN findings. Nevertheless, some trends will be obvious in Table 1.

Stormwater Outfalls

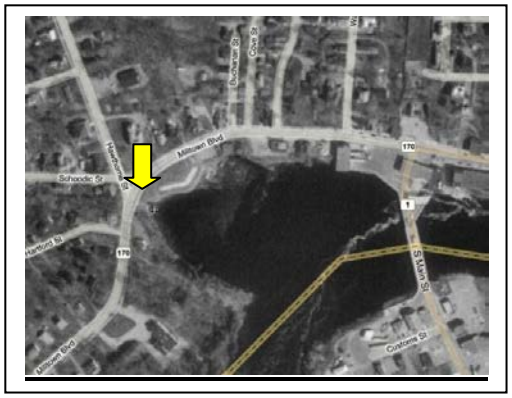
Six stormwater outfalls in the St. Stephen area that have previously monitored for high bacteria counts were included in this sampling series.

All were sampled under dry (no recent rainfall) and wet (heavy rainfall) conditions. All had at least a minor discharge under dry sampling conditions, suggesting that all receive some input from streams, seeps, groundwater or sanitary sewer lines on an ongoing basis.

The majority of the outfalls showed certain trends in results under dry and under wet conditions and these are discussed at the end of this section. Findings specific to individual sites are described below.

Important note: The names assigned to these sites have been in use for some time to indicate the nearest access to the outfalls. SCEP wishes to make it clear that there are no findings to suggest that the named locations contribute to bacterial results in any way.

The Cove at Dover Hill Site SCE-10MB



Location: 45°11'33"N 67°17'17"W

This outfall serves major stormwater lines that extend up Hawthorne Street and Milltown Boulevard and, with their lateral lines, collect water from roughly 2.7km of stormwater pipe. This outfall also discharges the flow of a small year-round stream that joins the stormwater flow just above the outfall.

E.coli results from this site were much lower than in past years, (allowing for different sampling methods) and were similar under both dry and wet sampling conditions (300-230MPN/100ml). The total coliform counts were also similar, and within levels seen in nature, suggesting that the stream that discharges to this site may be the major and natural contributor. SCEP collected bacterial samples roughly 300m up this stream in some years, finding low *E.coli* but very high total coliforms, probably originating from a large upstream marsh. It would be useful to collect additional samples both near the marsh and where the stream joins the stormwater line, to see if there are any sources between these points.

This site had low levels of some hydrocarbons in its outflow under dry conditions; none were recorded in the very high flow from the stream and stormwater lines under wet conditions.

Above Riverside Grocery Site SCE-11MB

Location: 45°11'33"N 67°17'10"W

This outfall serves roughly 168m of Milltown Boulevard and Buchanan Street.

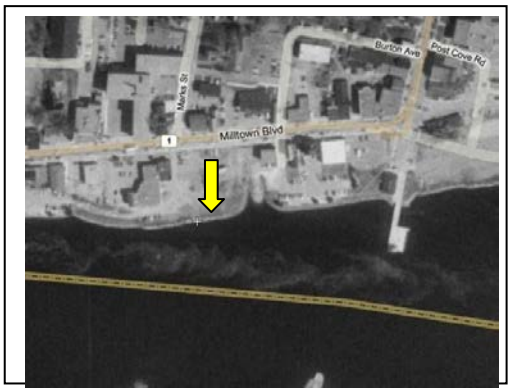
E.coli results from this site were high (2000MPN/100ml) under dry conditions but low (50MPN/100ml) under wet conditions, with total coliforms following the same trend. This suggests

that there may be some ongoing bacterial loading to this collector line that is significantly diluted by the stormwater runoff.

This site showed very high total coliform levels under dry conditions (272,000MPN/100ml), which warrants further investigation.

This site also recorded low levels of some hydrocarbons in its outflow under dry conditions but not under wet conditions.

Chocolate Park Site SCE-14MB



Location: 45°11'30"N 67°16'47"W

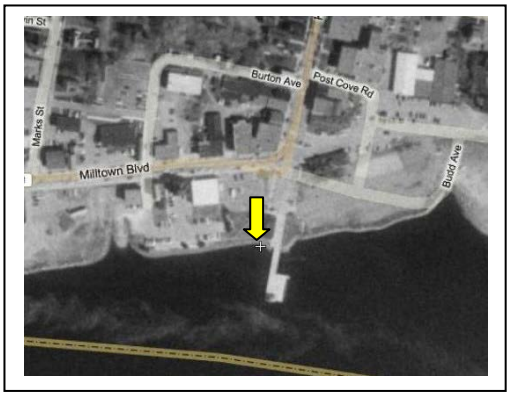
This outfall serves a major stormwater line that extends up Marks Street and gathers lateral lines that run outward to Victoria Street, Porter Street, Queen Street and others. Approximately 5.5 km of storm sewer drain to this site

Dry weather (low flow) *E.coli* and total coliform results for this site were the highest in this study, exceeding all other sites by five-fold for *E. coli* (102,000MPN/100ml) and at least seven-fold for total coliforms (517,000MPN/100ml) with the exception of one site (Riverside) that recorded slightly less than half that number. Wet weather bacteria results were also among the highest in this study.

This site has consistently had very high bacteria results since SCEP monitoring began here in 2004; its flow regularly tends to be cloudy and have some odour. Because of the extensive network of sewer lines that drain to this outfall, it will be time-consuming to identify the sources of this contamination but expedient to do so, given the outfall's close proximity to the downtown boat launch.

This site also recorded low levels of some hydrocarbons in its outflow under dry but not wet conditions.

Pizza Delight/Wharf Site SCE-20MB



Location: 45°11'31"N 67°16'37"W

This outfall discharges roughly 300m of storm sewer lines from short sections of King Street and Milltown Boulevard.

E. coli results at this site have varied widely over the years that SCEP has sampled this location, and did so again during this study. A moderate finding of 1000MPN/100ml in dry weather was

offset by a wet weather count that exceeded the limit of the test method used (i.e. an unknown number higher than 24,190MPN/100ml). Total coliform results showed a similar trend (3700MPN/100ml under dry conditions and >24,190 under wet conditions). This was one of only two sites to have higher bacteria readings under wet (high flow) vs. dry (low flow) conditions.

It was the only site to record hydrocarbons in the outflow during wet conditions (none were detected in dry conditions). It was also the only site to record antimony, and had the highest reading for arsenic, both of which are used in car batteries. It was one of only two outfalls to have traces of fluoride (note: the town does not fluoridate its drinking water).

<u>Picnic Kiosk</u> Site SCE-21MB

Location: 45°11'32"N 67°16'39"W

This outfall discharges stormwater from approximately 4km of collector pipes that extend as far as 1 km inland, toward the elementary school.

Like Chocolate Park, this site had very high bacteria results in dry weather (22,000 MPN/100ml for *E. coli* and 73,000MPN/100ml for total coliform). Similarly, its large drainage area makes it difficult to locate and correct bacterial sources. However, given the high public use this location will soon receive due to the new Civic Centre and hotel complex, the Town could consider early steps to address the issue.

This was the second site to show traces of fluoride in its discharge. Results also indicated low levels of some hydrocarbons and moderate level of arsenic under dry conditions and toluene under wet conditions – all of these potentially due to road runoff.

<u>Seniors Apartment Building</u> Site SCE-28B

Location: 45°11'30"N 67°15'59"W

This outfall now discharges the flow of a minor stream and small stormwater drainages that extend inland past the hospital. Most of this flow is on the surface, not culverted.

The site recorded low *E.coli* (50-120MPN/ 100ml) and moderate total coliform levels (2360-8160MPN/100ml) that could be attributed to reasonably natural levels under dry and spring runoff conditions. There do not appear to be major issues to be studied further at this location.

The site did show low levels of some hydrocarbons in dry weather and trace of toluene under wet conditions, all presumed to come from nearby roads.

Table 1. St. Croix Estuary Project bacteriological data for select St. Stephen stormwater outfalls, 2003-2013. See page 4 for information on CFU vs. MPN analyses. Test methodologies and detection limits varied from year to year (see earlier reports for details) thus comparisons between years are unreliable. Values recorded as > (greater than) exceeded the stated upper limit of the test method; those recorded as TNTC also exceeded the limit of the test method but this limit was not noted. Values noted as < (less than) fell below the stated limit of the test method. The 2003-2011 results in this table are taken from earlier SCEP reports, with some with some corrections based on a review of site locations and methodologies.

Dover Hill (Cove 1) SCE-10MB

Parameter / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. coli (CFU/100ml)	80,000	1,370	885	870	366	1,933	6,650		1,280 1,800		
E. coli (MPN/100ml)								>1700		300	230
Total coliform (CFU/100ml)	>200,000	14,450	>2,000	>20,000	>2,420	>10,000	12,350		TNTC		
Total coliform (MPN/100ml)										4,350	4,610

Riverside SCE-11B

Parameter / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. coli (CFU/100ml)						14,999	>32,000		1,320 11,600		
E. coli (MPN/100ml)								<2		2,000	50
Total coliform (CFU/100ml)						>10,000	>32,000		3,480		
Total coliform (MPN/100ml)										272,000	1,860

Chocolate Park SCE-14B

Parameter / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. coli (CFU/100ml)		53,000		>20,000	>2,420	>10,000	10,500		TNTC 1,200		
E. coli (MPN/100ml)								130		102,000	14,140
Total coliform (CFU/100ml)		560,000		>20,000	>2420	>10,000	>32,000		TNTC		
Total coliform (MPN/100ml)										517,000	>24,190

Pizza Delight/Wharf SCE-20MB

Parameter / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. coli (CFU/100ml)		42,000		52	49	2,666	3,000		18,000		
E. coli (MPN/100ml)								>1,700		1,000	>24,190
Total coliform (CFU/100ml)		42,000		1,040	>2,420	>10,000	>32,000				
Total coliform (MPN/100ml)										3,700	>24,190

Picnic Kiosk SCE-21B

Parameter / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. coli (CFU/100ml)	65,000	99,000		>20,000	>2,420	>10,000	13,900		0		
E. coli (MPN/100ml)								>1,700		22,000	990
Total coliform (CFU/100ml)	>200,000	831,000		>20,000	>2,420	>10,000	34,100		0		
Total coliform (MPN/100ml)										73,000	9,210

Seniors Apartment Building SCE-28B

Parameter / Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
E. coli (CFU/100ml)		310		296		<33	400		5		
E. coli (MPN/100ml)								79		50	170
Total coliform (CFU/100ml)		42,000		5,920		1,367	15,600				
Total coliform (MPN/100ml)										2,360	8,160

Sample collection dates and analyses:

2003-2009: Collection dates are identified in earlier St. Croix Estuary Project reports; samples analyzed by Water Metrics (2004) or St. Croix Estuary Project Inc. (other years).

2010: Collected August 13, analyzed by Environment Canada (Moncton)

2011: First sample for all except Pizza/Wharf and Seniors collected Feb. 22 or Mar. 1, analyzed by Eastern Charlotte Waterways Inc. Others collected Sept. 6, analyzed by Aztec Analytics

2012: Collected October 24, analyzed by NB Dept. Environment & Local Government

2013: Collected March 13, analyzed by NB Dept. Environment & Local Government

General outfall findings

Urban stormwater carries a wide variety of pollutants from roads, homes and business into local waterways. Bacteria are always a primary concern, and have been the major focus of SCEP monitoring in the past. Nutrients from fertilizers, wild and pet animal wastes, detergents, food wastes, sanitary sewer lines (where still connected to storm sewers) and vehicle exhaust can encourage the growth of undesirable marine plants and algae. SCEP has measured some of these nutrients on occasion.

This study continued to investigate bacterial levels, to assist the Town of St. Stephen to monitor and take steps to eliminate the remaining sanitary sewer connections to its stormwater sewer system, but it also expanded monitoring to allow a preliminary look at some of the other components of the Town's stormwater.

One of the objectives was to compare water discharges under dry weather conditions with those under wet weather conditions (immediately following a major rainfall or snowmelt), on the assumption that the latter would carry a large spike of pollutants from off the land and into the estuary. The results suggest some other conclusions.

Urban stormwater contains heavy metals such as lead, copper and zinc that can come from worn tires, brake linings, vehicle exhaust, batteries, paint and rust. It carries oils, grease and other hydrocarbons that leak from vehicles, settle to the ground from exhaust fumes or are discarded down drains by various users. It also transports salts used to de-ice winter roads. This study collected initial data that can begin to examine the presence of some of these, and a few of the findings are noted below. Stormwater also carries sediments, pesticides, herbicides and other complex, potentially harmful, compounds that were not included in this study.

Samples from the six stormwater outfalls included analyses for bacteria (*E. coli* and total coliform) and for the DELG multi-parameter *B inorganic package on two occasions – dry weather, low flow conditions and wet weather, high flow conditions – offering a preliminary opportunity to compare low flow and high flow results. Samples were also collected from a St. Croix River site roughly 2.5-3.5 km upstream (Milltown boat launch) on five occasions, under both dry weather and wet weather conditions – including the heavy rainfall recorded for the outfalls – and analyzed for the same parameters, allowing some comparison to local environmental conditions.

For all test parameters, the mean (average) findings from all stormwater samples equalled or exceeded the mean values for the average river samples, in some cases by a high degree (see Table 2). The highest exceedences included indicators of salt content (sodium, chloride, magnesium, conductivity) and nutrients (nitrate, nitrate+nitrite and total Kjeldahl nitrogen) but also indicated higher levels of a number of metals (aluminum, arsenic, antimony, iron, lead, zinc). Additional sampling, and separate analyses of wet and dry condition results are warranted.

Notable differences were also found, collectively, for the stormwater outfall results between dry and wet weather conditions. The highest values for parameters related to salt content were found during dry, low flow conditions in the fall. Some examples are given in Table 3.

Table 2. For the 31 inorganic parameters included in this study (NB Dept. of Environment & Local Government Inorganic Chemistry Package *B), mean results for St. Stephen stormwater outfalls (six sites, two samples each, N=12) equalled or exceeded results for the river mainstem (one site, N=5) for all of these. The highest exceedences were for nitrate, chloride, sodium, nitrate+nitrite, total Kjeldahl nitrogen, zinc, magnesium and conductivity.

# test parameters (of 31)	7	6	6	4	5	3
% by which outfall results exceeded river results	0%	1-200%	201-600%	601-1000%	1001-1500%	>1500%

These local results support extensive studies that demonstrate that the impacts of winter road salting are felt year-round. In 2001, following a five-year study, Environment Canada considered adding road salt to the country's list of most toxic substances but instead instituted a program of voluntary practices to reduce its use. The New Hampshire Department of Environmental Services offers an excellent review of the environmental, health and economic effects of road salt use, and these are surprisingly wide-spread (see reference section).

Table 3. Comparison of mean values for select parameters related to salt content from six St. Stephen stormwater outfalls, under dry (low flow) and heavy rainfall (high flow) conditions. Low flow samples collected October 24, 2012 after four days without rainfall; high flow samples collected March 13, immediately following a 53mm rainfall and heavy snowmelt. See Appendix 1 for detailed results and Appendix 4 for a description of the parameters.

Parameter	Alkalinity mg/l	Chloride mg/l	Conductivity uS/cm	Magnesium mg/l	Potassium mg/l	Sodium mg/l	Hardness mg/l
Dry mean	129.55	288.70	1232.7	20.52	7.77	183.30	193.62
Wet mean	47.32	122.92	538.5	5.60	3.05	65.77	84.37

Salt spread in the winter melts into its component elements, some of which are carried off directly into storm drains. But many of these find their way into nearby soils or groundwater, are absorbed by vegetation or are temporarily captured in crevices in pavement and drainpipes, where they slowly leach out and make their way into local watercourses. More study would be needed to determine whether the high chemical levels in the low flows that occur for most of the year, or the low chemical levels carried in the infrequent high flows, have more of an impact on the river and estuary, and what the total year-round effects are.

Nutrients and metals did not show as clear a trend based on wet or dry weather conditions. The variations in these appeared to be more related to site-specific or seasonal conditions.

Table 4. Comparison of mean values for select parameters for metals and nutrients from six St. Stephen stormwater outfalls, under dry (low flow) and heavy rainfall (high flow) conditions. Low flow samples collected October 24, 2012 after four days without rainfall; high flow samples collected March 13, immediately following a 53mm rainfall and heavy snowmelt. See Appendix 1 for detailed results and Appendix 4 for a description of the parameters.

Parameter	Aluminum ug/l	Lead ug/l	Arsenic ug/l	Copper ug/l	Nitrogen (Total Kjeldahl) mg/l	Phosphorus (Total) mg/l
Dry mean	0.080	0.23	2.08	0.0300	1.32	0.013
Wet mean	0.500	4.60	1.08	0.0100	0.09	0.09

Recommendations

1. Discontinue testing at Site SCE-28B (Seniors Apartment Building), as no significant issues remain at this outfall.

2. Continue monitoring for bacteria, inorganics and hydrocarbons at the remaining five sites in the coming year, under the same protocols, to extend the working database begun under this project, with the following special considerations:

3. Consider the results at the Cove at Dover Hill (SCE-10MB) as a benchmark for the other four sites, all of which have notable issues. Conduct additional bacteria testing on the lower 300m of the stream that empties into this outfall, to try to confirm whether it is the source of the *E. coli* and total coliform bacteria at this site.

4. Accompany sampling at Riverside (SCE-11MB) with a field survey, and possibly additional bacterial sampling, to see if an obvious source of its high total coliform numbers can be identified.

5. Encourage the Town of St. Stephen to begin steps to progressively identify and eliminate the sources of very high *E. coli* and total coliforms at the three sites in the downtown core: Chocolate Park (SCE-14MB), Pizza Delight/Wharf (SCE-20MB) and the Picnic Kiosk (SCE-21MB). These outfalls could pose a public health risk as they are adjacent to the municipal boat launch, municipal wharf and new civic centre, respectively. Additional testing and studies may be needed to assist the Town to address these outfalls.

6. Consider a future, more in-depth, evaluation of the extent and effects of year-round road salt runoff to the waterfront, with early suggestions on how to reduce these.

Streams

Five rivers and streams that discharge to the St. Croix estuary area were included in this project. Sampling was conducted at sites, and by methods, previously used for Department of Environment & Local Government (DELG) surveys and so could both contribute to, and draw from, DELG's on-going environmental database.

Two sites – the St. Croix River at Milltown and the Digdeguash River – are longterm DELG sampling locations. The other three sites – at Dennis Stream, Gallop Stream and Waweig River – were established by the St. Croix International Waterway Commission in 1999 for provincial water classification assessments. Of these, the St. Croix River site is the most urbanized: outfalls from a municipality, pulp mill, nearby roadways and other development lie upstream. It represents the estuary's largest freshwater input and, as noted earlier, supplies river baseline data for the stormwater outfall study. The Dennis Stream site also experiences some urban impacts, largely from commercial shopping areas and municipal stormwater outfalls roughly 3km upstream. The remaining three watercourses are largely rural, with occasional influences from residential, forestry and/or agricultural sources. Further information on these sampling stations is given in Table 5.

Table 5. 2012-2013 St. Croix Estuary Project freshwater sampling stations. Longitudes and Latitudes are noted in NAD 83 format.

Station Code	Location	Latitude N	Longitude W
00AR0092	St. Croix River, at Milltown boat launch	45°19'3474''	67°25'8322"
SC-DEN 1	Dennis Stream, above axe factory	45°10'190''	67°17'930"
SC-GALL1	Gallop Stream, above Lilly Hill bridge	45°23'8321"	67°19'0065"
SC-WAW1	Waweig River, above 1406 Route 127	45°13'720"	67°08'260"
00AR0021	Digdeguash River, at Stillwater Road	45°12'191"	66°57'258"

Each site was sampled on six occasions between October 24, 2012 and March 25, 2013. The March 13-14, 2013 sample recorded spring runoff conditions, following a 53mm rainfall and heavy snowmelt. The October 24, 2012 sample occurred four days after a 66mm rainfall, still capturing relatively high flow conditions in the streams, although flows had by then dropped to low in the stormwater outfalls. The other three samples were collected in winter river conditions under lower flows.

While limited analyses have been performed, some trends were observed and warrant further review after additional samples are collected.

The St. Croix River at Milltown and Dennis Stream had higher values for a number of development-related parameters than the three rural streams. This was particularly true for the St. Croix River site, which had the highest mean values for 19 of the 31 parameters in the provincial *B inorganic analysis package. Dennis Stream had higher readings than the three rural streams for nine parameters, significantly so for six (chloride, conductivity, magnesium, potassium, sodium and zinc) that are commonly associated with road salt.

Early spring runoff carries away, in a very short time, pollutants that have accumulated in snow banks throughout the winter, along with dead vegetation and other natural debris that has accumulated along frozen shorelines. Studies show that this sudden release of stored pollutants and natural debris can have significant longterm effects.

One of the most common is "spring acid shock": a short-lived but often dramatic drop in pH. Power plants, factories and vehicles emit significant amounts of sulfur dioxide and nitrogen oxides that can be carried long distances on air currents until they come into contact with water – rain, fog, snow or surface water –and react to form sulphuric and nitric acid.

These acids and other chemicals that are stored in winter snows can be released into rivers and streams suddenly, and in quantity, on a major snowmelt. This short-term high acidity (low pH) also releases heavy metals – including aluminum – from soils and other sources that are quickly carried into local waterways where they have negative impacts on many aquatic species. It also interferes with the ability of fish, amphibians and other aquatic life forms to hatch, grow and take in the oxygen and nutrients they need to survive.

The five freshwater sites in this study were sampled shortly following a 53mm rainfall and major snowmelt on March 12-13, 2013, seeking to capture information on spring runoff impacts to the St. Croix estuary area's major freshwater tributaries and, ultimately, the estuary area itself. These samples found no significant change in pH (see Table 6), however it could be that:

a) Spring acid shock doesn't typically occur on these St. Croix waterways, possibly due to buffering by local soil and forest conditions that counteract it (see Selected references), or
b) 2013 was an atypical year when spring runoff pollution "spikes" were spread over a wider range of conditions, or
c) The samples collected were just hours or days away from the current year's peak "acid shock" conditions.

Table 6. Comparison of mean values for select parameters from samples taken at five St. Croix area streams and rivers under high flow, spring snowmelt conditions vs. other conditions. Snowmelt samples collected March 13-14, 2013, following a 53mm rainfall and snowmelt; other samples collected on four occasions between October 24, 2012 and March 25, 2013. See Appendix 2 for detailed results and Appendix 4 for a description of the parameters.

Parameter	pH	Aluminum ug/l	Manganese mg/l	Phosphorus (Total) mg/l
Mean – all streams, spring snowmelt	6.54	0.312	0.086	0.020
Mean – all streams, other conditions	6.95	0.081	0.023	0.009

The collected samples suggest that bacterial pollution is not a significant issue at any of these freshwater discharges to the estuary: the majority recorded few or no *E. coli* bacteria and those that did (primarily during the March 13-14 spring runoff event) were all well below Canada's contact recreation guideline, with one exception: a single high count of 500MPN/100ml at the St. Croix River Milltown site on March 13, with much natural sediment and debris floating downriver on the freshet.

Recommendations

1. Collect additional wide-spectrum data (DENV *B inorganic parameters) for St. Croix area freshwater discharges, to support better analyses and planning about current development impacts (St. Croix River and Dennis Stream), future development (all streams) and the potential longterm effects of these outflows on St. Croix coastal waters.
2. If possible, collect continuous pH and select other data at some or all of these sites to determine whether spring runoff (or select other temporary conditions) has limiting effects on freshwater species, and potentially on the estuary area's marine species.
3. Carry out more thorough analyses of all of the collected data, to gain better insight into the likely interactions of human activities, climate change and local water ecosystems, toward trying to better manage these into the future.

Estuary wharf sites

Preliminary data was collected at three wharves along the St. Croix estuary – St. Stephen (upper estuary), Bayside (mid estuary) and St. Andrews (lower estuary) – to establish a baseline for future freshwater/estuarine and climate change studies. Temperature, pH, conductivity, salinity and dissolved oxygen were recorded at one meter depth intervals at all three wharves on the same five days that the freshwater streams were sampled.

The St. Andrews wharf profiles showed this to be a fully marine site, with water mixing from surface to bottom: all parameters gave relatively consistent profile readings on all occasions.

The Bayside wharf showed some freshwater influence (lower salinity) at the surface and less vertical water turnover (lower dissolved oxygen) at lower depths. Only a partial depth profile could be obtained at this site: the cable on the sampling meter was not long enough to reach the bottom.

The St. Stephen wharf is a clear example of a 'salt wedge' estuary site: here the less-dense freshwater from the St. Croix River floats cleanly in a layer on top of the denser saltwater from Passamaquoddy Bay, before these have the chance to mix. Appendix 3c details this layering.

Climate change is causing more frequent extreme rainfalls: when the deluge of water from these reaches the coast, it temporarily dilutes the saltwater and affects marine species that cannot tolerate low salinity. Climate change is also making ocean waters more acidic (carbon dioxide from human activities – the major cause of climate change – combines with seawater to form carbonic acid), and this too affects the marine ecosystem. Freshwater runoff from acidic spring snowmelts can contribute to this. Measuring and adapting to these changes will rely, in part, on knowing the nature of the estuary before these occur.

Recommendations

1. Continue to collect data at the three estuary wharf sites to provide a baseline to assess the emerging, climate-change driven, effects of freshwater discharges on the marine ecosystem.

Appendix 1. Stormwater outfall field and laboratory results, St. Croix Estuary Project, 2012-2013. At April 5, 2013

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	Water Temp as C	Dissolved Oxygen mg/l	Alk-G mg/l as CaCO3	Al ug/l as Al	Sb ug/l as Sb	As ug/l as As	Cd ug/l as Cd	Ca-D ug/l as Ca	Cl mg/l as Cl-	Cr ug/l as Cr	Color as color units
SCE-10MB	2012/10/24	1337	160040-211213204	941200800	8.5	11.50	33.50	0.088	L 0	L 0	L 0	16.40	75.40	0.0014	Q 48.9
(Cove)	2013/03/13	1651	164147-201301443	941300006	0.6	16.21	12.20	0.490	L 0	L 0	L 0	6.56	40.00	0.0011	Q 168
SCE-11B	2012/10/24	1353	160039-201213199	941200801	11.5	9.43	97.80	0.045	L 0	L 0	L 0	30.90	80.60	0.0050	Q 55.8
(Riverside)	2013/03/13	1713	164147-201301444	941300007	2.2	13.90	51.80	0.180	L 0	L 0	L 0	21.40	117.00	0.0023	Q 51.1
SCE-14MB	2012/10/24	1412	160039-201213200	941200802	14.2	8.22	152.00	0.120	L 0	1.4	L 0	67.00	244.00	0.0085	Q 107
(Choc Park)	2013/03/13	1740	164147-201301445	941300008	3.8	13.47	60.50	0.580	L 0	1.5	L 0	33.10	142.00	0.0040	Q 186
SCE-20B	2012/10/24	1430	160039-201213201	941200803	13.0	7.64	228.00	0.096	1.5	6.3	L 0	65.20	839.00	0.0120	Q 89.6
(Pizza/Wharf)	2013/03/13	1755	164147-201301446	941300009	4.0	12.91	54.60	0.640	L 0	2.1	0.1	27.40	92.50	0.0034	Q 212
SCE-21B	2012/10/24	1450	160039-201213202	941200804	13.7	7.23	142.00	0.130	L 0	3.6	L 0	44.10	402.00	0.0083	Q 78.6
(Kiosk)	2013/03/13	1810	164147-201301447	941300010	3.6	13.00	59.40	0.650	L 0	1.9	L 0	29.20	226.00	0.0036	Q 248
SCE-28B	2012/10/24	1535	160039-201213203	941200805	10.6	9.90	124.00	0.025	L 0	1.2	L 0	39.00	91.20	0.0066	Q 29.4
(Seniors)	2013/03/13	1840	164147-201301448	941300011	2.7	13.3	45.40	0.470	L 0	1	L 0	29.60	120.00	0.0025	Q 154

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	Cond as uS/cm	Cu ug/l as Cu	F mg/l as F	Fe mg/l as Fe	Pb ug/l as Pb	Mg-D mg/l as Mg	Mn mg/l as Mn	Ni mg/l as Ni	NO3 mg/l as N	NOx mg/l as N
SCE-10MB	2012/10/24	1337	160040-211213204	941200800	337.0	0.0024	L 0	0.156	L 0	4.80	0.020	L 0	0.1	0.15
(Cove)	2013/03/13	1651	164147-201301443	941300006	181.0	0.0027	L 0	0.528	1.7	1.68	0.098	L 0	0.13	0.18
SCE-11B	2012/10/24	1353	160039-201213199	941200801	487.0	0.0310	L 0	0.086	L 0	7.34	0.019	L 0	0.44	0.49
(Riverside)	2013/03/13	1713	164147-201301444	941300007	525.0	0.0027	L 0	0.174	1.3	4.47	0.038	L 0	0.47	0.52
SCE-14MB	2012/10/24	1412	160039-201213200	941200802	1140.0	0.0720	L 0	0.240	L 0	18.00	0.053	L 0	1.6	1.7
(Choc Park)	2013/03/13	1740	164147-201301445	941300008	635.0	0.0073	L 0	0.636	1.7	5.67	0.055	L 0	1.1	1.1
SCE-20B	2012/10/24	1430	160039-201213201	941200803	3220.0	0.0110	0.181	1.480	1.4	55.00	0.680	L 0	0.5	0.56
(Pizza/Wharf)	2013/03/13	1755	164147-201301446	941300009	459.0	0.0220	L 0	0.750	20	4.57	0.079	L 0	1.1	1.1
SCE-21B	2012/10/24	1450	160039-201213202	941200804	1640.0	0.0320	0.159	1.150	L 0	30.60	1.100	L 0	0.51	0.56
(Kiosk)	2013/03/13	1810	164147-201301447	941300010	925.0	0.0062	L 0	0.842	1.8	12.60	0.150	L 0	0.55	0.6
SCE-28B	2012/10/24	1535	160039-201213203	941200805	572.0	0.0048	L 0	0.353	L 0	7.38	0.260	L 0	0.16	0.21
(Seniors)	2013/03/13	1840	164147-201301448	941300011	506.0	0.0037	L 0	0.605	1.1	4.58	0.290	L 0	0.29	0.34

Appendix 1 (cont). Stormwater outfall field and laboratory results, St. Croix Estuary Project, 2012-2013.

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	NO2 mg/l as N	pH	K mg/l as K	Na mg/l as Na	SO4 mg/l as SO4	TOC mg/l as C	TP-L mg/l as P	NH3 T mg/l as N	HARD mg/l as CaCO3	TKN mg/l as N	Turb as NTU
SCE-10MB	2012/10/24	1337	160040-211213204	941200800	L 0	7.76	1.20	43.10	10.60	5.9	0.011	0.011	60.70	L 0	1.5
(Cove)	2013/03/13	1651	164147-201301443	941300006	L 0	7.32	1.10	23.90	3.60	6.5	0.024	0.030	23.30	0.3	17.0
SCE-11B	2012/10/24	1353	160039-201213199	941200801	L 0	7.71	3.30	55.70	12.30	8	0.095	0.118	107.00	1.2	2.1
(Riverside)	2013/03/13	1713	164147-201301444	941300007	L 0	7.84	2.40	66.10	8.12	4.4	0.035	0.020	71.80	0.6	4.4
SCE-14MB	2012/10/24	1412	160039-201213200	941200802	0.06	7.92	5.90	198.00	22.60	10.5	0.390	0.540	241.00	4.0	6.3
(Choc Park)	2013/03/13	1740	164147-201301445	941300008	L 0	7.86	3.20	73.80	8.48	8.1	0.094	0.101	106.00	1.2	21.0
SCE-20B	2012/10/24	1430	160039-201213201	941200803	0.06	8.02	22.00	498.00	95.70	8	0.140	0.510	389.00	1.2	7.2
(Pizza/Wharf)	2013/03/13	1755	164147-201301446	941300009	L 0	7.73	3.60	53.40	10.20	6.7	0.250	0.420	87.30	1.9	30.0
SCE-21B	2012/10/24	1450	160039-201213202	941200804	L 0	7.71	12.00	238.00	59.10	11.6	0.140	0.240	236.00	1.2	5.0
(Kiosk)	2013/03/13	1810	164147-201301447	941300010	L 0	7.84	5.30	120.00	27.70	6	0.065	0.071	125.00	0.8	25.0
SCE-28B	2012/10/24	1535	160039-201213203	941200805	L 0	8.01	2.20	67.00	13.40	6.5	0.010	0.013	128.00	0.3	2.3
(Seniors)	2013/03/13	1840	164147-201301448	941300011	L 0	7.72	2.70	57.40	5.89	6.4	0.043	0.118	92.80	0.6	13.0

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	ZN mg/l as Zn	Total Coliform as MPN/100ml	E. coli as MPN/100ml	Benzene as mg/l	Toluene as mg/l	Ethyl-benzene as mg/l	Total Xylenes as mg/l	C6-C10 hydrocarbons mg/l
SCE-10MB	2012/10/24	1337	160040-211213204	941200800	L 0	4350	300	N 0	N 0	N 0	N 0	N 0
(Cove)	2013/03/13	1651	164147-201301443	941300006	0.005	4610	230	N 0	L 0	N 0	N 0	N 0
SCE-11B	2012/10/24	1353	160039-201213199	941200801	0.011	272000	2000	N 0	N 0	N 0	N 0	N 0
(Riverside)	2013/03/13	1713	164147-201301444	941300007	0.006	1860	50	N 0	N 0	N 0	N 0	N 0
SCE-14MB	2012/10/24	1412	160039-201213200	941200802	0.019	517000	102000	N 0	N 0	N 0	N 0	L 0
(Choc Park)	2013/03/13	1740	164147-201301445	941300008	0.019	>24190	14140	N 0	N 0	N 0	N 0	N 0
SCE-20B	2012/10/24	1430	160039-201213201	941200803	0.01	37000	1000	N 0	N 0	N 0	N 0	L 0
(Pizza/Wharf)	2013/03/13	1755	164147-201301446	941300009	0.03	>24190	>24190	N 0	4E-04	N 0	N 0	L 0
SCE-21B	2012/10/24	1450	160039-201213202	941200804	0.063	73000	22000	N 0	N 0	N 0	N 0	N 0
(Kiosk)	2013/03/13	1810	164147-201301447	941300010	0.019	9210	990	N 0	5E-04	N 0	L 0	L 0
SCE-28B	2012/10/24	1535	160039-201213203	941200805	L 0	2360	50	N 0	N 0	N 0	N 0	N 0
(Seniors)	2013/03/13	1840	164147-201301448	941300011	0.008	8160	170	N 0	4E-04	N 0	L 0	L 0

Appendix 1 (cont). Stormwater outfall field and laboratory results, St. Croix Estuary Project, 2012-2013.

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	>C10-C16 hydrocarbons mg/l	>C16-C21 hydrocarbons mg/l	>C21-<C32 hydrocarbons mg/l	Modified TPH mg/l	Other Field data: Air Temp (C)	Weather	Rain last 24 hrs, mm
SCE-10MB	2012/10/24	1337	160040-211213204	941200800	L 0	0.029	0.043	0.072	13.0	sun	0
(Cove)	2013/03/13	1651	164147-201301443	941300006	N 0	N 0	N 0	N 0	7.6	overcast, mist	53
SCE-11B	2012/10/24	1353	160039-201213199	941200801	L 0	0.029	0.043	0.072	13.4	sun	0
(Riverside)	2013/03/13	1713	164147-201301444	941300007	L 0	L 0	N 0	L 0	7.9	overcast, mist	53
SCE-14MB	2012/10/24	1412	160039-201213200	941200802	0.029	0.18	0.38	0.59	13.6	sun	0
(Choc Park)	2013/03/13	1740	164147-201301445	941300008	L 0	L 0	L 0	L 0	6.6	overcast, mist	53
SCE-20B	2012/10/24	1430	160039-201213201	941200803	N 0	L 0	L 0	L 0	13.0	sun	0
(Pizza/Wharf)	2013/03/13	1755	164147-201301446	941300009	0.02	0.051	0.094	0.17	6.7	overcast, mist	53
SCE-21B	2012/10/24	1450	160039-201213202	941200804	0.018	0.083	0.13	0.23	15.4	sun	
(Kiosk)	2013/03/13	1810	164147-201301447	941300010	L 0	L 0	L 0	L 0	5.6	overcast, mist	53
SCE-28B	2012/10/24	1535	160039-201213203	941200805	L 0	L 0	0.048	0.048	16.8	sun	
(Seniors)	2013/03/13	1840	164147-201301448	941300011	L 0	L 0	N 0	L 0	5.6	overcast, mist	53

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	Other Field Data: Observations
SCE-10MB	2012/10/24	1337	160040-211213204	941200800	Low flow
(Cove)	2013/03/13	1651	164147-201301443	941300006	High flow. Water clear, cold
SCE-11B	2012/10/24	1353	160039-201213199	941200801	Low flow
(Riverside)	2013/03/13	1713	164147-201301444	941300007	Moderate flow. Water clear
SCE-14MB	2012/10/24	1412	160039-201213200	941200802	Low flow
(Choc Park)	2013/03/13	1740	164147-201301445	941300008	Moderate flow. Water cloudy, some odour
SCE-20B	2012/10/24	1430	160039-201213201	941200803	Low flow
(Pizza/Wharf)	2013/03/13	1755	164147-201301446	941300009	Low-moderate flow. Water very cloudy
SCE-21B	2012/10/24	1450	160039-201213202	941200804	Low flow
(Kiosk)	2013/03/13	1810	164147-201301447	941300010	Moderate flow. Water cloudy.
SCE-28B	2012/10/24	1535	160039-201213203	941200805	Low flow
(Seniors)	2013/03/13	1840	164147-201301448	941300011	Moderate flow. Water clear. Bank erosion

Appendix 2. Stream field and laboratory results, St. Croix Estuary Project, 2012-2013. At April 5, 2013

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	Water Temp as C	Dissolved Oxygen mg/l	Alk-G mg/l as CaCO3	Al ug/l as Al	Sb ug/l as Sb	As ug/l as As	Cd ug/l as Cd	Ca-D ug/l as Ca	Cl mg/l as Cl-	Cr ug/l as Cr	Color as color units
00AR0092	2012/10/24	1312	160040-211213204	941200806	10.6	9.22	9.80	0.018	L 0	L 0	L 0	4.91	4.36	0.0010	Q 133
(Milltown launch)	2012/12/04	1424	161585-201214500	941200811	1.6	13.39	13.70	0.160	L 0	L 0	L 0	6.25	8.63	0.0010	Q 104
	2013/02/27	1315	163730-201301098	94130001	1.2	13.92	12.50	0.110	L 0	L 0	L 0	4.73	5.62	0.0008	Q 69.6
	2013/03/13	1628	164147-201301449	941300012	1.8	13.92	11.40	0.550	L 0	1.1	L 0	5.30	17.60	0.0013	Q 219
	2013/03/25	1235	164462-201301711	941300019	2.4	13.82	10.60	0.100	L 0	L 0	L 0	5.23	11.90	L 0.0000	Q 70.3
SC-DEN 1	2012/10/24	1245	160040-201213205	941200807	9.6	12.56	9.35	0.210	L 0	L 0	L 0	3.60	4.41	L 0.0005	Q 160
(Dennis)	2012/12/04	1410	161585-201214501	941200812	1.3	14.50	8.73	0.150	L 0	L 0	L 0	4.62	6.86	0.0006	Q 104
	2013/02/27	1335	163730-201301099	94130002	0.2	15.10	11.10	0.140	L 0	L 0	L 0	5.27	13.40	0.0010	Q 81.8
	2013/03/14	1250	164182-201301467	941300013	0.5	14.79	5.24	0.260	L 0	L 0	L 0	2.93	9.60	L 0.0000	Q 92.9
	2013/03/25	1254	164462-201301712	941300020	1.4	15.36	7.34	0.120	L 0	L 0	L 0	3.93	11.80	L 0.0000	Q 81.3
SC-GALL 1	2012/10/24	1616	1600040-201213206	941200808	8.6	11.46	3.30	0.180	L 0	L 0	L 0	2.74	2.14	L 0.0005	Q 94
(Gallop)	2012/12/04	1512	161585-201214502	941200813	1.2	14.59	4.48	0.110	L 0	L 0	L 0	3.05	3.13	L 0.0000	Q 56.3
	2013/02/27	1400	163730-201301100	94130003	0.3	15.38	5.15	0.088	L 0	L 0	L 0	3.37	5.50	0.0000	Q 46.5
	2013/03/14	1350	164182-201301468	941300014	0.4	14.92	2.12	0.280	L 0	L 0	L 0	1.68	2.81	L 0.0000	Q 82.3
	2013/03/25	1320	164462-201301713	941300021	1.7	14.78	3.83	0.082	L 0	L 0	L 0	2.78	4.50	L 0.0000	Q 47.7
SC-WAW 1	2012/10/24	1641	160040-201213207	941200809	8.0	11.57	5.10	0.220	L 0	L 0	L 0	3.00	3.08	L 0.0005	Q 94.2
(Waweig)	2012/12/04	1530	161585-201214503	941200814	0.2	15.15	5.76	0.140	L 0	L 0	L 0	3.58	4.43	L 0.0005	Q 56.1
	2013/02/27	1425	163730-201301101	94130004	0.2	15.28	7.26	0.100	L 0	L 0	L 0	3.57	5.47	0.0007	Q 41.6
	2013/03/14	1425	164182-201301469	941300015	0.3	14.69	2.91	0.260	L 0	L 0	L 0	1.94	3.29	L 0.0000	Q 79.2
	2013/03/25	1350	164462-201301714	941300022	0.7	15.35	5.92	0.098	L 0	L 0	L 0	3.12	5.22	L 0.0000	Q 43.0
00AR0021	2012/10/24	1714	160040-201213208	941200810	8.5	10.81	6.77	0.200	L 0	L 0	L 0	4.24	2.50	L 0.0000	Q 154.0
(Digdeguash)	2012/12/04	1400	161585-201214504	941200815	0.3	14.44	9.07	0.120	L 0	L 0	L 0	4.50	3.56	L 0.0005	Q 74.1
	2013/02/27	1500	163730-201301102	94130005	0.5	14.35	11.10	0.100	L 0	L 0	L 0	5.47	4.31	0.0009	Q 64.8
	2013/03/14	1535	164182-201301470	941300016	0.4	14.35	3.24	0.210	L 0	L 0	L 0	1.85	2.97	L 0.0000	Q 84.4
	2013/03/25	1428	164462-201301715	941300023	1.1	14.84	8.88	0.100	L 0	L 0	L 0	4.16	3.64	L 0.0000	Q 73.0

Appendix 2 (cont). Stream field and laboratory results, St. Croix Estuary Project, 2012-2013.

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	Cond as uS/cm	Cu ug/l as Cu	F mg/l as F	Fe mg/l as Fe	Pb ug/l as Pb	Mg-D mg/l as Mg	Mn mg/l as Mn	Ni mg/l as Ni	NO3 mg/l as N	NOx mg/l as N	NO2 mg/l as N
00AR0092	2012/10/24	1312	160040-211213204	941200806	48.7	0.0007	L 0	0.319	L 0.000	0.97	0.030	L 0	L 0	L 0	L 0
(Milltown launch)	2012/12/04	1424	161585-201214500	941200811	84.7	L 0.0000	L 0	0.239	L 0.000	1.10	0.054	L 0	L 0	L 0	L 0
	2013/02/27	1315	163730-201301098	94130001	61.1	L 0.0000	L 0	0.163	L 0.000	0.85	0.032	L 0	L 0	0.05	L 0
	2013/03/13	1628	164147-201301449	941300012	90.8	0.0019	L 0	0.648	L 0.000	1.14	0.130	L 0	0.05	0.1	L 0
	2013/03/25	1235	164462-201301711	941300019	79.5	0.0005	L 0	0.158	2.600	1.00	0.034	L 0	L 0	0.06	L 0
SC-DEN 1	2012/10/24	1245	160040-201213205	941200807	43.9	0.0007	L 0	0.319	L 0.000	0.75	0.030	L 0	L 0	L 0	L 0
(Dennis)	2012/12/04	1410	161585-201214501	941200812	52.4	0.0006	L 0	0.305	L 0.000	1.08	0.035	L 0	L 0	0.06	L 0
	2013/02/27	1335	163730-201301099	94130002	78.4	0.0007	L 0	0.241	L 0.000	1.20	0.030	L 0	0.08	0.13	L 0
	2013/03/14	1250	164182-201301467	941300013	49.2	0.0008	L 0	0.361	L 0.000	0.75	0.082	L 0	L 0	0.08	L 0
	2013/03/25	1254	164462-201301712	941300020	65.5	0.0005	L 0	0.186	L 0.000	0.95	0.024	L 0	L 0	0.08	L 0
SC-GALL 1	2012/10/24	1616	1600040-201213206	941200808	27.3	0.0009	L 0	0.217	L 0.000	0.49	0.025	L 0	L 0	L 0	L 0
(Gallop)	2012/12/04	1512	161585-201214502	941200813	33.2	0.0060	L 0	0.225	L 0.000	0.63	0.026	L 0	L 0	0.07	L 0
	2013/02/27	1400	163730-201301100	94130003	43.9	L 0.0000	L 0	0.165	L 0.000	0.62	0.018	L 0	0.08	0.13	L 0
	2013/03/14	1350	164182-201301468	941300014	20.5	0.0007	L 0	0.367	L 0.000	0.37	0.100	L 0	L 0	L 0	L 0
	2013/03/25	1320	164462-201301713	941300021	37.0	L 0.0000	L 0	0.116	L 0.000	0.52	0.012	L 0	L 0	0.09	L 0
SC-WAW 1	2012/10/24	1641	160040-201213207	941200809	32.4	0.0007	L 0	0.244	L 0.000	0.61	0.016	L 0	L 0	L 0	L 0
(Waweig)	2012/12/04	1530	161585-201214503	941200814	39.1	L 0.0000	L 0	0.226	L 0.000	0.75	0.018	L 0	0.1	0.15	L 0
	2013/02/27	1425	163730-201301101	94130004	45.8	0.0005	L 0	0.151	L 0.000	0.72	0.010	L 0	0.13	0.18	L 0
	2013/03/14	1425	164182-201301469	941300015	22.4	0.0007	L 0	0.237	L 0.000	0.41	0.053	L 0	L 0	0.1	L 0
	2013/03/25	1350	164462-201301714	941300022	41.8	L 0.0000	L 0	0.116	L 0.000	0.64	0.009	L 0	0.12	0.17	L 0
00AR0021	2012/10/24	1714	160040-201213208	941200810	33.0	L 0.0006	L 0	0.297	L 0.000	0.74	0.018	L 0	L 0	L 0	L 0
(Digdeguash)	2012/12/04	1400	161585-201214504	941200815	40.6	L 0.0000	L 0	0.233	L 0.000	0.82	0.020	L 0	L 0	0.09	L 0
	2013/02/27	1500	163730-201301102	94130005	47.9	0.0007	L 0	0.181	L 0.000	0.89	0.018	L 0	0.1	0.15	L 0
	2013/03/14	1535	164182-201301470	941300016	21.5	0.0009	L 0	0.266	L 0.000	0.41	0.067	L 0	L 0	0.09	L 0
	2013/03/25	1428	164462-201301715	941300023	41.7	L 0.0000	L 0	0.160	L 0.000	0.72	0.017	L 0	0.07	0.12	L 0

Appendix 2. Stream field and laboratory results, St. Croix Estuary Project, 2012-2013.

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #	pH	K mg/l as K	Na mg/l as Na	SO4 mg/l as SO4	TOC mg/l as C	TP-L mg/l as P	NH3 T mg/l as N	HARD mg/l as CaCO3	TKN mg/l as N	Turb as NTU	ZN mg/l as Zn
00AR0092	2012/10/24	1312	160040-211213204	941200806	6.96	0.59	3.94	3.16	13.2	0.015	0.018	9.09	L 0	1.60	L 0
(Milltown launch)	2012/12/04	1424	161585-201214500	941200811	7.24	1.100	9.06	10.10	11.3	0.023	0.069	20.10	L 0	2.10	0.007
	2013/02/27	1315	163730-201301098	94130001	7.02	0.620	5.61	5.37	8.6	0.006	0.024	15.30	L 0	1.10	L 0
	2013/03/13	1628	164147-201301449	941300012	7.11	0.930	9.56	3.47	7.1	0.020	0.120	17.90	0.4	21.00	0.006
	2013/03/25	1235	164462-201301711	941300019	7.14	0.580	6.98	5.47	8.4	0.011	0.029	17.20	L 0	1.00	L 0
SC-DEN 1	2012/10/24	1245	160040-201213205	941200807	7.20	0.320	3.39	1.90	14.5	0.011	0.017	12.00	0.3	1.30	L 0
(Dennis)	2012/12/04	1410	161585-201214501	941200812	7.11	0.340	4.92	3.45	9.4	0.008	0.023	16.00	L 0	1.60	L 0
	2013/02/27	1335	163730-201301099	94130002	7.03	0.35	7.82	3.43	7.5	0.005	0.027	18.10	L 0	1.40	L 0
	2013/03/14	1250	164182-201301467	941300013	6.74	0.40	5.31	2.35	7.2	0.015	0.012	10.40	L 0	0.50	L 0
	2013/03/25	1254	164462-201301712	941300020	7.03	0.32	6.81	2.89	7.7	0.009	0.014	13.70	L 0	1.30	L 0
SC-GALL 1	2012/10/24	1616	1600040-201213206	941200808	6.59	0.29	2.01	3.07	9.8	0.007	0.013	8.87	L 0	0.41	L 0
(Gallop)	2012/12/04	1512	161585-201214502	941200813	6.86	0.26	2.59	3.99	6.3	0.007	0.013	10.20	L 0	0.79	0.009
	2013/02/27	1400	163730-201301100	94130003	6.77	0.28	3.61	3.93	4.8	0.003	0.014	11.00	L 0	0.63	L 0
	2013/03/14	1350	164182-201301468	941300014	6.19	0.33	1.90	2.03	8.0	0.018	0.010	5.73	L 0	2.00	L 0
	2013/03/25	1320	164462-201301713	941300021	6.74	0.28	3.04	3.69	5.1	0.008	L 0.000	9.08	L 0	0.49	L 0
SC-WAW 1	2012/10/24	1641	160040-201213207	941200809	6.78	0.35	2.53	2.25	11.0	0.008	0.013	9.99	L 0	0.55	L 0
(Waweig)	2012/12/04	1530	161585-201214503	941200814	7.00	0.37	3.09	3.04	7.1	0.012	0.025	12.00	0.3	1.20	L 0
	2013/02/27	1425	163730-201301101	94130004	6.86	0.35	3.68	3.22	5.0	0.005	0.017	11.90	L 0	0.66	L 0
	2013/03/14	1425	164182-201301469	941300015	6.31	0.38	2.16	1.60	8.0	0.018	0.012	6.54	L 0	1.90	L 0
	2013/03/25	1350	164462-201301714	941300022	6.91	0.31	3.53	3.04	5.2	0.008	L 0.000	10.40	L 0	0.58	L 0
00AR0021	2012/10/24	1714	160040-201213208	941200810	6.73	0.29	2.02	1.88	16.3	0.009	0.015	13.60	0.3	0.90	L 0
(Digdeguash)	2012/12/04	1400	161585-201214504	941200815	7.11	0.23	2.80	2.54	8.2	0.009	0.023	14.60	L 0	1.20	L 0
	2013/02/27	1500	163730-201301102	94130005	6.93	0.23	3.09	2.75	7.6	0.005	0.022	17.30	0.3	0.69	L 0
	2013/03/14	1535	164182-201301470	941300016	6.37	0.30	1.94	1.32	8.3	0.016	0.021	6.29	L 0	2.50	L 0
	2013/03/25	1428	164462-201301715	941300023	7.07	0.22	2.69	2.45	8.2	0.008	0.017	13.40	L 0	0.71	L 0

Appendix 2. Stream field and laboratory results, St. Croix Estuary Project, 2012-2013.

Values shown as zero (0) reflect no detectible presence at the limit of quantification (see test methods). L = below limit of quantification. Q = not a quality assured parameter. N = not detected . T = trace.

Station #	Date yyyy/mm/dd	Time	Lab # (Inorganic)	Field #		E. coli as MPN/100ml	Other Field data: Air Temp (C)	Weather	Rain last 24 hrs, mm	Observations
00AR0092	2012/10/24	1312	160040-211213204	941200806		30	13.5	sun	0	Mod-high flow (4670 cfs at Baring), falling. (Reflects Oct 20 rainfall, 66mm)
(Milltown launch)	2012/12/04	1424	161585-201214500	941200811			4.3	overcast	6.7	Low flow (1620 cfs at Baring). No ice
	2013/02/27	1315	163730-201301098	94130001	L	0	9.3	sun	0	Moderate-high flow (4670cfs at Baring). Ice along shore
	2013/03/13	1628	164147-201301449	941300012		500	7.4	overcast, mist	53	High flow (6230cfs), rising. Water tan-coloured. No ice
	2013/03/25	1235	164462-201301711	941300019		20	7.1	overcast	0	Moderate flow (3170 cfs at Baring)
SC-DEN 1	2012/10/24	1245	160040-201213205	941200807		10	7.8	sun	0	V. high flow (reflects Oct 20 rainfall, 66mm)
(Dennis)	2012/12/04	1410	161585-201214501	941200812			1.8	overcast	6.7	Average-low flow
	2013/02/27	1335	163730-201301099	94130002		110	8.3	sun	0	Average flow. Ice-covered except small openings. Some color to water.
	2013/03/14	1250	164182-201301467	941300013		290	5.3	sun	15	V. high flow (Mar 12-13 rain/snowmelt 50+mm). Mostly ice-free. Water tan colour.
	2013/03/25	1254	164462-201301712	941300020		90	3.5	overcast	0	Average flow. Water clear.
SC-GALL 1	2012/10/24	1616	1600040-201213206	941200808	L	0	11.3	sun	0	Average-high flow (reflects Oct 20 rainfall, 66mm)
(Gallop)	2012/12/04	1512	161585-201214502	941200813			2	overcast	6.7	Median or less flow. Some ice forming in pockets below the site
	2013/02/27	1400	163730-201301100	94130003	L	0	9.3	sun	0	Average flow, ice covered except for small openings
	2013/03/14	1350	164182-201301468	941300014	L	0	5.2	sun	15	V. high flow (Mar 12-13 rain/snowmelt 50+mm). Water light tan colour.
	2013/03/25	1320	164462-201301713	941300021	L	0	4	overcast	0	Average flow. Some ice flows hung up along shore.
SC-WAW 1	2012/10/24	1641	160040-201213207	941200809		50	10.7	sun	0	Average-high flow (reflects Oct 20 rainfall, 66mm)
(Waweig)	2012/12/04	1530	161585-201214503	941200814			1.6	overcast	6.7	Average-low flow. Ice forming along shore and downstream
	2013/02/27	1425	163730-201301101	94130004	L	0	8	sun	0	Average-high flow. Ice-covered except for small openings
	2013/03/14	1425	164182-201301469	941300015		150	5.5	sun	10	V. high flow (Mar 12-13 rain/snowmelt 50+mm). Ice-free except at shore, hung-up floes.
	2013/03/25	1350	164462-201301714	941300022	L	0	4.3	overcast	0	Average flow. Some small ice floes (30mm dia.) still moving downstream
00AR0021	2012/10/24	1714	160040-201213208	941200810		40	9	sun	0	High flow (reflects Oct 20 rainfall, 66mm)
(Digdeguash)	2012/12/04	1400	161585-201214504	941200815			2.5	overcast	6.7	Average flow. No ice
	2013/02/27	1500	163730-201301102	94130005	L	0	4.5	sun	0	Average flow. About one-third of channel ice-free.
	2013/03/14	1535	164182-201301470	941300016		180	4.3	sun/cloud	10	V. high flow (Mar 12-13 rain/snowmelt 50+mm). Ice-free but ice floes, some debris in water
	2013/03/25	1428	164462-201301715	941300023	L	0	5.6	cloudy	0	Average flow. Water level has dropped 1.5m from Mar 14

Appendix 3a. St. Andrews Wharf data, St. Croix Estuary Project, 2012-2013.

Sample depth as M	Water Temp as C	Cond as uS/cm	Salinity as ppt	Dissolved Oxygen mg/l	pH	Total Coliform as MPN/100ml	E. coli as MPN/100ml
Date: October 24, 2012. **Time AST**: 0820. **Tide**: Upper 1/3, falling (high at 0706). **Weather**: sun. **Air temp (C)**: 1.2							
Water depth (M): 10.0 **Wind direction**: SW. **Wind speed (mph)**: 5-10 . **Rainfall last 24 hrs (mm)**: 0							
0	12.06	35120	30.26	7.57	7.86		
1	12.06	35130	30.26	7.50	8.03		
2	12.14	35250	30.30	7.46	7.78		
3	12.12	35290	30.33	7.43	7.90		
4	12.15	35290	30.32	7.41	7.83		
5	12.15	35290	30.33	7.40	7.80		
6	12.15	35320	30.35	7.36	7.81		
7	12.12	35320	30.35	7.41	7.83		
8	12.13	35320	30.31	7.34	7.78		
9	12.13	35330	30.86	7.32	7.95		
Date: December 4, 2012. **Time AST**: 1240. **Tide**: Half, rising (high at 1533). **Weather**: overcast. **Air temp (C)**: 4.2							
Water depth (M): 7.3 **Wind direction**: SW. **Wind speed (mph)**: 3-5 . **Rainfall last 24 hrs (mm)**: 6.7							
0	8.18	32790	31.20	8.44	7.85		
1	8.23	32890	31.25	8.70	7.87		
2	8.18	32810	31.22	8.81	7.91		
3	8.19	32860	31.24	8.71	7.89		
4	8.18	32840	31.25	8.75	7.88		
5	8.17	32850	31.25	8.68	7.90		
6	8.18	32870	31.27	8.71	7.87		
7	8.18	32890	31.29	8.68	7.89		
Date: February 27, 2013. **Time AST**: 1120. **Tide**: Tide near high, falling. **Weather**: sun/cloud. **Air temp (C)**: 3.8							
Water depth (M): 8.3 **Wind direction**: SW. **Wind speed (mph)**: 8-10 . **Rainfall last 24 hrs (mm)**: 10-15							
0	1.96	28150	31.76	10.80	7.72		
1	2.01	28170	31.75	10.59	7.91		
2	1.97	28220	31.82	10.03	8.06		
3	2.16	28440	31.92	10.57	7.89		
4	2.12	28410	31.82	10.63	7.67		
5	2.03	28260	31.83	10.67	7.78		
6	2.12	28380	31.85	10.66	7.75		
7	2.12	28200	31.91	10.53	7.73		
8	2.10	28370	31.89	10.68	7.70		
Date: March 14, 2013. **Time AST**: 1605. **Tide**: Tide high, upper 1/3, falling.(High at 1445) **Weather**: Cloudy. **Air temp (C)**: 4.8							
Water depth (M): 9.7 **Wind direction**: NW. **Wind speed (mph)**: 10-12 . **Rainfall last 24 hrs (mm)**: 15-20							
0	3.03	27890	30.40	10.54	8.16		0
1	3.04	27900	30.36	10.54	7.86		
2	3.10	27920	30.34	10.05	7.83		
3	3.12	27910	30.34	10.20	7.80		
4	3.09	27960	30.43	10.07	7.76		
5	3.06	28540	31.18	10.10	7.84		
6	2.97	28670	31.38	10.20	7.86		
7	3.03	28780	31.50	9.83	7.89		
8	3.06	28850	31.52	9.41	7.85		
9	3.08	28940	31.60	9.41	7.86		
Date: March 25, 2013. **Time AST**: 10:33. **Tide**: Rising high Tide .(High at 11:16) **Weather**: Overcast. **Air temp (C)**: 4.5							
Water depth (M): **Wind direction**: . **Wind speed (mph)**: . **Rainfall last 24 hrs (mm)**: 0							
0	2.78	28210	31.05	10.24	7.63		
1	2.71	28210	31.10	10.18	7.67		
2	2.64	28210	31.17	10.46	7.68		
3	2.62	28220	31.19	10.50	7.72		
4	2.60	28220	31.21	10.60	7.76		
5	2.56	28230	31.24	10.47	7.76		
6	2.57	28220	31.23	10.32	7.82		
7	2.58	28210	31.21	10.45	7.67		
8	2.59	28210	31.20	10.46	7.84		
9	2.61	28200	31.17	10.48	7.81		
10	2.61	28200	31.18	10.40	7.89		
11	2.62	28220	31.16	9.37	7.82		

Appendix 3b. Bayside Wharf data, St. Croix Estuary Project, 2012-2013.

Sample depth as M	Water Temp as C	Cond as uS/cm	Salinity as ppt	Dissolved Oxygen mg/l	pH	Total Coliform as MPN/100ml	E. coli as MPN/100ml
Date: October 24, 2012. **Time AST**: 0915. **Tide**: Upper 1/3, falling (high at 0706). **Weather**: sun. **Air temp (C)**: 2.2							
Water depth (M): not available. **Wind direction**: SW. **Wind speed (mph)**: 5-10 . **Rainfall last 24 hrs (mm)**: 0							
0	12.08	31310	25.75	7.03	7.90		
1	12.40	34310	29.08	7.08	7.83		
2	12.59	34930	29.41	6.77	7.85		
3	12.66	35720	30.51	6.43	8.06		
4	12.72	35930	30.44	6.86	7.95		
5	12.76	35960	30.46	6.91	7.98		
6	12.77	35880	30.40	6.91	7.92		
7	12.76	35870	30.38	6.96	7.89		
8	12.76	35870	30.39	6.53	7.70		
9	12.77	36210	30.52	6.56	7.29		
10	12.79	36200	30.61	6.36	7.28		
11	12.79	36180	30.64	6.88	7.82		
12	12.79	36120	30.60	5.60	7.80		
13	12.79	36180	30.85	6.30	7.80		
14	12.79	36200	30.67	5.92	7.80		
15	12.80	36240	30.70	5.28	7.79		
Date: December 4, 2012. **Time AST**: 1312. **Tide**: Upper 1/3, rising (high at 1533). **Weather**: overcast. **Air temp (C)**: 4.4							
Water depth (M): not available. **Wind direction**: SW. **Wind speed (mph)**: 5-8. **Rainfall last 24 hrs (mm)**: 6.7							
0	7.28	28680	27.69	8.32	7.61		
1	7.45	29780	28.65	8.81	7.61		
2	7.53	30170	28.95	8.75	7.67		
3	7.89	31030	29.59	8.65	7.74		
4	7.90	31060	29.61	8.70	7.75		
5	7.99	31330	29.81	8.64	7.77		
6	8.06	31480	29.90	8.63	7.90		
7	8.10	31560	29.98	8.58	7.87		
8	8.38	32280	30.49	8.50	7.82		
9	8.41	32380	30.56	8.45	7.83		
10	8.42	32430	30.59	8.48	7.84		
11	8.43	32420	30.59	8.44	7.90		
12	8.43	32420	30.59	8.46	7.84		
13	8.44	32460	30.61	8.38	7.85		
14	8.52	32710	30.80	8.35	7.86		
15	8.54	32710	30.79	8.36	7.92		
(limit of measurement)							
Date: February 27, 2013. **Time AST**: 1150. **Tide**: Upper 1/3, rising (high at 1254). **Weather**: overcast. **Air temp (C)**: 2.1							
Water depth (M): not available. **Wind direction**: SW. **Wind speed (mph)**: 5-8 . **Rainfall last 24 hrs (mm)**: 0							
0	1.94	25200	28.14	10.89	7.84		
1	1.88	25330	28.36	10.93	7.86		
2	1.87	25920	29.11	10.86	8.00		
3	1.96	26710	29.97	10.03	7.86		
4	1.95	26830	30.12	10.01	7.90		
5	1.96	26880	30.18	10.05	7.88		
6	1.97	26910	30.21	9.70	7.91		
7	1.98	27030	30.34	9.18	7.90		
8	1.99	27120	30.44	9.30	7.91		
9	2.01	27260	30.59	10.23	7.64		
10	2.03	27400	30.76	9.37	7.87		
11	2.03	27410	30.77	9.20	7.70		
12	2.03	27410	30.78	9.12	7.89		
13	2.03	27440	30.80	9.74	7.85		
14	2.08	27840	31.25	9.76	7.26		
15	2.09	27850	31.25	9.16	7.51		
16	2.10	27840	31.24	8.92	7.51		
17	2.09	27840	31.23	8.11	7.62		
(limit of measurement)							

Appendix 3b (cont). Bayside Wharf data, St. Croix Estuary Project 2012-2013.

Sample depth as M	Water Temp as C	Cond as uS/cm	Salinity as ppt	Dissolved Oxygen mg/l	pH	Total Coliform as MPN/100ml	E. coli as MPN/100ml
Date: March 14, 2013. **Time AST**: 1445. **Tide**: High (high at 1445). **Weather**: Sunny. **Air temp (C)**: 6.2							
Water depth (M): not available. **Wind direction**: NW. **Wind speed (mph)**: 10-12 . **Rainfall last 24 hrs (mm)**: 10-15							
Other observations: 63mm rainfall in last 48 hours; heavy local freshwater runoff							
0	3.35	18080	18.44	11.64	7.81		
1	3.33	19750	20.36	11.57	7.83		
2	3.06	22730	24.25	10.24	7.79		
3	3.07	26670	28.97	10.15	7.85		
4	3.09	27090	29.39	10.35	7.85		
5	3.09	27130	29.41	10.51	7.82		
6	3.09	27160	29.45	10.30	7.90		
7	3.10	27160	29.45	10.23	7.87		
8	3.10	27150	29.46	10.42	7.92		
9	3.10	27230	29.52	10.56	7.81		
10	3.10	27220	29.53	10.30	7.86		
11	3.10	27270	29.58	10.24	7.88		
12	3.10	27280	29.61	10.33	7.82		
13	3.10	27330	29.67	10.44	7.88		
14	3.10	27340	29.67	10.50	7.78		
15	3.10	27350	29.69	10.05	7.76		
16	3.10	27390	29.82	10.03	7.81		
17	3.10	27870	30.33	9.82	7.82		
(limit of measurement)							
Date: March 25, 2013. **Time AST**: 11:15 **Tide**: High.(High at 11:16) **Weather**: Overcast. **Air temp (C)**: 3.8							
Water depth (M): not available. **Wind direction**: not noted. **Wind speed (mph)**: not noted. **Rainfall last 24 hrs (mm)**: 0							
0	2.54	22900	24.78	10.19	7.82		
1	2.62	23990	26.11	10.05	7.82		
2	2.63	24200	26.35	9.20	7.77		
3	2.65	27430	30.23	9.27	7.81		
4	2.65	27600	30.41	9.36	7.86		
5	2.62	27.31	30.12	9.90	7.85		
6	2.61	27240	30.01	9.77	7.88		
7	2.59	27270	30.07	9.87	7.85		
8	2.59	27330	30.15	9.53	7.88		
9	2.54	27460	30.34	9.70	7.85		
10	2.53	27630	30.58	9.23	7.88		
11	2.53	27630	30.54	9.31	7.91		
12	2.51	27630	30.56	9.28	7.92		
13	2.53	27650	30.60	9.35	7.85		
(limit of measurement)							

Appendix 3c. St. Stephen Wharf data, St. Croix Estuary Project, 2012-2013.

Sample depth as M	Water Temp as C	Cond as uS/cm	Salinity as ppt	Dissolved Oxygen mg/l	pH	Total Coliform as MPN/100ml	E. coli as MPN/100ml
Date: October 24, 2012. **Time AST**: 1005. **Tide**: half, falling (high at 0706). **Weather**: sun. **Air temp (C)**: 9.9							
Water depth (M): 4.9 **Wind direction**: SW. **Wind speed (mph)**: 2-5 . **Rainfall last 24 hrs (mm)**: 0							
0	11.05	7750	6.06	9.84	7.42		
1	11.19	10690	7.29	9.68	7.45		
2	11.38	13410	10.72	9.20	7.51		
3	11.55	17150	13.12	8.45	7.60		
4	12.55	27290	27.17	5.66	7.73		
Date: December 4, 2012. **Time AST**: 1438. **Tide**: Upper 1/3, rising (high at 1533). **Weather**: overcast. **Air temp (C)**: 4.6							
Water depth (M): 5.8 **Wind direction**: SW. **Wind speed (mph)**: 0-2 . **Rainfall last 24 hrs (mm)**: 6.7							
0	2.41	22080	1.88	13.69	8.03		
1	4.44	12090	11.77	9.81	7.48		
2	5.64	18980	18.31	8.70	7.59		
3	6.76	24950	24.11	7.85	7.72		
4	6.96	25870	24.85	9.02	7.80		
5	7.24	27150	26.01	8.62	7.85		
Date: February 27, 2013. **Time AST**: 1235. **Tide**: near high, rising.(High at 1254) **Weather**: sun/cloud. **Air temp (C)**: 3.6							
Water depth (M): 5.4 **Wind direction**:SW **Wind speed (mph)**: 15-20 **Rainfall last 24 hrs (mm)**: 10-15							
0	1.23	2430	2.58	13.75	7.60		
1	1.34	11920	13.27	11.77	7.42		
2	1.56	19320	21.34	10.62	7.63		
3	1.66	20600	22.76	10.64	7.80		
4	1.73	22360	24.90	10.54	7.75		
5	1.78	23140	25.78	10.23	7.82		
Date:March 14, 2013. **Time AST**: 1315 **Tide**: near high, rising.(High at 1445) **Weather**: sun/cloud. **Air temp (C)**: 4.9							
Water depth (M): 5.4 **Wind direction**: W **Wind speed (mph)**: 5-7 **Rainfall last 24 hrs (mm)**: 10-15							
Other obs: Surface salinity 0.08. Water very tan colour yesterday but less so today: Mar 12-13 rainfall/snowmelt of 50+mm							
0	2.20	99	0.08	14.22	8.50	2480	
1	2.14	114	0.14	13.32	7.36		
2	2.11	702	0.62	13.15	7.36		
3	2.08	2220	1.34	12.70	6.63		
4	2.17	9401	9.58	11.84	6.31		
5	2.51	19210	20.41	10.50	6.84		
Date:March 25, 2013. **Time AST**: 1200 **Tide**: near high, falling.(High at 1133) **Weather**: sun/cloud. **Air temp (C)**: 13.3							
Water depth (M): 6 **Wind direction**: **Wind speed (mph)**: **Rainfall last 24 hrs (mm)**: 0							
0	2.10	11210	11.45	12.46	7.11		
1	2.09	12270	12.86	12.45	7.11		
2	2.08	16090	16.90	11.82	6.97		
3	2.45	23730	25.97	9.63	7.26		
4	2.42	24460	26.82	9.84	7.33		
5	2.40	24770	27.19	9.57	7.40		

Appendix 4. Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

Appendix 4. Summary of parameters included in New Brunswick Water Classification water quality assessments. Unless otherwise noted, the Canada Guidelines cited are the Canadian Environmental Quality Guidelines for the Protection of Aquatic Life.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Alkalinity, Grans (Alk-G)	Indicates water's ability to neutralize acid. Stated as an equivalent value of calcium carbonate in mg/l.			30-500 mg/l is generally acceptable. 2-10 mg/l shows sensitivity to acidification.
Aluminum (Al)	The most abundant metal in the earth's crust. An essential trace element for life processes, toxic to fish at higher levels.	≤ 5 μg/l at pH≤ 6.5 ≤ 100 μg/l at pH>6.5		
Ammonia (NH_3)	A nitrogen/hydrogen form generated by plant and animal excretions; manufactured in inorganic form for use in fertilizers and cleaners. It affects oxygen transport in blood and is toxic to fish at low levels.	Varies with temperature and pH, generally ≤1370 -2200 μg/l		Generally <100 μg/l in surface waters
Antimony (Sb)	A brittle, inert metal often found with lead, silve and copper deposits. Used in compounds ranging from metal alloys to medicines.			
Arsenic (As)	A semi-metallic element found naturally in the common mineral arsenopyrite. A byproduct of smelting; used in industrial processses. Accumulates in the body. Some forms are quite toxic.	≤ 50 μg/l		Typically 0-10 μg/l in surface waters
Bacteria, *E. coli* (EC)	One of the fecal coliform bacteria most commonly used as an indicator of sewage pollution. Listed as the most probable number (MPN) in 100ml water. N.B. standard is a geometric mean of a minimum of 5 samples in a 30 day period.	For swimming waters, a mean of <200 MPN for 5 samples in a 3 day period and <400 MPN for any one sample; no guideline is set for aquatic life	Class AP: no *e.coli*. Class 0, AL & A: as naturally occurs. Class B: <200. Class C: <400. Class B & C (tidal shellfish areas): < 14.	

Appendix 4 (cont). Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Cadmium (Cd)	A soft metal found in association with metallic ores. Used in batteries, electroplating and solder. Toxic above trace levels; accumulates in the body.	≤0.017μg/l		Typically 0.1-10μg/l in natural surface waters
Calcium, dissolved (Ca-D)	An alkaline-earth metal vital for bone development and muscle function. It and magnesium primarily determine water hardness.			< 15 mg/l is common in this region's surface waters. Can be up to 100 mg/l, even higher in tidal waters.
Carbon, total organic (TOC)	Organic carbon is required for most biological processes. This indicates the amount of organic (plant and animal) matter in the water: it will deplete waterborne oxygen as it decays.			General range is 1-30 mg/l but < 10 mg/l is typical in higher quality waters
Chloride (Cl)	Major inorganic ion; with sodium forms common salt. Essential for life in trace amounts. As chlorine or chloride, used commonly in road salting, water and sewage disinfection and bleaches.			Generally <10mg/l in freshwaters
Chlorophyll A (ChlA)	Green pigment found in plants; can be used to estimate the amount of plant life in the water.			Generally < 4 mg/l in unproductive, nutrient-poor waters; 10-100 ug/l in very productive or enriched lakes
Chromium (Cr)	A metal used extensively to harden and plate other metals. Used by the body in its trivalent form to metabolize fats and carbohydrates; toxic in other forms	≤8.9 μg/l for trivalent chromium, ≤1 μg/l for other forms		Generally ranges 0-17μg/l in surface waters

Appendix 4 (cont). Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Clarity (Secchi)	An index of how far light penetrates into the water; measured as the maximum depth at which a 25cm diameter 'secchi' disk with black and white quadrants can be seen in the water.	For recreation, >1.2m viewing depth when measured without a viewing scope; no guideline for aquatic life		Decrease in secchi reading may indicate increased suspended matter; this often occurs at lake turnover in spring and fall and during algae blooms
Color, Apparent (Clra)	Color given to water by dissolved matter, suspended particles and light, measured on a color band scale.	Mean value not signifi-cantly less than that tobe expected for those waters on a seasonal basis		Varies significantly. Decaying vegetation, tree bark and other organic matter color water naturally
Conductivity (Cond)	Ability to carry an electrical current, helpful in determining the amount of dissolved matter in water.			Normal range 10-50 usie/cm in NB waters . Groundwater often higher than surface water.
Copper (Cu)	A metal essential, in trace amounts, to blood cell formation, nerves and the immune system; toxic above trace levels. Used in manufacturing metals and in fungicides and pesticides.	From ≤2 μg/l at a water hardness of 0-120mg/l to ≤4 μg/l at a hardness of > 180mg/l		Generally less than 50μg/l in surface waters
Fluoride (F)	A compound of the gas fluorine and oxgen. In trace amounts it aids bone and tooth formation; toxic in higher amounts. Often added to drinking water to prevent dental cavities.			Usually found in surface waters in a range of 0-2 mg/l
Hardness (Hard)	A measure of the calcium, magnesium and other divalent ions in water, expressed in calcium carbonate equivalent in mg/l. Increased hardness can decrease metal toxicities and acidity but increase mineral deposits.			Varies from 0-30 mg/l in very soft water to >180 mg/l in very hard water

Appendix 4 (cont). Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Iron (Fe)	A metal, the fourth most common element on earth. Essential in forming hemoglobin (the oxygen-carrying blood pigment), also present in enzmes and proteins. Interferes with insect and fish reproduction and respiration.	≤300 µg/l		Usually less than 500 µg/l in surface waters
Lead (Pb)	A metal; its resistance to corrosion led to its extensive use in plumbing, paint and batteries until it was found to have a cumulative toxic effect on humans.	≤ 1µg/l - ≤7µg/l, depending on water hardness		Typically 0-40 µg/l in natural surface waters
Macro-invertebrates, benthic	Bottom-dwelling aquatic insects and other invertebrate animals large enough to be visible. The types and numbers of these are a good indicator of water characteristics over time.		As naturally occur in New Brunswick waters	Profiles are being developed which relate the macro-invertebrates found to various water quality types.
Magnesium (Mg)	A metal involved in bone growth and nerve and muscle function. Forms the core of the plant photosynthesis compound, chlorophyll. With calcium, primarily determines water hardness.			Normal range is 1-100 mg/l in surface waters
Manganese (Mn)	A metal involved in bone growth and energy production. May be essential to vitamin B1 utilization.			Usually >0.2mg/l in surface waters
Nickel (Ni)	A metal used extensively in alloys, it occurs naturally in trace amounts in foods and may be needed for human health. However it accumulates in the food chains of aquatic species, with some toxic effects.	Ranges from 25 µg/l at a water hardness of 1-60 mg/l to 150 µg/l at a hardness of >180 mg/l		Generally 15-20 µg/l in surface waters

Appendix 4 (cont). Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Nitrite (NO_2)	A transitory form of oxidized nitrogen produced by bacteria in nature, also found in industrial and sewage effluents. Toxic to humans and others above low levels.	≤60 µg/l		Usually < 1 µg/l in surface waters
Nitrate (NO_3)	The most common, stable form of nitrogen in surface waters. A product of natural nitrogen-fixing cycles and rock leaching, also found in sewage, industrial discharges and fertilizer runoff.			0.1-5 mg/l common in surface water; may be 100 mg/l or more in water affected by groundwater, sewage or fertilizers.
Nitrate + Nitrite (NO_x)	The combined inorganic forms of oxidized nitrogen. A major nutrient source for aquatic plants but can be toxic to fish at higher levels.			0.1-5 mg/l common in surface water; higher in water influenced by groundwater, sewage or fertilizer runoff.
Nitrogen, total Kjeldahl (TKN)	Nitrogen is the earth's most common gas and a key building block of many compounds. It is measured here as the sum of the organic forms of nitrogen and ammonia.			Commonly 0.1-0.5 mg/l in surface waters
Oxygen, dissolved (DO)	Oxygen is one of earth's most versatile and abundant elements. Dissolved in water, it is used for respiration by most aquatic life. Dissolved oxygen levels are affected by temperature and aeration: cold or standing water generally have lower levels. Often measured in parts per million (ppm): 1ppm = 1 mg/l.	≥5.5-6mg/l for warm-water species; 6.5-9 mg/l for coldwater species: higher values for early life stages	*for cold-water species*: ≥9.5ppm (early stages), ≥6.5ppm (other stages) *for warm-water species:* ≥6.0ppm (early stages), ≥5.0ppm (other stages), *in estuarine waters:* ≥80% saturation	Generally 4-10ppm in surface waters
pH (pH)	A measure of acidity/alkalinity based upon hydrogen ion concentration. A value of 7 is neutral; lower is acidic and higher is alkaline	6.5 - 9.0 for aquatic life, 6.5-8.5 for contact recreation		Natural freshwaters range pH4-9. A pHof 6.0-7.5 is most common in this region

Appendix 4 (cont). Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Phosphorus, total (TP-L)	A non-metallic element common in in-organic and organic forms. An essential plant nutrient and key biological building block; stimulates plant growth. Used commonly in fertilizers, cleaners and water conditioners.			Should be ≤ 25 μg/l in lakes and reservoirs to prevent excess algae growth, generally ≤ 10 μg/l in rivers
Potassium (K)	An alkali metal essential for function of nerves, muscles and vital organs.			Generally < 10mg/l, rarely as high as 20mg/l
Sodium (Na)	A major alkali metal and important inorganic ion. With other elements, it forms salts widely used in households, industry and road maintenance. Helps regulate body fluid balance and blood pressure.			1 mg/l -100,000 mg/l is common in surface waters
Solids, total suspended (TSS) or (SS)	Measure of the solid particles, organic and inorganic, that can be filtered from the water.	For clear waters ≤ 25mg/l above background for short term, ≤5mg/l for longterm. ≤10% change if background is >100mg/l		
Sulphate (SO_4)	An oxidized form of sulfur; comes naturally from rock leaching and biological processes. Used in some industrial processes.			5-5000 mg/l is found in surface waters
Temperature (Temp)	A measure of heat energy. Affects water's ability to hold dissolved oxygen and the respiration rate of most aquatic organisms	Varies, to keep changes within the tolerance range of the aquatic species present		Summer range of 18-25°C is common for lake surface waters; annual range of 0-25 °C is typical for all waters

Appendix 4 (cont). Background on inorganic test parameters used in New Brunswick water studies.

Reprinted from: St. Croix International Waterway Commission. 2000. Future Water Quality in the St. Croix Watershed: A Proposal. Pages 80-86. St. Stephen, New Brunswick.

PARAMETER (table abbreviation)	DESCRIPTION	CANADA GUIDELINE	PROPOSED NB STANDARD	WATER-RELATED BACKGROUND
Turbidity (Turb)	A measure of water clarity resulting from particles in the water (silt, algae, etc). Measured in nephelometric turbidity units (NTU).	For clear waters ≤ 8 NTU above background for short term, ≤ 2NTU for longer term. For turbid waters ≤10% change.		Can range 0.1-1000 NTU in natural waters, but is typically 0.1-5 NTU
Zinc (Zn)	A natural metal used in many alloys (ex: brass, bronze, galvanized steel). Essential to immune system and cell development in trace amounts; toxic to aquatic life at higher levels.	<30 μg/l		Typically <50 μg/l in natural surface waters.

Units of measure:
mg/l: milligrams per liter. μg/l: micrograms per liter (1000 micrograms = 1 milligram). ppm: parts per million.

Primary references:
Canadian Council of Ministers of the Environment. 1999. Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment. Winnipeg. Man.
R.N. McNeely, V.P. Neimanis and L. Dwyer. 1979. Water Quality Sourcebook: A Guide to Water Quality Parameters. Environment Canada, Ottawa, Ont.

Appendix 5. Test method references, St. Croix Estuary Project water monitoring program, 2012-2013.

Laboratory test method references, New Brunswick Department of Environment & Local Government, 2012.

Parameter	Instrument/Method Reference	Limit of Quantitation
Al Aluminum	Inductively Coupled Plasma-Mass Spectrometer (EPA 200.8)	0.001mg/l
As Arsenic	Inductively Coupled Plasma-Mass Spectrometer (EPA 200.8)	1.0ug/l
Alk Alkalinity	Auto Titration (Std Methods 2320.B) online 2011	---
Ca Calcium	Inductively Coupled Plasma (EPA 200.7)	0.100mg/l
Cd Cadmium	Inductively Coupled Plasma-Mass Spectrometer (EPA 200.8)	0.1ug/l
Chl"A" Chlorophyll A	HP Diode Array Spectrophotometry (Std. Methods 10200H) online 2011	0.5ug/l
Cl Chloride	Ion Chromatography (Std. Methods 4110B) online 2011	0.050mg/l
CLRA Color (apparent)	HACH Colorimetric (Std. Methods 2120C) online 2011	5
Cond Conductivity	Conductivity Meter Automated (Std. Methods 2510B) online 2011	---
Cr Chromium	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	0.0005mg/l
Cu Copper	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	0.0005mg/l
TOC Total Organic Carbon	Combustion and NDIR SM 5310B Online 2011	1.0mg/l
E. Coli	Colilert Method SM 9223B online 2001	MPN/100ml
F Fluroide	F-ion Selective Electrode automated (Std. Methods 4500-F-C) online 2011	0.100mg/l
Fe Iron	Inductively Coupled Plasma (EPA 200.7)	0.010mg/l
HARD Hardness	Calculated (EPA 200.7)	0.67mg/l
K Potassium	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	0.10mg/l
Mg Magnesium	Inductively Coupled Plasma (EPA 200.7)	0.10mg/l
Mn Manganese	Inductively Coupled Plasma (EPA 200.8)	0.005mg/l

Parameter	Instrument/Method Reference	Limit of Quantitation
Na Sodium	Inductively Coupled Plasma (EPD 200.7)	0.10mg/l
NH3 Ammonia	Auto Analyzer II Automatic Phenate Method (Std. Methods 4500-NH3G) online 2011	0.010mg/l
Ni Nickel	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	0.005mg/l
NO_3-D Nitrite	Calculated	0.05mg/l
NO_2-D Nitrate	Lachat Flow Injection SM 4500-NO3I CD –Red Flow Inj. Method online 2011	0.05mg/l
NO_x Nitrite & Nitrate	Lachat Flow Inj. CD-Red Flow Injection Method SM 4500-NO3I	0.05mg/l
Pb Lead	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	0.001mg/l
pH	PH Electrode Automated SM 4500 H+ online 2011	---
Sb Antimony	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	1.0ug/l
SO^4 Sulphate	Ion Chromatography (Std. Methods 4110B) online 2011	0.050mg/l
SS (TSS) Suspended Solids	Gravimetric – 934 – AH Filter Paper Microwave Dried SM 25400 online 2011	10mg/l
TP-L Total Phosphorus	Lachate Std. Methods 4500-PI	0.002mg/l
Turb Turbidity	Nephelometic Method (Std. Methods 2130B) Automated online 2011	0.2NTU
TN Total Nitrogen	Technicon Auto Analyzer II Technicon (Method No 329-74 W/B)	0.3mg/l
Zn Zinc	Inductively Coupled Plasma – Mass Spectrometer (EPA 200.8)	0.005mg/l

Appendix 5 (cont.). Test method references, St. Croix Estuary Project water monitoring program, 2012-2013.

Laboratory test method references, New Brunswick Department of Environment & Local Government, 2012.

Parameter	Instrument/Method Reference	Limit of Quantitation
Benzene	GC/MS – Atlantic RBCA Guidelines for Laboratories ver 3.0	0.20ug/l
Toluene	GC/MS – Atlantic RBCA Guidelines for Laboratories ver 3.0	0.20ug/l
Ethylbenzene	GC/MS – Atlantic RBCA Guidelines for Laboratories ver 3.0	0.30ug/l
Total Xylenes	GC/MS – Atlantic RBCA Guidelines for Laboratories ver 3.0	0.40ug/l
C_6-C_{10} Hydrocarbons	GC/MS – Atlantic RBCA Guidelines for Laboratories ver 3.0	5ug/l
>C_{10}-C_{16} Hydrocarbons	GC/FID – Atlantic RBCA Guidelines for Laboratories ver 3.0	15ug/l
>C_{16}-C_{21} Hydrocarbons	GC/FID – Atlantic RBCA Guidelines for Laboratories ver 3.0	15ug/l
>C_{21}-<C_{32} Hydrocarbons	GC/FID – Atlantic RBCA Guidelines for Laboratories ver 3.0	20ug/l
Modified TPH	Calculated parameter -addition of concentration from all 4 carbon ranges. Does not include BTEX concentration	n/a

Field instrument references, St. Croix Estuary Project, 2012.

Parameter	Instrument	Limit of quantification
Temperature	YSI Model 55 YSI Model 556 MPS	± 0.2°C ± 0.15°C
Dissolved oxygen	YSI Model 55 YSI Model 556 MPS	± 0.3mg/l ± 0.2mg/l
pH	YSI Model 556 MPS	± 0.2 units
Conductivity	YSI Model 556 MPS	± 1uS/cm
Salinity	YSI Model 556 MPS	± 0.01ppt

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