Water Quality Trends in Selected Water Bodies of Newfoundland & Labrador

Canada-Newfoundland
Water Quality Monitoring
Agreement

Water Resources Management Division
Department of Environment

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Executive Summary

This report examines trends in 36 different water quality parameters from 65 different water quality monitoring stations located on representative rivers throughout the province of Newfoundland and Labrador. An examination of land and water use activities ongoing in each watershed allowed identification of likely causes and/or factors contributing to improving or deteriorating water quality trends. This report also ranks the 65 water quality stations as pristine, semi-impaired, or impaired.

Water quality data has been collected as part of the Canada-Newfoundland Water Quality Monitoring Agreement since 1986. Water quality parameters in this monitoring program include major chemical and physical parameters, such as dissolved oxygen, pH, turbidity, colour, conductivity, nutrients, major ions and metals.

Using statistical analytical methods, including time series plots and the nonparametric Spearman Correlation Coefficient, trend was determined over the period of record for each parameter. Many parameters exhibited no observed change, while others consistently displayed change. Throughout the province, turbidity and colour were generally displaying deteriorating trends, while conductivity, and the metals copper, lead and mercury, were consistently displaying improving trends. The deteriorating trend in turbidity, and to a lesser extend colour, can be linked to a variety of land disturbance activity including forestry, quarrying and construction. Increasing trends in precipitation have also influenced deteriorating trends in turbidity and colour, and improving trends in conductivity. Reductions in the rate of atmospheric deposition of copper, lead and mercury have lead to improving trends in these metals.

Urban rivers displayed a greater degree of change than rivers in more pristine watersheds. Of particular note was the deteriorating trend in nitrate/nitrite and nitrogen in more developed river basins, and a corresponding improving trend in phosphorous. The deteriorating trend in nitrate/nitrite and nitrogen is from a combination of sewage (direct outfalls and leaking septic systems), and residential and agricultural fertilizer application. The improving trend in phosphorous can be linked to phosphorous control measures first implemented in the mid 70's. Surprisingly, even in pristine watersheds change was often observed in metals, major ions, turbidity and colour.

Connections can be made between certain observed trends and known anthropogenic activity (past and present) in the watershed. For example, improving pH levels throughout the Exploits River indicate moderation of the effects of acid mine leachate from the now abandoned ASARCO zinc, copper and lead mine. Deteriorating trends in nitrate/nitrite on the Lower Humber can be linked to agricultural activity in the fertile Humber Valley area, in addition to sewage effluent from the towns of Deer Lake and Pasadena. Some improvements in rivers in St. John's can be linked to the greater awareness organizations like the Quidi Vidi-Rennies River Development Foundation and Virginia River Conservation Society have generated amongst the public concerning the cleanup and enhancement of these river systems and abatement of pollution causing practices.

In addition to localized connections between observed trends and watershed activities, several more global trend-causing factors were also identified. Global bans on leaded gasoline, and phosphorous control measures imposed on detergents have seen deteriorating trends in both lead and phosphate throughout the province. Improvements in atmospheric emissions from major pollution sources (including many industries and factories located along the Eastern Seaboard of North America) have also seen improving trends in pollutants identified as having significant atmospheric contributions in waterbodies including sulphate, mercury, lead, copper and zinc. Changes in climate since the start of water quality monitoring in the province seem also to have had an effect on some parameters. Increased precipitation has resulted in increased turbidity and decreased major ion concentration.

To categorize the monitoring sites, a ranking was performed by applying the Canadian Water Quality Index (CWQI) with water quality guidelines produced by the Canadian Council of Ministers of the Environment (CCME). Rivers in the Western Region of the province were in a more pristine state than rivers in the

Eastern Region of the province, where the highest number of impaired rivers was found. The level of urban development is much higher in the Eastern Region of the province, and has obviously had an impact on the quality of these rivers.

This report provides an outline on the path forward to continue building upon the findings made here. Recommendations include dissemination of this information to the public, retooling of the water quality monitoring network, more in depth analysis using GIS and water quality modeling tools, and pursuing additional courses of investigation including studying spatial variations within watersheds, and the effect of climate change on water quality.

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Introduction

Environment Canada and the Department of Environment have been monitoring surface water quality of selected water bodies in the province since 1986 under the Canada-Newfoundland Water Quality Monitoring Agreement. The purpose of this Agreement is:

- Coordination and integration of federal and provincial water quality monitoring activities
- Assessment of the suitability of water for various beneficial water uses
- Development of pollution control regulations, water quality guidelines and objectives
- Use of the collected data for trend analysis, water quality modeling, environmental assessment studies, research undertakings, legislative formulations, and federal-provincial-international agreements and commitments

Because of growing public interest and demand for such information, the Department of Environment is publishing the data using a trend report format. This report can then guide people in their decisions on how to use water, and promote actions to correct water quality problems.

This trend report is based on data collected regularly and consistently since 1986. The data is evaluated to determine whether water quality is improving, deteriorating or remaining the same over the years. Water quality guidelines are used to help rank sites as pristine, impaired or semi-impaired. Knowledge of environmental and anthropogenic factors affecting each basin are used to determine possible causes for observed water quality trends.

In order for any long-term trend analysis to provide accurate results, samples must be taken in the same way and at the same location, and analyzed using consistent methods over periods of 5 to 10 years. If locations or methods of sampling or measuring change over time, it becomes difficult to tell whether a trend is due to a change in water quality or just a change in locations or methods. Regular monitoring requires measuring at regular intervals that are frequent enough to be representative of water quality for the water body.

Water quality guidelines are safe levels of water quality indicators provided by the Canadian Council of Ministers for the Environment (CCME) to protect sensitive uses of water such as drinking, aquatic life and recreation. They establish a general reference against which the state of water quality in a water body can be checked. However, local water quality conditions such as high background levels of certain parameters are frequently not taken into account.

The main potential sources of pollution are industry, forestry, mining, urban development, agriculture and stream alterations. Each of these encompasses a wide range of activities that have been proven to negatively impact water quality in the form of point source and non-point source pollution.

Objectives and Scope

The overall objective of this study is to provide an analysis of water quality data collected since 1986, and based on the findings from this analysis, recommend changes to the Agreement water quality monitoring network. Specific objectives include:

- Analysis of available water quality data using statistical techniques to document changes in water quality
- Identify sources and causes of water quality degradation
- Identify major water quality problems
- Analyze temporal variations among various monitored parameters on a watershed basis along with spatial water quality changes within various geographic regions
- Rank and classify water bodies into pristine, semi-impaired, and impaired categories based on trend analysis results, in conjunction with the Canadian Water Quality Index (CWQI) using Canadian Council of Ministers of Environment (CCME) water quality guidelines

- Make recommendations on what can be done to improve water quality where there are deteriorating trends or other water quality concerns, and to maintain water quality where there are no present concerns
- Make recommendations for reorganization of the Agreement water quality monitoring network in terms of size, monitoring parameters and media
- Make recommendations for further study

The scope of this report, however, is limited to an assessment of change in water quality since 1986, and a ranking of water bodies according to water quality. The ranking or status of the rivers will examine the degree of attainment of water quality objectives, while trend analysis will focus on whether water quality is changing over the long term and possible reasons for this. Some aspects of the other objectives will be touched on, but not in depth.

The study is based on published and unpublished data on water quality and watershed characteristics available from the Department of Environment. The report examines trend in, and ranks, 65 different monitoring sites on bodies of water throughout the province. These waterbodies provide geographic representation and range from those that are relatively pristine to those heavily impacted by human activity. Because of this, the trend report can be viewed as being indicative of the trends in water quality of the province as a whole.

Methodology

Considerable attention has been given to the testing of water quality data for trend over time in recent years. The reasons for this include the fact that only recently has there been enough data available to make such analysis feasible, and because of the intrinsic interest in the question of changing water quality arising out of environmental concern, and the effect of anthropogenic activity.

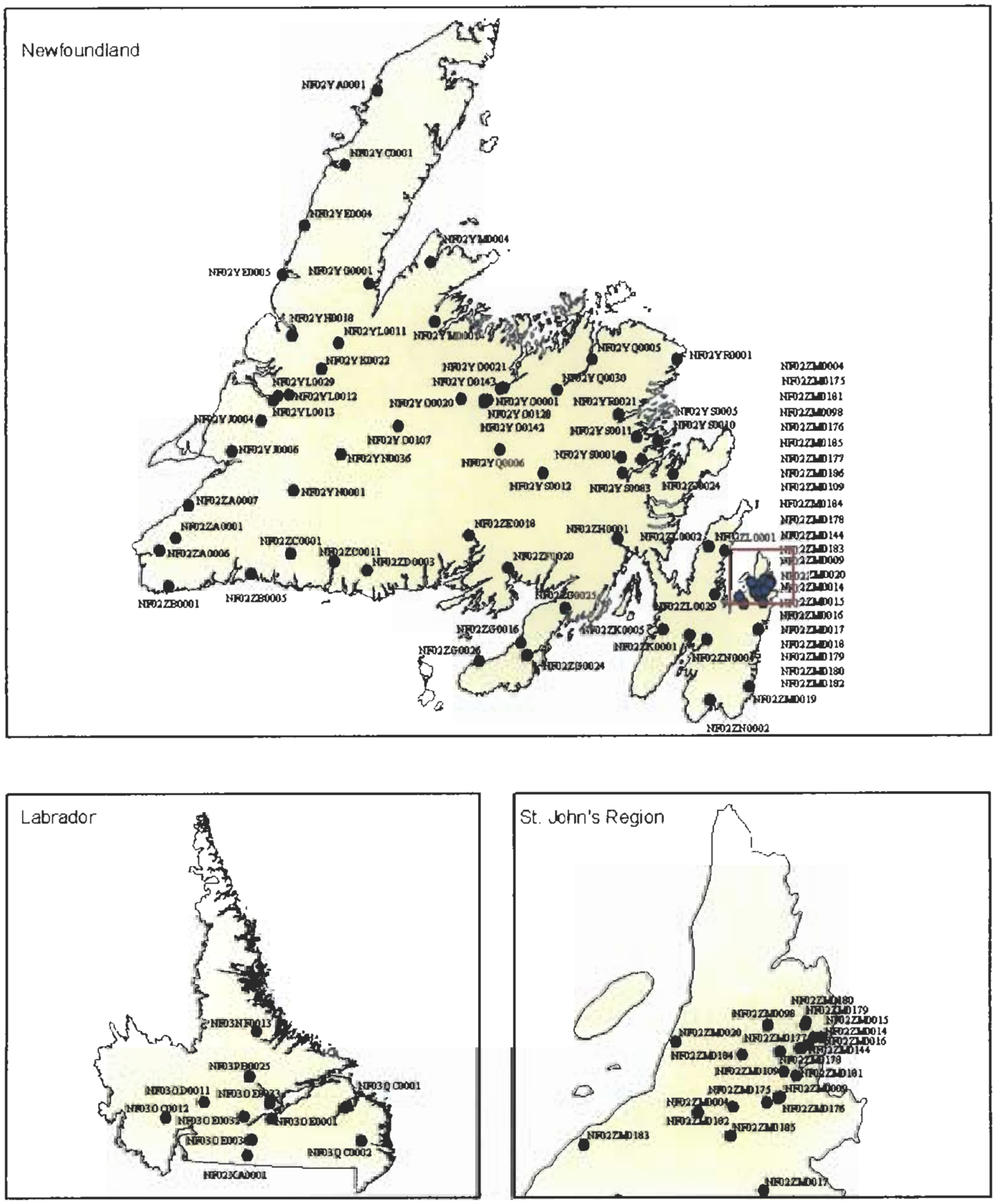
The methods that are suitable for the detection and estimation of trends are determined by how a trend is defined. Simply speaking, trend analysis determines whether the measured values of a water quality parameter increase or decrease during a period of time. However, the type of trend analysis depends on the data set characteristics and the program objective for which the data are collected (Johnson, 1994). Techniques for trend analysis include time regression, regression on non-normal transformations, analysis of variance, flow/concentration regression, paired regression, and nonparametric techniques.

Factors that complicate the analysis of water quality time series include non-normal distributions, seasonality, dependence on the rate of flow, the presence of missing observations, outliers, serial dependence and the existence of censored data. The large amounts of data to be analyzed, along with the various characteristics of that data, made certain trend analysis techniques unfeasible or too time consuming to perform. In the end, a combination of time series plots, moving averages, and use of the nonparametric Spearman's rank correlation coefficient were decided on to test for trend.

Two of the main methods to test for trends over time described in the following section involve use of Spearman's rank correlation coefficient. This nonparametric test was used because it has been found to be more robust, have a high power, and perform well in comparison to its parametric counterparts (Forester, 2000). Calculation of the Spearman coefficient was made using the statistical software application SYSTAT 7.0.

Sampling stations are located throughout the province to provide geographical representation and sufficient monitoring for more strategic rivers. Waterbodies of interest are divided into four regions- Eastern, Central, Western and Labrador. A map of Agreement water quality stations can be found in Figure 1.

Figure 1: Canada-Newfoundland Water Quality Monitoring Agreement Sites



Parameter Groupings

A wide variety of chemical and physical indicators of water quality were measured as part of the Agreement monitoring program. These indicators include:

- **Turbidity** measures the amount of particulate matter in water, which can occur due to natural erosion of the Earth's surface, but can be affected by land disturbances, waste discharges and dams.

- **Colour** in water ranges naturally from nil to tea-coloured, depending on the amounts of organic and inorganic material dissolved in the water. Pulp mills and some other industrial effluents can increase the colour of water to objectionable levels.

- **Dissolved Oxygen** is a vital part of the air that is dissolved in water. Minimum amounts are essential for aquatic organisms to breath. It can be depleted to harmfully low levels by bacteria consuming the organic matter in sewage, industrial effluents, agricultural wastes and decaying algal blooms.

- **pH** is a measure of the acid or alkaline nature of water, which can be affected by waste discharges, acid precipitation, or too much algal growth.

- **Major Ions** such as calcium, sodium, magnesium, potassium, chloride, sulphate and fluoride are present in all natural waters, but can be affected by waste discharges and land disturbance. **Conductivity** can be considered an overall indicator of changes in major ions.

- **Nutrients** include forms of carbon, nitrogen, phosphorous, as well as silica, which are essential for aquatic plants such as algae. Waste discharges and land use can increase nutrient levels in water, causing too much algal, fungal or bacterial growth and harming water uses. Agricultural fertilizers and manure, as well as sewage and septic tank effluents can increase nitrate levels.

- **Trace Elements** include aluminium, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, vanadium and zinc. These metals are normally present in minute amounts, but can be increased to harmful levels by waste discharges and runoff from land disturbances, transportation corridors and other developed areas.

The Agreement water quality data included parameters that had both field and laboratory results, total and extractable results, and dissolved and extractable results. For the trend analysis, laboratory results were used for conductivity and pH, total values were used for all metals, and dissolved values were used for all major ions.

The four major categories of water quality parameters are identified in the following table.

Table 1- Agreement Water Quality Parameters by Major Grouping

Physical and Chemical Parameters	Major Ions	Nutrients	Trace Elements and Metals
Turbidity	Calcium	Nitrogen	Aluminium
Colour	Sodium	Nitrate & Nitrite	Arsenic
Dissolved Oxygen	Magnesium	Phosphorous	Barium
pH	Potassium	Silica	Beryllium
Conductivity	Sulphate	Dissolved Organic Carbon	Cadmium
	Chloride		Cobalt
	Floride		Chromium
			Copper
			Iron
			Lead
			Lithium
			Manganese
			Mercury

			Molybdenum
			Nickel
			Selenium
			Strontium
			Zinc
			Vanadium

The monitoring data for these variables is available on a monthly, bi-monthly to quarter-monthly basis depending on the site for a period of record covering 1986-2000. The duration of all records is not equal, however.

Agreement Water Quality Data Characteristics

In determining the most appropriate statistical methods that could be used in trend analysis, the characteristics of the Agreement water quality data first had to be determined. The following is a brief overview of the Agreement water quality data characteristics:

Distribution of data

Water quality data does not usually follow convenient probability distributions such as the well-known normal distribution on which many classical statistical methods are based. The majority of parameters displayed a lack of normally distributed data. The assumption of a normal distribution of data is required for parametric statistical methods such as linear regression. As the Agreement data regularly departed from normality, a non-parametric statistical test for trend had to be adopted for the analysis. Another indication of non-normality is the skewness of the distributions, the majority of which were positive or right skewed. Of the commonly measured water quality variables, only temperature, pH and dissolved oxygen can be considered to be typically or near normal (Hirsch and Slack, 1984).

Censored data

Parameters with observations below analytical detection limits that are replaced by constant values (and other problems with the distribution of the data including missing data values) are described as censored data. These types of error can invalidate analysis of the water quality time series. The test for normality revealed that data for many parameters is grouped at certain values (ie. there is no smooth distribution of data). The standard practice is that for Agreement values less than the detection limit, a value of half the detection limit is taken. Parameters with frequent occurrence of censored data include: floride, beryllium, cadmium, mercury, molybdenum, and to a lesser extent chromium, cobalt, and nickel. Over the period of record, the frequency of occurrence of less than detect values decreased significantly due to improvements in laboratory technology and thus lower detection limits.

Serial Dependence of Data and Seasonal Variance

Occurs when consecutive observations are correlated (ie. high values followed by high values, low values followed by low values). All parameters indicate a high level of positive autocorrelation. This indicates the data is periodic, and fitting a straight line to the data will result in errors with regards to the linear regression. From autocorrelation plots, it is evident the data shows a yearly (12 month) trend. The periodic nature of many of the parameters can be observed from the time series plots.

Outliers

Outliers are observations three standard deviations above or below the mean. If not removed from the data sets, outliers can possibly influence the statistical analysis. In this trend analysis outliers were left in the data sets as they can indicate important phenomena, not necessarily erroneous data. The outliers will be demonstrated using time series plots.

Descriptive Statistics

Tables of typical statistical measures of the Agreement water quality data were produced including: mean, standard error, median, mode, standard deviation, sample variance, skewness, range, minimum, maximum and count. Microsoft Excel's Data Analysis ToolPak was used to produce the above descriptive statistics.

12-Month Moving Averages

Time series plots of all parameters at each Agreement water quality site were produced, including the 12-month moving averages. These plots provide a general indication of trend, and support observations made later in the statistical trend analysis. Each parameter was graphed using scatterplots in Excel, using time in cumulative months as the independent variable.

Spearman Trend Analysis

The entire data series for each parameter, paired with cumulative month, will be analyzed using the nonparametric Spearman's criterion to detect the existence of trend. The existence of a trend is checked using the test statistic t_t and is checked for significance at the level of 5% from statistical tables of the Student's t-distribution. The Spearman rank-correlation coefficient is described as:

$$R_{SP} = 1 - \frac{6\sum_{i=1}^{n}(D_i D_i)}{n(n^2 - 1)}$$

where n is the total number of values in each time series, D is the difference and I is the chronological order number. The difference between rankings is computed as $D_i = K_{xi} - K_{yi}$, where: K_{xi} is the rank of a measured variable in chronological order and K_{yi} is the series of measurements transformed to its rank equivalent, by assigning the chronological order number of the measurement in the original series to the corresponding order number in the ranked series, y. The null hypothesis, H_0: $R_{SP} = 0$ (there is no trend) against the alternate hypothesis, H_1: $R_{SP} <$ or > 0 (there is a trend), is checked with the test statistic:

$$t_t = R_{SP}\left[\frac{n-2}{1-R_{SP}^2}\right]^{0.5}$$

where t_t has Student's t-distribution, with $\nu = n-2$ degrees of freedom. At a significant level of 5%, the time series has no trend if $t\{\nu, 2.5\%\} < t_t < t\{\nu, 97.5\%\}$ (Antonopoulous et al., 1998).

Monthly Spearman Trend Analysis

This test for trend uses Spearman's rank-correlation coefficient on the monthly values for each year, one month at a time, and provides a test for upward or downward trend over the years of record. The exact distribution of R_{SP} can be obtained for $n < 6$, from statistical tables found in Appendix A.

The matrix produced will then be evaluated for significant values using the table of critical values of the Spearman rank-correlation coefficient. A significant positive value of R_{SP} indicates an increasing trend while a significant negative value indicates a decreasing trend for that month. Significance was determined at four different levels: 5%, 2%, 1%, and 0.5%. A majority of months with either negative or positive values indicates trend for that individual water quality parameter (El-Shaarawi et al., 1983).

Overall Trend

To determine whether Agreement water quality parameter values have increased or decreased over the period of record, a summary matrix has been produced for each Agreement site comparing the total Spearman trend, the monthly Spearman trend, and the 12-month moving average trend. A majority of indicators of trend were used to determine the overall trend for each individual parameter.

Ranking of Agreement Water Quality Sites

The concept of clean water or acceptable levels of water quality varies depending on the use of the water. Water quality objectives or guidelines have been defined as the desirable levels of quality to be attained in receiving waters, and take into account many uses such as drinking water, aquatic life, recreation, agriculture and aesthetics (Forester, 2000).

To be able to compare the status of water quality between Agreement sites across the province, analysis was performed using the Canadian Water Quality Index (CWQI). The Provincial Water Quality Objectives, which are taken from the CCME water quality guidelines, were used to assess the environmental significance (CCME, 2002). Based on the CWQI values, trend analysis results, and knowledge of activity in the basins, water bodies can be ranked as pristine, semi-impaired and impaired for the following water uses: drinking water and aquatic life.

Results and Discussion

The outcome of the various analysis methods provided a comprehensive picture of the status and trends in water quality throughout the province. For each statistically significant trend, a possible explanation of its cause is made based on sources known to contribute to water pollution and activities ongoing in the watershed. Province-wide trends, along with localized trends were both observed.

Sources of Water Quality Trends

Various water quality problems exist due to the wide variety of needs and preferences in society for the use of surface water. The complexity of aquatic ecosystems further complicates the attainment of acceptable water quality. The most common water quality problems include (Sanders et al., 2000):

- Eutrophication from the abundance of nutrients
- Oxygen depletion from the degradation of organic matter
- Hygienic problems from the existence of pathogenic organisms
- Salinization due to high concentrations of ions such as calcium, sodium and chloride
- Acidification from atmospheric deposition
- The persistence of heavy metals, organiochlorides and other toxins
- High turbidity and high amounts of suspended material
- Thermal pollution

The following table identifies possible causes behind the increasing and decreasing water quality trends observed in the province.

Table 2- Potential Factors Affecting Water Quality

Cause	Explanation	Parameters Affected
Climate Change	Streamflow has an important effect on the level of many water quality indicators. Peak flows have increased levels of suspended solids and related indicators, while low flows are associated with increased levels of dissolved ions.	Turbidity Major Ions Conductivity
Abatement	Through greater awareness people are: using less harmful household products and disposing of them safely, using phosphate-free soaps and detergents, reducing or eliminating use of fertilizers and pesticides on lawn and garden, checking and repairing fluid leaks from vehicles, not putting toxic chemicals down the drain, forming community stewardship groups to care for local waterbodies and provide stream enhancement, etc.; Phosphorous Control Act; move to unleaded gasoline; buffer zone regulations; using silt screens on construction sites.	Metals Nutrients Major Ions Turbidity pH Dissolved Oxygen Conductivity
Farming	Runoff from farms treated with manure, fertilizer, lime, pesticides, herbicides, etc.; farming practices such as land clearing, tillage,	Nutrients Metals

	ploughing, irrigation, grazing, feedlots and animal corrals; aquaculture.	pH Turbidity Major Ions Dissolved Oxygen
Forestry	Increased runoff from disturbed land, removal of vegetation, road construction and use, timber harvesting, etc.; silviculture practices.	Turbidity Colour
Urban Development	Urban runoff from roofs, streets, parking lots, etc. carries by-products of human activity into receiving waters; overflow, cross-connections and leakage from sewer mains; corrosion of water pipes; local industries and businesses may discharge wastes to street gutters and storm drains; street cleaning; road salting; land clearing for new development and construction; water withdrawals; lawn care.	Nutrients Metals Turbidity Major Ions pH
Rural Sewage Systems	Overloading and malfunction of septic systems from rural housing or cabin developments.	Nutrients
Transportation	Roads, railways, pipelines, hydro-electric corridors, bridges, etc.; chemicals from motor vehicles.	Nutrients Turbidity Metals
Mining	Runoff from mines and mine wastes, quarries and test well sites; residuals from nitrogen-based explosives; acid mine drainage.	Turbidity pH Metals Major Ions Dissolved Oxygen
Landfill	Seepage from landfills and hazardous waste facilities. Deposition from incinerators.	Nutrients Metals pH Dissolved Oxygen
Recreation	Large variety of recreational land uses including ski resorts, boating and marinas, campgrounds, parks, tourist chalets, golf courses, hunting, cabin development, ATV and snowmobile trails, etc.	Nutrients Turbidity Metals
Atmospheric Deposition	Long range transport of atmospheric pollutants and deposition on land and water surfaces; acid rain; also reduction in atmospheric pollutants through international initiatives such as the ban on leaded gasoline.	Nutrients Metals pH Major Ions
Industry	Wastes and sludge from industries such as pulp and paper mills, saw mills, smelting, metal production or plating, etc.	Metals Colour Dissolved Oxygen
Sewage	Disposal of liquid wastes from municipal wastewater effluents, sewage sludge, industrial effluents and sludge, wastewater from home septic systems, cross-connections; legal and illegal dumping in water courses.	Nutrients Metals Turbidity Dissolved Oxygen
Stream Modification	Stream alterations such as dams, weirs, bridges, culverts, armoring, fish ladders, dredging, channelization; nutrients settle with suspended sediments in reservoirs while scouring occurs downstream of dams, flowing streams slow to form slack water pools.	Metals Dissolved Oxygen Nutrients Turbidity
Natural Sources	Local waterfowl populations; local geology; soil chemistry; forest fires; synergistic effects; flow conditions.	Major Ions Nutrients Metals Dissolved Oxygen pH Conductivity

It should be restated that the link between observed water quality trends and possible causes made in this report are not definitive. The purpose of linking possible causes to effects is for continuity, so that water quality trends will not be viewed in a vacuum. The suggested causes and their impact on water quality, however, have been well documented in the past in watersheds in other jurisdictions. The assumption of causes made here are reasonable, based on similar observances and known characteristics and activity in the watershed.

Agreement Datasets Used for Trend Analysis

The Agreement datasets fell into 4 categories:

i) *Full Data Sets*- datasets with over 29 data points and greater than 6 years of data for each month of the year (for 6 or more individual months) for all parameters of interest

ii) *Partial Temporal Data Sets*- datasets with over 29 data points but less than 6 years of data for each month of the year for all parameters of interest

iii) *Partial Parameter Data Sets*- datasets with more than 29 data points and greater than 6 years of data for each month of the year (for 6 or more individual months) for some of the parameters of interest

iv) *Incomplete Data Sets*- datasets with less than 29 data points for all parameters of interest, not included in the analysis

The following tables describe which of the above categories all Agreement datasets fall into by region, including the period of record for each site.

Table 3- Categories of Agreement Sites in the Eastern Region Including Period of Record

Full Data Set	Partial Data Set-Temporal	Partial Data Set-Parameter	Incomplete Data Set
Waterford River- NF02ZM0009 Oct 1986-Oct 1999	Kellys Brook- NF02ZM0144 Dec 1990-Oct 1999	Pipers Hole River- NF02ZH0001 Jan 1986-Jun 2000	Waterford River- NF02ZM0182 Aug 1998-Oct 1999
Virginia River- NF02ZM0014 Oct 1986-Oct 1999	Garnish River- NF02ZG0016 Feb 1986-Aug 2000	Rocky River- NF02ZK0001 Jan 1986-Oct 2000	Waterford River- NF02ZM0175 Aug 1997-Oct 1999
Rennies River- NF02ZM0016 Oct 1986- Oct 1999	Mundy Pond- NF02ZM0109 Oct 1991-Aug 1999		South Brook- NF02ZM0185 Aug 1998-Oct 1999
Quidi Vidi Outlet- NF02ZM0015 Oct 1986-Oct 1999			South Brook- NF02ZM0176 Aug 1997-Oct 1999
Broad Cove Brook- NF02ZM0020 Oct 1986-Jun 1998			Waterford River- NF02ZM0181 Aug 1998-Oct 1999
Goulds Brook- NF02ZL0029 Jun 1989-Oct 1999			Virginia River- NF02ZM0098 Aug 1998-Oct 1999
Grand Bank Brook- NF02ZG0026 Jun 1989- Oct 1996			Virginia River- NF02ZM0180 Aug 1998-Oct 1999
Hearts Content Brook- NF02ZL0002 Oct 1986- Apr 1998			Virginia River- NF02ZM0179 Aug 1998-Oct 1999
Mobile River- NF02ZM0018 Oct 1986-Mar 1997			Learys Brook- NF02ZM0184 Aug 1998-Oct 1999
Northeast River- NF02ZK0005 Nov 1986-Oct 1999			Learys Brook- NF02ZM0178 Aug 1998- Oct 1999
Northwest Brook- NF02ZN0002			Rennies River- NF02ZM0177

Oct 1986-Aug 1999			Aug 1998-Oct 1999
Rattle Brook- NF02ZG0025 Oct 1986-Oct 1995			Kelligrews River- NF02ZM0183 Jul 1998-Oct 1999
Salmonier River- NF02ZN0004 Aug 1987-Oct 1999			Nut Brook- NF02ZM0186 Oct 1998- Aug 1999
Seal Cove River- NF02ZM0019 Oct 1986-Jun 1995			Waterford River- NF02ZM0004 Mar 1999-Oct 1999
Spout Cove Brook- NF02ZL0001 Oct 1986-Jun 1995			
Tides Brook- NF02ZG0024 Oct 1986-Aug 1999			
Raymond Brook- NF02ZM0017 Oct 1986-Aug 1999			

Table 4- Categories of Agreement Sites in the Central Region Including Period of Record

Full Data Set	Partial Data Set-Temporal	Partial Data Set-Parameter	Incomplete Data Set
Terra Nova River- NF02YS0012 Aug 1986-Aug 1995	Bay du Nord River- NF02ZF0020 May 1989-Aug 1995	Exploits River- NF02YO0001 Jan 1986-Sept 1999	Corduroy Brook- NF02YO0142 Mar 1995-Sept 1999
Bread Cove Brook- NF02YS0010 Aug 1986- Dec 1995	Jeddore Lake- NF02ZE0018 May 1989-July 1996	Indian Brook- NF02YM0001 Jan 1986-Mar 1997	Star Brook- NF02YN0036 Apr 1995-May 1997
Southern Bay River- NF02ZJ0024 Aug 1986-Aug 1999	Middle Brook- NF02YR0021 May 1989-Sept 1999		Exploits River- NF02YO0143 Mar 1999-Sept 1999
North West Gander River- NF02YQ0006 Aug 1986-Sept 1999	Exploits River- NF02YO0021 Nov 1986-Sept 1999		Exploits River- NF02YO0128 Mar 1999-Sept 1999
Gander River- NF02YQ0005 Aug 1986-Apr 1994			Northwest River- NF02YS0083 May 1999-Sept 1999
Pound Cove Brook- NF02YR0001 Aug 1986-Sept 1999			
Gander River- NF02YQ0030 Aug 1989-Sept 1999			
South West Brook- NF02YM0004 Aug 1986-July 1999			
Terra Nova River- NF02YS0001 Aug 1986-Sept 1999			
Exploits River- NF02YO0020 Aug 1986-Sept 1999			
Exploits River- NF02YO0107			

May 1989-Sept 1999			
Southwest Brook- NF02YS0005 Aug 1986-Sept 1999			
Terra Nova River NF02YS0011 Aug 1986-Sept 1999			

Table 5- Categories of Agreement Sites in the Western Region Including Period of Record

Full Data Set	Partial Data Set- Temporal	Partial Data Set- Parameter
Western Brook- NF02YE0005 Aug 1986-Jul 1999	Humber Canal- NF02YK0022 Apr 1989-Apr 1995	Harrys River- NF02YJ0006 Jan 1986-Sep 1998
Upper Humber- NF02YL0011 Aug 1986-Jun 1999	Wild Cove Brook- NF02YL0029 Jan 1989-Jul 1999	Grandys Brook- NF02ZC0001 Jan 1986-Oct 1999
Lower Humber- NF02YL0012 Aug 1986-Jun 1999	Ste Genevieve River- NF02YA0001 Jan 1989-Apr 1999	Grey River- NF02ZD0003 Jan 1986-Oct 1999
Lloyds River- NF02YN0001 Aug 1986-Apr 1997	White Bear River- NF02ZC0011 Jan 1989-Feb 1996	Isle aux Mort River- NF02ZB0001 Jan 1986-Sep 1999
Pinchgut Brook- NF02YJ0004 Aug 1986-Mar 1999		Torrent River- F02YC0001 Jan 1986-May 1999
Grand Codroy River- NF02ZA0006 Aug 1986-Mar 1999		
South Branch River- NF02ZA0001 Aug 1986-Jan 1997		
Cing Cerf Brook- NF02ZB0005 Dec 1986-Jun 1999		
Corner Brook- NF02YL0013 Aug 1986-Jul 1999		
Crabbes River- NF02ZA0007 Aug 1987-Mar 1999		
Lomond River- NF02YH0018 Aug 1986-Jul 1999		
Main River-NF02YG0001 Aug 1986-Apr 1999		
Portland Creek- NF02YE0004 Aug 1986-Feb 1997		

Table 6- Categories of Agreement Sites in the Labrador Region Including Period of Record

Partial Data Set- Temporal and Parameter	Incomplete Data Set
Churchill Falls- NF03OE0001 Jun 1986-Sep 2000	Naskaupi River- NF03PB0025 Oct 1998-Aug 2000
Eagle River- NF03QC0001 Jan 1986- Feb 2000	Little Mecatina River- NF02XA0001 Jan 2000-
	Ugjoktok River- NF03NF0013 Mar 1999-Aug 2000
	Atikonak River- NF03OC0012 Mar 1999-Jul 2000
	East Metchin River- NF02OD0011 Mar 1999-Dec 2000
	Minipi River- NF03OE0030

	Aug 1999-Jan 2000
	Pinus River- NF03OE0032 Aug 1999-Mar 2000
	Big Pond Brook- NF03OE0033 Aug 1999-
	Alexis River- NF03QC0002

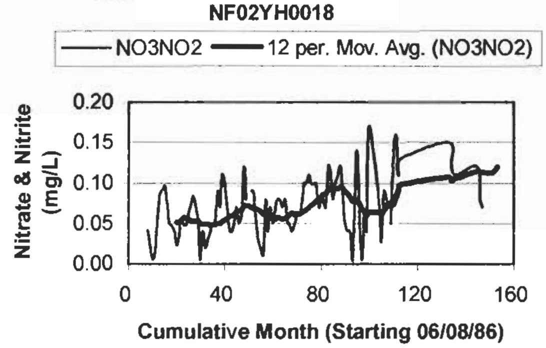
Descriptive Statistics

Descriptive statistics of all water quality parameters for each Agreement sampling site, and a table of water quality parameter codes can be found in Appendix B. These tables provide useful summary information on the Agreement water quality data sets and are helpful for initial analyses. For example, a skewness value close to zero denotes a normal distribution. The majority of parameters do not have a skewness value close to zero.

12-Month Moving Averages

Time series plots, including the calculated 12-month moving averages, of all water quality parameters for each Agreement sampling site can be found in Appendix C. These plots support the observations of trend discussed below through visual inspection of the 12-month moving average trendline. Outliers and extreme values can also be observed by visual inspection of the time series plots. Parameters with the most frequent occurrence of outliers included: copper, zinc, turbidity, chromium, phosphorous, and nitrate/nitrite.

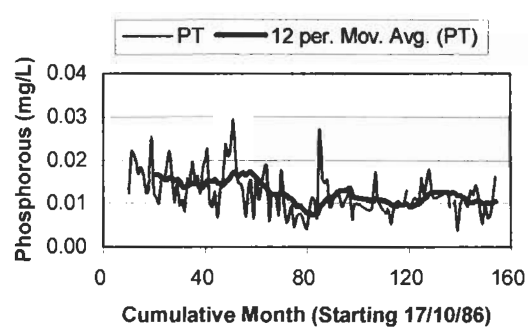
Figure 2: Nitrate/Nitrite Time Series-NF02YH0018

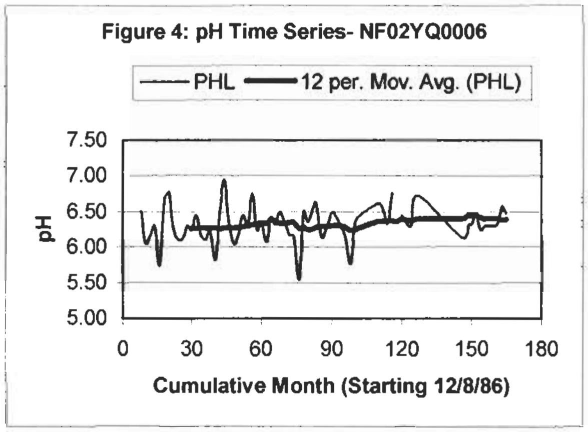


The adjacent figure illustrates increasing concentration in nitrate/nitrite over time, indicating a deteriorating trend in this parameter for Lomond River, located in the Western Region of the province. The cause of this increasing trend is most likely due to intensive cabin development around Bonne Bay Big Pond and Bonne Bay Little Pond, and problems associated with rural septic systems.

The figure to the right illustrates decreasing concentration in phosphorous over time, indicating an improving trend in this parameter for Quidi Vidi Lake at the outlet. This site is located in the Eastern Region of the province. The cause of this decreasing trend is due to control measures limiting the use of phosphorous in detergents and such implemented in the mid 1970's. Over time these control measures continued to grow stricter.

Figure 3: Phosphorous Time Series-NF02ZM0015





The figure to the left illustrates no change in pH over the period of record, indicating neither an improving nor deteriorating trend in this parameter for North West Gander River, located in the Central Region of the province.

Spearman Trend Analysis

Spearman trend analysis of the entire data series of each parameter for all Agreement water quality sampling sites can be found in Appendix D. For data sets of $n > 29$, values of the test statistic (t_t) between 0.196 and -0.196 are not significant, indicating no trend. Values of t_t greater than 0.196, or less than -0.196, indicate changes in that specific parameter over time at a certain rate.

Parameters with a highly significant test statistic values ($t_t < -3.5$ or $t_t > 3.5$) were observed in all regions except Labrador. Many parameters in the Eastern Region had three or more highly significant test statistic values, most notably nitrogen with seven, turbidity with nine, and molybdenum with ten. The highest test statistic value in the Eastern region was for potassium (-9.771) at Tides Brook. Many parameters in the Central Region had at least one highly significant test statistic value. Conductivity had the most at eight, followed by sodium at seven. The sampling site at Exploits River below Millertown Dam had very high test statistic values, with the highest for the region being for zinc (-20.394). Three parameters in particular dominated the Western Region for highly significant test statistic values- sodium with seven, turbidity with ten, and mercury with fourteen. The highest test statistic value in the Western region was for sodium (-10.329) at Portland Creek.

Monthly Spearman Trend Analysis

Matrices of monthly Spearman correlation coefficients for each parameter for all Agreement water quality sampling sites can be found in Appendix E. The Spearman correlation coefficient values are marked by stars (*) to indicate their level of significance. Parameters such as conductivity, colour, turbidity, sodium, and mercury frequently displayed the highest number of significant values.

Overall Trend

Tables summarizing the observed trends from the time series plots of 12-month moving averages, the Spearman trend analysis on the entire data sets, and the monthly spearman trend analysis for each parameter for all Agreement water quality sampling sites can be found in Appendix F. The three methods used here reinforce each other by either showing a consistent downward trend, upward trend, or no discernable trend at all. At no point were opposite trends indicated by the analysis. Generally, the more significant the overall Spearman trend, as indicated by the test statistic value, the higher the probability all three analysis methods agreed.

Provincial maps indicating the existence of improving, deteriorating or no observed trend for each parameter, for each Agreement water quality site, can be found in Appendix G.

Universal Trends Throughout the Province

Amongst the different parameters and parameter groupings several overall trends were detected. For this analysis, major ions were ignored individually, as they contribute collectivity to conductivity. Some of the observed trends include:

- A decrease (or improving trend) in **conductivity** and by extension, major ion concentration, (**calcium, sodium, magnesium, potassium, sulphate, chloride**) throughout the province.
- An increase (or deteriorating trend) in **colour** throughout the province.
- An increase (or deteriorating trend) in **turbidity** throughout the province.
- An increase (or deteriorating trend) in **nitrate/nitrite** and **nitrogen** throughout the province.
- A decrease (or improving trend) in **arsenic** throughout the province, more significantly in South Coast Rivers including the Avalon.
- A decrease (or improving trend) in **barium** throughout the province.
- An increase (or deteriorating trend) in **beryllium, cadmium** and **molybdenum** throughout the province. However, these three parameters had the highest occurrence of censored data that is believed to have had some influence on the trend analysis.
- A decrease (or improving trend) in **copper** throughout the province.
- A decrease (or improving trend) in **mercury** throughout the province.
- A decrease (or improving trend) in **lead** throughout the province.
- A decrease (or improving trend) in **phosphorous** in rivers of the Central and Easter Region.
- The occurrence of trend in **cobalt** and **manganese** (all showed a majority of improving trends) is most apparent in water quality stations from the Eastern Region.
- An increase (or deteriorating trend) in **nickel** in rivers in non-urban areas of the Avalon and eastern rivers of the Central Region.
- An increase (or deteriorating trend) in **sulphate** in urban rivers of St. John's.
- Frequent improving trends in **zinc**, **strontium**, **lithium**, and **selenium** throughout the province.

The following two figures give an indication of the observed universal trends for color and mercury throughout the province.

Figure 5: Trends in Colour in Canada-NL Water Quality Monitoring Agreement Sites

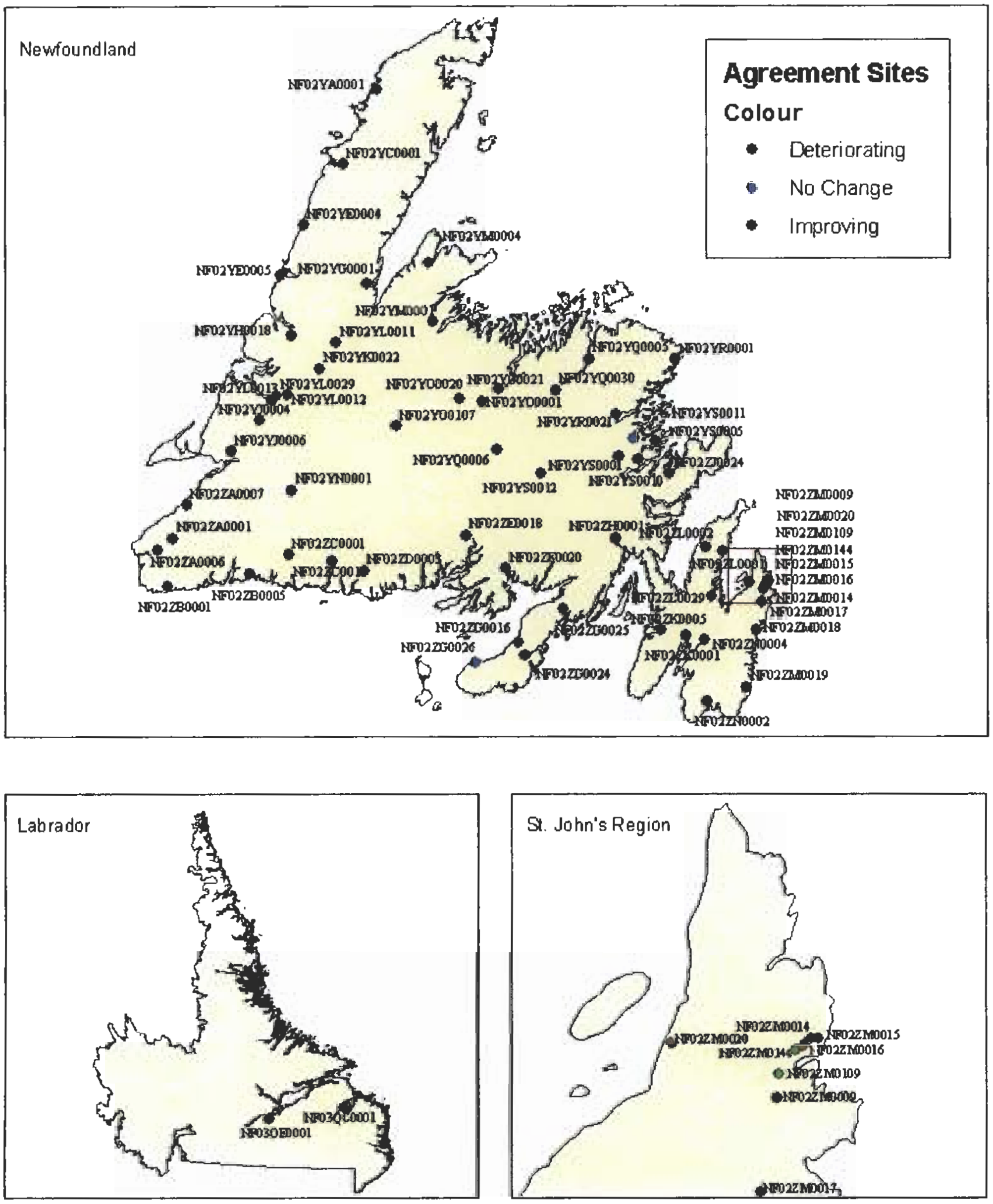
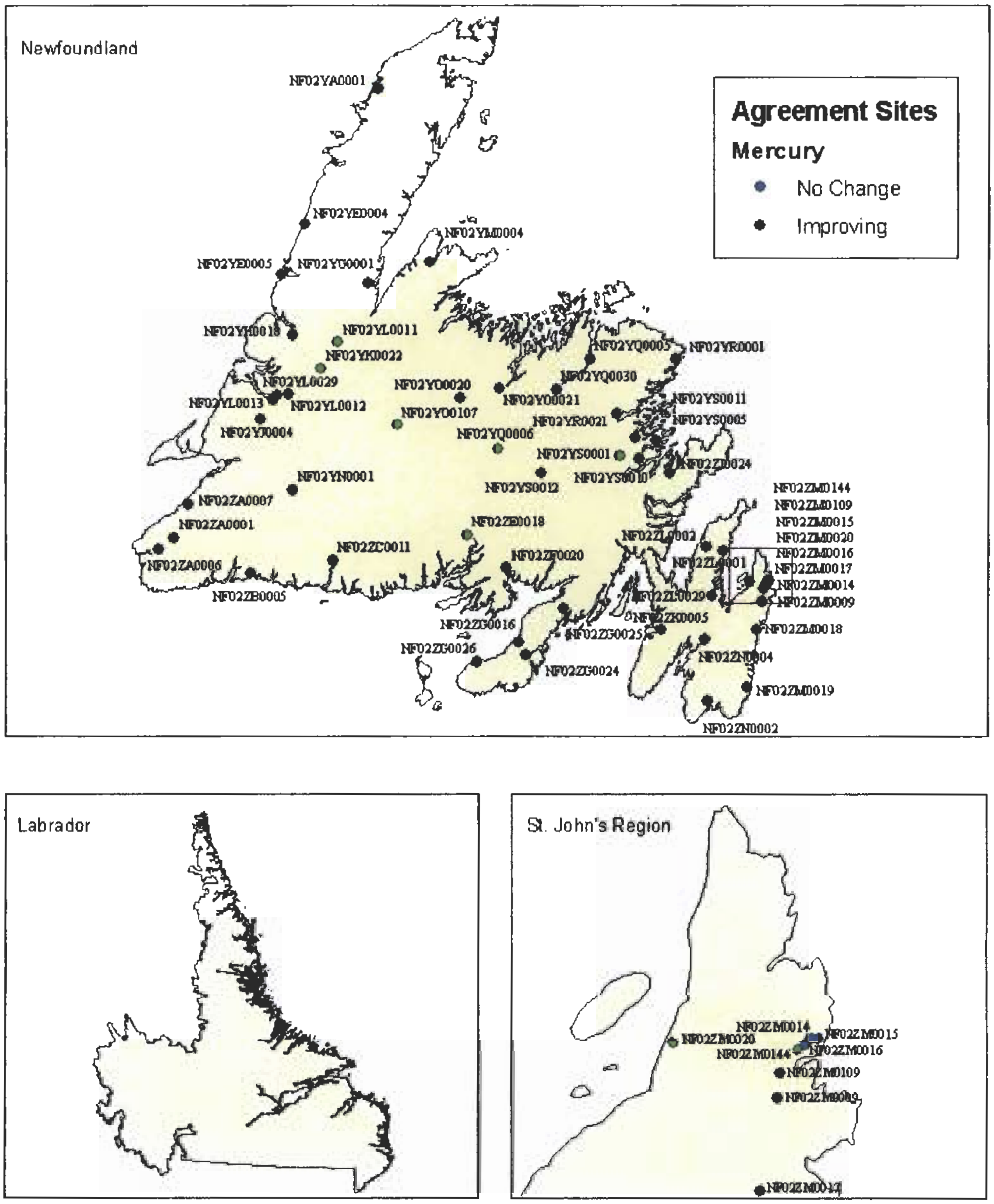


Figure 6: Trends in Mercury in Canada-NL Water Quality Monitoring Agreement Sites



Universal Sources of Water Quality Trends

To understand what could be causing observed trends in water quality parameters, watershed activities and levels of development for each river of interest were cross-referenced with known sources of water quality trends. The Department of Environment has catalogued watershed activities in a site documentation database. Several noticeable occurrences emerged from this analysis:

- Representative plots of precipitation since 1986 were generated for each region of the province (see Appendix H). From each region there was a noticeable upward trend in precipitation since 1986. In pristine watersheds where there was little development or activity, trends were frequently observed in major ions (and conductivity), turbidity, and colour. As these trends were observed in all regions of the province, their cause was linked to climate change. Increased precipitation leads to increased runoff, which in turn leads to decreased concentrations of major ions (and conductivity) and increased sediment loads, affecting turbidity and colour.

- Monitoring in pristine Arctic environments has revealed the presence of contaminants far from their source as a result of atmospheric deposition. Recent observations have shown reductions in lead levels, linked to reduced global emissions of lead into the atmosphere from leaded gasoline, since the 1970's. It has also revealed declining trends in zinc, declining trends in copper since 1991, and declining trends in mercury since 1990 (Indian & Northern Affairs Canada, 1997). These results were mirrored in many of the more pristine watersheds of Newfoundland. Copper, mercury and lead (and to a lesser extent barium, zinc, selenium, and arsenic) frequently displayed improving trends in watersheds with little human activity or development. The cause of these trends is most likely linked to reductions in the levels of contaminants from atmospheric deposition, due to improved emissions from pollution sources- local, continental and global.

- Phosphorous Control Acts were implemented in the mid 1970's and continued to reduce the amounts of phosphorous used in detergents throughout the 1980's. The results of this abatement are most evident in more populated urban areas (particularly St. John's).

- There are several river stewardship programs or societies, which try to promote, encourage, and maximize the ecological value of different rivers in the province. Such rivers include Virginia River, Rennies River, Waterford River, Cordroy Brook, and Corner Brook. These river societies plan river enhancement activities, including river restoration to facilitate fish spawning, alleviation of pollution, and the development of appropriate public access to the system. In many rivers, such programs have led to improved water quality through increased public awareness of harmful activities.

Rivers Displaying Similar Trends

A brief analysis was also performed to determine if there were any similarities in the observed trends of different rivers. In several cases, rivers with similar geography, or levels of watershed activity displayed remarkably similar trends. Groupings of rivers with observed similarities in water quality trends include:

- Significant improvements in water quality were observed in both Kelly's Brook and Mundy Pond, both urban sites located in St. John's.
- The St. John's urban Rennies River, Waterford River, Virgina River and Quidi Vidi Lake all displayed similar trends in the same water quality parameters.
- Rivers on the Burin Peninsula including Rattle Brook, Garnish River and more significantly Tides Brook and Grand Bank Brook displayed similar trends in the same water quality parameters.
- Rivers on the Avalon including Goulds Brook, Broad Cove Brook, Raymond Brook, Mobile River, Seal Cove River, Northwest Brook and Salmonier River displayed moderately similar trends in the same water quality parameters.
- Water quality stations throughout the Exploits River basin displayed similar trends, however, sites in the upper basin had a higher degree of similarity with each other, as did sites in the lower portion of the basin.
- Rivers in the Bonavista-Terra Nova-Trinity region including Pound Cove Brook, Middle Brook, Bread Cove Brook and South West Brook at Terra Nova National Park, and Southern Bay River all displayed similar trends in the same water quality parameters.
- In the Bay d'Espoir area of the South Coast, Bay du Nord River and Jeddore Lake displayed similar trends in the same water quality parameters.
- There was significant similarity in observed water quality trend characteristics in the Humber Valley-Gros Morne region. Observed groupings include: Western Brook, Portland Creek, Main

River and Lomond Brook; Upper Humber River, Lower Humber River and Humber Canal; Corner Brook and Pinchgut Brook. The rivers within groupings displayed more particular similarities, but links were also observed between groupings.

- Rivers along the South Coast including Cing Cerf Brook, White Bear River, Grandys Brook and Grey River displayed moderately similar trends in the same water quality parameters.
- Rivers in the St. George's region including Lloyds River, Crabbes River, South Branch River and Grand Codroy River displayed moderately similar trends in the same water quality parameters.
- Rivers in Labrador including Churchill River and Eagle River displayed moderately similar trends in the same water quality parameters.

Eastern Rivers

The following sections summarize results for the rivers of the Eastern Region of the province.

Hearts Content Brook

Hearts Content Brook displayed deteriorating colour and turbidity. It displayed deteriorating DOC. It also displayed deteriorating beryllium, cadmium and molybdenum. There was an improving trend in phosphorous. There was also an improving trend in barium, copper, mercury, lead, and selenium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, and also increasing turbidity, colour, and DOC. Small scale domestic harvesting of wood may also be affecting colour, turbidity and DOC. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Reductions in atmospheric deposition have affected metals such as copper, mercury and lead, and are likely influencing barium and selenium levels.

Table 7- Trend Summary for Hearts Content Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	**Climate Change**	Colour	**Climate Change/Forestry**
Phosphorous	**Abatement**	Turbidity	**Climate Change/Forestry**
Barium	**Atmospheric Deposition**	Dissolved Organic Carbon	**Climate Change/Forestry**
Copper	**Atmospheric Deposition**	Beryllium	**Censored**
Mercury	**Atmospheric Deposition**	Cadmium	**Censored**
Lead	**Atmospheric Deposition/ Abatement**	Molybdenum	**Censored**
Selenium	**Atmospheric Deposition**		

Spout Cove Brook

Spout Cove Brook displayed deteriorating colour and turbidity. It displayed deteriorating DOC. It also displayed deteriorating iron and manganese. There was an improving trend in conductivity. There was an improving trend in phosphorous. There was also an improving trend in arsenic, mercury, lead, barium, copper, selenium, strontium, and vanadium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and the concentration of major ions, while increasing turbidity, colour and DOC. Small scale domestic harvesting of wood may also be affecting colour, turbidity and DOC. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Reductions in atmospheric deposition have affected metals such as copper, mercury and lead. Other improving trends in metals are attributed to atmospheric deposition, however other factors may have contributed. The cause of deteriorating trends in iron and manganese is unknown.

Table 8- Trend Summary for Spout Cove Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	**Colour**	**Climate Change/Forestry**
Sodium	**Climate Change**	**Turbidity**	**Climate Change/Forestry**

Magnesium	Climate Change	Dissolved Organic Carbon	Climate Change/Forestry
Chloride	Climate Change	Iron	Unknown
Phosphorous	Abatement	Manganese	Unknown
Arsenic	Atmospheric Deposition		
Barium	Atmospheric Deposition		
Copper	Atmospheric Deposition		
Mercury	Atmospheric Deposition		
Molybdenum	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Selenium	Atmospheric Deposition		
Strontium	Atmospheric Deposition		
Vanadium	Atmospheric Deposition		

Goulds Brook

Goulds Brook displayed deteriorating conductivity and colour. It also displayed a deteriorating trend in beryllium, cadmium, chromium, molybdenum, nickel, strontium and zinc. There was an improving trend in phosphorous, nitrate/nitrite and nitrogen. There is also an improving trend in aluminum, cobalt and manganese.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions like potassium, while increasing colour. The use of road salt on transportation corridors in this basin may be affecting conductivity, sodium and chloride. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. The cause of improving trends in metals such as aluminium, cobalt and manganese is most likely due to general abatement practices. Deteriorating trends in sulphate and metals like chromium, nickel, strontium and zinc are probably linked to urban development and transportation corridors located in the basin. The cause of improving nitrate/nitrite and nitrogen levels is unknown.

Table 9- Trend Summary for Goulds Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Potassium	Climate Change	Colour	Climate Change
Phosphorous	Abatement	Conductivity	Transportation
Nitrate & Nitrite	Unknown	Sodium	Transportation
Nitrogen	Unknown	Chloride	Transportation
Aluminium	Abatement	Sulphate	Unknown / Urban Development
Cobalt	Abatement	Beryllium	Censored
Manganese	Abatement	Cadmium	Censored
		Molybdenum	Censored
		Chromium	Transportation/ Urban Development
		Nickel	Transportation/ Urban Development
		Strontium	Transportation/ Urban Development
		Zinc	Transportation/ Urban Development

Broad Cove Brook

Broad Cove Brook displayed deteriorating conductivity, colour and turbidity. It displayed deteriorating nitrogen. It also displayed deteriorating barium, beryllium, cadmium, lithium, molybdenum, nickel and zinc. There were improving trends in copper and mercury.

Reductions in atmospheric deposition have affected metals such as copper and mercury. Urban development has affected colour, turbidity, and increased levels of other metals such as barium, lithium, nickel, and zinc. The application of road salt has also affected major ion and conductivity levels. Farming activities in the basin may be linked to increasing levels of nitrogen. The degree of urbanization in this basin has increased in recent years, and has had a negative impact on water quality.

Table 10- Trend Summary for Broad Cove Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Copper	Atmospheric Deposition	Conductivity	Urban Development/ Transportation
Mercury	Atmospheric Deposition	Colour	Urban Development
		Turbidity	Urban Development
		Sodium	Transportation
		Chloride	Transportation
		Nitrogen	Farming
		Beryllium	Censored
		Cadmium	Censored
		Molybdenum	Censored
		Barium	Urban Development
		Lithium	Urban Development
		Nickel	Urban Development
		Zinc	Urban Development

Virginia River @ Outlet to Quidi Vidi

Virginia River displayed deteriorating colour and turbidity. It displayed deteriorating trends in nitrate/nitrite and nitrogen. It also displayed a deteriorating trend with molybdenum. There was an improving trend in pH. There was an improving trend in phosphorous. There were also improving trends in barium, beryllium, cobalt, selenium, strontium and zinc.

This site is located in the heart of St. John's and is heavily affected by urban development. The Virginia River Conservation Society has spearheaded the cleanup of this system promoting river enhancement and abatement of pollution causing practices. These activities have led to improving trends in metals such as barium, beryllium, cobalt, selenium, strontium and zinc. Abatement practices along with natural limestone geology, and lime application on lawns may have also influenced pH. Climate change has affected major ion concentration. Urban development, a couple of quarries, and extensive stream modification have influenced colour and turbidity. Increased nitrogen and nitrate/nitrite levels are also influenced by urban activities including fertilizing lawns and the presence of a major golf course.

Table 11- Trend Summary for Virginia River at Outlet to Quidi Vidi

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Abatement/ Urban Development/ Natural Sources	Colour	Urban Development
Calcium	Climate Change	Turbidity	Urban Development / Mining/ Stream Modification
Magnesium	Climate Change	Sulphate	Urban Development
Phosphorous	Abatement	Nitrate & Nitrite	Urban Development / Recreation
Barium	Abatement	Nitrogen	Urban Development / Recreation
Beryllium	Abatement	Molybdenum	Censored
Cobalt	Abatement		
Selenium	Abatement		
Strontium	Abatement		
Zinc	Abatement		

Kelly's Brook

Kelly's Brook displayed a deteriorating trend in phosphorous. There was an improving trend in conductivity and colour. There was an improving trend in nitrogen. There were also improving trends in barium, beryllium, cadmium, cobalt, copper, iron, mercury, lithium, manganese and strontium.

Kelly's Brook had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Kelly's Brook is a highly polluted urban stream that has seen improvements in nearly all parameters as a result of cleanup of some sewer cross-connections, various abatement measures practiced by the population of St. John's, and a reduction in leachate over time from the old town landfill located in its headwaters. The stream is also entirely culverted, which may also be affecting some parameters. Phosphorous levels may be increasing as a result of urban activities, such as fertilizer application on the soccer and baseball fields in the Kelly's Brook headwaters, or sewer cross-connections.

Table 12- Trend Summary for Kelly's Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Colour	Stream Modification	Phosphorous	Urban Development/ Sewage
Conductivity	Stream Modification		
Calcium	Stream Modification		
Magnesium	Stream Modification		
Potassium	Stream Modification		
Sulphate	Stream Modification		
Chloride	Stream Modification		
Nitrogen	Stream Modification/ Abatement		
Barium	Stream Modification/ Abatement		
Beryllium	Stream Modification/ Abatement		
Cadmium	Stream Modification/ Abatement		
Cobalt	Stream Modification/ Abatement		
Copper	Stream Modification/ Abatement		
Iron	Stream Modification/ Abatement		
Mercury	Stream Modification/ Abatement		
Lithium	Stream Modification/ Abatement		
Manganese	Stream Modification/ Abatement		
Strontium	Stream Modification/ Abatement		

Rennies River @ Carnell Dr

Rennies River displayed a deteriorating trend in colour and turbidity. It displayed a deteriorating trend in DOC, nitrate/nitrite and nitrogen. It also displayed a deteriorating trend in lithium and molybdenum. There was an improving trend in pH. There was an improving trend in phosphorous. There was also an improving trend in barium, cadmium, cobalt, iron, manganese, lead and strontium.

This site is located in the heart of St. John's and is heavily affected by urban development. The Quidi Vidi-Rennies River Development Foundation has spearheaded the cleanup of this system promoting river enhancement and abatement of pollution causing practices. These activities have led to improving trends in metals such as barium, cadmium, cobalt, iron, manganese, lead and strontium. Abatement practices along with natural limestone geology, and lime application on lawns and farm fields may have also influenced pH. Climate change has affected major ion concentration. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Urban development has influenced colour, turbidity, sulphate and lithium. Increased nitrogen, nitrate/nitrite and DOC levels are influenced by urban activities such as lawn fertilizing, farming and a major golf course located in the basin.

Table 13- Trend Summary for Rennies River at Carnell Drive

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Farming/ Abatement/ Urban Development / Natural Sources	Colour	Urban Development
Magnesium	Abatement/ Climate	Turbidity	Urban Development

	Change		
Phosphorous	Abatement	Sulphate	Urban Development
Barium	Abatement	Dissolved Organic Carbon	Urban Development / Farming/ Recreation
Cadmium	Abatement	Nitrate & Nitrite	Urban Development / Farming/ Recreation
Cobalt	Abatement	Nitrogen	Urban Development / Farming/ Recreation
Iron	Abatement	Lithium	Urban Development
Manganese	Abatement	Molybdenum	Censored
Lead	Abatement/ Atmospheric Deposition		
Strontium	Abatement		

Mundy Pond

Mundy Pond displayed a deteriorating trend in DOC. There was an improving trend in conductivity, colour and turbidity. There was an improving trend in nitrogen. There were also improving trends in barium, beryllium, cadmium, cobalt, iron, lithium, manganese, strontium and zinc.

Mundy Pond had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Mundy Pond is a highly polluted urban waterbody that has seen improvements in nearly all parameters as a result of various abatement measures practiced by the population of St. John's. Dredging has occurred in Mundy Pond to remove gravel and debris, which may have resulted in increased dilution and mixing of parameters, and increased settling time. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and the concentration of major ions. DOC levels may be increasing as a result of urban activities affecting natural organic decay.

Table 14- Trend Summary for Mundy Pond

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Abatement/ Stream Modification/ Climate Change	Dissolved Organic Carbon	Urban Development/ Natural Sources
Magnesium	Abatement/ Stream Modification/ Climate Change		
Potassium	Abatement/ Stream Modification/ Climate Change		
Colour	Abatement/ Stream Modification		
Turbidity	Abatement/ Stream Modification		
Nitrogen	Abatement/ Stream Modification		
Barium	Abatement/ Stream Modification		
Beryllium	Abatement/ Stream Modification		
Cadmium	Abatement/ Stream Modification		
Cobalt	Abatement/ Stream Modification		
Iron	Abatement/ Stream Modification		
Lithium	Abatement/ Stream Modification		
Manganese	Abatement/ Stream Modification		
Strontium	Abatement/ Stream Modification		
Zinc	Abatement/ Stream Modification		

Waterford River @ Kilbride

Waterford River displayed deteriorating colour and turbidity. It displayed deteriorating DOC, nitrate/nitrite, nitrogen and silica. It also displayed deteriorating beryllium, lithium and molybdenum. There was an improving trend in pH. There was an improving trend in phosphorous. There was also an improving trend in cobalt, mercury, manganese and strontium.

This site is located within St. John's and is heavily affected by urban development. The Friends and Lobbyists of the Waterford River have spearheaded the cleanup of this system promoting river enhancement and abatement of pollution causing practices. These activities have led to improving trends in metals such as cobalt, mercury, manganese, and strontium. Reductions in levels of atmospheric deposition may also be affecting mercury. Abatement practices along with natural limestone geology, and lime application on lawns and farm fields may have also influenced pH. Climate change has affected major ion concentration. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Urban development and two major quarries have influenced colour, and turbidity. Urban development has also affected sulphate and lithium levels. Increased nitrogen, nitrate/nitrite, silica and DOC levels are influenced by a combination of urban activities such as lawn fertilizing, farming and sewage cross-connections.

Table 15- Trend Summary for Waterford River at Kilbride

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Farming/ Urban Development/ Abatement/ Natural Sources**	**Colour**	**Urban Development / Mining**
Magnesium	Abatement/Climate Change	Turbidity	Urban Development / Mining
Phosphorous	Abatement	Sulphate	Urban Development
Cobalt	Abatement	Dissolved Organic Carbon	Urban Development / Farming
Mercury	Abatement/ Atmospheric Deposition	Nitrate & Nitrite	Farming/ Sewage/ Urban Development
Manganese	Abatement	Nitrogen	Farming/ Sewage/ Urban Development
Strontium	Abatement	Silica	Urban Development / Farming
		Beryllium	Censored
		Molybdenum	Censored
		Lithium	Urban Development

Quidi Vidi Lake Outlet

Quidi Vidi Lake displayed deteriorating colour and turbidity. It displayed deteriorating DOC, nitrate/nitrite and nitrogen. It also displayed deteriorating molybdenum. There was an improving trend in pH. There was an improving trend in phosphorous. There were also improving trends in barium, cobalt, iron, manganese, lead and strontium.

This site is located in the heart of St. John's and is heavily affected by urban development. The Quidi Vidi-Rennies River Development Foundation and Virginia River Conservation Society have spearheaded the cleanup of this system promoting river enhancement and abatement of pollution causing practices. These activities have led to improving trends in metals such as barium, cobalt, iron, manganese, lead and strontium. Abatement practices along with natural limestone geology, and lime application on lawns and farm fields may have also influenced pH. Climate change has affected major ion concentration. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Urban development, stream modification and quarrying activity have influenced colour and turbidity. Increased nitrogen, nitrate/nitrite and DOC levels are influenced by a combination of urban activities including fertilizing lawns and the presence of two golf courses, farming and sewage cross-connections.

Table 16- Trend Summary for Quidi Vidi Lake Outlet

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Farming/ Abatement/ Urban Development/ Natural Sources**	Colour	**Urban Development / Mining/ Stream Modification**
Magnesium	**Abatement/ Climate Change**	Turbidity	**Urban Development / Mining/ Stream Modification**

Phosphorous	Abatement	Dissolved Organic Carbon	Urban Development / Farming
Barium	Abatement	Nitrate & Nitrite	Farming/ Sewage/ Recreation/ Urban Development
Cobalt	Abatement	Nitrogen	Farming/ Sewage/ Recreation/ Urban Development
Iron	Abatement	Molybdenum	Censored
Manganese	Abatement		
Lead	Abatement/ Atmospheric Deposition		
Strontium	Abatement		

Raymond Brook

Raymond Brook displayed deteriorating turbidity. It also displayed deteriorating beryllium, cadmium, molybdenum and nickel. There were improving trends in aluminium, arsenic, barium, cobalt, mercury, manganese and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, while increasing turbidity. Sub-urban development, wood harvesting and farming activity may also be affecting turbidity. Reductions in atmospheric deposition have affected metals such as arsenic, mercury and zinc. Other improving trends in metals are attributed to atmospheric deposition, however various abatement practices may have contributed. A combination of urban development and transportation corridors running through the basin has affected chloride and nickel levels.

Table 17- Trend Summary for Raymond Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Potassium	Abatement/ Climate Change	Turbidity	Urban Development/ Climate Change/ Forestry/ Farming
Aluminium	Abatement/ Atmospheric Deposition	Chloride	Urban Development/ Transportation
Arsenic	Abatement/ Atmospheric Deposition	Beryllium	Censored
Barium	Abatement/ Atmospheric Deposition	Cadmium	Censored
Cobalt	Abatement/ Atmospheric Deposition	Molybdenum	Censored
Mercury	Abatement/ Atmospheric Deposition	Nickel	Transportation/ Urban Development
Manganese	Abatement/ Atmospheric Deposition		
Zinc	Abatement/ Atmospheric Deposition		

Mobile River

Mobile River displayed deteriorating colour and turbidity. It also displayed deteriorating silica. There was an improving trend in conductivity. There were also improving trends in cobalt, mercury, manganese and lead.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and major ion concentration, while increasing turbidity, color and silica. Sewage outfall from a local high school, domestic wood harvesting and cabin development may also be affecting colour and turbidity. Reductions in atmospheric deposition have affected metals such as mercury and lead, and may also be influencing other improving metal trends.

Table 18- Trend Summary for Mobile River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Sewage/ Forestry/ Recreation
Sodium	Climate Change	Turbidity	Climate Change/ Sewage/ Forestry/ Recreation
Potassium	Climate Change	Silica	Climate Change
Chloride	Climate Change		
Cobalt	Atmospheric Deposition		
Mercury	Atmospheric Deposition		
Manganese	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		

Seal Cove River

Seal Cove River displayed a deteriorating trend in colour and turbidity. It also displayed deteriorating cobalt. There was an improving trend in phosphorous. There were also improving trends in chromium, copper, mercury and lead.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and increasing color and turbidity. Domestic wood harvesting and cabin development may also be affecting colour and turbidity. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Reductions in atmospheric deposition have affected metals such as copper, mercury and lead, and may also be influencing the improving trend in chromium. The cause of increasing cobalt is unknown.

Table 19- Trend Summary for Seal Cove River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Phosphorous	Abatement	Colour	Climate Change/ Forestry/ Recreation
Chromium	Atmospheric Deposition	Turbidity	Climate Change/ Forestry/ Recreation
Copper	Atmospheric Deposition	Cobalt	Unknown
Mercury	Atmospheric Deposition		
Lead	Atmospheric Deposition		

Northwest Brook

Northwest Brook displayed deteriorating colour and turbidity. It displayed deteriorating nitrogen. It also displayed deteriorating beryllium, cadmium, molybdenum, nickel and vanadium. There was an improving trend in conductivity. There were also improving trends in barium, copper, mercury and lithium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and potassium concentration, while increasing color and turbidity. Domestic wood harvesting may also be affecting colour and turbidity. Reductions in atmospheric deposition have affected metals such as copper and mercury, and may also be affecting barium and lithium. Nitrogen levels may be increasing due to leaking or faulty cabin septic systems. The cause of the increasing trend in nickel and vanadium is unknown.

Table 20- Trend Summary for Northwest Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Forestry
Potassium	Climate Change	Turbidity	Climate Change/ Forestry
Barium	Atmospheric Deposition	Nitrogen	Rural Sewage Systems

Copper	Atmospheric Deposition	Beryllium	Censored
Mercury	Atmospheric Deposition	Cadmium	Censored
Lithium	Atmospheric Deposition	Molybdenum	Censored
		Nickel	Unknown
		Vanadium	Unknown

Salmonier River

Salmonier River displayed deteriorating colour and turbidity. It displayed deteriorating nitrogen. It also displayed deteriorating arsenic, beryllium, cadmium, chromium, molybdenum and nickel. There were improving trends in pH and conductivity. There was an improving trend in phosphorous. There were also improving trends in aluminium, barium, iron, mercury, lithium, strontium and vanadium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and major ion concentration, while increasing color and turbidity. Domestic wood harvesting and cabin development may also be affecting colour and turbidity. Reductions in atmospheric deposition and various abatement practices have affected metal levels. The cause of the improving trend in pH is likely due to general abatement practices and/or natural sources. Sewage outfall from the Salmonier Correctional Institute and faulty cabin septic systems may be affecting nitrogen levels. Major transportation corridors running through the basin are influencing metals like arsenic, chromium and nickel.

Table 21- Trend Summary for Salmonier River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Abatement/ Natural Sources**	Colour	**Climate Change/ Forestry/ Recreation**
Conductivity	**Climate Change**	Turbidity	**Climate Change/ Forestry/ Recreation**
Sodium	**Climate Change**	Nitrogen	**Sewage**
Potassium	**Climate Change**	Beryllium	**Censored**
Chloride	**Climate Change**	Cadmium	**Censored**
Phosphorous	**Abatement**	Molybdenum	**Censored**
Aluminium	**Atmospheric Deposition/ Abatement**	Arsenic	**Transportation**
Barium	**Atmospheric Deposition/ Abatement**	Chromium	**Transportation**
Iron	**Atmospheric Deposition/ Abatement**	Nickel	**Transportation**
Mercury	**Atmospheric Deposition/ Abatement**		
Lithium	Atmospheric Deposition/ Abatement		
Strontium	Atmospheric Deposition/ Abatement		
Vanadium	Atmospheric Deposition/ Abatement		

Rocky River

Rocy River displayed deteriorating dissolved oxygen. It displayed deteriorating nitrate/nitrite and nitrogen. It also displayed deteriorating cadmium, chromium and copper. There was an improving trend in turbidity. There was also an improving trend in arsenic.

Rocky River had only a partial set of parameters in its dataset. Sewage outfall from the towns of Whitbourne and Markland, in addition to farming activity, lawn fertilizing, faulty septic systems and a golf course are affecting nitrogen and nitrate/nitrite levels. This nutrient loading is in turn affecting dissolved oxygen levels. Sub-urban development and major transportation corridors running through the basin are affecting chromium and copper levels. The cause of the improving trend in turbidity is unknown. Reductions in atmospheric deposition may be responsible for the trend in arsenic.

Table 22- Trend Summary for Rocky River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Turbidity	**Unknown**	**Dissolved Oxygen**	**Sewage**
Arsenic	**Atmospheric Deposition**	Nitrogen	**Sewage/ Farming/ Recreation/ Urban Development**
		Nitrate & Nitrite	**Sewage/ Farming/ Recreation/ Urban Development**
		Chromium	**Urban Development / Transportation**
		Copper	**Urban Development / Transportation**
		Cadmium	**Censored**

Northeast River

Northeast River displayed deteriorating nitrogen. It also displayed deteriorating beryllium, cadmium, molybdenum and nickel. There was an improving trend in pH. There was an improving trend in phosphorous. There were also improving trends in lithium, lead and strontium.

Natural limestone geology is influencing pH levels. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Reductions in atmospheric deposition are affecting metals like lead, and are likely influencing lithium and strontium levels. Transportation corridors running through the basin are affecting chloride and nickel levels. Farming and faulty cabin septic systems may be affecting nitrogen.

Table 23- Trend Summary for Northeast River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Natural Sources**	**Chloride**	**Transportation**
Phosphorous	**Abatement**	Nitrogen	**Farming/ Rural Sewage Systems**
Lithium	**Atmospheric Deposition**	Beryllium	**Censored**
Lead	**Atmospheric Deposition/ Abatement**	Cadmium	**Censored**
Strontium	**Atmospheric Deposition**	Molybdenum	**Censored**
		Nickel	**Transportation**

Pipers Hole River

Pipers Hole River displayed deteriorating colour. It also displayed deteriorating DOC and nitrogen. There was an improving trend in conductivity. There was also an improving trend in arsenic.

Pipers Hole River had only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and major ion concentration, while increasing color and DOC. Reductions in atmospheric deposition may have affected arsenic. Seepage from faulty cabin septic tanks may be affecting nitrogen levels.

Table 24- Trend Summary for Pipers Hole River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	Colour	**Climate Change**
Calcium	**Climate Change**	Dissolved Organic Carbon	**Climate Change**
Magnesium	**Climate Change**	Nitrogen	**Rural Sewage Systems**

Sulphate	Climate Change		
Chloride	Climate Change		
Arsenic	Atmospheric Deposition		

Rattle Brook

Rattle Brook displayed deteriorating turbidity. There was an improving trend in phosphorous. There were also improving trends in arsenic, chromium, copper, mercury, lead and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing major ion concentration, while increasing turbidity. Reductions in atmospheric deposition have affected metals such as copper, mercury, lead and zinc, and are likely influencing arsenic and chromium. Phosphorous control measures have lead to an improving trend in this parameter.

Table 25- Trend Summary for Rattle Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Potassium	Climate Change	Turbidity	Climate Change
Phosphorous	Abatement		
Arsenic	Atmospheric Deposition		
Chromium	Atmospheric Deposition		
Copper	Atmospheric Deposition		
Mercury	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Zinc	Atmospheric Deposition		

Tides Brook

Tides Brook displayed deteriorating colour and turbidity. It displayed deteriorating nitrogen. It also displayed deteriorating cobalt, iron and molybdenum. There was an improving trend in conductivity. There was an improving trend in nitrate/nitrite. There were also improving trends in barium, copper, mercury, lead, strontium and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and major ion concentration, while increasing colour and turbidity. Quarrying activity may also be affecting colour and turbidity. Reductions in atmospheric deposition have affected metals such as copper, mercury, lead and zinc, and are likely influencing barium and strontium levels. Faulty cabin septic systems may be influencing nitrogen levels. The cause of deteriorating trends in cobalt and iron, and the improving trend in nitrate/nitrite is unknown.

Table 26- Trend Summary for Tides Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Mining
Sodium	Climate Change	Turbidity	Climate Change/ Mining
Potassium	Climate Change	Nitrogen	Rural Sewage Systems
Nitrate & Nitrite	Unknown	Cobalt	Unknown
Barium	Atmospheric Deposition	Iron	Unknown
Copper	Atmospheric Deposition	Molybdenum	Censored
Mercury	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Strontium	Atmospheric Deposition		
Zinc	Atmospheric Deposition		

Garnish River

Garnish River displayed deteriorating beryllium, copper and molybdenum. There were improving trends in arsenic and lead.

Garnish River had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Reductions in atmospheric deposition have affected arsenic and lead. The cause of the deteriorating trend in copper is unknown.

Table 27- Trend Summary for Garnish River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Arsenic	Atmospheric Deposition	Copper	Unknown
Lead	Atmospheric Deposition/ Abatement	Beryllium	Censored
		Molybdenum	Censored

Grand Bank Brook

Grand Bank Brook displayed improving conductivity. There was in an improving trend in nitrate/nitrite. There was also an improving trend in barium and mercury.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and major ion concentration. Reductions in atmospheric deposition have affected metals such as mercury and possibly barium. The cause of the improving nitrate/nitrite trend is unknown.

Table 28- Trend Summary for Grand Bank Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change		
Sodium	Climate Change		
Magnesium	Climate Change		
Potassium	Climate Change		
Nitrate & Nitrite	Unknown		
Barium	Atmospheric Deposition		
Mercury	Atmospheric Deposition		

Central Rivers

The following sections summarize results for rivers in the Central Region of the province.

South West Brook at Baie Verte

South West Brook displayed deteriorating turbidity, nitrogen and beryllium. Conductivity and major ions displayed an improving trend. There was an improving trend in phosphorus. There were also improving trends in barium, mercury, lithium, molybdenum, lead and strontium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing turbidity. Forestry and quarrying activity in the basin may also be affecting turbidity. Reductions in atmospheric deposition have affected sulphate and metals such as mercury and lead, and are likely influencing improving trends in other metals. The trend in phosphorous can be linked to phosphorous control measures started in the 1970's. Leaks from sewers and lawn fertilizing are possibly contributing to increased nitrogen levels.

Table 29- Trend Summary for South West Brook at Baie Verte

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Turbidity	Climate Change/ Forestry/ Mining
Calcium	Climate Change	Nitrogen	Sewage/ Urban

			Development
Sodium	Climate Change	Beryllium	Censored
Magnesium	Climate Change		
Potassium	Climate Change		
Sulphate	Climate Change/ Atmospheric Deposition		
Chloride	Climate Change		
Phosphorous	Abatement		
Barium	Atmospheric Deposition		
Mercury	Atmospheric Deposition		
Lithium	Atmospheric Deposition		
Molybdenum	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Strontium	Atmospheric Deposition		

Indian Brook

Indian Brook displayed deteriorating colour and phosphorous. There was an improving trend in conductivity and most major ions.

Indian Brook has only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing colour. Forestry activity in the basin may also be affecting colour. Reductions in atmospheric deposition have also affected sulphate. Leaking septic systems from developments located near the sampling site, such as cottages and an Irving station, and farming activity may be contributing to increased phosphorous levels.

Table 30- Trend Summary for Indian Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Forestry
Calcium	Climate Change	Phosphorous	Farming/ Rural Sewage Systems
Sodium	Climate Change		
Magnesium	Climate Change		
Sulphate	Climate Change/ Atmospheric Deposition		
Chloride	Climate Change		

Exploits River below Millertown Dam

Exploits River below the Millertown Dam displayed deteriorating beryllium and chromium. Conductivity and major ions displayed and improving trend. There was an improving trend in dissolved oxygen and pH. There was an improving trend in phosphorous, nitrogen and silica. There was also and improving trend in aluminium, arsenic, barium, cadmium, copper, mercury, manganese, lead, strontium and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration. Reductions in atmospheric deposition have affected sulphate and metals such as copper, mercury and lead. Over time effects of acid mine leachate from the now abandoned ASARCO zinc, copper and lead mine have lessoned, reducing metal and pH levels. The mine phased out operations beginning in 1979, until the doors were finally closed in 1984. Arsenic, mercury and cadmium are particularly associated with sulphide ores and are released during mining and refining operations. Abatement of mine effluent dumping has also increased dissolved oxygen levels. Phosphorous levels have improved due to phosphorous control measures started in the 1970's. Primary sewage treatment, in the form of lagoons installed in Buchan's Junction and Millertown in recent years, may have resulted in the improving trend in nitrogen. Transportation corridors running through the basin are possibly affecting chromium levels

Table 31- Trend Summary for Exploits River below Millertown Dam

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Abatement	Beryllium	Censored
Dissolved Oxygen	Abatement	Chromium	Transportation
Conductivity	Climate Change		
Calcium	Climate Change		
Sodium	Climate Change		
Magnesium	Climate Change		
Potassium	Climate Change		
Sulphate	Climate Change/ Atmospheric Deposition		
Chloride	Climate Change		
Phosphorous	Abatement		
Nitrogen	Abatement		
Silica	Abatement		
Aluminium	Abatement/ Atmospheric Deposition		
Arsenic	Abatement/ Atmospheric Deposition		
Barium	Abatement/ Atmospheric Deposition		
Cadmium	Abatement/ Atmospheric Deposition		
Copper	Abatement/ Atmospheric Deposition		
Mercury	Abatement/ Atmospheric Deposition		
Manganese	Abatement/ Atmospheric Deposition		
Lead	Abatement/ Atmospheric Deposition		
Strontium	Abatement/ Atmospheric Deposition		
Zinc	Abatement/ Atmospheric Deposition		

Exploits River at Aspen Brook Park

Exploits River at Aspen Brook Park displayed deteriorating colour. There was an improving trend in conductivity and most major ions. There was and improving trend in phosphorous. There was also an improving trend in arsenic, barium, copper, mercury, lithium, manganese, lead, strontium and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing colour. Forestry activity in the basin may also be affecting colour. Reductions in atmospheric deposition have affected sulphate and metals such as copper, mercury and lead. Over time effects of acid mine leachate from the now abandoned ASARCO zinc, copper and lead mine have lessened, reducing metal and pH levels. The mine phased out operations beginning in 1979, until the doors were finally closed in 1984. Arsenic, mercury and cadmium are particularly associated with sulphide ores and are released during mining and refining operations. Phosphorous levels have improved due to phosphorous control measures started in the 1970's.

Table 32- Trend Summary for Exploits River at Aspen Brook Park

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Abatement	Colour	Climate Change/ Forestry
Conductivity	Climate Change		
Calcium	Climate Change		
Sodium	Climate Change		
Potassium	Climate Change		
Sulphate	Climate Change/ Atmospheric Deposition		
Chloride	Climate Change		
Phosphorous	Abatement		
Arsenic	Abatement/ Atmospheric Deposition		

Barium	Abatement/ Atmospheric Deposition		
Copper	Abatement/ Atmospheric Deposition		
Mercury	Abatement/ Atmospheric Deposition		
Lithium	Abatement/ Atmospheric Deposition		
Manganese	Abatement/ Atmospheric Deposition		
Lead	Abatement/ Atmospheric Deposition		
Strontium	Abatement/ Atmospheric Deposition		
Zinc	Abatement/ Atmospheric Deposition		

Exploits River at Grand Falls

Exploits River at Grand Falls displayed deteriorating colour. It also displayed deteriorating nitrate/nitrite and nitrogen. There was an improving trend in conductivity and most major ions. There was an improving trend in turbidity and pH. There was also an improving trend in arsenic.

The Exploits River at Grand Falls has only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration. Reductions in atmospheric deposition have also affected sulphate and possibly arsenic. Over time effects of acid mine leachate from the now abandoned ASARCO zinc, copper and lead mine have lessened, reducing arsenic and pH levels. In the past, the Abitibi Consolidated pulp and paper mill in Grand Falls discharged general mill wastes including sulphite waste liquor, wash water, and water spillage, all containing wood fiber. Today, no sulphite is used in the milling process, and much has been done to significantly reduce the amount of wood fiber released into the Exploits. These improvements in effluent waste may be reflected in some of the water quality trends, however the deteriorating trend in colour is most likely due to mill effluent. The Exploits is also used as receiving waters for sewage effluent from communities such as Badger and Grand Falls-Windsor, affecting nitrogen and nitrate/nitrite levels. The process of floating logs down tributaries and the Exploits River to the mill was stopped in 1994, which may be responsible for the improving trend in turbidity. Closing of the former municipal landfill waste disposal site in 1990, located 3km upstream from this sampling site on the bank of the Exploits River, may also be influencing improving trends.

Table 33- Trend Summary for Exploits River at Grand Falls

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Abatement	Colour	Industry/ Climate Change
Turbidity	Abatement	Nitrate & Nitrite	Sewage
Conductivity	Climate Change/ Abatement	Nitrogen	Sewage
Calcium	Climate Change/ Abatement		
Sodium	Climate Change/ Abatement		
Magnesium	Climate Change/Abatement		
Sulphate	Climate Change/ Atmospheric Deposition/ Abatement		
Chloride	Climate Change/ Abatement		
Arsenic	Abatement/ Atmospheric Deposition		

Exploits River at Bishop Falls

Exploits River at Bishop Falls displayed deteriorating colour. It also displayed deteriorating nitrate/nitrite and beryllium. There was an improving trend in conductivity and sulphate. There was also an improving trend in pH. Phosphorous also displayed an improving trend along with arsenic, barium, copper, lithium, strontium, vanadium and zinc.

Exploits River at Bishops Falls had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and sulphate concentration. Reductions in atmospheric deposition have also affected sulphate and metals such as copper, lead and zinc. Over time effects of acid mine leachate from the now abandoned ASARCO zinc, copper and lead mine have lessened, reducing metal and pH levels. The closing in 1990 of the former Grand Falls landfill site, on the bank of the Exploits River, has also influenced improving trends in water quality at this site. Effluent discharged into the Exploits River from the Abitibi Consolidated pulp and paper mill in Grand Falls is affecting colour. The Exploits is also used as receiving waters for sewage effluent from communities such as Badger, Grand Falls-Windsor and Bishops Falls, affecting nitrate/nitrite levels.

Table 34- Trend Summary for Exploits River at Bishop Falls

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Abatement**	Colour	**Industry/ Climate Change**
Conductivity	**Climate Change/ Abatement**	Nitrate & Nitrite	**Sewage**
Sulphate	**Climate Change/ Atmospheric Deposition/ Abatement**	Beryllium	**Censored**
Phosphorous	**Abatement**		
Arsenic	**Abatement/ Atmospheric Deposition**		
Barium	**Abatement/ Atmospheric Deposition**		
Copper	**Abatement/ Atmospheric Deposition**		
Lithium	**Abatement/ Atmospheric Deposition**		
Lead	**Abatement/ Atmospheric Deposition**		
Strontium	**Abatement/ Atmospheric Deposition**		
Vanadium	**Abatement/ Atmospheric Deposition**		
Zinc	**Abatement/ Atmospheric Deposition**		

North West Gander River

North West Gander River displayed deteriorating beryllium and cadmium. There was an improving trend in potassium and sulphate. There was an improving trend in phosphorous. Metals such as arsenic, barium, copper, mercury and lithium also displayed an improving trend.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing potassium and sulphate concentration. Reductions in atmospheric deposition have also affected sulphate and metals such as copper and mercury, and possibly other metals as well. The cause of the improving trend in phosphorous is most likely from natural geological sources.

Table 35- Trend Summary for North West Gander River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Potassium	**Climate Change**	**Beryllium**	**Censored**
Sulphate	**Climate Change/ Atmospheric Deposition**	Cadmium	**Censored**
Phosphorous	**Natural Sources**		
Aluminium	**Atmospheric Deposition**		
Arsenic	**Atmospheric Deposition**		
Barium	**Atmospheric Deposition**		
Copper	**Atmospheric Deposition**		
Mercury	**Atmospheric Deposition**		
Lithium	**Atmospheric Deposition**		
Vanadium	**Atmospheric Deposition**		

Gander River at Appleton

Gander River at Appleton displayed deteriorating beryllium, cadmium, molybdenum and vanadium. There was an improving trend in conductivity and half the major ions. There was also an improving trend in aluminium, arsenic, barium, iron, lithium and strontium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration. Reductions in atmospheric deposition may have affected the observed improving trends in metals. A combination of landfill leachate and sewage effluent from the communities of Appleton, Glenwood, Benton and Gander may be influencing vanadium.

Table 36- Trend Summary for Gander River at Appleton

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	**Beryllium**	**Censored**
Calcium	**Climate Change**	Cadmium	**Censored**
Magnesium	**Climate Change**	Molybdenum	**Censored**
Potassium	**Climate Change**	Vanadium	**Landfill/ Sewage**
Aluminium	**Atmospheric Deposition**		
Arsenic	**Atmospheric Deposition**		
Barium	**Atmospheric Deposition**		
Iron	**Atmospheric Deposition**		
Lithium	**Atmospheric Deposition**		
Strontium	**Atmospheric Deposition**		

Gander River

Gander River displayed deteriorating turbidity and magnesium. It also displayed deteriorating dissolved organic carbon and nitrogen. Metals like iron and nickel also displayed deteriorating trends. There was an improving trend observed in sodium, potassium and the metal cadmium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing major ion concentration, while increasing turbidity and DOC. Reductions in atmospheric deposition have affected cadmium levels. Sewage effluent from Appleton, Glenwood, Benton and Gander is affecting nitrogen levels. A combination of landfill leachate and sewage effluent from these communities may also be influencing magnesium, iron and nickel levels. Runoff from transportation routes through the basin may also be affecting iron and nickel.

Table 37- Trend Summary for Gander River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	**Climate Change**	**Turbidity**	**Climate Change**
Potassium	**Climate Change**	**Magnesium**	**Landfill/ Sewage**
Cadmium	**Atmospheric Deposition**	**Dissolved Organic Carbon**	**Climate Change**
		Nitrogen	**Sewage**
		Iron	**Transportation/ Landfill/ Sewage**
		Nickel	**Transportation/ Landfill/ Sewage**

Pound Cove Brook

Pound Cove Brook displayed deteriorating colour, turbidity and pH. It also displayed deteriorating trends in nitrogen and cadmium. There was and improving trend in conductivity, calcium and sulphate. There was and improving trend in phosphorus. There was also an improving trend in copper, lithium, nickel, lead and selenium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing turbidity and colour. Forestry activity in the basin may also be affecting colour and turbidity. Reductions in atmospheric deposition have also affected sulphate and metals such as copper and lead. It may also be influencing improving trends in other metals. Seepage from faulty cabin septic tanks may be affecting nitrogen levels. Natural geological sources may be responsible for the decrease in both phosphorous and pH.

Table 38- Trend Summary for Pound Cove Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Forestry
Calcium	Climate Change	Turbidity	Climate Change/ Forestry
Sulphate	Climate Change/ Atmospheric Deposition	pH	Natural Sources
Phosphorous	Natural Sources	Nitrogen	Rural Sewage Systems
Copper	Atmospheric Deposition	Cadmium	Censored
Lithium	Atmospheric Deposition		
Nickel	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Selenium	Atmospheric Deposition		

Middle Brook

Middle Brook displayed deteriorating turbidity and pH. It also displayed deteriorating beryllium, cadmium, nickel and zinc. There was an improving trend in conductivity, most major ions and dissolved oxygen. There was an improving trend in silica. There was also an improving trend in mercury, lithium, lead, strontium and vanadium.

Middle Brook had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing turbidity. Quarrying activity in the basin may also be affecting turbidity. Reductions in atmospheric deposition have also affected sulphate and metals such as mercury and lead. It may also be influencing improving trends in other metals. Natural geological sources may be responsible for the decrease in pH. Transportation routes running through the basin may be influencing nickel and zinc levels. The cause of improving dissolved oxygen and silica is unknown. This sampling site is in relatively shallow water and water quality may be significantly impacted by low flows.

Table 39- Trend Summary for Middle Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Dissolved Oxygen	Unknown	Turbidity	Climate Change/ Mining
Conductivity	Climate Change	pH	Natural Sources
Calcium	Climate Change	Beryllium	Censored
Sodium	Climate Change	Cadmium	Censored
Magnesium	Climate Change	Nickel	Transportation
Potassium	Climate Change	Zinc	Transportation
Sulphate	Climate Change/ Atmospheric Deposition		
Silica	Unknown		
Mercury	Atmospheric Deposition		
Lithium	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Strontium	Atmospheric Deposition		
Vanadium	Atmospheric Deposition		

Terra Nova River at Newton Lake

Terra Nova River at Newton Lake displayed deteriorating turbidity and cadmium. There was and improving trend in half the major ions and dissolved organic carbon. There was also an improving trend in mercury, lead and strontium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing major ion concentration, and increasing turbidity. Reductions in atmospheric deposition have affected metals such as mercury and lead, and possibly strontium. The cause of decreasing DOC is most likely due to natural factors.

Table 40- Trend Summary for Terra Nova River at Newton Lake

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	**Climate Change**	Turbidity	**Climate Change**
Magnesium	**Climate Change**	Cadmium	**Censored**
Potassium	**Climate Change**		
Dissolved Organic Carbon	**Natural Sources**		
Mercury	**Atmospheric Deposition**		
Lead	**Atmospheric Deposition/ Abatement**		
Strontium	**Atmospheric Deposition**		

Terra Nova River at Terra Nova

Terra Nova River at Terra Nova displayed deteriorating turbidity. There were deteriorating trends in half the major ions. There was a deteriorating trend in nitrate/nitrite, nitrogen and silica. There was also a deteriorating trend in beryllium and cadmium. There were improving trends in mercury and selenium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, and increasing turbidity and silica. Forestry and quarrying activity in the basin may also be affecting turbidity levels. Reductions in atmospheric deposition have affected metals such as mercury and possibly selenium. The cause of increasing calcium, potassium and chloride is most likely linked to the Terra Nova landfill. Faulty or leaking septic systems from the community of Terra Nova are influencing nitrogen and nitrate/nitrite levels.

Table 41- Trend Summary for Terra Nova River at Terra Nova

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Mercury	**Atmospheric Deposition**	Turbidity	**Climate Change/ Forestry/ Mining**
Selenium	**Atmospheric Deposition**	Calcium	**Landfill**
		Potassium	**Landfill**
		Chloride	**Landfill**
		Nitrate & Nitrite	**Rural Septic Systems**
		Nitrogen	**Rural Septic Systems**
		Silica	**Climate Change**
		Beryllium	**Censored**
		Cadmium	**Censored**

Terra Nova River at E.S. Spencer Bridge

Terra Nova River at E.S. Spencer Bridge displayed deteriorating turbidity. It also displayed deteriorating beryllium, cadmium, cobalt and iron. There was an improving trend in magnesium, mercury and lead.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing magnesium, while increasing turbidity. Forestry and quarrying activity in the basin may also be affecting turbidity levels. Reductions in atmospheric deposition have affected metals such as mercury and lead. A combination of leachate from the Terra Nova landfill and runoff from transportation routes may be affecting cobalt and iron levels. A railway bridge comprised of steel and iron is situated upstream from this sampling site. Corrosion of this bridge may also be influencing increasing iron levels at this site.

Table 42- Trend Summary for Terran Nova River at E.S. Spencer Bridge

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Magnesium	**Climate Change**	Turbidity	**Climate Change/ Forestry/ Mining**
Mercury	**Atmospheric Deposition**	Beryllium	**Censored**
Lead	**Atmospheric Deposition/ Abatement**	Cadmium	**Censored**
		Cobalt	**Landfill/ Transportation**
		Iron	**Landfill/ Transportation**

Bread Cove Brook

Bread Cove Brook displayed deteriorating colour, turbidity and pH. It also displayed deteriorating aluminium. There was an improving trend in conductivity and most major ions. There was also an improving trend in copper, mercury, lithium, lead, strontium and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing colour and turbidity. Forestry and quarrying activity in the basin may also be affecting turbidity levels. Reductions in atmospheric deposition have affected metals such as copper, mercury, lead and zinc. It may also be influencing lithium and strontium levels. Natural geological sources may be influencing pH levels. The source of increasing aluminium is unknown.

Table 43- Trend Summary for Bread Cove Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	Colour	**Climate Change**
Calcium	**Climate Change**	Turbidity	**Climate Change/ Forestry/ Mining**
Sodium	**Climate Change**	pH	**Natural Sources**
Magnesium	**Climate Change**	Aluminium	**Unknown**
Potassium	**Climate Change**		
Sulphate	**Climate Change/ Atmospheric Deposition**		
Copper	**Atmospheric Deposition**		
Mercury	**Atmospheric Deposition**		
Lithium	**Atmospheric Deposition**		
Lead	**Atmospheric Deposition**		
Strontium	**Atmospheric Deposition**		
Zinc	**Atmospheric Deposition**		

South West Brook at Terra Nova National Park

South West Brook at Terra Nova National Park displayed deteriorating colour and turbidity. It also displayed deteriorating beryllium and molybdenum. There was an improving trend in conductivity and most major ions. There was an improving trend in phosphorous. Metals such as barium, cadmium, cobalt, chromium, lithium, lead, strontium and vanadium also displayed improving trends.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing colour and turbidity. Forestry activity in the basin may also be affecting turbidity and colour. Reductions in atmospheric deposition have affected sulphate and metals such as cadmium and lead. It may also be influencing improving trends in other metals. Natural geological sources may be influencing phosphorous levels.

Table 44- Trend Summary for South West Brook at Terra Nova National Park

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	Colour	**Climate Change/ Forestry**

Calcium	Climate Change	Turbidity	Climate Change/ Forestry
Sodium	Climate Change	Beryllium	Censored
Magnesium	Climate Change	Molybdenum	Censored
Potassium	Climate Change		
Sulphate	Climate Change/ Atmospheric Deposition		
Phosphorous	Natural Sources		
Barium	Atmospheric Deposition		
Cadmium	Atmospheric Deposition		
Cobalt	Atmospheric Deposition		
Chromium	Atmospheric Deposition		
Lithium	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		
Strontium	Atmospheric Deposition		
Vanadium	Atmospheric Deposition		

Southern Bay River

Southern Bay River displayed deteriorating colour and turbidity. It also displayed deteriorating beryllium, cadmium, molybdenum and nickel. There was an improving trend in conductivity, sodium and chloride. There was also an improving trend in phosphorous. Metals such as copper, mercury and lead also displayed improving trends.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing colour and turbidity. Forestry activity in the basin may also be affecting turbidity and colour. Reductions in atmospheric deposition have affected metals such as copper, mercury and lead. Natural geological sources may be influencing phosphorous levels. Transportation routes running through the basin may be influencing nickel levels.

Table 45- Trend Summary for Southern Bay River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Forestry
Sodium	Climate Change	Turbidity	Climate Change/ Forestry
Chloride	Climate Change	Beryllium	Censored
Phosphorous	Natural Sources	Cadmium	Censored
Copper	Atmospheric Deposition	Molybdenum	Censored
Mercury	Atmospheric Deposition	Nickel	Transportation
Lead	Atmospheric Deposition/ Abatement		

Bay du Nord River

Bay du Nord River displayed improving trends in half the major ions. There was an improving trend in dissolved organic carbon. There was also an improving trend in mercury, lithium, lead, selenium and strontium.

Bay du Nord River had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, and decreasing major ion concentration. Reductions in atmospheric deposition have affected metals such as mercury and lead, and possibly other metals. The cause of decreasing DOC is most likely due to natural factors.

Table 46- Trend Summary for Bay du Nord River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Calcium	**Climate Change**		
Sodium	**Climate Change**		
Potassium	**Climate Change**		
Dissolved Organic Carbon	**Natural Sources**		
Mercury	**Atmospheric Deposition**		
Lithium	**Atmospheric Deposition**		
Lead	**Atmospheric Deposition/ Abatement**		
Selenium	**Atmospheric Deposition**		
Strontium	**Atmospheric Deposition**		

Jeddore Lake

Jeddore Lake displayed deteriorating silica and zinc. There was an improving trend in conductivity and most major ions. There was also and improving trend in mercury, lithium and strontium.

Jeddore Lake had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing silica. Reductions in atmospheric deposition have affected metals such as mercury, and possibly lithium and strontium. The increase in zinc is most likely due to natural factors.

Table 47- Trend Summary for Jeddore Lake

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	Silica	**Climate Change**
Calcium	**Climate Change**	Zinc	**Natural Sources**
Sodium	**Climate Change**		
Magnesium	**Climate Change**		
Potassium	**Climate Change**		
Mercury	**Atmospheric Deposition**		
Lithium	**Atmospheric Deposition**		
Strontium	**Atmospheric Deposition**		

Western Rivers

The following sections summarize results for rivers in the Western and Labrador Regions of the province.

Ste Genevieve River

Ste Genevieve River displayed deteriorating nitrate/nitrite and nitrogen. It also displayed deteriorating beryllium, cadmium, cobalt, chromium, molybdenum, nickel, lead, vanadium and zinc. There was an improving trend in aluminium.

Ste. Genevieve River had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions. Reductions in atmospheric deposition have also affected sulphate. Cabin development and faulty septic systems around Ten Mile Lake and Round Lake have contributed to the nutrient loading. The increase in certain metals may be related to the network of dams used for flow control in this watershed. The cause of the improving trend in aluminium and deteriorating trend in potassium is unknown.

Table 48- Trend Summary for Ste. Genevieve River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	**Climate Change**	**Potassium**	**Unknown**
Sulphate	**Climate Change/ Atmospheric Deposition**	Nitrate & Nitrite	**Rural Sewage Systems**
Chloride	**Climate Change**	Nitrogen	**Rural Sewage Systems**
Aluminium	**Unknown**	Beryllium	**Censored**
		Cadmium	**Censored**
		Molybdenum	**Censored**
		Cobalt	**Stream Modification**
		Chromium	**Stream Modification**
		Nickel	**Stream Modification**
		Lead	**Stream Modification**
		Vanadium	**Stream Modification**
		Zinc	**Stream Modification**

Torrent River

Torrent River displayed deteriorating colour. It also displayed deteriorating nitrogen. There was an improving trend in conductivity and turbidity. There was also an improving trend in arsenic.

Torrent River had only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing colour. Forestry activity may also be affecting colour. Reductions in atmospheric deposition have also affected sulphate and possibly arsenic. The practice of transporting logs down Torrent River to Hawke's Bay by Bowater Inc. ceased in the early 60's and may be responsible for the improving trend in turbidity. The source of deteriorating nitrogen is unknown.

Table 49- Trend Summary for Torrent River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	**Colour**	**Climate Change/ Forestry**
Sodium	**Climate Change**	**Nitrogen**	**Unknown**
Sulphate	**Climate Change/ Atmospheric Deposition**		
Chloride	**Climate Change**		
Turbidity	**Abatement**		
Arsenic	**Atmospheric Deposition**		

Portland Creek

Portland Creed displayed deteriorating colour and turbidity. It displayed deteriorating DOC, nitrate/nitrite and nitrogen. It also displayed deteriorating aluminium, beryllium, cadmium, cobalt, iron, manganese, molybdenum and nickel. There were improving trends in pH and conductivity. There were also improving trends in barium, copper, mercury, lead and selenium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and major ion concentration, while increasing DOC, turbidity and colour. Forestry activity may also be affecting colour and turbidity. Reductions in atmospheric deposition have affected sulphate and certain metals including copper, mercury and lead, and possibly barium and selenium. The improving trend in pH is likely due to natural geological conditions. Cabin development and faulty septic systems around Portland Creek Pond have contributed to nutrient loading. No obvious explanation can be found for the increase in other metals in Portland Creek, unless it is a natural phenomena. The cause of the deteriorating trend in calcium is unknown.

Table 50- Trend Summary for Portland Creek

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Natural Sources	Colour	Climate Change/ Forestry
Conductivity	Climate Change	Turbidity	Climate Change/ Forestry
Sodium	Climate Change	Calcium	Unknown
Potassium	Climate Change	Dissolved Organic Carbon	Climate Change
Sulphate	Climate Change/ Atmospheric Deposition	Nitrate & Nitrite	Rural Sewage Systems
Chloride	Climate Change	Nitrogen	Rural Sewage Systems
Barium	Atmospheric Deposition	Aluminium	Unknown/ Natural Sources
Copper	Atmospheric Deposition	Beryllium	Unknown/ Natural Sources
Mercury	Atmospheric Deposition	Cadmium	Unknown/ Natural Sources
Lead	Atmospheric Deposition/ Abatement	Cobalt	Unknown/ Natural Sources
Selenium	Atmospheric Deposition	Iron	Unknown/ Natural Sources
		Manganese	Unknown/ Natural Sources
		Molybdenum	Unknown/ Natural Sources
		Nickel	Unknown/ Natural Sources

Western Brook

Western Brook displayed deteriorating colour and turbidity. It displayed deteriorating nitrate/nitrite, nitrogen and silica. It also displayed deteriorating aluminium, arsenic, beryllium and cadmium. There were improving trends in pH and conductivity. There were also improving trends in copper, mercury and strontium.

pH is possibly affected by the natural limestone geology of the watershed. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing conductivity and major ion concentration, while increasing turbidity, colour, DOC and silica. Reductions in atmospheric deposition have affected certain metals including copper, mercury, and possibly strontium. Other metals displaying deteriorating trends are likely affected by the operation of boat tours in Western Brook Pond during the summer season. The septic systems at the tourist chalets in Western Brook Pond might be influencing nitrate/nitrite and nitrogen levels.

Table 51- Trend Summary for Western Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Natural Sources	Colour	Climate Change
Conductivity	Climate Change	Turbidity	Climate Change
Sodium	Climate Change	Dissolved Organic Carbon	Climate Change
Chloride	Climate Change	Nitrate & Nitrite	Rural Sewage Systems/ Recreation
Copper	Atmospheric Deposition	Nitrogen	Rural Sewage Systems/ Recreation
Mercury	Atmospheric Deposition	Silica	Climate Change
Strontium	Atmospheric Deposition	Beryllium	Censored
		Cadmium	Censored
		Molybdenum	Censored
		Aluminium	Recreation
		Arsenic	Recreation
		Cobalt	Recreation

Main River

Main River displayed deteriorating colour and turbidity. It also displayed deteriorating beryllium. There was an improving trend in conductivity. There was also an improving trend in copper, mercury and lead.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions and conductivity, while increasing turbidity and colour. Forestry might also be affecting colour and turbidity. Reductions in atmospheric deposition have also affected sulphate and certain metals including copper, mercury and lead.

Table 52- Trend Summary for Main River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change/ Forestry
Sodium	Climate Change	Turbidity	Climate Change/ Forestry
Potassium	Climate Change	Beryllium	Censored
Sulphate	Climate Change/ Atmospheric Deposition		
Chloride	Climate Change		
Copper	Atmospheric Deposition		
Mercury	Atmospheric Deposition		
Lead	Atmospheric Deposition/ Abatement		

Lomond Brook

Lomond Brook displayed deteriorating colour, turbidity and pH. It displayed deteriorating DOC, nitrate/nitrite, nitrogen and silica. It also displayed deteriorating beryllium, cadmium and molybdenum. There was an improving trend in barium, copper and mercury.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, while increasing turbidity, colour, DOC and silica. Forestry, cabin development, and several quarries might also be affecting colour and turbidity. Reductions in atmospheric deposition have affected certain metals including copper, mercury, and possibly barium. Cabin development and faulty septic systems around Bonne Bay Big Pond and Bonne Bay Little Pond have contributed to deteriorating nitrate/nitrite and nitrogen levels.

Table 53- Trend Summary for Lomond Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	Climate Change	Colour	Climate Change/ Forestry/ Recreation/ Mining
Potassium	Climate Change	Turbidity	Climate Change/ Forestry/ Recreation/ Mining
Chloride	Climate Change	pH	Unknown
Barium	Atmospheric Deposition	Dissolved Organic Carbon	Climate Change
Copper	Atmospheric Deposition	Nitrate & Nitrite	Rural Sewage Systems
Mercury	Atmospheric Deposition	Nitrogen	Rural Sewage Systems
		Silica	Climate Change
		Beryllium	Censored
		Cadmium	Censored
		Molybdenum	Censored

Upper Humber River

The Upper Humber River displayed deteriorating colour and turbidity. It also displayed deteriorating beryllium, cadmium and molybdenum. There was an improving trend in mercury.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, while increasing turbidity and colour.

Forestry activity is also affecting turbidity and colour. Reductions in atmospheric deposition have also affected sulphate and mercury.

Table 54- Trend Summary for Upper Humber River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	**Climate Change**	**Colour**	**Climate Change/ Forestry**
Sulphate	**Climate Change/ Atmospheric Deposition**	**Turbidity**	**Climate Change/ Forestry**
Mercury	**Atmospheric Deposition**	**Beryllium**	**Censored**
		Cadmium	**Censored**
		Molybdenum	**Censored**

Humber Canal

The Humber Canal displayed deteriorating turbidity and dissolved oxygen. It also displayed deteriorating nitrate/nitrite. There was an improving trend in pH. There was also an improving trend in arsenic and mercury.

pH is affected by the natural limestone geology of the watershed. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, while increasing turbidity. Forestry and the presence of several quarries in the basin might also be affecting turbidity. Reductions in atmospheric deposition have affected metals like mercury, and possibly arsenic. Road salt from Deer Lake is possibly affecting chloride levels. Sewage inputs are influencing nitrate/nitrite levels, which in turn are affecting dissolved oxygen levels. The extensive stream alteration in this basin from dams and canals might also be affecting dissolved oxygen.

Table 55- Trend Summary for Humber Canal

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Natural Sources**	**Turbidity**	**Climate Change/ Forestry/ Mining**
Sodium	**Climate Change**	**Dissolved Oxygen**	**Sewage/ Stream Modification**
Arsenic	**Atmospheric Deposition**	**Chloride**	**Urban/ Transportation**
Mercury	**Atmospheric Deposition**	**Nitrate & Nitrite**	**Sewage**

Lower Humber River

The Lower Humber River displayed deteriorating colour, turbidity and dissolved oxygen. It displayed deteriorating nitrate/nitrite, nitrogen and silica. It also displayed deteriorating iron. There was an improving trend in pH. There was also an improving trend in barium, mercury and lead.

pH is influenced by the natural limestone geology in this watershed and the application of lime for farming purposes. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, while increasing turbidity, colour and silica. Forestry, farming, several quarries, and urban development from Pasadena and Deer Lake are also affecting colour and turbidity. Reductions in atmospheric deposition have affected metals such as mercury, lead, and possibly barium. Increasing nitrate/nitrite and nitrogen levels are a result of farming, and sewage effluent from communities upstream, which is in turn affecting dissolved oxygen levels. Iron levels might possibly be affected by leachate from landfills in the basin or from stream alterations such as hydro dams and bridges.

Table 56- Trend Summary for Lower Humber River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	**Natural Sources/ Farming**	**Colour**	**Climate Change/ Forestry/ Farming/ Urban Development**
Sodium	**Climate Change**	**Turbidity**	**Climate Change/ Forestry/ Farming/ Mining/ Urban Development**

Potassium	Climate Change	Dissolved Oxygen	Farming/ Sewage
Barium	Atmospheric Deposition	Calcium	Farming
Mercury	Atmospheric Deposition	Nitrate & Nitrite	Farming/ Sewage
Lead	Atmospheric Deposition	Nitrogen	Farming/ Sewage
		Silica	Farming/ Climate Change
		Iron	Landfill/ Stream Modification

Wild Cove Brook

Wild Cove Brook displayed deteriorating turbidity, dissolved oxygen and pH. It displayed a deteriorating trend in DOC, nitrate/nitrite and nitrogen. It also displayed a deteriorating trend in aluminium, barium, iron, lithium, nickel, and zinc. There was an improving trend in arsenic and mercury.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and increasing turbidity. Reductions in atmospheric deposition have affected metals like mercury and possibly arsenic. Leachage from the Corner Brook Landfill and Genesis Organics bark pile are affecting other metals, pH, dissolved oxygen and nutrients. Bird populations that frequent the area might also be affecting nitrate/nitrite and nitrogen levels.

Table 57- Trend Summary for Wild Cove Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Arsenic	Atmospheric Deposition	Turbidity	Climate Change/ Landfill
Mercury	Atmospheric Deposition	Dissolved Oxygen	Landfill
		pH	Landfill
		Potassium	Landfill
		Dissolved Organic Carbon	Landfill
		Nitrate & Nitrite	Landfill/ Natural
		Nitrogen	Landfill/ Natural
		Aluminium	Landfill
		Barium	Landfill
		Iron	Landfill
		Lithium	Landfill
		Nickel	Landfill
		Zinc	Landfill

Corner Brook

Corner Brook displayed deteriorating colour and turbidity. It displayed deteriorating trends in DOC, nitrate/nitrite and nitrogen. It also displayed a deteriorating trend in aluminium. There were improving trends in copper, mercury and lead.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, increasing turbidity, colour and DOC. Forestry activity and several quarries are also affecting colour and turbidity. Reductions in atmospheric deposition are affecting metals such as copper, mercury and lead. Urban development in the City of Corner Brook is affecting nutrient levels as is runoff from the Corner Brook golf course. Metals such as aluminium and iron are possibly related to hydro dams and reservoirs in the watershed, urban activity, and transportation routes including pipeline and hydroelectric corridors.

Table 58- Trend Summary for Corner Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Copper	Atmospheric Deposition	Colour	Climate Change/ Forestry/ Mining
Mercury	Atmospheric Deposition	Turbidity	Climate Change/Forestry/ Mining
Lead	Atmospheric Deposition/	Dissolved Organic	Climate Change

	Abatement	Carbon	
		Nitrate & Nitrite	Urban/ Recreation
		Nitrogen	Urban/ Recreation
		Aluminium	Stream Modification/ Urban Development/ Transportation
		Iron	Stream Modification/ Urban Development/ Transportation

Pinchgut Brook

Pinchgut Brook displayed deteriorating colour, turbidity, dissolved oxygen and pH. It displayed a deteriorating trend in DOC, nitrate/nitrite and silica. It also displayed deteriorating trends in beryllium, cadmium and molybdenum. There were improving trends in barium, copper, mercury, lead and zinc.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of major ions, while increasing turbidity, colour, DOC and silica. Forestry and cabin development along Pinchgut Lake might also be influencing colour and turbidity. Reductions in atmospheric deposition are affecting sulphate and metals such as copper, mercury, lead and zinc, and possibly barium. Faulty septic systems might be influencing nitrate/nitrate levels, which in turn are affecting dissolved oxygen levels. The cause of the deteriorating trend in pH is unknown.

Table 59- Trend Summary for Pinchgut Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	**Climate Change**	Colour	**Climate Change/ Forestry/ Recreation**
Potassium	**Climate Change**	Turbidity	**Climate Change/ Forestry/ Recreation**
Sulphate	**Climate Change/ Atmospheric Deposition**	Dissolved Oxygen	**Rural Sewage Systems**
Chloride	**Climate Change**	pH	**Unknown**
Barium	**Atmospheric Deposition**	Dissolved Organic Carbon	**Climate Change**
Copper	**Atmospheric Deposition**	Nitrate & Nitrite	**Rural Sewage Systems**
Mercury	**Atmospheric Deposition**	Silica	**Climate Change**
Lead	**Atmospheric Deposition/ Abatement**	Beryllium	**Censored**
Zinc	**Atmospheric Deposition**	Cadmium	**Censored**
		Molybdenum	**Censored**

Harry's River

Harry's River displayed deteriorating colour. It displayed a deteriorating trend in phosphorous. It also displayed a deteriorating trend in beryllium and cadmium. There was an improving trend in dissolved oxygen and conductivity. There was an improving trend in nitrate/nitrite. There was also an improving trend in arsenic.

Harry's River had only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and the concentration of major ions, while increasing colour. Forestry activity may also be contributing to the trend in colour. Reductions in atmospheric deposition may also be affecting sulphate and arsenic levels. The cause of the improving trend in nitrate/nitrite and dissolved oxygen, and deteriorating trend in phosphorous is unknown.

Table 60- Trend Summary for Harry's River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Dissolved Oxygen	**Unknown**	**Colour**	**Climate Change/ Forestry**

Conductivity	Climate Change	Phosphorous	Unknown
Sodium	Climate Change	Beryllium	Censored
Magnesium	Climate Change	Cadmium	Censored
Sulphate	Climate Change/ Atmospheric Deposition		
Chloride	Climate Change		
Nitrate & Nitrite	Unknown		
Arsenic	Atmospheric Deposition		

Lloyds River

Lloyds River displayed deteriorating turbidity and dissolved oxygen. It displayed a deteriorating trend in nitrate/nitrite. It also displayed a deteriorating trend in beryllium, cadmium, cobalt and vanadium. There was an improving trend in copper and mercury.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing the concentration of major ions, and increasing turbidity. Forestry, several quarries and mineral exploration might also be affecting turbidity. Reductions in atmospheric deposition are affecting metals such as copper and mercury. Several parameters in Lloyds River displayed trends with no obvious source.

Table 61- Trend Summary for Lloyds River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sodium	Climate Change	Turbidity	Climate Change/ Forestry/ Mining
Potassium	Climate Change	Dissolved Oxygen	Unknown
Copper	Atmospheric Deposition	Nitrate & Nitrite	Unknown
Mercury	Atmospheric Deposition	Beryllium	Censored
		Cadmium	Censored
		Cobalt	Unknown
		Vanadium	Unknown

Crabbes River

Crabbes River displayed deteriorating turbidity. It also displayed deteriorating beryllium, manganese and molybdenum. There was an improving trend in pH. There was an improving trend in DOC. There was also an improving trend in copper and selenium.

pH is affected by natural limestone geology in the watershed. Reductions in atmospheric deposition are affecting metals such as copper and possibly selenium. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and increasing turbidity. Farming and forestry activity might also be affecting turbidity. Manganese levels might be affected by the South Branch landfill. The cause of the improving trend in DOC is unknown.

Table 62- Trend Summary for Crabbes River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
pH	Natural Sources	Turbidity	Climate Change/ Forestry/ Farming
Dissolved Organic Carbon	Unknown	Beryllium	Censored
Copper	Atmospheric Deposition	Molybdenum	Censored
Selenium	Atmospheric Deposition	Manganese	Landfill

South Branch River

South Branch River displayed a deteriorating trend in turbidity. It also displayed deteriorating beryllium and manganese. There was an improving trend in conductivity. There was also and improving trend in mercury and lead.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and the concentration of major ions, while increasing turbidity. Forestry and farming activity might also be affecting turbidity. Reductions in atmospheric deposition are influencing trend in metals such as mercury and lead. Manganese levels might be affected by the South Branch landfill.

Table 63- Trend Summary for South Branch River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	**Turbidity**	**Climate Change/ Forestry/ Farming**
Calcium	**Climate Change**	Beryllium	**Censored**
Sodium	**Climate Change**	Manganese	**Landfill**
Potassium	**Climate Change**		
Mercury	**Atmospheric Deposition**		
Lead	**Atmospheric Deposition/ Abatement**		

Grand Codroy River

Grand Codroy River displayed deteriorating turbidity. It displayed a deteriorating trend in silica. It also displayed a deteriorating trend in molybdenum and nickel. There was an improving trend in conductivity. There were also improving trends in arsenic, barium, copper, lead and strontium.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and the concentration of major ions, while increasing turbidity and silica. Forestry and several quarries might also be contributing to turbidity. Reductions in atmospheric deposition may be affecting sulphate, and metals such as copper, lead, and possibly arsenic, barium and strontium. Runoff from the TCH may be affecting the trend in nickel.

Table 64- Trend Summary for Grand Codroy River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	**Turbidity**	**Climate Change/ Forestry/ Mining**
Calcium	**Climate Change**	**Silica**	**Climate Change**
Sodium	**Climate Change**	**Molybdenum**	**Censored**
Magnesium	**Climate Change**	**Nickel**	**Transportation**
Potassium	**Climate Change**		
Sulphate	**Climate Change/ Atmospheric Deposition**		
Chloride	**Climate Change**		
Arsenic	**Atmospheric Deposition**		
Barium	**Atmospheric Deposition**		
Copper	**Atmospheric Deposition**		
Lead	**Atmospheric Deposition/ Abatement**		
Strontium	**Atmospheric Deposition**		

Isle aux Mort River

Isle aux Mort River displayed a deteriorating trend in phosphorous. There was an improving trend in conductivity and turbidity.

Isle aux Mort River had only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow and decreasing the concentration of conductivity and major ions. The cause of the improving trend in turbidity and deteriorating trend in phosphorous is unknown.

Table 65- Trend Summary for Isle aux Mort River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Phosphorous	Unknown
Calcium	Climate Change		
Magnesium	Climate Change		
Turbidity	Unknown		

Cing Cerf Brook

Cing Cerf Brook displayed deteriorating trends in turbidity and dissolved oxygen. It also displayed a deteriorating trend in phosphorous. There was an improving trend in arsenic and mercury.

Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing the concentration of major ions, and increasing turbidity. Activities at the Hope Brook Gold Mine might also be affecting turbidity and manganese. Reductions in atmospheric deposition may be affecting metals such as mercury and possibly arsenic. Sewage effluent from the mine residence or mining activity itself may be affecting phosphorous levels, which in tern are affecting dissolved oxygen levels.

Table 66- Trend Summary for Cing Cerf Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Potassium	Climate Change	Turbidity	Climate Change/ Mining
Arsenic	Atmospheric Deposition	Phosphorous	Sewage/ Mining
Mercury	Atmospheric Deposition	Manganese	Mining
		Dissolved Oxygen	Sewage/ Mining

Grandys Brook

Grandys Brook displayed deteriorating colour. It also displayed a deteriorating trend in beryllium and cadmium. There was an improving trend in conductivity. There was also an improving trend in arsenic and barium.

Grandy's Brook had only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and the concentration of major ions, while increasing colour. Reductions in atmospheric deposition may be affecting metals such as arsenic and barium.

Table 67- Trend Summary for Grandys Brook

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	Climate Change	Colour	Climate Change
Magnesium	Climate Change	Beryllium	Censored
Floride	Climate Change	Cadmium	Censored
Arsenic	Atmospheric Deposition		
Barium	Atmospheric Deposition		

White Bear River

White Bear River displayed deteriorating turbidity and dissolved oxygen. It also displayed deteriorating trends in cobalt, chromium and molybdenum. There was an improving trend in nitrate/nitrite. There was also an improving trend in arsenic, iron, mercury and selenium.

White Bear River had only a partial temporal dataset, which means only 2 out of the 3 trend analysis methods could be used, possibly affecting the number of parameters displaying trends. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing the concentration of major ions, and increasing turbidity. Reductions in atmospheric deposition may be affecting metals such as mercury and possibly arsenic, and selenium. Other metals such as cobalt and chromium may be influenced by the hydroelectric developments in the watershed, including the construction of dams, reservoirs and electric corridors for transmission lines. Dissolved oxygen may be affected by slack water held in the reservoirs. The cause of improving nitrate/nitrite is unknown.

Table 68- Trend Summary for White Bear River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Potassium	**Climate Change**	Turbidity	**Climate Change**
Nitrate & Nitrite	**Unknown**	Cobalt	**Stream Modification/ Transportation**
Arsenic	**Atmospheric Deposition**	Chromium	**Stream Modification/ Transportation**
Iron	**Atmospheric Deposition**	Molybdenum	**Censored**
Mercury	**Atmospheric Deposition**	Dissolved Oxygen	**Stream Modification**
Selenium	**Atmospheric Deposition**		

Grey River

Grey River displayed deteriorating colour. There was an improving trend in conductivity. There was also an improving trend in arsenic.

Gray River had only a partial set of parameters in its dataset. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing conductivity and the concentration of major ions, while increasing colour. Reductions in atmospheric deposition may be affecting arsenic levels. Hydroelectric development in this basin as part of the Bay d'Espoir generating station may also be influencing colour.

Table 69- Trend Summary for Grey River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Conductivity	**Climate Change**	Colour	**Climate Change/ Stream Modification**
Sodium	**Climate Change**		
Magnesium	**Climate Change**		
Potassium	**Climate Change**		
Chloride	**Climate Change**		
Arsenic	**Atmospheric Deposition**		

Labrador Rivers

The following sections summarize results for rivers in the Labrador Region of the province.

Churchill River

Churchill River displayed deteriorating colour. It also displayed a deteriorating trend in potassium and nitrogen. There was an improving trend in sulphate.

Churchill River had only a partial data set in terms of parameters and sufficient period of record. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, decreasing the concentration of major ions, and increasing colour. Reductions in atmospheric deposition may also be affecting sulphate. Urban development in the towns of Labrador City, Wabush and Deer Lake may also be influencing colour and nitrogen levels through sewage inputs. Iron ore mining and hydroelectric developments on the Churchill River may be contributing to colour as well. The source increasing potassium is unknown.

Table 70- Trend Summary for Churchill River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Sulphate	**Climate Change/ Atmospheric Deposition**	**Colour**	**Climate Change/ Stream Alteration/ Mining**

		Potassium	Unknown
		Nitrogen	Sewage

Eagle River

Eagle River displayed a deteriorating trend in nitrate/nitrite and nitrogen. There was an improving trend in turbidity, sulphate and chloride.

Eagle River had only a partial dataset in terms of parameters and sufficient period of record. Changes in climate since 1986 have resulted in an increasing trend in precipitation across the province, affecting streamflow, and decreasing the concentration of major ions. Reductions in atmospheric deposition may also be affecting sulphate. Wastewater from several outfitter camps may be contributing to nutrient levels. The cause of improving turbidity is uknown.

Table 71- Trend Summary for Eagle River

Improving Trend	Cause of Trend	Deteriorating Trend	Cause of Trend
Turbidity	**Unknown**	**Nitrate & Nitrite**	**Recreation**
Sulphate	**Climate Change/ Atmospheric Deposition**	**Nitrogen**	**Recreation**
Chloride	**Climate Change**		

Categorization of Agreement Water Quality Sites

The categorization of Agreement water quality sites as pristine, semi-impaired and impaired is based on four factors:

- The period of record and completeness of the data set for all parameters of interest
- The number of improving and deteriorating trends among water quality parameters
- The CWQI value based on the water quality guidelines for aquatic use and the associated ranking of all Agreement sites based on this value
- Development pressures within the watershed

The scheme used for ranking sites is a subjective one that takes into account all the above factors. For example, the Waterford River at Kilbride has a dataset going back to 1986, displayed 10 deteriorating trends and 7 improving trends, had an aquatic WQI value of 67 (out of 100), was ranked 54th out of the 65 Agreement water quality sites according to aquatic WQI values, and is under medium development pressure. Because the dataset was full, there were more deteriorating trends than improving trends, the WQI value was only fair, the river was ranked in the bottom twenty percent of Agreement sites, and the basin is under moderate development pressure, the river was categorized as impaired.

Summary tables of the number of improving and deteriorating trends for each Agreement water quality site can be found in Appendix I. Summary tables of the CWQI values for each Agreement site can also be found in Appendix I. As can be seen from the CWQI ranking summary table below, the highest ranked or more pristine rivers are heavily weighted with rivers from the Western Region. Rivers from the Central Region display a fairly even distribution from pristine to impaired. Rivers from the Eastern Region are more heavily weighted in the center and bottom end of the water quality index ranking.

Table 72- Water Quality Index Ranking

Ranking	Site Name	Site Number	Aquatic CWQI
1	Lomond River	YH0018	88
2	Ste. Genevieve River	YA0001	87
3	Indian Brook	YM0001	87
4	Torrent River	YC0001	86
5	Pinchgut Brook	YJ0004	83
6	Exploits River (@ Grand Falls)	YO0001	81
7	Gander River (@ Appleton)	YQ0030	81
8	Corner Brook	YL0013	79
9	Grey River	ZD0003	79
10	Lloyds River	YN0001	79
11	Lower Humber	YL0012	79
12	Spout Cove Brook	ZL0001	78
13	Harrys River	YJ0006	78
14	Cing Cerf Brook	ZB0005	78
15	Gander River	YQ0005	78
16	Hearts Content Brook	ZL0002	77
17	Goulds Brook	ZL0029	77
18	Salmonier River	ZN0004	77
19	Humber Canal	YK0022	77
20	White Bear River	ZC0011	77
21	Isle aux Mort River	ZB0001	75
22	Portland Creek	YE0004	75
23	Tides Brook	ZG0024	74
24	Rattle Brook	ZG0025	74
25	Seal Cove River	ZM0019	74
26	Northwest Brook	ZN0002	74
27	Raymond Brook	ZM0017	74
28	Eagle River	QC0001	74
29	Grand Codroy	ZA0006	74
30	South Branch River	ZA0001	74
31	Bread Cove Brook	YS0010	74
32	Mobile River	ZM0018	73
33	Middle Brook	YR0021	73
34	Southern Bay River	ZJ0024	73
35	Grand Bank Brook	ZG0026	72
36	Northeast River	ZK0005	72
37	South West Brook (@ Baie Verte)	YM0004	72
38	Jeddore Lake	ZE0018	72
39	Western Brook	YE0005	71
40	Grandys Brook	ZC0001	71
41	South West Brook (@ Terra Nova Park)	YS0005	71
42	Pound Cove Brook	YR0001	71
43	Pipers Hole River	ZH0001	70
44	Rocky River	ZK0001	70
45	Broad Cove Brook	ZM0020	70
46	Wild Cove Brook	YL0029	70
47	North West Gander River	YQ0006	70
48	Garnish River	ZG0016	69
49	Upper Humber	YL0011	69
50	Quidi Vidi Lake	ZM0015	68
51	Main River	YG0001	68
52	Terra Nova River (@ Terra Nova)	YS0001	68
53	Bay du Nord River	ZF0020	68
54	Waterford River (@ Kilbride)	ZM0009	67
55	Terra Nova River (@ ES Spencer Bridge)	YS0011	67
56	Exploits River (@ Biships Falls)	YO0021	66
57	Virgina River (@ Boulevard)	ZM0014	65
58	Exploits River (@ Aspen Brook Park)	YO0020	65
59	Rennies River (@ Carnell Dr)	ZM0016	64
60	Churchill River	OE0001	63
61	Crabbes River	ZA0007	63
62	Exploits River (b/l Millertown Dam)	YO0107	63
63	Terra Nova River (@ Newton Lake)	YS0012	62
64	Mundy Pond	ZM0109	59
65	Kellys Brook	ZM0144	50

Labrador
Western
Central
Eastern

The Development Level Index ranking of each Agreement water quality station's watershed can also be found in Appendix I. This index evaluates the level of anthropogenic activity in the watershed with respect to forestry, mining, agriculture, urbanization, recreation, linear development, hydro, industrial and municipal water use, etc. The ranking indicates a fairly even distribution of Central Rivers from high to low development pressure. There is a slight weighting of Western Rivers towards lower levels of development pressure, and a more noticeable weighting of Eastern Rivers towards higher levels of development pressure.

The following tables categorize rivers from each region as pristine, semi-impaired or impaired.

Table 73- Water Quality Status of Eastern Agreement Sites

Pristine	Semi-Impaired	Impaired
Spout Cove Brook- NF02ZL0001	Hearts Content Brook- NF02ZL0002	Broad Cove Brook- NF02ZM0020
	Goulds Brook- NF02ZL0029	Virginia River (@ Boulevard)- NF02ZM0014
	Raymond Brook- NF02ZM0017	Kellys Brook- NF02ZM0144
	Mobile River- NF02ZM0018	Rennies River (@ Carnell Dr)- NF02ZM0016
	Seal Cove River- NF02ZM0019	Mundy Pond- NF02ZM0109
	Northwest Brook- NF02ZN0002	Waterford River (@ Kilbride)- NF02ZM0009
	Salmonier River- NF02ZN0004	Quidi Vidi Lake- NF02ZM0015
	Rocky River- NF02ZK0001	
	Northeast River- NF02ZK0005	
	Pipers Hole River- NF02ZH0001	
	Rattle Brook- NF02ZG0025	
	Tides Brook- NF02ZG0024	
	Garnish River- NF02ZG0016	
	Grand Bank Brook- NF02ZG0026	

Table 74- Water Quality Status of Central Agreement Sites

Pristine	Semi-Impaired	Impaired
Indian Brook- NF02YM0001	South West Brook (@ Baie Verte)- NF02YM0004	Exploits River (@ Bishop Falls)- NF02YO0021
Southern Bay River- NF02ZJ0024	Exploits River (below Millertown Dam)- NF02YO0107	Exploits River (@ Grand Falls)- NF02YO0001
Jeddore Lake- NF02ZE0018	Terra Nova River (@ ES Spencer Bridge)- NF02YS0011	
South West Brook (@Terra Nova National Park)- NF02YS0005	Terra Nova River (@ Terra Nova)- NF02YS0001	
	Gander River (@ Appleton)- NF02YQ0030	
	Pound Cove Brook- NF02YR0001	
	Middle Brook- NF02YR0021	
	Bread Cove Brook- NF02YS0010	
	Terra Nova River (@ Newton Lake)- NF02YS0012	
	Gander River- NF02YQ0005	
	Northwest Gander River- NF02YQ0006	
	Exploits River (@ Aspen Brook Park)- NF02YO0020	

	Bay du Nord River- NF02ZF0020	

Table 75- Water Quality Status of Western Agreement Sites

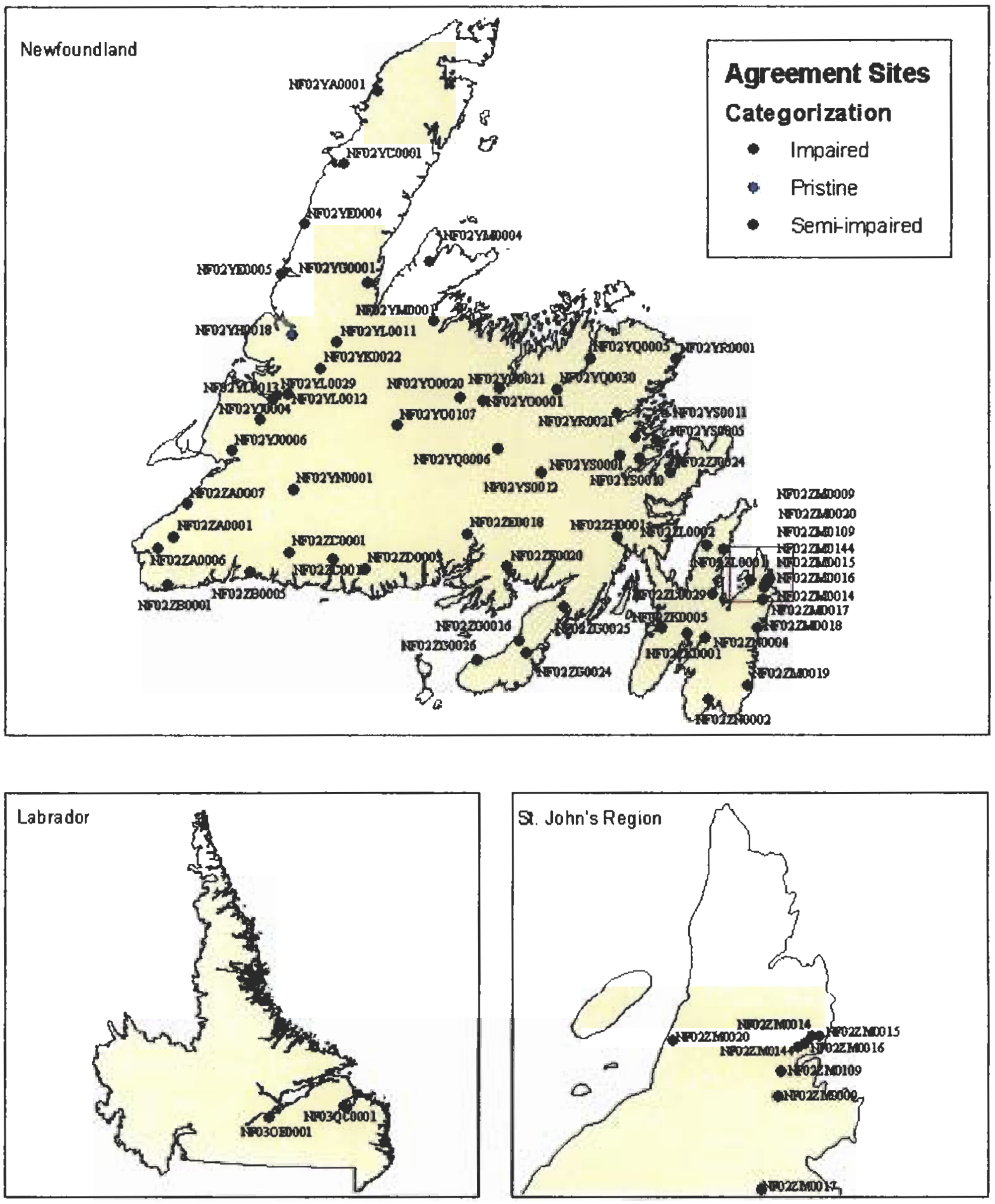
Pristine	Semi-Impaired	Impaired
Ste Genevieve River- NF02YA0001	Portland Creek- NF02YE0004	Wild Cove Brook- NF02YL0029
Torrent River- NF02YC0001	Western Brook- NF02YE0005	
Main River- NF02YG0001	Upper Humber- NF02YL0011	
Lomond River- NF02YH0018	Lower Humber- NF02YL0012	
Lloyds River- NF02YN0001	Humber Canal- NF02YK0022	
Isle aux Mort River- NF02ZB0001	Corner Brook- NF02YL0013	
Grandys Brook- NF02ZC0001	Pinchgut Brook- NF02YJ0004	
Grey River- NF02ZD0003	Harrys River- NF02YJ0006	
	Crabbes River- NF02ZA0007	
	South Branch River- NF02ZA0001	
	Grand Codroy River- NF02ZA0006	
	Cing Cerf Brook- NF02ZB0005	
	White Bear River- NF02ZC0011	

Table 76- Water Quality Status of Labrador Agreement Sites

Pristine	Semi-Impaired	Impaired
Eagle River- NF03QC0001	**Churchill River- NF03OE0001**	

The status of all Canada-Newfoundland water quality monitoring Agreement sites throughout the province is summarized in the map in Figure 7.

Figure 7: Status of Canada-Newfoundland Water Quality Monitoring Agreement Sites



Conclusions and Recommendations

The results of this study indicate that there have been changes in many water quality parameters throughout the rivers monitored as part of the Canada-Newfoundland Water Quality Monitoring Agreement since 1986. Changes have resulted in both improvement and deterioration in some water quality parameters. In trying to link factors affecting these changes, it is obvious that local and global conditions both have an impact on this dynamic, for even in pristine watersheds, significant change was observed. The overall status of Agreement waterbodies reveals the majority of rivers have experienced some negative impact, however, only a handful can truly be classified as impaired.

Several steps are required to build upon the results contained within this study. Returning to the objectives of this report, several have been met, but others still require further work. The information from this study is intended to contribute towards decision and policy making in the future. With this goal in mind, the following recommendations are made:

- reorganization of the Agreement water quality monitoring network in terms of size, monitoring parameters and media
- establishment of provincial water quality objectives
- dissemination to the public of the information provided in this report in a user-friendly, watershed-based format
- identification and recognition of major water quality problems
- production of plans of action to improve water quality where there are deteriorating trends or other water quality concerns, and to maintain water quality where there are no present concerns

In addition to the above issues, this report has highlighted several important areas requiring further study. These include:

- Further investigation into the sources and causes of water quality trends.
- An analysis of spatial variations for watersheds with more than one sampling site.
- Further statistical analysis to fit trend models to the data to describe the amount or rate of change, and for future prediction.
- In depth watershed analysis using GIS and water quality modeling tools.
- Further investigation into the effect of climate change on water quality.
- Further investigation into atmospheric deposition and its effect on water quality.

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