

Baxter Creek Watershed Alliance
53 King Street West, Box 325, Millbrook, ON, L0A 1G0
baxtercreekwatershed@gmail.com
www.baxtercreekwatershed.org



**Overview of the Baxter Creek Provincial Water Quality Monitoring Network:
A Study for the Baxter Creek Watershed Alliance (BCWA)**

Brooke Ceci, Trent University, School of the Environment
In association with the Baxter Creek Watershed Alliance
April 2023. Version 1.0.

Table of Contents

1.0 Introduction	3
2.0 Methodology	3
2.1 Sample Fraction Analysis	3
2.2 Trend Line Analysis.....	4
3.0 Trend Results: Active Station (17002107702)	4
3.1 Phosphorus species (P, PO ₄ ³⁻).....	4
3.2 Nitrogen species (TKN, NO ₂ ⁻ , NO ₃ ⁻ , TNitrate, TNitrogen).....	5
3.3 Sodium (Na)	9
3.4 Chloride (Cl ⁻).....	9
3.5 Dissolved Oxygen (DO)	10
4.0 Discussion	10
4.1 Initial Parameter Analysis Results	10
4.2 Sources of Nutrients	12
4.3 Potential Applications & Outcomes.....	13
4.4 Limitations & Areas of Concern.....	14
4.5 Future Recommendations.....	14
5.0 References	14
6.0 Appendix	15

1.0 Introduction

A baseline Baxter Creek stream water quality trend analysis was conducted as the first step of a multi-step, multi-year study that will inform the Baxter Creek Watershed Alliance's long-term watershed research study. To accomplish this, data was obtained from the Ministry of the Environment, Conservation and Parks Provincial Water Quality Monitoring Network (PWQMN), which was sampled from Baxter Creek through the Ministry's Environmental Monitoring and Reporting Branch and analyzed by the Ministry's Laboratory Service Branch. Water quality data on Baxter Creek located in Millbrook within the township of Cavan-Monaghan, was extrapolated from the PWQMN data set, to perform initial cursory analysis and long-term trend analysis.

The vision with this project was to collect raw data for nutrients that indicate water quality including phosphorus (P), nitrogen (N), sodium (Na), and chloride (Cl), as well as measured dissolved oxygen (DO) content, to produce information on the water quality of Baxter Creek. Comparative analysis between the PWQMN dataset and an anticipated dataset compiled from a biology professor at Trent University, Nolan Pearce, for the same stream system and other nearby rural sub watersheds is expected to allow for critical interpretation of this information. This will then allow for the creation of knowledge products which will be used to inform and guide actions based in the Baxter Creek watershed and provide education to the public about possible environmental issues associated with stream water quality.

2.0 Methodology

The Baxter Creek water quality data was obtained through the Ministry's open data and information products (PWQMN), as well as a dataset compiled by a biology professor at Trent University. The PWQMN data files for the Baxter Creek stations were accessed through the Ontario government website; Baxter Creek has three stations total: one active and two inactive. Raw data for all three stations were downloaded and compiled into master datasets that show the concentrations of the nutrients of interest over its sampling period. The pivot table function in Microsoft Excel was used to generate yearly average concentrations of the nutrients, to assess differences and overall trends.

2.1 Sample Fraction Analysis

Phosphorus and nitrogen analysis involve a physical filtration whereby the water sample undergoes a process to separate the particulate and aqueous fractions. Unfiltered results include the amount of chemical associated with both the particulate and the aqueous fractions. Filtered results include the amount of chemical associated with just the aqueous fraction.

Knowledge on the filtration status of a sample is essential as values for the same characteristic may be very different between filtered and unfiltered water samples (U.S. Environmental Protection Agency, 2017).

2.2 Trend Line Analysis

Trend analysis for each nutrient was analyzed through a linear trendline (black solid line) and a moving average trendline (red dashed line). The equation of the trendline and R^2 value listed on the graph are associated with the black linear trendline. The linear trendline is known as a 'line of best fit' that shows the general pattern or overall direction of the data overtime. The trendline equation indicates the numerical relationship between the two variables: time and nutrient concentrations. The R^2 value indicates how reliable the trendline is and how well it fits the data; the closer the R^2 value is to 1, the better fit the data which means a strong relationship between the variables.

3.0 Trend Results: Active Station (17002107702)

Stream, Station ID: Baxter Creek, 17002107702

Location: Zion 4th Ln, SW of Millbrook

Status: Active

First-Last Year Sampled: 1977-2019

Latitude, longitude: 44 8' 7" N, 78 27' 26" W

3.1 Phosphorus species (P, PO_4^{3-})

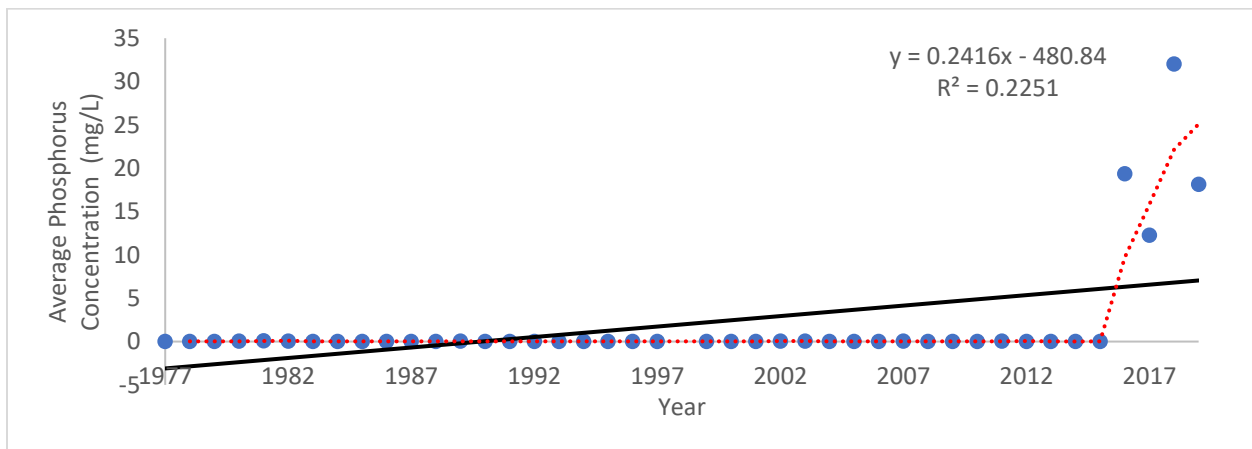


Figure 1. Yearly average (unfiltered total) phosphorus (P) concentrations in Baxter Creek from active station (17002107702) from 1977-2019.

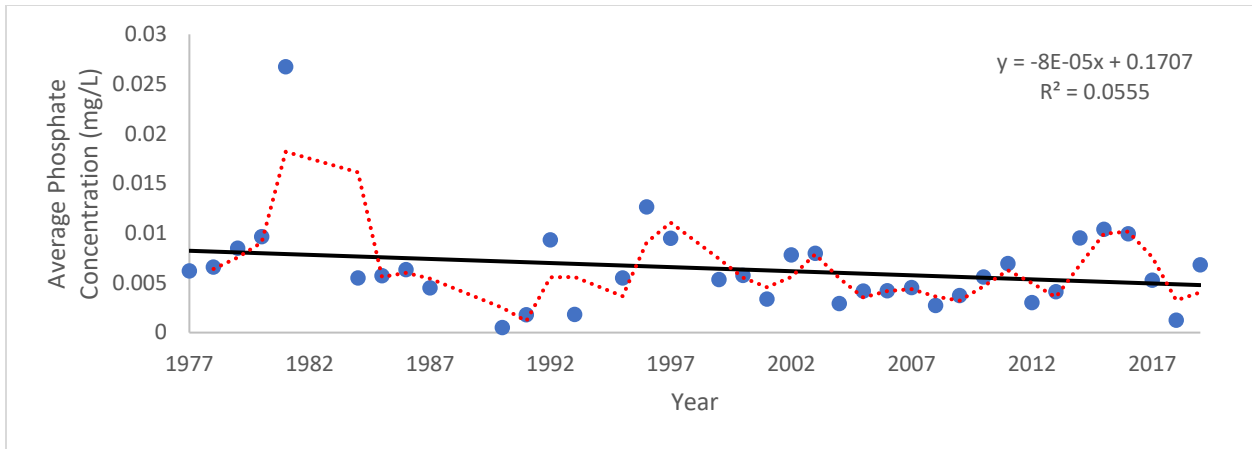


Figure 2. Yearly average (filtered reactive) phosphate (PO_4^{3-}) concentrations in Baxter Creek from active station (17002107702) 1977-2019.

3.2 Nitrogen species (TKN, NO_2^- , NO_3^- , TNitrate, TNitrogen)

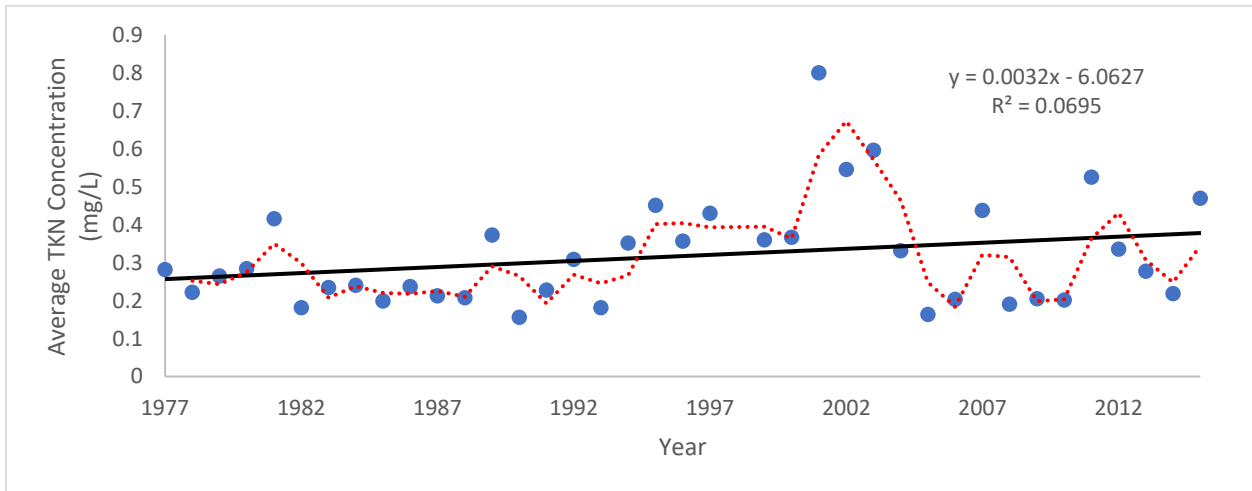


Figure 3. Yearly average (unfiltered reactive) total Kjeldahl nitrogen (TKN) concentrations in Baxter Creek from active station (17002107702) from 1977-2015.

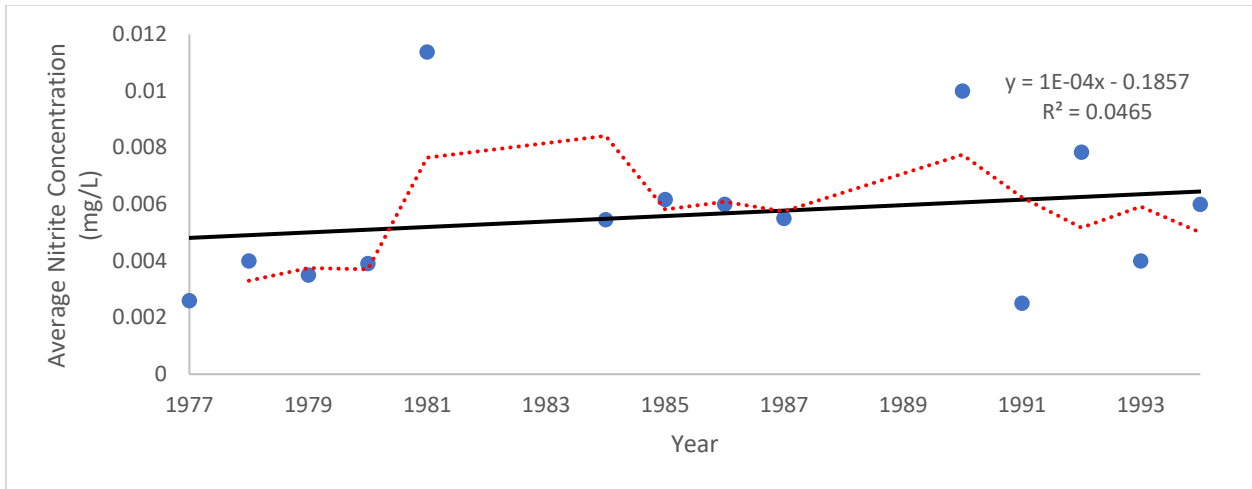


Figure 4. Yearly average (filtered reactive) nitrite (NO_2^-) concentrations in Baxter Creek from active station (17002107702) from 1977-1994.

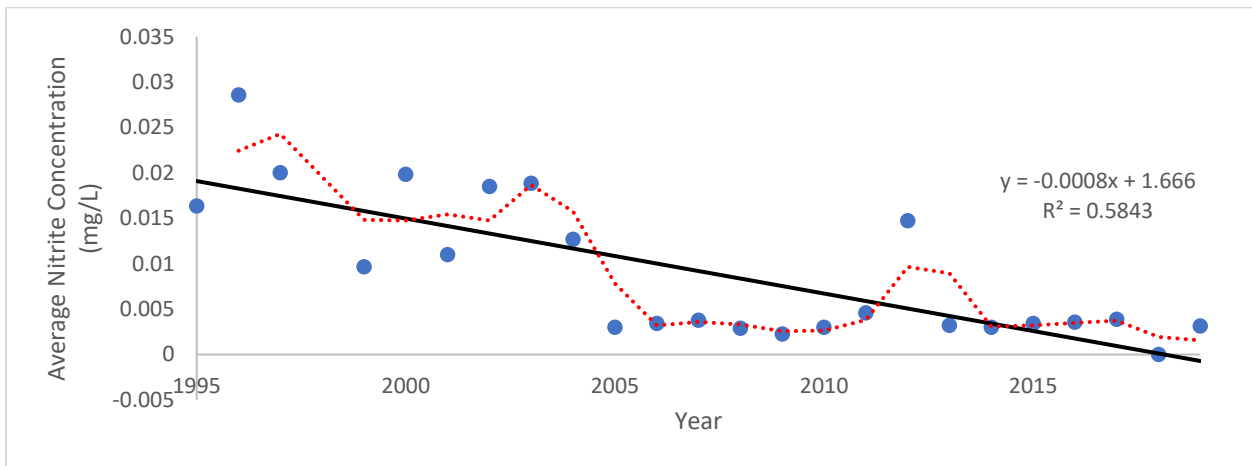


Figure 5. Yearly average (unfiltered reactive) nitrite (NO_2^-) concentrations in Baxter Creek from active station (17002107702) from 1995-2019.

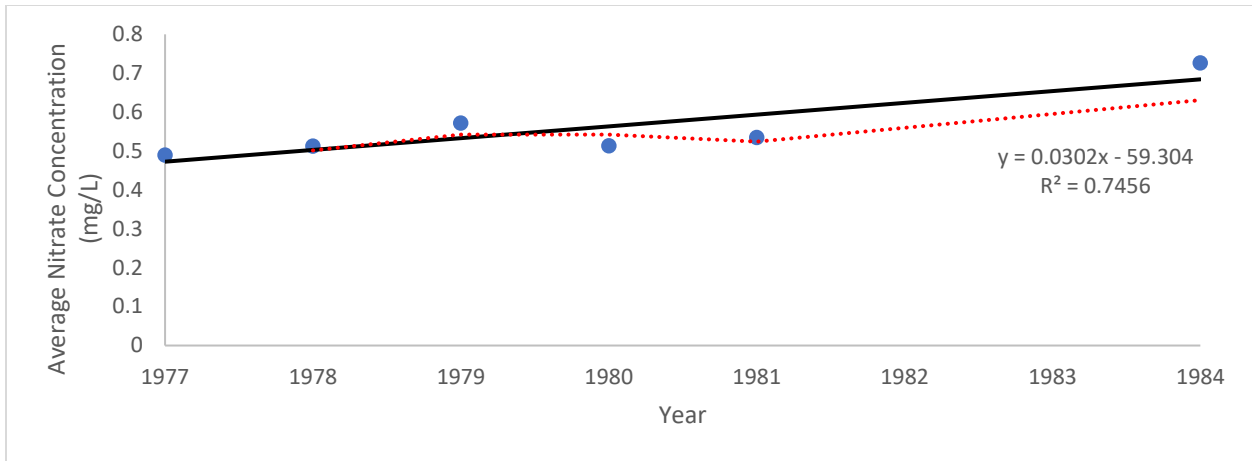


Figure 6. Yearly average (filtered reactive) nitrate (NO_3^-) concentrations in Baxter Creek from active station (17002107702) from 1977-1984.

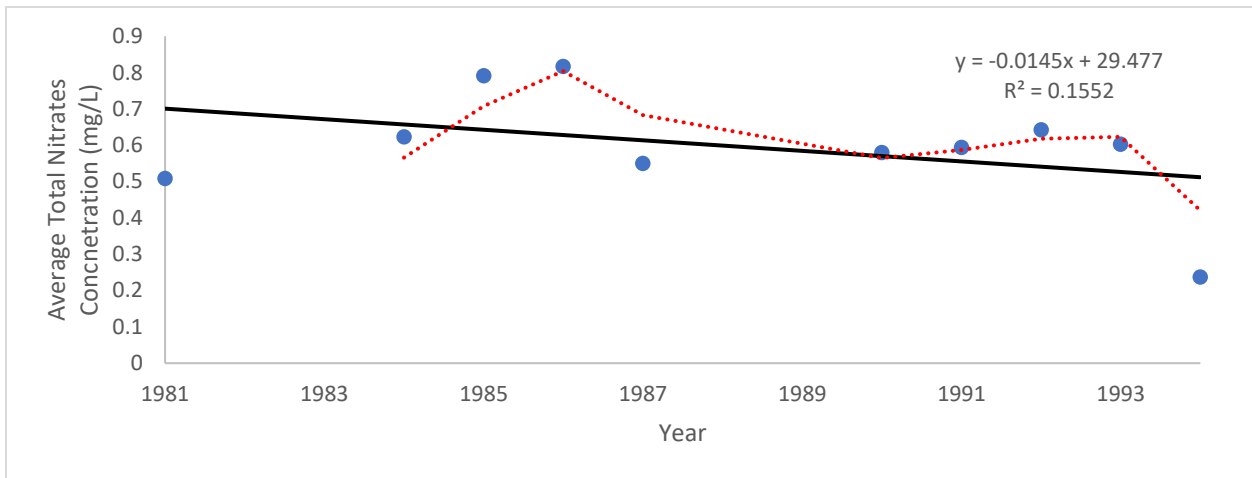


Figure 7. Yearly average (filtered reactive) total nitrate (TN) concentrations in Baxter Creek from active station (17002107702) from 1981-1994.

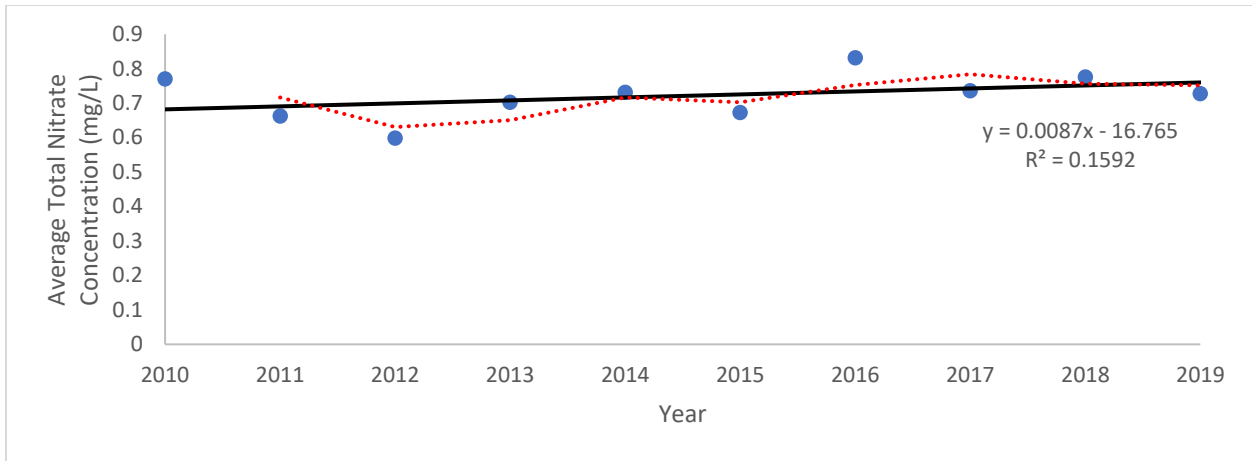


Figure 8. Yearly average (unfiltered reactive) total nitrate (TNitrate) concentrations in Baxter Creek from active station (17002107702) from 2010-2019.

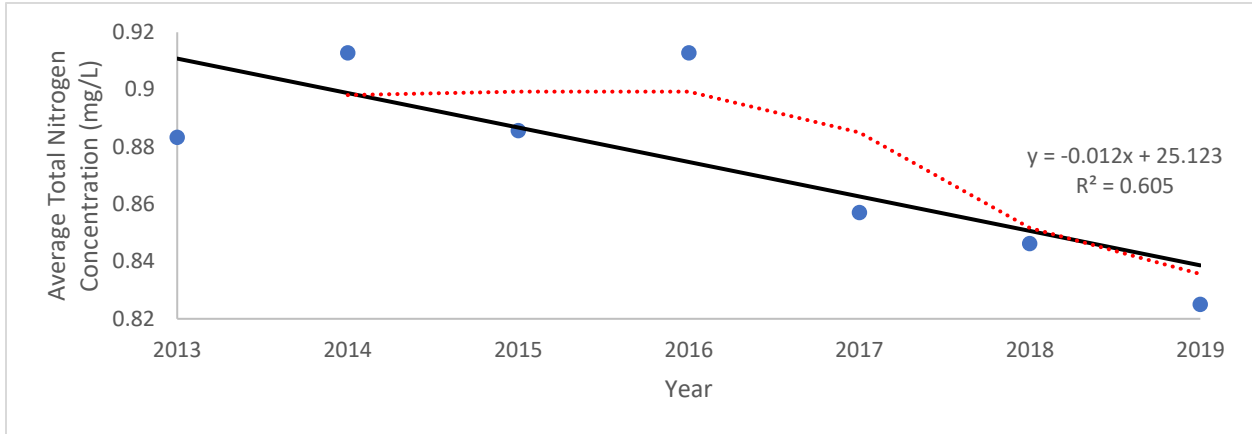


Figure 9. Yearly average total nitrogen (TNitrogen) concentrations in Baxter Creek from active station (17002107702) from 2013-2019.

3.3 Sodium (Na)

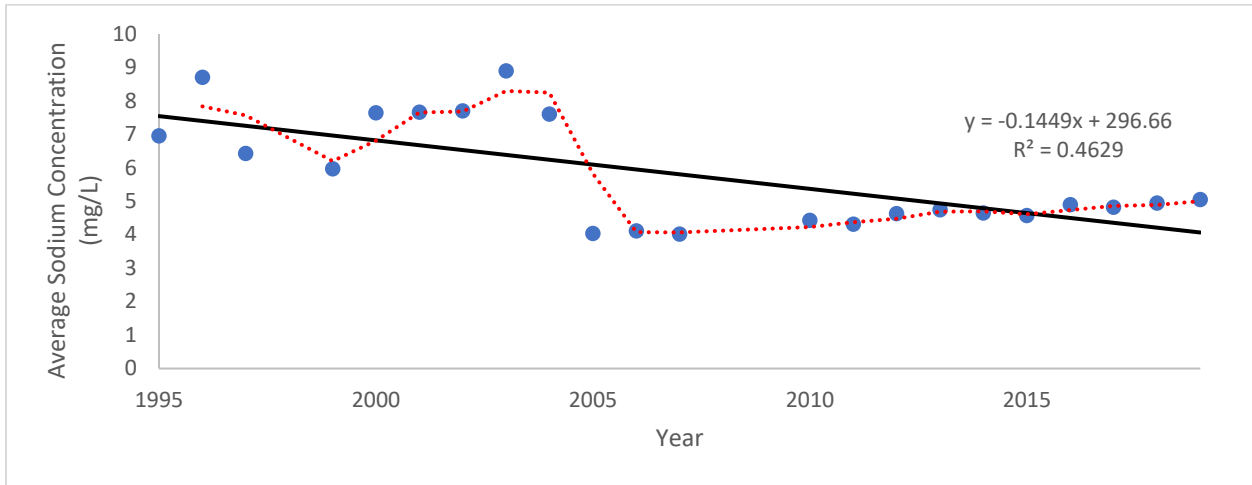


Figure 10. Yearly average (unfiltered) sodium (Na) concentrations in Baxter Creek from active station (17002107702) from 1995-2019.

3.4 Chloride (Cl⁻)

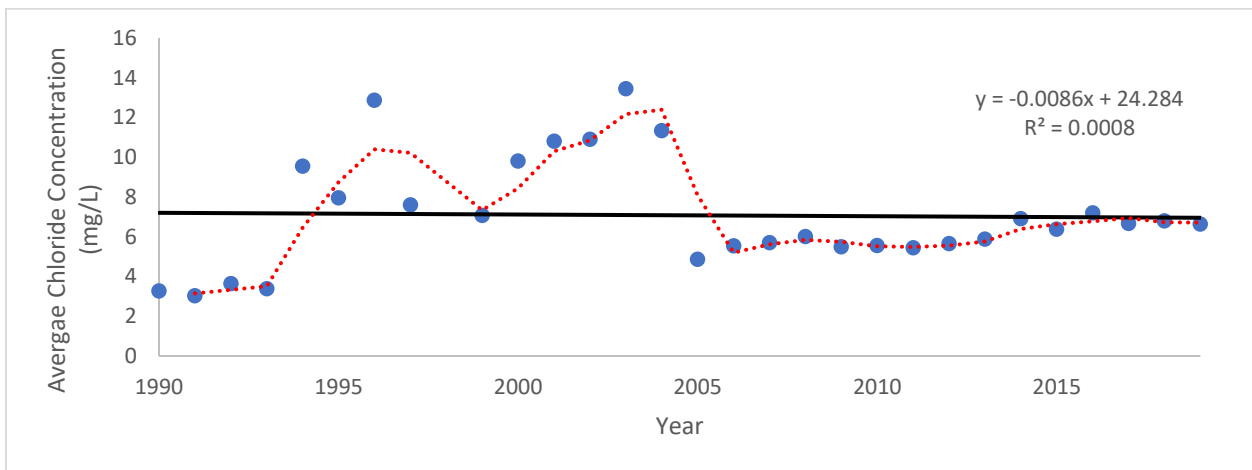


Figure 11. Yearly average (unfiltered reactive) chloride (Cl⁻) concentrations in Baxter Creek from active station (17002107702) from 1990-2019.

3.5 Dissolved Oxygen (DO)

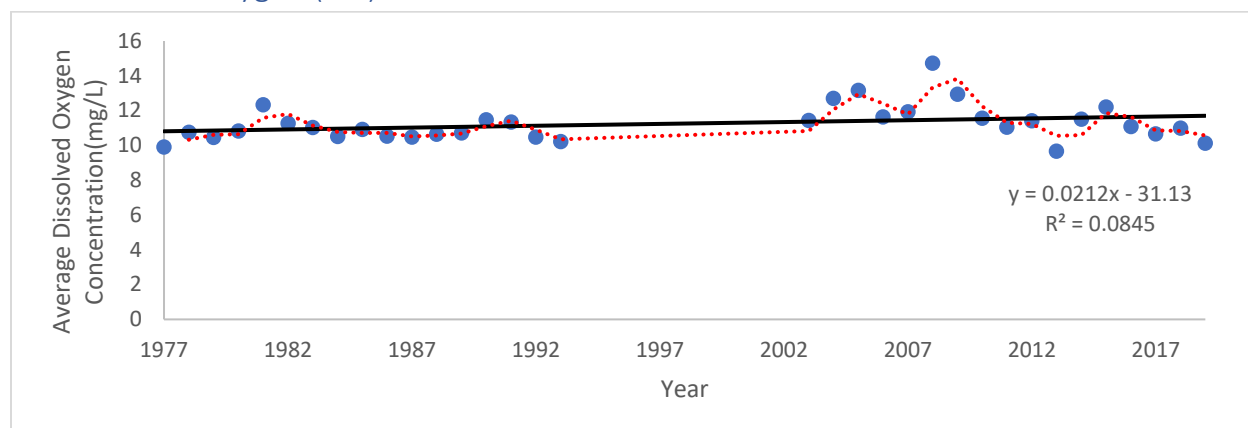


Figure 12. Yearly average dissolved oxygen (DO) concentrations in Baxter Creek from active station (17002107702) from 1977-2019.

4.0 Discussion

4.1 Initial Parameter Analysis Results

There are evident changes in concentrations for the parameters shown. Yearly average phosphorus concentrations (Figure 1) remained around 0 mg/L up until 2016 where spikes are evident through the moving average trendline. The lowest yearly average concentration was 0 mg/L which occurred for several years, and the highest 32 mg/L occurring in 2018. These spikes should be analyzed cautiously as the change in laboratory methodologies could be influencing this increase; a change in laboratory detection limits could generate an inaccurate trend line. Despite the change in methodology's, phosphorus concentrations appear to be increasing in Baxter Creek. The R^2 value of 0.2251 indicates a weak/no strong relationship between time and P concentrations.

Yearly average phosphate concentrations (Figure 2) remained relatively consistent with no significant increases or decreases occurring during the sample period. The lowest yearly average concentration was 0.005 mg/L in 1990, and the highest 0.26 mg/L in 1981. The highest concentration should be tested for its significance to determine if it is a true outlier, as it appears to be an anomaly. Phosphate concentrations appear to be decreasing in Baxter Creek. The R^2 value of 0.0555 is very low, indicating no relationship between time and average PO_4^{3-} concentrations.

Total Kjeldahl nitrogen concentrations (Figure 3) gradually increased over the sampling period with both the linear trendline and moving average trendline displaying overall concentration increases. The lowest yearly average concentration was reported in 1990 at 0.156 mg/L, and the highest in 2001 at 0.8 mg/L. Total Kjeldahl nitrogen concentrations appear to be increasing in Baxter Creek. The R^2 value of 0.0695 is very low, indicating no relationship between time and average TKN concentrations.

Filtered nitrite concentrations (Figure 4) increased over the sample period, evident through both the linear and moving average trendlines. Filtered samples include the amount of chemical associated with just the aqueous fraction. The lowest yearly average concentration was reported in 1991 at 0.0025 mg/L, and the highest in 1981 at 0.011 mg/L. The last sample year for filtered nitrite occurred in 1993 which means this is not entirely reflective of the current nitrite concentrations within Baxter Creek; future sampling should occur to analyze current and more up to date nitrite concentrations within the stream. The R^2 value of 0.0465 is very low, indicating no relationship between time and average filtered nitrite concentrations.

Unfiltered nitrite concentrations (Figure 5) include the amount of chemical associated with both the particulate and the aqueous fractions. Concentrations decreased over the sample period with both the linear and moving average trendline showing a negative trend. The lowest yearly average was reported in 2018 at 0 mg/L, and the highest in 1996 at 0.028 mg/L. Unfiltered nitrite concentrations seem to be decreasing in Baxter Creek. The R^2 value of 0.5843 indicate a weak but present relationship between unfiltered nitrite and time; this could be reflective of nitrite accumulating within the stream sediment overtime.

Analysis of filtered nitrate concentrations (Figure 6) occurred from 1977 to 1984, which is a limitation for analyzing current concentrations within Baxter Creek. For the years sampled, the linear and moving average trendline indicate that filtered nitrate concentrations were gradually increasing with the last reported concentration in 1984 having the highest yearly average of 0.726 mg/L observed. The R^2 value of 0.7456 show a relationship between nitrate concentrations and time, which indicates that current nitrate concentrations most likely continued on an increasing trajectory in Baxter Creek. The lowest yearly average concentration was reported in its first year of sampling of 1977 at 0.49 mg/L.

Filtered total nitrate concentrations were reported from 1981 to 1994 (Figure 7). The linear and moving average trendline indicate decreasing concentrations in Baxter Creek. The lowest yearly average concentration was reported at 0.237 mg/L in 1994, and the highest in 1986 at 0.816 mg/L. The R^2 value of 0.1552 is very low, indicating no strong relationship between time and average filtered total nitrate concentrations.

Unfiltered total nitrate concentrations (Figure 8) remain relatively stagnant with a slightly observable increase in both the linear and moving average trendlines. The lowest reported concentration occurred in 2012 at 0.598 mg/L, and the highest in 2016 at 0.831 mg/L. Unfiltered total nitrate concentrations appear to be very gradually increasing in Baxter Creek. The R^2 value of 0.1592 is very low, indicating no strong relationship between time and average unfiltered total nitrate concentrations.

Total nitrogen concentrations (Figure 9) appear to be on a decreasing trajectory in Baxter Creek, observable through both the linear and moving average trendlines. The lowest reported yearly average concentration for the attained dataset was reported in 2019 at 0.825

mg/L, and the highest occurring in both 2014 and 2016 at 0.912 mg/L each. The R^2 value of 0.605 indicates a relationship is present between total nitrogen concentrations and time.

Yearly average sodium concentrations (Figure 10) show interesting results: the linear trendline indicates a decreasing trend, while the moving average indicates an increasing trend since around 2006. Sodium concentrations in Baxter Creek appear to be headed towards an increasing trajectory. The lowest reported yearly average concentration occurred in 2007 at 4.02 mg/L, and the highest in 2003 at 8.89 mg/L. The R^2 value of 0.4629 indicates a very weak relationship between sodium concentrations and time.

Chloride concentrations (Figure 11) show a similar trend as sodium with the linear trendline indicating a stagnant yet slightly decreasing trend while the moving average shows an increasing trend since around 2006. Through the years 1994 to 2004, chloride concentrations somewhat spike but plateau after 2004. From 2005 onwards, yearly average concentrations begin to slightly increase. The lowest recorded concentration occurred in 1991 at 3.03 mg/L, and the highest in 2003 at 13.45 mg/L. The R^2 value of 0.0008 is extremely small, indicating no relationship between chloride concentrations and time.

Dissolved oxygen concentrations (Figure 12) show a stable increasing trend through both the linear and moving average trendlines. There was a gap in sampling that occurred from 1993 to 2001. The lowest and highest yearly average DO concentrations occurred in 2013 and 2008 at 9.6 mg/L and 14.72 mg/L, respectively. The R^2 value of 0.0845 is extremely small, indicating no relationship between DO concentrations and time.

4.2 Sources of Nutrients

There are many point and nonpoint sources of the nutrients analyzed, with anthropogenic sources majorly influencing stream concentrations. Point sources are discrete, identifiable sources of pollution. Point sources of nitrogen and phosphorus include and are not limited to municipal and industrial wastewater effluent, runoff and leachate from waste disposal sites, runoff and infiltration from animal feedlots, and unsewered industrial sites runoff (Carpenter et al., 1998). Wastewater effluent is a major source of nitrite into the environment.

Nonpoint sources are diffuse pollution which is the release of pollutants from a range of activities, not just one source. Human activities, including agriculture and urbanizing development, are the primary nonpoint sources of nutrient inputs to receiving waters, especially nitrogen and phosphorus (Howarth et al., 2000). Agricultural activity, including cropland and pastureland, are a primary nonpoint source of nitrogen and phosphorus species (Smith, 2003). A major source of nitrate in the environment occurs through the application of fertilizers, which is often rinsed off the land during precipitation events (*i.e.*, runoff), into nearby surface waters. The highest loading of nutrients to receiving waters are observed in

areas with a high population density and in watersheds with a high prevalence of intensive agricultural practices such as row crop systems (Howarth et al., 2000; Smith, 2003).

Similarly, to nitrogen and phosphorus, sodium and chloride enter the environment via point and nonpoint sources. Agriculture, stormwater runoff, and salt application on roads during the winter months are major nonpoint sources of these nutrients into streams. A major source of both sodium and chloride into the environment occur via road salt applications. Point sources of chloride include industrial and wastewater treatment sources, as well as industrial processes that use chemicals containing chloride. Point sources of sodium include industrial discharge pipes and/or sewage treatment plants.

Although not a nutrient, dissolved oxygen is a parameter indicative of water quality. Levels of DO in water are impacted by temperature, atmospheric pressure, water flow, and the presence of pollutants. Low levels of DO can have harmful impacts on aquatic ecosystems and ultimately change the stream ecosystem composition. Measuring DO content can inform areas within a stream where pollution may be present.

The use of all these nutrients requires adequate monitoring and management to protect the health of aquatic ecosystems as well as drinking water sources. Both point and nonpoint sources can have negative impacts to water quality, so it is vital to manage these sources accordingly. An enhanced understanding of point and nonpoint source nutrient export will allow land managers to make informed land use and land management decisions (Nelligan et al., 2021). This can be achieved via best management practices and stringent guidelines to ensure a healthy aquatic ecosystem for current and future generations.

4.3 Potential Applications & Outcomes

This water quality trend analysis can provide several outcomes including:

1. **Identifying changes in water quality over time:** trend analysis will allow us to identify any significant changes in water quality parameters over a specific period. We can determine if there have been gradual increases or decreases in the levels of pollutants/nutrients in the water.
2. **Evaluation of the effectiveness of pollution control measures:** this information can be used to refine existing strategies or develop new ones to address specific pollution issues.
3. **Prediction of future water quality conditions:** by extrapolating the trends observed in the water quality data, we can predict future conditions and make informed decisions about future water management strategies.
4. We can determine whether water bodies are meeting **regulatory standards and guidelines**, which can inform policy decisions to ensure environmental standards are being met.

5. **Identification of potential activities related to pollution:** exact point sources can't necessarily be identified, but trend analysis can help detect potential activities related to pollution, such as agricultural runoff or industrial discharges, depending on certain nutrient concentrations. Results can then be targeted for further investigation and remediation, which can inform best management practices (BMPs).

Overall, water quality trend analysis can provide valuable information to policymakers and water managers as well as other stakeholders in the effort to protect and improve the quality of the water resources within the Baxter Creek community.

4.4 Limitations & Areas of Concern

A limitation and area of concern for this study is the change in laboratory analysis methods for each nutrient over the sample period. Over the sample period, laboratory methodologies changed with evolving technology and analysis techniques. The change in methods typically indicates a change in detection limit, which raises concern over comparing nutrient concentrations over time. Inconsistencies and differences between lab methods can generate inaccurate trend lines which would inaccurately inform the study. Changes in lab methods overtime should be recognized for each nutrient and considered when critically analyzing changes in concentrations over time.

4.5 Future Recommendations

Future recommendations for this study are to obtain the dataset compiled by Nolan Pearce to critically compare water quality results overtime in Baxter Creek. Having more than one dataset to compare and analyze will help produce accurate reports on the state of the environment. State of the environment reports can be published to inform and educate the watershed community of Baxter Creek and promote the importance of watershed health and water quality.

Additionally, long-term stations should be set up to sort out the upper and lower watershed activities that are related to water quality in Baxter Creek.

5.0 References

- Carpenter, S.R., Caraco, N.F., Correll, D.L., Howarth, R.W., Sharpley, A.N., & Smith, V.H. (1998). Nonpoint pollution of surface waters with phosphorus and nitrogen. *Ecological Applications*, 8(3), 559-568. [https://doi.org/10.1890/1051-0761\(1998\)008\[0559:NPOSWW\]2.0.CO;2](https://doi.org/10.1890/1051-0761(1998)008[0559:NPOSWW]2.0.CO;2)
- Howarth, R.W., Anderson, D.M., & Cloern, J.E. (2000). Nutrient Pollution of Coastal Rivers, Bays, and Seas. *Issues in Ecology*, 7, 1-15.

- Nelligan, C., Sorichetti, R.J., Yousif, M., Thomas, J.L., Wellen, C.C., Parsons, C.T., & Mohamed M.N. (2021). Then and now: Revisiting nutrient export in agricultural watersheds within southern Ontario's Great Lakes Basin. *Journal of Great Lakes Research*, 47, 1689-1701. <https://doi.org/10.1016/j.jglr.2021.08.010>
- Smith, V.H. (2003). Eutrophication of freshwater and marine ecosystems: A global problem. *Environmental Science & Pollution Research*, 10, 126-139. doi:10.1065/espr2002.12.142
- U.S. Environmental Protection Agency. (2017). *Best Practices for Submitting Nutrient Data to the Water Quality eXchange (WQX)*. Created in collaboration with the U.S. Environmental Protection Agency, the U.S. Geological Survey and Water Quality eXchange state partners. https://www.epa.gov/sites/default/files/2017-06/documents/wqx_nutrient_best_practices_guide.pdf

6.0 Appendix

All relevant documentation can be found in the following Google Drive link:

<https://drive.google.com/drive/folders/1SDlxFxTdMybGjMEjQidB12XAB31BFoht>

The following documents are within the Google Drive:

- *MASTER 1965-1971 Baxter Creek Water Quality (Station Inactive 17002101002)
- *MASTER 1972-1990 Baxter Creek Water Quality (Station Inactive 17002106902)
- *MASTER 1977-2019 Baxter Creek Water Quality (Station Active 17002107702)
- Active Station Nutrient Trends
- Inactive Station 17002101002 Nutrient Trends
- Inactive Station 17002106902 Nutrient Trends
- MDL_request_B-Ceci
- METHOD_CODE_EN
- Parameter Summary List
- Provincial Water Quality Monitoring Network (PWQMN)_Metadata-EN
- REMARK_VALUQUALIF_CODES_EN