INVESTIGATING LAND USE & CLIMATIC EFFECTS ON SMALL CATCHMENT WATER QUALITY

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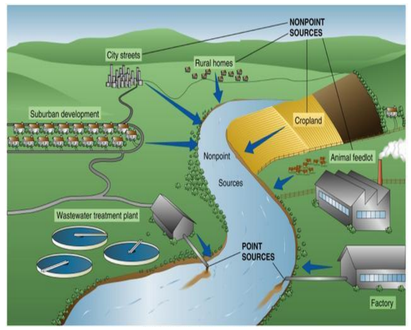
INTRODUCTION

The Niagara Region is comprised of a variety of land uses all contributing to the functioning system that exists in this landscape. These land uses include those naturally occurring (woodlands, wetlands) and anthropogenically created such as urban and agricultural landscapes. The agricultural industry is a prominent figure in the region, covering nearly 40% of the total land area[1]. This extensive presence of agriculture raise concerns regarding impacts on freshwater resources. Most notable in the Great Lakes Basin, agricultural impacts from nutrient loading and sediment transfer are among the top impairments on water quality[2]. Land use effects on hydrological networks exist through two forms of pollution; point and non-point source pollution[(3,4)]. The effects pollutants have on water resources involve decreasing general water quality, deplete aquatic habitats, and increase advancements in eutrophication processes[2].

Increasing variability in precipitation events raises further concerns to the vulnerability that hydrological systems face with surrounding land uses. Change in precipitation rate, volume and frequency leave exposed lands, such as agricultural fields, to increased runoff[4]. Oppositely, catchments which are dominated with heavy vegetated land result in less runoff volume due to a reduction in precipitation reaching the surface[5]. As a result, increases with regards to precipitation intensity will impact those watersheds housing more agricultural and urban land versus those with heavier vegetative surfaces due to the drastic difference in surface runoff. This increases concentrations of harmful nutrients such as phosphorus and nitrates.



Source: Pearson Canada Inc.

Figure 1.0 This diagram illustrates the land uses which harm watersheds through point and non-point source pollution.

Source: http://content.usatoday.com/communities/sciencefair/post/2010/10/nitrogen-cycle-broken/1#.VyDRFqgrKUk

Figure 2.0 A large volume of surface runoff from an agricultural field is shown after a precipitation event. Contaminants within the transported sediment are transferred into surrounding hydrological networks impairing water quality.

OBJECTIVES

The main objective of the proposed research is to examine the effects land use and climatic variations have on small catchment water chemistry in three (3) Niagara watersheds. Two hypothesis' are generated, 1) catchments which are dominated by agricultural land uses will influence water chemistry, specifically phosphorus and nitrogen; 2) precipitation events will effect increasing water chemistry variables in agriculture watersheds.

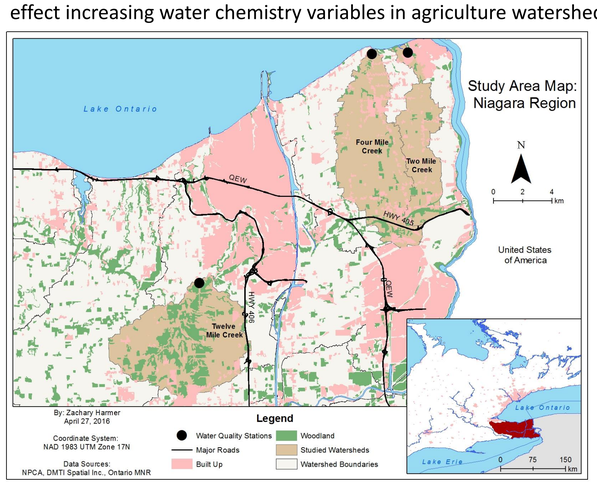


Figure 3.0
Illustrating locations of the three studied watersheds (Two Mile, Four Mile and Twelve Mile Creek) in this research relative to surrounding land use/land cover types such as built up and woodlands.

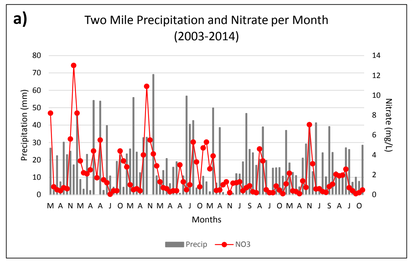
DATA & METHODS

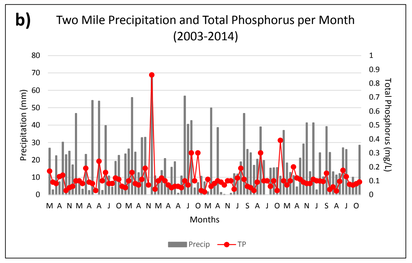
- Water chemistry data accessed through the Niagara Peninsula Conservation Authority
- Monthly (April to November) "grab" sampling from 2003 to 2014 as part of the *Surface Water Quality Monitoring Program*
- Daily precipitation data collected through Environment Canada's archived climate database
- Total precipitation was summed between sampling date and **10** days prior
- This allowed for capturing runoff volume from upstream environments and time lag for concentrations to reach sampling location and date
- All data analyzed in *R* (version 3.2.2) or Microsoft Excel

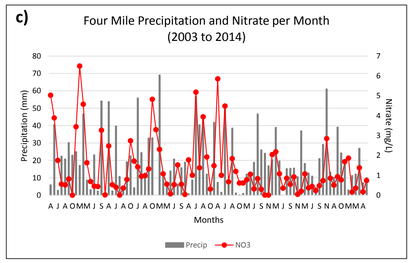
Table 1 Locations of sampling sites in the studied watersheds. Water samples are collected from these sites monthly from April to November.

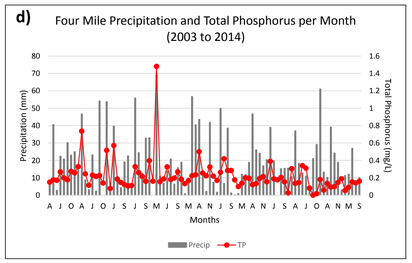
Watershed	Site Name	Easting (m E)	Northing (m N)	Road Access
Two Mile Creek	TM001	654591.3	4790755.3	Lakeshore Rd.
Four Mile Creek	FU004	652125.15	4790644.35	Lakeshore Rd.
Twelve Mile Creek	TW007	640355.85	4775032.65	1st Louth St.

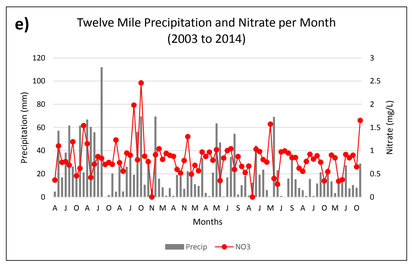
RESULTS











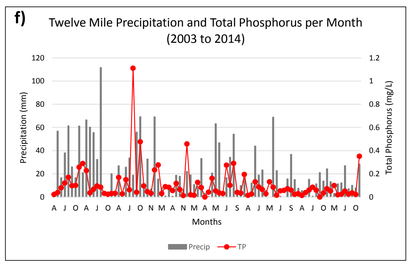


Figure 4.0 a) & **b)** demonstrate the relationship between precipitation and nitrate and phosphorus within the Two Mile Creek watershed. The Two Mile Creek, at the downstream edge flows through built-up land, resulting in lower levels of phosphorus concentrations. **c)** & **d)** display results from the Four Mile Creek watershed. This portion of the region is dominated by agricultural land, specifically vineyards and orchards. As a result, concentrations in phosphorus and nitrogen are higher. Finally, **e)** & **f)** illustrate the relationship found within the Twelve Mile Creek watershed. Forested land takes up the majority of the area in this watershed resulting in low concentrations between nitrate and phosphorus. Each of the figures illustrates the response water quality parameters have in catchments with varying land uses.

Table 2 Correlations between precipitation and nutrient concentrations. All correlations are positive, however are weak to medium in strength. This illustrates that correlations do exist however are quite minor in most cases.

Watershed	NO_3 Correlation	Level of Correlation	Total Phosphorus Correlation	Level of Correlation
Two Mile Creek	0.240	Weak Positive	0.405	Medium Positive
Four Mile Creek	0.367	Medium Positive	0.486	Medium Positive
Twelve Mile Creek	0.101	Weak Positive	0.223	Weak Positive

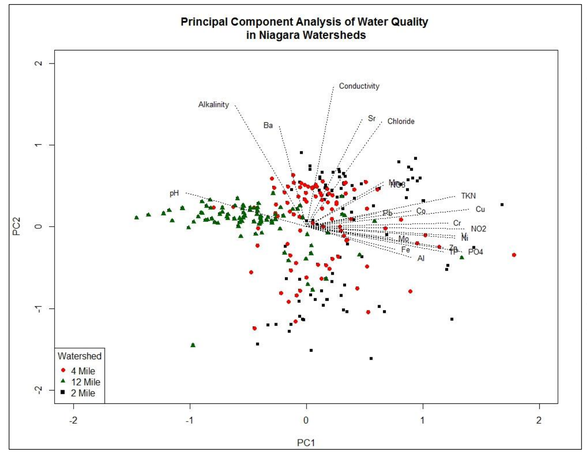


Figure 5.0
This Principal Component Analysis (PCA) illustrates correlation between water chemistry variables themselves and between the three watersheds. Twelve Mile Creek is heavily correlated to pH, while being inversely correlated to variables on the right. However, those variables on the right are strongly correlated to one another. The Two and Four Mile Creek watersheds are strongly correlated between each other and with variables such as nitrate (NO_3), chloride and conductivity. This plot allows to conclude that the watersheds with land uses other than a vegetated (Twelve Mile Creek) are influencing water quality parameters, be that negatively or positively.

CONCLUSIONS

- Precipitation events, 10 days prior to sampling, influence concentrations of water quality parameters such as phosphorus and nitrate. This is illustrated through the peaks in nutrient concentrations with precipitation increases
- Weak to medium positive correlations exist between precipitation and nutrient concentrations; notably, Twelve Mile Creek has the lowest correlation showing that water chemistry is not influenced by precipitation. This corresponds to research regarding minimal runoff in vegetated watersheds
- Land uses have influence on water chemistry variables as shown in the PCA by visually assessing the correlation all parameters have with watersheds dominated by anthropogenic land uses

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