Proposal for the Municipality of Brockton:
Sampling and monitoring the Lake Rosalind Drinking Water System to identify and quantify the source of fecal pollution in the well system using microbial source tracking Method E3499.

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1. Introduction

The Lake Rosalind watershed consists of surface water used for recreation and domestic plumbing for residents living on and around Lake Rosalind. Additionally there are approximately 68 residents that are connected to the municipal well system along Road 4, of which at least one non-permitted private water supply is located in the same area. The well system faces both capacity and quality challenges and the lake has been faced with persistent harmful algae blooms since 2010.

2. Rationale

This proposal was produced in an effort to better monitor and control microbial and nutrient contamination into both the well system water and the Lake Rosalind and Marl Lake surface water. Since 2010, the two lakes have been subject to reoccurring harmful algae blooms. Over the same time period the well system has recorded counts of *E. coli* in the GUDI well raw water primarily in the fall and an increasing trend of nitrate concentration indicating both microbial and nutrient contamination. Action to mitigate the pollution and remediate the quality of both the well and surface water are to expand monitoring the water quality of the wells to include microbial source tracking method E3499. Additionally, an effort should be made to preserve land zoned as Environmentally Protected or Hazardous within the Lake Rosalind watershed and restore sensitive areas that are subject to erosion and agriculture runoff. The capacity of the water supply system in the community has also been recognized as a significant risk to not support the existing and future water demands for the community (Melchin et al., 2016). After reviewing the publically available documents and incorporating “best practice” scientific principles, there is evidence to support that past zoning changes have negatively impacted both surface and ground water in the area.

2.1 Drinking Water

Demand

The existing water supply has been noted that it cannot meet the current demand at all times of the year. Well #1 has been clearly impacted by drought, with shown effects of reduced well yield during seasons that lack precipitation over extended periods of time (Shannon, 2017; Shannon 2018). Additional confirmation can be found in the Tier Three Water Budget and Local Area Risk Assessment. The impact of climate change has resulted in recent droughts that have negatively impacted the supply of the current drinking water system.

The two wells that supply water to the Community of Lake Rosalind have had historical issues with meeting the existing residential demands. As recently as the summer of 2012, the water levels in both wells fell below safe operating levels and the wells were unable to supply demand to the community (Melchin et al., 2016). Well #1 is a shallow dug well that extends less than 4 m below surface and is vulnerable from both water quality and quantity perspectives. Well #3 is a deeper well that extends 23 m below surface; however, the static water levels in Well #3 vary dramatically (up to 7 m) from one year to the next and fall to depths below the pump intake, which lies over 16 m below surface. It was interpreted that during these periods, the well could not service the demands of the community (Melchin et al. 2016).

The Tier Three Assessment establishes the risk that a community's sources of water will not be able to meet allocated water demands, taking into consideration climate and other water uses. Land use in the Study Area is primarily agricultural with natural areas such as forests and wetlands scattered throughout. Urban areas exist along the shores of Lake Rosalind and Marl Lake (Melchin et al., 2016). As Local Area B (Lake Rosalind Wells) was assigned a Significant Risk Level, all consumptive demands or areas of recharge reduction (due to land use development) within this area are classified as Significant Water Quantity Threats (Melchin et al, 2016).

Quality

The following data was sourced from the Walkerton Drinking Water System Summary Reports from 2010 to 2018, prepared by Veolia Water in accordance with Schedule 22, Ontario Regulation 170/03. These documents are publically available and reflect the quality of the drinking water over the past 8 years. The reports indicate that the municipal system, which consists of Well #1 and Well #3, provides the community with water that meets the Drinking Water Quality Standards in Ontario Regulation 169/03 with the exception of sodium, which often exceeds the value found in the regulation.

The other important parameter that should cause concern noted in the public water supply reports is the increasing trend associated with the concentration of nitrates (Figure 1). The MAC of nitrates in drinking water is 10 mg/L as nitrogen (MOECC, 2006). Nitrates are present in water (particularly ground water) as a result of the decay of plant or animal material, the use of agricultural fertilizers, domestic sewage or treated wastewater contamination, or geological formations containing soluble nitrogen compounds (MOECC, 2006).

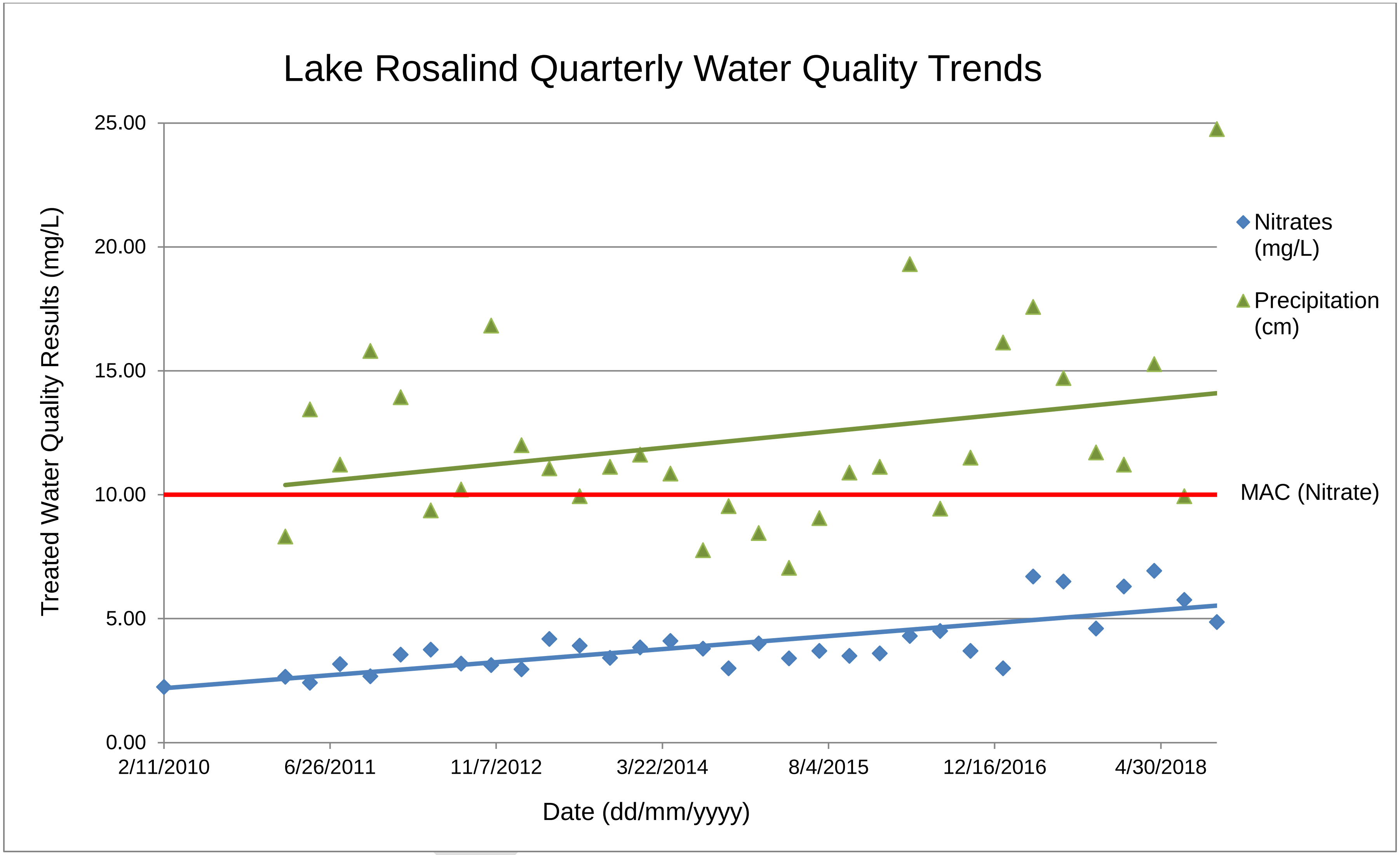

Figure 1. Information Sourced from Lake Rosalind Drinking Water System 2010 – 2018 Summary Reports and precipitation data available for Walkerton, Ontario:Sourced https://www.worldweatheronline.com/lang/en-ca/walkerton-weather-averages/ontario/ca.aspx accessed April 25th 2019.

As noted in the Tier 3 assessment, the area around the municipal wells is primarily agricultural with some medium density residential. Based on the counts of the fecal indicator *E.coli* measured in Well #1 primarily during the fall months compounded with the increasing trend of nitrates and precipitation, strongly suggests the source of pollution is livestock manure and/or domestic wastewater, and is influencing the nitrate concentrations (Figure 2). Microbial Source Tracking (MST), MECP Method E3499 could be performed to confirm and quantify the source as human, cattle and/or swine. Walkerton quarterly precipitation data (used due to data availability and proximity radius) was plotted along the same time period and shares a similar and parallel trend with the nitrate levels, suggesting that flooding effects from climate change are correlated with nitrate levels.

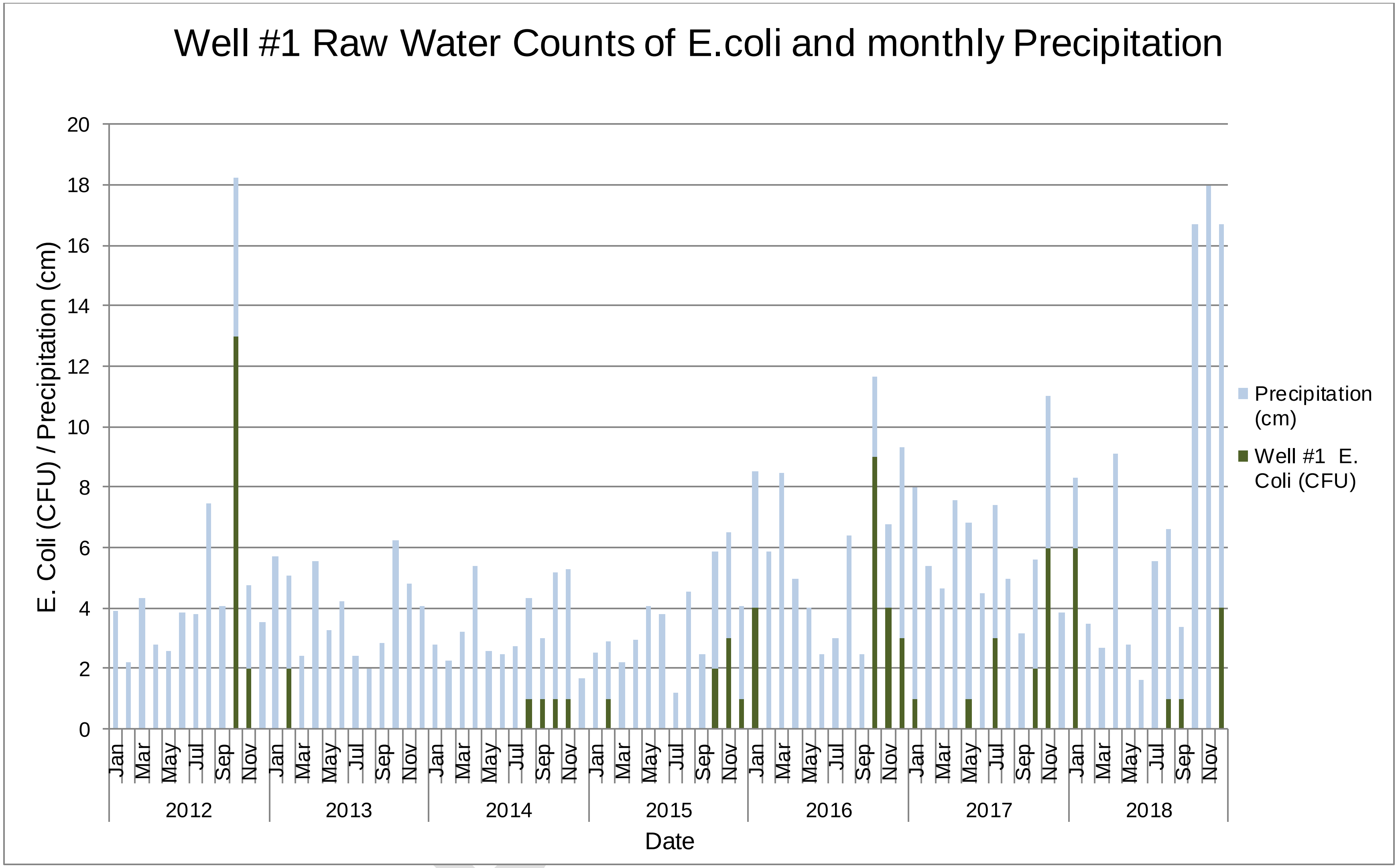

Figure 2. Information Sourced from Lake Rosalind Drinking Water System 2012 – 2018 Summary Reports and precipitation data available for Walkerton, Ontario: Sourced https://www.worldweatheronline.com/lang/en-ca/walkerton-weather-averages/ontario/ca.aspx accessed April 25th 2019.

Figure 3. Lake Rosalind Biological Sampling Plan

2.2 Storm Water

Storm water is water that originates during precipitation events and during snow/ ice melt. Storm water will either soak or infiltrate into the ground, be held on the surface and evaporate or runoff and end up in the watershed, ultimately Lake Rosalind. The Environmentally Protected and Hazardous zones located around the lake are necessary for storm water management to not only protect residential infrastructure, but also the quantity and quality of water entering the lake and water table. Results from water quality testing completed by the Lake Rosalind Water Quality Committee (Figure 3) show elevated nutrient loading.

The riparian zone is noted as the interface between land and a body of water. It is known as a terrestrial biome of the earth, where plant habitats and communities along the banks are characterized as hydrophilic. If constructed and undisturbed, this zone acts as a buffer to control, trap, and treat storm water as it travels by gravity to lower elevation. These zones are necessary to reduce the velocity of storm water, allowing it to infiltrate the ground, recharge the water table, control erosion, reduce turbidity, and reduce nutrient concentrations as it travels down and enters the body of water.

Tori Waugh, Agriculture Outreach Coordinator for the Saugeen Valley Conservation Authority, presented a widely accepted scientific method to improve the health of inland lakes which follows a three step approach. Step 1 to avoid and prevent; Step 2 to control, trap, and treat water using grassed waterways, tree planting, storm water retention ponds, swales and berms; Step 3 to manage riparian zones through the construction of wetlands and natural channel designs (modified from Tomer et al. 2013)

As it relates to the municipal water system, groundwater recharge refers to the amount of water that infiltrates and seeps through the unsaturated zone and ultimately reaches the water table. The rate of groundwater recharge is dependent on a number of factors including precipitation, evapotranspiration, land use and vegetation, surficial soil type (geology), and physiography. Recharge is enhanced in areas where the ground surface is hummocky and direct runoff to nearby creeks and rivers is inhibited (Melchin et al. 2016). As Well #1 is largely influenced by the water table, inhibiting runoff in that area using the three step approach above would improve the well recharge rate and water security for the future.

2.3 Waste Water

A tertiary septic system that complies with the Effluent Quality Criteria as regulated by the Ontario Building Code (table 8.6.2.2.A) releases a reduced strength effluent from a normal residential waste count of 120-150 mg/L BOD5 to ~ 15 mg/L (Septic Systems Ontario, 2019). However, the average water usage of a 4 person residence is ~ 1000 L/day, therefore 15 000 mg/day of BOD5 would be entering the watershed and consuming oxygen as it is broken down in the lake. Although this system performs better than a traditional system, there is a waste product being generated where persistent harmful algal blooms exist. Lastly, detergents and soaps that contain surfactants and water softener brine high in sodium also are not treated by septic systems.

3. Objectives

This purpose of this proposal is to incorporate Microbial Source Tracking as a monitoring tool to identify the source of fecal contamination in the Well #1 and Well #3 system. As noted in Figure 3, these two sampling locations will be added with the surface water samples to determine the relative quantity of human, bovine, and/or swine sources.

This information will help demonstrate how the local ground and surface water supply and quality are linked to the management of storm water, waste water and other land use practices.

4. Methods

The sampling frequency will be conducted bi-weekly from the raw sample ports at both Well #1 and Well #3 for baseline numbers. Additional sampling will be completed following precipitation events ≥ 15 mm to correlate if precipitation influences fecal contamination in the well system. Sampling will be conducted from as early as May

2019 to November of 2019 for bother surface and ground water. Additional ground sampling may be continued after November if resources are available.

The samples will be stored at 4°C for less than 48 hours and filtered with a 0.45 µm filter prior to DNA extraction. The laboratory work will be conducted at the University of Guelph in a biohazard Class 2 Lab following the standard operating procedures in Method E3499 by the Ministry of Environment Conservation and Parks.

The samples will be analyzed for human, bovine and swine specific copies of *Bacteroides* genetic markers and quantified against a known standard curve. The same sample will also be analyzed for *E. coli* and compared because it is currently the regulatory standard used in drinking and recreational waters.

5. Estimated In-kind Support

Table 1. Estimated In-kind support

Item	Class	Description	Budget		
			Cost	Quantity	Sub Total
1	In House Reagents	E. coli plates and agar	15	40	600
2		human, bovine and swine primers and probes	750	2	1500
3		plasmid standards	10	6	60
4		lab supplies and bottles			200
5	Labour	Lead Researcher	25	10	250
6		Research assistant	20	20	400
7	Gas	200 km /trip x 20 trips x 11 L/ 100km x $1.25 / L			550
				Subtotal Cost	$ 3,560.00
				15 % Contingency	$ 534.00
				Total estimate	$ 4,094.00

Note: Only considering 2 sample sites over the course of 1 year.

6. Communication

A report to summarize the findings from the water sampling and monitoring will be submitted to the Municipality of Brockton and Veolia. The findings will also be submitted as part of a Master's thesis and may include conference presentations or case studies to provide information to other owners and operators of drinking water systems.

7. References

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