Rideau Valley Conservation Authority

Sustainable Drainage Project – Rideau Lakes Township

Monitoring Report/Summary

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Executive Summary

To better understand the physical and chemical risk of stormwater contributions into Big Rideau Lake, two drainage features were sampled over the course of the 2022 ice-free season (May to November). Features were selected to represent both artificial (i.e., stormwater catch basins) and natural drainage systems (small tributaries/drainage ditches). For the purposes of this project, monitoring efforts were focused on the village of Portland and its immediate surrounding area. With the support of Rideau Lakes Township, Big Rideau Lake Association, Rideau Lakes Lake Association Committee (RRLAC), and Cataraqui Region Conservation Authority, staff at RVCA collected grab samples from May to November and deployed continuous monitoring devices in each system.

Results from the study suggest that both during normal conditions, and during precipitation events select sampled parameters; Chloride (Cl^-), Nitrate (NO^-_3), Nitrite (NO^-_2), Ammonia (NH^-_3), Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), and Total Suspended Solids (TSS), exceeded the recommended guidelines. These exceedances were observed more consistently and frequently within the artificial drainage system when compared to the natural drainage feature.

Continuous monitoring devices in both systems also demonstrated increased variability in measures of specific conductance. This variability was increasingly pronounced within the artificial drainage system in comparison to the natural drainage system. Changes in the degree of variability were also identified during precipitation events suggesting a greater risk to water quality degradation during precipitation events.

Results from this study suggest limitations in buffering and filtration capacity within artificial drainage systems in comparison to the natural drainage feature. Further consideration should be given to the implementation of Low-Impact Development (LID) techniques across the region to promote and improve water storage and filtration in regions where these may be limited. In more natural based ecosystems, LID techniques can be implemented to help reduce and slow stormwater contributions. In the case of the natural drainage feature, water retention (i.e., bioretention gardens, infiltration trenches, swales, filter strips, tile drainage control structures, cover crops, etc.) features may also help to slow water movement across the landscape forcing its storage and improving the landscapes' ability to store nutrients or contaminants. While in artificial or altered systems, more diverse LID techniques can be implemented, including water retention, filtration, or infiltration structures (i.e., constructed storm system filters, swales, bioretention gardens, rain barrels, grid or permeable paving systems, etc.) (RVCA 2022).

Table of Contents

Overview

With many water bodies within Rideau Lakes Township seeing increased pressure through human impact and land use, downstream water quality impacts have become of increasing concern. There is also concern for stormwater management as more frequent and intense storms are expected. To better understand the risk of these impacts to Big Rideau Lake, two drainage features were selected for study. These features include a constructed stormwater management system (i.e., a series of catch basins) located within the village of Portland, and a natural drainage system (i.e., a tributary to Big Rideau Lake). Grab samples were collected, and continuous monitoring devices were deployed in both to better understand the overall risk from both systems during regular flow and increased flow from precipitation conditions.

Project Design

Study and Sampling Locations

To understand stormwater contributions to Big Rideau Lake and within Rideau Lakes Township, two drainage features were selected for study. Selection was based on their watershed characteristics being representative the types of constructed and natural drainage systems present within Rideau Lakes Township and the Big Rideau Lake catchment area. For this study, efforts were focused on selecting systems that could present consistent water levels throughout the course of the season, while also representing both natural drainage features (i.e., smaller tributaries) and artificial drainage (i.e., humanmade stormwater collection and distribution systems). As a result, an unnamed natural drainage feature located outside the village of Portland adjacent to the Portland Bay Conservation Area, and a stormwater catch basin within the Main St. Outfall catchment within the village of Portland were selected for study (Figure 1). In the case of the unnamed natural drainage feature, sampling occurred on the downstream side at the HWY 15 crossing (Figure 2), while in the artificial drainage system the catch basin located on the downstream side of Main & Water St. was selected (Figures 3 & 4). Sampling locations along each drainage system were selected based on their proximity to the outflow to Big Rideau Lake, and their ability to capture overall potential contaminant (nutrients, salts, etc.) concentrations from each drainage system.

Figure 1. Selected drainage features and sampling locations within Portland, ON, Canada.

Figure 2 2. Downstream (right) and upstream (left) views at the HWY 15 crossing of an unnamed drainage feature located adjacent to the Portland Bay Conservation Area. Photos were taken in April 2022.

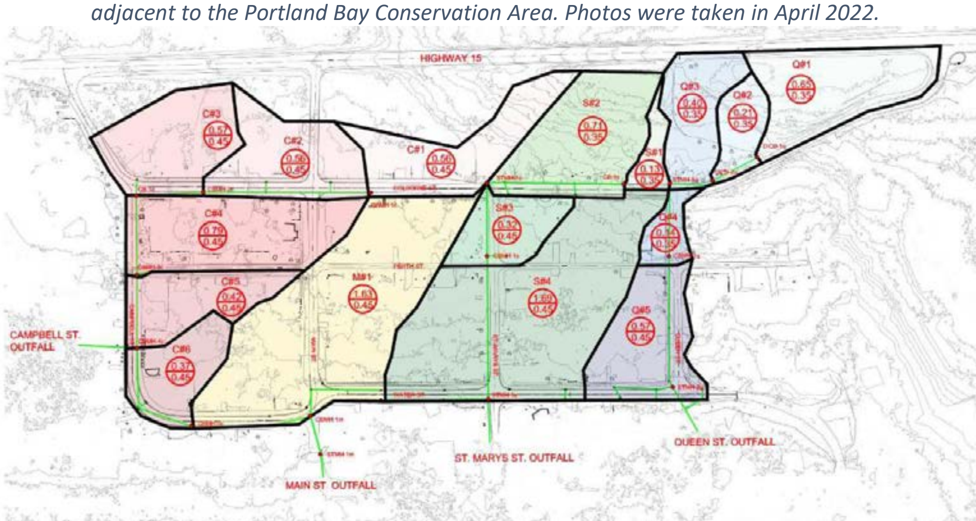

Figure 33. Portland stormwater outfall catchment areas. The Main St. Outfall catchment (yellow) was selected for this study (Jewell Engineering, 2018).

Figure 44. Exterior (left) and interior (right) view of the downstream Main & Water St. Catch Basin.

Sampling Protocol

Grab Samples

To standardize sampling, Ontario Provincial Water Quality Monitoring Network (PWQMN) sampling protocols were applied to both systems. Given that neither system had been previously sampled for water quality concerns, a baseline sampling regime was used to provide a better understanding. To do this, samples were collected every two weeks starting on May 11th. Sampling occurred at this rate until November 10th. To understand stormwater impacts, samples were collected during 6 precipitation events (about 1 per month). Samples were collected during or shortly after the precipitation event to capture active runoff. A threshold of forecasted 20mm of rain was set as a benchmark for qualifying precipitation events. All collected water samples were analyzed by the City of Ottawa Laboratory according to standardized methodologies.

Continuous Monitoring

To improve understanding of changes in conductivity and water level, continuous monitoring devices were deployed into each system. The deployed logging devices were positioned to capture a full record of changes occurring in the system to augment the in-person sampling.
Due to supply chain issues, loggers were not deployed until mid-June, and were removed from the system at the end of the monitoring season.

Precipitation Data

Precipitation data was collected using Rideau Valley Conservation Authority's (RVCA) rain gauge located at the Portland Bay Conservation Area. Supplemental precipitation data for the region was also collected using at home rain gauges hosted by volunteers with the Big Rideau Lake Association.

Results

Precipitation Volumes

Based on the RVCA Low Water Response assessment criteria, monthly precipitation accumulation in the Portland region was comparable to or slightly exceeded the expected regional historic normal (*ECCC Canadian Climate Normals, 1981-2010*) during the study period. As we entered the 2022 monitoring season, the Portland region was estimated to be in a state of surplus (Table 1). As the season progressed this surplus weaned and precipitation was reduced during the late summer/early fall months (August – October). This resulted in a deficit in the late summer/early fall months. This deficit was visible in the water levels observed in both systems. Over the course of the monitoring period, 6 precipitation events were successfully sampled. These precipitation events ranged in volume from 11.8 to 34.6mm of rain and varied in intensity and duration (Table 2). Precipitation events were selected based on their forecasted precipitation volumes (i.e., ≥ 20mm), although not all storms selected materialized to the forecasted volumes.

Table 1. Portland precipitation relatively to regional historic normal from May/01/2022 – Nov/22/2022; Historic normal derived from ECCC Climate Normal (1981-2010).

Month	Portland	Historical Average	% Of Historical Average
May	88	79.65	110.50%
June	98	88.88	110.30%
July	111.2	89.04	124.90%
August	45.8	82.59	55.50%
September	57.8	91.16	63.40%
October	43.8	86.27	50.80%
November	53.4	60.56	88.20%
Total	498	578.15	86.10%

Table 2. Sampled precipitation events and their associated precipitation volumes (daily total) collected from RVCA's Portland Rain Gauge system located at the Portland Bay Conservation Area.

Event Date (mm/dd/yyyy)	Precipitation Volume (mm)
05/27/2022	11.8
07/12/2022	26.4
07/18/2022	33.4
09/13/2022	16.2
10/13/2022	14
11/11/2022	34.6

Grab Samples

Collected samples were submitted and analyzed at the Robert O Pickard Environmental Centre Lab (City of Ottawa). Samples were analyzed for select parameters which included: Chloride (Cl^-), Nitrate (NO^-_3), Nitrite (NO^-_2), Ammonia (NH^-_3), Conductivity, Total Kjeldahl Nitrogen (TKN), Total Phosphorus (TP), and Total Suspended Solids (TSS). These parameters were selected for their role as lake health and stormwater management indicators. To assess overall concentrations, results were compared against surface water quality guidelines, including Provincial (Queens Printer for Ontario, 1994) and Canadian water quality guidelines (CCME, 2022). These guidelines aim to estimate concentrations of parameters at which aquatic health may be harmed. In many cases, Water Quality objectives were surpassed in both systems, posing the potential for harm to downstream aquatic environments.

All reported water quality values are concentrations and do not reflect accurate loading estimates, as a proper discharge assessment could not be completed on either feature

It should be noted, that as the monitoring season progressed, conditions within the unnamed drainage feature began to closely resemble a wetland system (Figure 5). As water levels also began to decline, the system became increasingly fragmented, resulting in shallow pools of standing water. The sampling done under these conditions (i.e., August to November) were not representative of regular flow conditions. These results likely skewed values from this system towards higher values demonstrating a wetland's function to retain or bind nutrients, despite minimal to no downstream flow and reduced discharge risk (i.e., transport/loading risk).

In the case of the catch basin, internal water levels declined similarly to the natural system. Due to system design, there is an assumed measure of backflow from Big Rideau Lake into the system. This backflow likely impacted early season water levels and collected results (i.e., dilution source). As lake levels began to decline during the late summer/fall season (i.e., August to November), water levels within the catch basin also declined to below the outflow pipe. It should be noted that any values observed during this period (August to November) are representative of collected storm water and water flows; however, they may not be representative of water conditions moving downstream into Big Rideau Lake.

Figure 55. *Water level observations collected on October 18th during baseline sampling event at the unnamed drainage feature located adjacent to the Portland Bay Conservation Area.*

When evaluating total phosphorous (TP) results, the Provincial Water Quality Objective (PWQO) was exceeded in all samples in both baseline and precipitation event sampling within the catch basin system (Table 3). In the natural drain, TP exceeded the guideline 75% of the time during baseline sampling, and 83.3% of the time during precipitation events (Table 4). When comparing the two systems, average collected results from the catch basin were lower than the unnamed drainage feature when comparing the whole monitoring period on record. When results were separated based on water level conditions (i.e., May - July, and August-November) results collected from the catch basin during higher water level conditions (i.e., May - July) were about 4.75 times greater during baseline sampling, and about 8 times greater during precipitation events compared to the unnamed natural drainage feature. During lower water level conditions (i.e., stagnant flow), the catch basin did produce higher nutrient concentrations, however as noted above, these concentrations are more representative of wetland like conditions (figure 5) and may not pose downstream risk to water quality as a result of limited water movement.

In the case of nitrogen, multiple forms of nitrogen were evaluated and analyzed. Total Kjeldahl Nitrogen (TKN), a measure of the organic fragments of nitrogen and ammonia and ammonium, results suggested that the estimated guideline of 0.5 (RVCA, 2014) was exceeded in approximately 31% of the baseline samples, and 100% of the precipitation event samples within the catch basin system (Table 3). In the unnamed drainage feature, this guideline was exceeded in all baseline samples but was only exceeded in 83.4% of precipitation event samples (Table 4). When comparing the two sites, collected TKN concentrations from the catch basin were less overall during both baseline and precipitation event sampling across the whole monitoring season, however during higher water level conditions (i.e., May to July) the unnamed drainage feature demonstrated lower average TKN values during precipitation events (about ~1.6 times less).

Table 3. Summary values of concentrations for collected samples during 19 sampling events (13 baseline, 6 precipitation events) between May 5th and November 11th from the outflow catch basin located at Water St. & Main St. in Portland, ON

Baseline Sampling						
Guidelines (PWQO[*a]/CWQG[◊b])	TP[c] (mg/L)	TKN[d] (mg/L)	NH_3[e] (mg/L)	NO_3[f] (mg/L)	NO_2[g] (mg/L)	Cl^-[h] (mg/L)
	0.02*	0.5	0.02*	13*	0.06◊	120*
Median (mg/L)	0.053	0.45	0.045	3.14	0.02	79.13
75th Percentile (mg/L)	0.063	0.55	0.065	5.65	0.04	213.7
Percent of samples exceeding the guideline	100%	31%	62%	0%	0%	38%
Precipitation Events						
Median (mg/L)	0.2705	1.35	0.0395	0.49	0.02	26.42
75th Percentile (mg/L)	0.658	1.8075	0.07075	1.4075	0.02	35.5825
Percent of samples exceeding the guideline	100%	100%	83%	0%	0%	0%

**Represents a PWQO, ◊ Represents a CWQG*

[a]Provincial Water Quality Objective, [b] Canadian Water Quality Guideline, [c] Total Phosphorus, [d] Total Kjeldahl Nitrogen, [e] Ammonia, [f] Nitrate, [g] Nitrite, [h] Chloride

Table 4. Summary values of concentrations for collected samples during 19 sampling events (13 baseline, 6 precipitation events) from an unnamed drainage system located adjacent to the Portland Bay Conservation Area and sampled from the downstream side at HWY 15

Baseline Sampling						
Guidelines (PWQO[*a]/CWQG[◊b])	TP[c] (mg/L)	TKN[d] (mg/L)	NH_3[e] (mg/L)	NO_3[f] (mg/L)	NO_2[g] (mg/L)	Cl^-[h] (mg/L)
	0.02*	0.5	0.02*	13*	0.06◊	120*
Median (mg/L)	0.069	1.01	0.007	0.05	0.02	10.06
75th Percentile (mg/L)	0.413	3.6	0.011	0.12	0.02	14.75
Percent of samples exceeding the guideline	75%	100%	8%	0%	0%	0%
Precipitation Events						
Median (mg/L)	0.2465	1.635	0.01	0.045	0.02	18.24
75th Percentile (mg/L)	0.36425	2.5675	0.03275	0.05	0.02	25.5375
Percent of samples exceeding the guideline	83%	83%	33%	0%	0%	0%

**Indicates a PWQO, ◊ Indicates a CWQG*

[a]Provincial Water Quality Objective, [b] Canadian Water Quality Guideline,[c] Total Phosphorus, [d] Total Kjeldahl Nitrogen, [e] Ammonia, [f] Nitrate, [g] Nitrite, [h] Chloride

When evaluating ammonia, 62% of samples exceeded the guideline during baseline sampling events, and roughly 83% of samples exceeded the guidelines during precipitation events in the catch basin system. In the unnamed drainage feature, only 8% of samples exceeded the guidelines during baseline sampling events, and roughly 33% of samples exceeded the guidelines during precipitation events. In the case of Nitrates and Nitrites, guidelines were not exceeded in either system; however, nitrate values presented roughly 62 times higher in the catch basin than in the unnamed natural drainage feature during baseline sampling events. This was the highest observed comparison across all parameters.

Chloride concentrations present within collected samples were only found to exceed the guidelines during baseline sampling within the catch basin system (38%). When comparing the two systems, the catch basin system demonstrated results roughly 8 times higher during baseline sampling events compared to the unnamed natural drainage system. This was similar for precipitation events; however less pronounced, where the catch basin system demonstrated median results roughly 1.5 times greater than the unnamed drainage feature.

As a stormwater focused parameter, total suspended solids (TSS) guidelines are based upon changes to a system from base values. The Canadian Council for the Ministers of the Environment do not recommend a change greater than 25 mg/L from background levels when background levels are <250mg/L (Canadian Council of Ministers of the Environment, 2002). When considering these factors, TSS was evaluated as a comparison between background and precipitation event values (or previous sampling event values). In this case, for all 6 precipitation events, TSS values were found to demonstrate a change greater than the recommended guidelines in roughly 67% of the samples. In the case of the unnamed drainage feature, TSS values were only found to exceed the guideline in roughly 50% of the samples (Table 5).

Table 5. Total Suspended Solids change between baseline and precipitation event sampling (6 events) in two drainage features located in and surrounding Portland, ON.

Guidelines (CWQG[a])	TSS[b] 25 (mg/L)	
	Main & Water St. Catch Basin	Unnamed Natural Drainage Feature
Median Change (mg/L)	54	18.5
Percent of samples exceeding the guideline	67%	50%

[a] Canadian Water Quality Guideline, [b] Total Suspended Solids

Continuous Monitoring

Due to supply chain limitations, data logger deployment was delayed in comparison to grab sample monitoring. This problem was further exacerbated due to lake backflow and water level interruptions during the late summer and early fall months. This resulted in limited data collection using the continuous monitoring devices. In the case of the catch basin, continuous monitoring devices were only submerged and accurately recording between deployment on June 21st, and August 18th, 2022. The unnamed drainage feature suffered a greater data loss, with data only accurately being recorded between deployment on June 10th, and July 30th, when water levels were no longer sufficient for logger submersion. These devices were deployed to monitor fluctuations in conductivity, temperature, and water level over the course of the sampling period. Conductivity was selected as a key parameter for this study as it is commonly used as an indicator of discharge into systems and general water quality. As a measure of the electrical current of water, conductivity is often correlated to a measure of dissolved ions within a system. These ions can include forms of nutrients, metals, and salts.

When evaluating the conductivity and water level data, the change occurring over the course of a 24hr period was used as an indicator of variability. Over the course of a 24-hour period, a reasonable degree of variability is to be expected. Variability outside of this range (>75th percentile) was considered abnormal and indicative of a discharge event. Table 6 outlines the expected ranges of variability for both water level and specific conductance (conductivity standardized to 25°C). When using these standards, there were 5 events that met these requirements within the catch basin drain, and 6 events within the unnamed natural drainage feature. Additionally, when comparing the two systems, conductivity variability appeared to be much greater in the Catch Basin system compared to the unnamed natural drain with both the median and the 75th percentile appearing roughly 3.5 times greater than the unnamed natural drain. For this report, two specific events that coincided with grab sampling activities were further evaluated. These events occurred on July 12th and July 18th, 2022 (Table 2).

Table 6. Calculated median and 75th percentile of daily changes in specific conductance (uS/cm) and water level (m above datum) collected from solinist LTC logging devices deployed in two drainage systems in Portland, ON.

	SPC* (uS/cm)	
	Main & Water St. Catch Basin	Unnamed Natural Drainage Feature
Median	121.36	31.26
75th Percentile	236.23	64.78
	Water Level (m above datum)	
Median	0.015	0.019
75th Percentile	0.023	0.027

**Specific Conductance (conductivity standardized to 25°C)*

When evaluating the event on July 12th, 2022, within the catch basin system, shortly after precipitation begins and as water level increases there is an observed decline in measured conductivity. This is likely a result of a dilution effect occurring with an influx of new water from upstream. As the precipitation continues, specific conductivity increases and continues to rise until a new equilibrium is met (Figure 5). In the case of the natural drain, this fluctuation was much less pronounced, and a new equilibrium was reached at a much quicker rate (Figure 6).

A similar event occurred on July 18th, 2022, that also produced similar results. In the case of the Main& Water St. Catch basin, a dilution effect was reach shortly after precipitation commences, however as the precipitation continues, SPC steadily increases and continues to rise as water levels begin to decline (Figure 7). The unnamed natural drainage feature presented similar results to the July 12th event, with a small dilution effect being indicated shortly after precipitation, with equilibrium being reached shortly after dilution (Figure 8).

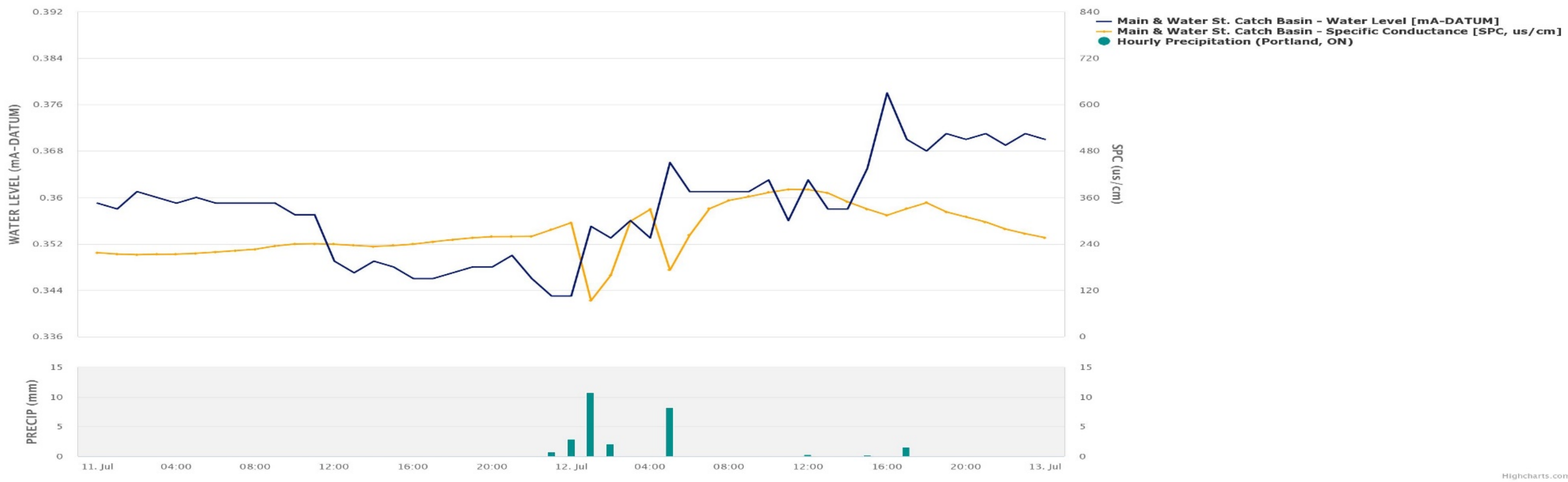

Figure 6. Analyzed specific conductance (SPC, uS/cm) and water level (m above datum) collected from a deployed solinist LTC logger deployed within the Main St. & Water St. catch basin located in Portland, ON compared to hourly precipitation data collected from the RVCA Portland rain gauge for the time period of July 11th, 2022, to July 13th, 2022.

Figure 56. Analyzed specific conductance (SPC, uS/CM) and water level (m above datum) collected from a deployed solinist LTC logger deployed in an unnamed natural drainage feature located adjacent to the Portland Bay Conservation Area in Portland, ON compared to hourly precipitation data collected from RVCA's Portland Rain Gauge for the time period of July 11th to 13th, 2022.

Figure 8. Analyzed specific conductance (SPC, uS/cm) and water level (m above datum) collected from a deployed solinist LTC logger deployed within the Main St. & Water St. catch basin located in Portland, ON compared to hourly precipitation data collected from the RVCA Portland rain gauge for the time period of July 11th, 2022, to July 13th, 2022

Figure 77. Analyzed specific conductance (SPC, uS/CM) and water level (m above datum) collected from a deployed solinist LTC logger deployed in an unnamed natural drainage feature located adjacent to the Portland Bay Conservation Area in Portland, ON compared to hourly precipitation data collected from the Portland Rain Gauge located in Portland, ON for the time period of July 17th to 19t .

Discussion

When considering all collected data, results suggested that the artificial drainage system, otherwise referred to as the catch basin, generally demonstrated higher values and results on average when water levels and flow was present compared to the unnamed natural drainage feature. This is likely due to the difference in land use within each individual catchment. Given that the artificial drainage feature is located within the village of Portland and services a series of predominantly hardened surfaces (i.e., paved roadways, sidewalks) it is likely that there is little to no water retention within this region. In the case of the unnamed natural drainage feature, this system has a greater ability to store water. As an example, upstream of the unnamed natural drainage feature lies a wetland complex that nears agricultural fields and forested area. Based on land uses present in each catchment, it is probable that there is increased water retention capacity surrounding the unnamed natural drainage feature compared to the catch basin system. As noted in the grab sample results, values of nutrients and contaminants were elevated across all parameters in the catch basin system compared to the unnamed natural drainage feature. This also further suggests that the limited retention within the catch basin catchment may also impact the landscapes' ability to filter contaminants from the system. In the case of the unnamed drainage system, the presence of wetland plants and the land uses upstream are likely beneficial in storing and filtering excess precipitation and subsequent runoff or discharge from the landscape.

One of the more notable findings was the presence of backwater within both systems, and the effects of dilution during precipitation events. Data collected from both the continuous monitoring devices for precipitation events suggested that as precipitation and runoff processes began, in both systems there was a dilution effect observed immediately after precipitation. This suggests that there may be a short lag time at the beginning of precipitation events before runoff or contaminants enter each system and the dilution of backwater concentrations was occurring. Notably, in the unnamed natural drainage feature this dilution and discharge event was significantly less pronounced than in the catch basin system. Similarly, variability in conductivity and water level in the unnamed natural drain compared to the catch basin system were reduced further, suggesting stormwater impacts may be less pronounced in a natural system. As mentioned above, this is due to the system's ability to buffer contaminants, potentially due to its wetland like characteristics and the permeable surfaces available within its catchment. These surfaces would further mitigate contaminants before they enter downstream water courses, and in the long term better protecting downstream water quality.

Conclusions

Results collected from both the artificial and natural drainage systems in Portland, ON suggest water quality guidelines were exceeded. These exceedances occurred more consistently in the artificial drainage system (catch basin) when compared to the natural drainage system. Results also suggested an increased risk to water quality during precipitation events as observed through increased conductivity measurements and guideline exceedances within collected grab samples. To better preserve the long-term health of downstream water bodies, improvements to water filtration and retention within the township should be strongly considered. The collected results also further identify the need for improved water filtration and retention in regions where hardened surface dominates. In this case, the unnamed natural drainage feature did present lower contaminant values when water was present within the system and it is suspected that it is a result of its ability to retain water and contaminants resulting in a decrease in discharge (i.e., loading) risk. In these artificial or altered areas, it is possible that LID techniques would provide avenues to correct this. These could include the implementation of bioretention gardens, rain barrels, permeable or grid pavers, infiltration trenches, swales, and/or filtration systems at both the lot level and township level to better divert and retain water, while also filtering and potentially removing contaminants (RVCA 2022). In regions where LID implementation options are limited, it is possible that artificial filtering processes (i.e., storm drain system retrofits) may help reduce risks to downstream water quality conditions. It should be noted that in more natural focused systems, LID implementation can still improve downstream water quality and better protect water quality long term (RVCA 2022). In this case, preserving wetlands, improving land cover (i.e., forested areas or cover crops), and/or improving drainage or water redirection structures (i.e., swales, drainage control structures) can help to improve water and contaminant absorption across the landscape (RVCA 2022). Along both systems, many lands are located within private ownership. This further highlights the need for education and awareness across the township to help promote the adoption of LID practices on individual properties and promote environmentally friendly sustainable drainage practices across the landscape (RVCA 2022).

Acknowledgements

RVCA would like to thank Rideau Lakes Township, Big Rideau Lake Association, Cataraqui Region Conservation Authority and the Rideau Lakes Lake Associations Committee for their support and assistance with this project. Special thanks to Gayle Mathe and Doris Albert of the Big Rideau Lake Association for their support in the collection of supplemental precipitation data within the Portland and Big Rideau Lake Catchment area.

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