Analysis of Stormwater Entering the Rideau Canal Skateway in Ottawa, Ontario

Analyse des eaux pluviales qui s'écoulent dans le Rideau Canal Skateway à Ottowa

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RÉSUMÉ

Chaque hiver, le canal Rideau à Ottawa, en Ontario, se transforme en la plus grande patinoire naturelle au monde. Cependant, les changements climatiques menacent la viabilité de la patinoire, car les températures hivernales plus chaudes raccourcissent la saison de patinage. La patinoire de 7,8 km reçoit les eaux pluviales provenant de centaines de déversoirs dont la taille varie de moins de 375 mm à 2,100 mm. Face à des conditions de formation de glace de plus en plus difficiles, les eaux pluviales deviennent un problème croissant pour la patinoire, car Ottawa connaît des conditions de dégel hivernal plus fréquentes. Ce projet examine la quantité et la qualité des eaux pluviales qui pénètrent dans le canal à partir d'un grand exutoire du centre-ville afin de déterminer si les apports d'eaux pluviales à la patinoire ont un impact sur la formation de glace. La conductivité, la température et le débit ont été mesurés à l'aide de capteurs installés dans le canal. Cette étude a révélé que 80% des eaux pluviales entrant dans le canal à partir du drain Cooper l'ont fait pendant une journée de débit élevé (49 jours sur 116). La quantité et la qualité des eaux pluviales entrant dans le canal lors de ces jours de débit élevé ont eu un impact plus important sur l'eau du canal que pendant le reste de la saison hivernale. De plus, la température et la conductivité de l'eau ont considérablement augmenté en aval. Toute mesure corrective mise en œuvre devrait viser à traiter ou à réduire la quantité d'eaux pluviales déversées pendant ces jours de débit élevé et dans la partie aval du canal afin d'optimiser l'impact sur la formation de glace dans le canal.

ABSTRACT

Each winter, the Rideau Canal in Ottawa, Ontario, is transformed into the world's largest naturally frozen skating rink. However, climate change is threatening the viability of the Skateway as warmer winter temperatures shorten the skating season. The 7.8 km Skateway winds through several historic Ottawa neighbourhoods and receives stormwater from hundreds of outfalls ranging in size from <375 mm to 2100 mm. Faced with increasingly challenging ice-forming conditions, stormwater is becoming more problematic to the Skateway as Ottawa experiences more frequent rain-on-snow and winter thaw conditions. This project examines the quantity and quality of stormwater entering the canal from one large downtown outfall to determine if stormwater inputs to the Skateway impact the ice formation. Conductivity, temperature, and flow rate were measured via sensors installed into the canal and storm sewer. This study found that 80% of stormwater entering the canal from the Cooper drain entered during a high flow day (49 out of 116 days). The quantity and quality of the stormwater entering the canal on these high flow days had a larger respective impact on the canal water than the rest of the winter season. As well as there being significant increases in water temperature and conductivity further downstream. Any remediation methods implemented should focus on treating or mitigating the quantity of stormwater outputs on these high flow days and the later canal segment to maximize impact on canal ice formation.

KEYWORDS

Chloride concentration, Conductivity, Stormwater, Temperature, Winter

1 INTRODUCTION

1.1 Background

The Rideau Canal Skateway, located in the Canadian capital, Ottawa, is a significant cultural, recreational and transportation asset. The site is designated a UNESCO World Heritage Site and has been in operation for more than 50 years (Bergman, et al., 2022). The Skateway typically attracts 1 million visitors per year, providing a substantial recreational value to the city. In addition to recreational use, the Skateway is used by some residents for commuting throughout winter months.

Climate change is warming Canadian winters and shortening the outdoor skating season, with Ontario experiencing three additional days above freezing per year due to climate change (Young, DeFonza, Veitch, Dahl, & Martin, 2024). In Montreal (located 150 km north-east of Ottawa), the skating season is expected to be reduced by 15 – 75% in coming years (Dickau, Matthews, Guertin, & Seto, 2020). Further east, the municipality of Halifax discontinued its ice thickness testing in 2024 due to a decline in ice-skating days. And, in 2022-2023 the skate season was cancelled for the Rideau Skateway because of warm winter conditions.

Figure 1: Map of the Rideau Canal Skateway with the sensor and sampling locations.

1.2 Objectives

Faced with increasingly challenging ice-forming conditions, stormwater is becoming more problematic to the Skateway as Ottawa experiences more frequent rain-on-snow and winter thaw conditions. The Rideau Canal has over 150 stormwater outfalls covering more than 270 hectares, with Cooper Drain having the second-largest catchment (Figure 1). The National Capital Commission, the overseeing body for the Skateway, has partnered with Carleton University to investigate the extent to which stormwater inputs to the canal are contributing to poor ice formation. Stormwater entering the canal can affect ice formation, ice quality, and longevity, which in turn affect the duration of the skating season. The water quality was monitored over the 2024/2025 winter, with the water quality (conductivity and temperature) measured throughout the canal and the flow rate measured at one of the largest outfalls.

2 METHODS

2.1 Field Data Collection

Conductivity loggers (Solinst Levellogger 5 LTC Model 3001) were installed upstream and downstream of the stormwater outfall, as well as immediately inside the sewer (Figure 1). Sensors recorded temperature and electrical conductivity at 30-minute intervals. Sensors were deployed in PVC casing, with a float, weight, and anchor to keep their positions floating in the canal. A continuous wave Doppler ultrasound flowmeter (FloPro XCi) measured water depth and velocity inside the Drain (S2 in Figure 1). The conductivity sensors and flow meter were installed in late October through early November, 2024.

Water samples were collected at S2 (Figure 1) between January and March. The water was collected in 500 mL polyurethane bottles and stored in a fridge at 5°C. While the samples from S2 were collected using a 12-volt pump (Mini-Typhoon) connected to PVC hosing to pump the water from the stormwater pipe to the surface.

The water samples were initially tested with a probe (Pocket Pro+ Multi 2 Tester), to determine their conductivity. The samples were stored until May when they were sent to an external laboratory (Eurofins, Ottawa, ON) where ion chromatography was preformed to determine the chloride concentrations. Conductivity – chloride relationship was derived from water samples collected at S2.

2.2 Data Processing

Data analysis has been performed in R, with RStudio version 2025.05.0. The data were processed and cleaned by removing negative values caused by the occasional backwater flow into the drain and by correcting raw sensor measurements. Flowmeter depth readings were adjusted to account for the sensor installation height. Dataset were also cropped to the skating season, spanning November 21st, 2024 to March 16th, 2025. Raw conductivity data were converted to specific conductivity using the following temperature correction:

Specific Conductance = Conductivity / (1 + 0.02 * (temperature (°C) - 25)). [Equation 1]

Flow data was further divided into stormwater flow and dry weather flow days to better characterize hydraulic conditions. Stormwater flow days, defined as days with stormwater inputs to the Skateway from the Drain, were identified based on the minimum discharge (2,048 m3/day) that could be consistently measured over a 24-hr period. This threshold was calculated using the minimum velocity detected by the flowmeter (0.02 m/s) and the dry weather water level in the drain (0.395 m). Conductivity, chloride and flow data were combined to calculate chloride loading to the Skateway. Freezing point depression was also calculated from chloride concentrations using the following equation (She, Kemp, Richards, & Loewen, 2016):

Freezing Point Depression = 0.0001441*Chloride Concentration [Equation 2]

3 RESULTS AND DISCUSSION

The 2024/25 skate season had 116 days, of which 49 were stormwater flow days (Figure 2). Over the season, the total volume of flow from the Copper Drain was 229,980 m^3, with an average flow rate of 0.023 m^3/s and an average daily volume of 1,982 m^3. Approximately 80% (189,560 m^3) of the stormwater entering the Skateway over the winter season was output during stormwater flow days, while the remaining 20% (40,420 m^3) entered during dry weather flow conditions.

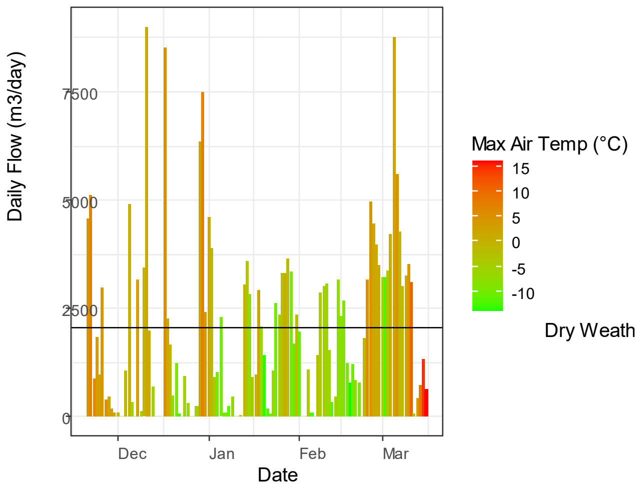

Figure 2: Daily flow inside the Copper Drain coloured by the maximum daily air temperature.

Figure 3 plots differences in temperature and specific conductivity between upstream (S1) and downstream of the Copper Drain and between downstream of the drain (S3) and the downstream end of the Skateway (S6), and shows the comparison of water quality at S1, S3, and S6. Temperature and conductivity were found to be significantly different at each location ($p<0.05$). On stormwater flow days, water temperatures at S3 were, on average, 0.18 °C colder than at S1. Over the season, 7 conductivity spikes were downstream of Copper Drain; however, for six weeks (Feb 1st until the end of the winter season), specific conductivity was observed to be lower downstream. This suggests that despite high conductivity observed in the Drain, stormwater inputs frequently had a dilution effect in the Skateway.

Further downstream of the Copper Drain, temperature and conductivity continued to increase within the Skateway. As several additional stormwater outfalls discharge into this section of the Skateway, these inputs further degrade the water quality. The end of the Skateway (S6) exhibited higher temperatures than downstream of Copper Drain (S3) approximately 90% of the time, with temperature differences between 0°C and 3.3°C. Similarly, S6 had higher values than S3 99.7% of the time, with differences from 0 µS/cm to 18,000 µS/cm.

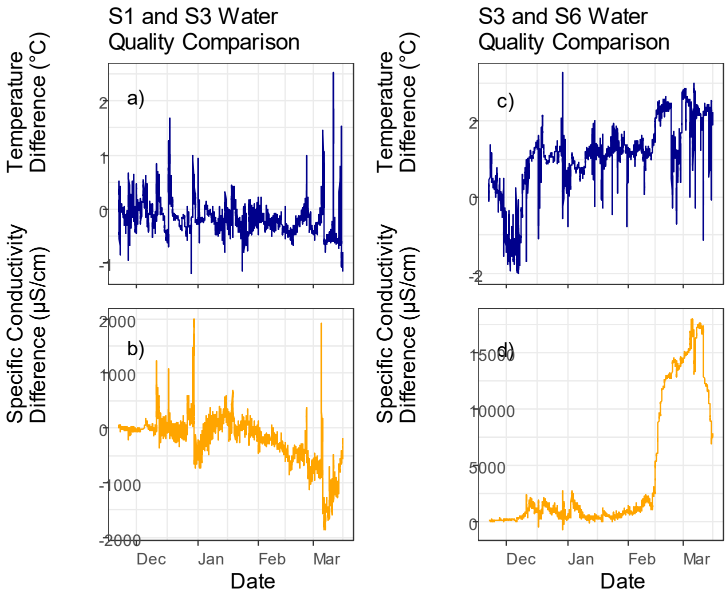

Figure 3: Comparison between S1, S3, and S6 for a) temperature difference, and b) conductivity difference.

Overall, the Copper drain released 173,122 kg of chloride to the Skateway over the course of the winter, with approximately 90% (158,107 kg) entering during the identified stormwater flow days. Despite these loads, average freezing point depression at S1 and S3 was negligible, 0.003°C and 0.057°C, respectively. Over the season the maximum freezing point depression was 0.12 °C at S1 and 0.57°C at S3.

4 CONCLUSION

Stormwater flow days have a disproportionally large impact on the stormwater inputs to the Skateway relative to the rest of the winter season. As such, remediation efforts should prioritize these periods. Although stormwater significantly increases water temperature and conductivity within the Skateway, the resulting freezing-point depression was not significant.

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