Real-Time Water Quality Deployment Report

Paddy’s Pond at Outlet

January 4, 2024 to April 25, 2024

Government of Newfoundland & Labrador
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CONTENTS

GENERAL 3

MAINTENANCE AND CALIBRATION OF INSTRUMENT 3

DATA INTERPRETATION 5

WATER TEMPERATURE 5
pH 8
SPECIFIC CONDUCTIVITY 10
DISSOLVED OXYGEN 12
TURBIDITY 14

APPENDIX A: MEAN DAILY TEMPERATURE AND TOTAL PRECIPITATION 16

APPENDIX B: WATER PARAMETER DESCRIPTION 18

APPENDIX C: QA/QC GRAB SAMPLE FIELD RESULTS 19

General

The Department of Environment and Climate Change, Water Resources Management Division staff monitor water quality in real-time at Paddy's Pond at outlet to Three Arm Pond (47.488129N, 52.893809W).

Data compilation and analysis for this report includes the dates between January 4, 2024 to April 25, 2024.

Figure 1: Paddy's Pond at Outlet Real-Time Water Quality Station location.

Maintenance and Calibration of Instrument

As part of the Quality Assurance and Quality Control protocol (QAQC), an assessment of the reliability of data recorded by an instrument is made at the beginning and end of the deployment period. The procedure is based on the approach used by the United States Geological Survey.

Upon deployment, a QA/QC Sonde is temporarily deployed *in situ*, adjacent to the Field Sonde. Depending on the degree of difference between each parameter from the Field and QA/QC sondes, a qualitative rank is assigned (See Table). The possible ranks, from most to least desirable, are Excellent, Good, Fair, Marginal, and Poor. A grab sample is also taken for additional confirmation of conditions at deployment and to allow for future modelling studies.

Table 1: Ranking classifications for deployment and removal

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (°C)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	<+/-1
pH (unit)	<=+/-0.2	>+/-0.2 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Sp. Conductance (µS/cm)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Sp. Conductance > 35 µS/cm (%)	<=+/-3	>+/-3 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20
Dissolved Oxygen (mg/L) (% Sat)	<=+/-0.3	>+/-0.3 to 0.5	>+/-0.5 to 0.8	>+/-0.8 to 1	>+/-1
Turbidity <40 NTU (NTU)	<=+/-2	>+/-2 to 5	>+/-5 to 8	>+/-8 to 10	>+/-10
Turbidity > 40 NTU (%)	<=+/-5	>+/-5 to 10	>+/-10 to 15	>+/-15 to 20	>+/-20

At the end of a deployment period, a freshly cleaned and calibrated QA/QC Sonde is placed *in situ*, adjacent to the Field Sonde. Deployment and removal comparison rankings for the station at Paddy’s Pond deployed from January 4, 2024, to April 25, 2024, are summarized in Table 2.

Table 2: Qualitative QA/QC comparison rankings for Paddy’s Pond at outlet station January 4, 2024, to April 25, 2024.

Station	Date	Action	Comparison Ranking				
			Temperature	**pH**	**Conductivity**	**Dissolved Oxygen**	**Turbidity**
Paddy’s Pond at Outlet	2024-01-04	Deployment	Excellent	Excellent	Poor	Fair	Excellent
	2024-01-04	Grab Sample #2024-1700-00-SI-SP	N/A	Good	Poor	N/A	Excellent
	2024-04-25	Removal	Good	Fair	Poor	Fair	Excellent

- On January 4, 2024, a real-time water quality monitoring instrument was deployed at the station Paddy’s Pond at Outlet. The instrument was deployed for a period of 113 days and was removed on April 25, 2024.

- Comparison rankings between the Quality Assurance/Quality Control (QAQC) instrument and the field instrument at Paddy's Pond outlet on January 4, 2024, reveal alignment in some parameters but discrepancies in others. Both instruments agree on temperature, pH, and turbidity, ranking them as ‘Excellent’, indicating accurate and reliable measurements. However, there are disparities in conductivity and dissolved oxygen rankings, with the field instrument showing a ‘Poor’ ranking for specific conductivity and a ‘Fair’ ranking for dissolved oxygen. Given the ‘Poor’ comparison ranking for conductivity between grab sample (#2024-1700-00-SI-SP) and the field sonde, this indicates the likelihood of a calibration error or sensor issue with the field sonde sensor. Grab sample comparison rankings were also provided for pH and turbidity as ‘Good’ and ‘Excellent’ respectively.

DATA INTERPRETATION

The following graphs and discussion illustrate water quality data obtained hourly from January 4, 2024, to April 25, 2024, at Paddy's Pond at outlet to Three Arm Pond, St. John's, NL.

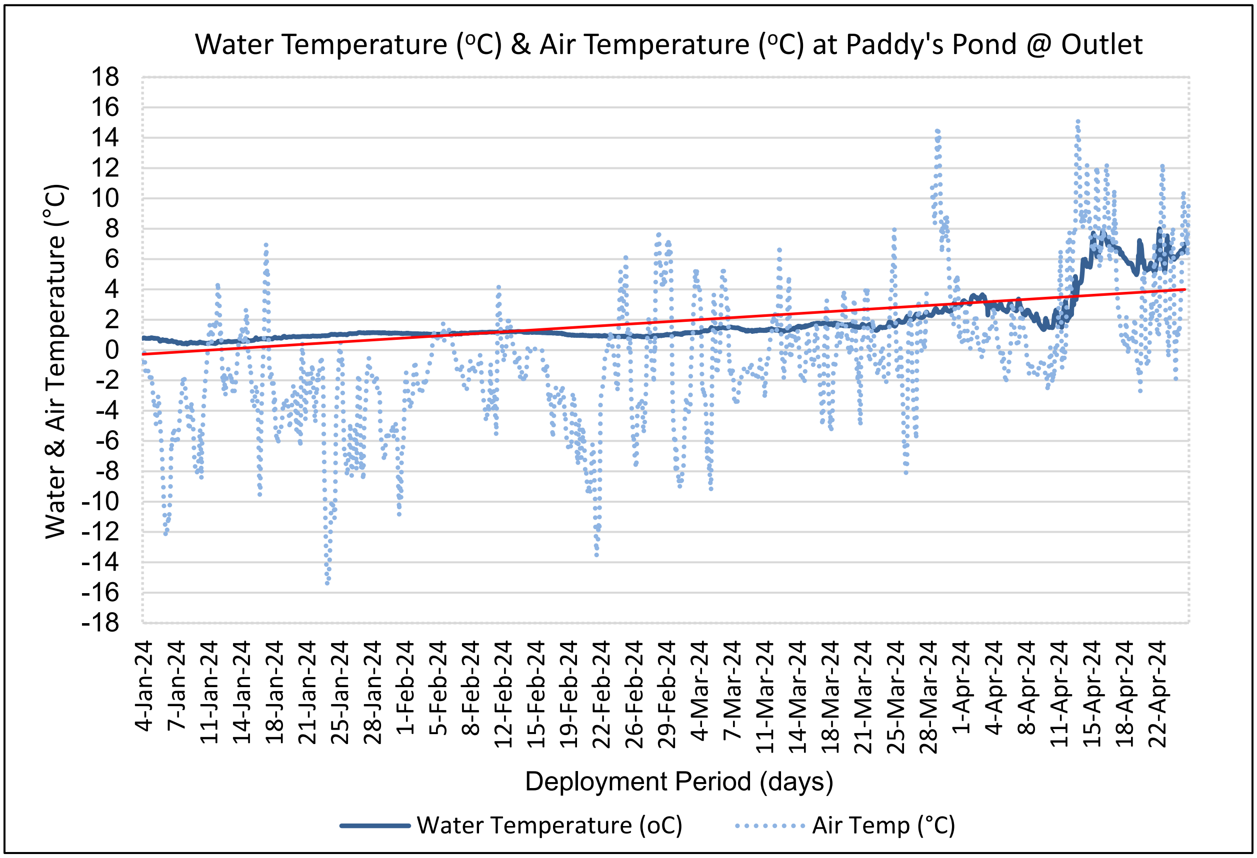
Stage is not monitored at this station to date and as such cannot be discussed with respect to other monitored water quality parameters. All data used in the preparation of the graphs and subsequent discussion adhere to this stringent QA/QC protocol.

Mean daily temperature and total precipitation data was obtained from the Department of Environment and Climate Change Canada (ECCC) historical weather data at https://climate.weather.gc.ca/historical_data/search_historic_data_e.html and can be found illustrated in Appendix A. Gaps in available daily data were removed for graphing purposes.

Water Temperature

- Water Temperature is a major factor used to describe water quality. Temperature has major implications on both the ecology and chemistry of a water body, governing processes such as the metabolic rate of aquatic plants and animals and the degree of dissolved oxygen saturation.

- It should be noted that the temperature sensor on any sonde is the most important. All other parameters can be broken down into three groups: temperature dependent, temperature compensated and temperature independent. As the temperature sensor is not isolated from the rest of the sonde, the entire sonde must be at the same temperature before the sensor will stabilize. The values may take some time to climb to the appropriate reading; if a reading is taken too soon it may not accurately portray the water body.



Mean	Median	Min	Max
1.86	1.18	0.39	8.00

Figure 2: Water temperature (°C) values at Paddy's Pond at Outlet.

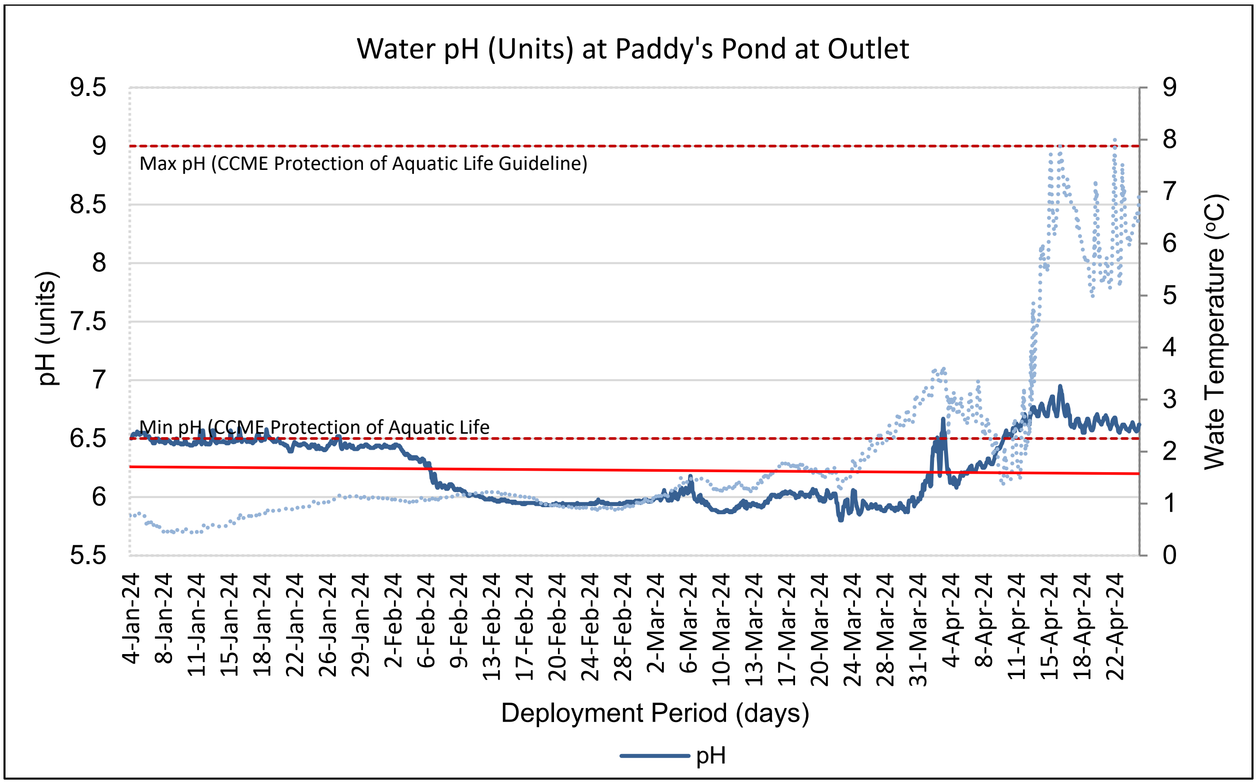
- Figure 2 depicts the daily temperature for Paddy's Pond at Outlet Station over a 113-day period, spanning from January 4 to April 25, 2024. Temperature fluctuations ranged from a minimum of 0.39°C to a maximum of 8.00°C, with a median of 1.18°C and a mean of 1.86°C. These variations likely reflect seasonal changes from winter to spring, as water temperature fluctuated naturally in correlation to air temperature. As ice melts, the temperature of the water rises, leading to an increase in overall temperature readings.

- In the initial months of deployment, from January to mid-February, average temperatures remain relatively low and stable, fluctuating between approximately 0.4 and 1.2 degrees Celsius. However, there is a discernible uptick in late February, with readings hovering around 1.0 to 1.2 degrees Celsius. As March unfolds, temperatures undergo a more substantial increase, ranging from 1.2 to 2.8 degrees Celsius. This warming trend continues throughout March and into April, with temperatures surpassing 3.0 degrees Celsius and peaking above 6.0 degrees Celsius towards the end of April. Such fluctuations underscore the seasonal dynamics inherent in freshwater ecosystems, with temperature changes influencing critical ecological processes and overall system health.

- In late March a natural diurnal variation patterns began. This pattern was characterized by significant fluctuations between daytime and nighttime temperatures, as expected during the summer season. Daytime temperatures typically rise due to solar radiation and warm air temperatures, while nighttime temperatures tended to decrease as heat dissipated into the atmosphere. These diurnal variations reflect the dynamic interplay between solar heating, atmospheric conditions, and water body characteristics, contributing to the overall thermal dynamics of the aquatic environment.

pH

- pH is used to give an indication of the acidity or basicity of a solution. A pH of seven (7) denotes a neutral solution while lower values are acidic and higher values are basic. Technically, the pH of a solution indicates the availability of protons to react with molecules dissolved in water. Such reactions can affect how molecules function chemically and metabolically.
- pH values are temperature dependant as well as influenced by photosynthesis and respiration by aquatic organisms. The concentration of dissolved carbon dioxide in the water throughout the day, especially overnight when oxygen production is reduced relative to carbon dioxide levels. Carbon dioxide dissolved in water yields a slightly acidic solution.



Mean	Median	Min	Max
6.23	6.15	5.80	6.95

Figure 3: pH (pH units) at Paddy's Pond at outlet from August 24, 2023, through September 14, 2023.

- The pH of Paddy's Pond in the specified period ranged from 5.87 to 6.81 pH units. At the beginning of January, the average daily pH was relatively stable, fluctuating around 6.5. However, from mid-January to mid-February, there was a gradual decline in pH, reaching its lowest point of around 5.94. This decrease could be attributed to freezing water temperatures. As water freezes, carbon dioxide (CO^2) may be released, leading to a decrease in pH. This is because dissolved CO^2 forms carbonic acid when it reacts with water, which can lower the pH of the water. The pH change upon freezing may also depend on the buffering capacity of the water. If the pond water has a high buffering capacity, it can resist changes in pH even when CO^2 is released, or solutes are concentrated during freezing. In this case, the pH may not change significantly.

- Subsequently, from mid-February to early March, there was a slight increase in pH, followed by relatively stable values around 6.0 until late March. From late March to mid-April, there was a noticeable increase in pH, peaking at around 6.81 in mid-April before gradually declining again towards the end of April. These fluctuations in pH could be influenced by factors such as seasonal variations, biological activity, and the input of organic matter or nutrients into the water body.

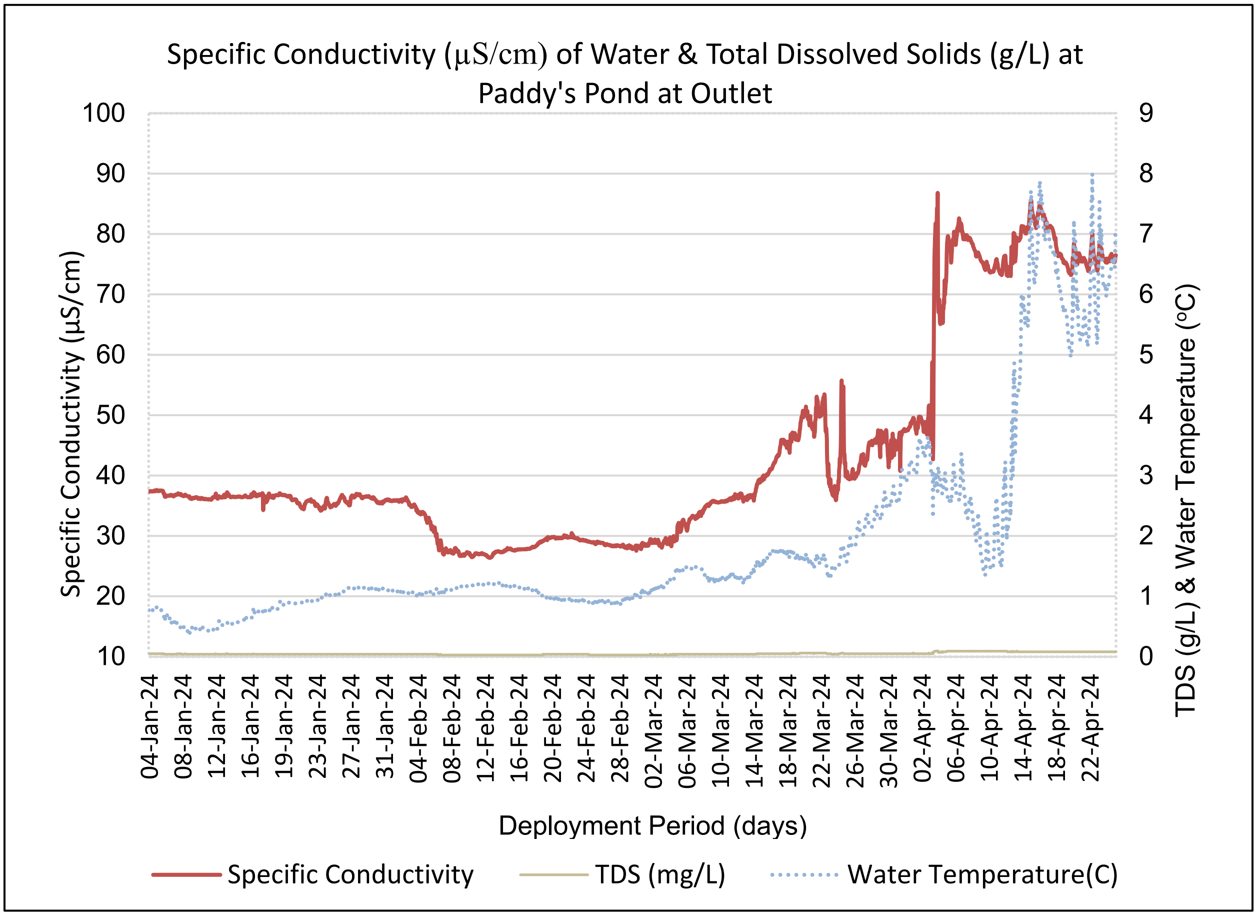
- Throughout the deployment period, the pH value trend (shown in solid red) was uniform, however minimal variability within 5.80 to 6.95 pH units was observed during peak day-time pH levels. A mean unit value of 6.23 and median of 6.15 units (Figure 3) was determined through statistical analysis.

- Most pH values were below the CCME Protection of Aquatic Life minimum pH guideline of 6.5 units until early to mid-April and below the maximum pH CCME Protection of Aquatic Life guideline (horizontal dashed lines). It must be noted that these are national guidelines and do not reflect the peculiarities of Newfoundland geology. This guideline provides a basis for the overall health of the waterbody. Paddy's Pond at Outlet pH values were slightly below the minimum guideline but historically typical for this waterbody. Other pH reducing influences include lower water temperatures and the addition of more acidic rainwater and/or snowmelt runoff during precipitation events. (See Figure 7 – Appendix A).

- Diurnal variation pattern became increasingly visible from mid-March to April. The magnitude of variation correlates to daily water temperature range, length of days and fluctuations in photosynthesis and respiration rates. Inconsistencies to the diurnal variation pattern, as seen on March 24, 2024, March 31 – April 4, 2024, and April 15, 2024, is likely the result of an increase in precipitation events as seen in Appendix A - Figure 7. The addition of cool precipitation can decrease water temperature, lowering the concentration of dissolved ions and specific conductivity.

Specific Conductivity

- Conductivity relates to the ease of passing an electric charge – or resistance – through a solution. Conductivity is highly influenced by the concentration of dissolved ions in solution: distilled water has zero conductivity (infinite resistance) while salty solutions have high conductivity (low resistance). Specific Conductivity is corrected to 25°C to allow comparison across variable temperatures.



Mean	Median	Min	Max
37.6	34.2	26.4	86.5

Figure 4: Specific Conductivity (µS/cm) & TDS values at Paddy's Pond at Outlet.

- The conductance of Paddy's Pond fluctuated over the observed period, ranging from 26.4 µS/cm to 86.5 µS/cm with a mean of 37.6 µS/cm and median of 34.2 µS/cm. Initially, in January, the specific conductance remained relatively stable, varying between approximately 36 and 37 µS/cm. However, towards the end of January and continuing into February, there was a significant decrease in specific conductance, reaching its lowest point of around 26.72 µS/cm. This decline might be attributed to factors such as decreased dissolved ion concentrations or dilution due to increased precipitation or snowmelt.

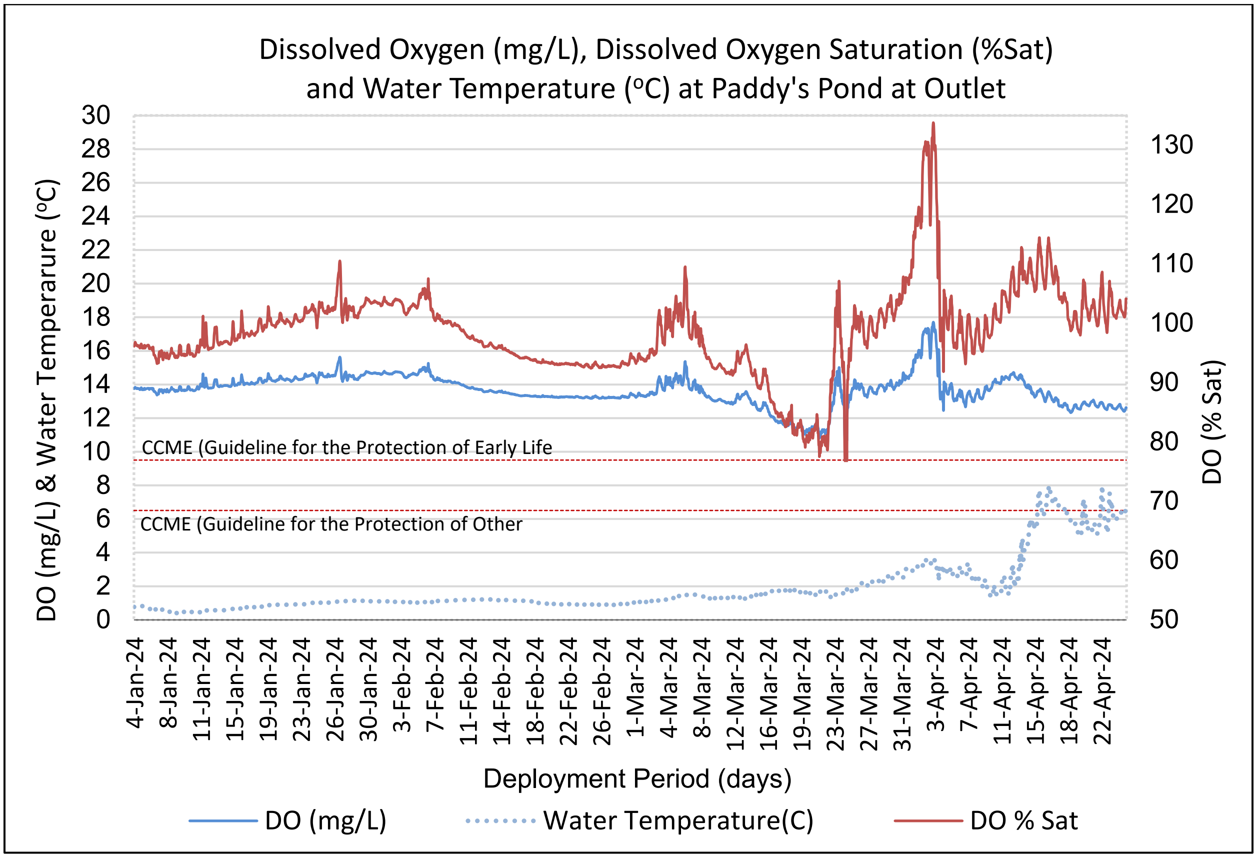
- From late February through early March, there was a gradual increase in specific conductance, likely due to factors such as reduced dilution, increased ion concentrations from mineral dissolution, or changes in the water source. In mid-March, there was a sudden and significant spike in specific conductance, reaching its peak of around 83.12 µS/cm. This notable increase could be influenced by factors like elevated ion concentrations from geological processes, increased nutrient runoff, or changes in water source or flow.

- Towards the end of March and into April, specific conductance remained relatively high, gradually decreasing but still ranging between approximately 70 and 80 µS/cm. This is likely the result of the addition ions of weathering rocks and minerals, snowmelt and runoff.

- The calculated Total Dissolved Solids (TDS) value ranged from 0.0300 g/L to 0.1000g/L throughout the deployment period.

Dissolved Oxygen

- Dissolved oxygen is a metabolic requirement of aquatic plants and animals. The concentration of oxygen in water depends on many factors, especially temperature – the saturation of oxygen in water is inversely proportional to water temperature. Oxygen concentrations also tend to be higher in flowing water compared to still, lake environments. Low oxygen concentrations can give an indication of excessive decomposition of organic matter or the presence of oxidizing materials.



Parameter	Mean	Median	Min	Max
DO (mg/L)	13.66	13.68	10.67	17.71
DO (% Sat)	98.4	98.4	76.8	133.8

Figure 5: Dissolved Oxygen (mg/L & Percent (%) Saturation) values at Paddy's Pond at Outlet.

- It should be noted that seasonal freezing and thawing of ponds from winter to spring can impact DO concentrations by affecting oxygen exchange with the atmosphere, rates of oxygen production and consumption by aquatic organisms, and water circulation patterns.

- Statistical analysis of dissolved oxygen (DO) levels in a Paddy's Pond, detailing both concentrations measured in (mg/L) and percent saturation (% Sat) were calculated and mean and median values for DO concentration were determined to be around 13.7 mg/L, showcasing stability within this range. However, fluctuations are evident, with instances of lower concentrations (minimum value of 10.67 mg/L) and higher concentrations (maximum value of 17.71 mg/L) observed across sampling period. Similarly, the mean and median values for DO saturation percentage indicate a generally high level of oxygen saturation at around 98.4%.

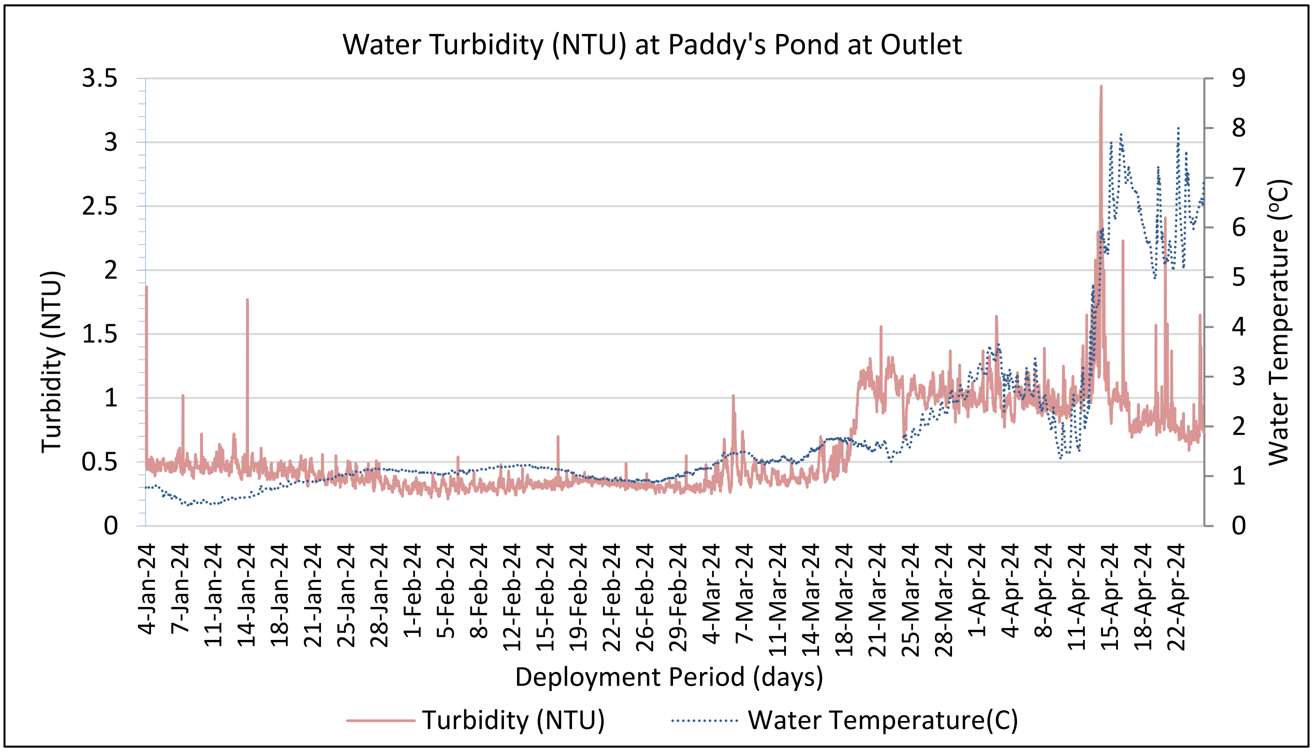
- The range between the minimum (76.8%) and maximum (133.8%) values indicates notable variability, potentially reflecting environmental dynamics or measurement anomalies. Low DO concentrations indicate possible instances where the water may be relatively undersaturated with oxygen. This could potentially be a cause for concern as it indicates a lower-than-ideal oxygen level for aquatic organisms. The maximum value of 133.8% is unusually high and could indicate either an error in measurement or some exceptional environmental conditions, such as super-saturation due to rapid aeration (thawing of ice) or photosynthesis. Dissolved oxygen (% Saturation) readings of greater than 100% air saturation can occur in ambient water because of the production of pure oxygen by photosynthetically-active organisms and/or because of non-ideal equilibration of dissolved oxygen between the water and the air above it.

- Diurnal variation pattern was most visible in early April at the end of the deployment period due longer sun hours and the correlation between water temperature and air temperature. Variations can be influenced by water depth during deployment as shallow water temperatures will change more rapidly, especially in a lake environment such as Paddy's Pond. As well as linked to the daily range of water temperature, duration of daylight, and fluctuations in rates of photosynthesis and respiration.

- The dissolved oxygen values were above the CCME Guideline for the Protection of Early Life Stages (9.5 mg/L) and remained above the CCME Guideline for the Protection of Other Life Stages (6.5mg/L) for the entire deployment period.

Turbidity

Turbidity is typically caused by fine suspended solids such as silt, clay, or organic material. Consistently high levels of turbidity tend to block sunlight penetration into a waterbody, discouraging plant growth. High turbidity can also damage the delicate respiratory organs of aquatic animals and cover spawning areas.



Mean	Median	Min	Max
0.6	0.4	0.2	3.4

Figure 6: Water turbidity (NTU) values at Paddy's Pond at Outlet

- The turbidity measurements for Paddy's Pond reveal valuable information about the water quality in this ecosystem. With a mean turbidity of 0.6 NTU, the average clarity suggests generally clear water conditions with minimal suspended particles or sediment. The median turbidity of 0.4 NTU aligns closely with the mean, indicating relatively consistent clarity across the dataset, albeit with some variability. The minimum turbidity value of 0.2 NTU represents exceptionally clear water, highlighting periods of excellent visibility within the pond. However, the maximum turbidity of 3.4 NTU signifies instances of elevated cloudiness, likely attributed to environmental factors such as sediment runoff or wave action.

- Initially, from January to mid-March, the average daily turbidity remains relatively stable, hovering around 0.3 to 0.5 NTU, indicating consistent water clarity during this time. However, starting from late March, there was noticeable increase in turbidity, peaking around mid to late March, where turbidity levels exceed 1 NTU, indicating a significant increase in suspended particles or sediment in the water. This increase in turbidity could be attributed to various factors such as ice/snowmelt, increased rainfall, runoff from surrounding land, or changes in the pond's ecosystem dynamics. The subsequent months see a gradual decrease in turbidity levels but still remain slightly elevated compared to the earlier months.

APPENDIX A: MEAN DAILY TEMPERATURE AND TOTAL PRECIPITATION

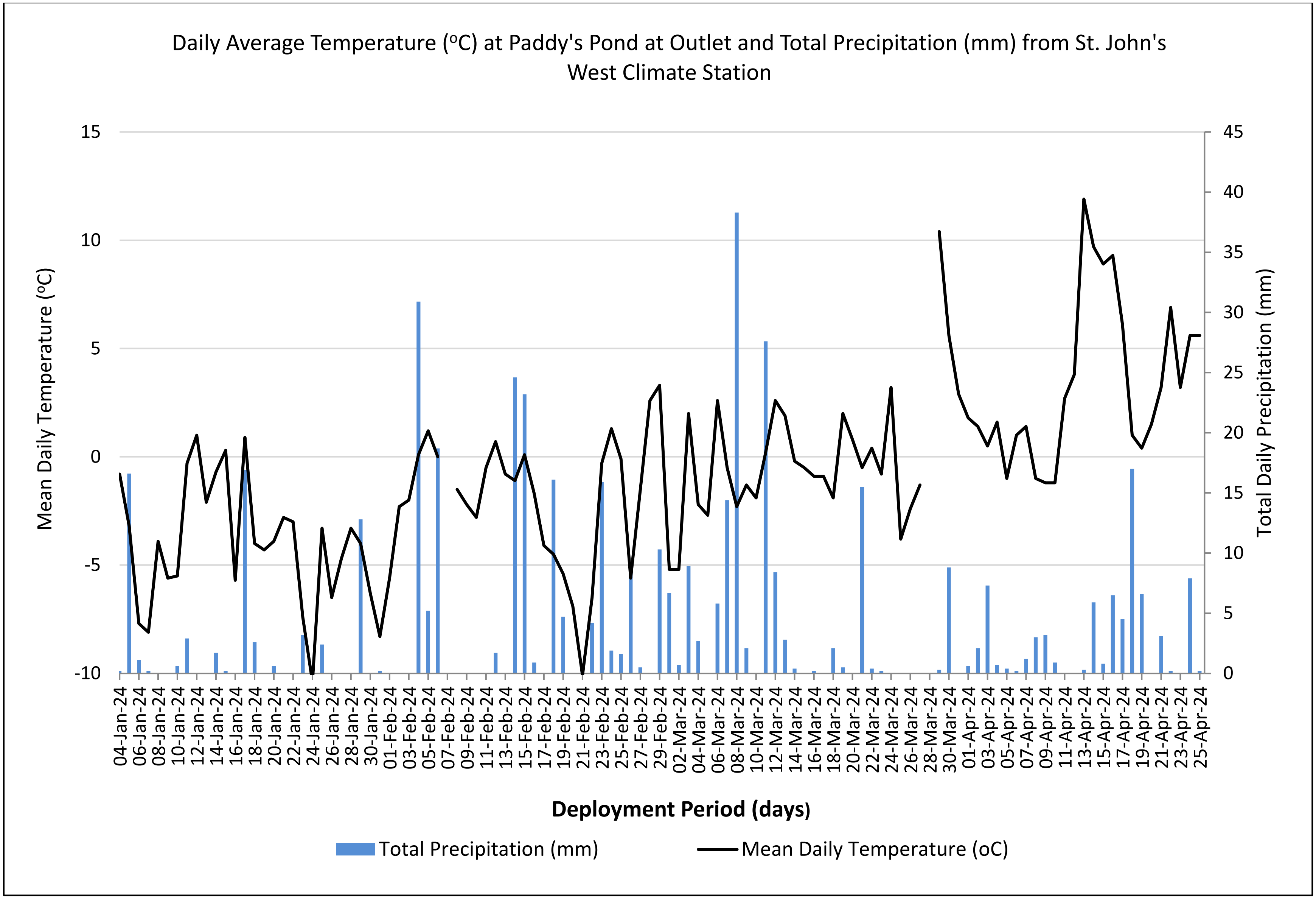


Figure 7: Mean daily air temperature and total precipitation at St. John's West near Paddy's Pond January 4, 2024, to April 25, 2024.

APPENDIX B: Water Parameter Description

Dissolved Oxygen - The amount of Dissolved Oxygen (DO) (mg/l) in the water is vital to aquatic organisms for their survival. The concentration of DO is affected by such things as water temperature, water depth and flow (e.g., aeration by rapids, riffles etc.), consumption by aerobic organisms, consumption by inorganic chemical reactions, consumption by plants during darkness, and production by plants during the daylight (Allan 2010).

pH - pH is the measure of hydrogen ion activity and affects: (i) the availability of nutrients to aquatic life; (ii) the concentration of biochemical substances dissolved in water; (iii) the efficiency of hemoglobin in the blood of vertebrates; and (iv) the toxicity of pollutants. Changes in pH can be attributed to industrial effluence, saline inflows or aquatic organisms involved in the photosynthetic cycling of CO_2 (Allan 2010).

Specific conductivity - Specific conductivity (µS/cm) is a measure of water's ability to conduct electricity, with values normalized to a water temperature of 25ºC. Specific conductance indicates the concentration of dissolved solids (such as salts) in the water, which can affect the growth and reproduction of aquatic life. Specific conductivity is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Stage – Stage (m) is the elevation of the water surface and is often used as a surrogate for the more difficult to measure flow.

Temperature - Essential to the measurement of most water quality parameters, temperature (^{o}C) controls most processes and dynamics of limnology. Water temperature is influenced by such things as ambient air temperature, solar radiation, meteorological events, industrial effluence, wastewater, inflowing tributaries, as well as water body size and depth (Allan 2010; Hach 2006).

Total Dissolved Solids - Total Dissolved Solids (TDS) (g/l) is a measure of alkaline salts dissolved in water or in fine suspension and can affect the growth and reproduction of aquatic life. It is affected by rainfall events, the composition of inflowing tributaries and their associated geology, saline inflow (e.g., road salt), agricultural run-off and industrial inputs (Allan 2010; Swanson and Baldwin 1965).

Turbidity - Turbidity (NTU) is a measure of the translucence of water and indicates the amount of suspended material in the water. Turbidity is caused by any substance that makes water cloudy (e.g., soil erosion, micro-organisms, vegetation, chemicals, etc.) and can correspond to precipitation events, high stage, and floating debris near the sensor (Allan 2010; Hach 2006; Swanson and Baldwin 1965.

APPENDIX C: QA/QC GRAB SAMPLE FIELD RESULTS