Real-Time Water Quality 2023 Annual Report

Marathon Gold Network

June 5 to December 31, 2023

Newfoundland Labrador

Government of Newfoundland & Labrador
Department of Environment and Climate Change
Water Resources Management Division

Contents

Acknowledgements

The Real-Time Water Quality Monitoring Network at Marathon Gold is successful in tracking emerging water quality issues due to the hard work and diligence of certain individuals. The management and staff of Marathon Gold work in cooperation with the management and staff of the Department of Environment and Climate Change's (ECC) Water Resources Management Division (WRMD), to ensure the protection of ambient water resources at Marathon Gold Operations in central Newfoundland.

Marathon Gold Environmental Coordinators are acknowledged for their hard work during the 2023 deployment period, and ensuring the Real-Time Water Quality Monitoring Network is operating to the standards set by WRMD.

Various individuals from WRMD have been integral in ensuring the smooth operation of such a technologically advanced network. WRMD staff played a lead role in coordinating and liaising between the major agencies involved, ensuring open communication lines. In addition, WRMD is responsible for the maintenance, data management/reporting, troubleshooting, and ensuring the quality assurance/quality control measures are implemented. WRMD provides data to the general public on a near real-time basis through the departmental web page (Real Time Water Quality Monitoring Program - Environment and Climate Change (gov.nl.ca)).

Staff with WRMD and Marathon Gold are fully committed to improving this network and ensuring it provides meaningful and accurate water quality/quantity data that can be used in the decision-making process. This network is only successful due to the cooperation of both agencies involved.

Abbreviations

ECC	Department of Environment and Climate Change
WRMD	Water Resources Management Division
NL	Newfoundland and Labrador
RTWQ	Real-time Water Quality
QA/QC	Quality Assurance and Quality Control
DO	Dissolved Oxygen
%Sat	Percent Saturation
TDS	Total Dissolved Solids
ORP	Oxidation Reduction Potential
PTE	Performance Testing and Evaluation
SW	Surface Water
GW	Ground Water
MG	Marathon Gold

Introduction

The Real Time Water Quality (RTWQ) network at Marathon Gold was successfully launched by WRMD in cooperation with Marathon Gold in 2022-23 with the establishment of three surface water (SW) monitoring stations and four ground water (GW) well monitoring well stations. The fourth SW station was installed on November 21, 2023 but water quality instrumentation was not deployed as all SW station equipment was removed for the winter to prevent ice damage. The network will undergo further expansion in 2024.

The objective of the network is to identify and track emerging water quality and quantity management issues in ground water and surface water and to ensure protection of ambient water resources in and around the Marathon Gold operations in a remote area of Central Newfoundland.

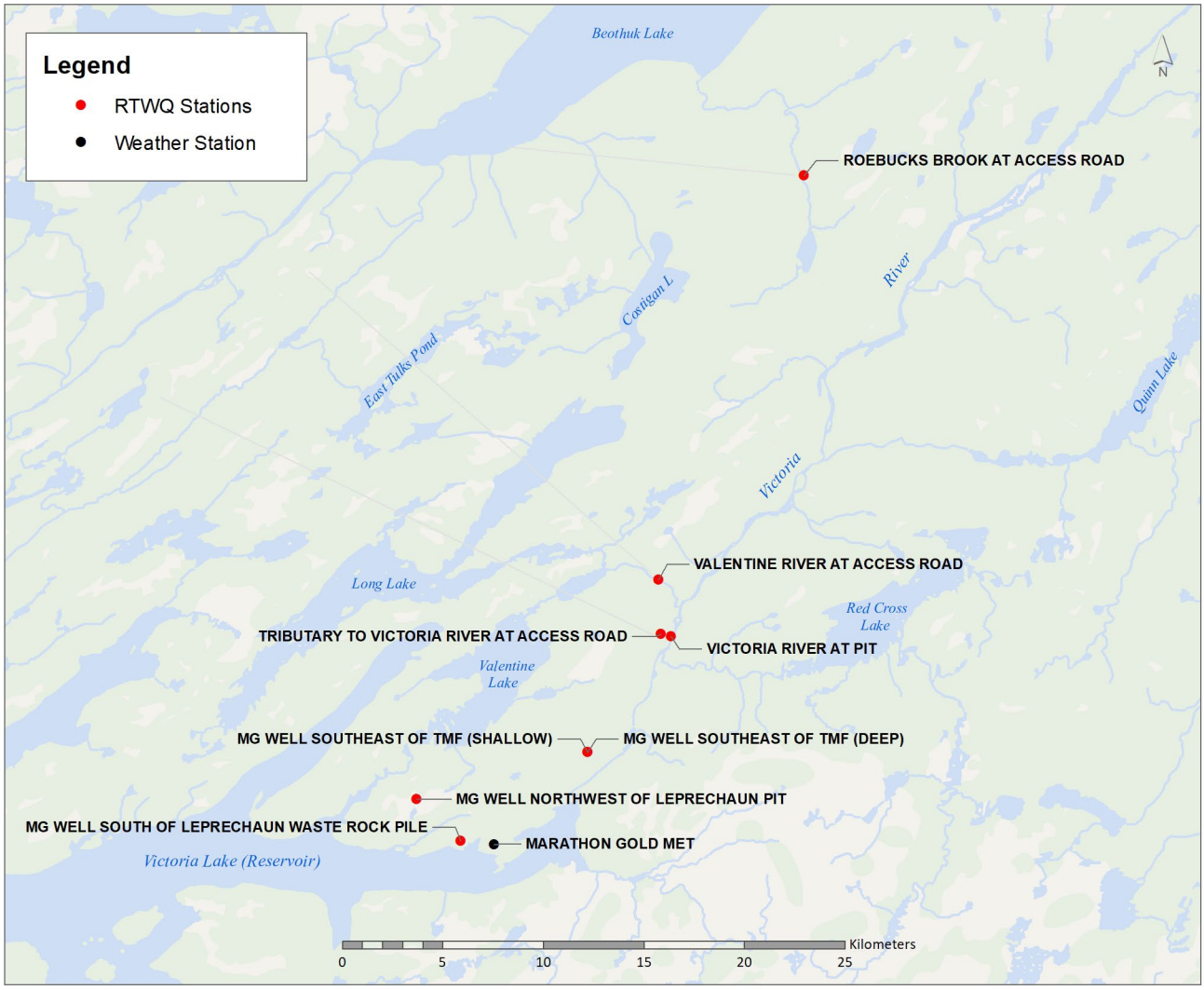

Figure 1: Marathon Gold Real Time Monitoring Network 2023

In 2023 the RTWQ network consisted of four surface water quality/quantity monitoring stations, four ground water quality/quantity monitoring stations and one climate monitoring station:

Table 1: Marathon Gold Real Time Monitoring Network Station List

Station Type	Station Name	Station Number	Installation Date
Surface Water Quality/Quantity	Victoria River at Outlet	NF02YN0047	November 2022
	Valentine River	NF02YN0048	November 2022
	Roebucks Brook	NF02YN0049	November 2022
	Tributary to Victoria River	NF02YN0050	November 2023
Ground Water Quality/Quantity	South of Leprechaun Waste Rock Pile Monitoring Well	NLGWMG01	June 2023
	Northwest of Leprechaun Pit Monitoring Well	NLGWMG02	June 2023
	Southeast of TMF Monitoring Well (Deep)	NLGWMG03	July 2023
	Southeast of TMF Monitoring Well (Shallow)	NLGWMG04	July 2023
Climate	Marathon Gold MET	NLENCL0014	June 2023

The surface water stations measure water quantity as stage level and multiple water quality parameters including: water temperature; pH; specific conductivity; dissolved oxygen and turbidity. Two additional parameters, total dissolved solids and percent saturation are calculated from measured parameters. Ground water stations measure: water elevation; water temperature; pH; specific conductivity; total dissolved solids (TDS) and oxygen reduction potential (ORP).

This annual deployment report illustrates, discusses and summarizes water quality related events from June 5 to December 31, 2023 throughout the monitoring network. While surface water stations were removed for the winter on November 23, ground water stations remain deployed throughout the year. During this time, three visits were made to each of the surface water stations and two visits made to each ground water station.

Maintenance and Calibration

It is recommended that regular maintenance and calibration of the instruments take place to ensure accurate data collection. This maintenance is the responsibility of WRMD staff and is performed as required, according to manuals and standard operating procedures for surface water or ground water instrumentation.

Maintenance for all instruments includes a thorough cleaning and replacement of any small sensor parts that are damaged or unsuitable for reuse. Once the instrument is cleaned, WRMD staff calibrate each sensor attachment for pH, specific conductivity, dissolved oxygen, turbidity and ORP, depending on the configuration.

An extended deployment period can result in instrument sensor drift, which may result in skewed data. Instrument sensors will still work to capture any water quality event, although exact data values collected may be inaccurate. Installation and removal dates for each station during the 2023 deployment season are summarized in Table 2. Surface water monitoring ended November 23rd as monitoring equipment was removed for the winter. Ground water monitoring equipment remains installed over the winter season.

Table 2: Installation and removal dates for Real Time Water Monitoring Stations 2023

		Installation	Removal	Deployment
Surface Water Network	Victoria River at Outlet Valentine River Roebucks Brook	June 5	July 13	38 days
		July 13	September 6	54 days
		September 6	November 23	78 days
Ground Water Network	South of Leprechaun	June 7	October 13	126 days
		October 13	Ongoing	
	Northwest of Leprechaun Pit	June 8	October 13	125 days
		October 13	Ongoing	
	Southeast of TMF (Deep)	July 12	October 12	90 days
		October 12	Ongoing	
	Southeast of TMF (Shallow)	July 12	October 12	90 days
		October 12	Ongoing	

Quality Assurance and Quality Control

As part of the Quality Assurance and Quality Control protocol (QA/QC), an assessment of the reliability of data recorded by a monitoring instrument is made at the beginning of deployment for ground water instruments and at deployment and removal for surface water instruments. The procedure is based on the approach used by the United States Geological Survey.

For surface water stations, at deployment and removal, a QA/QC Instrument is temporarily deployed adjacent to the field instrument in the water. Values for temperature, pH, conductivity, dissolved oxygen and turbidity are compared between the two instruments**.** Based on the degree of difference between parameters recorded by the field Instrument and QA/QC Instrument at deployment and at removal, a qualitative statement is made on the data quality (Table 3). A grab sample is also taken at deployment and values for pH, specific conductivity and turbidity are compared to the field sonde readings and ranked as a second check for sensor accuracy.

Table 3: Ranking classifications for deployment, removal and grab sample rankings

	Rank				
Parameter	**Excellent**	**Good**	**Fair**	**Marginal**	**Poor**
Temperature (oC)	<=+/-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

For ground water stations, monitoring wells are not big enough to permit two sondes to be installed adjacent to each other for concurrent field and QA/QC measurements. During maintenance, water levels are measured manually and a volume equivalent to three well casings is purged from the well prior to re-installation of the instrument and collection of grab samples. This process flushes stagnant water from the wells and ensures that the water being observed is aquifer water. After full purging of the well, the sonde is deployed and initial field readings are recorded. A grab sample is taken when possible to compare values of pH and specific conductance against the deployed sonde's initial field values as part of the QA/QC process.

It should be noted that the temperature sensor on any instrument 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 instrument, the entire instrument 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.

Deployment and removal comparison rankings for the Marathon Gold Network stations are summarized in Table 4 (surface water stations) and Table 5 (ground water stations) below. For additional information and explanations of rankings, please refer to the monthly deployment reports.

Table 4: Comparison Rankings for Marathon Gold Real Time Surface Water Monitoring Stations for 2023 Deployment Season

Station	Date	Action	Comparison Ranking				
			Temperature	pH	Conductivity	Dissolved Oxygen	Turbidity
Victoria River	June 5, 2023	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	July 13, 2023	Removal	Excellent	Good	Excellent	Good	Excellent
	July 13, 2023	Deployment	Excellent	Fair	Excellent	Excellent	Excellent
	Sept. 6, 2023	Removal	Excellent	Fair	Excellent	Fair	Excellent
	Sept. 6, 2023	Deployment	Excellent	Poor	Excellent	Fair	Excellent
	Nov 23, 2023	Removal	Excellent	Fair	Excellent	Good	Excellent
Valentine River	June 5, 2023	Deployment	Excellent	Fair	Excellent	Excellent	Excellent
	July 13, 2023	Removal	Excellent	Excellent	Excellent	Fair	Excellent
	July 13, 2023	Deployment	Excellent	Excellent	Excellent	Good	Excellent
	Sept. 6, 2023	Removal	Excellent	Good	Excellent	Marginal	Excellent
	Sept. 6, 2023	Deployment	Excellent	Good	Excellent	Marginal	Excellent
	Nov 23, 2023	Removal	Excellent	Fair	Excellent	Good	Excellent
Roebucks Brook	June 5, 2023	Deployment	Excellent	Good	Excellent	Excellent	Excellent
	July 13, 2023	Removal	Excellent	Good	Good	Good	Excellent
	July 13, 2023	Deployment	Excellent	Excellent	Excellent	Fair	Fair
	Sept. 6, 2023	Removal	Good	Poor	Excellent	Poor	Excellent
	Sept. 6, 2023	Deployment	Excellent	Poor	Good	Excellent	Excellent
	Nov 23, 2023	Removal	Excellent	Poor	Fair	Excellent	Excellent

Table 5: Comparison Rankings for Marathon Gold Real Time Ground Water Monitoring Stations for 2023 Deployment Season

Station	Date	Action	pH	Specific Conductivity
South of Leprechaun	June 7	Deployment	Poor	Fair
	October 13	Deployment	Poor	Good
Northwest of Leprechaun Pit	June 8	Deployment	Poor	Poor
	October 13	Deployment	Poor	Poor
Southeast of TMF (Deep)	July 12	Deployment	Fair	Excellent
	October 12	Deployment	Fair	Excellent
Southeast of TMF (Shallow)	July 12	Deployment	Poor	Fair
	October 12	Deployment	Marginal	Poor

Data Interpretation – Surface Water Network

The following graphs and discussions illustrate significant water quality-related events from June 5 through November 23, 2023 in the Marathon Gold real time surface water monitoring Network.

The hydrometric data presented in this report is quality controlled on a less frequent basis than water quality data due to differences in protocols. The hydrometric data shown in this report is provisional and has not undergone quality control checks.

Gaps in data may be the result of transmission loss, sensor error or data that is known to be erroneous and has been removed.

All stations performed very well in 2023 with minimal data loss.

Victoria River at Outlet

During the 2023 deployment season, water temperature ranged from 1.2°C to a maximum of 26.28°C (Table 6).

Temperatures steadily increased from initial deployment through late-July, after which they started to decrease again through September, October, and November (Figure 2), following seasonal patterns.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

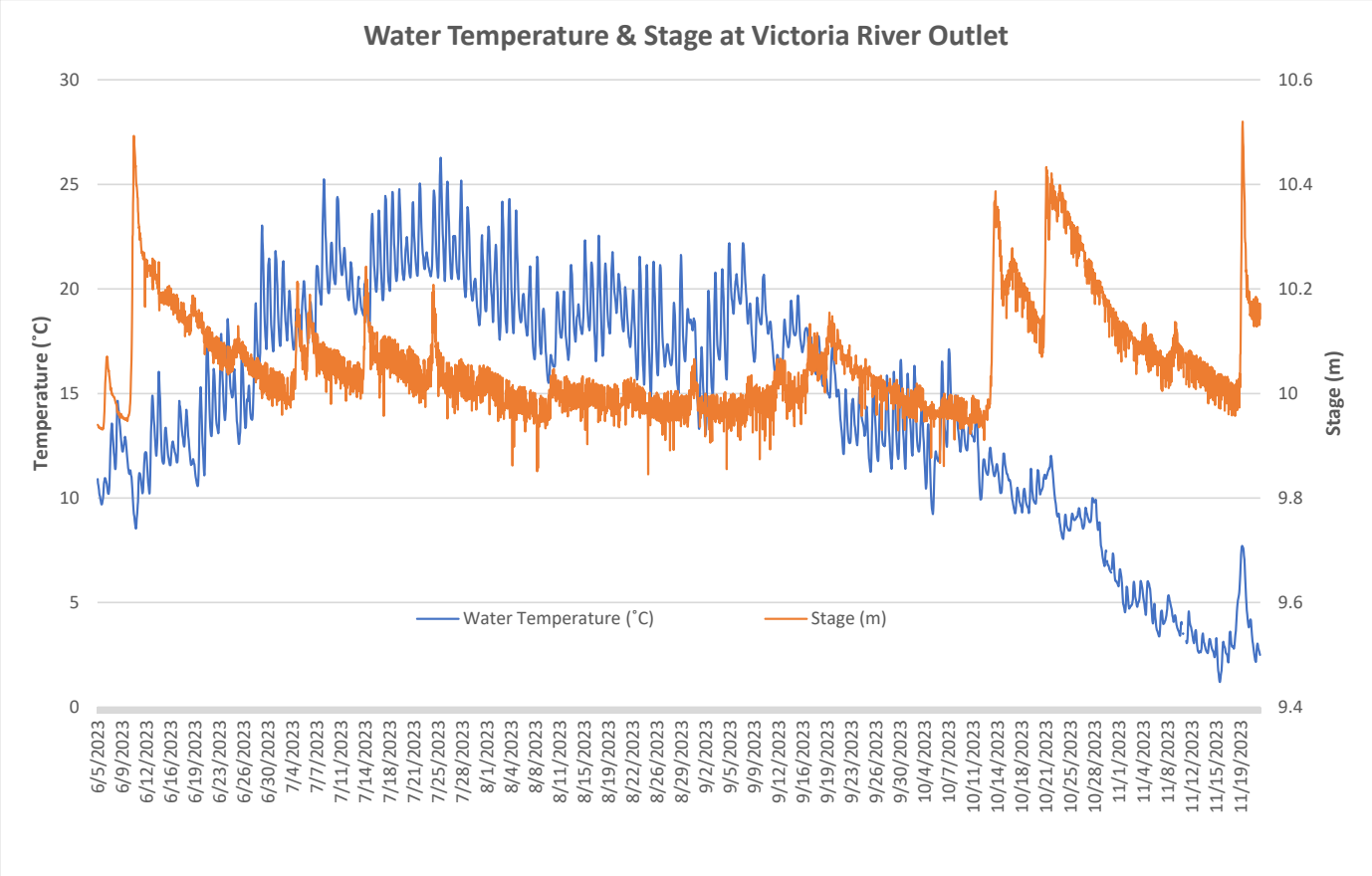

Figure 2: Water Temperature & Stage at Victoria River at Outlet

Table 6: Deployment Statistics for Water Temperature (˚C)

Water Temperature ˚C	2023
Min	1.2
Max	26.28
Median	15.18

Water temperature maintains a close relationship with air temperature (Figure 3). Increases and decreases in water temperatures throughout 2023 were associated with similar changes in air temperature. Air temperatures fluctuated to a greater extent each day when compared to water temperatures. Air temperature data was obtained from the Environment and Climate Change Canada climate station at Millertown.

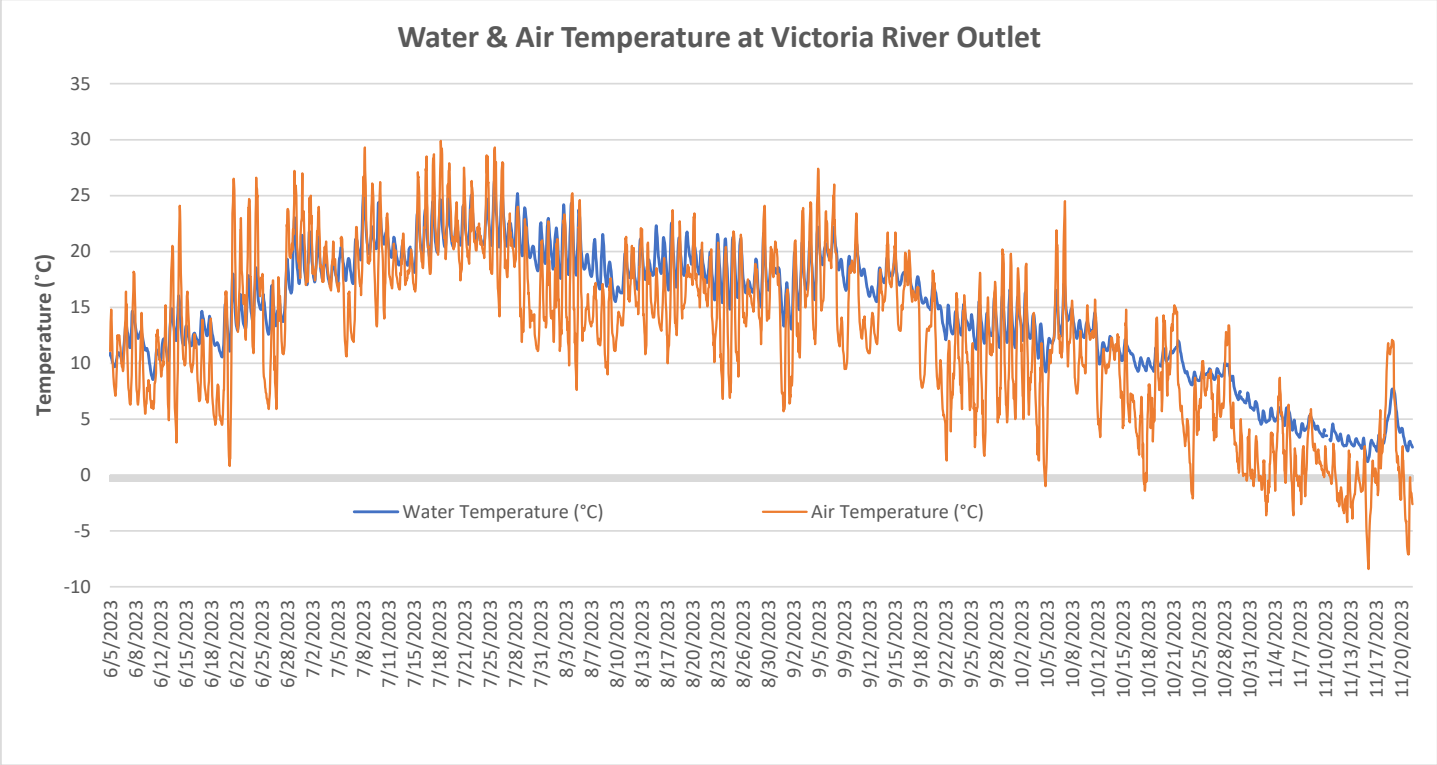

Figure 3: Water & Air Temperature at Victoria River at Outlet

During the 2023 deployment season, pH ranged from 6.60 pH units to a maximum of 7.43 pH units (Table 7).

During periods of stage increases at this station, pH frequently increases for a short period of time on most occasions. On other occasions, such as October 13, pH drops as the result of a large stage increase. pH was within the CCME's Guidelines for the Protection of Aquatic Life for the entire period of the deployment season (Figure 4).

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

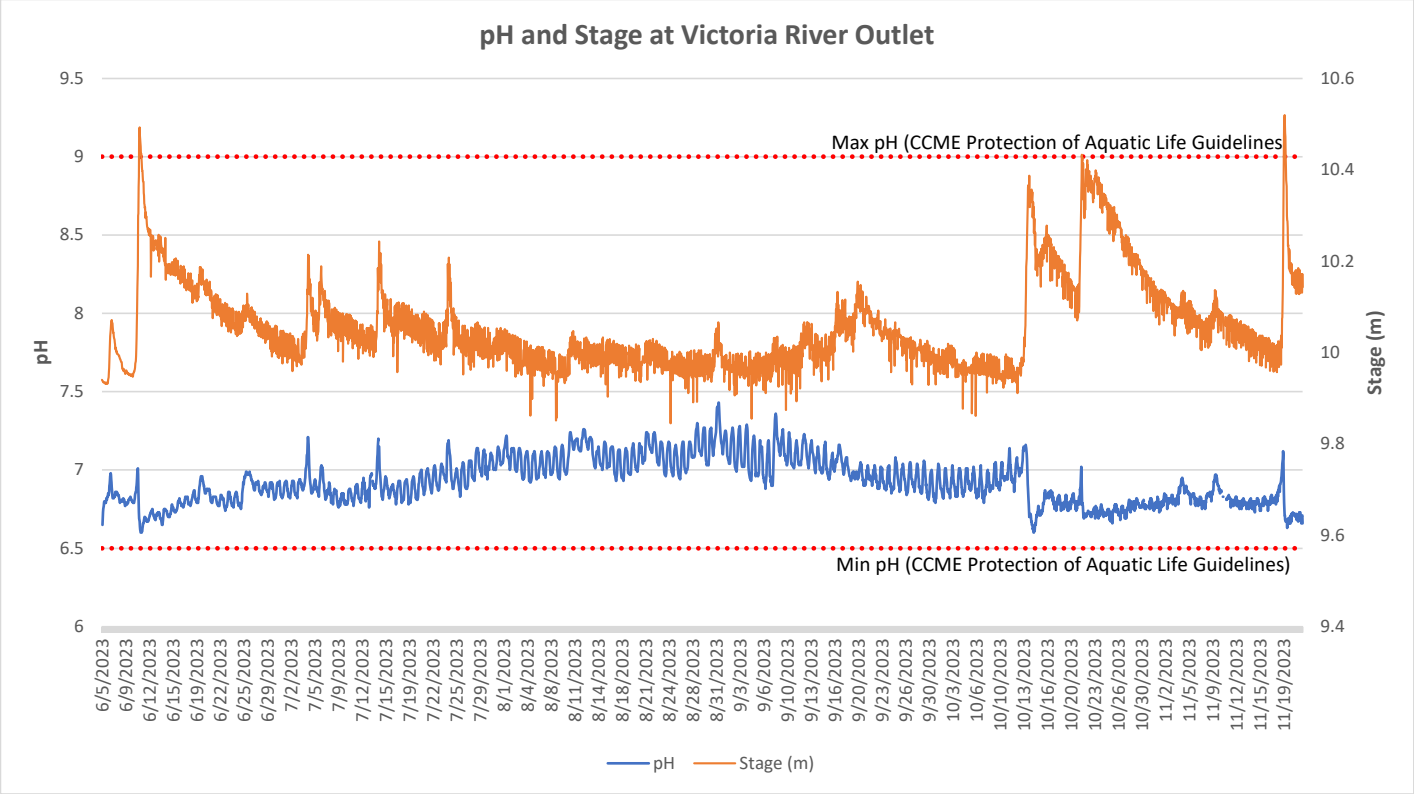

Figure 4: pH & Stage at Victoria River at Outlet

Table 7: Deployment Statistics for pH

pH	2023
Min	6.60
Max	7.43
Median	6.91

During the 2023 deployment season, specific conductivity values ranged from 18.7 µS/cm to a maximum of 59.7 µS/cm. An overall conductivity median of 24.2 µS/cm indicates that this station naturally has very low conductivity (Table 8).

Specific conductivity remained stable throughout the majority of the deployment season showing brief spikes during periods of high precipitation (Figure 5). This indicates the precipitation may cause particulates in the river sediment to re-suspend into the water column, increasing the conductivity for a short period of time before it settles out again.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

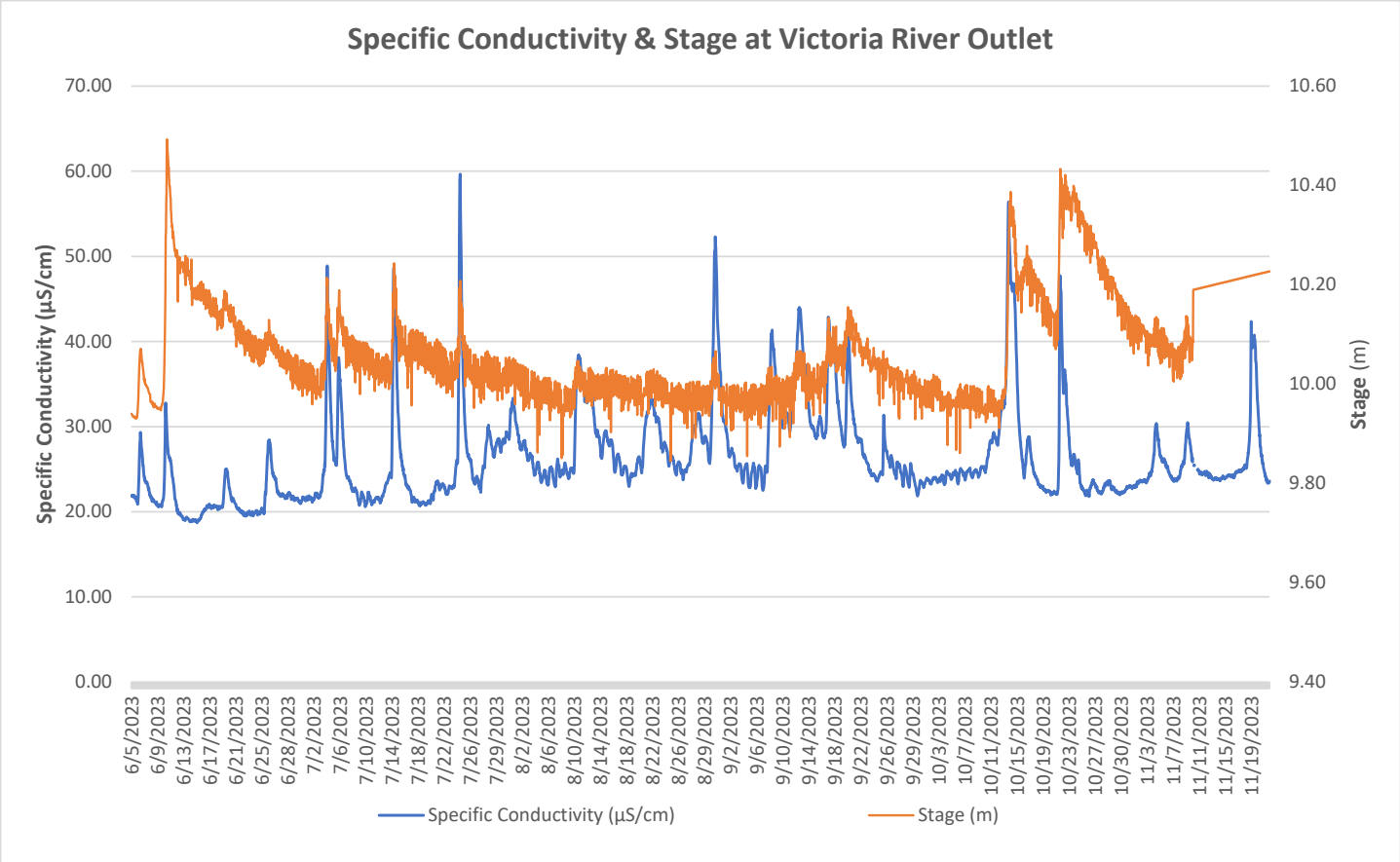

Figure 5: Specific Conductivity & Stage at Victoria River at Outlet

Table 8: Deployment Statistics for Specific Conductivity

Specific Conductivity µS/cm	2023
Min	18.7
Max	59.7
Median	24.2

During the 2023 deployment season, dissolved oxygen concentrations ranged from 8.04 mg/L to a maximum of 14.05 mg/L, with a median value of 9.97 mg/L. Saturation of dissolved oxygen ranged from 87.1% to 110.8%, with a median value of 98.5 % (Table 9).

Dissolved oxygen concentrations displayed typical seasonal fluctuations throughout the deployment season and exhibited an inverse relationship with water temperature (Figure 6). Dissolved oxygen values were high at the beginning of deployment when water temperatures were low. Dissolved oxygen values decreased steadily until August, after which they began to increase again through the remainder of deployment as water temperatures decreased into the fall season.

Dissolved oxygen values remained above the CCME's Guideline for the Protection of Other Life Stages (6.5mg/L) throughout deployment but fell below the Guideline for the Protection of Early Life Stages (9.5mg/L) mid-summer when water temperature was at it's highest.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

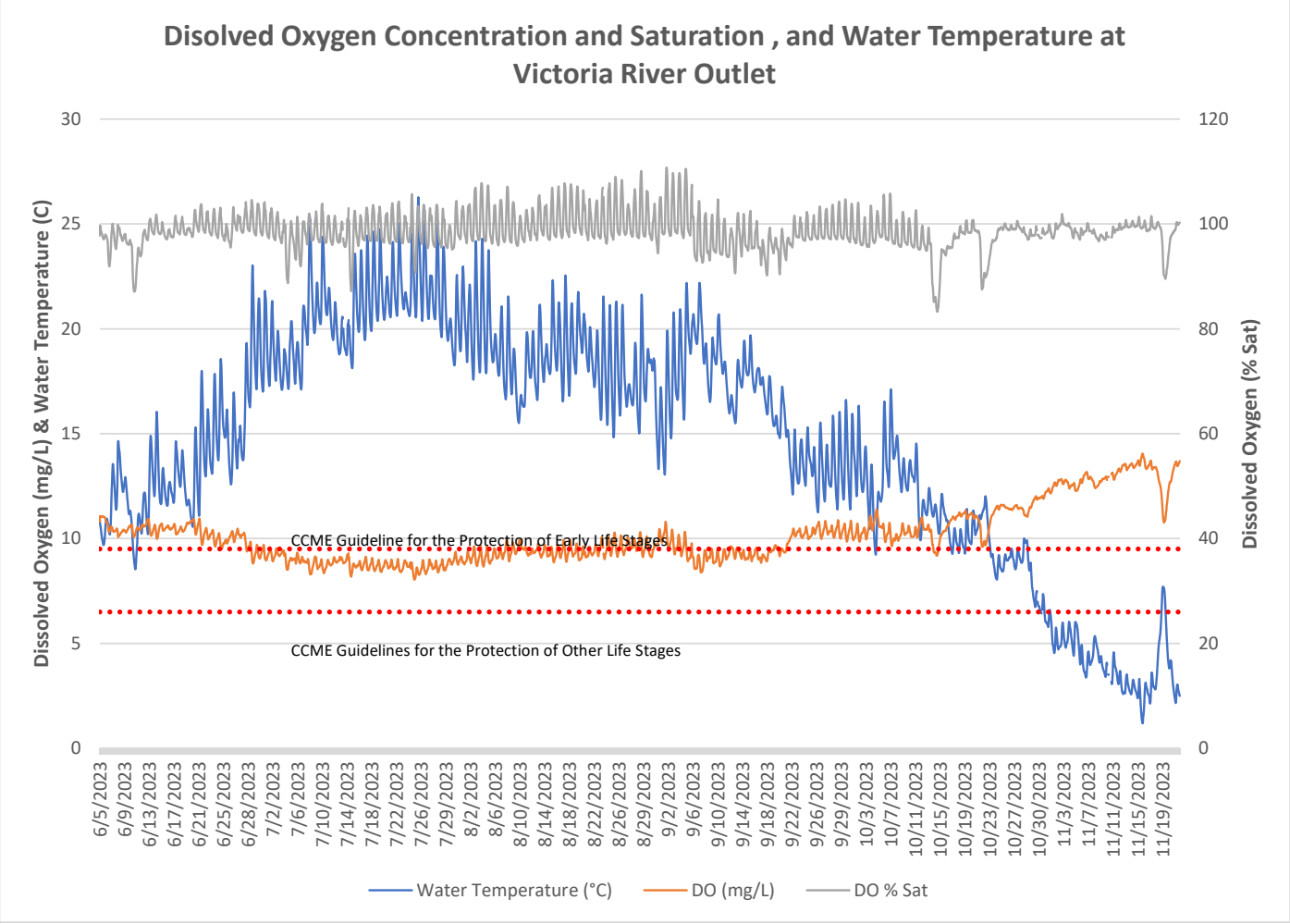

Figure 6: Dissolved Oxygen Concentration and Saturation & Water Temperature at Victoria River at Outlet

Table 9: Deployment Statistics for Dissolved Oxygen

Dissolved Oxygen (mg/L)	2023
Min	87.1
Max	110.8
Median	98.5
Percent Saturation (%)	2023
Min	8.04
Max	14.05
Median	9.97

During the 2023 deployment season, turbidity values ranged from -0.01 NTU to a maximum of 15.3 NTU. A median value of 0.073 NTU indicates that there is a low level of background turbidity at this station (Table 10).

Turbidity remained low throughout the deployment with occasional spikes associated with precipitation (Figure 7). This indicates rainfall associated with stage increases may stir up sediments in the area for a brief period of time before returning to background levels.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

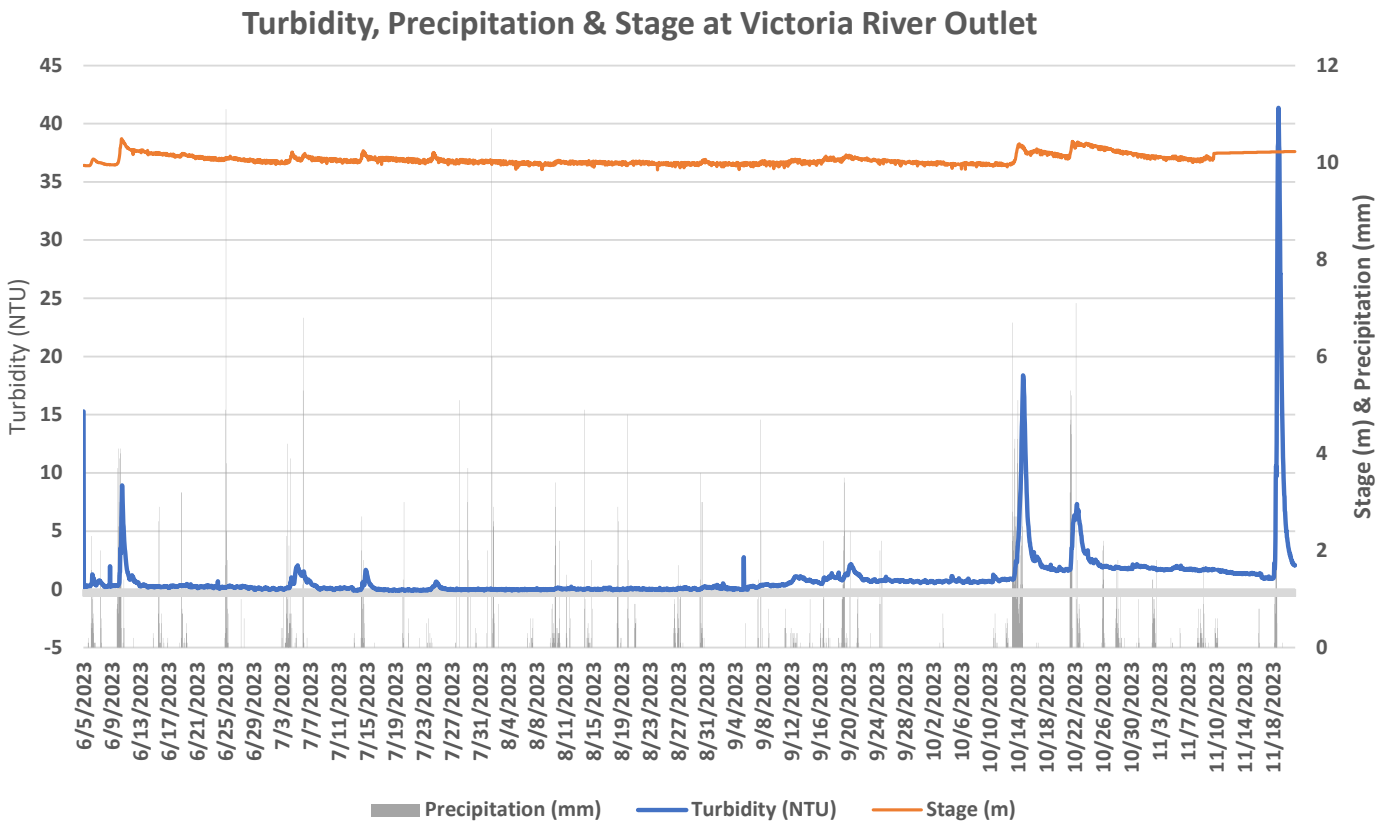

Figure 7: Turbidity, Precipitation & Stage at Victoria River at Outlet

Table 10: Deployment Statistics for Turbidity

Turbidity	2023
Min	-0.01
Max	15.3
Median	0.073

Valentine River

During the 2023 deployment season, water temperature ranged from 0.41ºC to a maximum of 26.88ºC with a median temperature of 15.5ºC (Table 11).

Water temperature was highest during mid-July (Figure 8). Water temperatures started to noticeably decrease from late July onwards as ambient air temperatures also decreased (Figure 8).

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

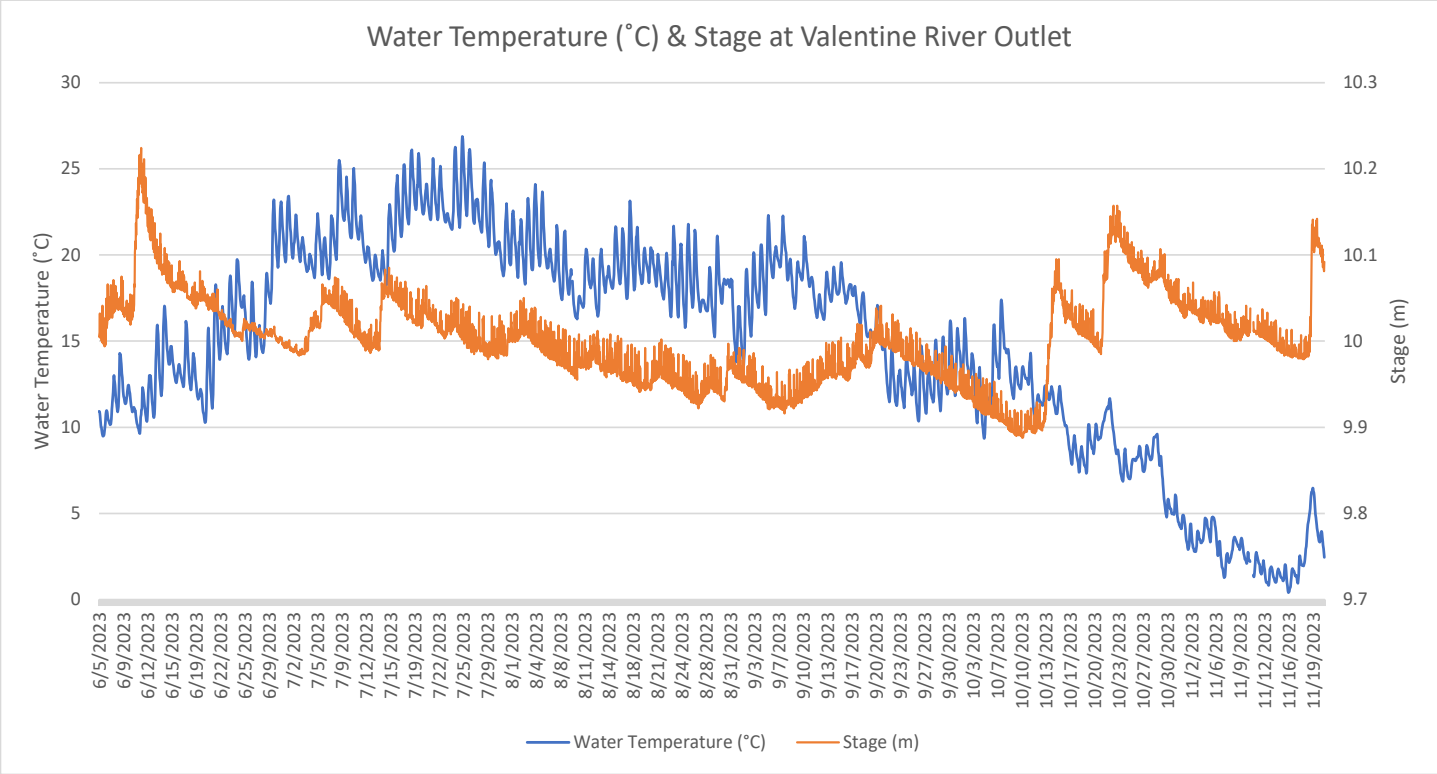

Figure 8: Water Temperature & Stage at Valentine River

Table 11: Deployment Statistics for Water Temperature

Water Temperature ˚C	2023
Min	0.41
Max	26.88
Median	15.55

Water temperatures showed a close relationship with ambient air temperatures (Figure 9). Increases and decreases in air temperatures were reflected as similar changes in water temperatures. Air temperatures fluctuate to a greater extent than water temperatures. Air temperature data was obtained from the Environment and Climate Change Canada climate station in Millertown.

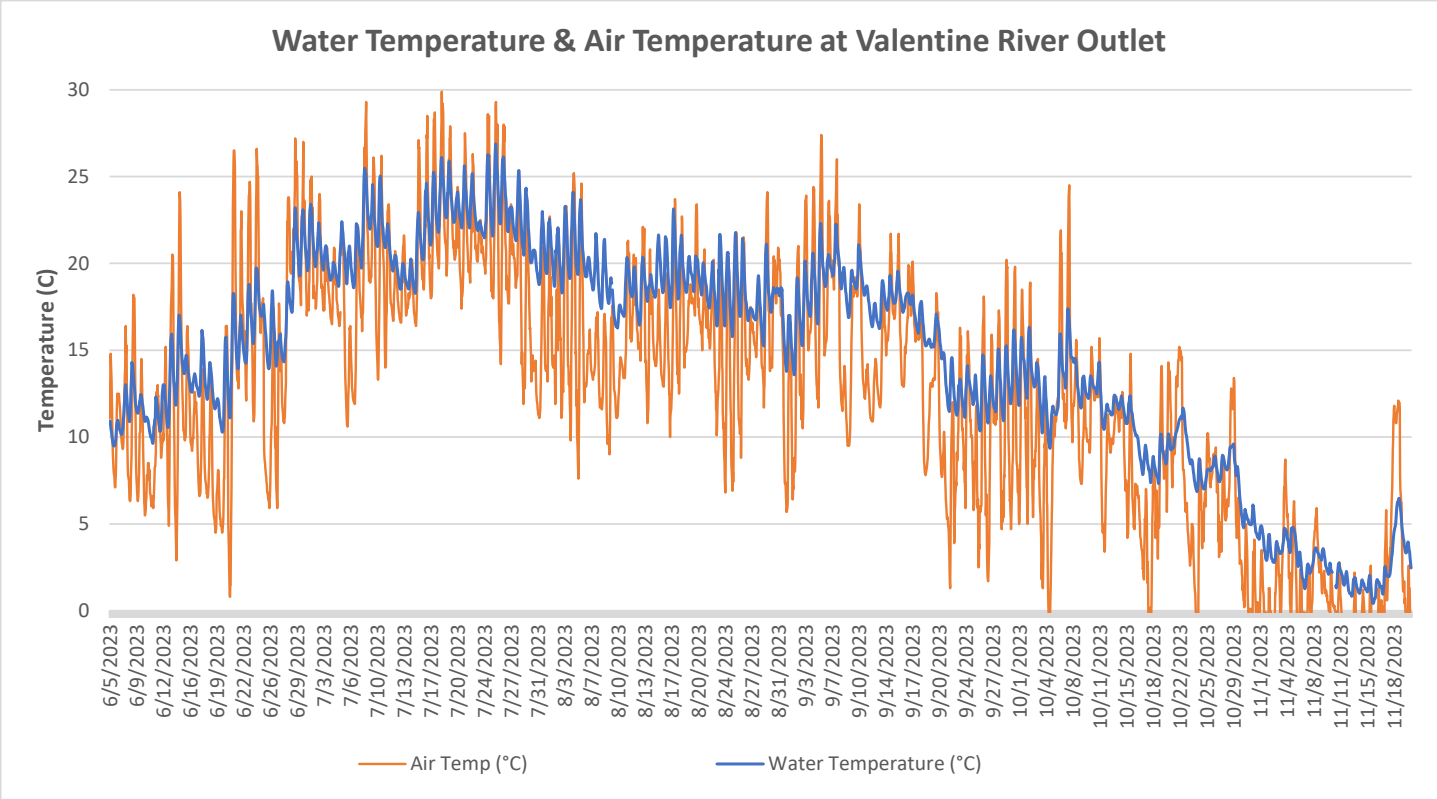

Figure 9: Water Temperature & Air Temperature at Valentine River

During the 2023 deployment season, pH ranged from 6.52 pH units to a maximum of 7.35 pH units with a median value of 6.94 pH units (Table 12).

Across the deployment season, pH data was reasonably stable. Stage is included in the graph below to show the relationship between water level and pH values. Generally, when stage increases, pH will drop for a short period of time. pH values were within the CCME's Guidelines for the Protection of Aquatic Life for the duration of the deployment season (Figure 10).

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

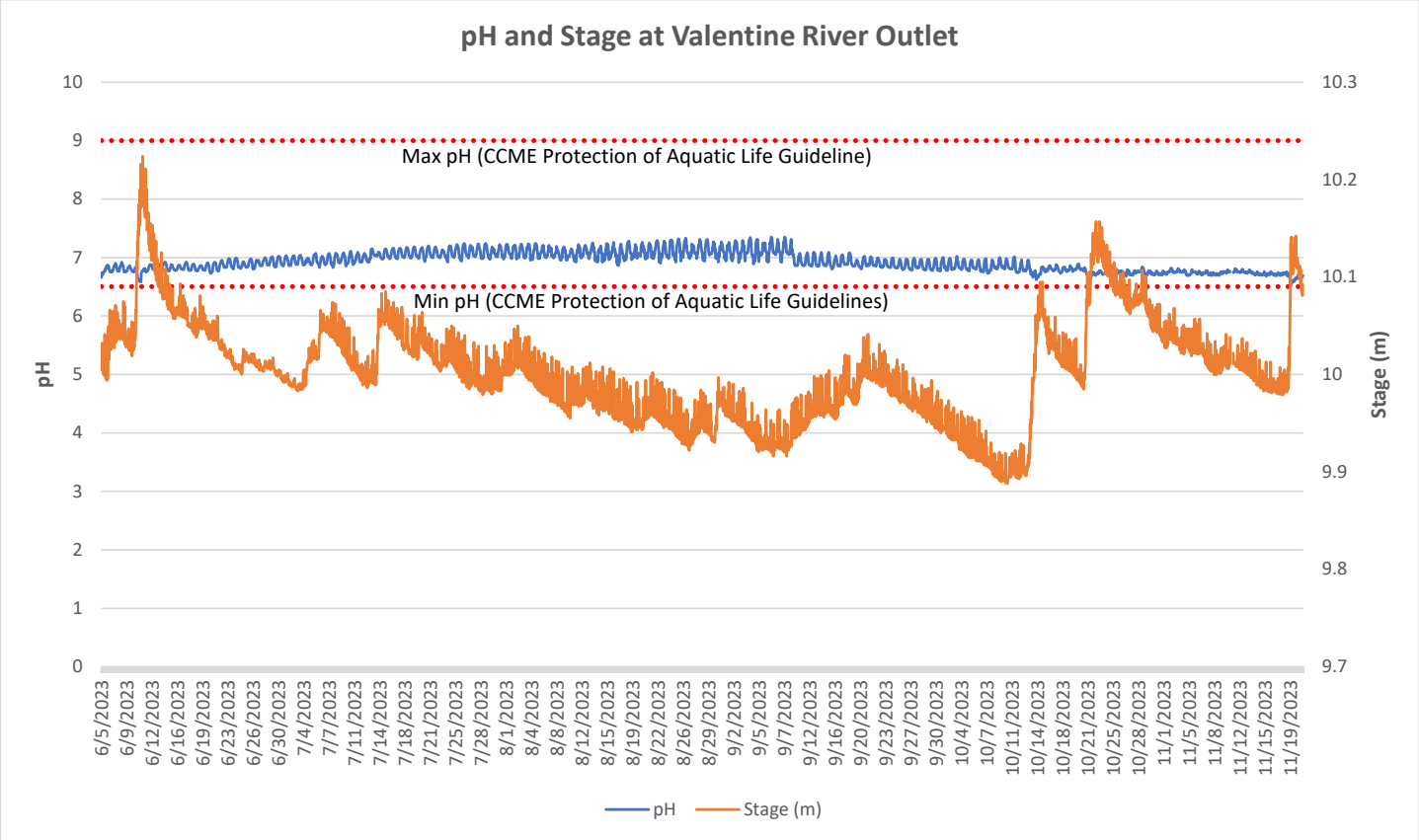

Figure 10: pH & Stage at Valentine River

Table 12: Deployment Statistics for pH

pH	2023
Min	6.52
Max	7.35
Median	6.94

During the 2023 deployment season, specific conductivity ranged from 20.6 µS/cm to a maximum of 27.5 µS/cm (Figure 11) with a median value of 24.5 µS/cm (Table 13).

Stage is included in the graph below to illustrate the relationship between conductivity and water level (Figure 11). In general, stage and conductivity exhibit an inverse relationship: when one parameter increases, the other decreases. In some instances, however, sharp increases in stage correlate with similar increases in conductivity, which is likely due to increased rainfall and resultant runoff.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

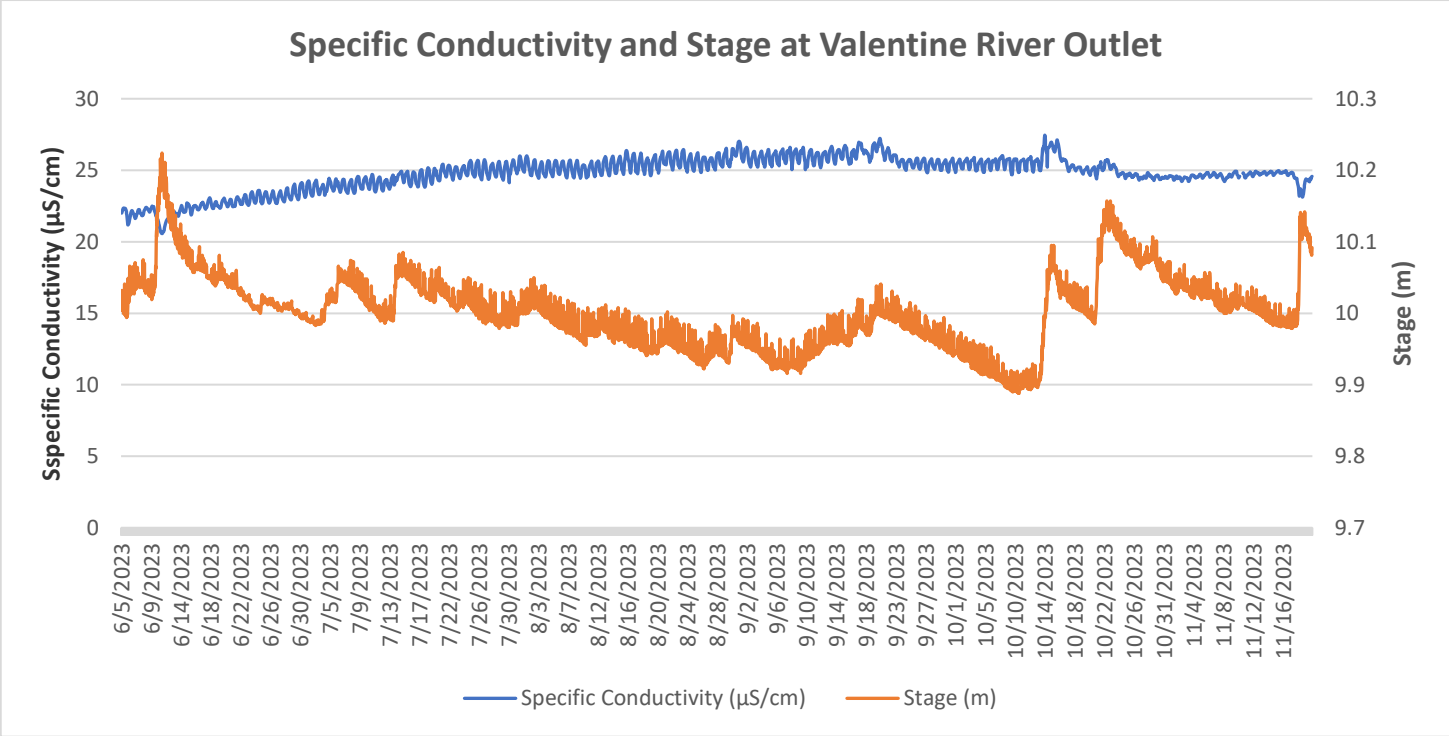

Figure 11: Specific Conductivity & Stage at Valentine River

Table 13: Deployment Statistics for Specific Conductivity

Specific Conductivity µS/cm	2023
Min	20.6
Max	27.5
Median	24.5

During the 2023 deployment season, dissolved oxygen concentrations ranged from 8.32 mg/L to a maximum of 14.63 mg/L, with a median value of 10.21 mg/L. Saturation of dissolved oxygen ranged from 96.6 % to 107.7 %, with a median value of 102.3 % (Table 14).

Dissolved oxygen concentrations exhibited typical seasonal trends and were inversely related to water temperature. Dissolved oxygen concentrations were lowest throughout July and August when water temperatures were warmest. As water temperatures decreased into late summer and fall, dissolved oxygen concentrations began to increase. Frequent fluctuations in dissolved oxygen levels are consistent with smaller daily changes in water temperature (Figure 12).

Dissolved oxygen concentrations were at or below the CCME's Guideline for the Protection of Early Life Stages (9.5mg/L) for much of the deployment period. This is to be expected as they correspond closely with increased water temperatures during the same time frame. Dissolved oxygen concentrations remained above the CCME's Guideline for the Protection of Other Life Stages (6.5mg/L) for the duration of the deployment season.

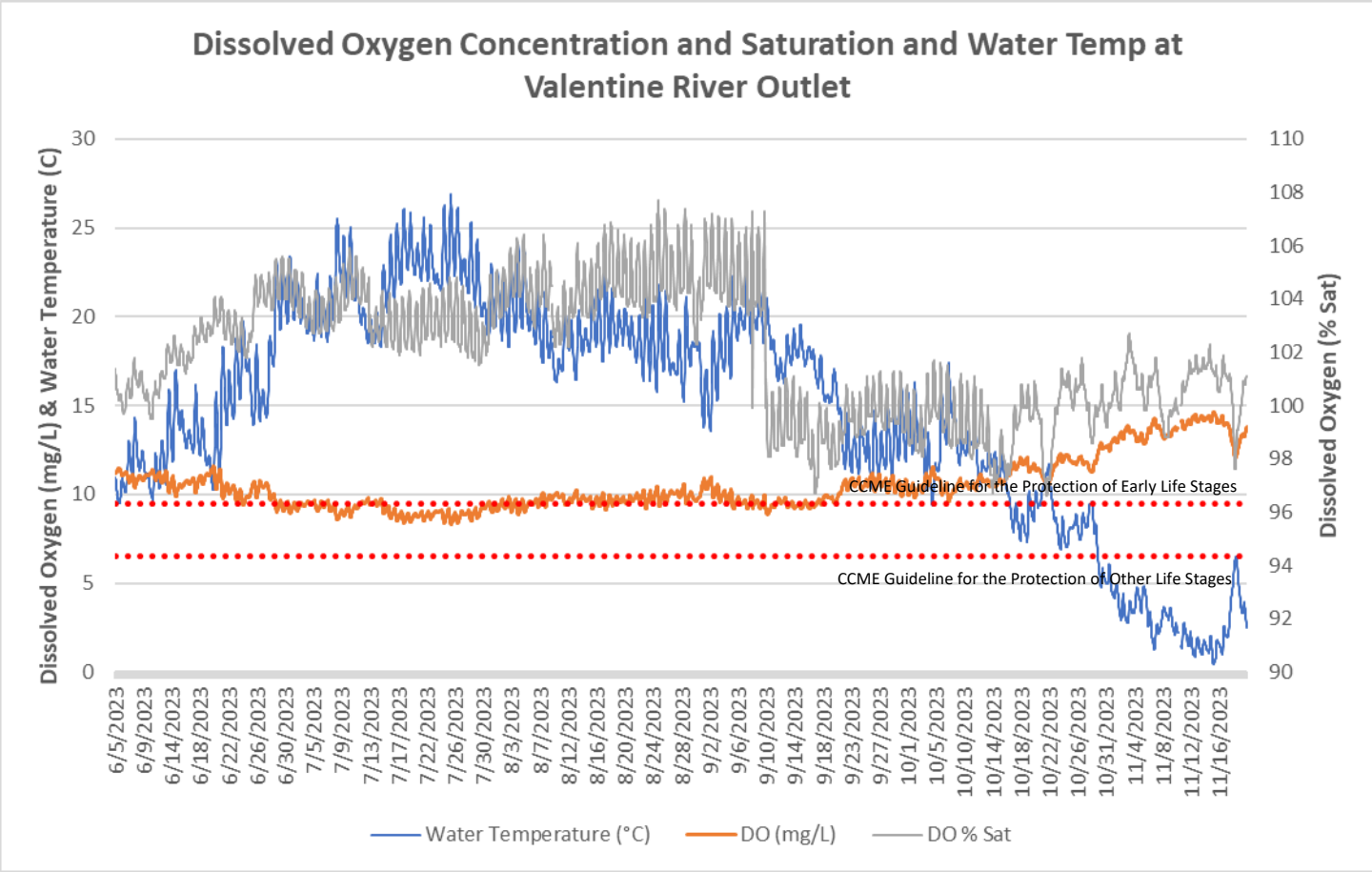

Figure 12: Dissolved Oxygen Concentration and Saturation & Water Temperature at Valentine River

Table 14: Deployment Statistics for Dissolved Oxygen

Dissolved Oxygen (mg/L)	2023
Min	8.32
Max	14.63
Median	10.21

Percent Saturation (%)	2023
Min	96.6
Max	107.7
Median	102.3

*

During the 2023 deployment season, turbidity values ranged from -0.4 NTU to a maximum of 70.9 NTU, with a median value of -0.1 NTU (Figure 13). A median value of -0.1 NTU indicates that there is little natural background turbidity at this station (Table 15).

Turbidity remained low throughout the deployment with a single spike late in the deployment period that appears to relate to an increased stage event. Turbidity remains low and does not respond to increases in stage associated with precipitation events through most of the deployment. This may suggest that there is not a lot of loose sediment to be stirred up by increased precipitation to increase turbidity.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

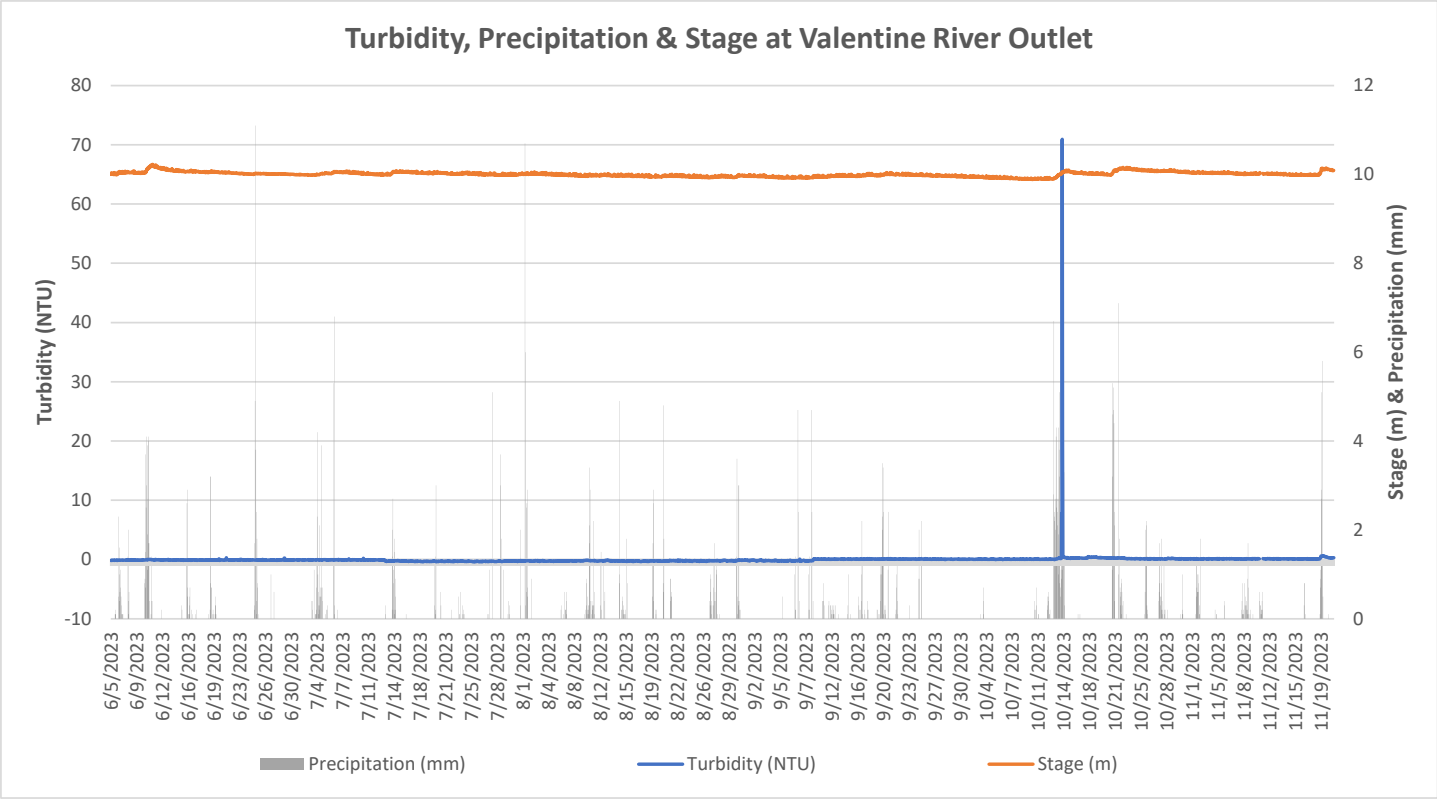

Figure 13: Turbidity & Stage at Valentine River

Table 15: Deployment Statistics for Turbidity

Turbidity (NTU)	2023
Min	-0.4
Max	70.9
Median	-0.1

Roebucks Brook

During the 2023 deployment season, water temperature ranged from 0.36°C to a maximum of 27.11°C, with a median value of 15.38°C (Table 16). Water temperatures were highest through mid-to-late July as air temperatures increased with the summer season. From late July onwards, water temperatures steadily declined as ambient air temperatures also declined (Figure 14).

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

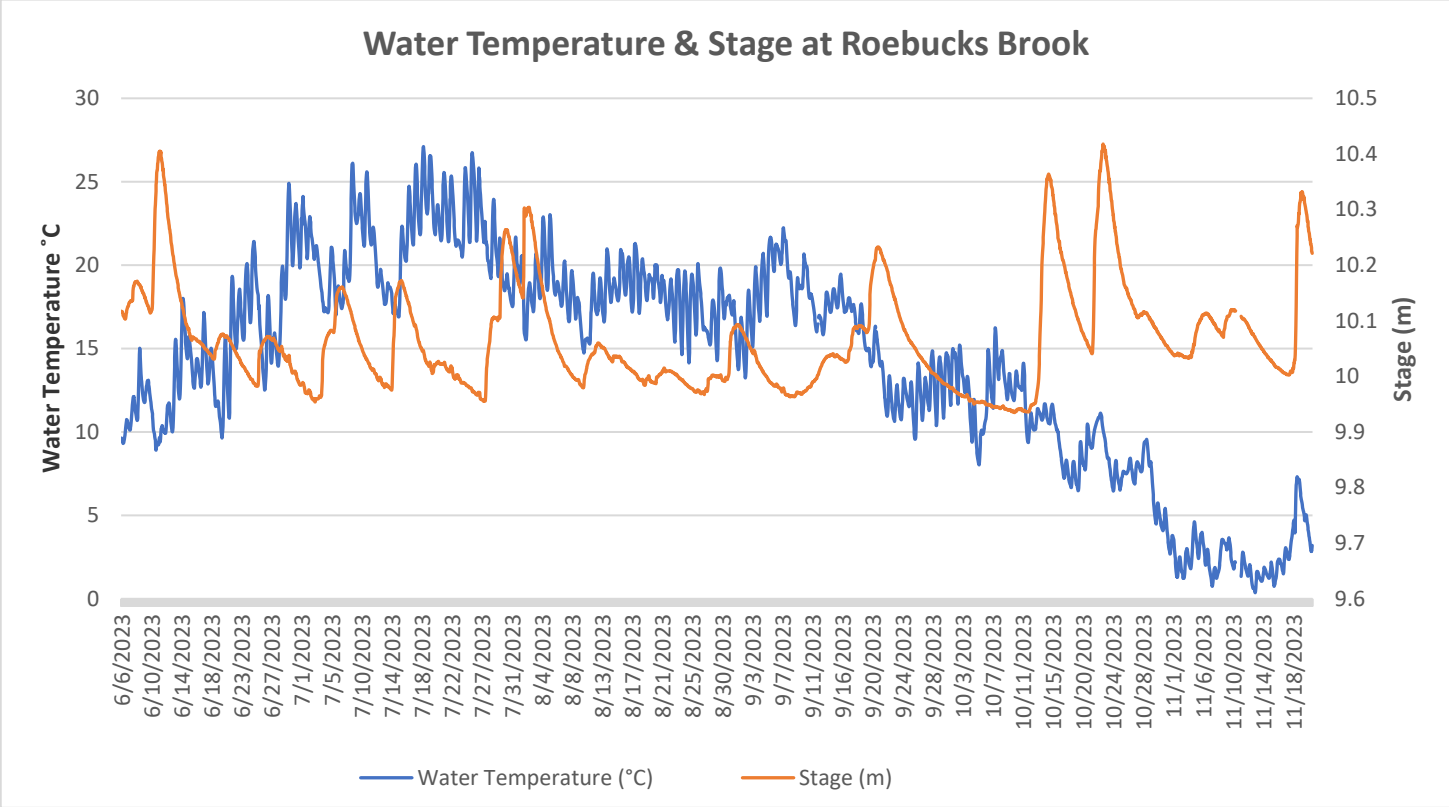

Figure 14: Water Temperature & Stage at Roebucks Brook

Table 16: Deployment Statistics for Water Temperature

Water Temperature ˚C	2023
Min	0.36
Max	27.11
Median	15.38

Water temperatures closely correlate with ambient air temperatures, with increases and decreases in ambient air temperatures being reflected in water temperatures (Figure 15). Air temperatures fluctuate to a greater extent each day as compared to water temperatures. Air temperature data was obtained from the Environment and Climate Change Canada climate station at Millertown.

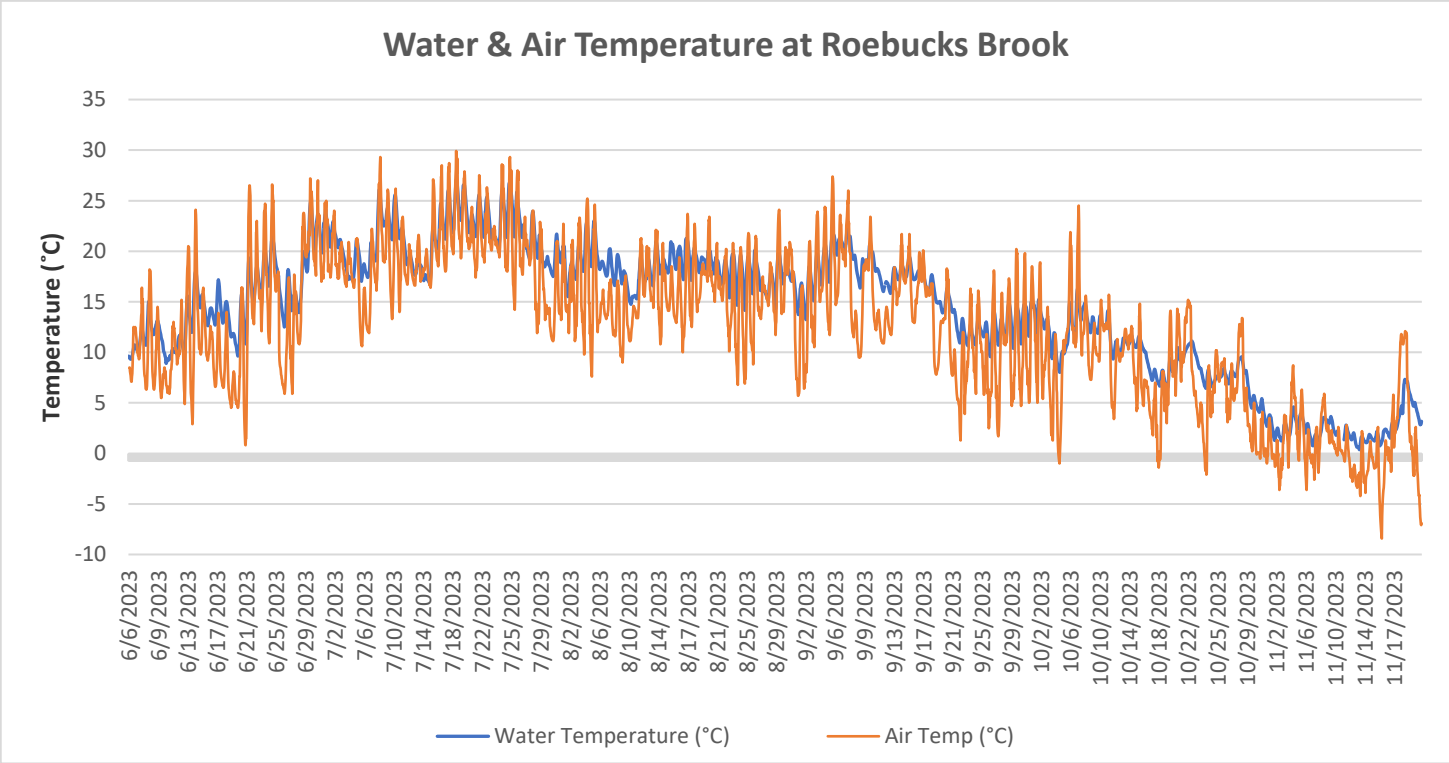

Figure 15: Water Temperature & Air Temperature at Roebucks Brook

During the 2023 deployment season, pH ranged from 6.07 pH units to a maximum of 7.25 pH units, with a median value of 6.91 (Table 17).

Stage data is included in Figure 16 to show how stage influences pH over time. In general, as stage decreases, pH increases and vice versa. This is a natural relationship and is expected in brooks.

pH values at this site were within the CCME's Guidelines for the Protection of Aquatic Life for the majority of the deployment season. There are a few instances where pH values fell below the CCME's Minimum Guideline (Figure 16). These correlated closely with a sharp increase in stage, which is to be expected.

Note that some data was removed near the end of the deployment period. pH levels began to spike into the mid-high teens, between 14-18 pH units, suggesting equipment failure. All pH readings from Nov 6 to end of deployment are unreliable and removed from the dataset.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

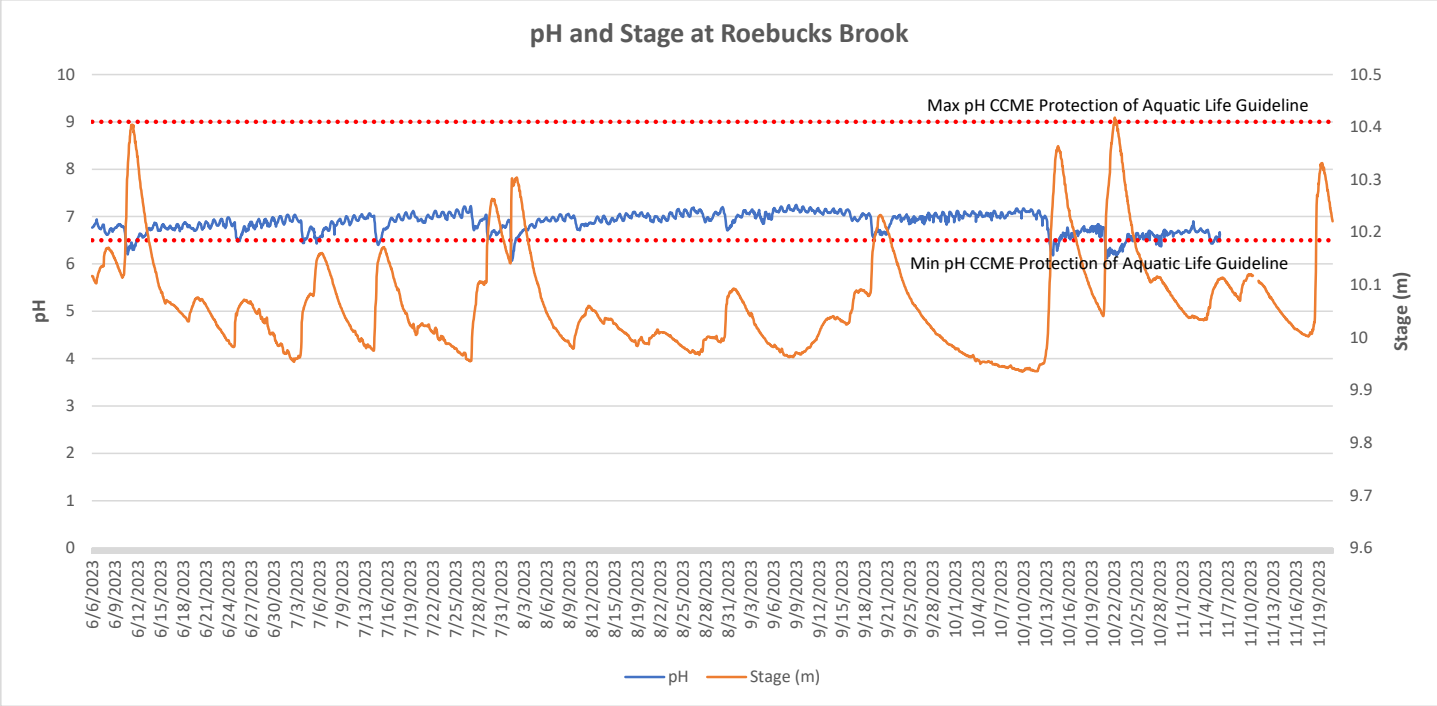

Figure 16: pH & Stage at Roebucks Brook

Table 17: Deployment Statistics for pH

pH	2023
Min	6.07
Max	7.25
Median	6.91

During the 2023 deployment season, specific conductivity levels ranged from 12.7µS/cm to a maximum of 43.7.0µS/cm, with a median value of 26.23 µS/cm (Table 18).

Specific conductivity changes with water level fluctuations: as stage increases, specific conductivity decreases. This is due to dilution of dissolved solids in the water column; as stage decreases, the concentration of dissolved solids increases, in turn increasing specific conductivity. This relationship is evident in the graph below (Figure 17).

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

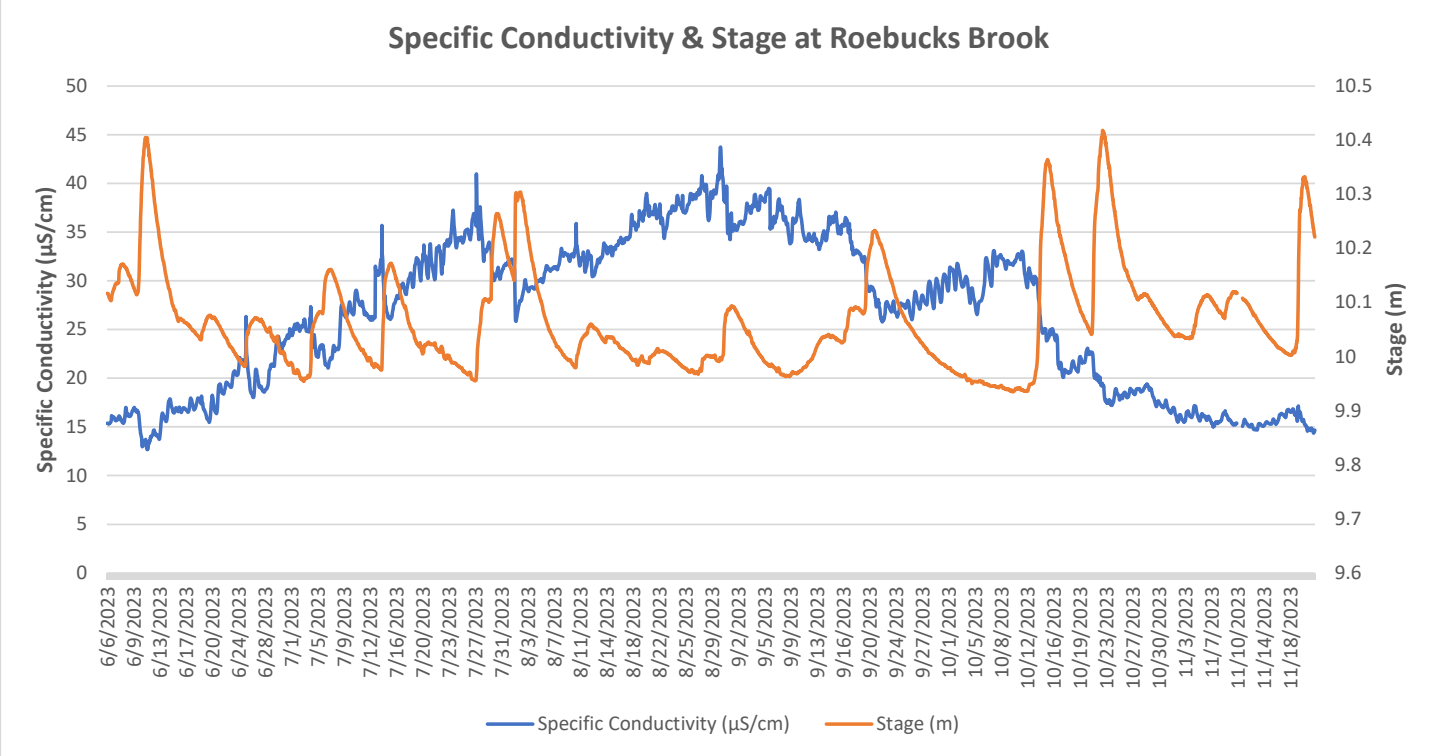

Figure 17: Specific Conductivity & Stage at Roebucks Brook

Table 18: Deployment Statistics for Specific Conductivity

Specific Conductivity µS/cm	2023
Min	12.7
Max	43.7
Median	26.23

During the 2023 deployment season, dissolved oxygen concentrations ranged from 7.94 mg/L to a maximum of 14.14 mg/L, with a median value of 9.84 mg/L. The saturation of dissolved oxygen ranged from 86.7% to 108.0 %, with a median value of 98.2% (Table 19).

Dissolved oxygen concentrations were lowest through mid-July when water temperatures were highest. Increases in water temperature result in less dissolved oxygen being present in a water body. As water temperatures started to decrease from late July onwards, dissolved oxygen concentrations started to increase (Figure 18).

Dissolved oxygen concentrations fell below the CCME's Guidelines for the Protection of Early Life Stages (9.5mg/L) through much of the deployment period but remained above the CCME Guidelines for the Protection of Other Life Stages (6.5mg/L) throughout the deployment season. Instances where dissolved oxygen levels fell below the CCME's Guideline for the Protection of Early Life Stages correlated closely with periods of warmer water temperatures.

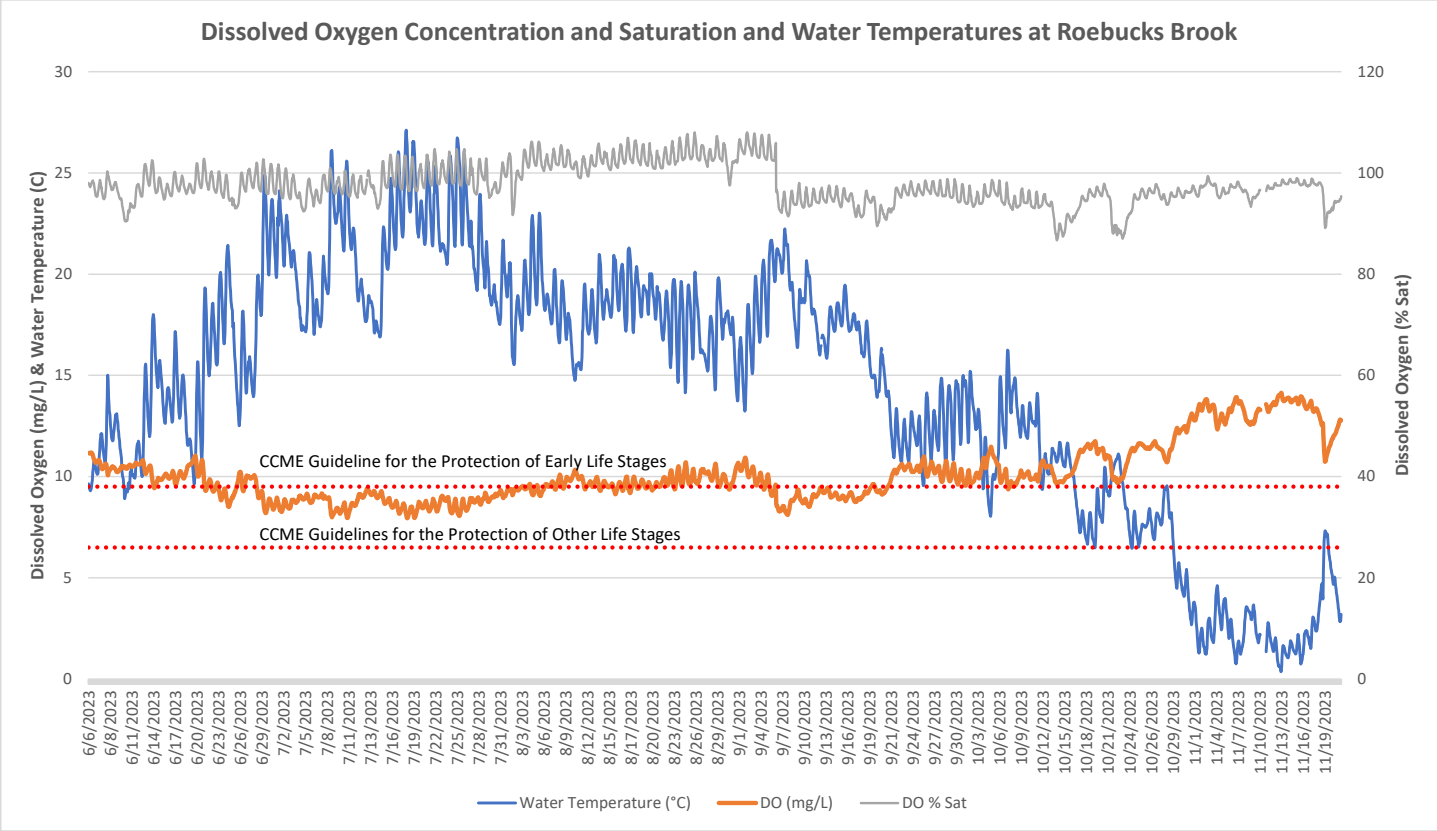

Figure 18: Dissolved Oxygen Concentration and Saturation & Water Temperature at Roebucks Brook

Table 19: Deployment Statistics for Dissolved Oxygen

Dissolved Oxygen (mg/L)	2023
Min	7.94
Max	14.14
Median	9.84

Percent Saturation (%)	2023
Min	86.7
Max	108
Median	98.2

During the 2023 deployment season, turbidity ranged from 0.2 NTU to a maximum of 488.3 NTU, with a median value of 2.07 NTU (Table 20). A median value of 2.07 NTU indicates that there is a very small amount of natural background turbidity at this station.

Turbidity remained stable throughout the deployment with occasional spikes during stage events associated with precipitation (Figure 19). This indicates rainfall associated with stage increases may stir up sediments in the area for brief periods of time before returning to background levels.

Please note that the stage data on the graph below is raw data. It has not undergone quality control checks.

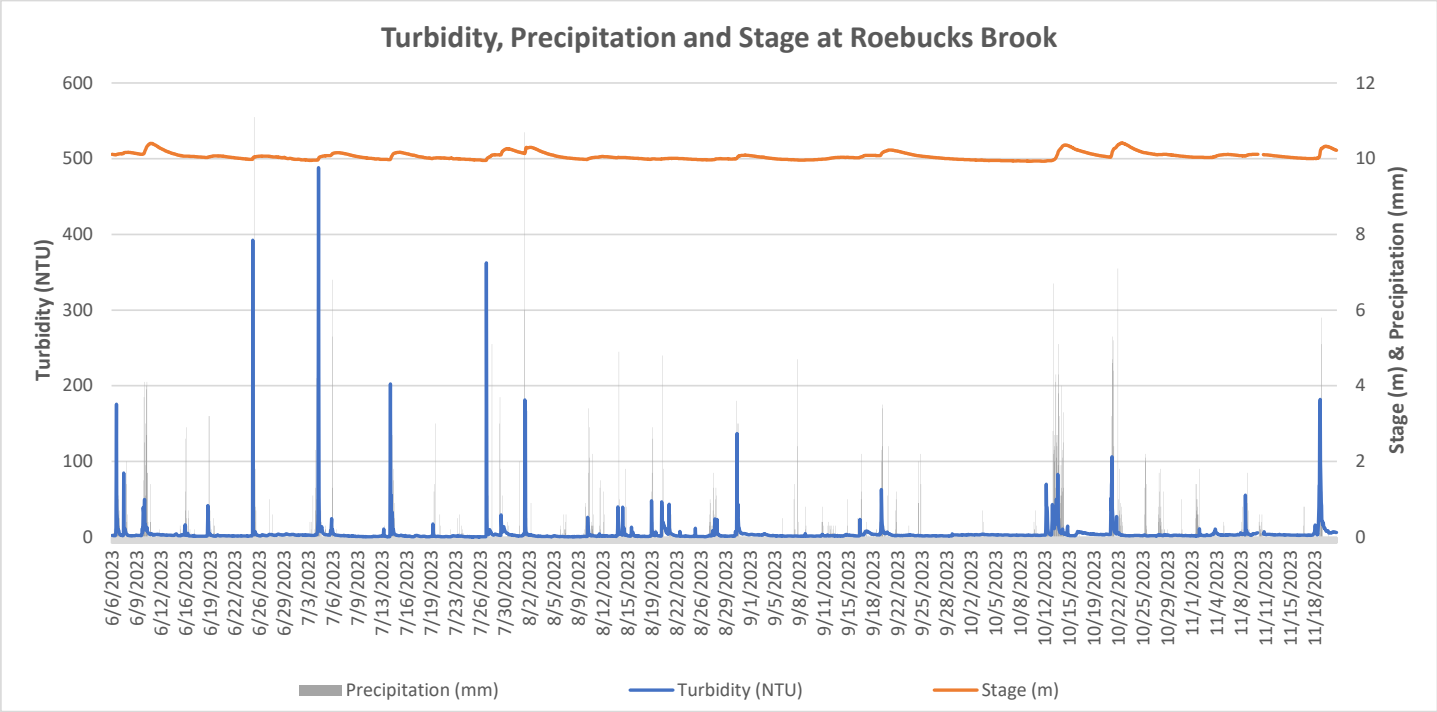

Figure 19: Turbidity, Precipitation & Stage at Roebucks Brook

Table 20: Deployment Statistics for Turbidity

Turbidity NTU	2023
Min	0.2
Max	488.3
Median	2.07

Multi-Station Comparison

The following section of this report focuses on comparisons between the three surface water stations in the Marathon Gold real-time monitoring network.

Temperature

During the 2023 deployment season, a comparison of water temperatures at all three real-time stations shows that the min of 0.36°C and maximum of 27.11°C both occurred at Roebucks Brook. This can be expected s Roebucks is the smallest waterbody amongst the stations. Median values at all three stations were very similar (Table 21).

Water temperature trends were similar at each of the three RTWQ stations, and closely resembled ambient air temperatures (Figure 20). Water temperatures at Victoria River at Outlet, Valentine River and Roebucks Brook all followed a similar trend, peaking in mid-July before slowly decreasing the remainder of the summer and into fall.

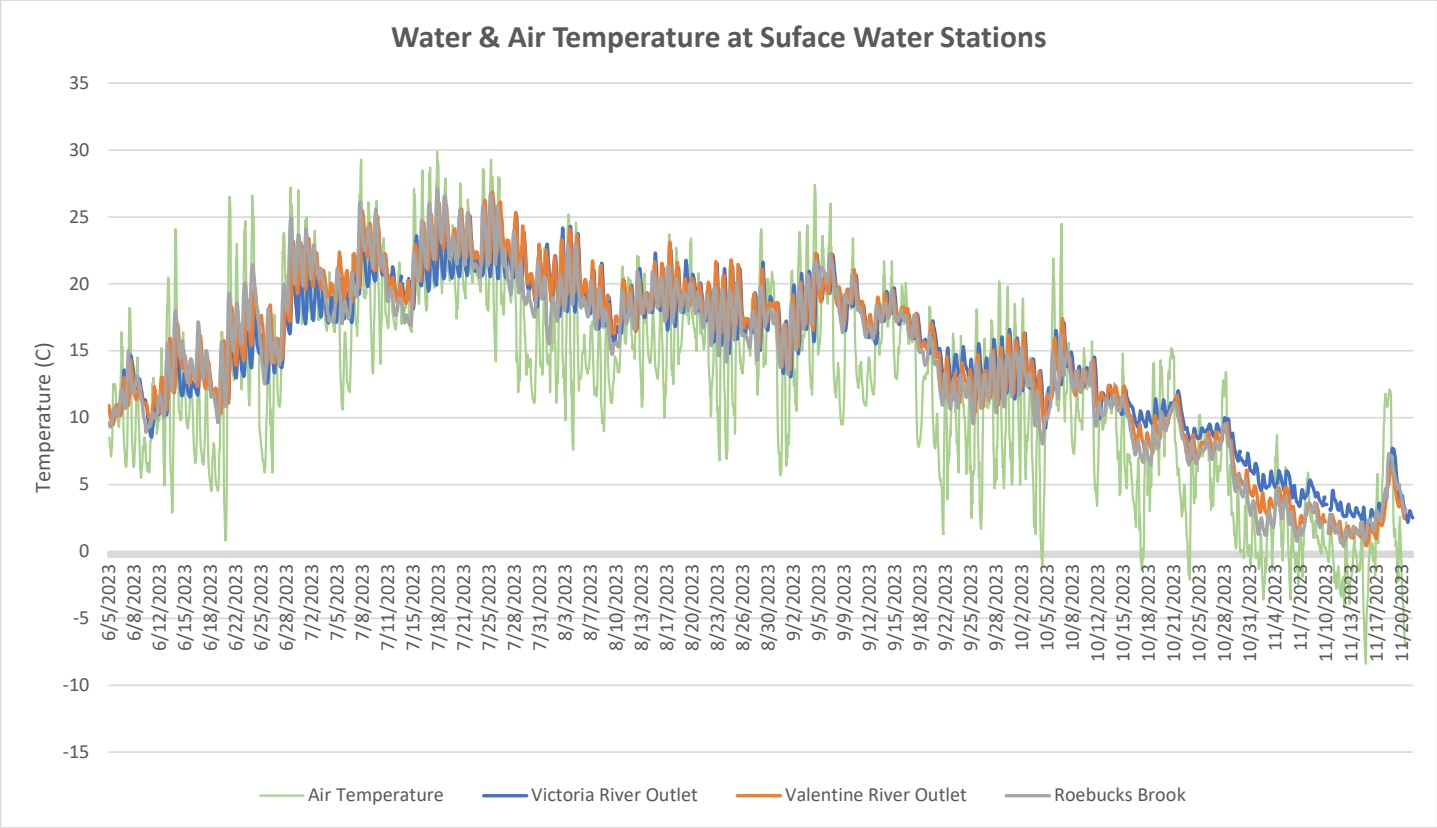

Figure 20: Water Temperature & Air Temperature at all RTWQ SW Stations

Table 21: Comparison Statistics for RTWQ SW stations

Temperature (°C)	Victoria River at Outlet	Valentine River	Roebucks Brook
Min	1.2	0.41	0.36
Max	26.28	26.88	27.11
Median	15.18	15.55	15.38

pH

During the 2023 deployment season, median pH values at all three real-time stations were nearly identical, ranging from 6.91 pH units at Victoria River at Outlet and Roebucks Brook to 6.94 pH units at Valentine River (Table 22).

Roebucks Brook showed some instances where pH fell below the CCME Guideline for Protection of Aquatic Live during periods of high stage, indicating pH in this brook is more strongly influenced by added precipitation than the other two rivers. pH data for Roebucks Brook was removed from November 6 onward due to concerns for its reliability as it was spiking to 14-16 pH units. pH data for Victoria River at Outlet and Valentine River stations remained within the CCME guidelines throughout deployment (Figure 21).

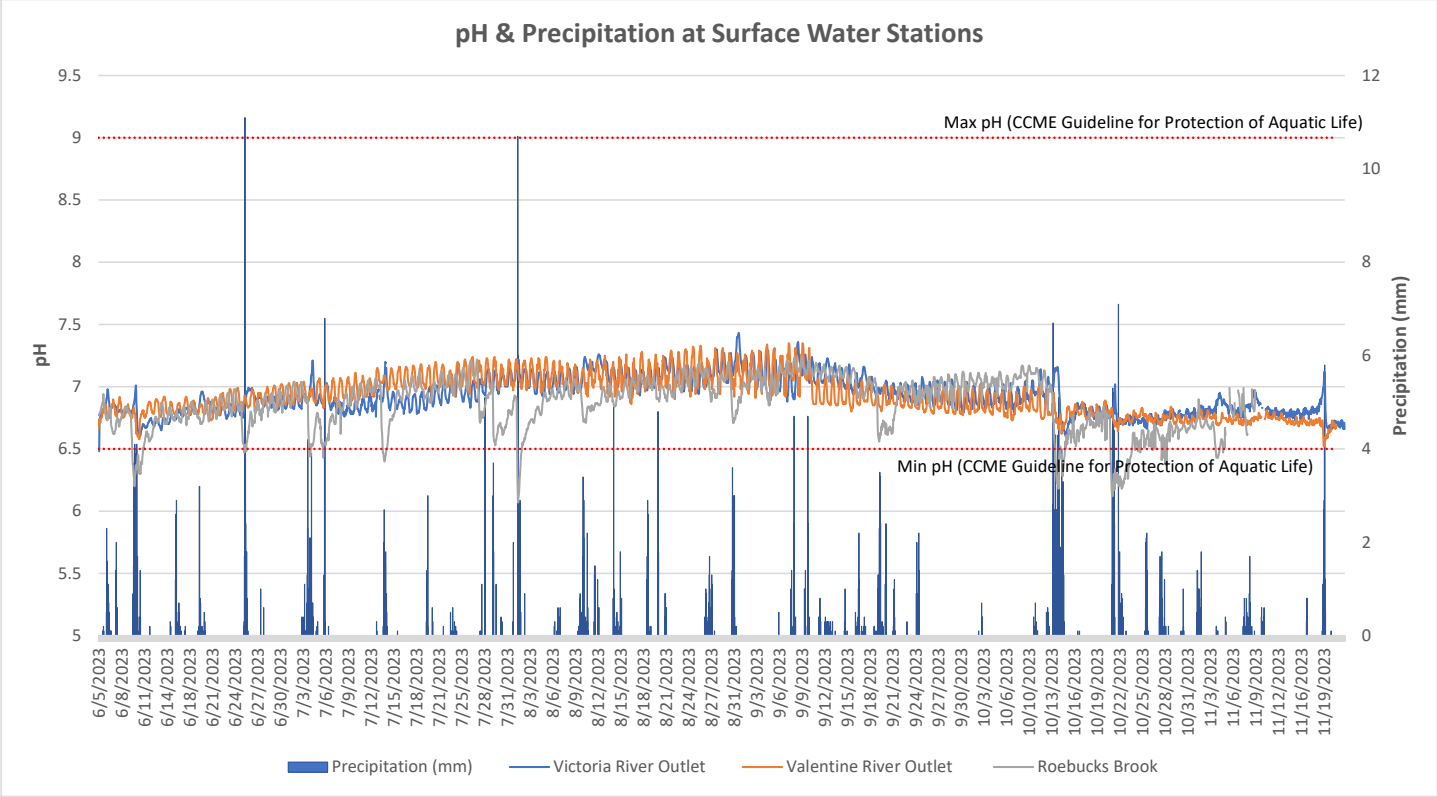

Figure 21: pH & Precipitation at all RTWQ SW Stations

Table 22: Comparison Statistics for RTWQ SW stations

pH (units)	Victoria River at Outlet	Valentine River	Roebucks Brook
Min	6.60	6.52	6.07
Max	7.43	7.35	7.25
Median	6.91	6.94	6.91

Specific Conductivity

During the 2023 deployment season, specific conductivity medians ranged from 24.2 µS/cm at Victoria River at Outlet to a 26.23 µS/cm at Roebucks Brook (Table 23). All medians were very similar.

Victoria River at Outlet specific conductivity remained stable throughout the deployment season with frequent spikes associated with high precipitation (Figure 22). This indicates the precipitation may cause particulates in the river sediment to re-suspend into the water column, increasing the conductivity for a short period of time before it settles out again. Roebucks Brook specific conductivity shows the typical pattern of fluctuation with precipitation: as stage increases, specific conductivity decreases.

Valentine River specific conductivity shows minimal fluctuations even as precipitation affects conductivity at other stations. This suggests that Valentine River may have minimal amounts of sediments to be stirred up by precipitation events.

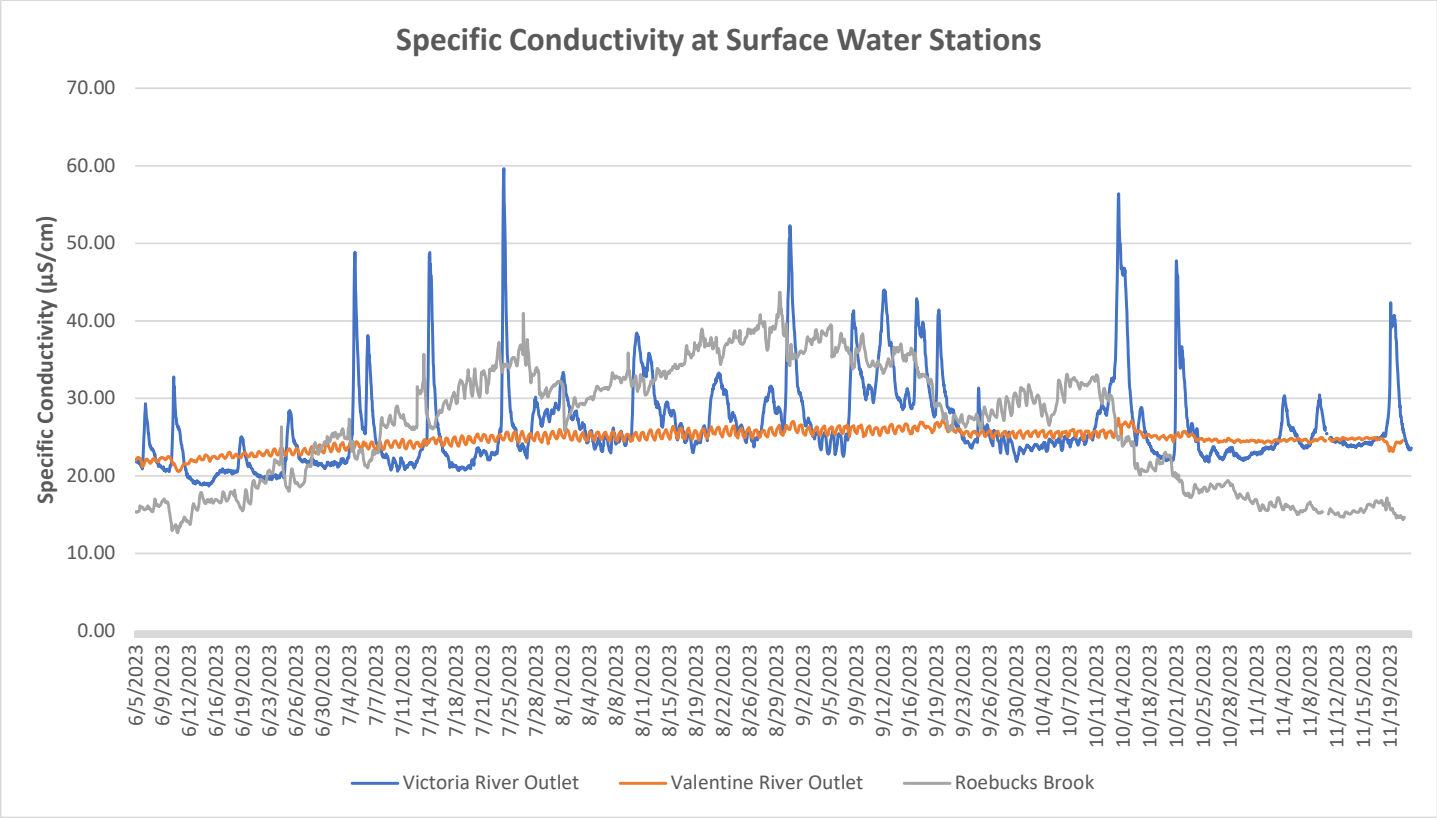

Figure 22: Specific Conductivity at RTWQ SW Stations

Table 23: Comparison Statistics for RTWQ SW stations

Specific Conductivity	Victoria River at Outlet	Valentine River	Roebucks Brook
Min	18.7	20.6	12.7
Max	59.7	27.5	43.7
Median	24.2	24.5	26.23

Dissolved Oxygen Concentration and Saturation of Dissolved Oxygen

During the 2023 deployment season, dissolved oxygen concentration medians ranged from 9.84 mg/L at Roebucks Brook to a maximum of 10.21 mg/L at Valentine River (Table 24). Dissolved oxygen concentrations displayed a typical inverse relationship with both water and ambient air temperatures at all stations (Figure 23a).

During the warmest period through July, dissolved oxygen levels at all stations fell below the CCME's Guideline for the Protection of Early Life Stages (9.5mg/L). Dissolved oxygen concentrations then rose above this guideline for most of August onwards as water temperatures decreased. Dissolved oxygen concentrations remained above the CCME's Guideline for the Protection of Other Life Stages (6.5 mg/L) for the duration of deployment at all stations (Figure 23a).

The observed changes in dissolved oxygen levels are not unusual and are to be expected during seasonal temperature changes. As air temperatures decreased into the cooler fall season, dissolved oxygen levels began to steadily increase.

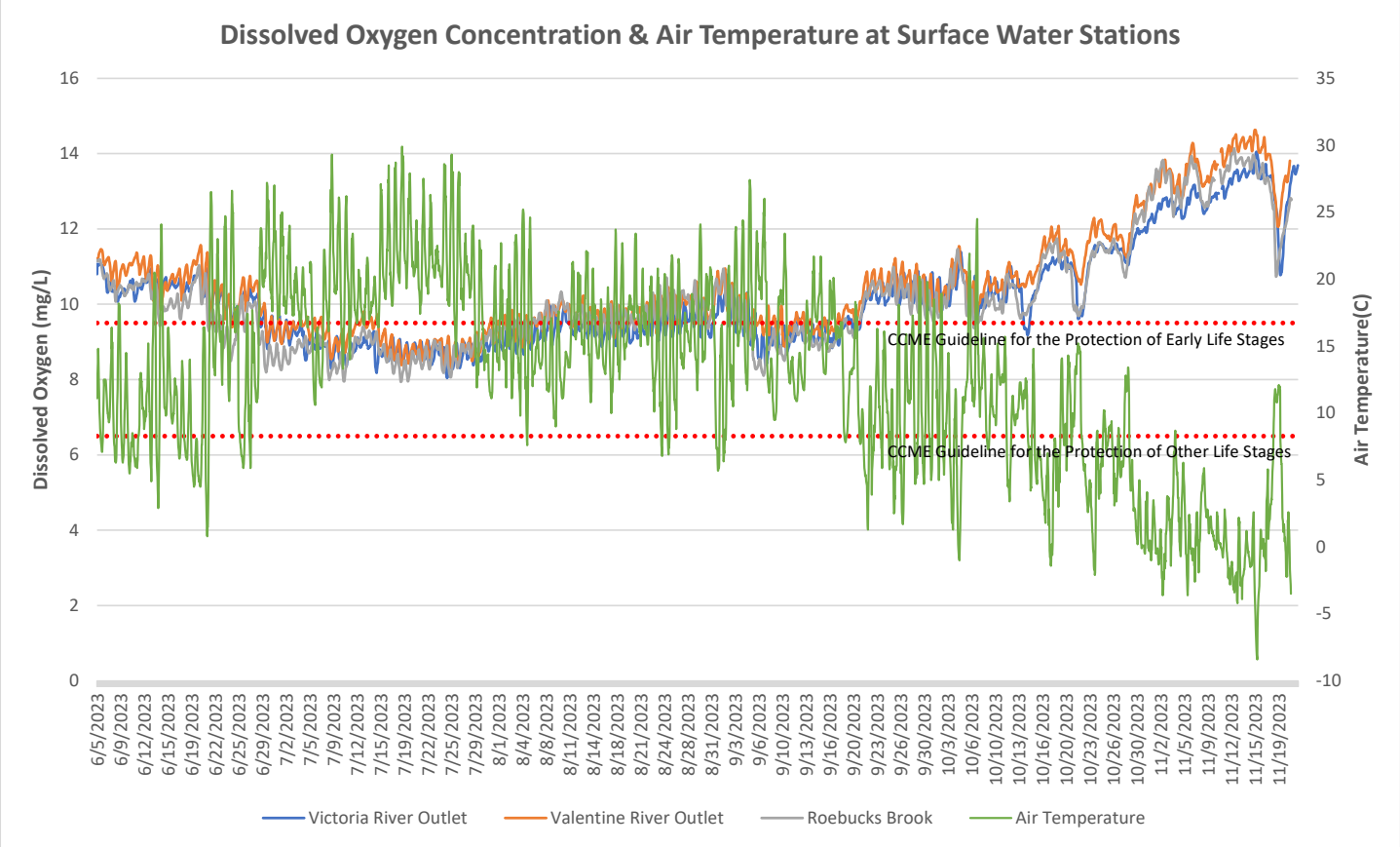

Figure 23a: Dissolved Oxygen Concentration & Air Temperature at RTWQ SW Stations

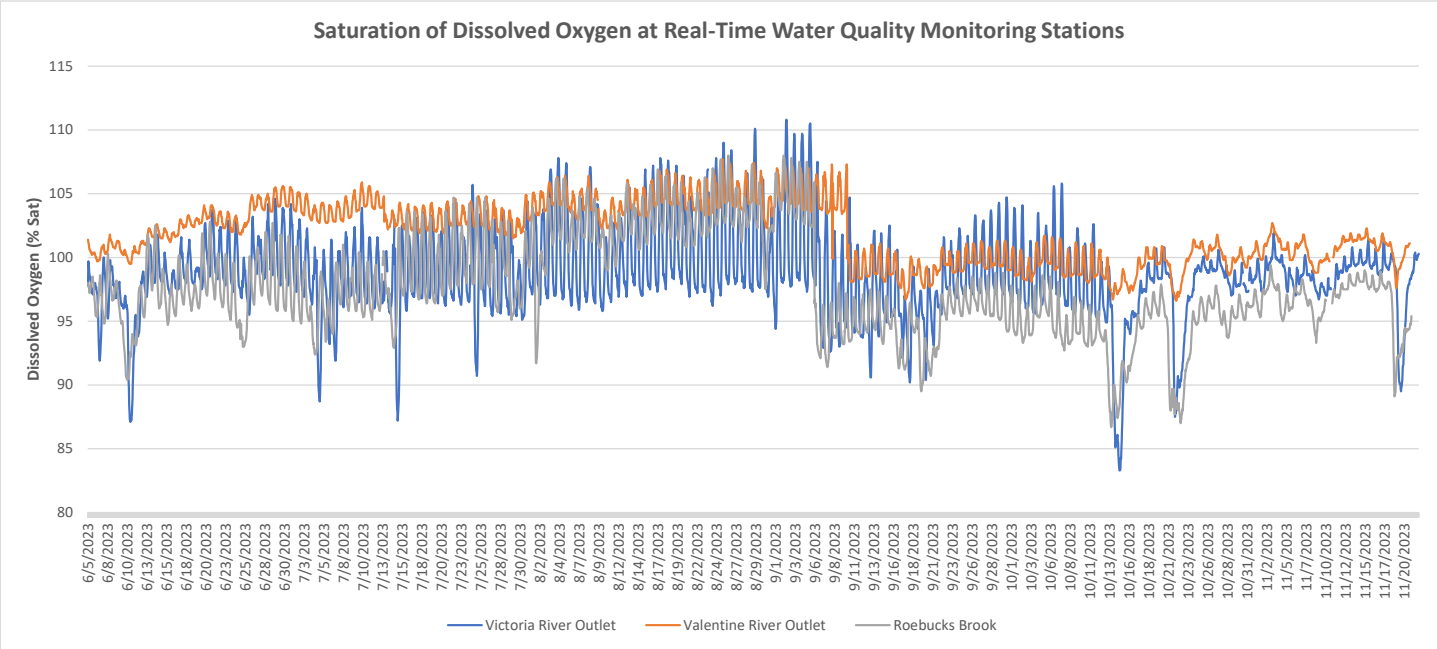

Figure 23b: Saturation of Dissolved Oxygen at RTWQ SW Stations

Table 24: Comparison Statistics for RTWQ SW stations

	Dissolved Oxygen (% Saturation)			Dissolved Oxygen mg/L)		
	Victoria River at Outlet	Valentine River	Roebucks Brook	Victoria River at Outlet	Valentine River	Roebucks Brook
Min	87.1	96.6	86.7	8.04	8.32	7.94
Max	110.8	107.7	108.0	14.05	14.63	14.14
Median	98.5	102.3	98.2	9.97	10.21	9.84

Turbidity

During the 2023 deployment season, turbidity ranged from -0.04 NTU at Valentine River station to a maximum of 488.3 NTU at Roebucks Brook station (Table 25). It is not unusual to see significant variability in turbidity data as this parameter is influenced by many factors (e.g. precipitation, runoff from surrounding environments, high water flow (bubbles), sediment build-up, and debris such as leaf litter). Median turbidity values at all stations indicate that there is very little background turbidity at these stations, which is to be expected (Table 25). Roebucks Brook does have a slightly higher median, and this can be expected as it is a small waterbody and the station is located downstream of the roadway and bridge leading to Marathon Gold. It is likely that extra sediment is added to the brook at this location and this causes the increased turbidity.

Figure 24a and 24b displays all turbidity data for the real-time surface water stations, as well as precipitation data, and clearly shows the relationship between precipitation events and increased turbidity levels.

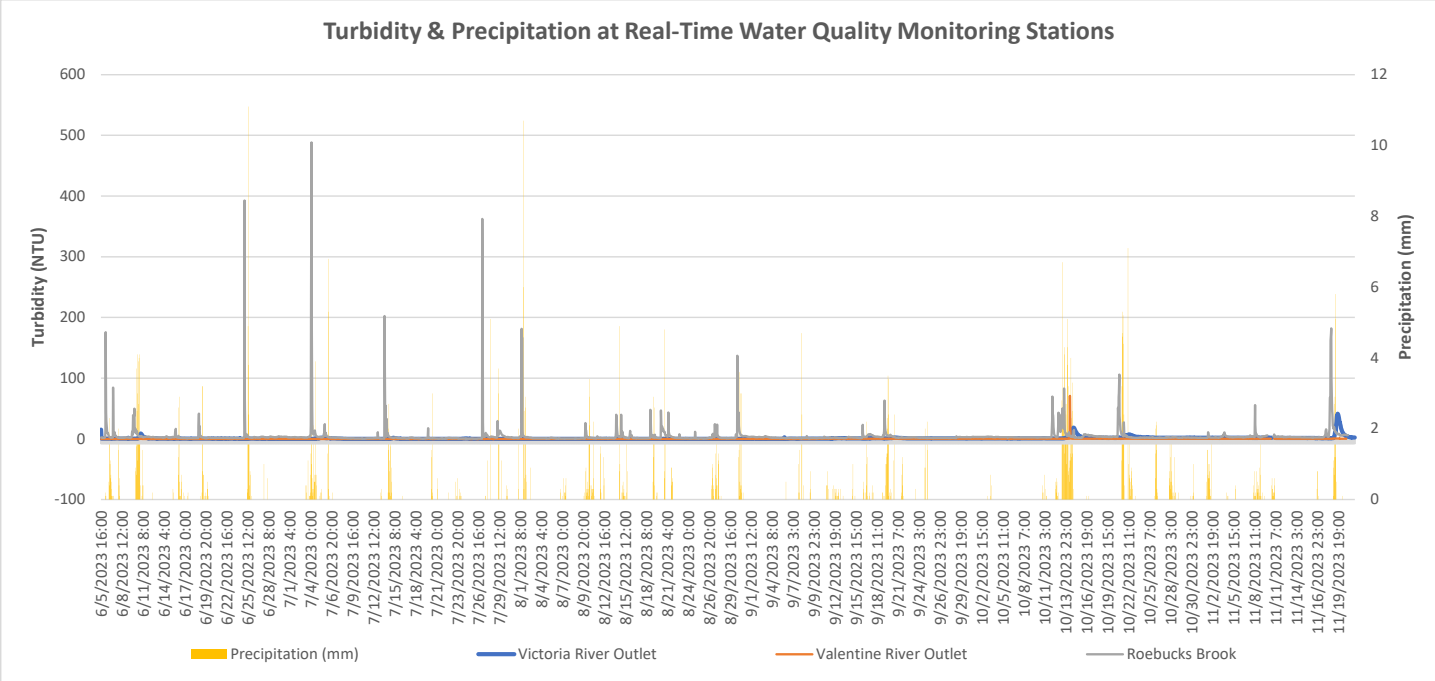

Figure 24a: Turbidity & Precipitation at RTWQ SW Stations

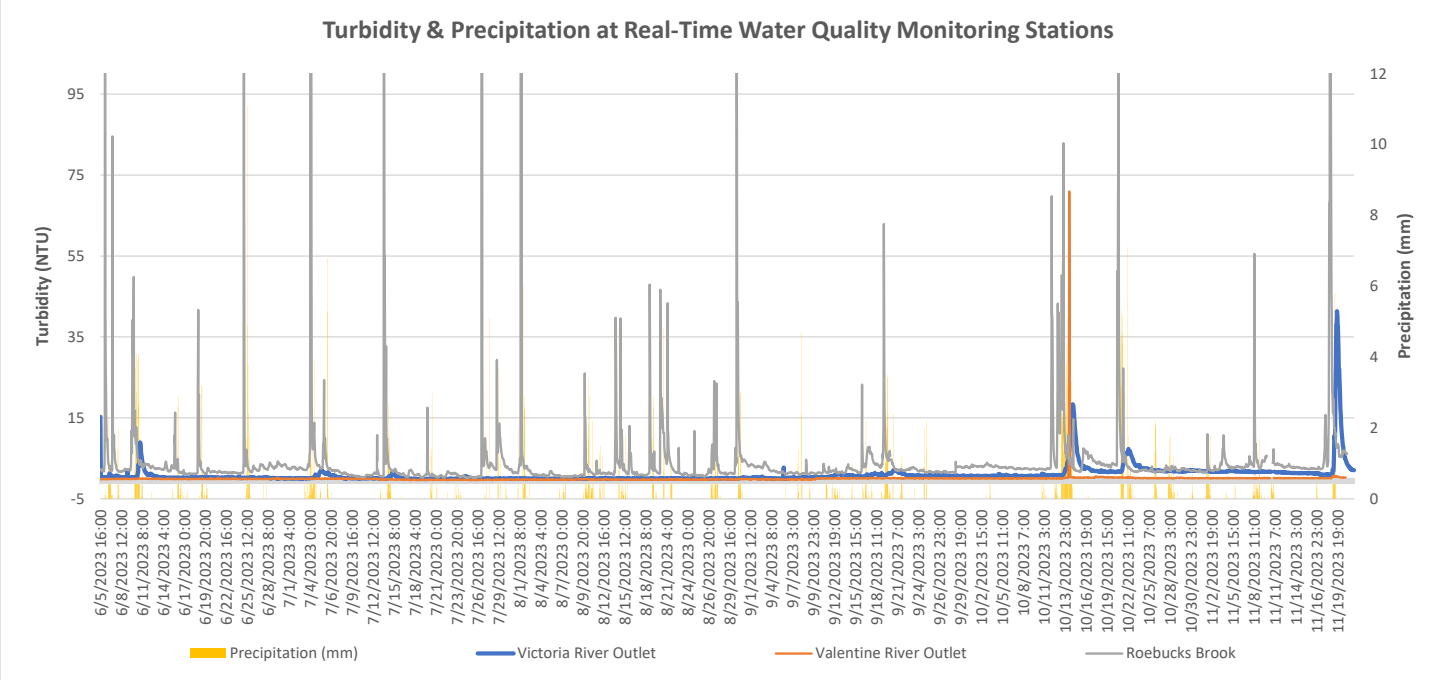

Figure 24b: Turbidity & Precipitation at RTWQ SW Stations (<100NTU)

Table 25: Comparison Statistics for RTWQ SW stations

Turbidity (NTU)	Victoria River at Outlet	Valentine River	Roebucks Brook
Min	-0.01	-0.04	0.2
Max	15.3	70.09	488.3
Median	0.073	-0.1	2.07

Stage

At all stations, stage level was influenced by precipitation events (Figure 25): the more precipitation, the high stage values rose. Roebucks Brook demonstrated larger increases after some precipitation events than the other stations as it is a significantly smaller waterbody. All stations had stage values which ranged less than 1m between minimum and maximum values during the deployment period (Table 26).

It is important to note that the Victoria River at Outlet station is downstream of the Victoria River dam, and thus is susceptible to controlled water releases from the dam when necessary.

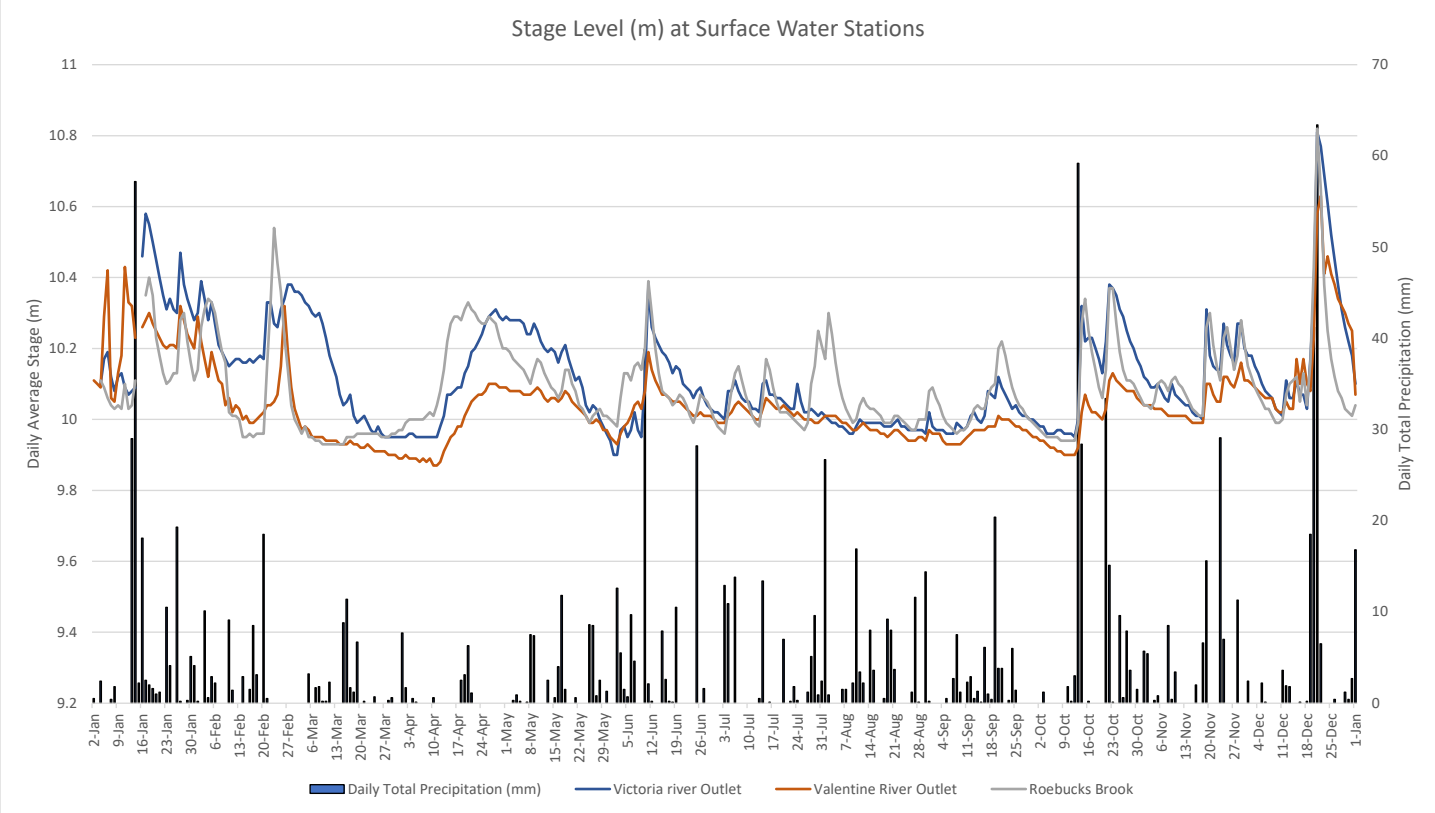

Figure 25: Daily Stage Level (m) & Total Daily Precipitation (mm) at RTWQ SW Stations

Table 26: Comparison Statistics for RTWQ SW stations

Stage (m)	Victoria River at Outlet	Valentine River	Roebucks Brook
Min	9.90	9.87	9.93
Max	10.81	10.63	10.82
Median	10.08	10.02	10.06

Data Interpretation – Ground Water Network

The following section of this report focuses on the four stations of the Ground Water Well Network operating in 2023, which include: South of Leprechaun Waste Rock Pile Monitoring Station (NLGWMG01), Northwest of Leprechaun Pit Monitoring Station (NLGWMG02), Southeast of TMF Monitoring Well (Deep)(NLGWMG03), and Southeast of TMF Monitoring Well (NLGWMG04). All stations were first deployed in the spring of 2023 but will be active year-round going forward.

Water Elevation

Water elevation (meters above sea level) at each station varied little throughout the deployment period (Table 27). NLWGMG02 showed the least variation, as can be expected as this is a deep well. The other three wells showed some degree of variation (Figure 26).

Notably, NLGWGM01 and NLGWGM04 show identical rises and falls at the same time throughout the deployment, though the magnitude of change is greatest at NLGWMG01.

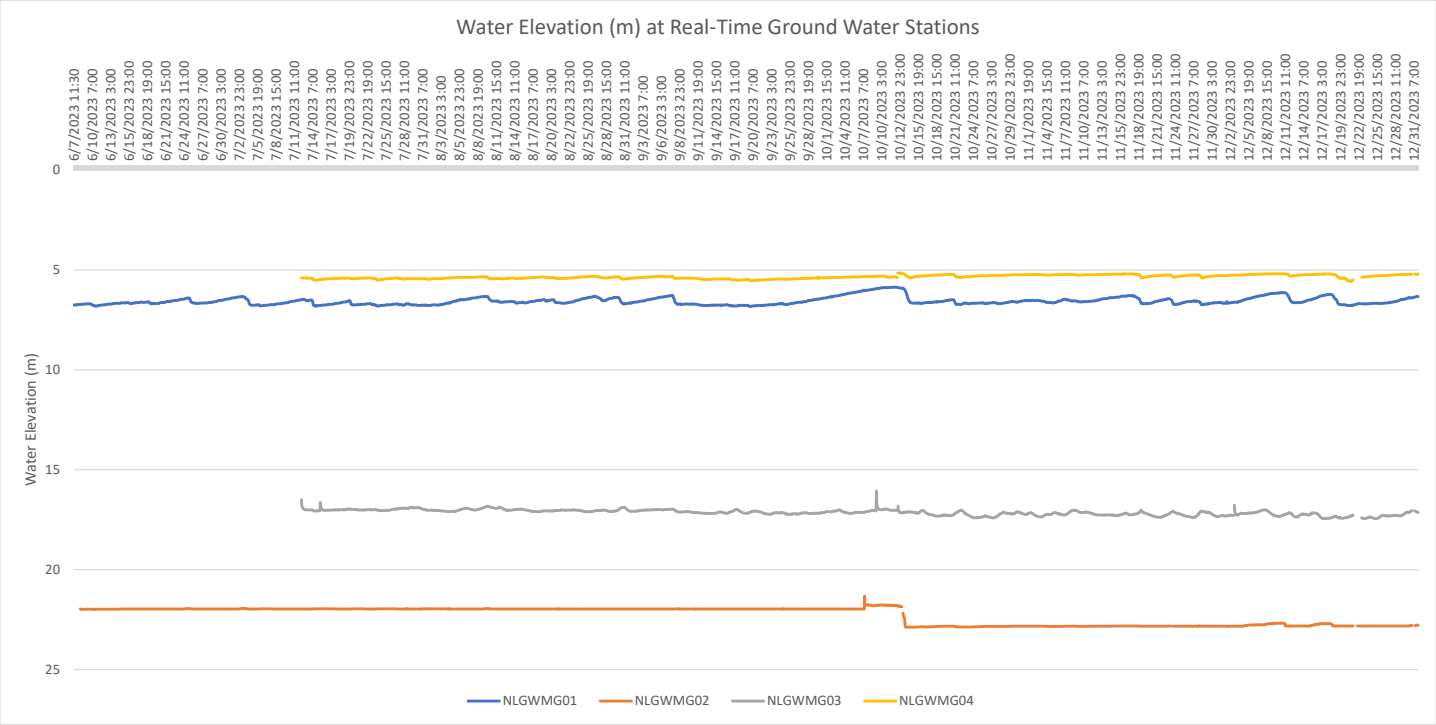

Figure 26: Water Elevation (m) at RTWQ GW Stations

Table 27: Comparison Statistics for RTWQ GW stations

Water Elevation (m)	NLGWMG01	NLGWMG02	NLGWMG03	NLGWMG04
Min	5.85	21.33	16.06	5.14
Max	6.83	22.88	17.45	5.57
Median	6.60	21.97	17.13	5.342

Water Temperature

Water temperature at all four stations ranged from 4.54°C at NLGWMG01 to 8.64°C at NLGWMG02 (Table 28). Median temperature for all stations was ranged from 5.16°C to 6.99°C. Temperatures did not vary significantly at NLGWMG03, showing very steady temperatures within a small range. This is a deep well and likely influenced minimally by surface water. NLGWMG01 and NLGWMG04 water temperatures show seasonal changes, warming in the summer and cooling into the fall (Figure 27). NLGWMG02 showed the most variability throughout the year despite being a relatively deep well.

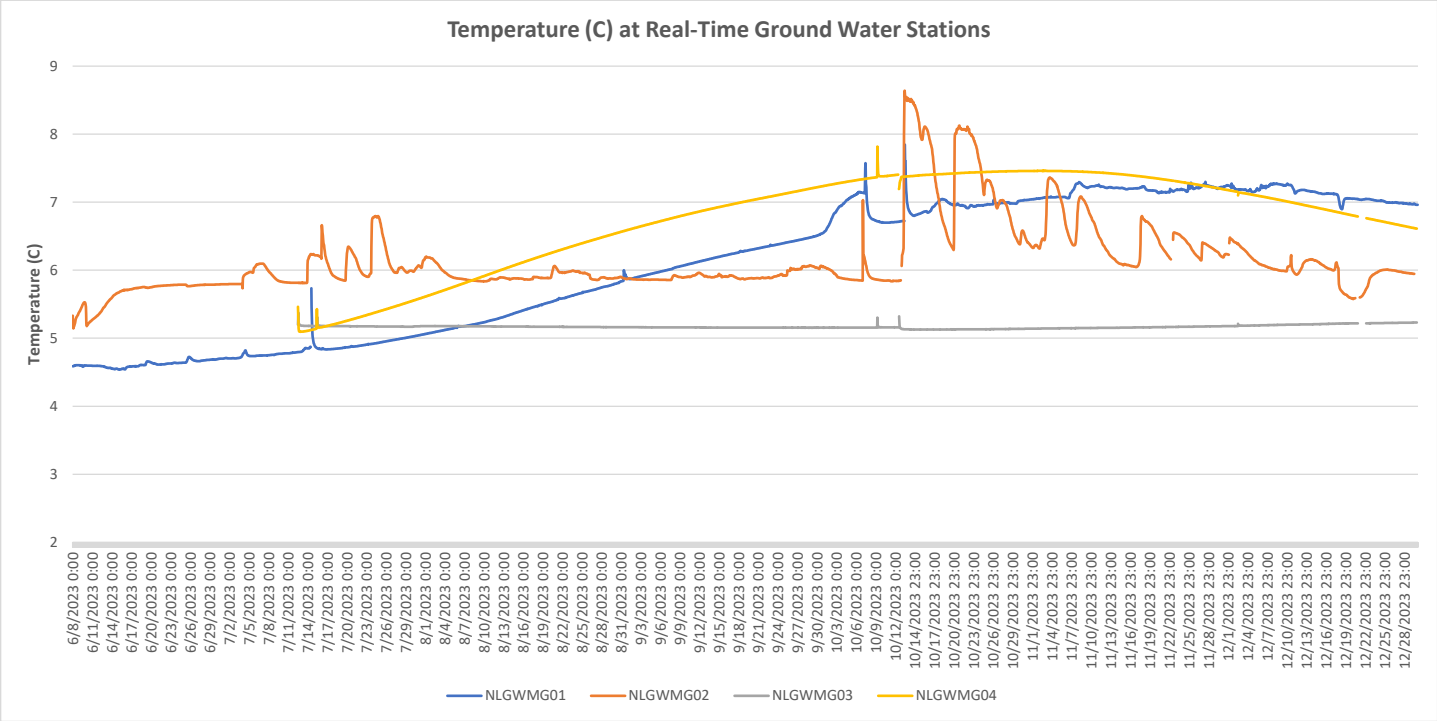

Figure 27: Water Temperature at Real-Time GW Stations

Table 28: Comparison Statistics for RTWQ GW stations

Temperature (°C)	NLGWMG01	NLGWMG02	NLGWMG03	NLGWMG04
Min	4.54	5.14	5.13	5.09
Max	7.85	8.64	5.37	7.82
Median	6.28	5.96	5.16	6.99

pH

Median pH values for all stations ranged from 5.30 pH units at NLGWMG01 to 8.06 pH units at NLGWMG03. NLGWMG03 and NLGWMG04 showed little variation throughout deployment. NLGWMG01 and NLGWMG02 showed the most variation but had similar median values at 5.97 and 5.98 respectively. All stations had sudden changes in values a few times during the year, likely associated with sample collection or maintenance at the wells. Longer term tracking of the pH at these stations is needed in order to see trends and potential impacts from mining operations.

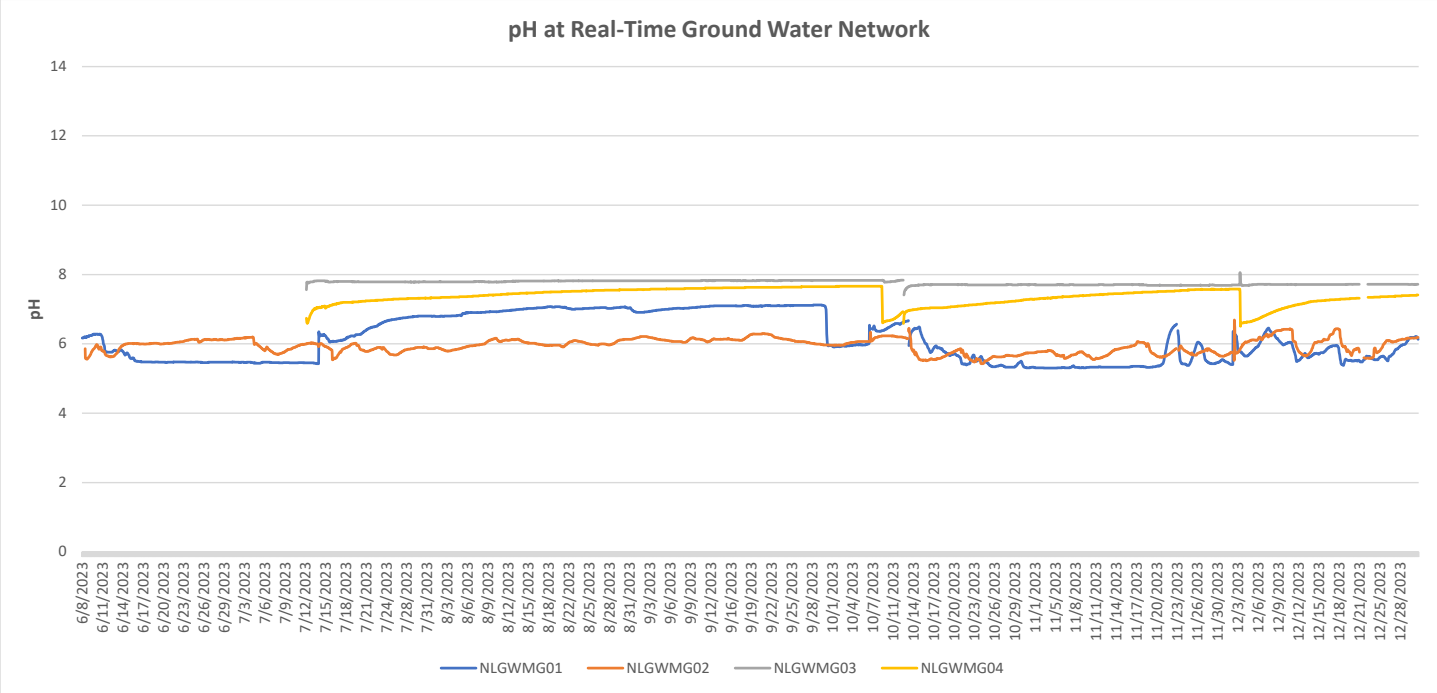

Figure 28: pH at Real-Time GW Stations

Table 29: Comparison Statistics for RTWQ GW stations

pH	NLGWMG01	NLGWMG02	NLGWMG03	NLGWMG04
Min	5.30	5.43	7.41	6.51
Max	7.12	6.69	8.06	7.66
Median	5.97	5.98	7.79	7.40

Specific Conductivity

Specific conductivity ranged from 12.97µS/cm at NLGWMG02 to 290.8µS/cm at NLGWMG03. NLGWMG03 varies little but this can be expected as this is a relatively deep well. NLGWMG02 is deeper yet shows considerable fluctuations. When compared, the median values at the four stations are also quite variable. Further data collection and analysis is required to determine aquifer trends and what is 'normal' for each well.

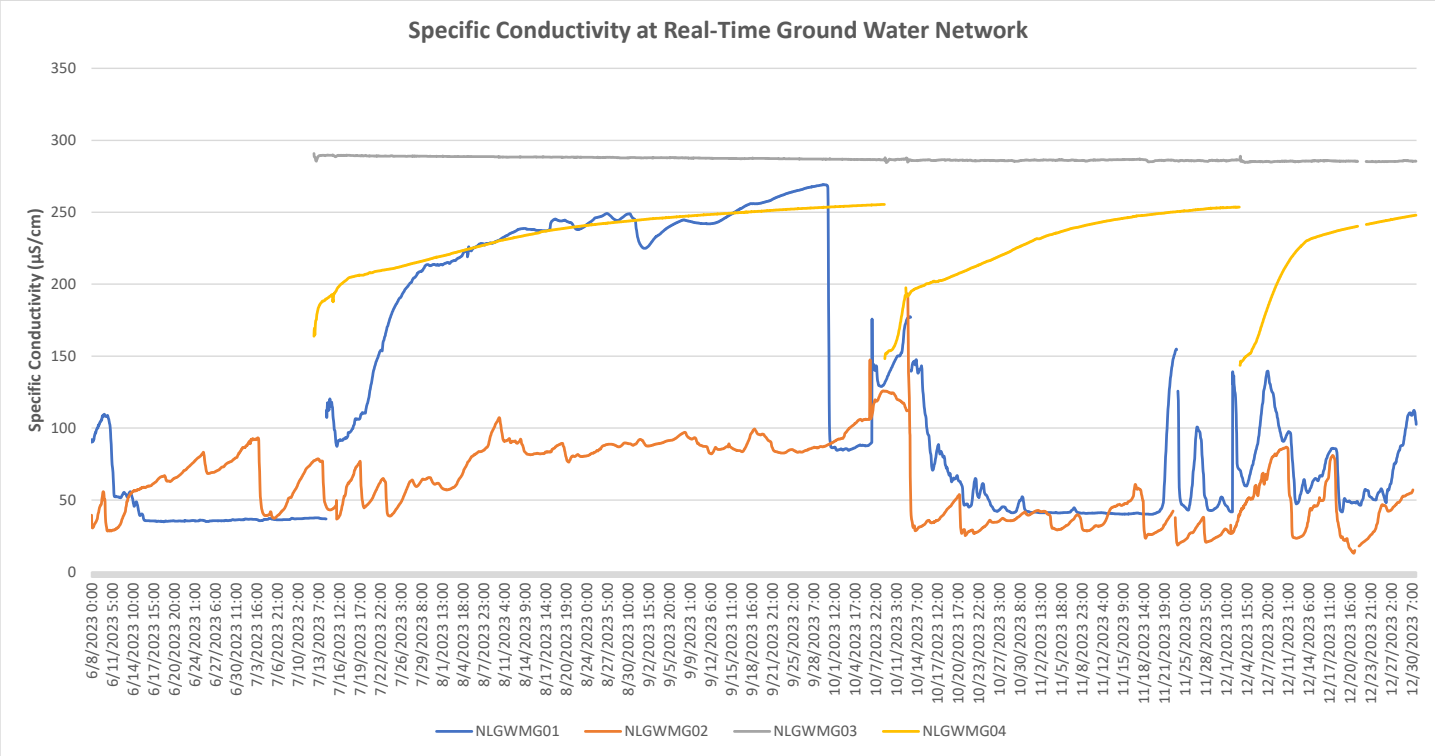

Figure 29: Specific Conductivity at Real-Time GW Network

Table 30: Comparison Statistics for RTWQ GW stations

	NLGWMG01	NLGWMG02	NLGWMG03	NLGWMG04
Min	34.8	12.97	284.5	143.6
Max	269.4	193.3	290.8	255.5
Median	87.8	61.8	286.8	238.8

Oxidation-Reduction Potential (ORP)

Oxygen Reduction Potential ranged from -438.6 mV at NLGWMG03, to 396.5 mV at NLGWMG02 (Table 31). NFGWMG02 remained oxidative throughout deployment but displayed significant fluctuations. NFGWMG03 was mainly reductive, and NLGWMG01 and NLGWMG04 varied between oxidative and reductive (Figure 30). Median values varied greatly amongst the four stations.

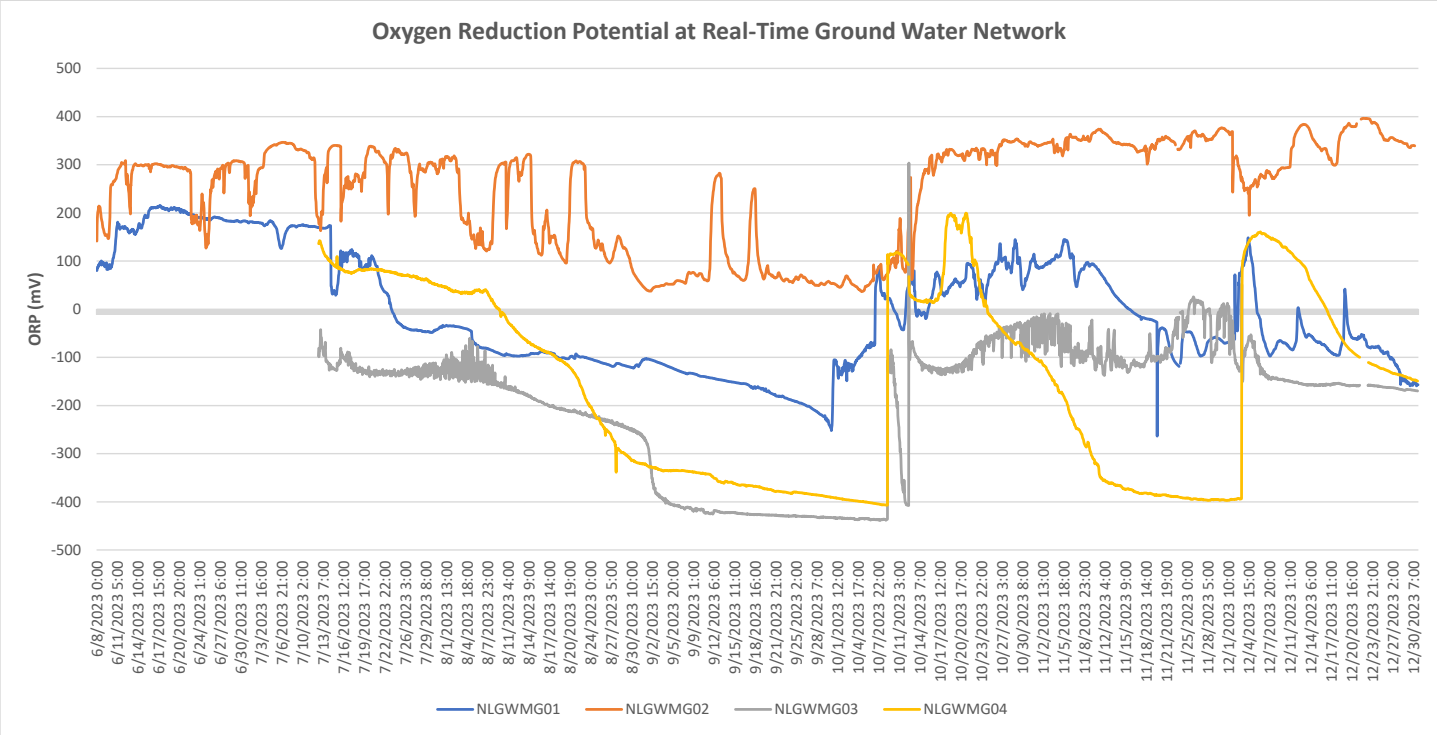

Figure 30: Oxygen-Reduction Potential at Real-Time GW Network

Table 31: Comparison Statistics for RTWQ GW stations

Orp	NLGWMG01	NLGWMG02	NLGWMG03	NLGWMG04
Min	-263.4	37.1	-438.6	-406.7
Max	215.7	396.5	303.6	199.5
Median	-41.0	296.2	-146.1	-123.7

Conclusions

The 2023 deployment season ran from June 5th until November 23rd for surface water and June 7th /July 12th to December 31st for the ground water stations. There were three deployment periods for surface water stations and two for ground water stations. Water quality instrumentation at surface water stations is removed for the winter while ground water instrumentation remains installed year-round.

Surface Water Stations

Most water quality events at the three RTWQ SW stations can be explained by precipitation events, spring thaw influences, and/or changes in air temperature as the seasons moved from spring to summer to fall.

Water temperature and dissolved oxygen were directly influenced by typical seasonal trends, increasing or decreasing with warming or cooling air temperatures. pH levels were generally maintained throughout deployment, except during high stage events or precipitation events when pH values decreased for a short period of time at Roebucks Brook.

Two of the SW stations show the typical pattern of specific conductivity fluctuating in correlation with precipitation. Victoria River at Outlet shows more dramatic increases with precipitation than Roebucks Brook. Valentine River shows minimal fluctuations despite precipitation events suggesting that Valentine River may have minimal amounts of sediments to be stirred up by precipitation.

Dissolved oxygen levels showed expected patterns at each station, with oxygen levels decreasing as water temperature increases, and increasing as water temperatures decrease. This can be seen for the daily pattern of warming and cooling, as well as the seasonal pattern of warming and cooling.

Turbidity data showed significant variation across the network; however, most turbidity increases were associated with precipitation events occurring at the same time. Observed turbidity events were generally short in duration and readings typically returned to background levels.

Ground Water Stations

The ground water network consists of two relatively shallow (NLGWMG01 and NLGWMG04) and two relatively deep (NLGWMG02 and NLGWMG03) monitoring wells. In general, the deeper wells seem to be relatively stable. In particular, NLGWMG03 shows little variation amongst the parameters.

The shallower wells, NLGWMG01 and NLGWMG04, are likely influenced more by weather events and seasonal variation as they demonstrated seasonal water temperature changes and had concurrent small variations in water elevation.

More data is required for analysis from the ground water monitoring network in order to determine aquifer trends and seasonal patterns near each monitoring station.

Path Forward

The success of the real-time water monitoring network is largely due to cooperation and hard work of Marathon Gold environmental staff and WRMD staff maintaining and monitoring the Marathon Gold RTWQ network. This network was first installed in 2022 with more installations to come in 2024. Continuation of monitoring into the future will allow us to advance annually in background knowledge and awareness of the area's characteristics. Data collected within this network is essential for identifying the difference between natural and anthropogenic events. As this agreement progresses into the 2024 deployment period for the Marathon Gold stations, the following is a list of planned activities to be carried out.

- WRMD staff will expand the RTWQ surface water and ground water networks in 2024. In addition, water quality instrumentation will be deployed at Tributary to Victoria River for the first time in 2024. See Appendix B for anticipated network composition in 2024.
- WRMD staff will perform site visits to audit and conduct maintenance and calibration procedures regularly. Marathon Gold staff will continue to provide on the ground support and expert assistance in planning and carrying out site specific tasks.
- If necessary, changes or improvements to deployment techniques will be adapted to each specific site, ensuring secure and suitable conditions for RTWQ.
- WRMD will work with Marathon Gold Environment staff to reassess the network design (station locations) and plan for any necessary or desired changes in 2024 or in future seasons.
- Open communication lines will continue to be maintained between WRMD and Marathon Gold employees involved with the agreement to respond to emerging issues on a proactive basis.
- Marathon Gold will receive deployment reports outlining the events that occurred in the previous deployment period and a 2024 annual report summarizing the events of the entire deployment season.
- WRMD will continue to work on Automatic Data Retrieval System to incorporate new capabilities when applicable.
- WRMD will continue to work on the creation of value-added products using the RTWQ data, remote sensing and water quality indices.
- WRMD will begin development of models using RTWQ data and grab sample data to estimate a variety of additional water quality parameters (*i.e.* TSS, major ions *etc*.).
- 2024 deployments will recommence in the Spring.

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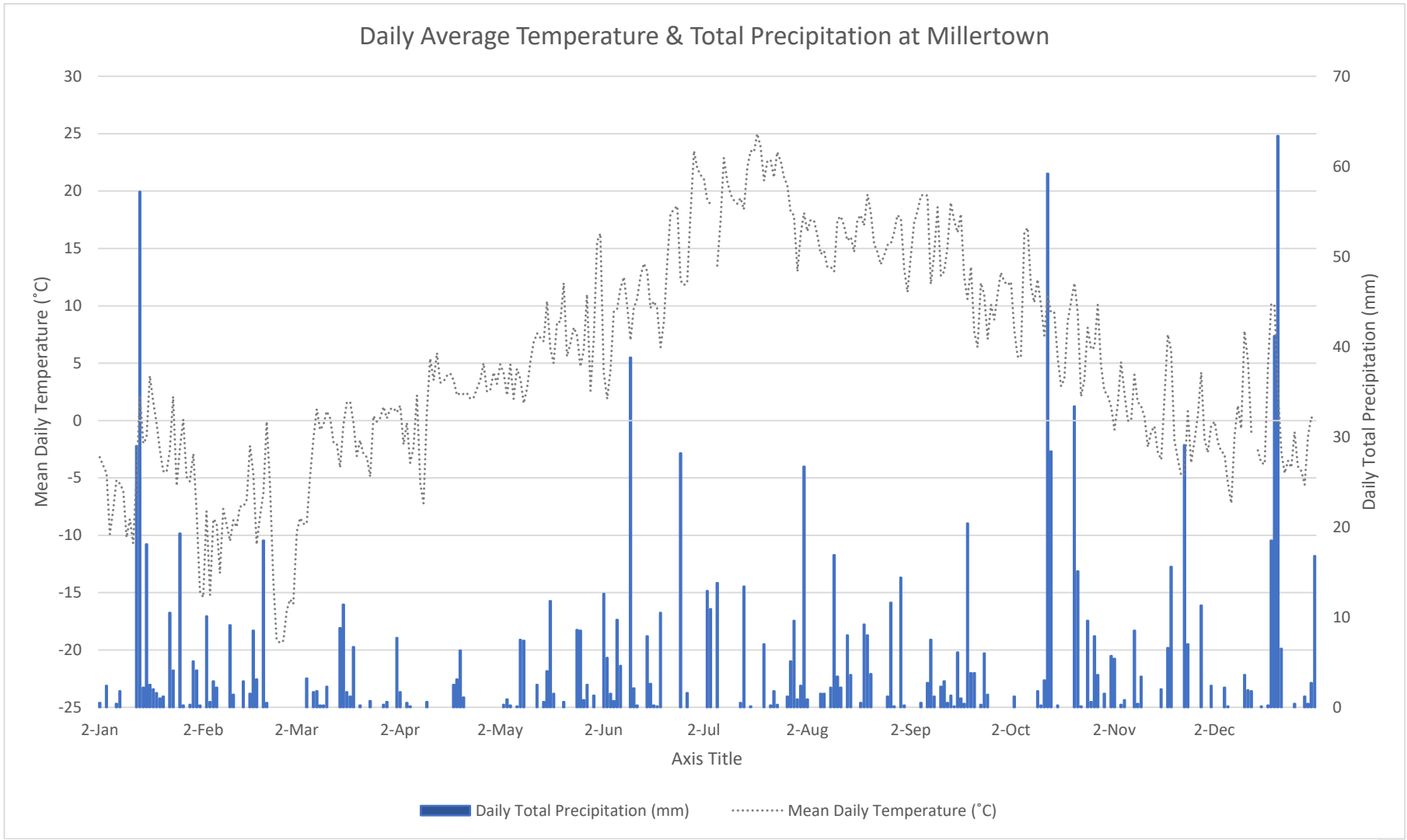
Appendix A: Daily Average Temperature and Precipitation at Millertown in 2023



Appendix B: Anticipated RTWQ Network at Marathon Gold in 2024

Station Name	Station Type	Station Number	Latitude	Longitude	Installation
Victoria River at Pit	SW	NF02YN0047	48˚24’28.36” N	57˚04’20.78” W	November 2022
Valentine River Outlet	SW	NF02YN0048	48˚25’28.65” N	57˚04’39.87” W	November 2022
Roebucks Brook	SW	NF02YN0049	48˚32’37.41” N	57˚00’47.17” W	November 2022
Tributary to Victoria River	SW	NF02YN0050	48˚ 24’ 30” N	57 ˚04’ 36” W	November 2023
Victoria River at Beothuk Lake	SW	NF02YN0051	48˚ 44’33.71” N	56 ˚40’43.3” W	June 2024
Frozen Ears Lake Outlet	SW	NF02YN0052	48˚ 23’21.92” N	57 ˚08’12.29” W	June 2024
South of Leprechaun Waste Rock Pile	GW	NLGWMG01	48˚20’49.99” N	57˚09’59.73” W	June 2023
Northwest of Leprechaun Pit	GW	NLGWMG02	48˚21’34.27” N	57˚11’10.38” W	June 2023
Southeast of TMF – Deep	GW	NLGWMG03	48˚22’24.45” N	57˚06’35.36” W	July 2023
Southeast of TMF – Shallow	GW	NLGWMG04	48˚22’24.45” N	57˚06’35.36” W	July 2023
South of Marathon Waste Rock Pile	GW	NLGWMG05	48˚23’36.09” N	57˚05’32.05” W	June 2024
Southwest Marathon Pit	GW	NLGWMG06	48˚23’31.76” N	57˚07’5.80” W	June 2024
Marathon MET Station	MET	NLENCL0014	48˚20’45.78” N	57˚09’07.01” W	June 2023