

Real-Time Water Quality Deployment Report

Teck Duck Pond Operations

2021



Government of Newfoundland & Labrador
Department of Environment & Climate Change
Water Resources Management Division
St. John's, NL, A1B 4J6 Canada

Introduction

Real-time monitoring (RTWQ) of surface and groundwater quality on the Teck: Duck Pond Operations site (Teck DPO) is carried out by the Department of Environment and Climate Change (ECC), Water Resources Management Division (WRMD). This work is undertaken in circumstances where industrial development has the potential to impact water bodies. The RTWQ program consists of more than 30 stations across the province from Voisey's Bay to St. Lawrence and Stephenville to St. John's.

RTWQ work at Teck DPO has been ongoing since 2006 with the installation of three monitoring stations: East Pond Brook (abbreviated EPB) station, Tributary to Gill's Pond Brook (abbreviated TGPB) station, and Monitoring Well after Tailings Dam A station.

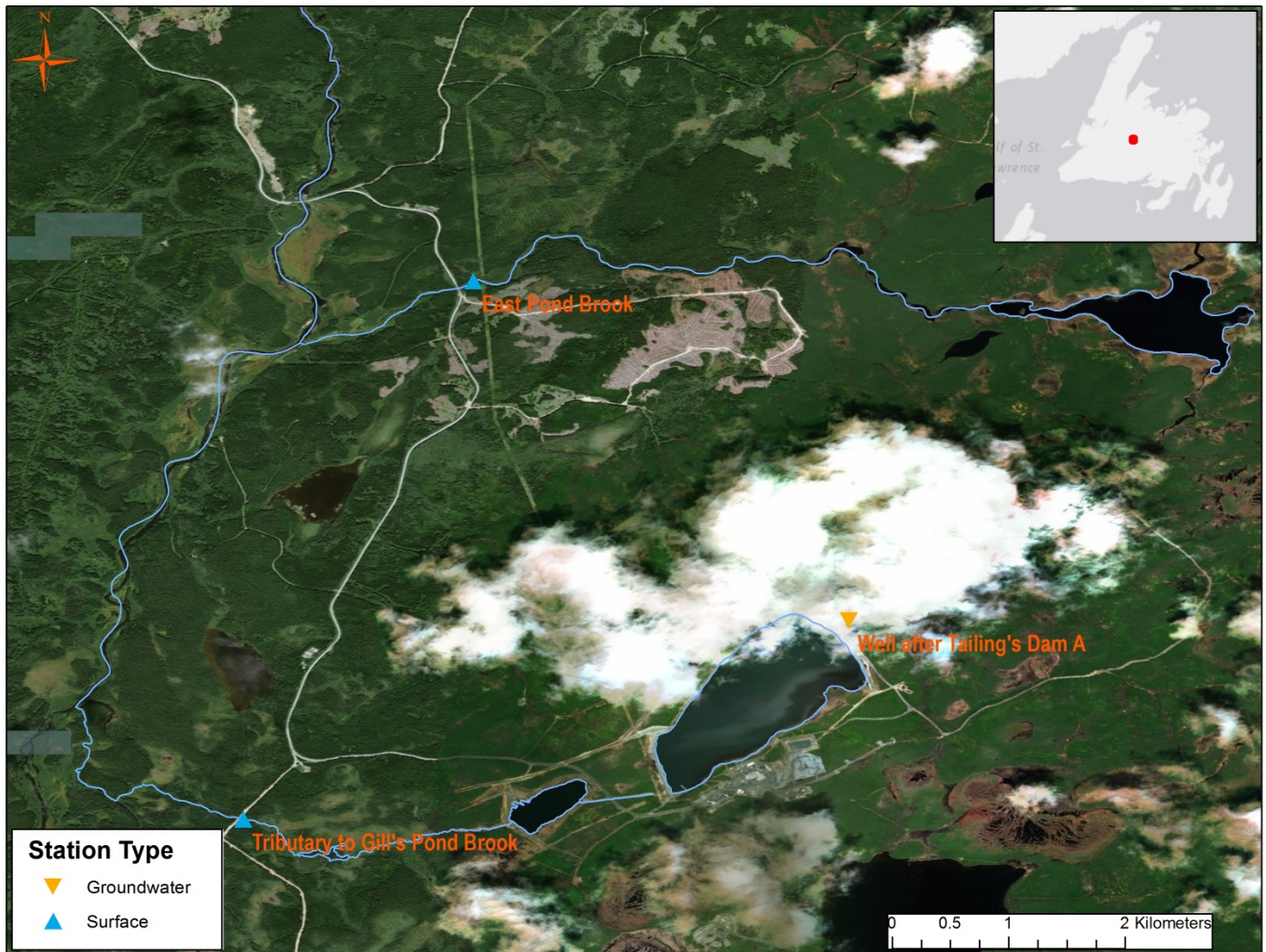


Photo 1: Aerial photo of Teck DPO project site and water quality stations

These stations, identified in Photo 1, were situated to observe water quality at key locations over the course of the Teck DPO project. EPB station was placed to intercept potential seepage from underneath flow control

structures that maintain the tailings management area. TGPB is placed to observe water quality following the ultimate discharge of treated effluent from the polishing pond into the environment. Well after Tailings Dam A is also located in the East Pond Brook watershed, but is immediately adjacent to the flow control structure that ensures the tailings management area drains towards the polishing pond and the eventual discharge point above TGPB station.

In this report, notable events and trends from 2021 are identified and discussed in relation to previous years. Thorough statistical analysis is intentionally avoided in favour of brief summary statistics.

Methods and Procedures

Work under the RTWQ program is conducted according to the *Protocols Manual for Real-Time Water Quality Monitoring in NL*¹. This document outlines the procedures, methods, and QAQC regimen used by all staff involved in the RTWQ program at all stations, province wide. For surface water monitoring, water quality instrumentation – in this case the Hydrolab DS5X multi-parameter sonde – is deployed on six-week intervals with *in situ* data validation at the beginning and end of deployment using an equivalent and freshly calibrated multi-parameter sonde. A grab sample is collected at the start of a deployment as an independent indicator of data quality.

Due to the narrow confines of a 2" monitoring well, insertion of additional instruments into the well for verification purposes results in considerable changes to the well chemistry. As a result, data validation is restricted to capturing a grab sample immediately prior to insertion of newly-calibrated monitoring equipment in the well. Protocol requires a volume equivalent to three well casings to be purged from the well prior to sampling. This process flushes stagnant water from the well and ensures that the water being observed is aquifer water. In May 2021, WRMD upgraded monitoring equipment at the well station.

In the next section, long-term data from both the surface and groundwater monitoring networks are presented as line and boxplots. Guidelines set by the *Canadian Council of Ministers of the Environment (CCME)* for Aquatic Life and site-specific guidelines are indicated by dashed lines. Grab sample data for pH, specific conductivity, and turbidity is presented as black dots in the same figures. Boxplots are presented to illustrate how water quality parameters change from year to year.

Summary statistics are presented for each surface and groundwater parameter in the next section. Each table lists the 2021 median, minimum, and maximum values. *Average median* values for each parameter are calculated from the median values of each previous year and are provided in the same tables and labelled as *average* for simplicity. Median values are preferred throughout this report as a more robust indicator of central tendency than average values, especially given the highly skewed nature of environmental data.

Results and Discussion

The following pages provide interpretation of water quality events and trends observed at each real-time water quality monitoring station at Teck DPO in 2021.

¹ <https://www.gov.nl.ca/eccm/files/waterres-rti-rtwg-nl-rtwg-manual.pdf>

Surface Water Network

The surface water network at Teck DPO consists of EPB and TGPB stations which are discussed in this section.

Water Temperature

Water temperatures in 2021 were higher than median temperatures from the previous years (see Table 1). This is likely annual variation and of no immediate concern.

Water temperatures are summarized in Table 1.

Table 1: Water Temperature at Teck DPO

Station	Segment	Median	Min	Max
East Pond Brook	Average	5.25	-0.32	29.05
	2021	7.33	0	28.85
Gills Pond Brook	Average	4.40	-0.45	27.8
	2021	6.77	-0.54	27.04

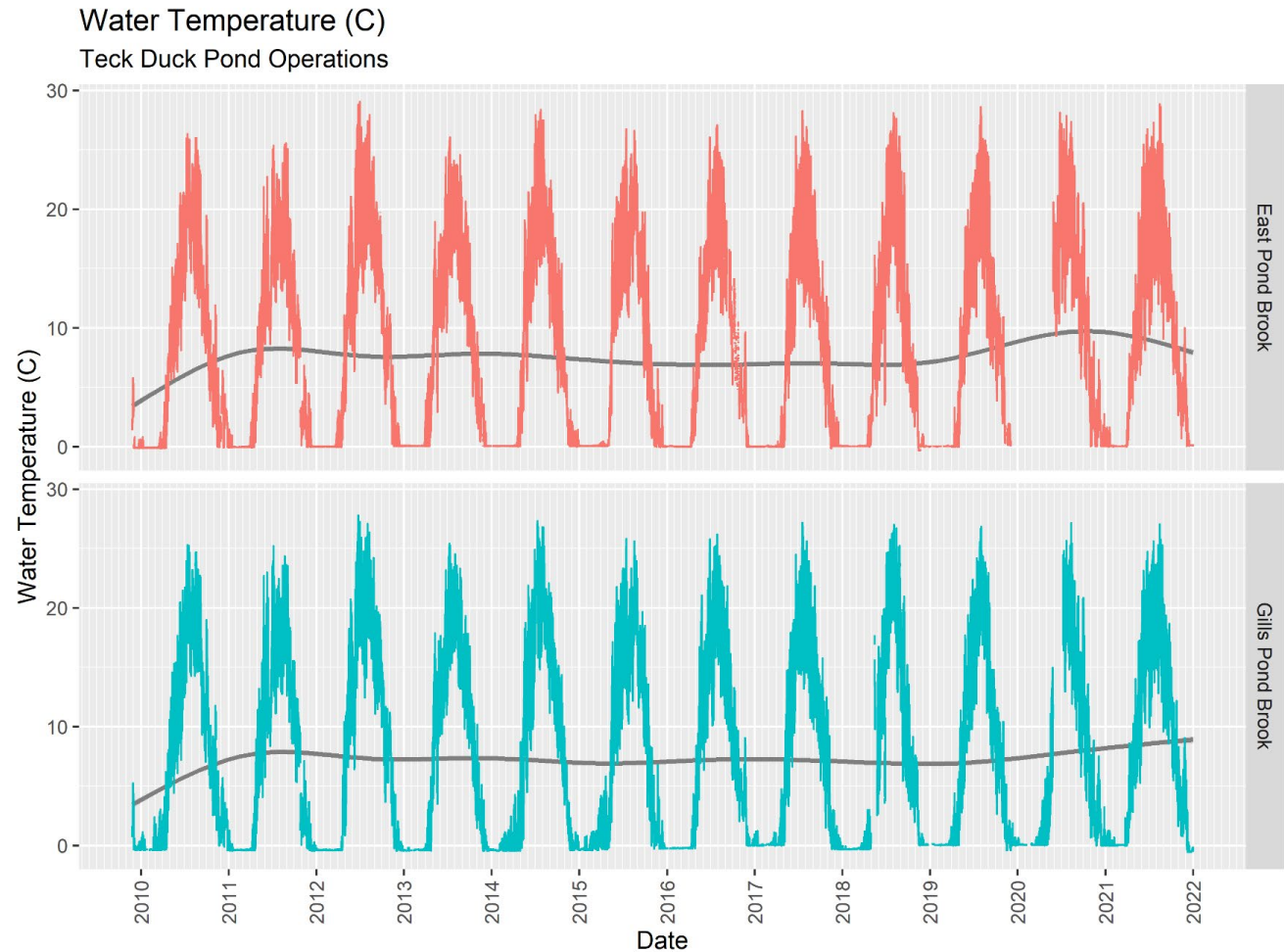


Figure 1: Water Temperature at Teck DPO

Figure 2 shows the range in water temperatures at EPB and TGPB stations since 2010. In that time span, at TGPB, 2021 was on par with 2020 but warmer than previous years. EPB was cooler than 2020 due to skewed 2020 data (missing winter values), but warmer than the previous few years.

Data from EPB and TGPB from 2021 were very similar to each other.

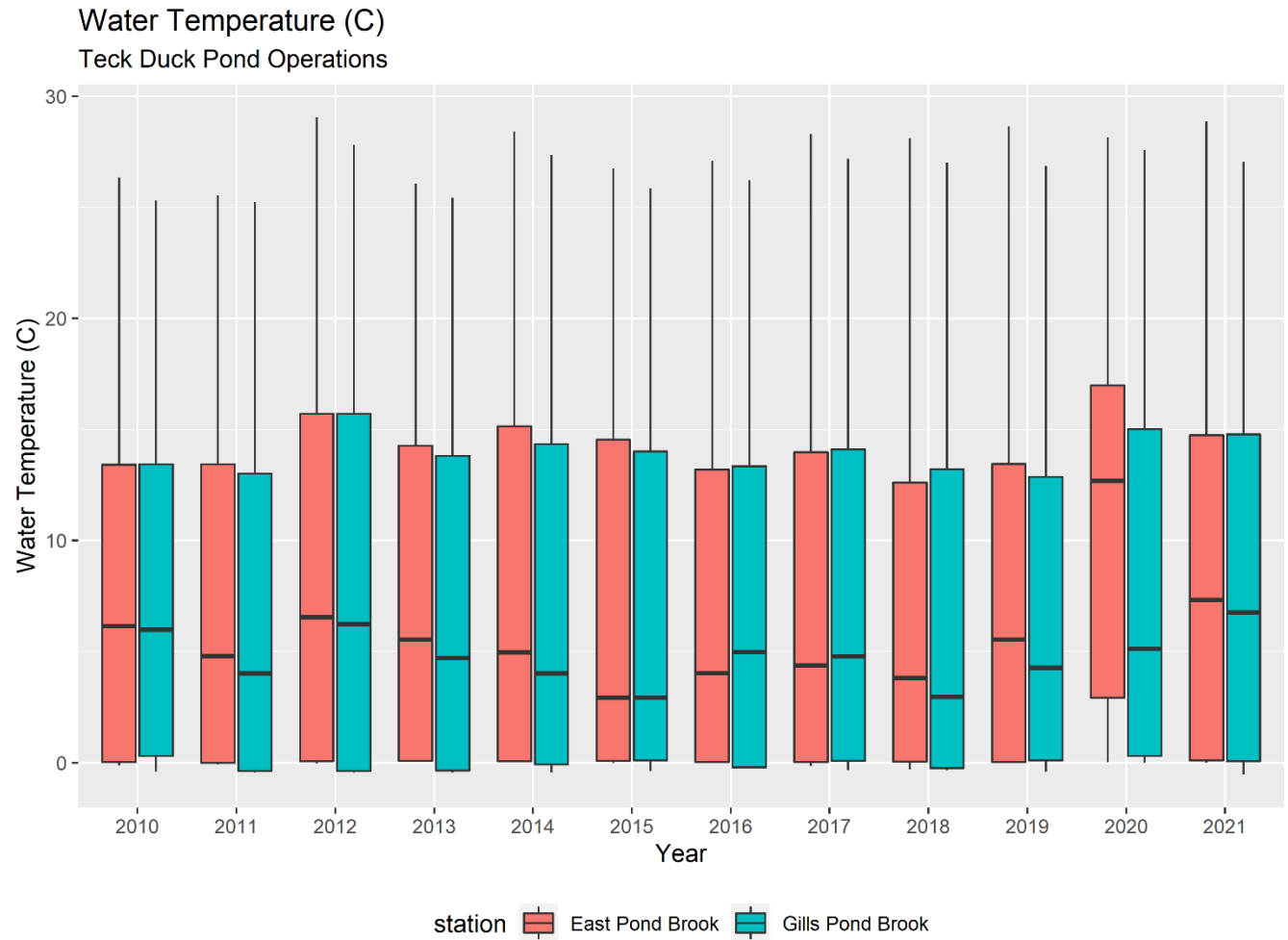


Figure 2: Boxplots of water temperature at Teck DPO

pH

Median pH values observed at EPB and TGPB stations in 2021 are not meaningfully different from values observed in the previous years (Table 2).

Figure 3 shows that pH levels at East Pond Brook typically fall at, or somewhat below, the CCME minimum guideline for the protection aquatic organisms (dashed lines). pH levels at Gill's Pond Brook typically fall at, or somewhat above, the minimum CCME guideline. The 2021 data was consistent with this trend as TGPB generally recorded higher pH values than EPB.

Ambient waters on the island of Newfoundland tend to be acidic due to natural geological and ecological characteristics. As such, the ambient waters of East Pond Brook are slightly acidic. Gills Pond Brook waters, however, were highly influenced by treated effluent discharged from an upstream polishing pond currently being decommissioned. These waters are treated to maintain a near-basic pH of 7.0.

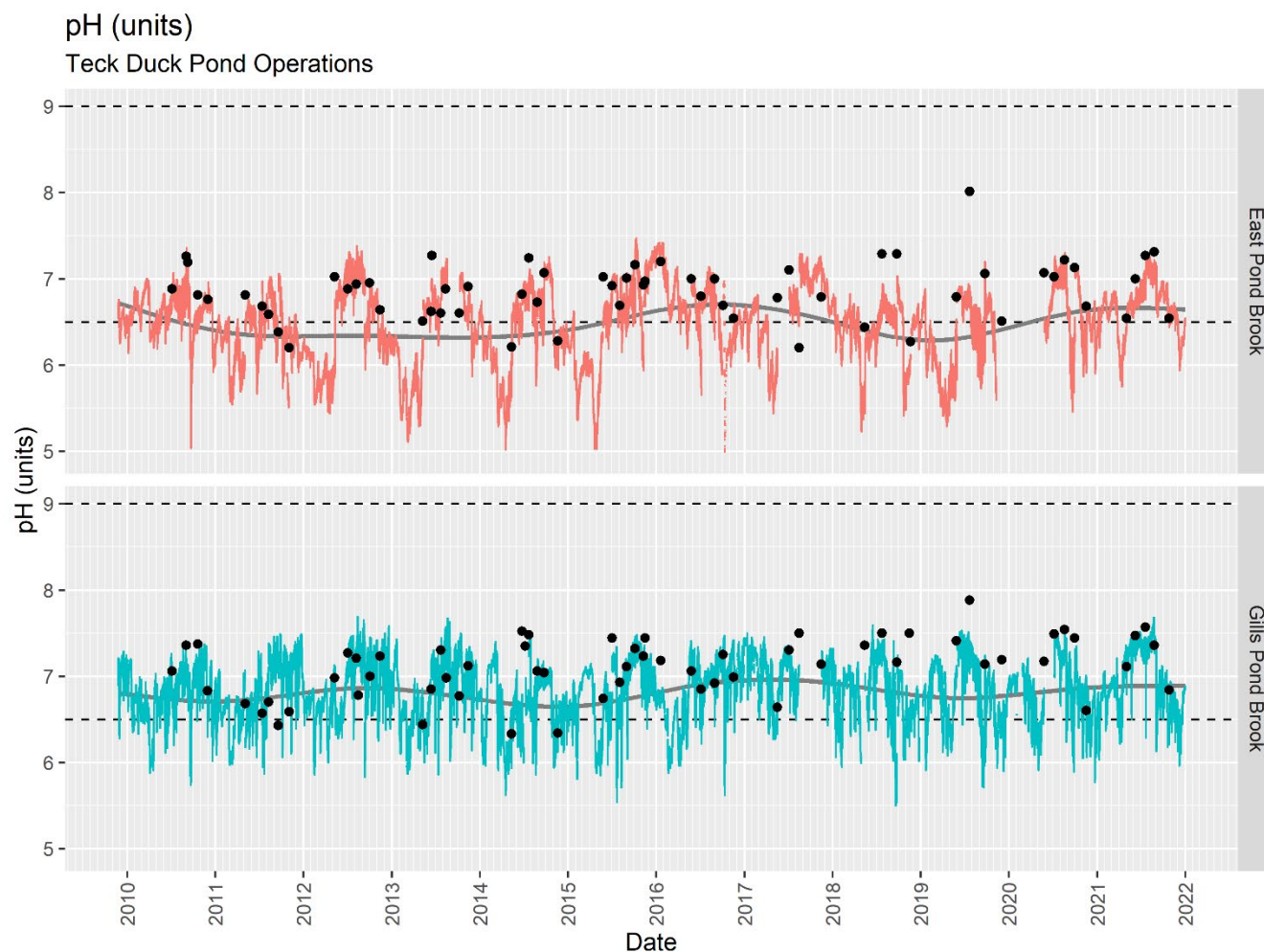


Figure 3: pH at Teck DPO

Table 2: pH at Teck DPO

Station	Segment	Median	Min	Max
East Pond Brook	Average	6.52	4.94	7.47
	2021	6.69	5.75	7.29
Gills Pond Brook	Average	6.82	5.50	7.69
	2021	6.89	5.96	7.68

pH values at EPB 2021 were somewhat higher than those observed 2018-2020. 2021 TGPB data was on par with 2018-2020 data, as seen in Figure 4. Median annual pH values at EPB reached a historical low in 2019, but have continually risen since then, while TGPB has been relatively stable during the same timeframe.

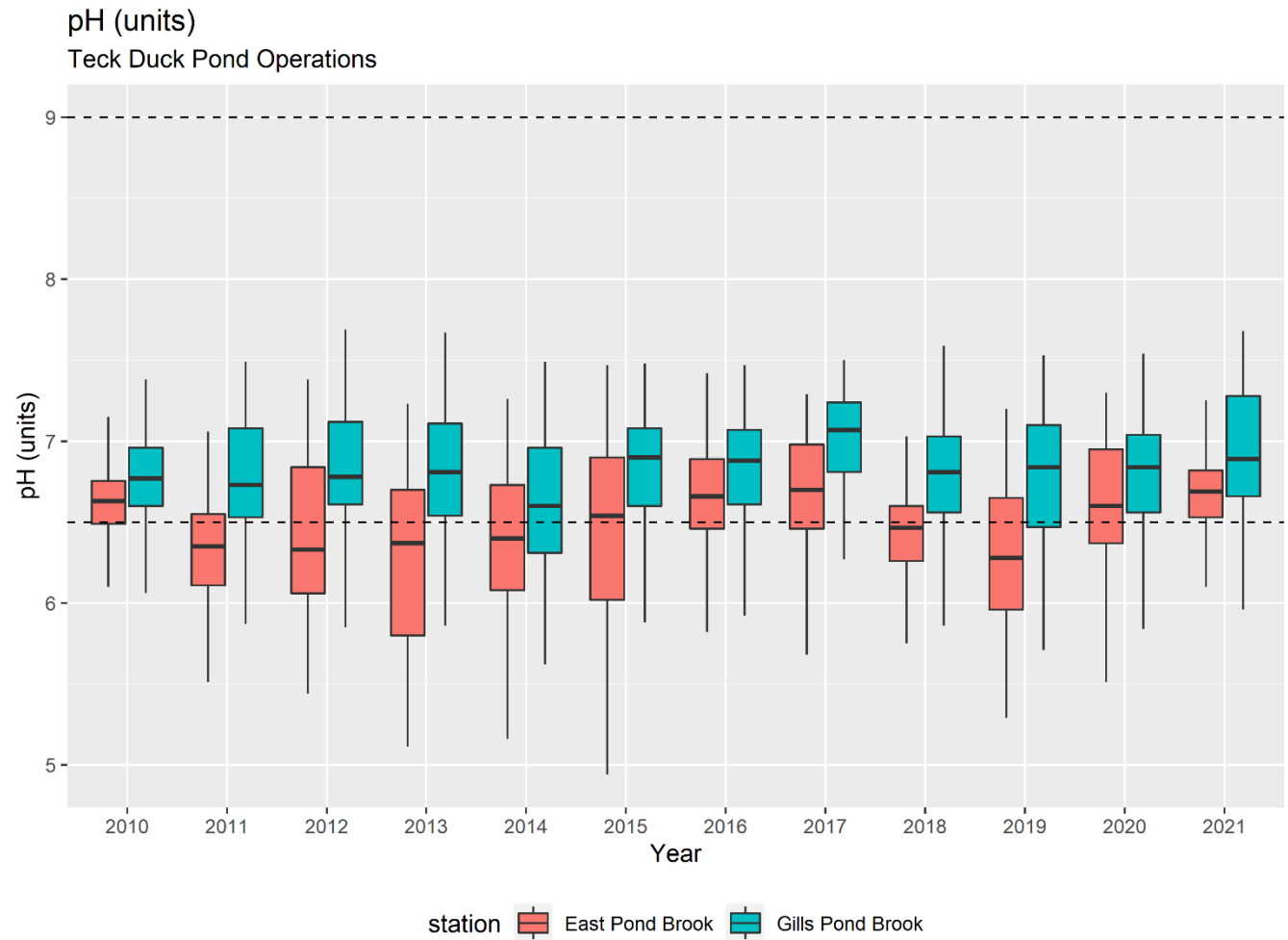


Figure 4: Boxplots of pH at Teck DPO

Specific Conductivity

In Table 3, median specific conductivity values at East Pond Brook in 2021 ranged much lower with the levels seen over the previous years. Tributary to Gills Pond Brook 2021 data was also relatively lower than levels seen over the previous years, as expected, due to the decommissioning of the mine site.

A slow and long term rising trend in conductivity previously observed in East Pond Brook data is evident in 2021 data, although it was not in the 2020 data, as shown by the trend line in Figure 5. The driving force behind this increase may be related to a number of factors such as atmospheric deposition of dust from industrial activity in the area, soil disturbance from nearby logging activities, or movement of dissolved solid-laden groundwater from the tailings management area higher in the watershed.

Table 3: Specific conductivity at Teck DPO

Station	Segment	Median	Min	Max
East Pond Brook	Average	27.2	6.3	97.3
	2021	27.6	4.2	52.4
Gills Pond Brook	Average	403	7.4	1771
	2021	159.8	14.5	880

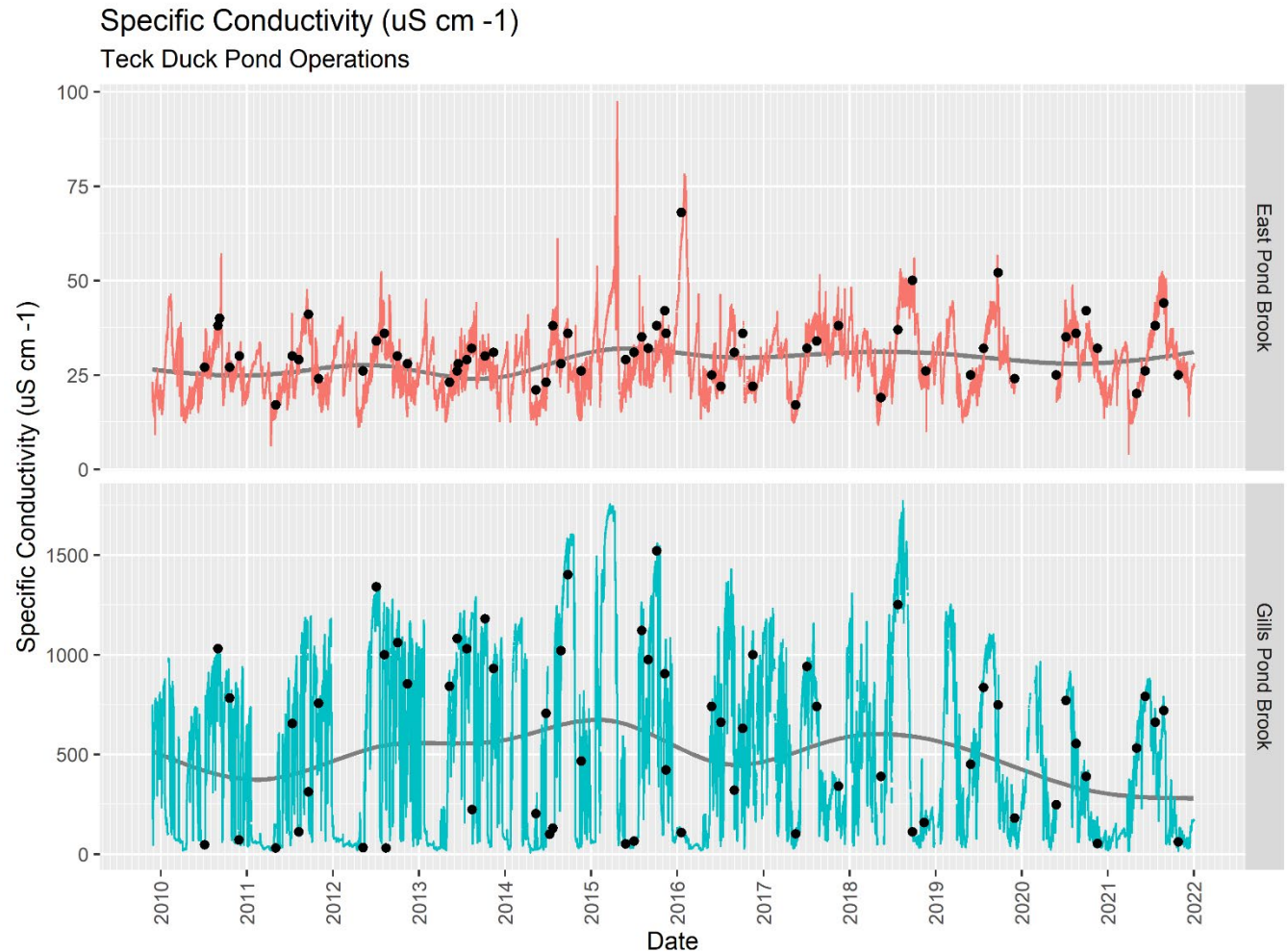


Figure 5: Specific Conductivity at Teck DPO

The influence of polishing pond effluent on water quality in Gill's Pond Brook over time is evident in Figure 6. Without polishing pond effluent, specific conductivity levels at EPB and TGPB stations would report values similar to one another. Specific conductivity at TGPB station, however, is substantially higher than EPB station which barely registers on the plot to the right.

Figure 6 also clearly shows how the gap between TGPB and EPB conductivity levels has decreased steadily as the mine proceeds through its operational and now decommissioning phases.

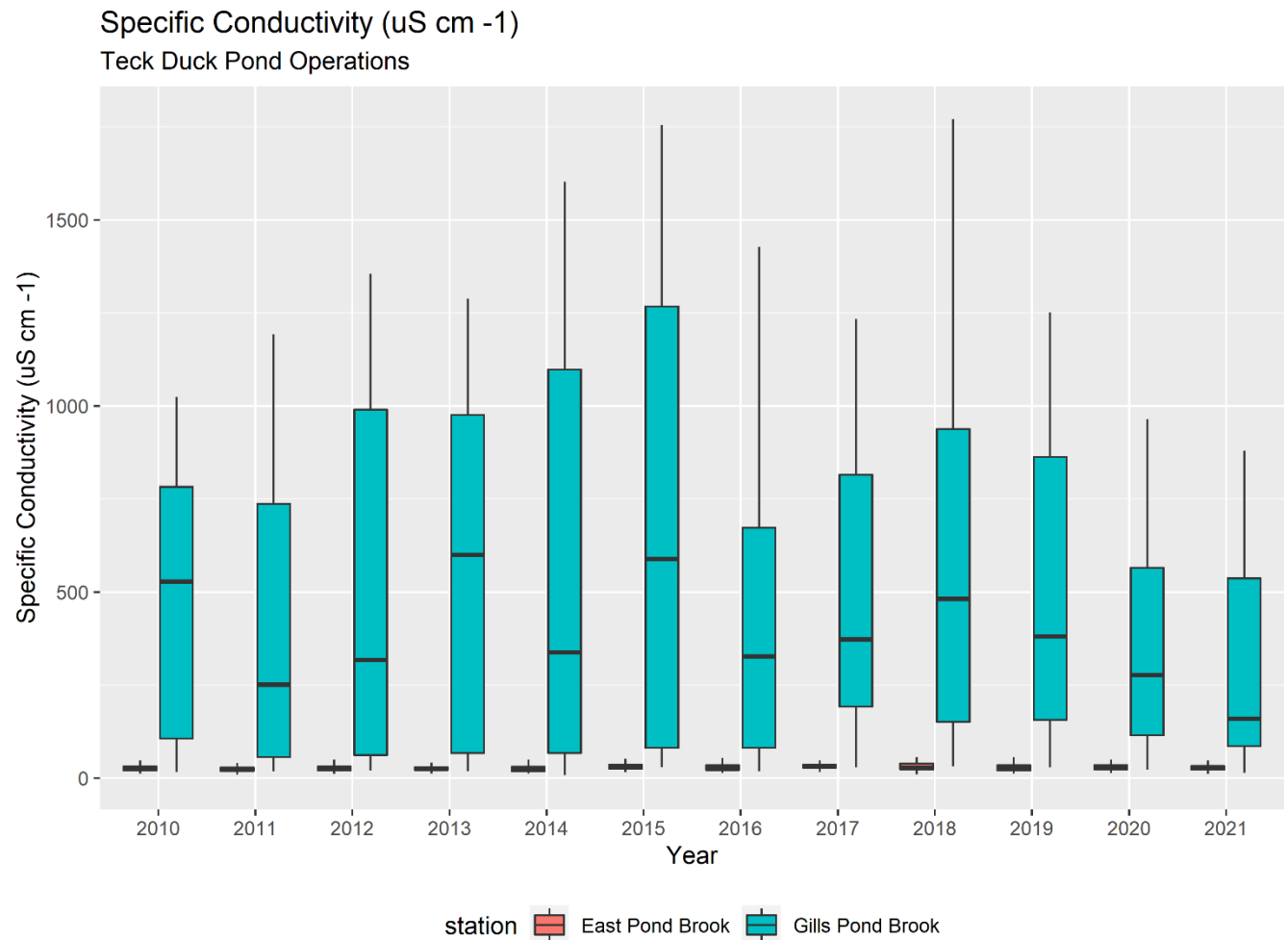


Figure 6: Boxplots of specific conductivity at Teck DPO

Dissolved Oxygen

Dissolved oxygen concentrations in 2021 were lower overall at both stations compared to the previous years (Table 4). However, both stations recorded higher minimum values in 2021 than in the historical data.

In 2021, all dissolved oxygen values were found to be above the CCME Aquatic Life Guideline for other life stages (6.5mg/L), but below the guideline for early stages (9.5 mg/L) during the warmer seasons when water can hold less oxygen (Figure 7). Guidelines are indicated on Figure 7 by dashed lines.

Table 4: Dissolved Oxygen at Teck DPO

Station	Segment	Median	Min	Max
East Pond Brook	Average	11.73	6.94	14.44
	2021	11.14	7.04	14.05
Gills Pond Brook	Average	11.64	6.41	14.38
	2021	11.28	7.33	13.63

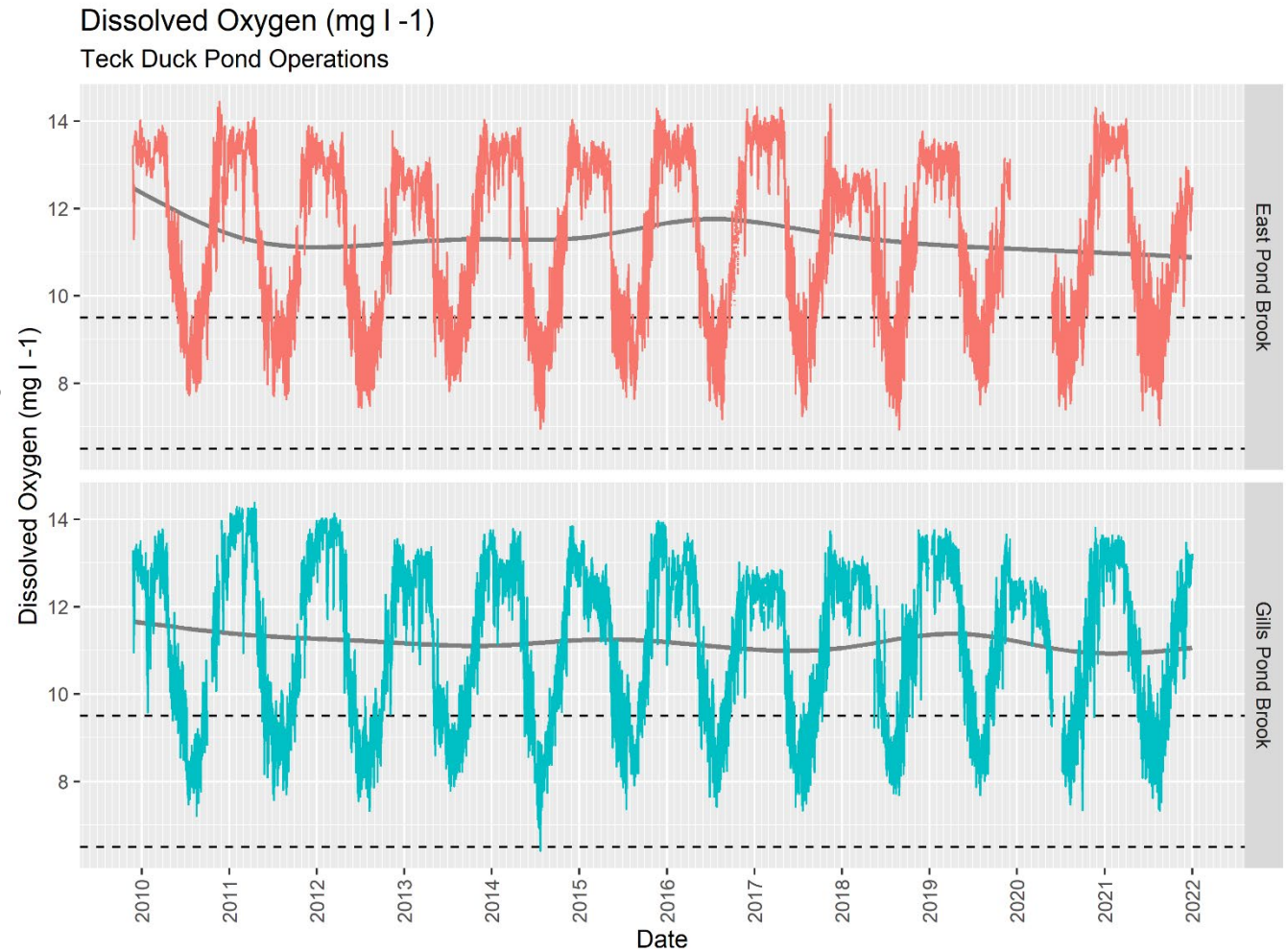


Figure 7: Dissolved oxygen at Teck DPO

As seen in Figure 8, dissolved oxygen concentrations have not changed in any considerable up- or downward trend since monitoring began. East Pond Brook's 2020 data is an exception, with significantly lower than normal oxygen levels. This is due to skewed 2020 data, with more data during the warmer summer months and no data from the cooler January to May months to affect the median.

Each box, which represents the central 75% of values, is generally greater than the least-conservative CCME guideline of 9.5 mg/l for the protection of aquatic biota in early life stages (black, dashed lines).

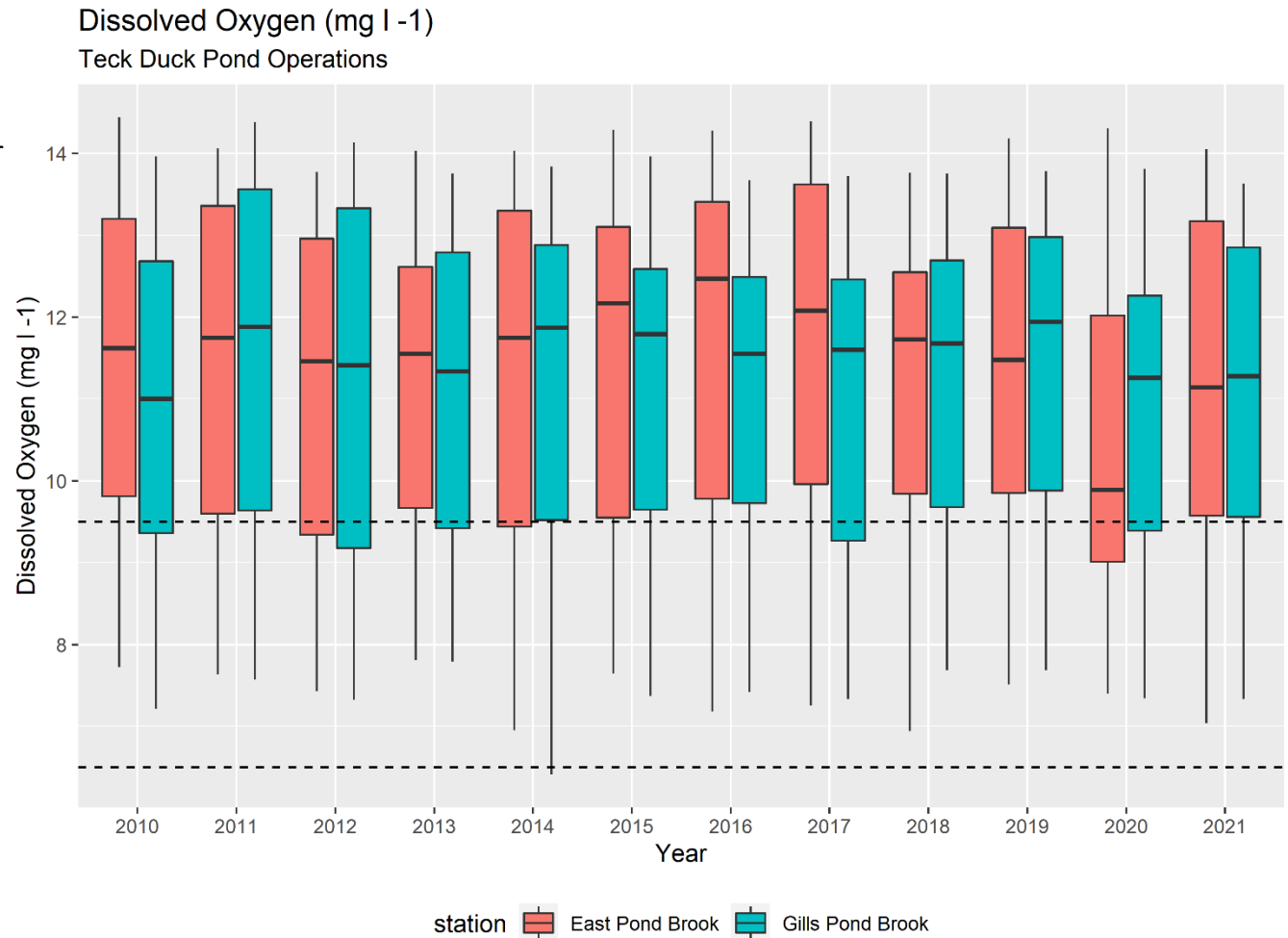


Figure 8: Boxplots of dissolved oxygen at Teck DPO

Turbidity

Turbidity levels at both Gill’s Pond Brook and East Pond Brook stations are generally very low (Table 5).

Despite median values of 0 NTU historically, Figure 9 shows that there are some notable periods of higher turbidity. At TGPB station, these periods are especially obvious from 2010 to mid-2014 and again in 2016. Following this period, turbidity events became fewer in number and lower in magnitude. In 2021, both stations reported a small level of background turbidity, with sporadic increases. Both stations reported maximum levels much lower than the historical averages. Only a small number of turbidity events were encountered at either station and were short in duration.

Table 6: Turbidity at Teck DPO

Station	segment	Median	Min	Max
East Pond Brook	Average	0	0	1789
	2021	0	0	287.4
Gills Pond Brook	Average	0	0	1635
	2021	0	0	385.4

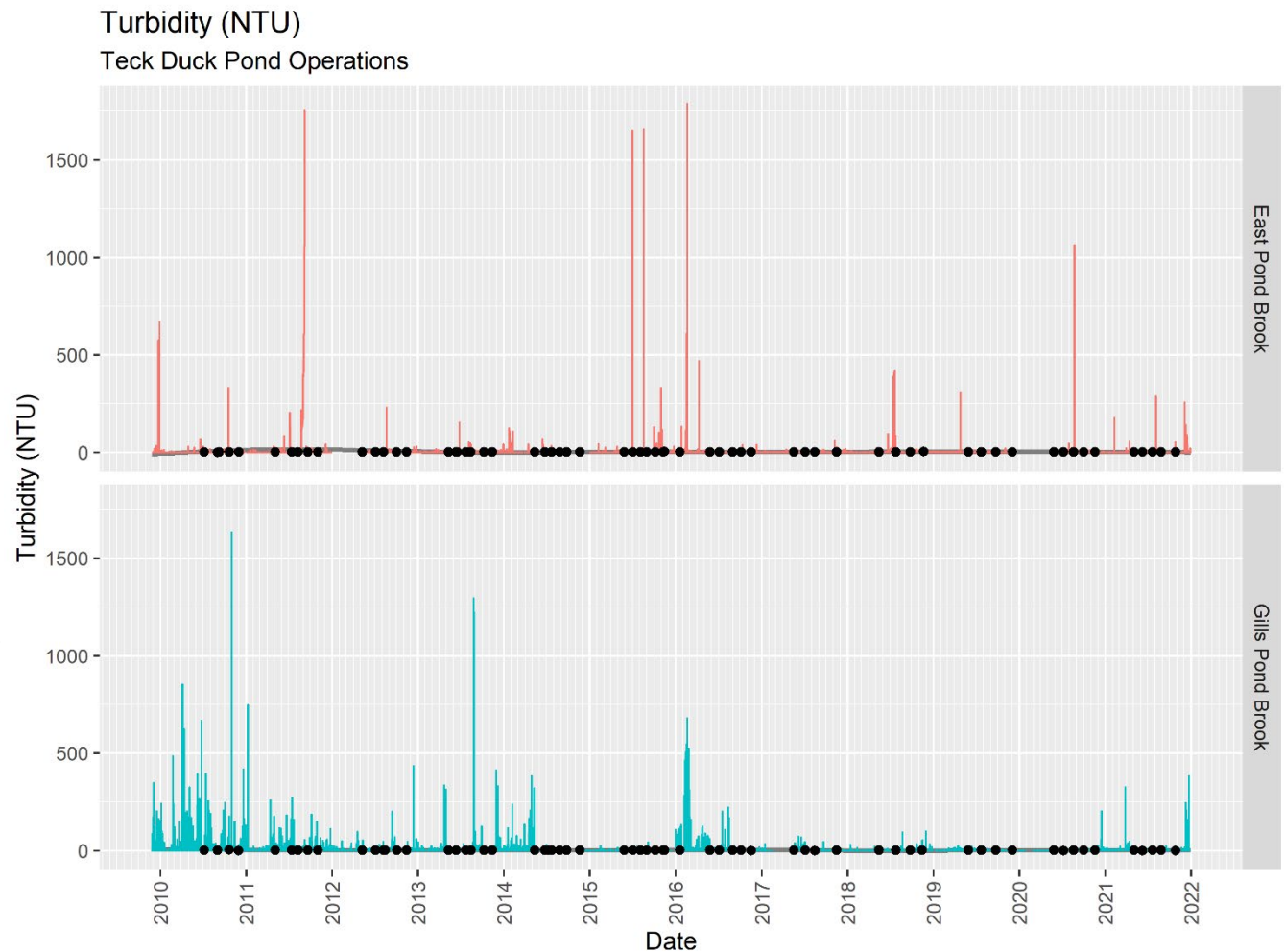


Figure 9: Turbidity at Teck DPO

The long-term characteristics of turbidity at the Teck DPO sites are seen in Figure 10. Within each boxplot, a central, horizontal black bar indicates median turbidity. Median values are generally located at 0 NTU, except for East Pond Brook in 2016, 2017, 2019 and 2020. Those four years seemed to indicate a rising trend in turbidity at that time, which has since decreased. The 2021 median value is lower than 2020. The upper range of turbidity values at East Pond Brook showed steady increases from 2015 to 2018. The 2019-2021 values show a decline, indicating a decreasing trend since 2018.

The mechanisms responsible for this increase and more recent decrease are not known but are likely related to closure work at Teck DPO or logging work occurring in the area.

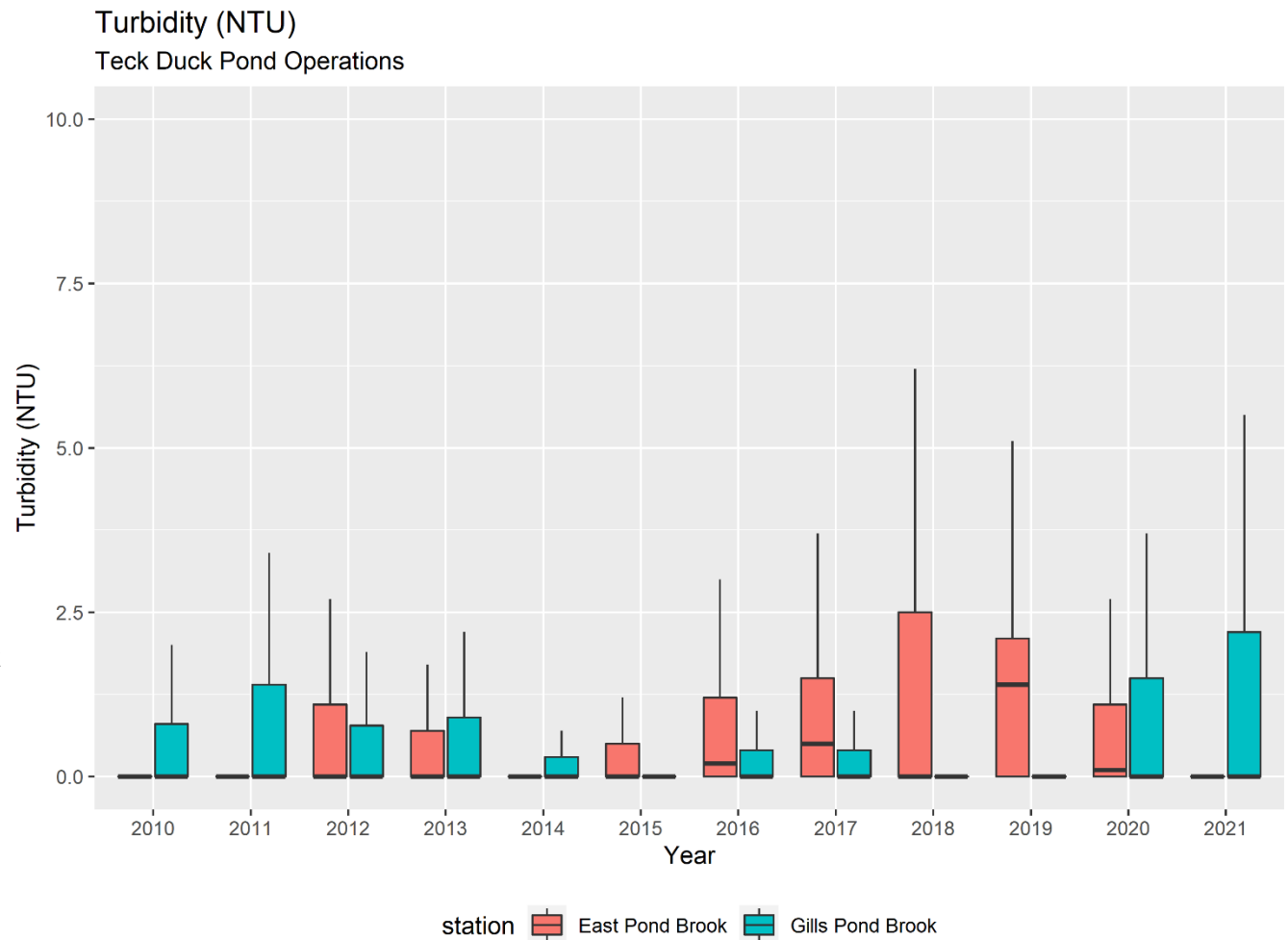


Figure 10: Boxplots of turbidity at Teck DPO

Well after Tailings Dam A

This section presents groundwater quality parameters from a location immediately adjacent to the northeastern downgradient edge of the tailings management area.

In May 2021, WRMD upgraded the monitoring equipment at the Well.

Water Temperature

In 2021 water temperatures fell within a range of 1.24°C, according to Table 7. These temperatures fall within historical ranges.

Figure 11 shows that annual low temperatures tend to occur in mid-July and annual high temperatures tend to occur in mid to late December. The 2021 data followed this trend while also recording the highest temperature on record.

Table 7: Water Temperature at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	5.31	4.46	6.13
2021	5.42	5.00	6.24

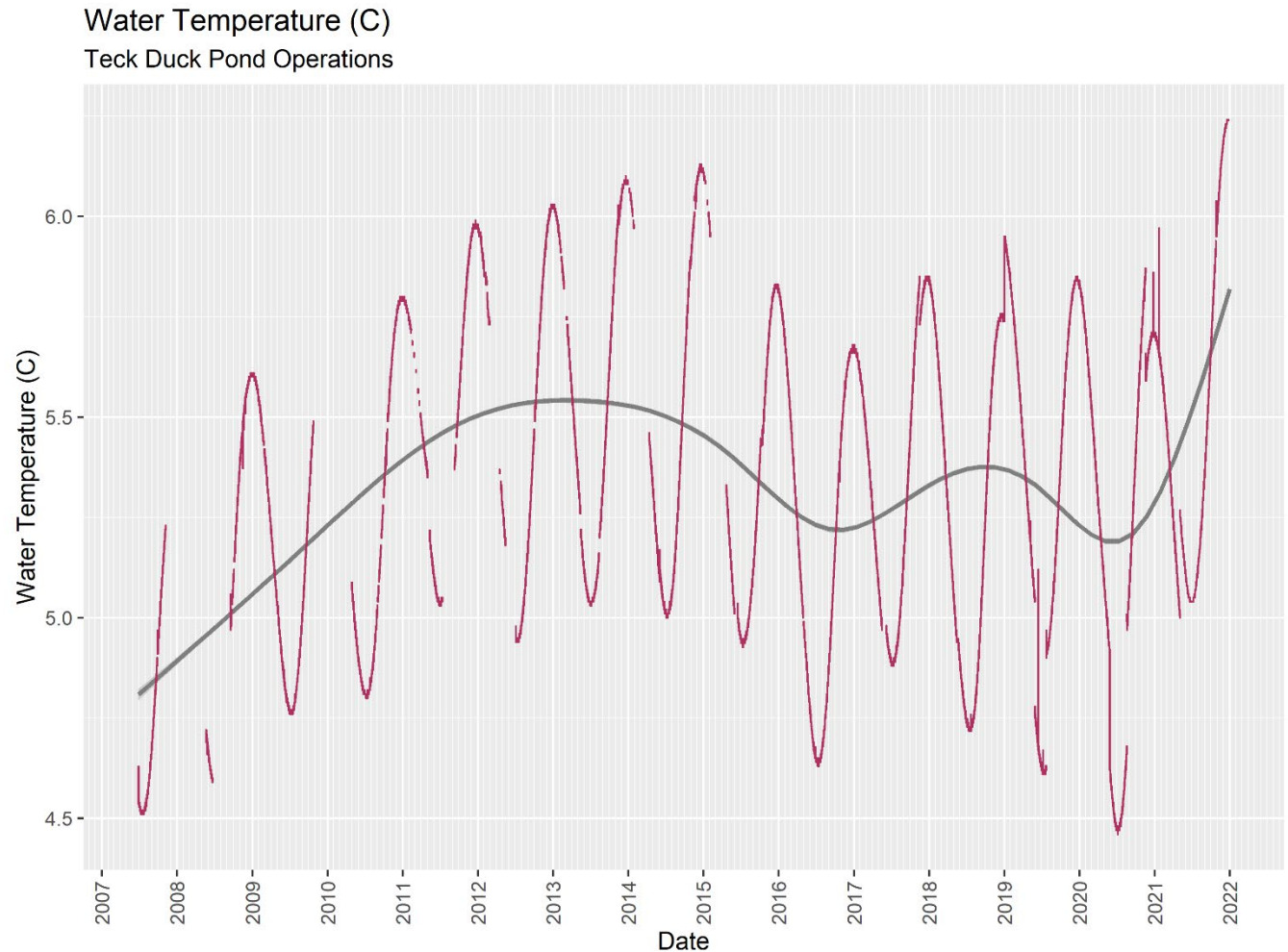


Figure 11: Water temperature at Well after Tailings Dam, Teck DPO

Figure 12 shows the consistency of water temperatures from 2008 to 2021 where there is considerable overlap in ranges from one year to the next. No notable trend is obvious at this time.

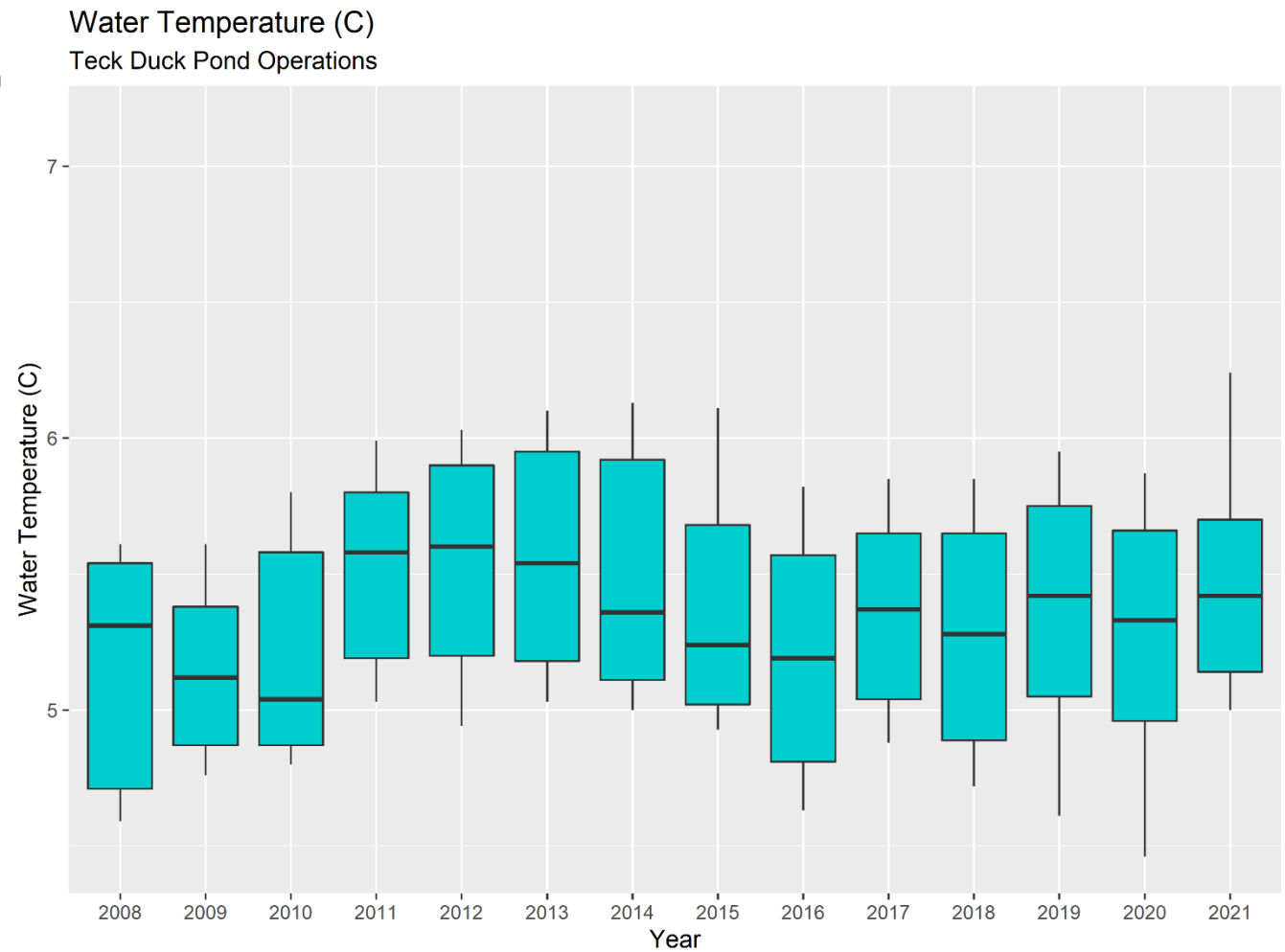


Figure 12: Boxplots of water temperature at Well after Tailings Dam, Teck DPO

pH

In 2021, median pH was much lower than the median pH calculated from previous years. The 2021 range was also lower than the historical values (Table 8).

Readily apparent in Figure 13 is the long period of time it takes for pH to stabilize in the well following routine maintenance. This effect can be attributed to factors such as sensor stabilisation or chemical change resulting from aquifer water being pulled into the borehole. The rising trend can take upwards of a month to stabilize.

In May 2021, WRMD installed new monitoring instrumentation which will hopefully lead to quicker stabilization of the pH sensor going forward.

Table 8: pH at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	8.57	7.05	9.42
2021	7.50	7.15	8.79

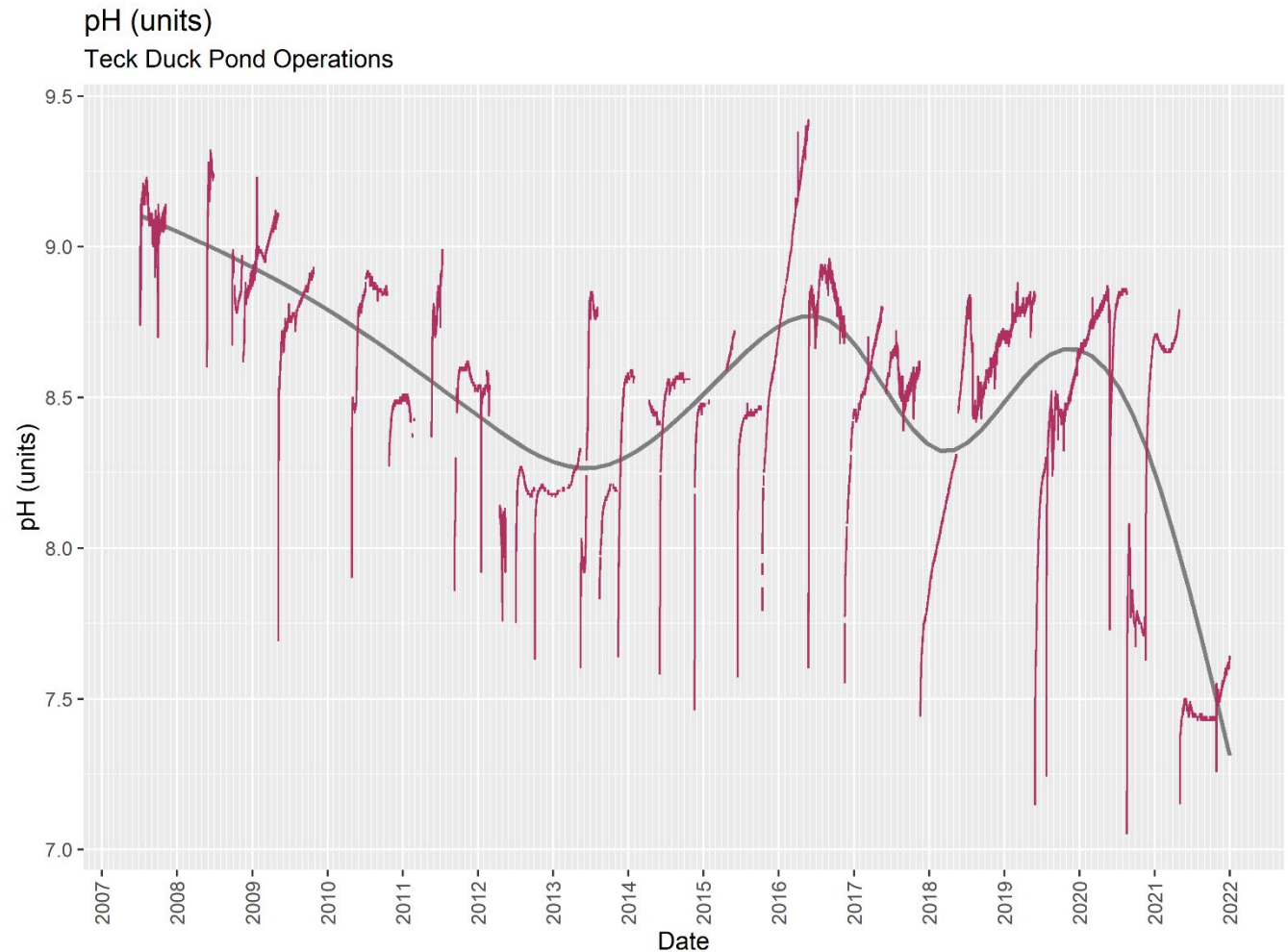


Figure 13: pH at Well after Tailings Dam, Teck DPO

The variance observed in Figure 13 makes it challenging to pick out trends or overall changes in pH. Figure 14 offers a clearer view of pH over time.

pH levels within the well tend to be alkaline in nature. Median levels from 2017 to 2020 were relatively stable with varying ranges, but the 2021 data is much lower and data falls within a very large range. The larger than normal range may be the result of the newly installed equipment being more capable of responding to changes in the aquifer, or the result of chemical changes in the aquifer.

Interestingly, Figure 14 appears to mirror an opposite and inverse relationship with water temperature (Figure 11). In years where water temperature is cooler, pH levels tend to be more alkaline and when water is warmer, conditions appear to be more acidic. It is unclear if this is coincidental or if there is an actual relationship between the two parameters at this location.

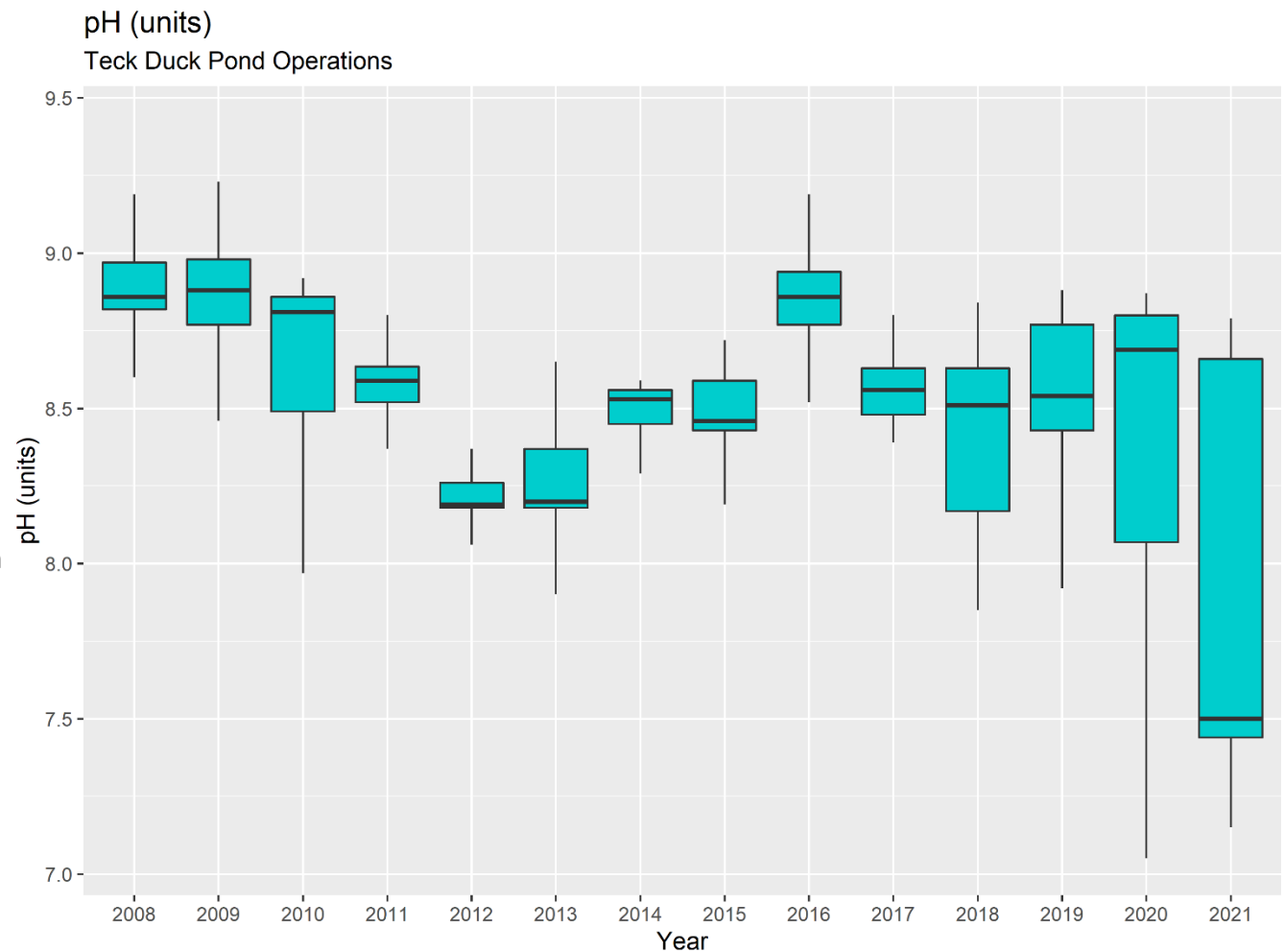


Figure 14: Boxplots of pH at Well after Tailings Dam, Teck DPO

Specific Conductivity

In 2021, specific conductivity values continued to show a downward trend (2018-2021) after peaking mid-2018 (Figure 15). The median value from 2021 was higher than historically, but values remained relatively stable throughout the year, varying minimally as per Table 9.

A plateau phase from 2014 to late 2015 was observed prior to a rising trend from 2016 to 2018. At this time, water level in the tailings management area was lowered to perform long-term stabilization work. A lower water level and deposition of materials may have resulted in the sudden increase in conductivity. Levels have declined steadily since 2018.

Table 9: Specific conductivity at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	799	210	989
2021	866	824	897

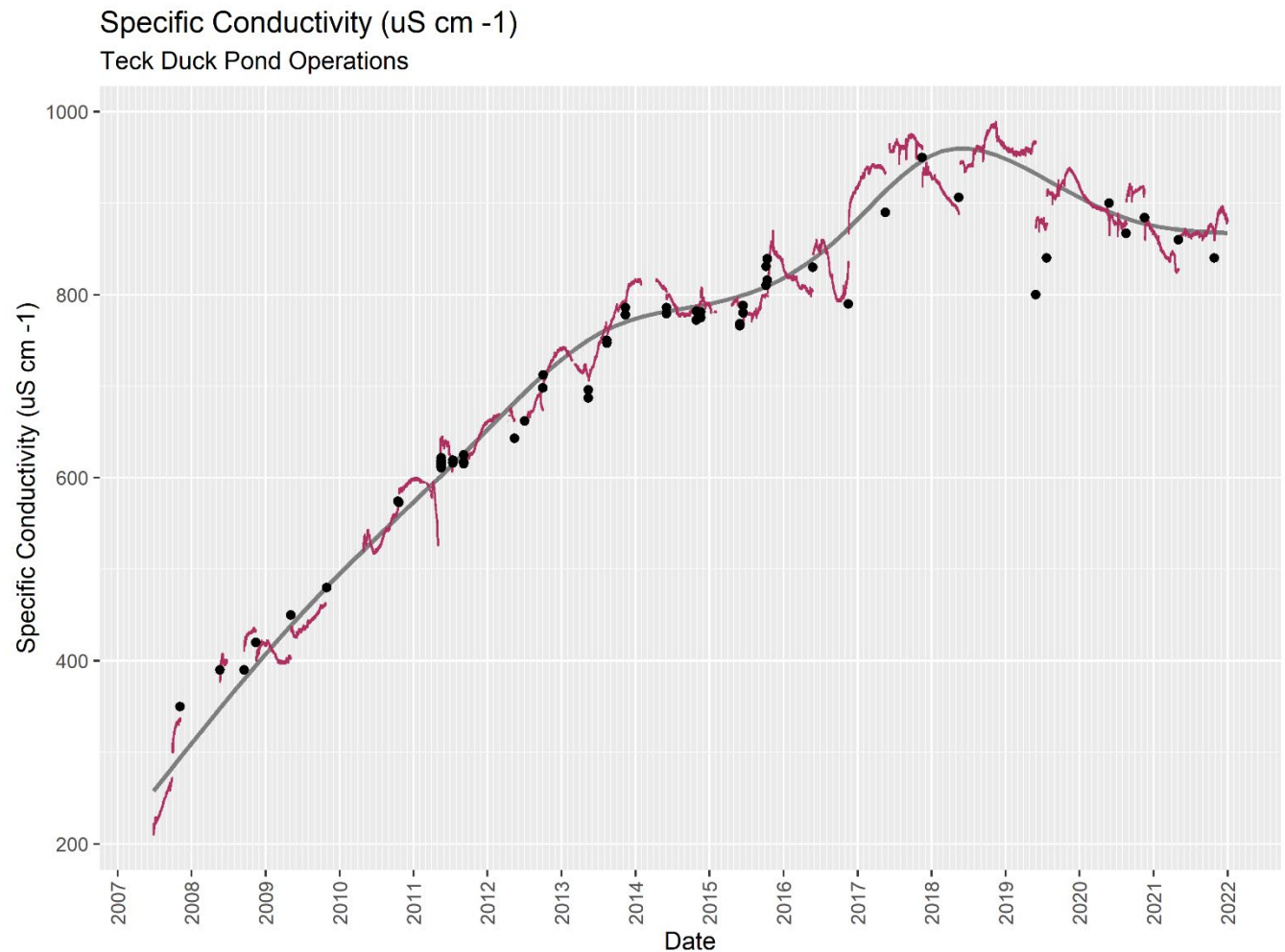


Figure 15: Specific Conductivity at Well after Tailings Dam, Teck DPO

In Figure 16, data from 2017-2019 show a distinct and separate data plateau from that seen from 2014 to 2016. Median values were significantly higher in 2017-2019 than in previous years. This may have resulted from work within the tailings management area as discussed in the previous Figure 15. Data from 2019-2021 show a continuing downward trend.

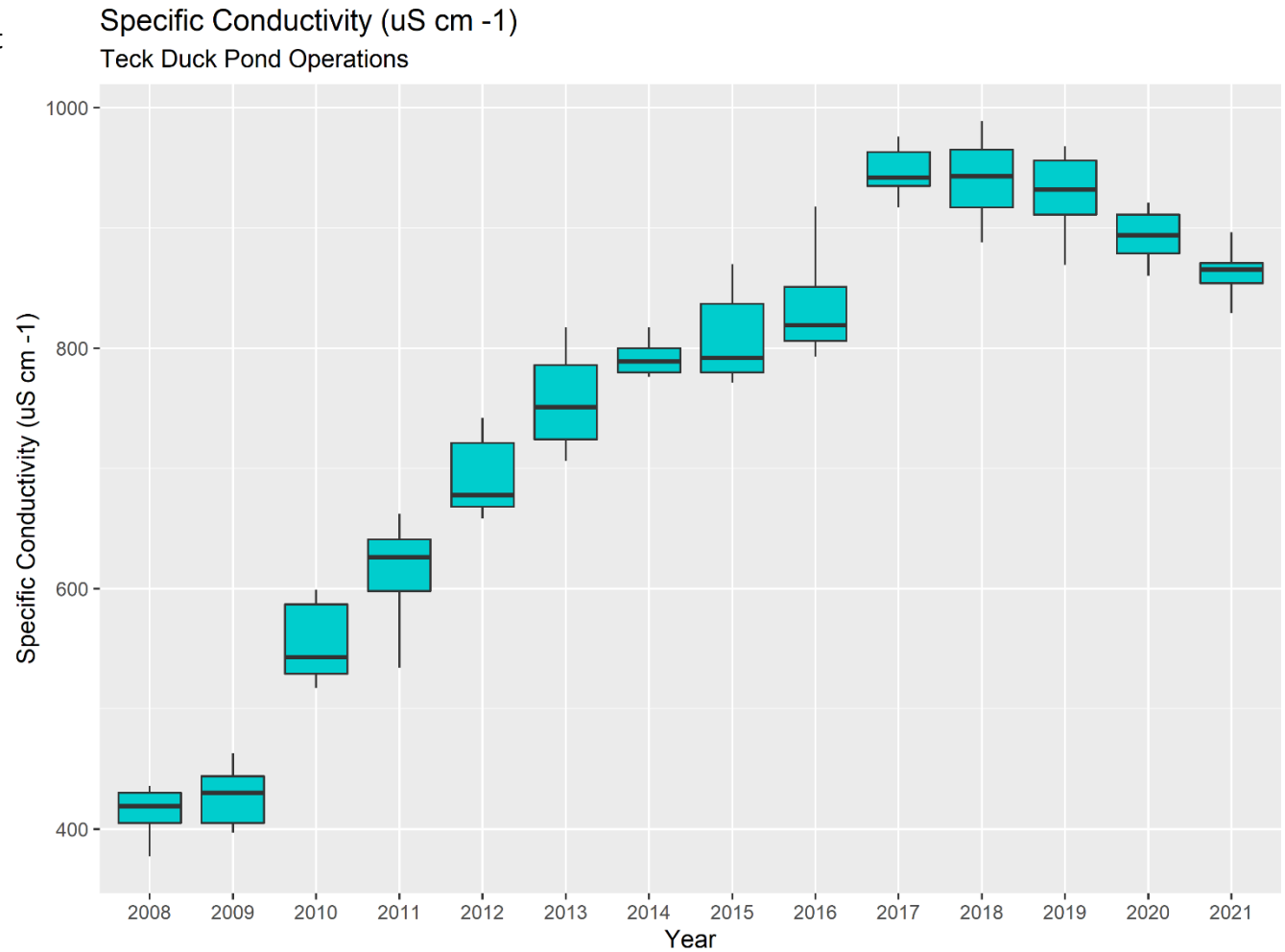


Figure 16: Boxplots of specific conductivity at Well after Tailings Dam, Teck DPO

Oxidation-Reduction Potential (ORP)

Conditions within the well are predominantly reductive with highly negative values (Table 10).

Much like pH, ORP tends to take a number of days to settle following routine maintenance as depicted in Figure 17. From 2007 to 2016, post-maintenance ORP values were found to be oxidative (> 0 mV) for a brief period before quickly falling to reductive levels (< 0 mV).

From 2016-2018, ORP values became increasingly reductive over time, before plateauing in 2018-2019. ORP values now show an upward trend for 2020-2021, although post-maintenance ORP values rarely reach oxidative levels. This may be evidence of a changing trend within the system.

Table 10: ORP at Well after Tailings Dam, Teck DPO

Segment	Median	Min	Max
Average	-302	-480	99.0
2021	-394	-460	-96.1

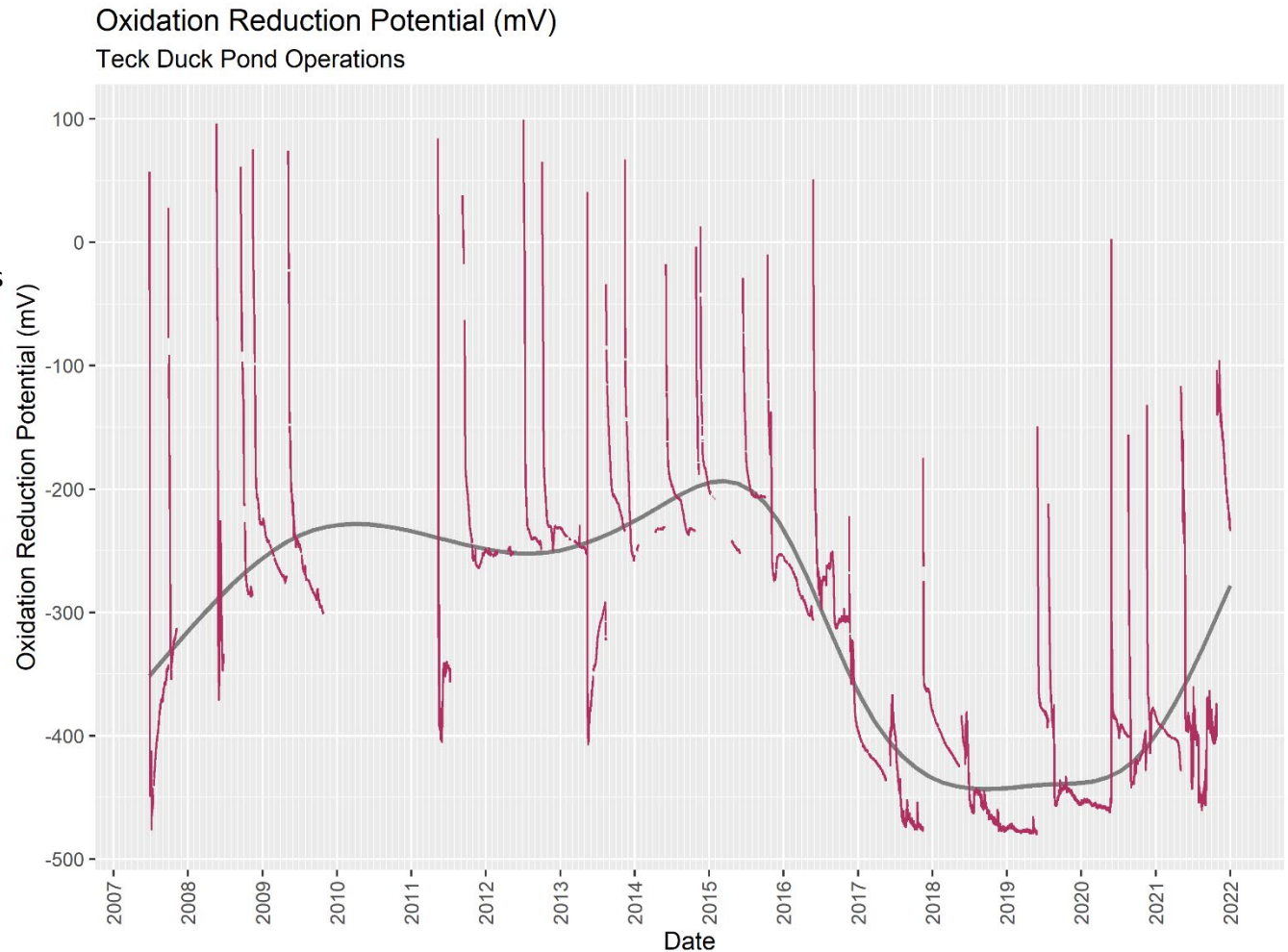


Figure 17: ORP at Well after Tailings Dam, Teck DPO

Figure 18 readily shows a continuous decline in ORP from 2016 to 2019, but an increase in 2020 and 2021. These changes could be indicative of a chemical change in the aquifer.

Notably, the change from 2016 to 2017 was significant, with a continuing downward trend 2017-2019 followed by increases in 2020-2021.

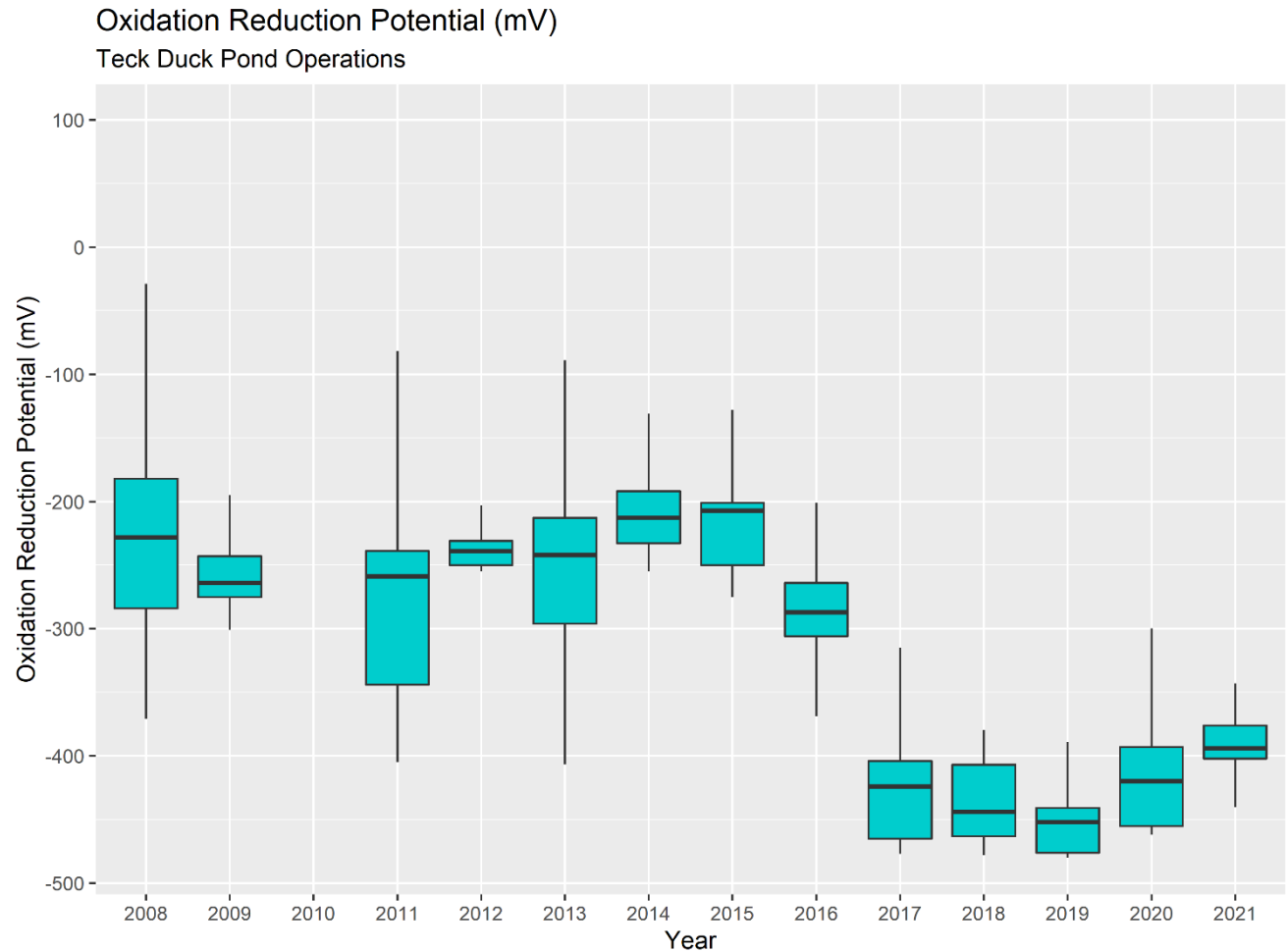


Figure 18: Boxplots of ORP at Well after Tailings Dam, Teck DPO

Water Elevation

Water elevation indicates the surface of the aquifer above sea level. Water level peaked in 2009 and declined until 2017 when a small uptick was observed in the latter part of 2017 into mid-2018 (Figure 19) before continuing to decline once again into 2021.

There was a pronounced drop in elevation early 2021 before it slowly rebounded again.

In 2021, water level showed very little variance (0.54m).

Table 11: Water elevation at Well after Tailings Pond, Teck DPO

Segment	Median	Min	Max
Average	270.76	270.31	271.21
2021	270.53	270.23	270.77

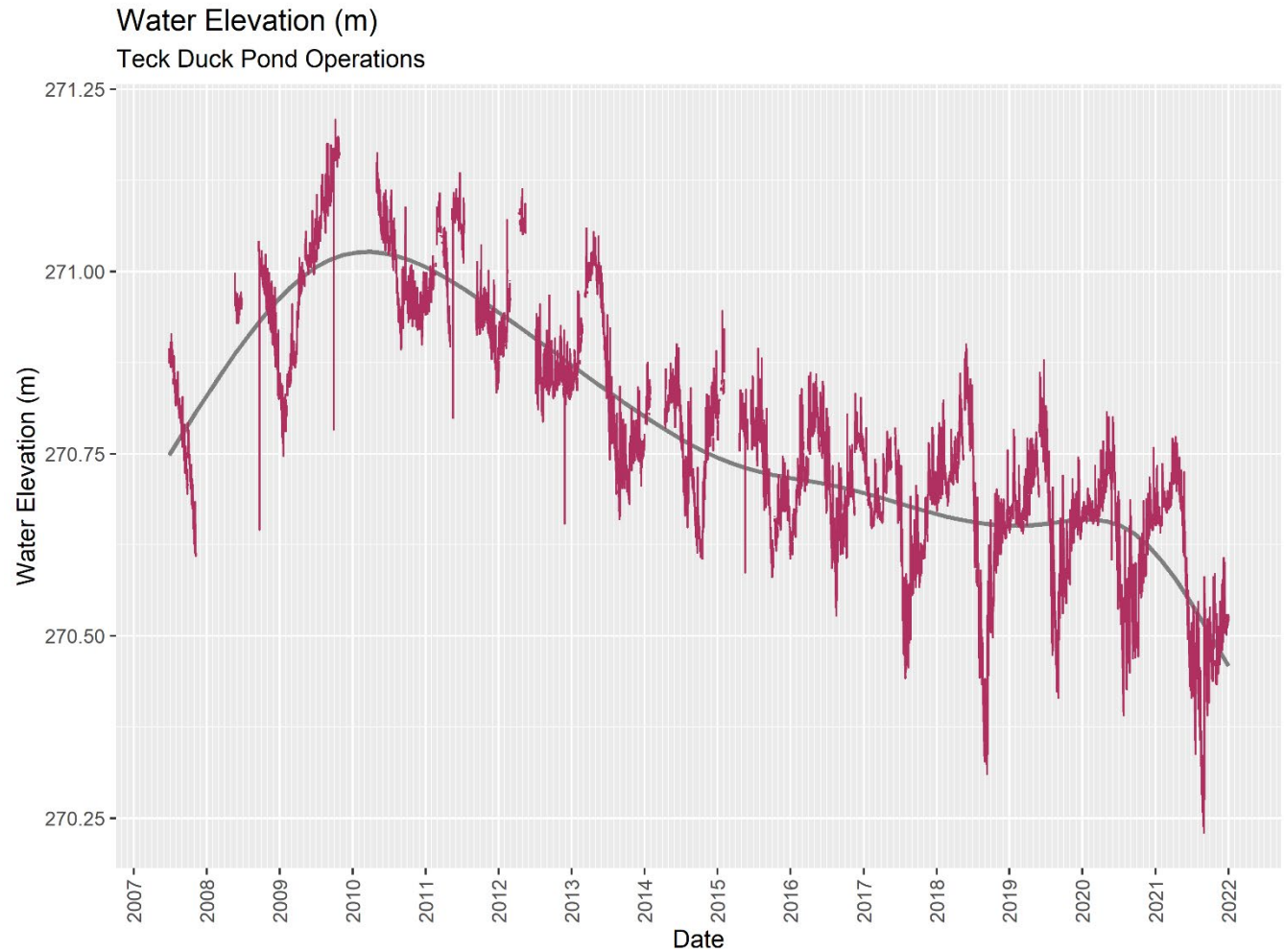


Figure 19: Water elevation at Well after Tailings Pond, Teck DPO

Figure 20 illustrates the long-term decline in water level from 2009 to 2017, the uptick observed in 2018, and the continued decline into 2021.

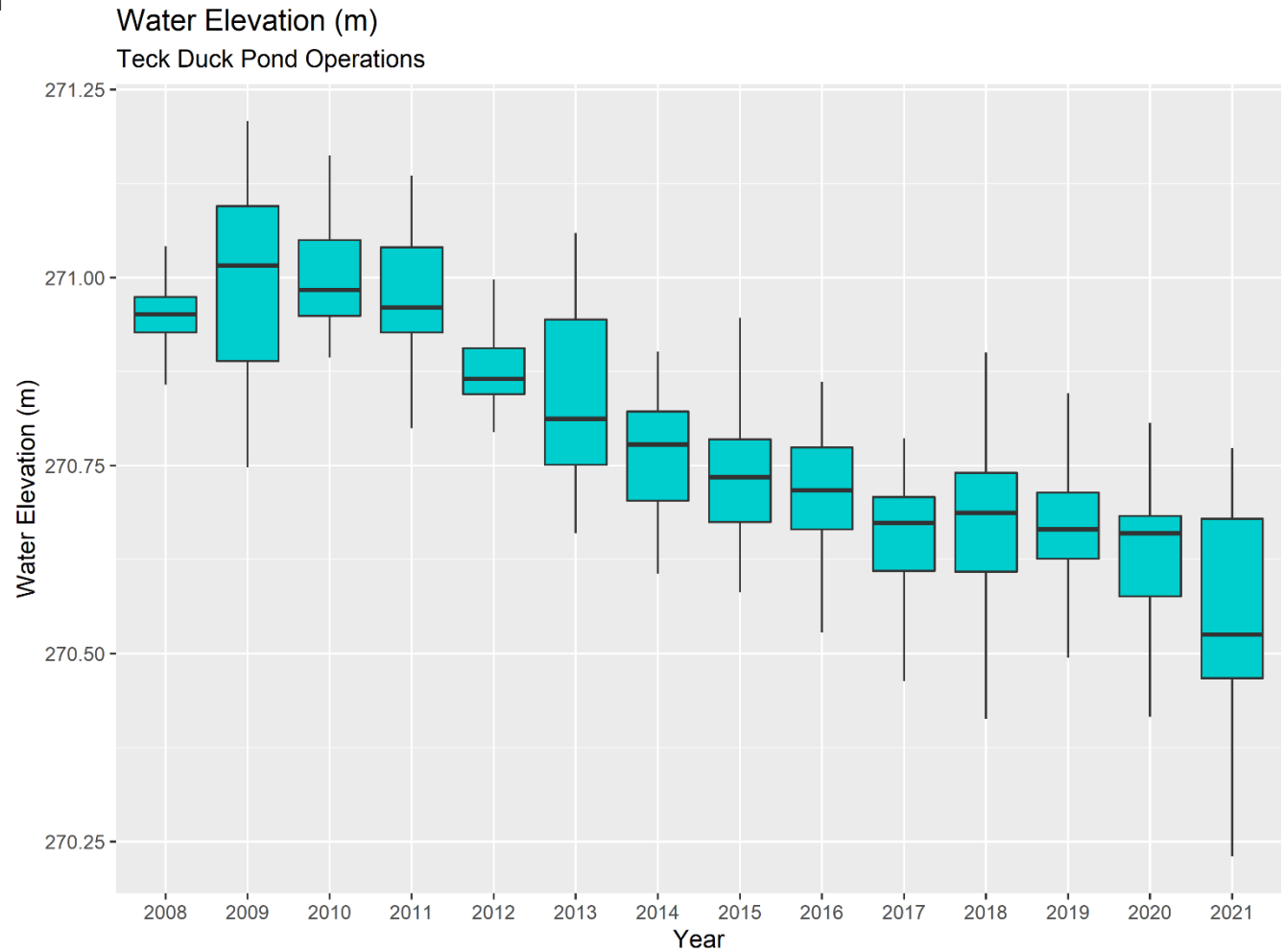


Figure 20: Boxplots of water elevation at Well after Tailings Pond, Teck DPO

Conclusion and Path Forward

Site closure and remediation work continued into 2021. Efforts that are being made to ensure long-term stability of the tailings management area could be implicated in some changes at each monitoring station over the previous five years, especially Well after Tailings Dam A. At this station, variations in pH, specific conductivity, and ORP were observed from 2017 to 2021. These changes are likely related to the ongoing remediation, decommissioning and closure work occurring throughout the site.

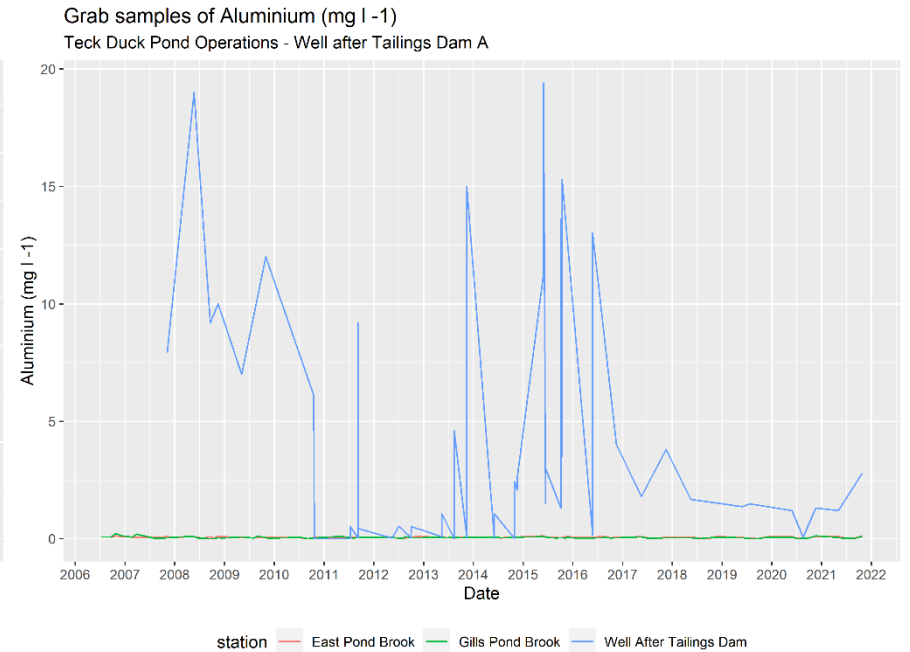
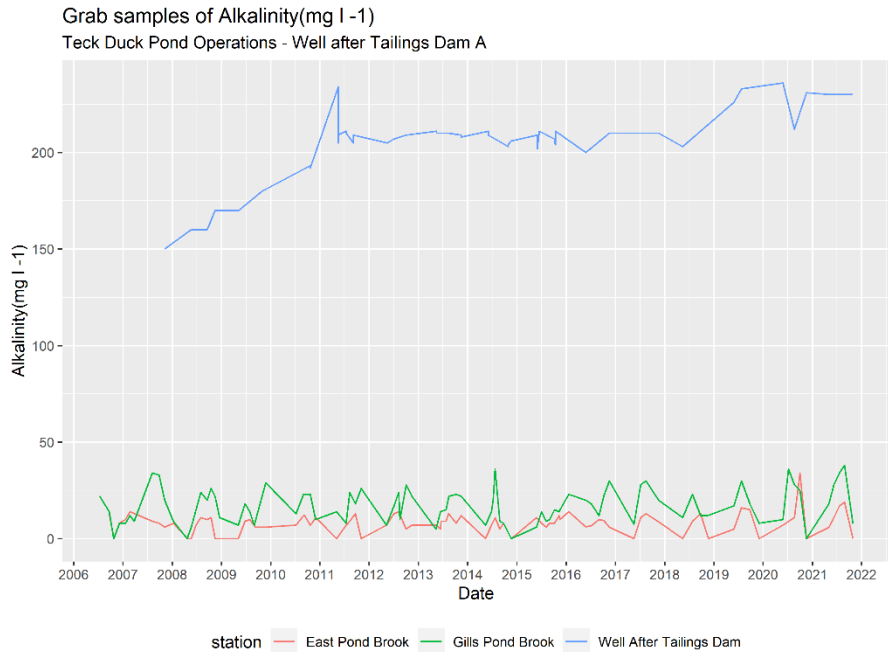
Tailings Dam A was constructed to direct flow from the tailings management area westward towards the Gills Pond watershed. Some changes in water quality seen at the EPB station over the years may have been related to seepage from the tailings area and work being conducted on site.

Water quality at East Pond Brook and Tributary to Gills Pond Brook was mostly within range of previous years. Of note is the conductivity at Tributary to Gills Pons Brook, which has been steadily decreasing during the decommissioning phase.

Monitoring efforts will continue for the duration of closure work and potentially longer if determined to be beneficial.

Appendix

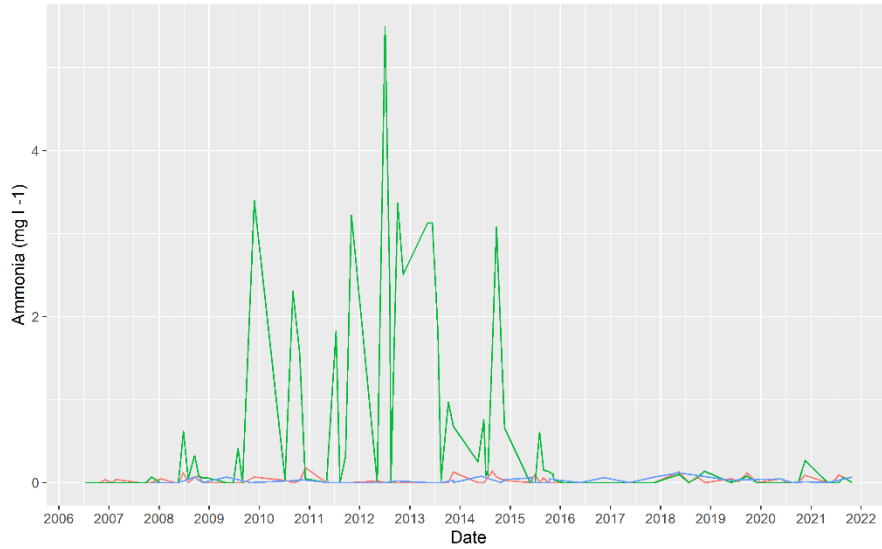
The following figures present grab sample results taken at East Pond Brook, Tributary to Gill's Pond Brook, and Well after Tailings Dam A stations. No discussion is provided for this section; graphs are provided for information purposes only.



Appendix

Grab samples of Ammonia (mg l-1)

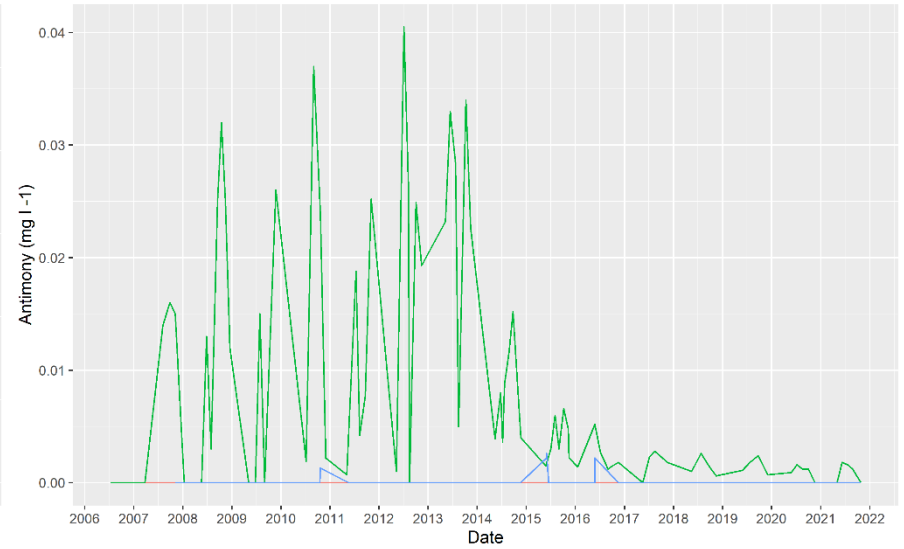
Teck Duck Pond Operations - Well after Tailings Dam A



station East Pond Brook Gills Pond Brook Well After Tailings Dam

Grab samples of Antimony (mg l-1)

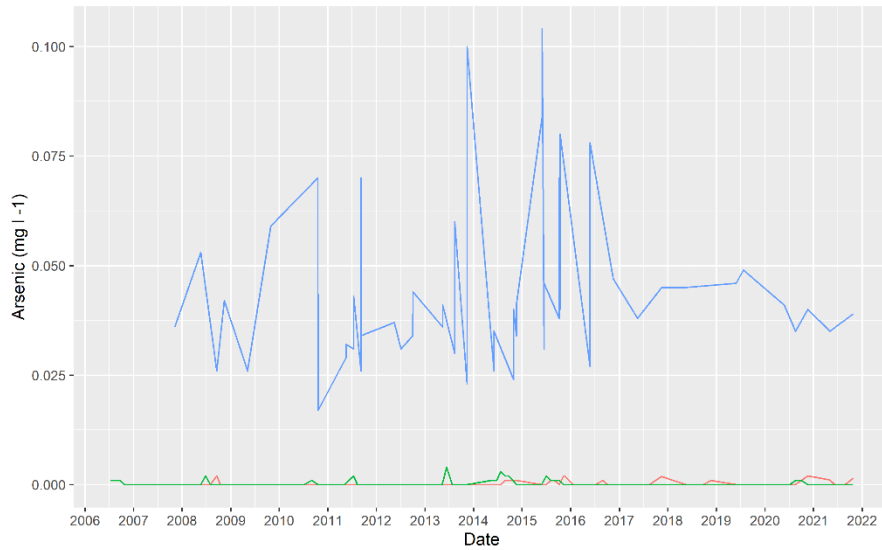
Teck Duck Pond Operations - Well after Tailings Dam A



station East Pond Brook Gills Pond Brook Well After Tailings Dam

Grab samples of Arsenic (mg l-1)

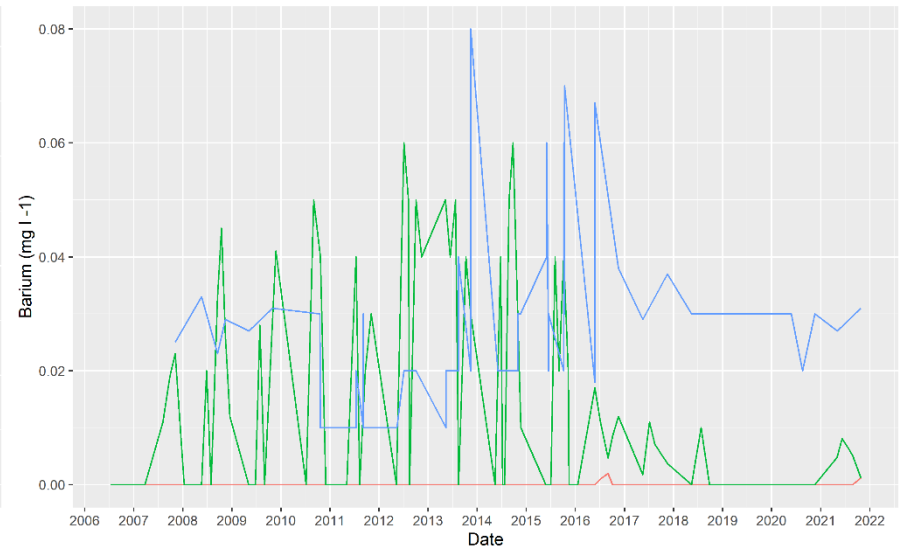
Teck Duck Pond Operations - Well after Tailings Dam A



station East Pond Brook Gills Pond Brook Well After Tailings Dam

Grab samples of Barium (mg l-1)

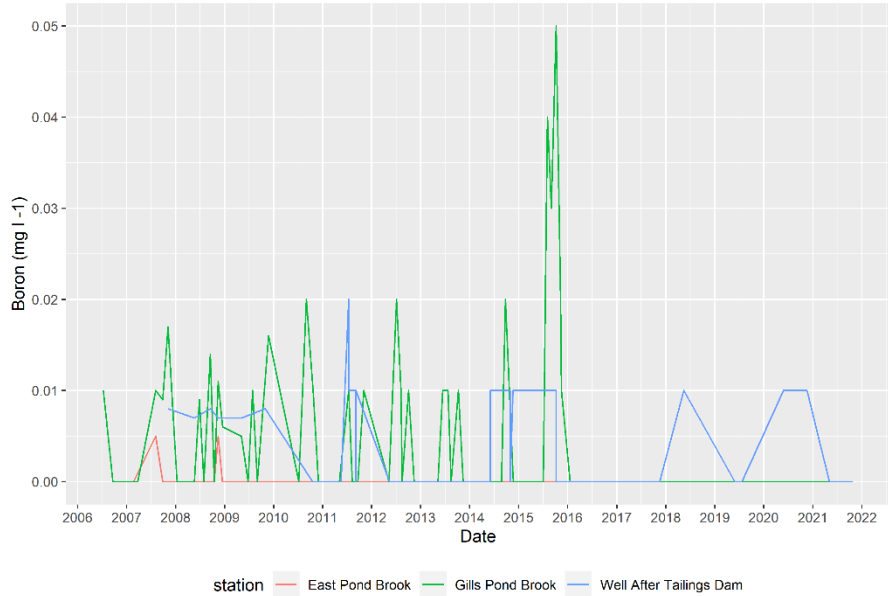
Teck Duck Pond Operations - Well after Tailings Dam A



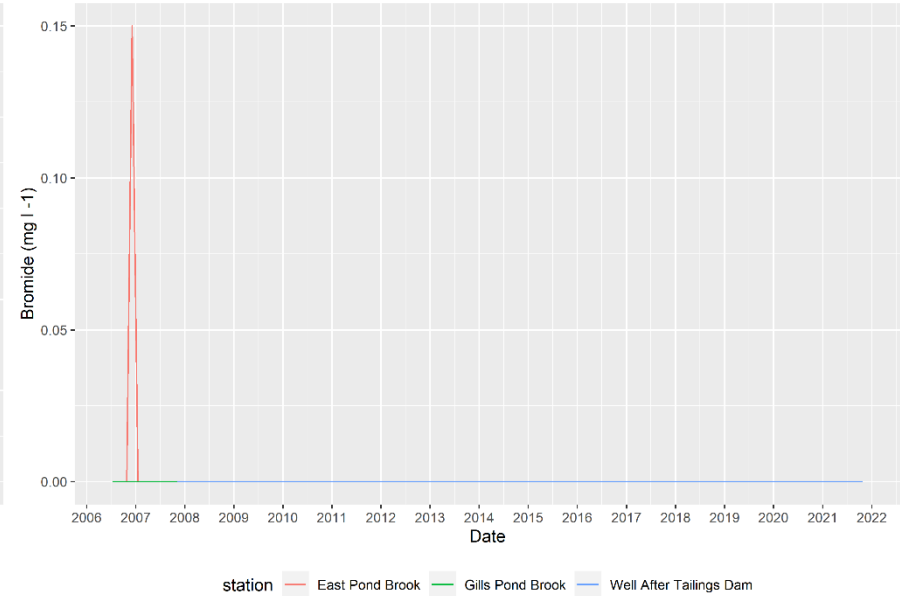
station East Pond Brook Gills Pond Brook Well After Tailings Dam

Appendix

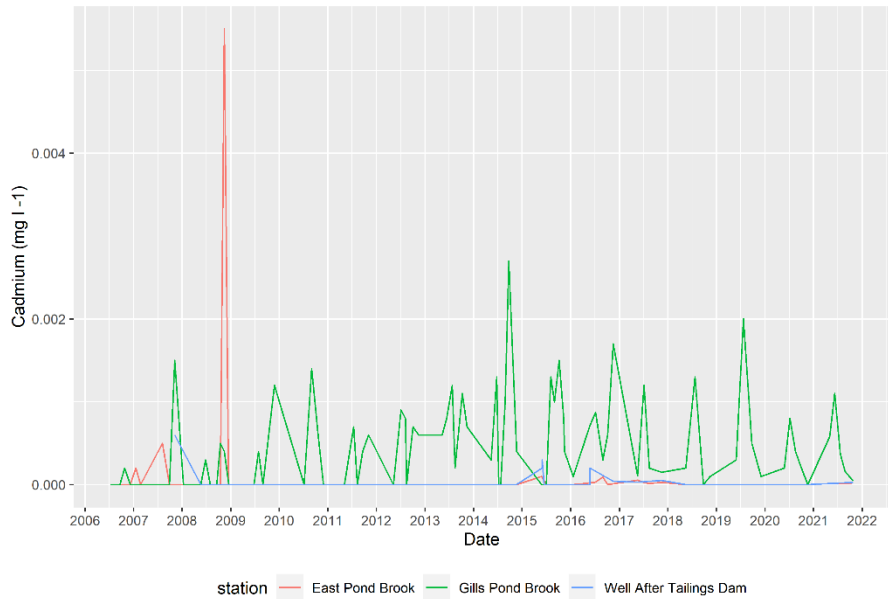
Grab samples of Boron (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



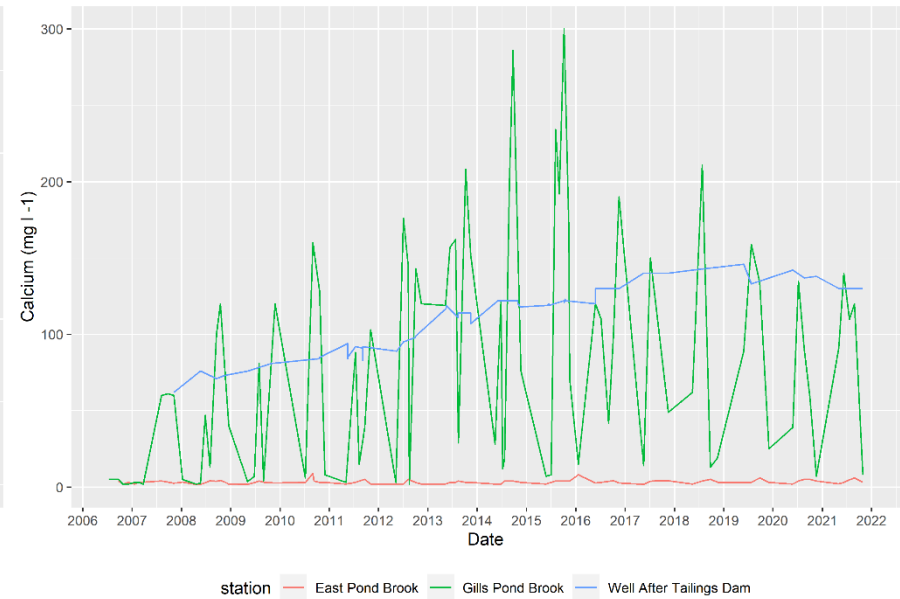
Grab samples of Bromide (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Grab samples of Cadmium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A

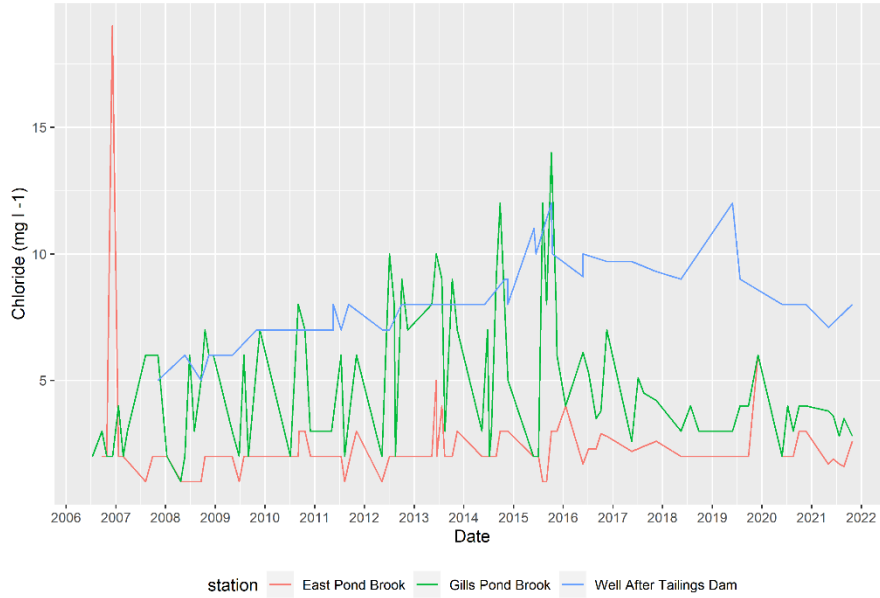


Grab samples of Calcium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A

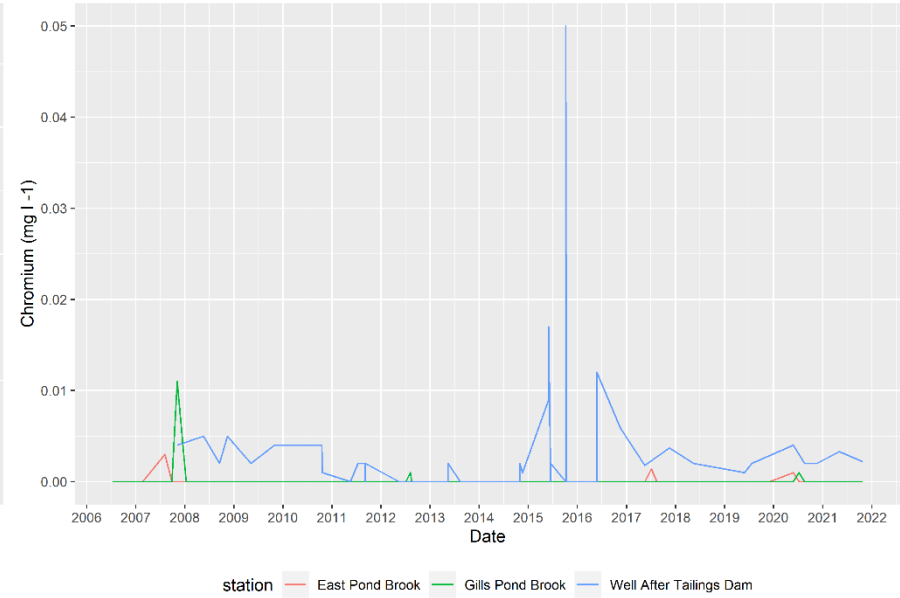


Appendix

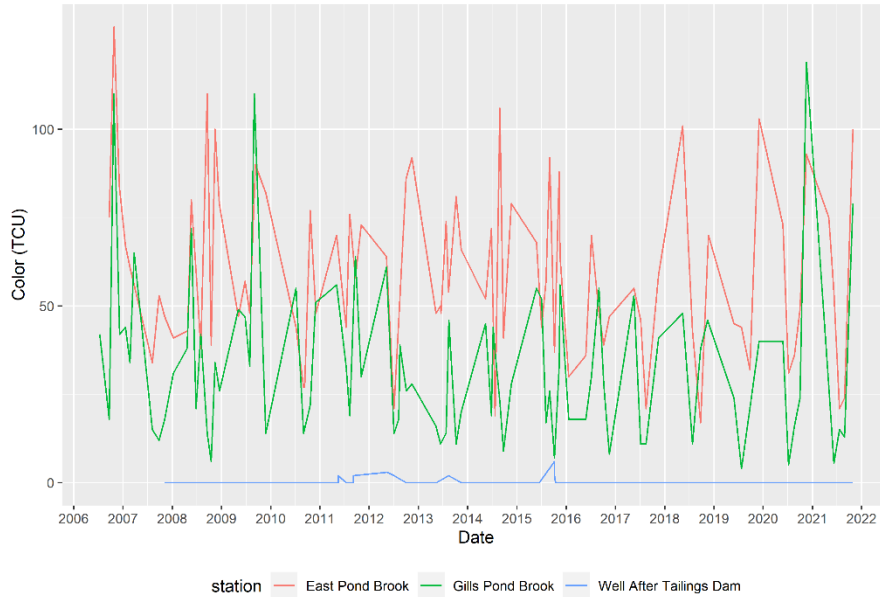
Grab samples of Chloride (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



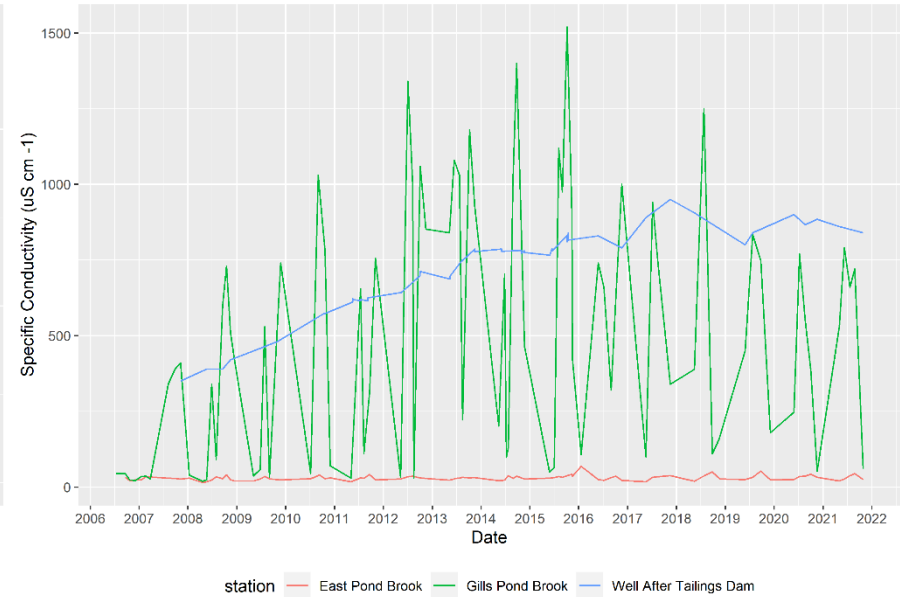
Grab samples of Chromium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Grab samples of Color (TCU)
Teck Duck Pond Operations - Well after Tailings Dam A



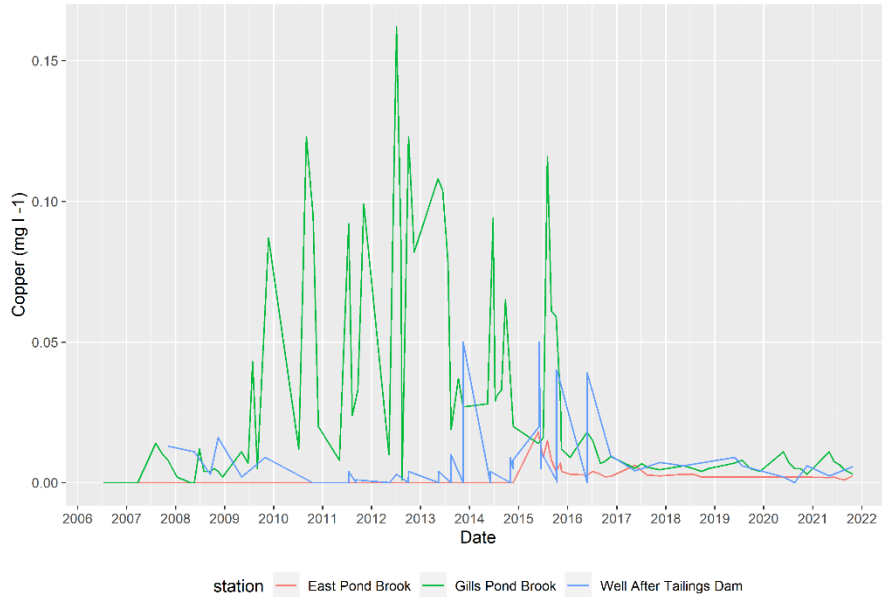
Grab samples of Specific Conductivity (uS cm⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Appendix

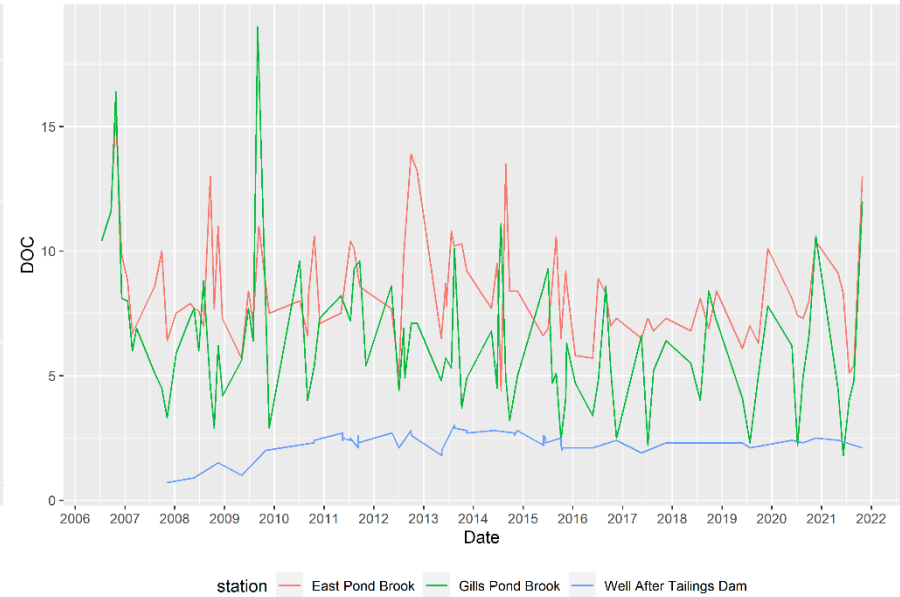
Grab samples of Copper (mg l⁻¹)

Teck Duck Pond Operations - Well after Tailings Dam A



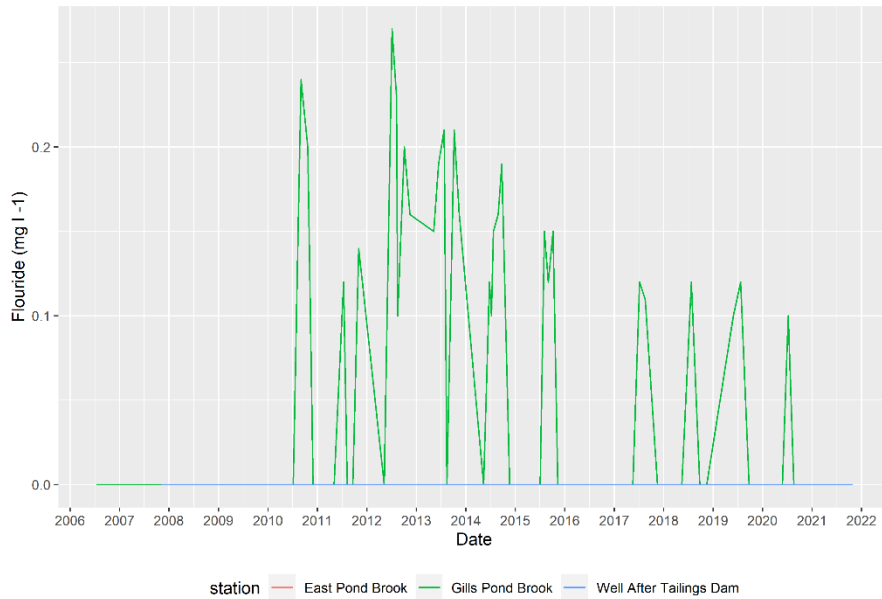
Grab samples of DOC

Teck Duck Pond Operations - Well after Tailings Dam A



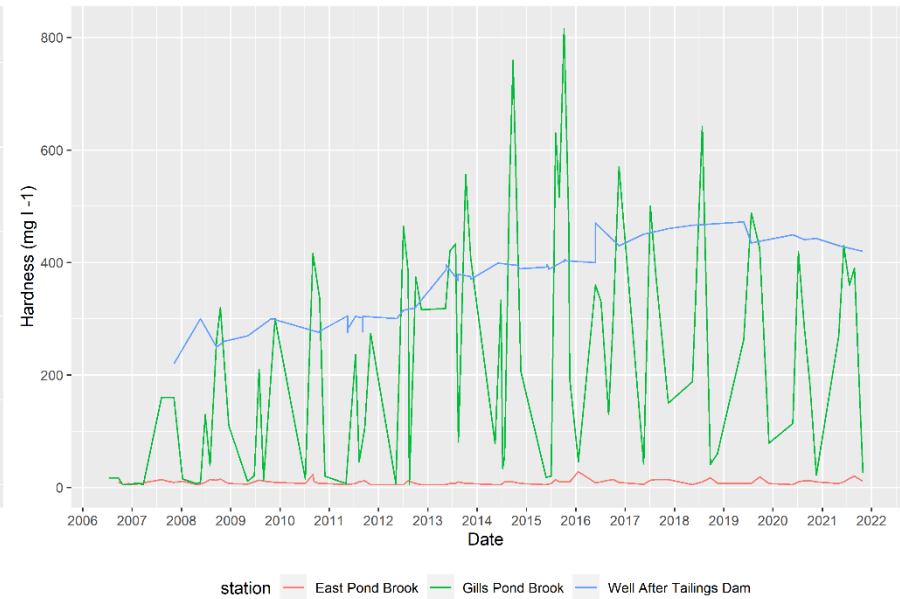
Grab samples of Fluoride (mg l⁻¹)

Teck Duck Pond Operations - Well after Tailings Dam A



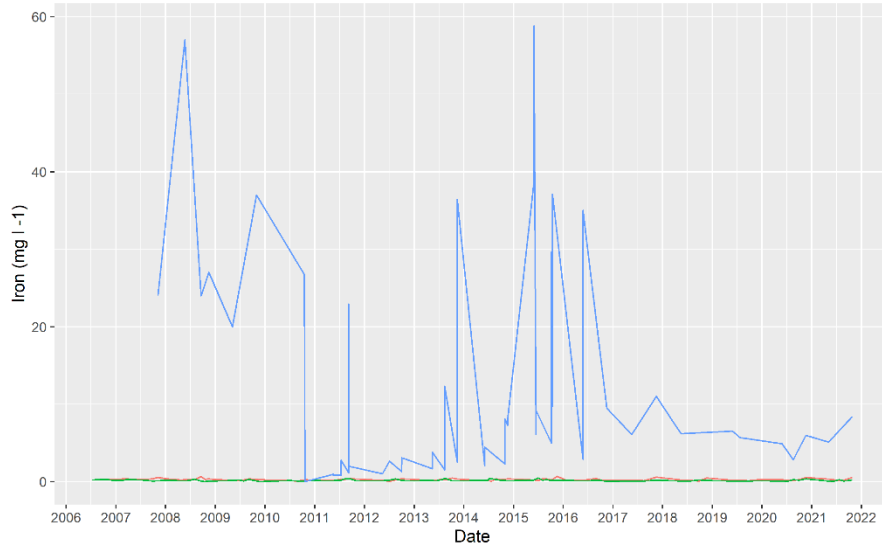
Grab samples of Hardness (mg l⁻¹)

Teck Duck Pond Operations - Well after Tailings Dam A



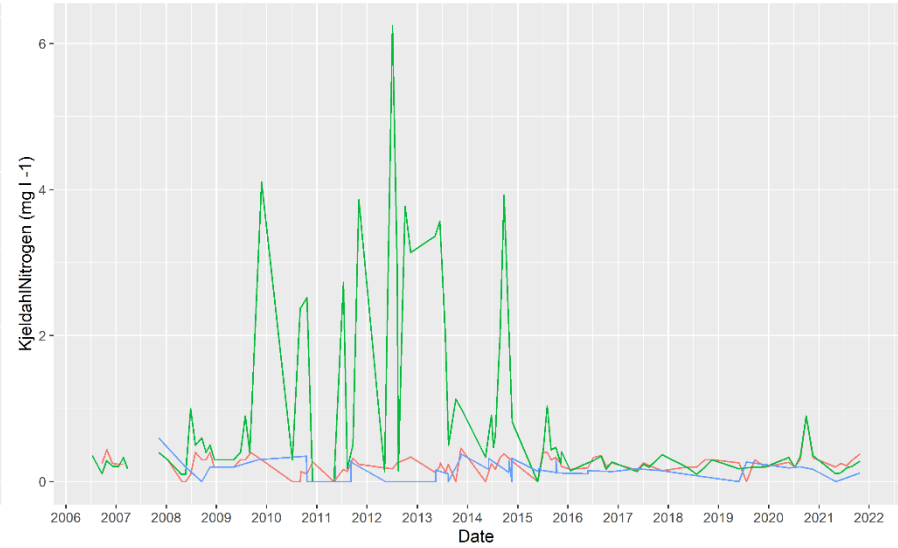
Appendix

Grab samples of Iron (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



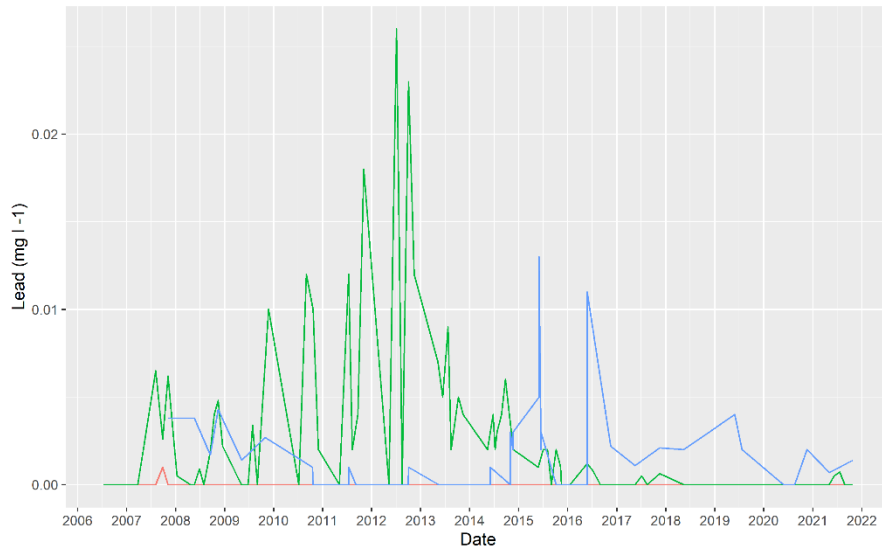
station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of KjeldahlNitrogen (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



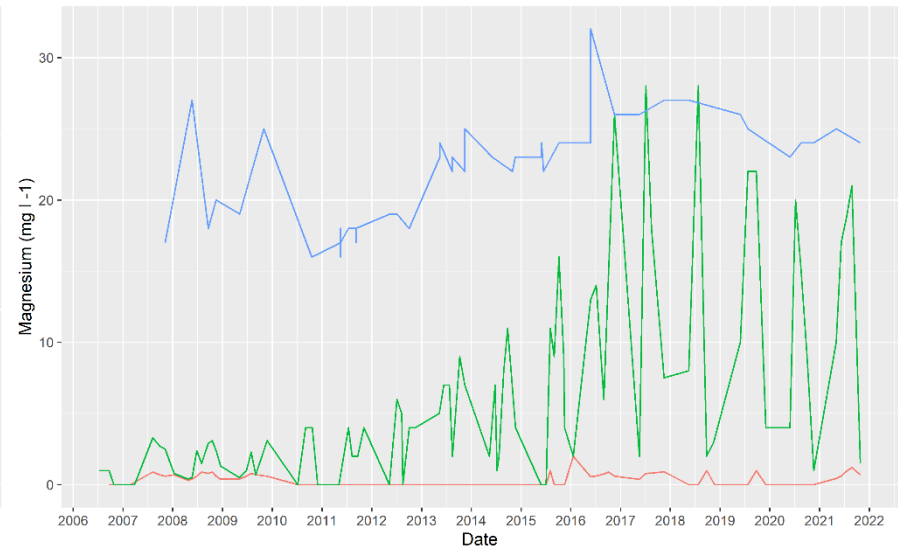
station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Lead (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Magnesium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A

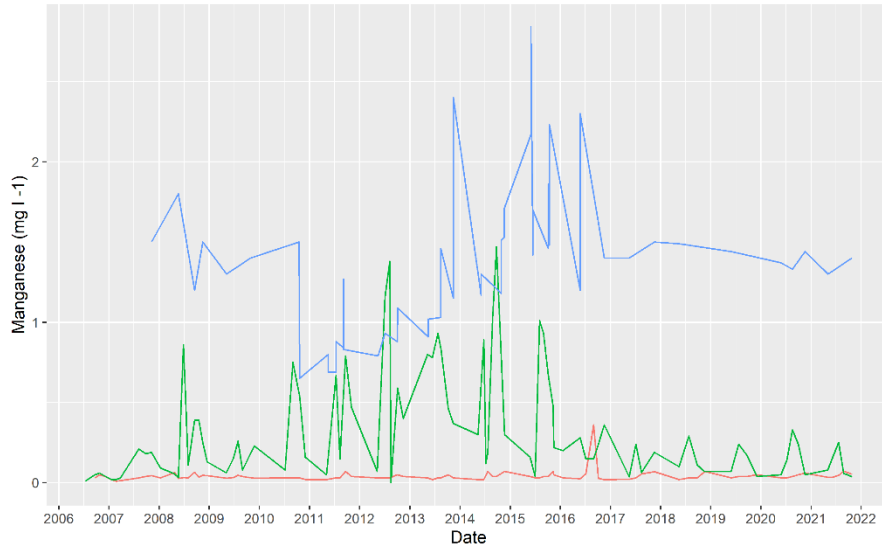


station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Appendix

Grab samples of Manganese (mg l⁻¹)

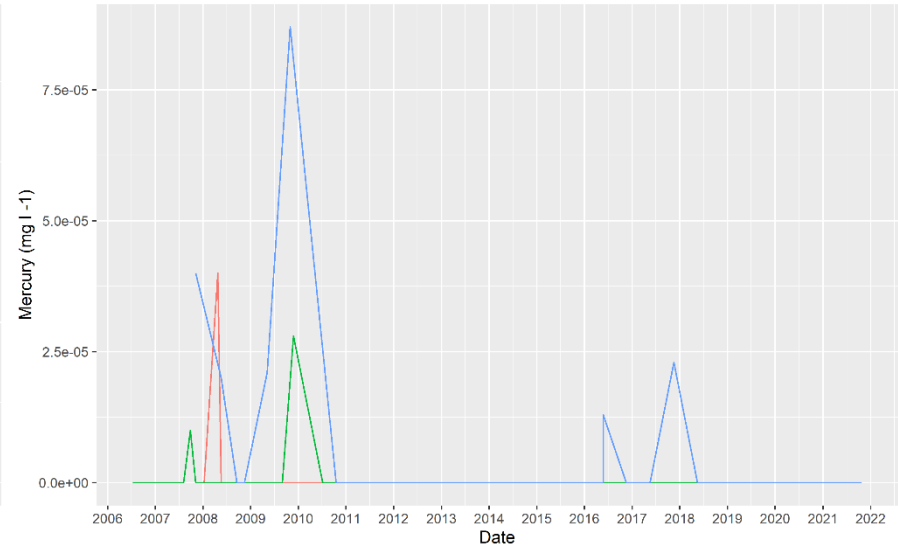
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Mercury (mg l⁻¹)

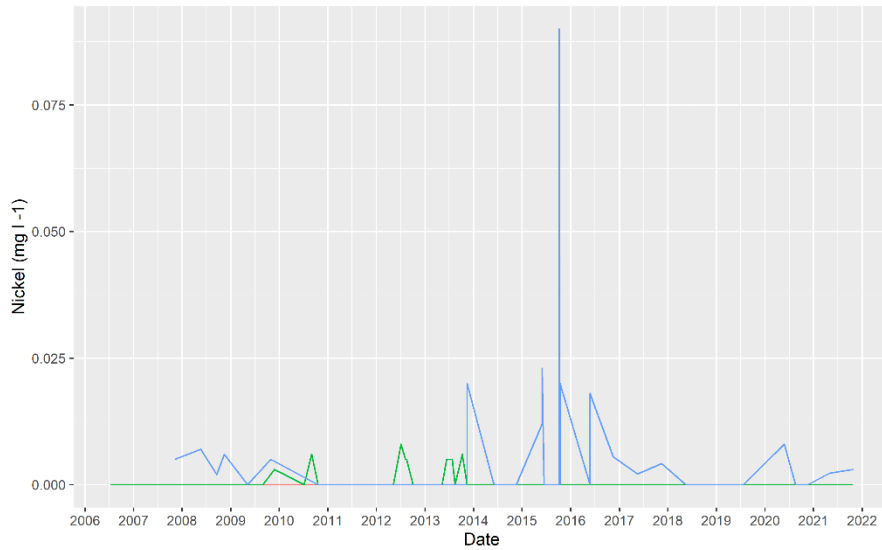
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Nickel (mg l⁻¹)

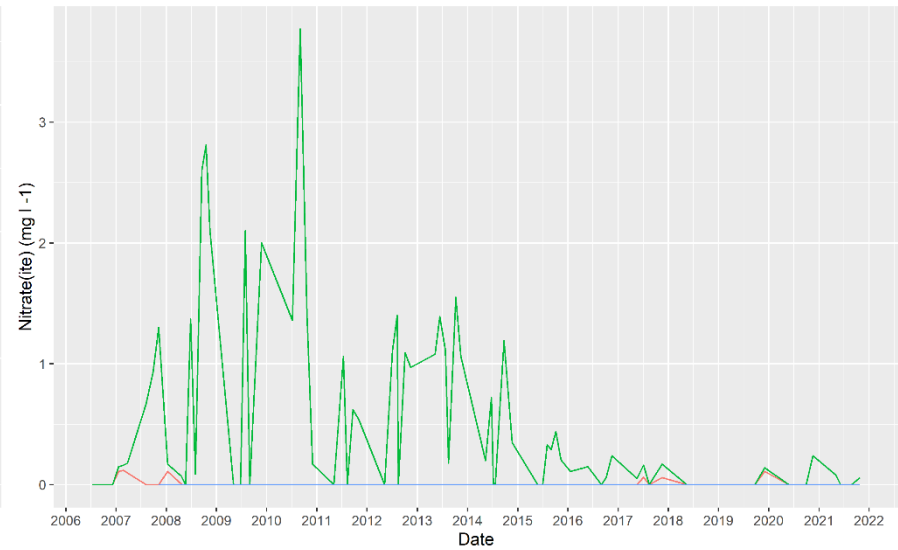
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Nitrate(ite) (mg l⁻¹)

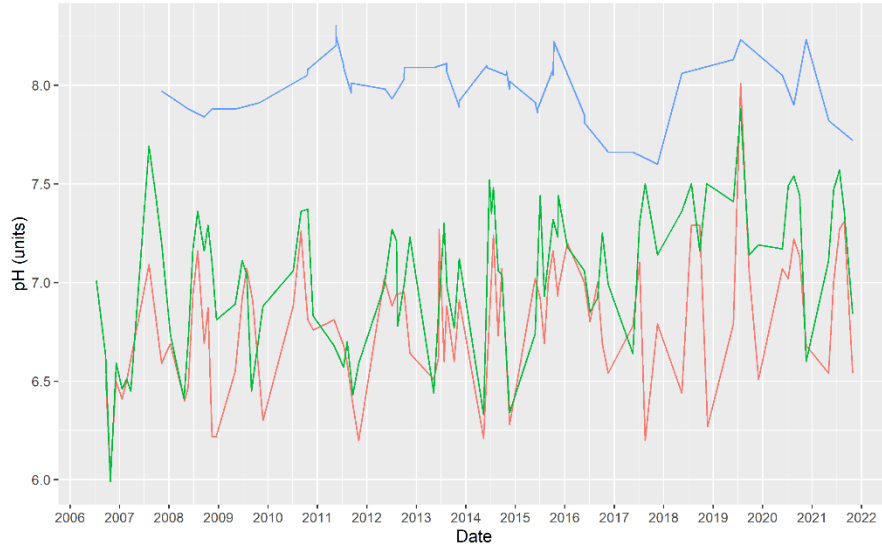
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

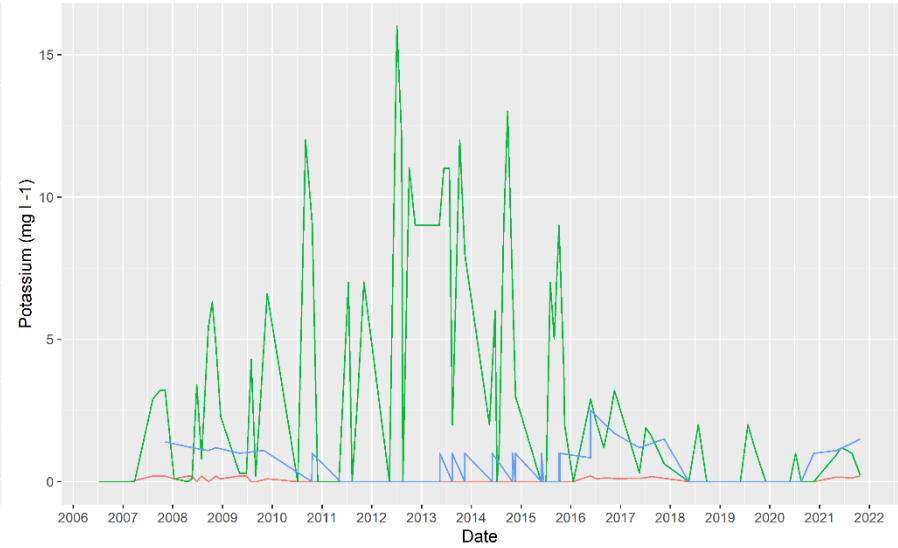
Appendix

Grab samples of pH (units)
Teck Duck Pond Operations - Well after Tailings Dam A



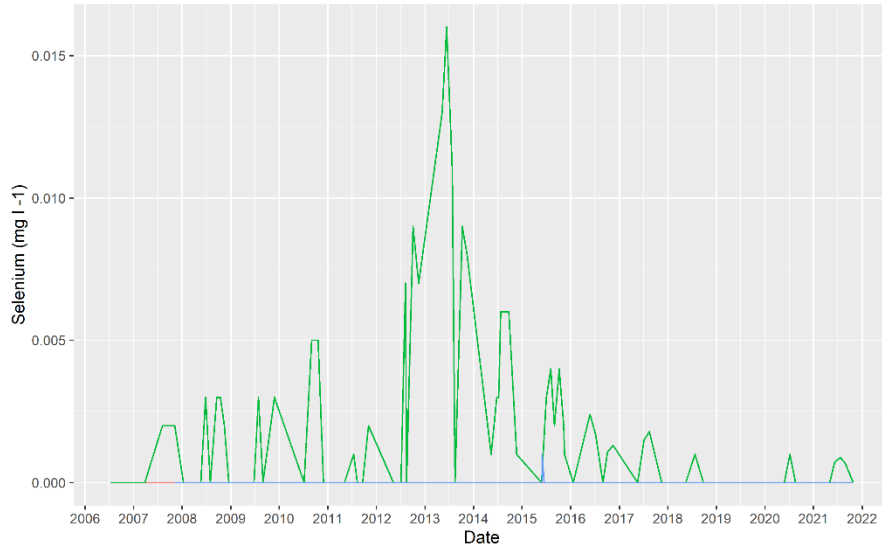
station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Potassium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



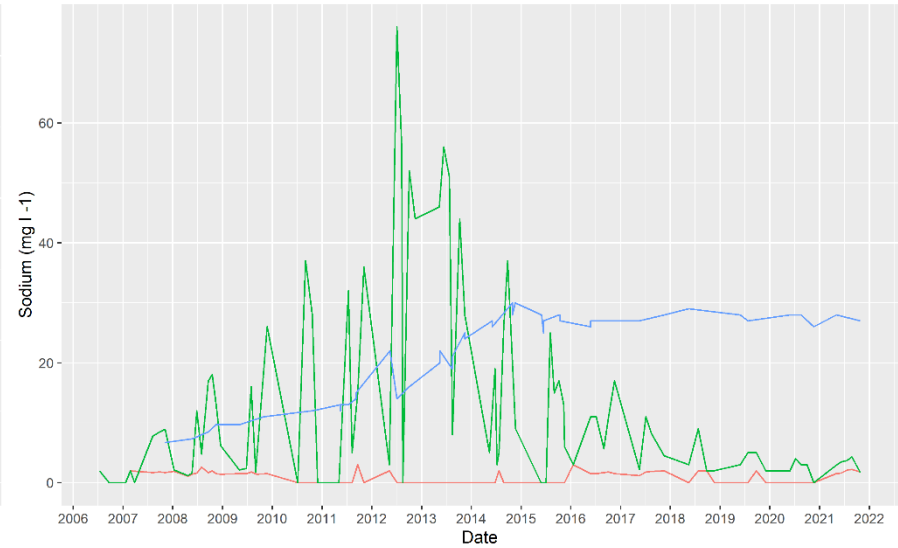
station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Selenium (mg l⁻¹)
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station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

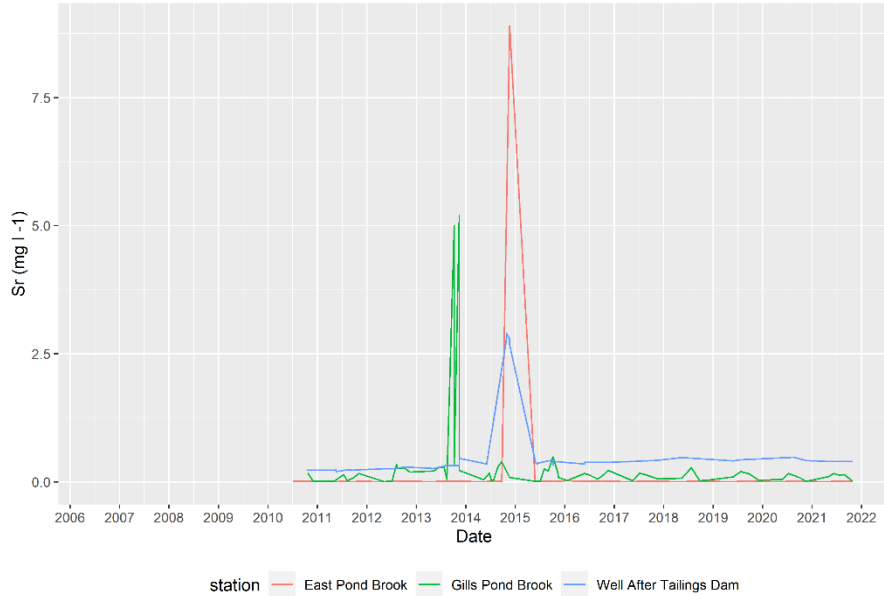
Grab samples of Sodium (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



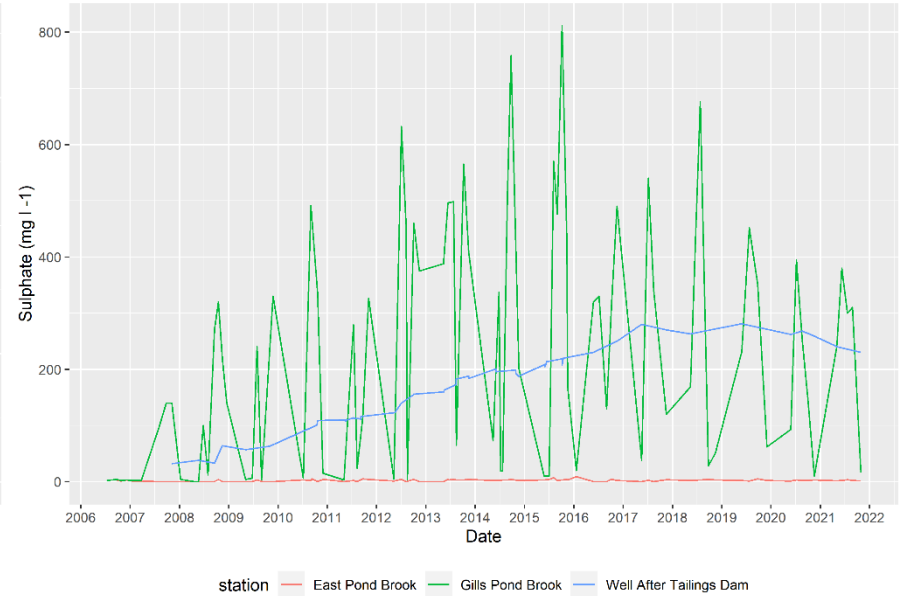
station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Appendix

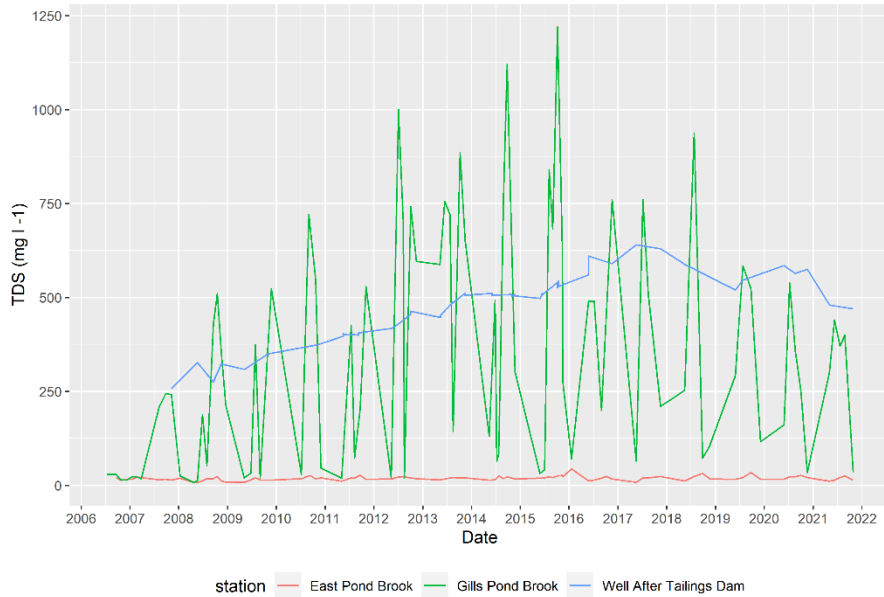
Grab samples of Sr (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



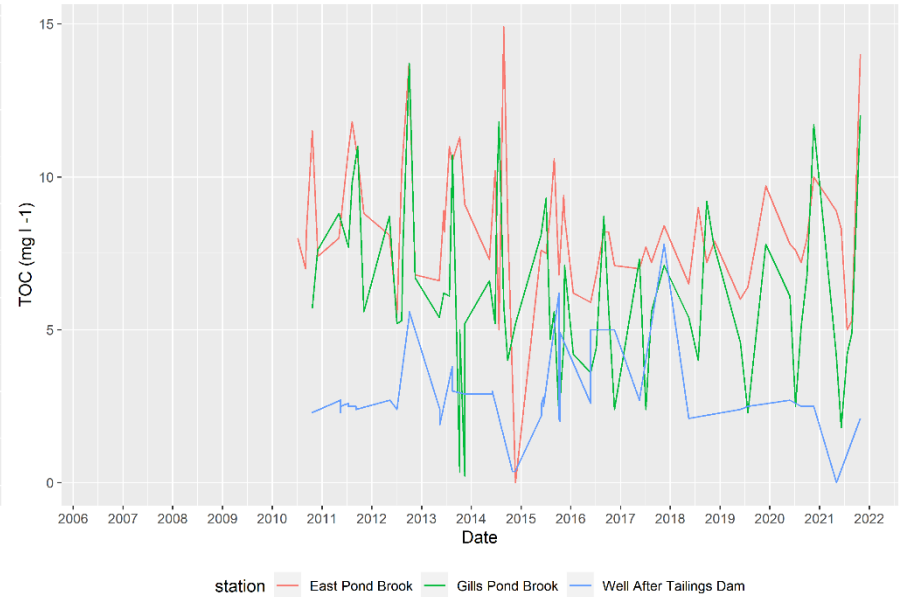
Grab samples of Sulphate (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



Grab samples of TDS (mg l⁻¹)
Teck Duck Pond Operations - Well after Tailings Dam A



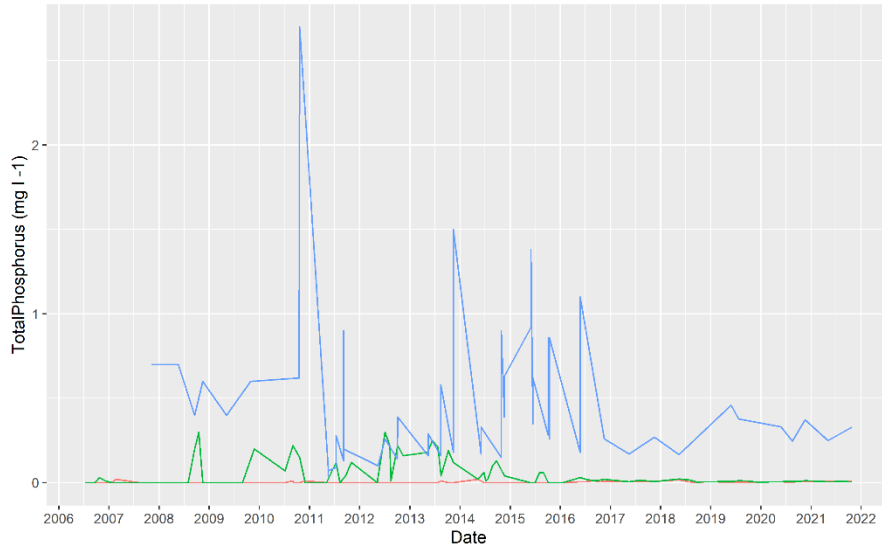
Grab samples of TOC (mg l⁻¹)
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Appendix

Grab samples of TotalPhosphorus (mg l⁻¹)

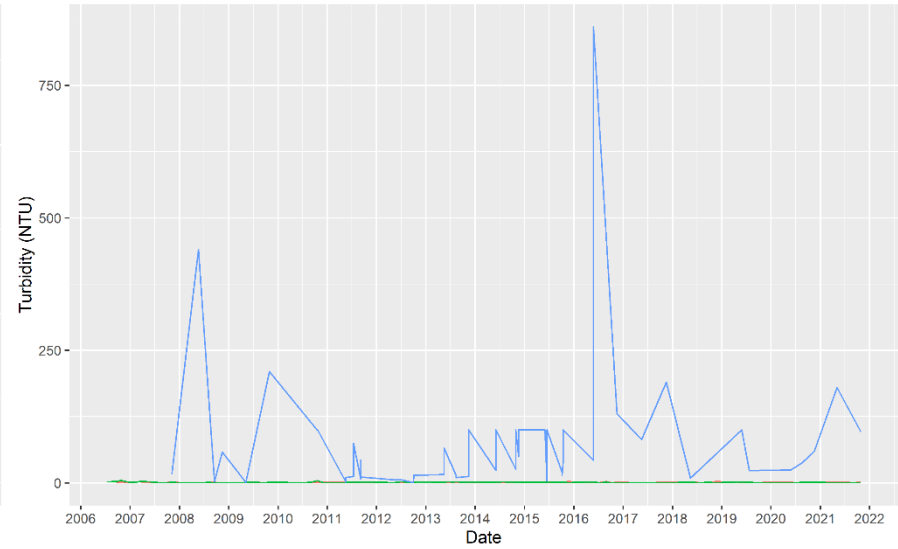
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station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Turbidity (NTU)

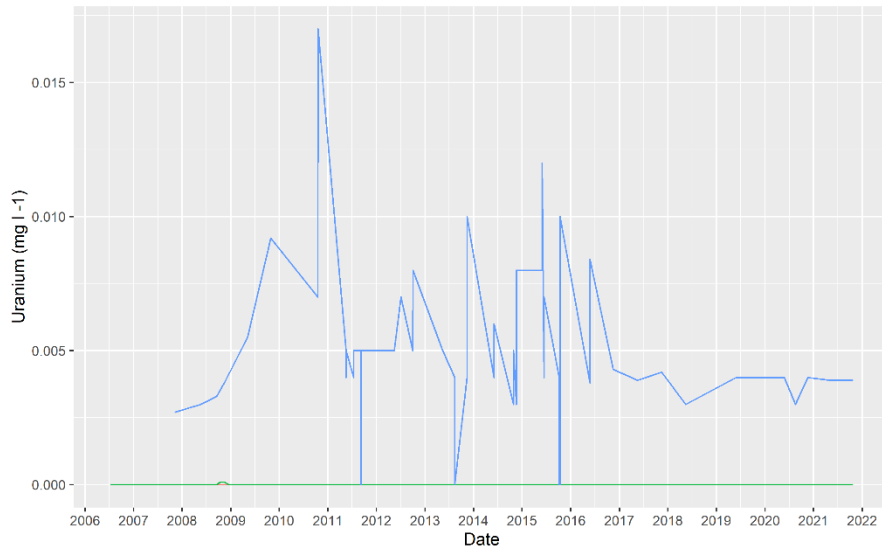
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Uranium (mg l⁻¹)

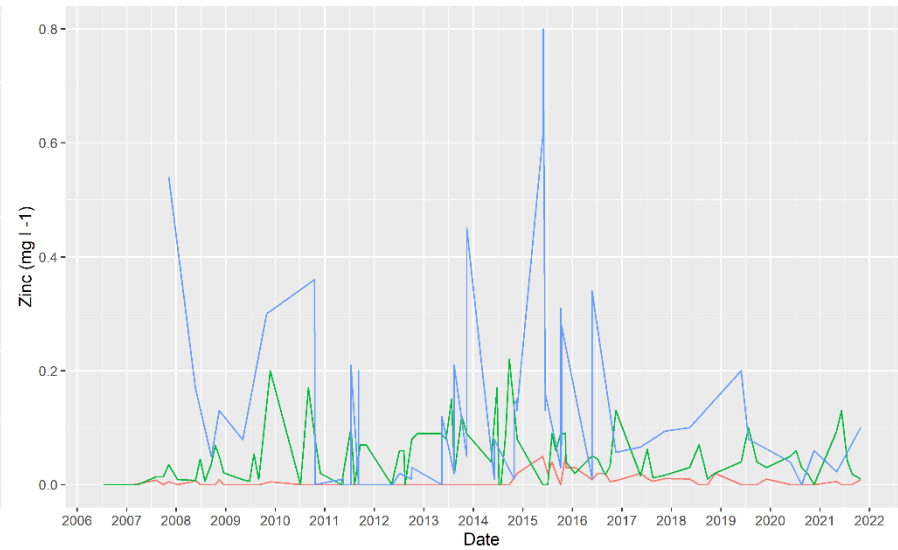
Teck Duck Pond Operations - Well after Tailings Dam A



station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam

Grab samples of Zinc (mg l⁻¹)

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station — East Pond Brook — Gills Pond Brook — Well After Tailings Dam