Sewage Treatment System Impact Monitoring Program

Volume 2: Appendices

Data Report 2022-23

Sydney WATER

Commercial-in-Confidence

Sydney Water

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Acknowledgement of Country

Sydney Water respectfully acknowledges the Traditional Custodians of the land and waters on which we work, live and learn. We pay respect to Elders past and present.

Table of contents

Figures

Tables

Appendix A: Hawkesbury-Nepean River

This Appendix includes graphical presentation of monitoring data for the Hawkesbury-Nepean River catchment that are directly linked with the assessment of WRRF impact. Summary tables, detailed statistical analyses outcomes are also included where relevant.

The inland Water Resource Recovery Facilities (WRRFs) that are discharging into this catchment are ordered from upstream (Picton) to downstream (Brooklyn).

Under each WRRF (Sub-chapters A-1 to A-15), the results are presented following the **Pressure**, **Stressor** and **Ecosystem Receptor** (**P-S-ER**) causal pathway elements.

For the **Pressure**, trend plots are included on wastewater quantity (discharge and inflow), quality, toxicity and discharge loads. Trends plots on other supplementary data are also included to improve our understanding on:

- weather condition ie catchment specific rainfall condition for each WRRF
- wastewater reuse/ recycling volume of relevant WRRF.

Wastewater quality and load plots are included in following four sub-groups, and then within each sub-group, analytes presented in alphabetical order:

- nutrients
- major conventional analytes
- trace metals
- other chemicals and organics (including pesticides)

Tests conducted on wastewater are specified in the Environment Protection Licence (EPL) issued by the NSW EPA for each WRRF (A-16). Data for all these measured analytes that have EPL concentration and load limits are included.

For the **Stressor**, data for the upstream and downstream tributary monitoring sites of each WRRF zone are presented first, and then the upstream and downstream monitoring site of main stream river (if any). Plots for each sites are presented in following two sub-groups and order:

- nutrients
  - ammonia nitrogen
  - oxidised nitrogen
  - total nitrogen
  - filterable total phosphorus
  - total phosphorus
- physico-chemical analytes
  - conductivity
  - dissolved oxygen (mg/L)
  - dissolved oxygen saturation (%)
  - pH
  - temperature
  - turbidity

Analytes included for the receiving water quality are in accordance with Sewage Treatment System Impact Monitoring Program (STSIMP, Sydney Water 2010).

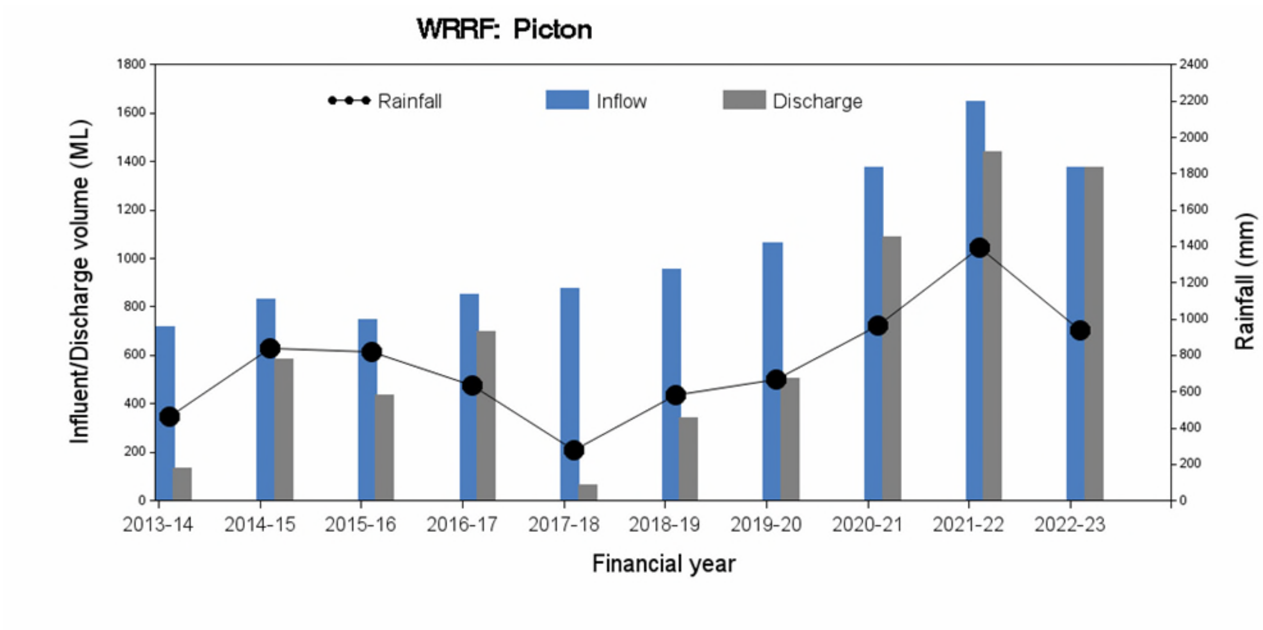
For the **Ecosystem Receptor,** following two approaches were taken:

- phytoplankton (trend plots)
  - chlorophyll-a
  - total phytoplankton biovolume
  - blue-green biovolume
  - toxic blue-green species counts
- macroinvertebrates
  - trend plots on SIGNAL-SG
  - ANOVA table

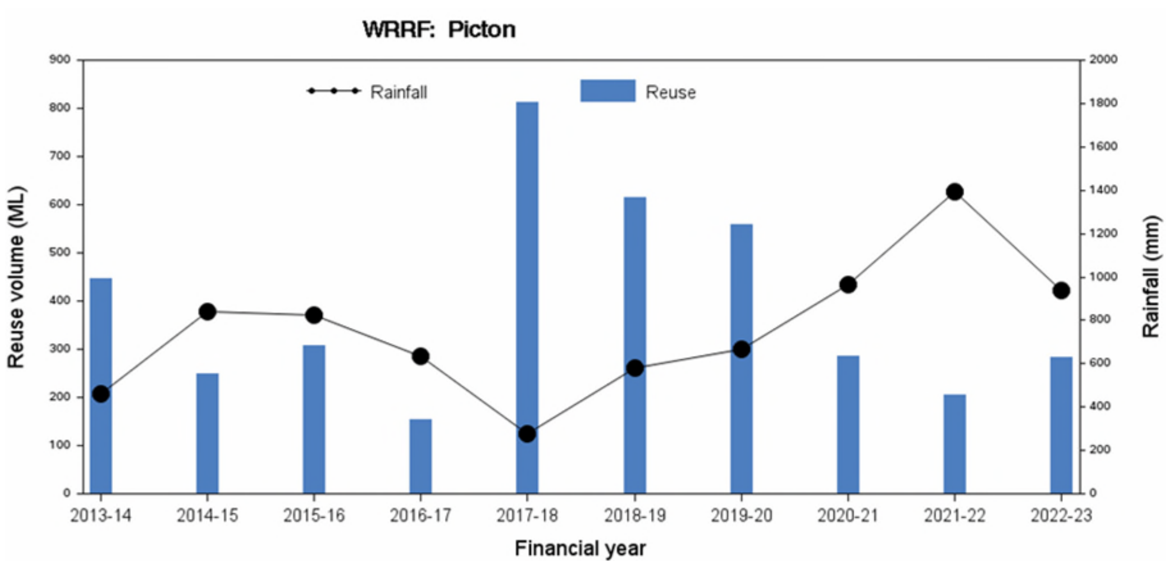
A-1 Picton WRRF

A-1.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

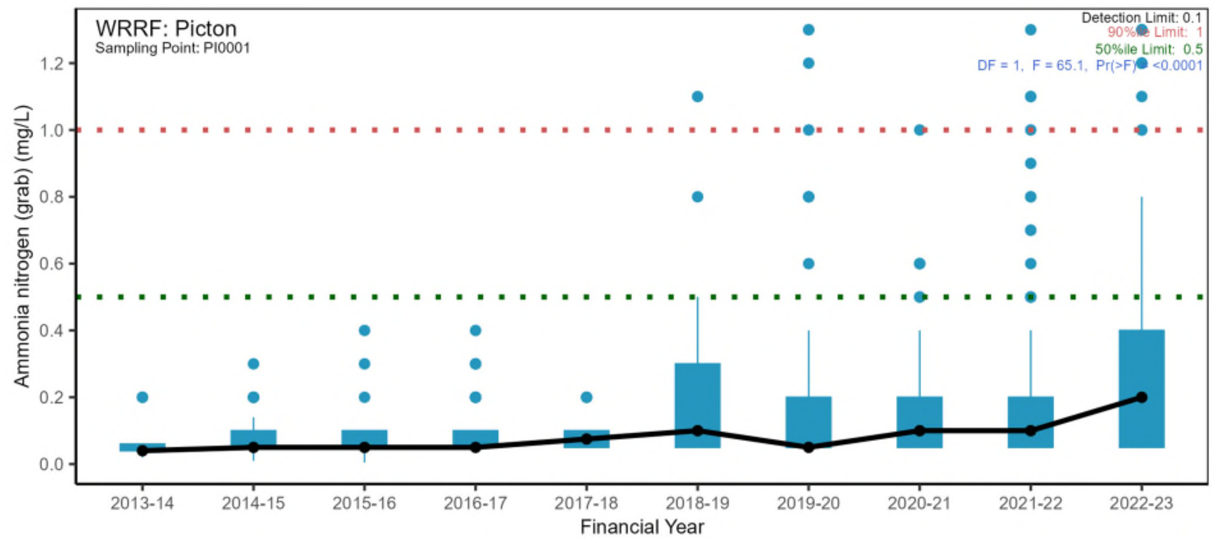


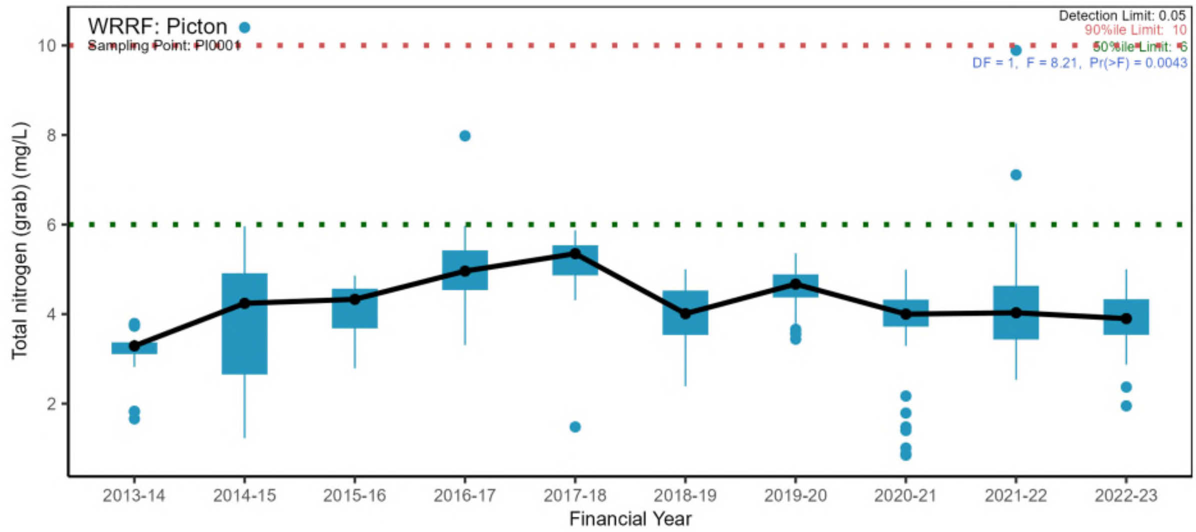
Reuse volume and rainfall

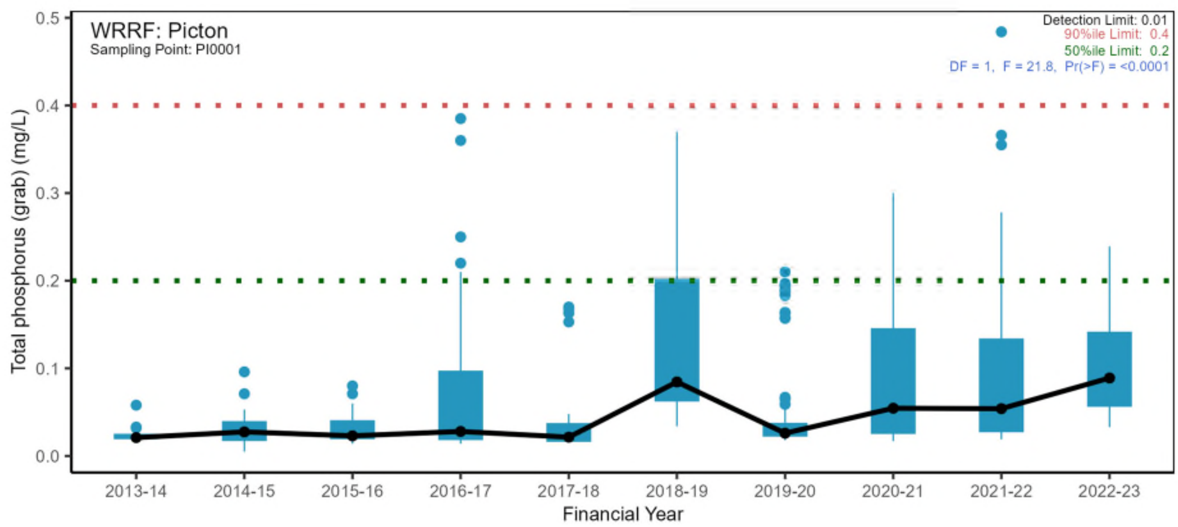


A-1.2 Pressure – Wastewater quality

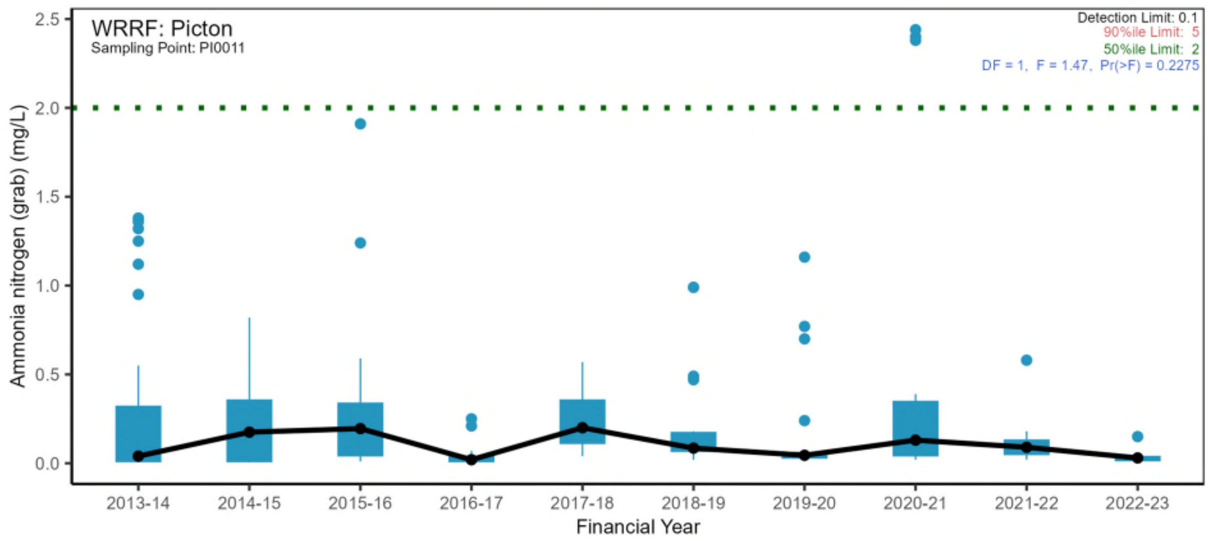
Nutrients: PI0001 Precautionary discharge

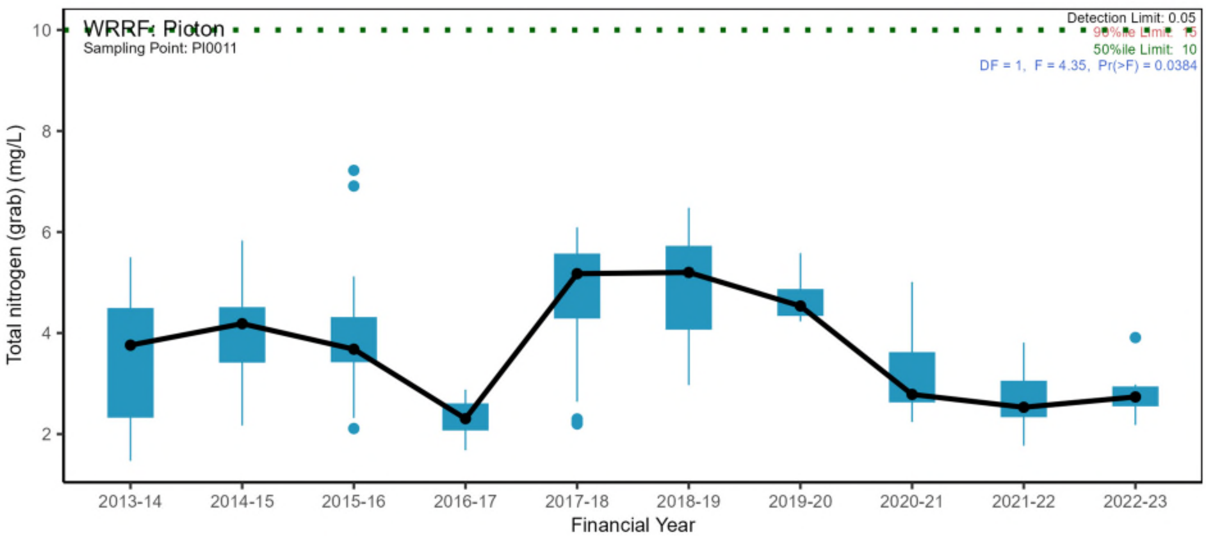


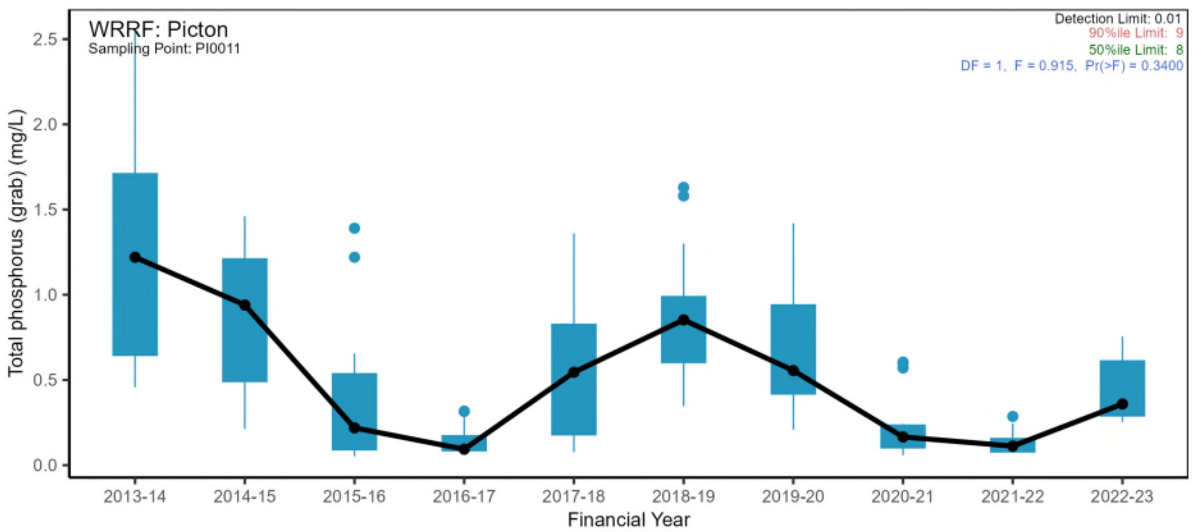




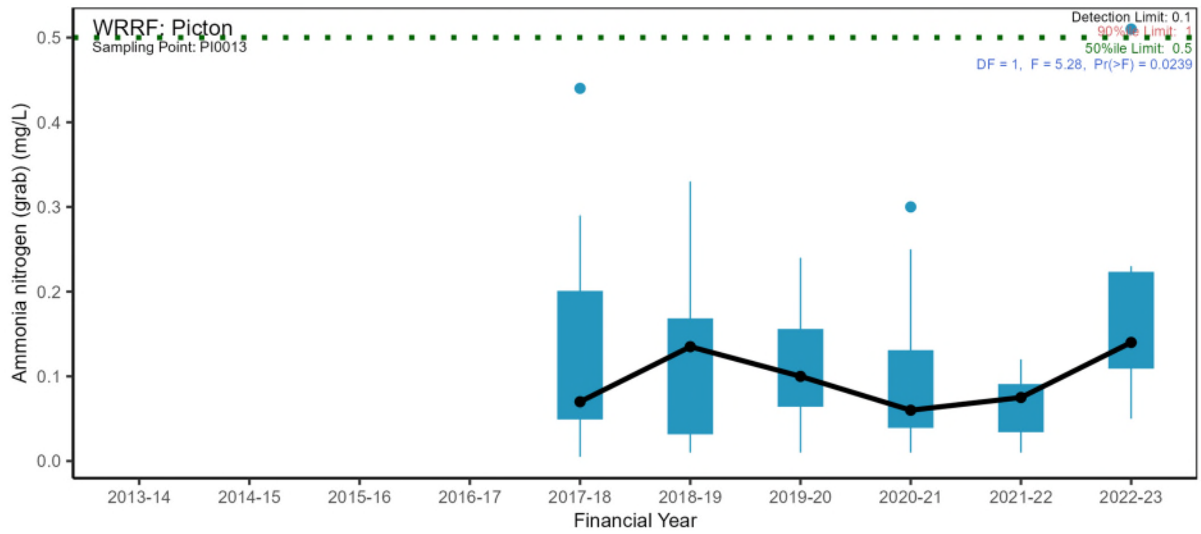
Nutrients PI0011 Irrigation

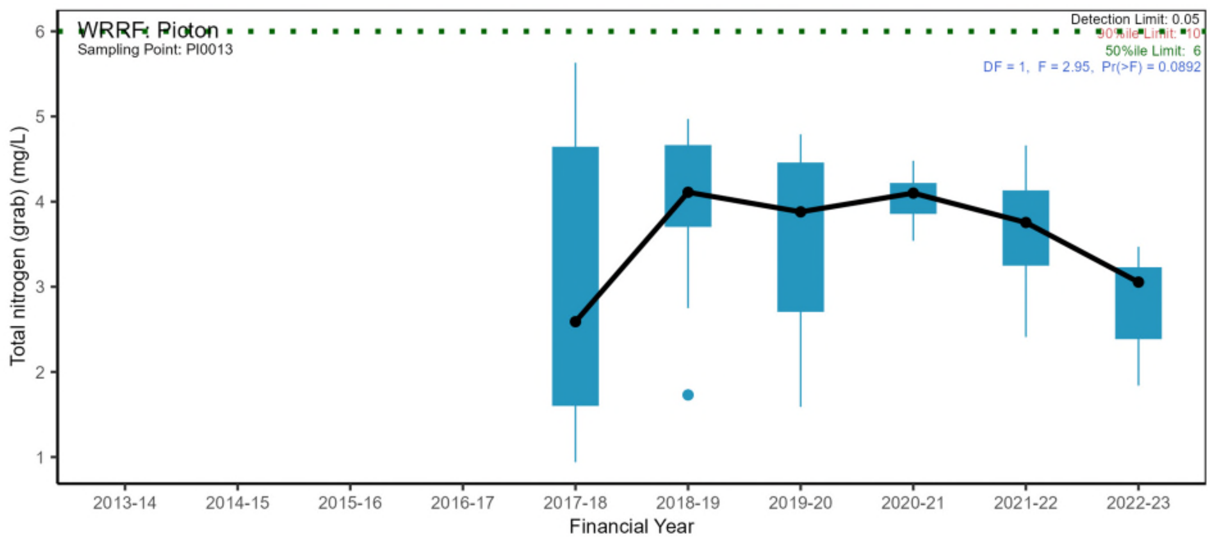


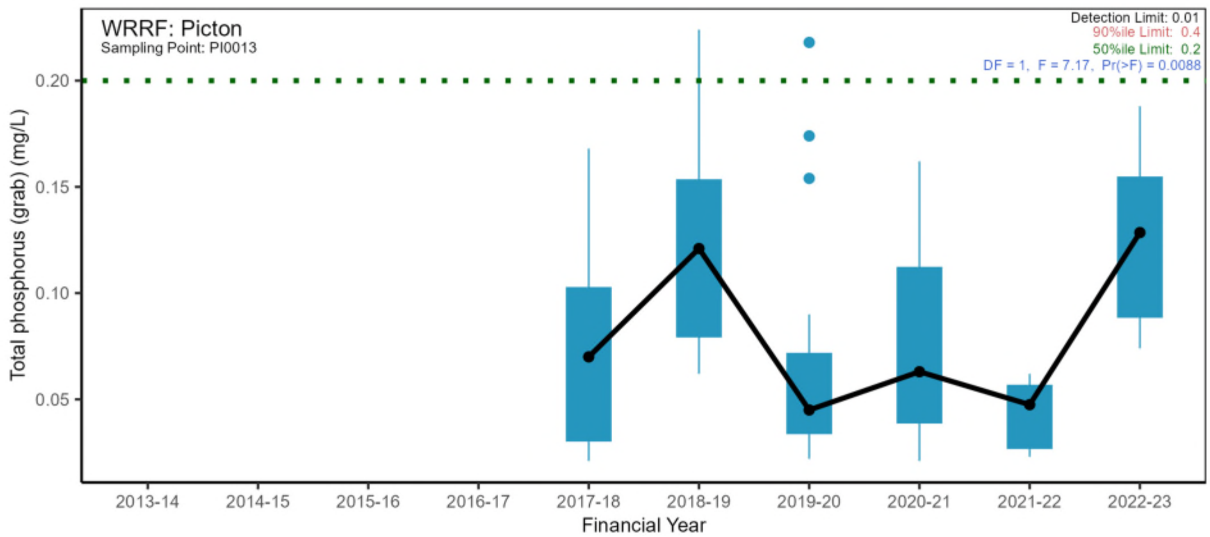




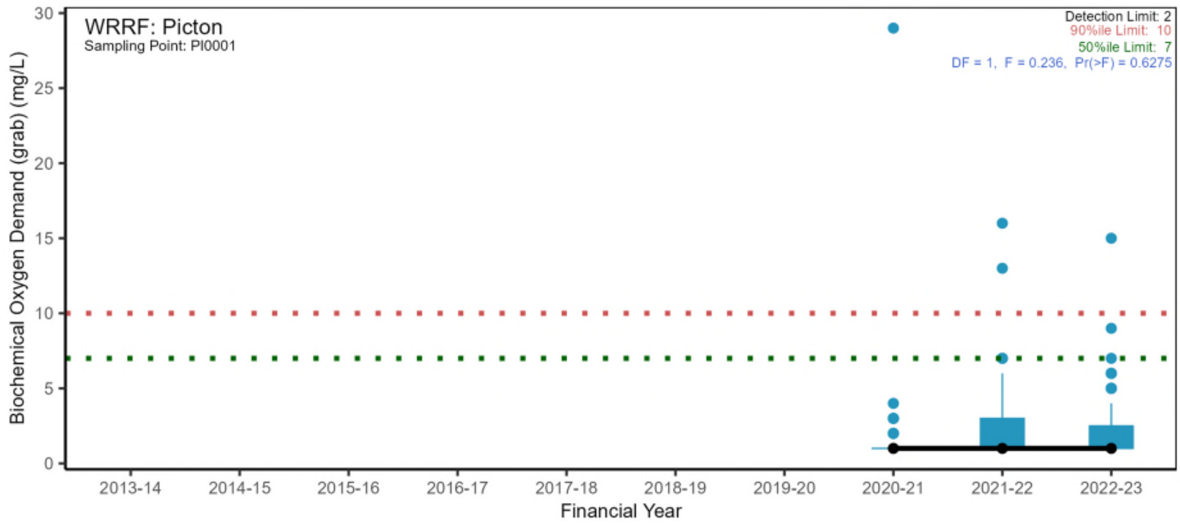
Nutrients: PI0013 Irrigation

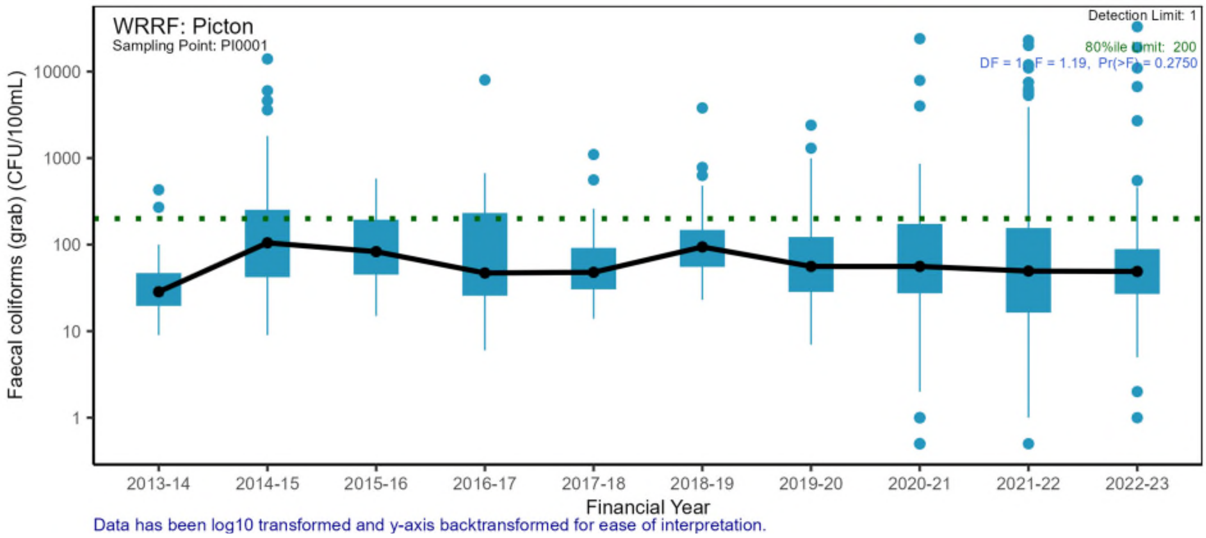


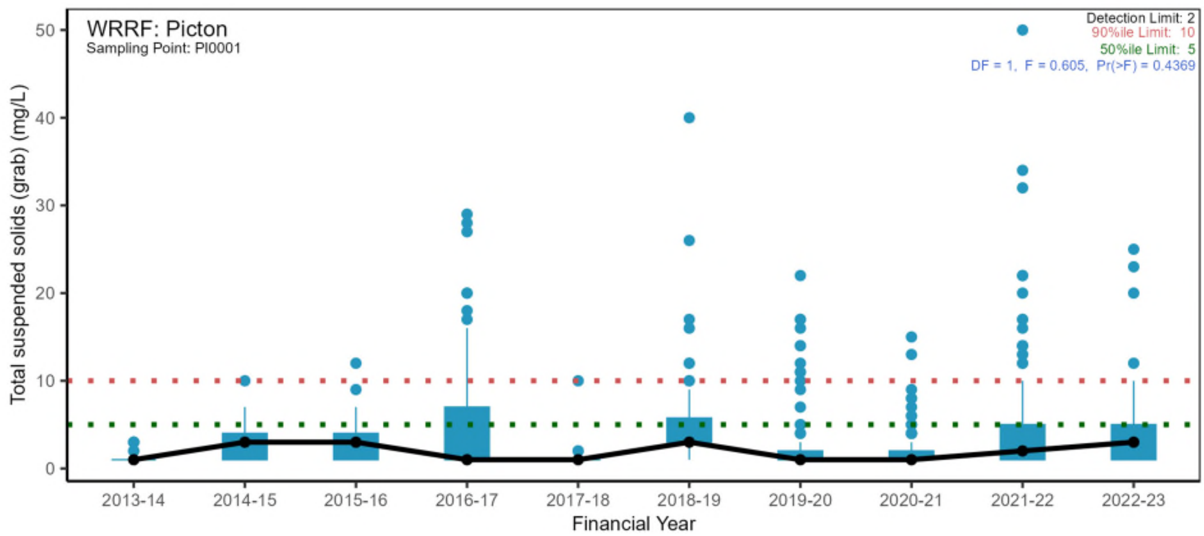


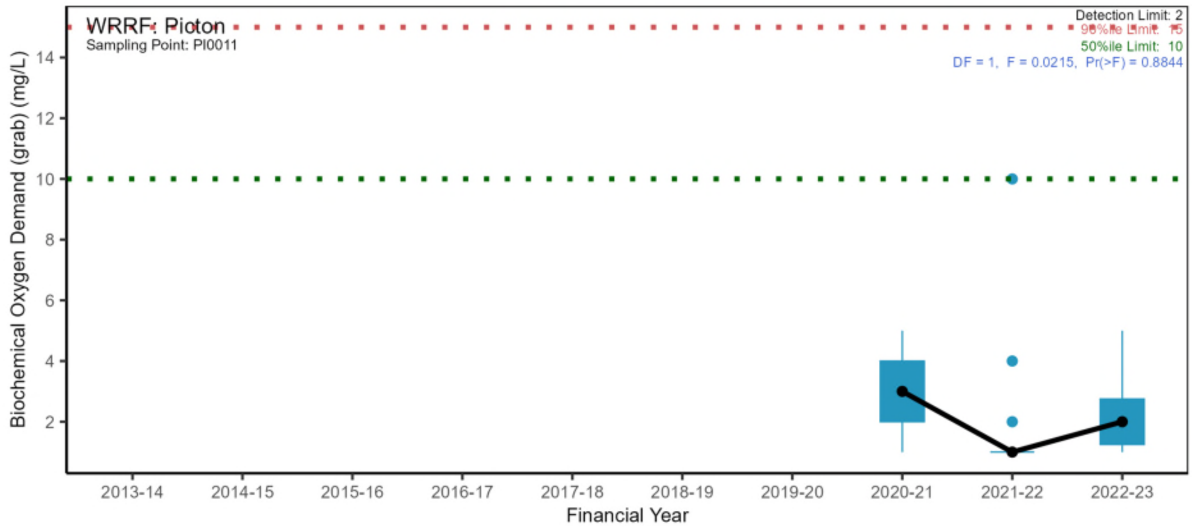


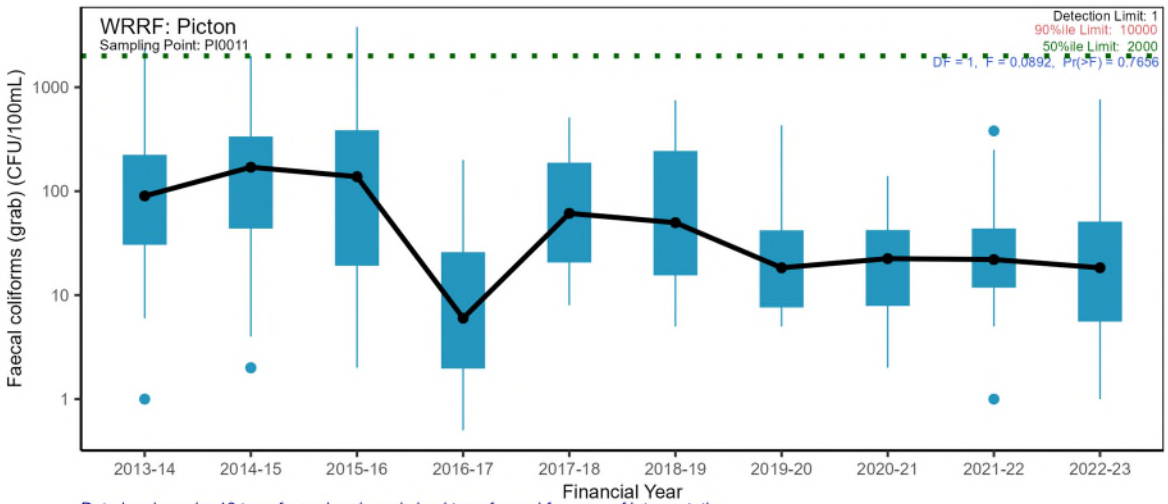
Major conventional analytes: PI0001 Precautionary discharge



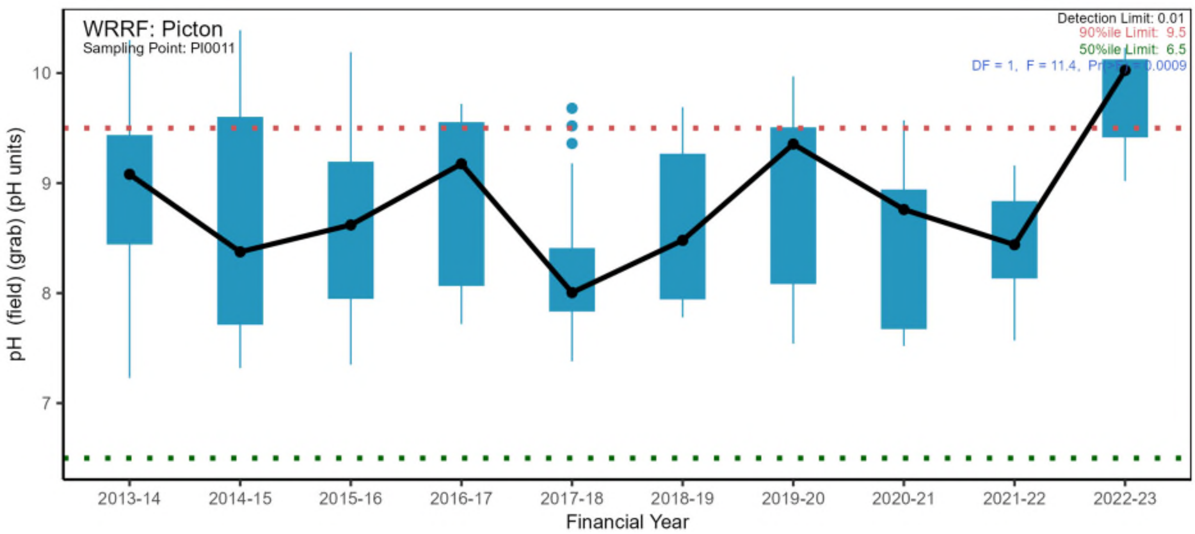


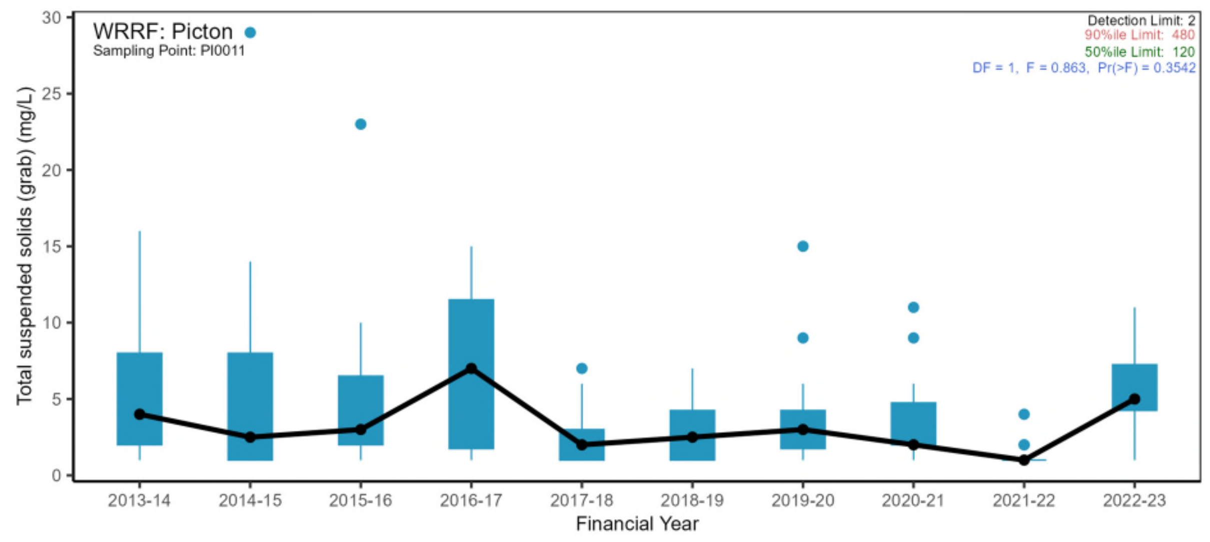




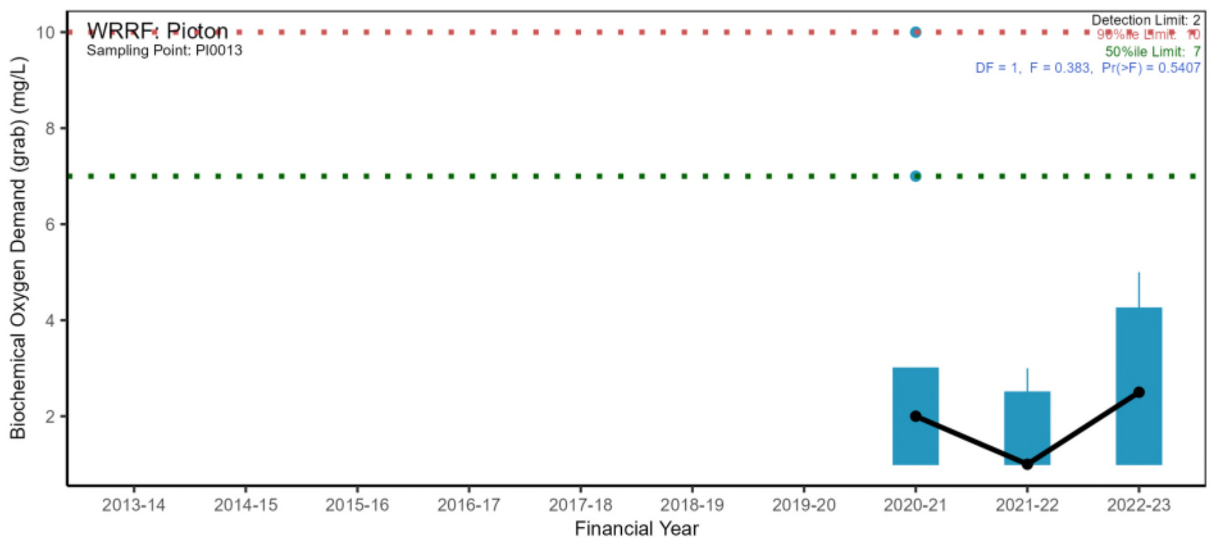


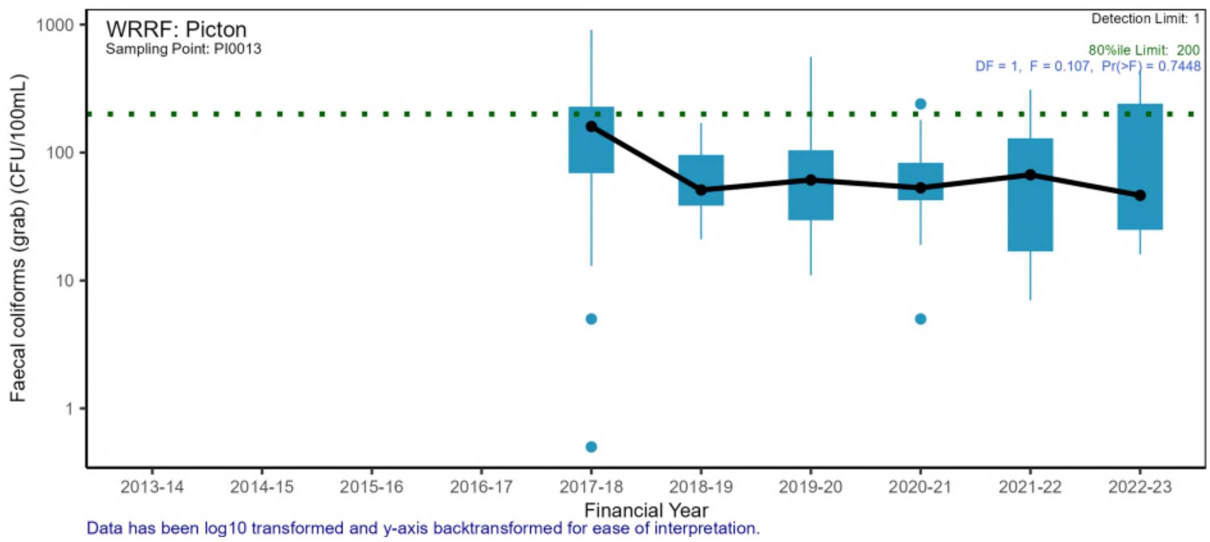
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

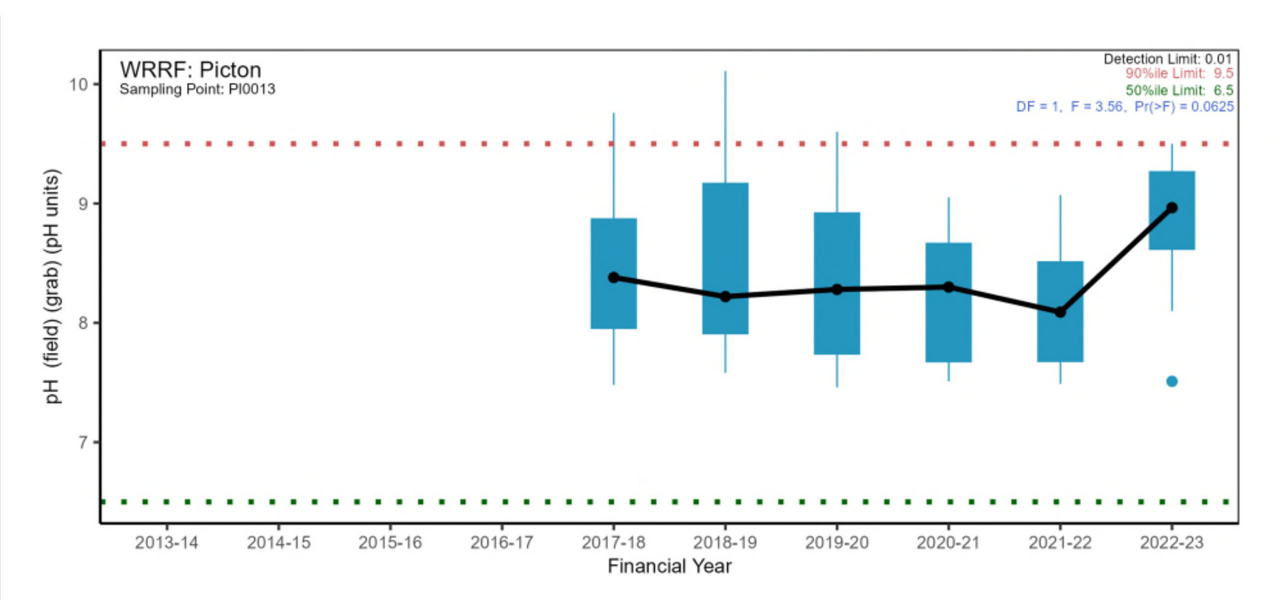


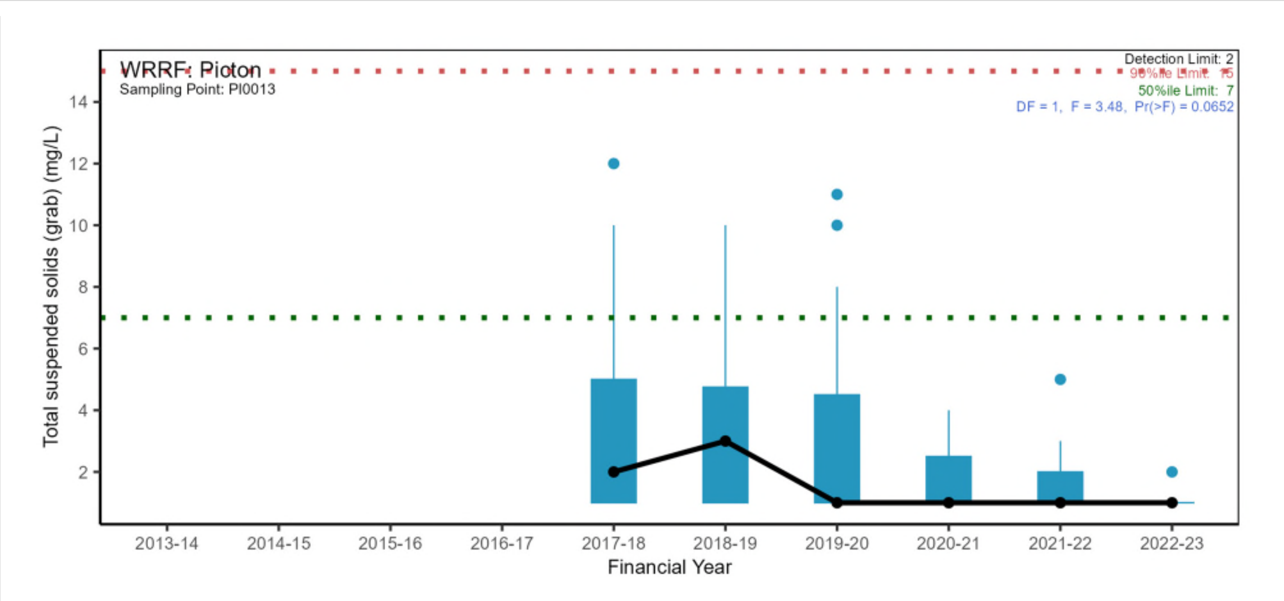


Major conventional analytes: PI0013 Irrigation







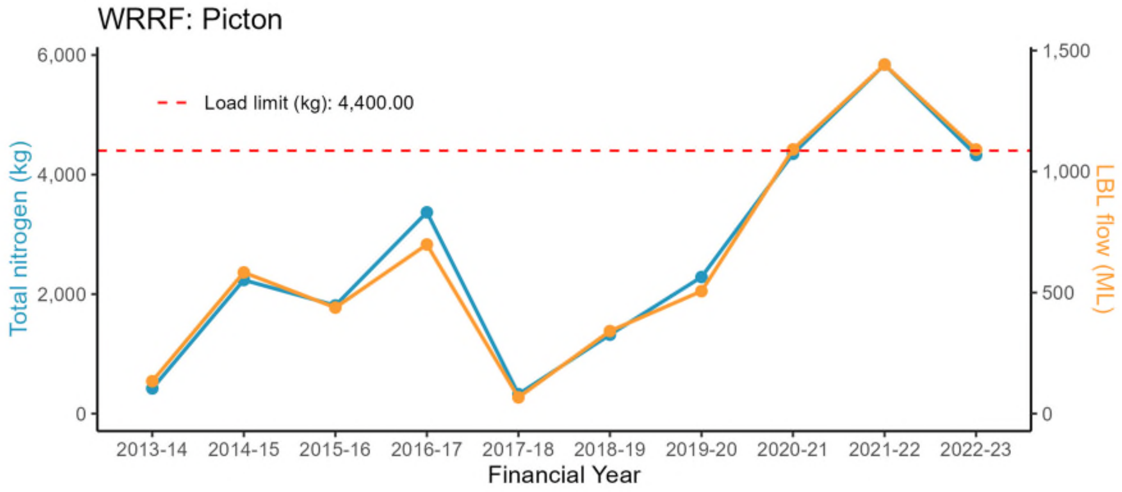


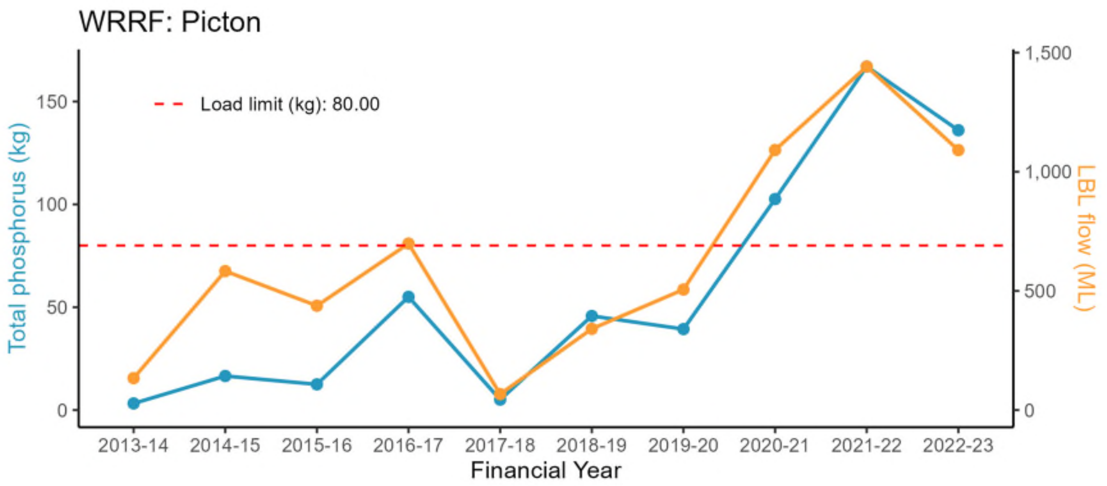
A-1.3 Pressure – Wastewater toxicity

No toxicity monitoring requirement at Picton WRRF

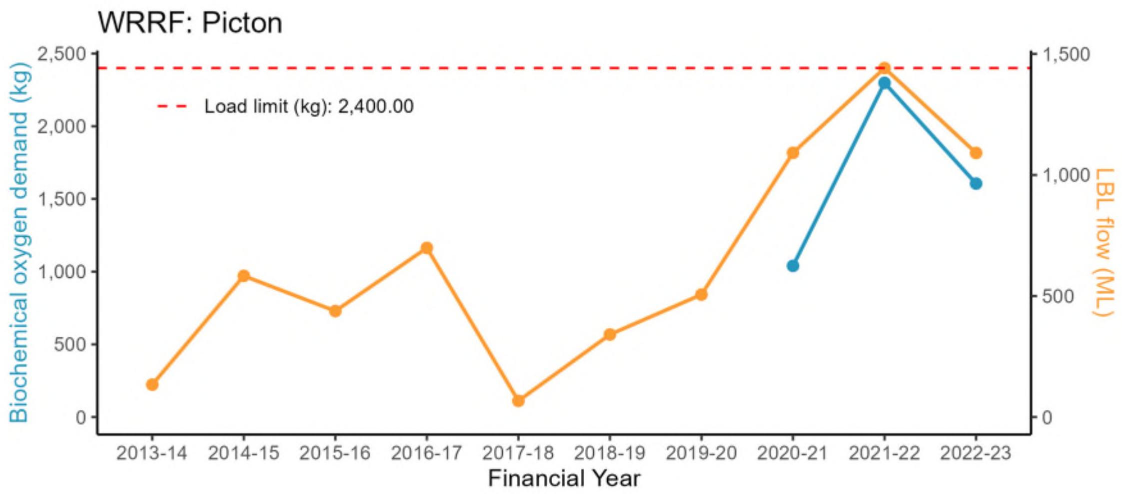
A-1.4 Pressure – Wastewater discharge load

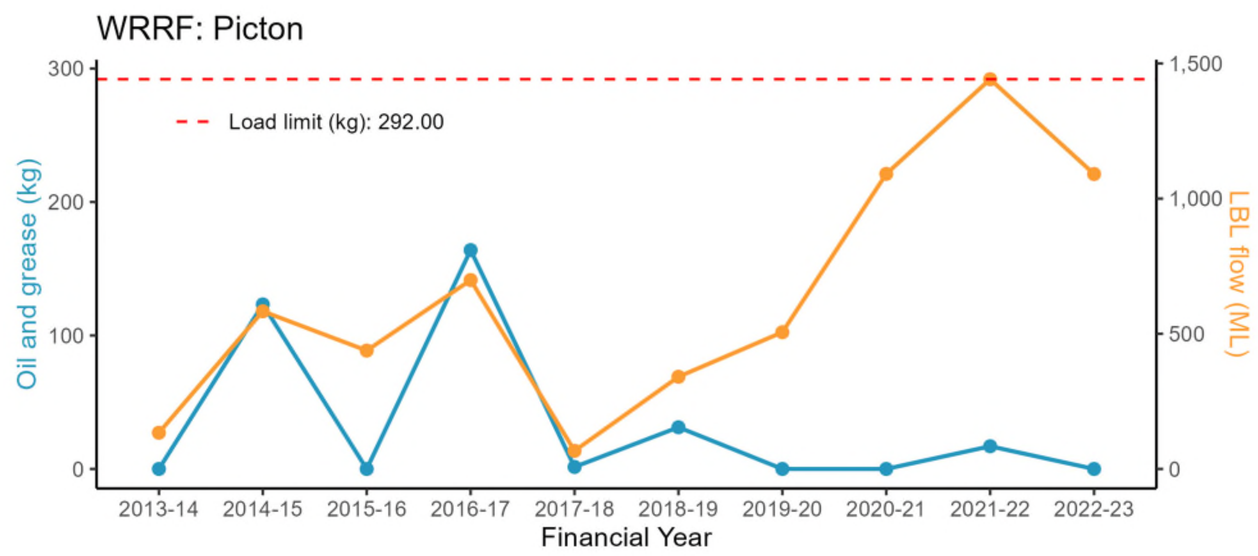
Nutrients





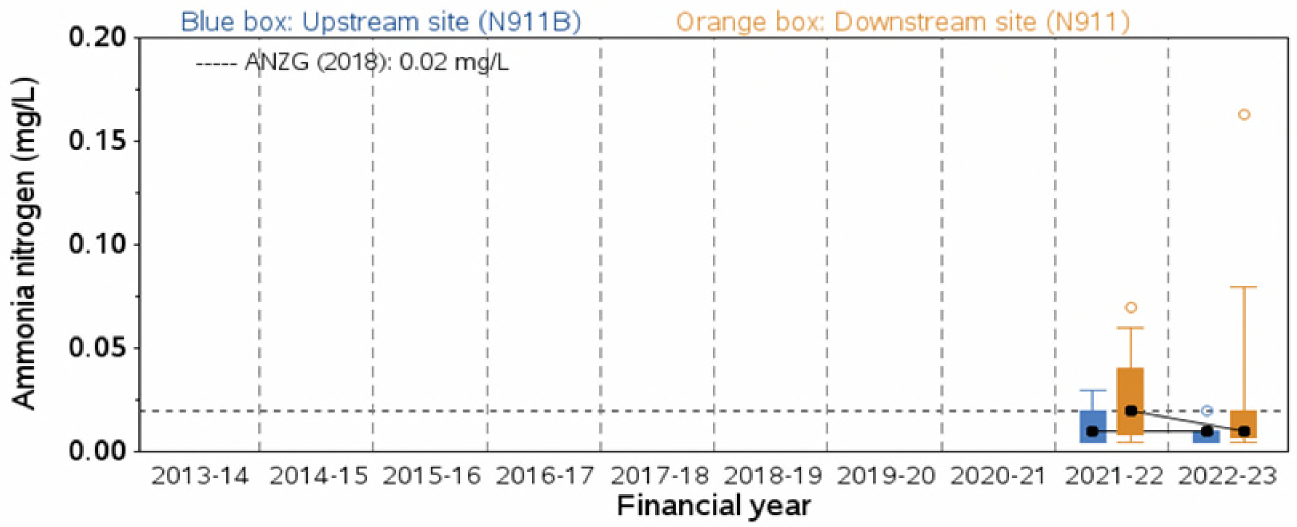
Major conventional analytes




WRRF: Picton
Load limit (kg): 292.00
Oil and grease (kg)
LBL flow (ML)
300
200
100
0
1,500
1,000
500
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Picton
Load limit (kg): 2,400.00
Total suspended solids (kg)
LBL flow (ML)
7,500
5,000
2,500
0
1,500
1,000
500
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

A-1.5 Stressor – Nutrients



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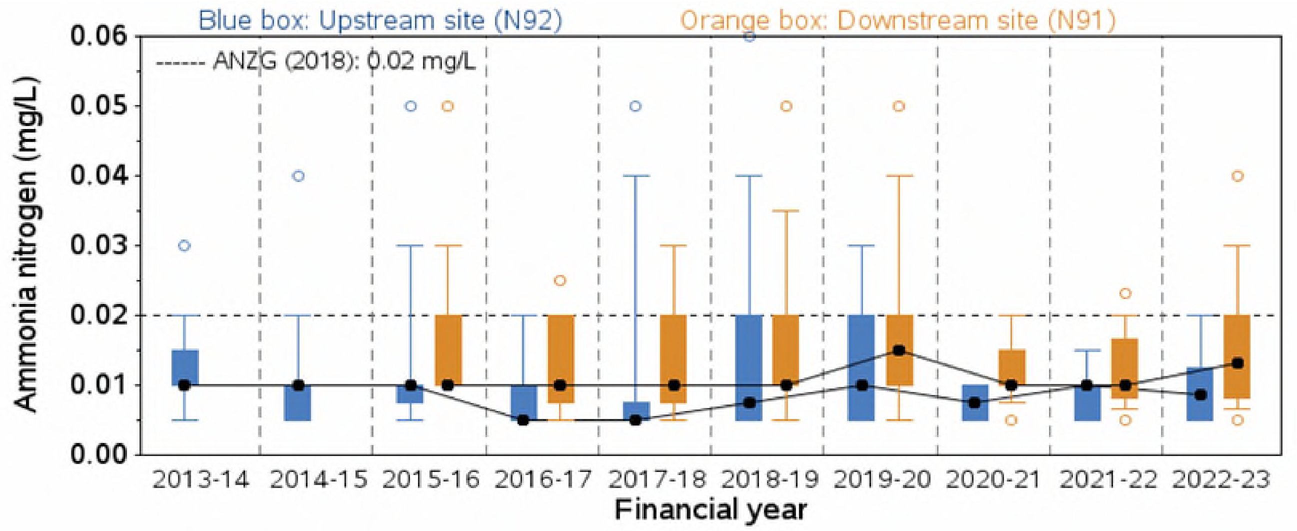
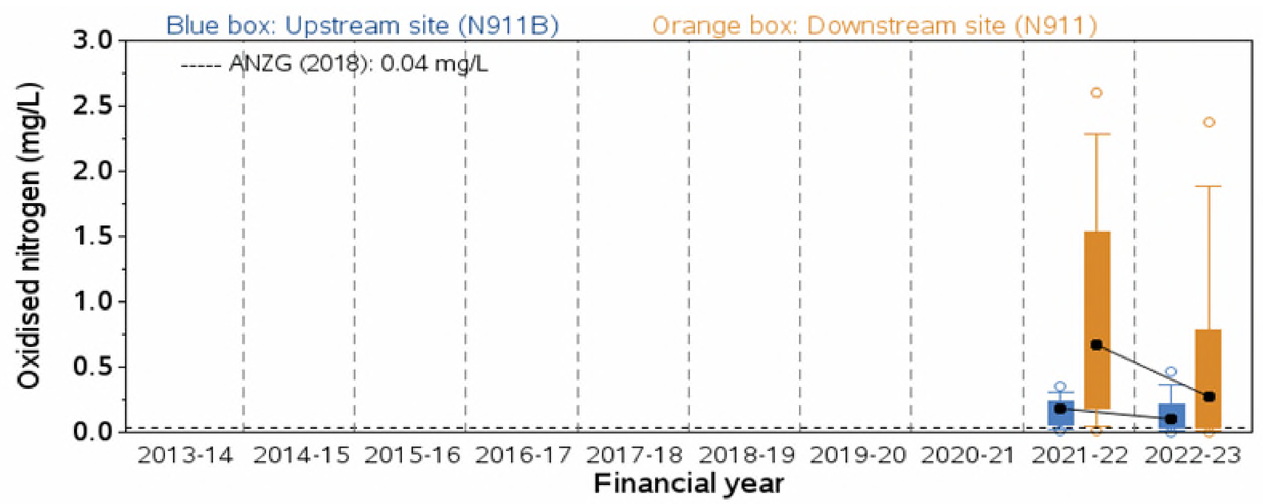
N911B	1	4.06	0.052	N911	1	0.01	0.9275



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N92	1	0.64	0.4266	N91	1	0.11	0.7379



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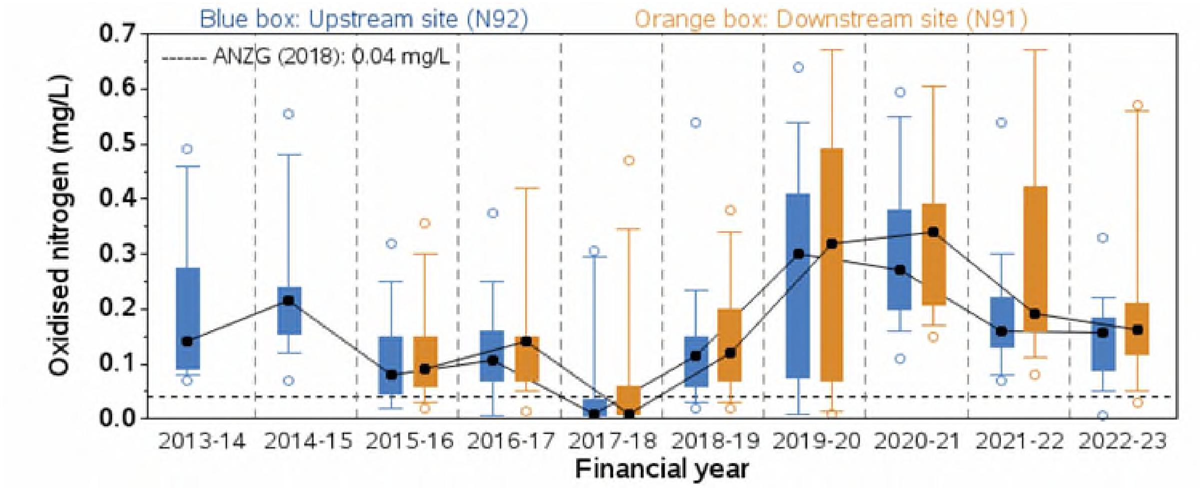
N911B	1	0.28	0.6031	N911	1	0.78	0.3831



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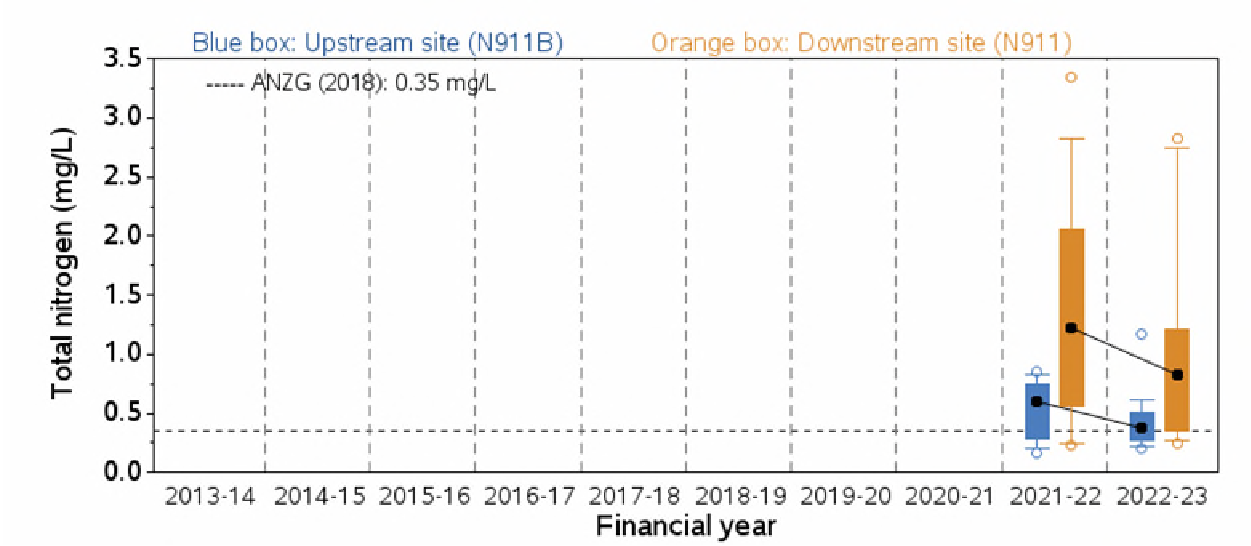
N92	1	0.86	0.3543	N91	1	0	0.989



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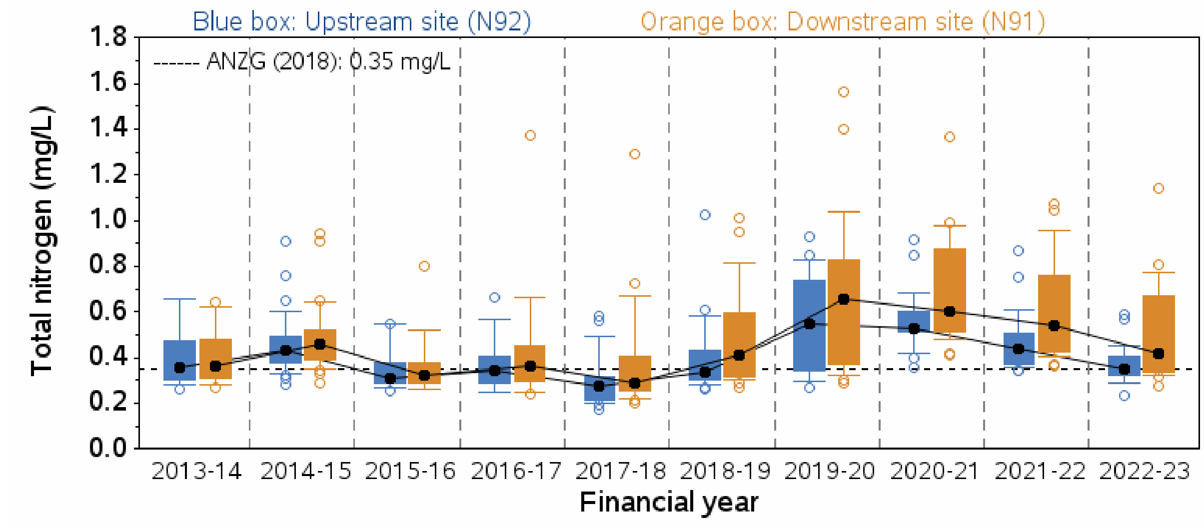
N911B	1	1.88	0.1801	N911	1	1.02	0.3206



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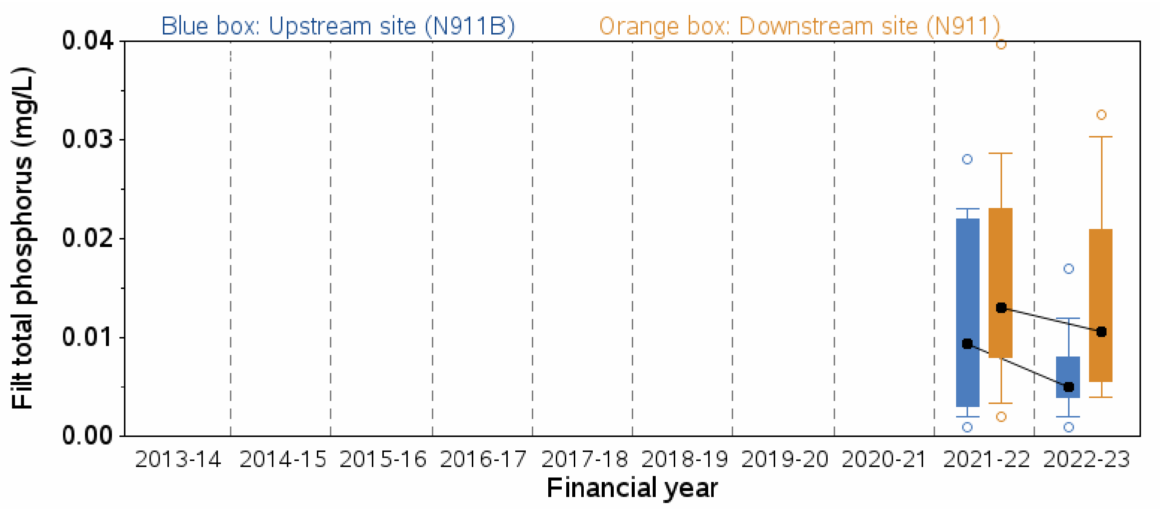
N92	1	2.91	0.09	N91	1	0.11	0.7411



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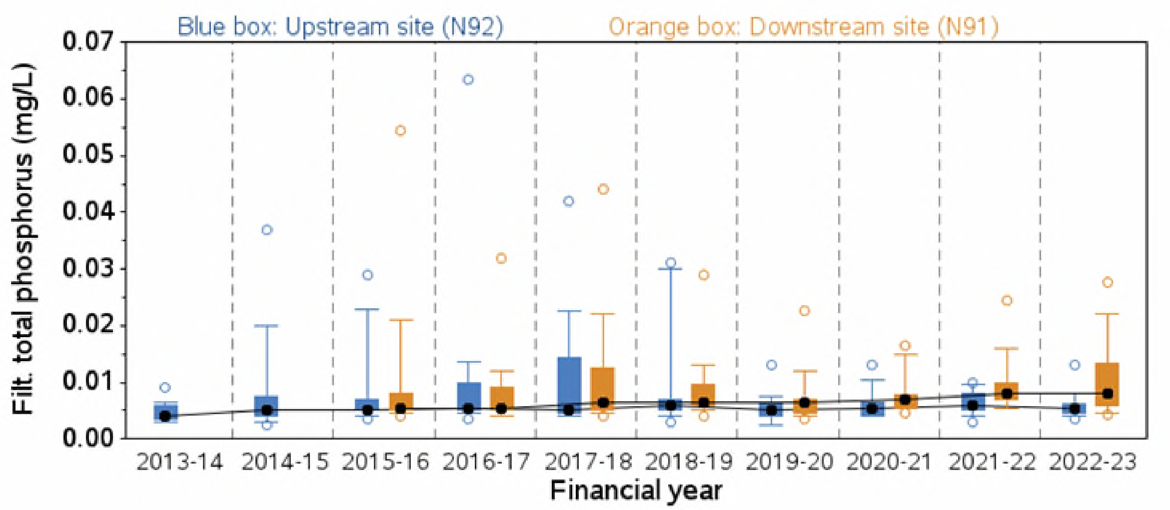
N911B	1	5.38	0.0267	N911	1	0.39	0.5362



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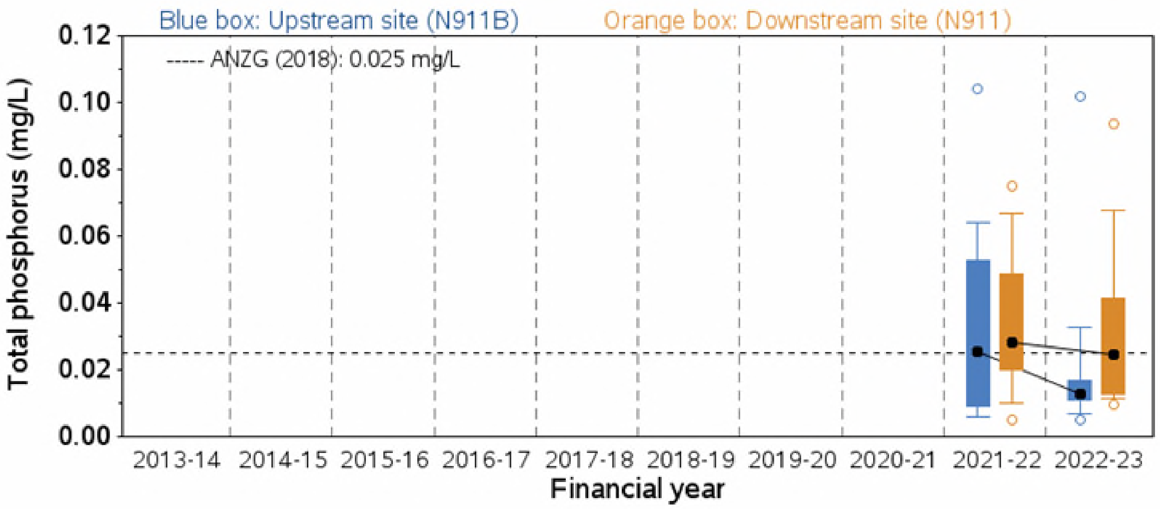
N92	1	0.88	0.3506	N91	1	1.37	0.2432



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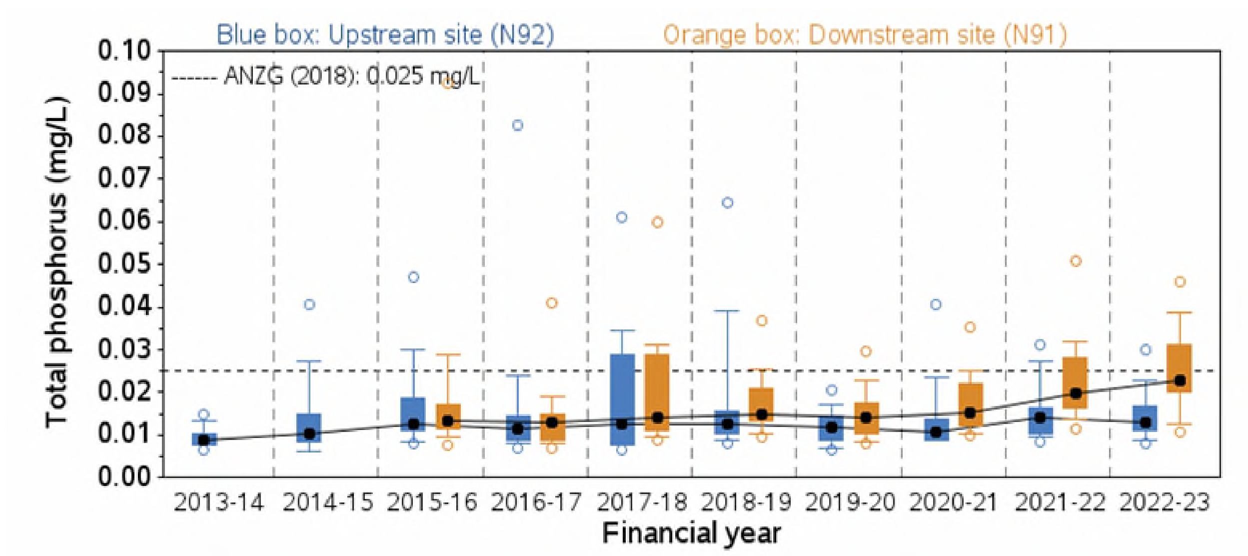
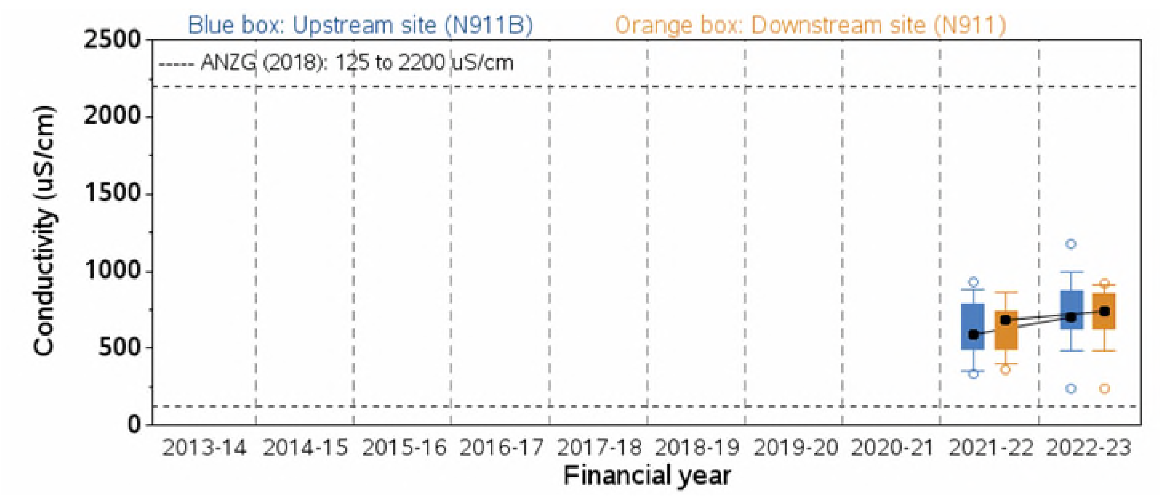
N911B	1	2.82	0.1028	N911	1	0.2	0.6615



Site	DF	F Value	Pr>F	Site	DF	F Value	Pr>F
N92	1	0	0.9447	N91	1	6.82	0.01

A-1.6 Stressor – Physico-chemical water quality



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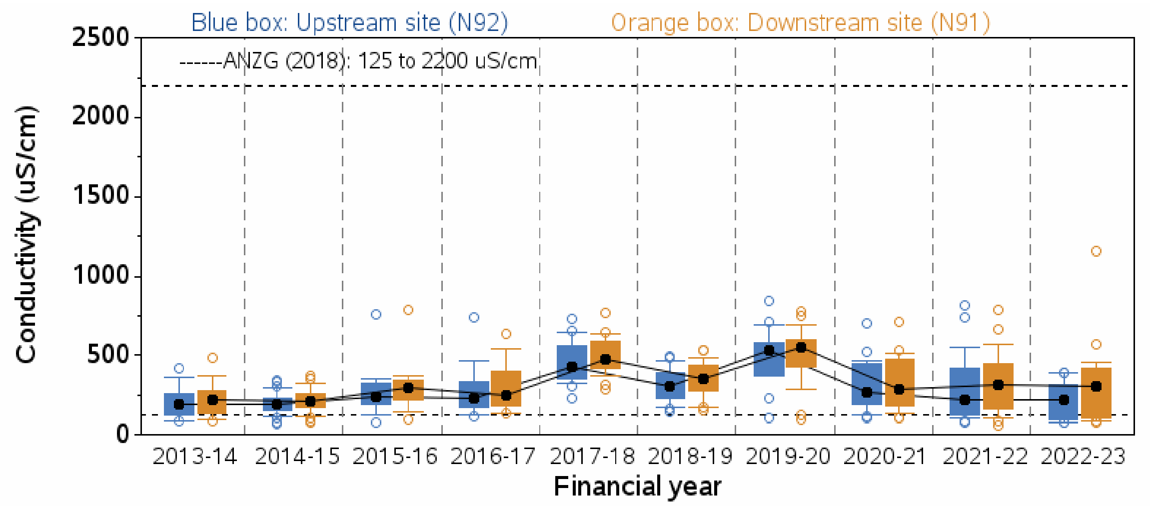
N911B	1	2.94	0.0959	N911	1	1.7	0.2011



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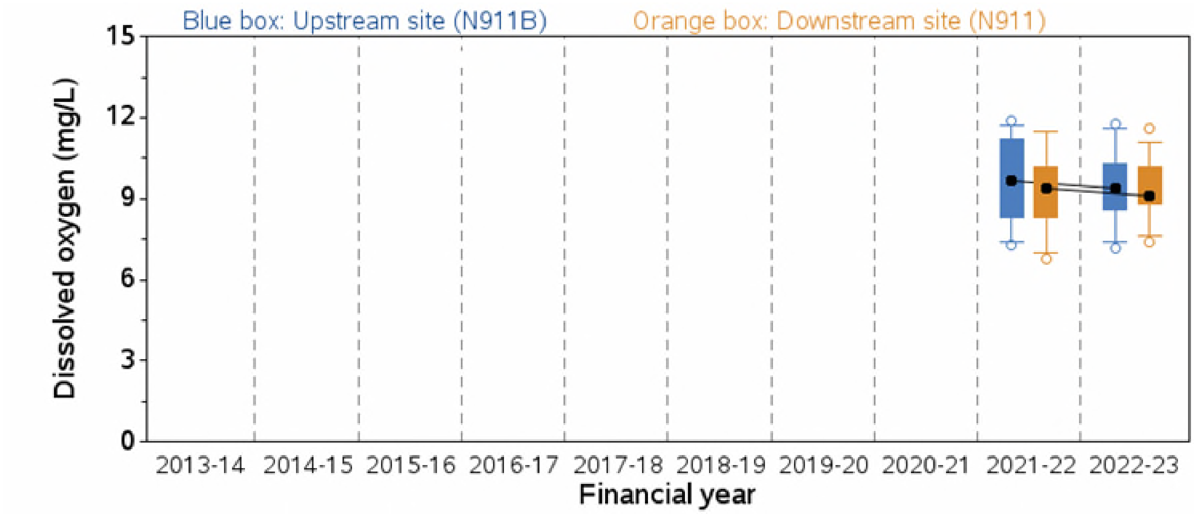
N92	1	4.2	0.042	N91	1	1.48	0.2262



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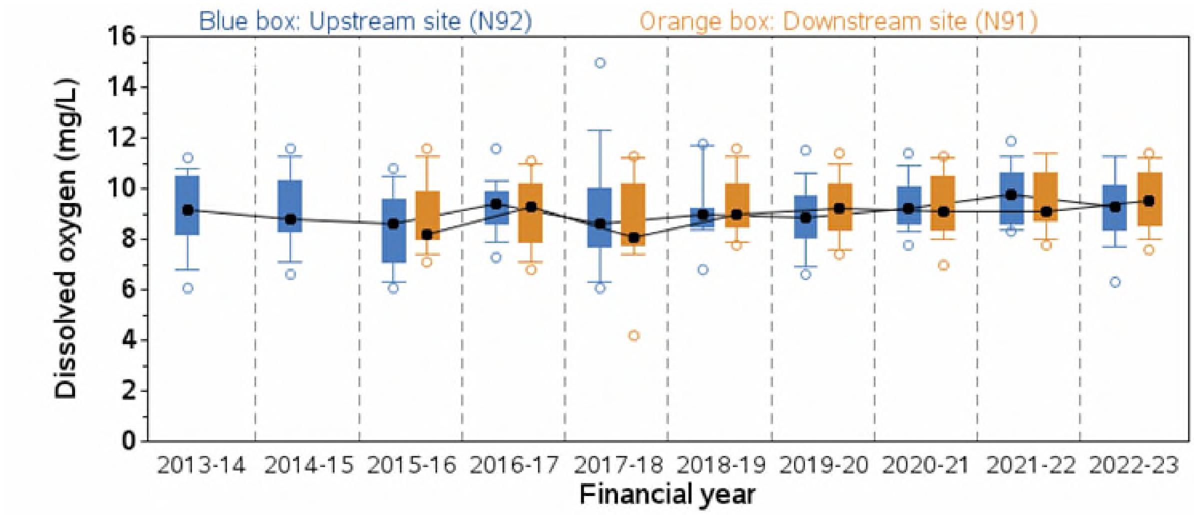
N911B	1	0.08	0.7759	N911	1	0.01	0.9357



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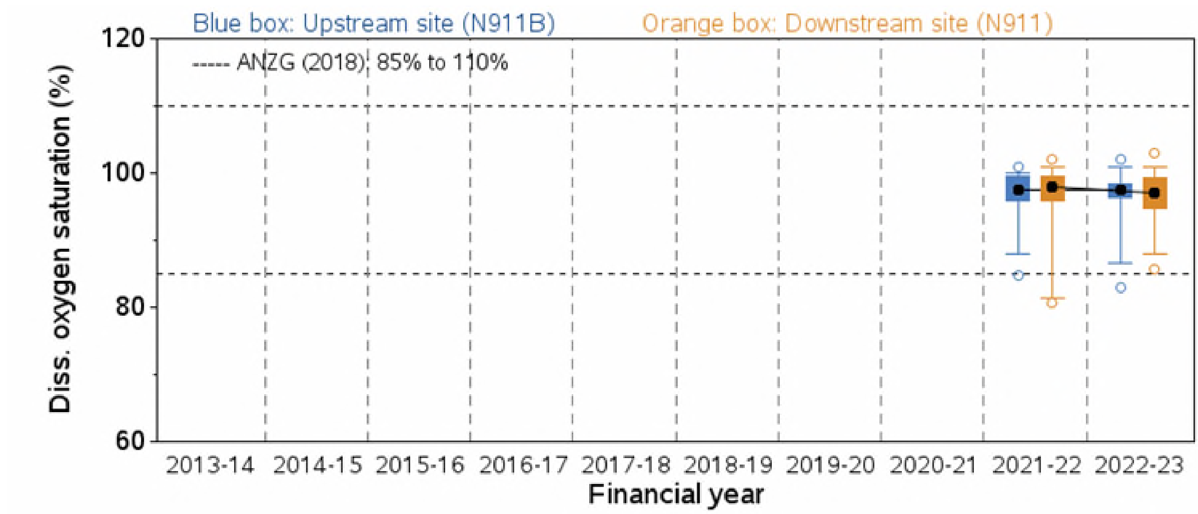

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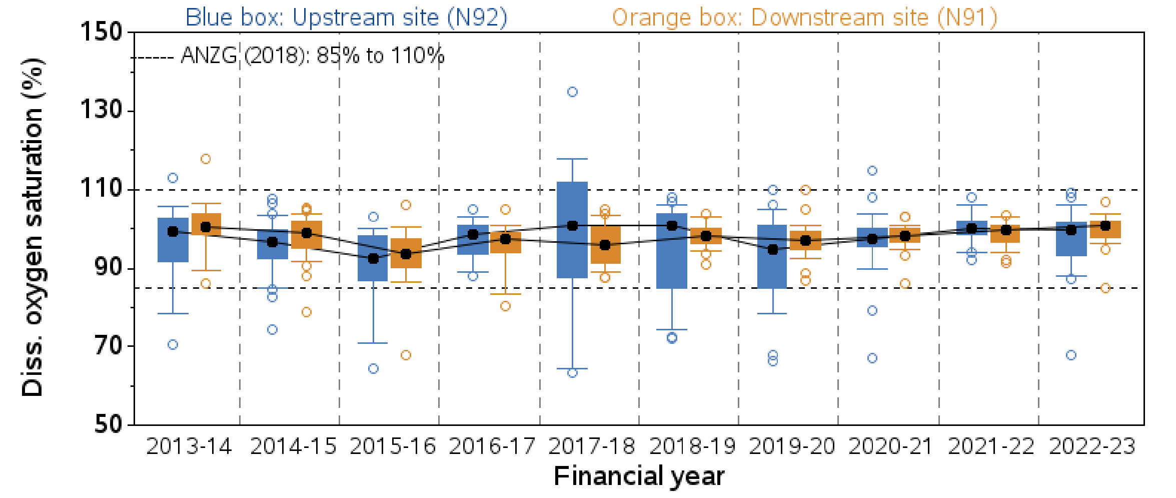

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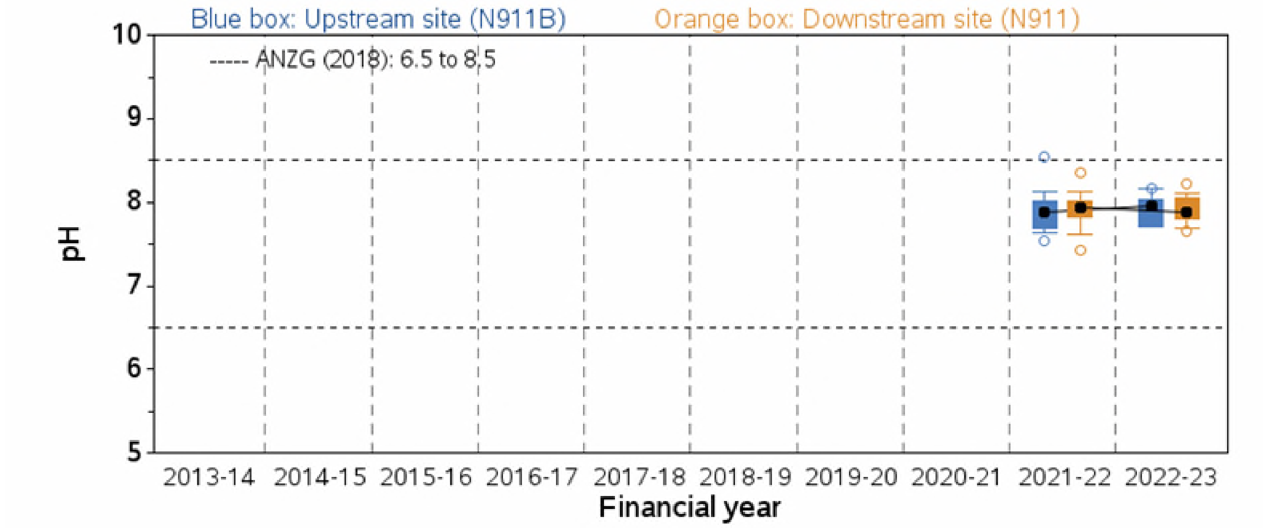
N92	1	0.08	0.7758	N91	1	8.53	0.0041



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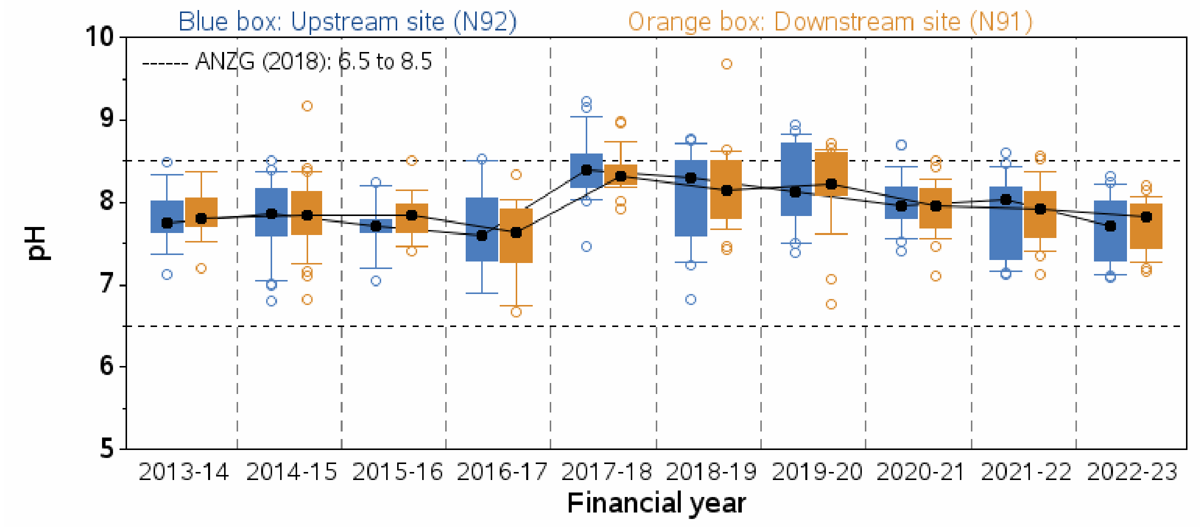
N911B	1	0.3	0.5878	N911	1	0	0.9643



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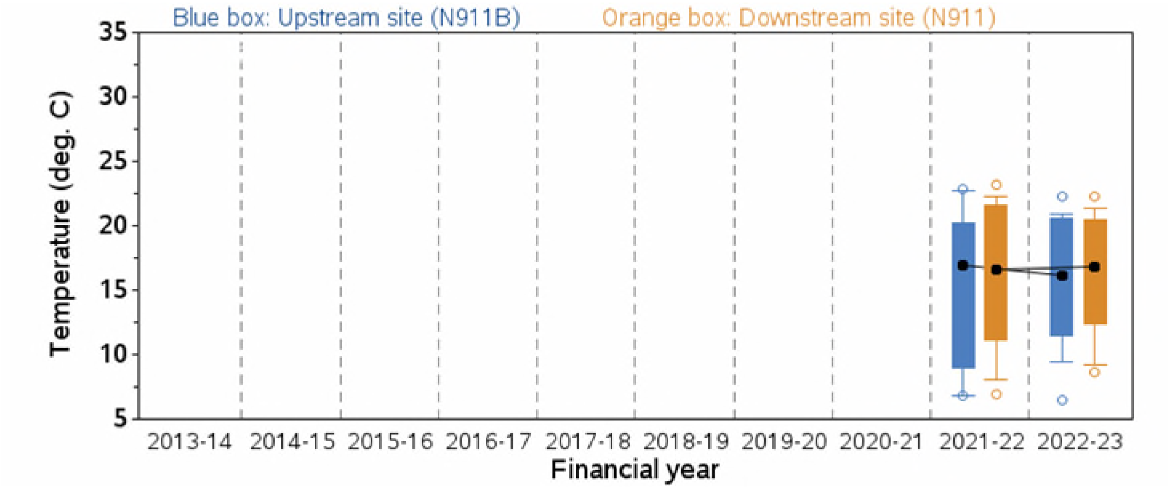
N92	1	6.68	0.0106	N91	1	7.24	0.008



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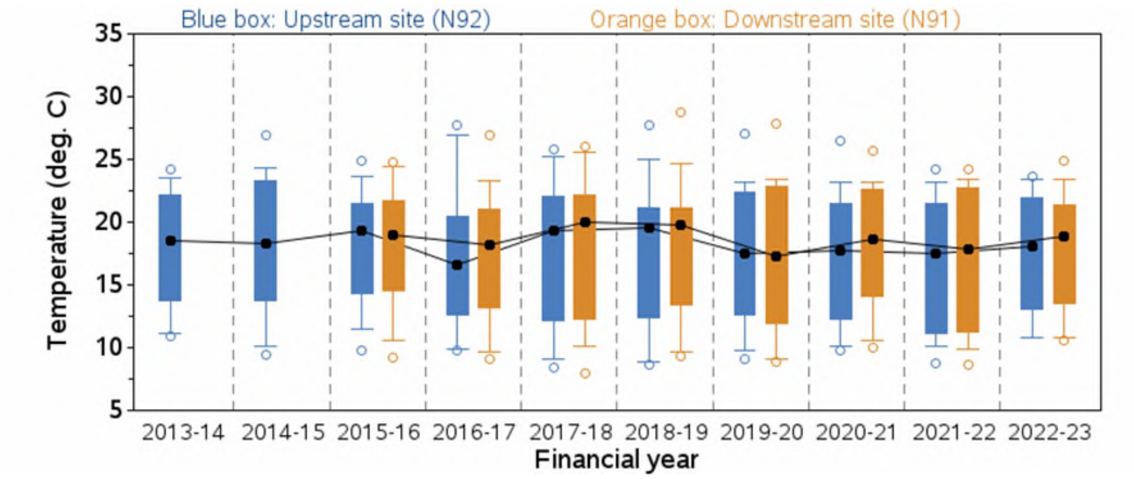
N911B	1	0.01	0.9243	N911	1	0.01	0.9365



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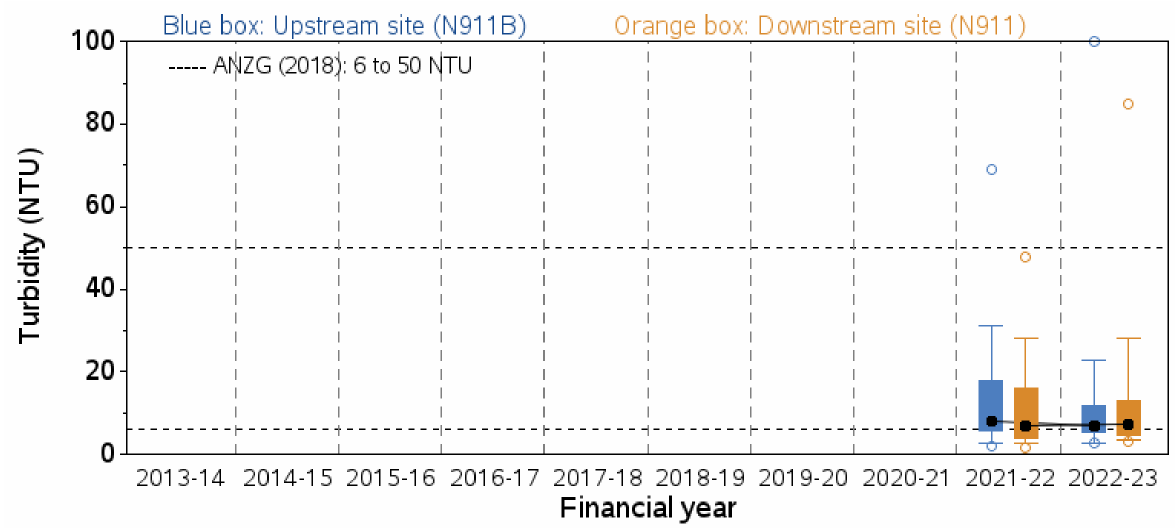
N92	1	0.04	0.8481	N91	1	0.04	0.8504



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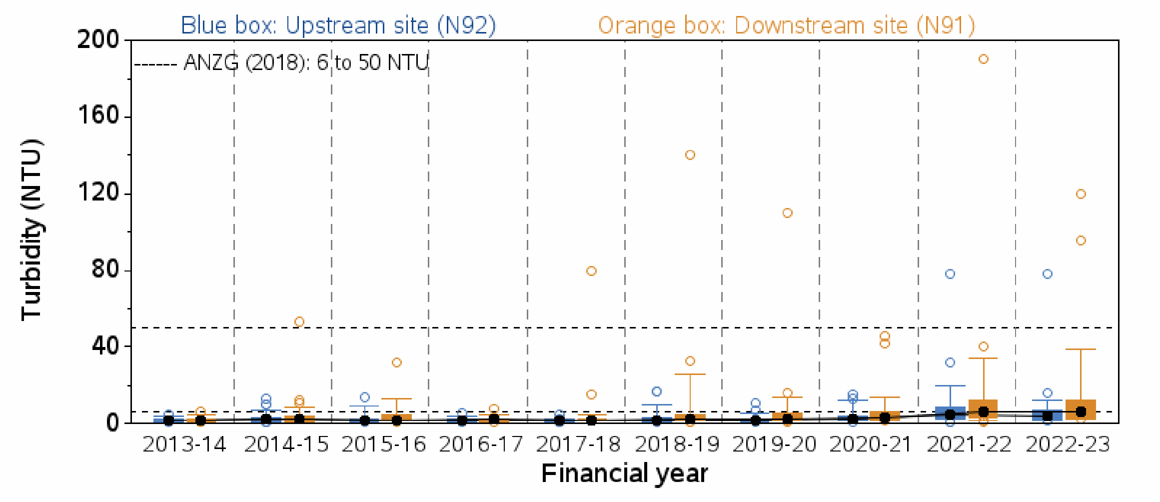
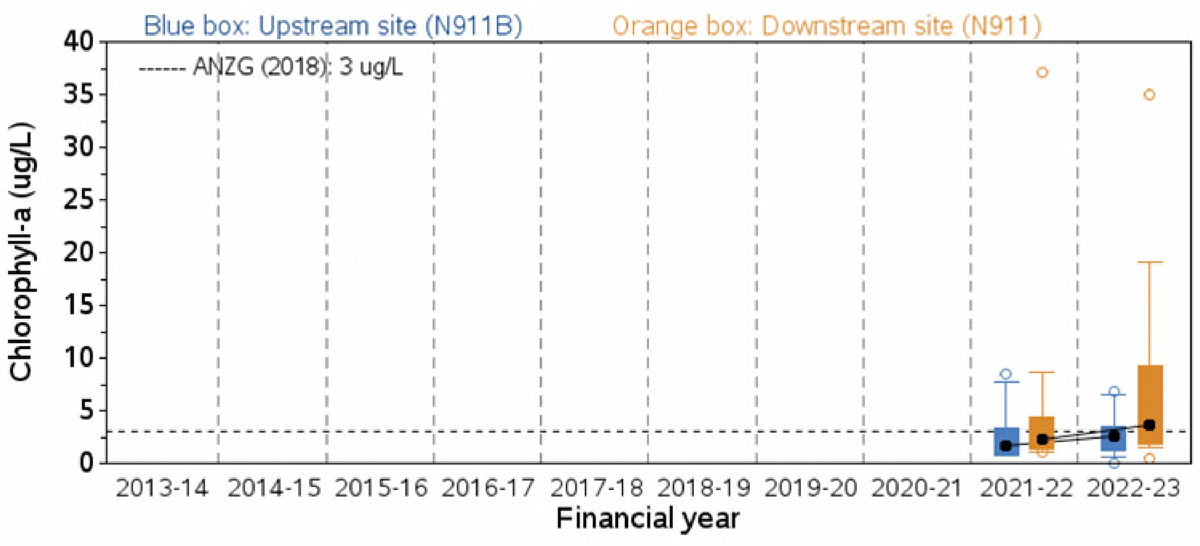


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N92	1	4.31	0.0394	N91	1	4.52	0.0353

A-1.7 Ecosystem receptor – Phytoplankton



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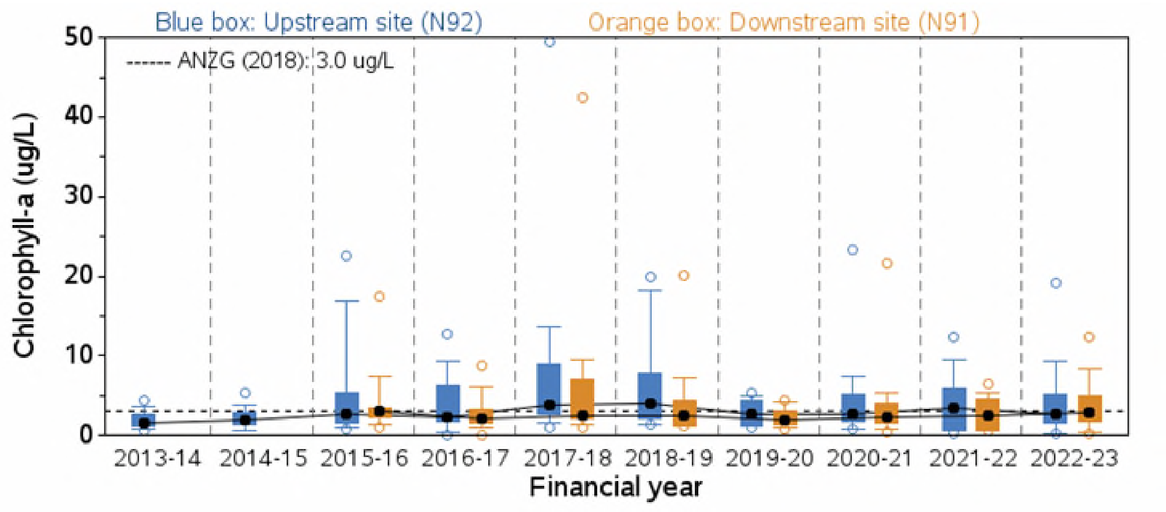
N911B	1	0.09	0.7653	N911	1	0.66	0.4214



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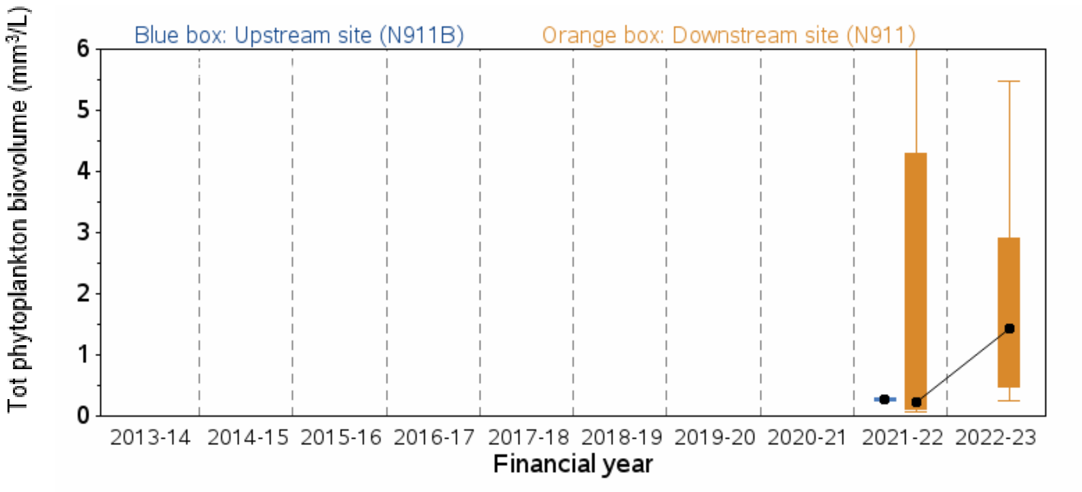

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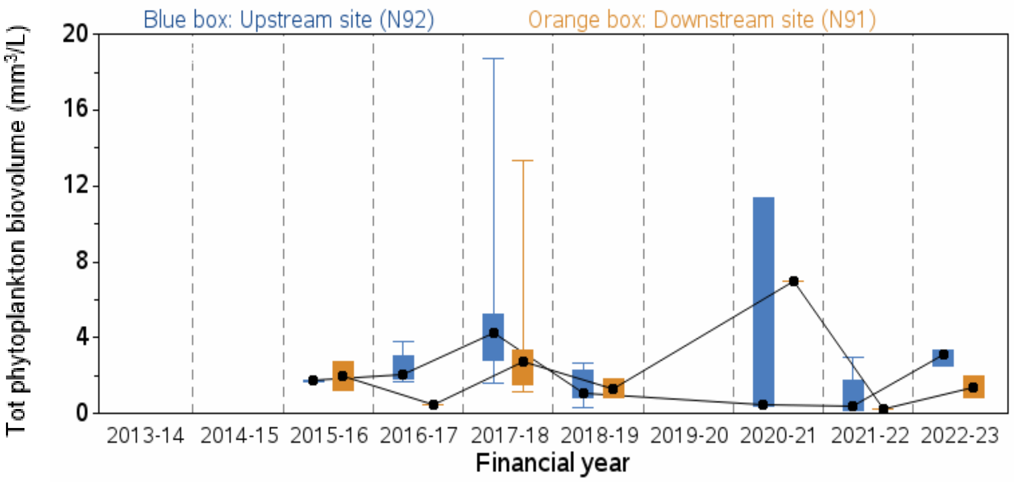
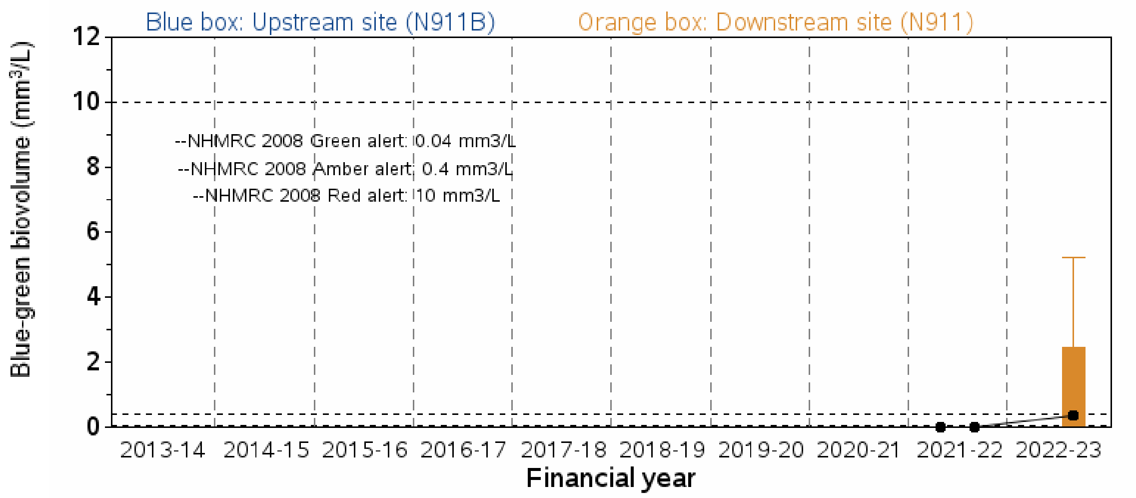
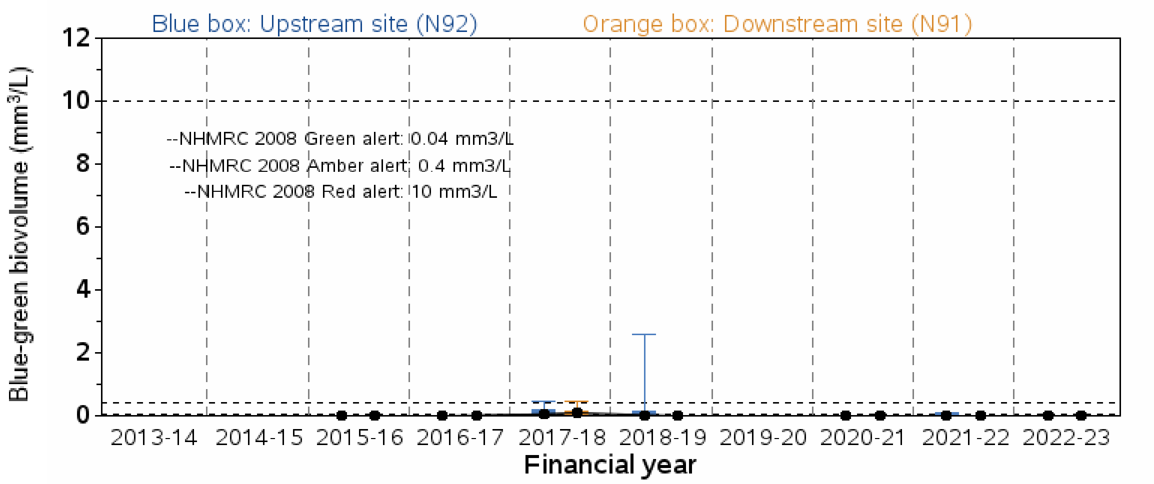


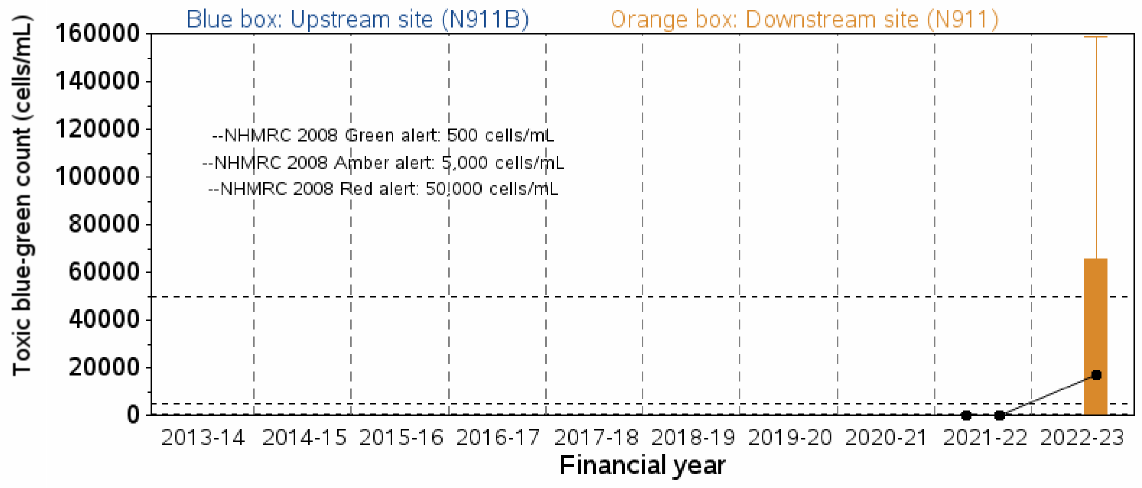
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N92	1	0	0.9996	N91	1	0.45	0.51



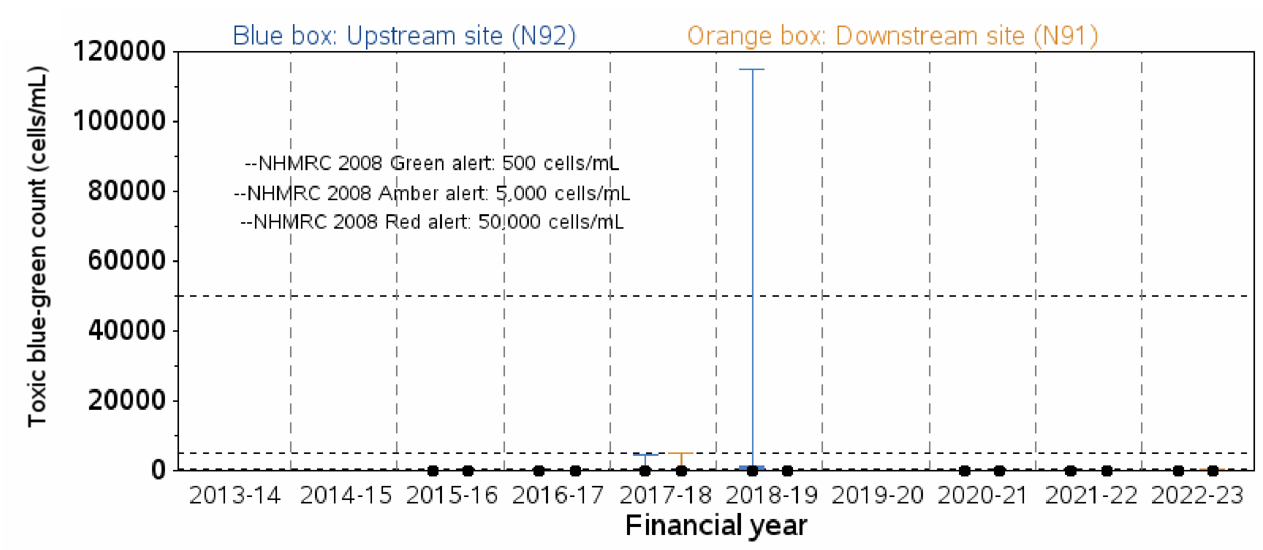
Site	DF	F Value	Pr>F	Site	DF	F Value	Pr>F
N911B	Insufficient data			N911	1	1.74	0.2236



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N92	1	0.23	0.6341	N91	1	0.46	0.5076



Site	DF	F Value	Pr>F	Site	DF	F Value	Pr>F
N911B	Insufficient data			N911	1	1.81	0.2151



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N92	1	0.13	0.7215	N91	1	0.12	0.7339

A-1.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for the Nepean River provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1995 and 2022. This comparison suggests downstream stream health was maintained at a level comparable to that of the upstream site recorded over the 1995 to 2022 period, with an improving trend in recent years, indicating wastewater discharge from Picton WRRF did not have a measurable negative impact on stream health during 2022-23 (Figure A-1).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under t-tests returned non-significant test outcomes (Table A-1) and confirmed the visual trend for 2022-23.

As no measurable negative impact on downstream stream health was detected, no further data analysis was undertaken.

Table A-1 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from the Nepean River near Picton WRRF

Waterway	Method	Statistic	DF	P value
Nepean River	Welch Two Sample t-test	-0.50	3.6	0.649

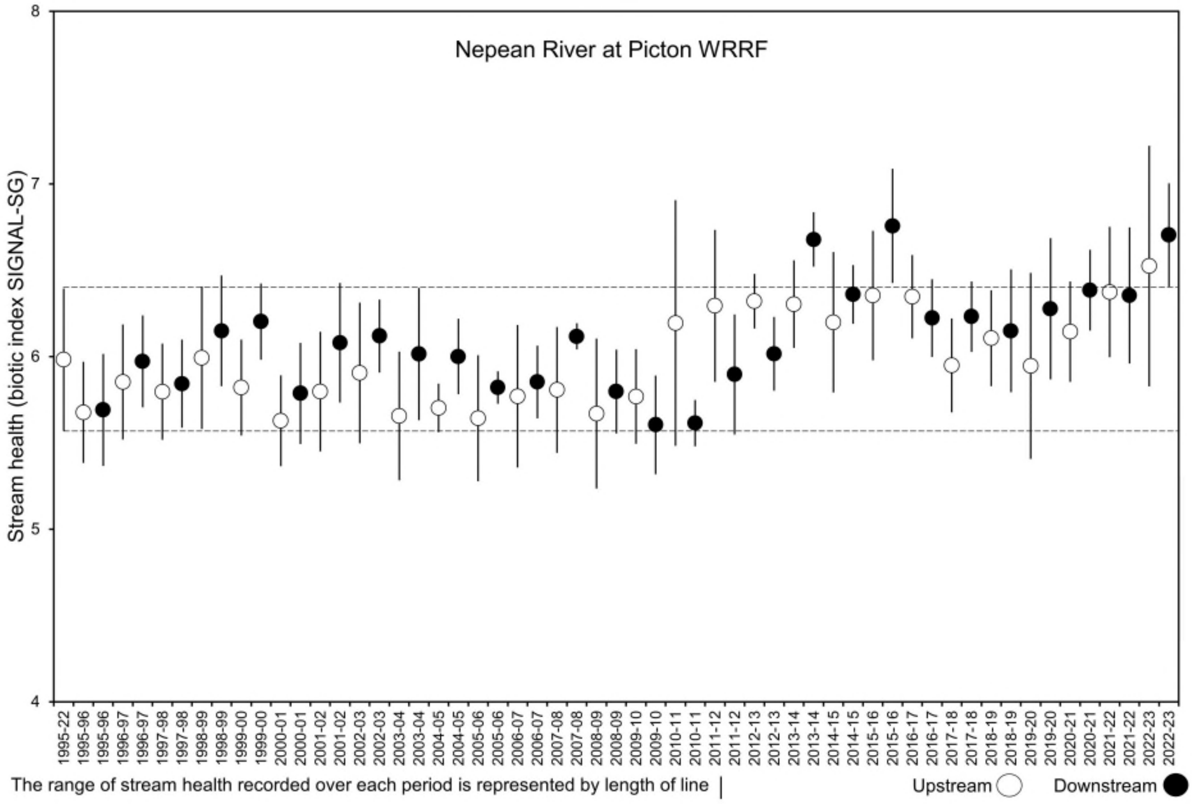
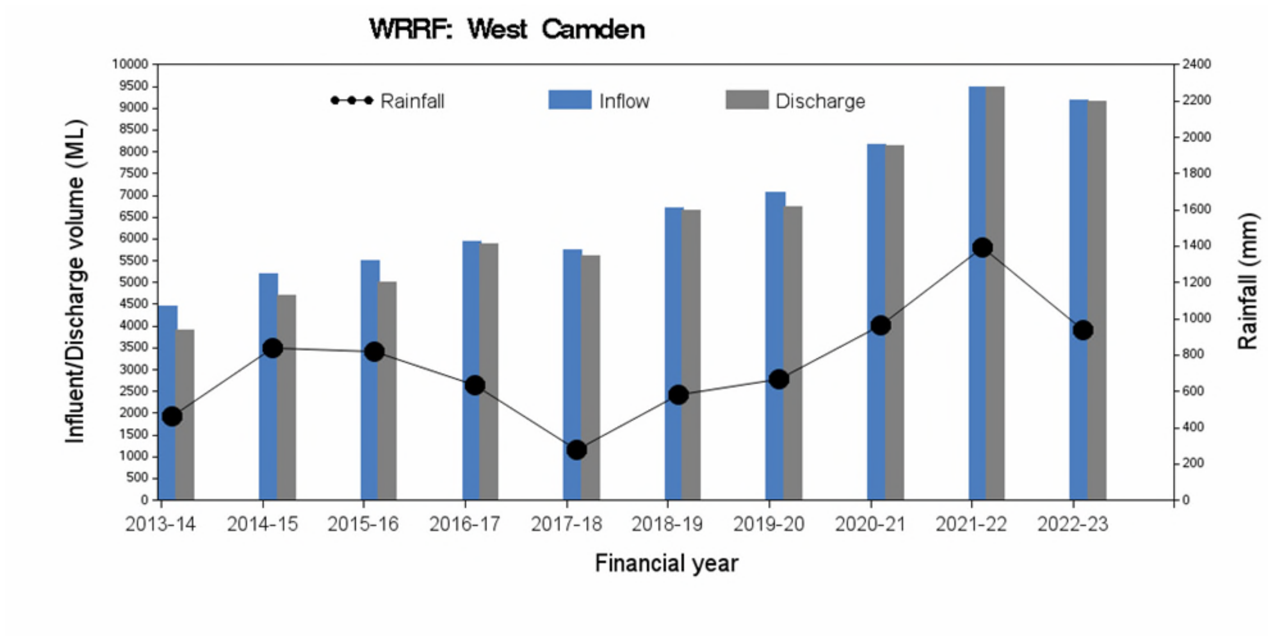


Figure A-1 Stream health of Nepean River near Picton WRRF

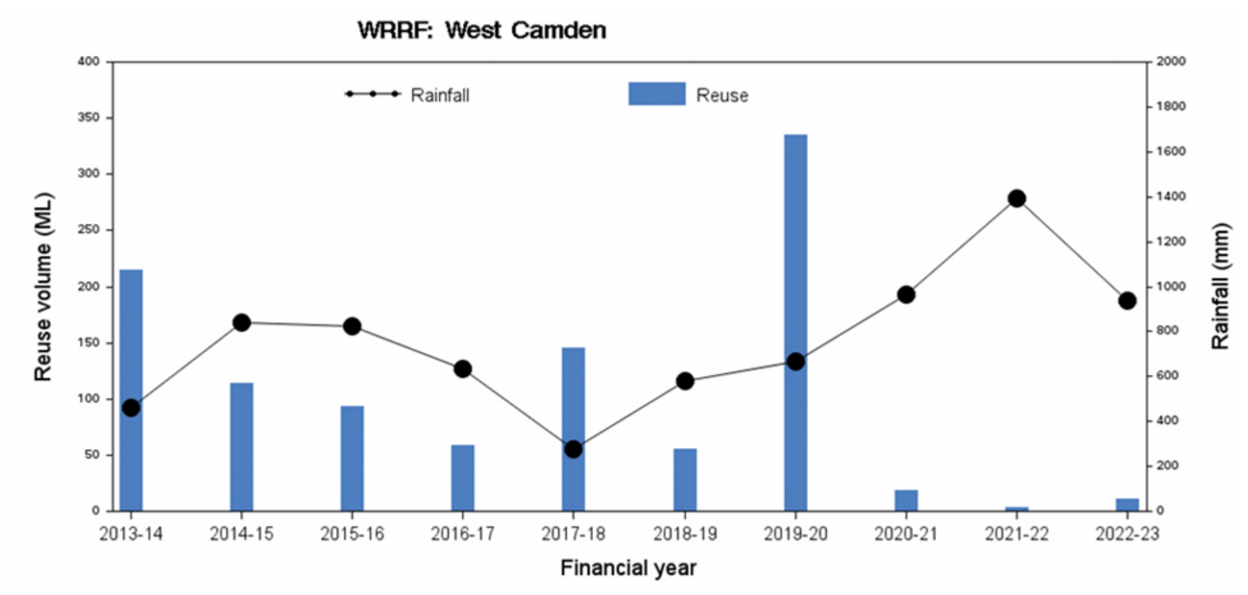
A-2 West Camden WRRF

A-2.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

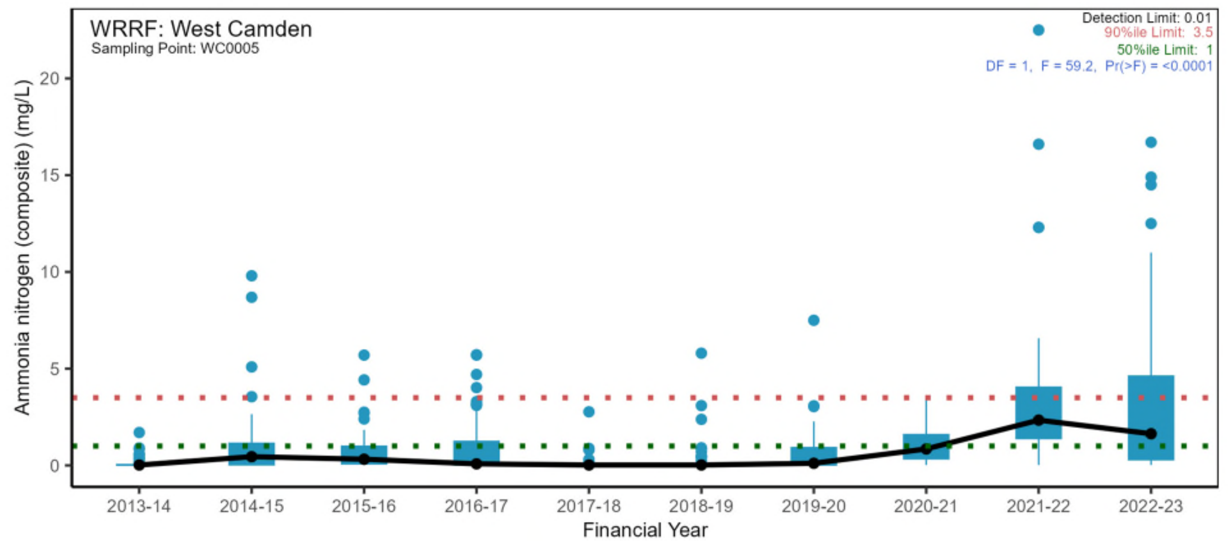


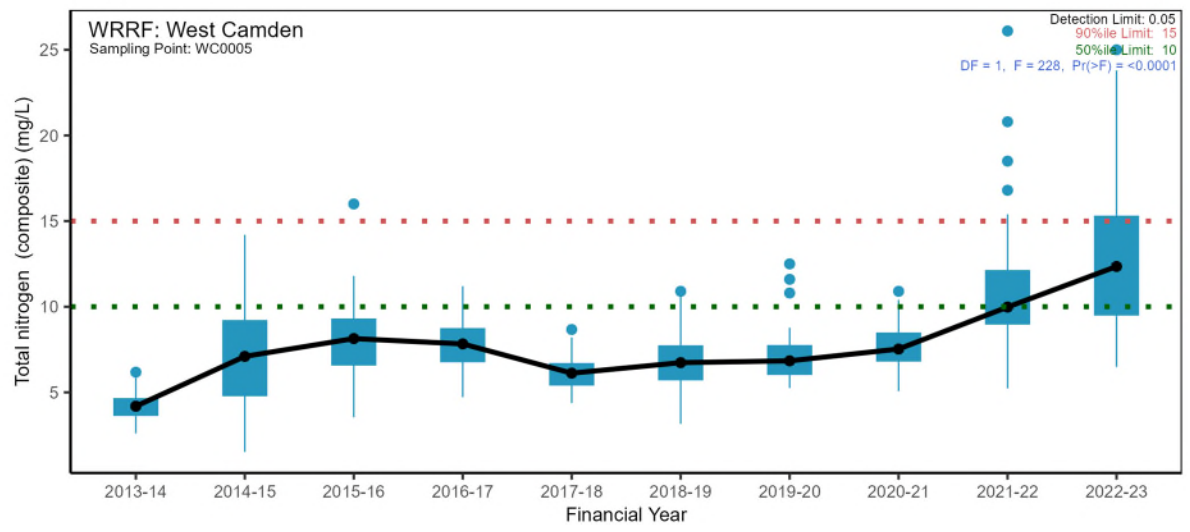
Reuse volume and rainfall

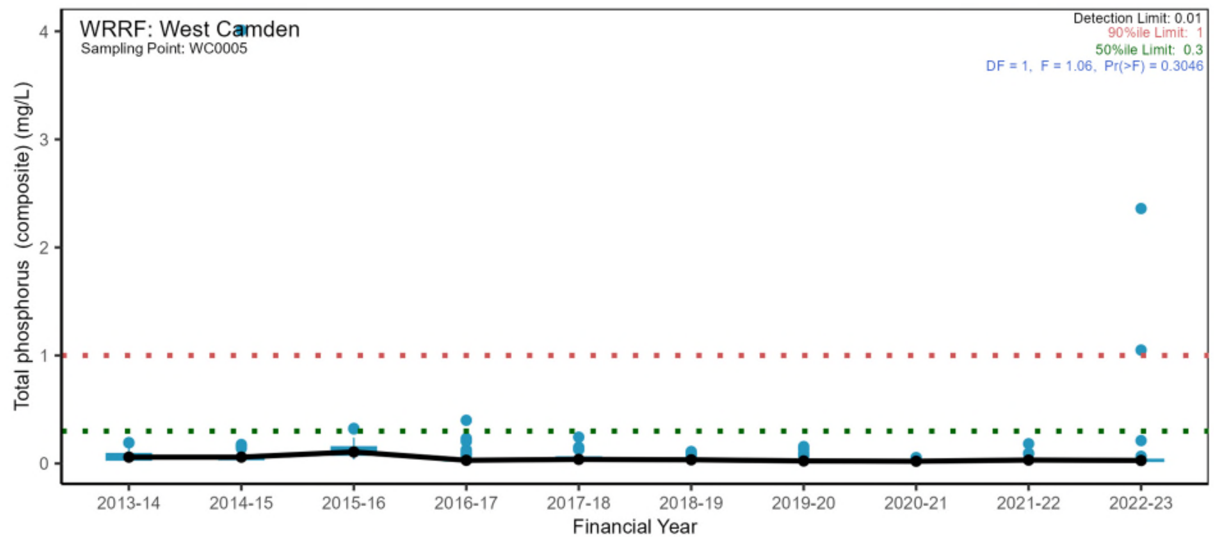


A-2.2 Pressure – Wastewater quality

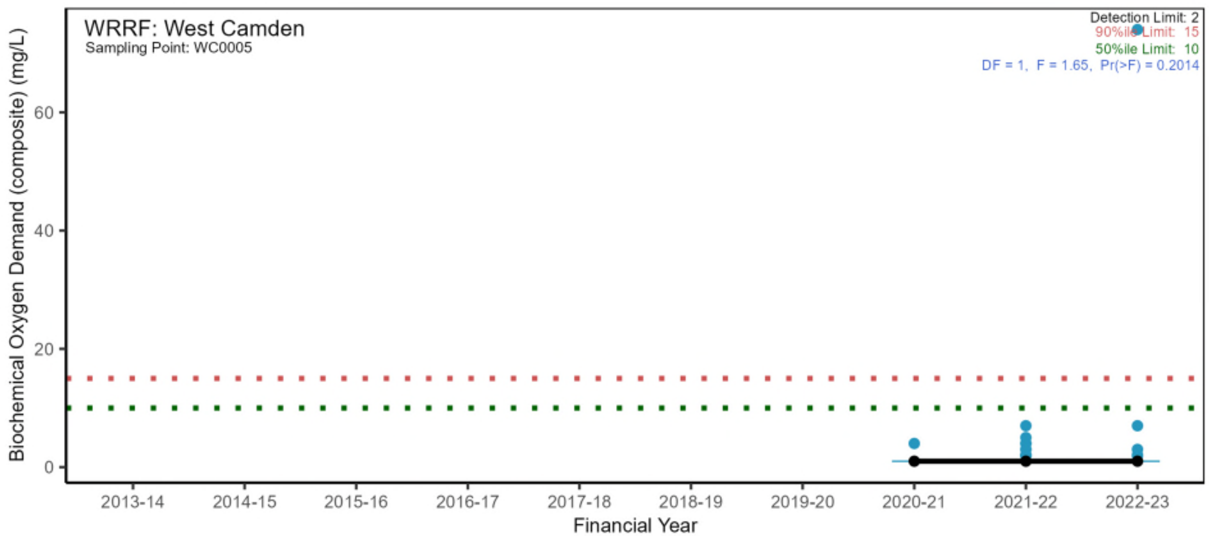
Nutrients

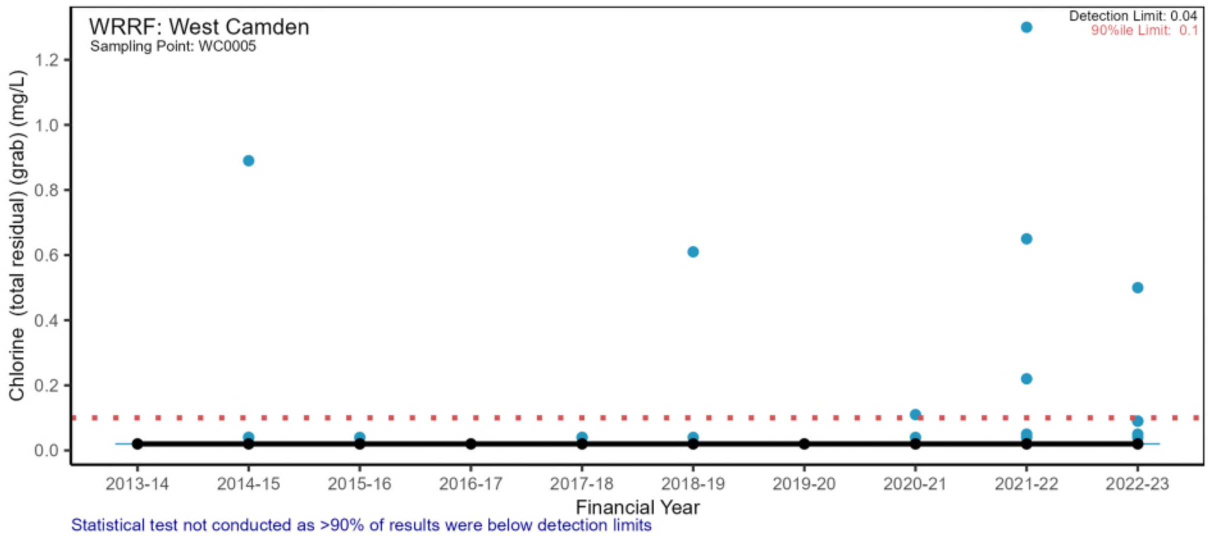


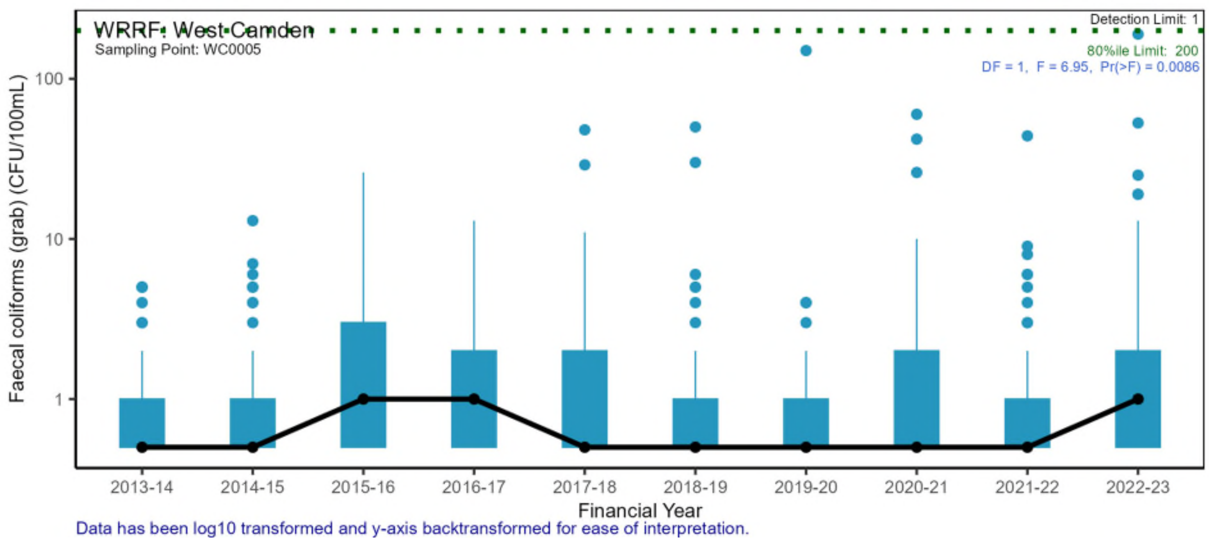


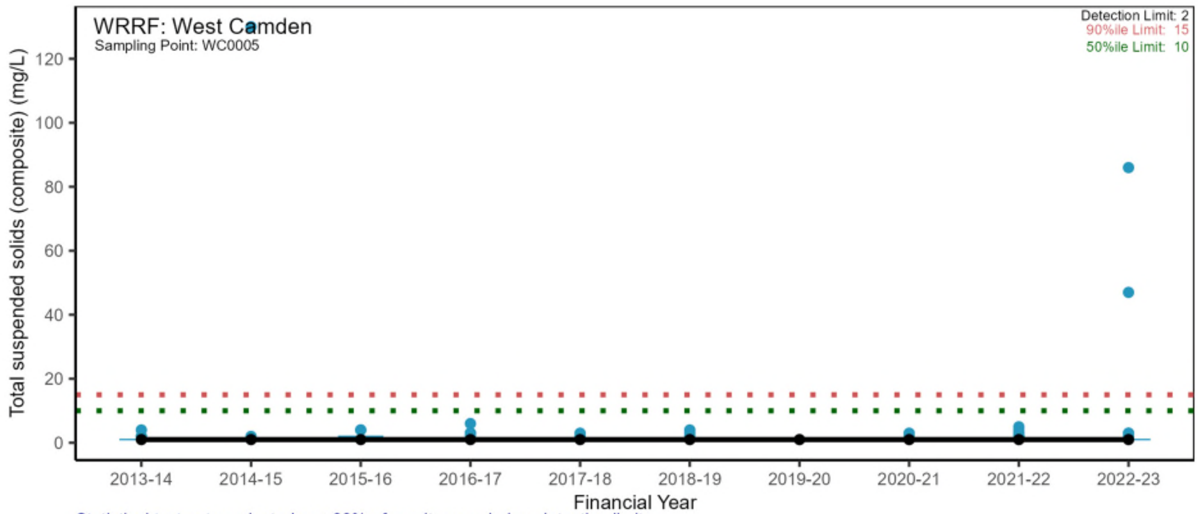


Major conventional analytes



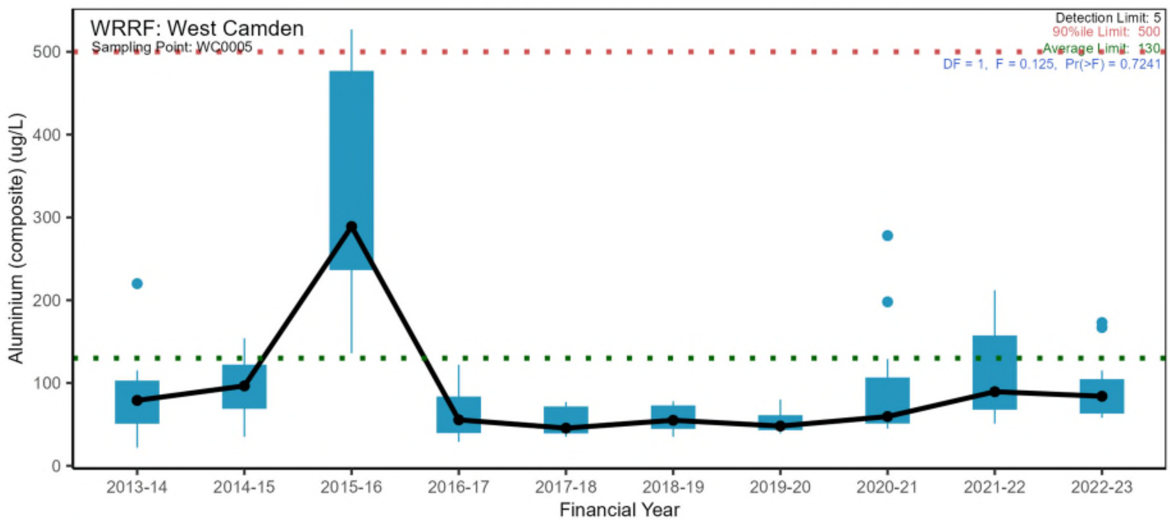


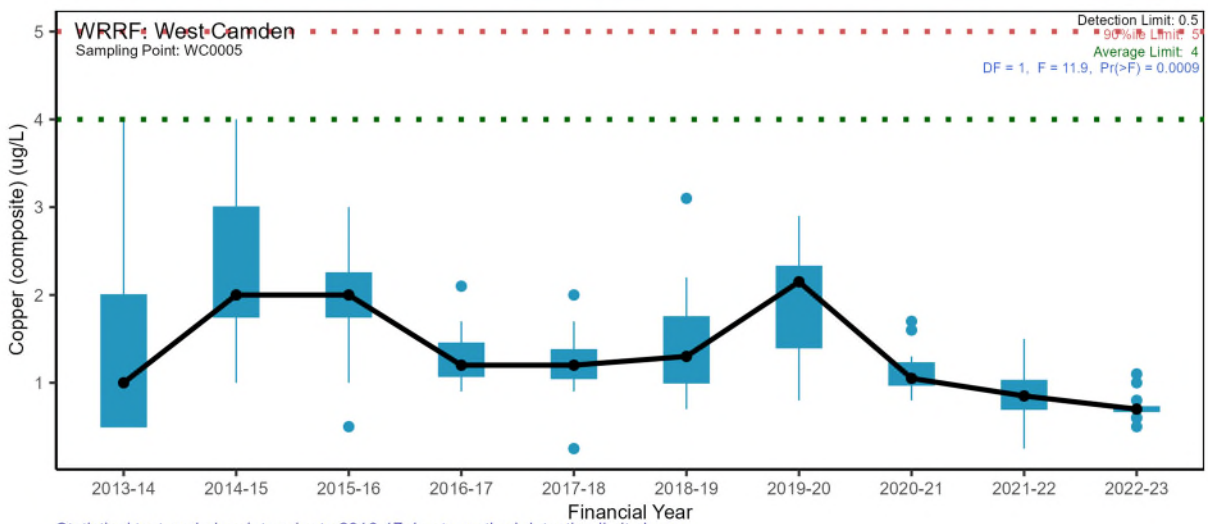




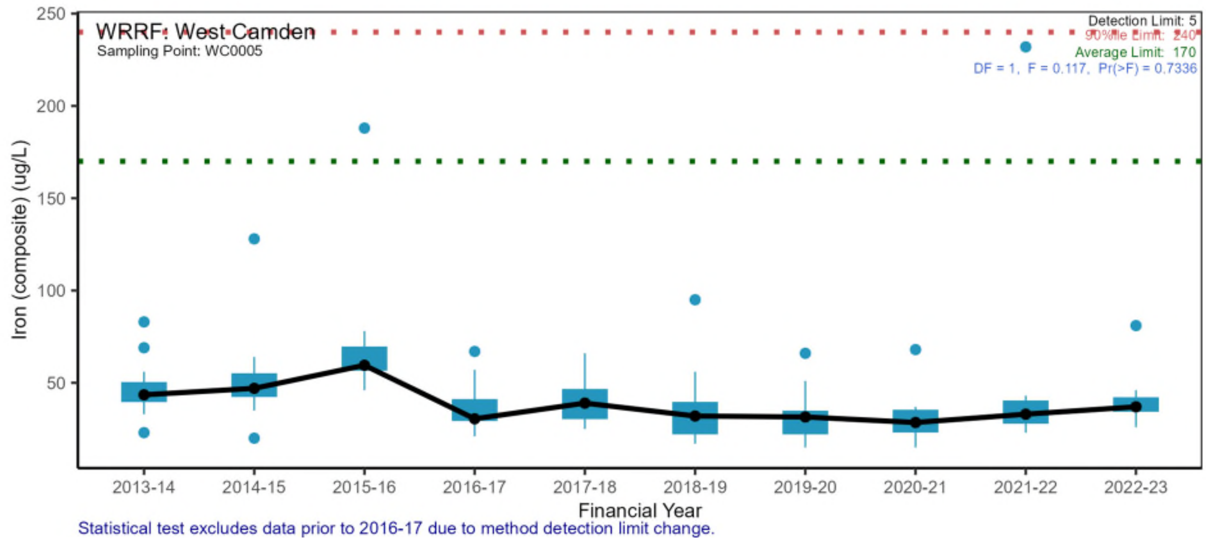
Statistical test not conducted as >90% of results were below detection limits

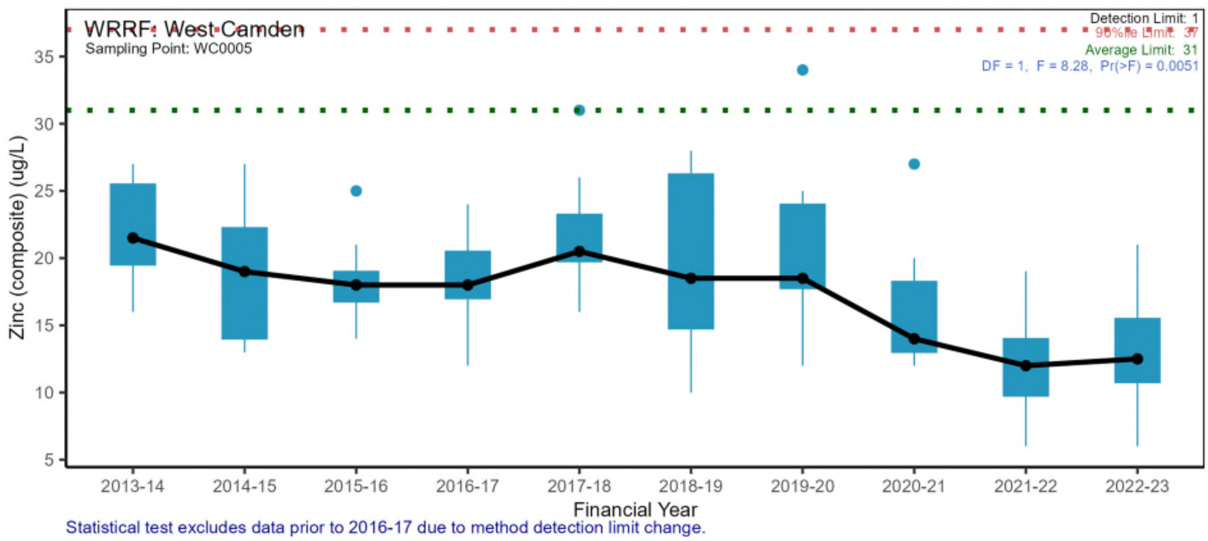
Trace metals



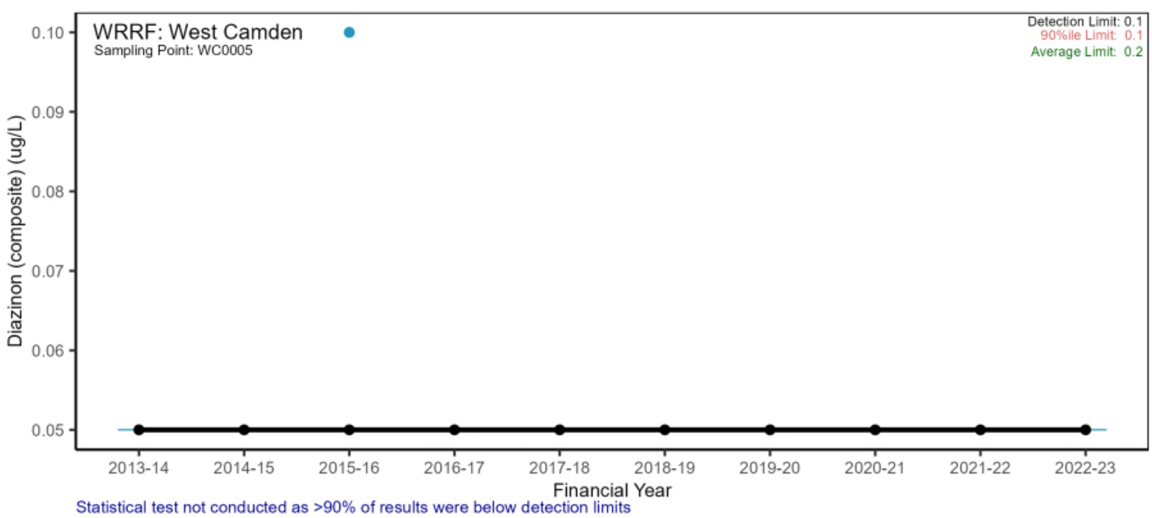


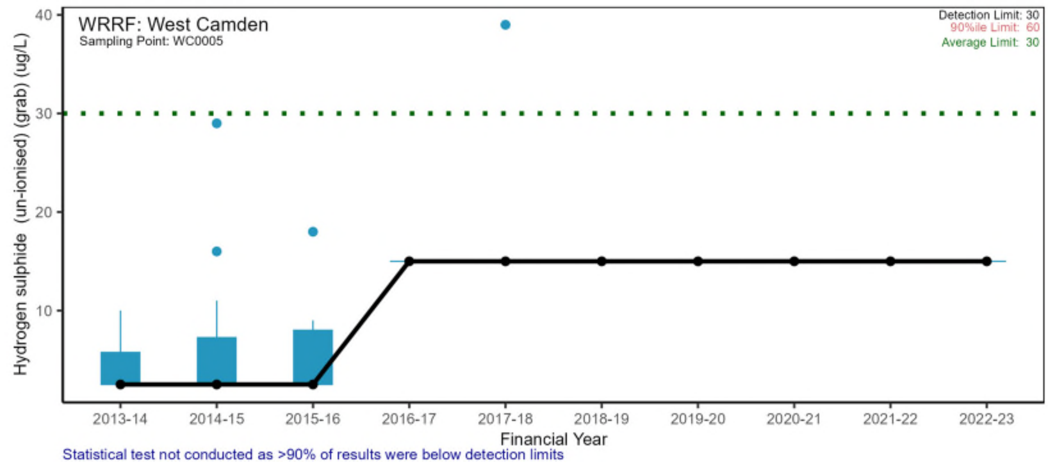
Statistical test excludes data prior to 2016-17 due to method detection limit change.



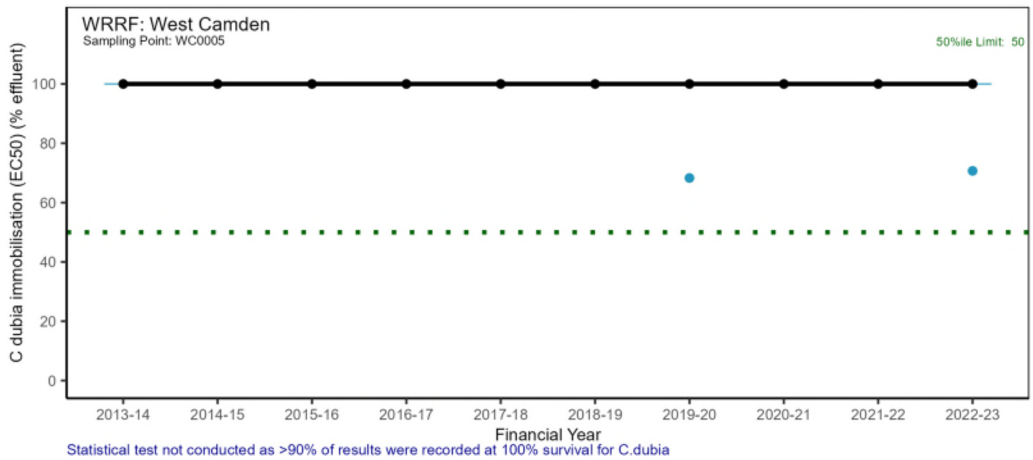


Other chemicals and organics (including pesticides)



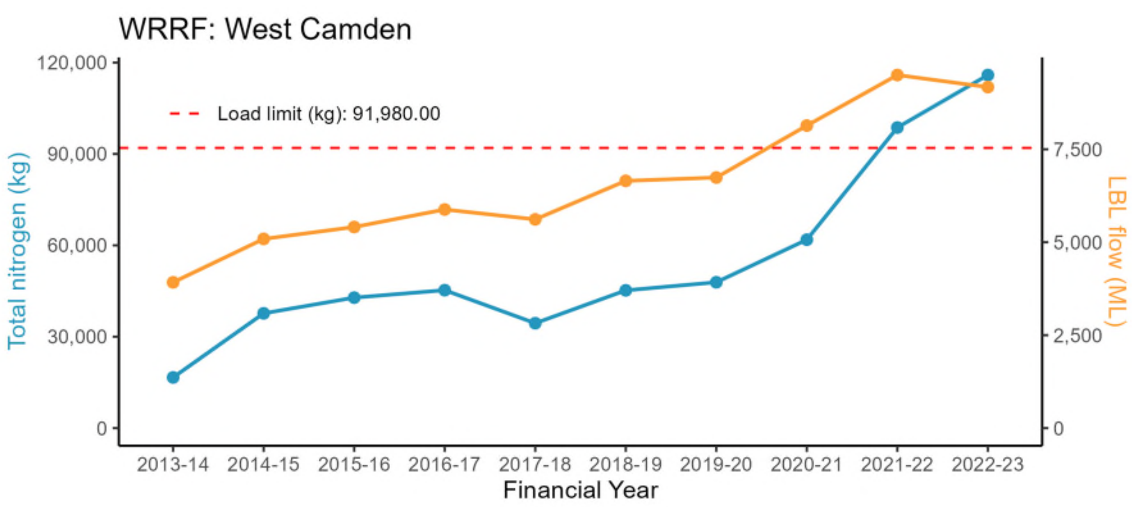


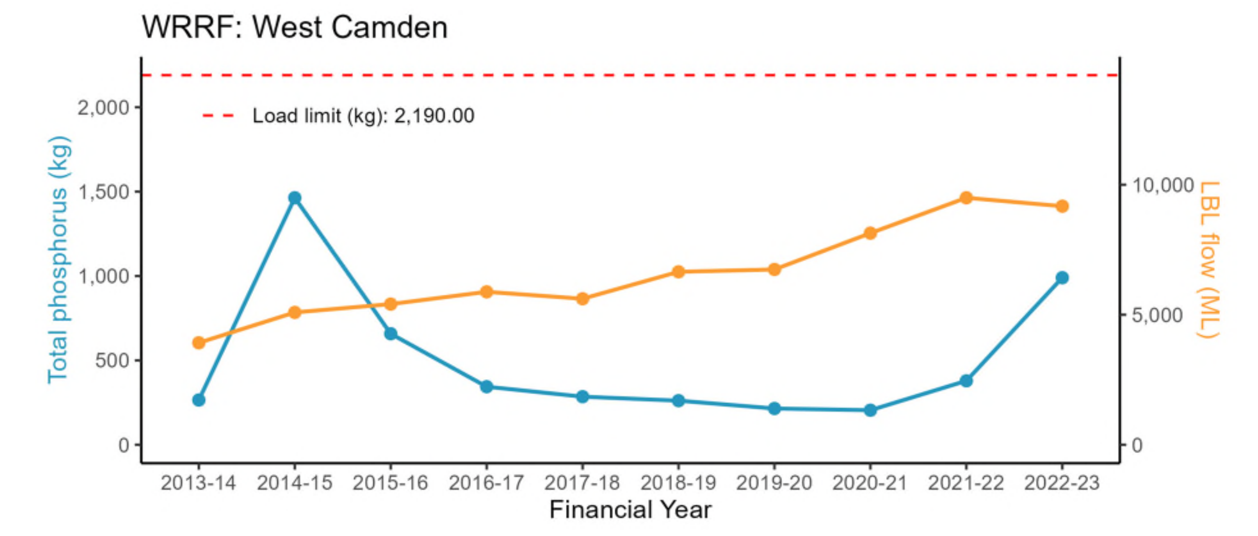
A-2.3 Pressure – Wastewater toxicity



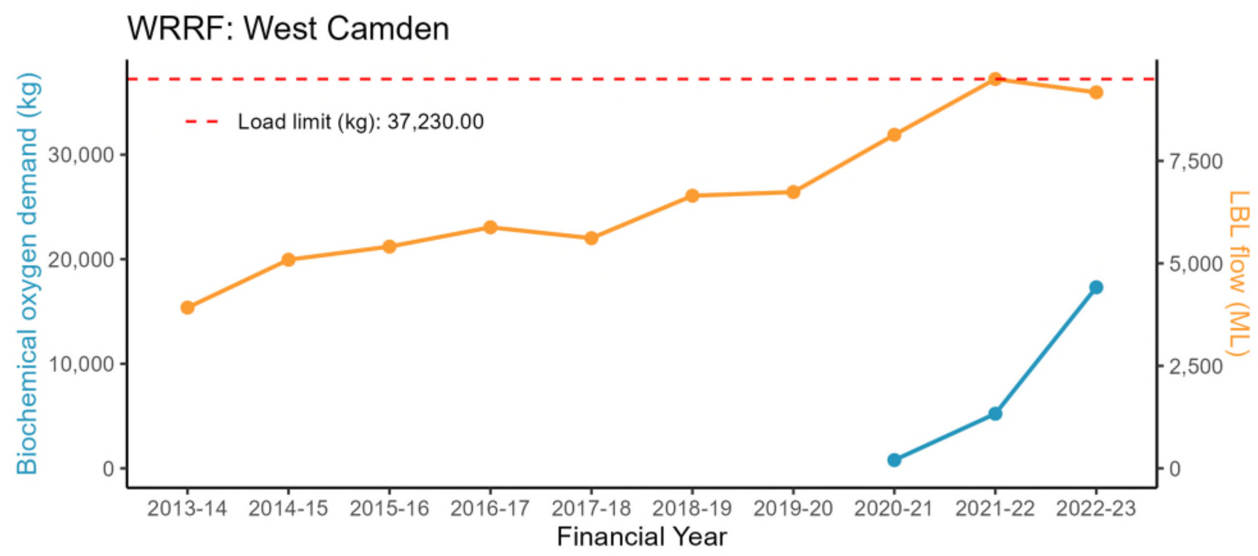
A-2.4 Pressure – Wastewater discharge load

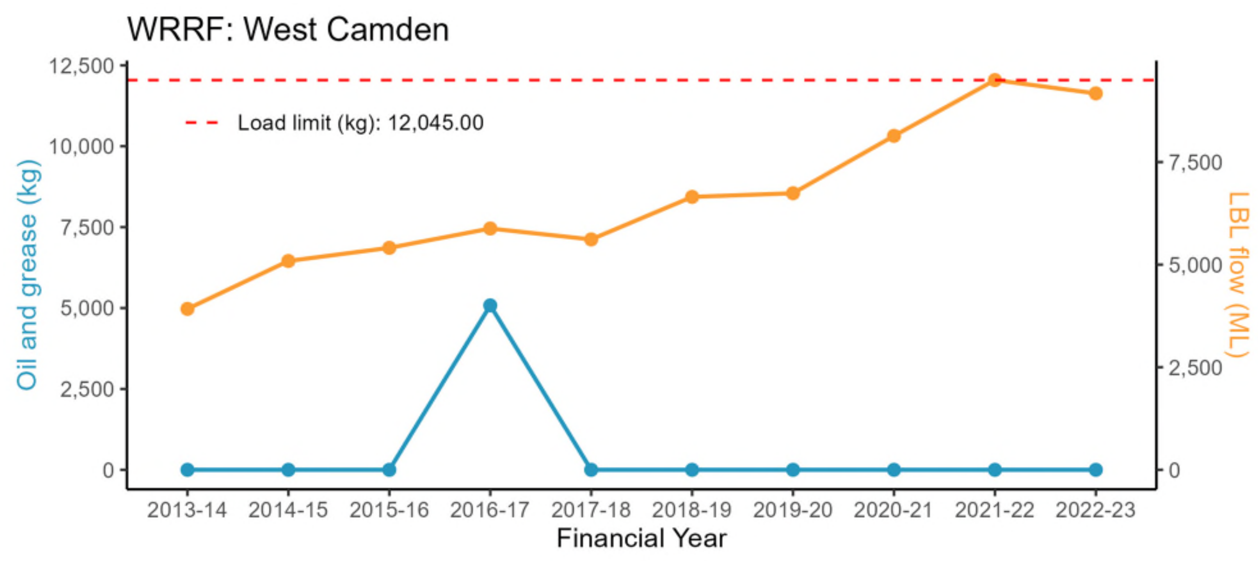
Nutrients

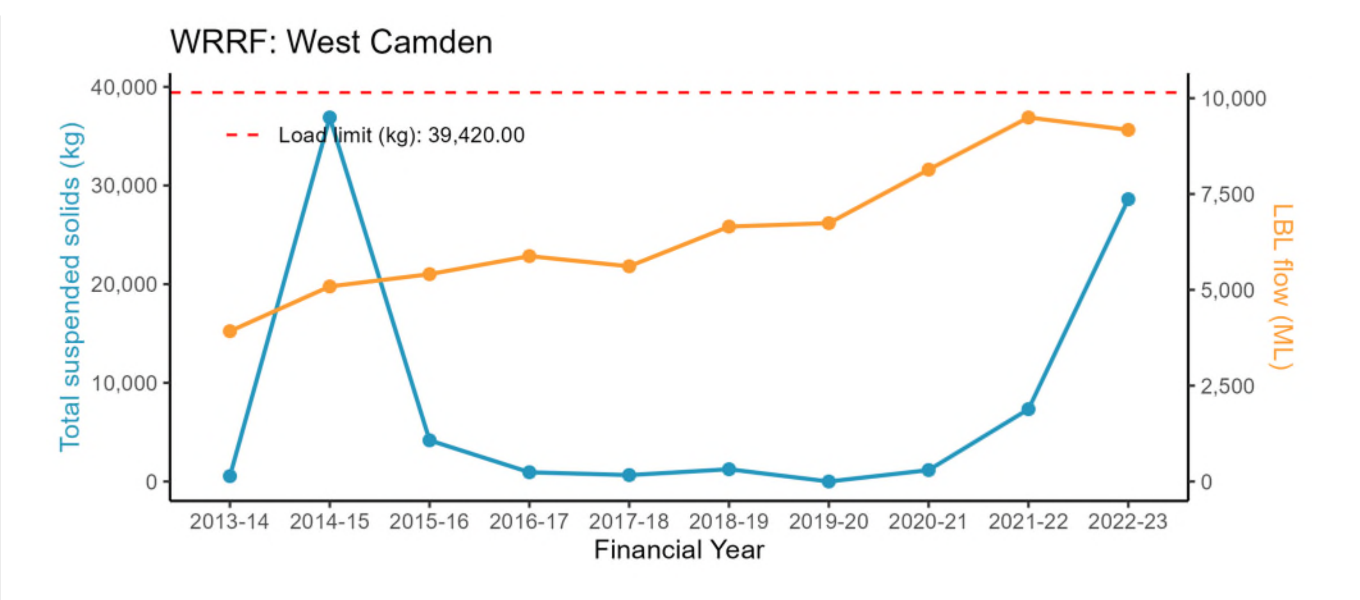




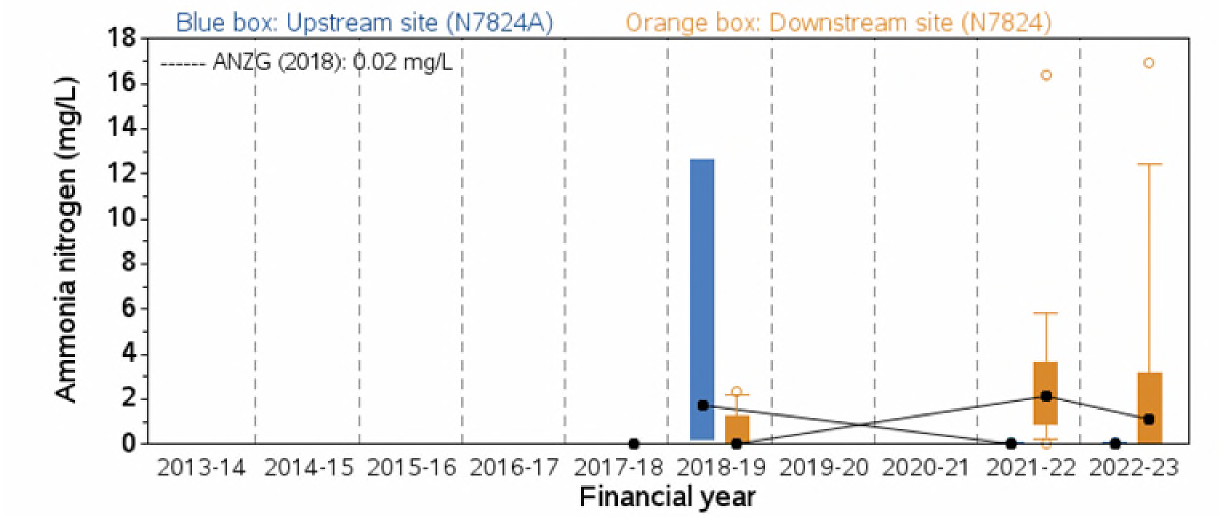
Major conventional analytes



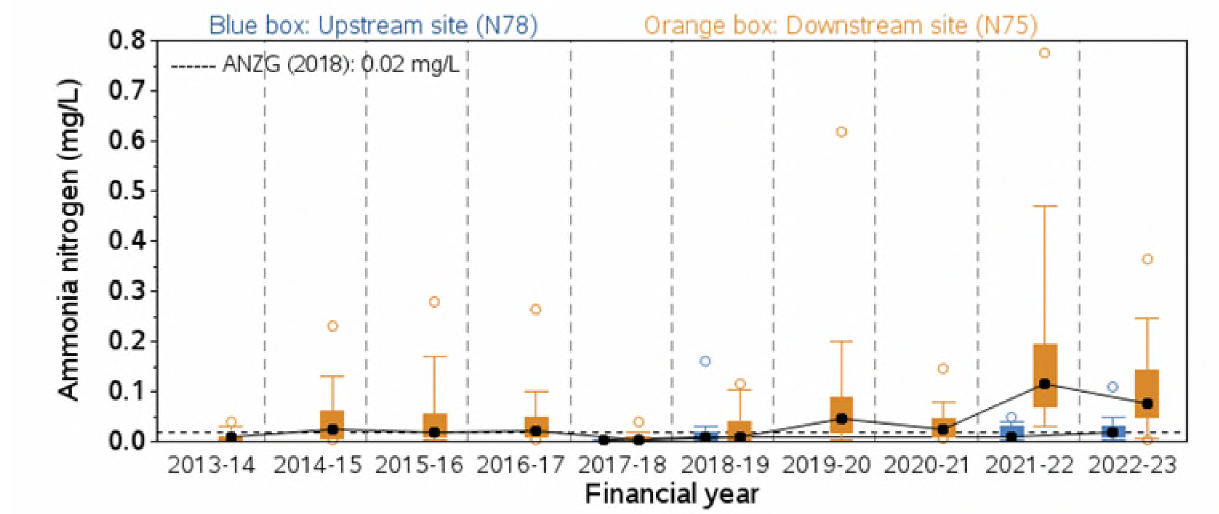



WRRF: West Camden
Load limit (kg): 39,420.00
Total suspended solids (kg)
LBL flow (ML)
Financial Year
40,000
30,000
20,000
10,000
0
10,000
7,500
5,000
2,500
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

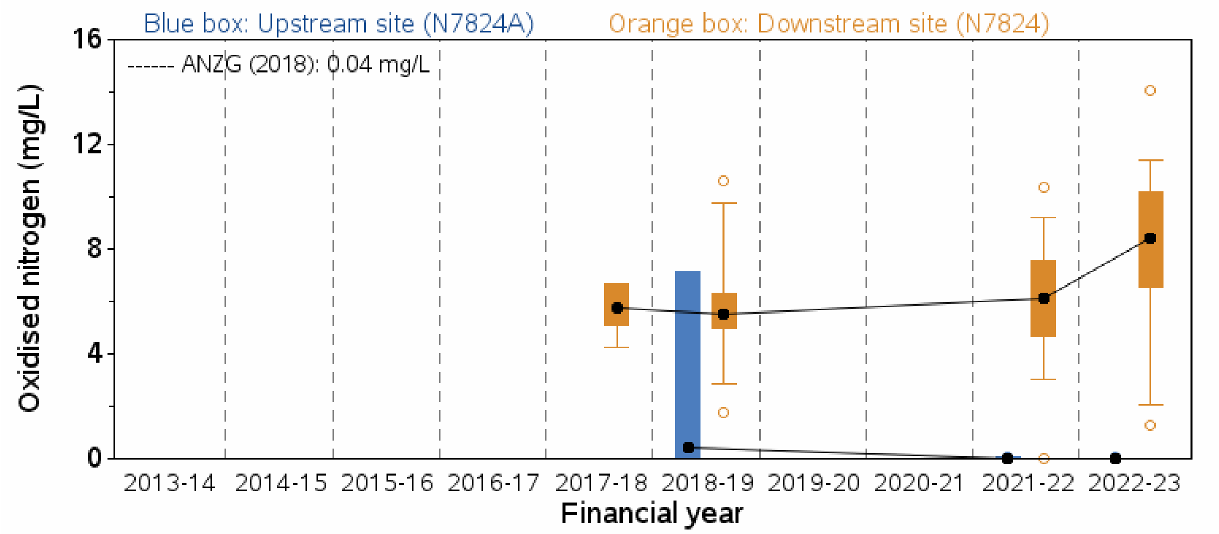
A-2.5 Stressor – Nutrients



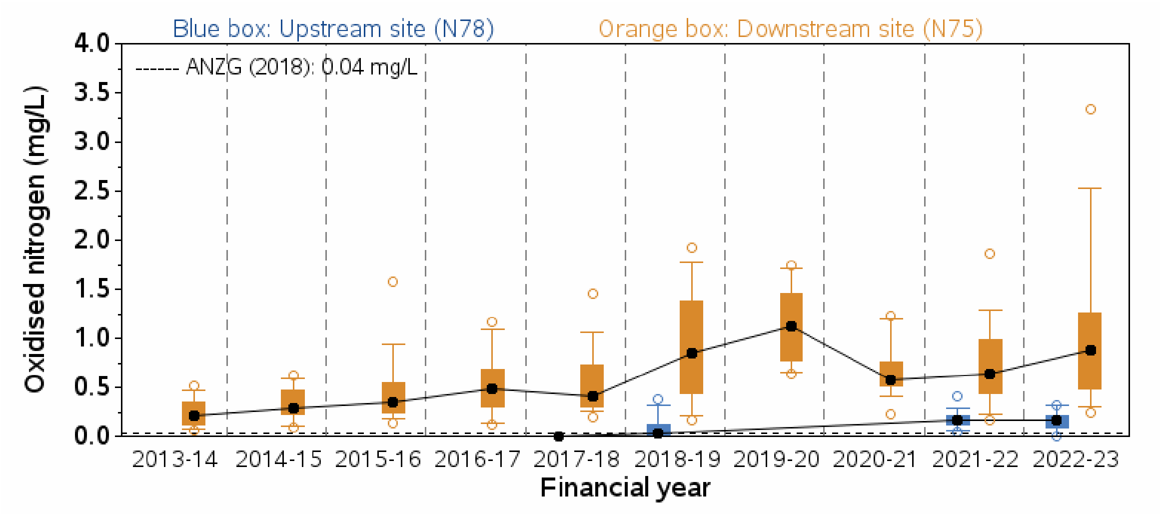
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	1.08	0.3054	N7824	1	2.37	0.1294



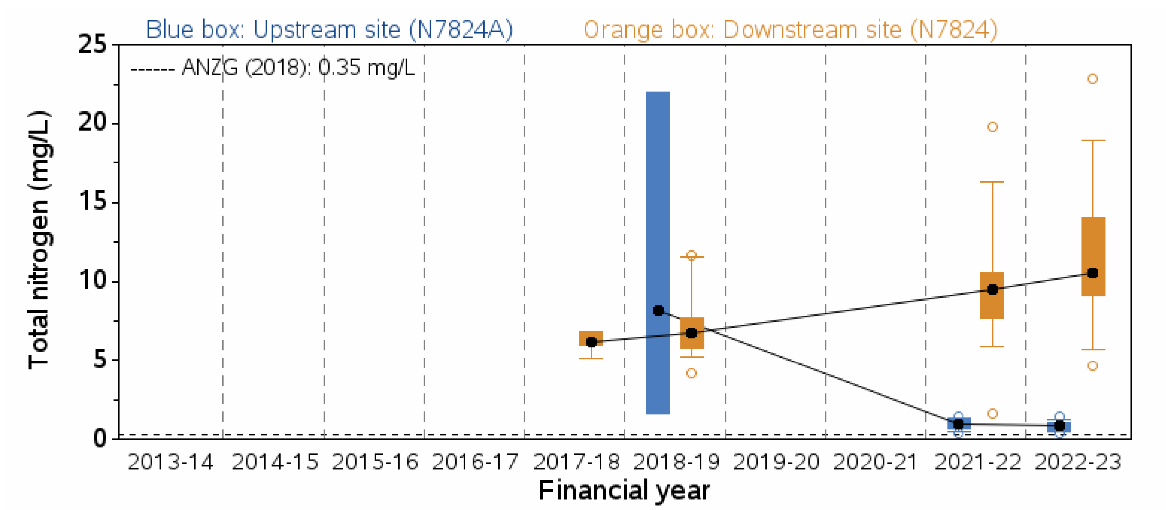
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.89	0.3498	N75	1	4.33	0.0391



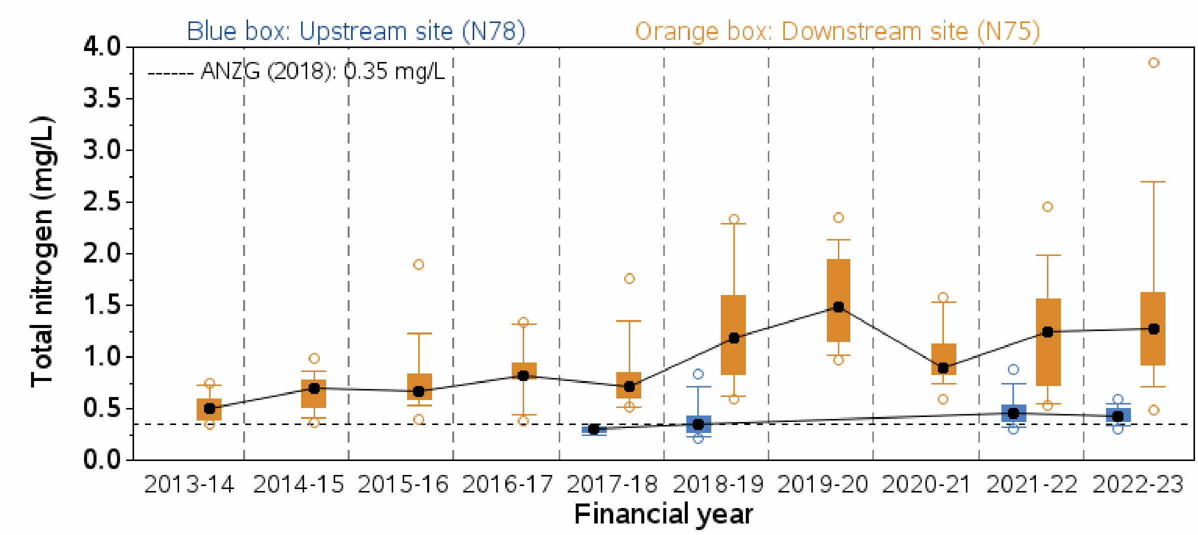
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	0.92	0.3438	N7824	1	7.06	0.0103



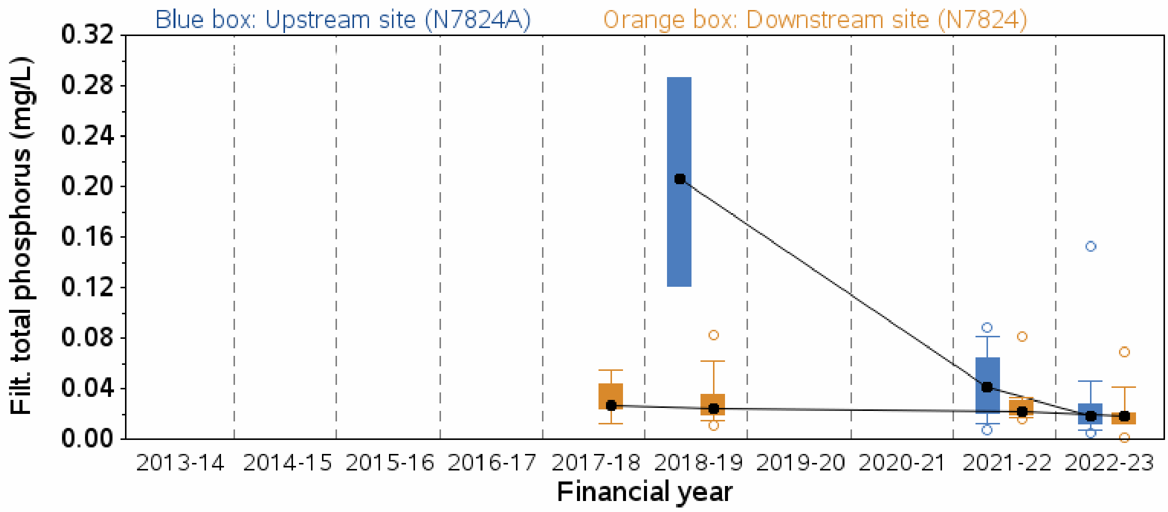
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	1.12	0.2935	N75	1	13.53	0.0003



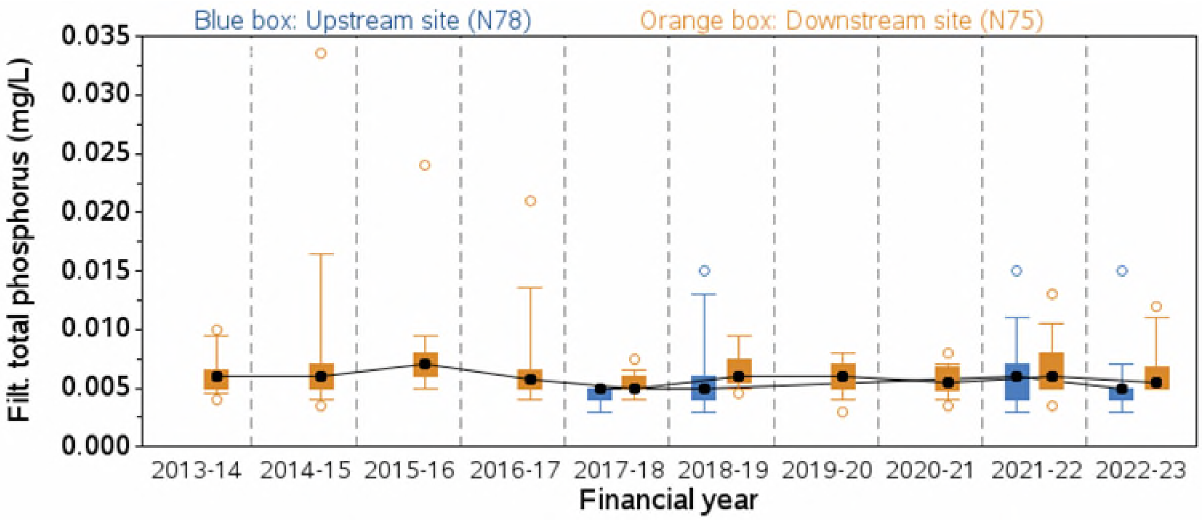
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	1.59	0.2156	N7824	1	10.79	0.0018



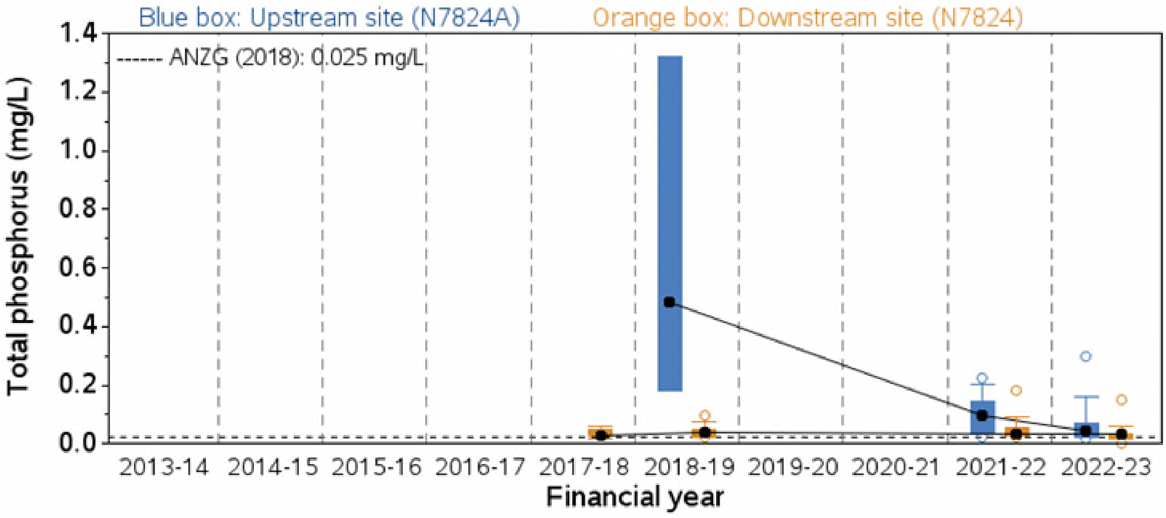
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.16	0.6908	N75	1	16.36	<.0001



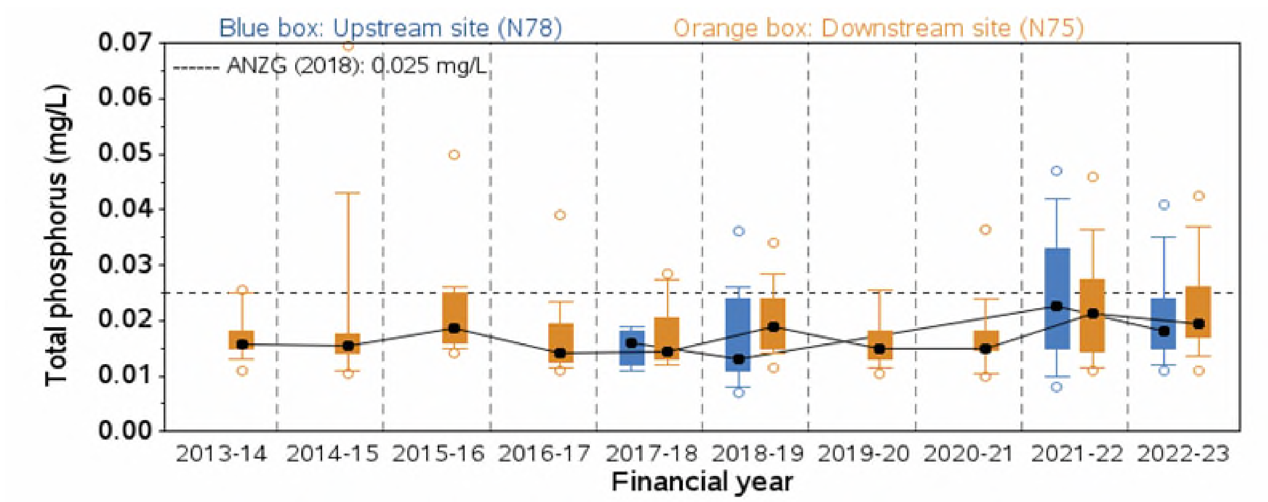
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	4.57	0.0395	N7824	1	3.26	0.0766



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.4	0.5286	N75	1	0.05	0.82

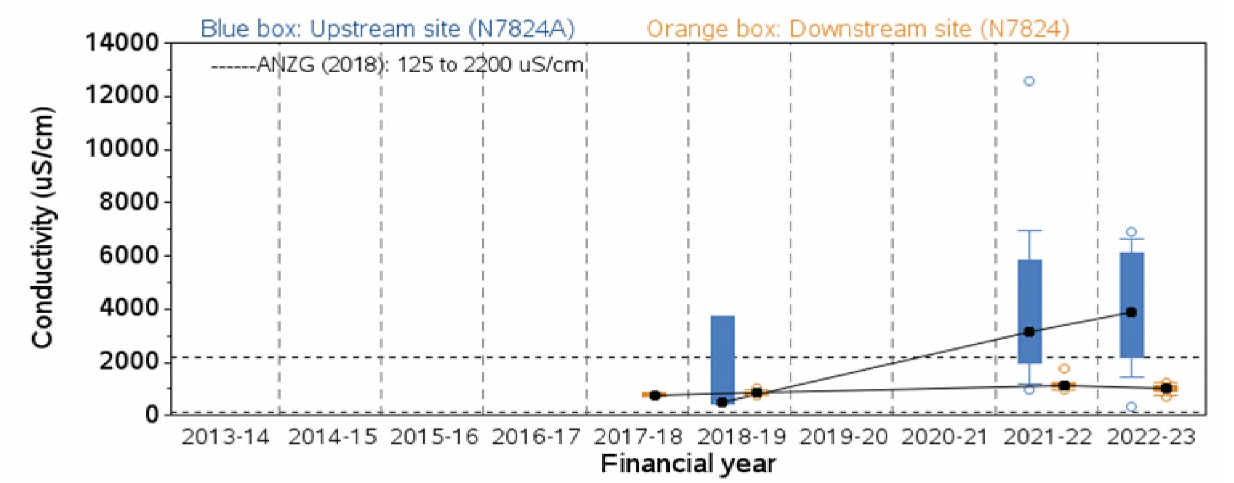


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	2.73	0.1073	N7824	1	0.68	0.4119

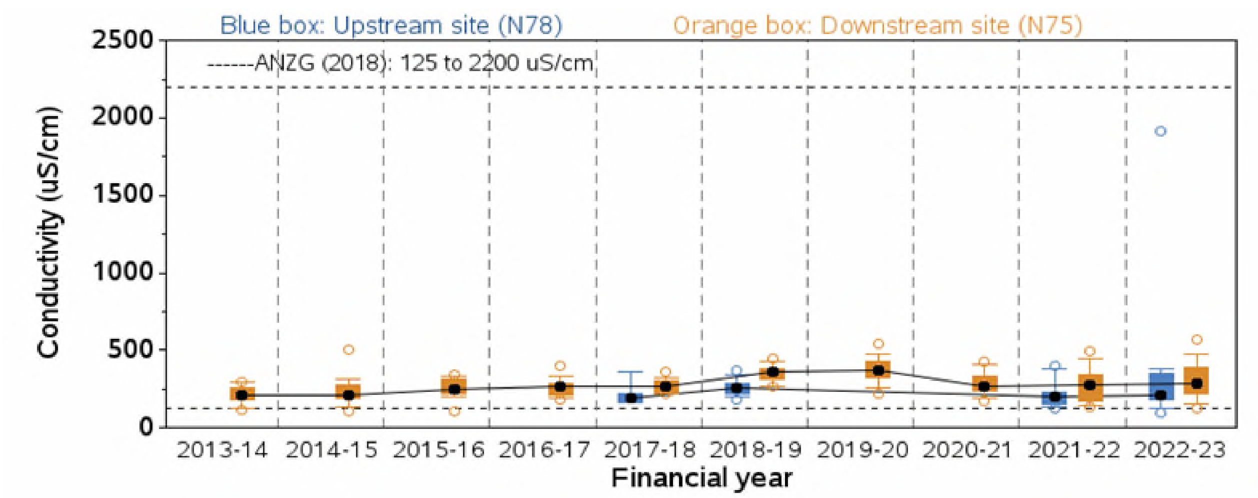


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.1	0.7546	N75	1	3.16	0.0774

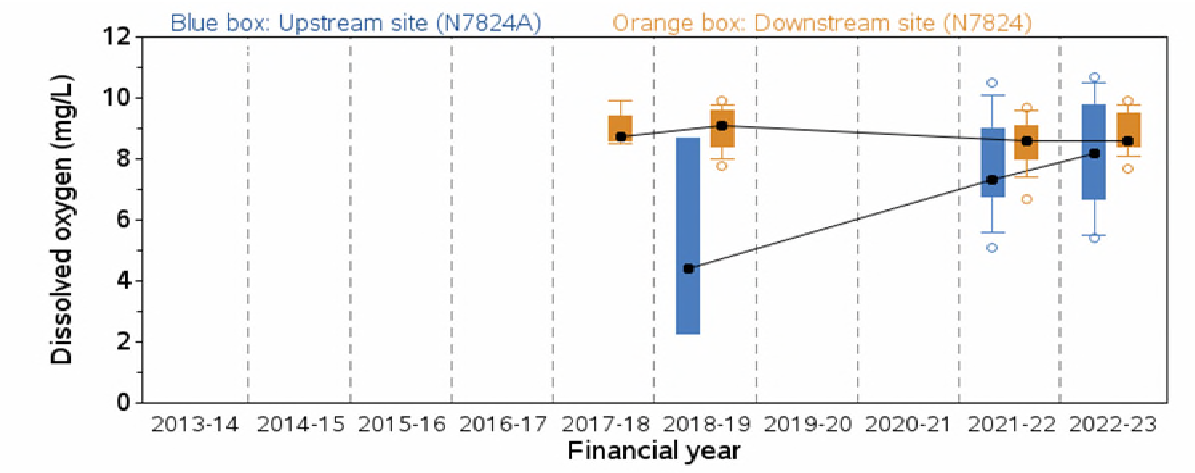
A-2.6 Stressor – Physico-chemical water quality



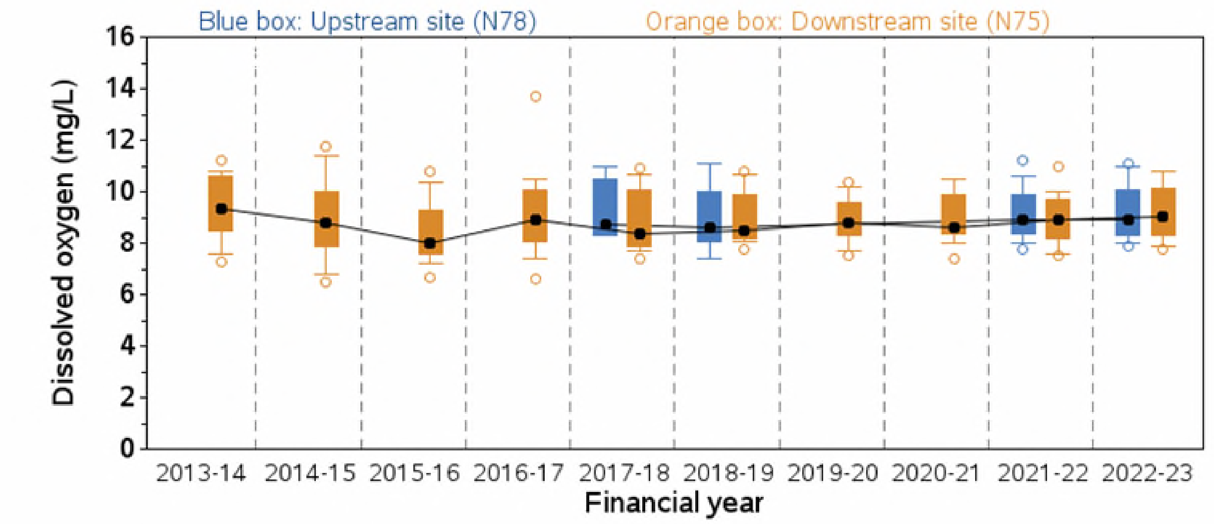
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	0.19	0.6658	N7824	1	0.62	0.4343



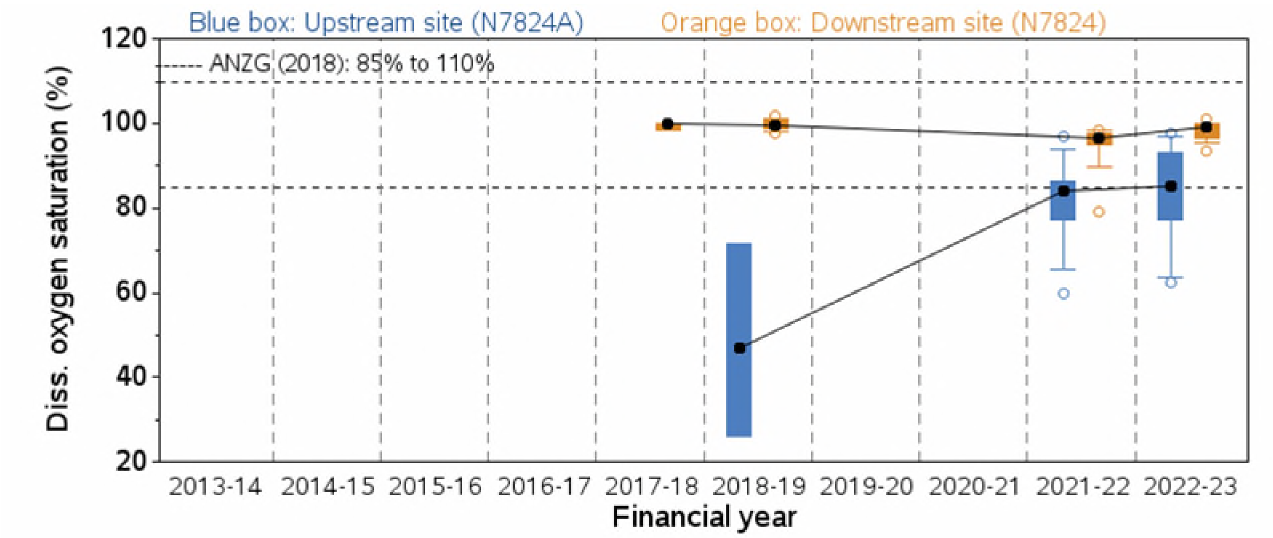
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	2.36	0.1302	N75	1	0.95	0.3309



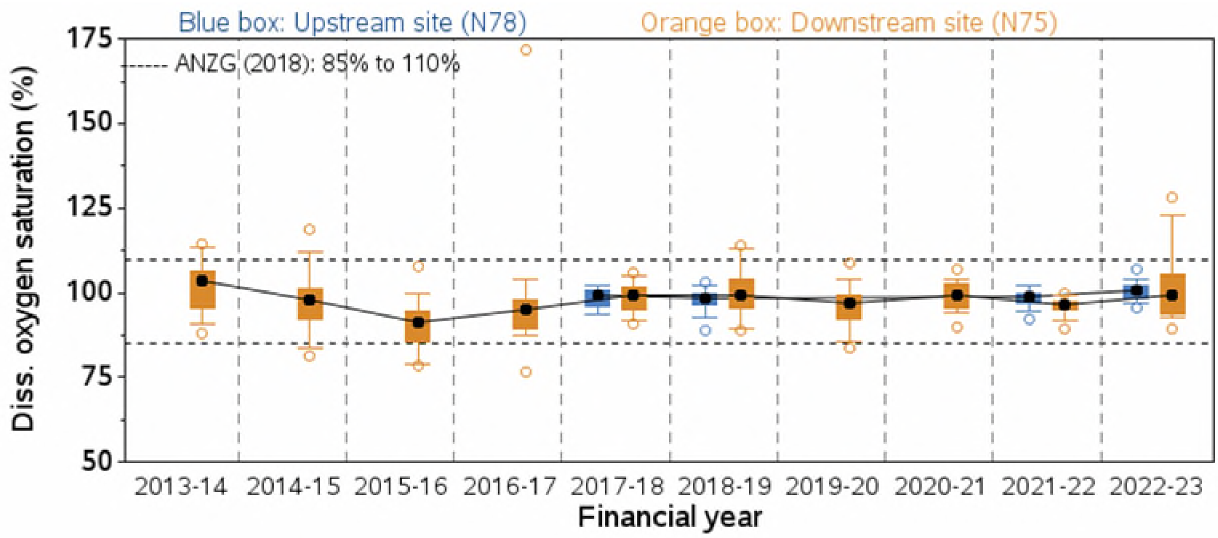
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	1.02	0.3187	N7824	1	0.01	0.9142



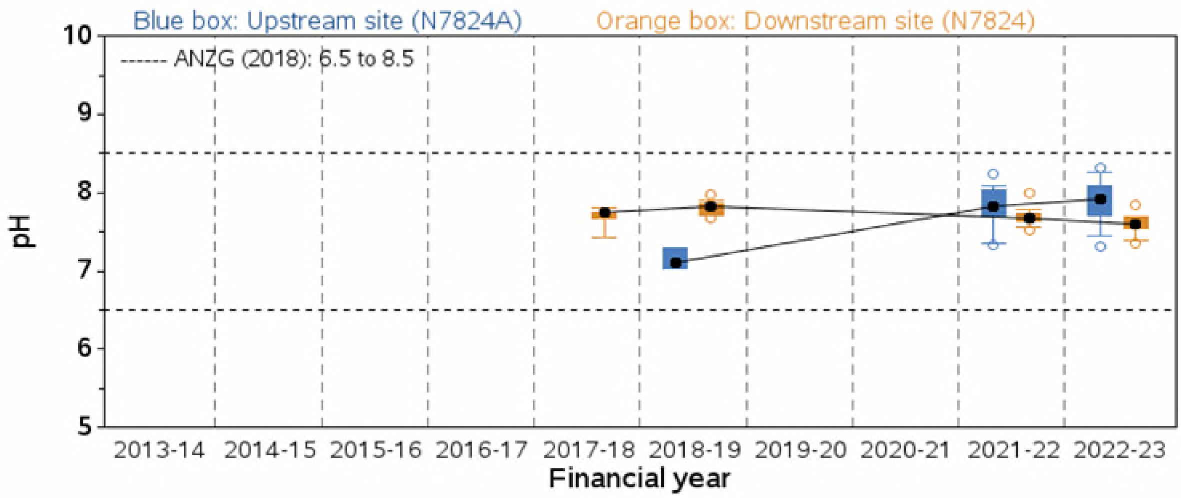
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.35	0.5549	N75	1	0.53	0.4683



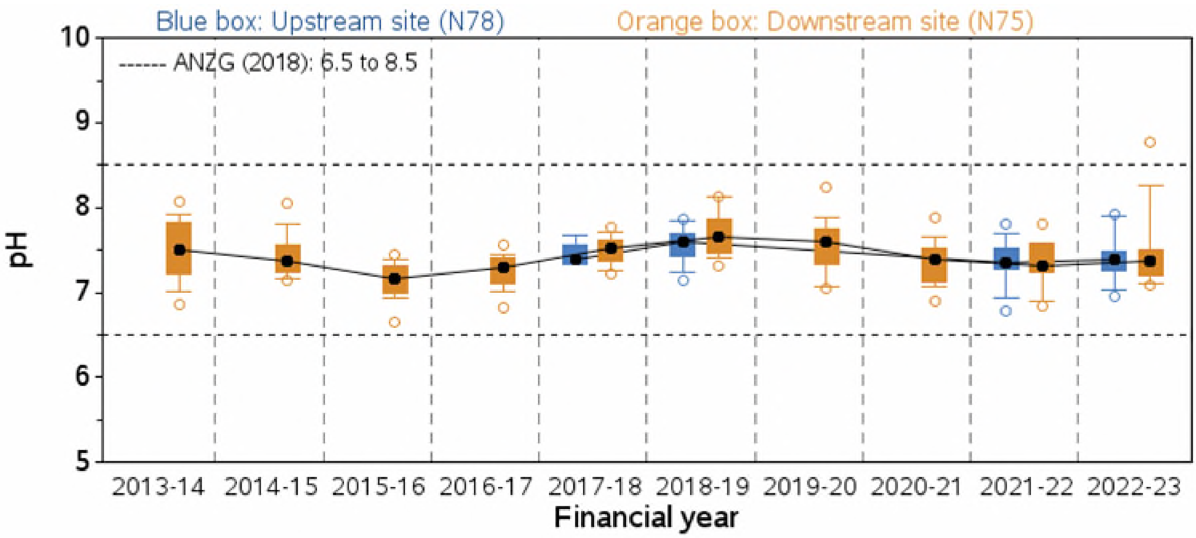
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	1.46	0.2342	N7824	1	0.29	0.5922



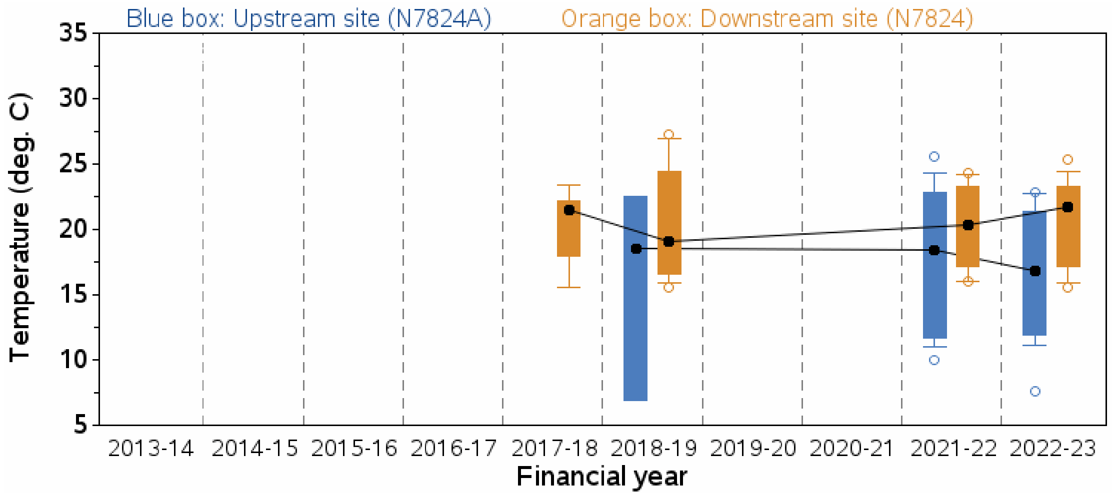
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	5.84	0.019	N75	1	2.25	0.1357



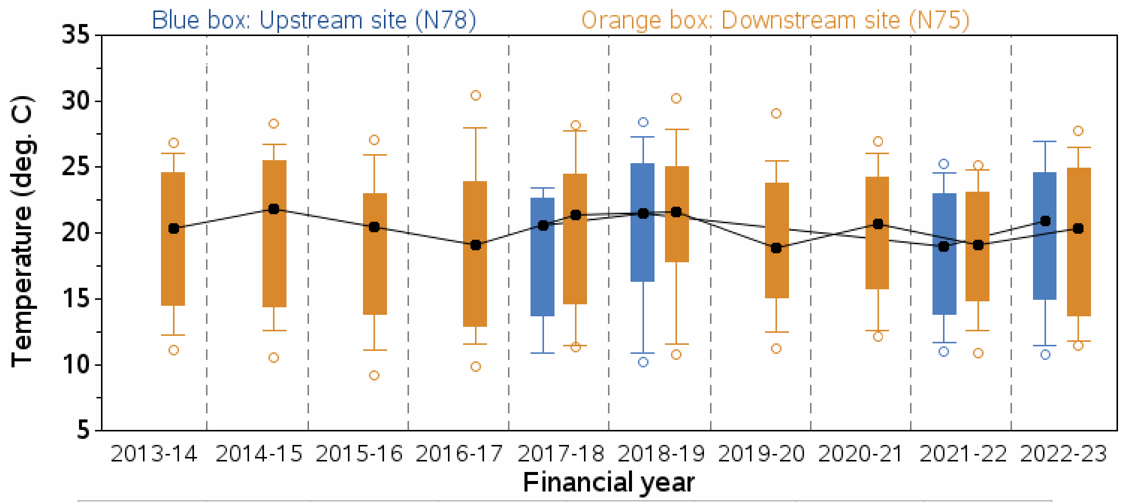
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	2.79	0.1036	N7824	1	19.89	<.0001



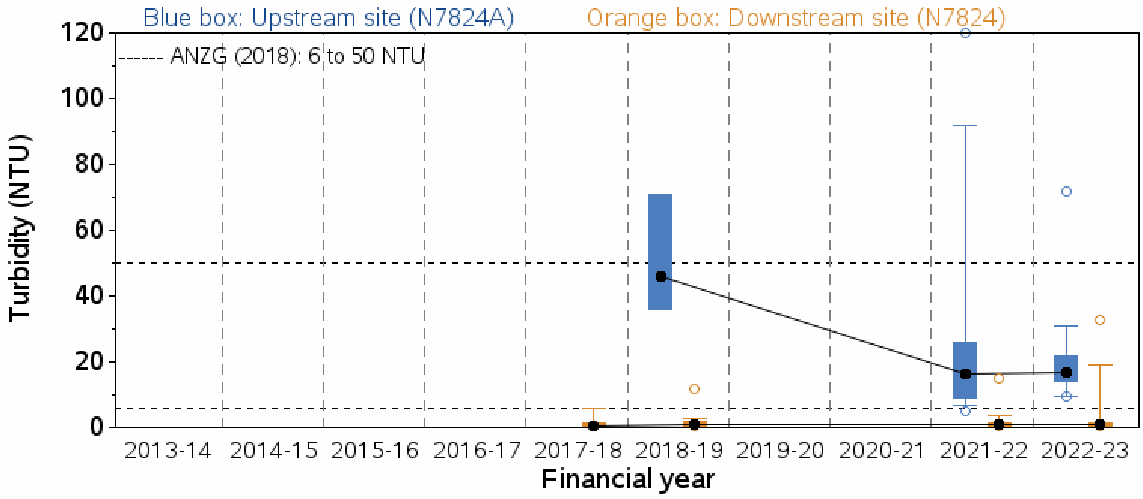
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.98	0.3258	N75	1	1.16	0.2827



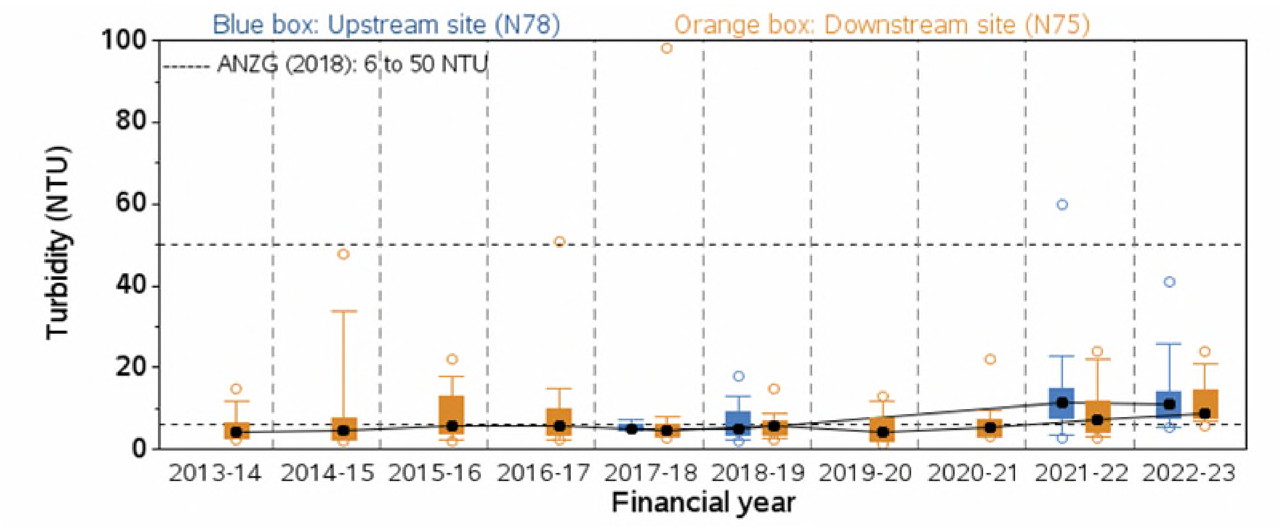
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	0.08	0.7809	N7824	1	0	0.9998



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0	0.9987	N75	1	0	0.9568

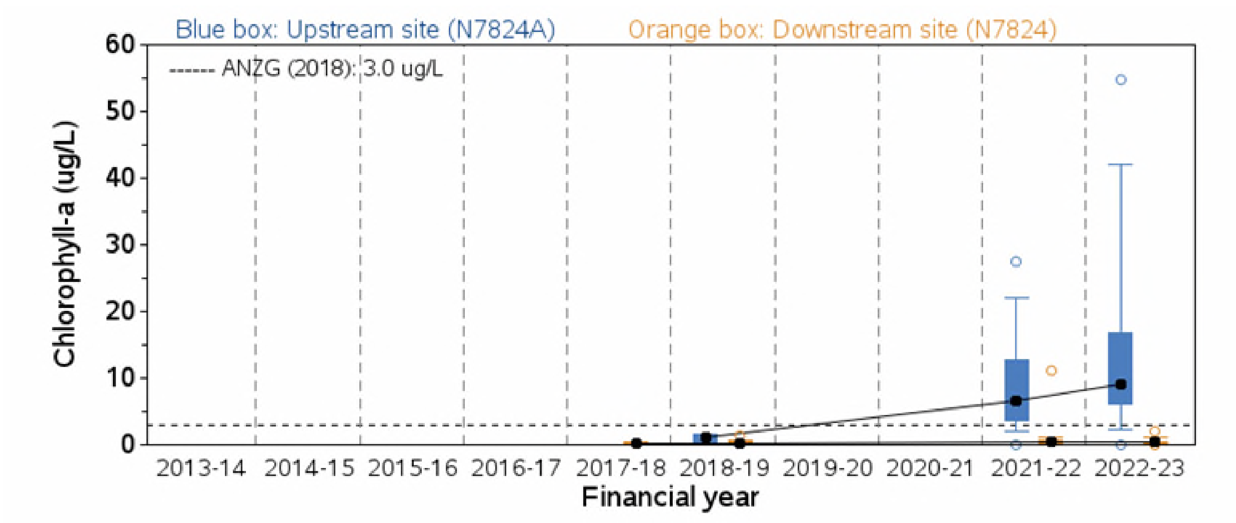


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	1.17	0.2861	N7824	1	2.05	0.1578

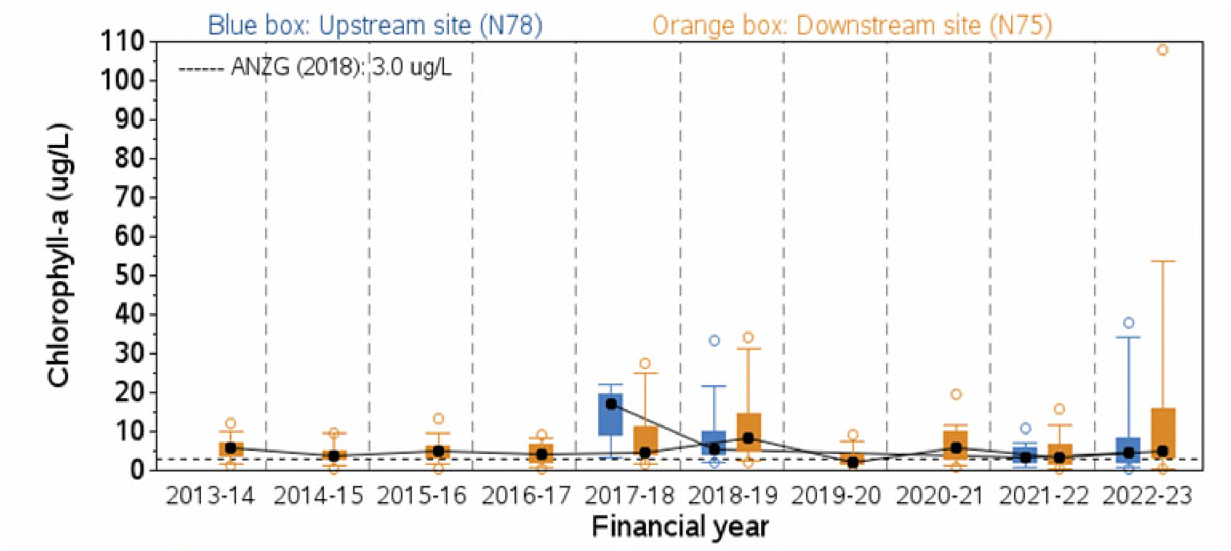


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	1.84	0.1808	N75	1	2.19	0.1405

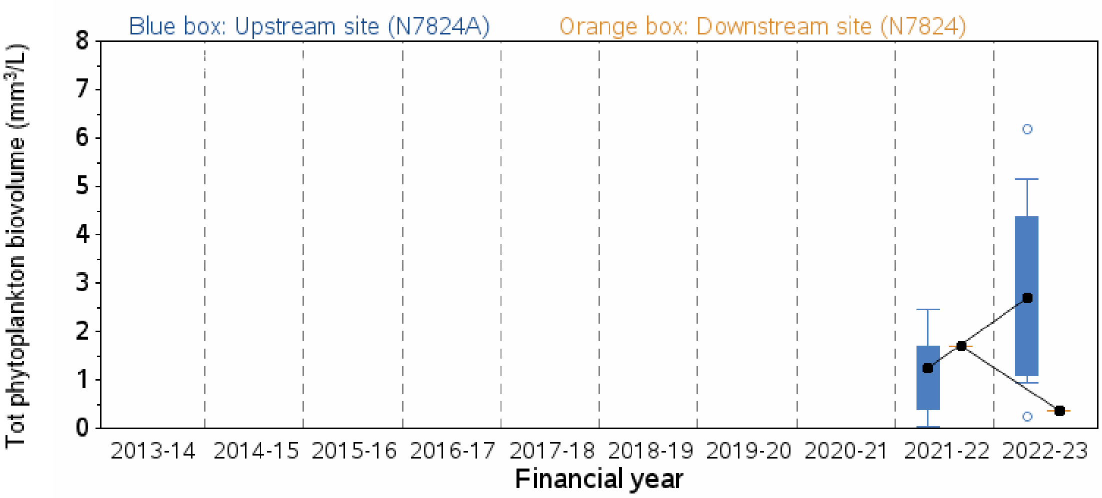
A-2.7 Ecosystem receptor – Phytoplankton



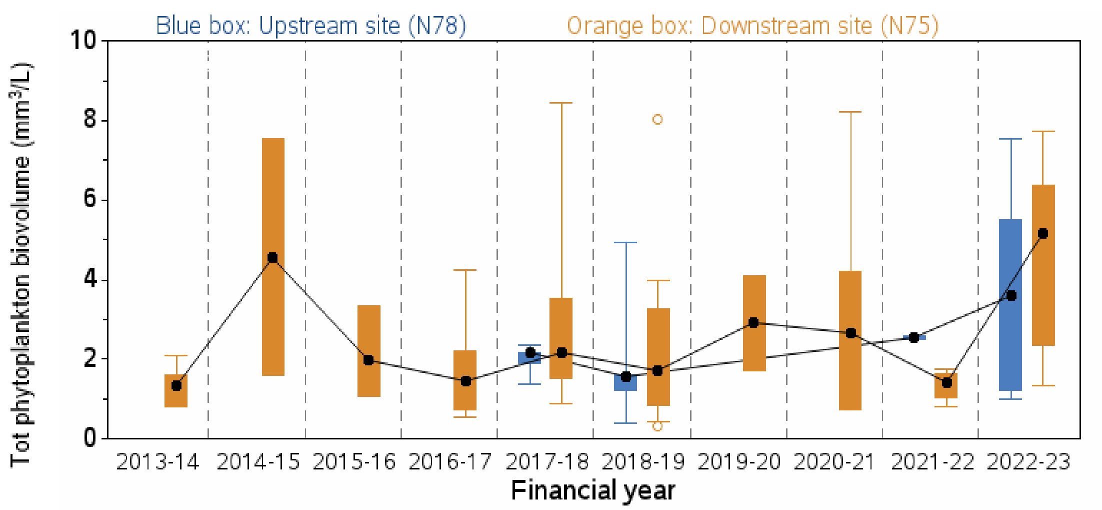
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	2.61	0.1146	N7824	1	0.22	0.6388



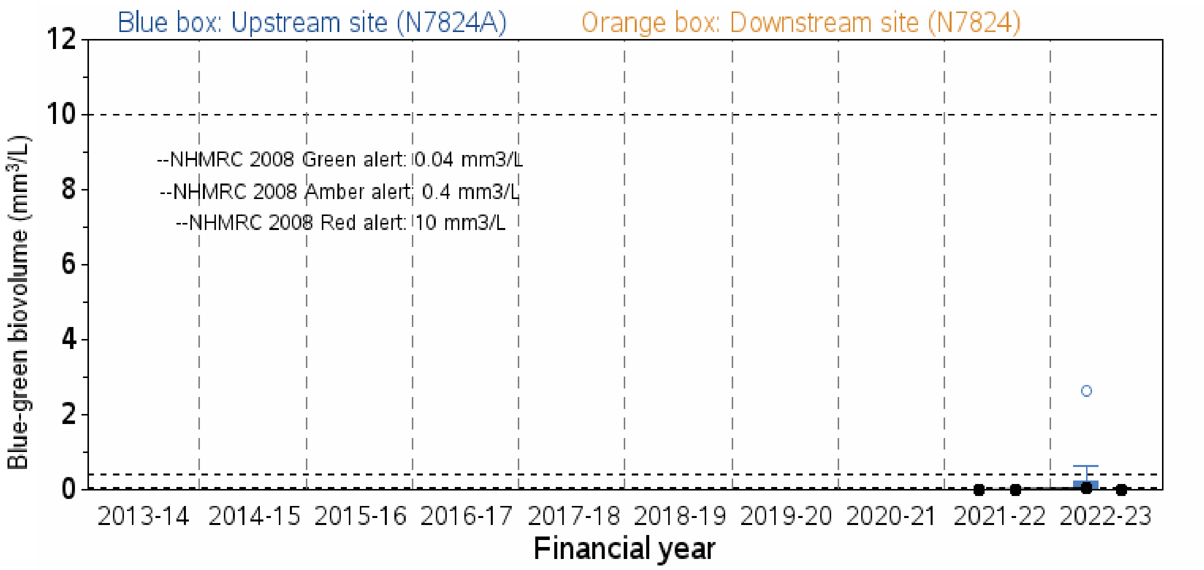
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	0.26	0.6107	N75	1	14.11	0.0002



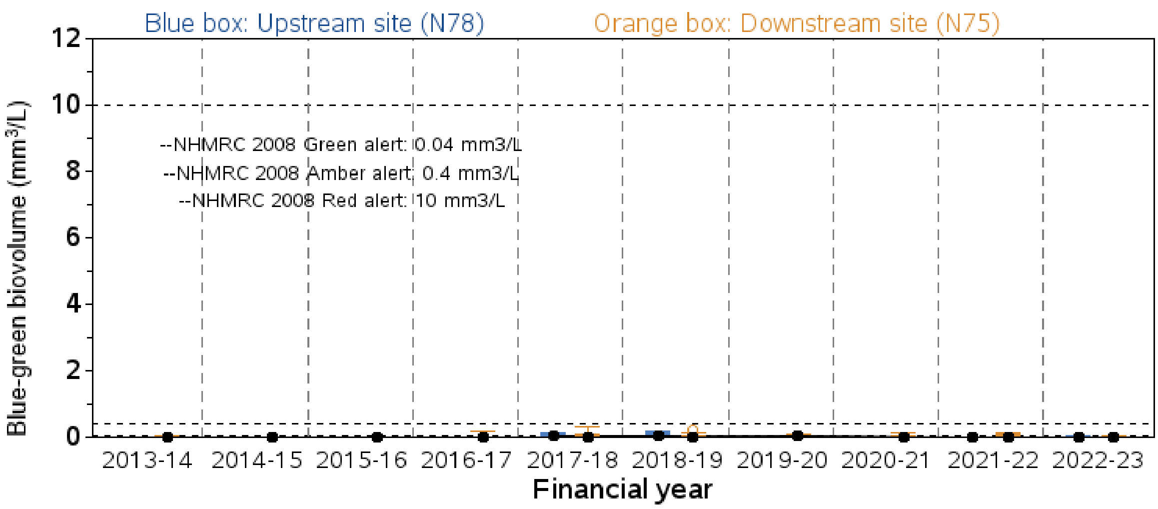
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	4.88	0.0396	N7824	Insufficient data		



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	4.08	0.0593	N75	1	6.4	0.0146



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N7824A	1	1.78	0.1982	N7824	Insufficient data		



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N78	1	3.82	0.0673	N75	1	0.39	0.5355

Note: Insufficient data to draw a plot on toxic blue-green count for N7824A and N7824

Note: Insufficient data to draw a plot on toxic blue-green count for N78 and N75

A-2.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plots provided assessments of stream health for both Matahil Creek near West Camden WRRF and in the Nepean River upstream-downstream of the confluence with Matahil Creek. These plots were based upon macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022–23 against that collected between 2004 to 2022 for Matahil Creek and 1995 to 2022 for the Nepean River. These visual comparisons suggest downstream stream health was maintained in the Nepean River over 1995 to 2023 (Figure A-3). A localised impact in stream health was indicated for Matahil Creek in 2022-23 (Figure A-2).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022–23 samples under t-tests returned a significant test outcome for Matahil Creek and a non-significant test outcome for the Nepean River (Table A-2), which confirmed the visual trends of respective SIGNAL-SG plots (Figure A-2 and Figure A-3).

As a measurable negative impact on downstream stream health was detected on Matahil Creek, further data analysis was undertaken.

Table A-2 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from the Matahil Creek and Nepean River waterways near West Camden WRRF

Waterway	Method	Statistic	DF	P value
Matahil Creek	Welch Two Sample t-test	3.80	8.8	0.004
Nepean River	Welch Two Sample t-test	-0.06	6.2	0.951

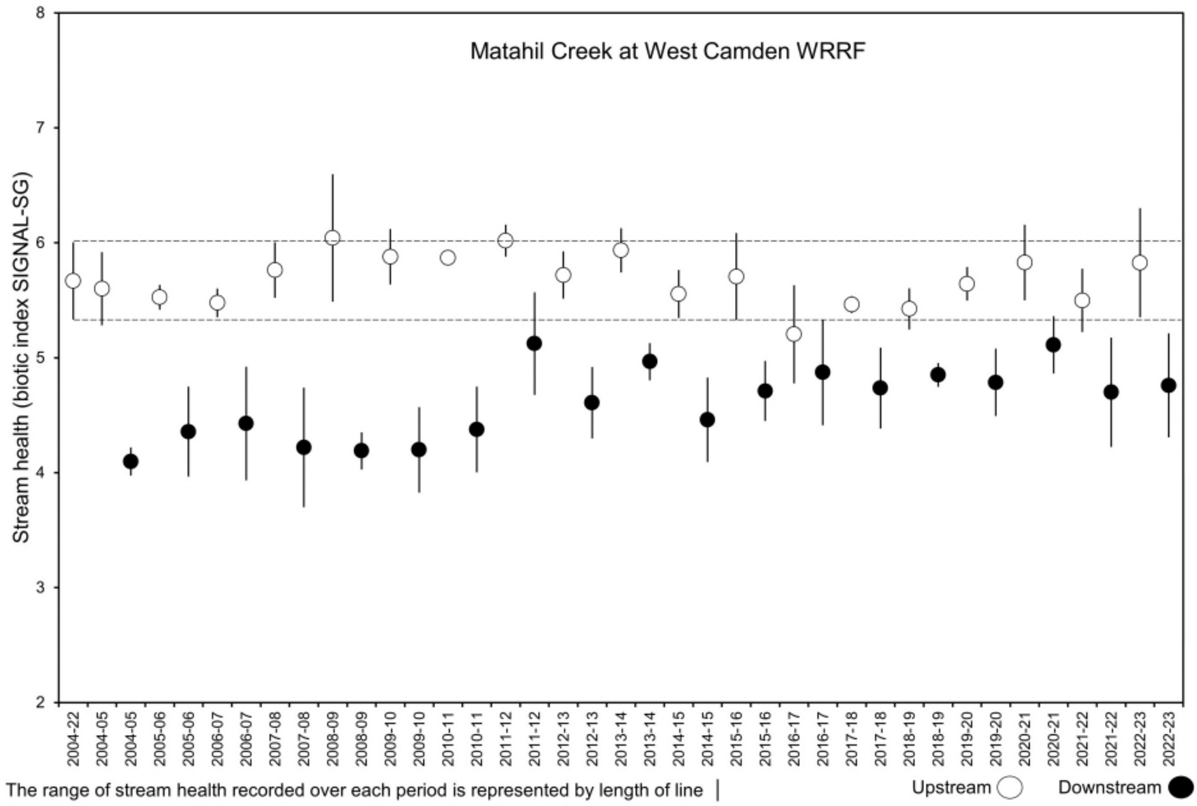


Figure A-2 Stream health of Matahil Creek near West Camden WRRF

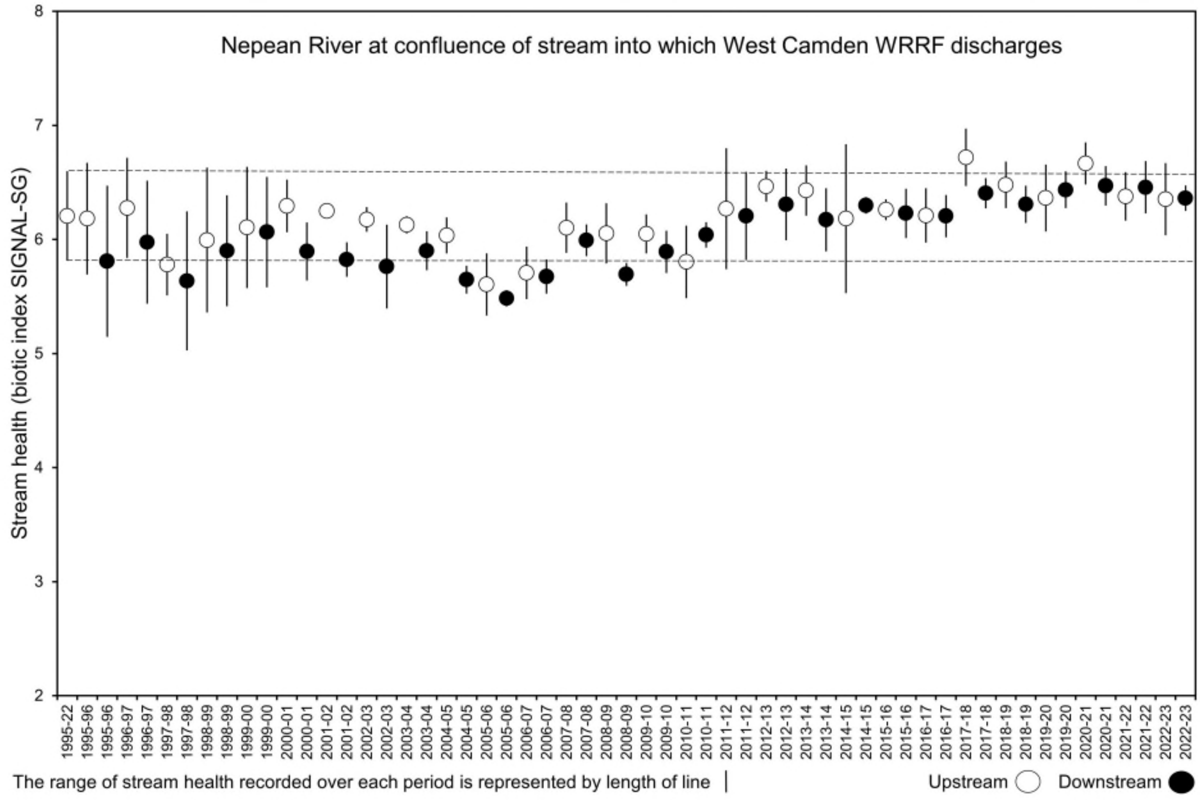


Figure A-3 Stream health of the Nepean River near West Camden WRRF

Matahil Creek sites

Edge habitat samples were collected consistently enough from Matahil Creek to allow multivariate analysis for the monitoring period 2004 to 2023. Distinct groups of samples separated by site were evident for Matahil Creek in the 2-dimensional ordination plot (Figure A-4).

The ordination pattern was confirmed in the corresponding tree diagram (dendrogram) from classification analysis as the first division separated all upstream site samples from all downstream site samples (Figure A-5). This initial separation also occurred at a quite low similarity of 14% (Figure A-5) compared with all Nepean River sites samples which exhibited a greater initial similarity level of 34% (Figure A-7).

The clear separation of Matahil Creek sites was also evident in the corresponding shade plot (Figure A-6) where downstream samples displayed less diversity when compared to the upstream site. The shade plot displayed a few taxa in common between the two sites such as the freshwater snail Physidae *Physela*, and the caddisfly larvae Leptoceridae *Triplectides*. The corresponding SIGNAL-SG grades showed that dominant taxa that occurred downstream have lower SIGNAL-SG grades than those of the upstream site, which is reflected in the separation of site SIGNAL scores displayed in Figure A-2.

The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 16 taxa identified for the edge habitat (Table A-8) out of 145 taxa. These taxa reflected those taxa which formed the main patterns within the shade plot (Figure A-6).

The PERMDISP analysis indicated a similar pattern of dispersion (spacing between same site samples) for the two sites (Table A-6). This outcome suggests the variability in taxonomic make-up of samples collected over time was at similar levels for both sites through the period tested

(2005 to 2023). This result then also implies subsequent results of ANOSIM tests are focused on community structure differences between sites.

The ANOSIM test run on the factor ‘Site’ returned a high range value (R = 0.986) confirming community structure was distinct at each site (Table A-6).

To further explore community structure, hypothesis testing was conducted with PERMANOVA. The PERMANOVA model comprised the fixed factors ‘Site’ and ‘Year’. ‘Year’ represented samples collected in years between 2005 and 2023. ‘Site’ had two levels, upstream and downstream. A statistically significant‘ Site x Year’ interaction was returned (Table A-5). The components of variation output indicated ‘Site’ explained approximately 16 times the variation than explained by ‘Year’.

A second run of ANOSIM based on Site-period sample groups displayed in above ordination plots returned a significant global R-value at a high level of 0.89 (Table A-7). Pairwise tests indicated the four upstream versus downstream comparisons also had high level R-values (close to or equaling the maximum R-value of 1). In contrast, the same site comparison of the two time periods within each site returned low level R-values. These pairwise test results suggest clear differences in assemblage structure between upstream and downstream sites, and that each site had a relatively stable community structure through time (Table A-7).

These results suggested downstream community structure in Matahil Creek was consistently altered by wastewater discharge from West Camden WRRF.

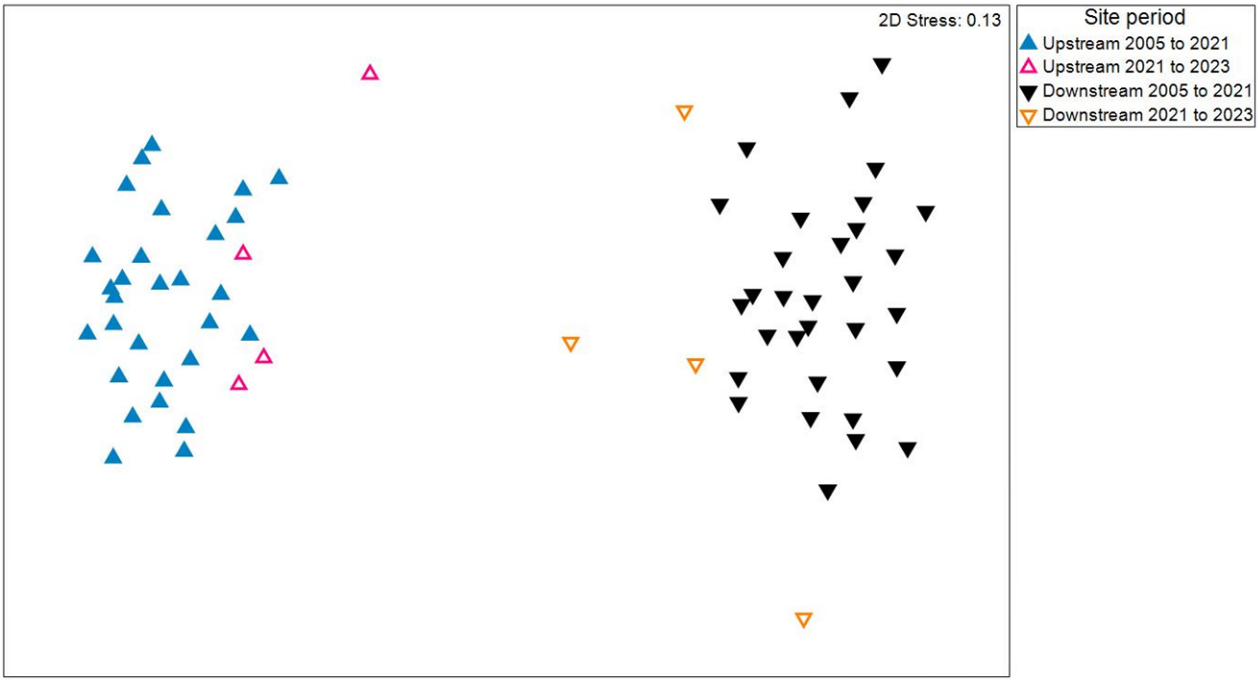


Table A-3 Two-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of Matahil Creek upstream and downstream sites of West Camden WRRF

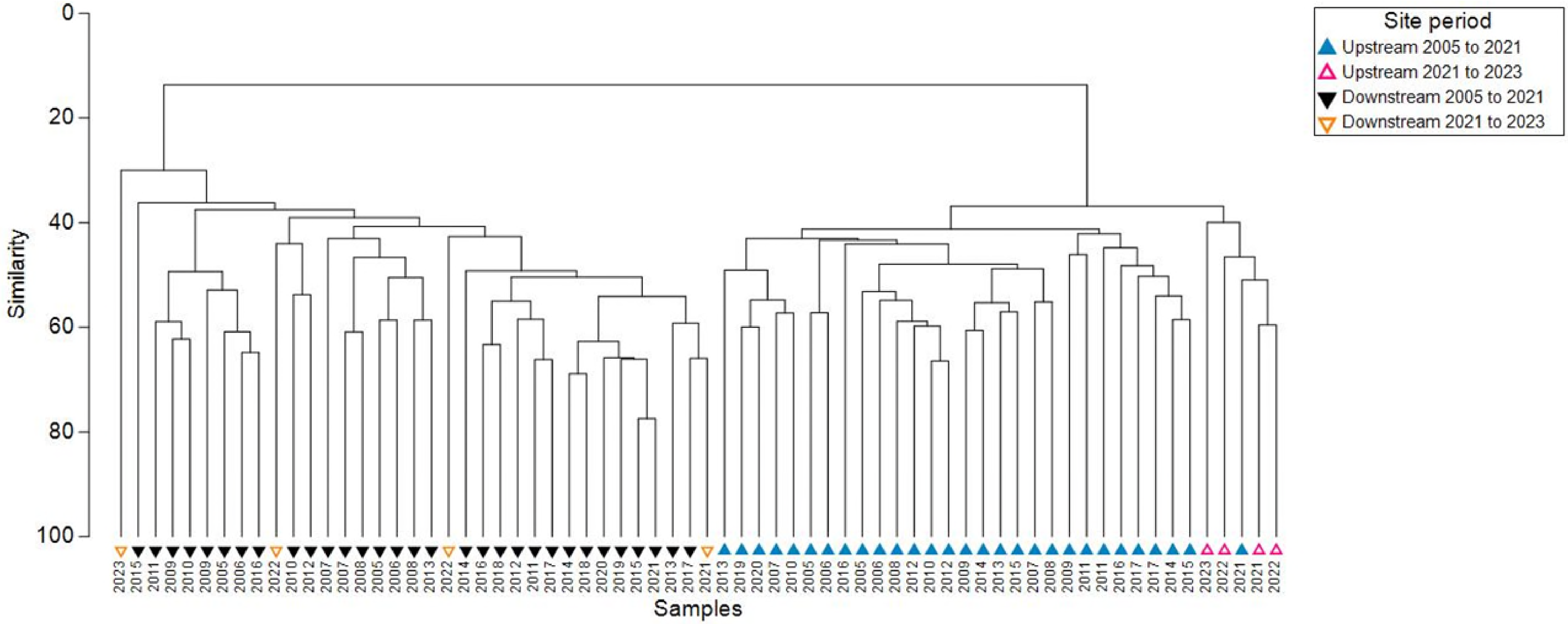


Figure A-4 Tree diagram of freshwater macroinvertebrate edge habitat community structure of Matahil Creek upstream and downstream sites of West Camden WRRF

Table A-4 ANOSIM test of 'Site' factor for edge habitat of Matahil Creek upstream and downstream sites of West Camden WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.986
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-5 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of Matahil Creek upstream and downstream sites of West Camden WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	19

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	62536	62536	41.06	0.0001	9923
Year	18	35099	1949.9	1.2803	0.0041	9679
SitexYear**	17	31723	1866.1	1.2252	0.0129	9703
Res	31	47214	1523			
Total	67	1.84E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	1977.3	44.466
S(Year)	119.74	10.943
S(SitexYear)	187.56	13.695
V(Res)	1523	39.026

Table A-6 PERMDISP test of 'Site' factor for edge habitat of Matahil Creek upstream and downstream sites of West Camden WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 68

DEVIATIONS FROM CENTROID
F: 0.058828 df1: 1 df2: 66
P(perm): 0.8175

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	35	40.628	1.2873
Upstream	33	40.236	0.95235

Table A-7 ANOSIM test of 'Site period' samples for edge habitat of Matahil Creek upstream and downstream sites of West Camden WRRF

Tests for differences between unordered Site period groups

Global Test

Sample statistic (R): 0.89
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 2005 to 2021, Upstream 2005 to 2021	0.998	0.01	Very large	9999	0
Downstream 2005 to 2021, Downstream 2021 to 2023	0.406	0.2	52360	9999	17
Downstream 2005 to 2021, Upstream 2021 to 2023	0.979	0.01	52360	9999	0
Upstream 2005 to 2021, Downstream 2021 to 2023	0.985	0.02	40920	9999	1
Upstream 2005 to 2021, Upstream 2021 to 2023	0.399	0.7	40920	9999	73
Downstream 2021 to 2023, Upstream 2021 to 2023	0.813	2.9	35	35	1

Table A-8 Genera subset whose multivariate pattern matches full genera set of the edge habitat of Matahil Creek upstream and downstream sites of West Camden WRRF

Subset of 16 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 145 genera identified with the same subset found on eight runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Coenagrionidae Ischnura,Physidae Physella,Belostomatidae Diplonychus,Chironomidae Dicrotendipes,Chironomidae Kiefferulus,Simuliidae Simulium,Libellulidae Nannophlebia,Scyphacidae Haloniscus,Tateidae Potamopyrgus,Atyidae Paratya,Baetidae Cloeon,Dytiscidae Necterosoma,Leptoceridae Notalina,Dytiscidae Hyphydrus,Hydrophilidae Berosus,Leptoceridae Triplectides

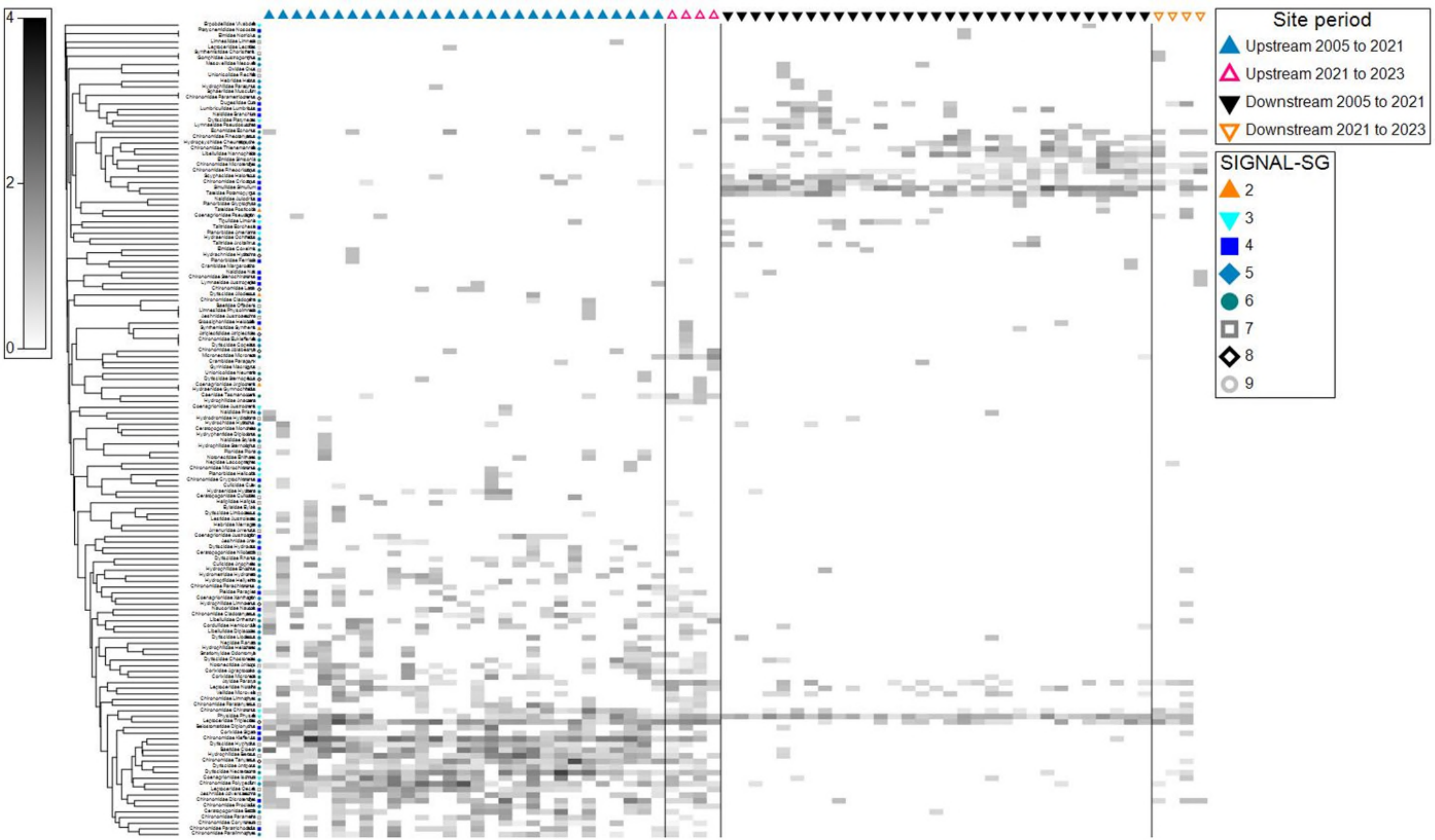


Figure A-5 Shade plot of freshwater macroinvertebrate edge habitat community structure of Matahil Creek upstream and downstream sites of West Camden WRRF

Nepean River sites

At both upstream and downstream sites on the Nepean River, edge habitat data was collected consistently enough through time (less sample collection gaps outlined in Volume 1 (Table 3-8) to allow multivariate analysis.

The Nepean River edge habitat data pattern was visually displayed in a 3-dimensional nMDS ordination plot, as the 2-dimensional plot had a poor (stress) value of 0.26. A stress value of > 0.2 represents points being placed almost arbitrarily in 2-dimensional space and the returned 2-dimensional stress value suggests that there is no clear pattern of site differences in the data. Addition of a third dimension provided a more acceptable stress value of 0.19. Data points were colour coded by Site-Time periods (Figure A-7). The addition of a third dimension did not reveal a clear separation of groups of upstream and downstream samples in the corresponding ordination plot (Figure A-7).

The lack of a clear upstream downstream site pattern in the ordination plot was confirmed in the corresponding tree diagram (Figure A-8). Initial separation of samples occurred at a moderate level of similarity (34%) (Figure A-8).

The shade plot of the Nepean River edge habitat lacked a distinct site difference in the taxa pattern as seen for the Matahil Creek sites. Rather, a less distinct difference between the 2021 to 2023 and 1995 to 2021 periods was apparent for both sites (Figure A-9). Looking at corresponding SIGNAL-SG grades revealed a mix of mid-range grades in both periods for both sites (Figure A-9).

The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 64 taxa for the edge habitat (Table A-13) out of 189 taxa. This subset of taxa formed the main visual pattern in the respective shade plot (Figure A-8).

The PERMDISP analysis indicated a similar pattern of dispersion (spacing between same site samples) for the 2 sites (Table A-11). This suggests the variability in taxonomic make-up of samples collected over time was at similar levels for both sites through the period tested (1995 to 2023). This result then also implies subsequent results of ANOSIM tests are focused on community structure differences between sites rather than within.

An ANOSIM test was run on the factor ‘Site’. The returned ANOSIM R-value was close to zero (0.093) (Table A-9), implying there was a lack of clearly different taxonomic assemblages present at each site, which was in contrast to the distinct community structure differences shown for Matahil Creek.

To further explore community structure, hypothesis testing was conducted using PERMANOVA (Table A-10). This model included the fixed factors ‘Site’ and ‘Year’. ‘Year’ represented samples collected in years between 1995 and 2023 whereas ‘Site’ had two levels, upstream and downstream. A statistically non-significant ‘Site x Year’ interaction was returned (Table A-10). This non-significant result allowed us to view the ‘Site’ and ‘Year’ results. Significant results were returned for ‘Site’ and ‘Year’. The components of variation output indicated ‘Year’ explained approximately 11 times the variation than explained by ‘Site’ (Table A-10).

A second run of ANOSIM based on Site-period sample groups returned a significant global R-value at a low level (0.189) (Table A-12). Pairwise test outputs were non-significant for one comparison, which was between the upstream vs downstream samples in the most recent period.

Both SIGNAL-SG and multivariate analysis results suggested downstream community structure in Matahil Creek was consistently altered by wastewater discharge from West Camden WRRF but this impact did not extend as far as the Nepean River.

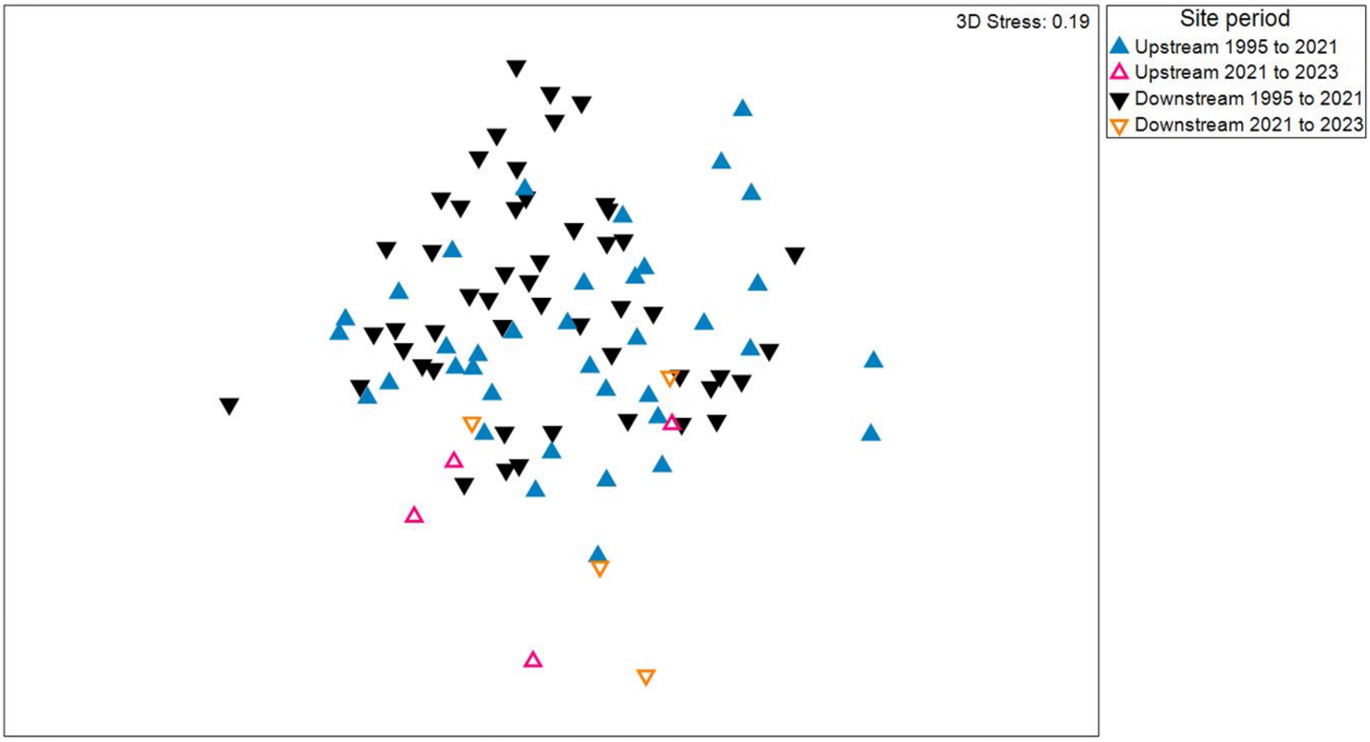


Figure A-6 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of sites upstream-downstream of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

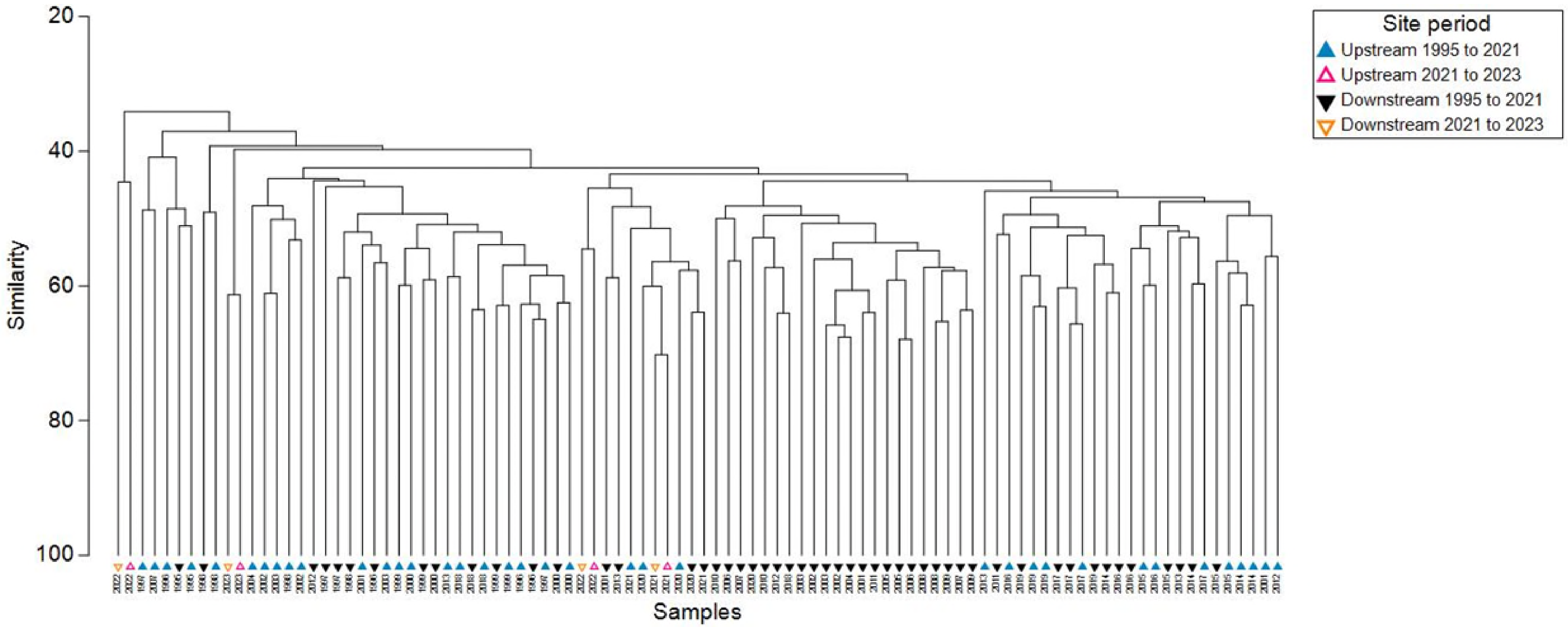


Figure A-7 Tree diagram of freshwater macroinvertebrate edge habitat community structure of sites upstream-downstream of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

Table A-9 ANOSIM test of 'Site' for edge habitat of upstream-downstream sites of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.093
Significance level of sample statistic: 0.03%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 2

Table A-10 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of upstream-downstream sites of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	29

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	perms
Site	1	2813.3	2813.3	2.3901	0.001	9922
Year	28	75617	2700.6	2.2944	0.0001	9619
SitexYear**	22	24289	1104.1	0.93801	0.8092	9602
Res	44	51789	1177			
Total	95	1.56E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	41.756	6.4619
S(Year)	466.05	21.588
S(SitexYear)	-40.35	-6.3522
V(Res)	1177	34.308

Table A-11 PERMDISP test of 'Site' for edge habitat of upstream-downstream sites of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 96

DEVIATIONS FROM CENTROID
F: 0.54713 df1: 1 df2: 94
P(perm): 0.4829

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	55	39.093	0.69585
Upstream	41	39.869	0.7788

Table A-12 ANOSIM test of 'Site period' for edge habitat of upstream-downstream sites of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.189
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1995 to 2021, Upstream 1995 to 2021	0.109	0.02	Very large	9999	1
Downstream 1995 to 2021, Downstream 2021 to 2023	0.386	0.8	341055	9999	76
Downstream 1995 to 2021, Upstream 2021 to 2023	0.505	0.1	341055	9999	9
Upstream 1995 to 2021, Downstream 2021 to 2023	0.3	2.4	101270	9999	241
Upstream 1995 to 2021, Upstream 2021 to 2023	0.39	0.6	101270	9999	56
Downstream 2021 to 2023, Upstream 2021 to 2023	-0.156	80	35	35	28

Table A-13 Genera subset whose multivariate pattern matches full genera set of the edge habitat of upstream-downstream sites of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

Subset of 64 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 189 genera identified with the same subset found on one run from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Aturidae Wheenyella,Coenagrionidae Ischnura,Palaemonidae Macrobrachium,Physidae Physella,Chironomidae Cricotopus,Chironomidae Cryptochironomus,Chironomidae Dicrotendipes,Corbiculidae Corbicula,Dugesiidae Cura,Glossiphoniidae Helobdella,Planorbidae Gyraulus,Platycnemididae Nososticta,Pleidae Paraplea,Chironomidae Cladotanytarsus,Chironomidae Polypedilum,Chironomidae Procladius,Coenagrionidae Pseudagrion,Hydrometridae Hydrometra,Hydrophilidae Helochares,Isostictidae Rhadinosticta,Libellulidae Diplacodes,Libellulidae Nannophlebia,Atyidae Paratya,Baetidae Cloeon,Ceratopogonidae Bezzia,Ceratopogonidae Monohelea,Chironomidae Nanocladius,Dytiscidae Necterosoma,Elmidae Coxelmis,Elmidae Ovolara,Gomphidae Austrogomphus,Hydraenidae Hydraena,Leptoceridae Notalina,Corixidae Micronecta,Unionicolidae Unionicola,Chironomidae Corynoneura,Chironomidae Parakiefferiella,Chironomidae Paramerina,Chironomidae Riethia,Haliplidae Haliplus,Hydrodromidae Hydrodroma,Hydrophilidae Berosus,Leptoceridae Oecetis,Leptoceridae Triaenodes,Limnesiidae Limnesia,Mideopsidae Gretacarus,Oxidae Oxus,Unionicolidae Koenikea,Unionicolidae Recifella,Veliidae Microvelia,Aturidae Albia,Calamoceratidae Anisocentropus,Chironomidae Ablabesmyia,Chironomidae Larsia,Chironomidae Tanytarsus,Dytiscidae Sternopriscus,Elmidae Austrolimnius,Hygrobatidae Coaustraliobates,Leptoceridae Triplectides,Leptophlebiidae Atalophlebia,Oxidae Flabellifrontipoda,Baetidae Centroptilum,Stratiomyidae Odontomyia,Micronectidae Micronecta

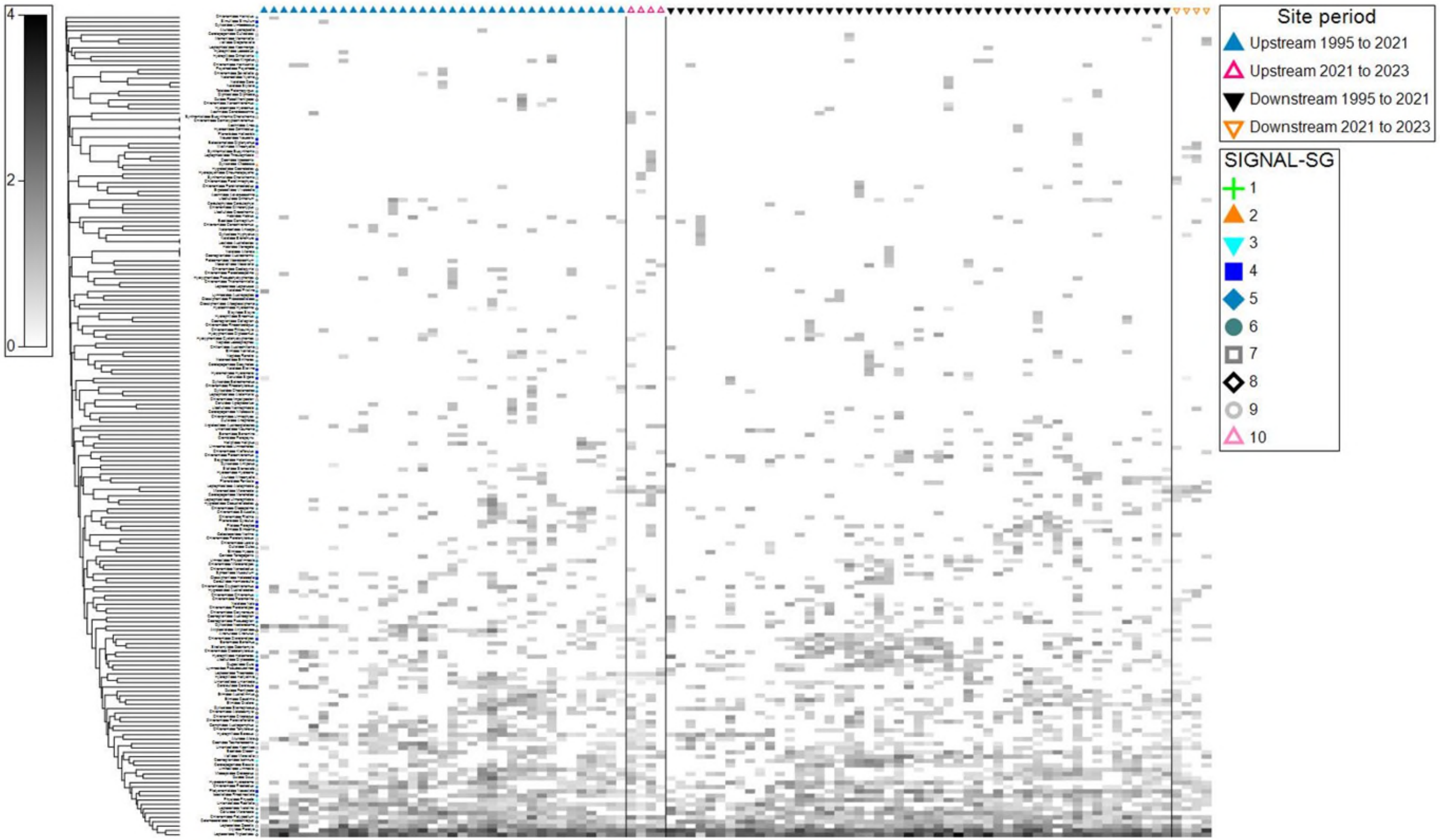
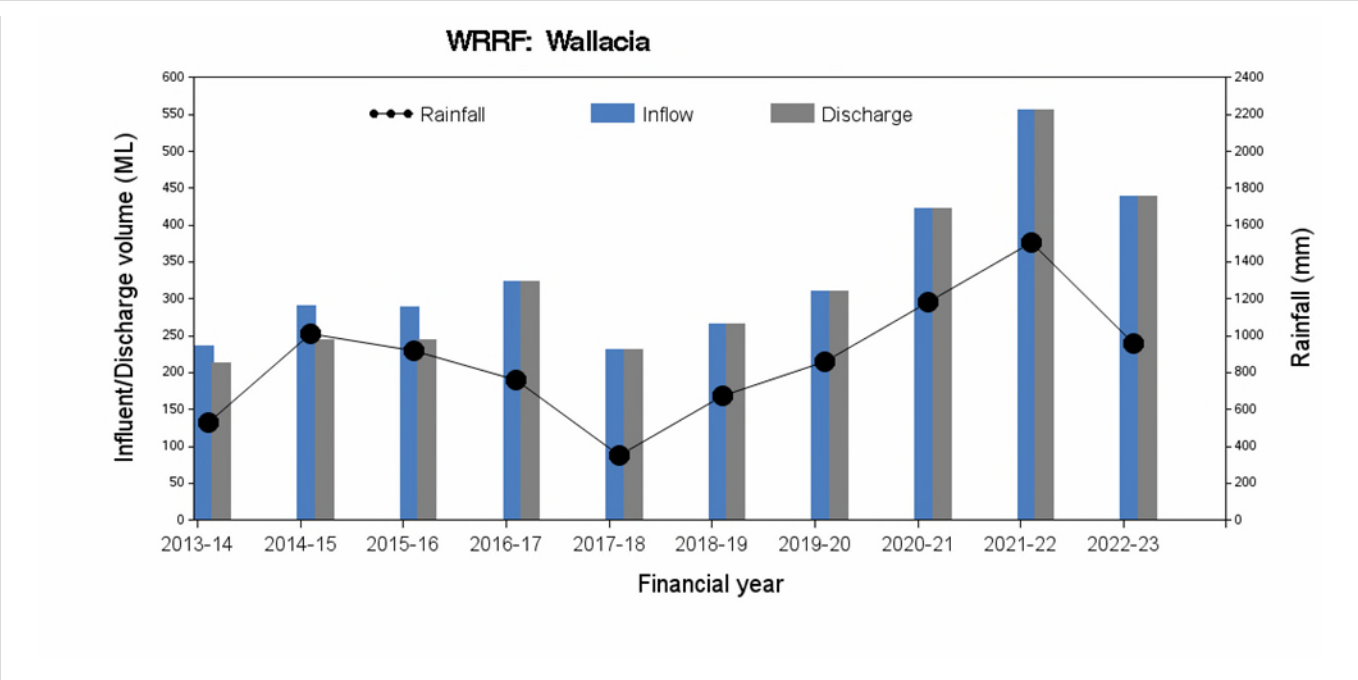


Figure A-8 Shade plot of the edge habitat of upstream-downstream sites of Nepean River at the confluence of Matahil Creek into which West Camden WRRF discharges

A-3 Wallacia WRRF

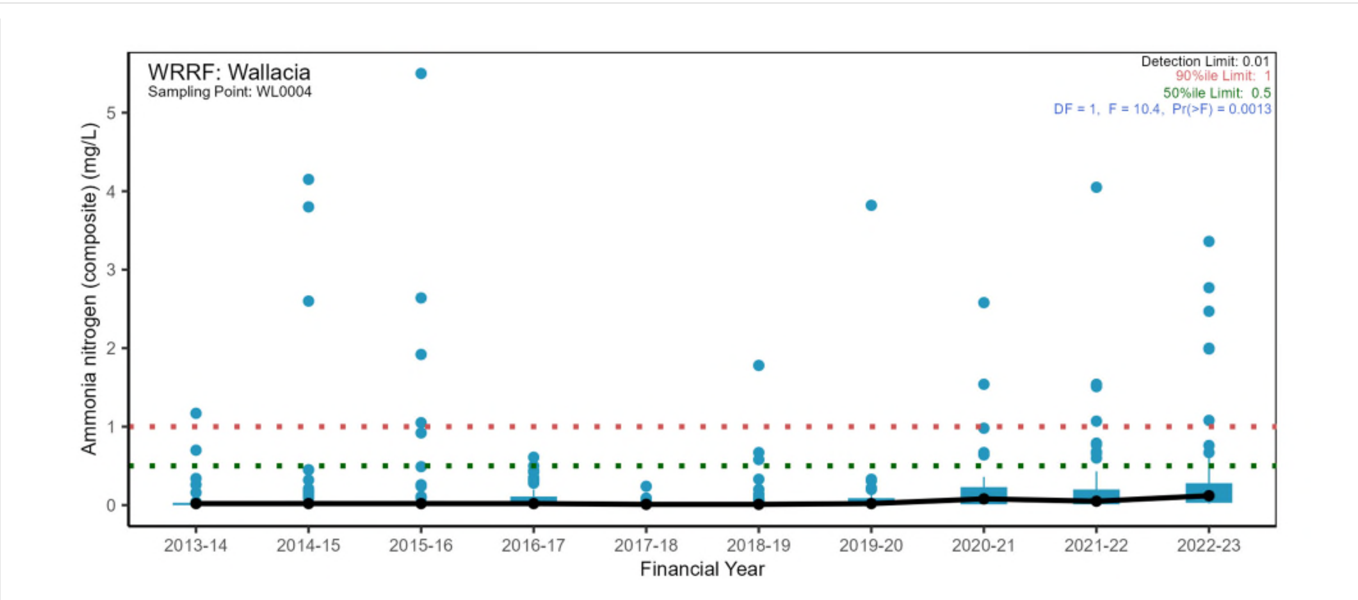
A-3.1 Pressure – Wastewater quantity

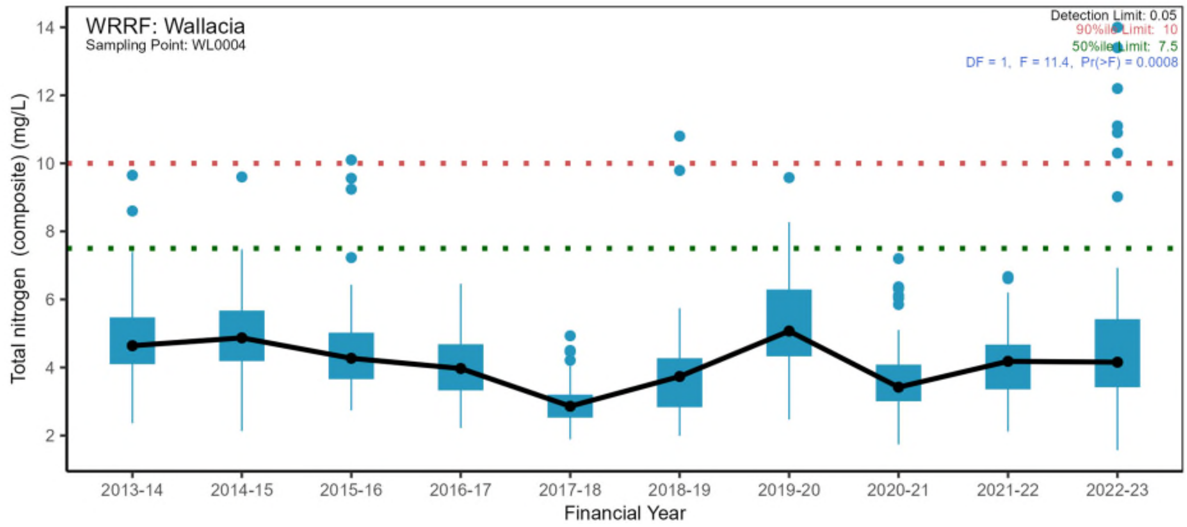
Inflow/ Discharge volume and rainfall

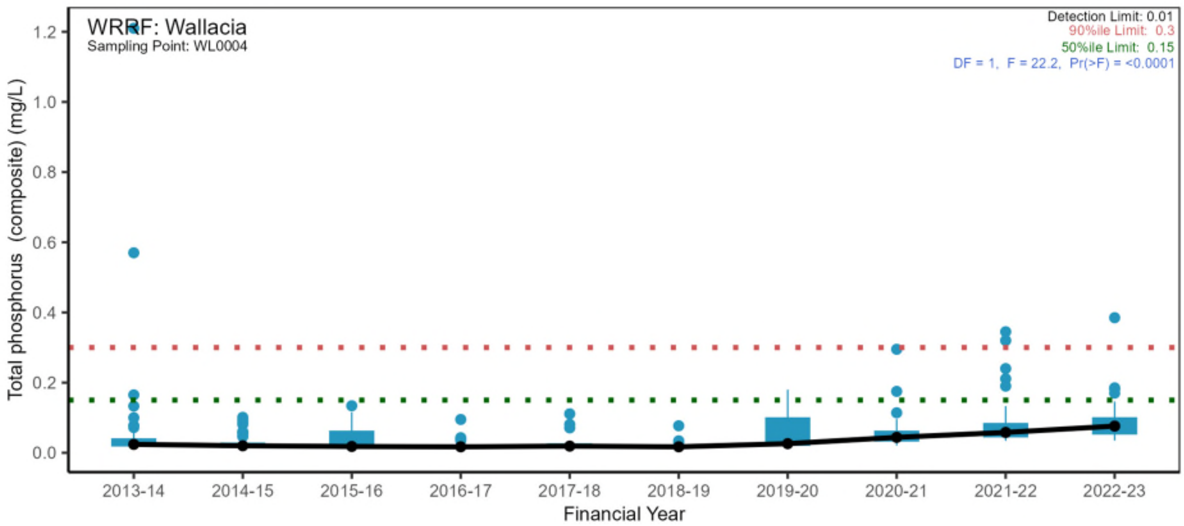


A-3.2 Pressure – Wastewater quality

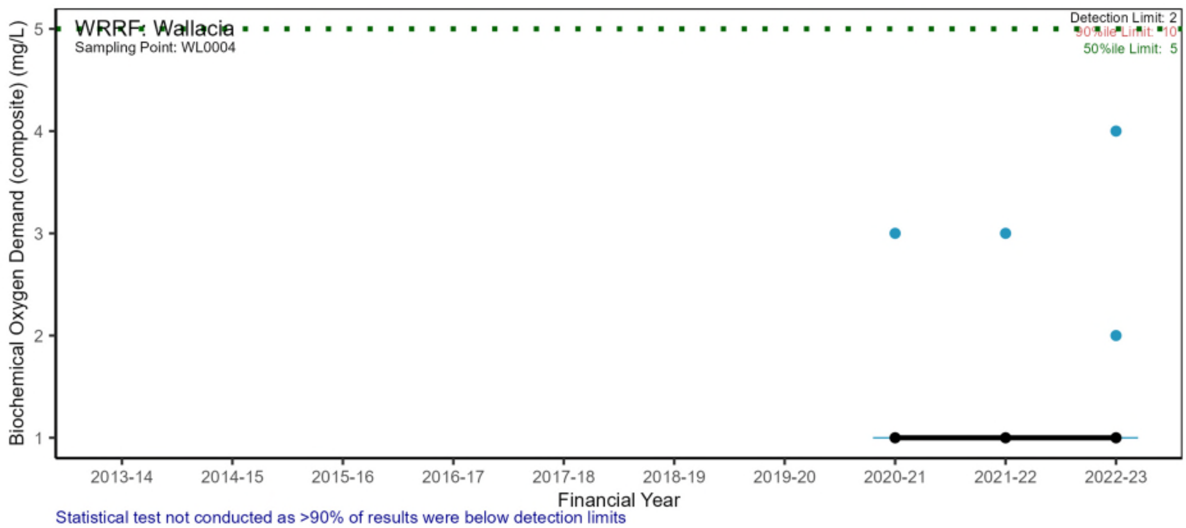
Nutrients

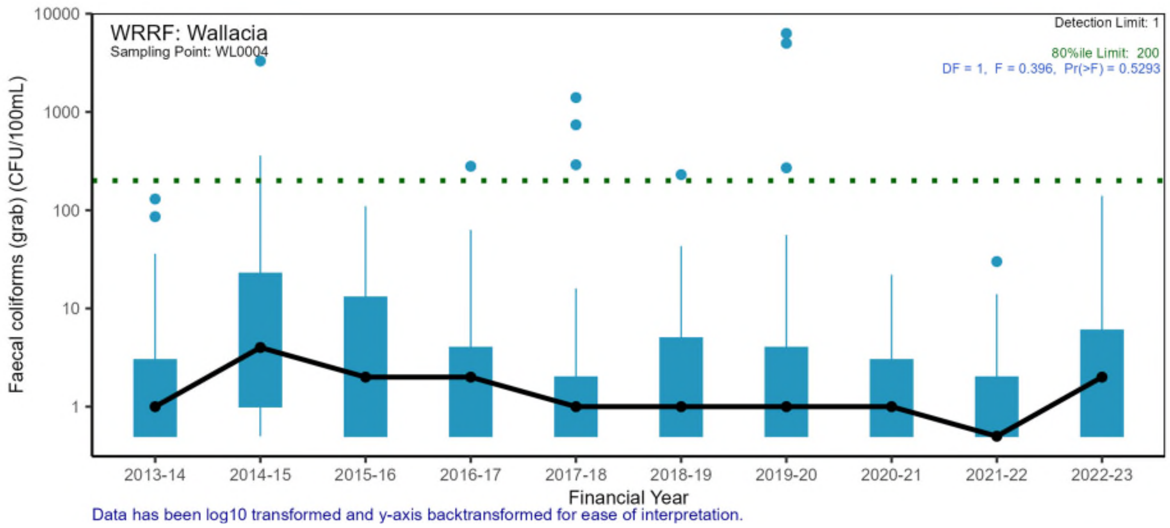


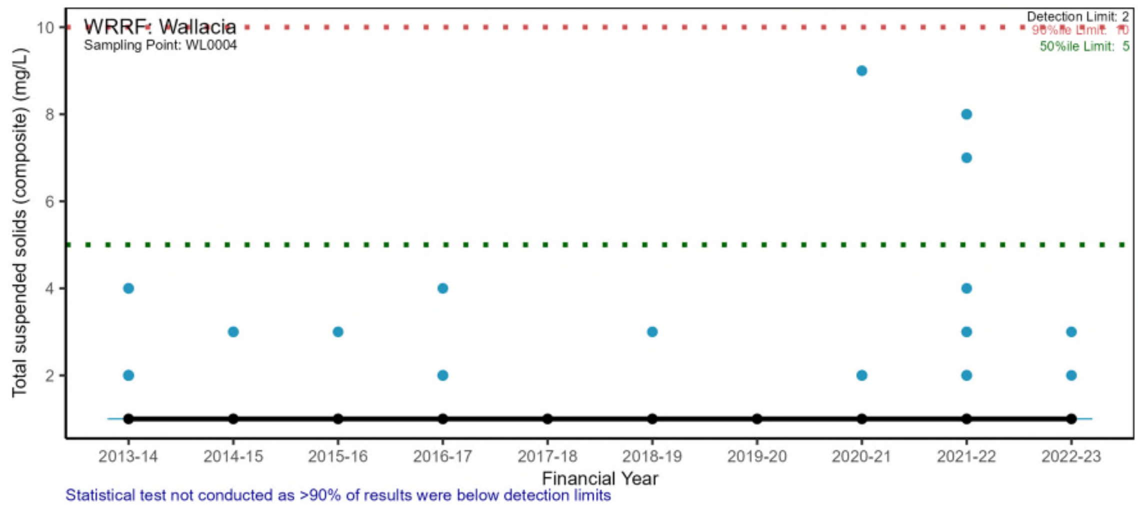




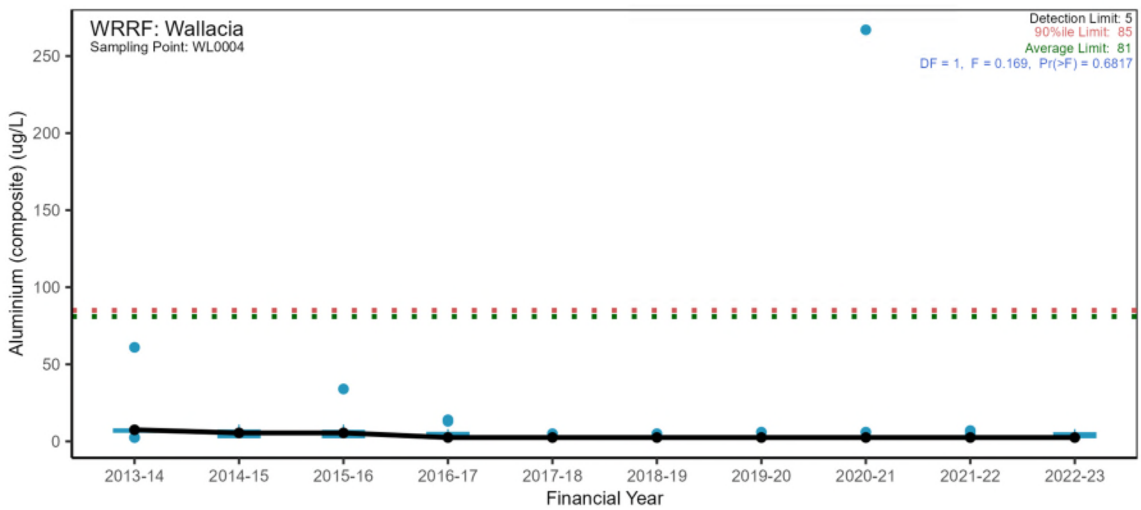
Major conventional analytes

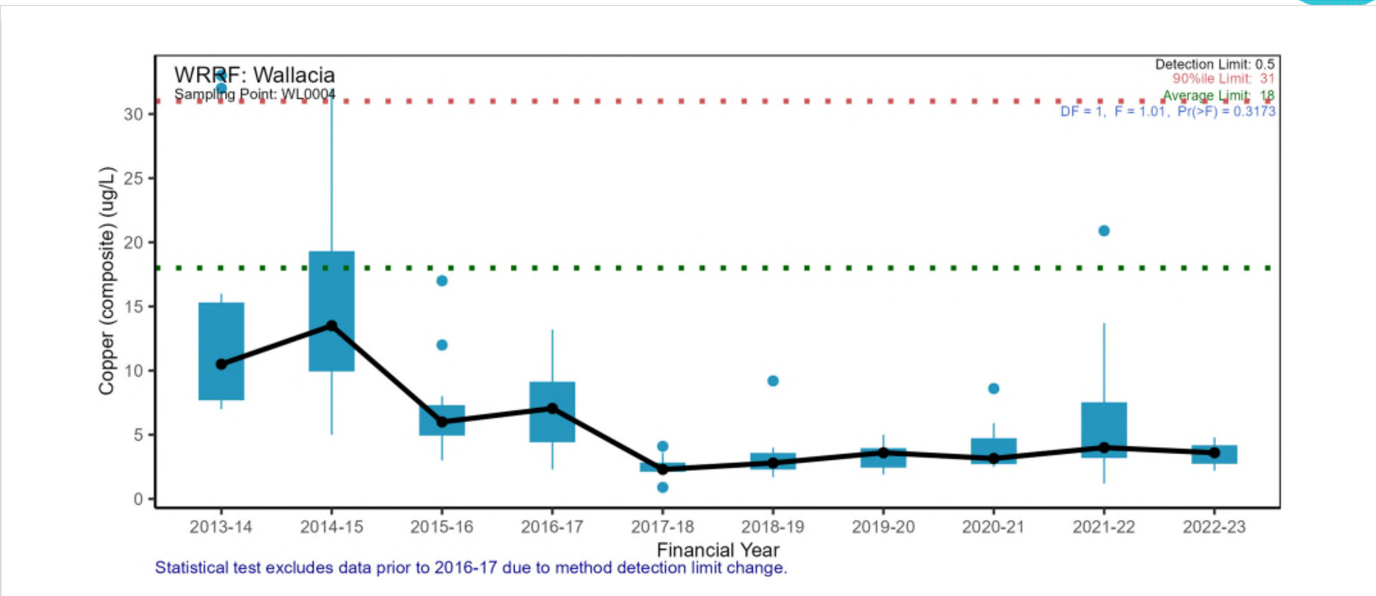


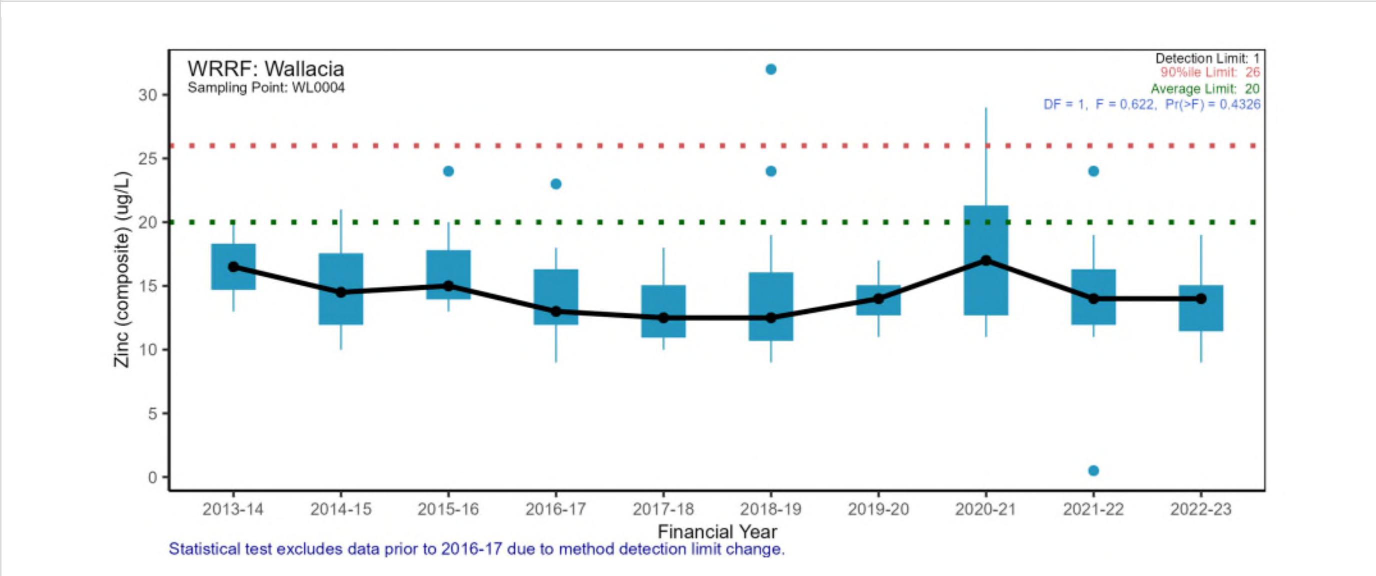




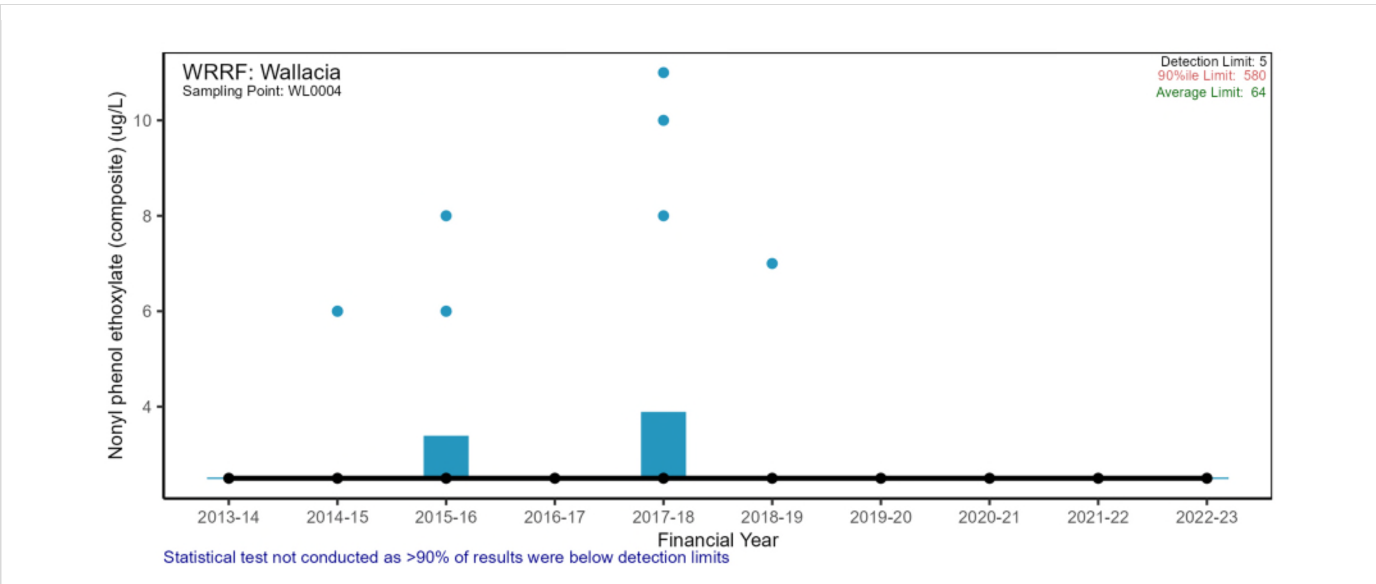
Trace metals

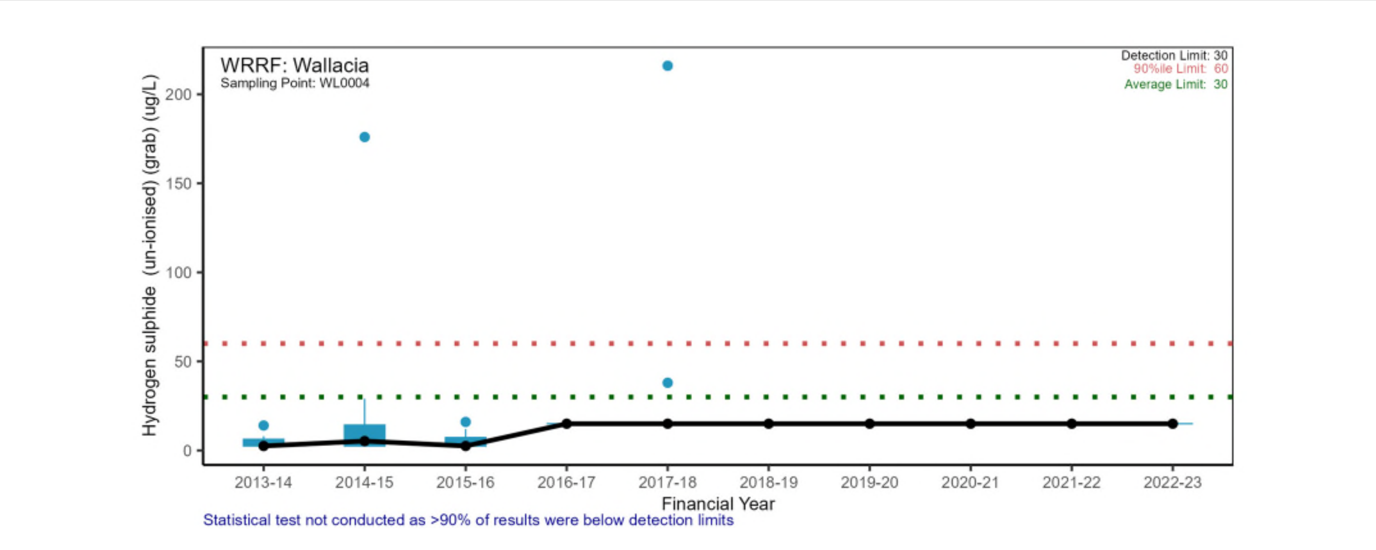




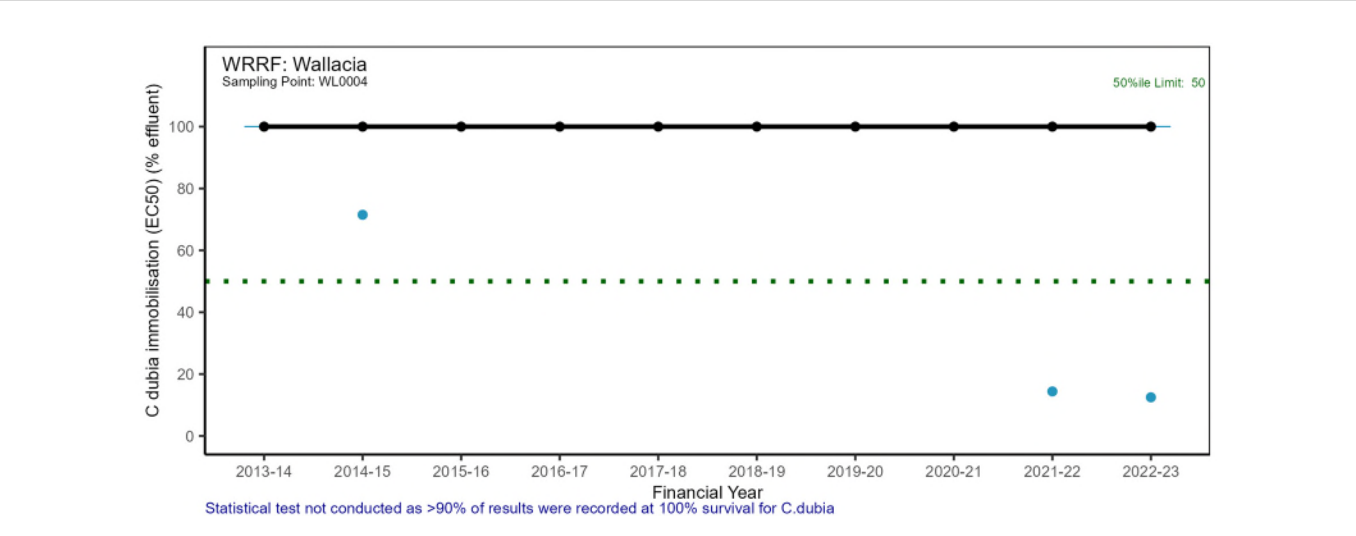


Other chemicals and organics (including pesticides)



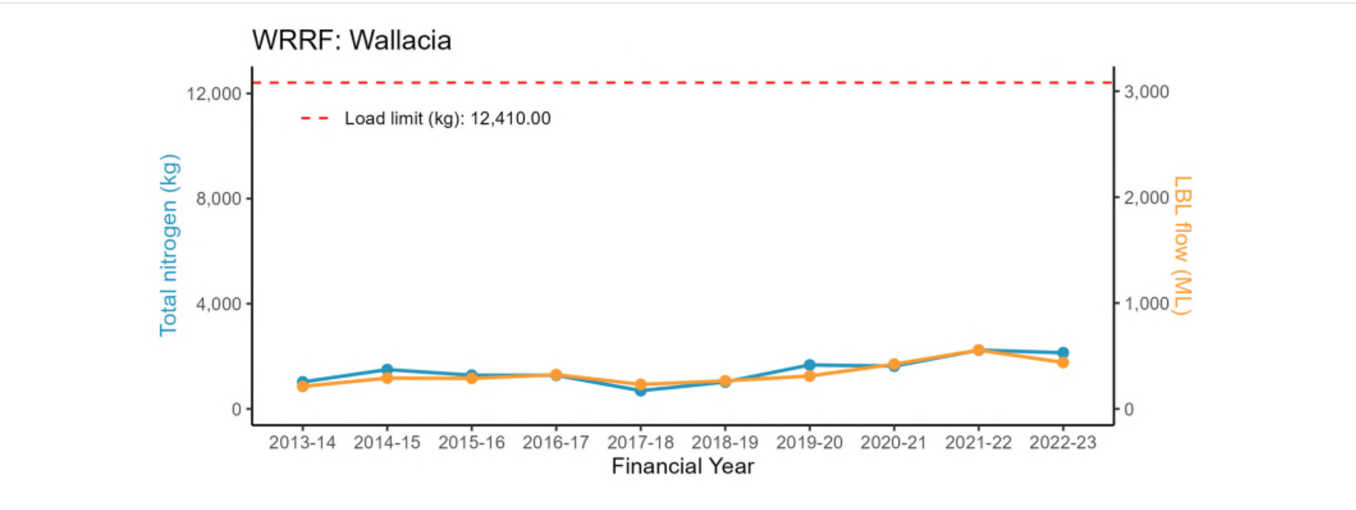


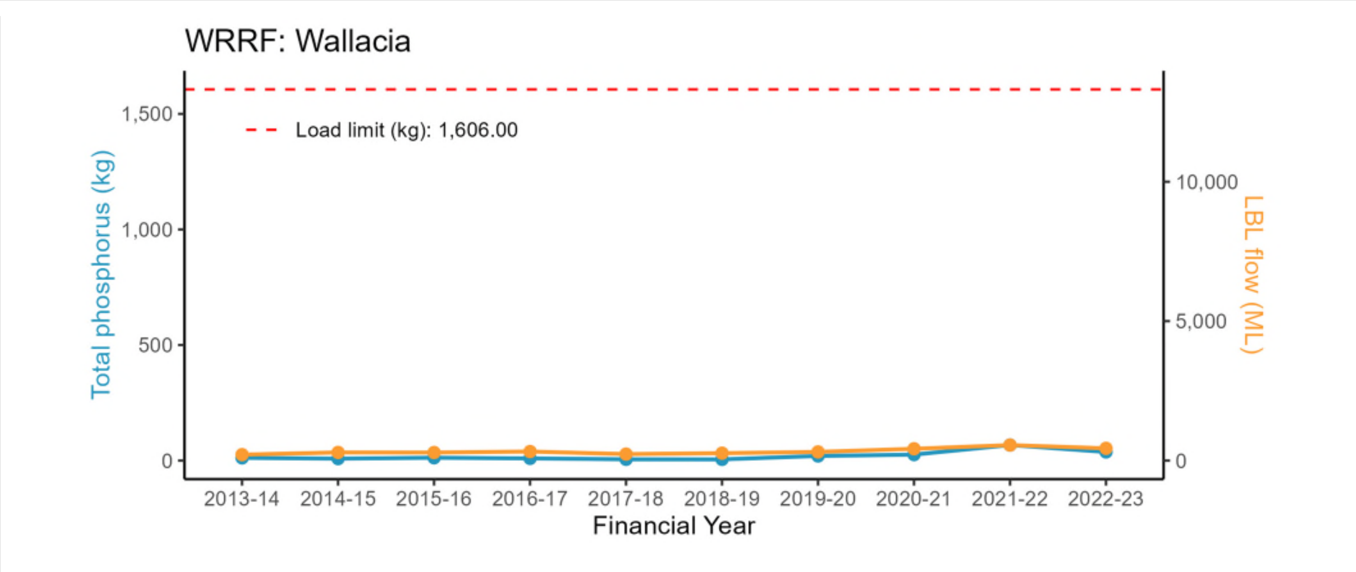
A-3.3 Pressure – Wastewater toxicity



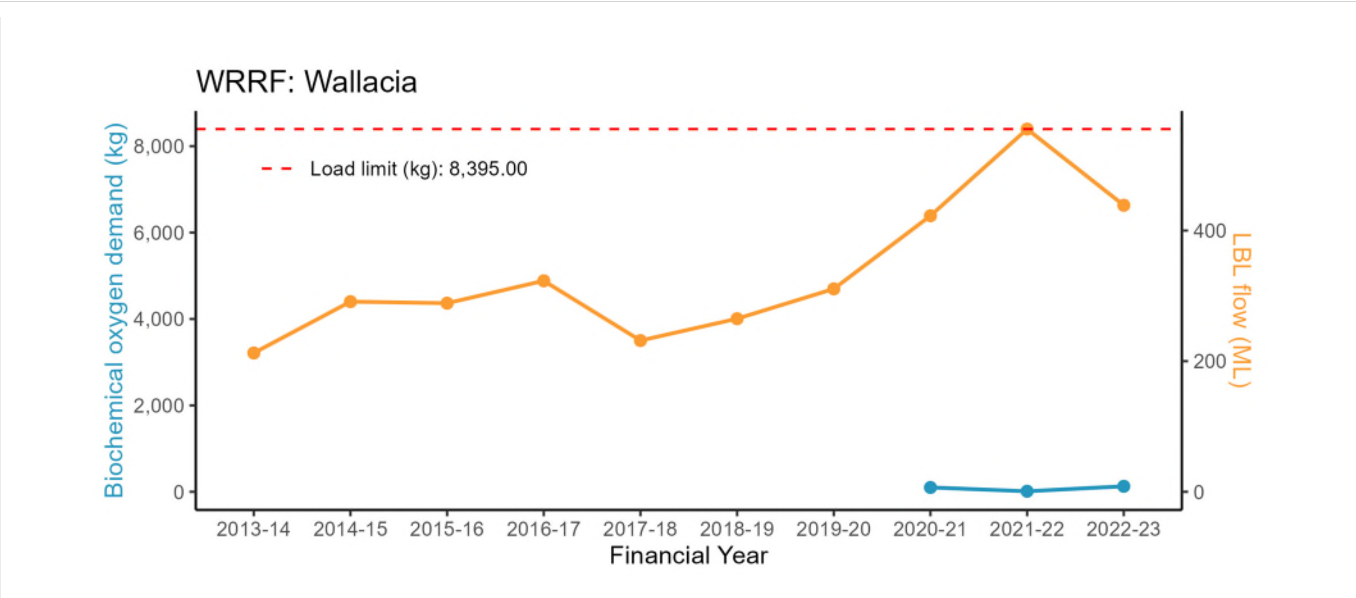
A-3.4 Pressure – Wastewater discharge load

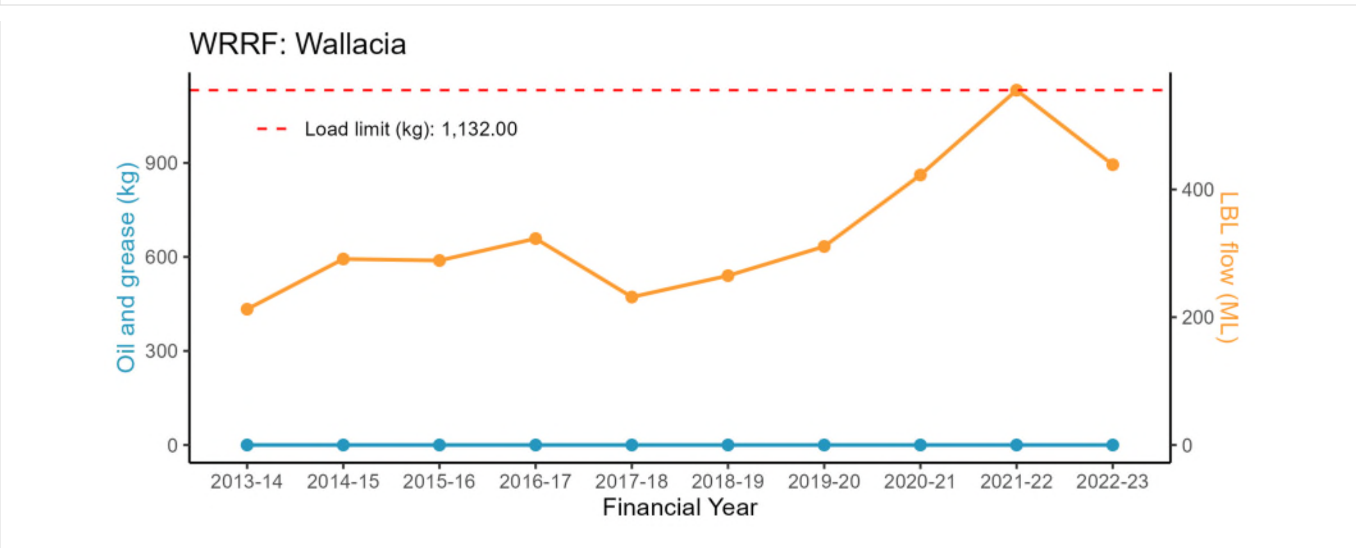
Nutrients

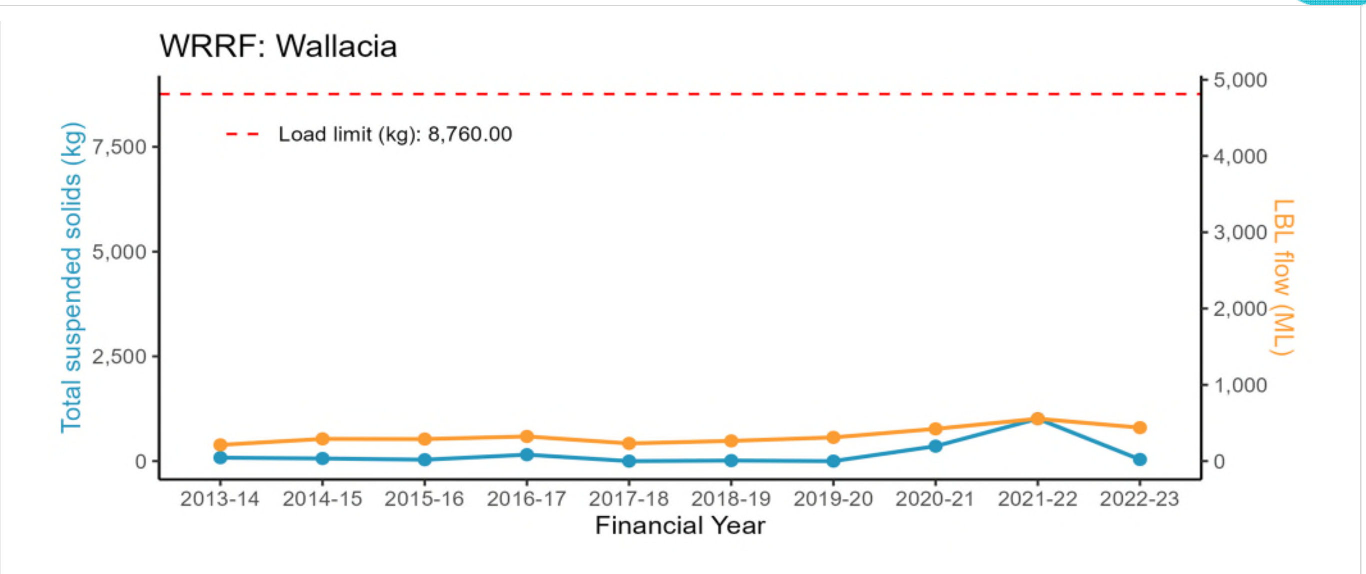




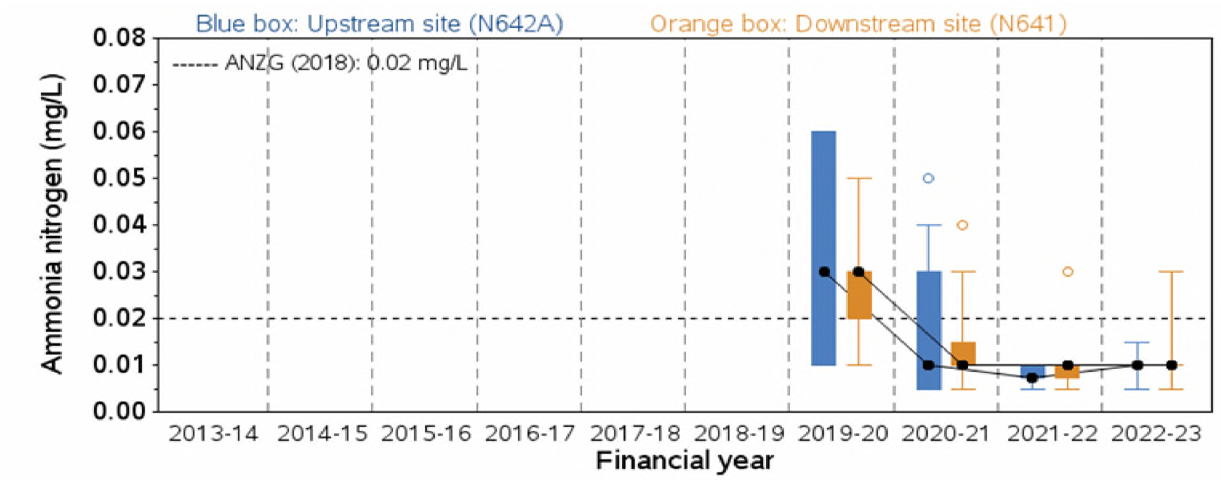
Major conventional analytes



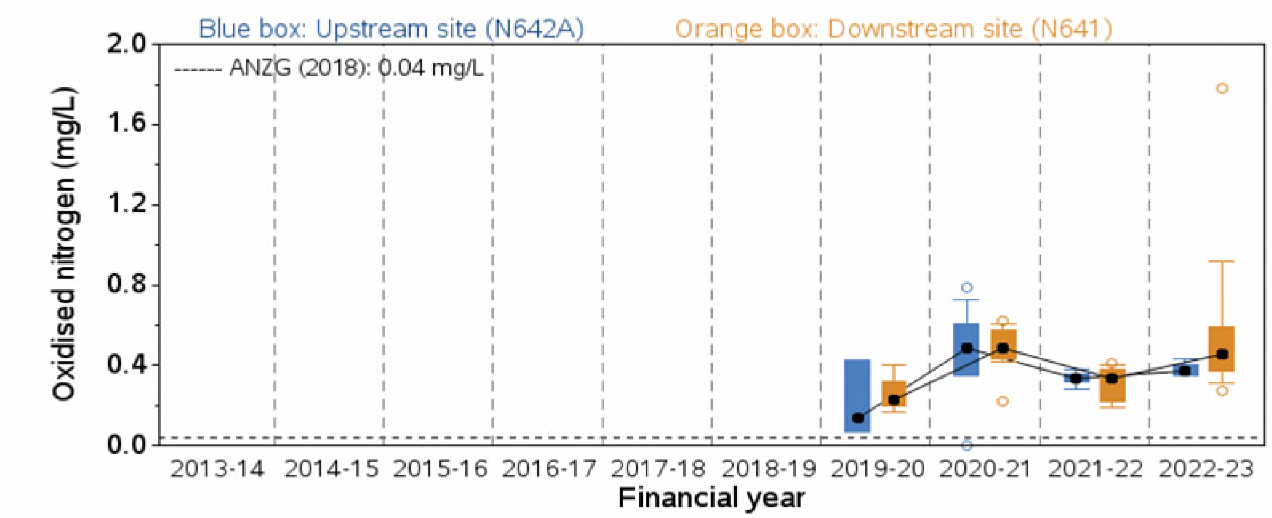




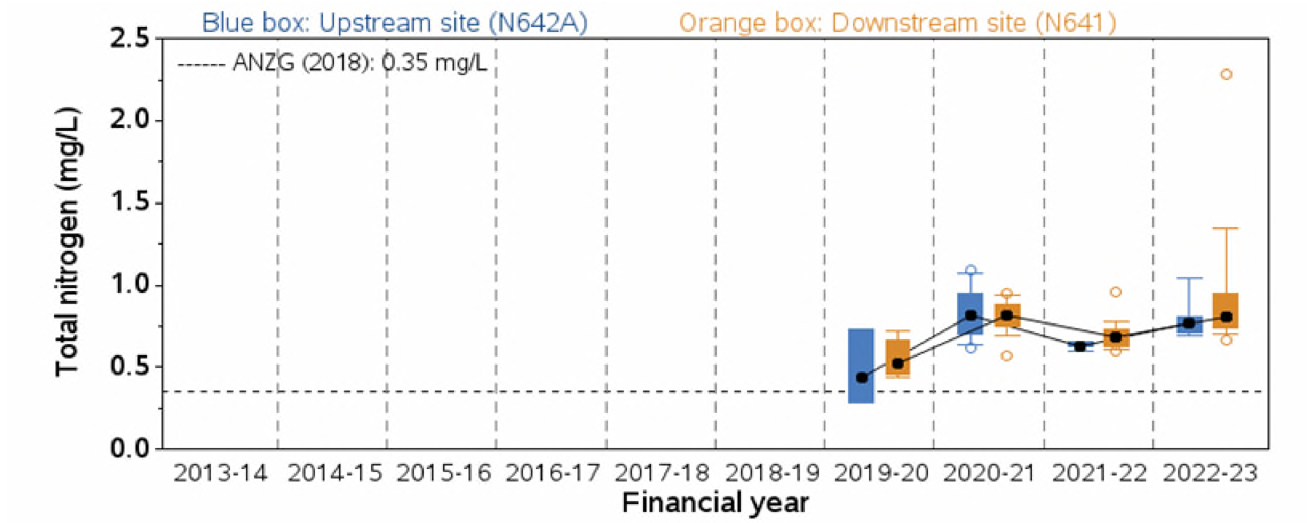
A-3.5 Stressor – Nutrients



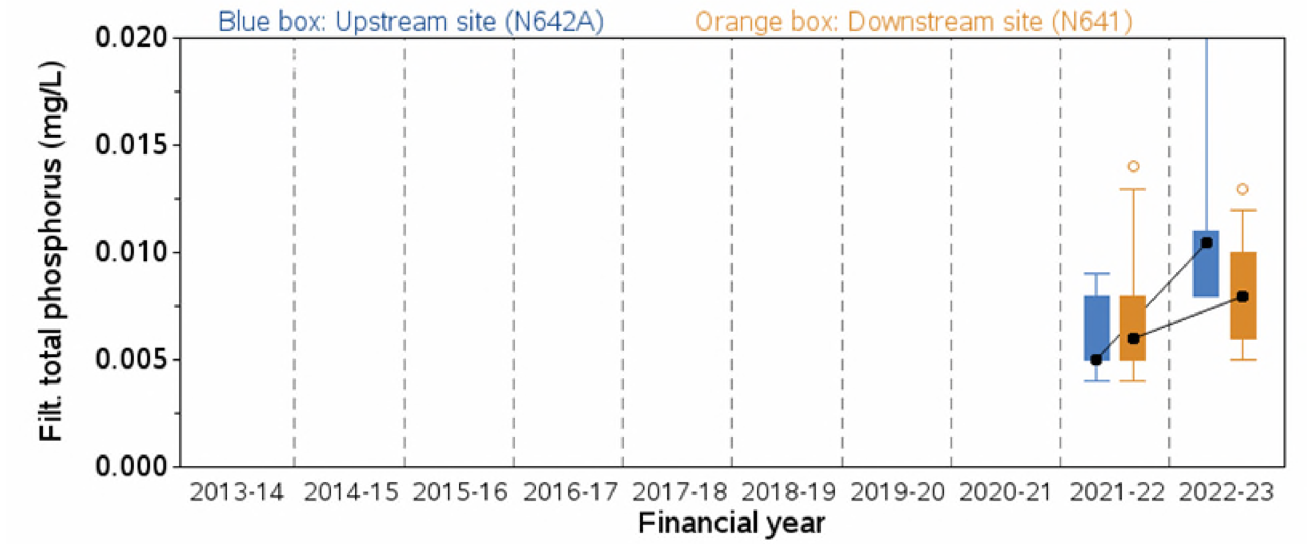
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	1.06	0.3122	N641	1	1.24	0.2712



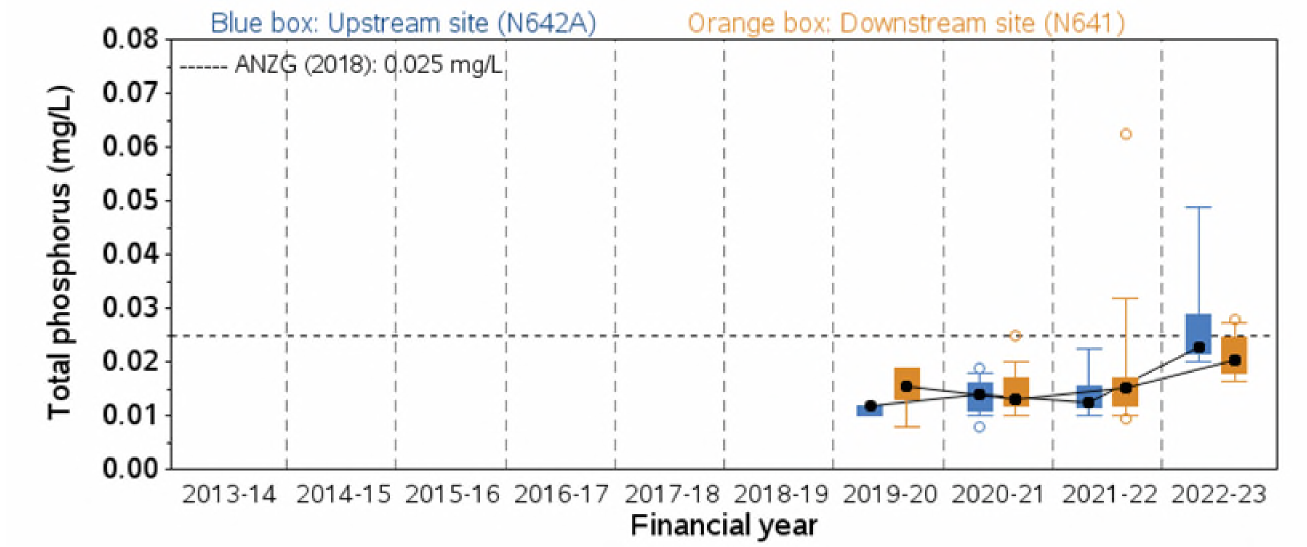
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	0.14	0.7155	N641	1	6.58	0.0133



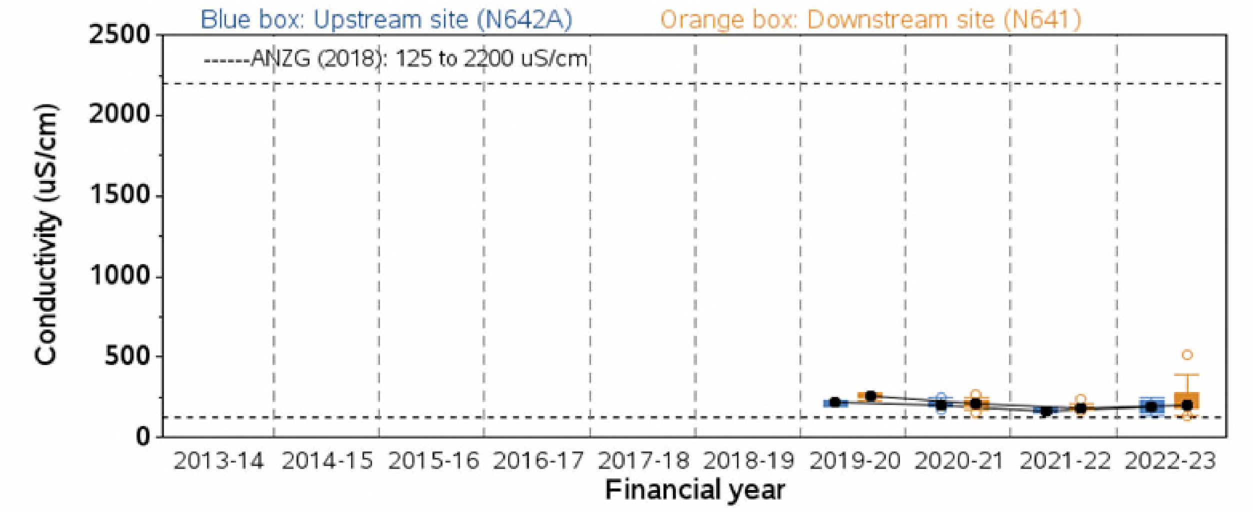
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	0.46	0.5042	N641	1	9.21	0.0038



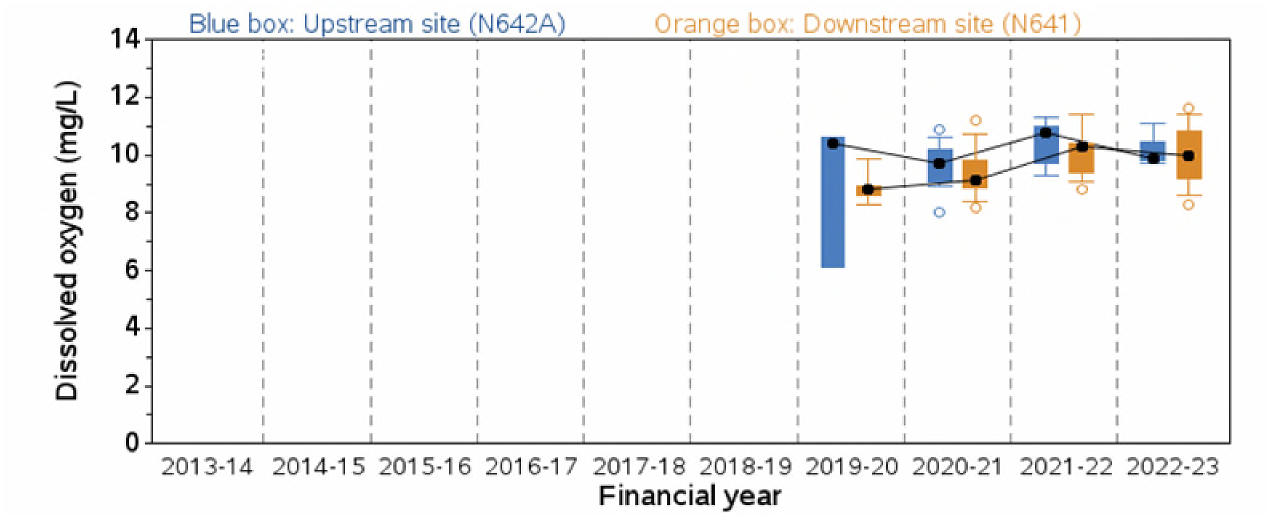
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	5.48	0.044	N641	1	1.42	0.2431



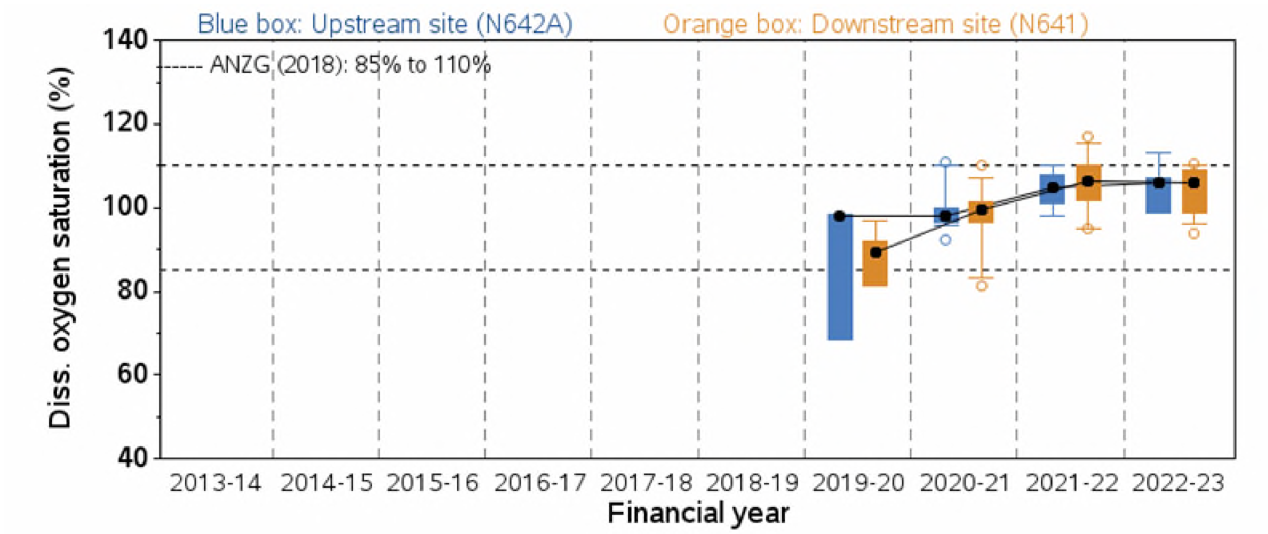
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	28.03	<.0001	N641	1	5.06	0.0289



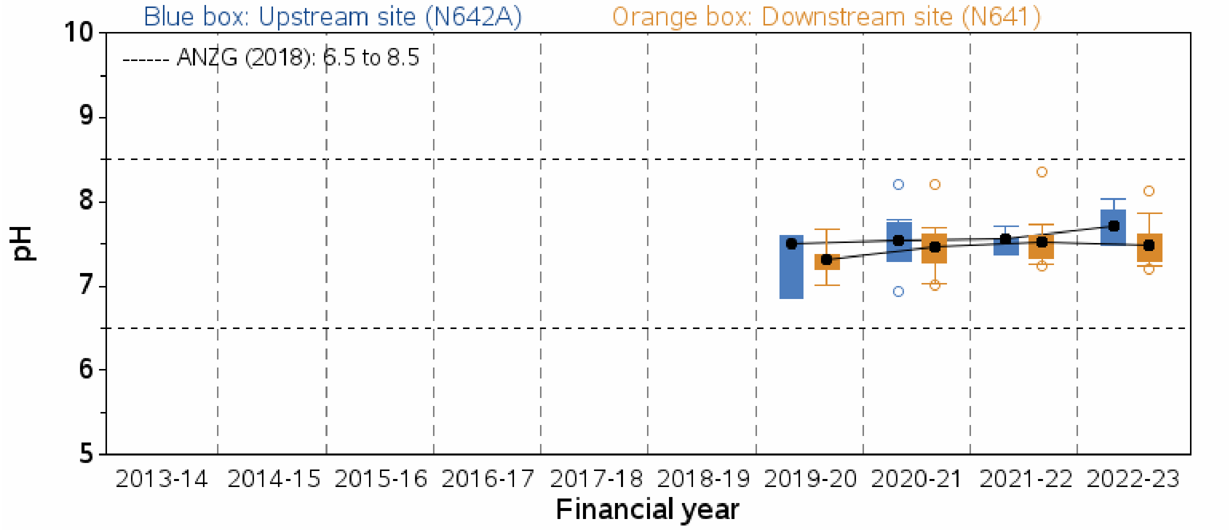
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	0.44	0.5136	N641	1	2.34	0.1322



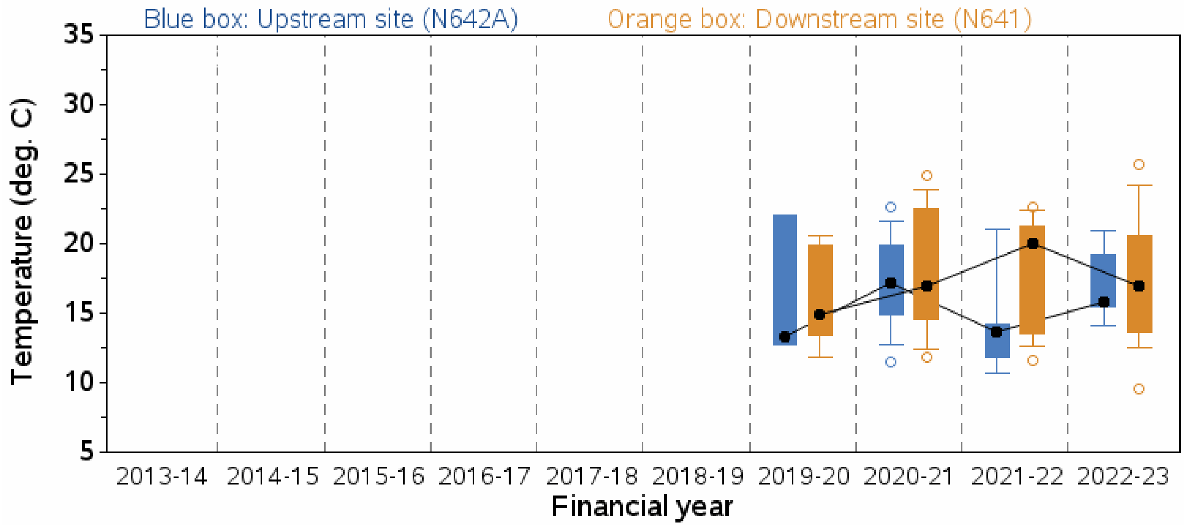
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	0.64	0.4326	N641	1	2.61	0.1121



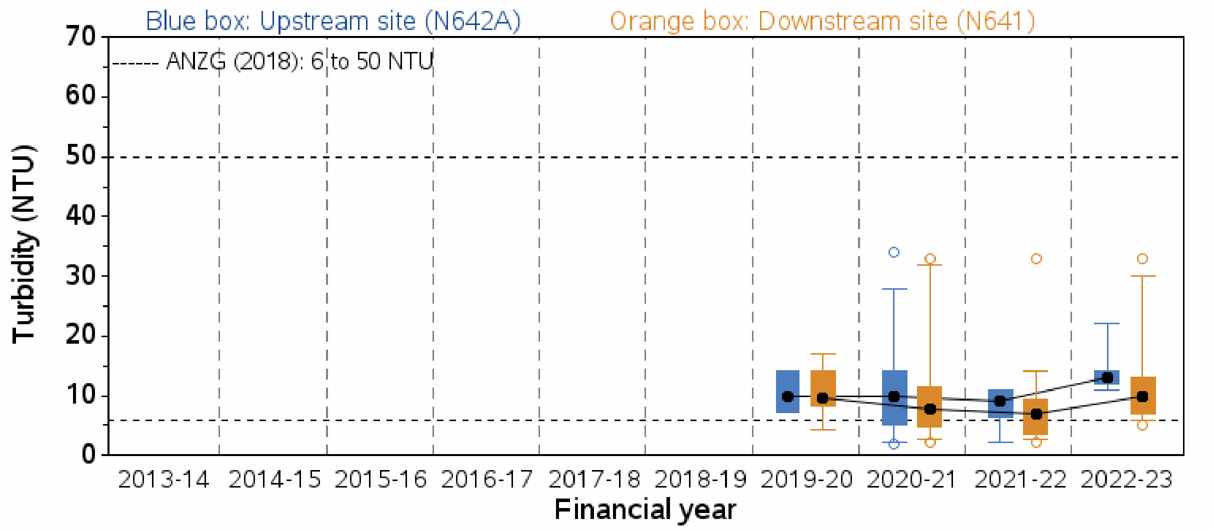
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	2.45	0.1293	N641	1	2.71	0.1058



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	2.95	0.0978	N641	1	0.18	0.6769

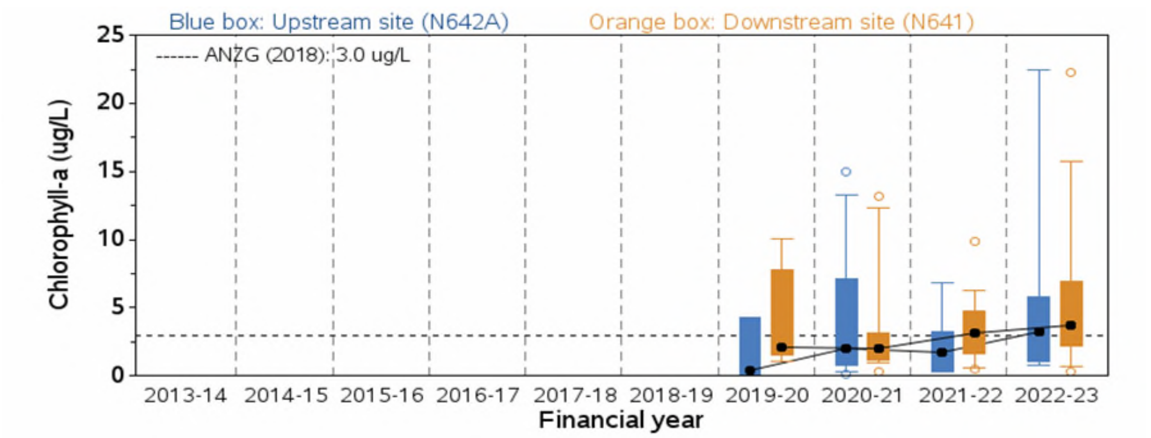


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	0.07	0.7907	N641	1	0.06	0.8008

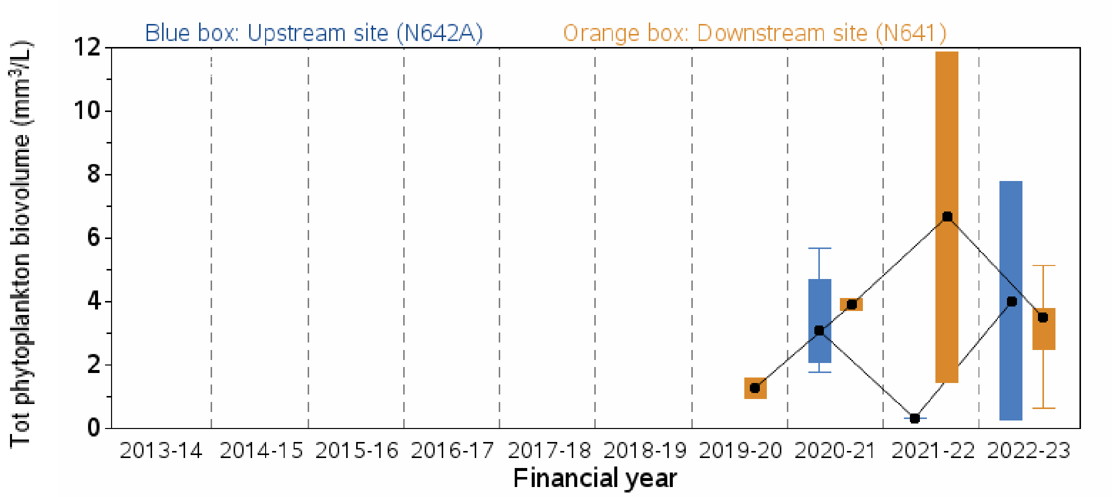


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	1.24	0.2764	N641	1	1.52	0.2239

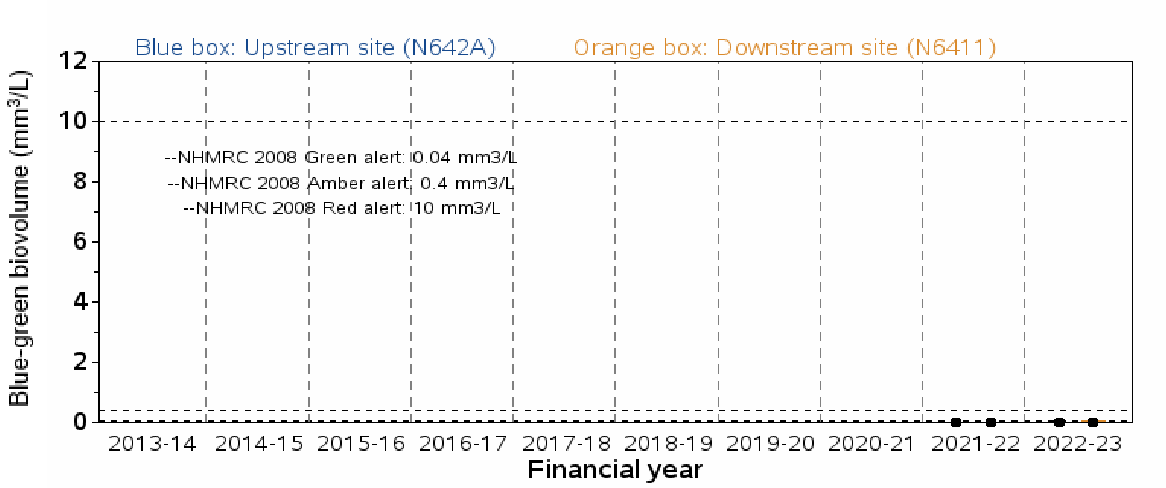
A-3.6 Ecosystem receptor – Phytoplankton



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	1	1.26	0.272	N641	1	2.66	0.1088



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	Insufficient data			N641	1	0.19	0.6736



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N642A	Insufficient data			N641	1	1.56	0.2801

Note: Insufficient data to draw a plot on toxic blue-green count for N642A and N641

A-3.7 Ecosystem receptor – Macroinvertebrates

The major rainfall events during 2022 resulted in an extended period the Warragamba River was in flood. This prevented sampling due to work health and safety (WHS) concerns at the upstream site for Wallacia WRRF during both spring 2022 and autumn 2023 seasons. Sampling at the downstream Wallacia WRRF site was not impacted, with samples being collected at edge habitats in both spring and autumn seasons in 2022-23.

Due to the lack of data from the upstream site, a nearby SoE site on the Nepean River, upstream of the confluence with the Warragamba River (N67) was used as a substitute (Volume 1 Figure 4- 15). N67 was considered a sensible proxy for upstream/ambient stream health due to proximity, similar geomorphological characteristics, and similar habitat to the downstream site on Warragamba River. As such, a comparison was made between these sites to assess any possible impacts from the discharges from Wallacia WRRF, with the site on the Nepean River (N67) referred to as 'upstream' and the site downstream of Wallacia WRRF on the Warragamba referred to as 'downstream', for brevity. These sites experienced periods of fluctuation between macrophyte-dominant and edge-dominant habitats, likely due to cycling of dry and wet/flooding periods over time. As such, due to the scarcity of macrophyte beds in 2022-23, only edge samples were assessed. This meant that edge sample data was sparse throughout the 2008 to 2023 period, therefore may lead to limitations in analysing and interpreting this data.

A SIGNAL-SG plot is provided below, which is based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from these sites between spring 2008 and autumn 2023. This comparison suggests mean downstream stream health for 2022-23 was at a lower level comparable to that of the historical range of the upstream site (Figure A-9).

A comparison of the upstream-downstream SIGNAL-SG scores for the 2022–23 samples under t-tests returned a significant test outcome (Table A-14). As a measurable difference in stream health was detected between these sites, further data analysis was undertaken.

Table A-14 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from waterways near Wallacia WRRF

Waterway	Method	Statistic	DF	P value
Nepean / Warragamba River	Welch Two Sample t-test	3.92	12.5	0.002

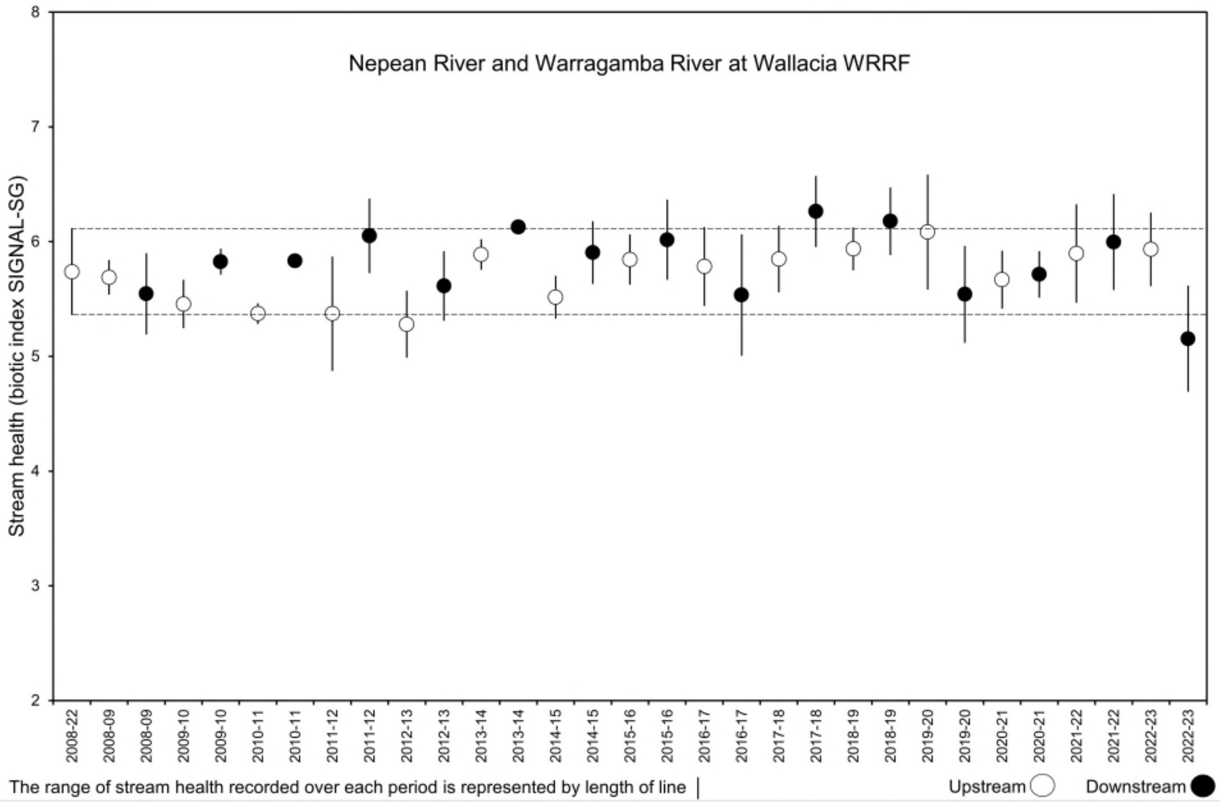


Figure A-9 Stream health of waterways near Wallacia WRRF

Edge habitats were collected consistently enough at the sites on the same sampling occasions to allow a multivariate analysis for the monitoring period of 2008 to 2023.

In the 2-dimensional nMDS ordination plot of the edge habitats at these sites, a relatively interspersed pattern of upstream and downstream samples was observed (Figure A-10), with the exception of one outlier for the downstream site for the recent period (2020 to 2023). This sample is the spring 2022 sample, which is what likely caused the significance in the t-test comparison. The generally interspersed pattern was confirmed in the corresponding tree diagram from cluster analysis as the first division did not separate a group of upstream samples from another group of downstream samples (Figure A-11).

The PERMDISP analysis indicated a non-significant pattern of dispersion for the two sites (Table A-17). This outcome suggests the variability in taxonomic make-up of samples collected over time was at similar levels for both sites through the period tested (2008 to 2023), and therefore implies subsequent results of ANOSIM tests are focused on community structure differences between sites.

An ANOSIM test was run on the factor ‘Site’. The returned R-values were at a low-range level (0.159) (Table A-15), suggesting site specific assemblages were not very distinguishable between the sites. This pattern is reinforced by the shade plots that do not show a distinct pattern or difference between the sites (Figure A-12). The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 34 taxa identified out of 138 taxa (Table A-19). These subsets of taxa reflect those taxa which formed the main visual patterns in the respective shade plots.

To further explore community structure, hypothesis testing was conducted with a PERMANOVA model. This model comprised the fixed factors ‘Site’ and ‘Year’ with ‘Year’ representing samples collected between 2008 and 2023 and ‘Site’ having two levels, upstream and downstream. A statistically non-significant ‘Site x Year’ interaction was returned, allows us to view the ‘Site’ and ‘Year’ results individually. Both ‘Site’ and ‘Year’ factors returned non-significant values, suggesting no difference across years, or between sites (Table A-16).

A second run of ANOSIM based on ‘Site-Period’ groups in the 2D ordination plot (Figure A-10) returned a significant global low-range R-value (0.254) (Table A-18). Under subsequent upstream-downstream pairwise comparisons, all tests returned R-values at levels that were that were expected from natural differences between groups from variation in the substratum composition of the habitats between sites (Table A-18). Besley and Chessman (2008) found R-values up to 0.66 for sites on the same near-pristine stream.

In summary, while SIGNAL-SG control plots and t-tests suggested differences between the upstream and downstream sites, further multivariate analysis demonstrated that community assemblages were not distinguishable between the sites. Lower SIGNAL-SG scores for the downstream site in 2022-23 were likely attributed to wet weather flows scouring out the waterway which may have had a greater impact on stream health than wastewater discharges from Wallacia WRRF.

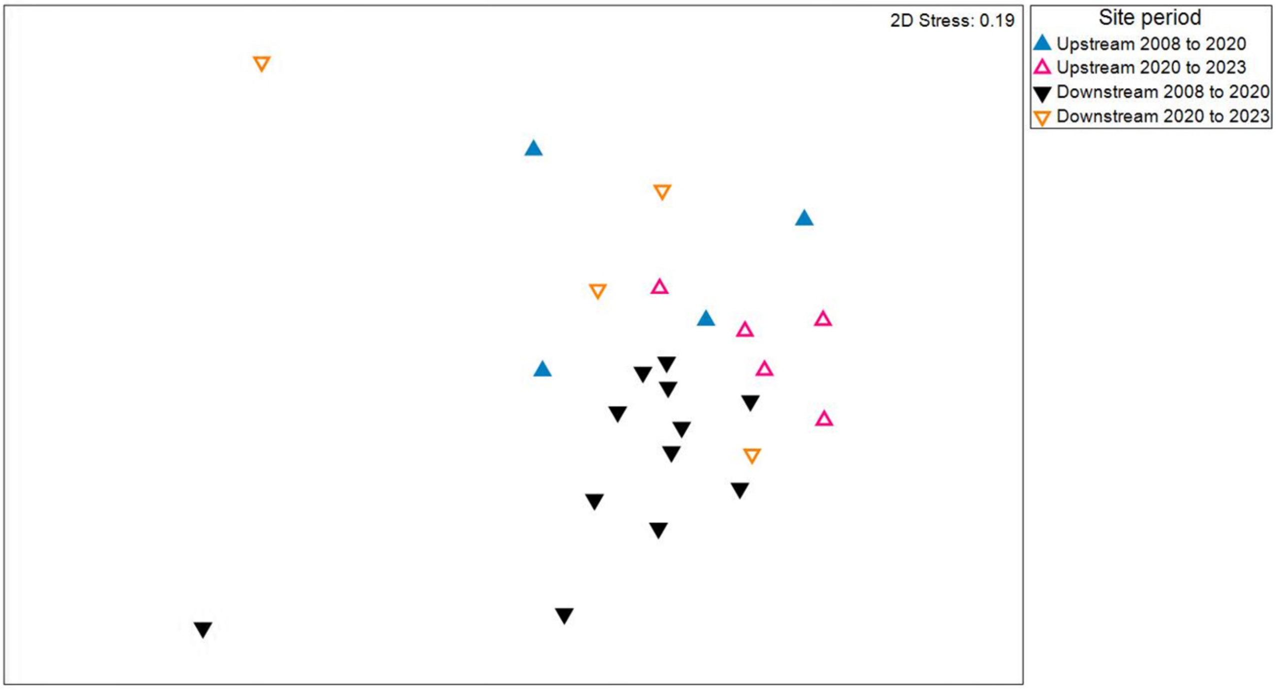


Figure A-10 Two dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream site of waterways near Wallacia WRRF

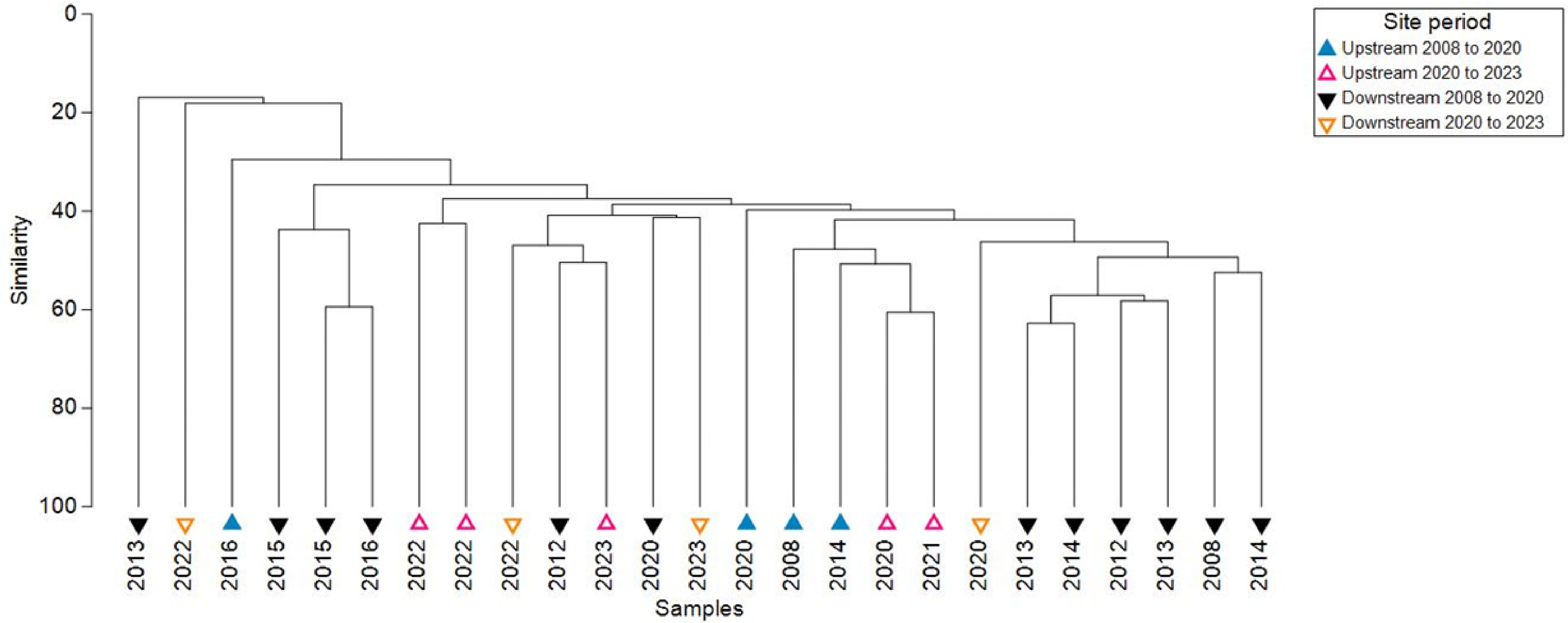


Figure A-11 Tree diagram of freshwater macroinvertebrate edge habitat community structure of upstream-downstream site of waterways near Wallacia WRRF

Table A-15 ANOSIM test of 'Site' factor for edge habitat of waterways near Wallacia WRRF

Tests for differences between unordered Site groups

Global Test
Sample statistic (R): 0.159
Significance level of sample statistic: 5%
Number of permutations: 9999 (Random sample from 2042975)
Number of permuted statistics greater than or equal to R: 496

Table A-16 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of waterways near Wallacia WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	10

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	3221.6	3221.6	1.8051	0.0844	9948
Year	9	20100	2233.3	1.2513	0.1029	9836
SitexYear**	5	10470	2093.9	1.1732	0.258	9893
Res	9	16063	1784.8			
Total	24	51409				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	189.59	13.769
S(Year)	189.87	13.779
S(SitexYear)	227.31	15.077
V(Res)	1784.8	42.247

Table A-17 PERMDISP test of 'Site' factor for edge habitat of waterways near Wallacia WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 25

DEVIATIONS FROM CENTROID
F: 1.0619 df1: 1 df2: 23
P(perm): 0.4021

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Upstream	9	40.02	1.958
Downstream	16	43.773	2.4844

Table A-18 ANOSIM test of ‘Site period’ for edge habitat of waterways near Wallacia WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.254
Significance level of sample statistic: 1.9%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 185

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Upstream 2008 to 2020, Downstream 2008 to 2020	0.326	5.7	1820	1820	103
Upstream 2008 to 2020, Upstream 2020 to 2023	0.175	11.1	126	126	14
Upstream 2008 to 2020, Downstream 2020 to 2023	0.052	40	35	35	14
Downstream 2008 to 2020, Upstream 2020 to 2023	0.244	6.3	6188	6188	387
Downstream 2008 to 2020, Downstream 2020 to 2023	0.282	8.1	1820	1820	148
Upstream 2020 to 2023, Downstream 2020 to 2023	0.269	4	126	126	5

Table A-19 Genera subset whose multivariate pattern matches full genera set of the edge habitat of waterways near Wallacia WRRF

Subset of 34 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 138 genera identified with the same subset found on 1 run from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Dicrotendipes,Coenagrionidae Austroagrion,Dugesiidae Cura,Platycnemididae Nososticta,Chironomidae Polypedilum,Isostictidae Rhadinosticta,Atyidae Paratya,Veliidae Microvelia,Chironomidae Tanytarsus,Leptoceridae Triplectides,Baetidae Cloeon,Ceratopogonidae Bezzia,Hydrodromidae Hydrodroma,Hydrophilidae Berosus,Ceratopogonidae Dasyhelea,Dytiscidae Allodessus,Hydrophilidae Enochrus,Unionicolidae Recifella,Chironomidae Chironomus,Libellulidae Diplacodes,Dytiscidae Necterosoma,Arrenuridae Arrenurus,Gerridae Tenagogerris,Haliplidae Haliplus,Unionicolidae Koenikea,Limnocharidae Limnochares,Palaemonidae Macrobrachium,Hydraenidae Gymnochthebius,Belostomatidae Diplonychus,Hebridae Hebrus,Corbiculidae Corbicula,Elmidae Kingolus,Leptophlebiidae Atalophlebia,Nepidae Laccoptrephes

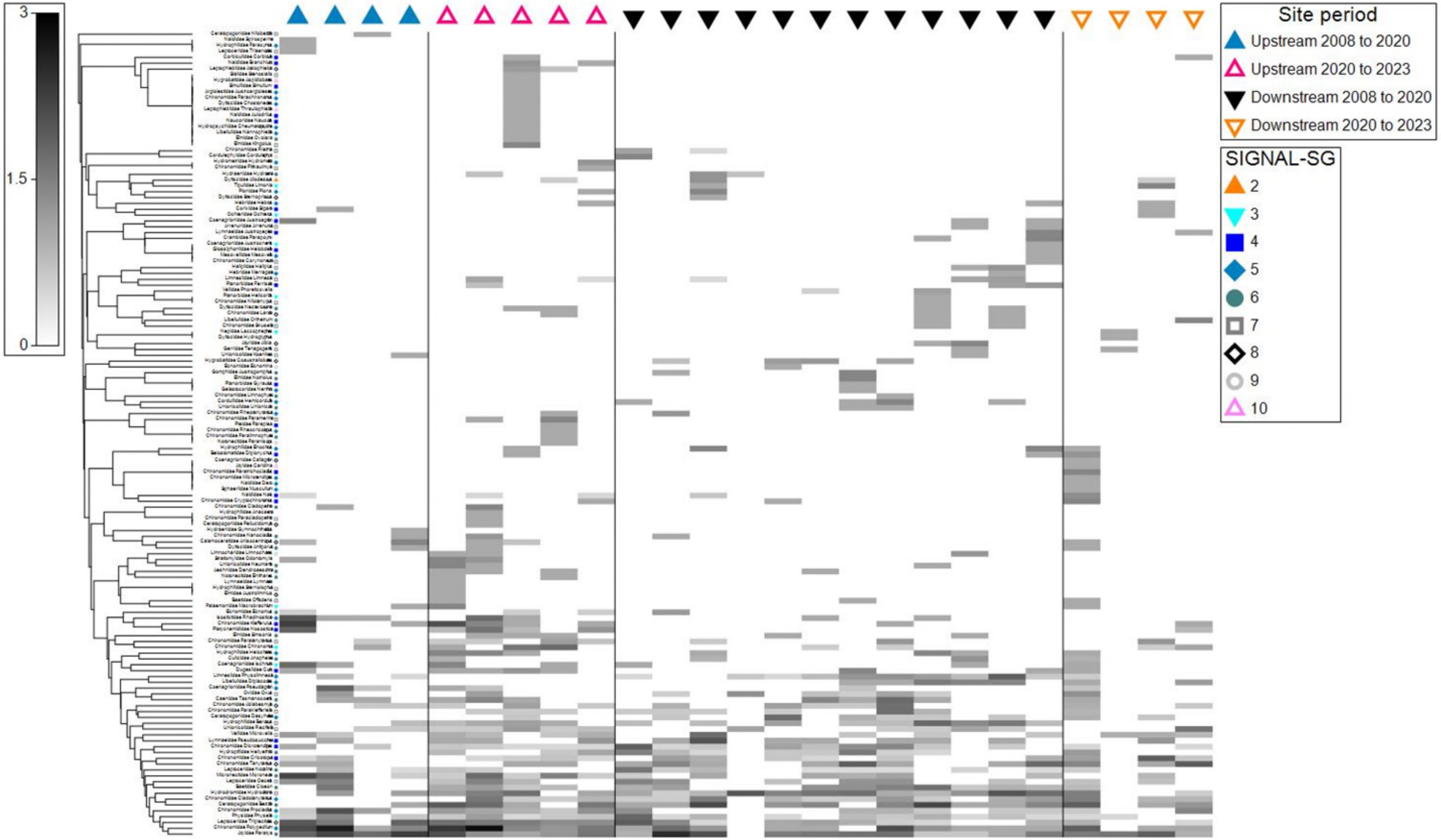
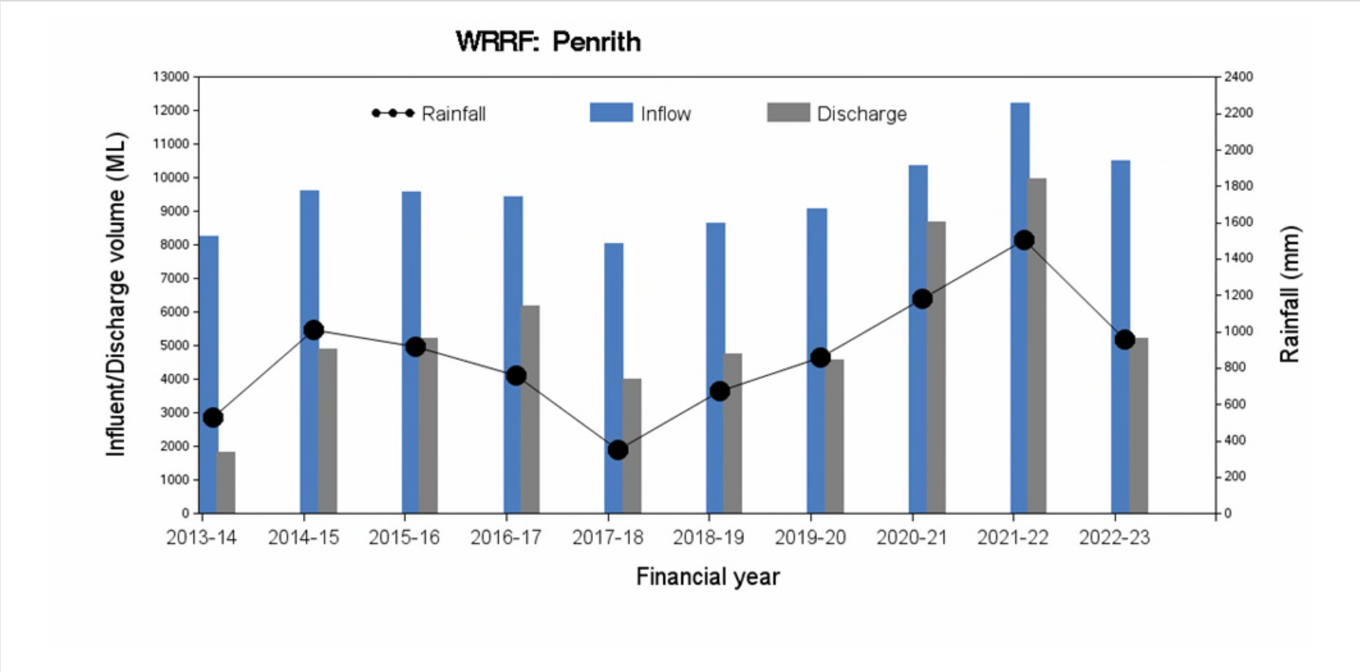


Figure A-12 Shade plot of freshwater macroinvertebrate edge habitat community structure of waterways near Wallacia WRRF

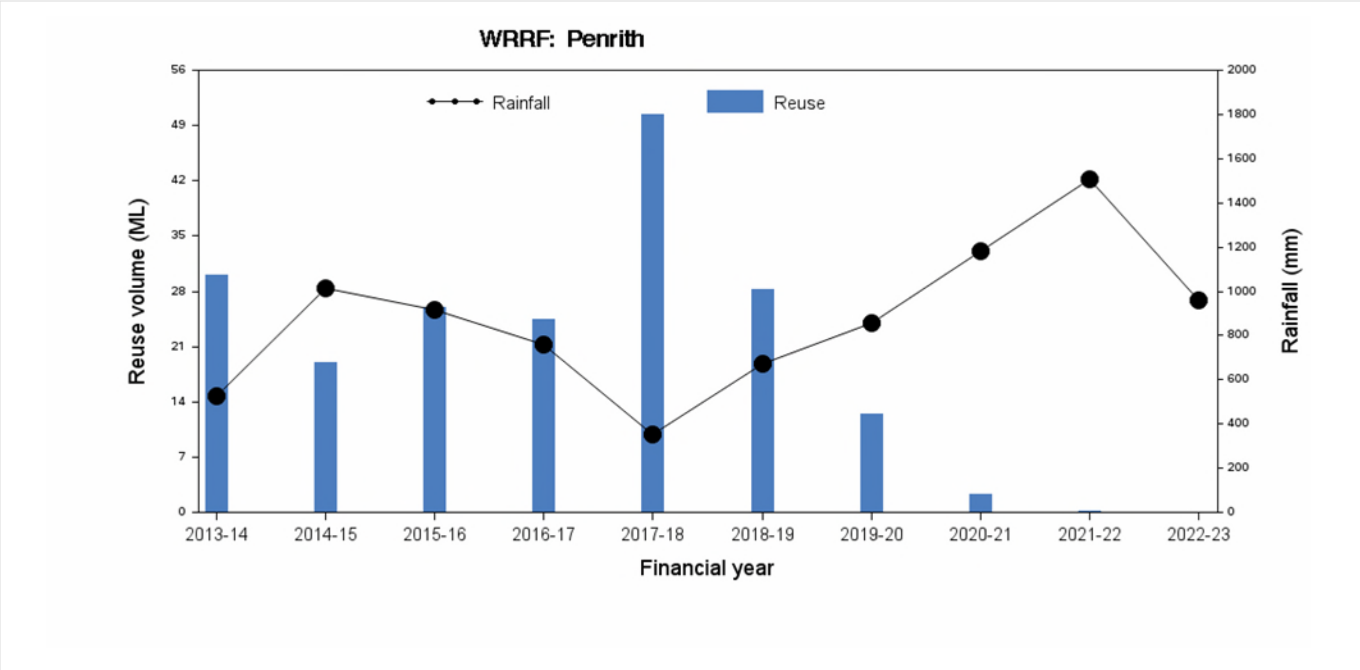
A-4 Penrith WRRF

A-4.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

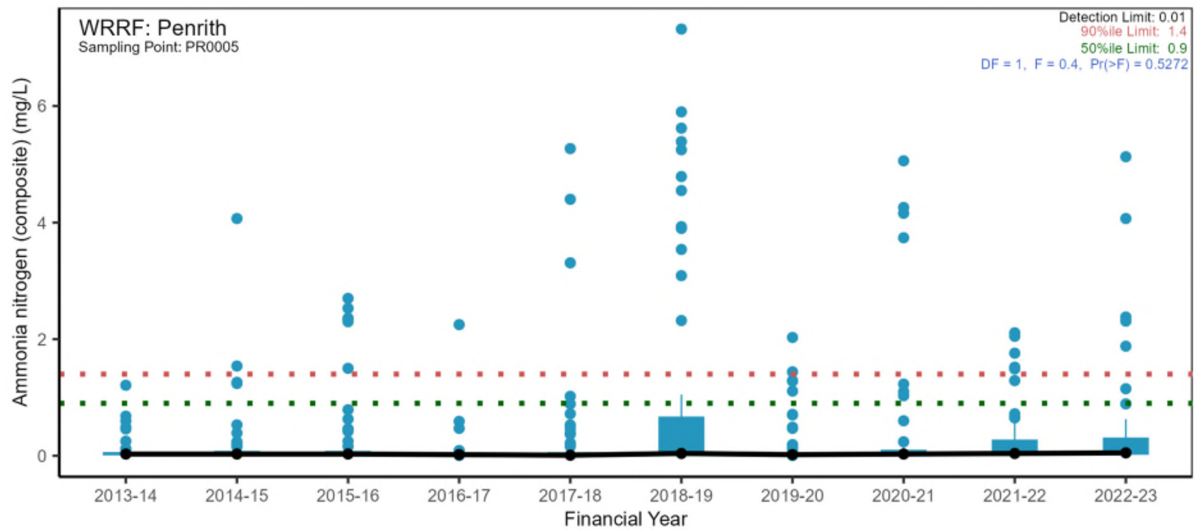


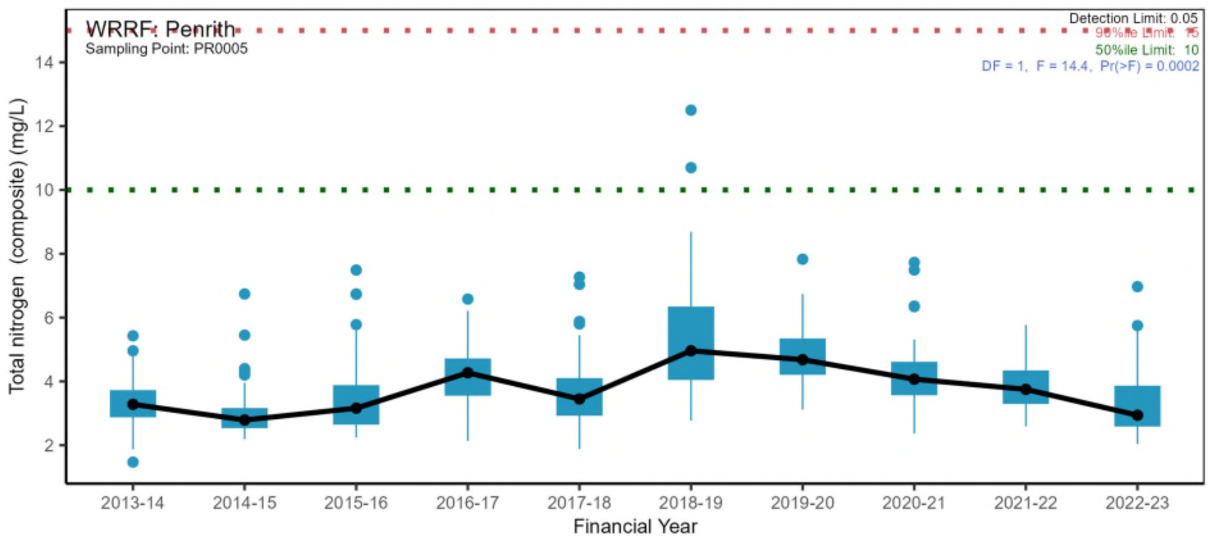
Reuse volume and rainfall

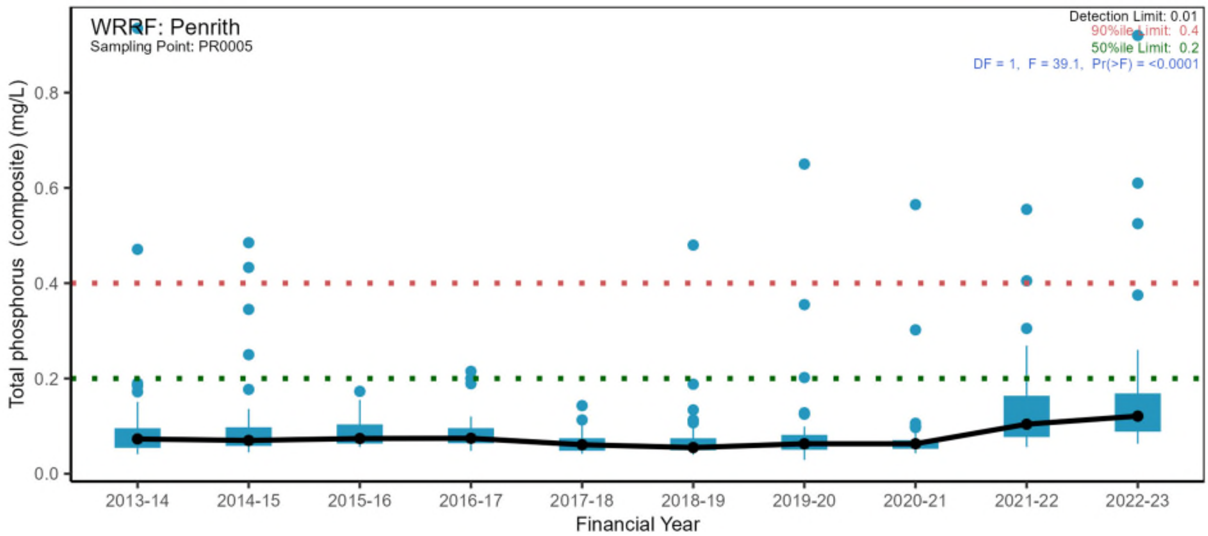


A-4.2 Pressure – Wastewater quality

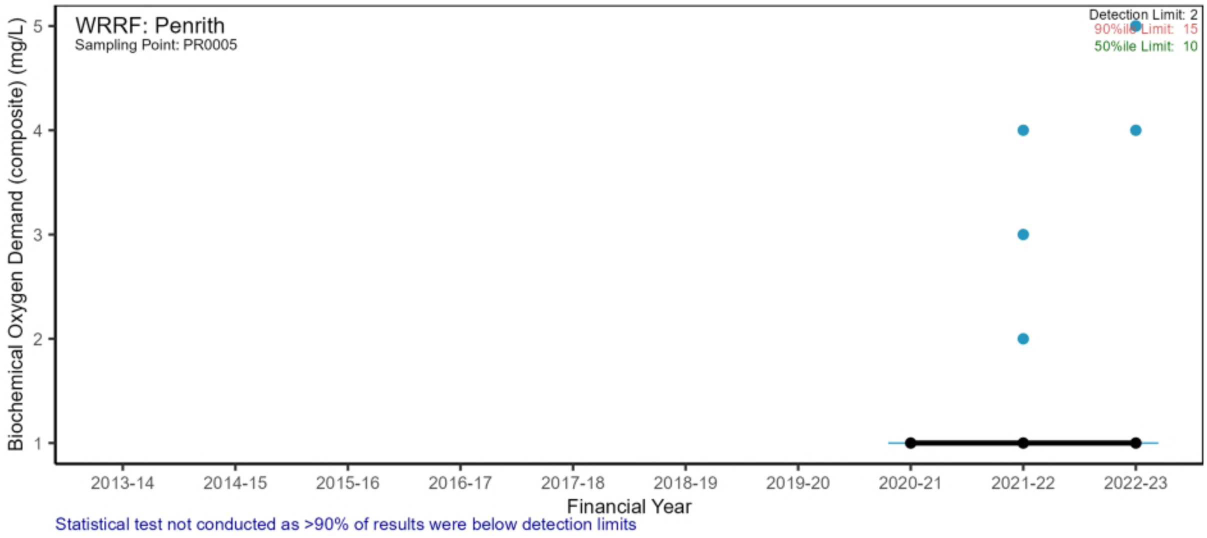
Nutrients: PR0005

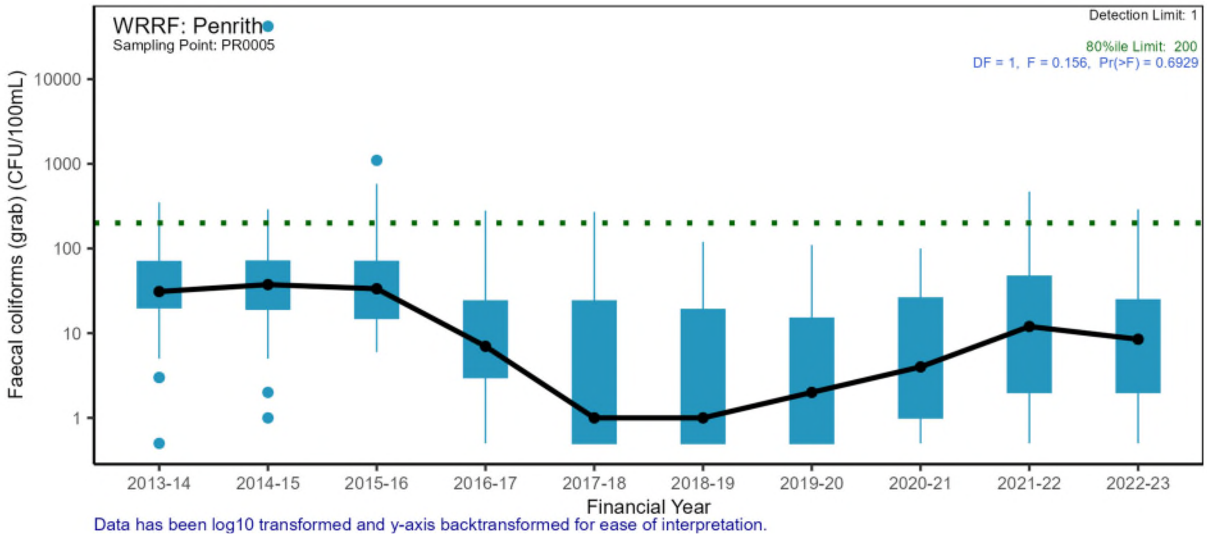


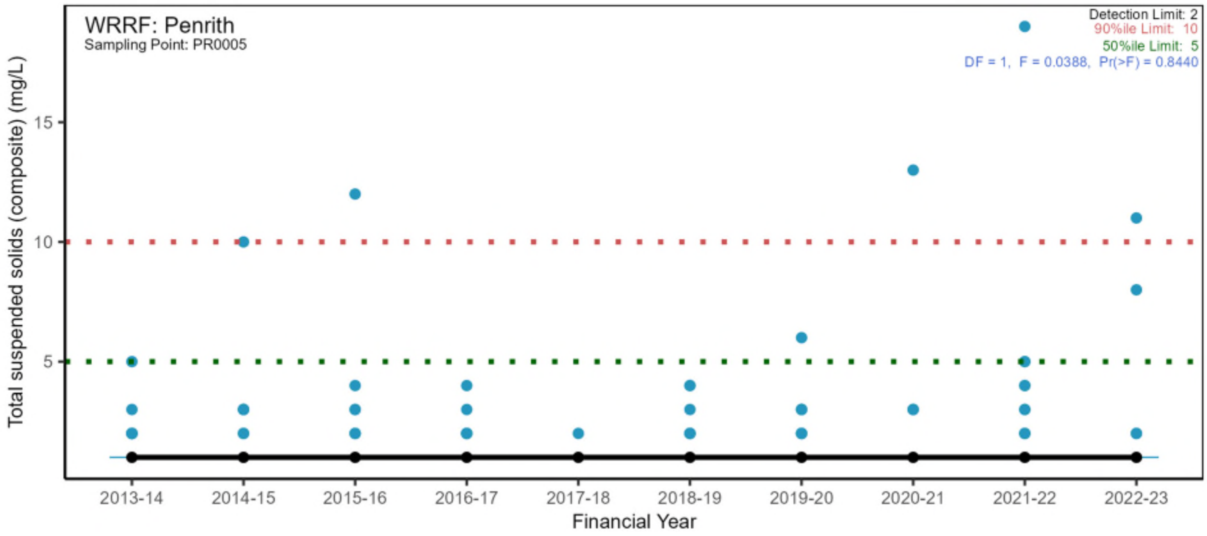




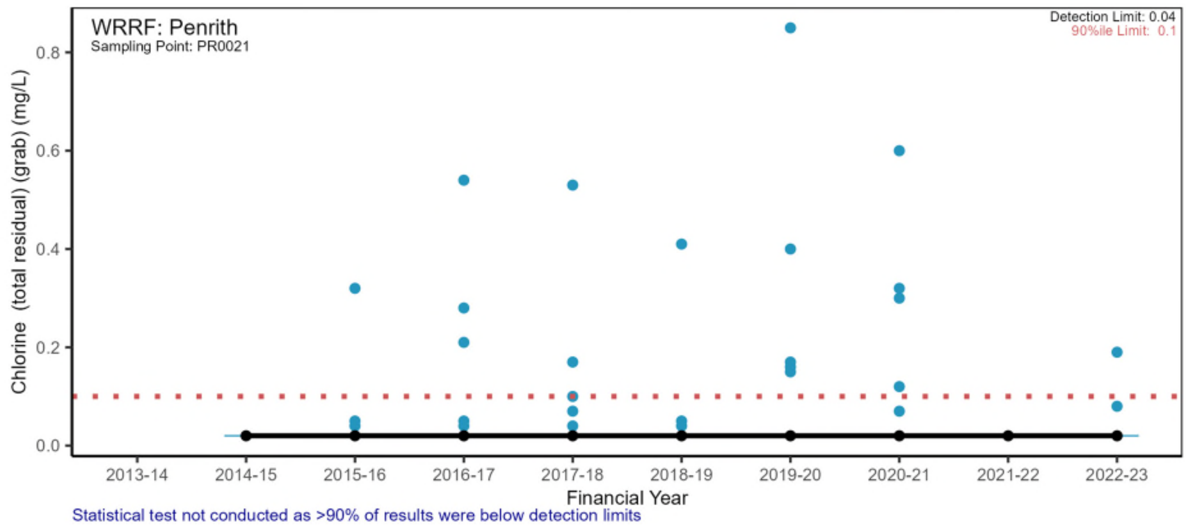
Major conventional analytes: PR0005



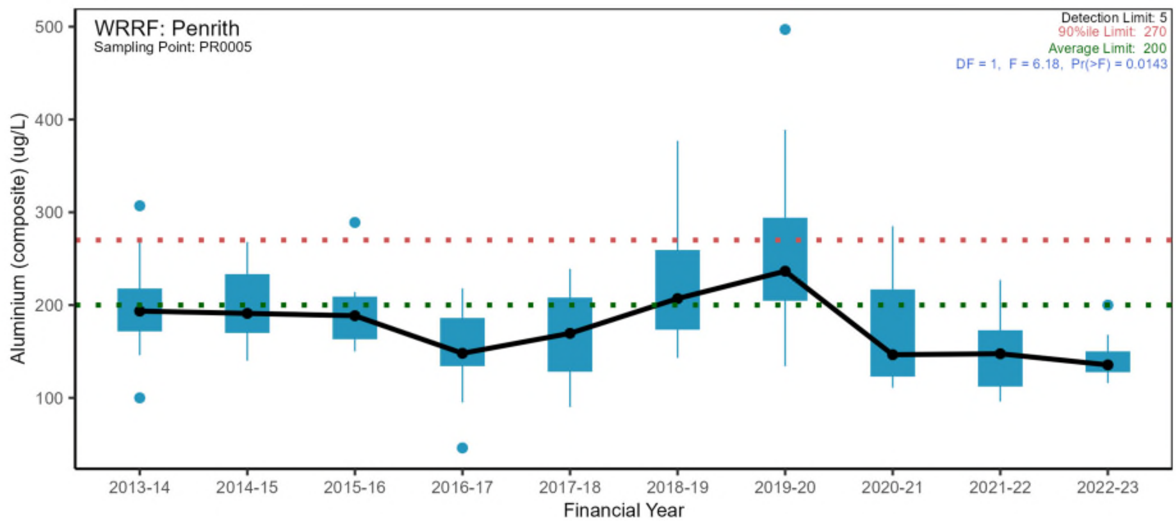


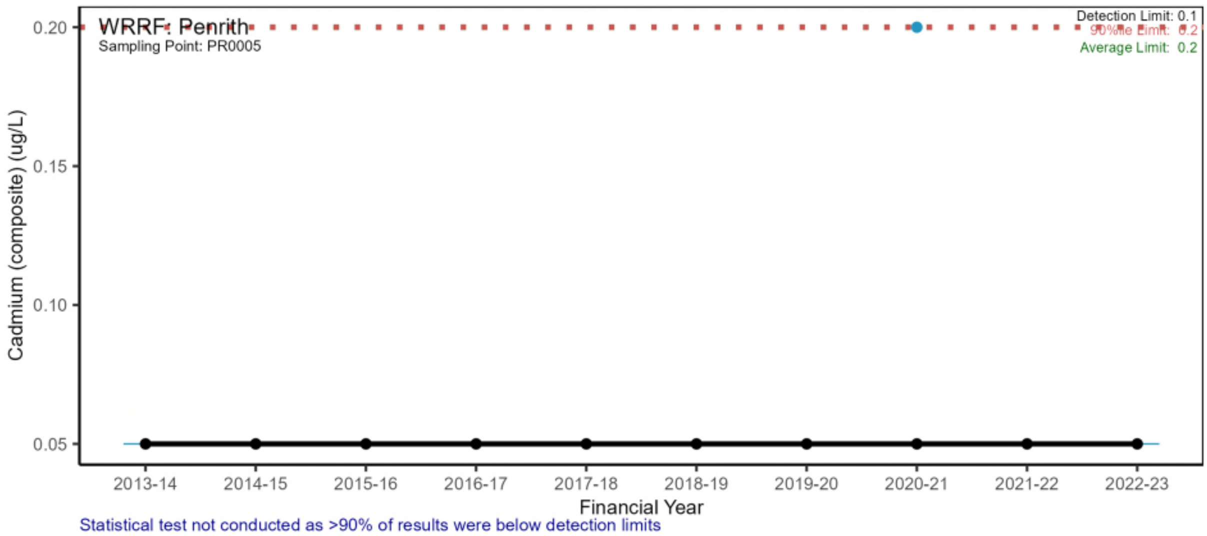


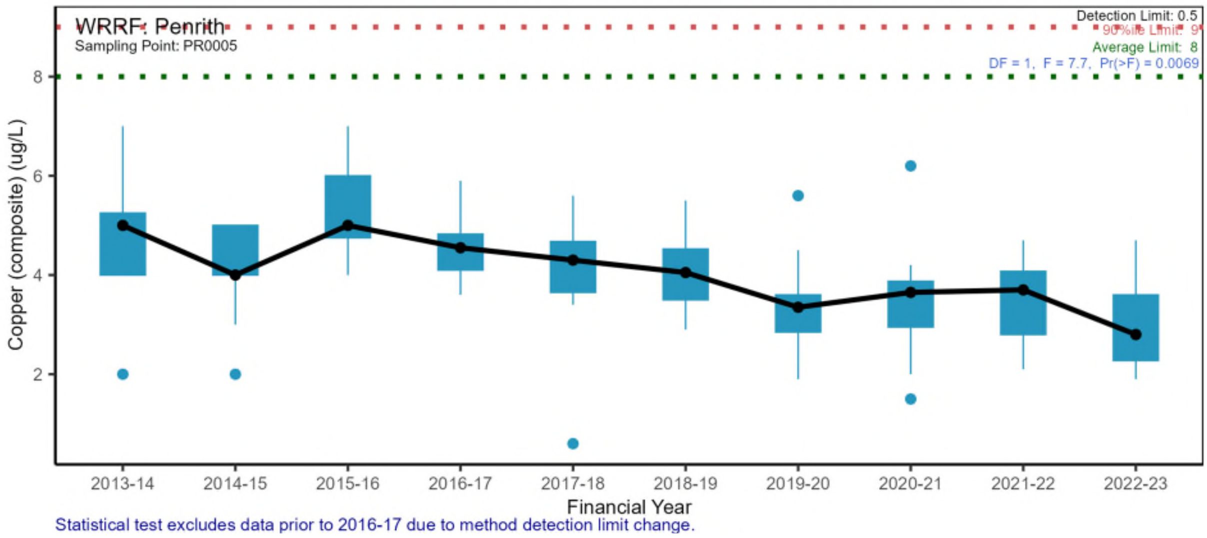
Major conventional analytes: PR0021



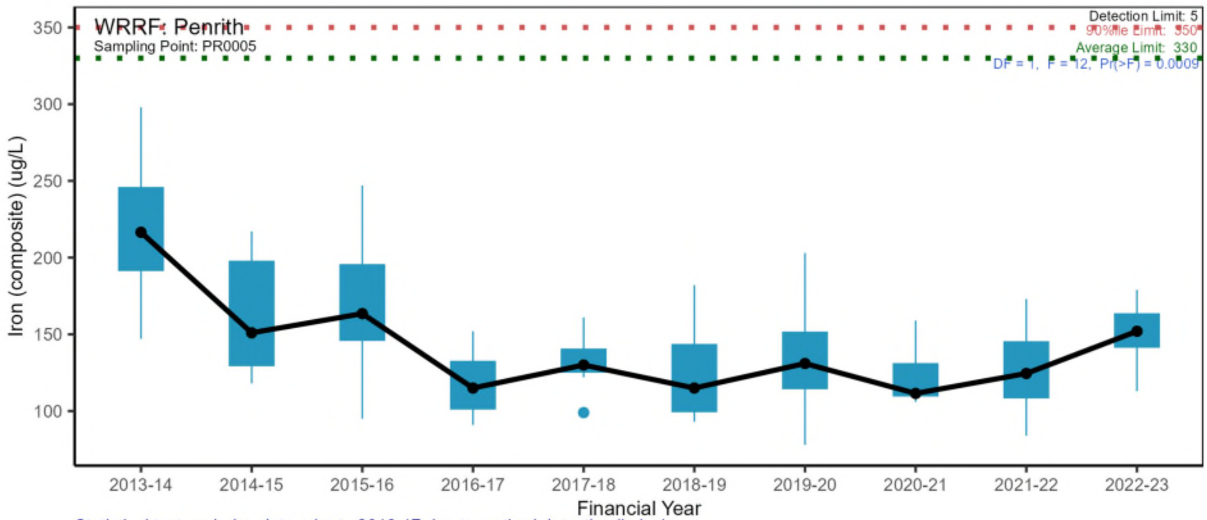
Trace metals: PR0005



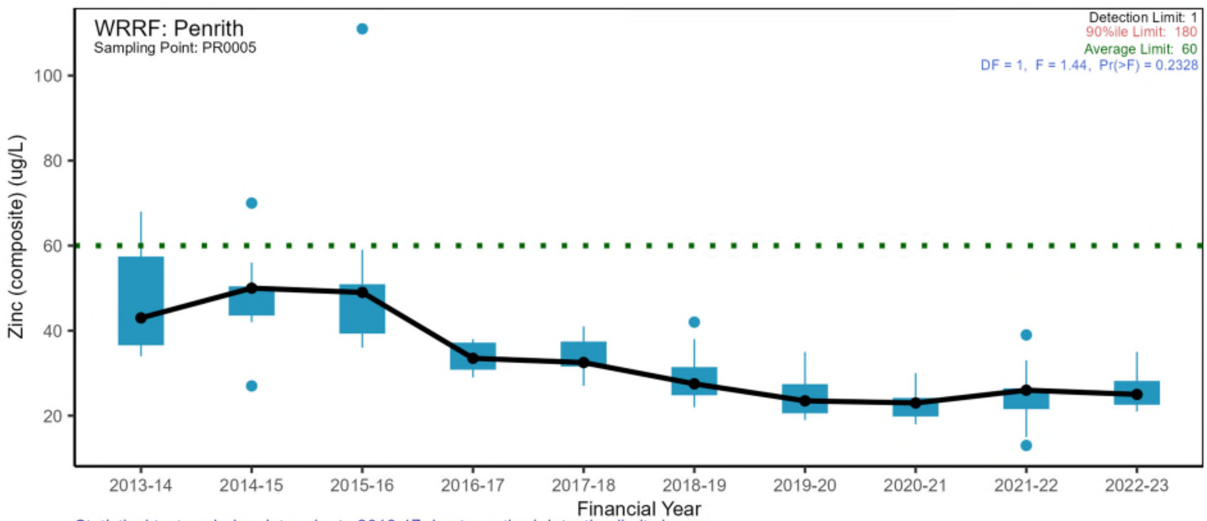




Statistical test excludes data prior to 2016-17 due to method detection limit change.

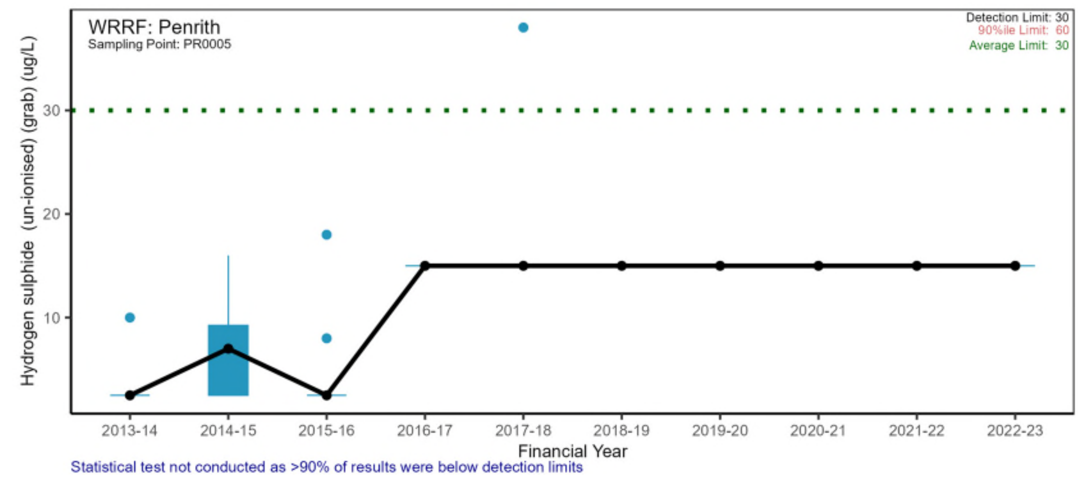


Statistical test excludes data prior to 2016-17 due to method detection limit change.

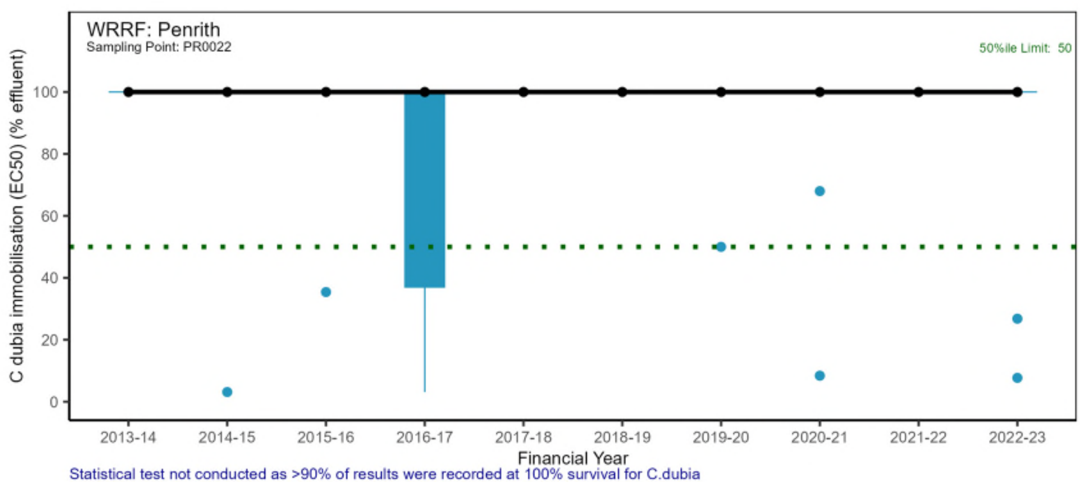


Statistical test excludes data prior to 2016-17 due to method detection limit change.

Other chemicals and organics (including pesticides): PR0005

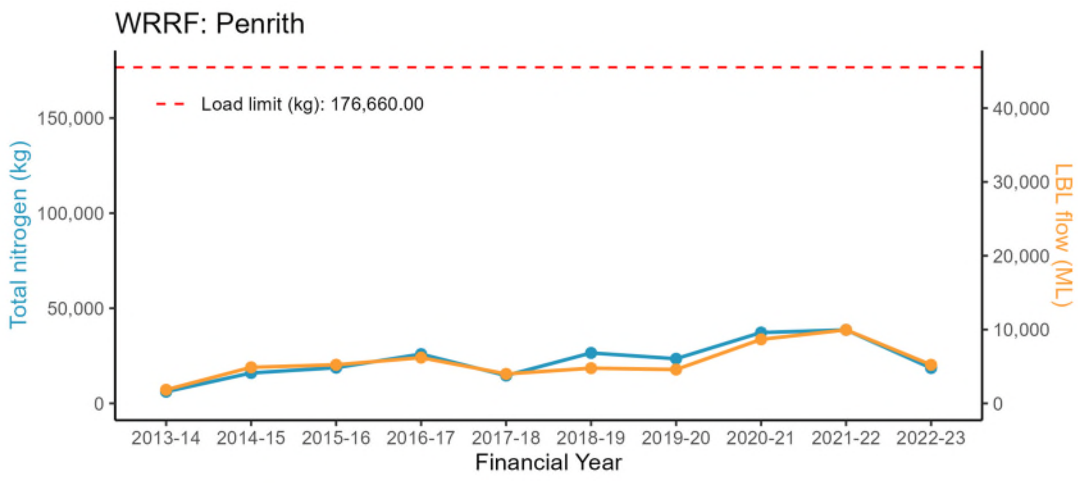


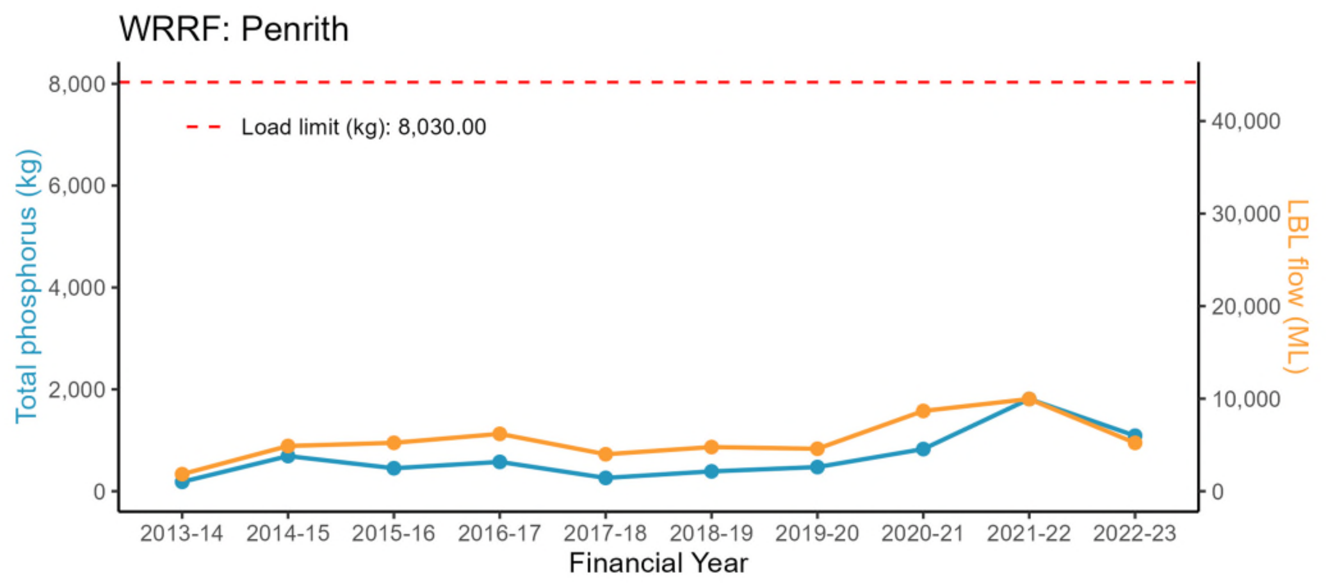
A-4.3 Pressure – Wastewater toxicity



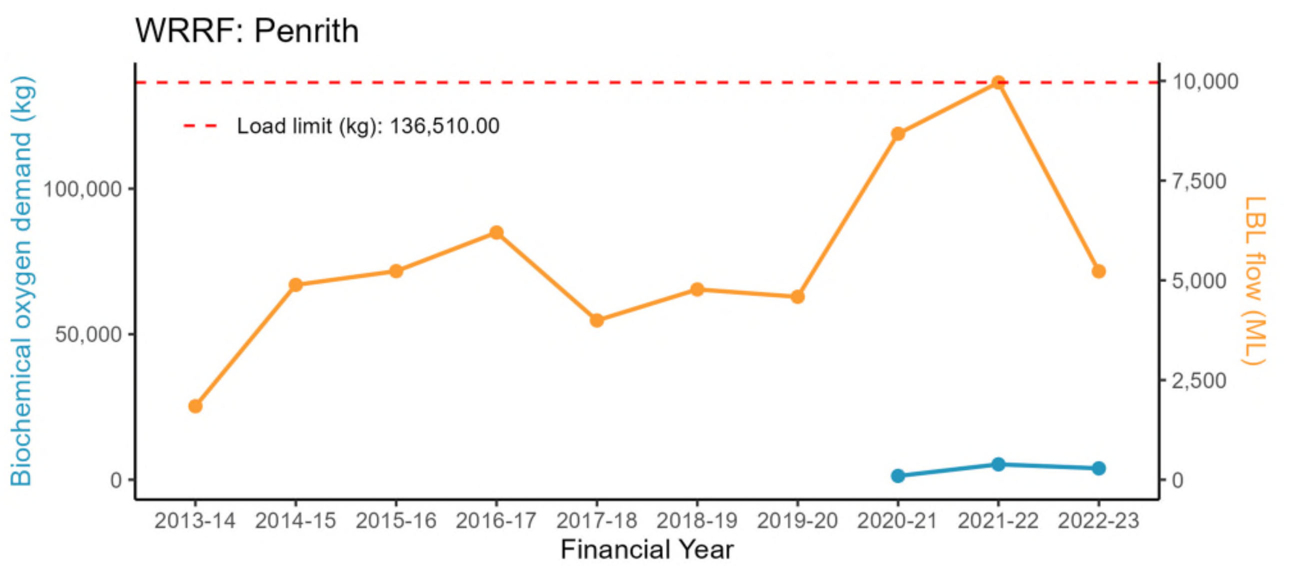
A-4.4 Pressure – Wastewater discharge load

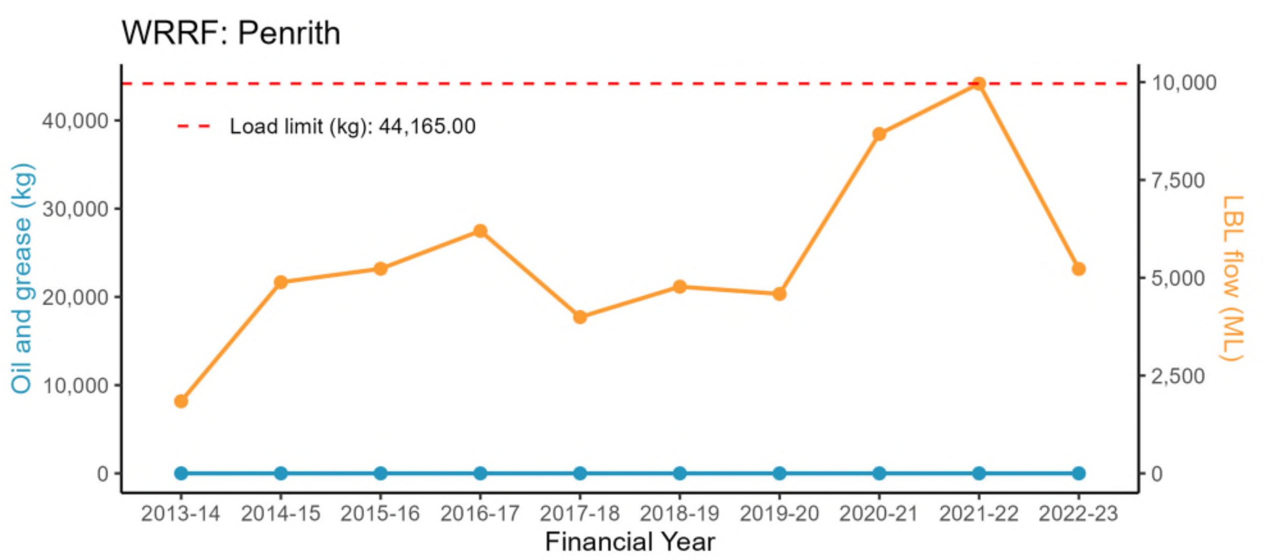
Nutrients

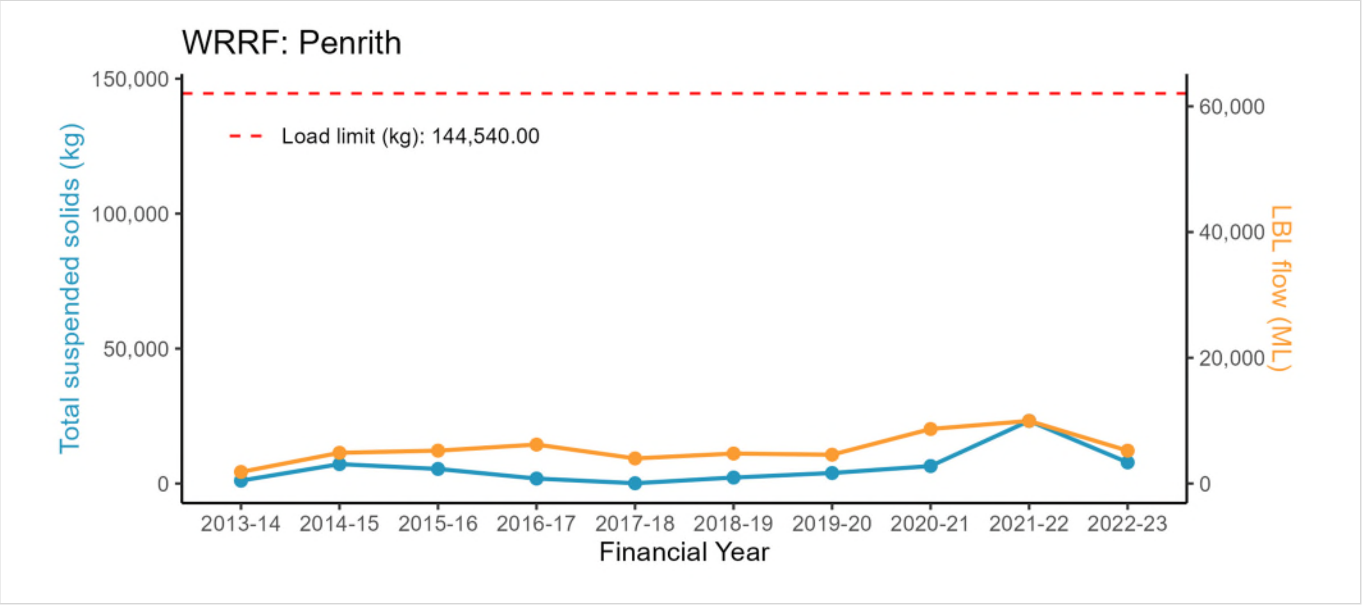




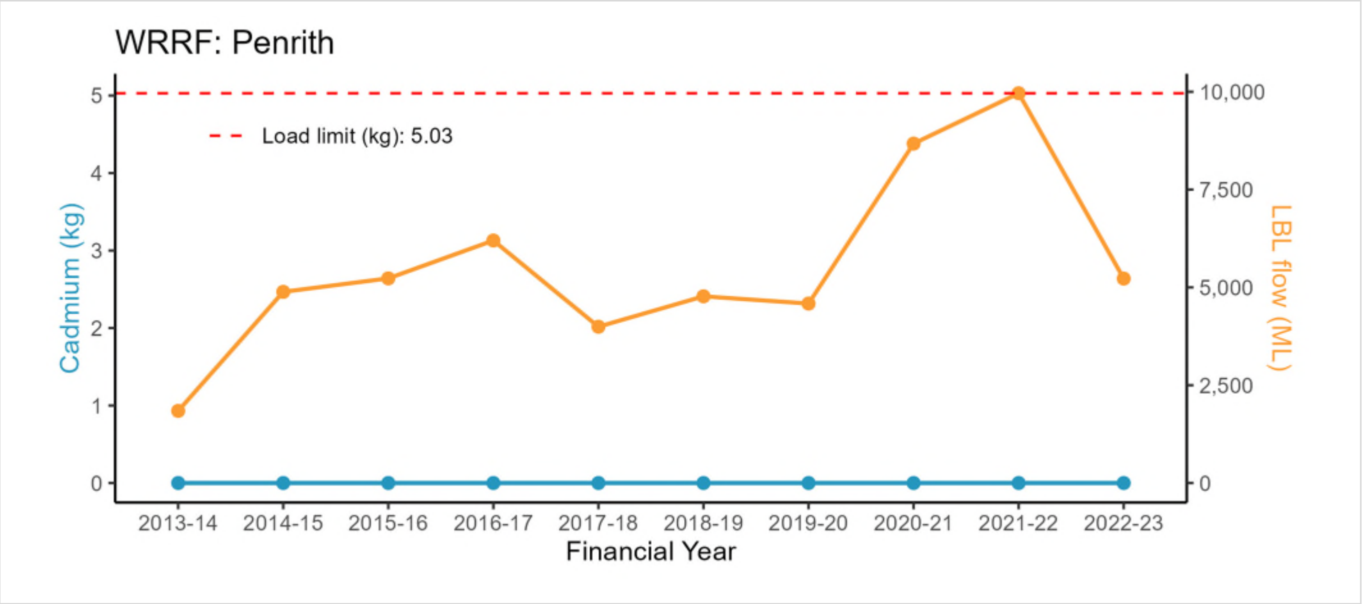
Major conventional analytes

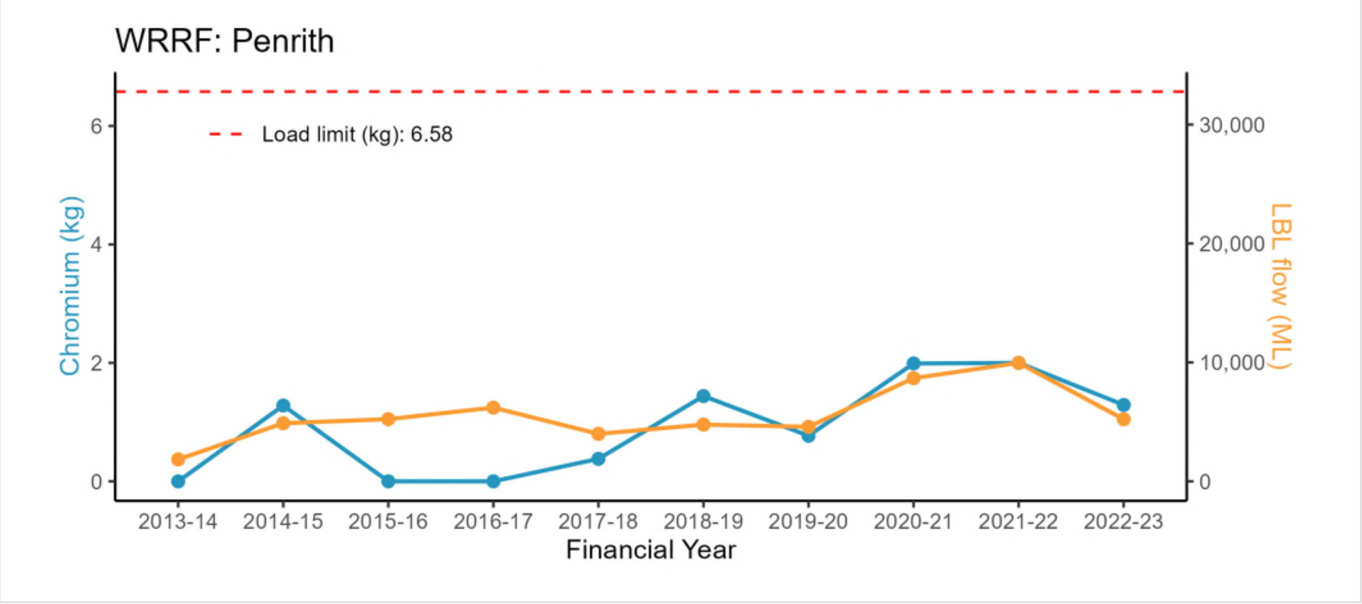


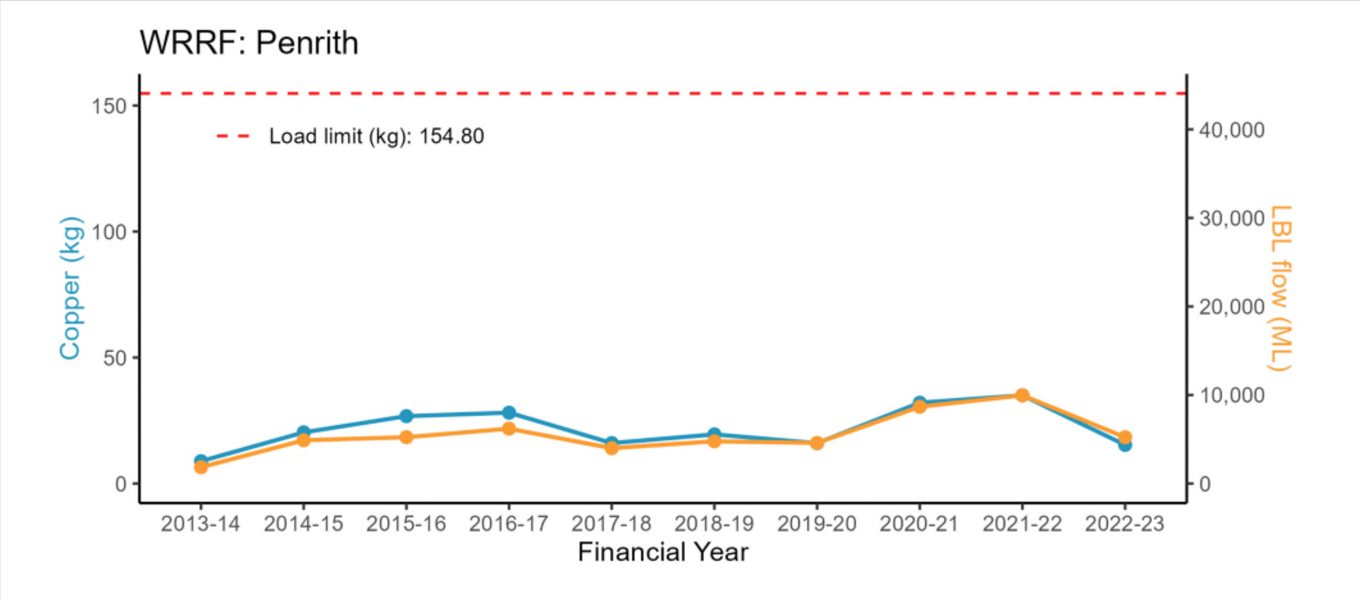


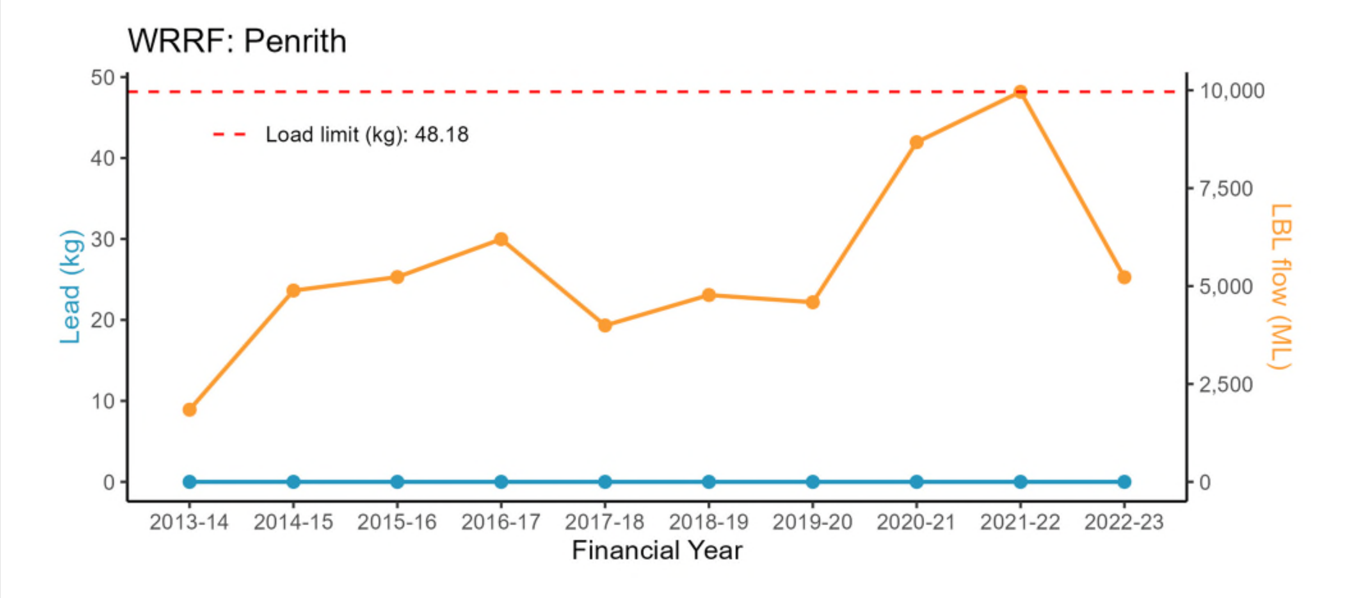


Trace metals






WRRF: Penrith
Load limit (kg): 154.80
Copper (kg)
LBL flow (ML)
150
100
50
0
40,000
30,000
20,000
10,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Penrith
Load limit (kg): 48.18
Lead (kg)
LBL flow (ML)
50
40
30
20
10
0
10,000
7,500
5,000
2,500
0
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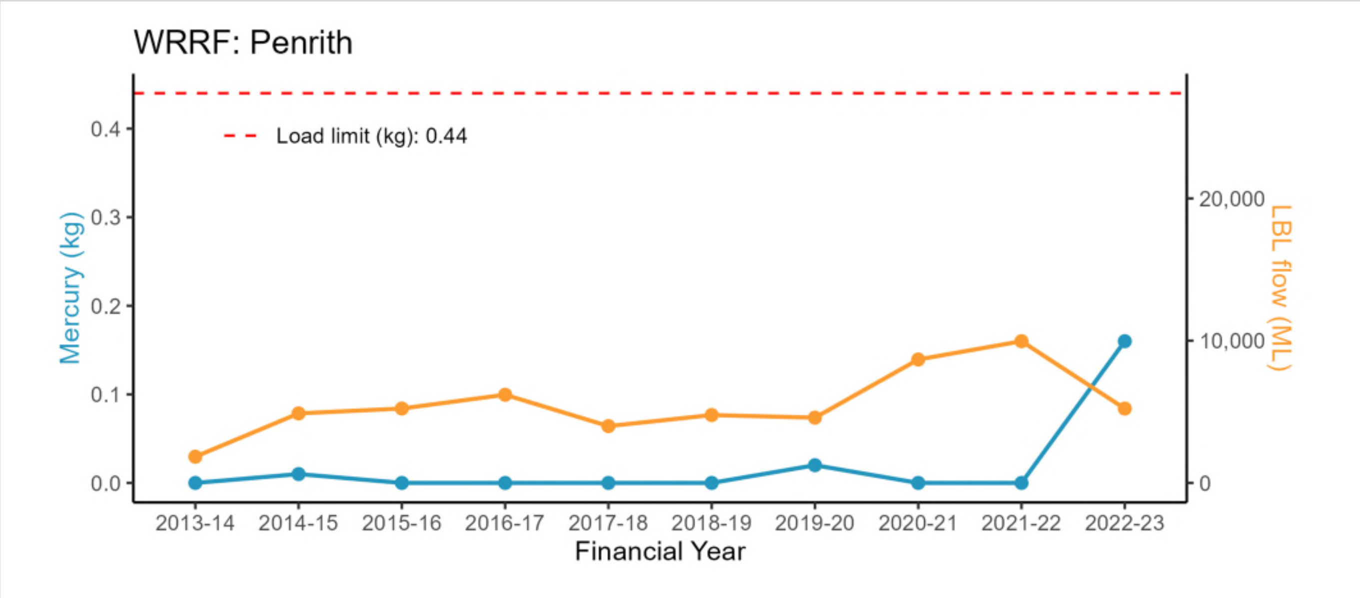
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Penrith
Load limit (kg): 0.44
Mercury (kg)
LBL flow (ML)
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0.2
0.1
0.0
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10,000
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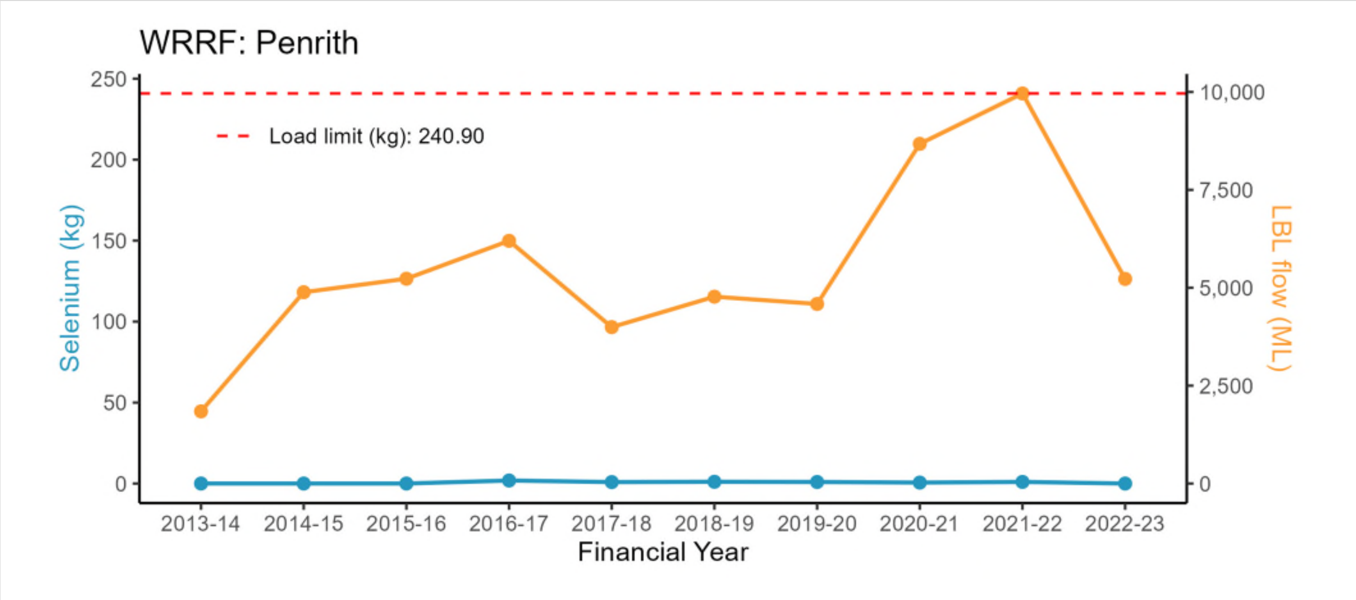
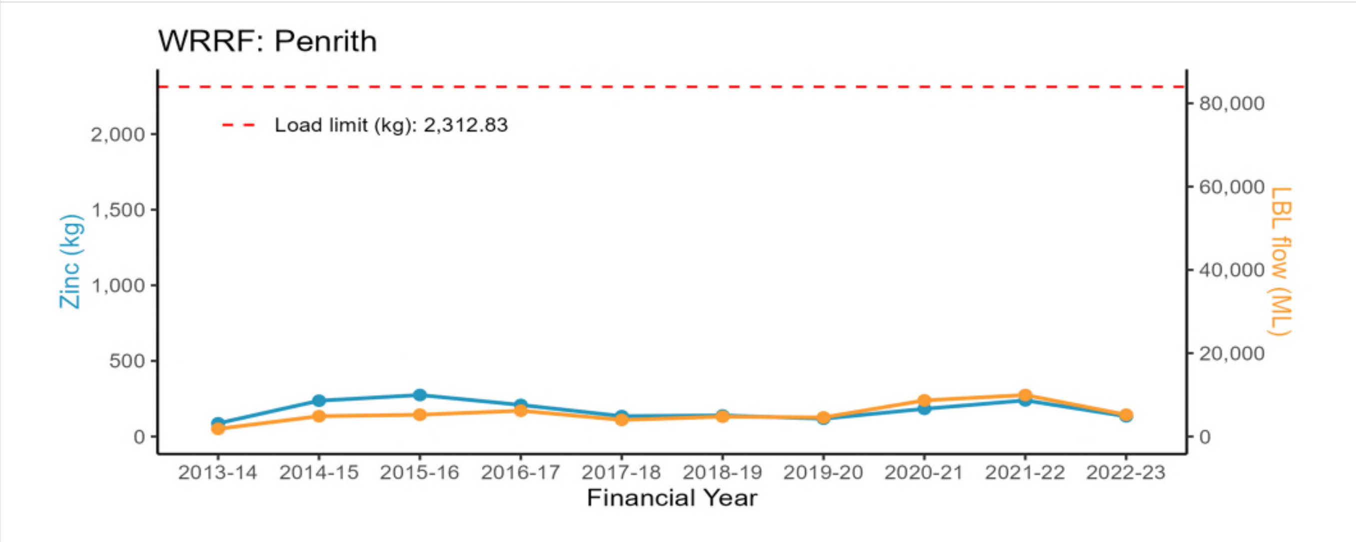
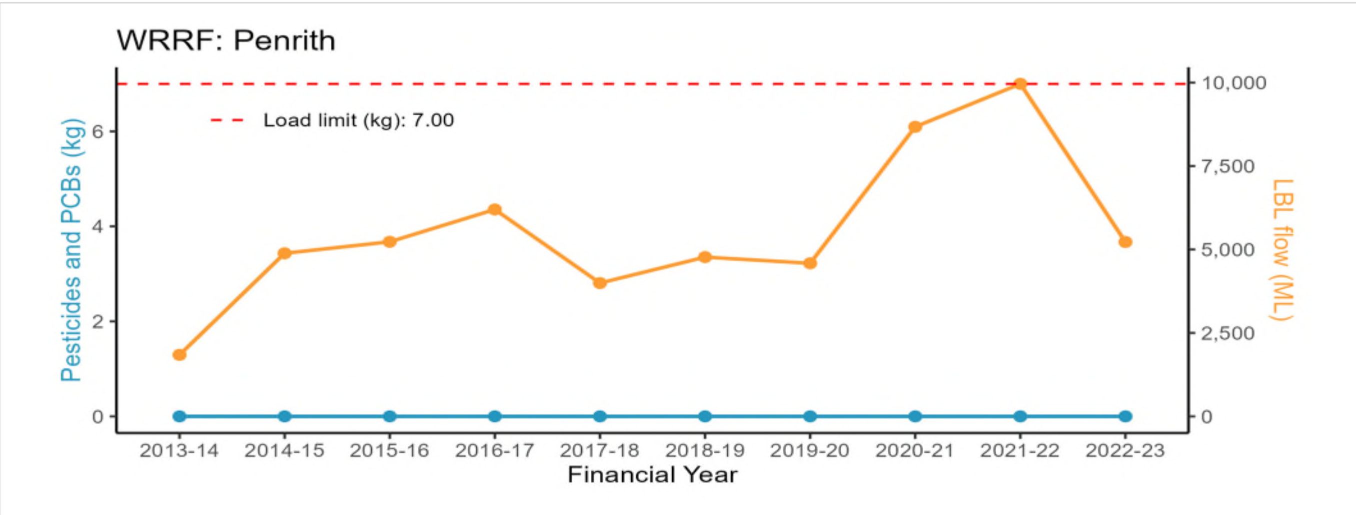
2021-22
2022-23
Financial Year

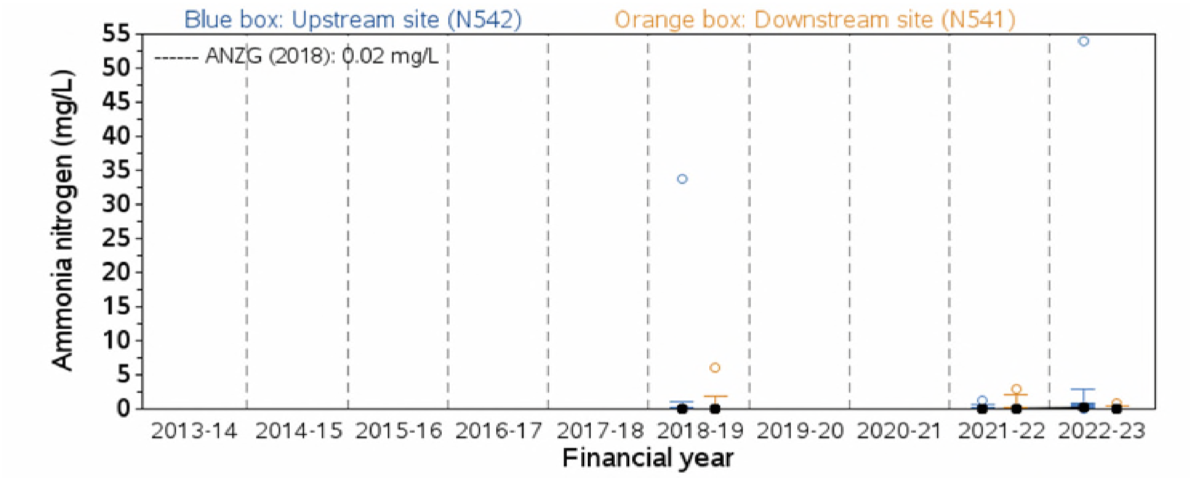




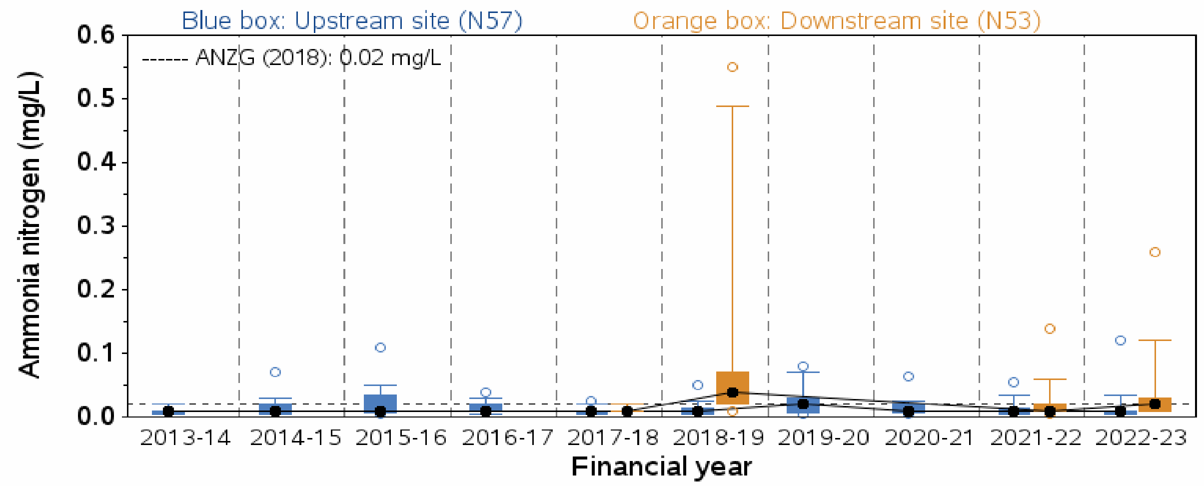
Other chemical and organics (including pesticides)



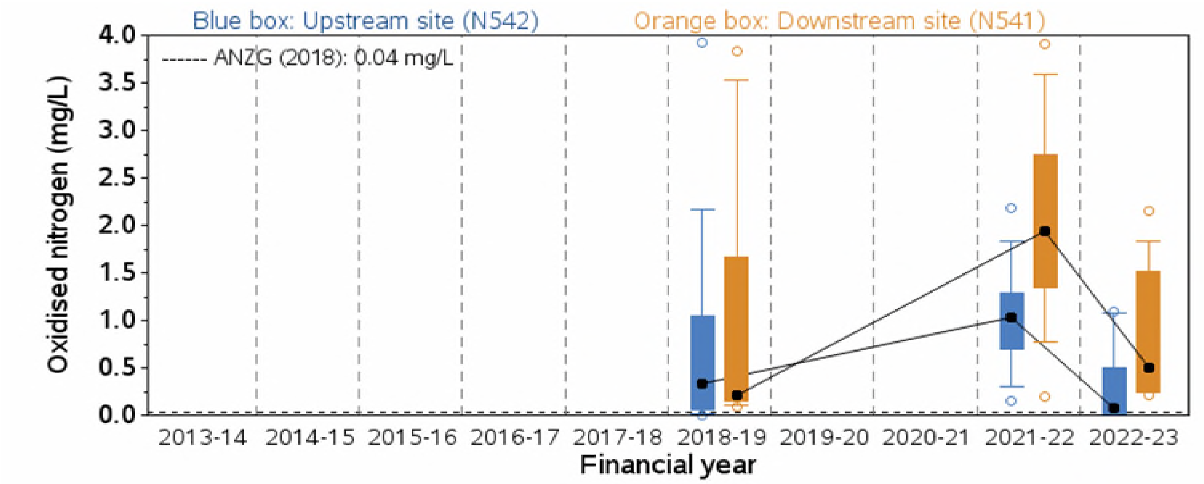
A-4.5 Stressor – Nutrients



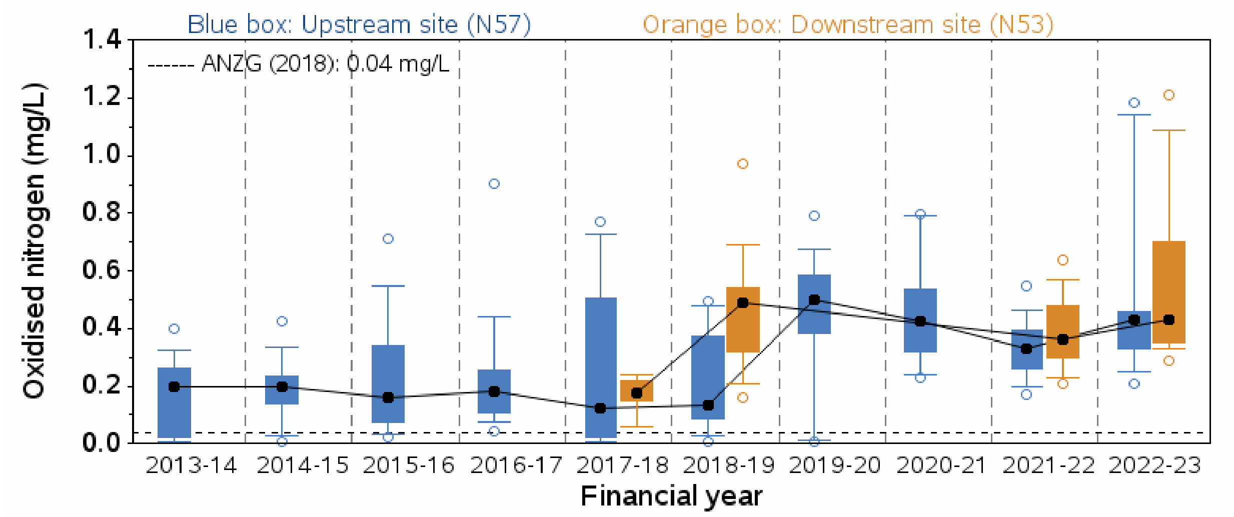
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.92	0.3409	N541	1	1.26	0.2677



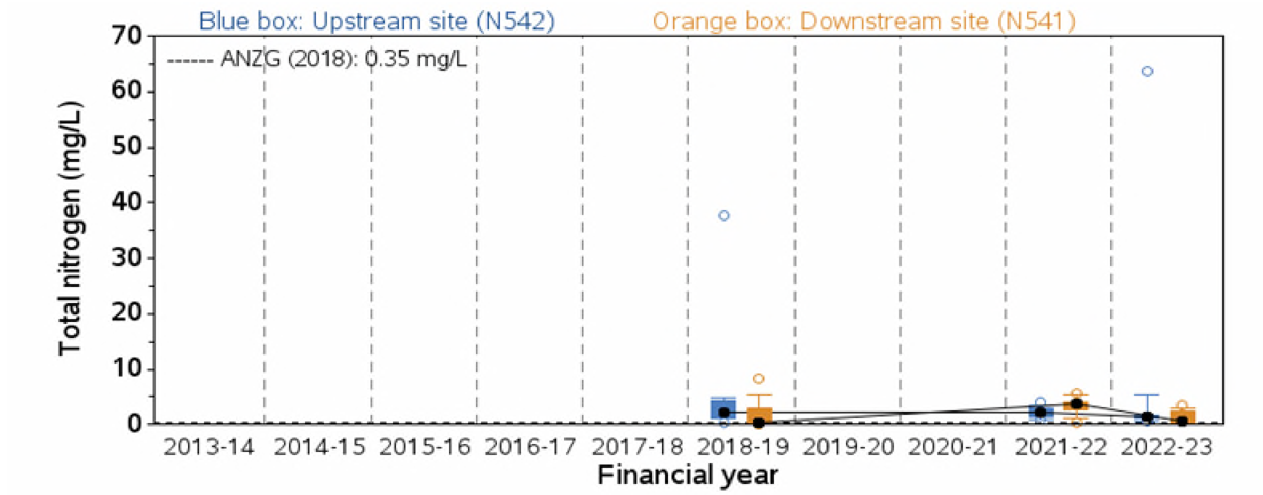
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0.11	0.7458	N53	1	0.38	0.542



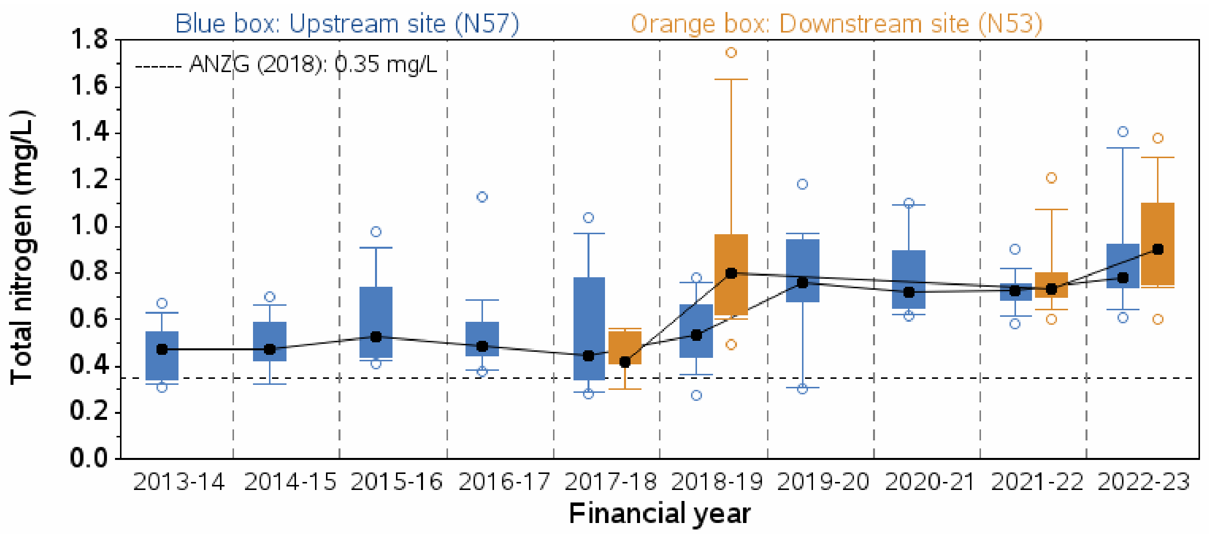
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	9.26	0.0037	N541	1	4.84	0.0324



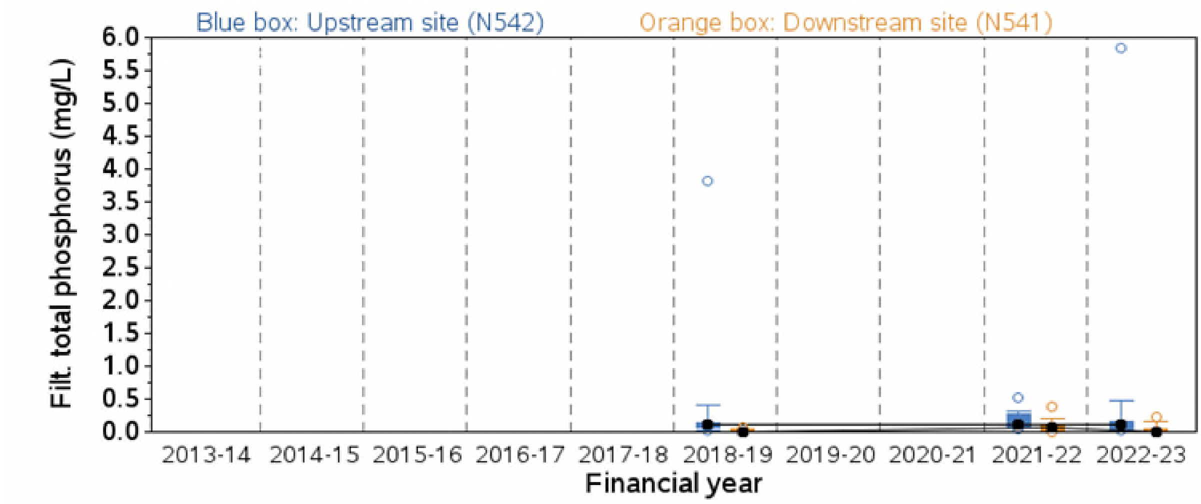
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	17.88	<.0001	N53	1	6	0.0177



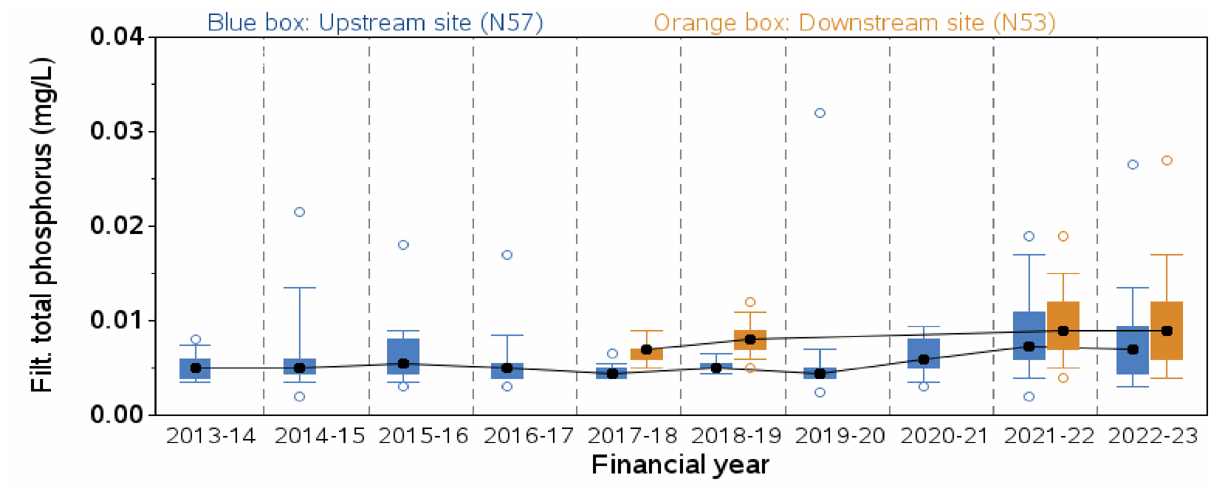
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.44	0.5099	N541	1	5.26	0.0261



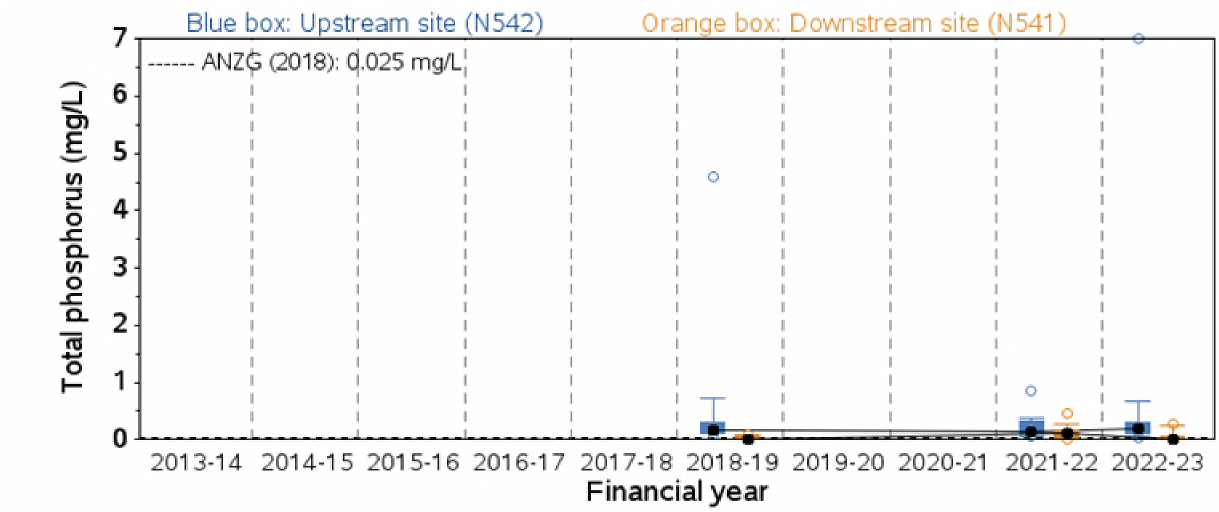
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	26.74	<.0001	N53	1	3.28	0.0756



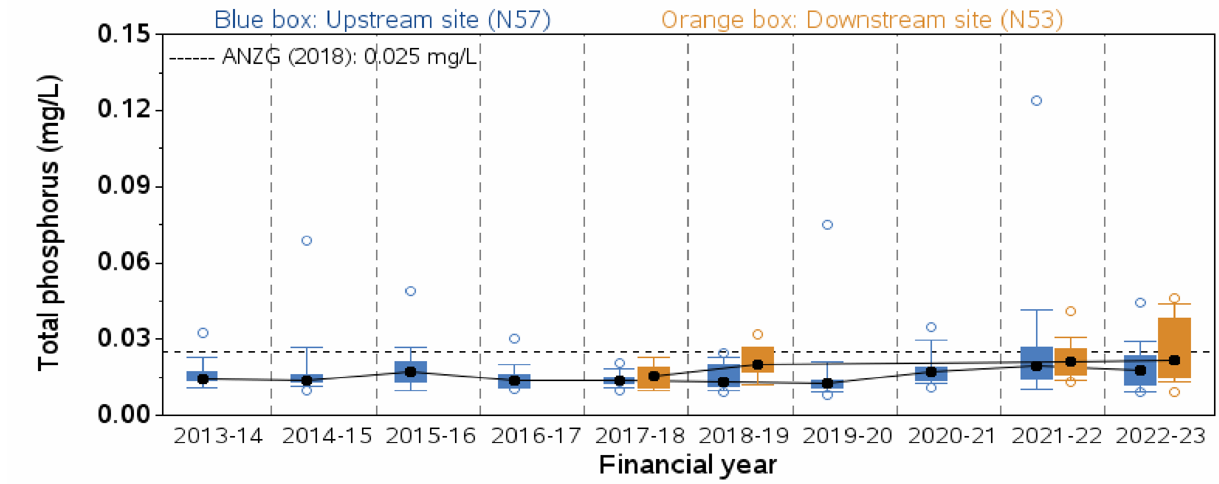
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.56	0.4569	N541	1	0.17	0.6813



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	4.16	0.0429	N53	1	1.6	0.2119

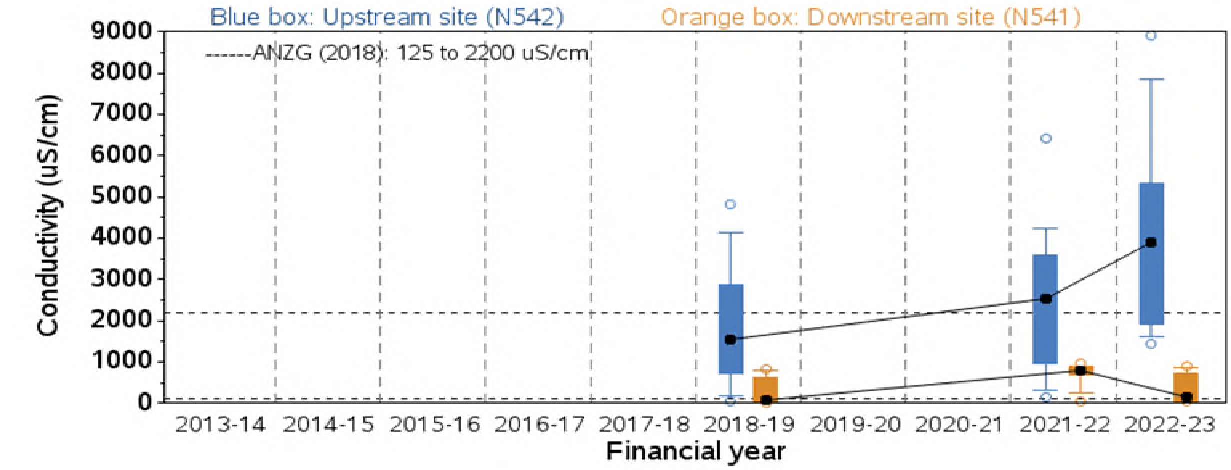


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.57	0.4536	N541	1	0.75	0.3895

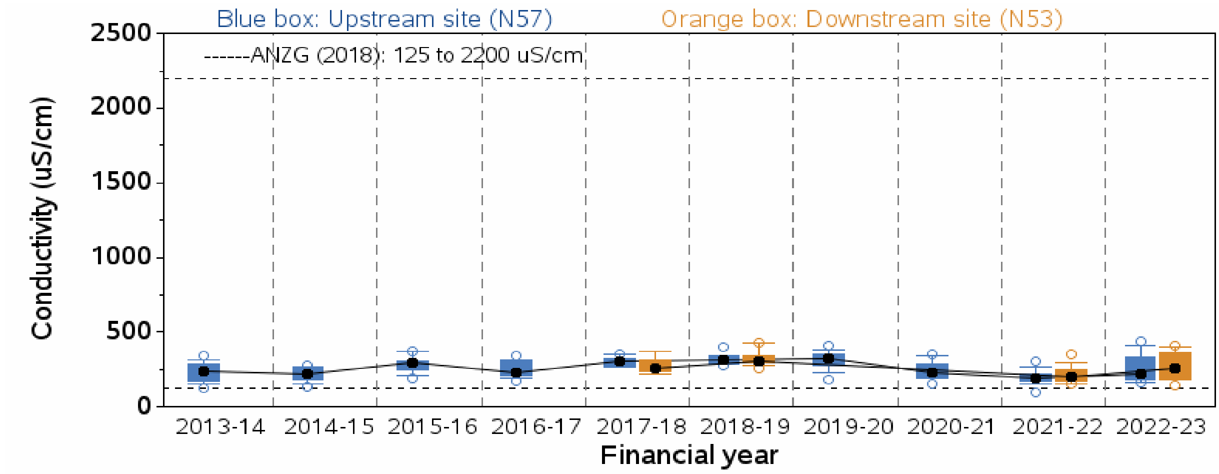


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0.3	0.5866	N53	1	2.95	0.0918

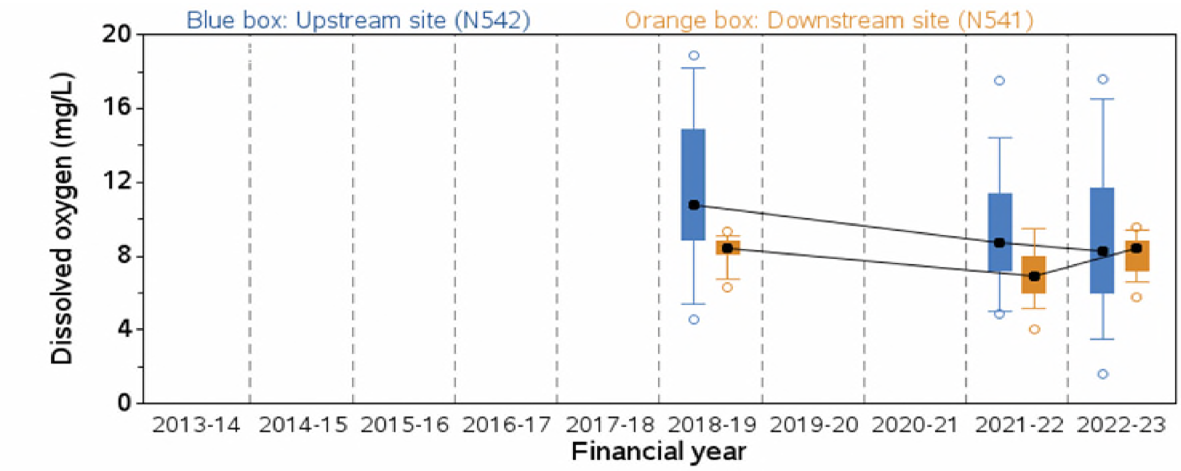
A-4.6 Stressor – Physico-chemical water quality



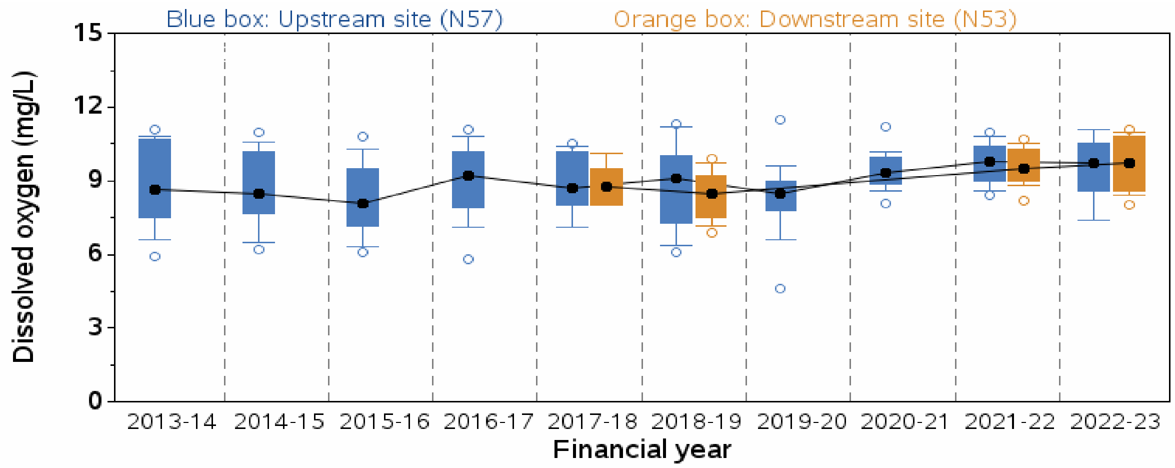
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	13.31	0.0006	N541	1	2.76	0.1028



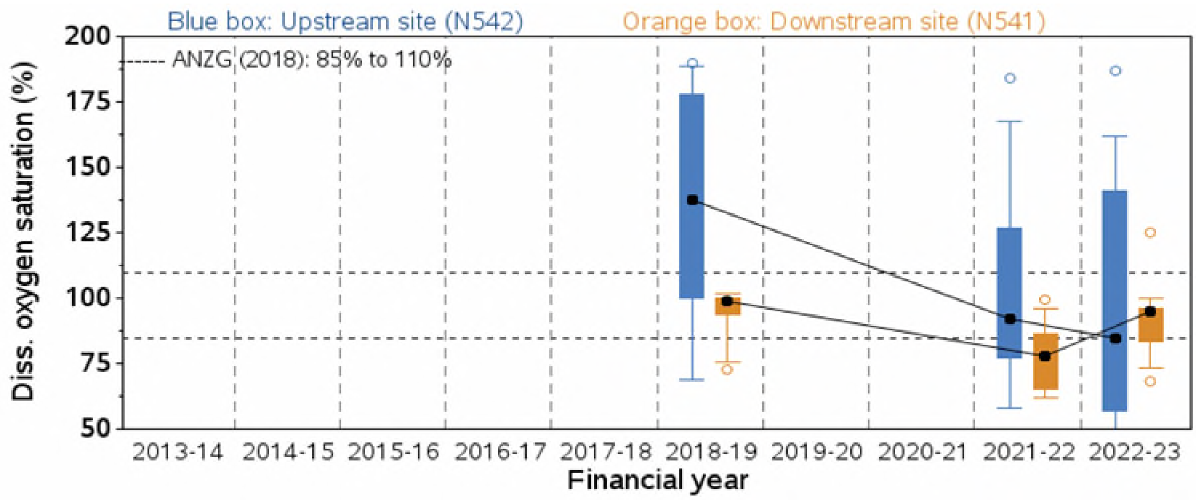
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0.01	0.9418	N53	1	0.01	0.9223



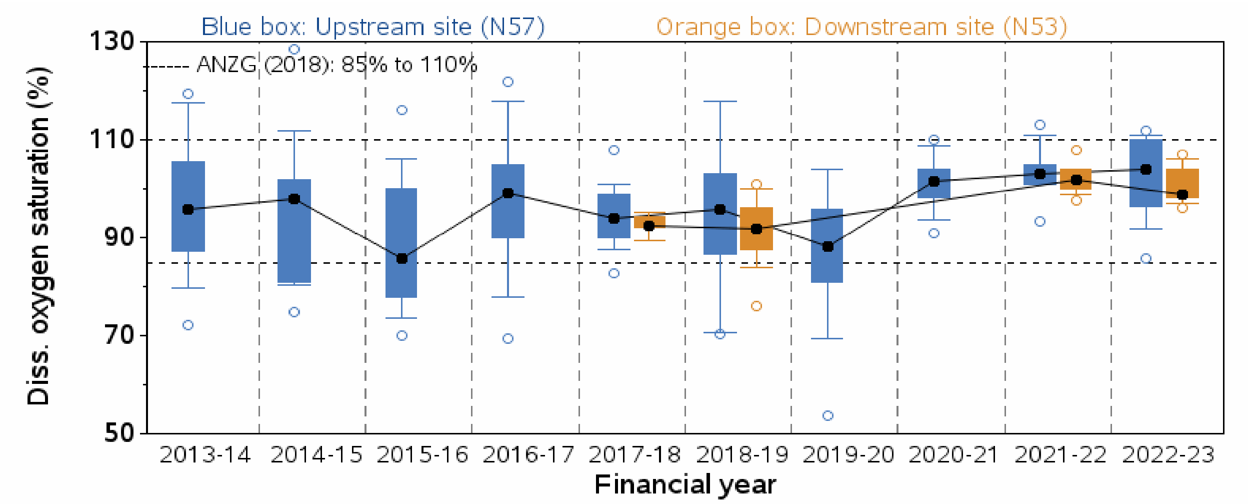
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.98	0.3268	N541	1	1.64	0.2057



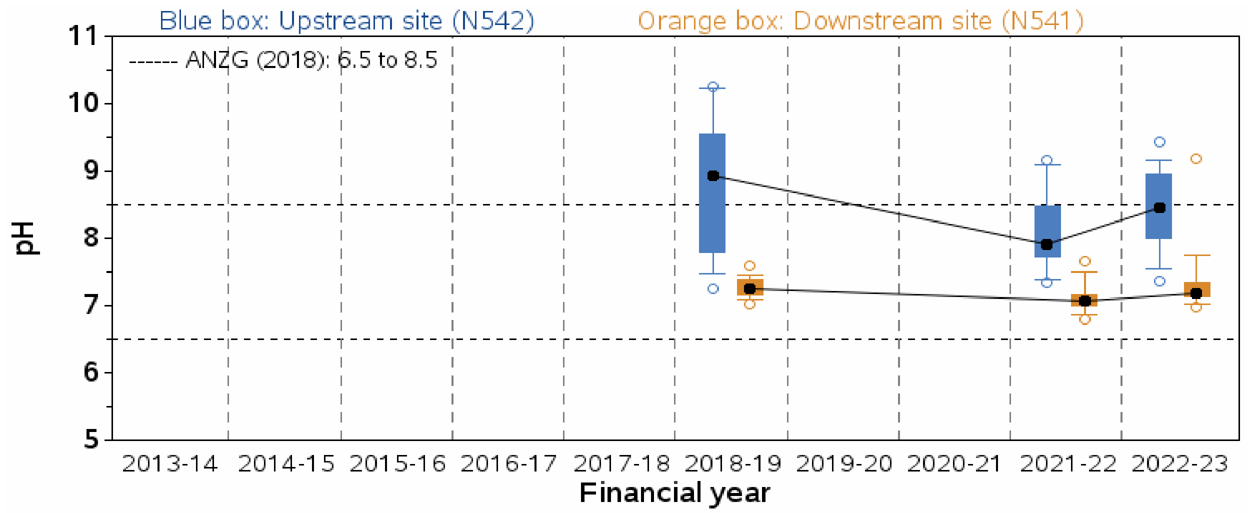
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	3.81	0.0524	N53	1	3.77	0.0574



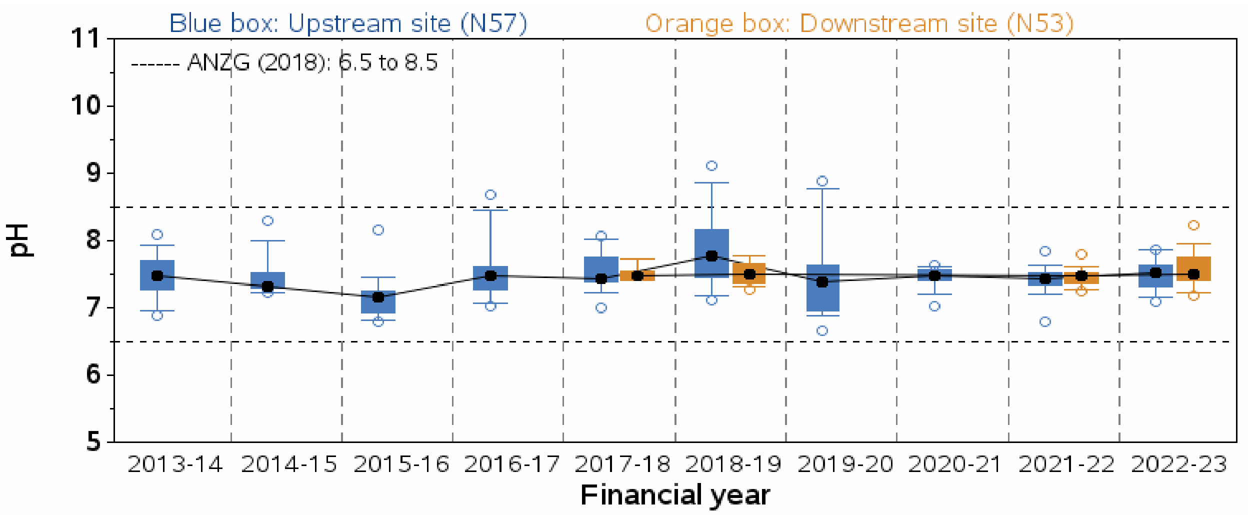
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	3.06	0.0865	N541	1	1.62	0.2094



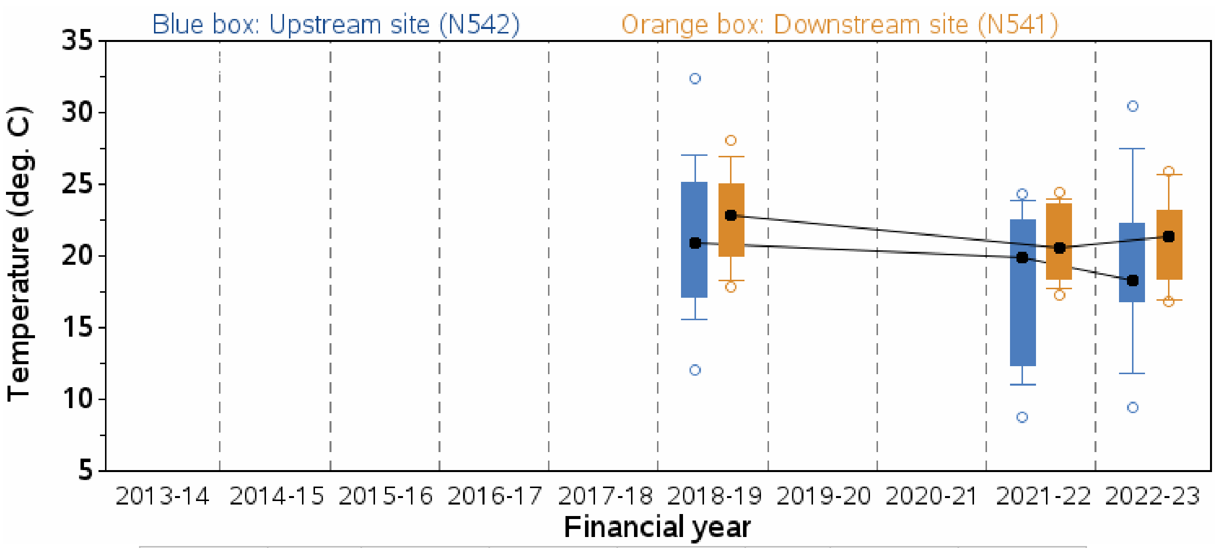
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	5.04	0.026	N53	1	7.79	0.0073



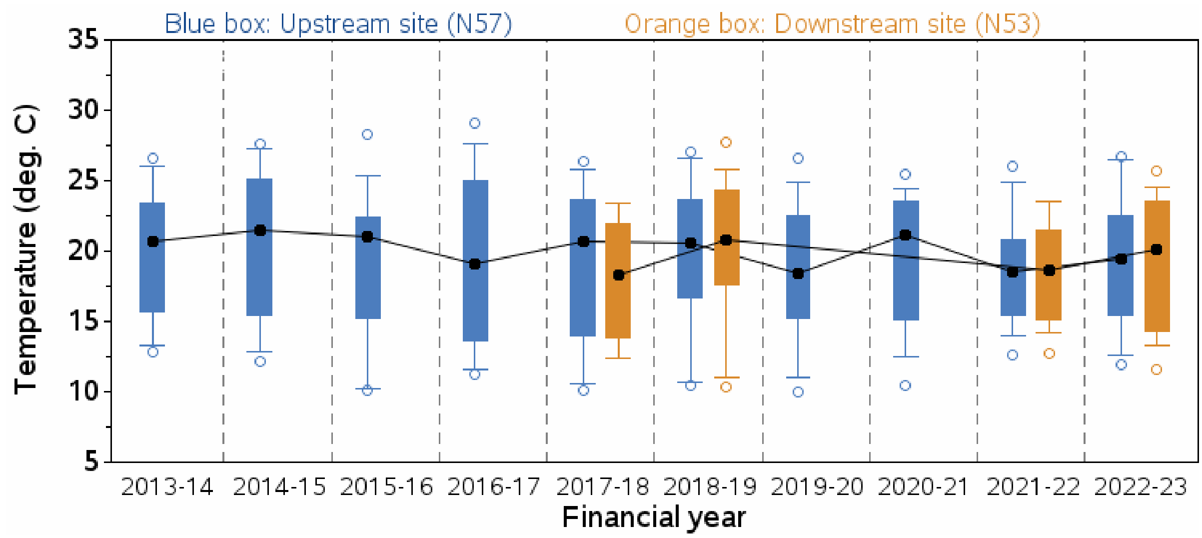
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0	0.9836	N541	1	2.96	0.0915



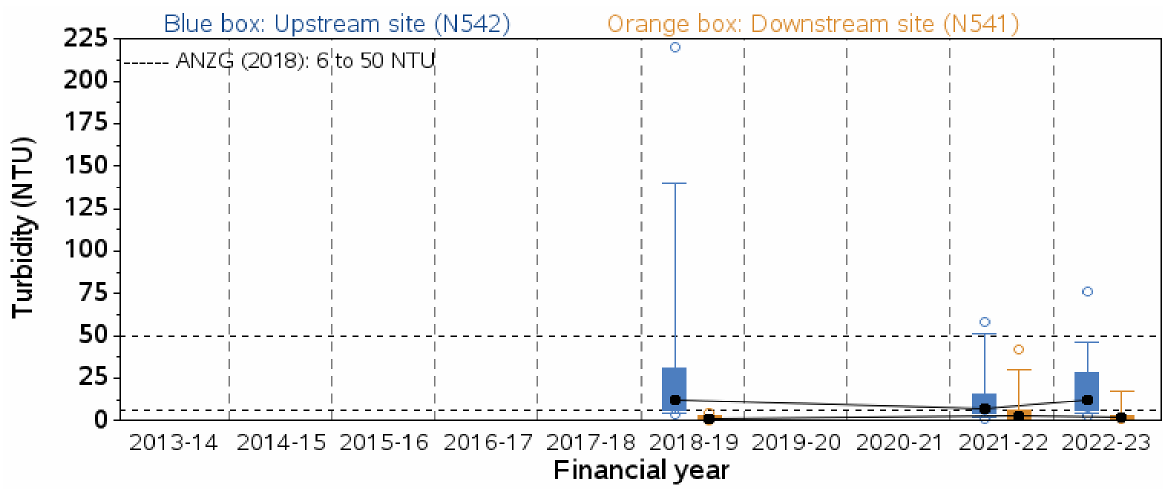
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0.04	0.8472	N53	1	1.74	0.1929



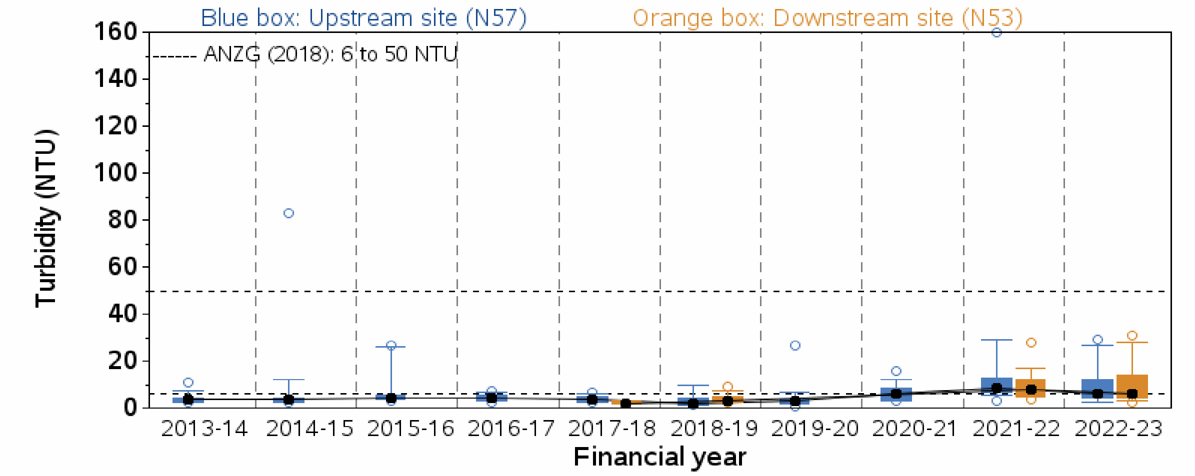
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.12	0.7298	N541	1	0.52	0.4726



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0.01	0.9212	N53	1	0.05	0.8185

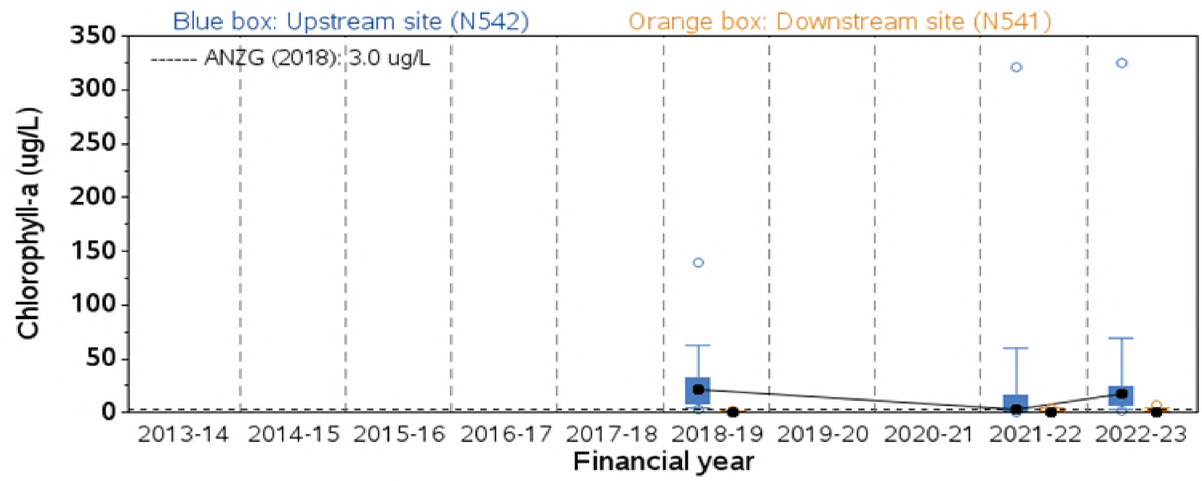


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.29	0.5904	N541	1	0.01	0.9033

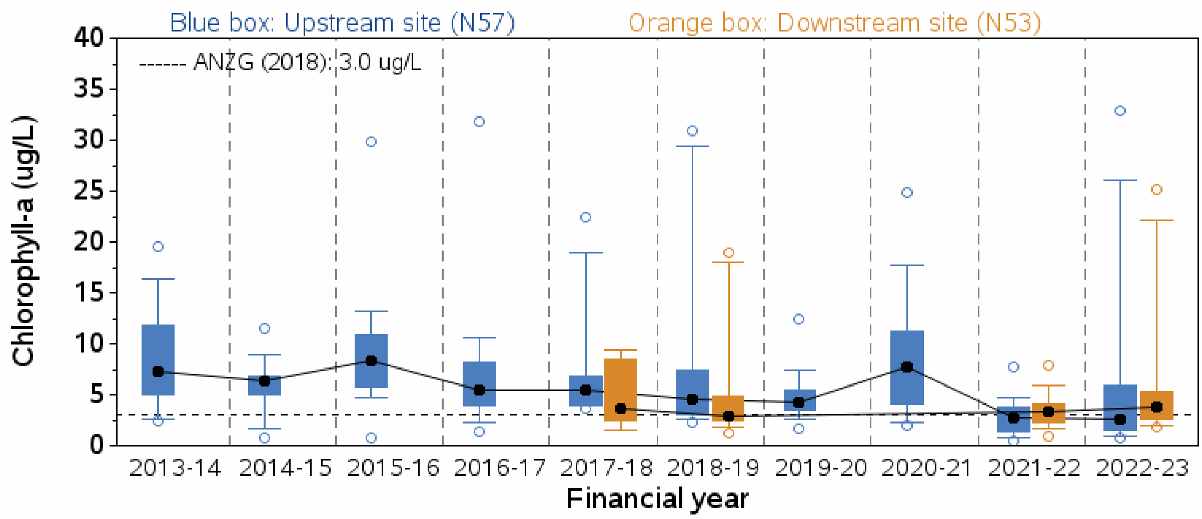


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0.63	0.4267	N53	1	6.48	0.0138

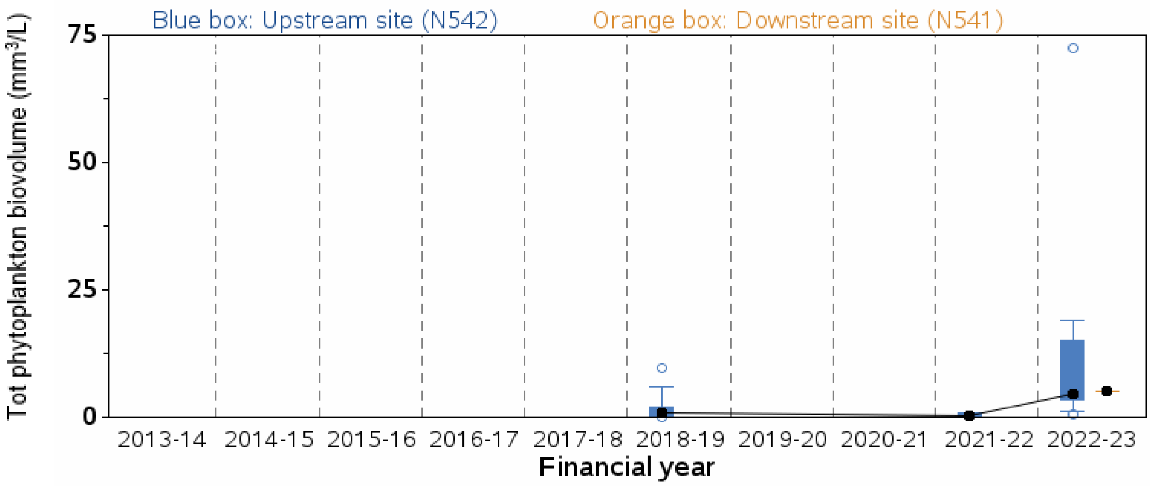
A-4.7 Ecosystem receptor – Phytoplankton



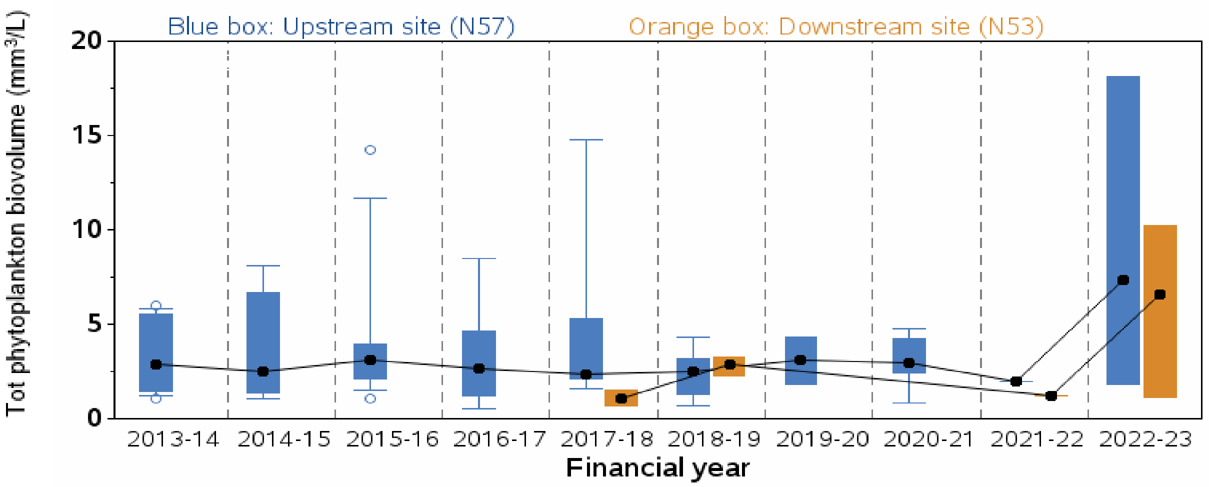
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.18	0.6717	N541	1	2.33	0.1335



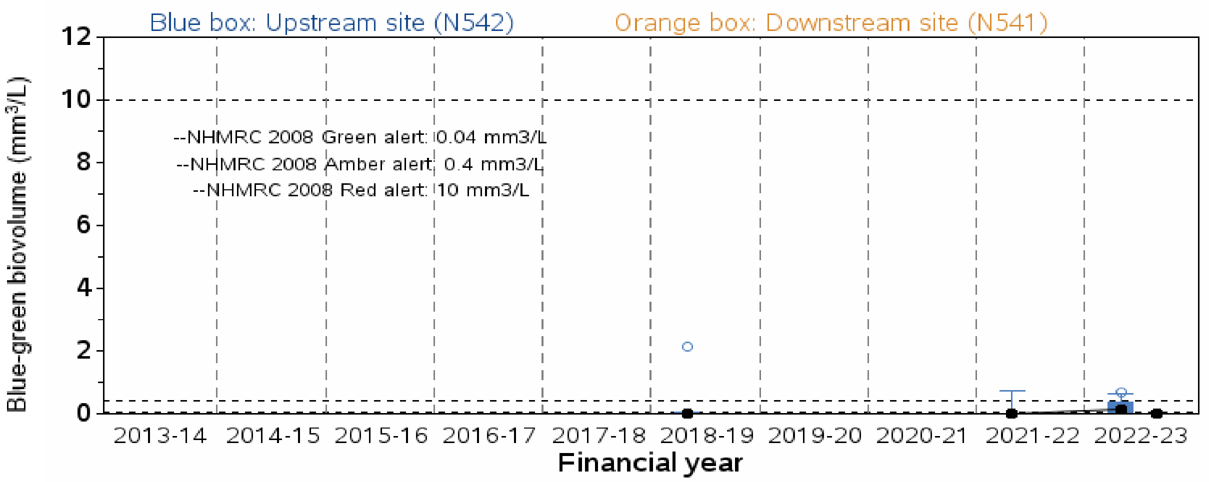
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	0	0.9781	N53	1	1.69	0.1993



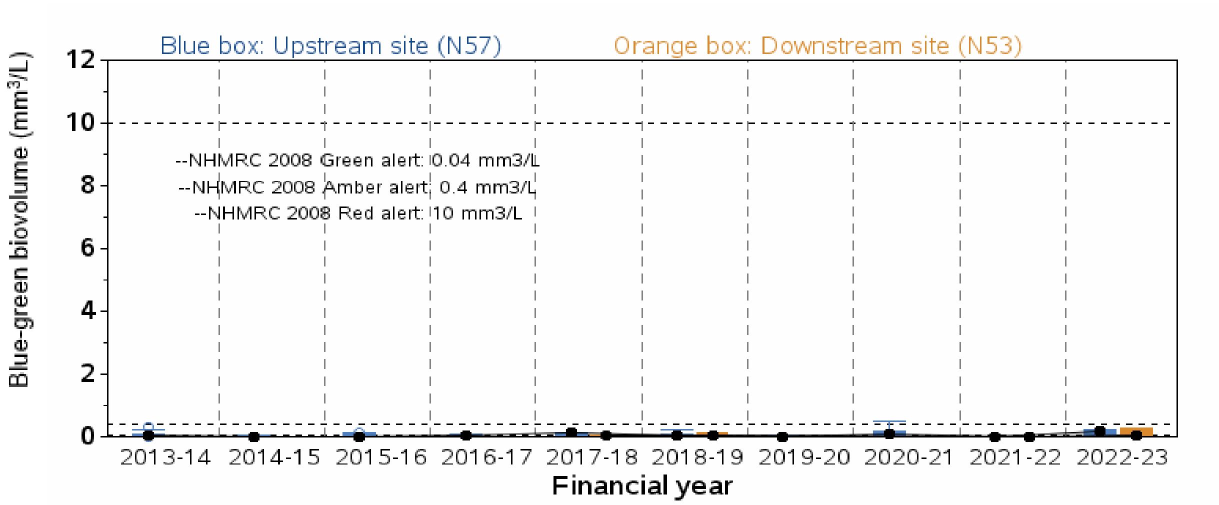
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	5.78	0.0229	N541	Insufficient data		



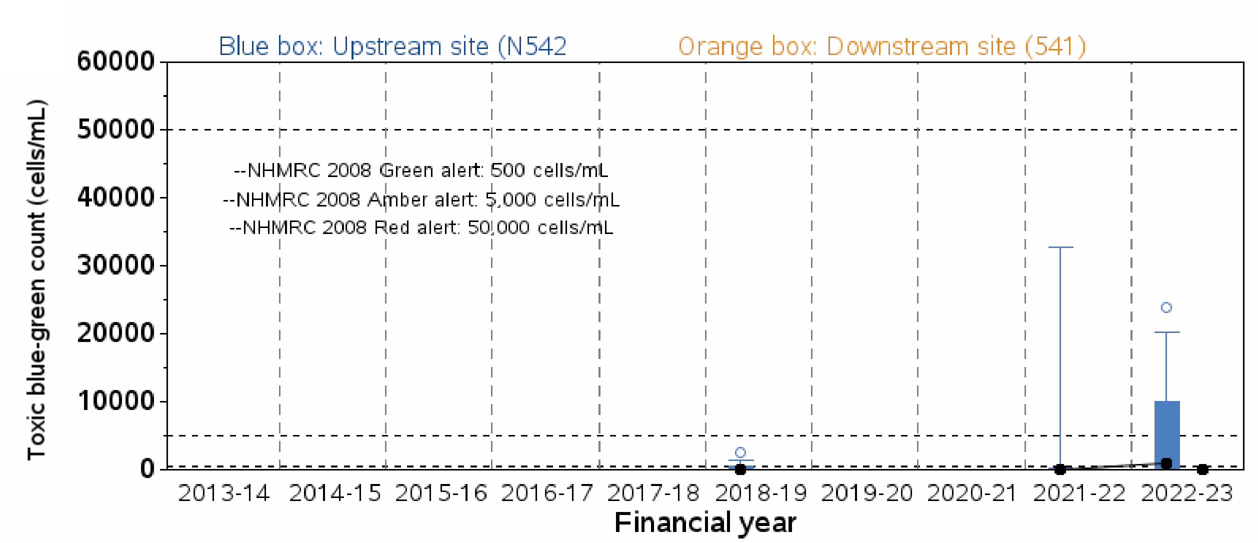
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	8.36	0.0054	N53	1	4.9	0.0625



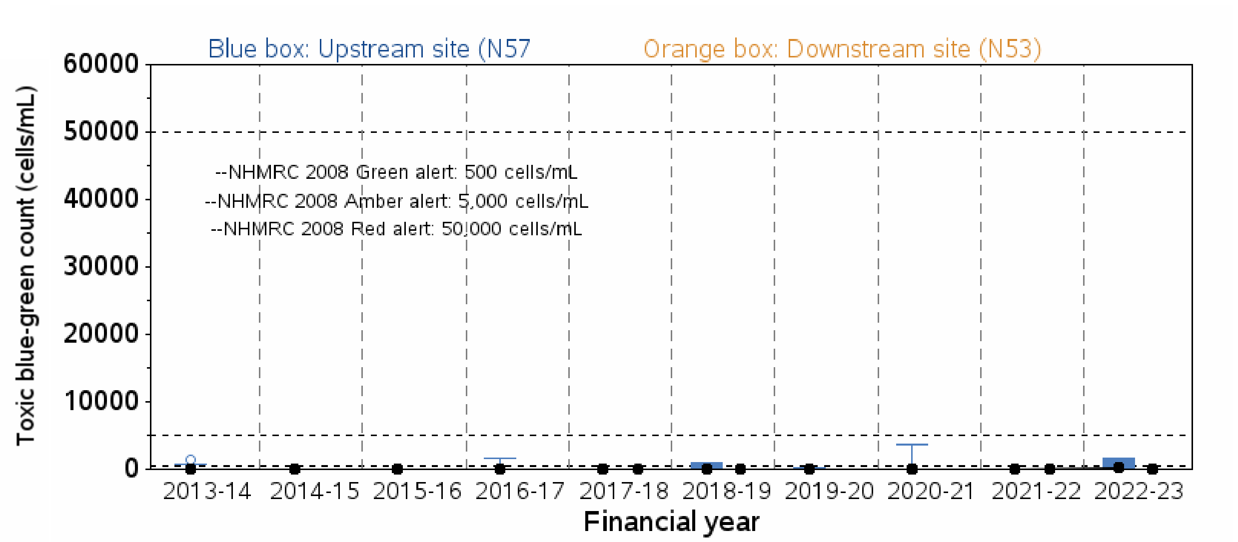
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	0.14	0.7063	N541	Insufficient data		



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	2.07	0.1558	N53	1	0.84	0.3886



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N542	1	1.76	0.1955	N541	Insufficient data		



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N57	1	1.67	0.2017	N53	1	0.47	0.5165

A-4.8 Ecosystem receptor – Macroinvertebrates

The major rainfall events in 2022 and the resulting extended period the Hawkesbury-Nepean River was in flood, prevented sampling due to WHS concerns in the Nepean River at the confluence of Boundary Creek into which Penrith WRRF discharges. As such, data for spring 2022 is not included for the upstream Nepean River site (N57) as the collection of atypical samples was likely and was not safe to undertake. Boundary Creek upstream-downstream samples of the Penrith WRRF were not impacted and were collected for both seasons.

The SIGNAL-SG plots provided assessments of stream health for both Boundary Creek near Penrith WRRF and the Nepean River upstream-downstream of the confluence with Boundary Creek. On some occasions, only one season can be compared due to reasons mentioned above. SIGNAL-SG plots were based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022–23 against that collected between 2003 to 2022 for the Boundary Creek sites and 1995 to 2022 for the Nepean River sites. These visual comparisons suggest downstream stream health was substantially higher in comparison to the upstream site, in both Boundary Creek and Nepean River sites. This indicates that the wastewater discharge from the Penrith WRRF did not have a measurable negative impact on stream health of either Boundary Creek (Figure A-13) or the Nepean River during 2022-23 (Figure A-14).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under t-tests returned a significant test outcome for Boundary Creek (Table A-20), reflecting the visual assessment that stream health was significantly higher at the downstream site (Figure A-13).

As no measurable negative impact on downstream stream health was detected on either Boundary Creek or the Nepean River, no further data analysis was undertaken.

Table A-20 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from the Boundary Creek and Nepean River waterways near Penrith WRRF

Waterway	Method	Statistic	DF	P value
Boundary Creek	Welch Two Sample t-test	-5.11	6.6	0.002
Nepean River	Welch Two Sample t-test	-1.89	2.3	0.182

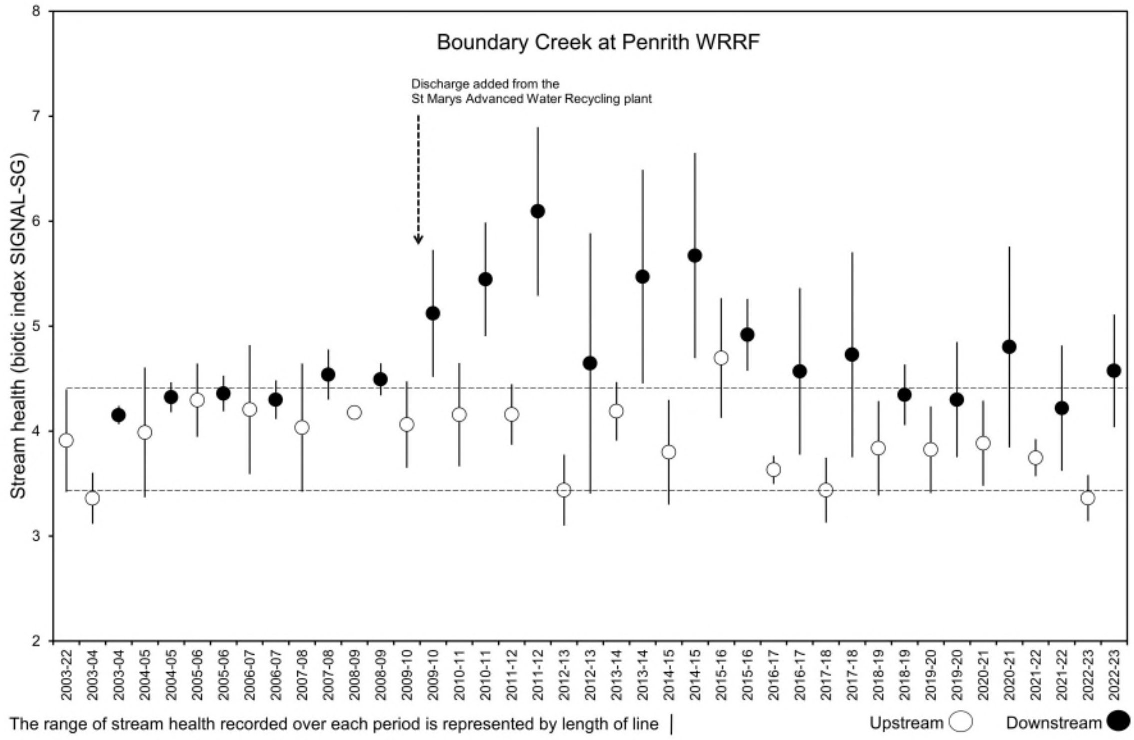


Figure A-13 Stream health of Boundary Creek near Penrith WRRF

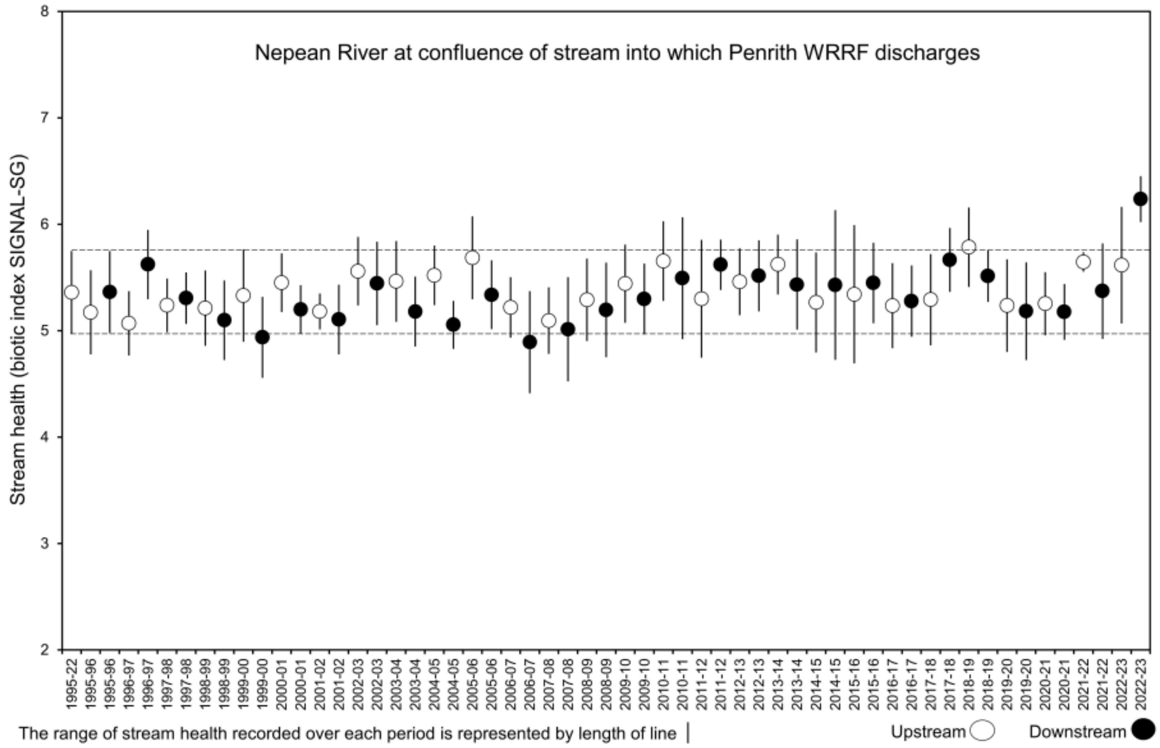
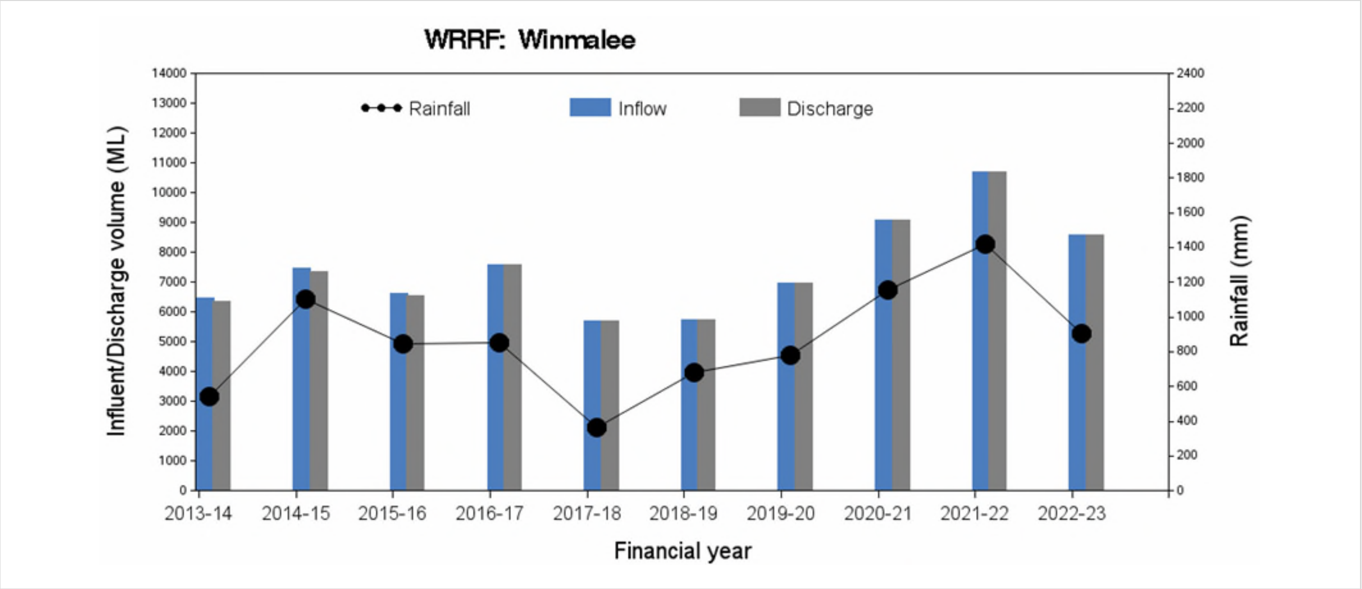


Figure A-14 Stream health of the Nepean River upstream-downstream of the confluence of Boundary Creek near Penrith WRRF

A-5 Winmalee WRRF

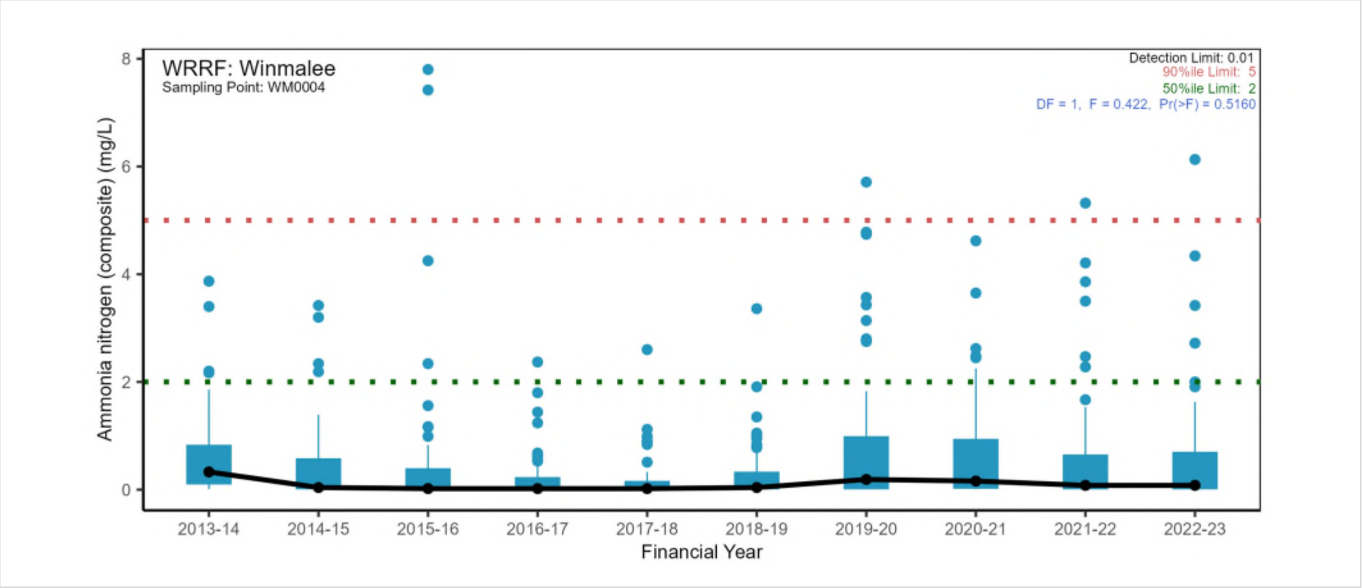
A-5.1 Pressure – Wastewater quantity

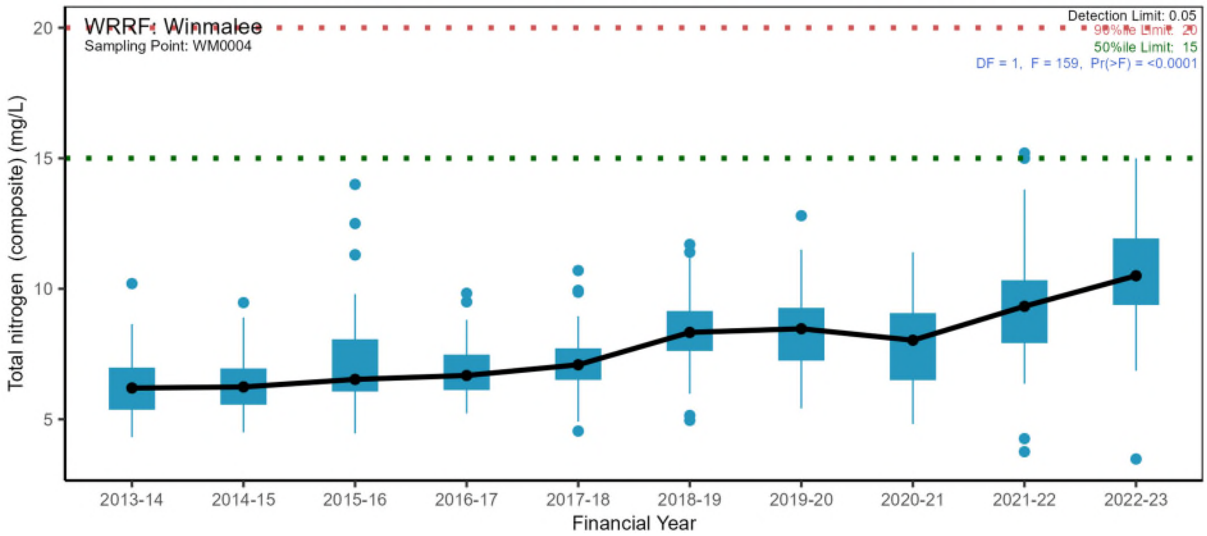
Inflow/ Discharge volume and rainfall

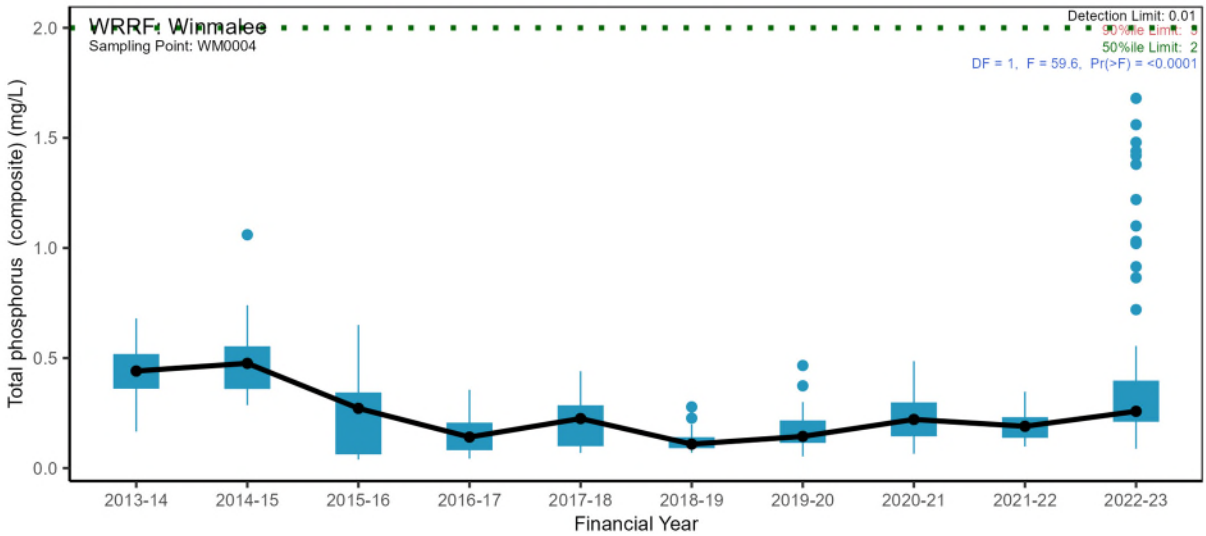


A-5.2 Pressure – Wastewater quality

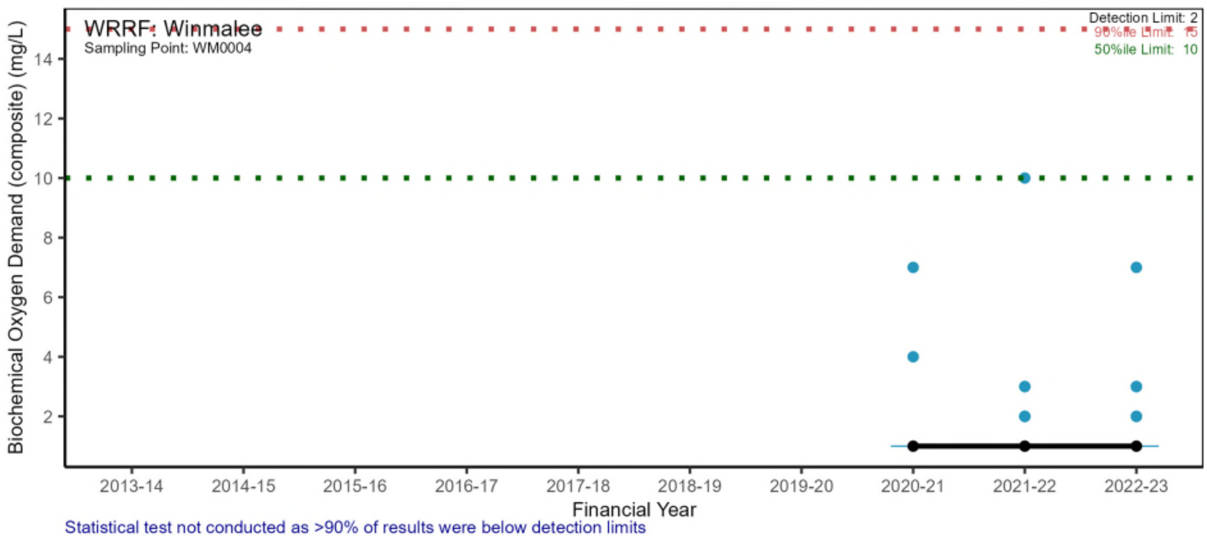
Nutrients

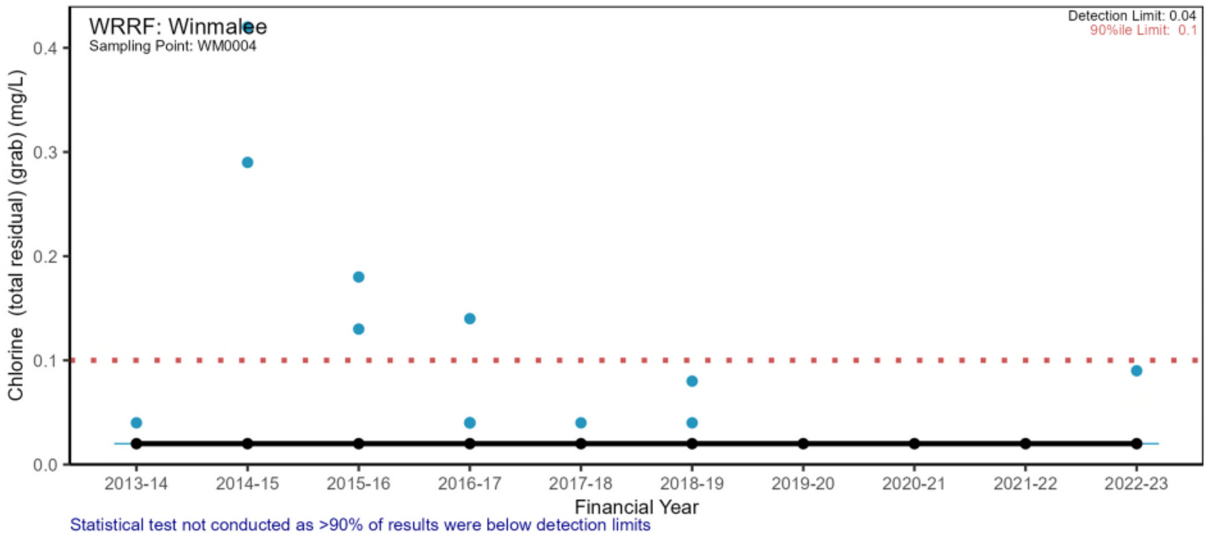


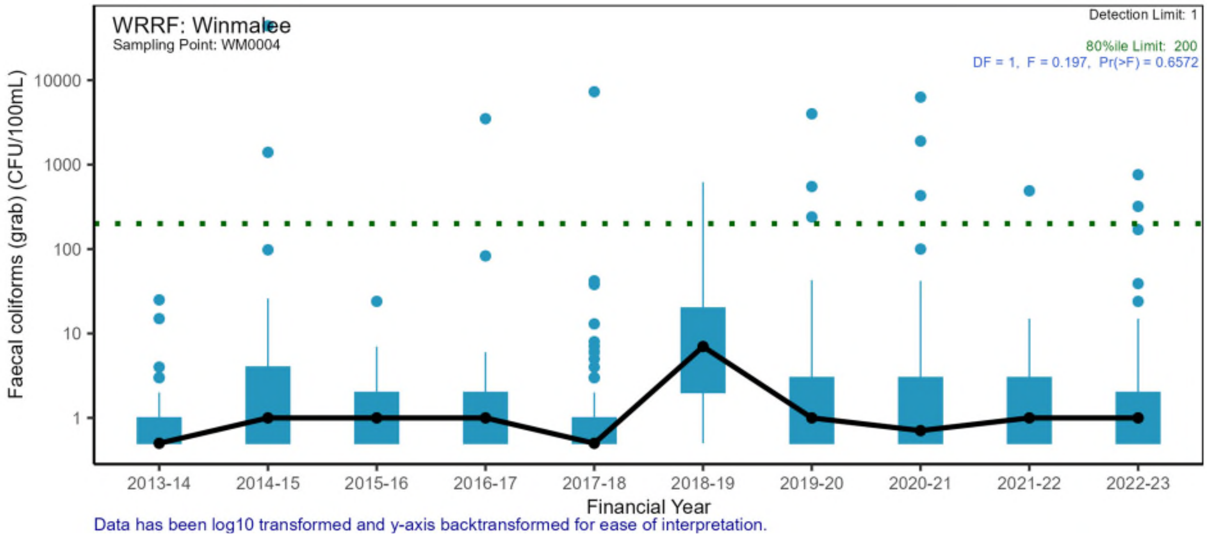


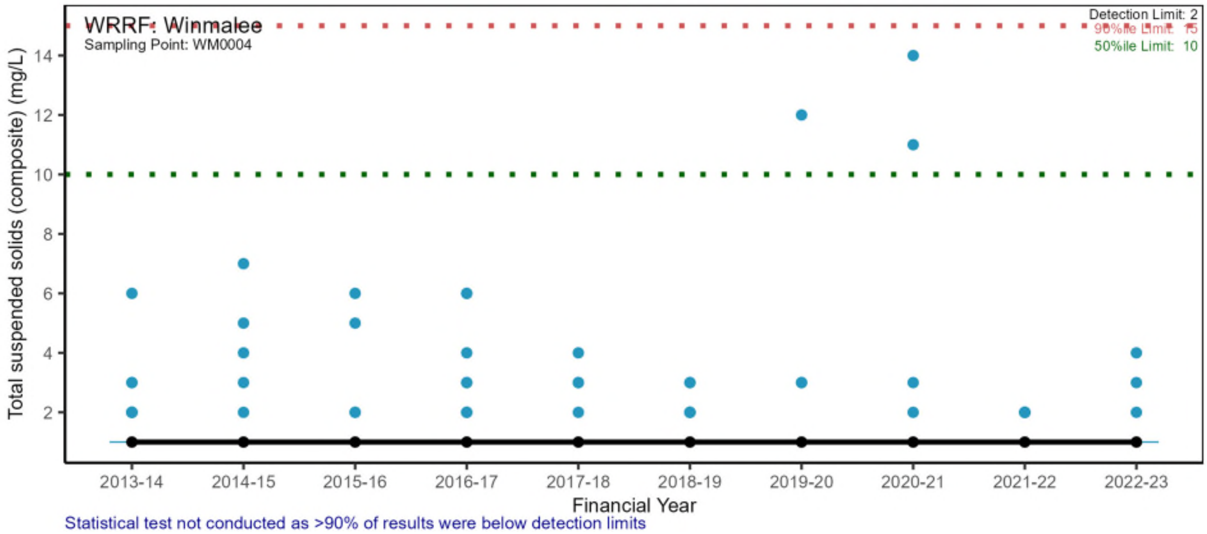


Major conventional analytes

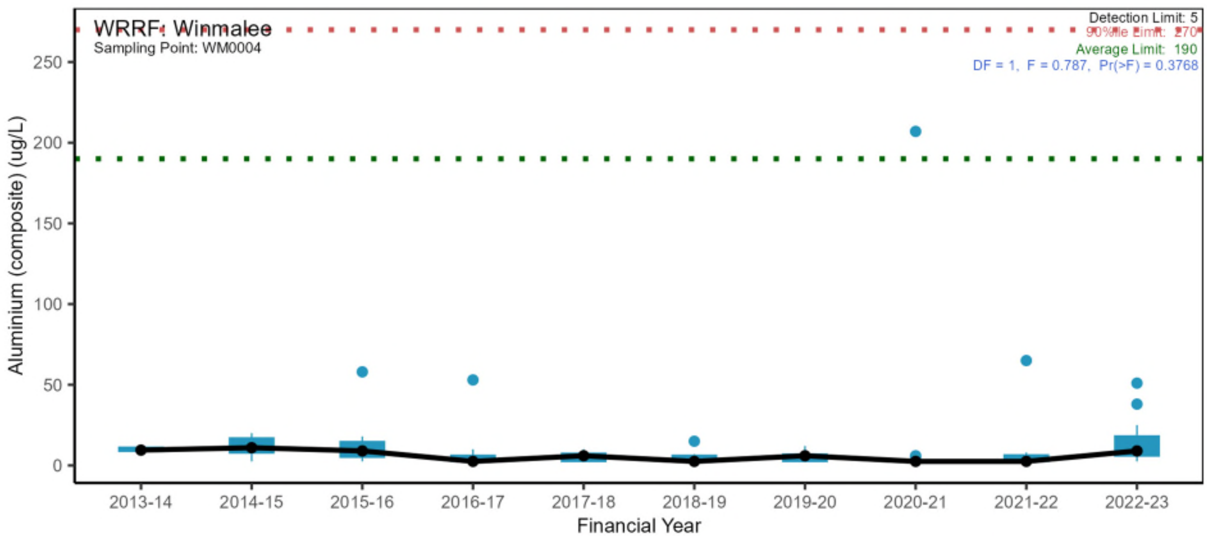


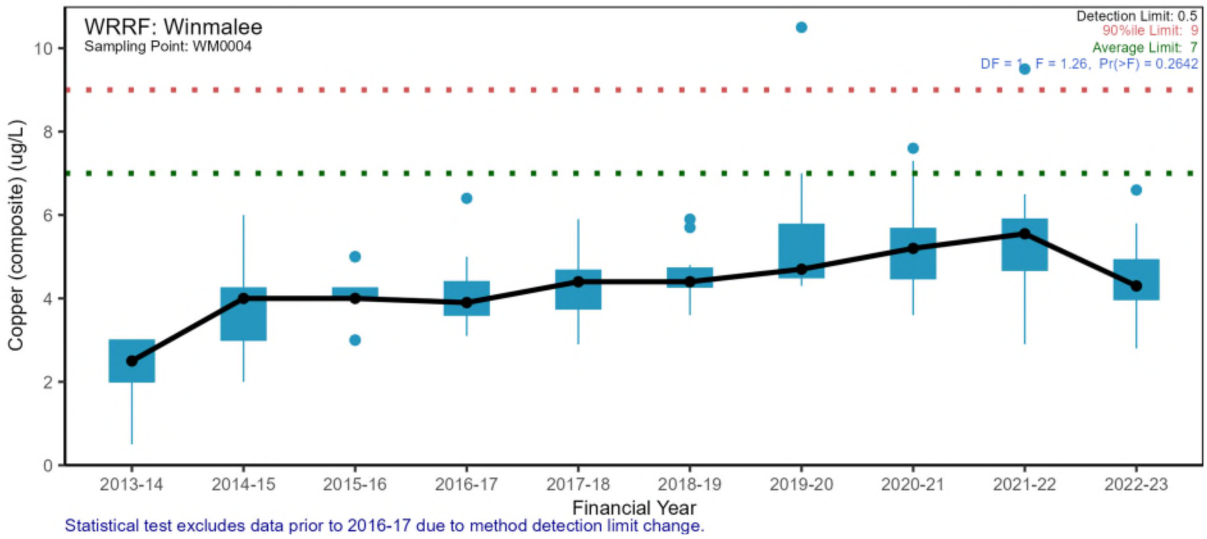

WRRF: Winmalee
Sampling Point: WM0004
Detection Limit: 0.04
90%ile Limit: 0.1
Chlorine (total residual) (grab) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Statistical test not conducted as >90% of results were below detection limits

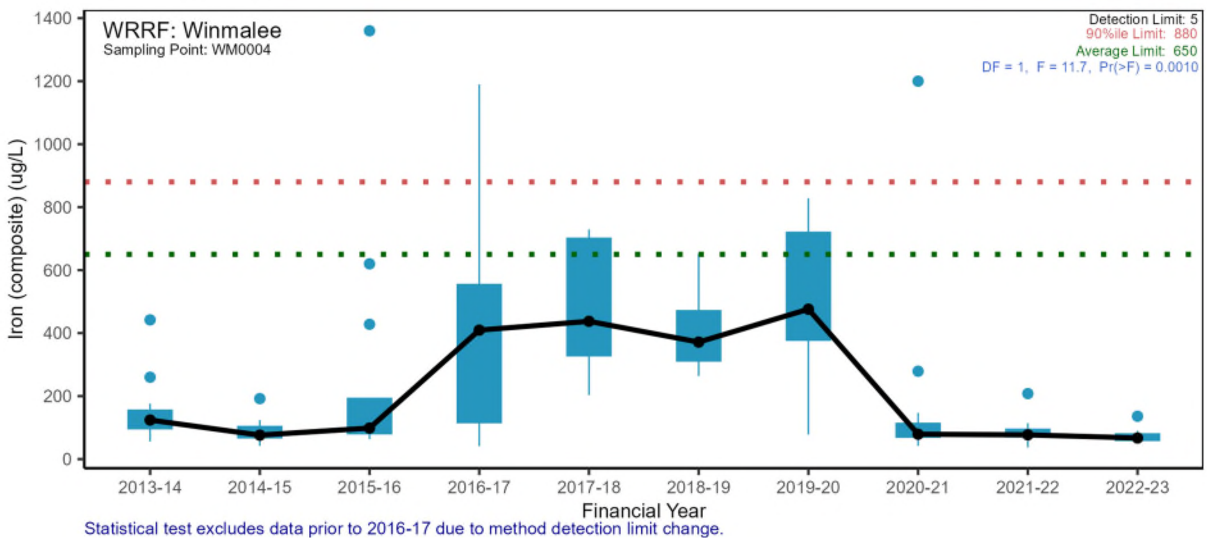

WRRF: Winmalee
Sampling Point: WM0004
Detection Limit: 1
80%ile Limit: 200
DF = 1, F = 0.197, Pr(>F) = 0.6572
Faecal coliforms (grab) (CFU/100mL)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

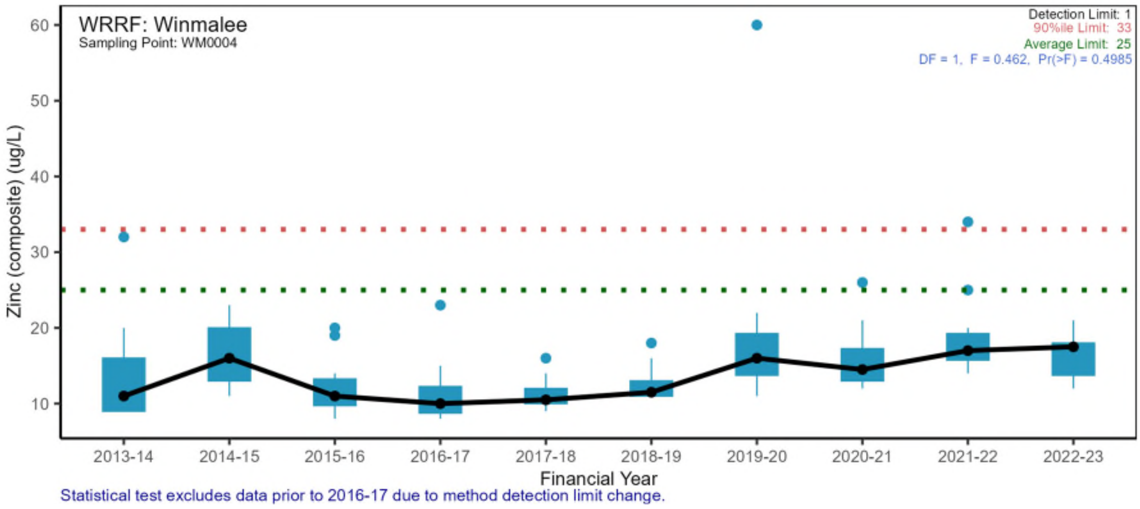

WRRF: Winmalee
Sampling Point: WM0004
Detection Limit: 2
90%ile Limit: 15
50%ile Limit: 10
Total suspended solids (composite) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Statistical test not conducted as >90% of results were below detection limits

Trace metals

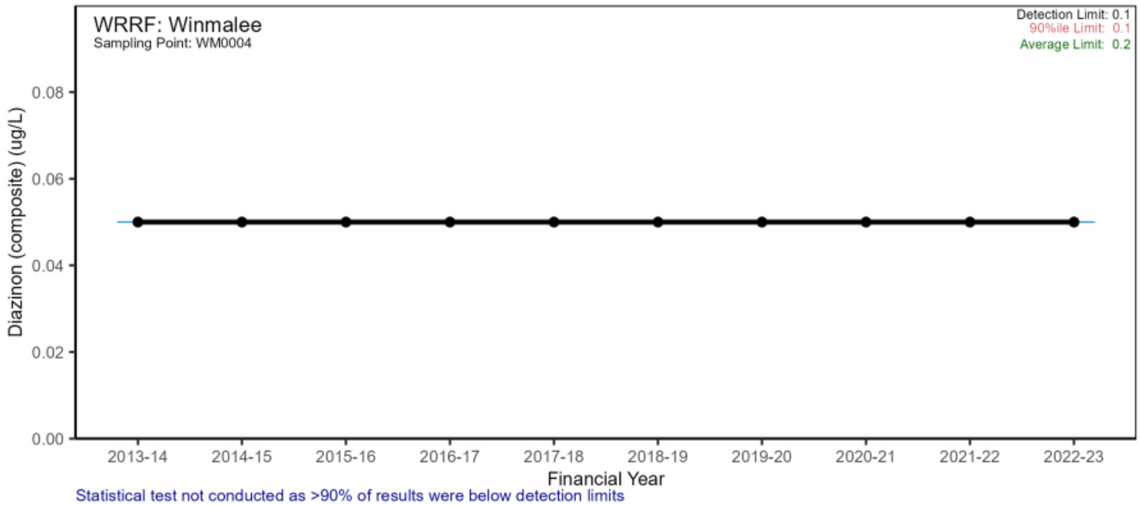




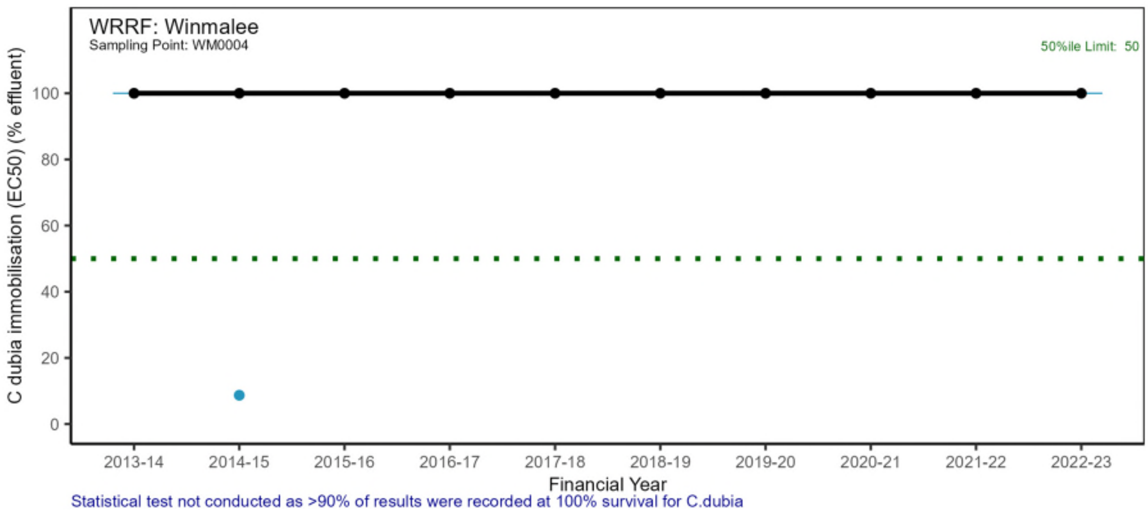




Other chemicals and organics (including pesticides)

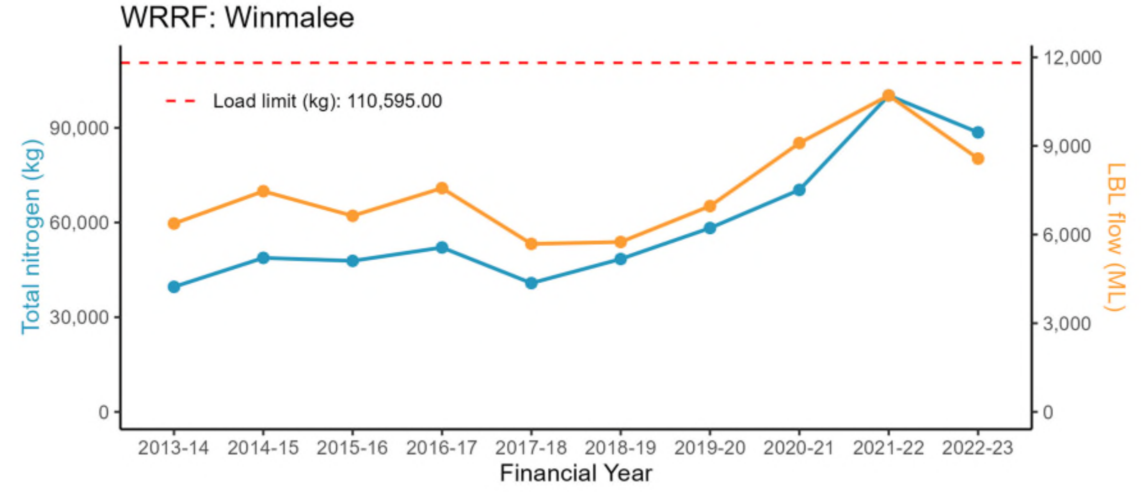


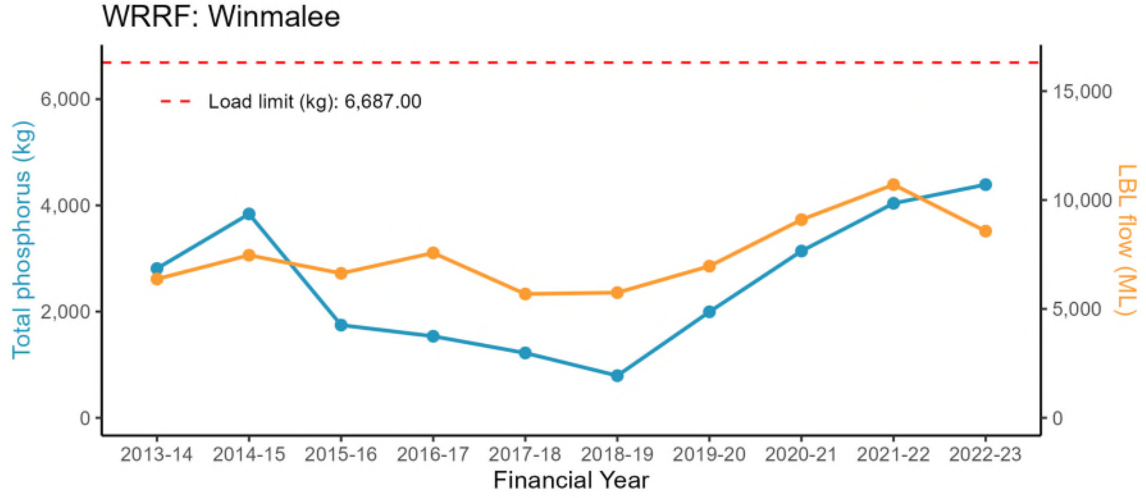
A-5.3 Pressure – Wastewater toxicity



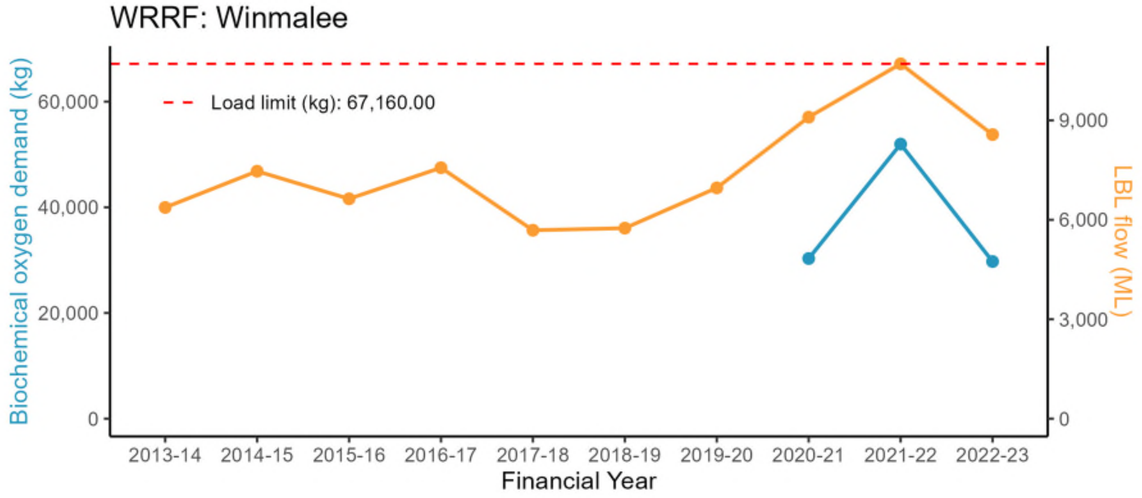
A-5.4 Pressure – Wastewater discharge load

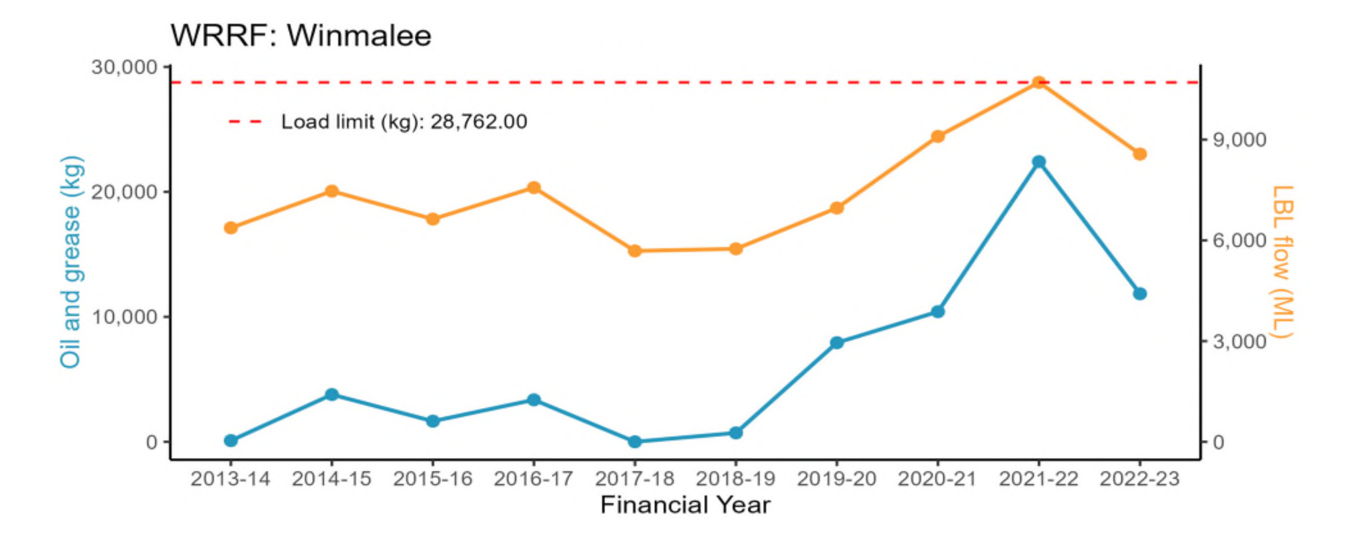
Nutrients

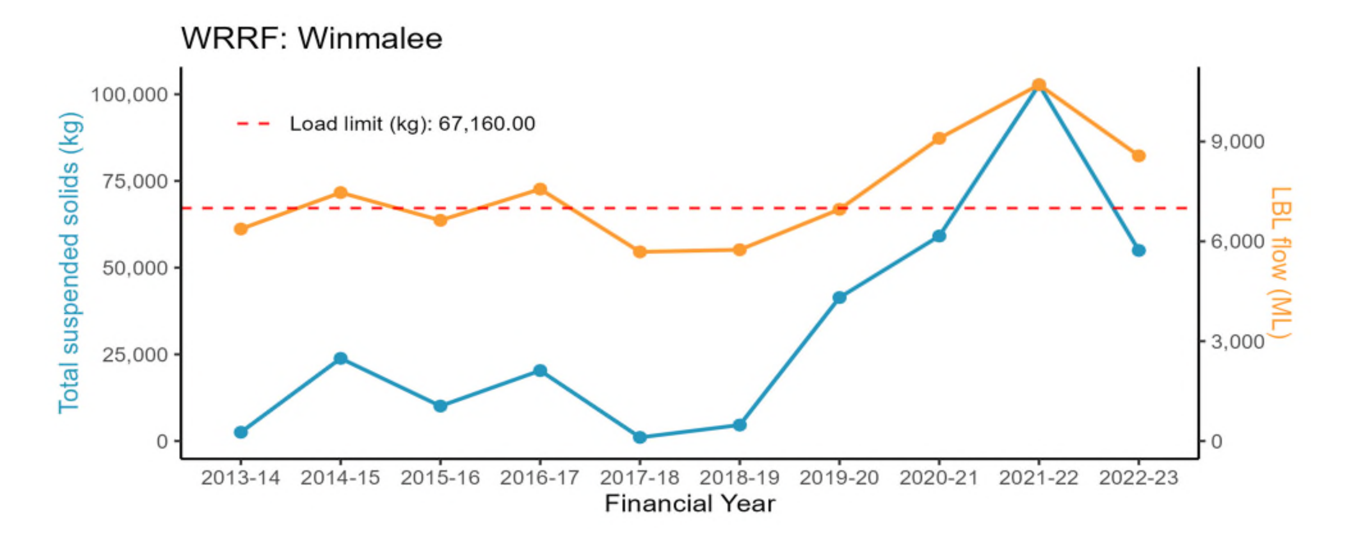




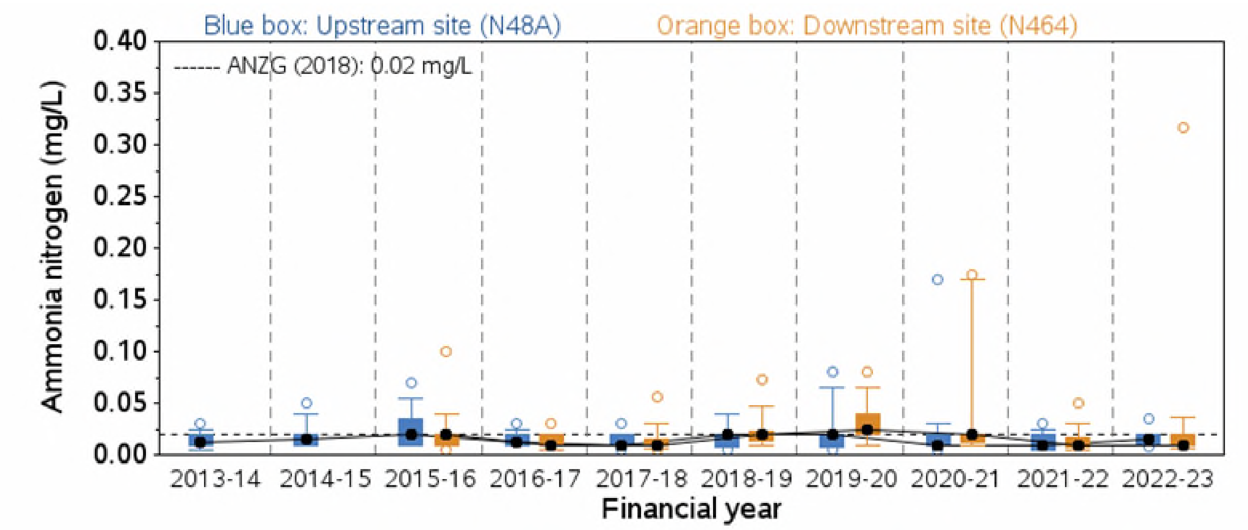
Major conventional analytes



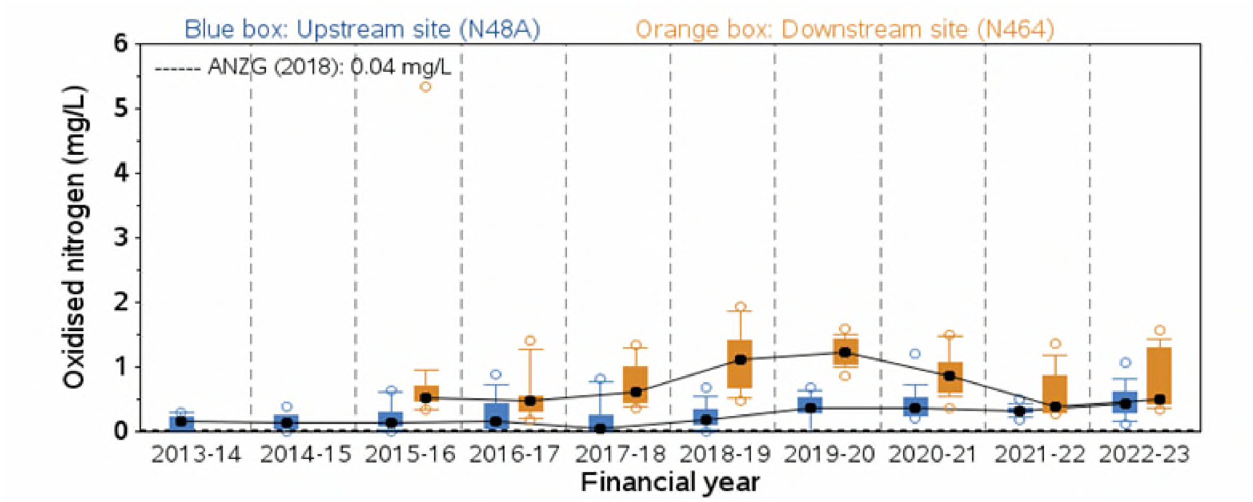




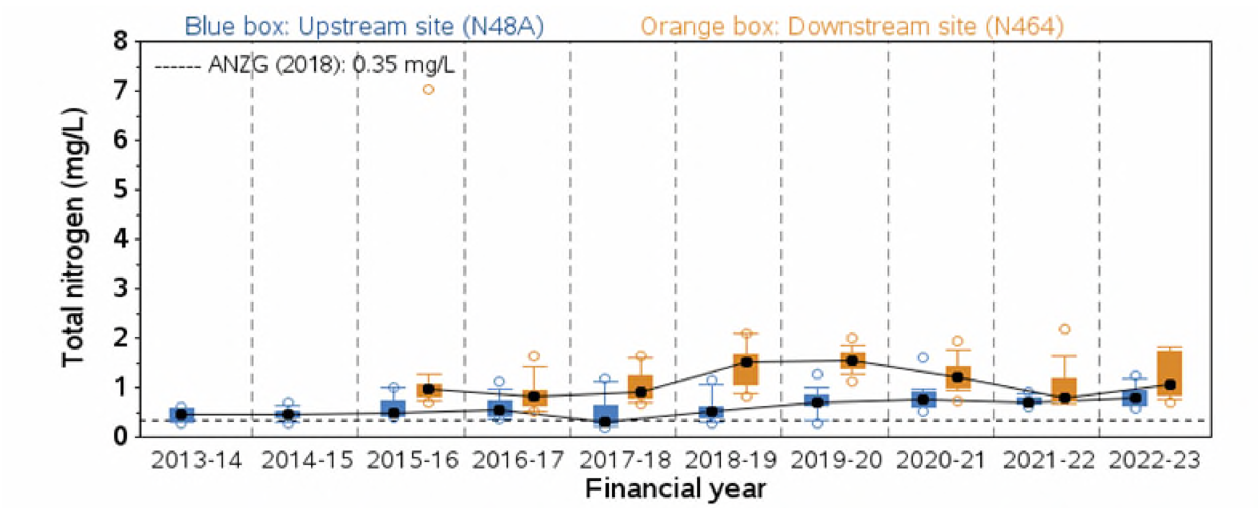
A-5.5 Stressor – Nutrients



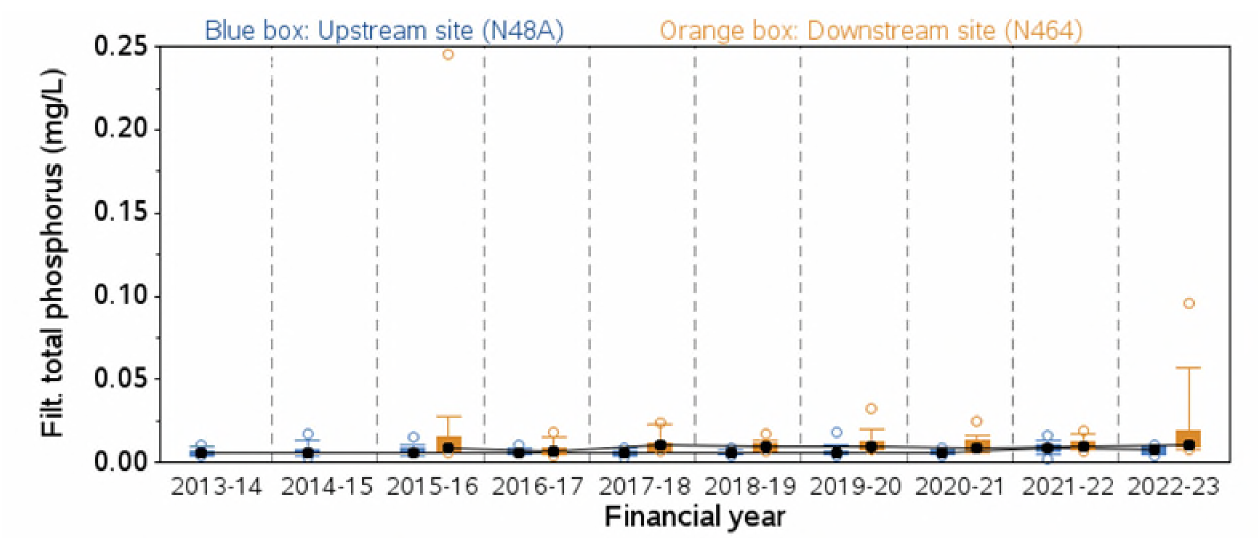
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.64	0.4235	N464	1	1.17	0.2805



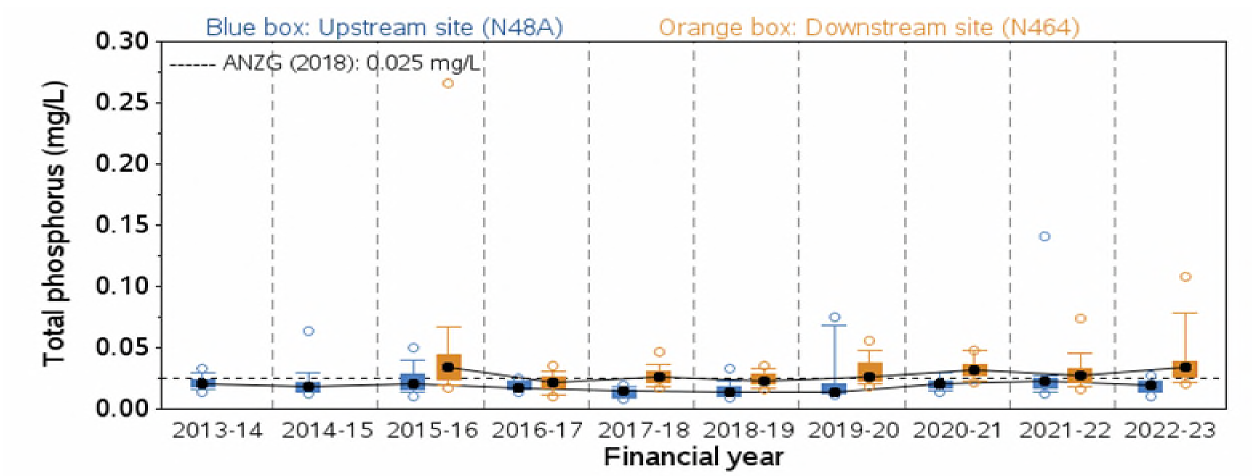
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	9.42	0.0025	N464	1	0	0.9514



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	12.35	0.0006	N464	1	0.07	0.7956

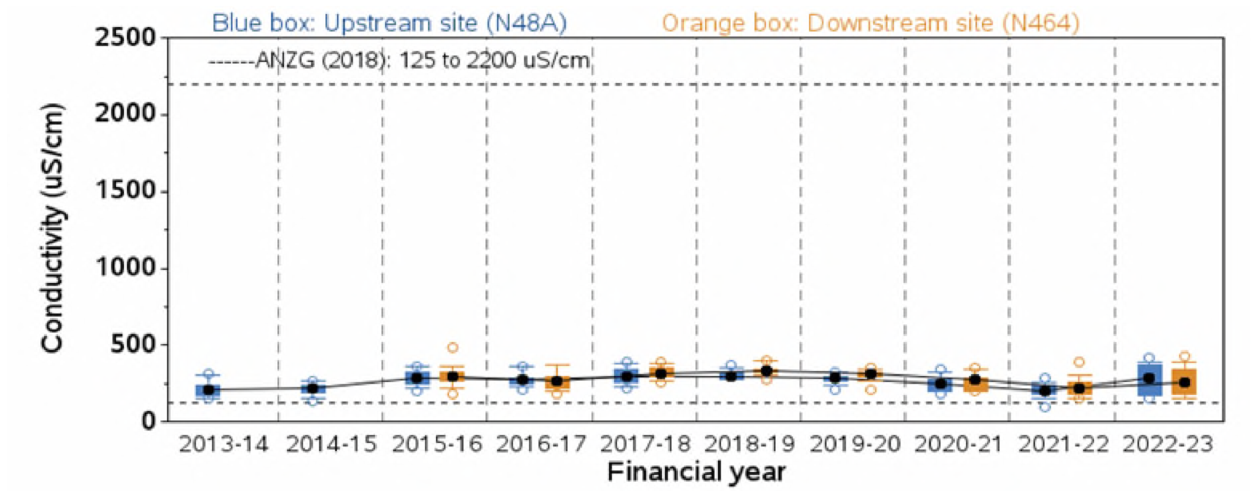


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	1	0.3189	N464	1	2.92	0.0896

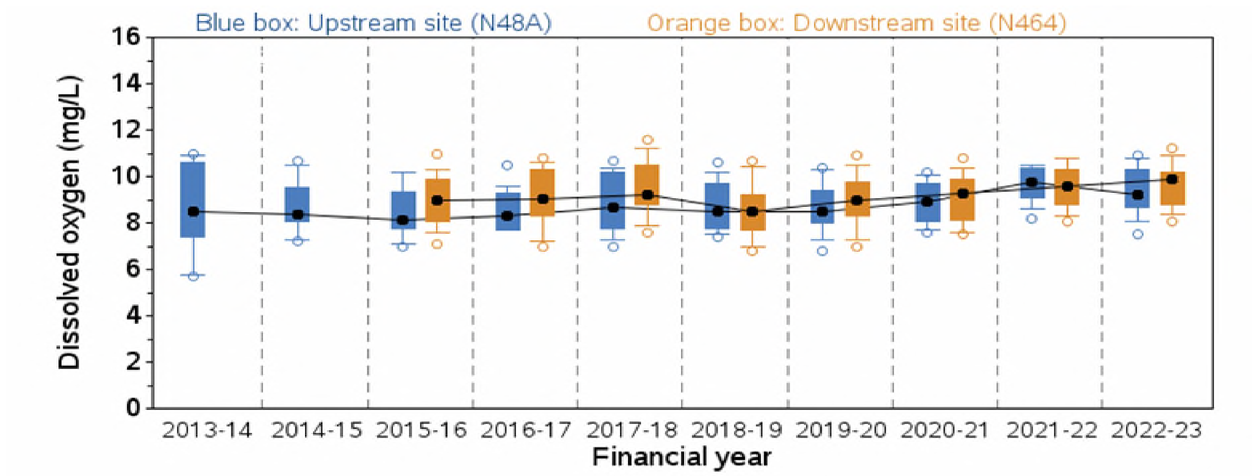


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.2	0.652	N464	1	3.14	0.0786

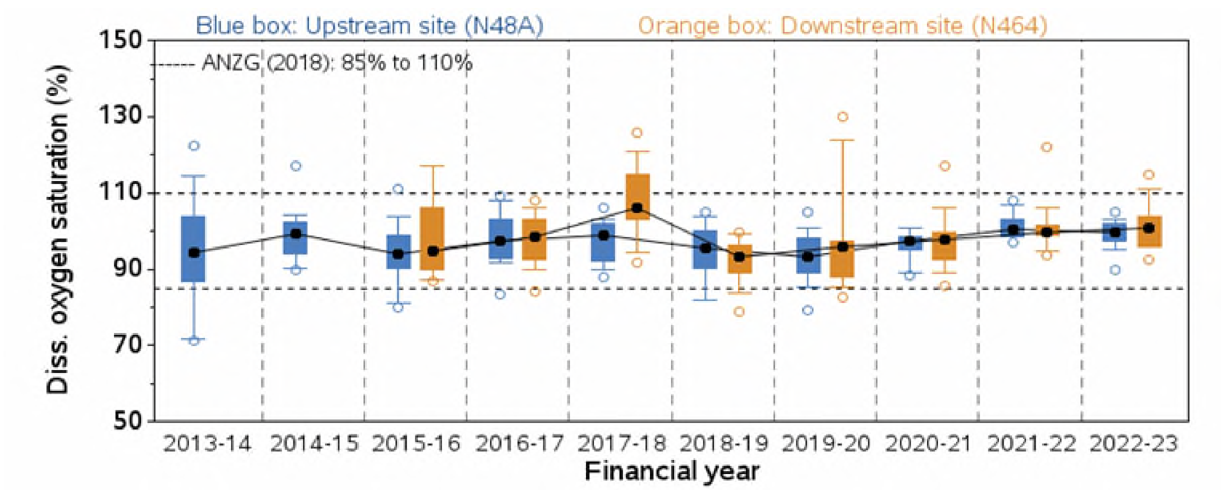
A-5.6 Stressor – Physico-chemical water quality



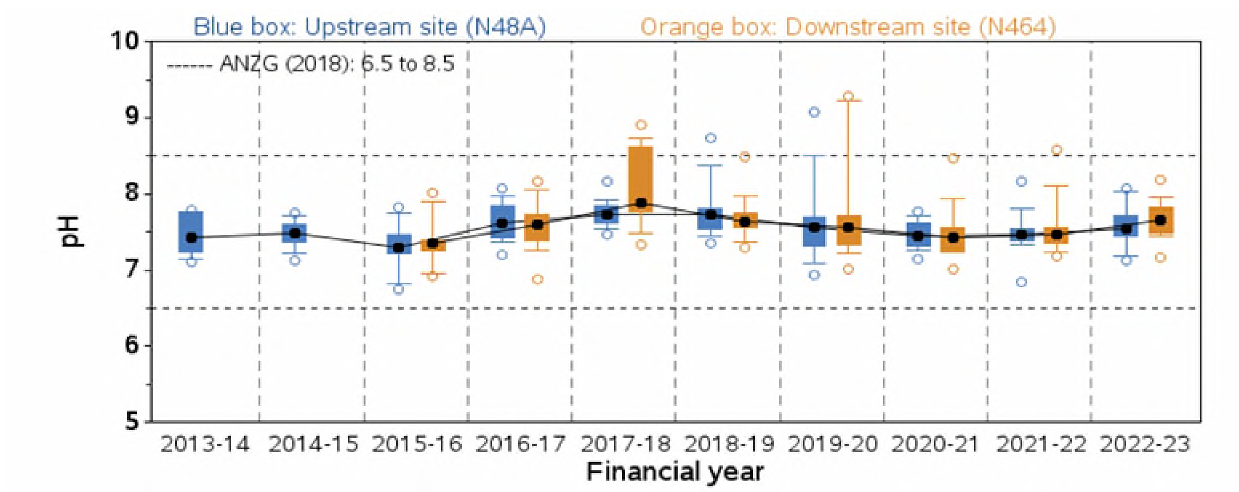
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	2.2	0.1397	N464	1	1.2	0.2756



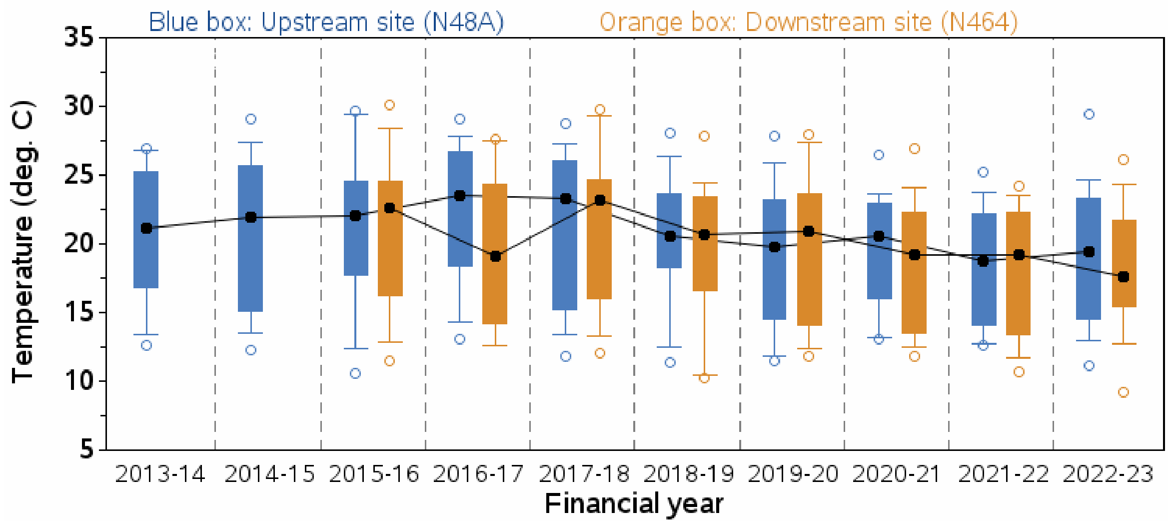
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	3.35	0.069	N464	1	3.03	0.0841



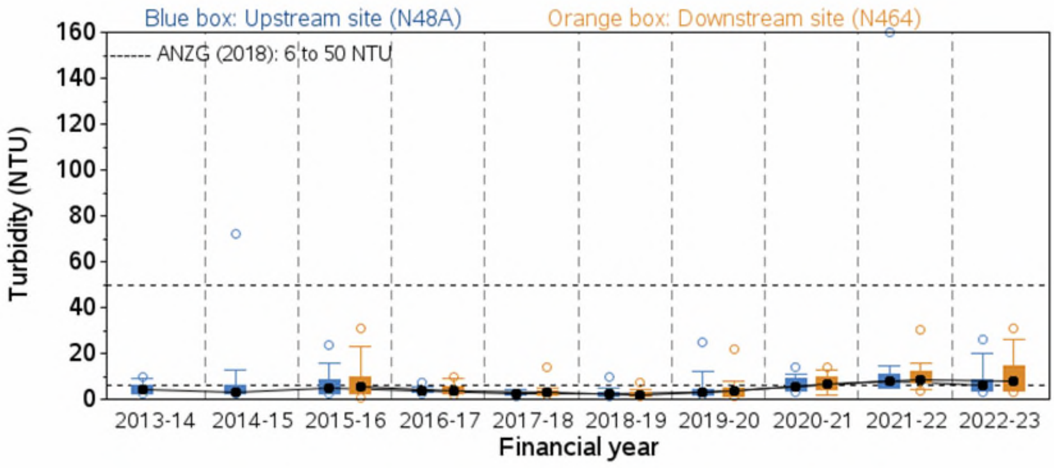
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	1.84	0.1773	N464	1	0.88	0.3495



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.08	0.7739	N464	1	0.03	0.8674

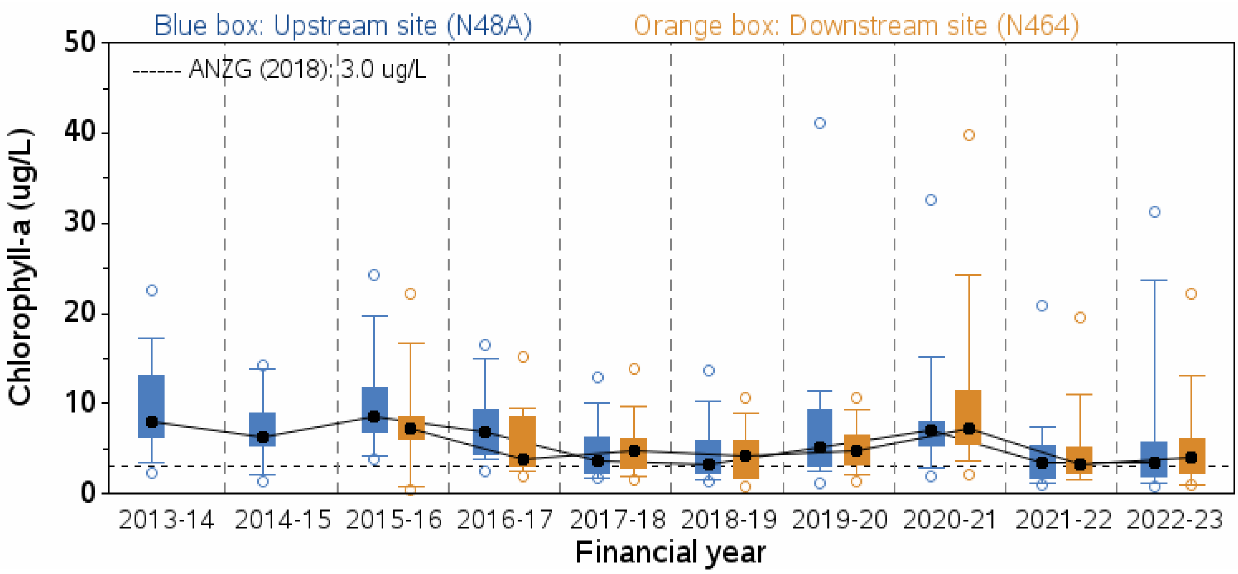


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.55	0.4599	N464	1	1.38	0.242

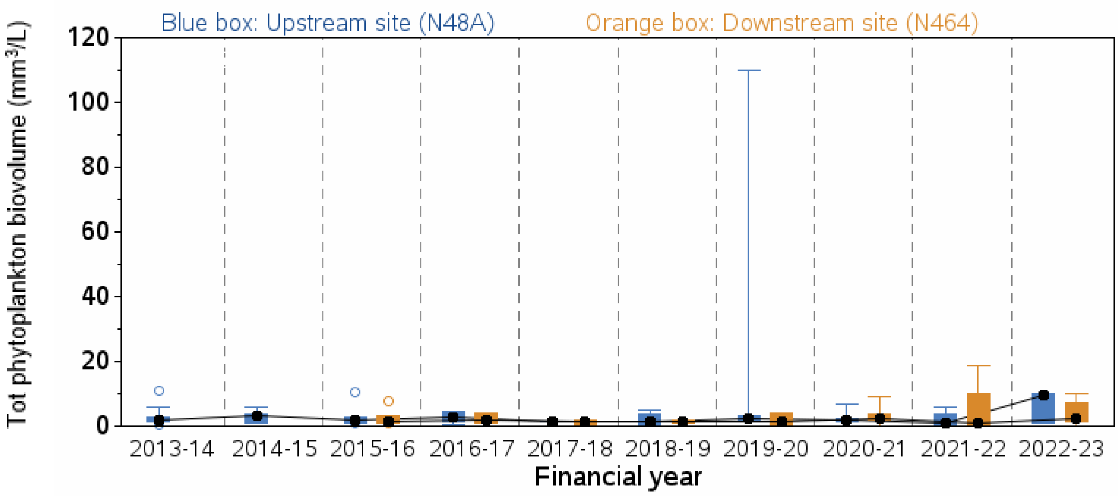


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.15	0.6972	N464	1	13.28	0.0004

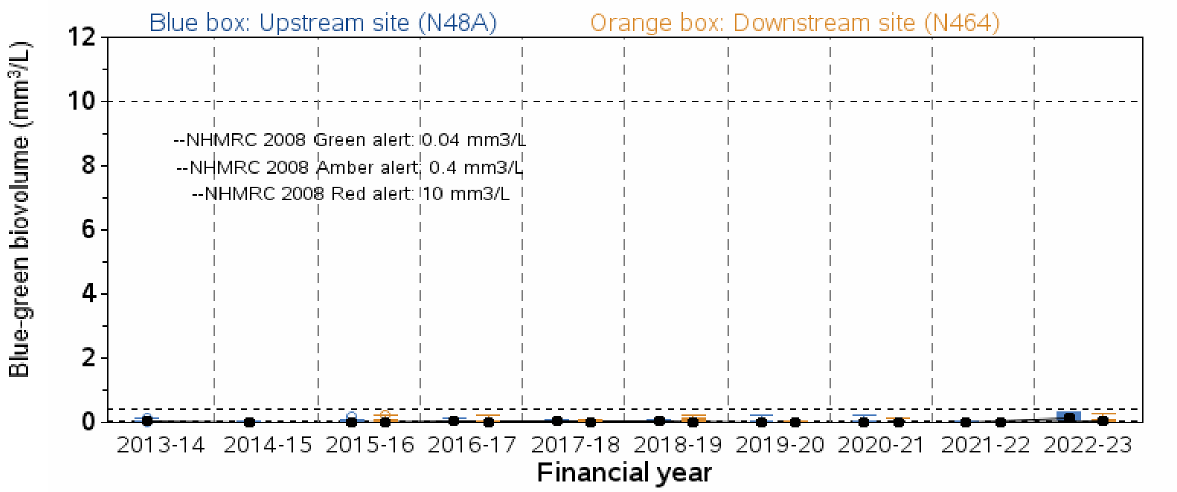
A-5.7 Ecosystem receptor – Phytoplankton



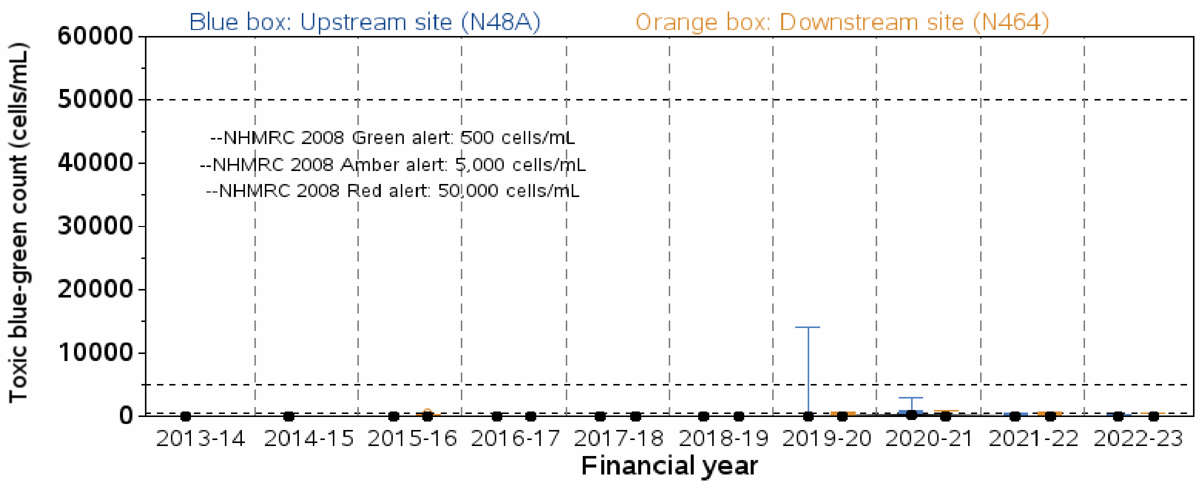
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.04	0.8448	N464	1	0.26	0.6084



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.11	0.7418	N464	1	0.99	0.3247



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	14.38	0.0003	N464	1	1.57	0.216



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N48A	1	0.04	0.8422	N464	1	0.38	0.5393

A-5.8 Ecosystem receptor – Macroinvertebrates

The major rainfall events in 2022 and the resulting extended period the Hawkesbury-Nepean River was in flood, prevented sampling due to WHS concerns in the Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges. As such, data for spring 2022 is not included for these Nepean River sites as the collection of atypical samples was likely and not safe to undertake. The unnamed creek samples at two locations downstream of the Winmalee WRRF were not impacted and were collected for both seasons. As the unnamed creek has no flow upstream of Winmalee WRRF under dry weather conditions, both sampling sites are situated downstream of the WRRF. The first site is located 0.3 km downstream of the WRRF, while the second downstream site is situated 3 km downstream of the WRRF in a natural bushland catchment that lacks other anthropogenic influences.

The SIGNAL-SG plots provided assessments of stream health for both the unnamed creek near Winmalee WRRF and in the Nepean River situated upstream-downstream of the confluence with the unnamed creek. On some occasions, only one season can be compared due to reasons mentioned above. Plots were based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022–23 against that collected between 2004 to 2023 for the unnamed creek and 1995 to 2023 for the Nepean River. The visual comparison for the unnamed creek suggests that stream health at the 0.3 km site continued to fall below the range observed at the 3 km downstream site over the 2004 to 2023 period (Figure A-15). Stream health at the upstream site on the Nepean River was well above its historical range, while downstream health was maintained at typical levels in 2022-23 (Figure A-16).

A comparison of SIGNAL-SG scores for the 2022-23 samples under t-tests returned a significant test outcome for the Unnamed Creek and a non-significant outcome for the Nepean River comparisons (Table A-21).

As a measurable negative impact on downstream stream health was detected on the unnamed creek, further data analysis was undertaken.

Table A-21 t-test of both downstream sites SIGNAL-SG scores from 2022-23 for unnamed creek below Winmalee WRRF and upstream-downstream SIGNAL-SG scores of 2022-23 samples from Nepean River near Winmalee WRRF

Waterway	Method	Statistic	DF	P value
Unnamed Creek	Welch Two Sample t-test	7.63	8.9	<0.001
Nepean River	Welch Two Sample t-test	2.43	3.3	0.085

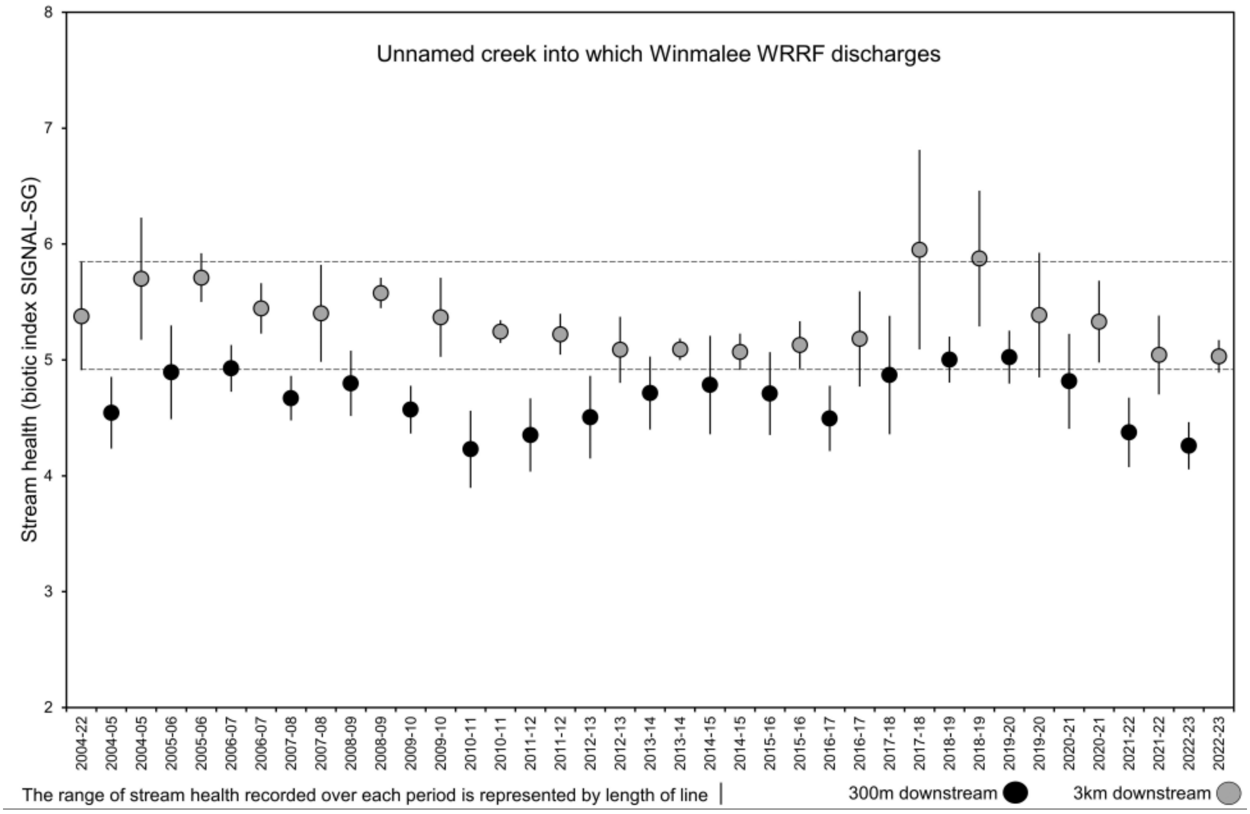


Figure A-15 Stream health of unnamed creek below Winmalee WRRF for 2 downstream sites

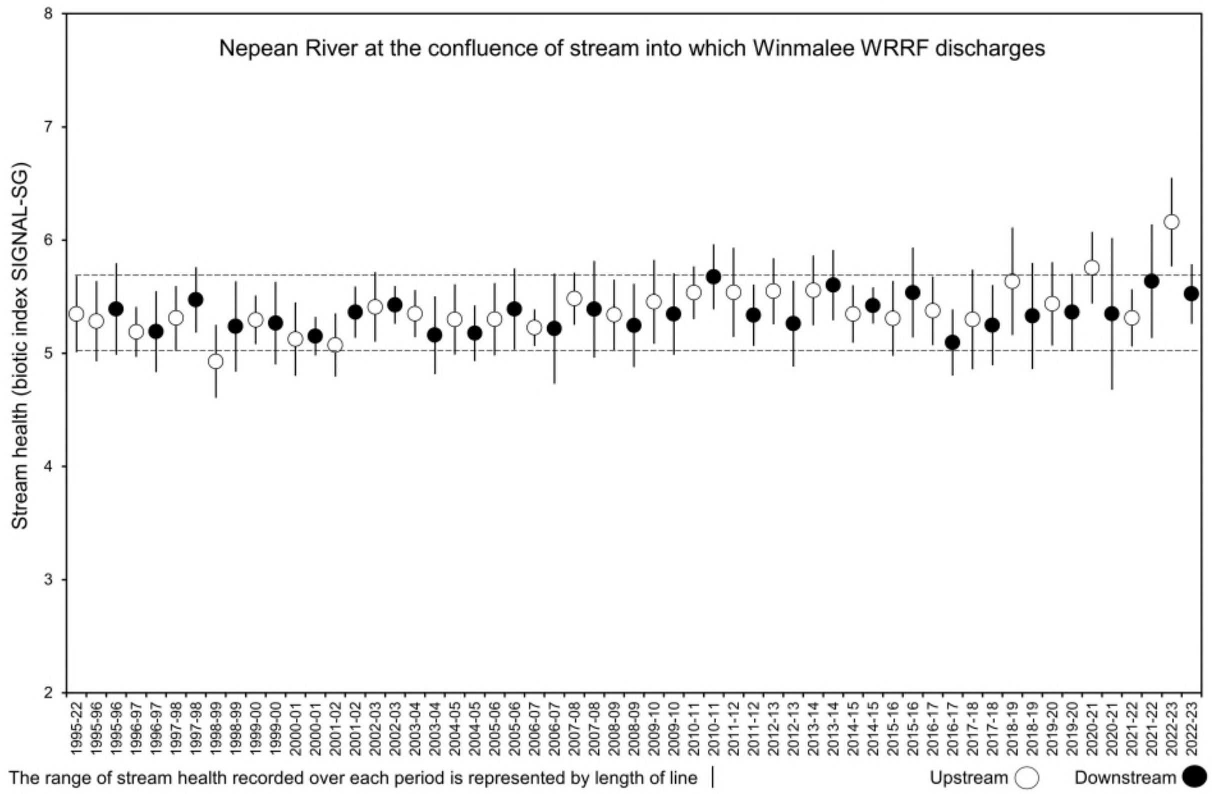


Figure A-16 Stream health of the Nepean River near Winmalee WRRF

Unnamed creek sites

Both edge and riffle habitat data were collected consistently at both downstream sites on the same sampling occasions to allow multivariate analysis for the monitoring period of 2004 to 2023. Samples from each habitat were analysed separately.

Distinct groups of samples were evident in the 3-dimensional ordination plot of edge habitat of the unnamed creek (Figure A-17). The nMDS ordination pattern was confirmed in the corresponding tree diagram (Figure A-19) from classification analysis where the second and third divisions separated the 2019 to 2022 0.3 km downstream period samples, and the fourth division separated most 0.3 km downstream samples from most 3 km downstream samples (Figure A-19). Despite not showing the early separation between time periods, the riffle habitat showed a similar split between sites at around the fourth and fifth separation level in the corresponding tree diagram (Figure A-20) and clear grouping of sites in the 3-dimensional ordination plot (Figure A-18).

The corresponding shade plots (Figure A-21 and Figure A-22) both displayed the tolerant taxon, the Blackfly larvae *Simulium* (SIGNAL-SG grade 4) as persistent through time and consistently abundant at the site 0.3 km downstream of the WRRF in both habitats. This taxon was absent on most collection occasions or occurred in much lower numbers at the 3 km downstream site. These shade plots illustrated that higher graded SIGNAL-SG taxa such as the non-biting midge larvae Chironomidae *Parametriocnemis* and caddisfly Leptoceridae *Triplectides* were more consistently collected from the site 3 km downstream, suggesting recovery in water quality with distance from the WRRF.

The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 29 taxa (out of 101) identified for the edge habitat (Table A-30) and 21 taxa (out of 67) for the riffle habitat (Table A-31). These subsets of taxa form the main visual patterns in the respective shade plots (Figure A-21 and Figure A-22).

The PERMDISP analysis indicated a non-significant pattern of dispersion (spacing between same site samples) for the edge (Table A-26) and riffle (Table A-27) habitats. These results imply the results of ANOSIM tests are focused on community structure differences between sites.

An ANOSIM test was run on the factor ‘Site’. The returned ANOSIM R-values were at mid-range levels (Table A-22) and (Table A-23), implying both downstream sites assemblage structures were distinguishable for both habitats.

To further explore the community structure, hypothesis testing was conducted with a PERMANOVA model. This model comprised the fixed factors ‘Site’ and ‘Year’. ‘Year’ represented samples collected in years between 2004 and 2023 and ‘Site’ having 2 levels, 0.3 km downstream and 3 km downstream. A statistically non-significant ‘Site x Year’ interaction was returned for the edge (Table A-24) and riffle (Table A-25) habitats. These non-significant results allowed us to view the ‘Site’ and ‘Year’ results. Statistically significant results were returned for ‘Year’ and ‘Site’ factors. The estimates of components of variation indicated ‘Site’ explained almost twice the variation than that explained by ‘Year’ for the edge habitat (Table A-24) and three times the variation than that explained by ‘Year’ for the riffle habitat (Table A-25).

A second run of ANOSIM based on ‘Site-period’ groups displayed in ordination plots returned a significant global mid-range R-value of 0.48 for the edge habitat (Table A-28). In the resulting pairwise comparisons, two tests returned R-values at a level (R = 0.706 and R = 0.678, Table A-28) above that expected from natural differences between groups from variation in the substratum composition of the habitats between sites. Besley and Chessman (2008) found R-values up to 0.66 for sites on the same near-pristine stream. A lower mid-range global R-value of 0.469 was returned for the riffle habitat with one corresponding pairwise test for the riffle habitat returning above an R-value of 0.66 (Table A-29).

These multivariate analysis results suggested community structure alteration from wastewater discharge in the unnamed creek was most evident in macroinvertebrate assemblages within the edge habitat.

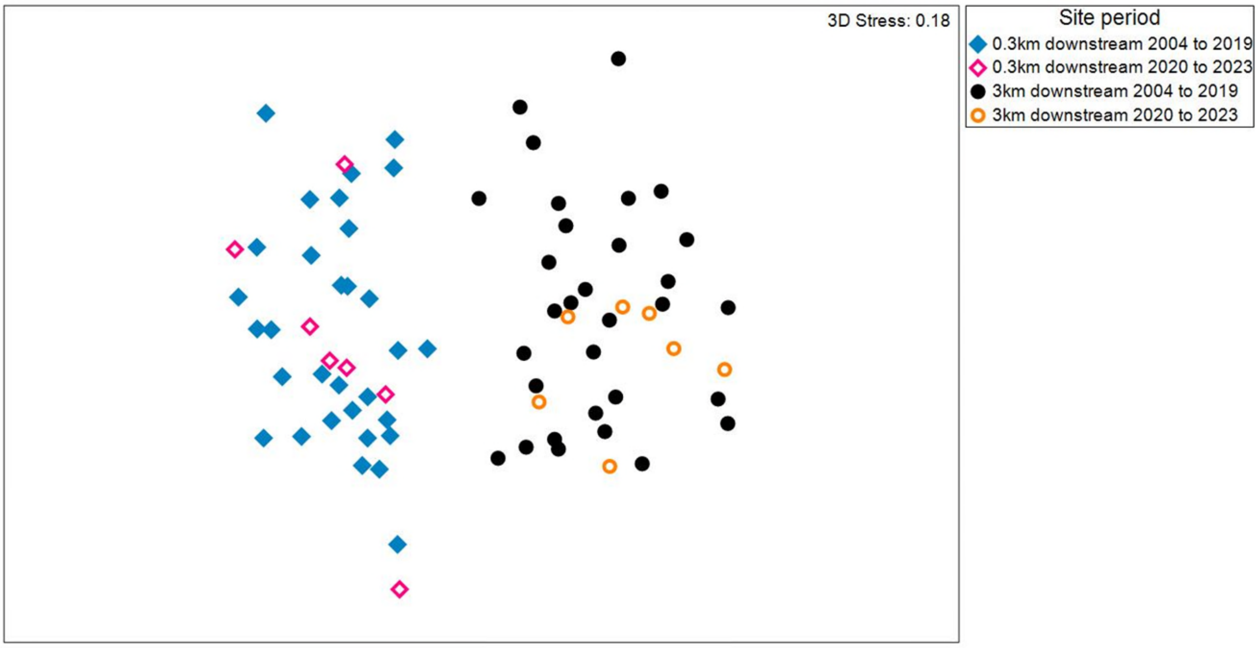


Figure A-17 Dimensions 1 and 3 of 3-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of both downstream sites of unnamed creek below Winmalee WRRF

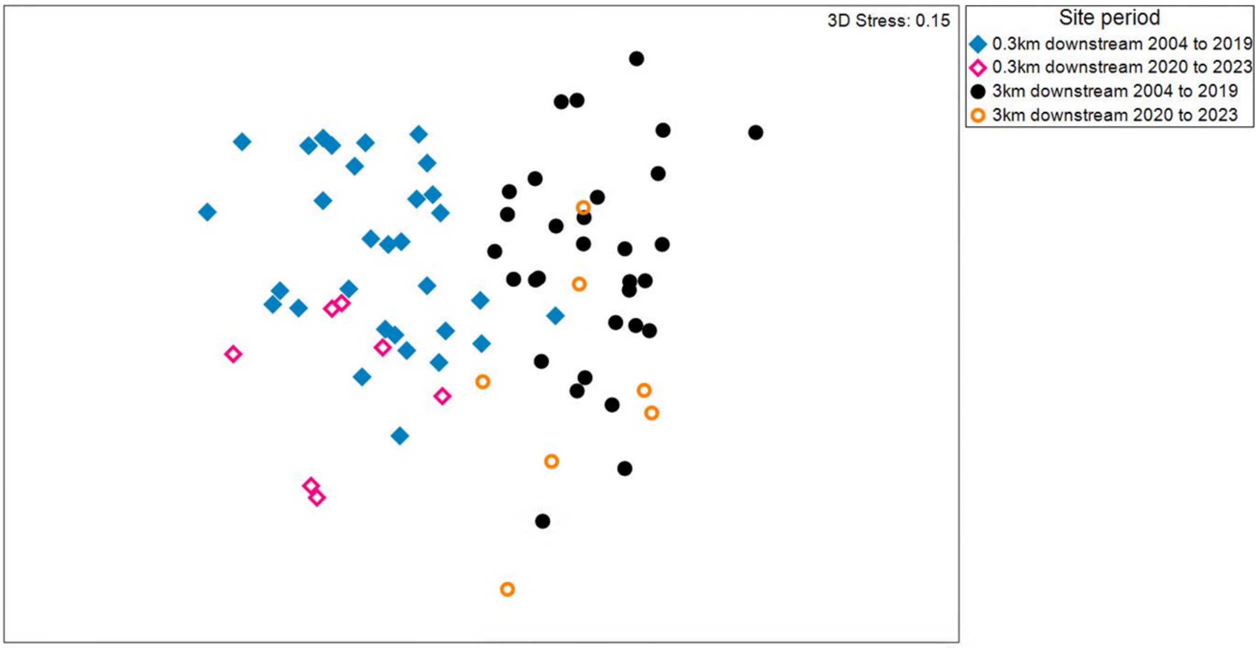


Figure A-18 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate riffle habitat community structure of both downstream sites of unnamed creek below Winmalee WRRF

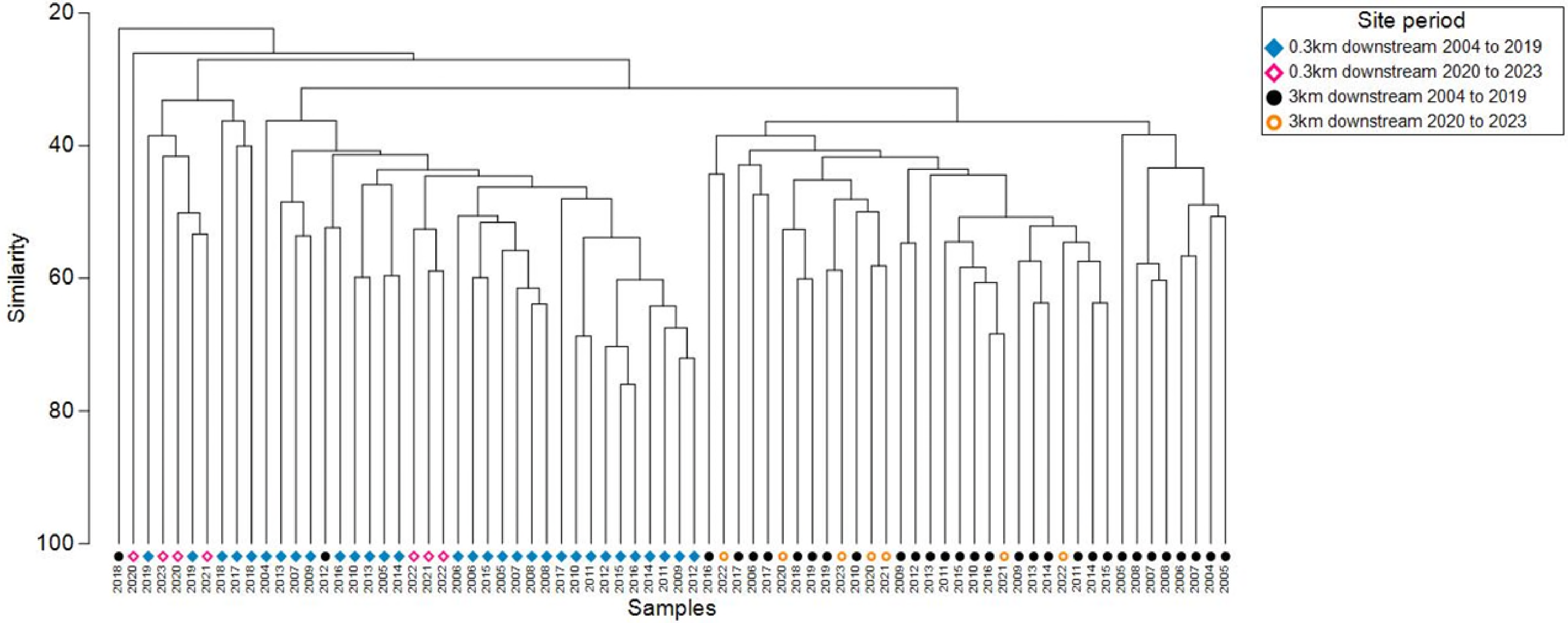


Figure A-19 Tree diagram of freshwater macroinvertebrate edge habitat community structure of both downstream sites of unnamed creek below Winmalee WRRF

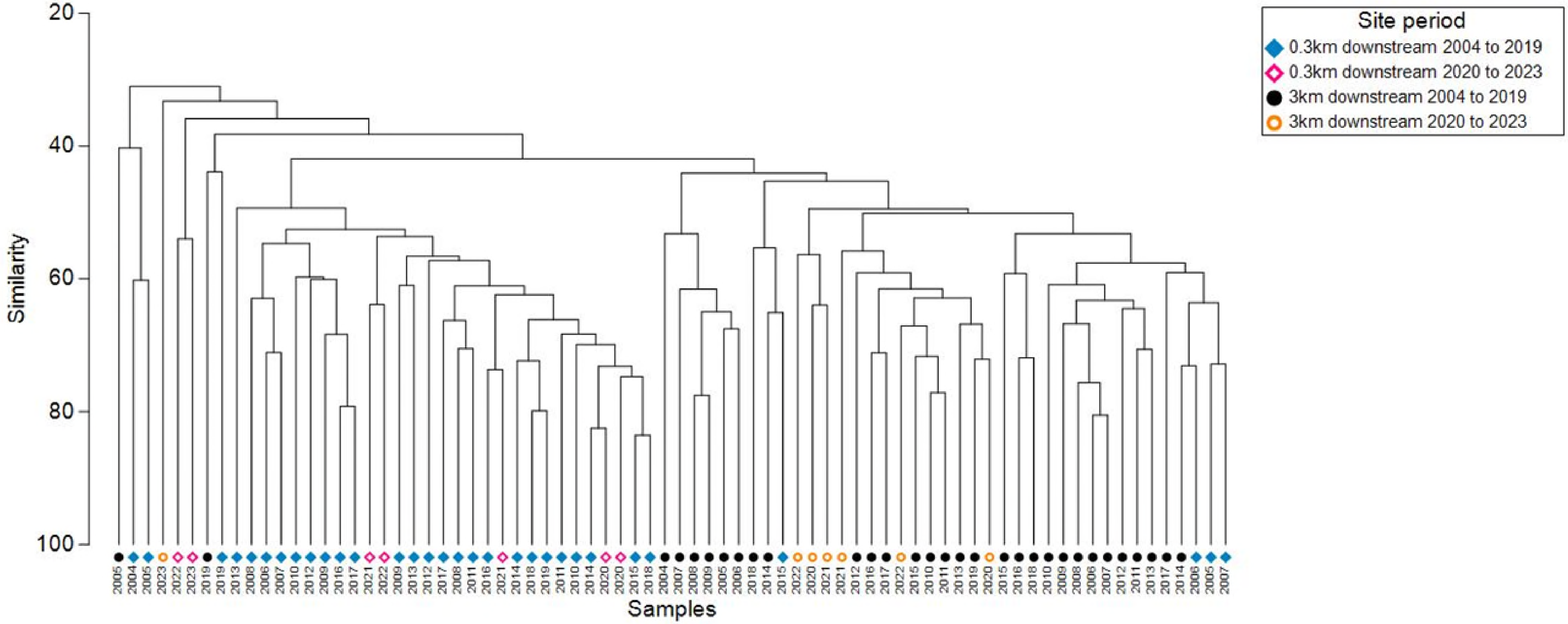


Figure A-20 Tree diagram of freshwater macroinvertebrate riffle habitat community structure of both downstream sites of unnamed creek below Winmalee WRRF

Table A-22 ANOSIM test of 'Site' factor for edge habitat unnamed creek near Winmalee WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.567
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-23 ANOSIM test of 'Site' factor for riffle habitat unnamed creek below Winmalee WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.471
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-24 PERMANOVA test of 'Site' and 'Year' factors for edge habitat unnamed creek below Winmalee WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	20

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	25492	25492	17.386	0.0001	9928
Year	19	53792	2831.2	1.9309	0.0001	9740
SitexYear	19	31233	1643.8	1.1211	0.1151	9704
Res	36	52785	1466.2			
Total	75	1.65E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	660.7	25.704
S(Year)	359.66	18.965
S(SitexYear)	93.595	9.6744
V(Res)	1466.2	38.292

Table A-25 PERMANOVA test of 'Site' and 'Year' factors for riffle habitat unnamed creek below Winmalee WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	20

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	22088	22088	19.234	0.0001	9938
Year	19	35560	1871.6	1.6298	0.0001	9790
SitexYear	19	20854	1097.6	0.95579	0.6262	9791
Res	36	41340	1148.3			
Total	75	1.20E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	575.83	23.996
S(Year)	190.57	13.805
S(SitexYear)	-26.756	-5.1726
V(Res)	1148.3	33.887

Table A-26 PERMDISP test of 'Site' factor for edge habitat unnamed creek below Winmalee WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 76

DEVIATIONS FROM CENTROID
F: 0.18405 df1: 1 df2: 74
P(perm): 0.6885

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
3km downstream	38	41.643	1.0911
0.3km downstream	38	42.346	1.222

Table A-27 PERMDISP test of 'Site' factor for riffle habitat unnamed creek below Winmalee WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 76

DEVIATIONS FROM CENTROID
F: 0.60627 df1: 1 df2: 74
P(perm): 0.4684

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
3km downstream	38	35.681	1.203
0.3km downstream	38	34.238	1.4096

Table A-28 ANOSIM test of ‘Site period’ samples for edge habitat unnamed creek below Winmalee WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.48
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
3km downstream 2004 to 2019, 3km downstream 2020 to 2023	-0.052	66.6	12620256	9999	6659
3km downstream 2004 to 2019, 0.3km downstream 2004 to 2019	0.54	0.01	Very large	9999	0
3km downstream 2004 to 2019, 0.3km downstream 2020 to 2023	0.706	0.01	12620256	9999	0
3km downstream 2020 to 2023, 0.3km downstream 2004 to 2019	0.678	0.01	12620256	9999	0
3km downstream 2020 to 2023, 0.3km downstream 2020 to 2023	0.633	0.06	1716	1716	1
0.3km downstream 2004 to 2019, 0.3km downstream 2020 to 2023	0.278	1.9	12620256	9999	192

Table A-29 ANOSIM test of ‘Site period’ samples for riffle habitat unnamed creek below Winmalee WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.469
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
3km downstream 2004 to 2019, 3km downstream 2020 to 2023	0.281	1.2	12620256	9999	118
3km downstream 2004 to 2019, 0.3km downstream 2004 to 2019	0.484	0.01	Very large	9999	0
3km downstream 2004 to 2019, 0.3km downstream 2020 to 2023	0.646	0.01	12620256	9999	0
3km downstream 2020 to 2023, 0.3km downstream 2004 to 2019	0.652	0.01	12620256	9999	0
3km downstream 2020 to 2023, 0.3km downstream 2020 to 2023	0.67	0.06	1716	1716	1
0.3km downstream 2004 to 2019, 0.3km downstream 2020 to 2023	0.198	6.8	12620256	9999	674

Table A-30 Genera subset whose multivariate pattern matches full genera set of the edge habitat unnamed creek below Winmalee WRRF

Subset of 29 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 101 genera identified with the same subset found on 30 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Chironomus,Physidae Physella,Chironomidae Cricotopus,Dugesiidae Cura,Lumbriculidae Lumbriculus,Simuliidae Simulium,Argiolestidae Austroargiolestes,Chironomidae Microtendipes,Chironomidae Polypedilum,Chironomidae Rheocricotopus,Chironomidae Rheotanytarsus,Chironomidae Thienemanniella,Corduliidae Hemicordulia,Hydropsychidae Cheumatopsyche,Libellulidae Nannophlebia,Scyphacidae Haloniscus,Talitridae Arcitalitrus,Tateidae Potamopyrgus,Atyidae Paratya,Elmidae Notriolus,Elmidae Simsonia,Hydraenidae Hydraena,Leptoceridae Notalina,Micronectidae Micronecta,Aeshnidae Austroaeschna,Veliidae Microvelia,Chironomidae Tanytarsus,Leptoceridae Triplectides,Tateidae Posticobia

Table A-31 Genera subset whose multivariate pattern matches full genera set of the riffle habitat unnamed creek below Winmalee WRRF

Subset of 21 (correlation 0.952) genera from riffle habitat whose pattern matches that of the full set of 67 genera identified with the same subset found on 6 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Physidae Physella,Chironomidae Cardiocladius,Chironomidae Cricotopus,Dugesiidae Cura,Naididae Nais,Simuliidae Simulium,Chironomidae Eukiefferiella,Chironomidae Microtendipes,Chironomidae Polypedilum,Chironomidae Rheocricotopus,Chironomidae Rheotanytarsus,Chironomidae Thienemanniella,Hydropsychidae Cheumatopsyche,Libellulidae Nannophlebia,Scyphacidae Haloniscus,Tateidae Potamopyrgus,Elmidae Notriolus,Elmidae Simsonia,Aeshnidae Austroaeschna,Chironomidae Parametriocnemus,Tateidae Posticobia

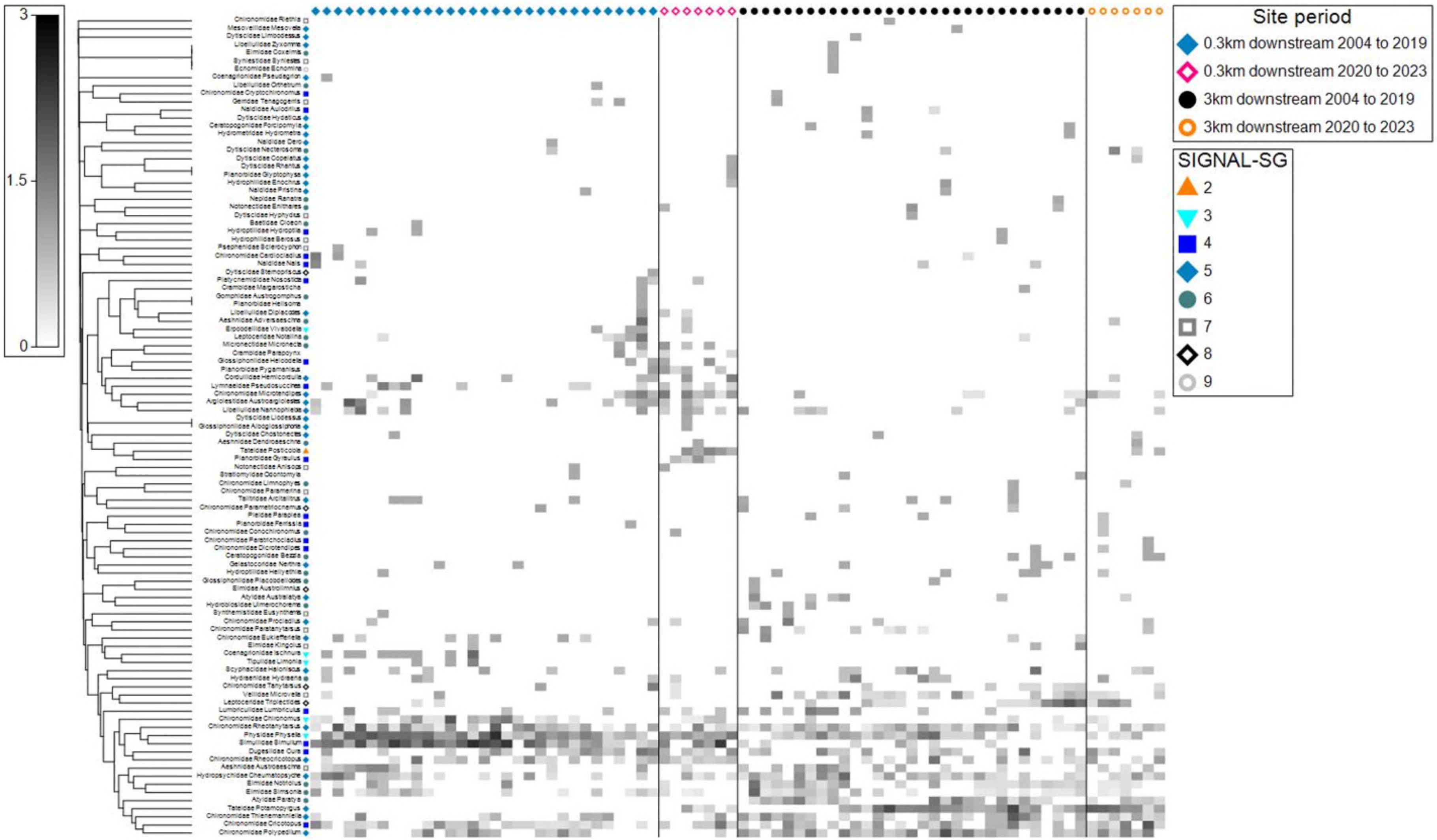


Figure A-21 Shade plot of freshwater macroinvertebrate edge habitat community structure of both downstream sites of unnamed creek below Winmalee WRRF

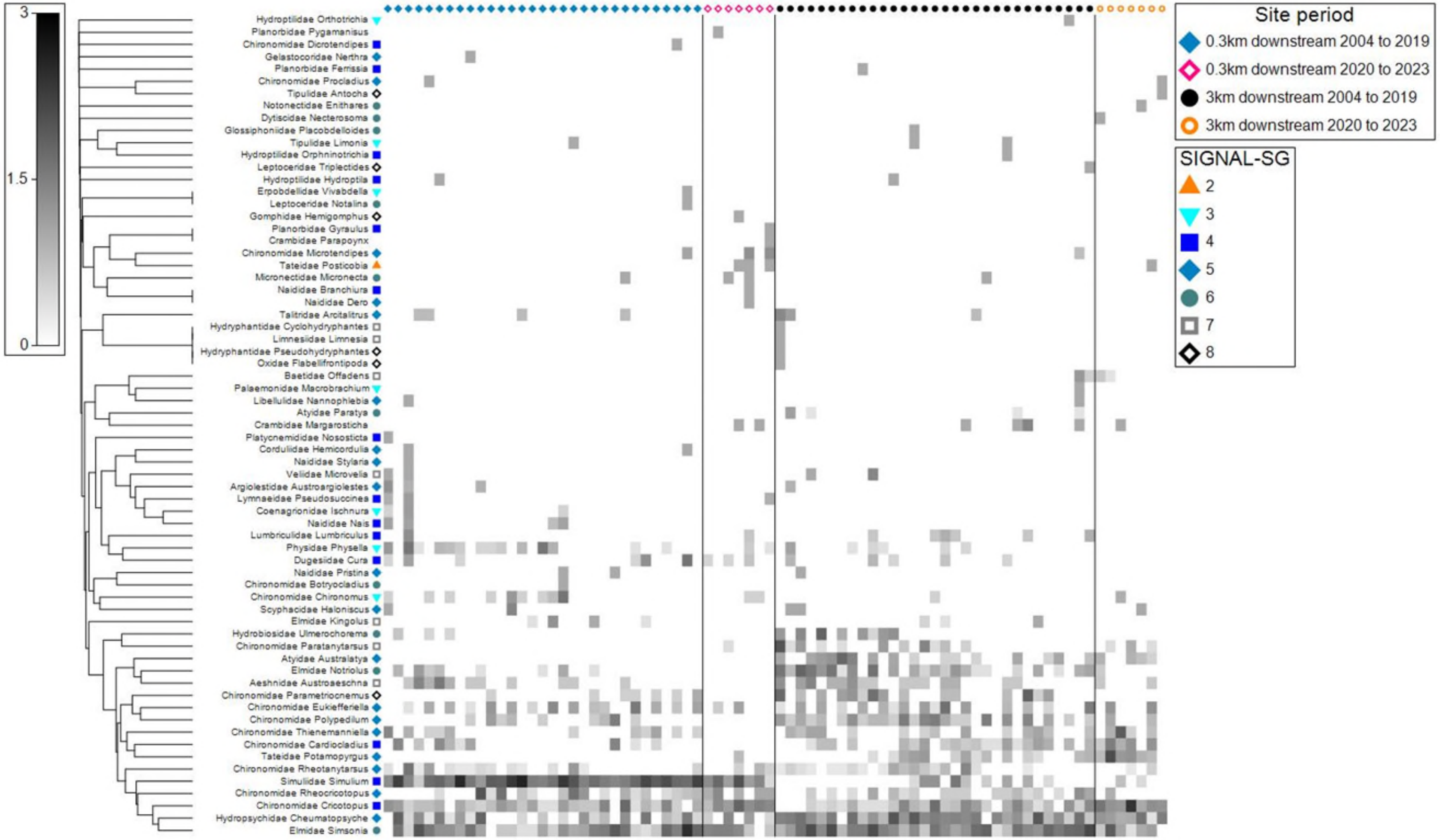


Figure A-22 Shade plot of freshwater macroinvertebrate riffle habitat community structure of both downstream sites of unnamed creek below Winmalee WRRF

Nepean River sites

Sufficient edge habitat data were collected consistently enough at upstream-downstream sites on the same sampling occasions to allow multivariate analysis for the monitoring period of 1995 to autumn 2023 (less sample collection gaps outlined in Volume 1 Table 3-8, and the spring 2022 flood restricted sampling mentioned above).

The Nepean River edge habitat data pattern was visually displayed in a 3-dimensional nMDS ordination plots to achieve an acceptable level of fit (stress) due to inherent variation. Data points were colour coded by 'Site period' with 2 periods 1995 to 2019 and 2020 to 2023. There was no clear separation of groups of upstream and downstream samples in the ordination plot (Figure A-23). Rather a mix of upstream and downstream samples was observed, with most recent samples intermingling with past samples.

The lack of a clear pattern between sites in the ordination plot was also apparent in the corresponding tree diagram (Figure A-24) and shade plot (Figure A-25) suggesting communities between sites were similar. Subsets of taxa defining the multivariate pattern are listed in Table A-36.

The PERMDISP analysis returned non-significant results (Table A-34), implying that results of ANOSIM tests are focused on community structure differences between upstream-downstream sites.

An ANOSIM test was run on the factor 'Site'. The returned ANOSIM R-value was at a very low level close to zero (Table A-32) implying the assemblage structure of sites was almost indistinguishable.

To further explore community structure, hypothesis testing was conducted with a PERMANOVA model. This model comprised the fixed factors 'Site' and 'Year' with 'Year' representing samples collected in years between 1995 and 2023 and 'Site' having two levels, upstream and downstream. For the edge habitat, a statistically non-significant 'Site x Year' interaction was returned (Table A-33). Both 'Site' and 'Year' factors resulted in significant results. Inspecting estimates of components of variation output indicated 'Year' explained almost four times the variation than that explained by 'Site' (Table A-33).

A second run of ANOSIM based on 'Site-period' samples displayed in the ordination plot returned a non-significant global R-value of 0.168 (Table A-35). Inspection of pairwise tests for the edge habitat indicated one of the six comparisons were non-significant and the significant tests had low-range R-values.

These results suggested community structure in the unnamed creek near the WRRF was altered by wastewater discharge from Winmalee WRRF but this impact did not extend as far as the Nepean River.

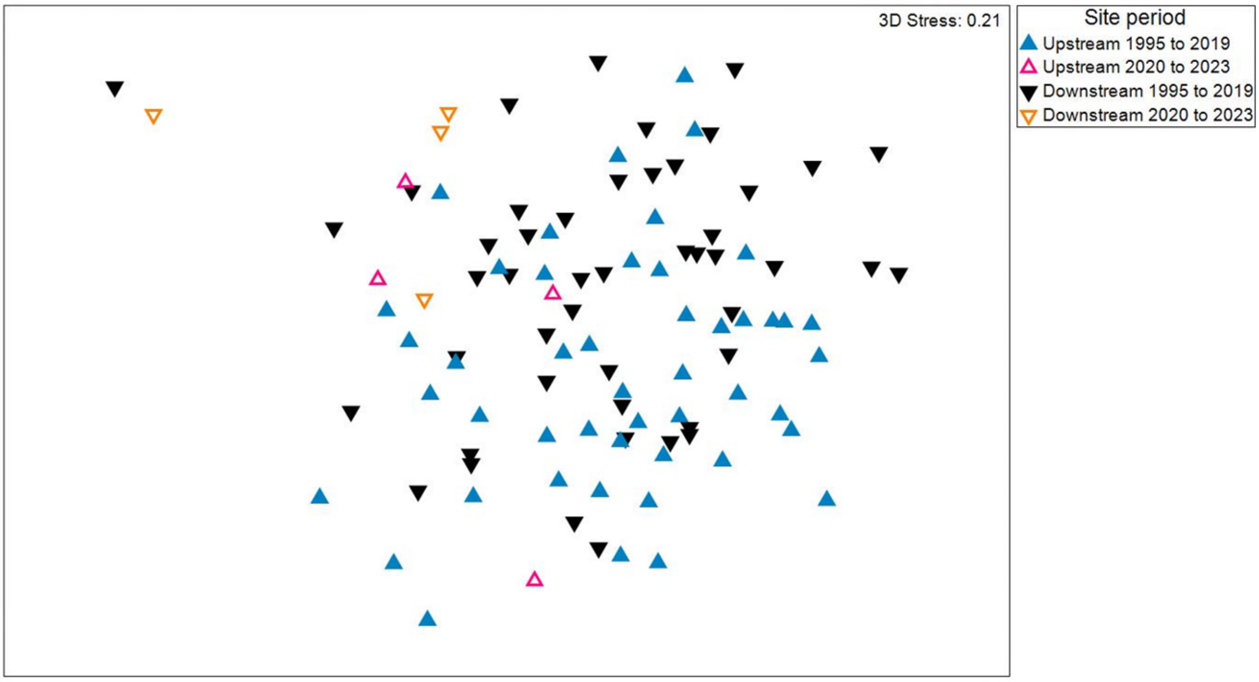


Figure A-23 Dimensions 1 and 2 of 3-dimensional nMDS ordination plot of freshwater macroinvertebrate edge habitat community structure of sites upstream-downstream of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

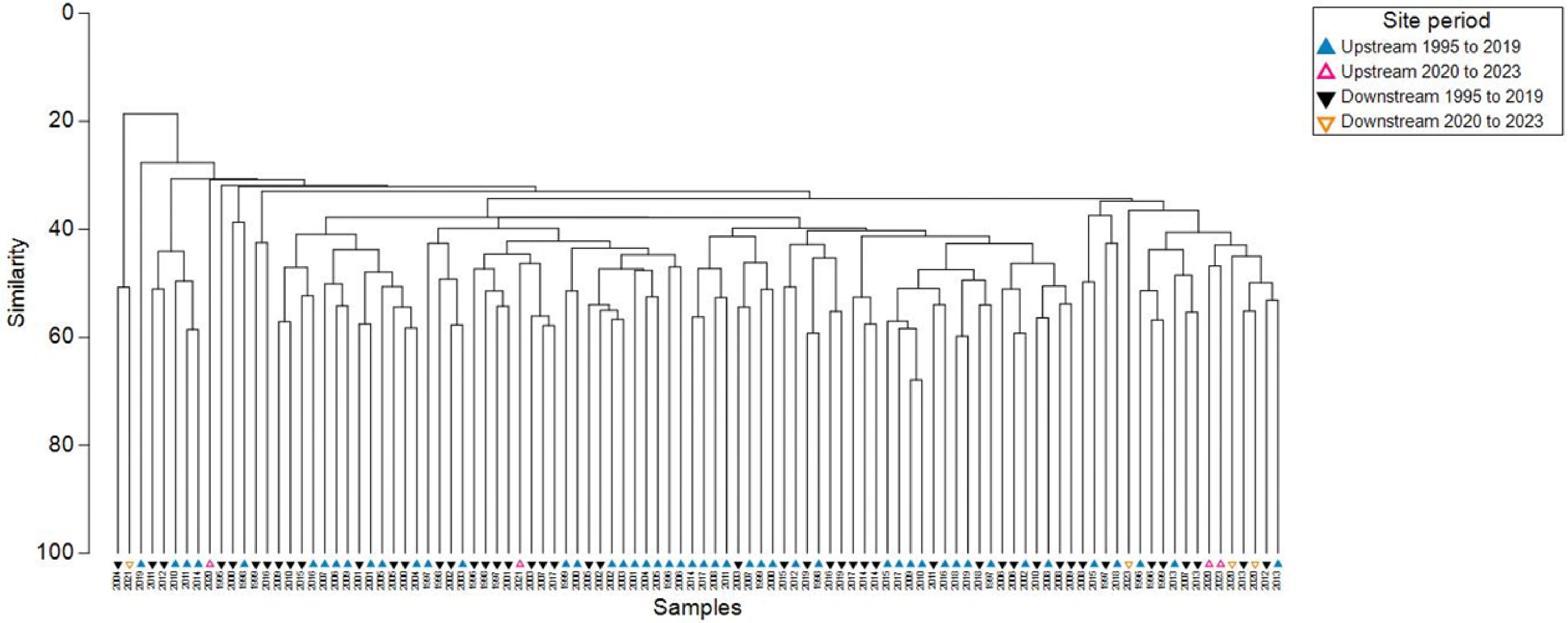


Figure A-24 Tree diagram of freshwater macroinvertebrate edge habitat community structure of sites upstream-downstream of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

Table A-32 ANOSIM test of 'Site' for edge habitat Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.096
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-33 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of upstream-downstream sites of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	28

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	6151.6	6151.6	3.6718	0.0001	9897
Year	27	79843	2957.1	1.7651	0.0001	9631
SitexYear**	26	47436	1824.5	1.089	0.1107	9624
Res	47	78742	1675.4			
Total	101	2.13E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	93.639	9.6767
S(Year)	356.03	18.869
S(SitexYear)	80.612	8.9784
V(Res)	1675.4	40.931

Table A-34 PERMDISP test of ‘Site’ for edge habitat of upstream-downstream sites of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 102

DEVIATIONS FROM CENTROID
F: 0.12283 df1: 1 df2: 100
P(perm): 0.7384

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	51	44.779	0.82839
Upstream	51	44.395	0.71796

Table A-35 ANOSIM test of 'Site period' for edge habitat of upstream-downstream sites of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.168
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1995 to 2019, Downstream 2020 to 2023	0.309	2.5	249900	9999	247
Downstream 1995 to 2019, Upstream 1995 to 2019	0.105	0.01	Very large	9999	0
Downstream 1995 to 2019, Upstream 2020 to 2023	0.27	3.7	249900	9999	365
Downstream 2020 to 2023, Upstream 1995 to 2019	0.482	0.2	249900	9999	20
Downstream 2020 to 2023, Upstream 2020 to 2023	0.031	37.1	35	35	13
Upstream 1995 to 2019, Upstream 2020 to 2023	0.347	0.9	249900	9999	85

Table A-36 Genera subset whose multivariate pattern matches full genera set of the edge habitat of upstream-downstream sites of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

Subset of 49 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 148 genera identified with the same subset found on 42 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Chironomus,Coenagrionidae Ischnura,Physidae Physella,Belostomatidae Diplonychus,Chironomidae Cricotopus,Chironomidae Cryptochironomus,Chironomidae Dicrotendipes,Coenagrionidae Austroagrion,Corbiculidae Corbicula,Dugesiidae Cura,Lumbriculidae Lumbriculus,Lymnaeidae Pseudosuccinea,Naucoridae Naucoris,Planorbidae Gyraulus,Platycnemididae Nososticta,Simuliidae Simulium,Chironomidae Cladotanytarsus,Chironomidae Microtendipes,Chironomidae Polypedilum,Chironomidae Procladius,Chironomidae Rheocricotopus,Chironomidae Rheotanytarsus,Coenagrionidae Pseudagrion,Hydrophilidae Helochares,Hydropsychidae Cheumatopsyche,Libellulidae Diplacodes,Libellulidae Nannophlebia,Limnesiidae Physolimnesia,Mesoveliidae Mesovelia,Atyidae Paratya,Baetidae Cloeon,Caenidae Tasmanocoenis,Ceratopogonidae Bezzia,Ecnomidae Ecnomus,Elmidae Coxelmis,Hydroptilidae Hellyethira,Leptoceridae Notalina,Libellulidae Orthetrum,Micronectidae Micronecta,Chironomidae Corynoneura,Hydrodromidae Hydrodroma,Hydrophilidae Berosus,Leptoceridae Oecetis,Unionicolidae Koenikea,Veliidae Microvelia,Calamoceratidae Anisocentropus,Chironomidae Ablabesmyia,Chironomidae Tanytarsus,Leptoceridae Triplectides

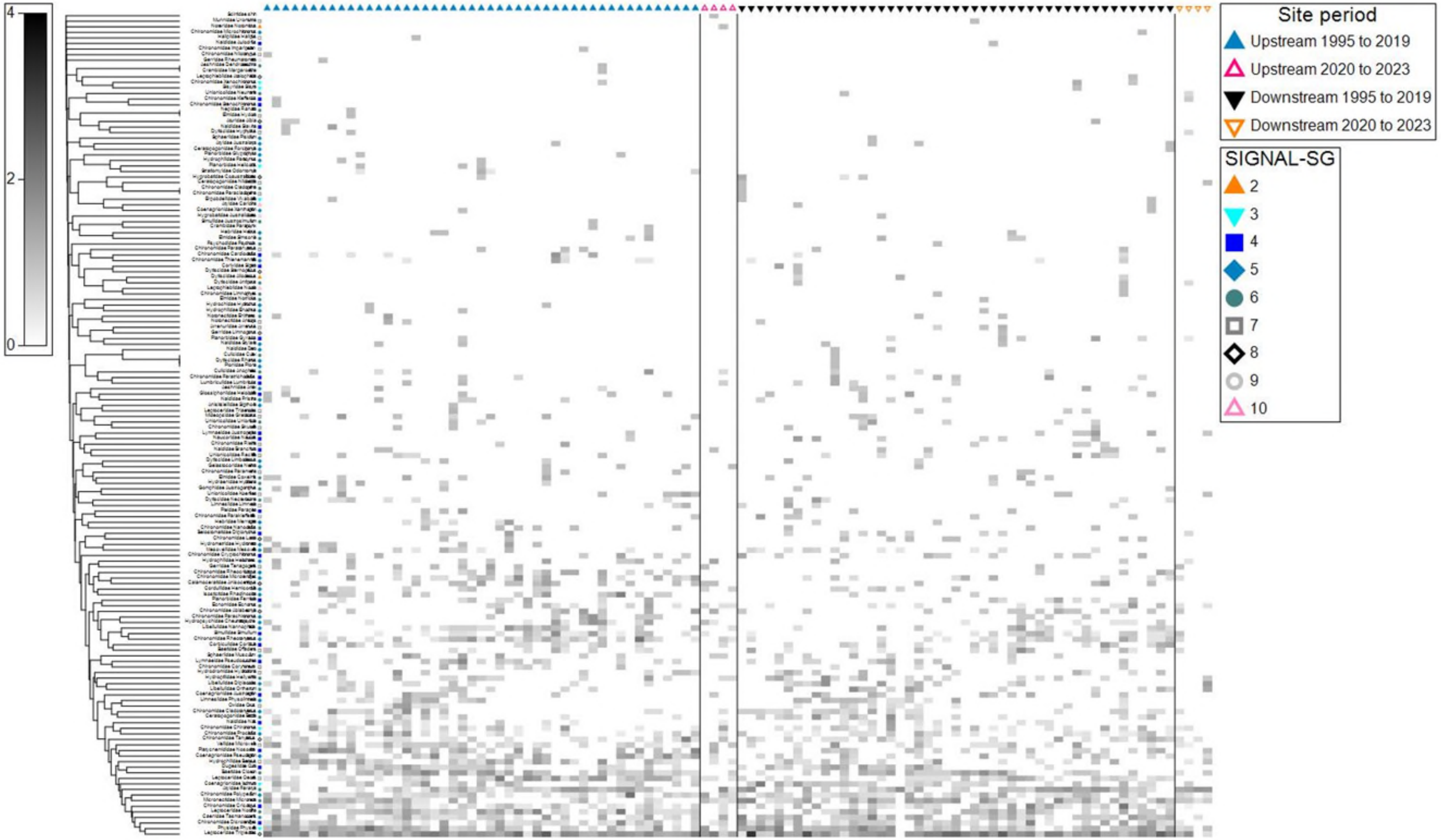
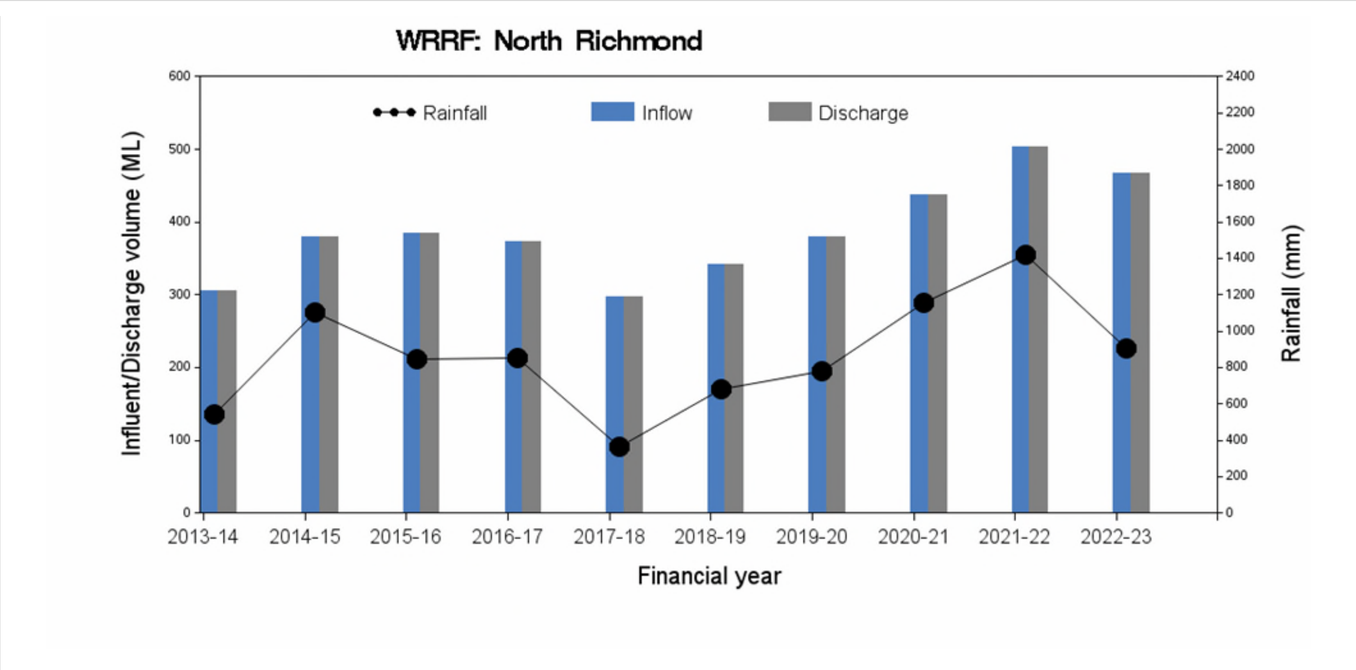


Figure A-25 Shade plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Nepean River at the confluence of the unnamed creek into which Winmalee WRRF discharges

A-6 North Richmond

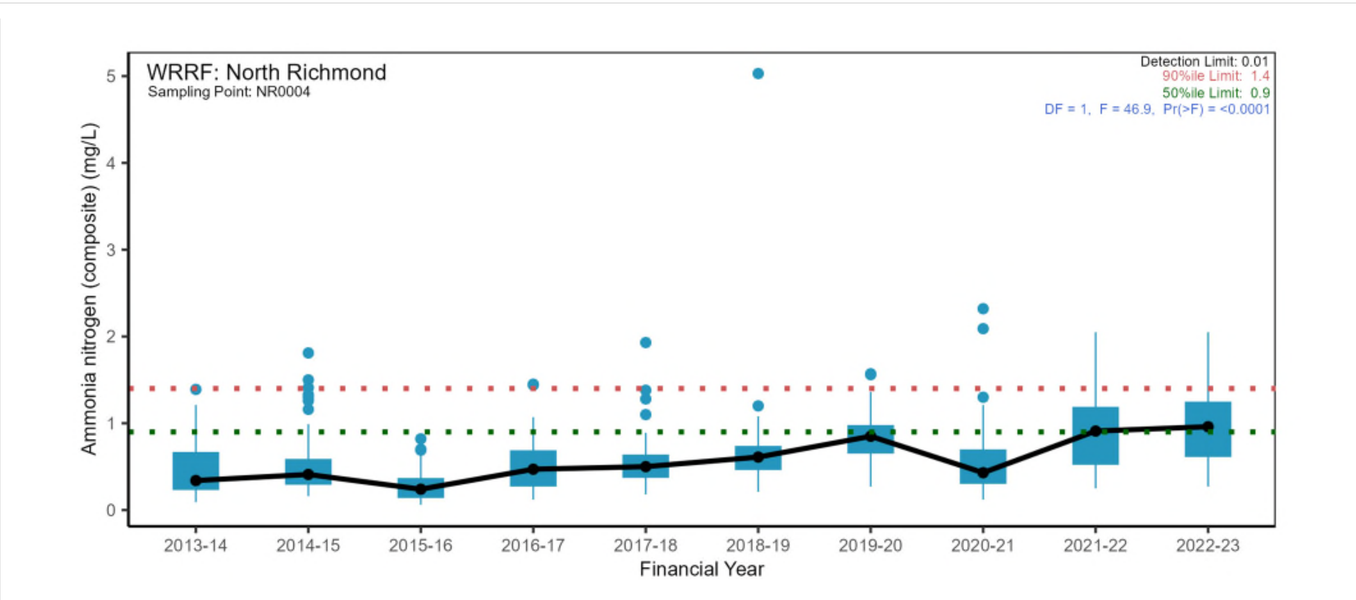
A-6.1 Pressure – Wastewater quantity

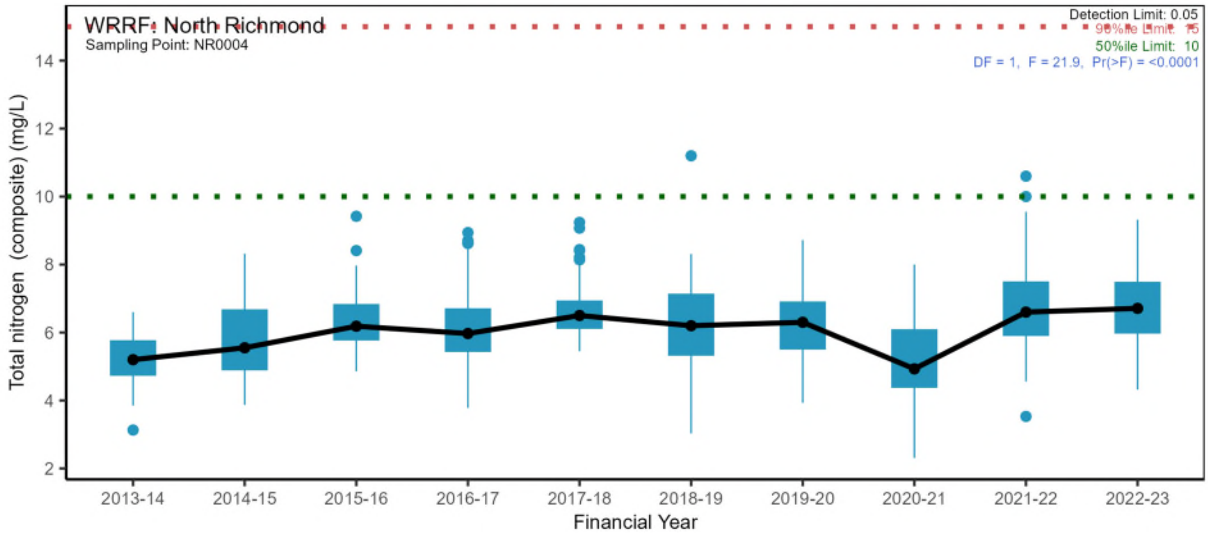
Inflow/ Discharge volume and rainfall

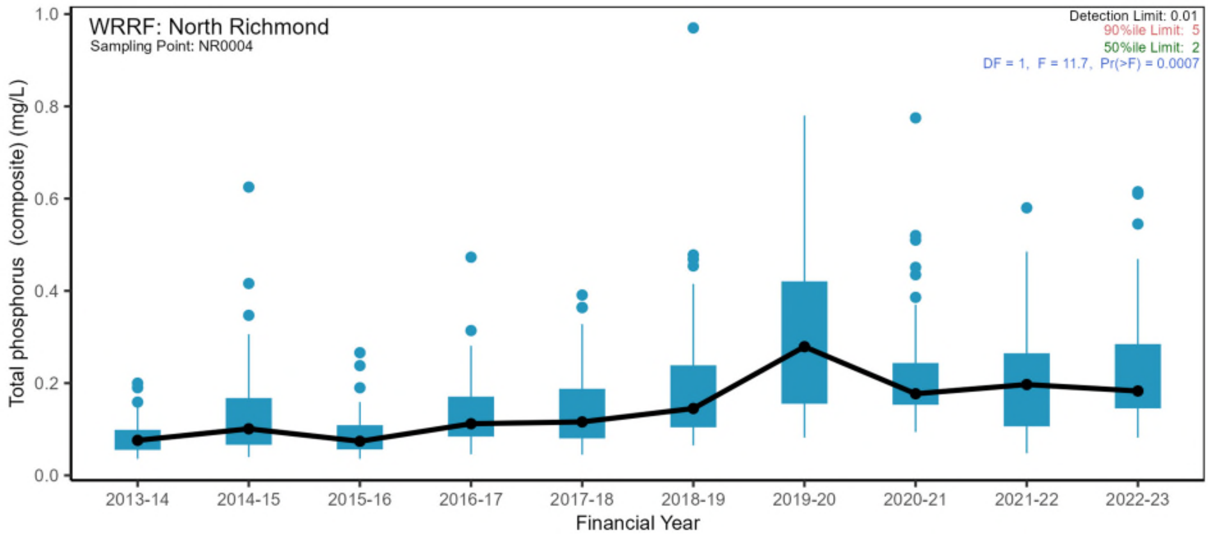


A-6.2 Pressure – Wastewater quality

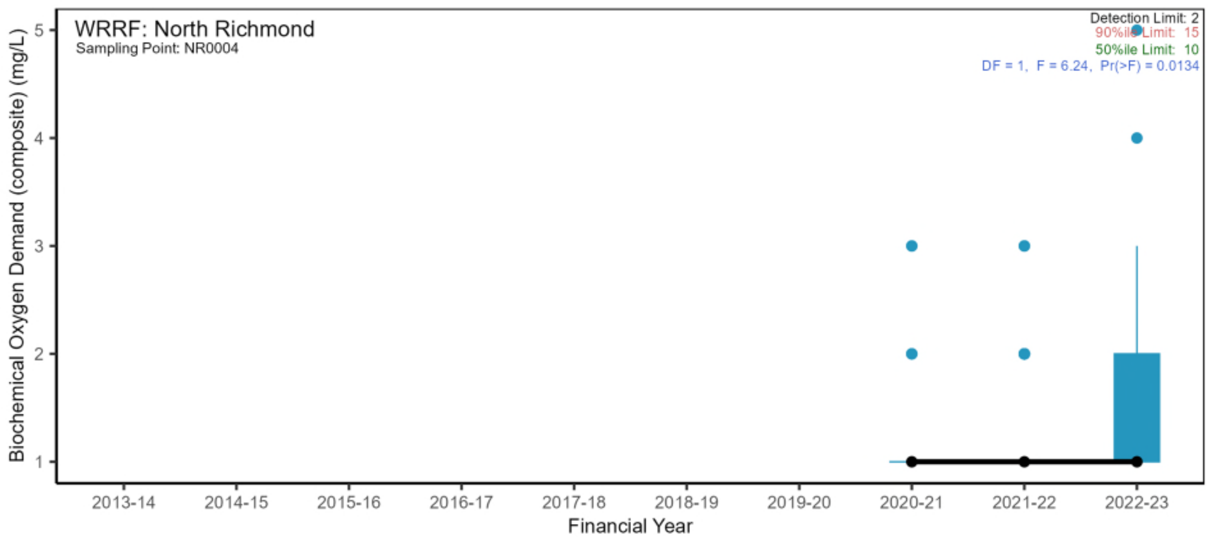
Nutrients

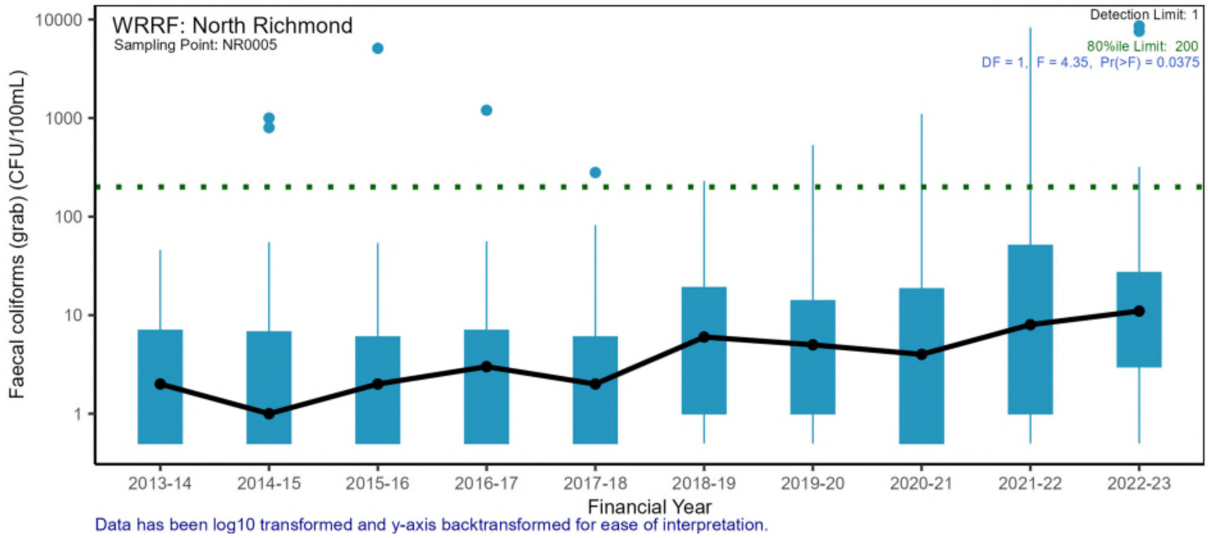


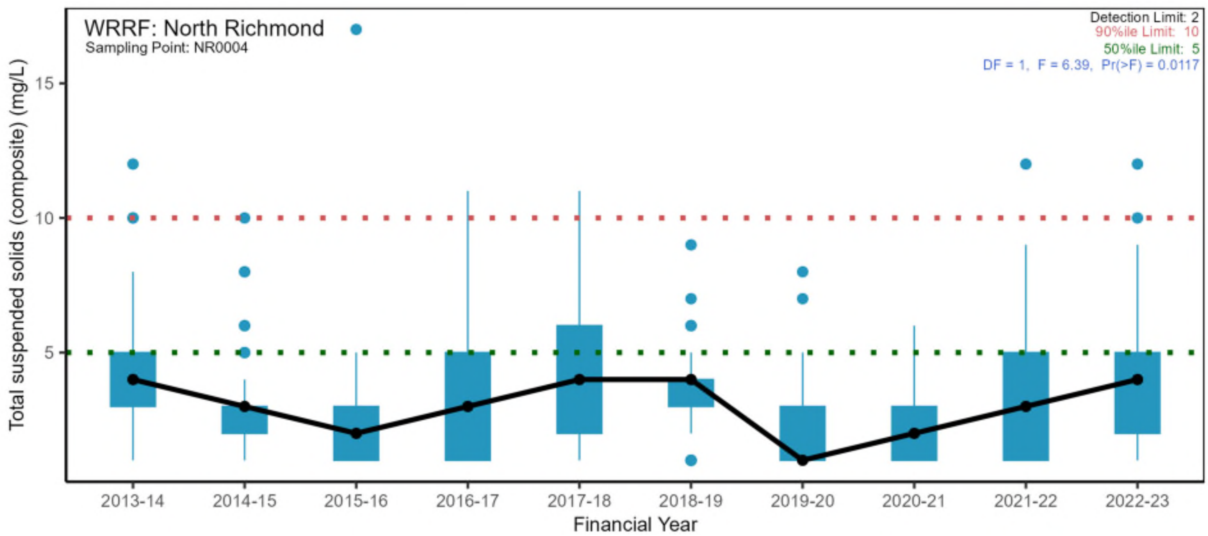




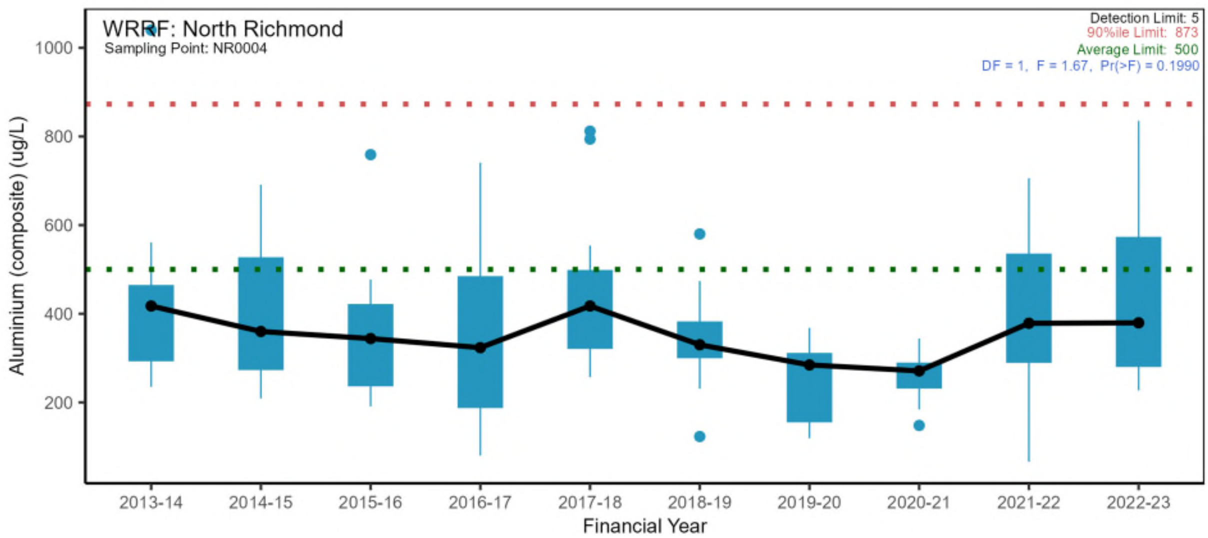
Major conventional analytes

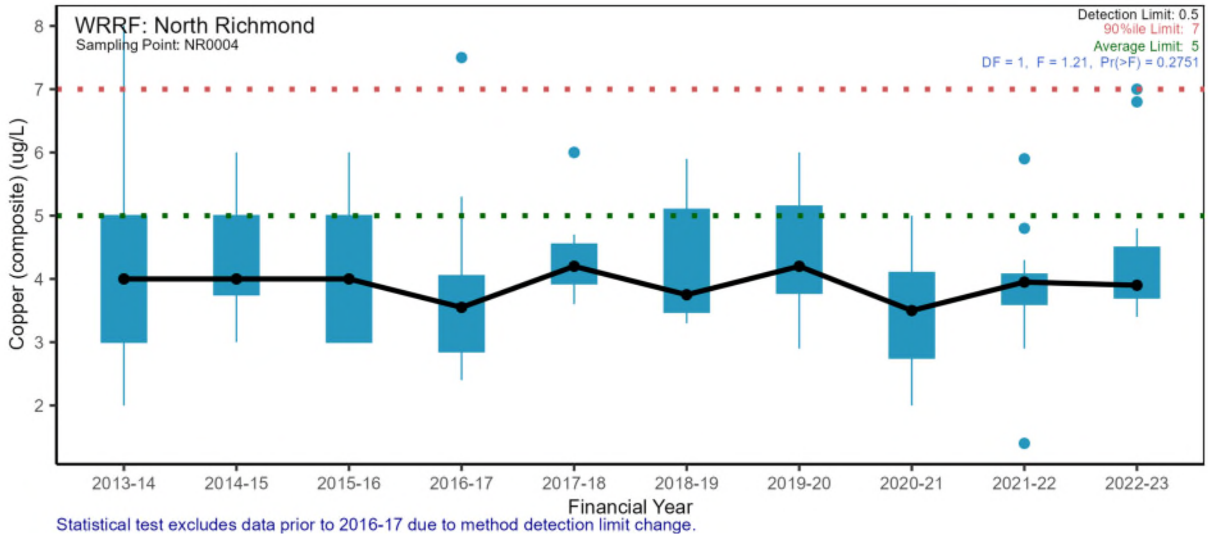




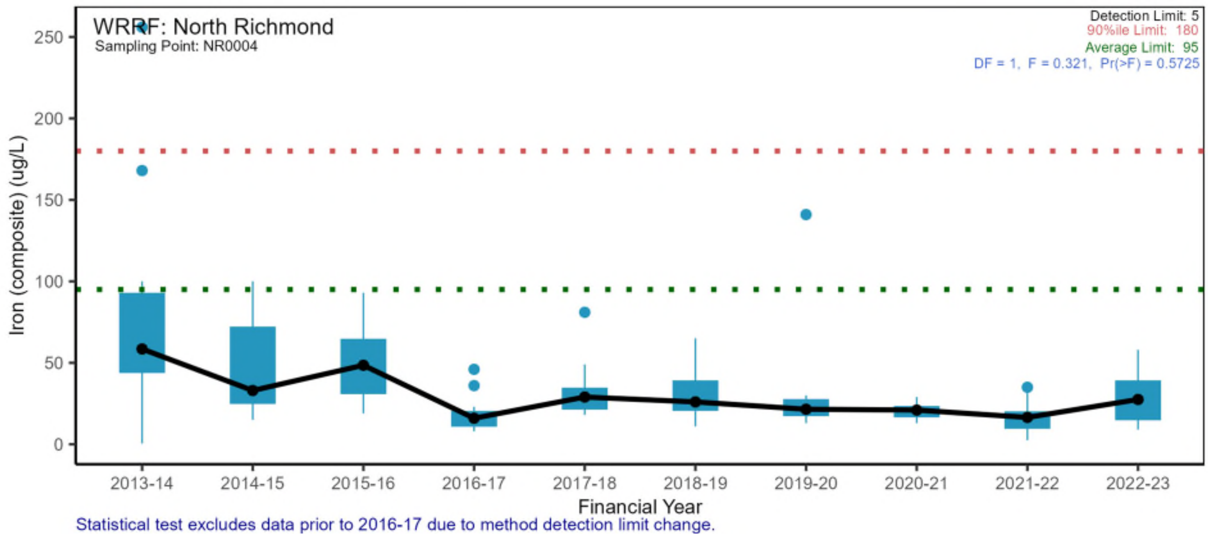


Trace metals

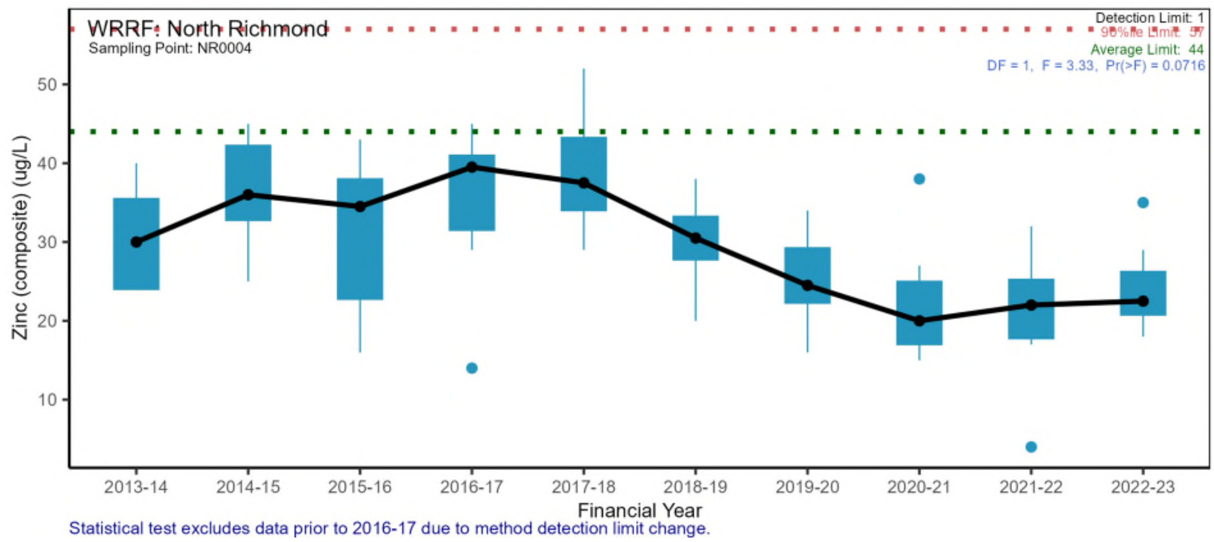




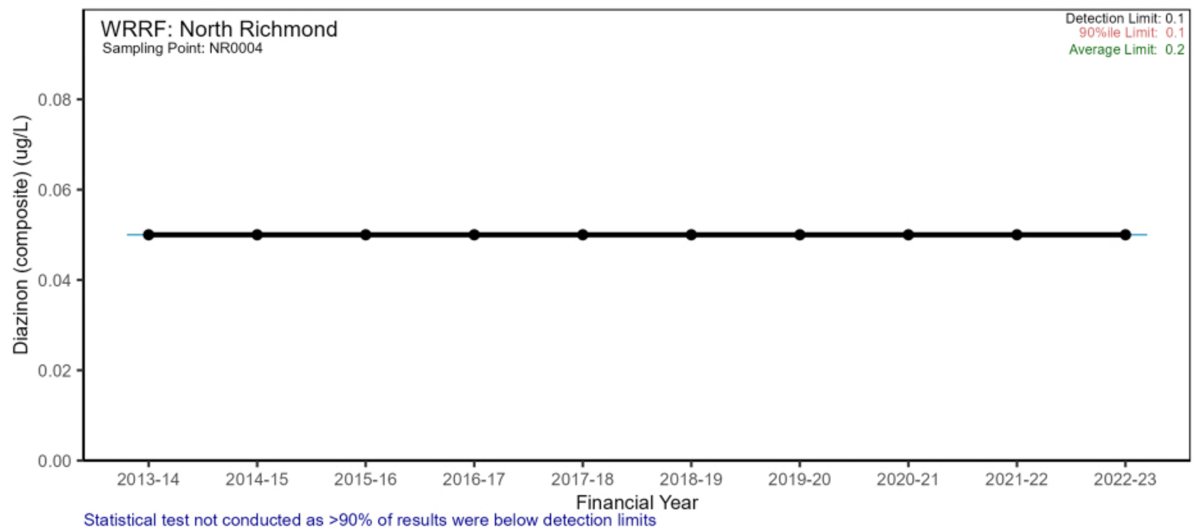
WRRF: North Richmond
Sampling Point: NR0004
Detection Limit: 0.5
90%ile Limit: 7
Average Limit: 5
DF = 1, F = 1.21, Pr(>F) = 0.2751
Copper (composite) (ug/L)
2
3
4
5
6
7
8
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.

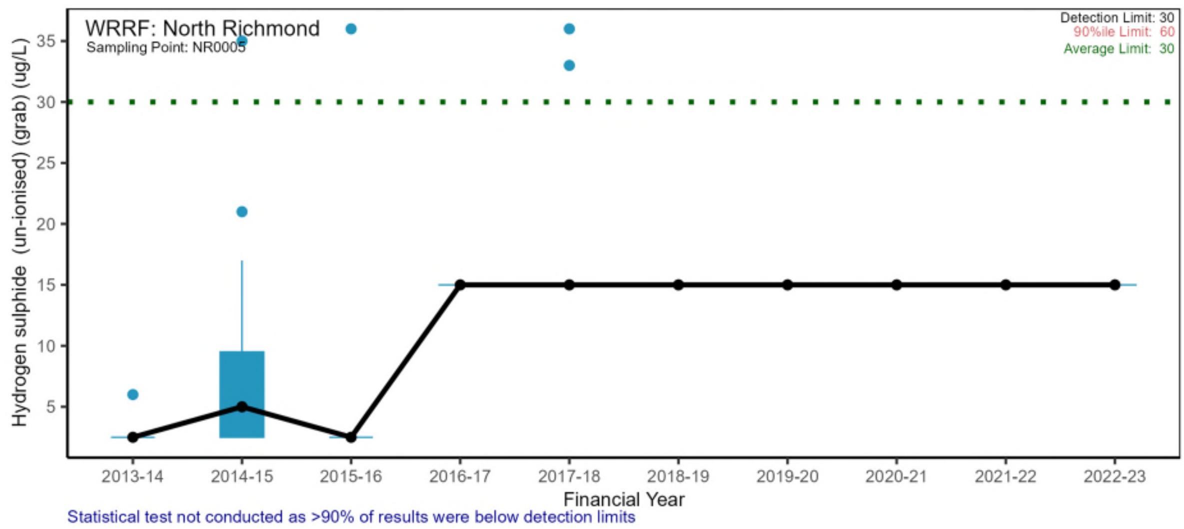


WRRF: North Richmond
Sampling Point: NR0004
Detection Limit: 5
90%ile Limit: 180
Average Limit: 95
DF = 1, F = 0.321, Pr(>F) = 0.5725
Iron (composite) (ug/L)
0
50
100
150
200
250
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.

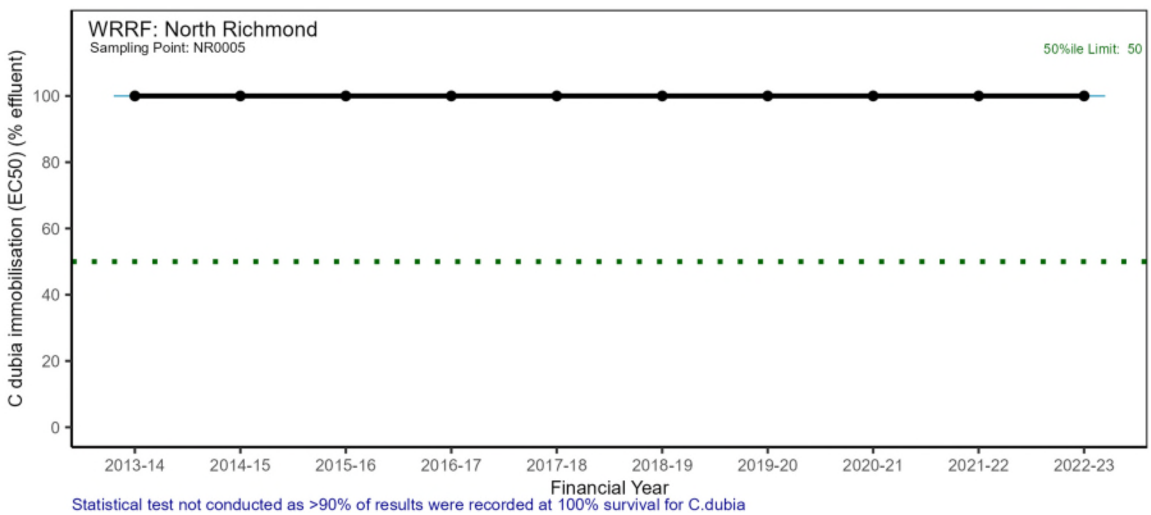


WRRF: North Richmond
Sampling Point: NR0004
Detection Limit: 1
90%ile Limit: 57
Average Limit: 44
DF = 1, F = 3.33, Pr(>F) = 0.0716
Zinc (composite) (ug/L)
10
20
30
40
50
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.



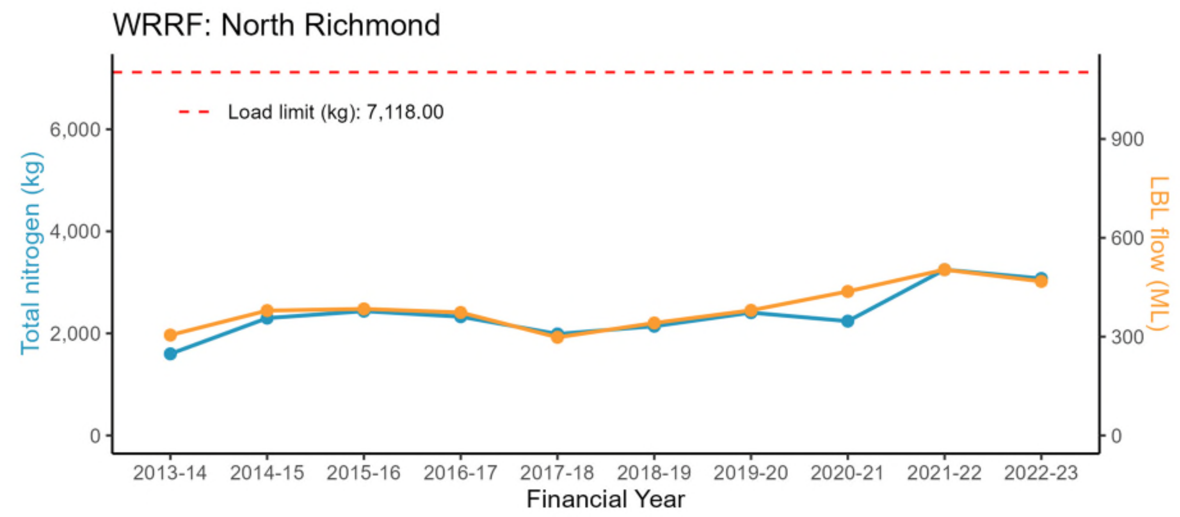


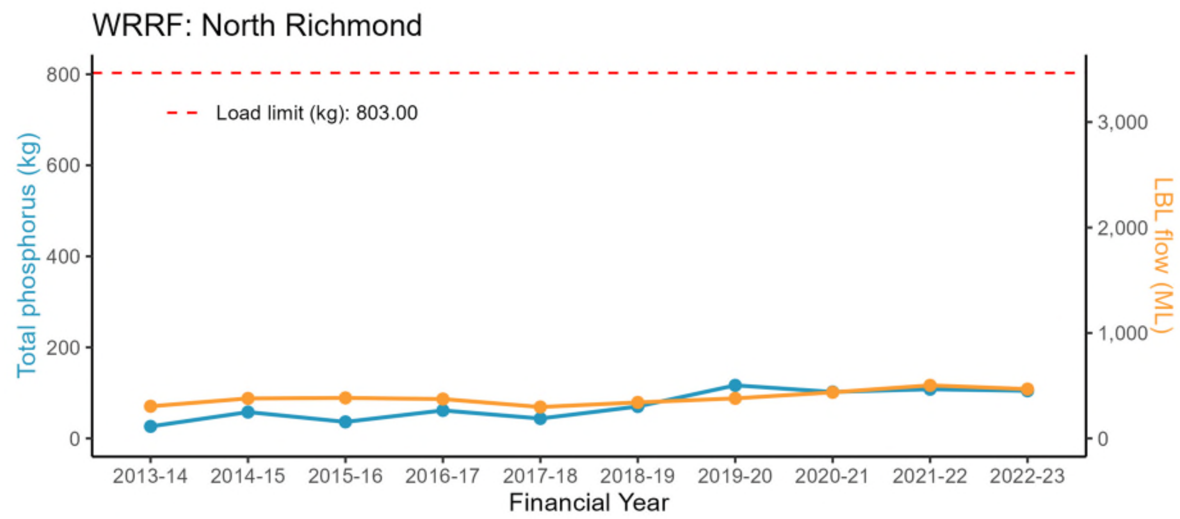
A-6.3 Pressure – Wastewater toxicity



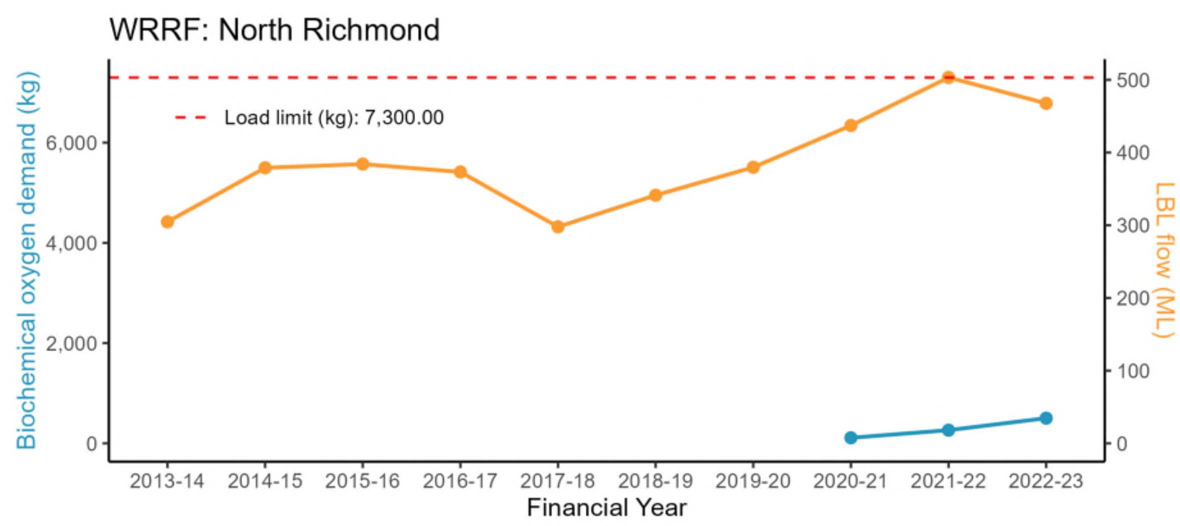
A-6.4 Pressure – Wastewater discharge load

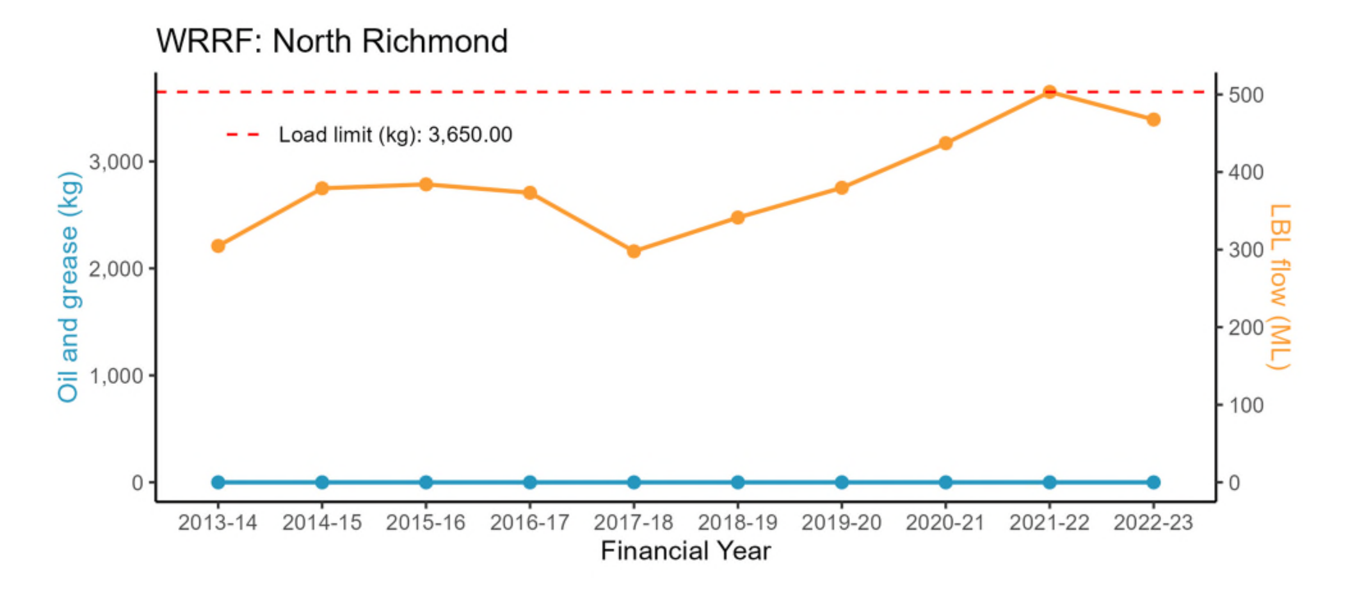
Nutrients

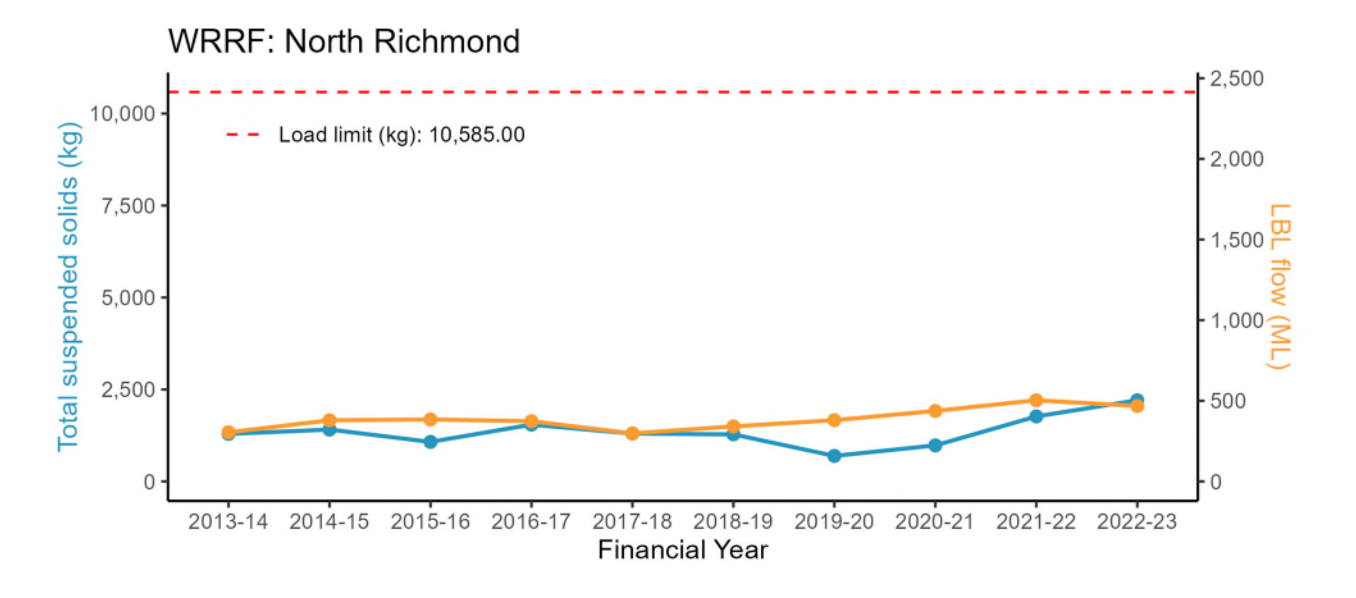




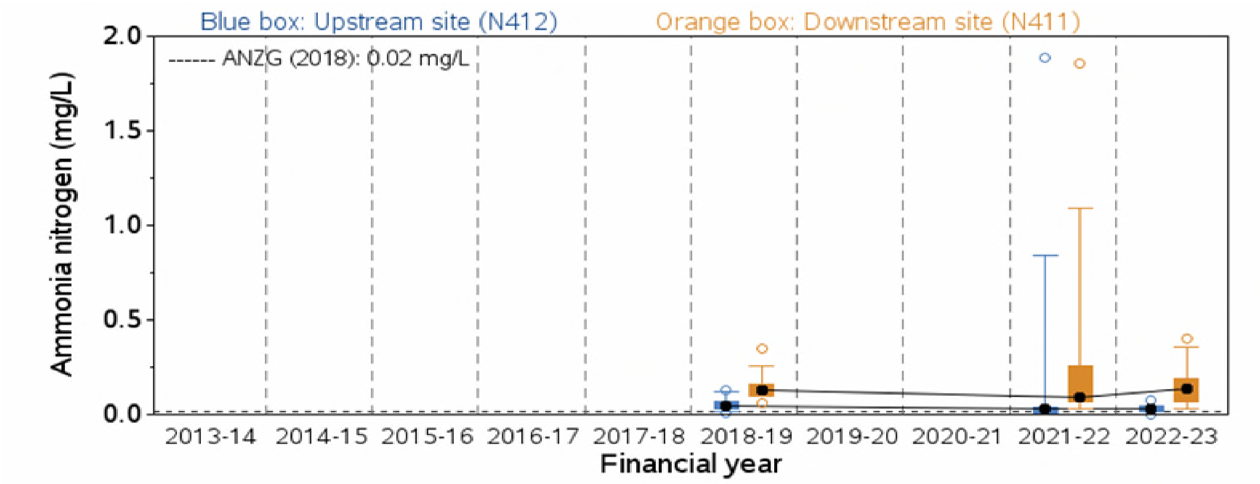
Major conventional analytes



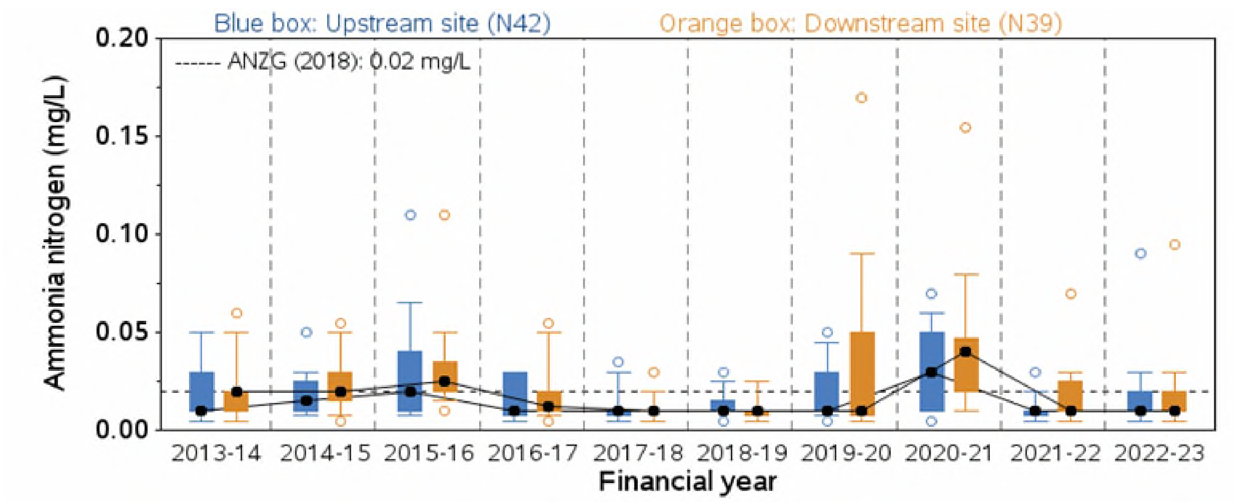

WRRF: North Richmond
Load limit (kg): 3,650.00
Oil and grease (kg)
LBL flow (ML)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


WRRF: North Richmond
Load limit (kg): 10,585.00
Total suspended solids (kg)
LBL flow (ML)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

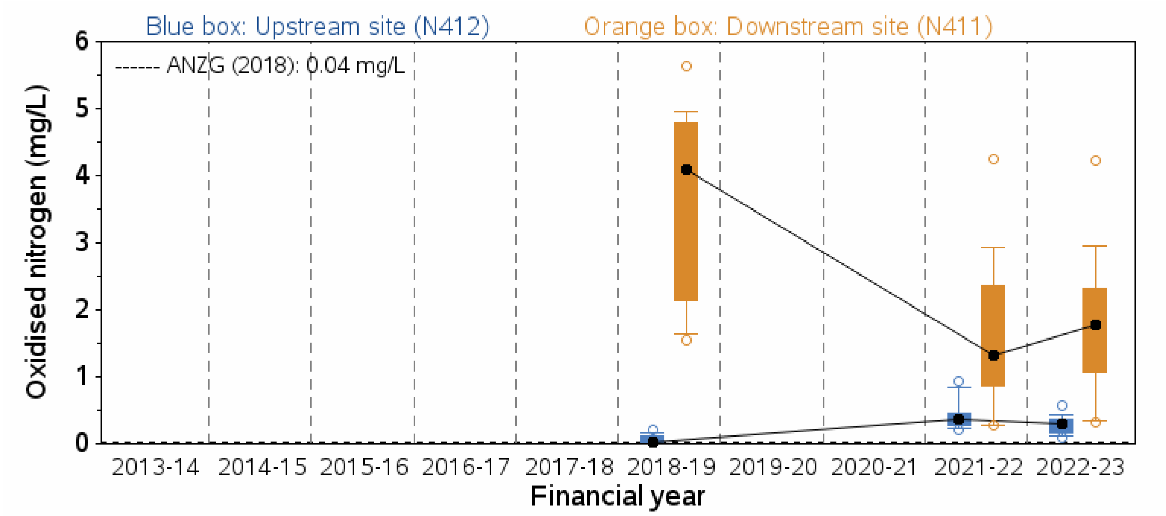
A-6.5 Stressor – Nutrients



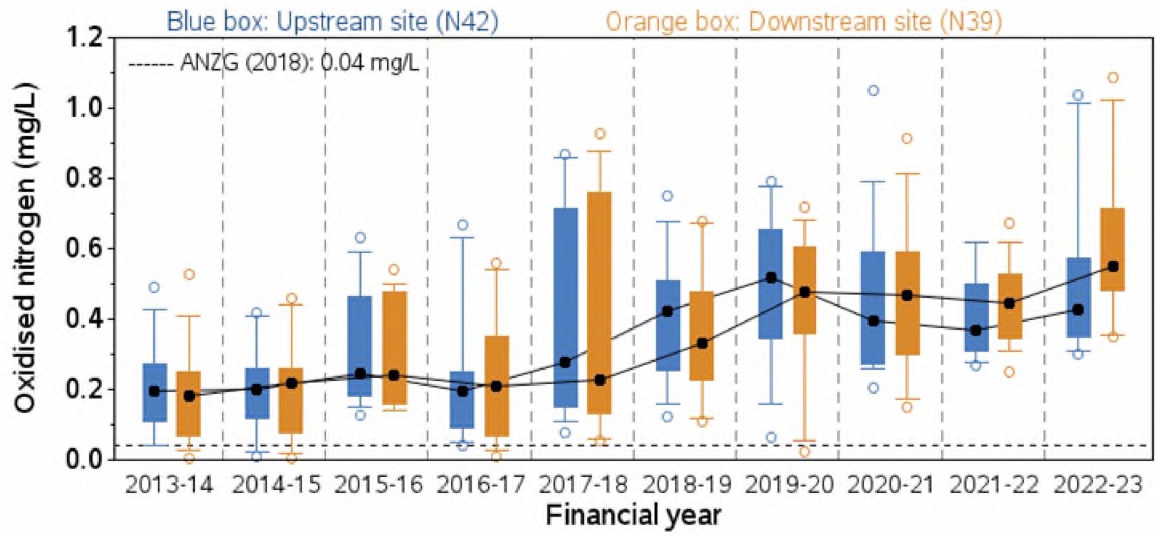
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	1.57	0.2168	N411	1	1.08	0.3049



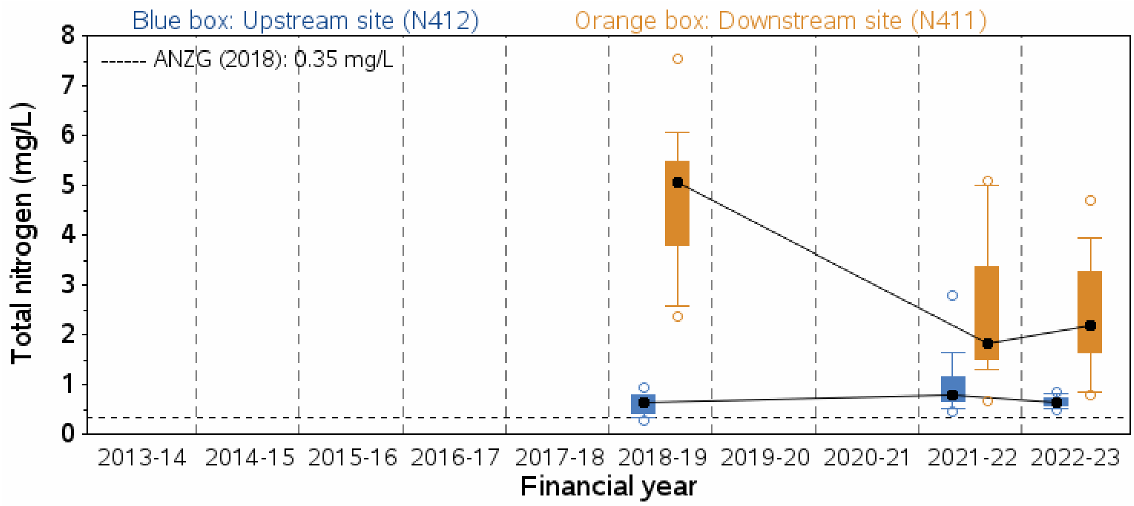
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.22	0.6374	N39	1	0.44	0.5094



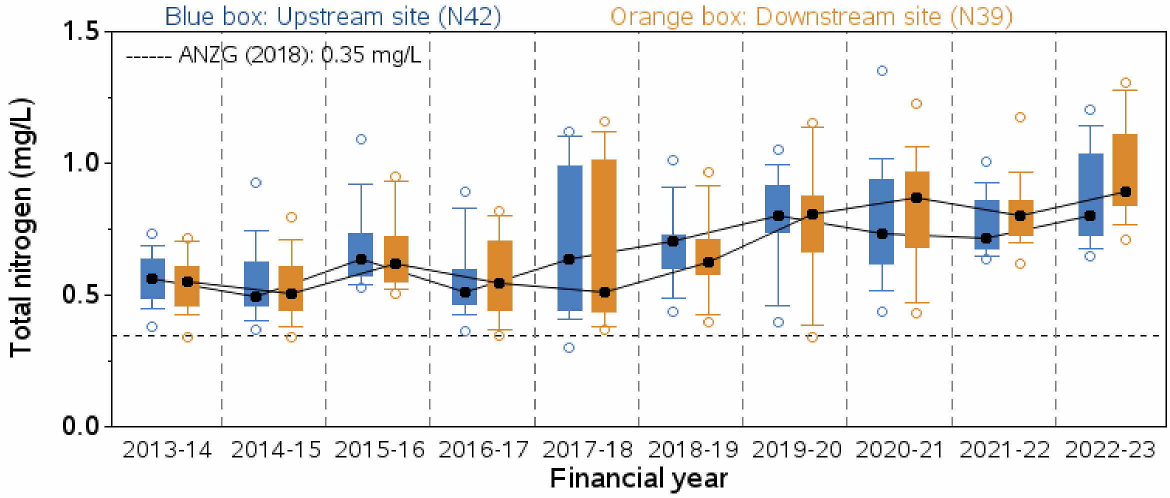
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	0.33	0.5672	N411	1	4.05	0.0498



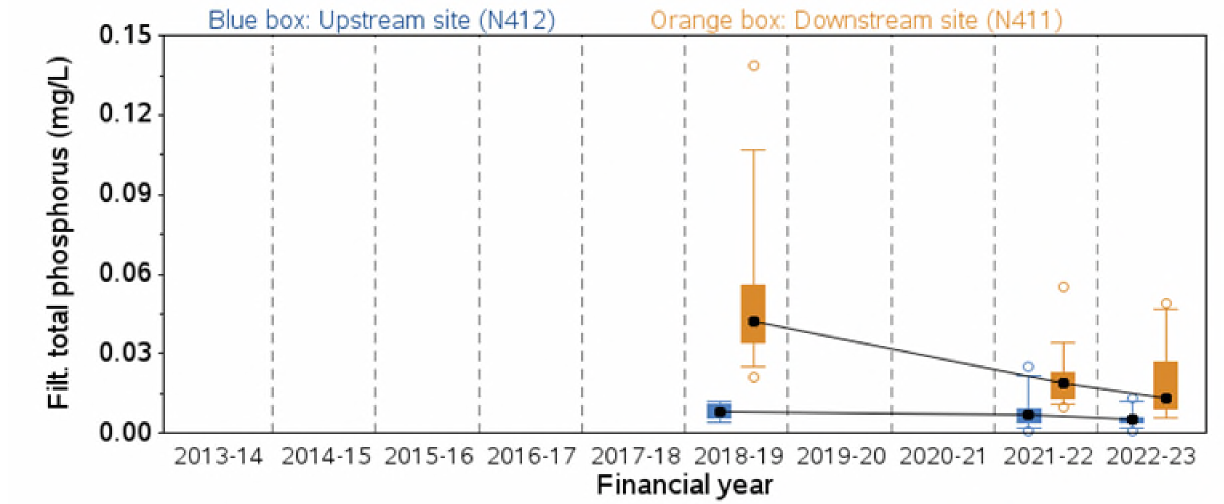
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	9.69	0.0022	N39	1	25.21	<.0001



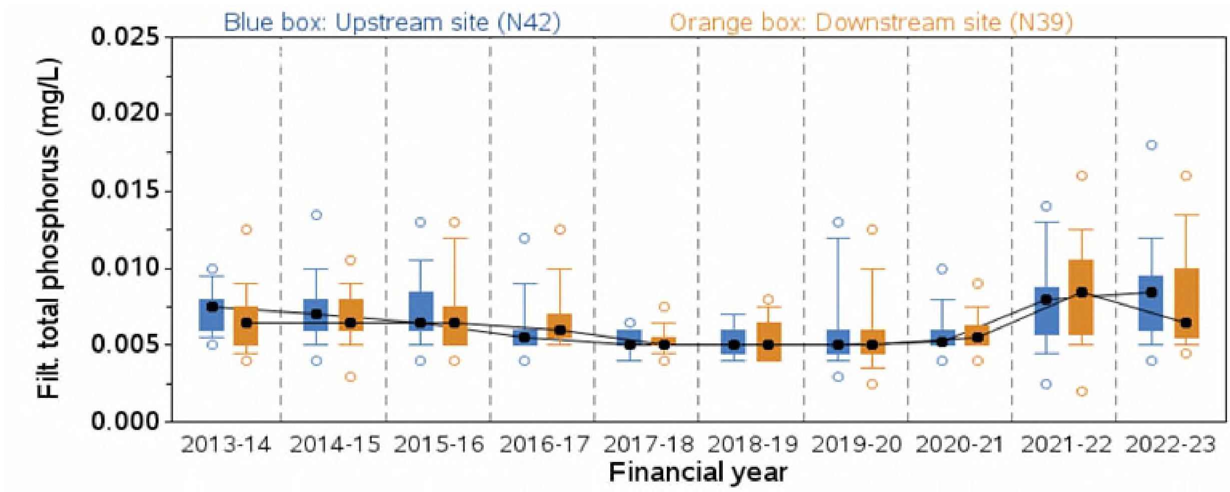
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	1.84	0.1815	N411	1	5.56	0.0225



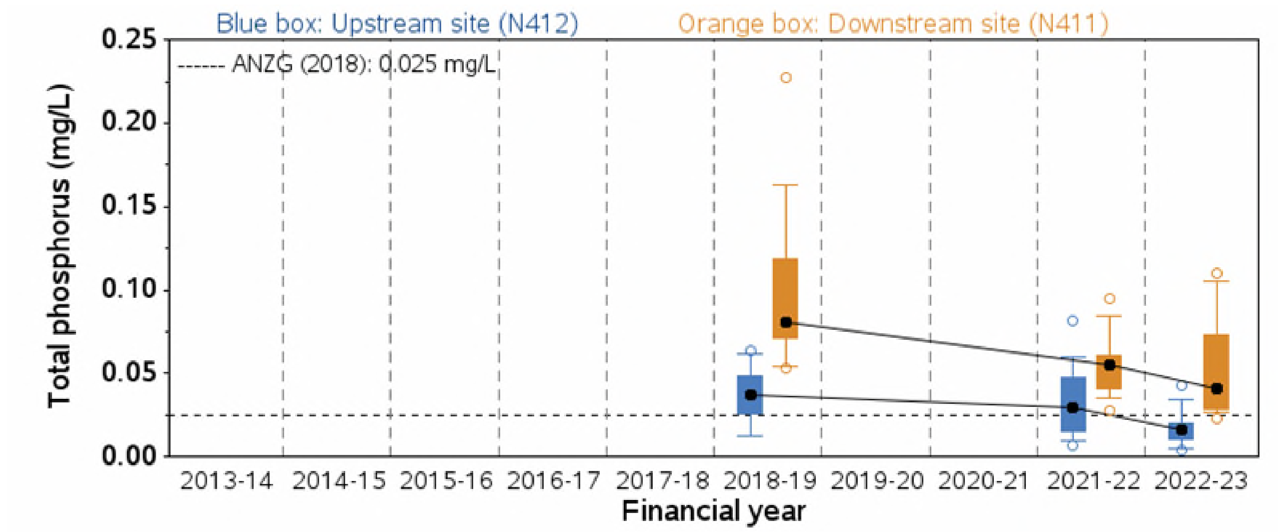
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	14.8	0.0002	N39	1	35.2	<.0001



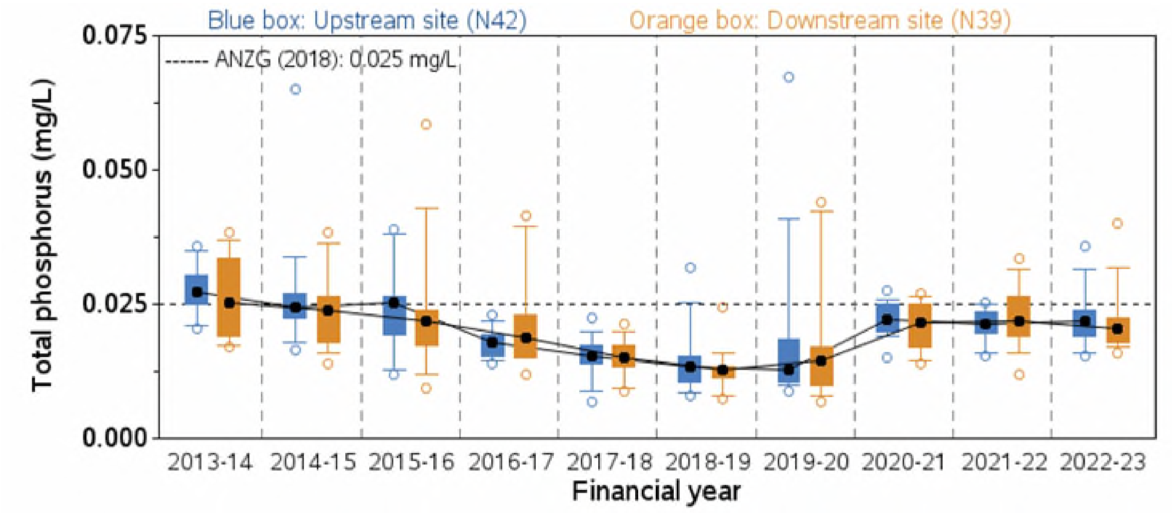
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	4.29	0.0437	N411	1	5.27	0.0261



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	9.79	0.0021	N39	1	5.76	0.0175

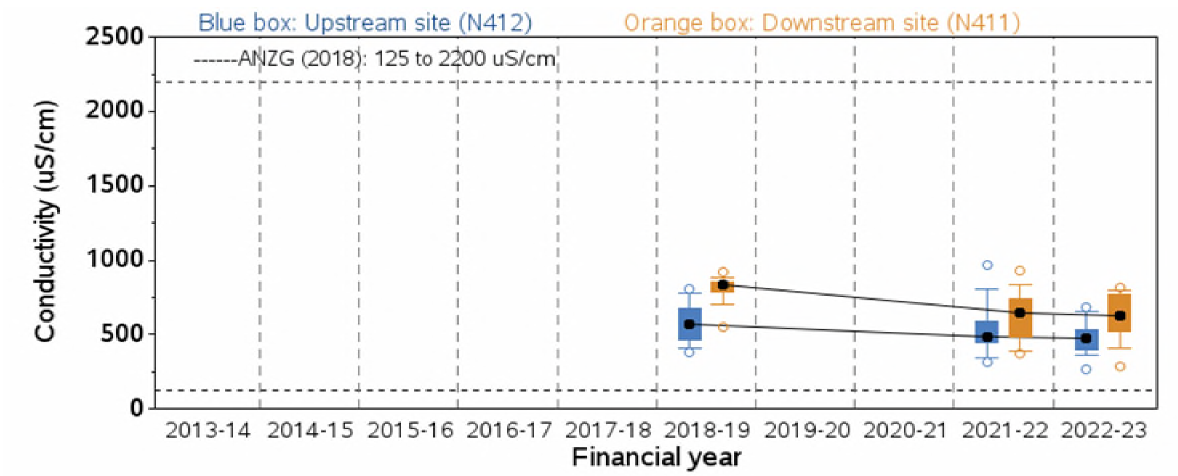


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	12.8	0.0008	N411	1	4.84	0.0326

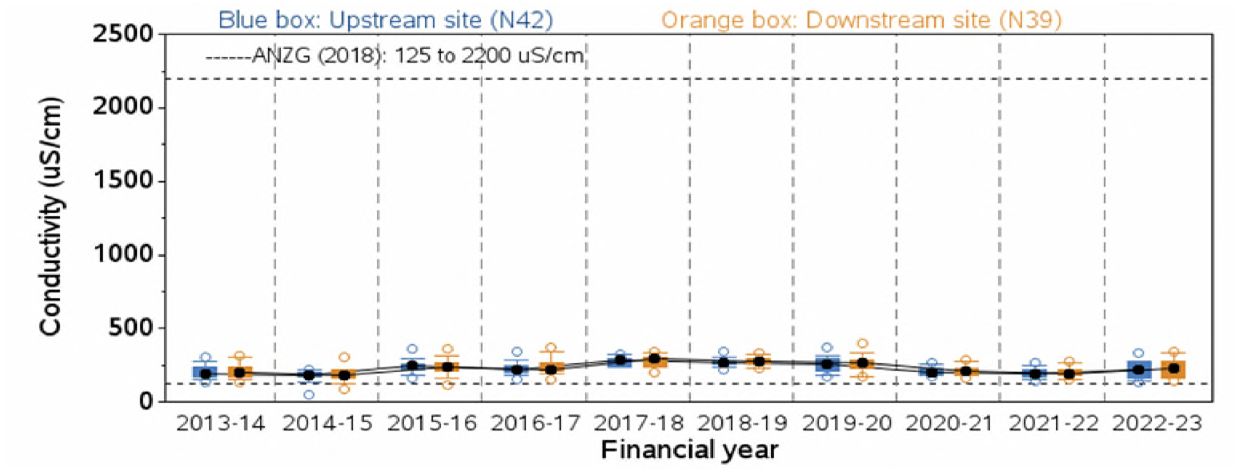


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.22	0.6407	N39	1	0.53	0.4683

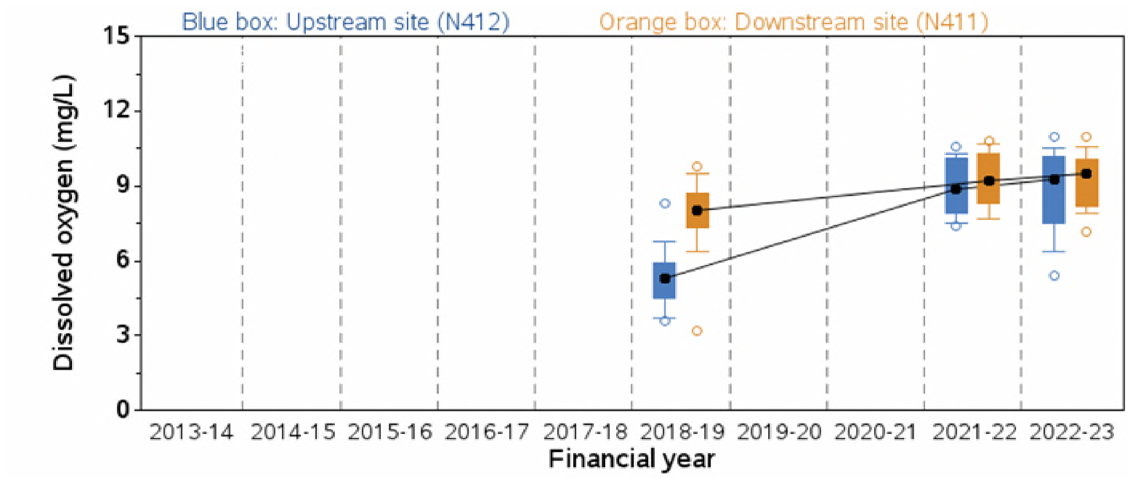
A-6.6 Stressor – Physico-chemical water quality



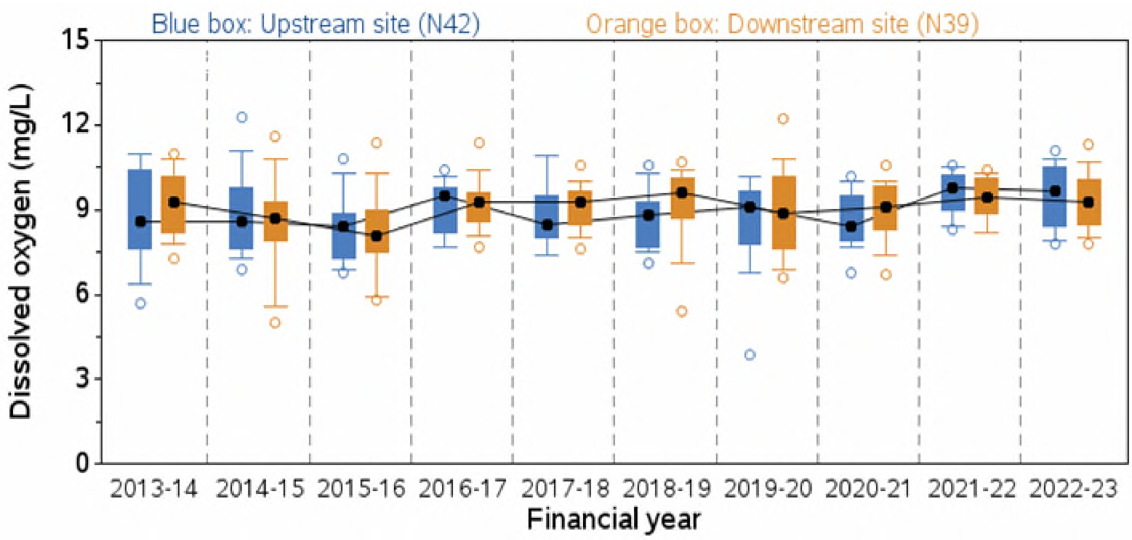
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	2.69	0.1078	N411	1	4.12	0.0478



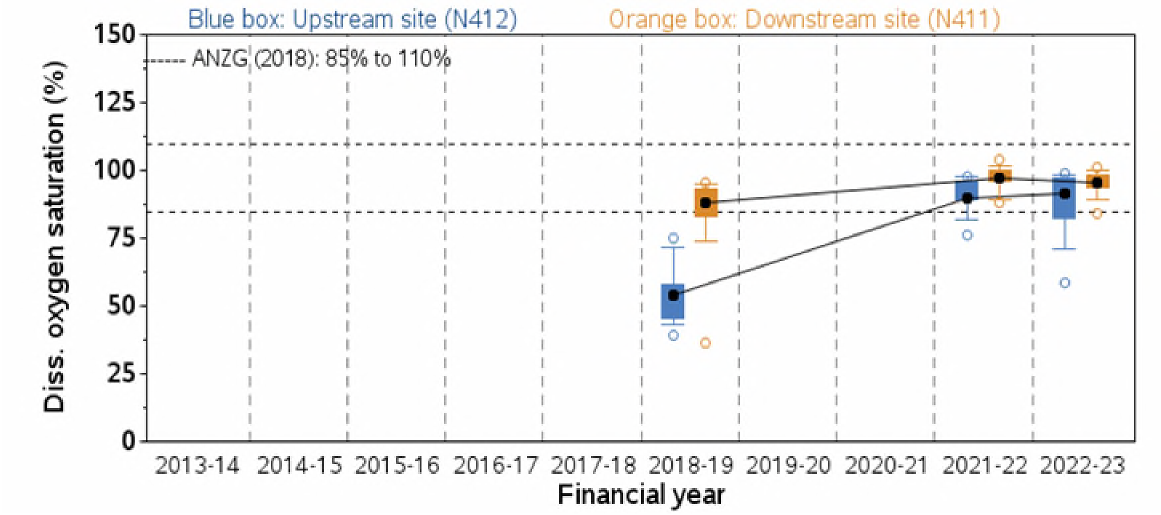
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	1.17	0.2804	N39	1	0.01	0.9342



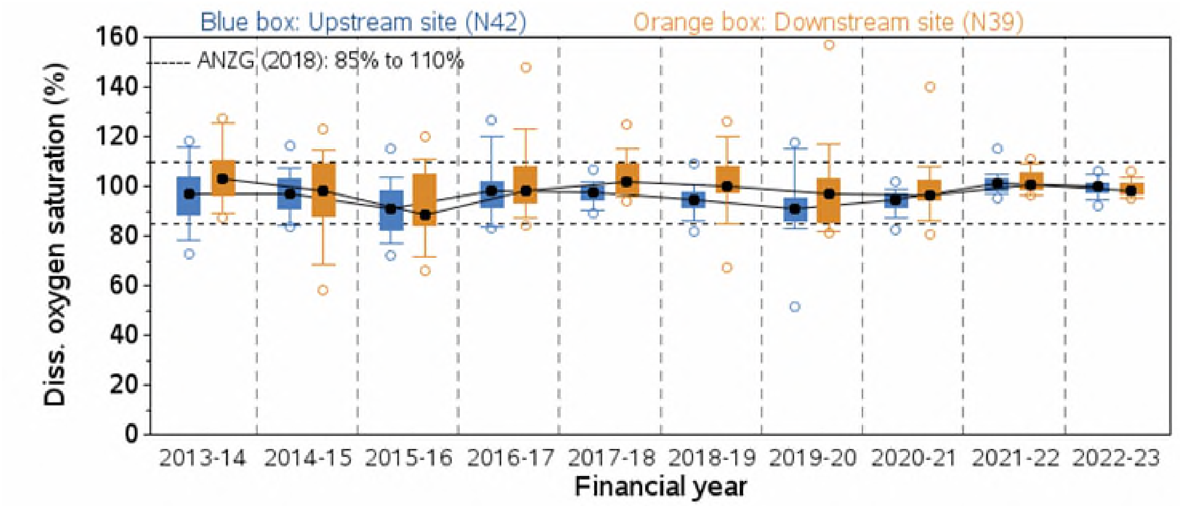
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	6.59	0.0135	N411	1	2.44	0.1252



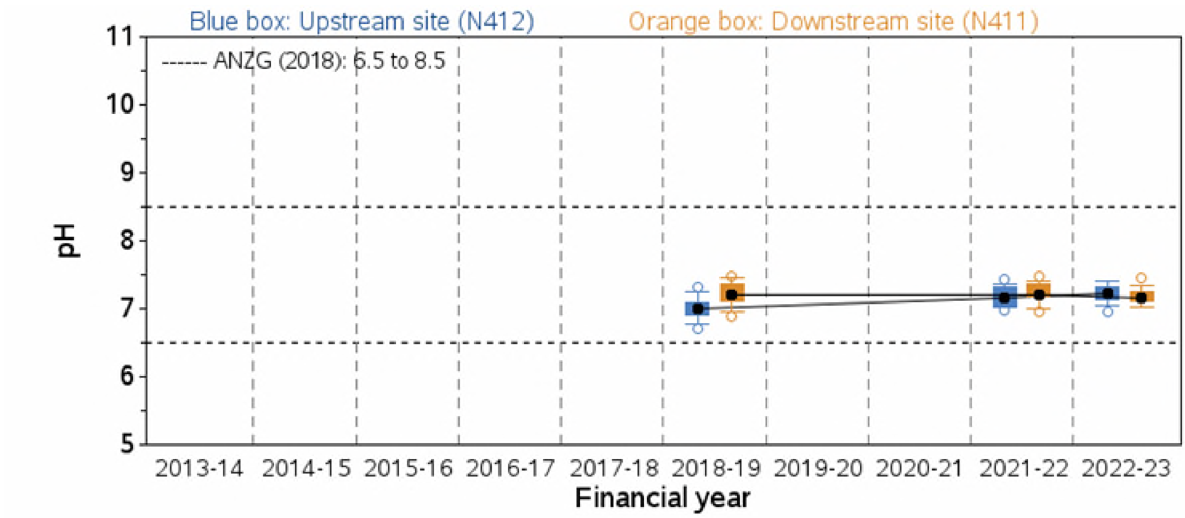
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	4.35	0.0385	N39	1	1.27	0.2612



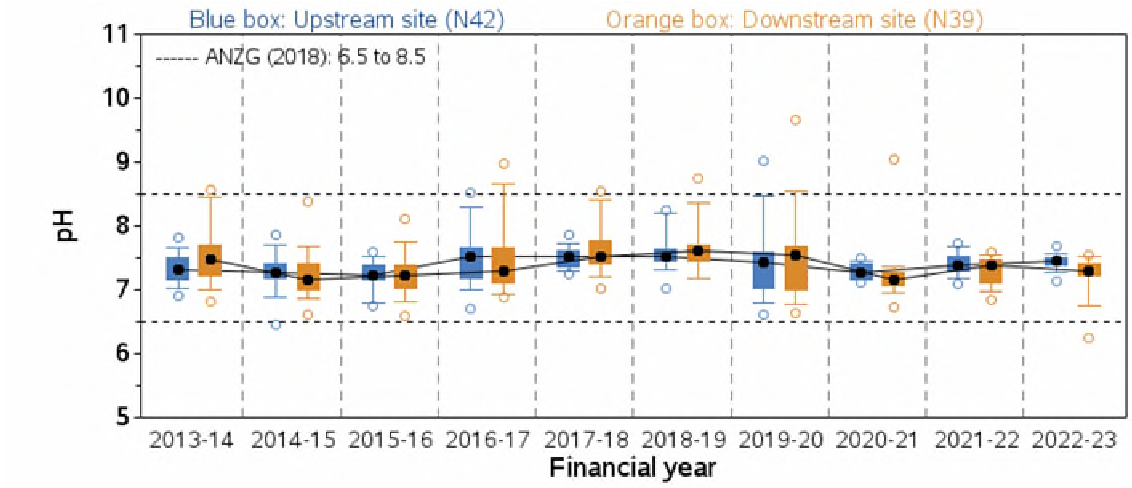
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	7.54	0.0085	N411	1	1.61	0.2104



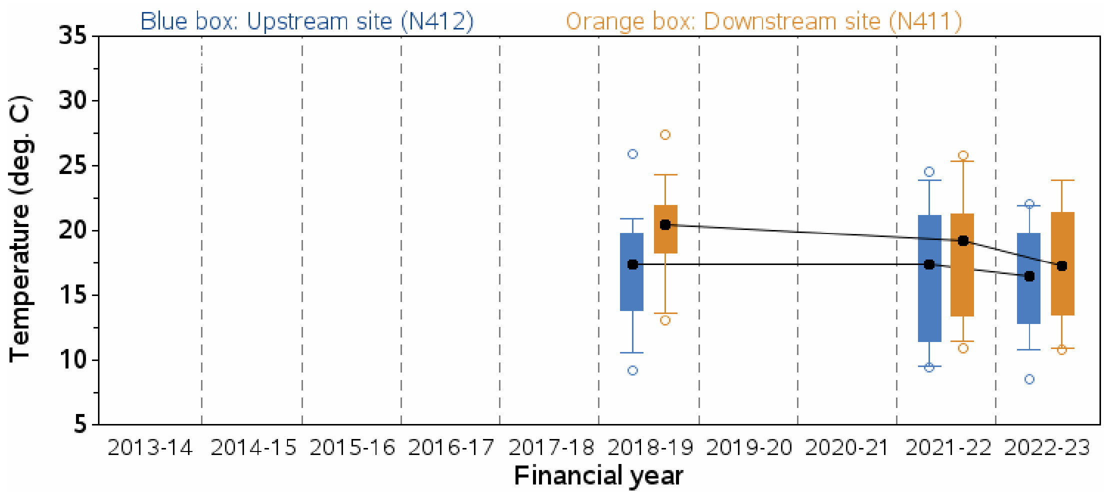
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	2.08	0.1513	N39	1	0.05	0.8236



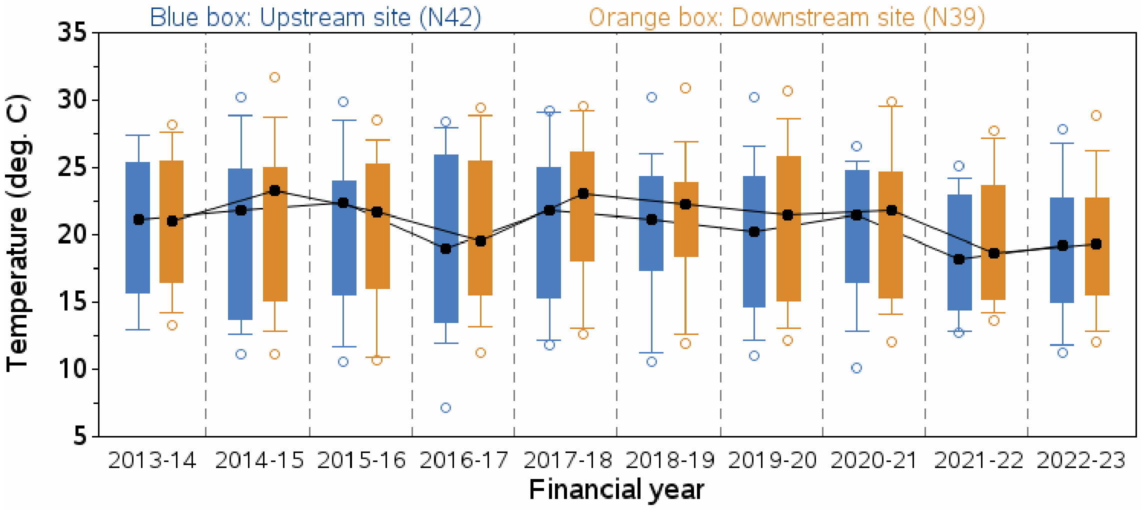
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	7.67	0.0081	N411	1	1.09	0.3007



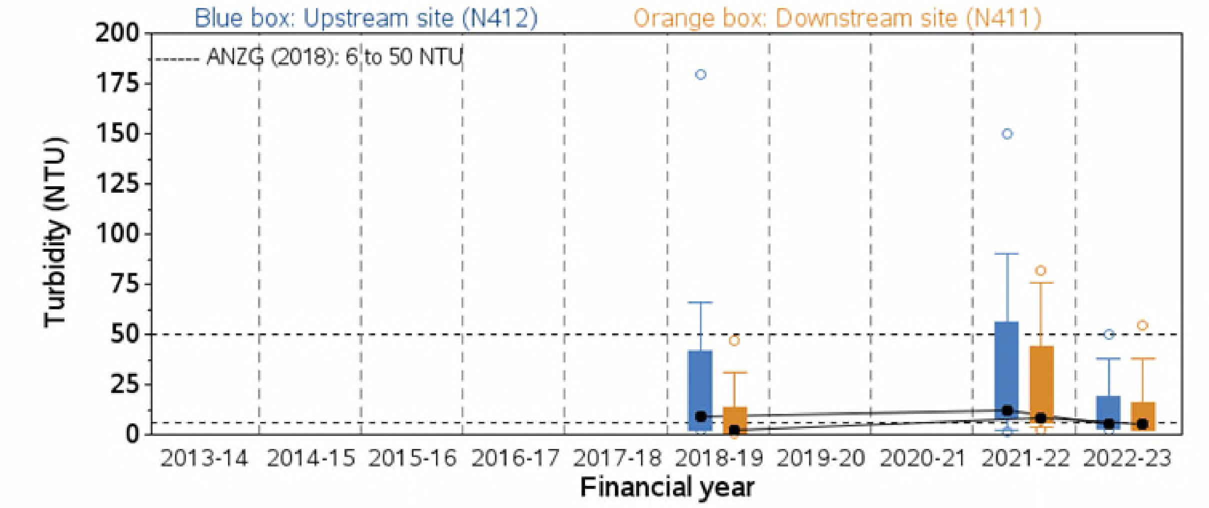
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.22	0.6367	N39	1	2.9	0.0904



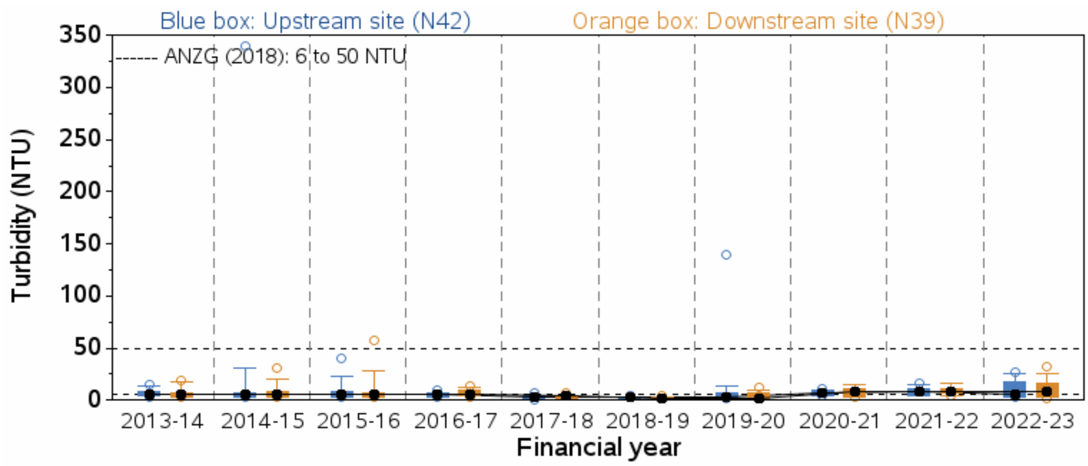
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	0.01	0.9252	N411	1	0.66	0.4202



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.71	0.4003	N39	1	0.97	0.3266

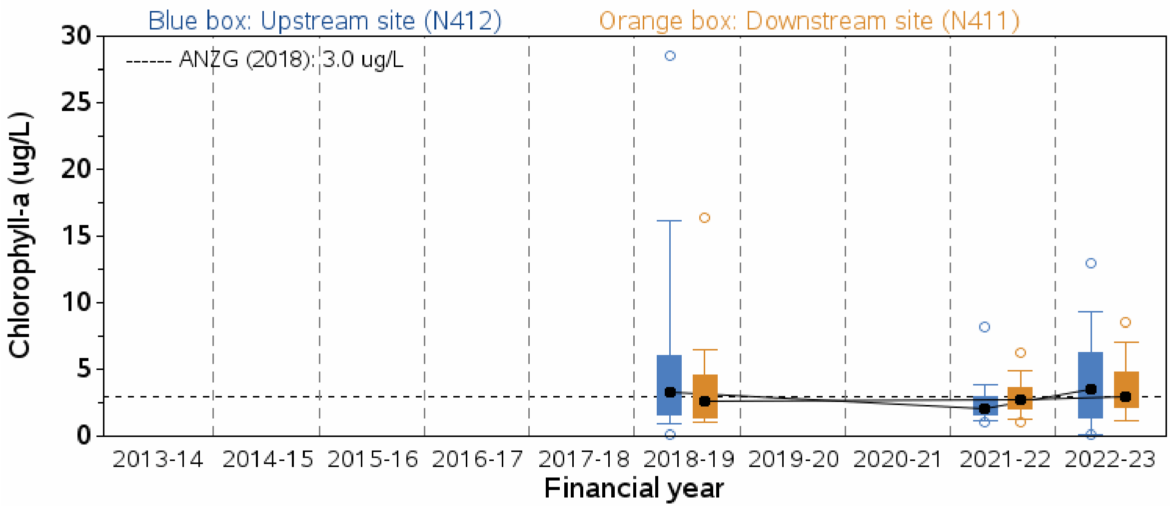


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	3.4	0.0714	N411	1	1.12	0.2944

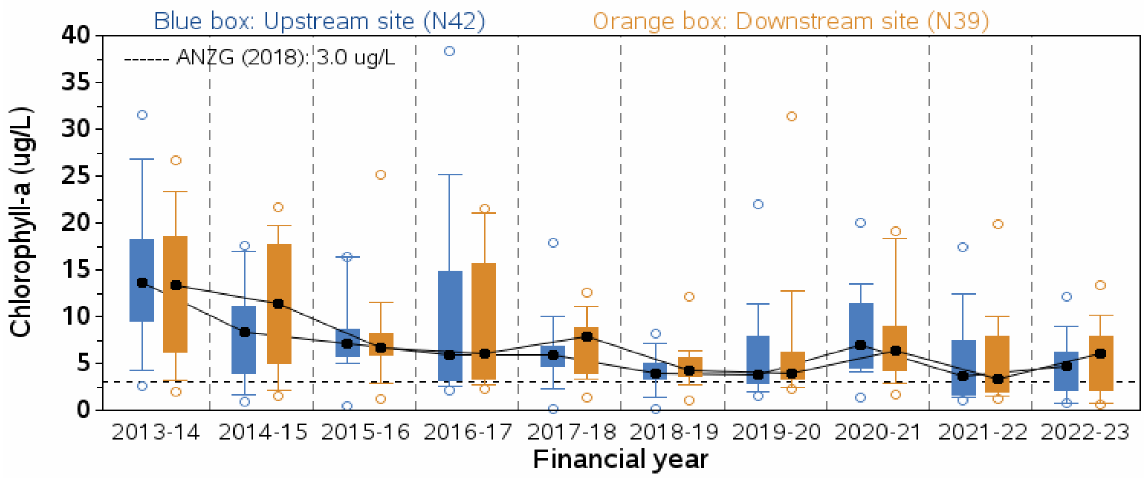


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.02	0.8962	N39	1	6.52	0.0116

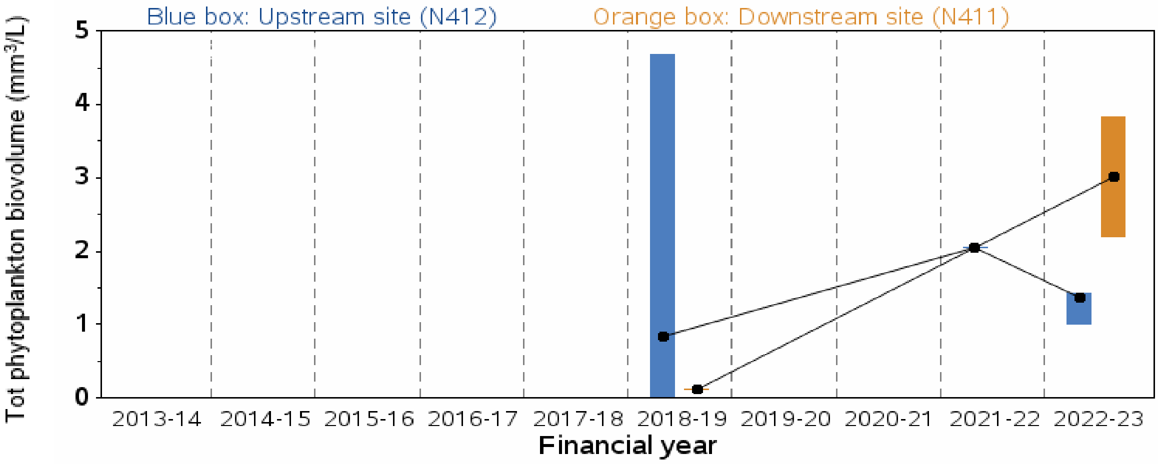
A-6.7 Ecosystem receptor – Phytoplankton



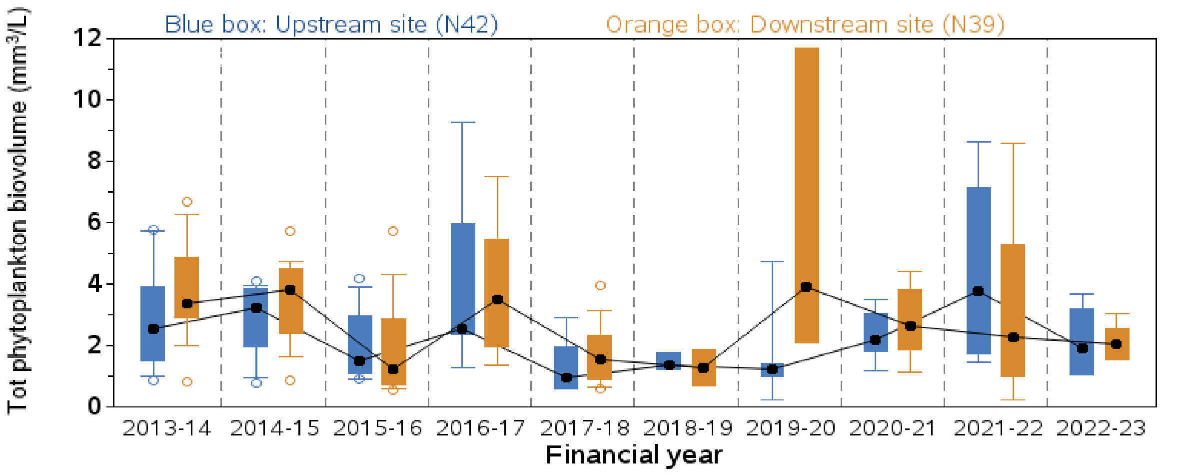
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	0	0.9967	N411	1	0.27	0.6062



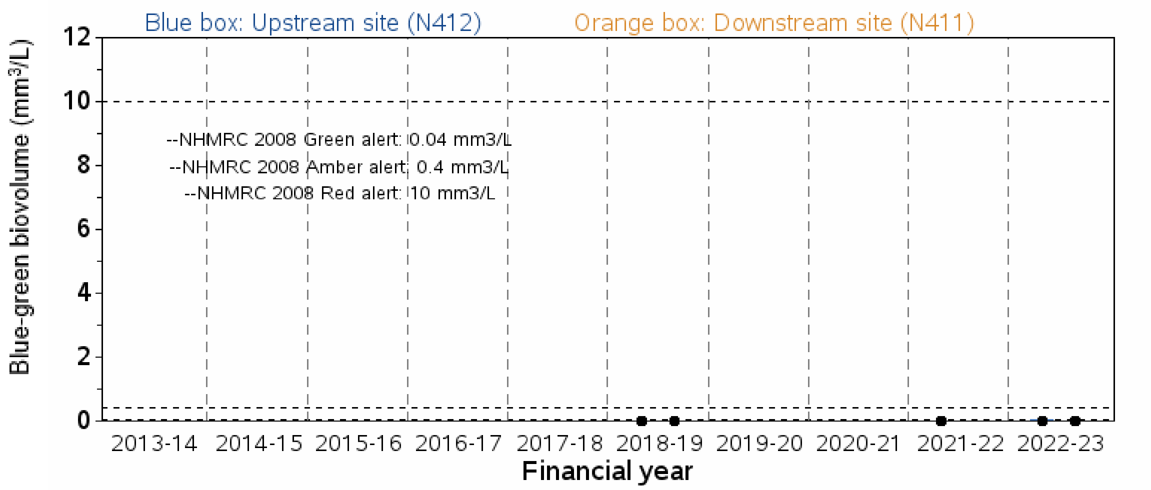
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	3.98	0.0477	N39	1	2.62	0.1075



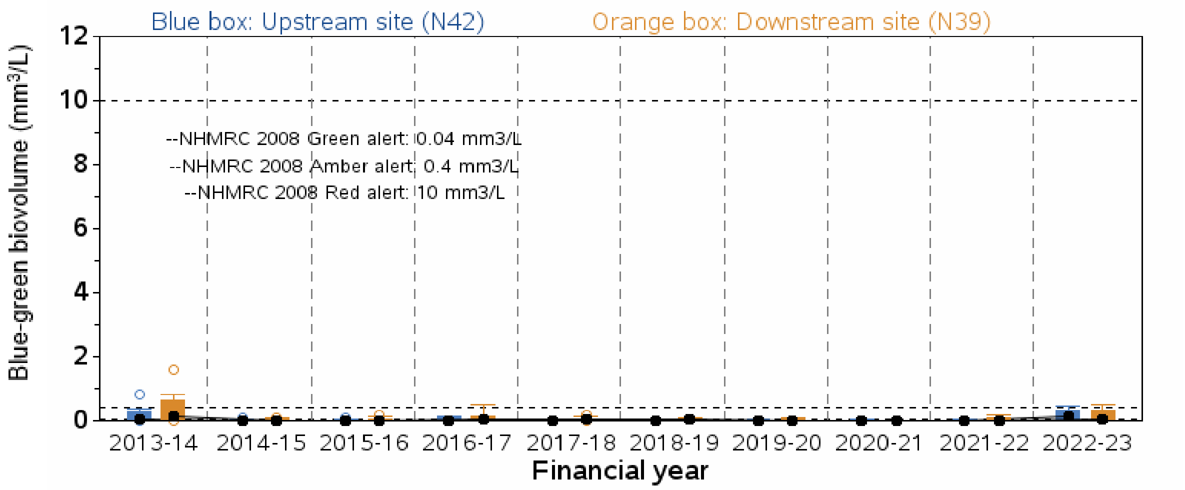
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	0.28	0.6221	N411	1	4.2	0.289



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.24	0.6223	N39	1	1.05	0.3098

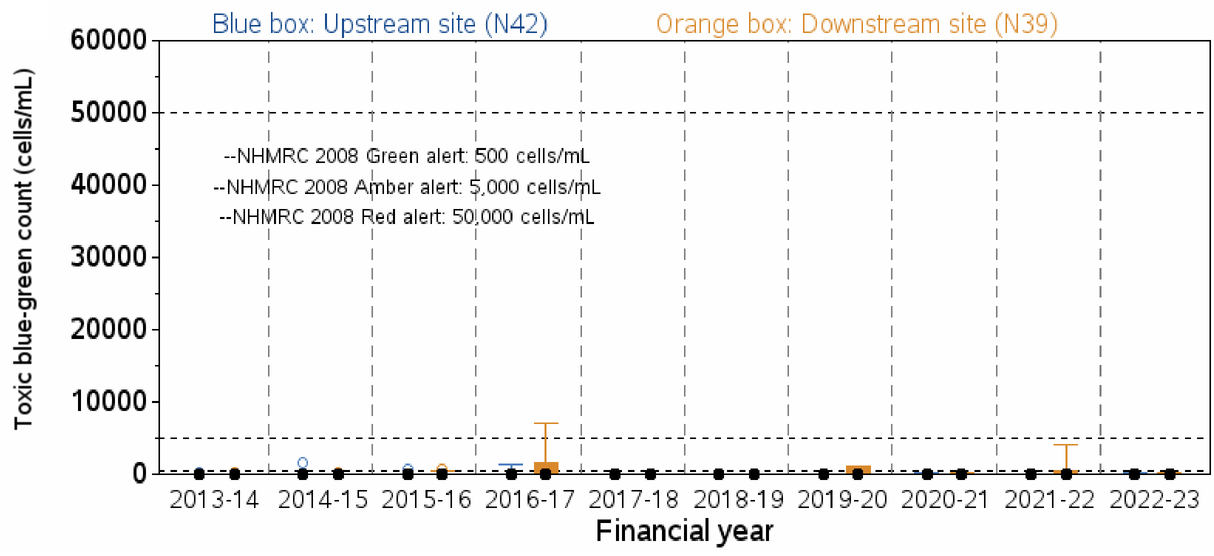


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N412	1	1.56	0.2674	N411	1	0.33	0.6667



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	4.53	0.0368	N39	1	0.18	0.6704

Note: Insufficient data to draw a plot on toxic blue-green count for N412 and N411



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N42	1	0.13	0.7171	N39	1	0.25	0.6156

A-6.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plots provided assessments of stream health for both Redbank Creek near North Richmond WRRF and in the Hawkesbury River upstream-downstream of the confluence with Redbank Creek. These plots were based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022–23 against that collected between 2005 to 2023 for Redbank Creek and 1995 to 2023 for the Hawkesbury River. These visual comparisons suggest downstream stream health was maintained at a level typical of the downstream site at Redbank Creek and the Hawkesbury River, while upstream stream health was highly variable at both Redbank Creek and Hawkesbury River sites (Figure A-26 and Figure A-27).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under t-tests returned a non-significant outcome for both Redbank Creek and the Hawkesbury River (Table A-37) confirming the visual trends for 2022-23.

No measurable negative impact on downstream stream health could be determined in the SIGNAL-SG plot and corresponding t-test for Redbank Creek, likely due to high variability between the returned sample SIGNAL-SG scores of the upstream site in 2022-23. No further data analysis was undertaken.

Table A-37 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Redbank Creek and Hawkesbury River near North Richmond WRRF

Waterway	Method	Statistic	DF	P value
Redbank Creek	Welch Two Sample t-test	2.30	5.4	0.065
Hawkesbury River	Welch Two Sample t-test	-0.69	7.2	0.510

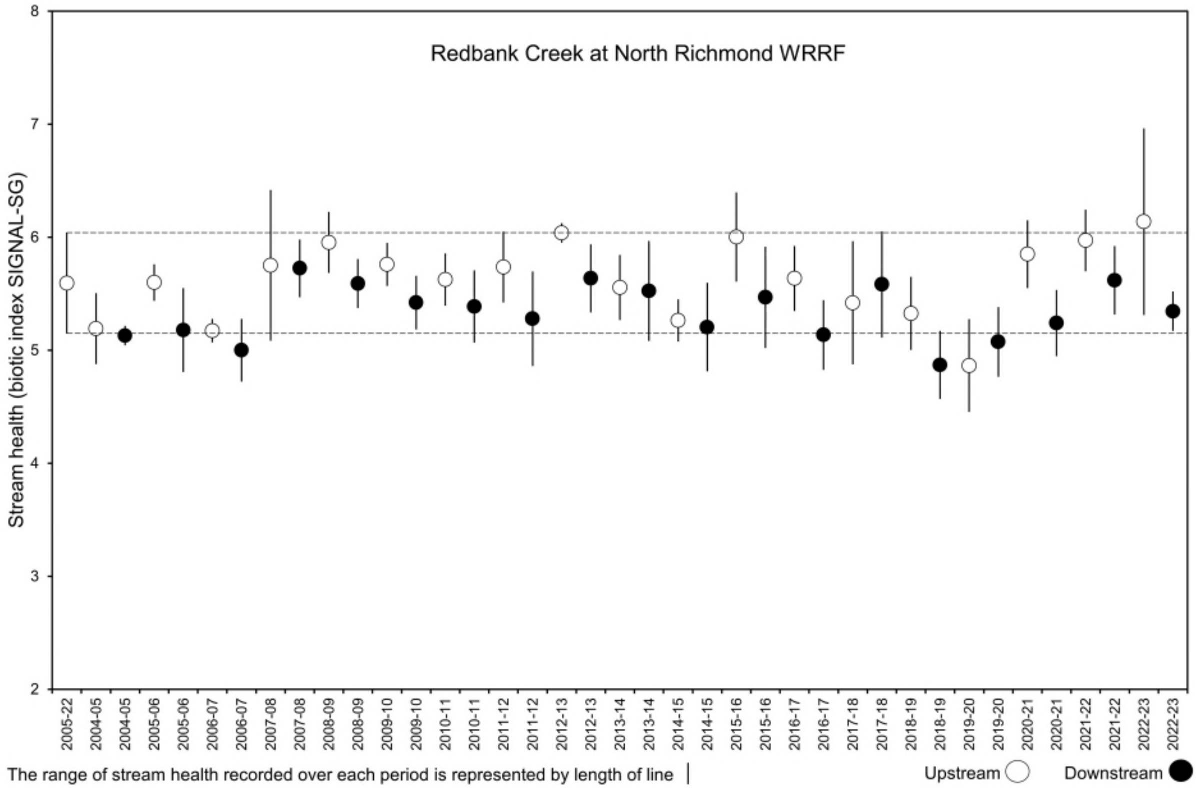


Figure A-26 Stream health of Redbank Creek near North Richmond WRRF

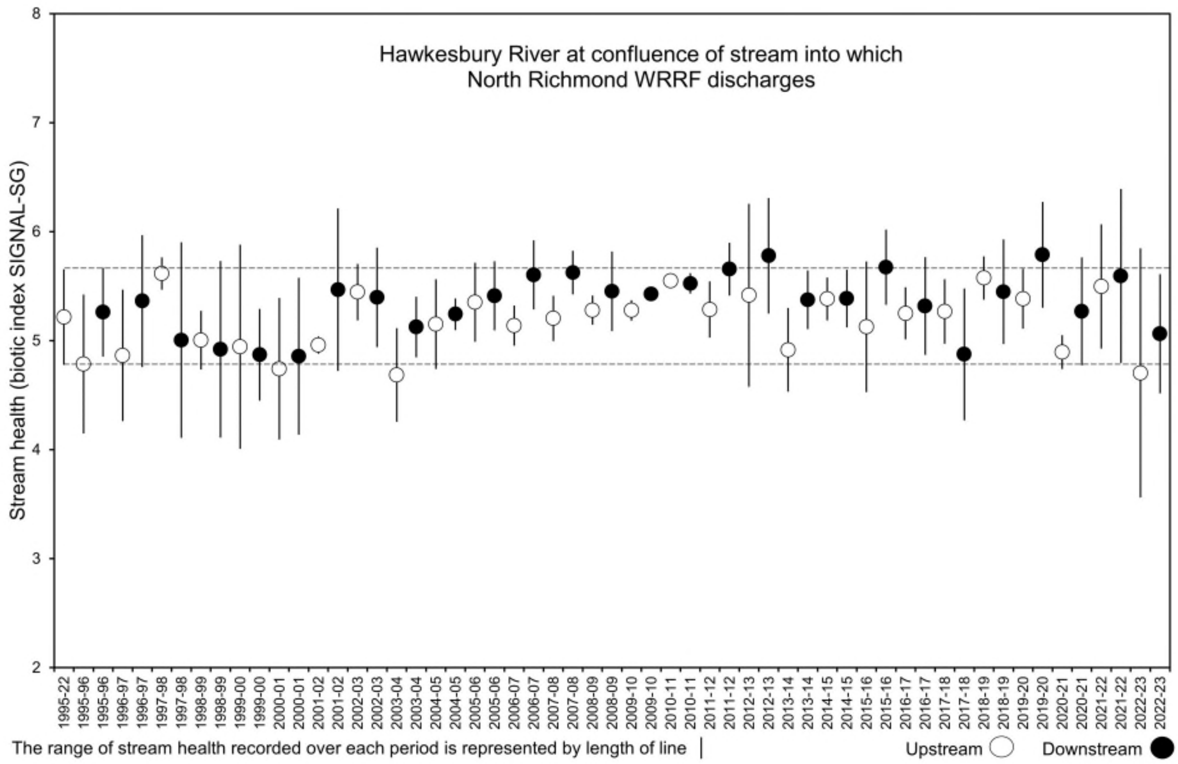
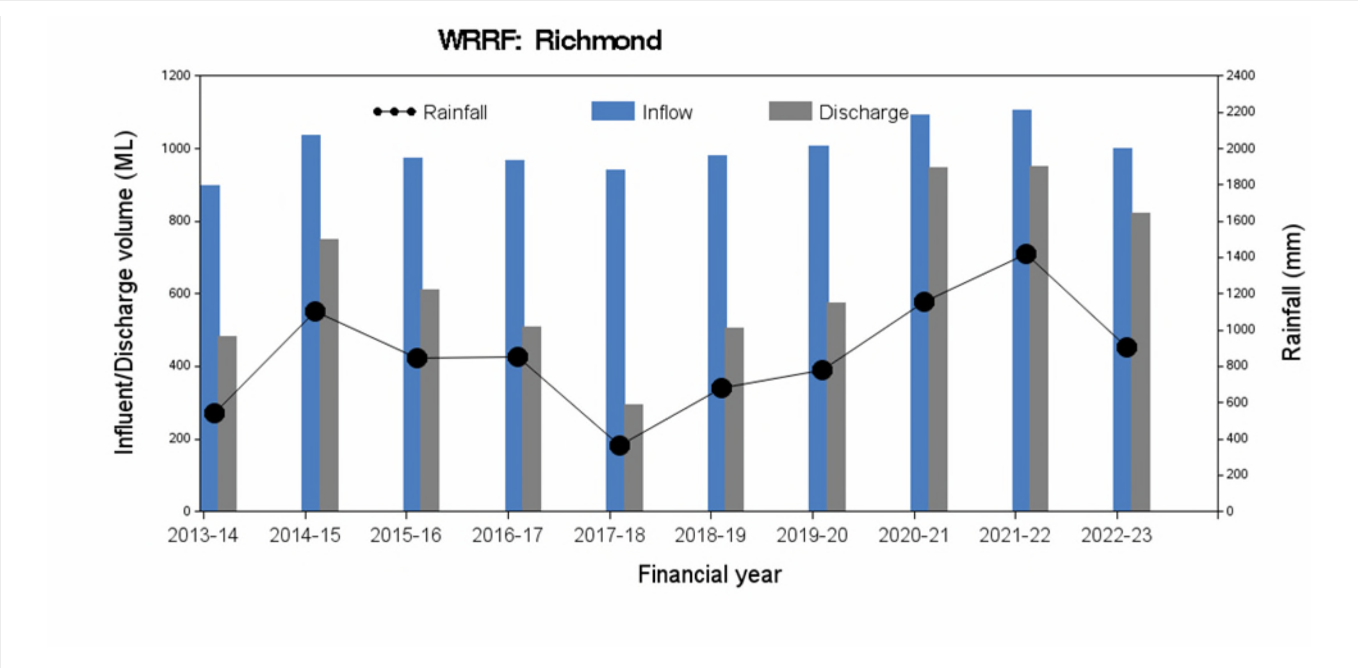


Figure A-27 Stream health of Hawkesbury River upstream-downstream of the confluence of Redbank Creek near North Richmond WRRF

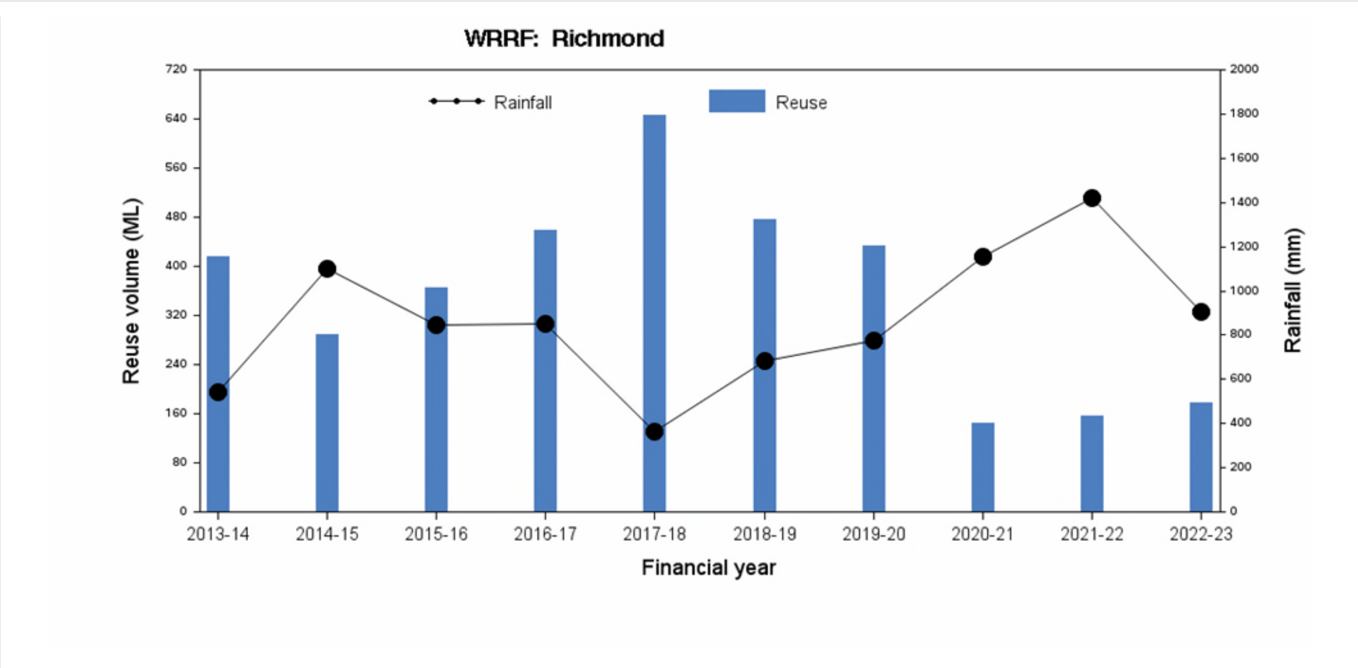
A-7 Richmond WRRF

A-7.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

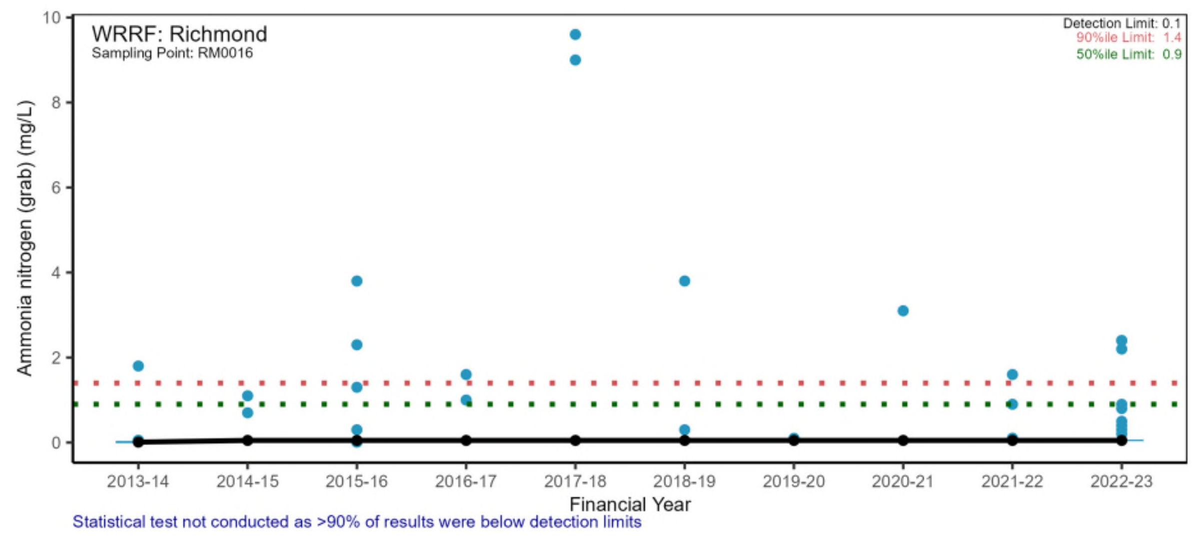


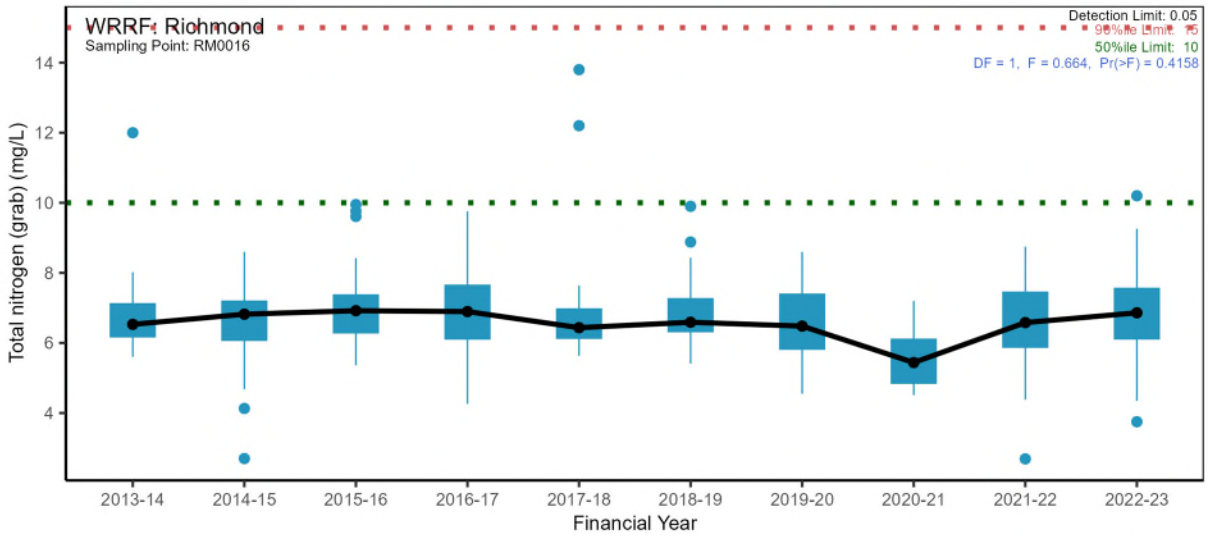
Reuse volume and rainfall

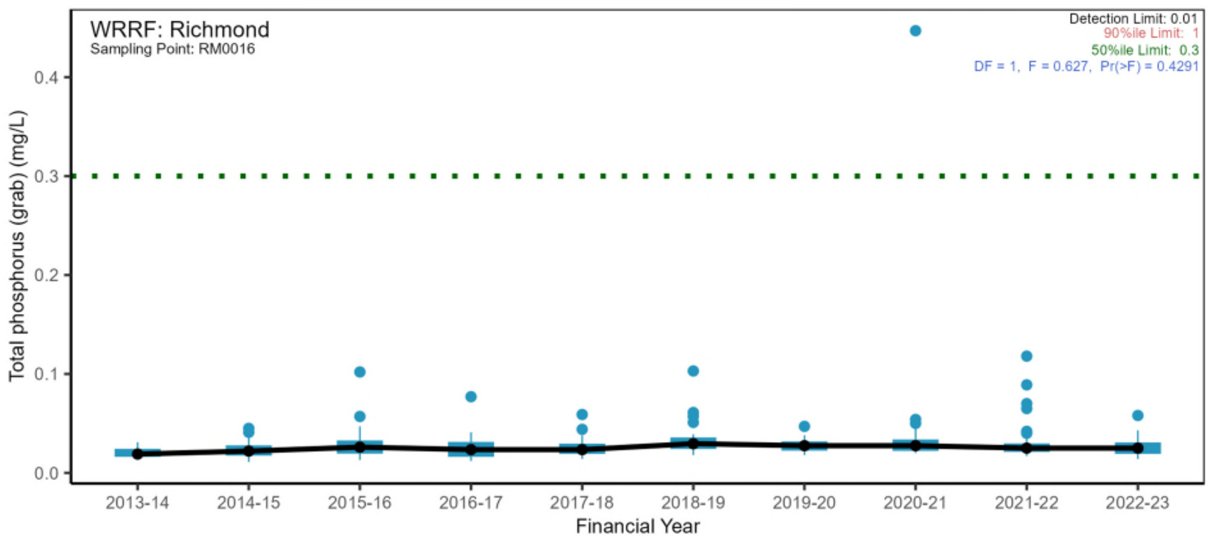


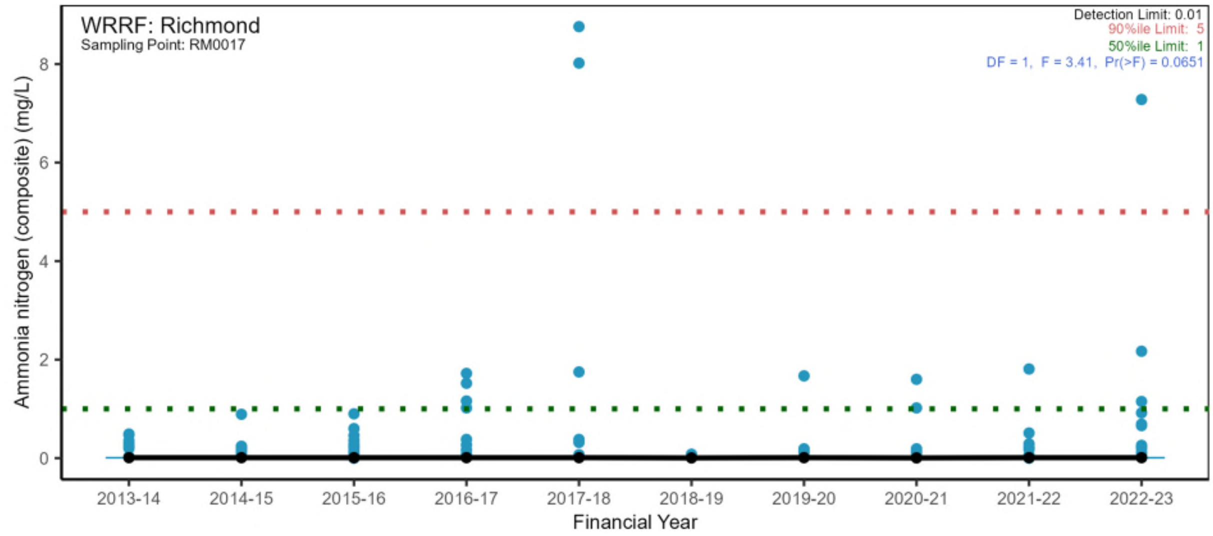
A-7.2 Pressure – Wastewater quality

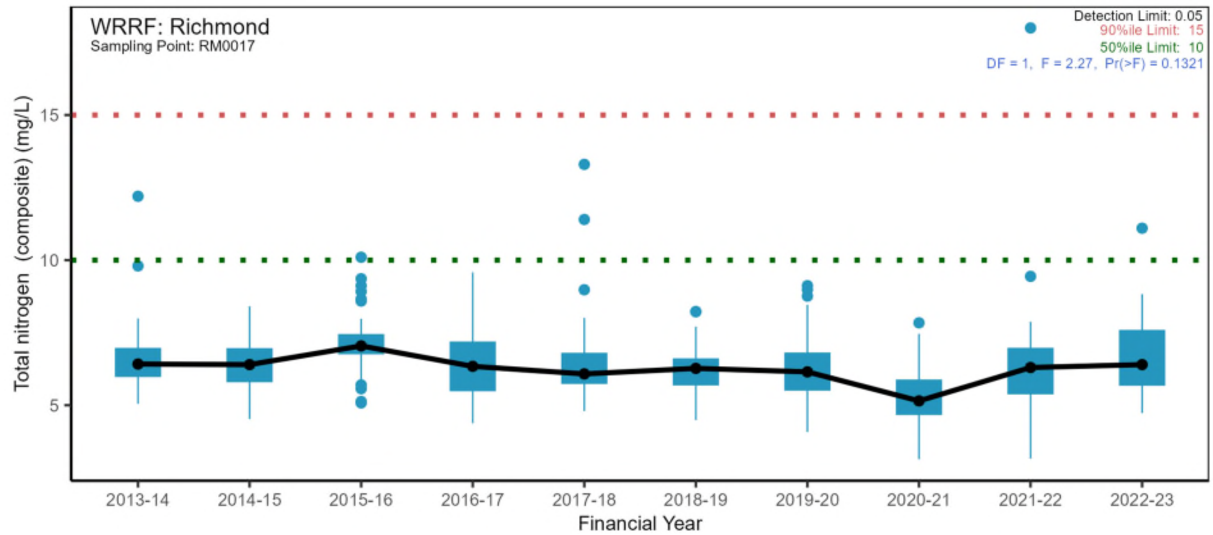
Nutrients (RM0016 Bypass Effluent)

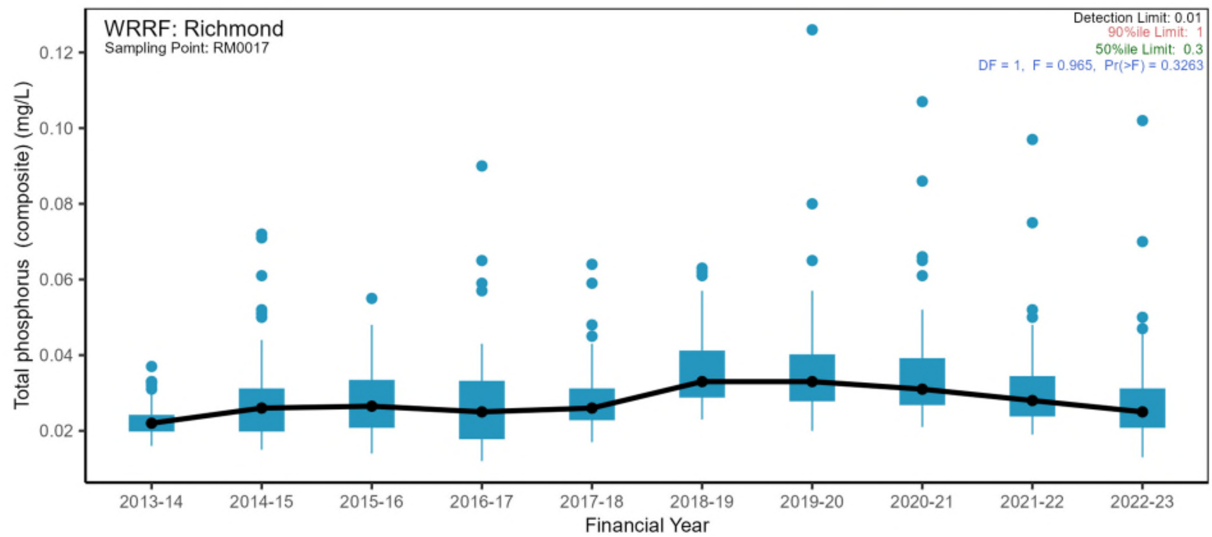


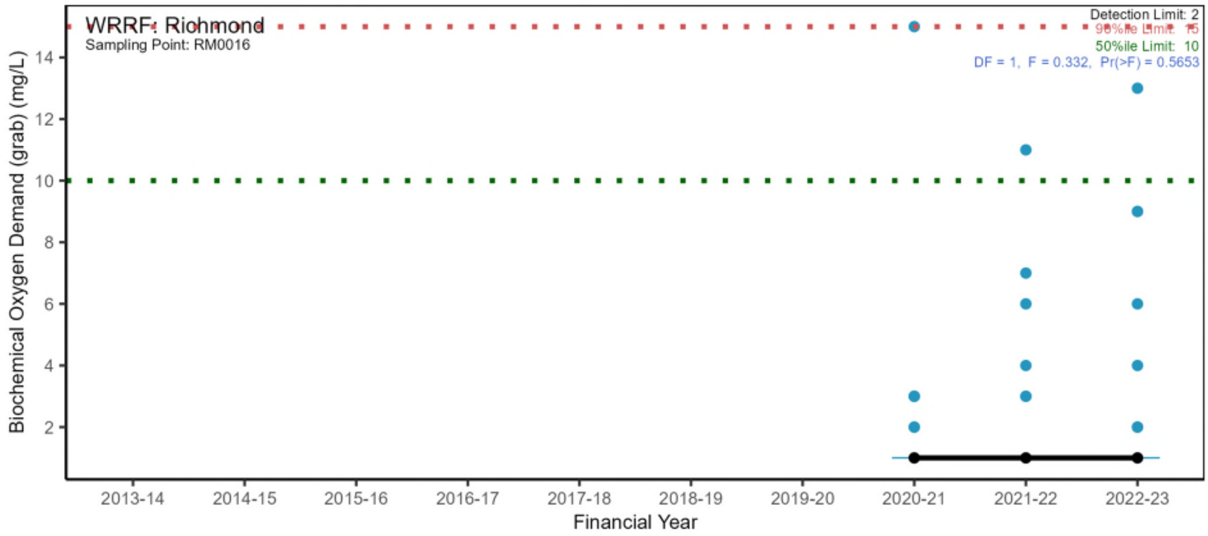


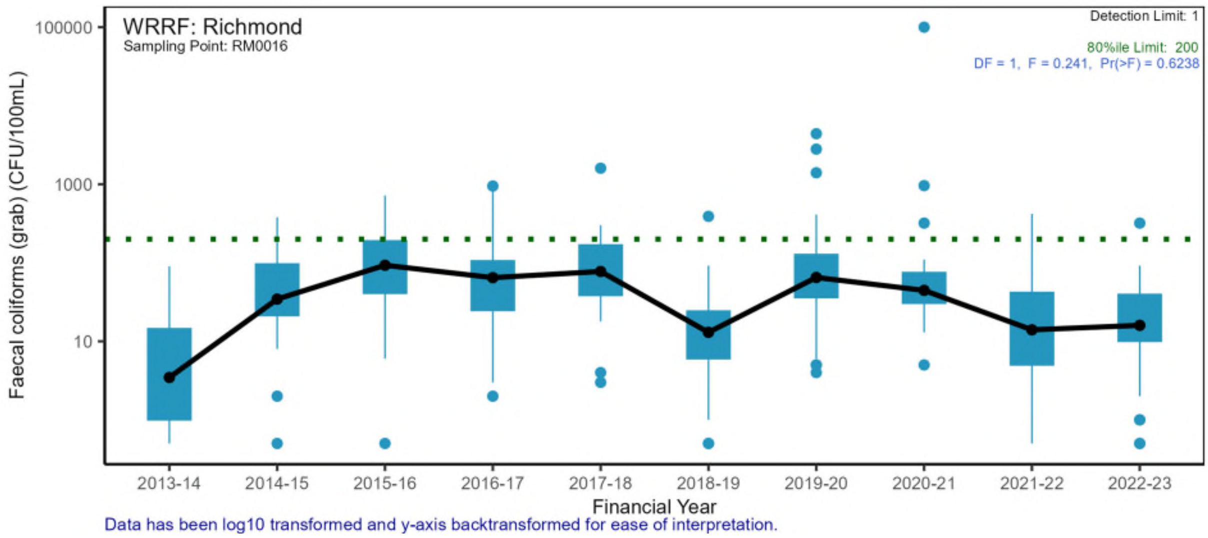


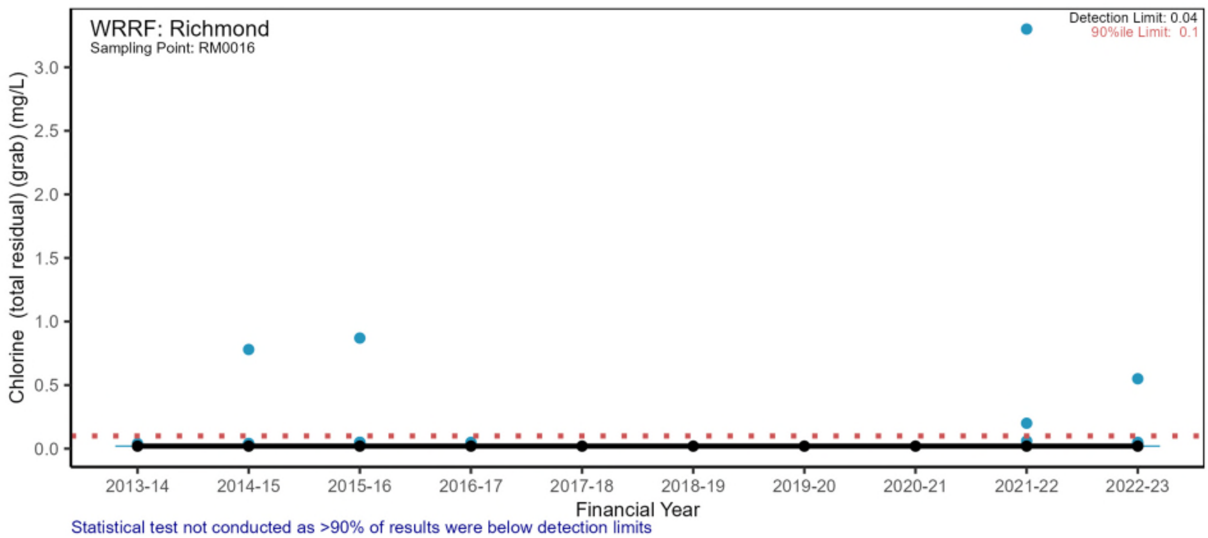

WRRF: Richmond
Sampling Point: RM0017
Detection Limit: 0.01
90%ile Limit: 5
50%ile Limit: 1
DF = 1, F = 3.41, Pr(>F) = 0.0651
Ammonia nitrogen (composite) (mg/L)
0
2
4
6
8
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

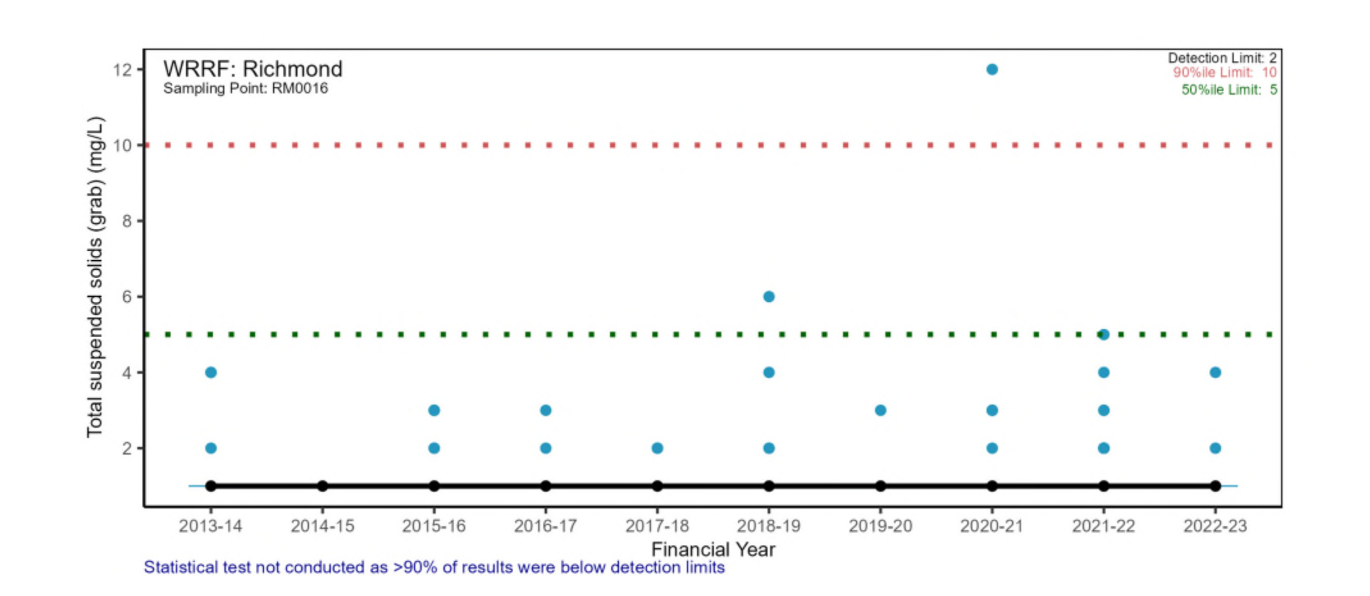

WRRF: Richmond
Sampling Point: RM0017
Detection Limit: 0.05
90%ile Limit: 15
50%ile Limit: 10
DF = 1, F = 2.27, Pr(>F) = 0.1321
Total nitrogen (composite) (mg/L)
5
10
15
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Richmond
Sampling Point: RM0017
Detection Limit: 0.01
90%ile Limit: 1
50%ile Limit: 0.3
DF = 1, F = 0.965, Pr(>F) = 0.3263
Total phosphorus (composite) (mg/L)
0.02
0.04
0.06
0.08
0.10
0.12
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

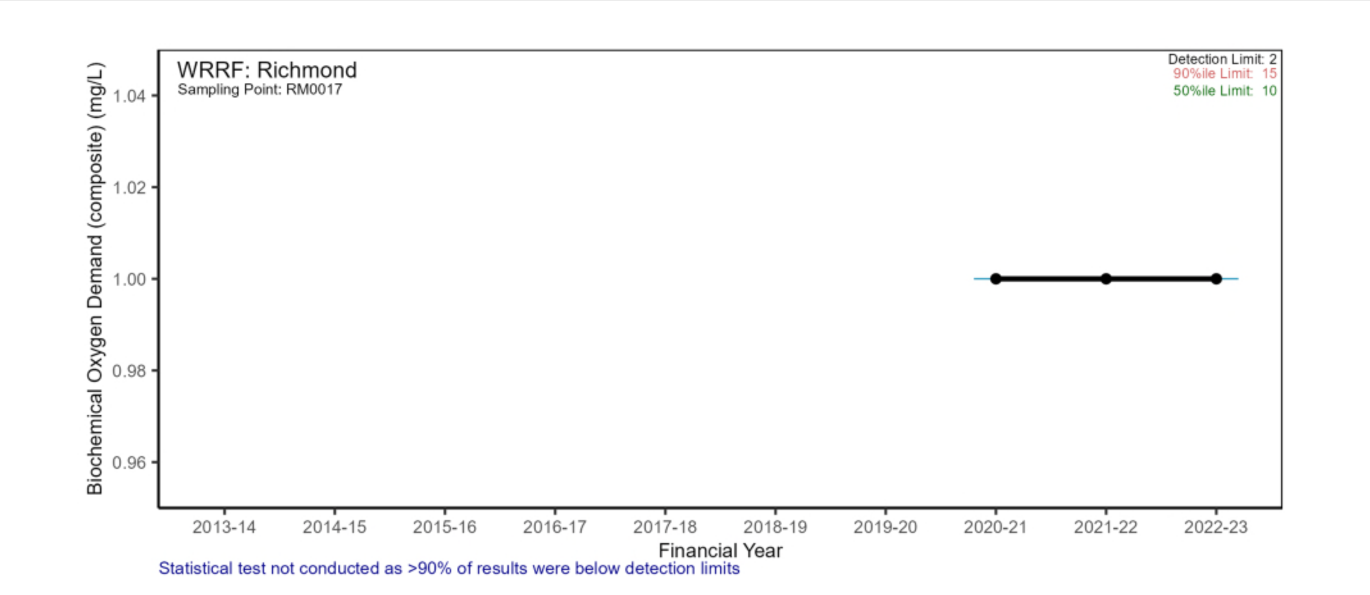

WRRF: Richmond
Sampling Point: RM0016
Detection Limit: 2
90%ile Limit: 15
50%ile Limit: 10
DF = 1, F = 0.332, Pr(>F) = 0.5653
Biochemical Oxygen Demand (grab) (mg/L)
14
12
10
8
6
4
2
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

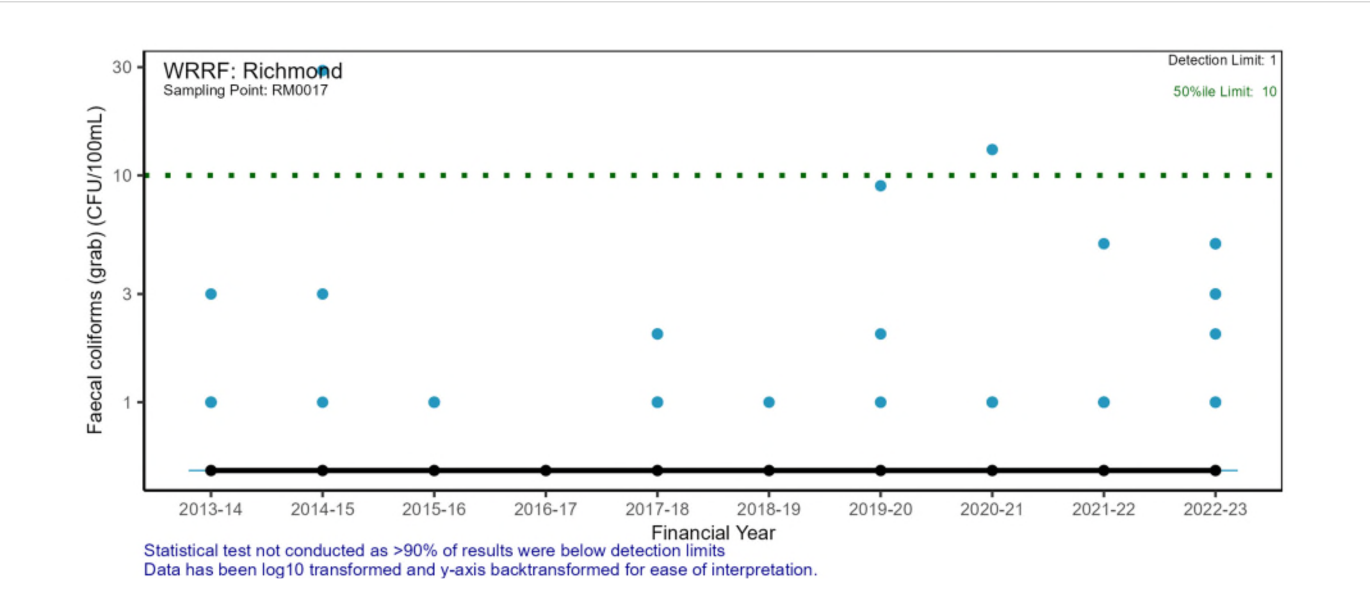

WRRF: Richmond
Sampling Point: RM0016
Detection Limit: 1
80%ile Limit: 200
DF = 1, F = 0.241, Pr(>F) = 0.6238
Faecal coliforms (grab) (CFU/100mL)
100000
1000
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

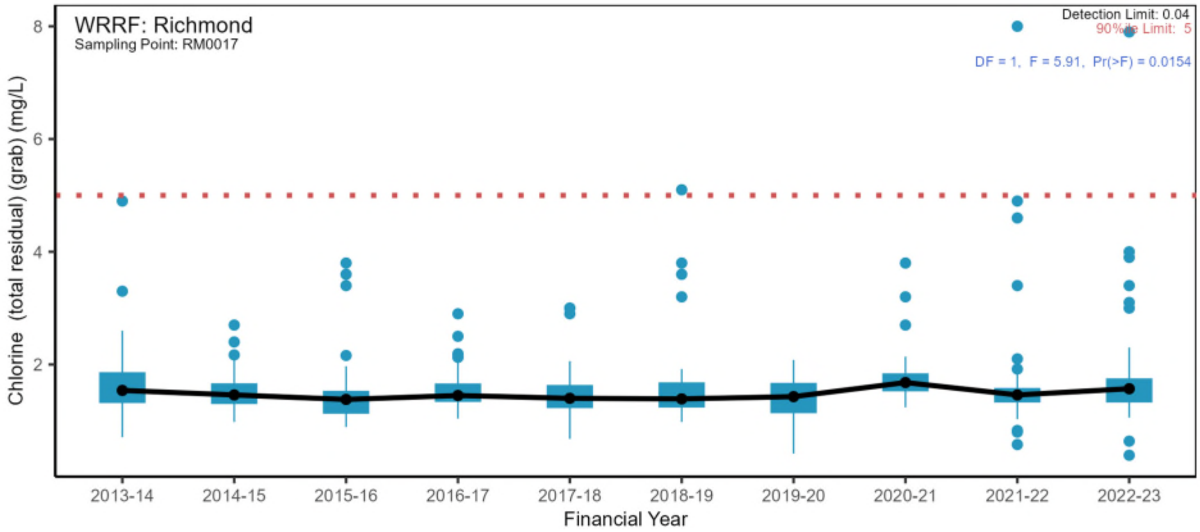

WRRF: Richmond
Sampling Point: RM0016
Detection Limit: 0.04
90%ile Limit: 0.1
Chlorine (total residual) (grab) (mg/L)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits

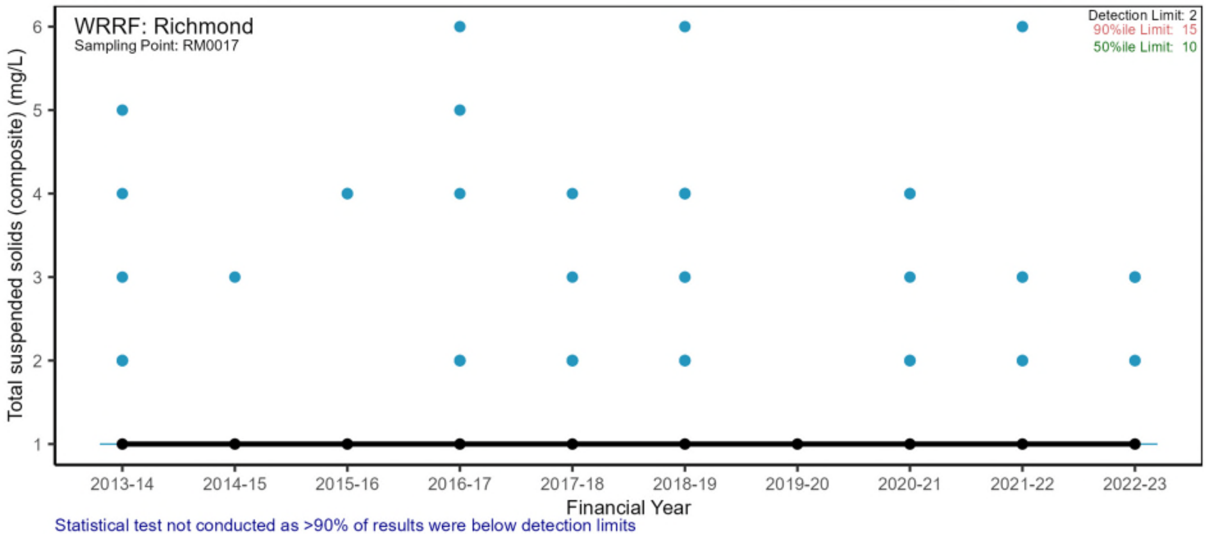


Major conventional analytes (RM0017 Effluent)

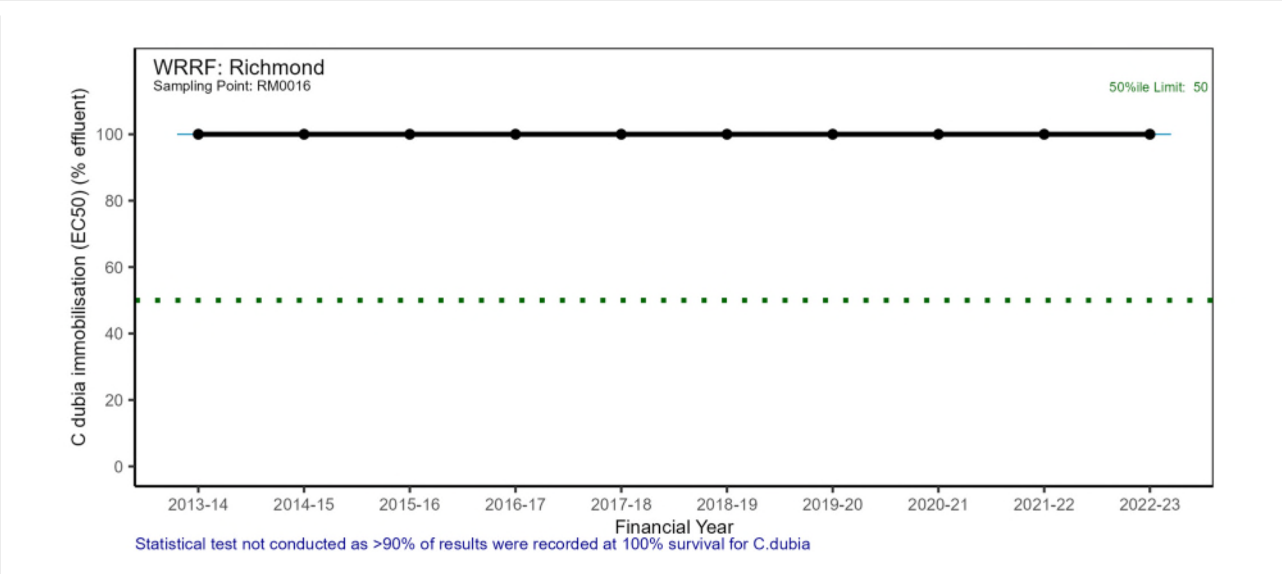





WRRF: Richmond
Sampling Point: RM0017
Detection Limit: 0.04
90%ile Limit: 5
DF = 1, F = 5.91, Pr(>F) = 0.0154
Chlorine (total residual) (grab) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

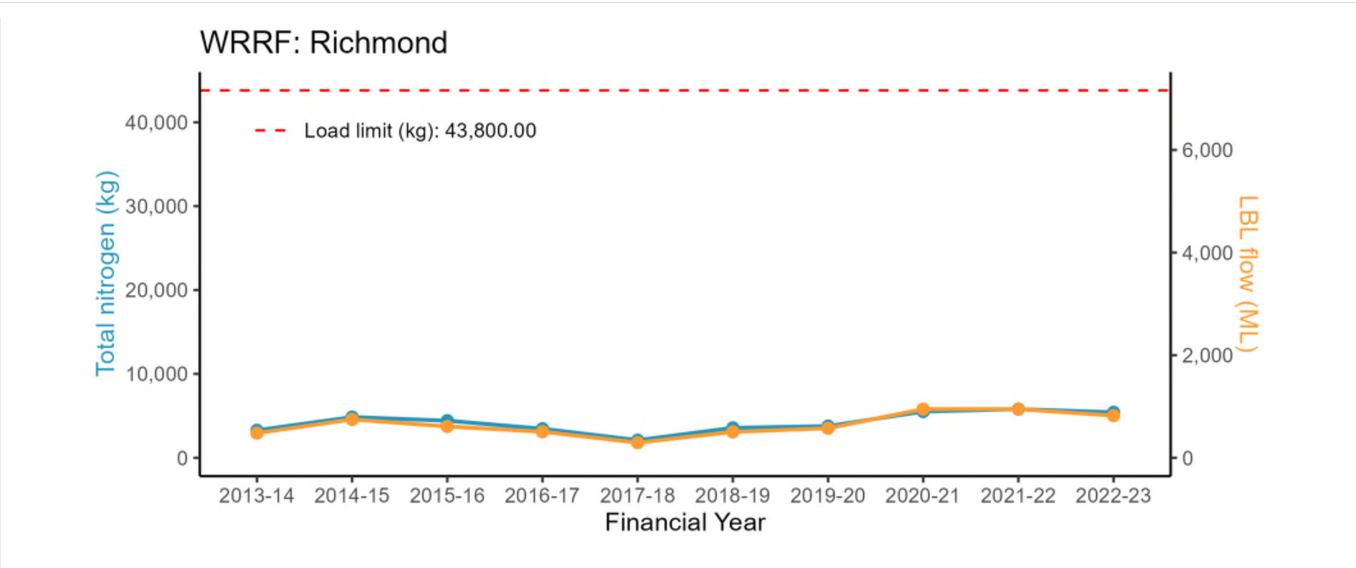

WRRF: Richmond
Sampling Point: RM0017
Detection Limit: 2
90%ile Limit: 15
50%ile Limit: 10
Total suspended solids (composite) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Statistical test not conducted as >90% of results were below detection limits

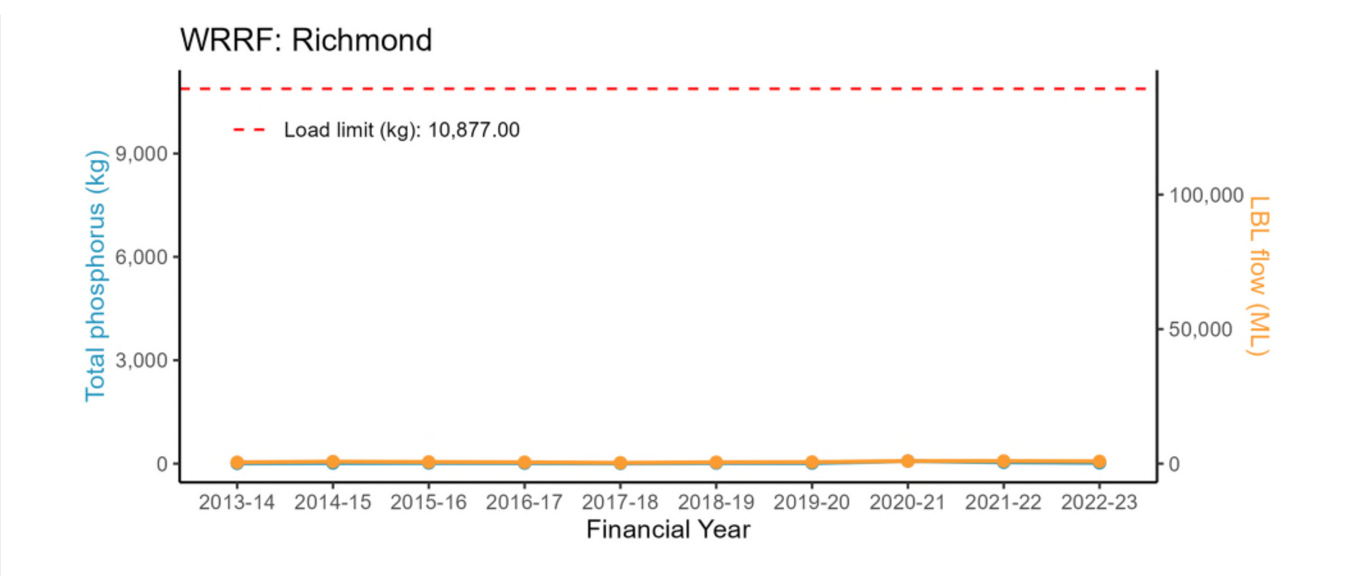
A-7.3 Pressure – Wastewater toxicity



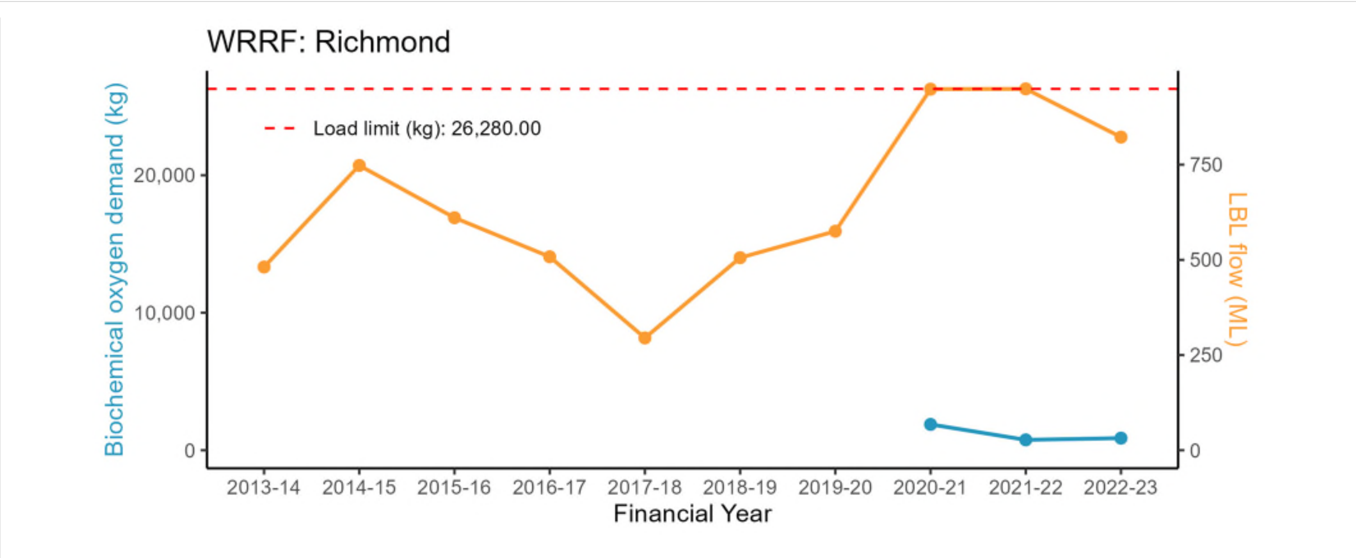
A-7.4 Pressure – Wastewater discharge load

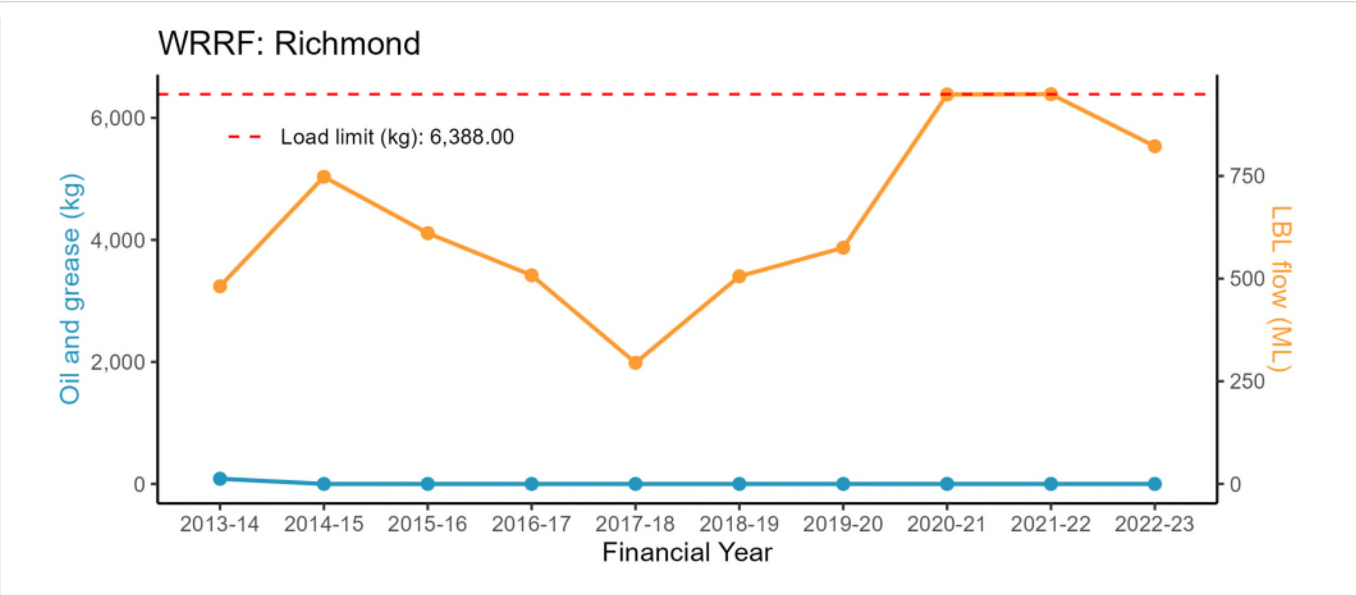
Nutrients

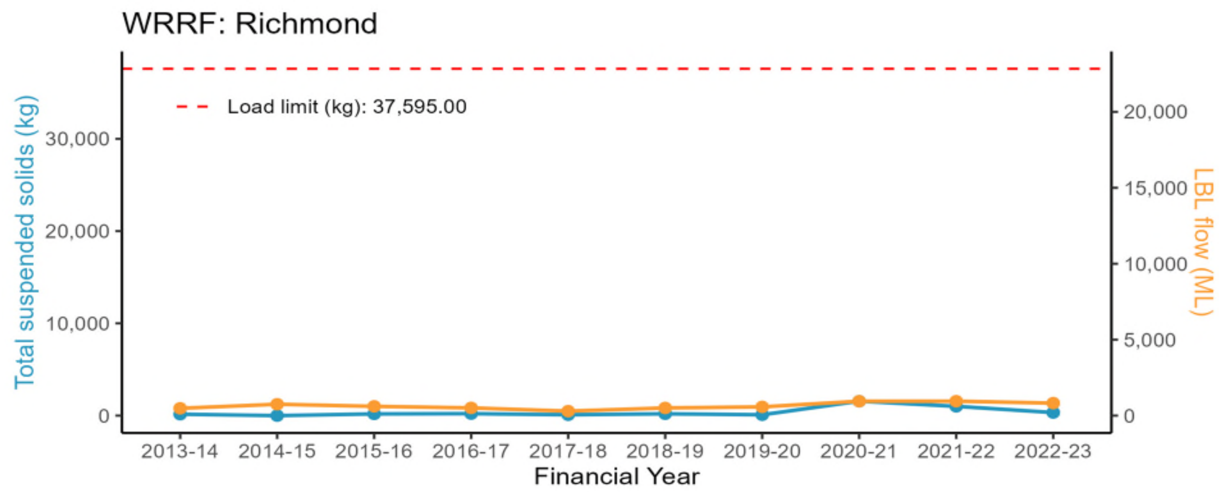




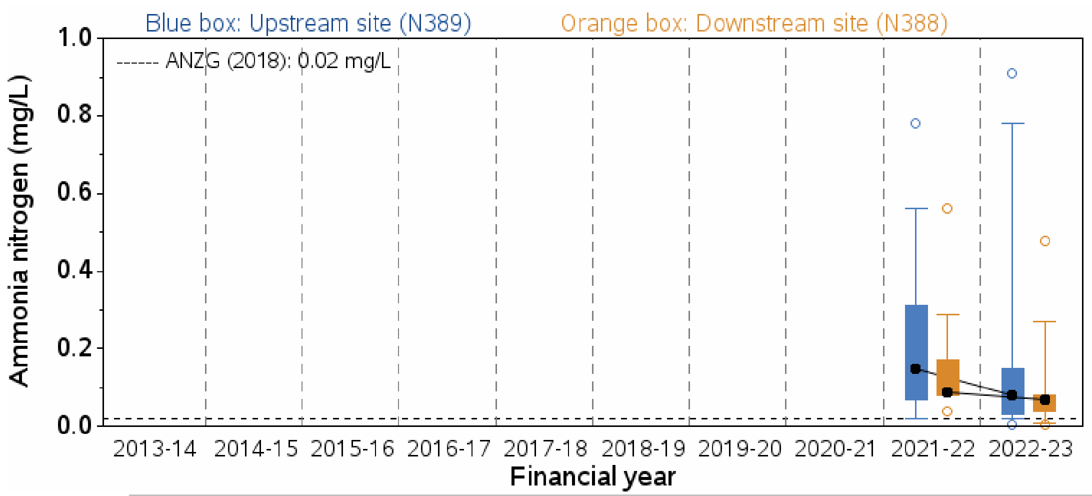
Major conventional analytes



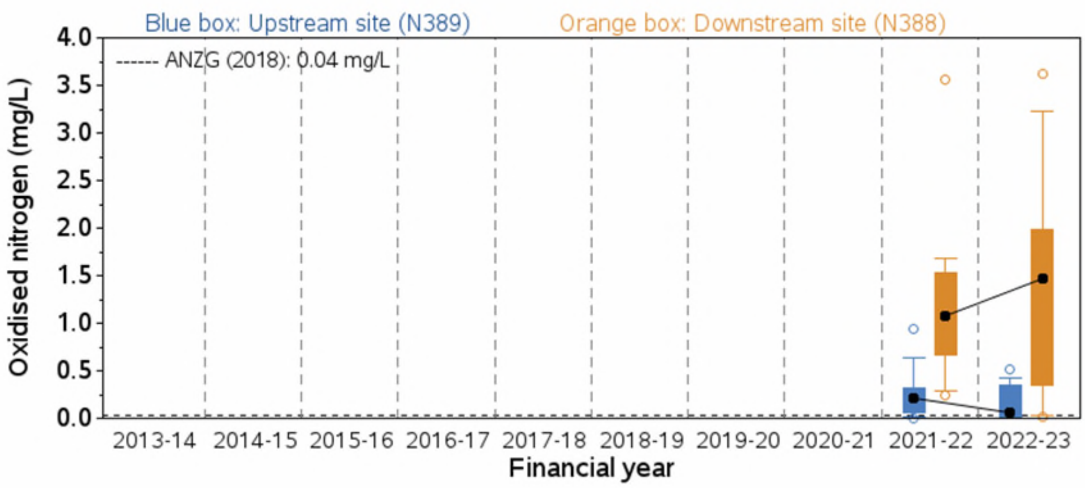




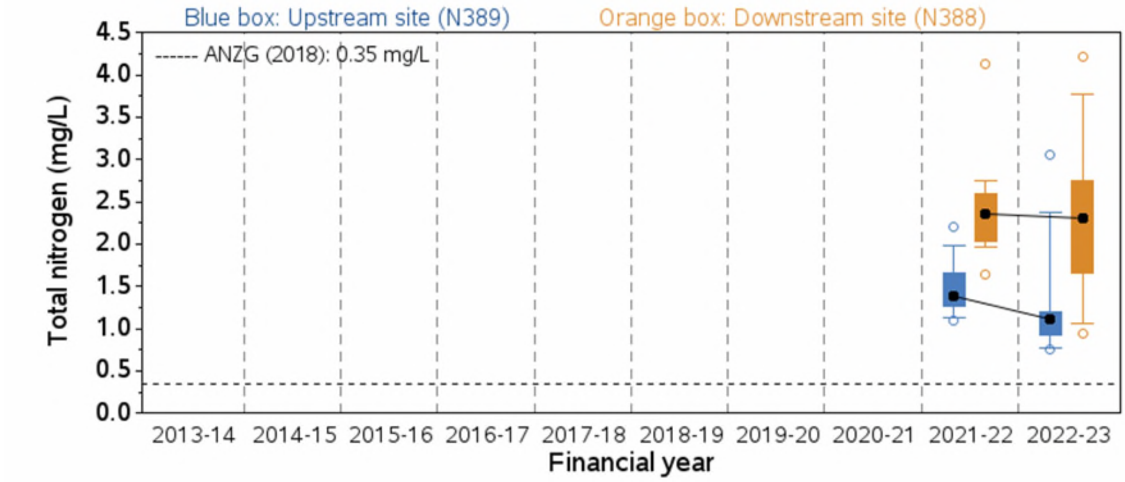
A-7.5 Stressor – Nutrients



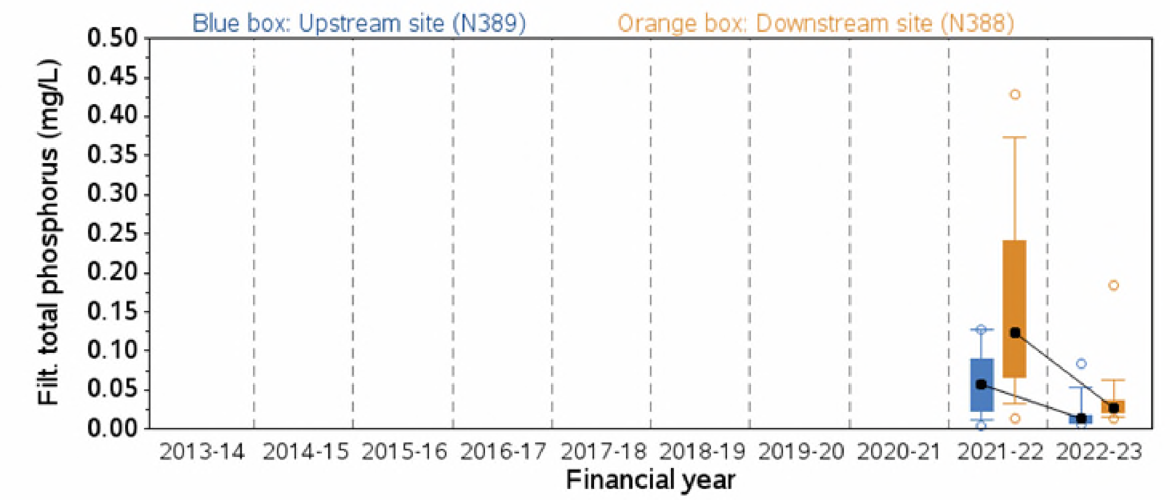
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.21	0.6488	N388	1	1.15	0.2936



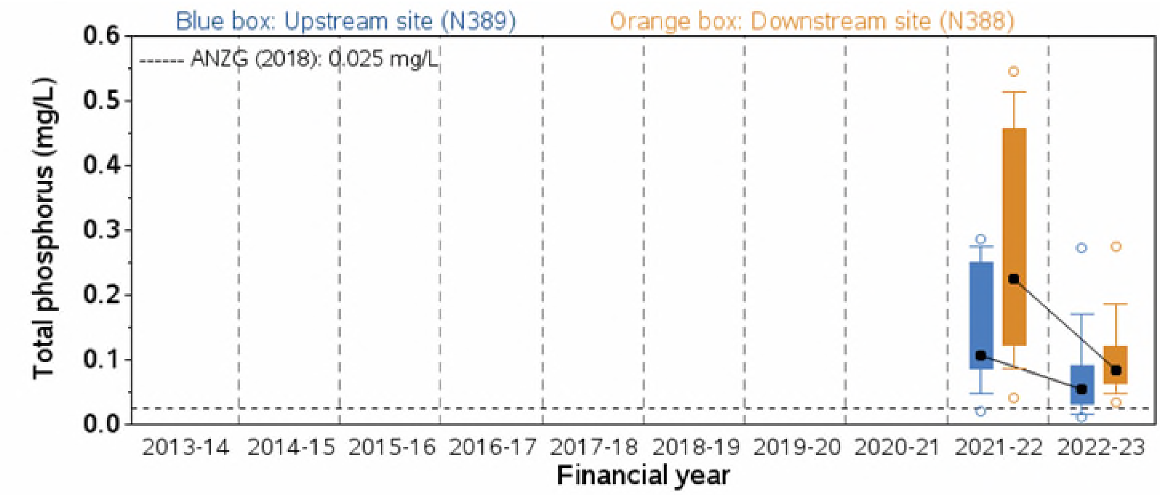
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	1.02	0.3217	N388	1	0.07	0.7976



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	1.44	0.2416	N388	1	0.17	0.6833

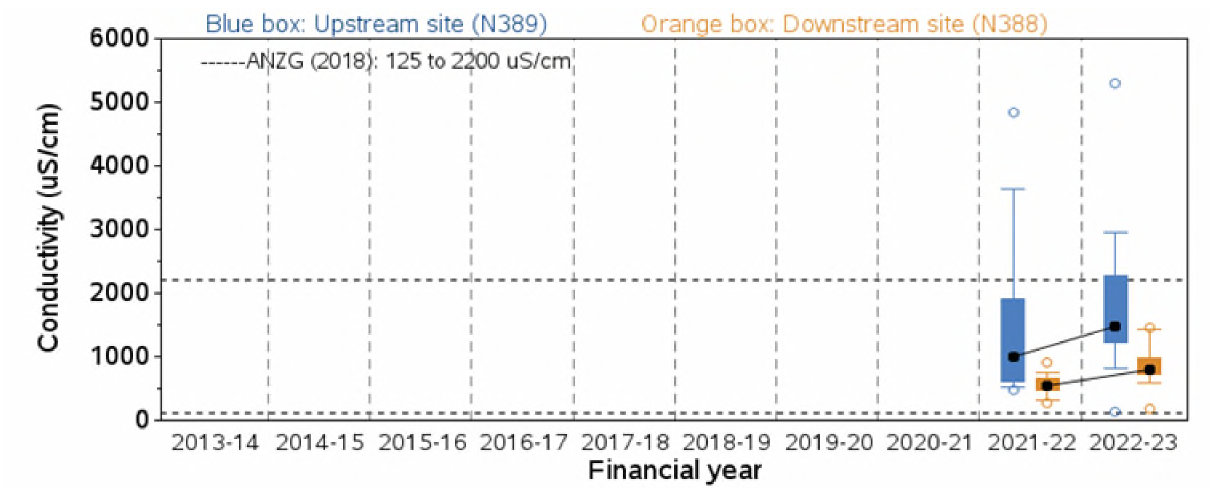


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	11.23	0.0026	N388	1	11.67	0.0021

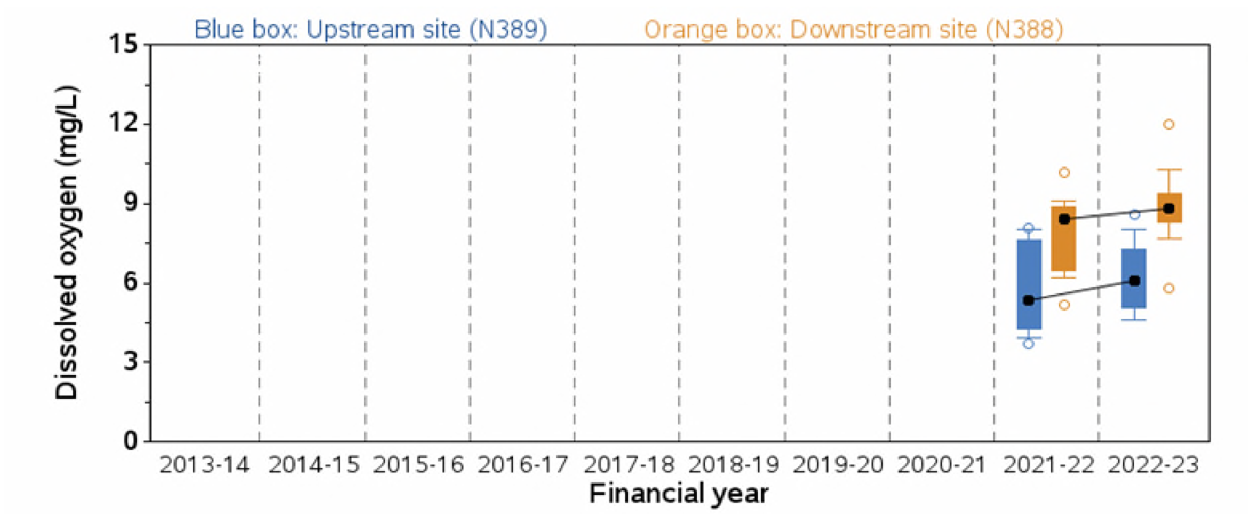


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	5.77	0.0241	N388	1	13.07	0.0013

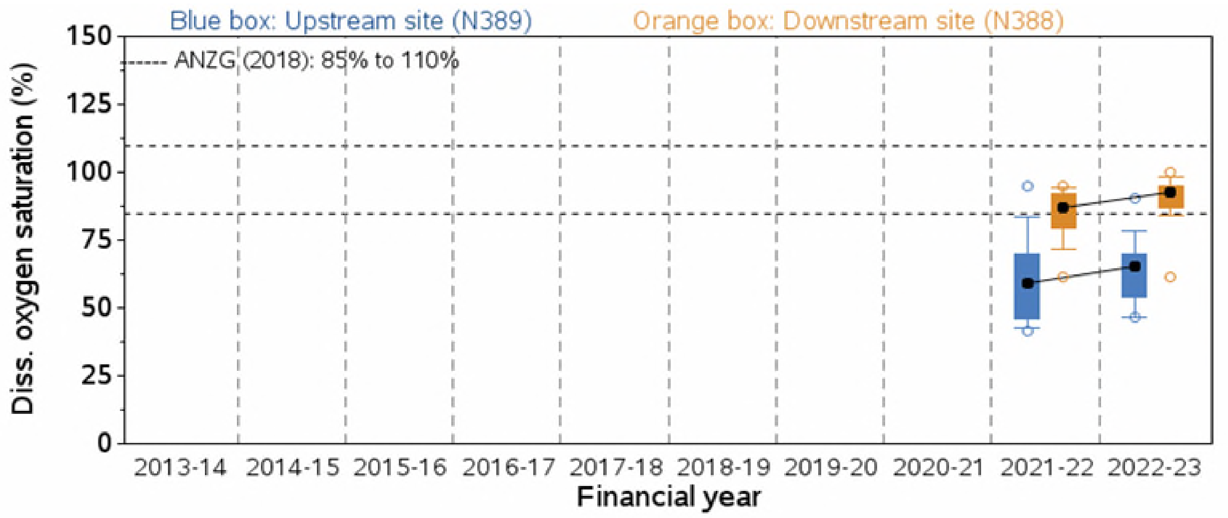
A-7.6 Stressor – Physico-chemical water quality



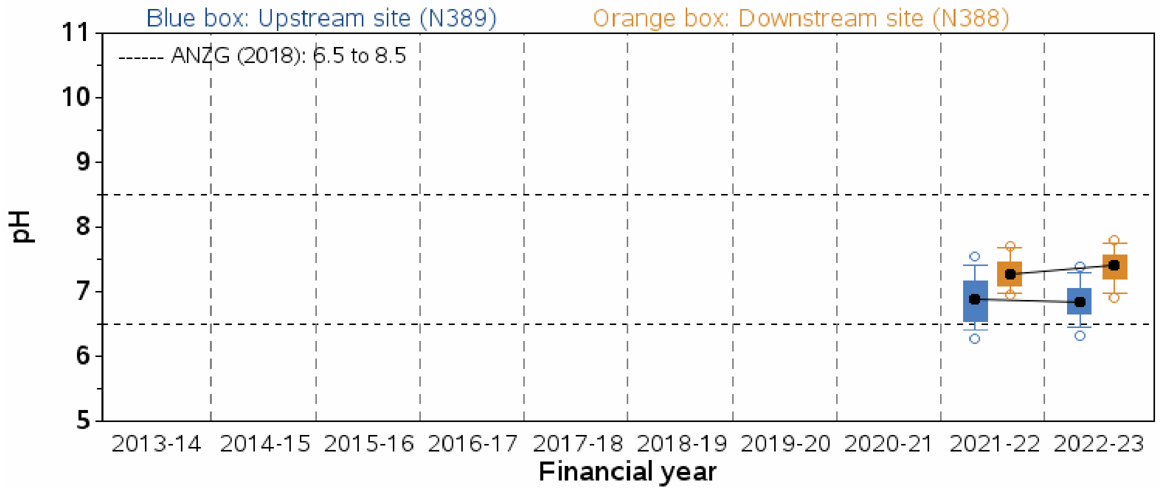
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.5	0.4877	N388	1	9.18	0.0055



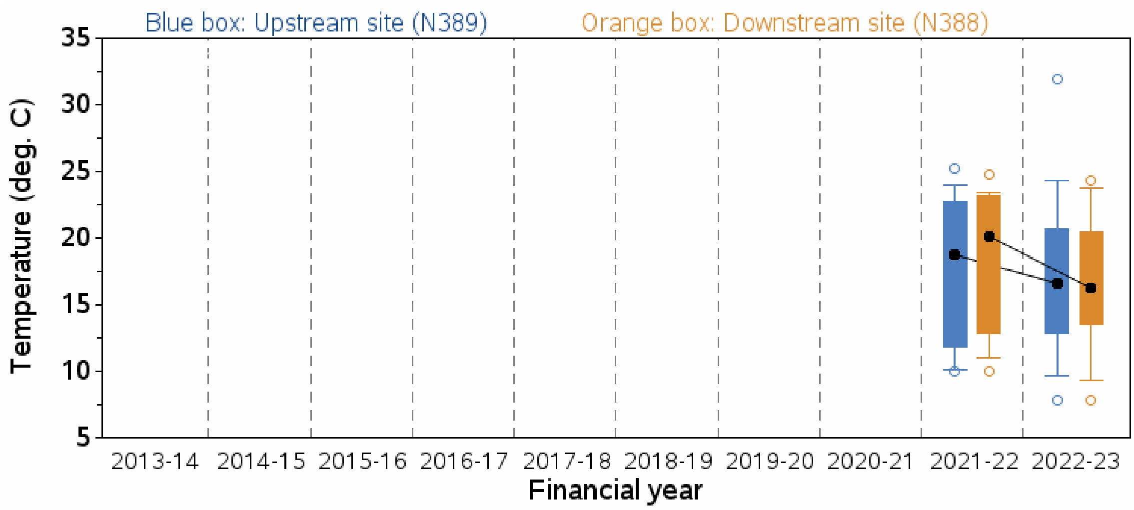
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.69	0.413	N388	1	3.7	0.0656



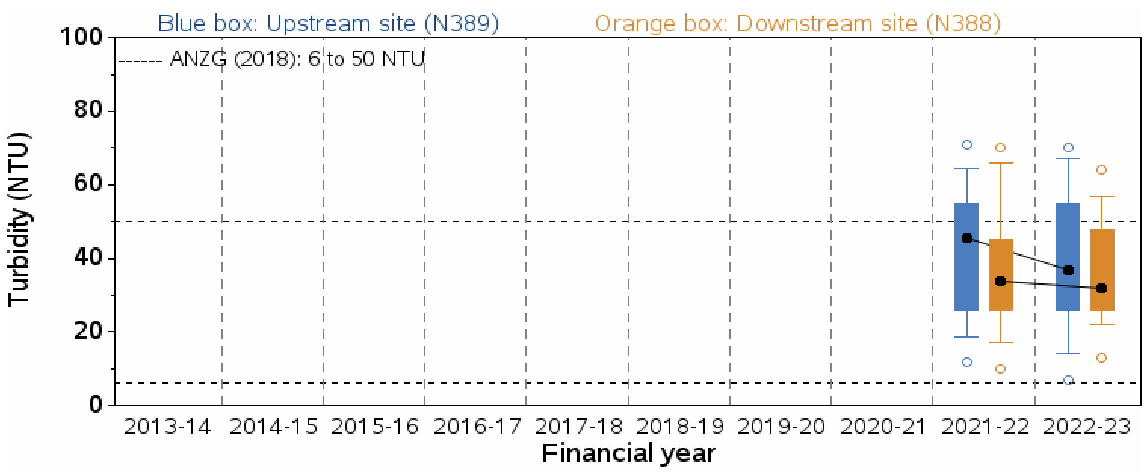
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.35	0.5601	N388	1	2.95	0.0979



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.17	0.6871	N388	1	1.15	0.2935

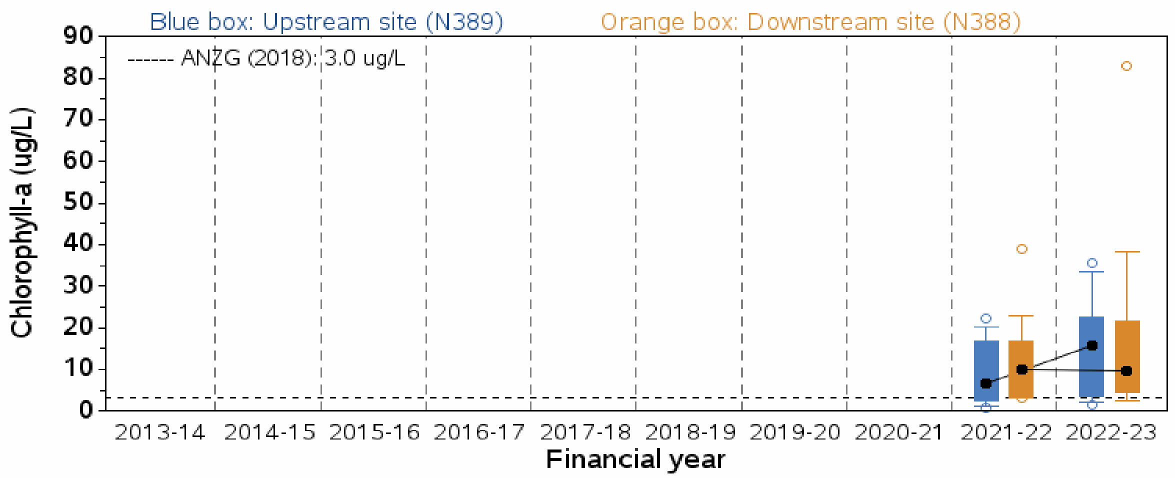


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.11	0.7419	N388	1	1.48	0.2345

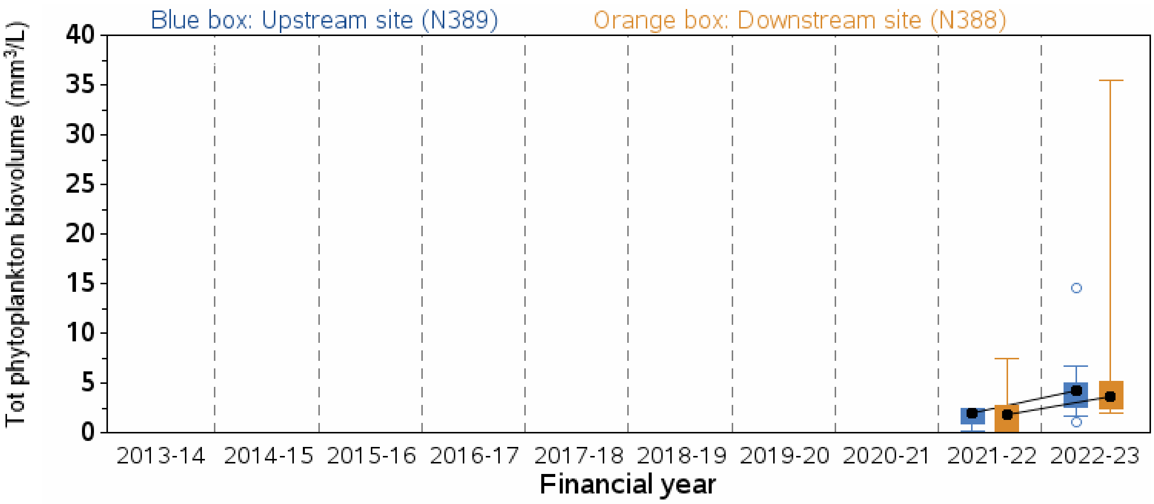


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.16	0.6944	N388	1	0	0.9793

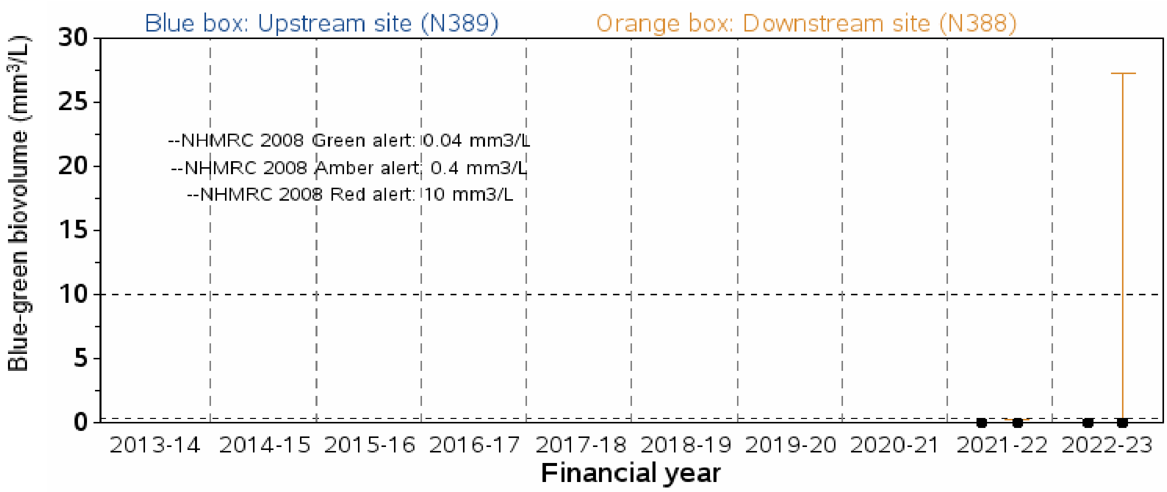
A-7.7 Ecosystem receptor – Phytoplankton



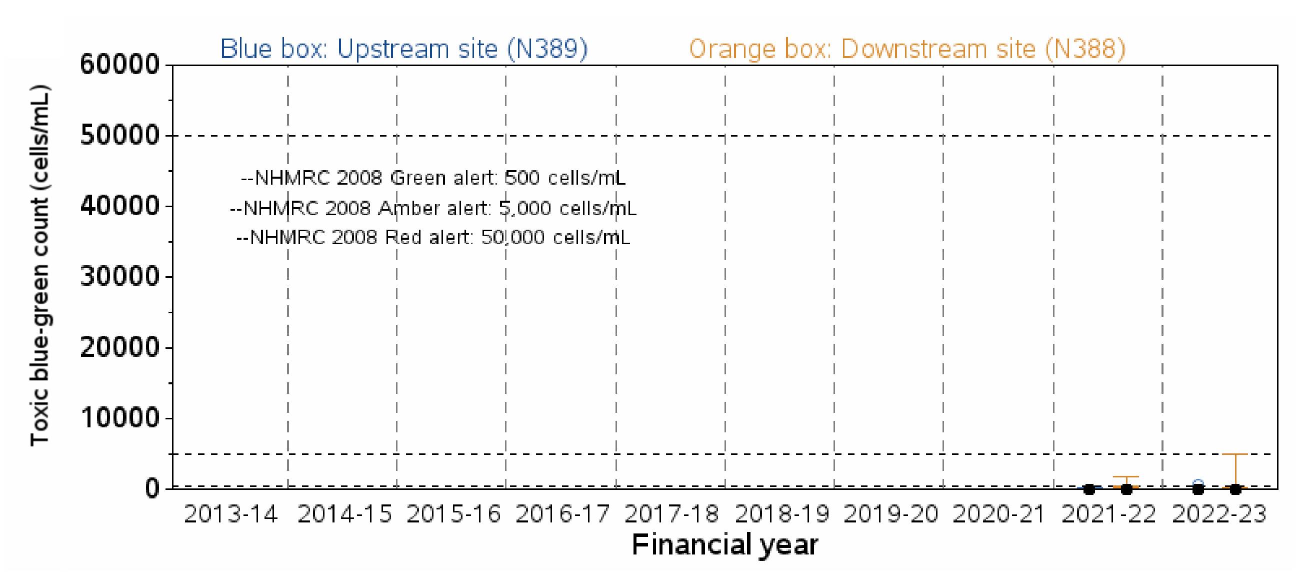
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	2.34	0.1383	N388	1	0.37	0.5472



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	3.57	0.0782	N388	1	1.53	0.2371



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.75	0.4016	N388	1	0.76	0.3967



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
N389	1	0.11	0.7431	N388	1	0.17	0.6872

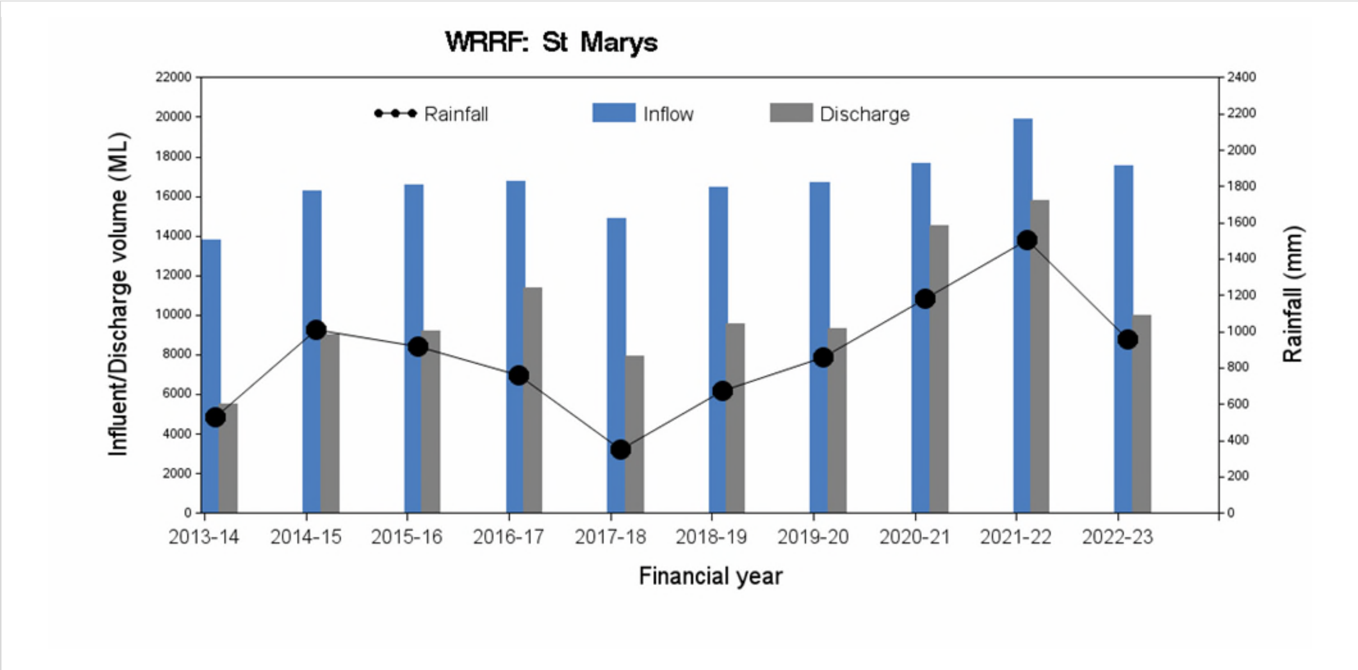
A-7.8 Ecosystem receptor – Macroinvertebrates

Assessment of stream health could not be conducted this year due to a low number of samples. Monitoring for sites upstream and downstream of Richmond WRRF began as part of the new SWAM program and other projects in 2022-23. Initial outcomes of SIGNAL-SG scores and t-tests can be performed from 2023-24 onwards, and multivariate analysis will commence once >4 years of continuous data is generated.

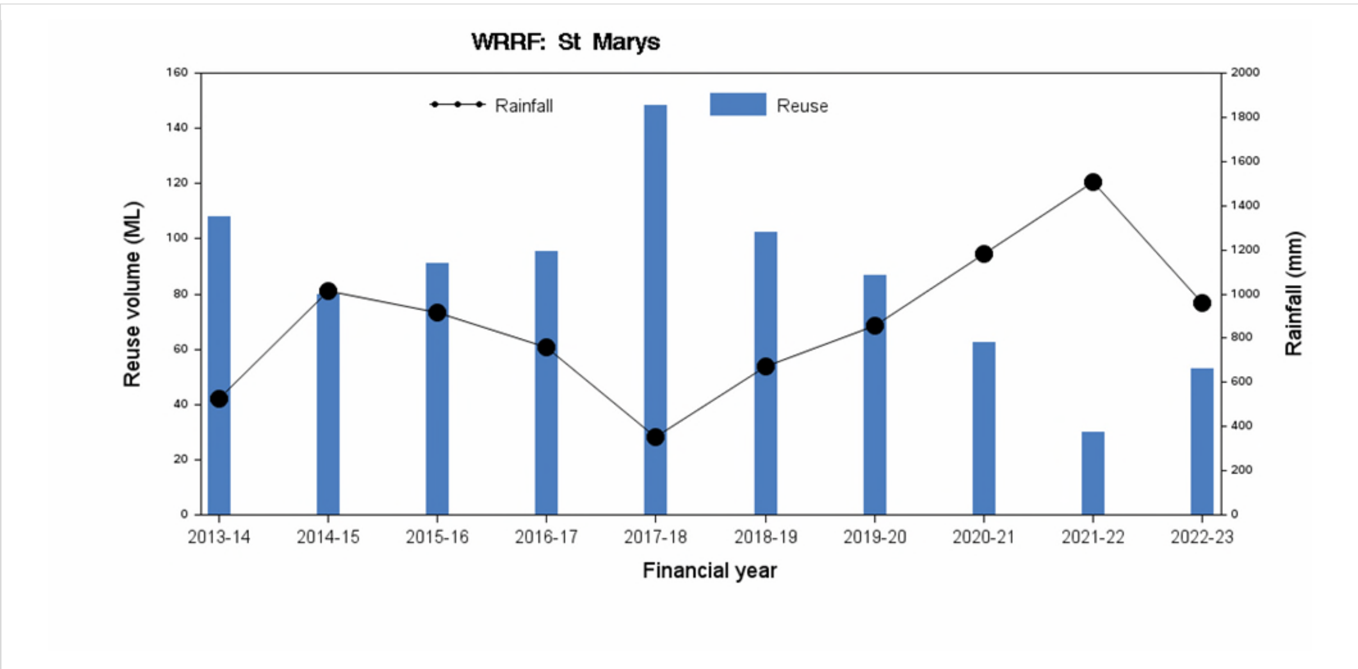
A-8 St Marys WRRF

A-8.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

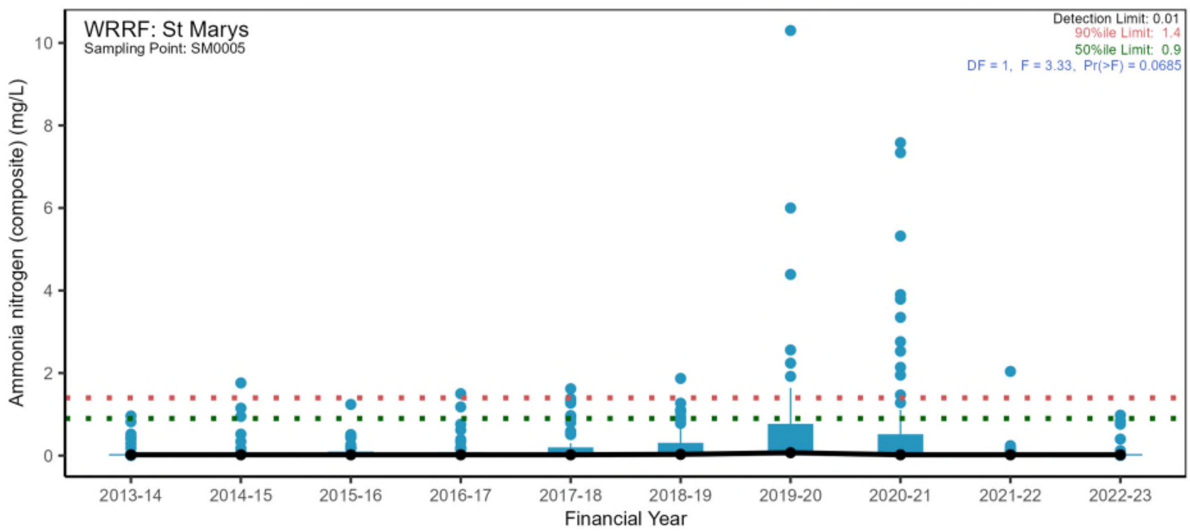


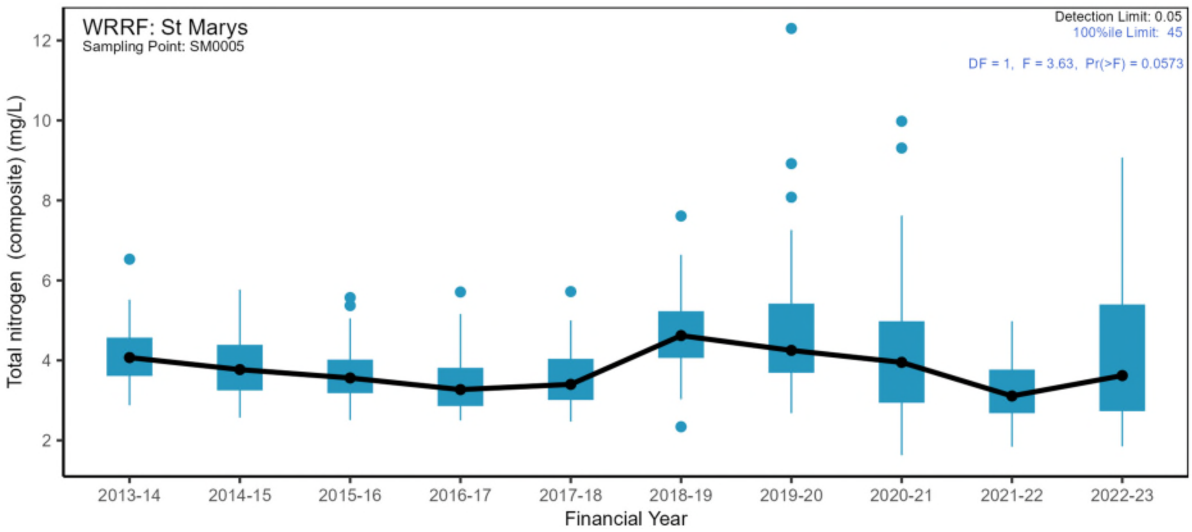
Reuse volume and rainfall

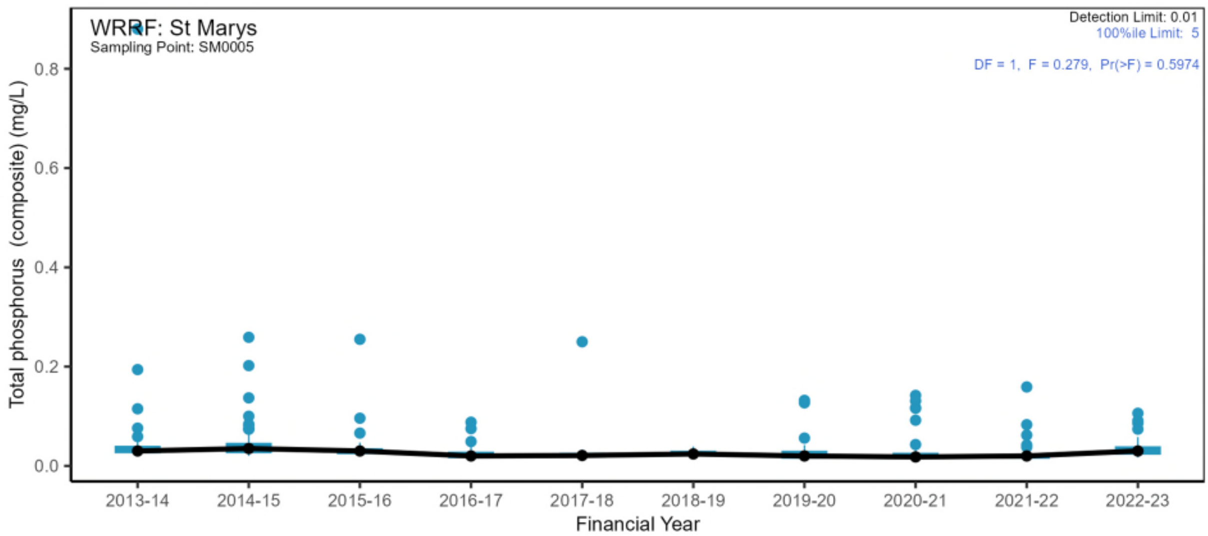


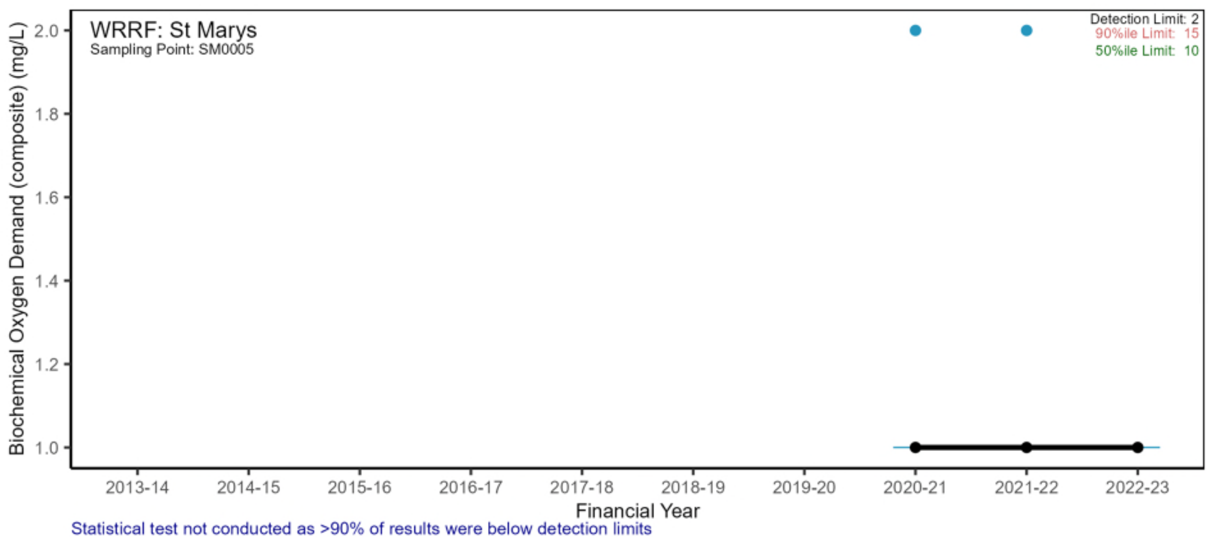
A-8.2 Pressure – Wastewater quality

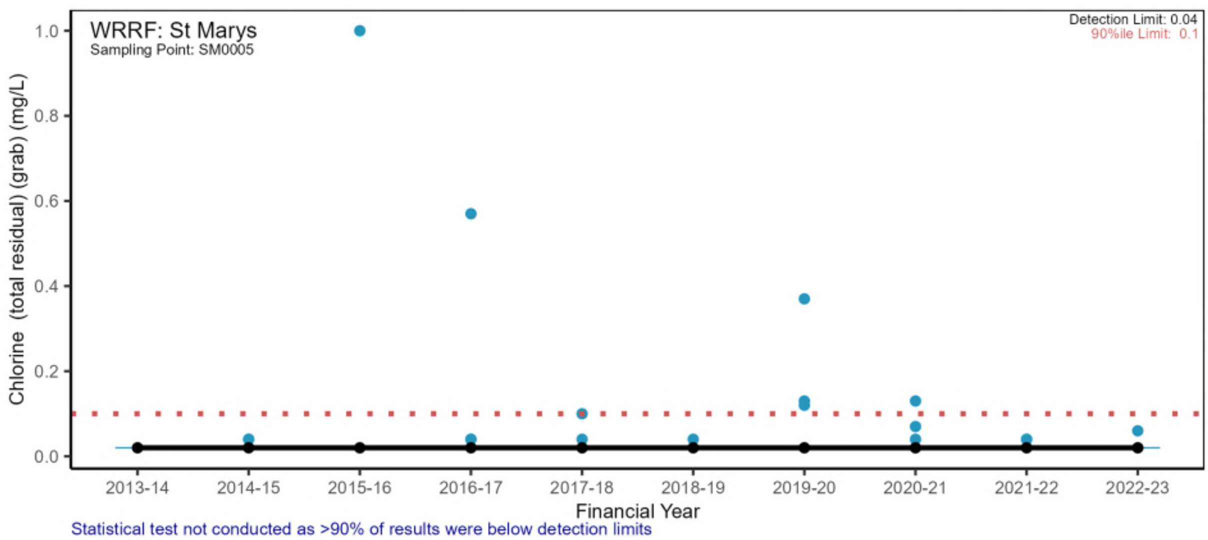
Nutrients

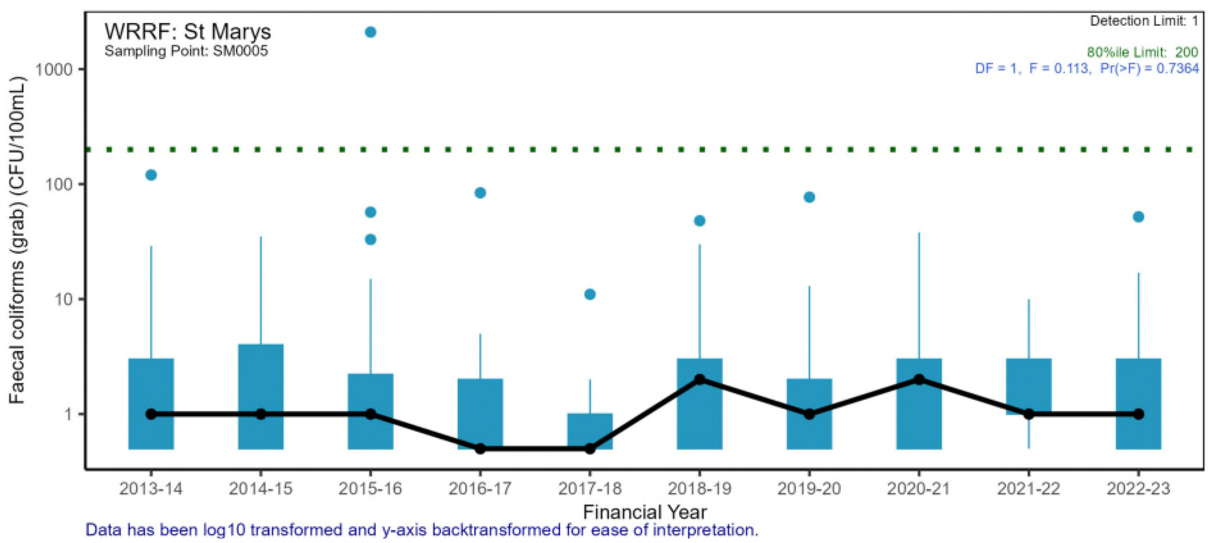


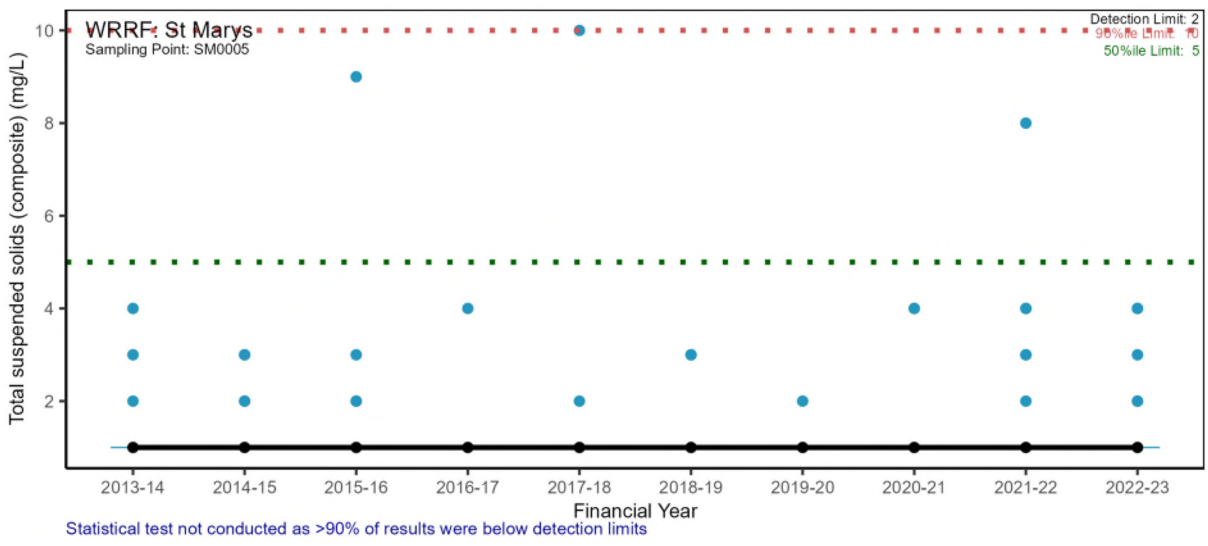




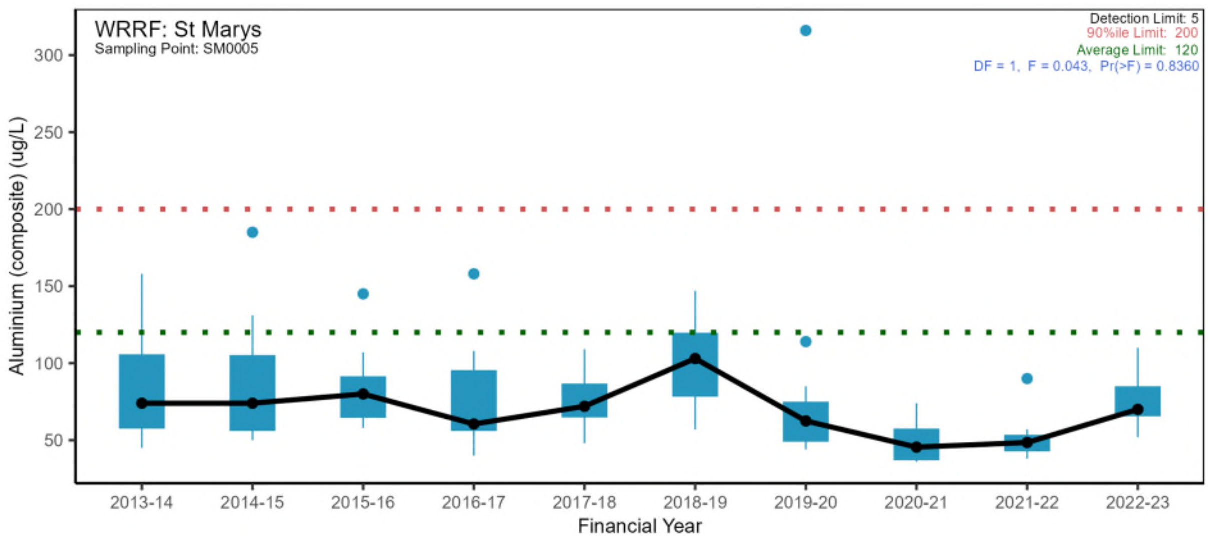

WRRF: St Marys
Sampling Point: SM0005
Detection Limit: 2
90%ile Limit: 15
50%ile Limit: 10
Biochemical Oxygen Demand (composite) (mg/L)
2.0
1.8
1.6
1.4
1.2
1.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits

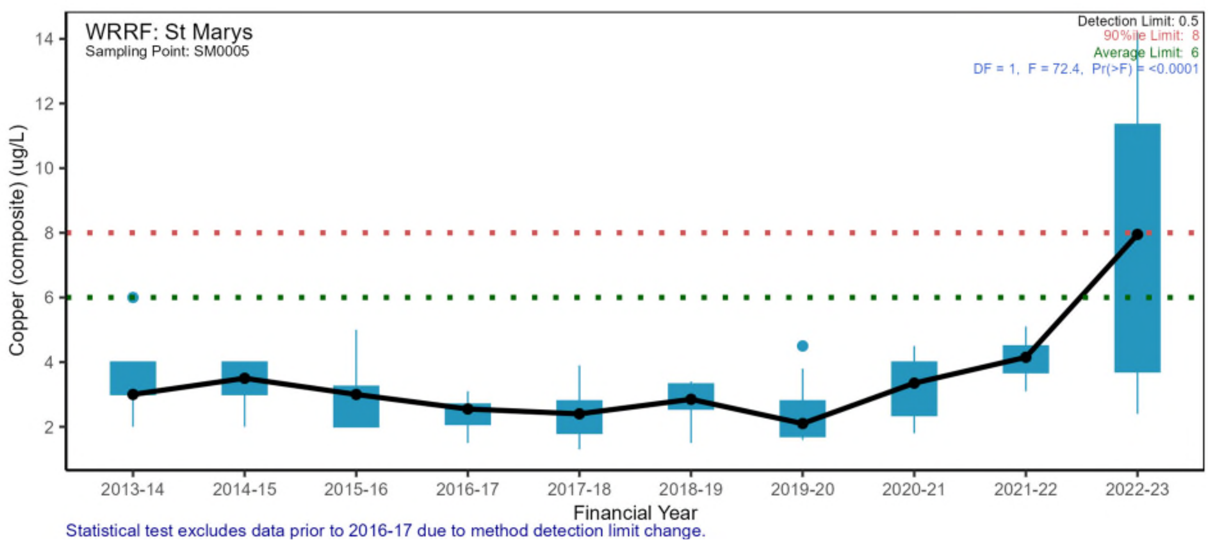

WRRF: St Marys
Sampling Point: SM0005
Detection Limit: 0.04
90%ile Limit: 0.1
Chlorine (total residual) (grab) (mg/L)
1.0
0.8
0.6
0.4
0.2
0.0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits

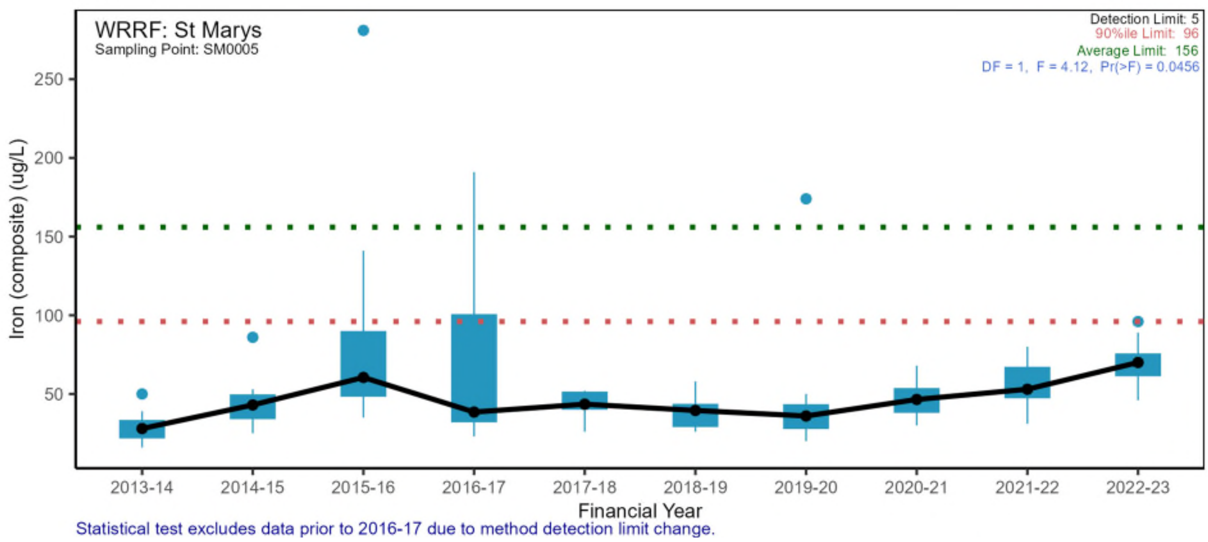

WRRF: St Marys
Sampling Point: SM0005
Detection Limit: 1
80%ile Limit: 200
DF = 1, F = 0.113, Pr(>F) = 0.7364
Faecal coliforms (grab) (CFU/100mL)
1000
100
10
1
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

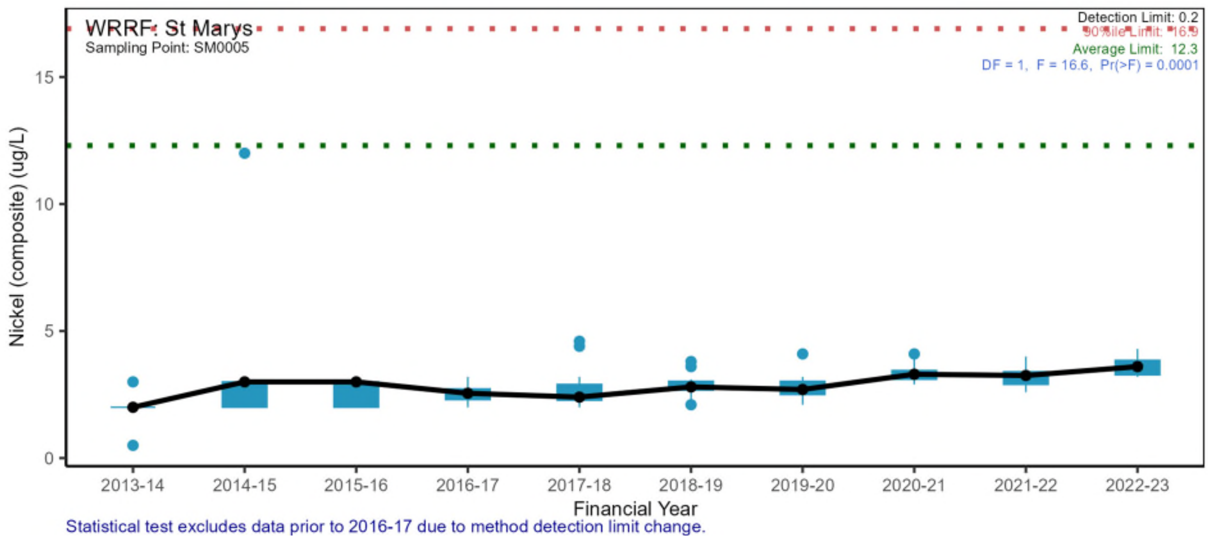


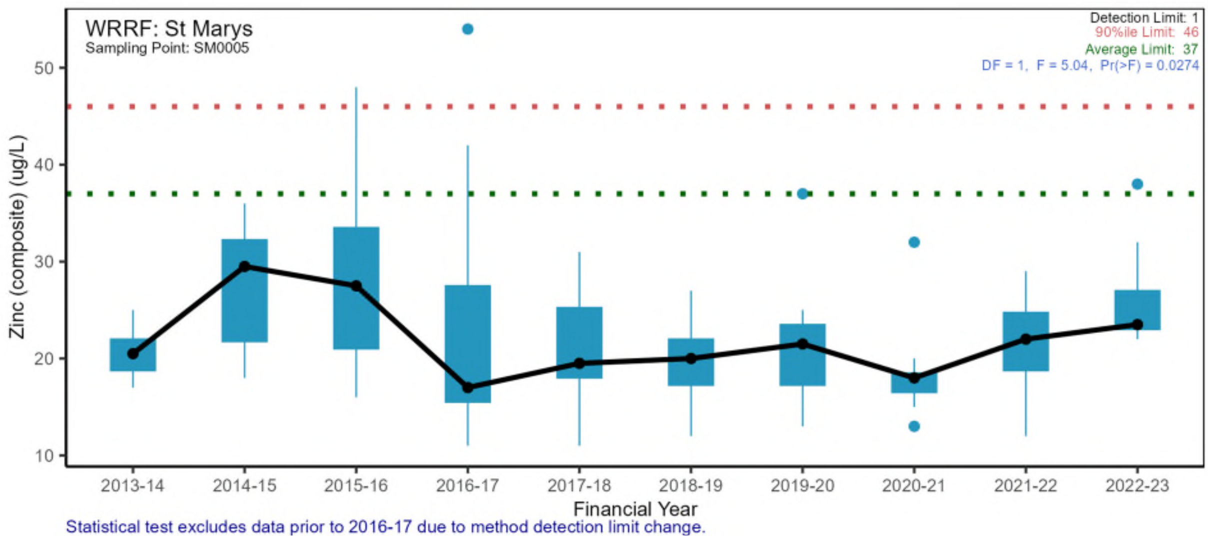
Trace metals

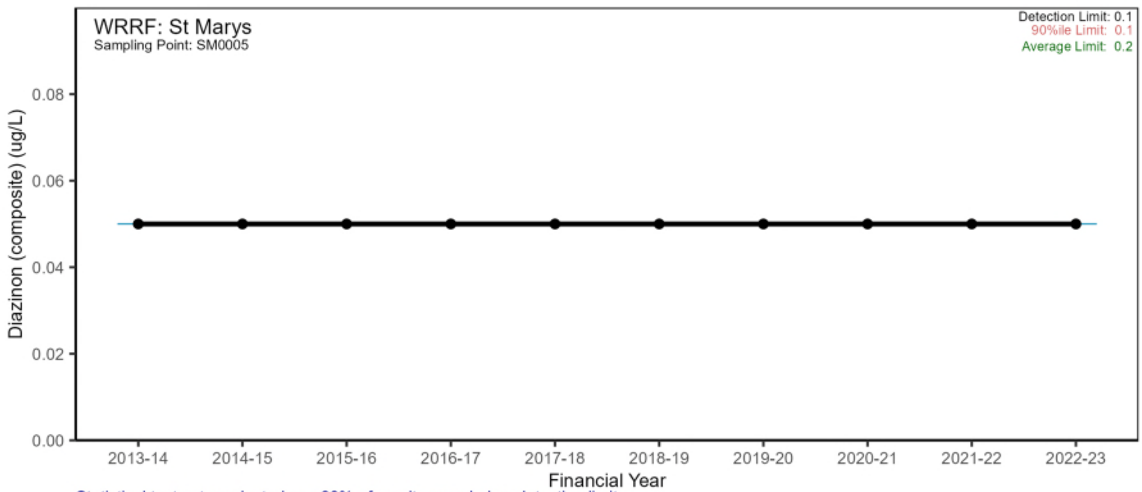




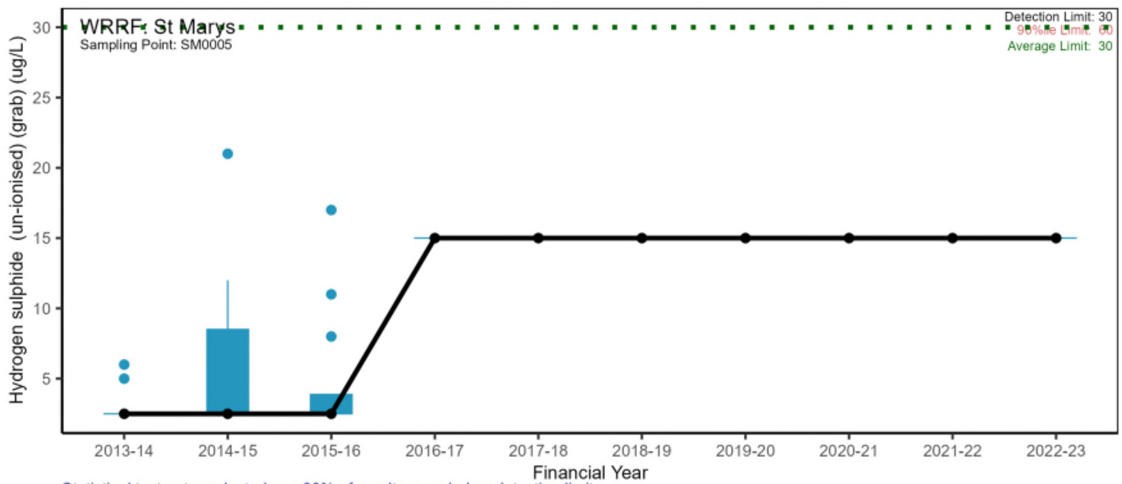

WRRF: St Marys
Sampling Point: SM0005
Detection Limit: 5
90%ile Limit: 96
Average Limit: 156
DF = 1, F = 4.12, Pr(>F) = 0.0456
Iron (composite) (ug/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Statistical test excludes data prior to 2016-17 due to method detection limit change.


WRRF: St Marys
Sampling Point: SM0005
Detection Limit: 0.2
90%ile Limit: 16.9
Average Limit: 12.3
DF = 1, F = 16.6, Pr(>F) = 0.0001
Nickel (composite) (ug/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Statistical test excludes data prior to 2016-17 due to method detection limit change.


WRRF: St Marys
Sampling Point: SM0005
Detection Limit: 1
90%ile Limit: 46
Average Limit: 37
DF = 1, F = 5.04, Pr(>F) = 0.0274
Zinc (composite) (ug/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Statistical test excludes data prior to 2016-17 due to method detection limit change.

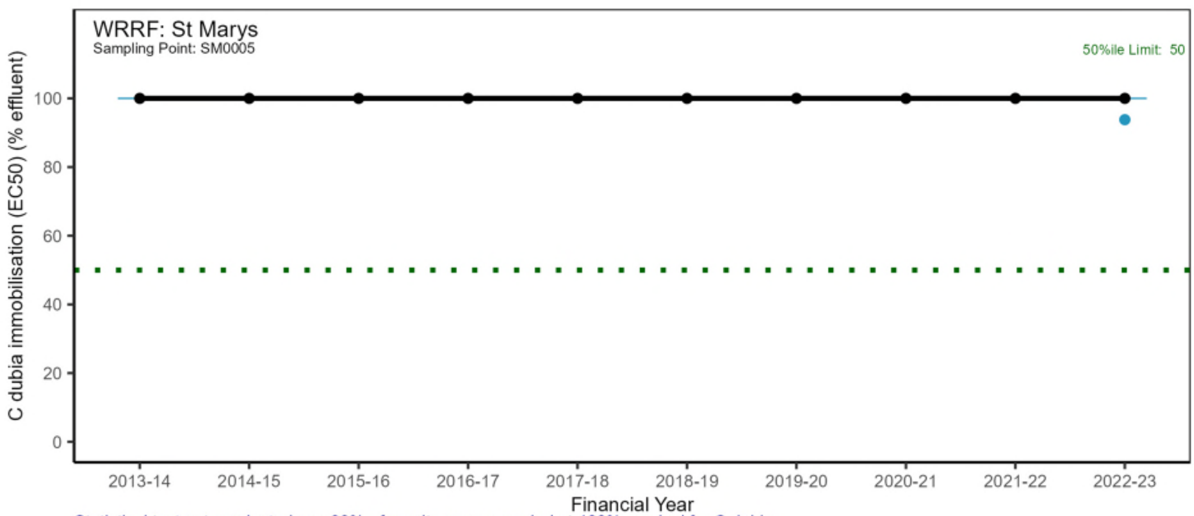


Statistical test not conducted as >90% of results were below detection limits



Statistical test not conducted as >90% of results were below detection limits

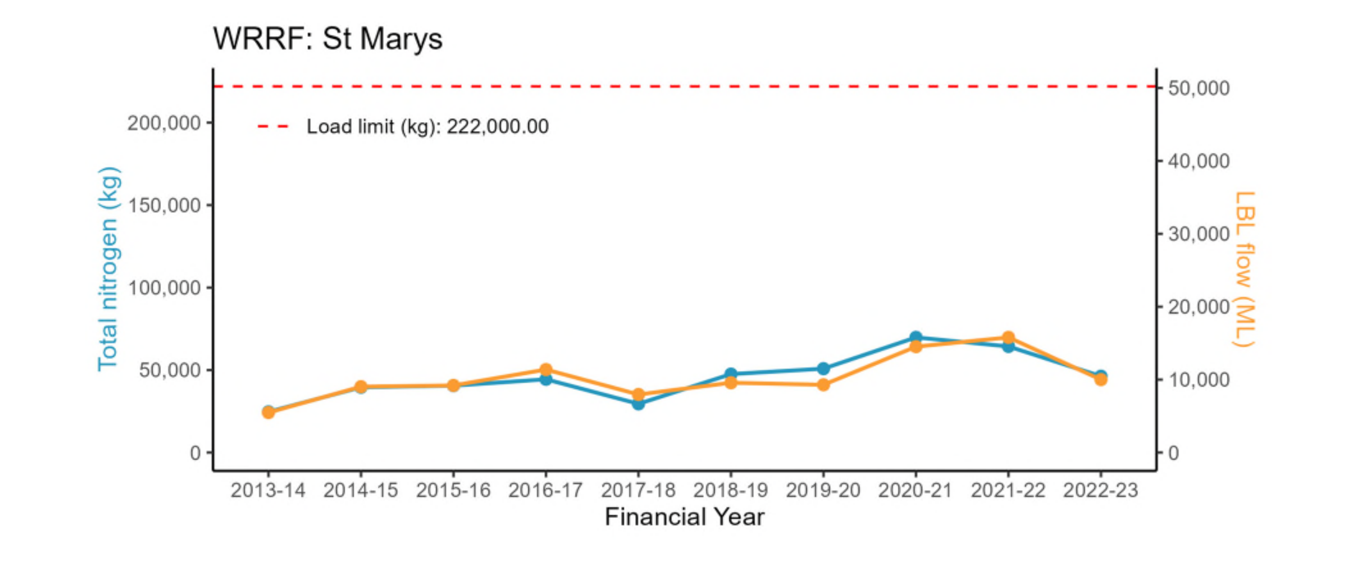
A-8.3 Pressure – Wastewater toxicity

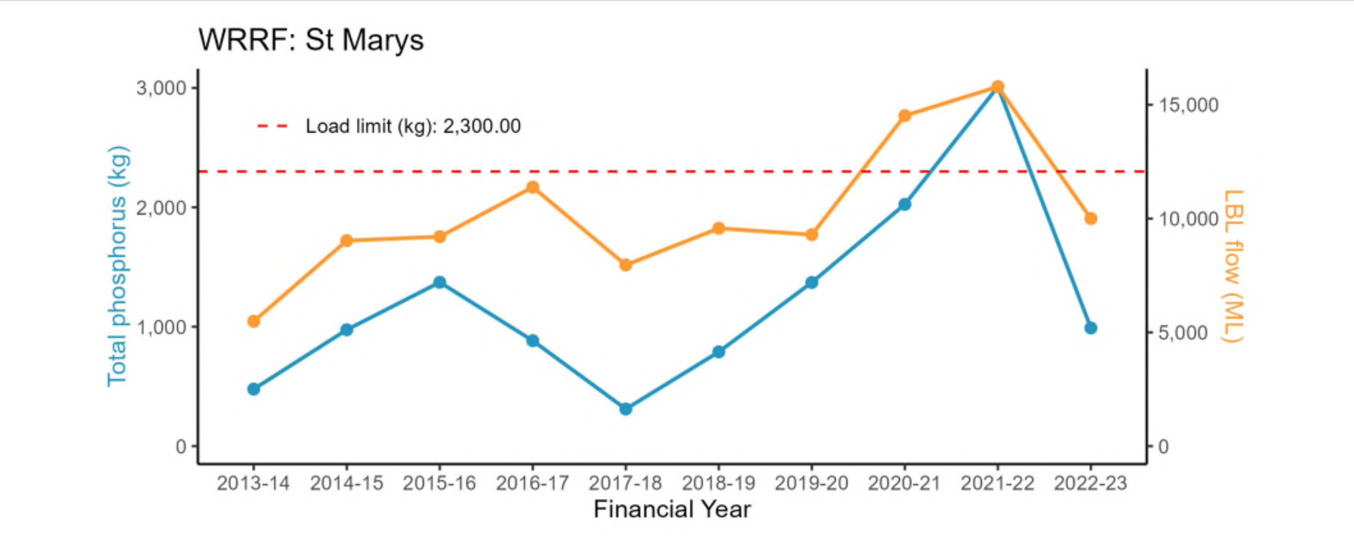


Statistical test not conducted as >90% of results were recorded at 100% survival for C.dubia

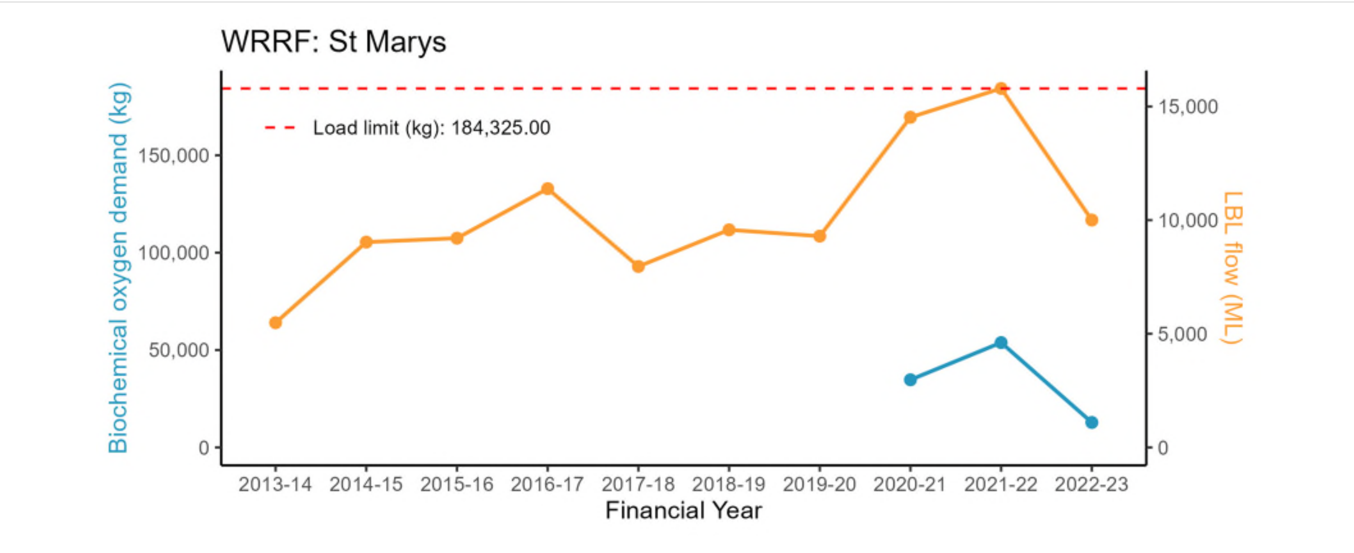
A-8.4 Pressure – Wastewater discharge load

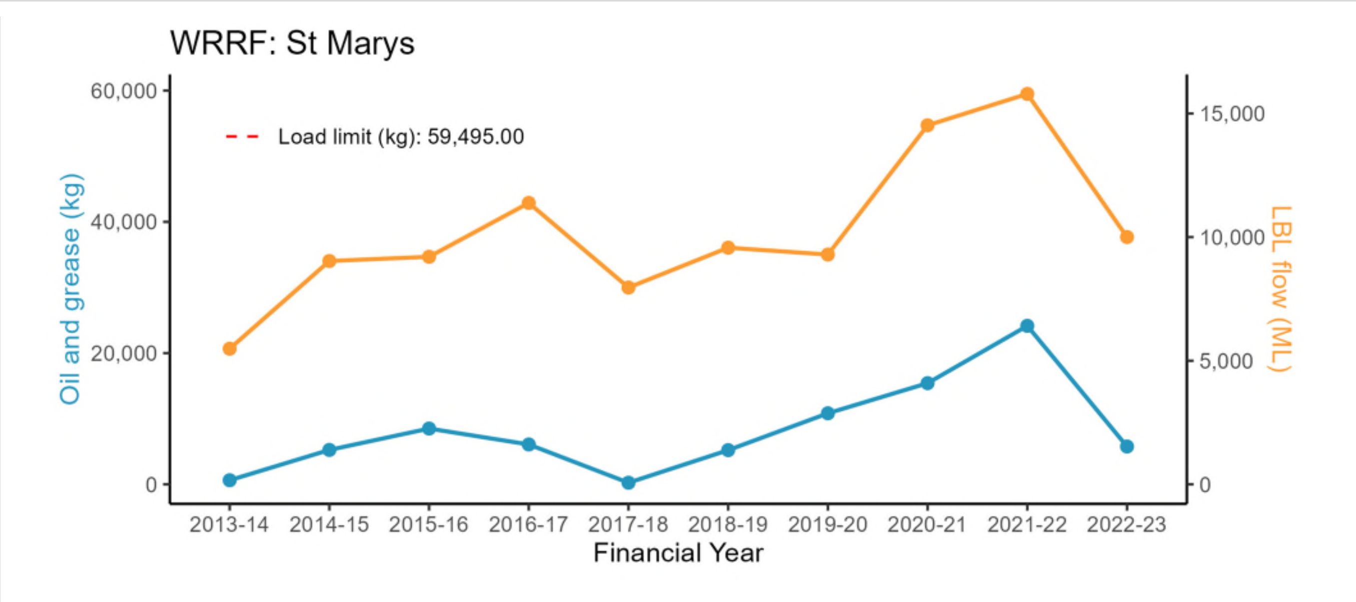
Nutrients

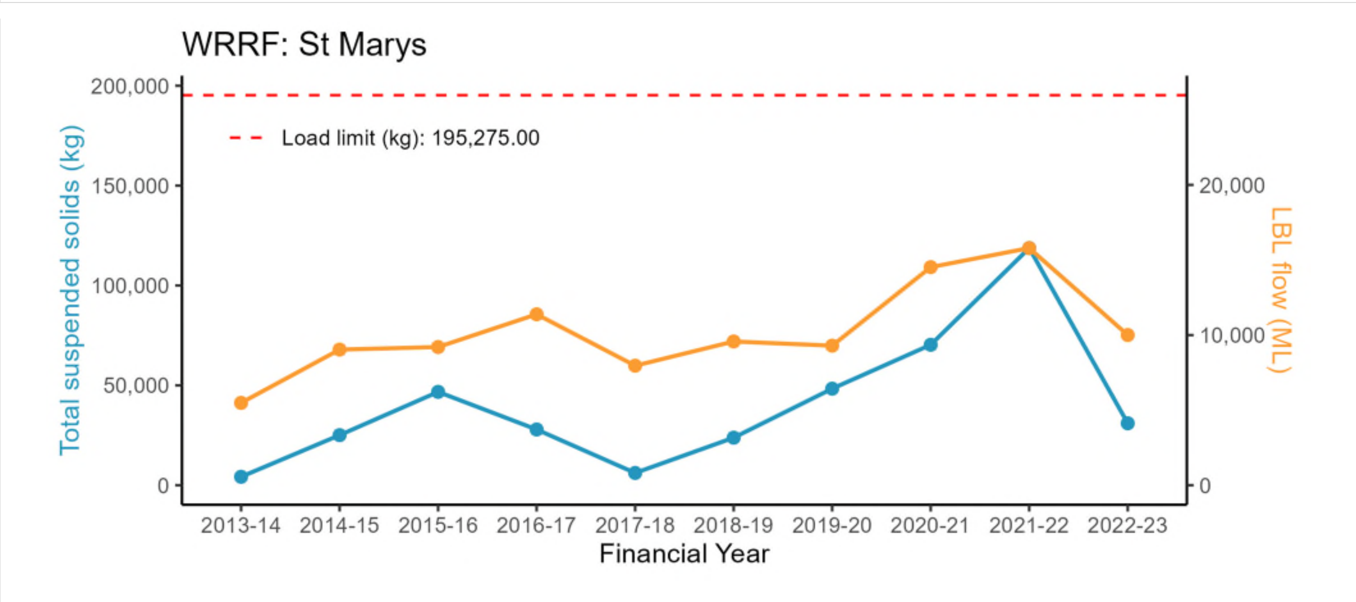




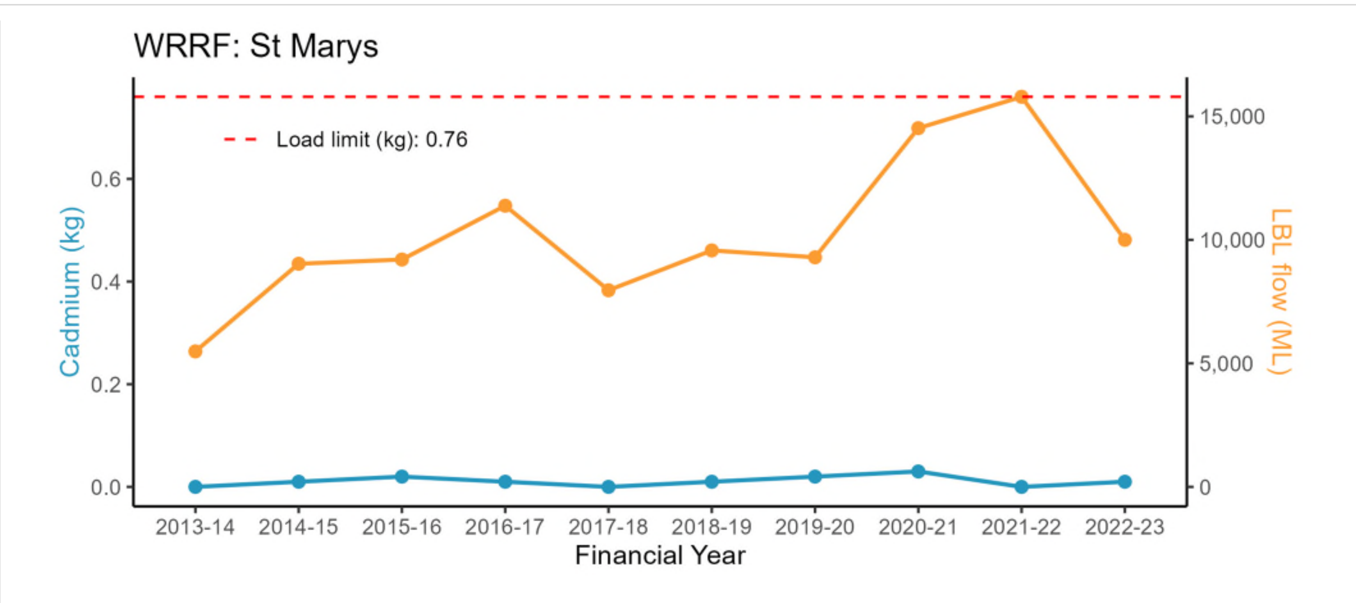
Major conventional analytes

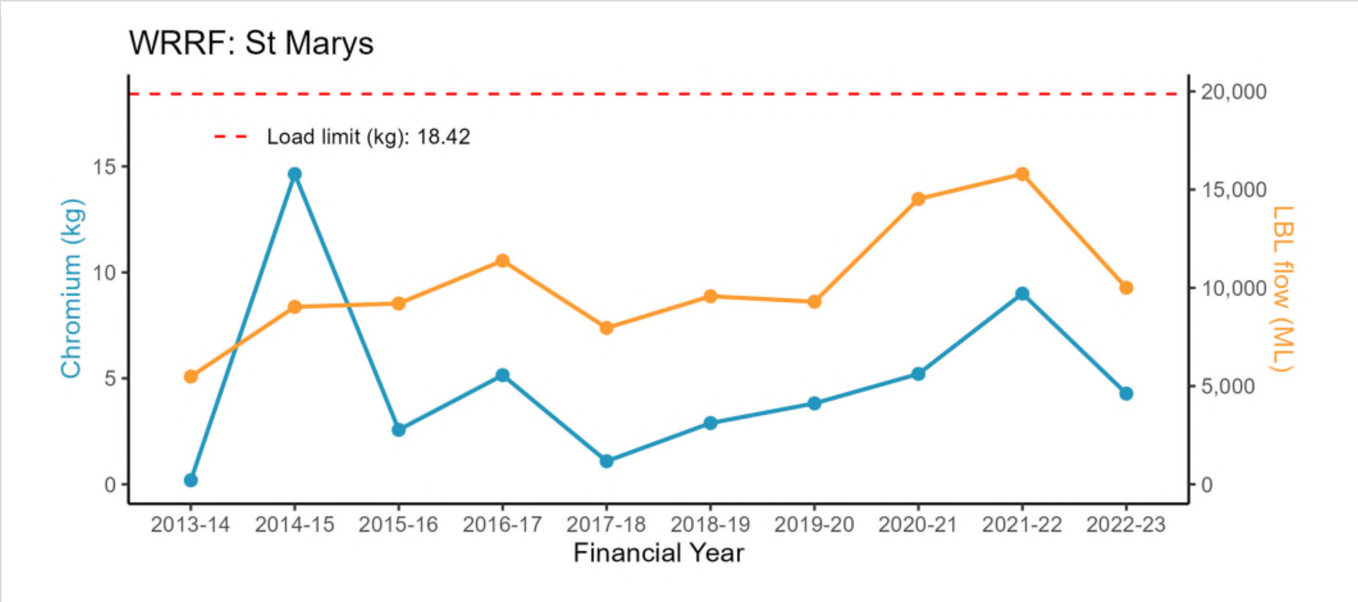


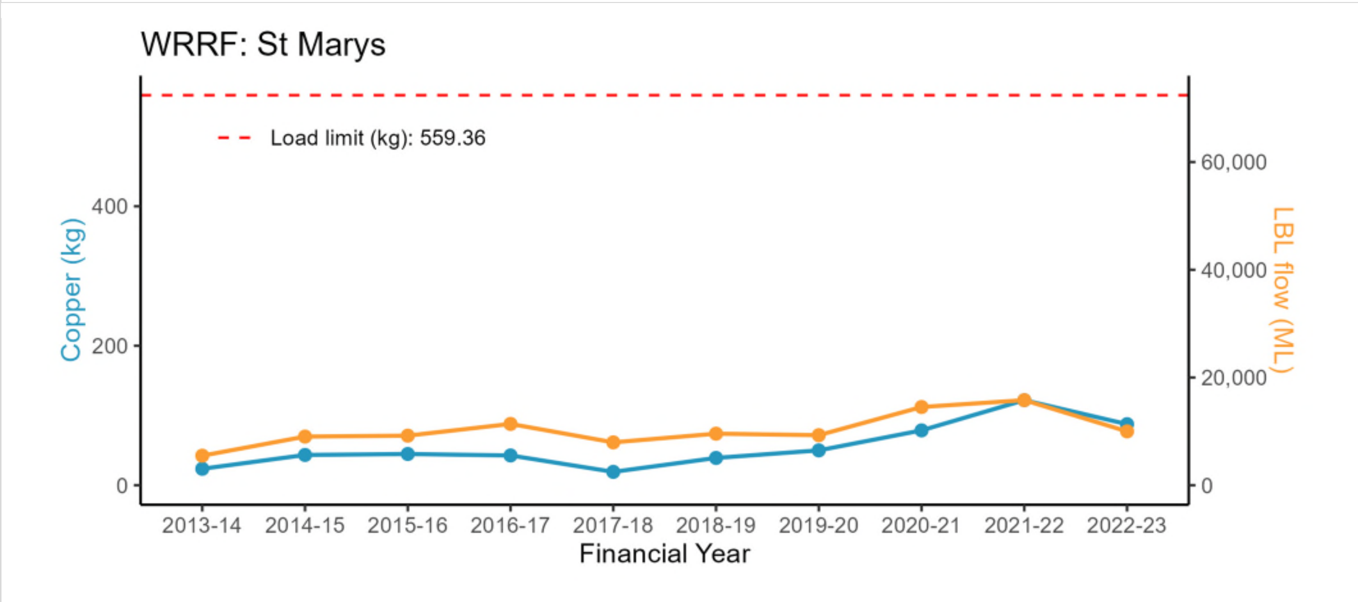


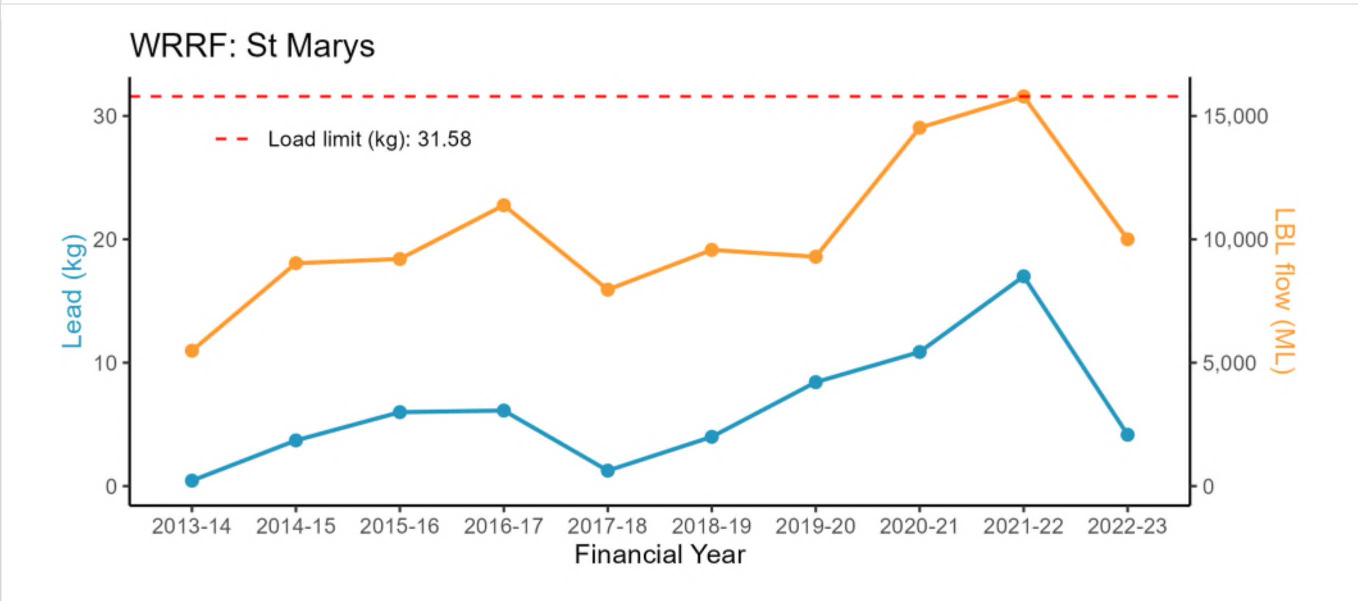


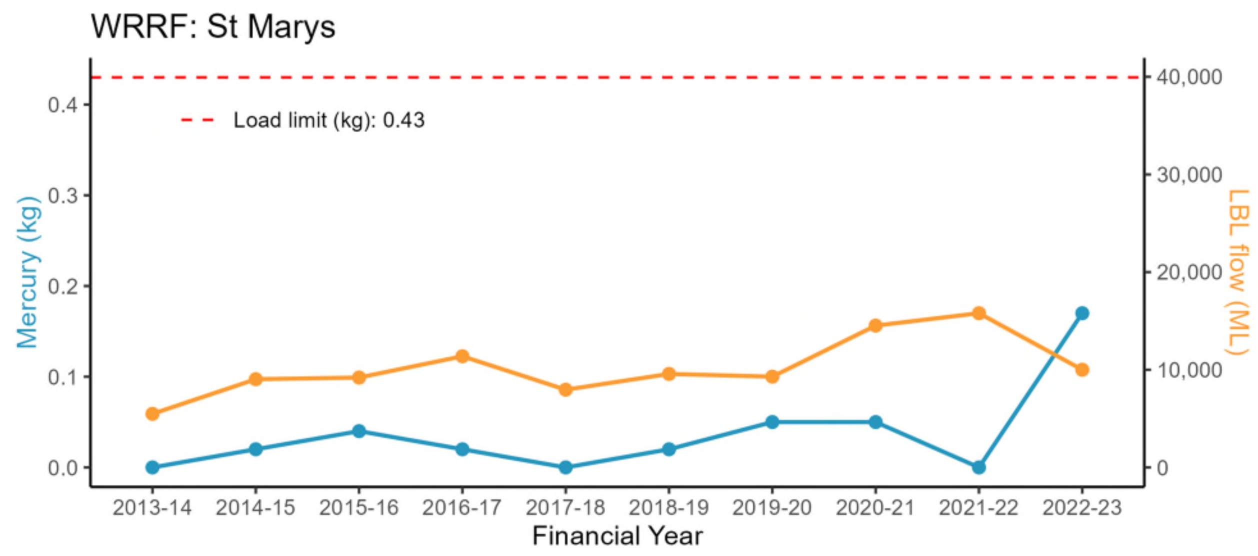
Trace metals



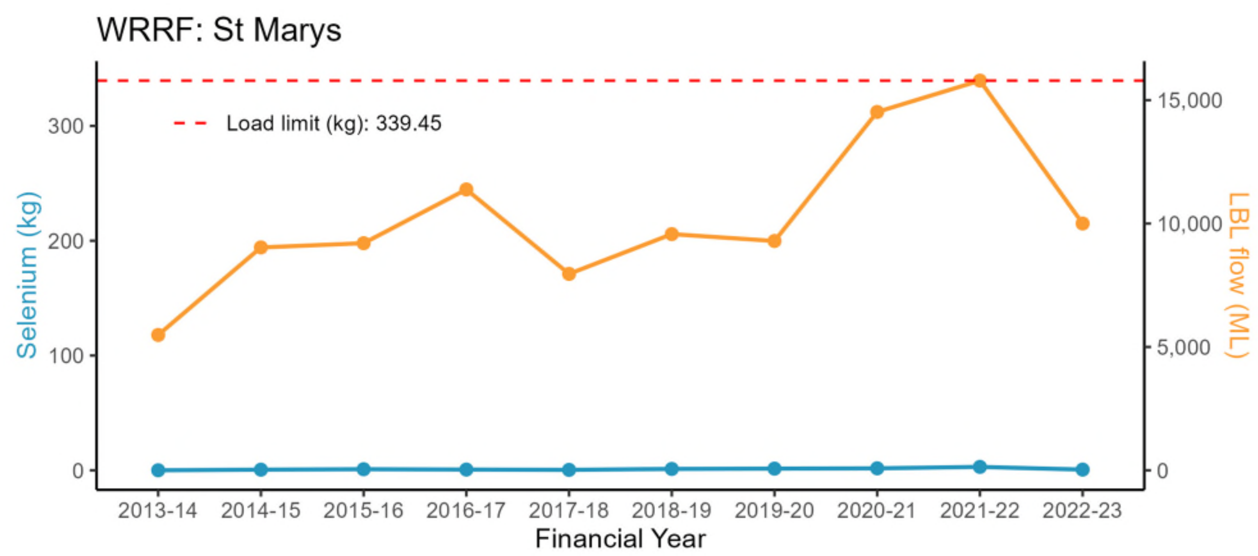

WRRF: St Marys
Load limit (kg): 18.42
Chromium (kg)
LBL flow (ML)
0
5
10
15
0
5,000
10,000
15,000
20,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: St Marys
Load limit (kg): 559.36
Copper (kg)
LBL flow (ML)
0
200
400
0
20,000
40,000
60,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

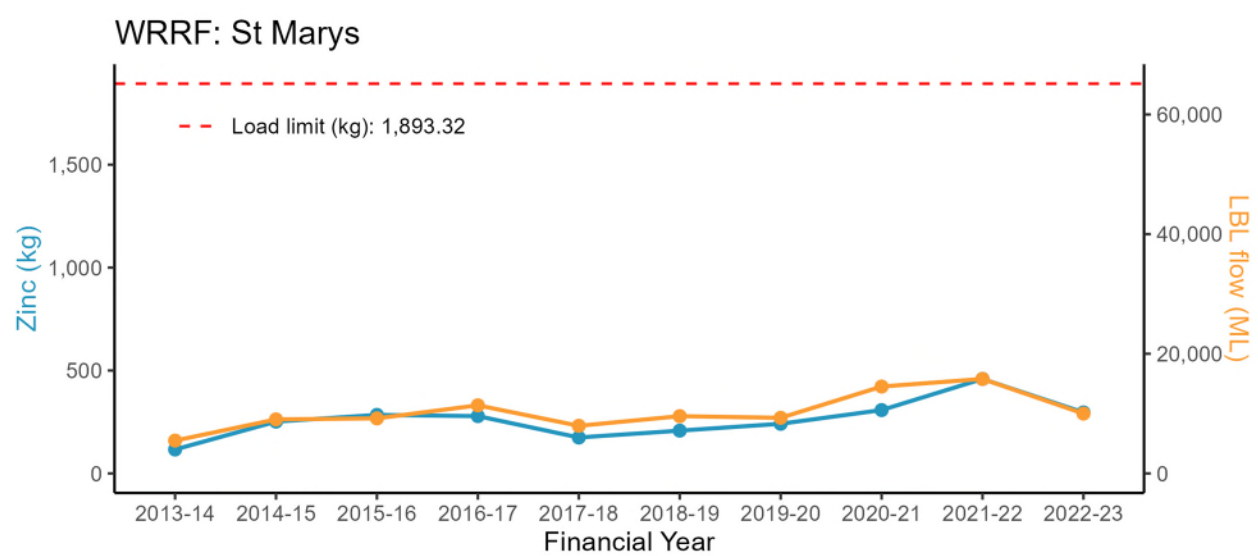

WRRF: St Marys
Load limit (kg): 31.58
Lead (kg)
LBL flow (ML)
0
10
20
30
0
5,000
10,000
15,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year



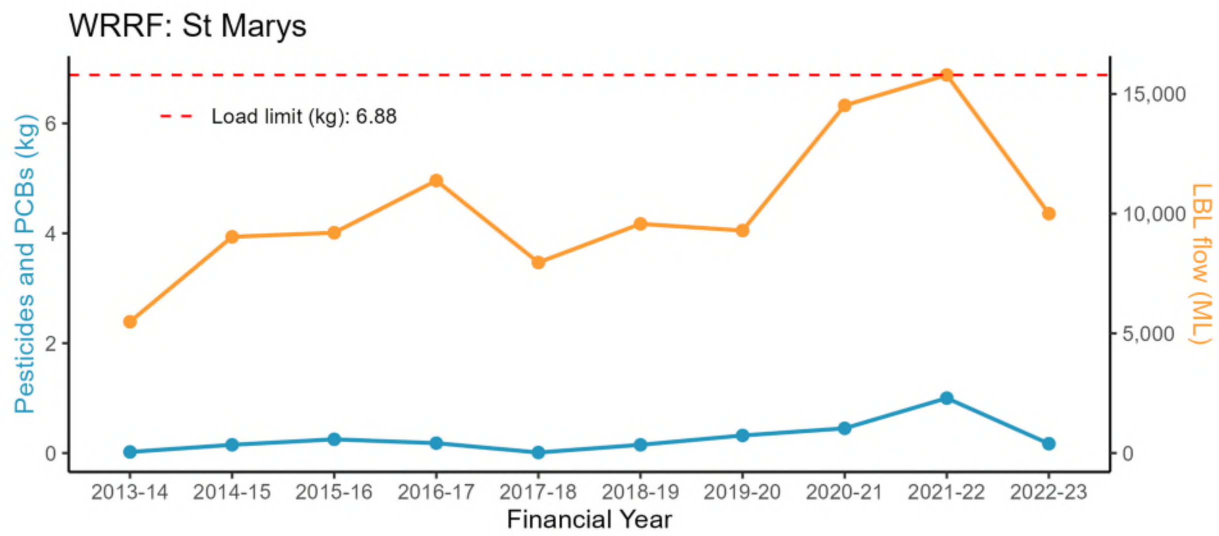
WRRF: St Marys
Load limit (kg): 0.43
Mercury (kg)
LBL flow (ML)
Financial Year
0.0
0.1
0.2
0.3
0.4
0
10,000
20,000
30,000
40,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23



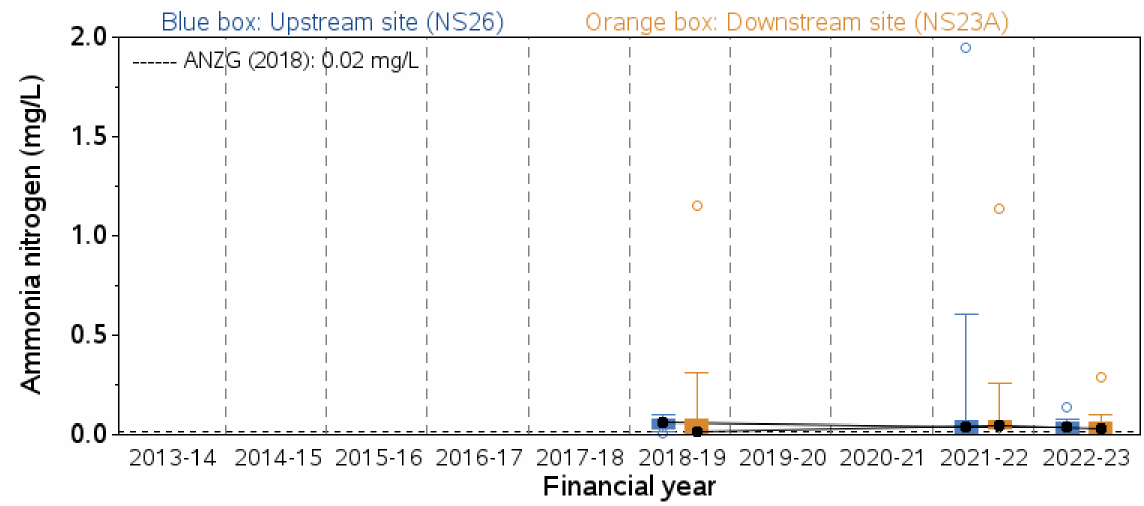
WRRF: St Marys
Load limit (kg): 339.45
Selenium (kg)
LBL flow (ML)
Financial Year
0
100
200
300
0
5,000
10,000
15,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23



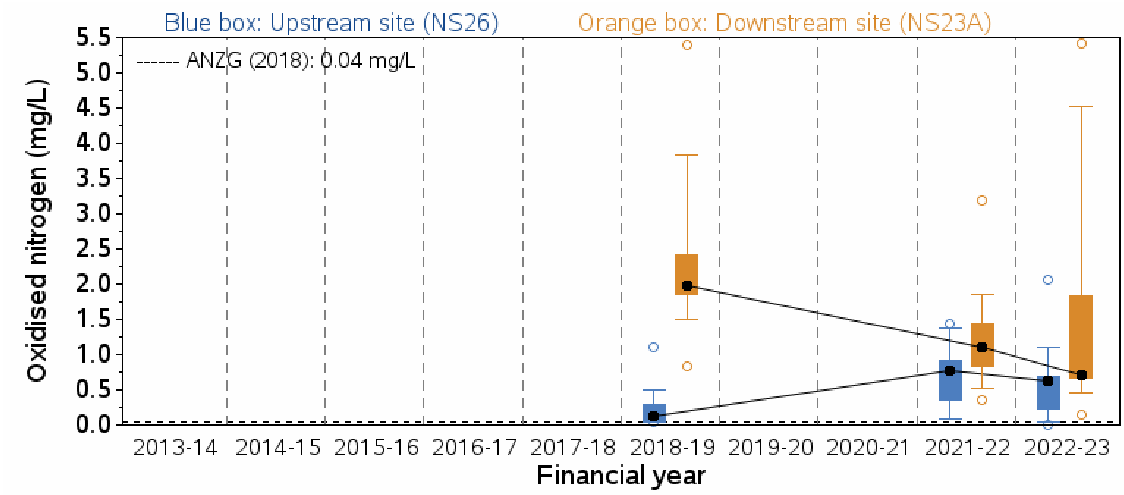
WRRF: St Marys
Load limit (kg): 1,893.32
Zinc (kg)
LBL flow (ML)
Financial Year
0
500
1,000
1,500
0
20,000
40,000
60,000
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23



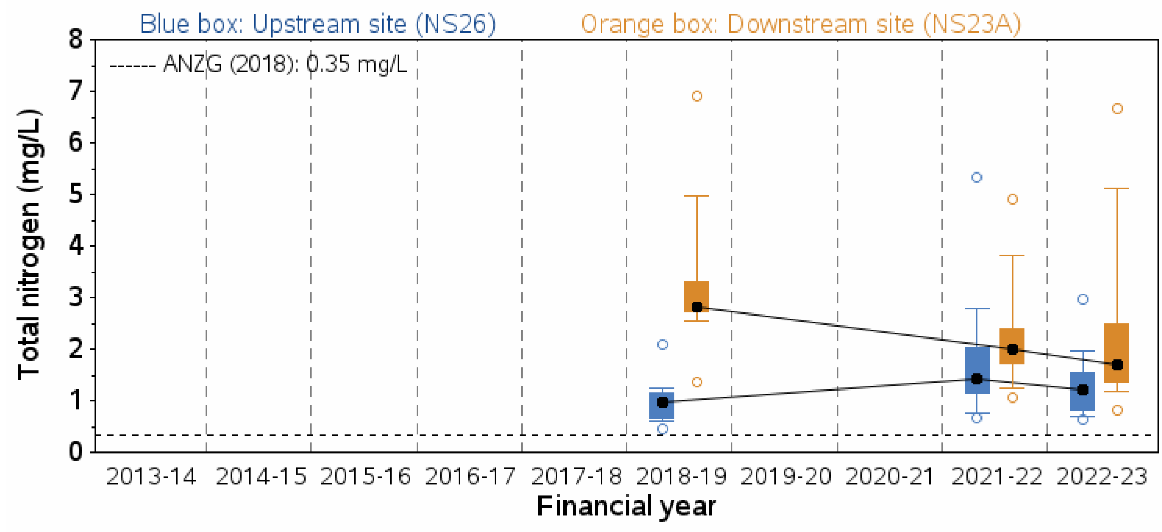
A-8.5 Stressor – Nutrients



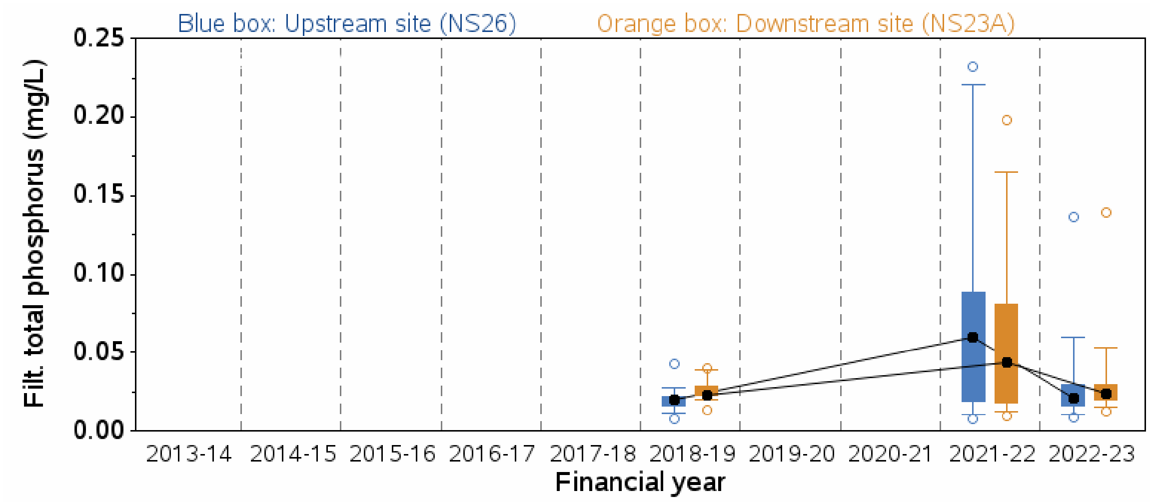
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	0.78	0.3808	NS23A	1	1.47	0.2318



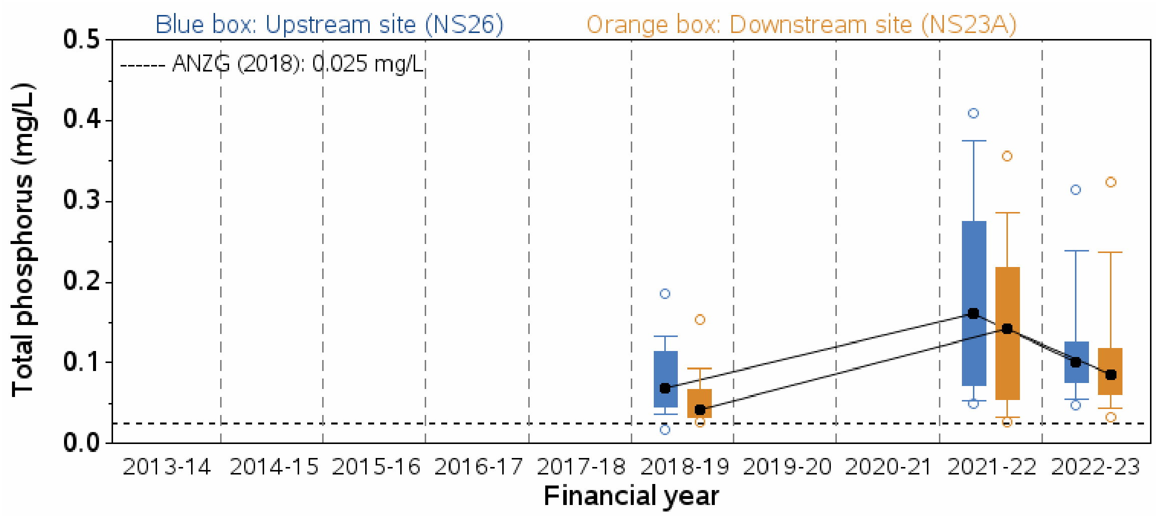
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	0.29	0.5946	NS23A	1	0.06	0.8012



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	0.23	0.6316	NS23A	1	0.45	0.5056

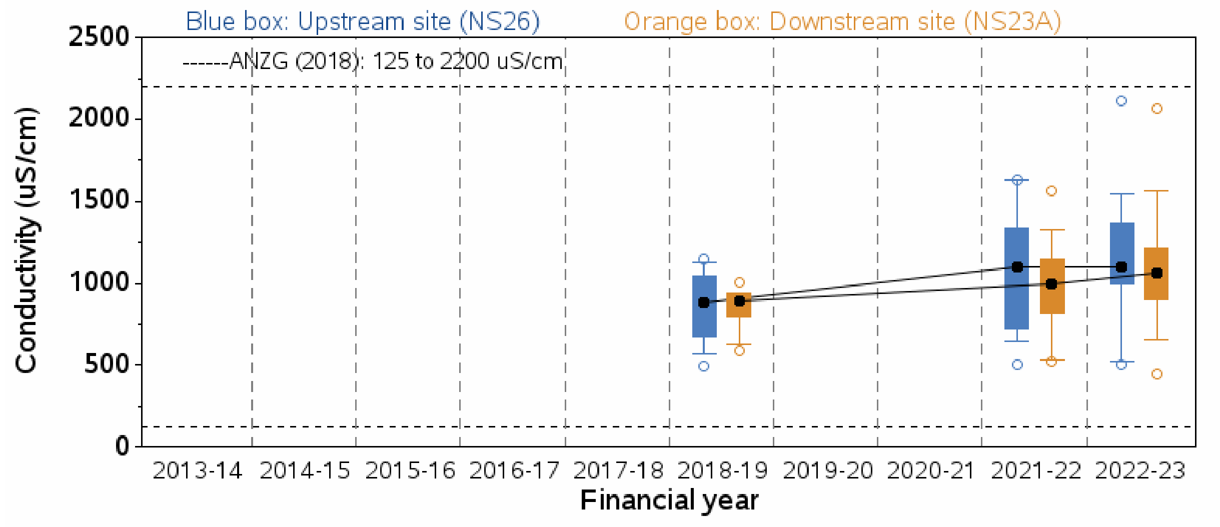


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	1.98	0.1664	NS23A	1	1.02	0.3179

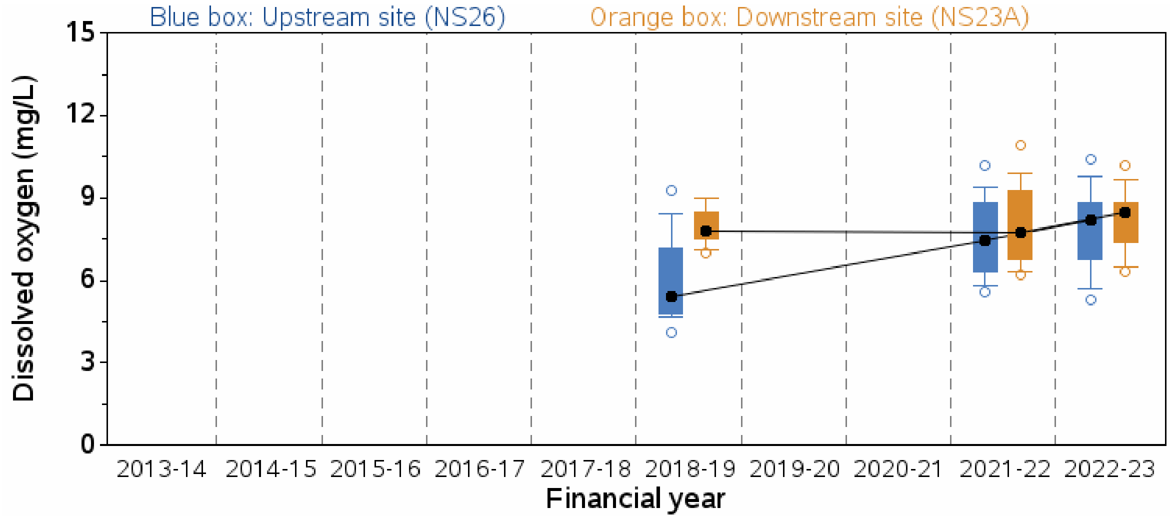


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	0.61	0.439	NS23A	1	0.01	0.9247

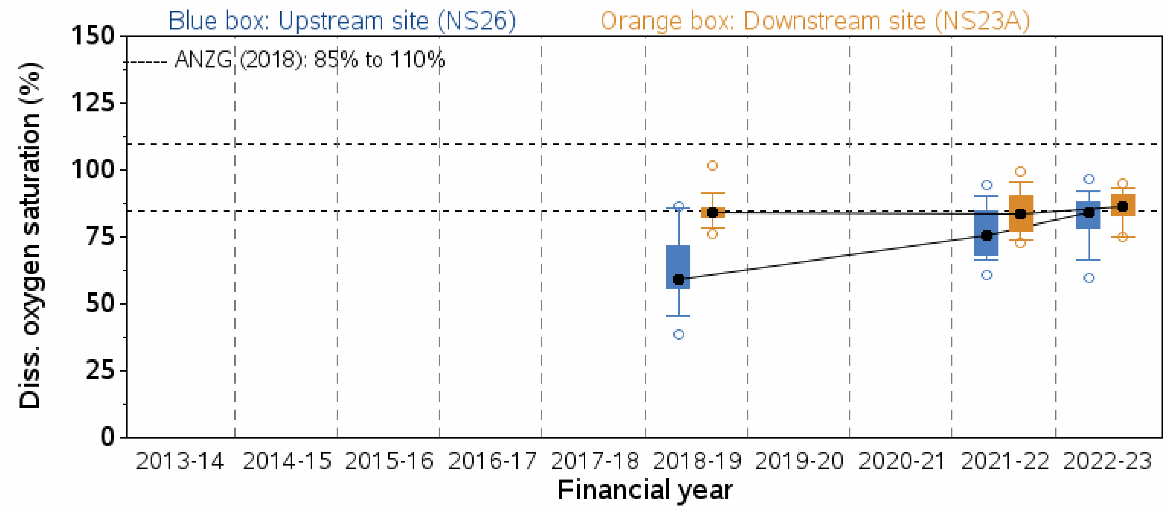
A-8.6 Stressor – Physico-chemical water quality



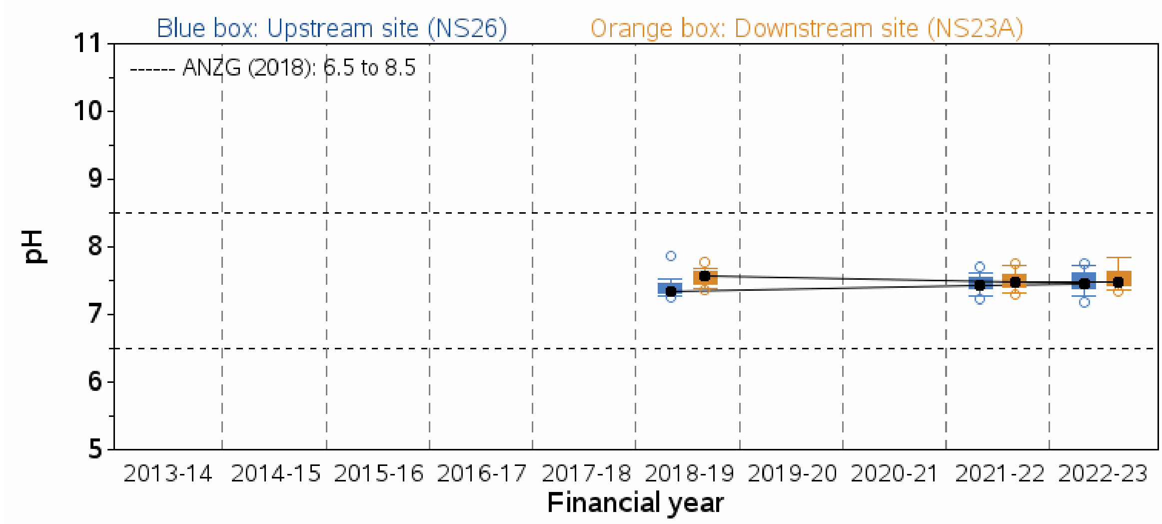
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	2.75	0.1039	NS23A	1	3.46	0.0696



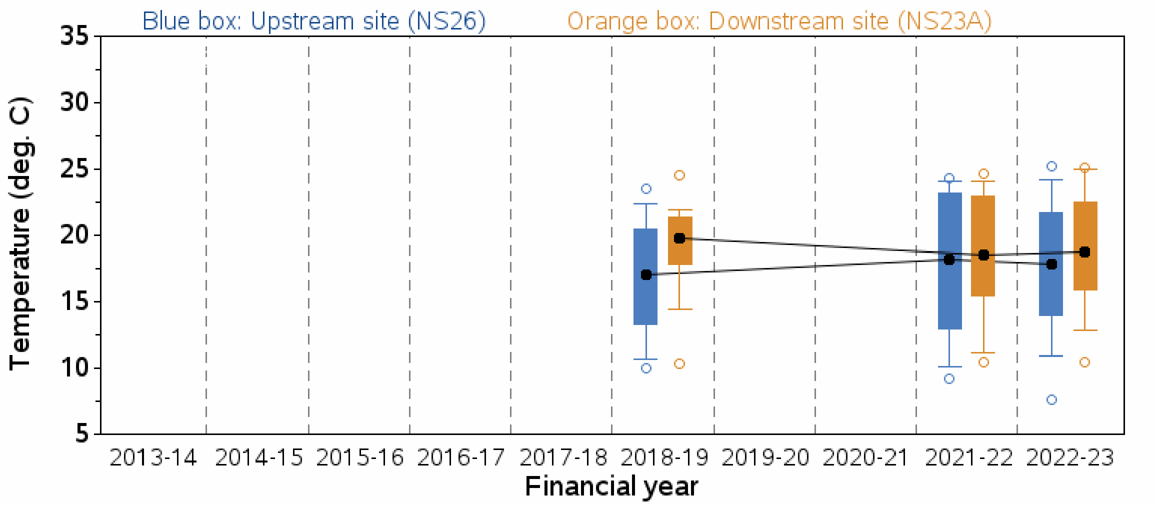
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	3.84	0.056	NS23A	1	0.16	0.6879



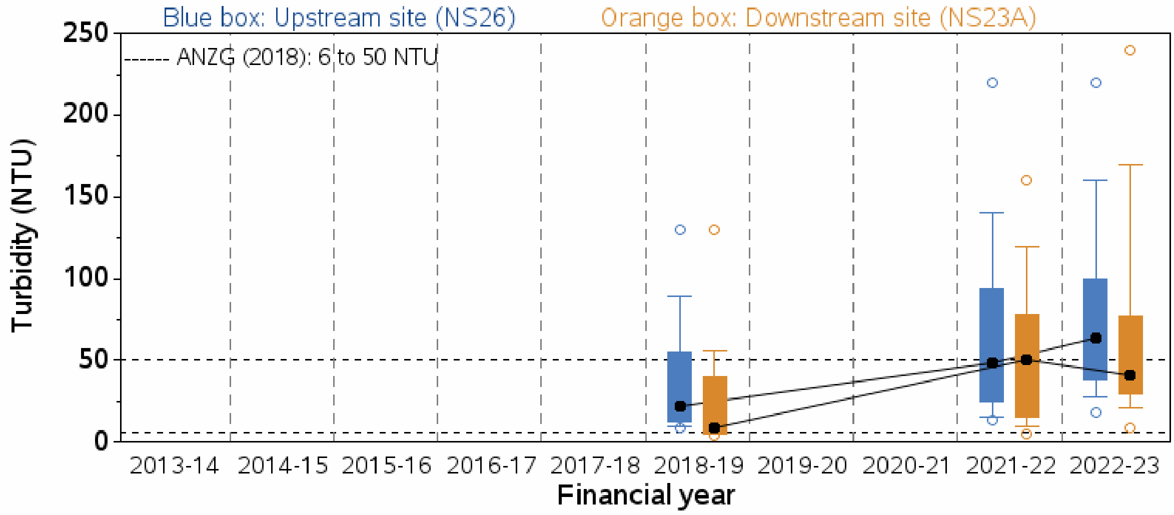
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	8.1	0.0066	NS23A	1	0.63	0.4314



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	1.85	0.1803	NS23A	1	0.18	0.6718

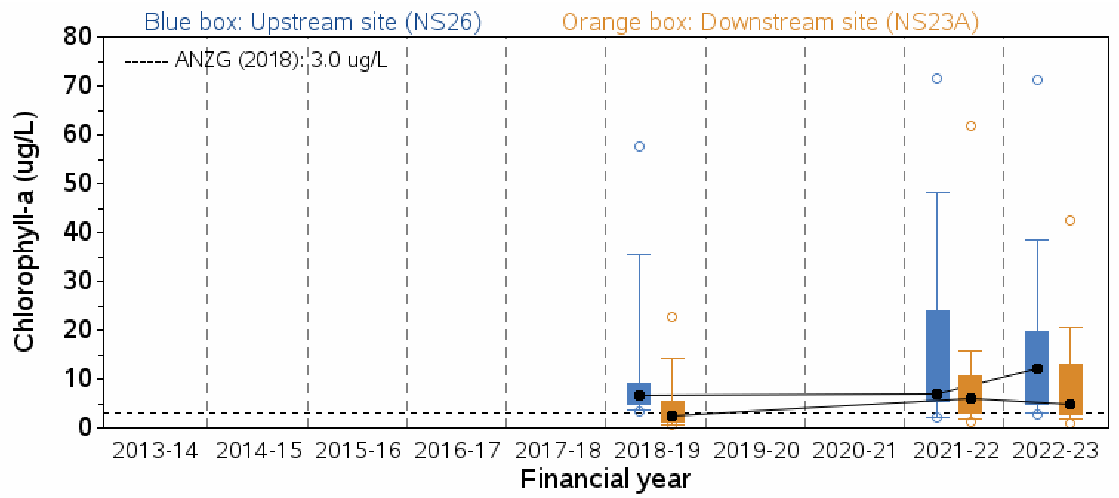


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	0.25	0.6205	NS23A	1	0	0.9622

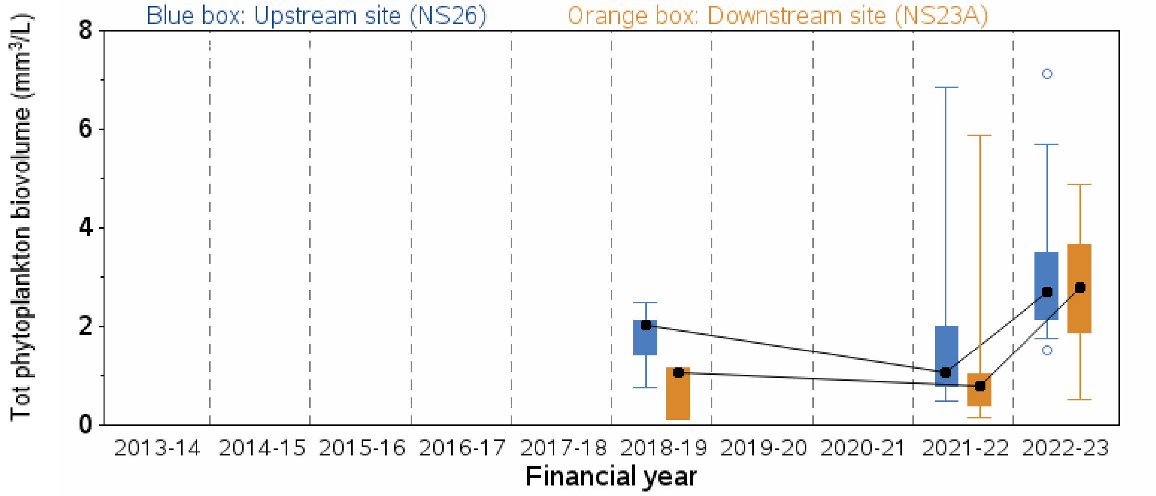


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	2.2	0.1448	NS23A	1	2.95	0.0924

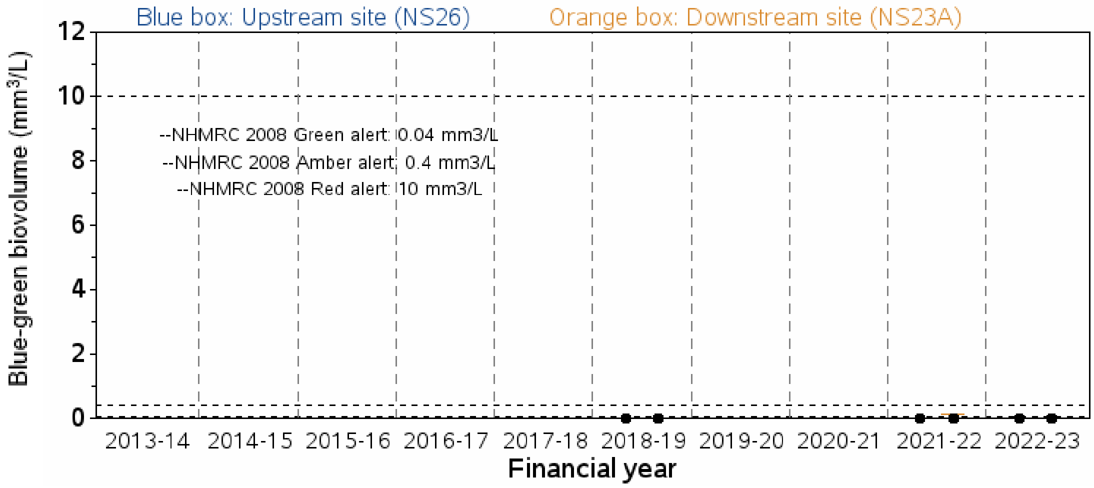
A-8.7 Ecosystem receptor – Phytoplankton



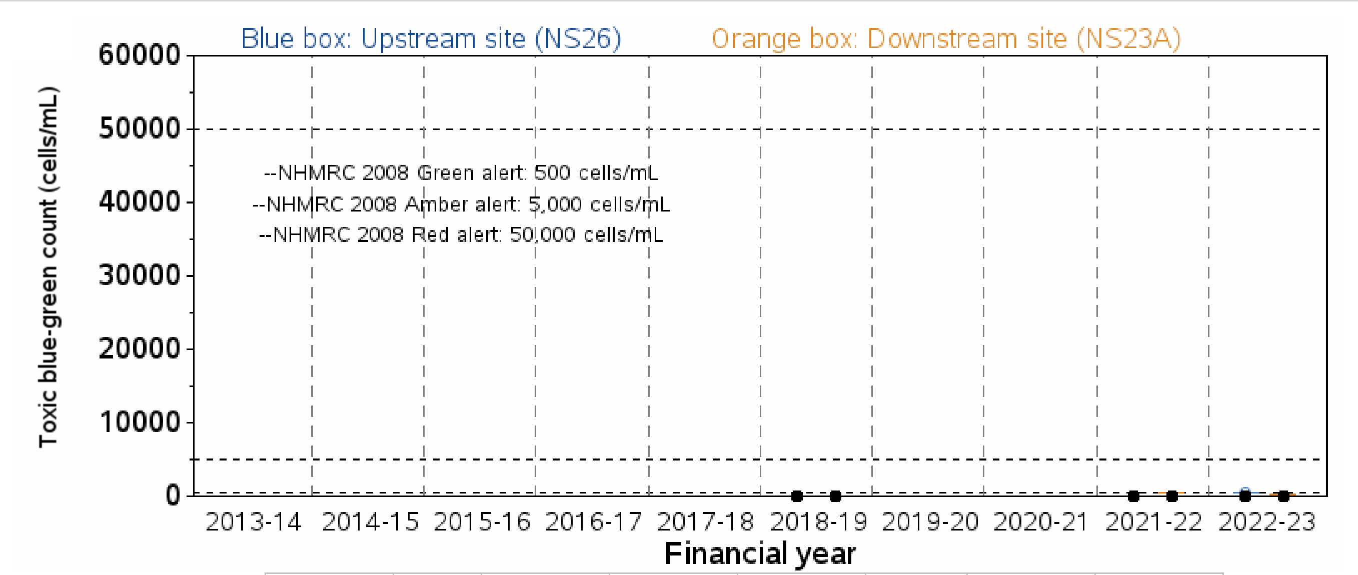
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	0.16	0.6951	NS23A	1	0.31	0.5795



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	3.83	0.0632	NS23A	1	3.3	0.0908



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	10.45	0.0038	NS23A	1	0.41	0.5347



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS26	1	2.82	0.1073	NS23A	1	0.04	0.842

A-8.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for South Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1995 and 2022. This comparison suggests downstream stream health was maintained at a level comparable to that of the upstream site indicating wastewater discharge from St Mary's WRRF did not have a measurable impact on stream health during 2022-23 (Figure A-28).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under a t-test returned a non-significant test outcome (Table A-38) and confirmed the visual trend of the SIGNAL-SG plot.

As no measurable negative impact on downstream stream health was detected, no further data analysis was undertaken.

Table A-38 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from South Creek near St Marys WRRF

Waterway	Method	Statistic	DF	P value
South Creek	Welch Two Sample t-test	0.72	10.0	0.486

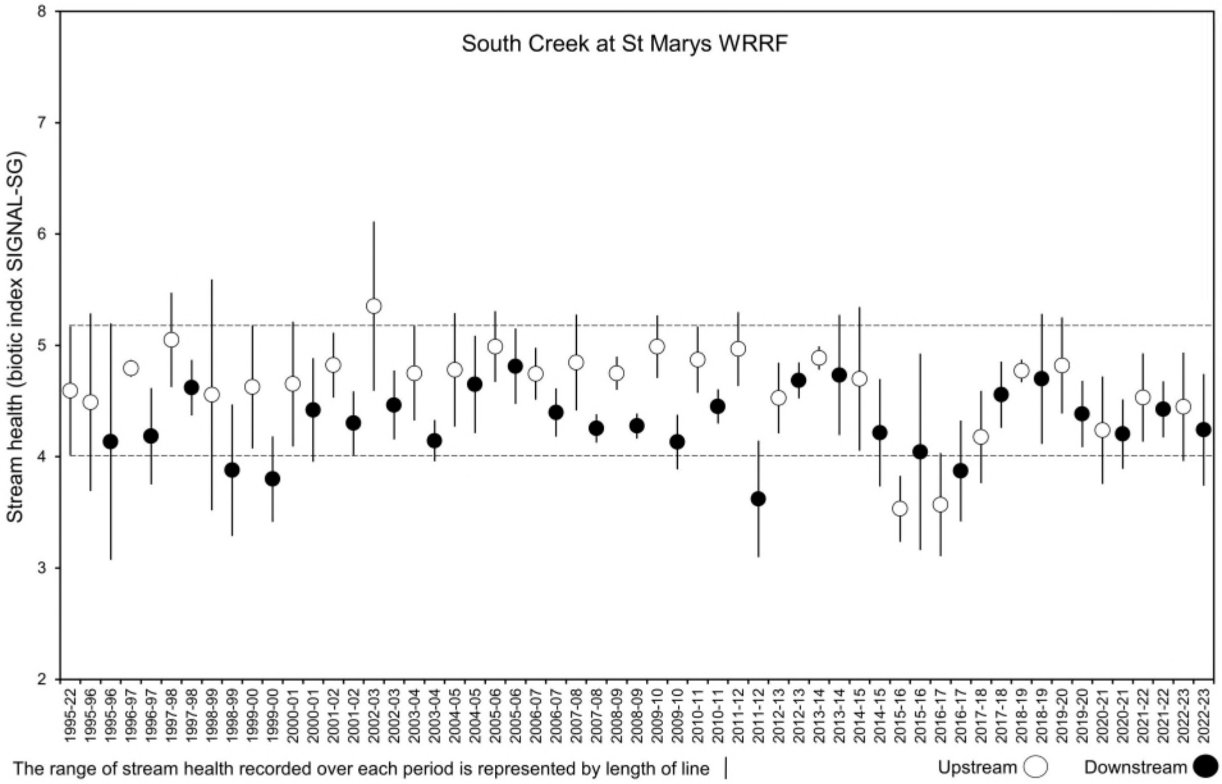
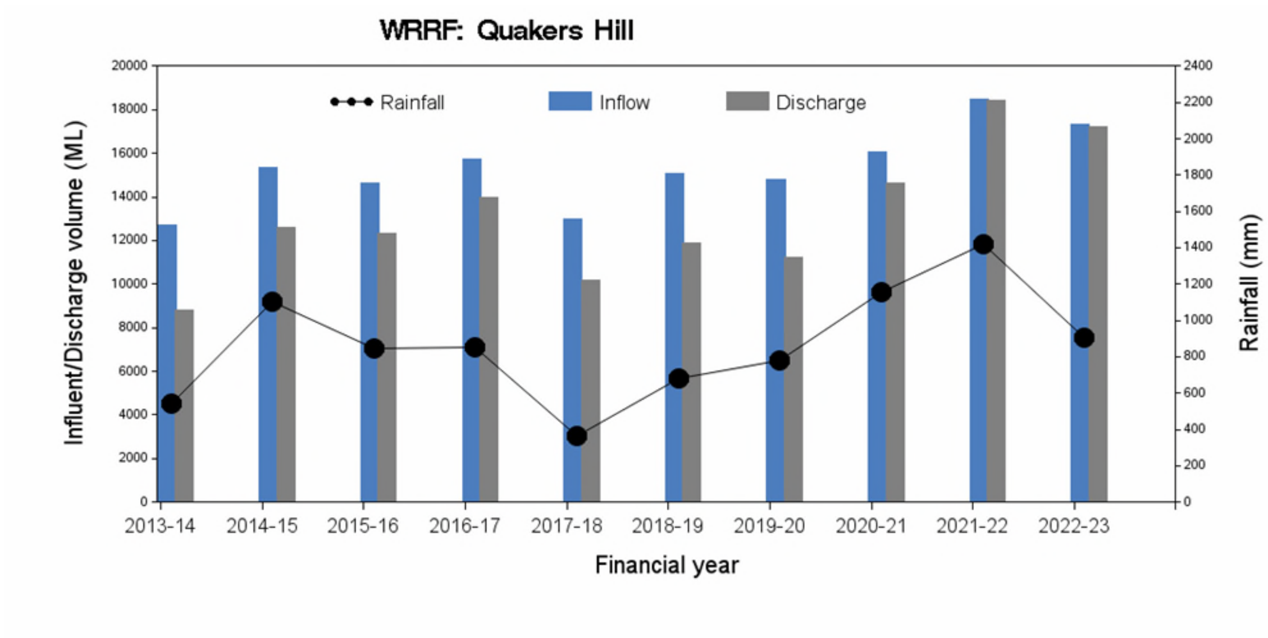


Figure A-28 Stream health of South Creek near St Mary's WRRF

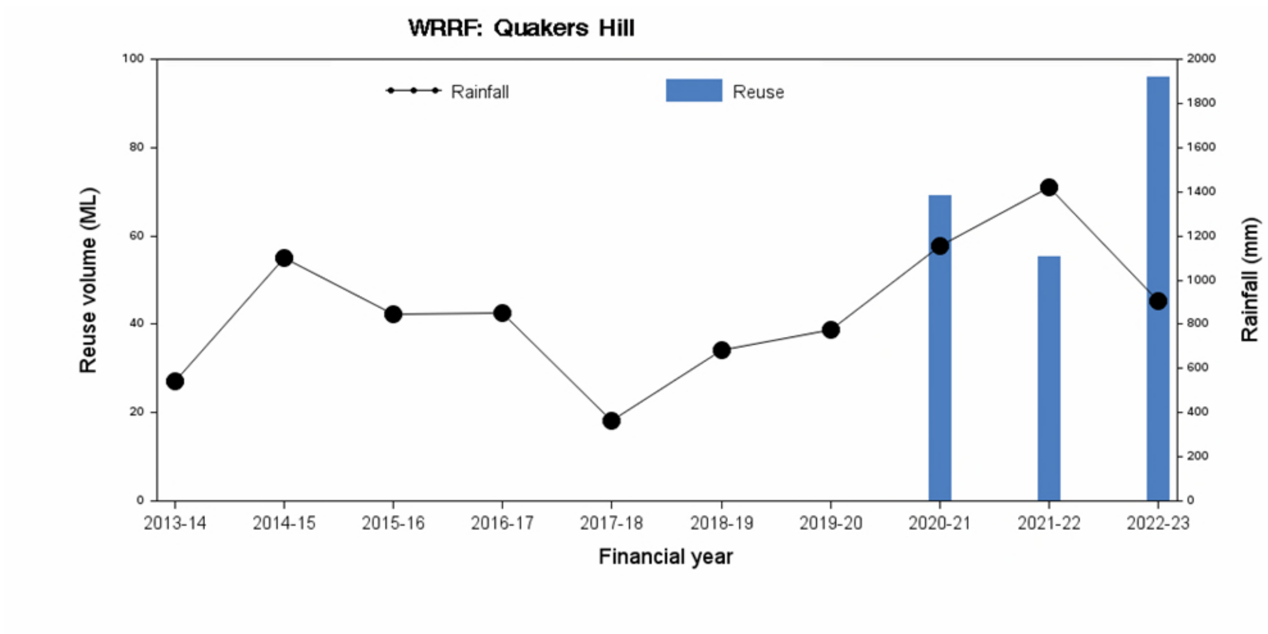
A-9 Quakers Hill WRRF

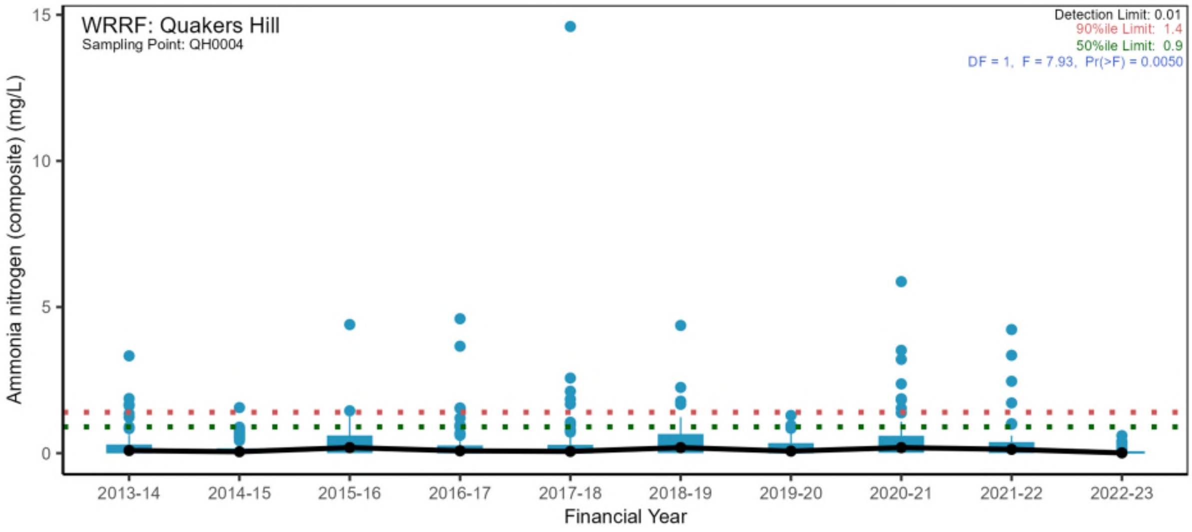
A-9.1 Pressure – Wastewater quantity

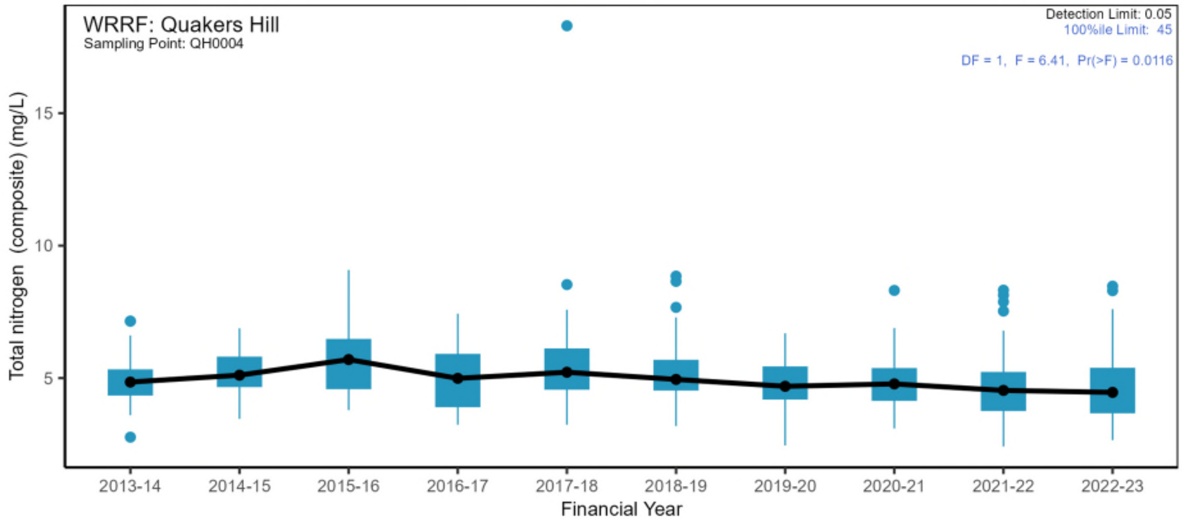
Inflow/ Discharge volume and rainfall

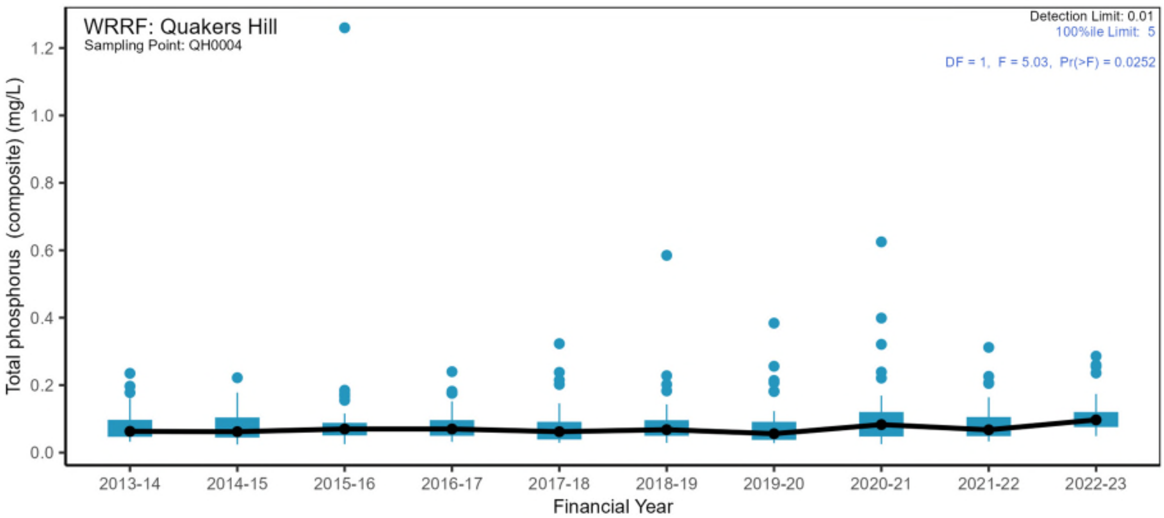


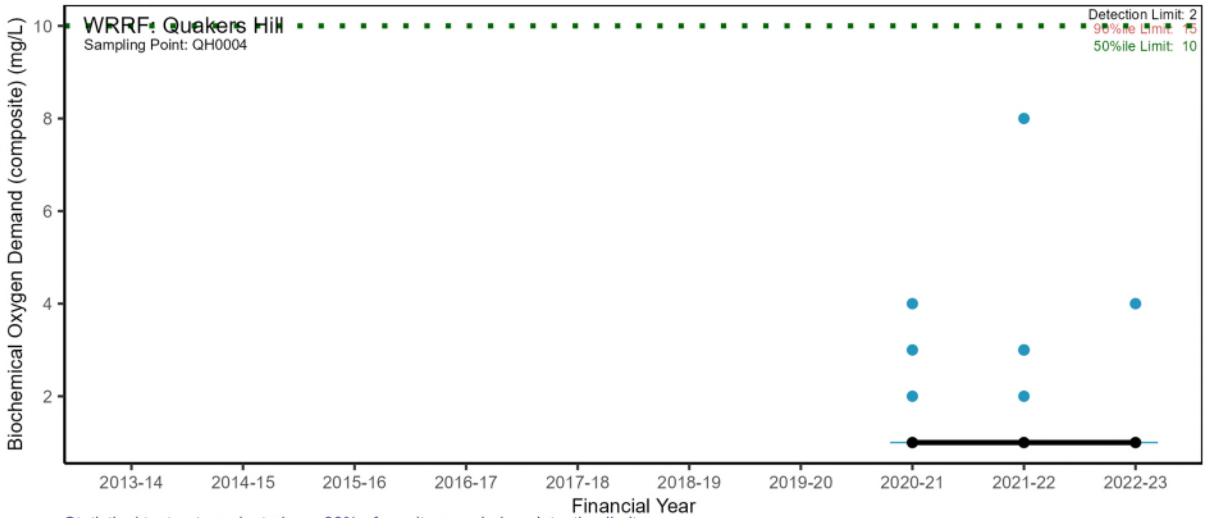
Reuse volume and rainfall



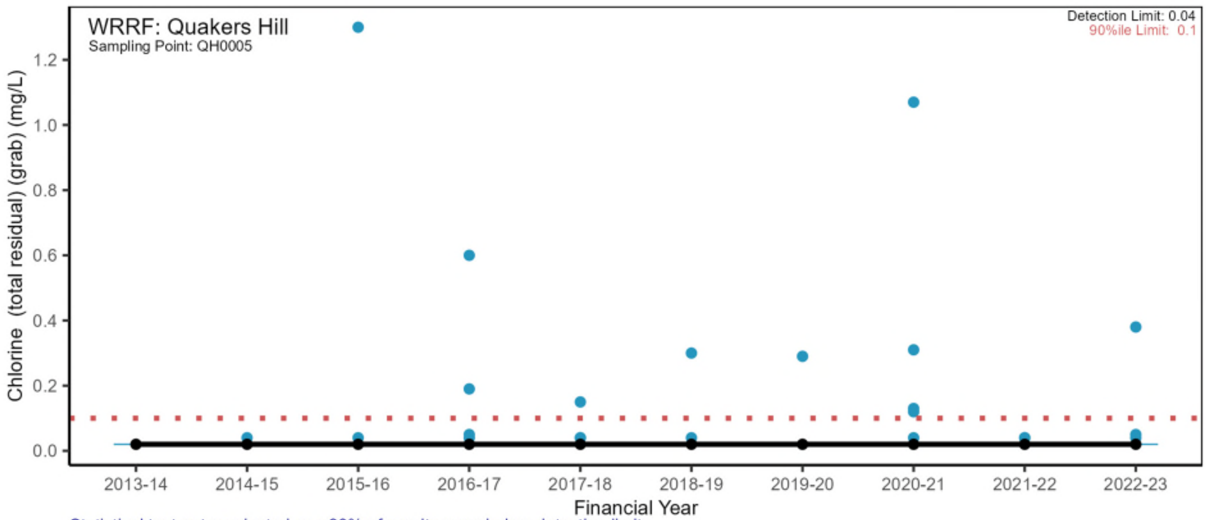

WRRF: Quakers Hill
Sampling Point: QH0004
Detection Limit: 0.01
90%ile Limit: 1.4
50%ile Limit: 0.9
DF = 1, F = 7.93, Pr(>F) = 0.0050
Ammonia nitrogen (composite) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


WRRF: Quakers Hill
Sampling Point: QH0004
Detection Limit: 0.05
100%ile Limit: 45
DF = 1, F = 6.41, Pr(>F) = 0.0116
Total nitrogen (composite) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

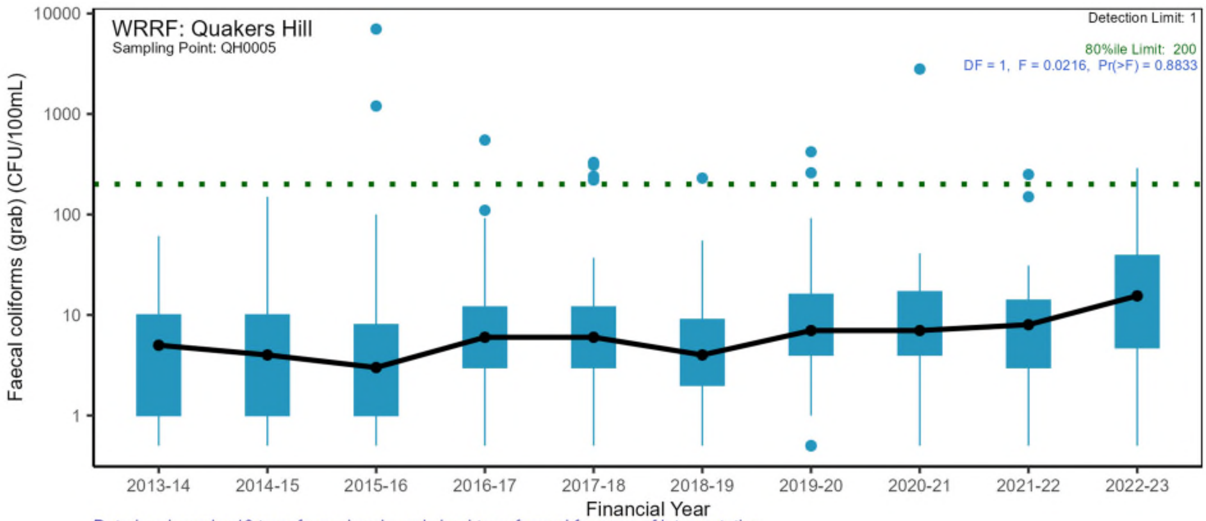

WRRF: Quakers Hill
Sampling Point: QH0004
Detection Limit: 0.01
100%ile Limit: 5
DF = 1, F = 5.03, Pr(>F) = 0.0252
Total phosphorus (composite) (mg/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23



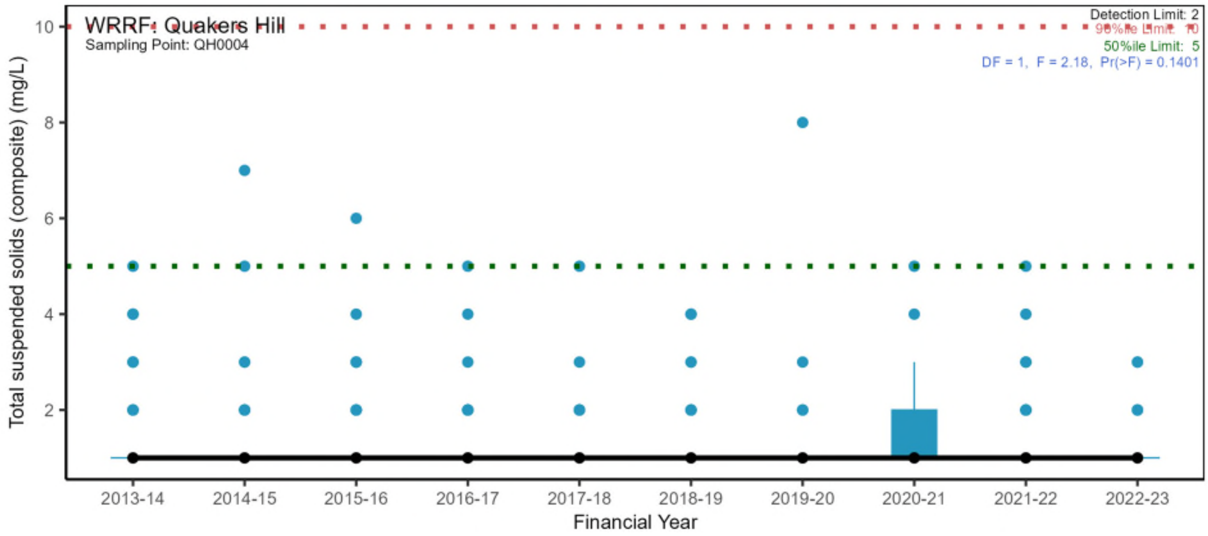
Statistical test not conducted as >90% of results were below detection limits



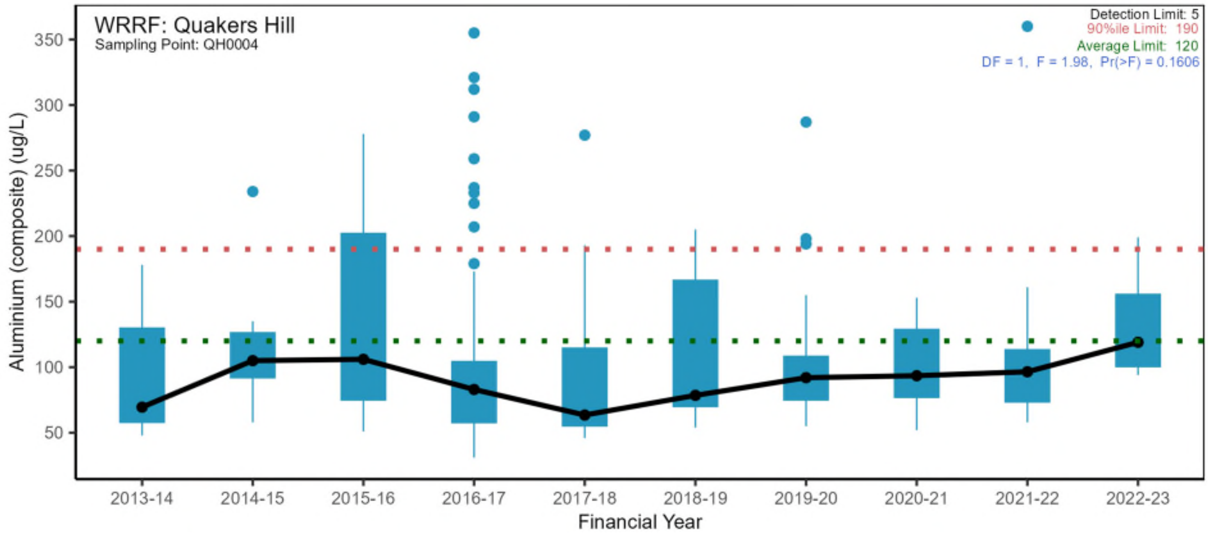
Statistical test not conducted as >90% of results were below detection limits

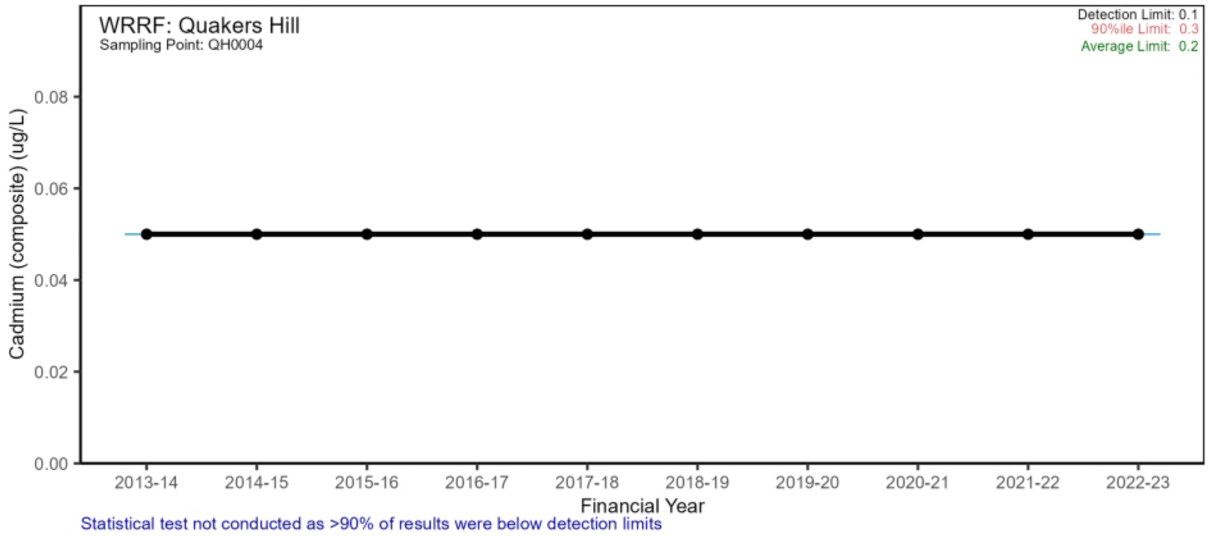


Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

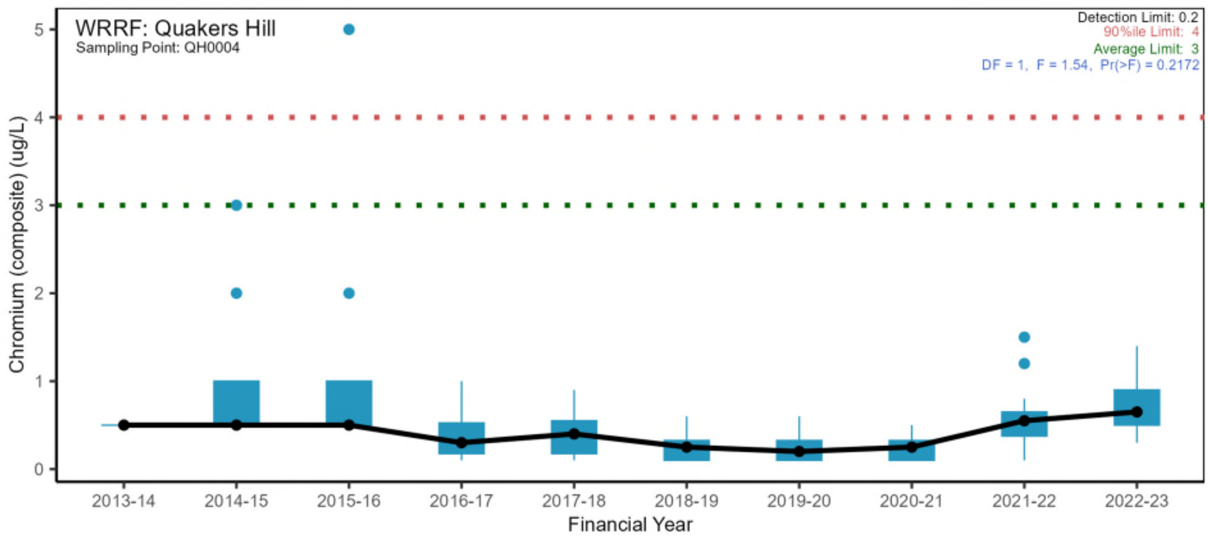


Trace metals

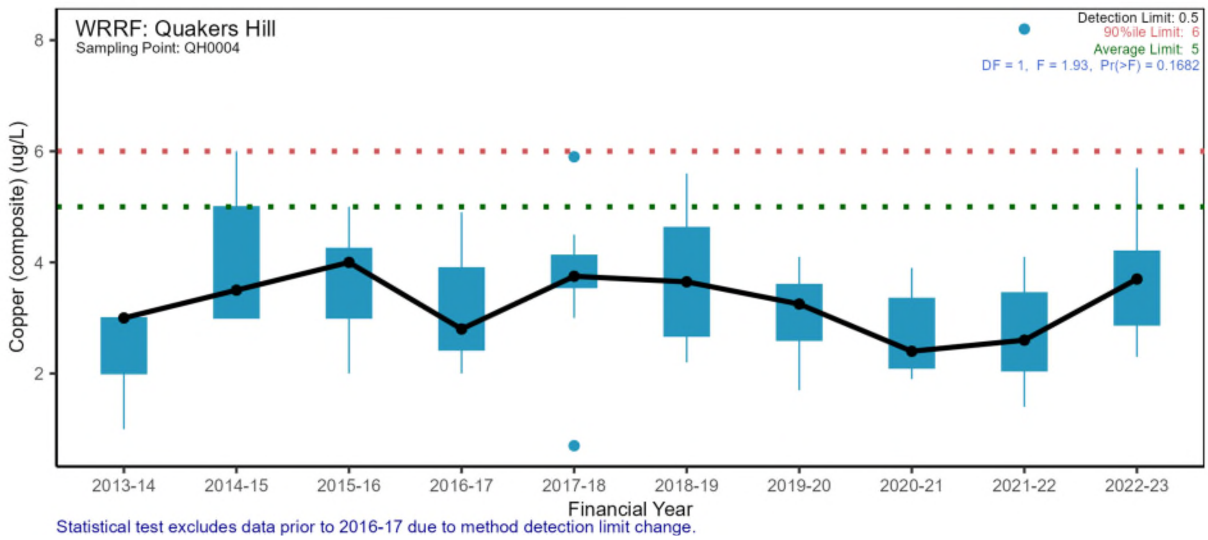




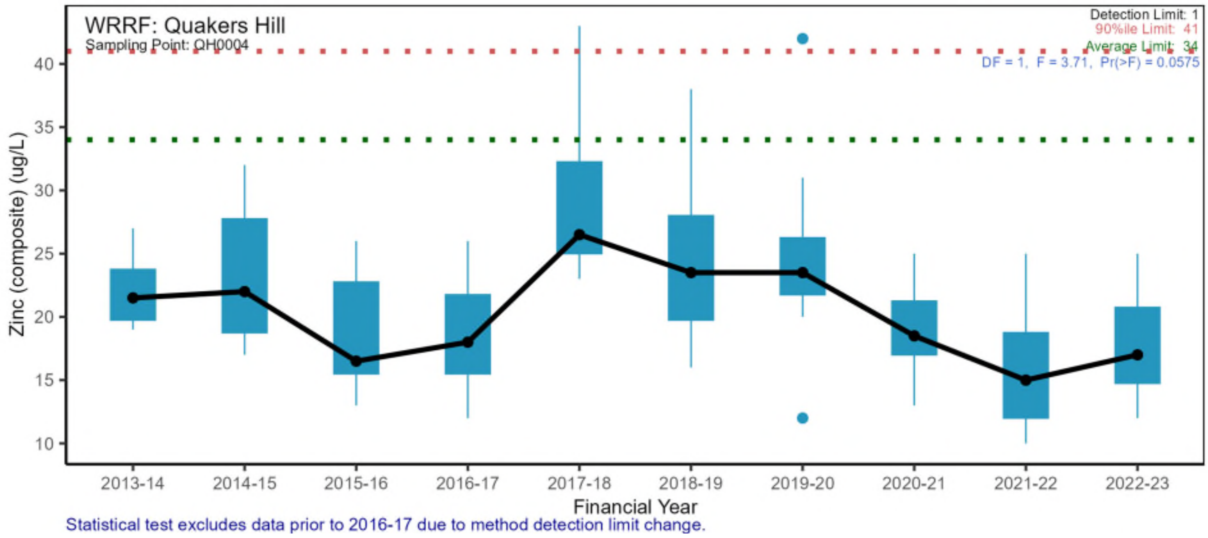
WRRF: Quakers Hill
Sampling Point: QH0004
Detection Limit: 0.1
90%ile Limit: 0.3
Average Limit: 0.2
Cadmium (composite) (ug/L)
0.08
0.06
0.04
0.02
0.00
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits



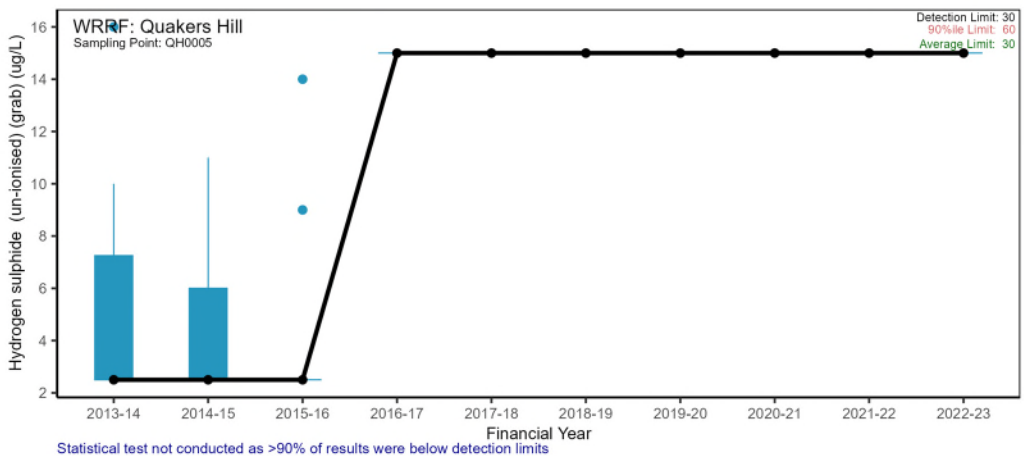
WRRF: Quakers Hill
Sampling Point: QH0004
Detection Limit: 0.2
90%ile Limit: 4
Average Limit: 3
DF = 1, F = 1.54, Pr(>F) = 0.2172
Chromium (composite) (ug/L)
5
4
3
2
1
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

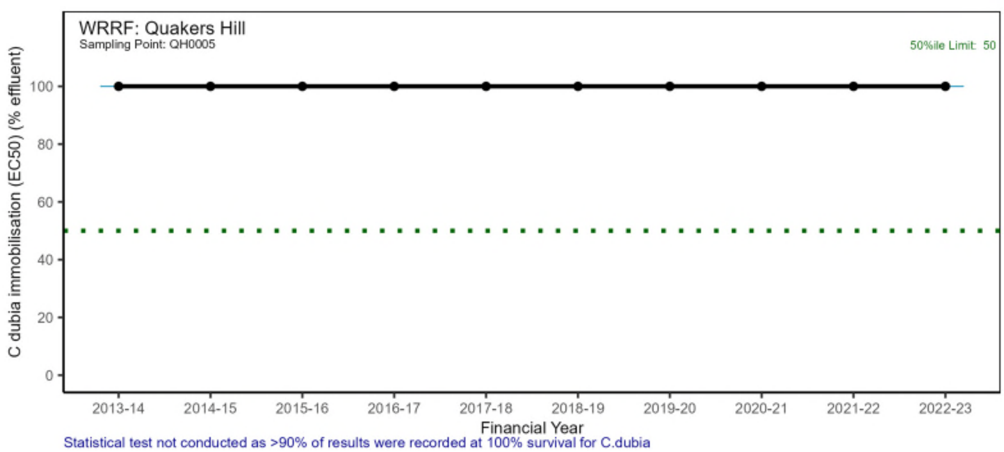


WRRF: Quakers Hill
Sampling Point: QH0004
Detection Limit: 0.5
90%ile Limit: 6
Average Limit: 5
DF = 1, F = 1.93, Pr(>F) = 0.1682
Copper (composite) (ug/L)
8
6
4
2
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.



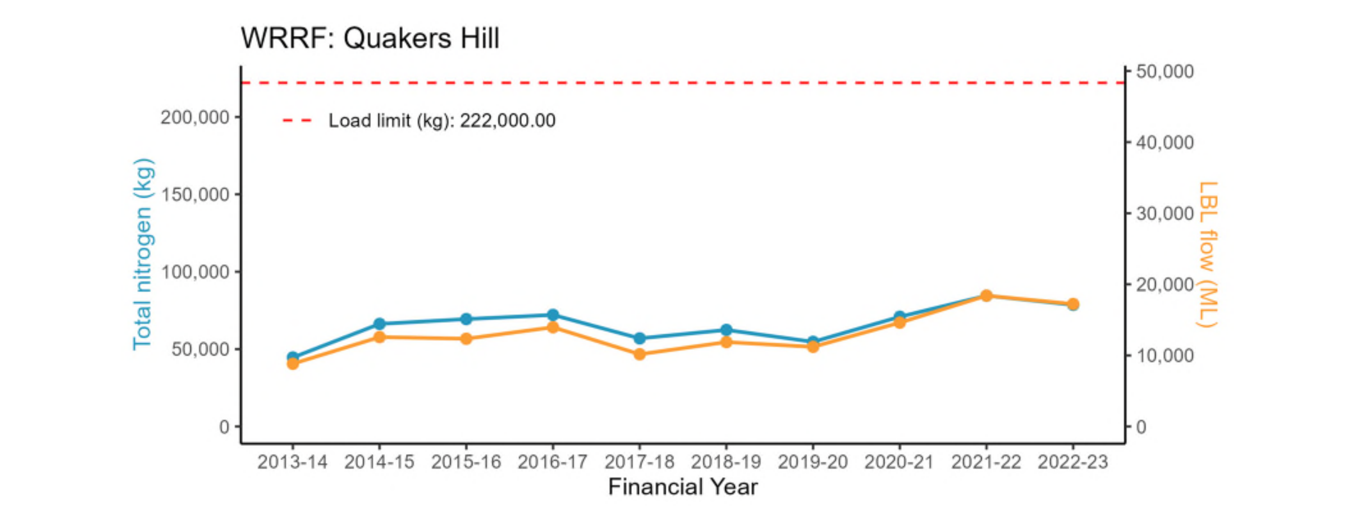
Other chemicals and organics (including pesticides)

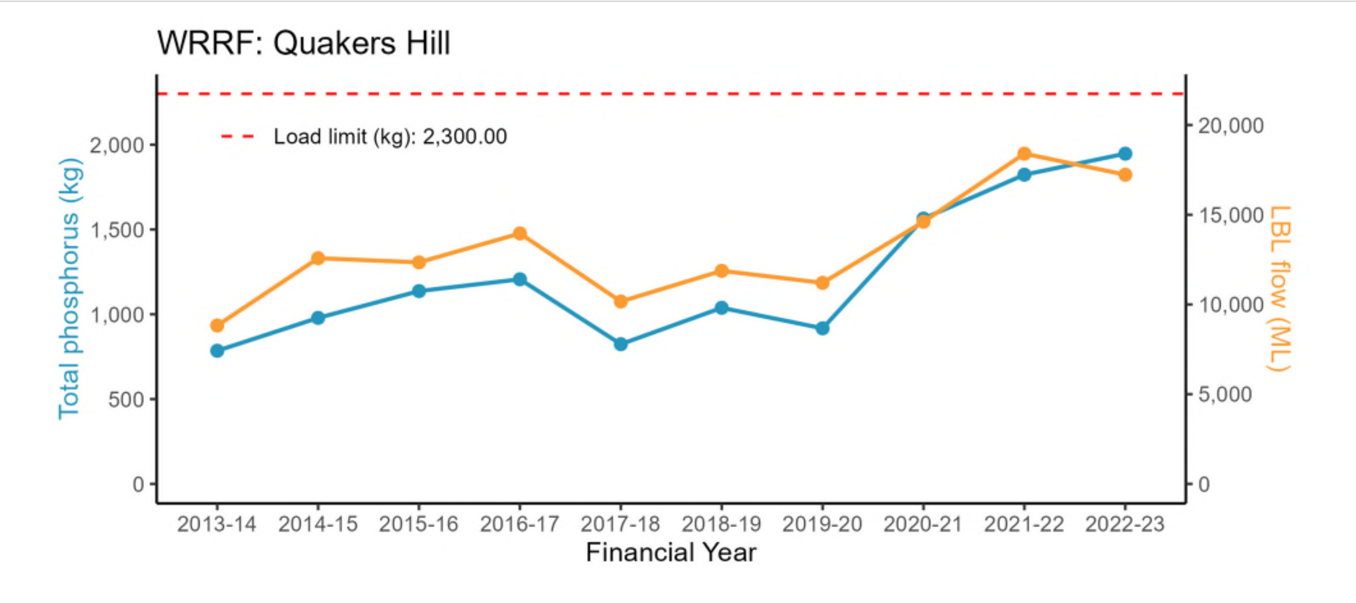


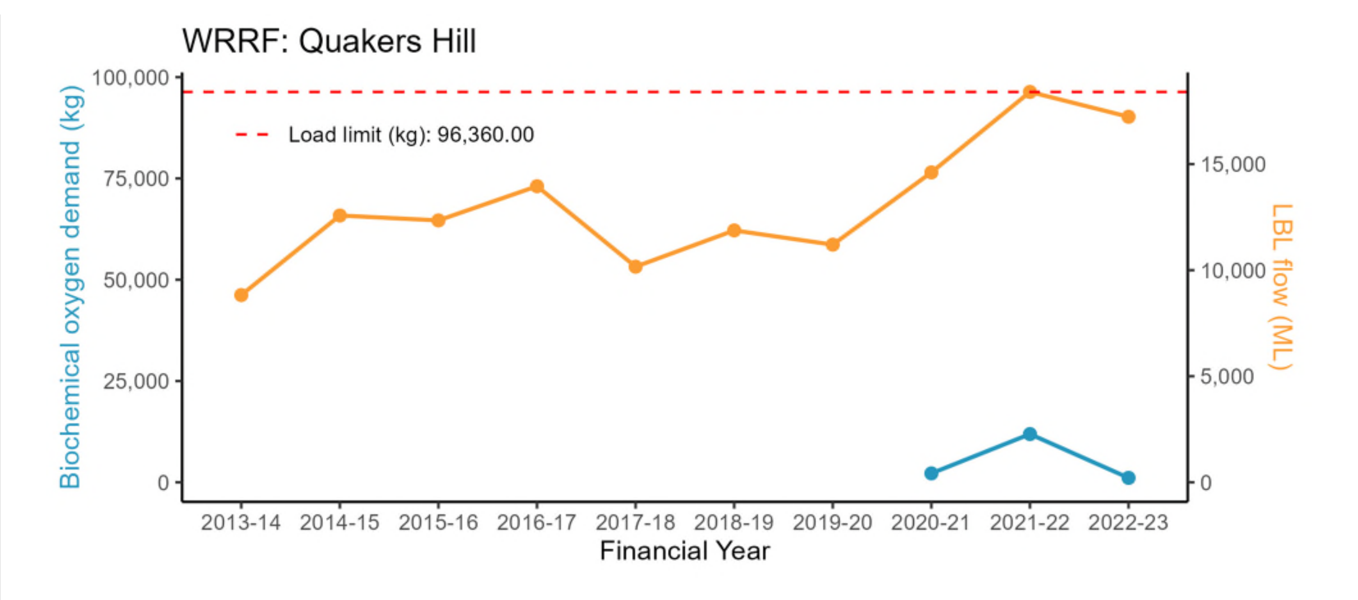


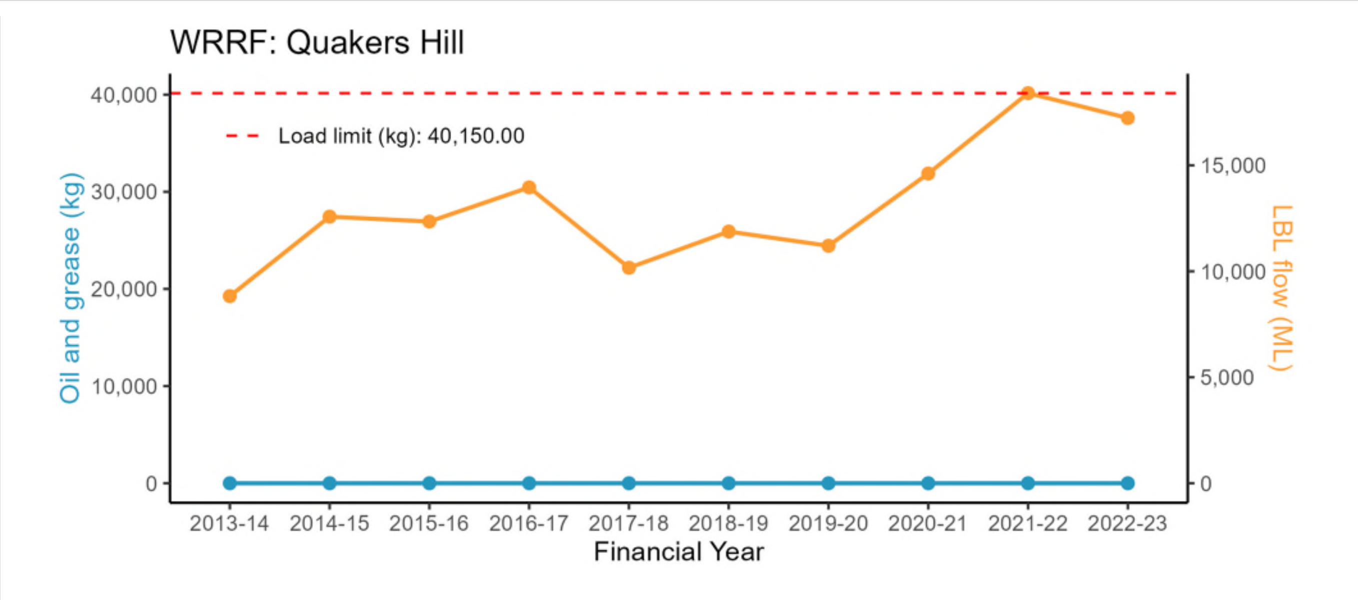
A-9.2 Pressure – Wastewater discharge load

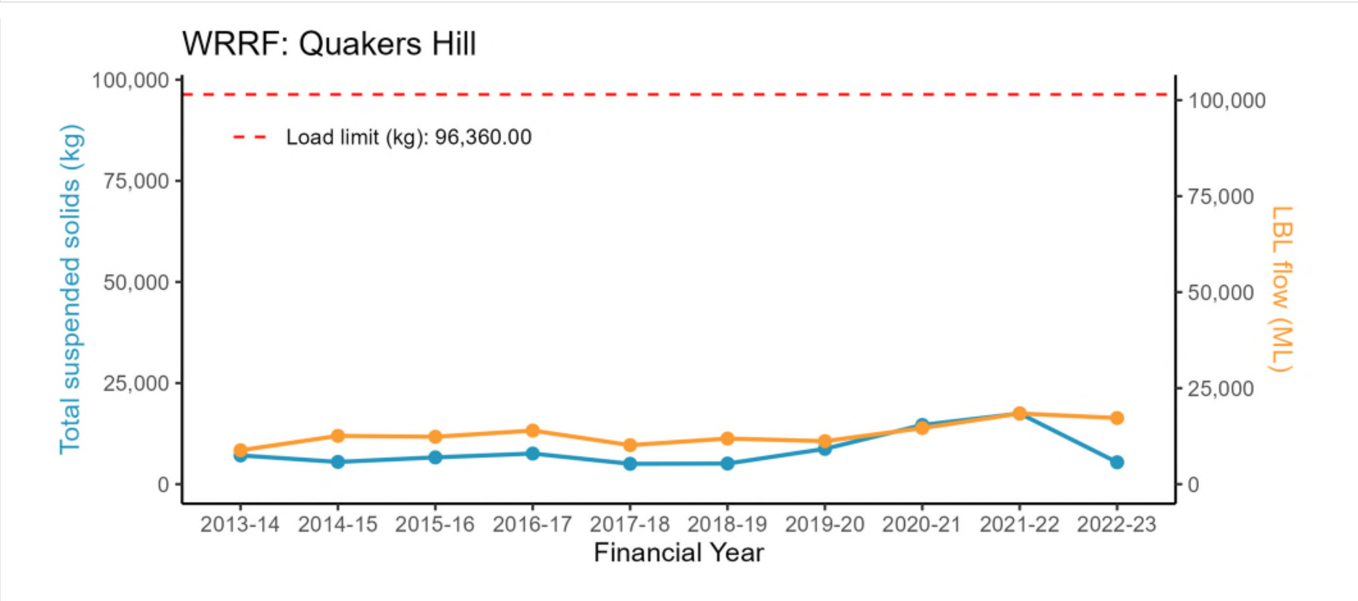
Nutrients

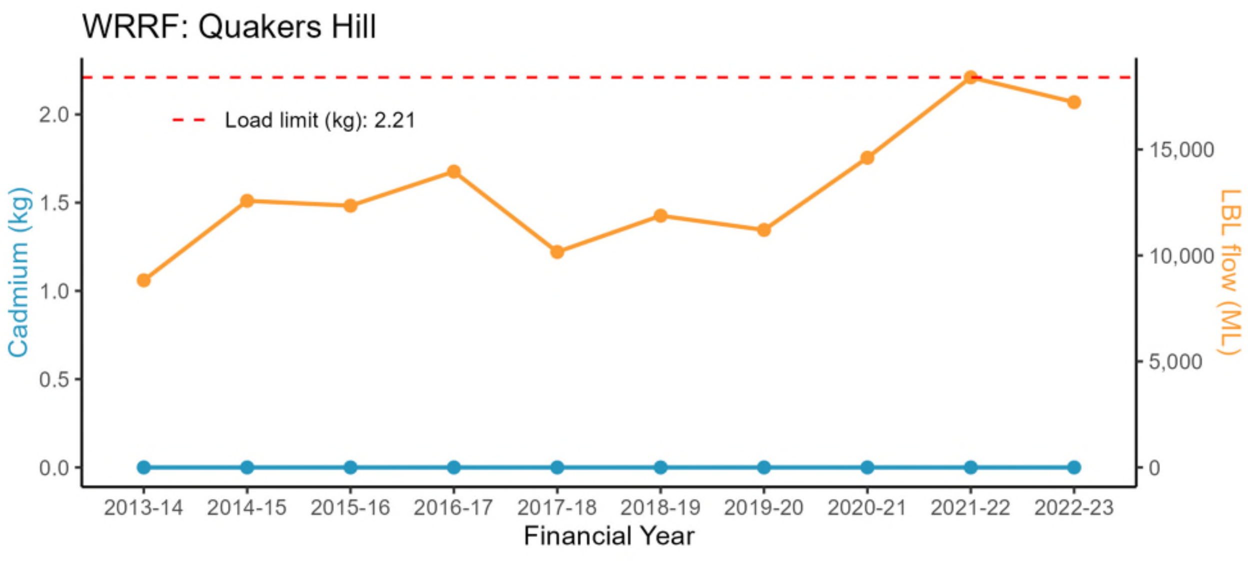


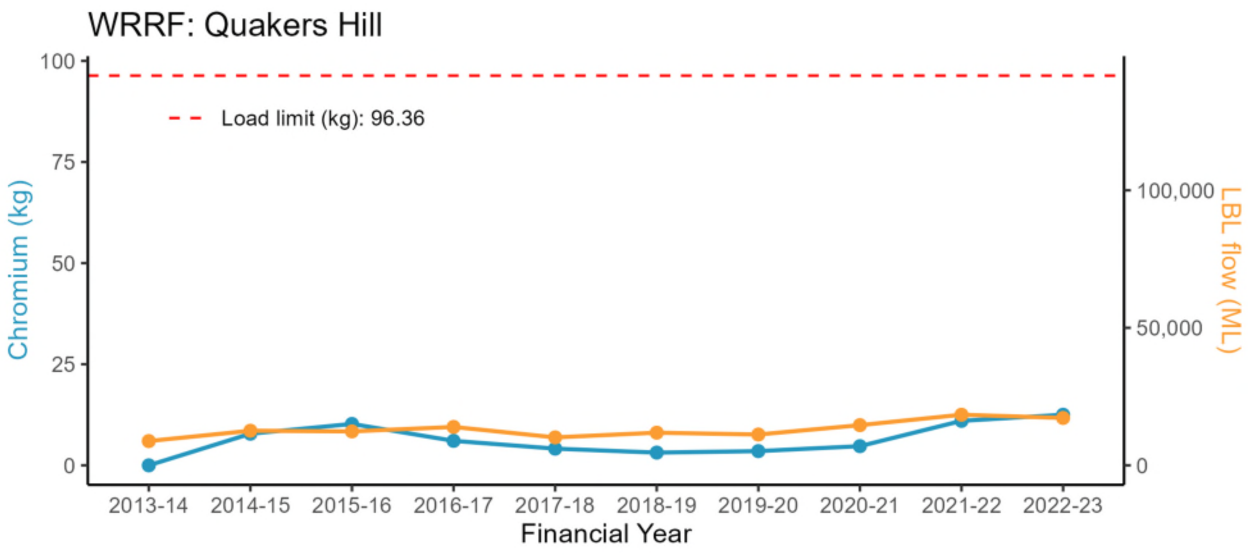


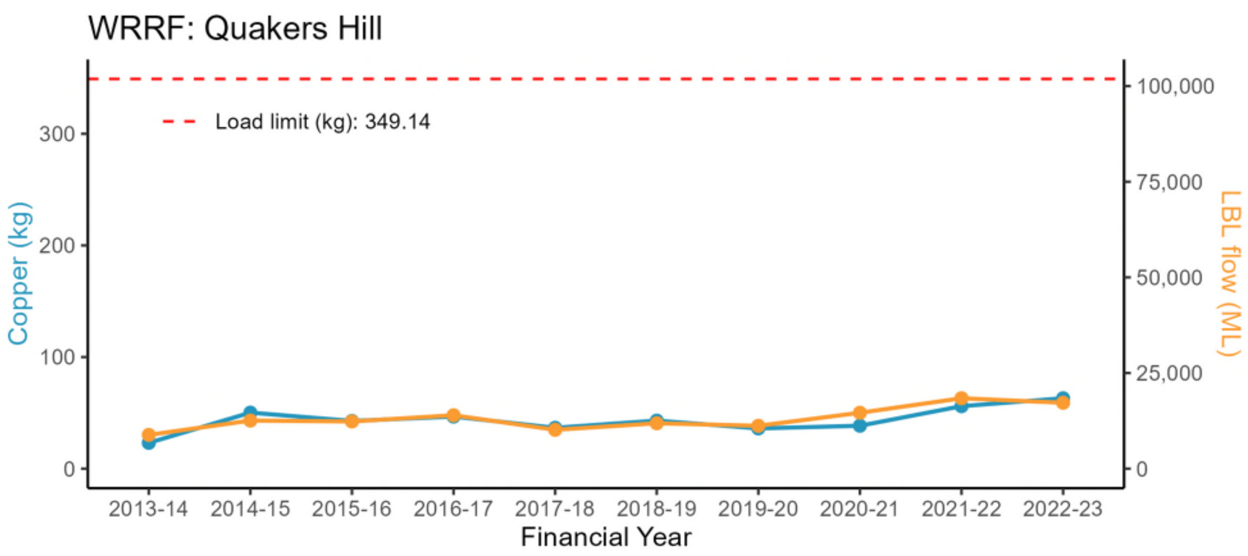

WRRF: Quakers Hill
Load limit (kg): 96,360.00
Biochemical oxygen demand (kg)
100,000
75,000
50,000
25,000
0
LBL flow (ML)
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

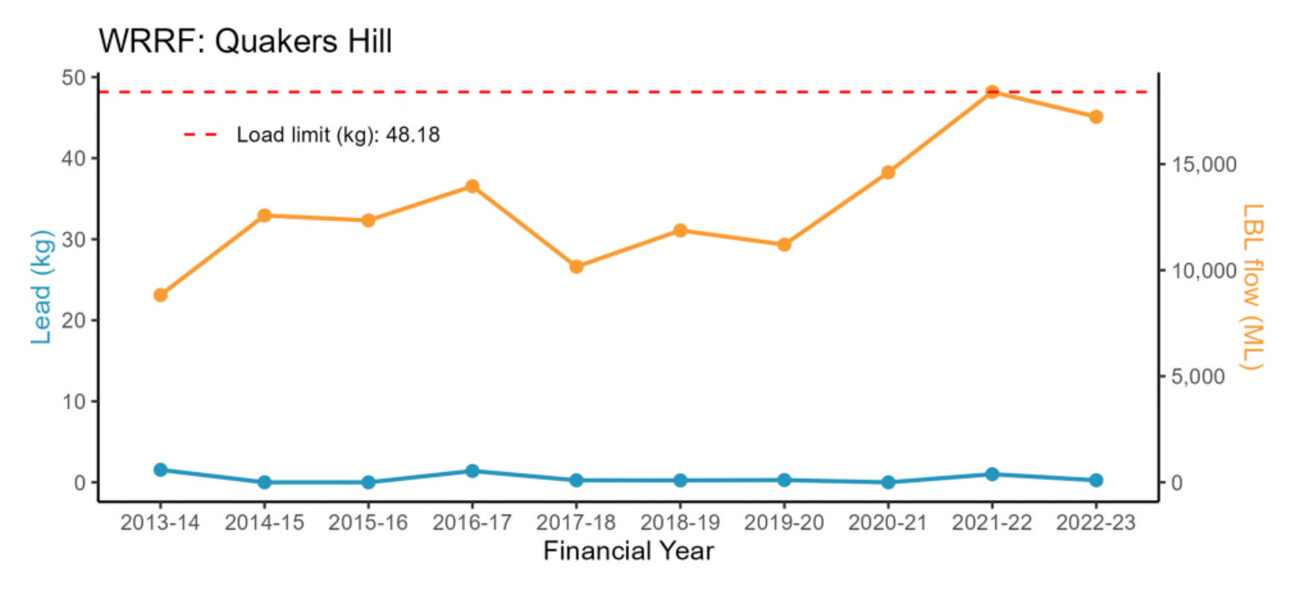

WRRF: Quakers Hill
Load limit (kg): 40,150.00
Oil and grease (kg)
40,000
30,000
20,000
10,000
0
LBL flow (ML)
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

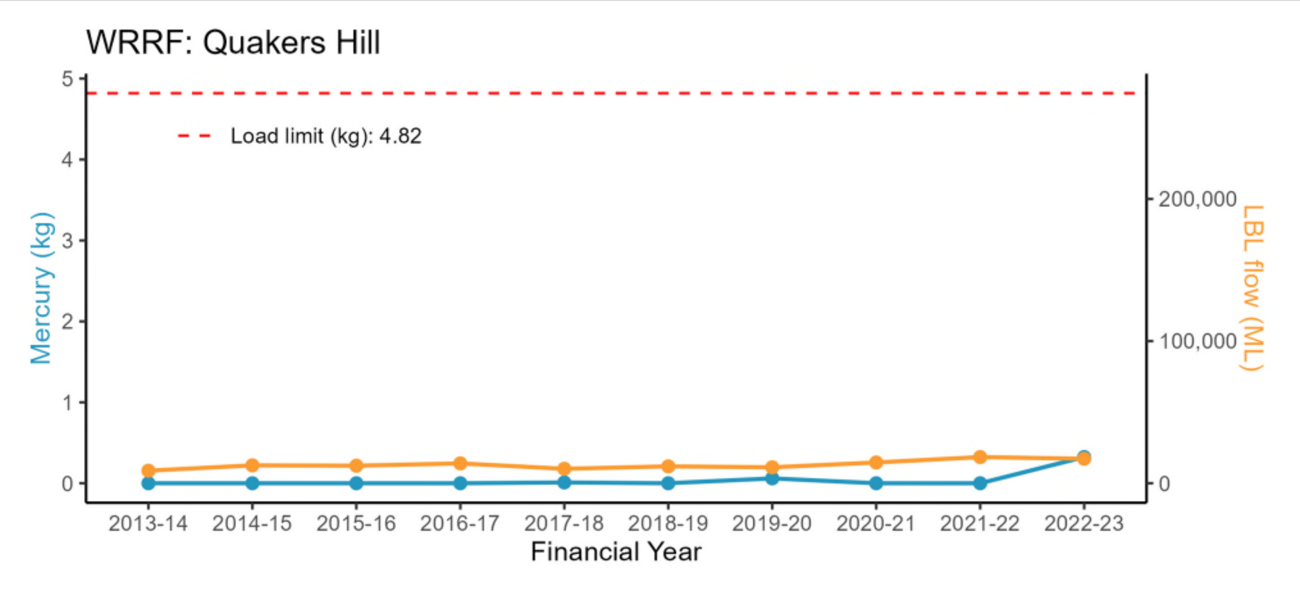

WRRF: Quakers Hill
Load limit (kg): 96,360.00
Total suspended solids (kg)
100,000
75,000
50,000
25,000
0
LBL flow (ML)
100,000
75,000
50,000
25,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

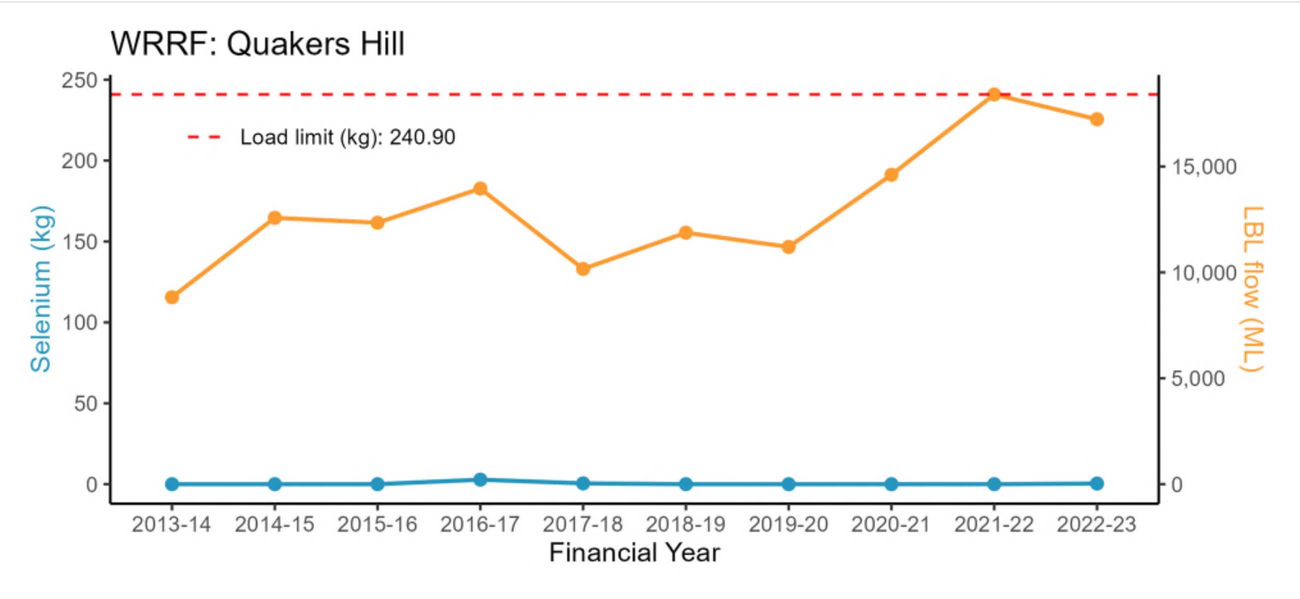

WRRF: Quakers Hill
Load limit (kg): 2.21
Cadmium (kg)
LBL flow (ML)
2.0
1.5
1.0
0.5
0.0
15,000
10,000
5,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

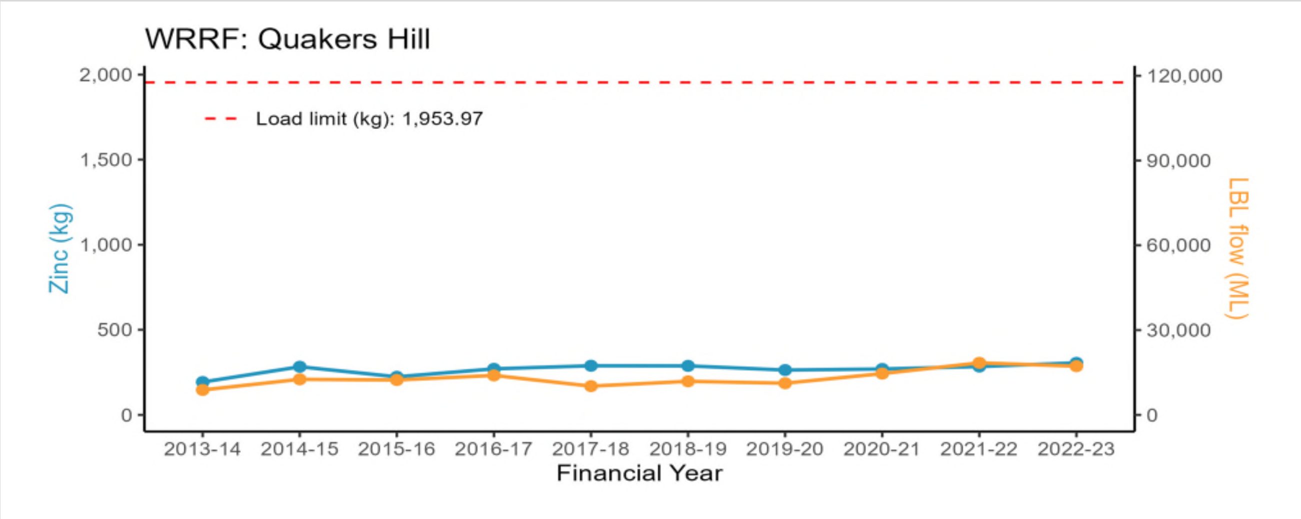

WRRF: Quakers Hill
Load limit (kg): 96.36
Chromium (kg)
LBL flow (ML)
100
75
50
25
0
100,000
50,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: Quakers Hill
Load limit (kg): 349.14
Copper (kg)
LBL flow (ML)
300
200
100
0
100,000
75,000
50,000
25,000
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

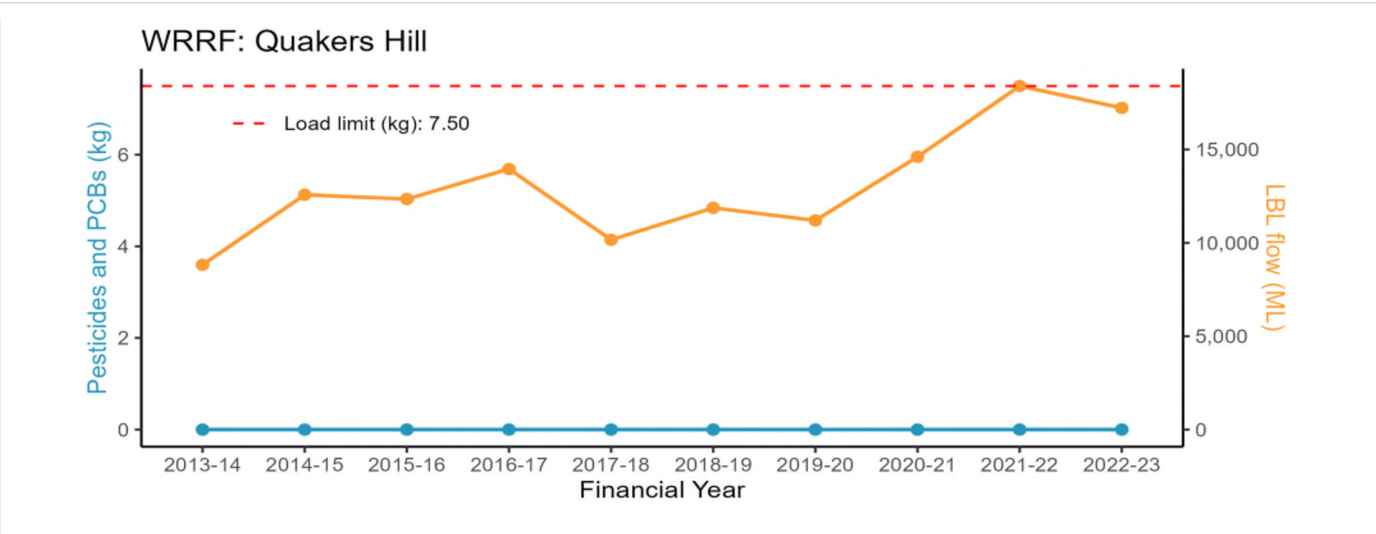

WRRF: Quakers Hill
Load limit (kg): 48.18
Lead (kg)
LBL flow (ML)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


WRRF: Quakers Hill
Load limit (kg): 4.82
Mercury (kg)
LBL flow (ML)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23

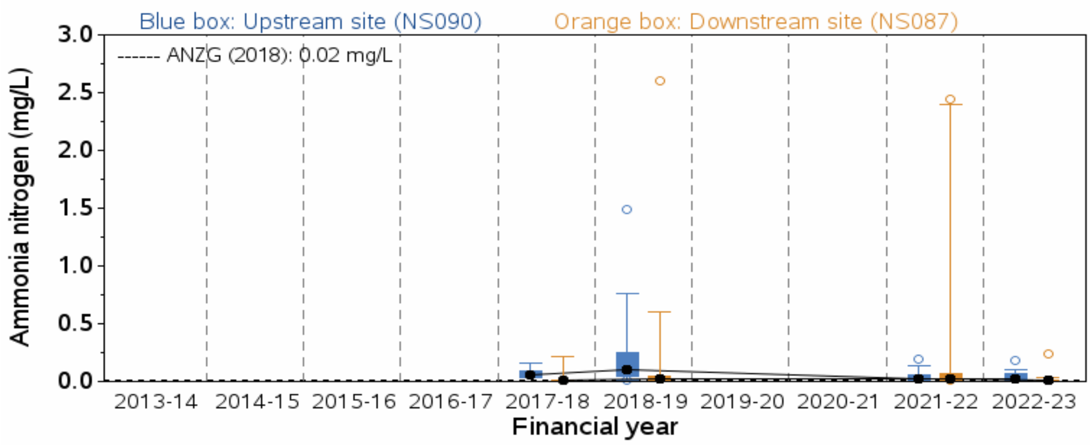

WRRF: Quakers Hill
Load limit (kg): 240.90
Selenium (kg)
LBL flow (ML)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23



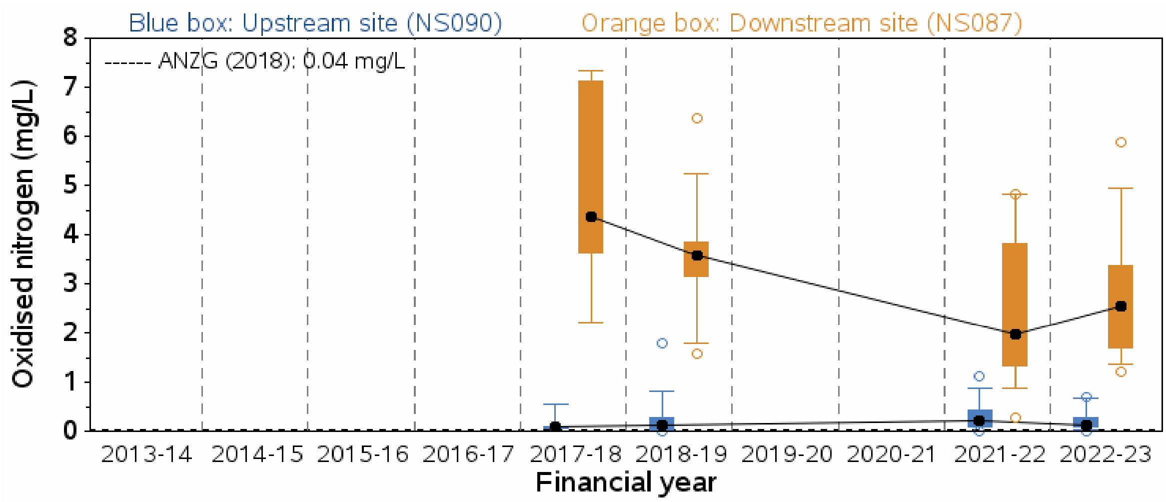
Other chemicals and organics (including pesticides)



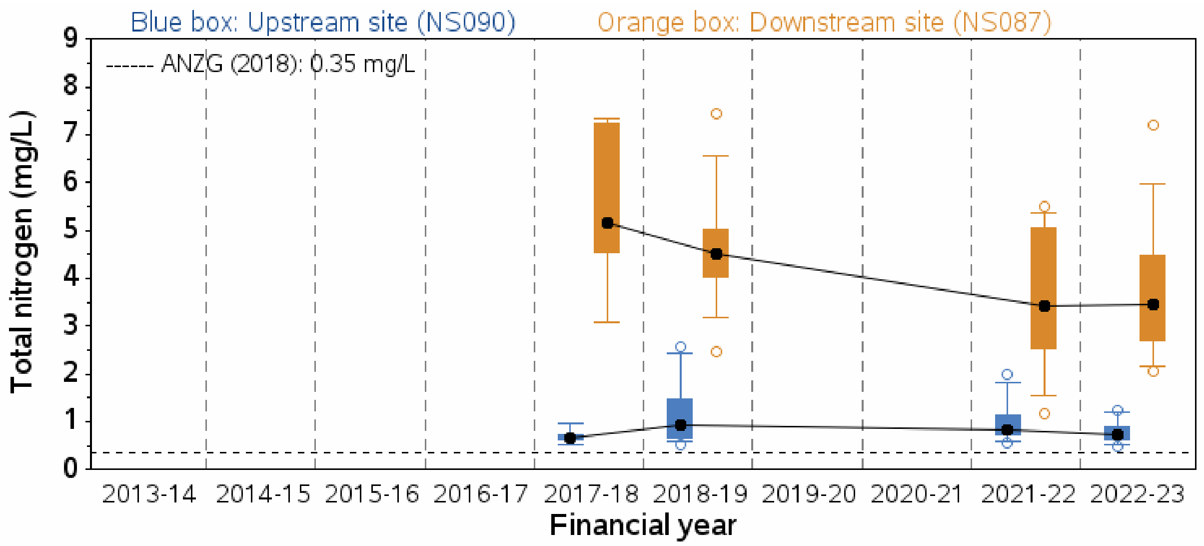
A-9.3 Stressor – Nutrients



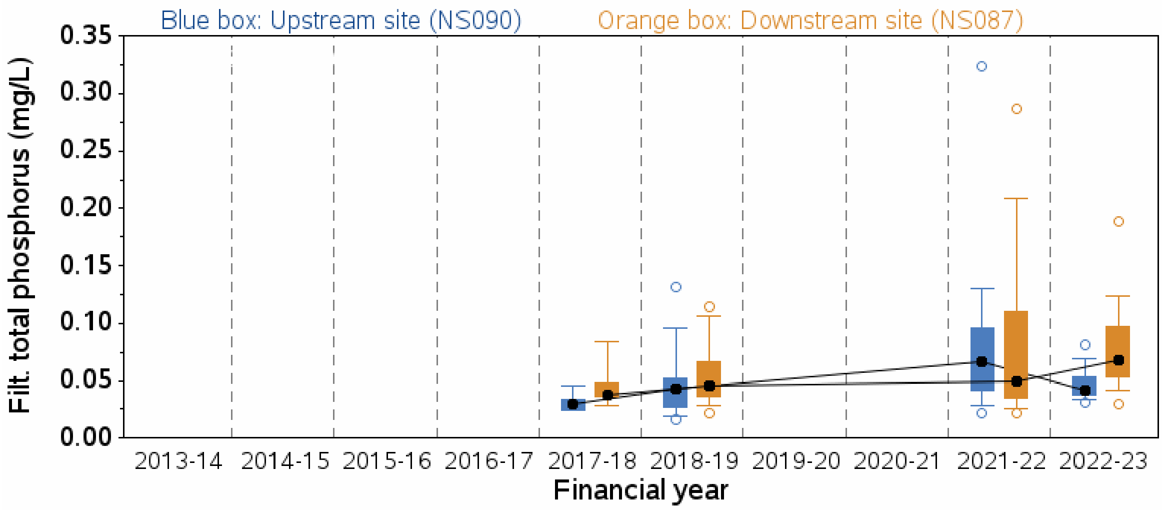
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	2.01	0.1619	NS087	1	2.38	0.1289



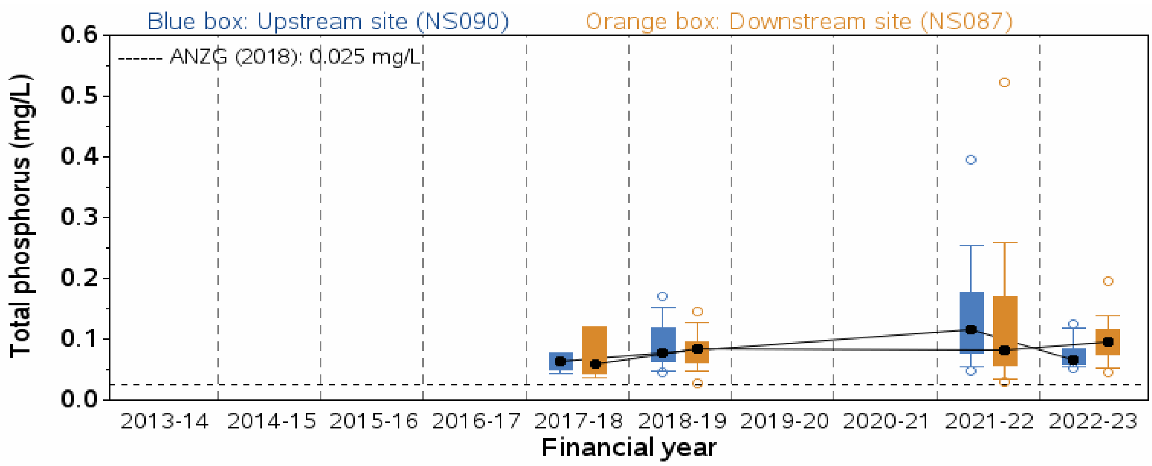
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	0.65	0.4219	NS087	1	1.12	0.295



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	3.57	0.0639	NS087	1	2.15	0.1479

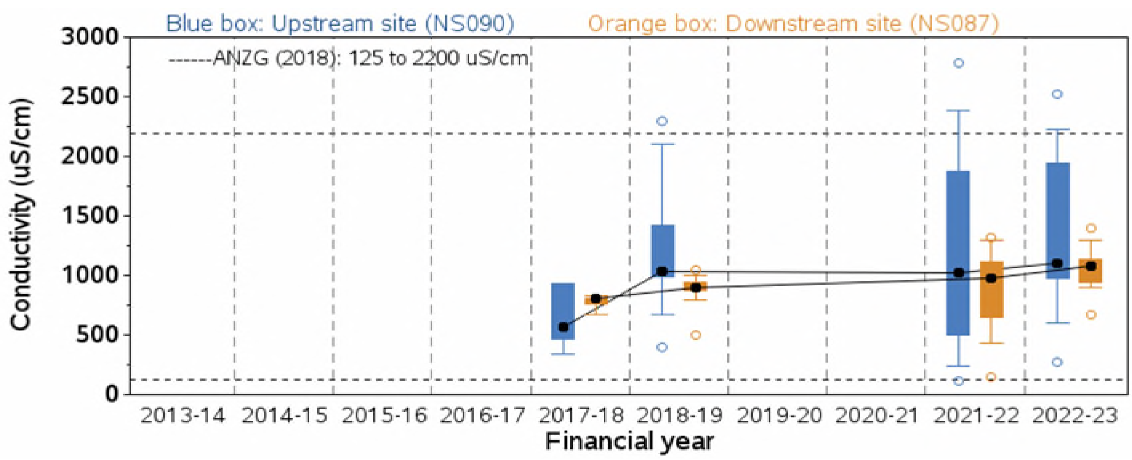


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	1.03	0.3156	NS087	1	0.82	0.3696

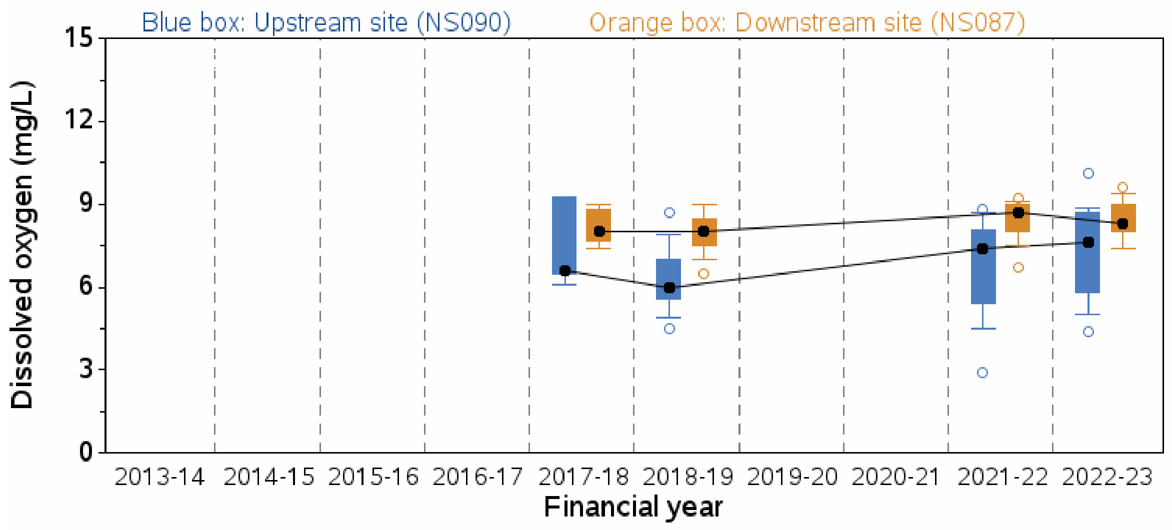


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	3.66	0.0609	NS087	1	0.07	0.7953

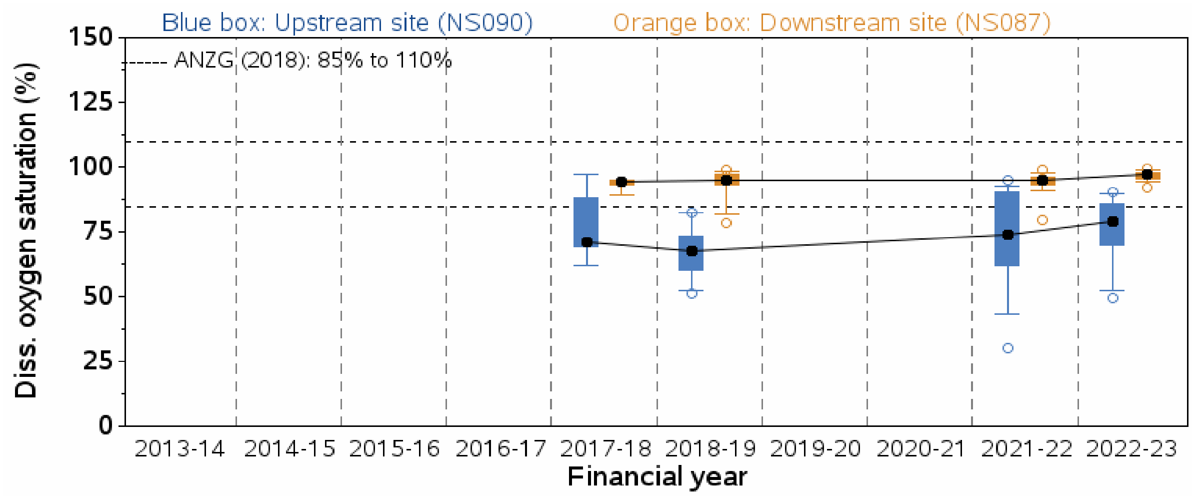
A-9.4 Stressor – Physico-chemical water quality



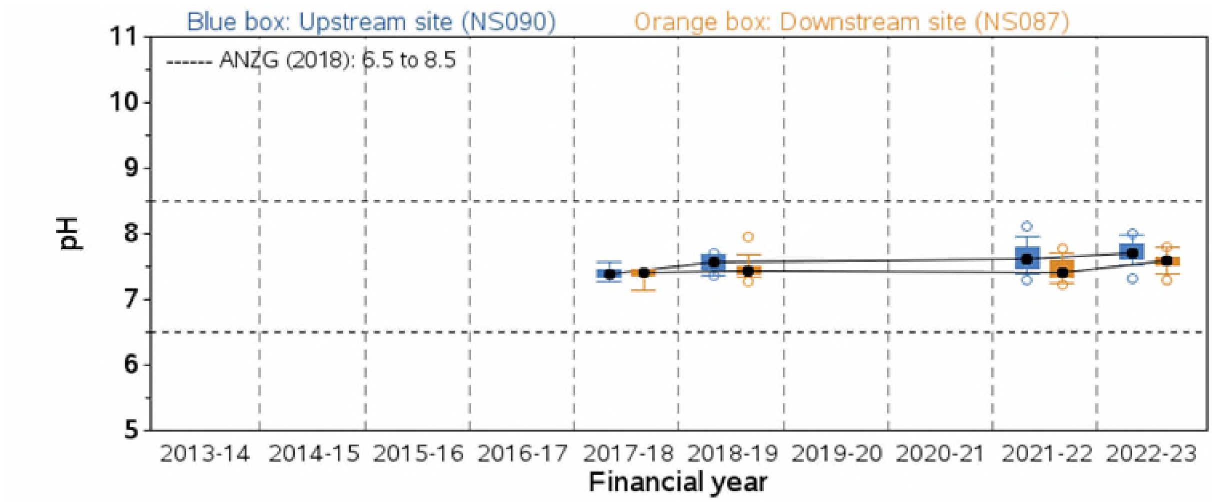
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	1.6	0.2117	NS087	1	8.8	0.0044



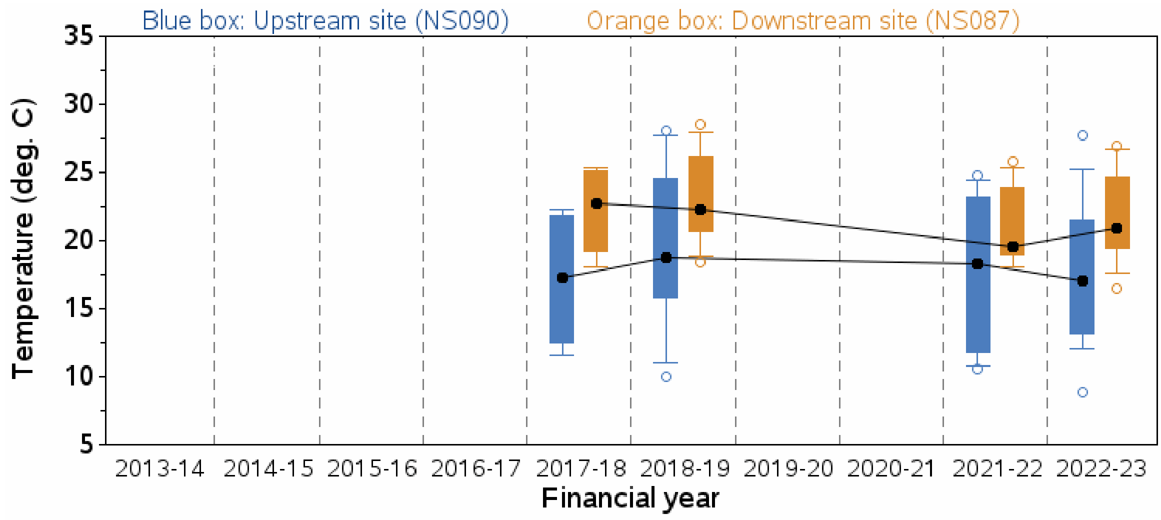
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	1.46	0.2321	NS087	1	2.51	0.1189



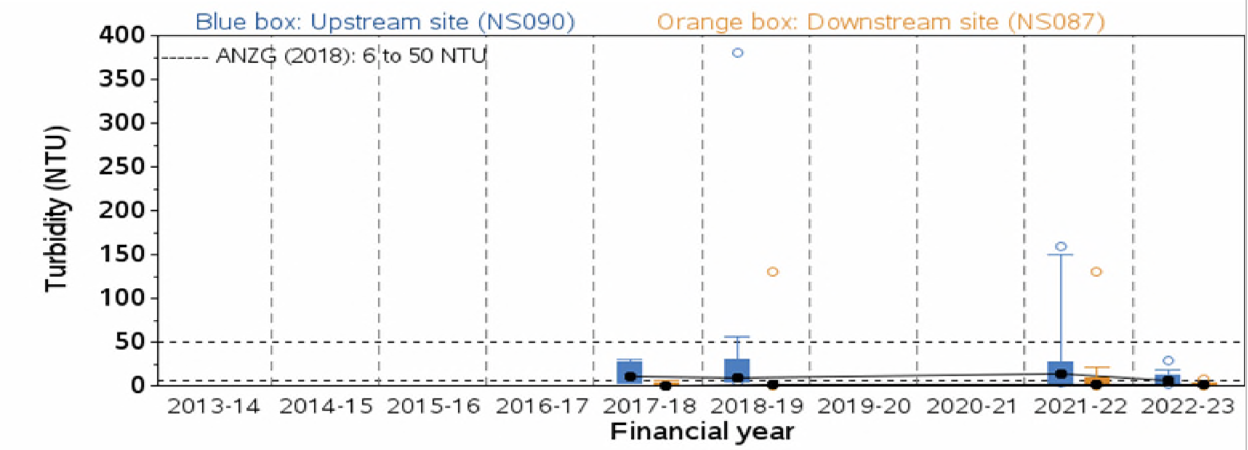
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	1.24	0.2695	NS087	1	5.95	0.0179



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	7.09	0.0101	NS087	1	8.04	0.0064

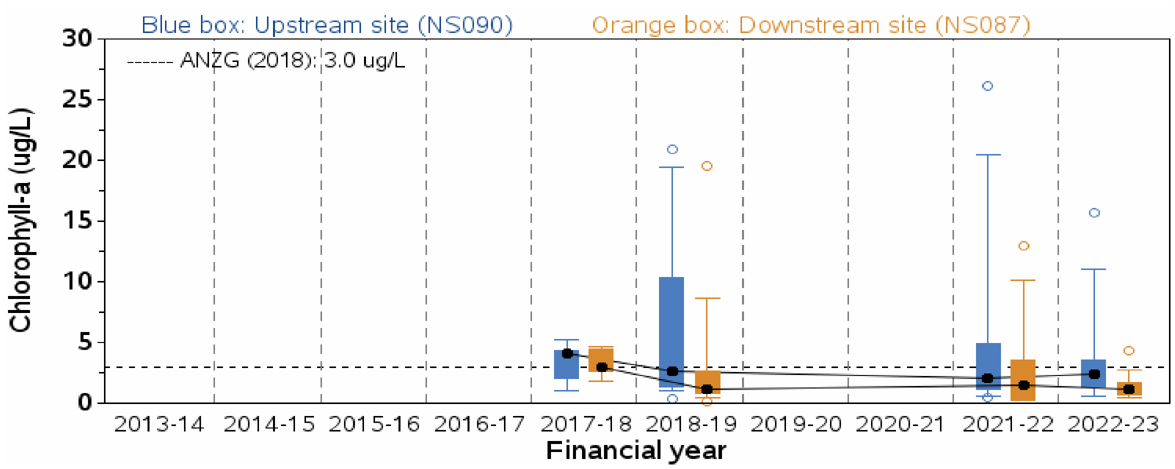


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	0.03	0.872	NS087	1	0.04	0.8473

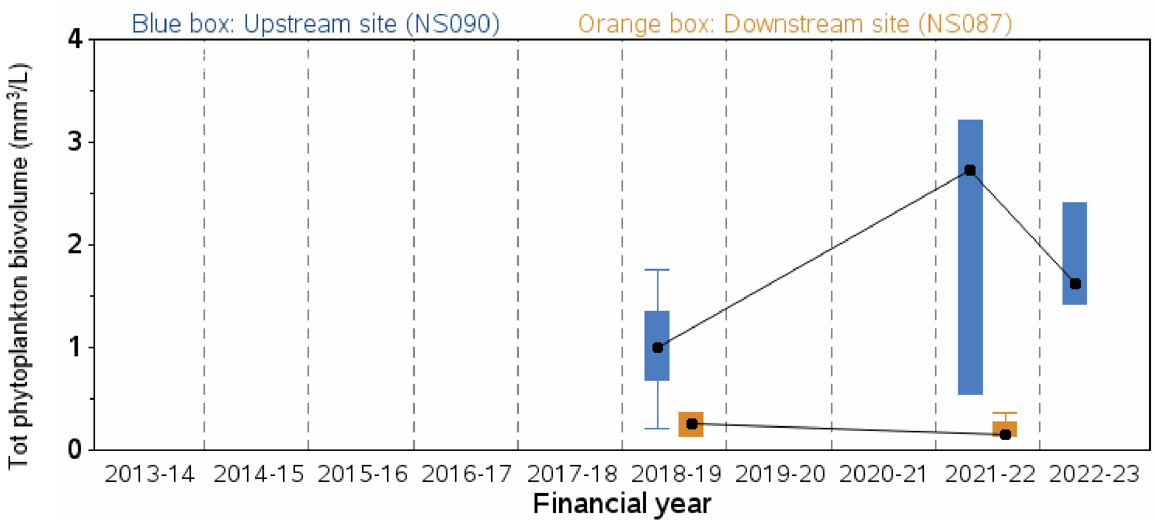


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	2.03	0.1597	NS087	1	1.16	0.2866

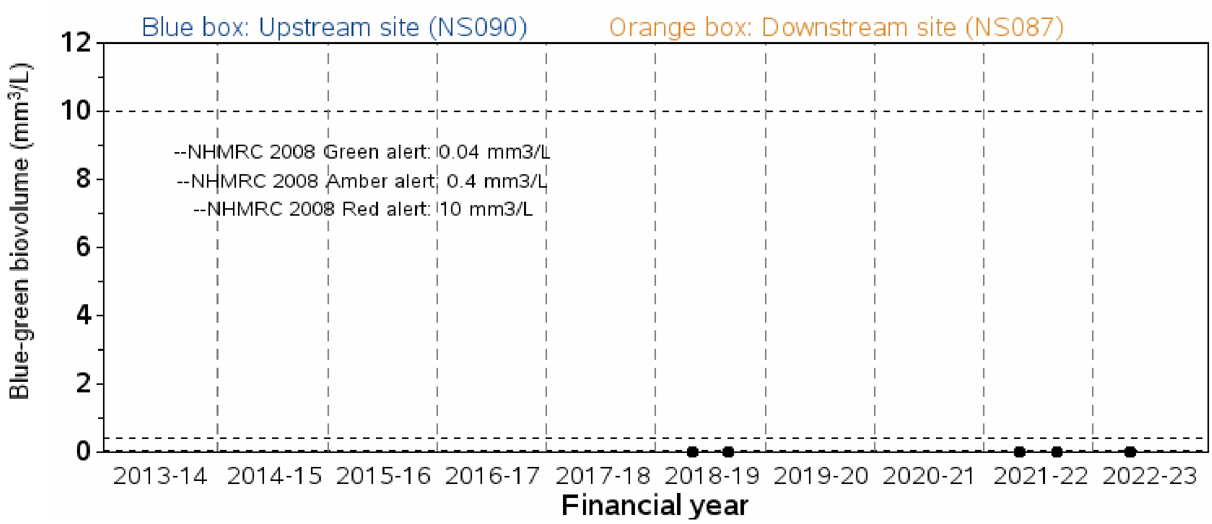
A-9.5 Ecosystem receptor – Phytoplankton



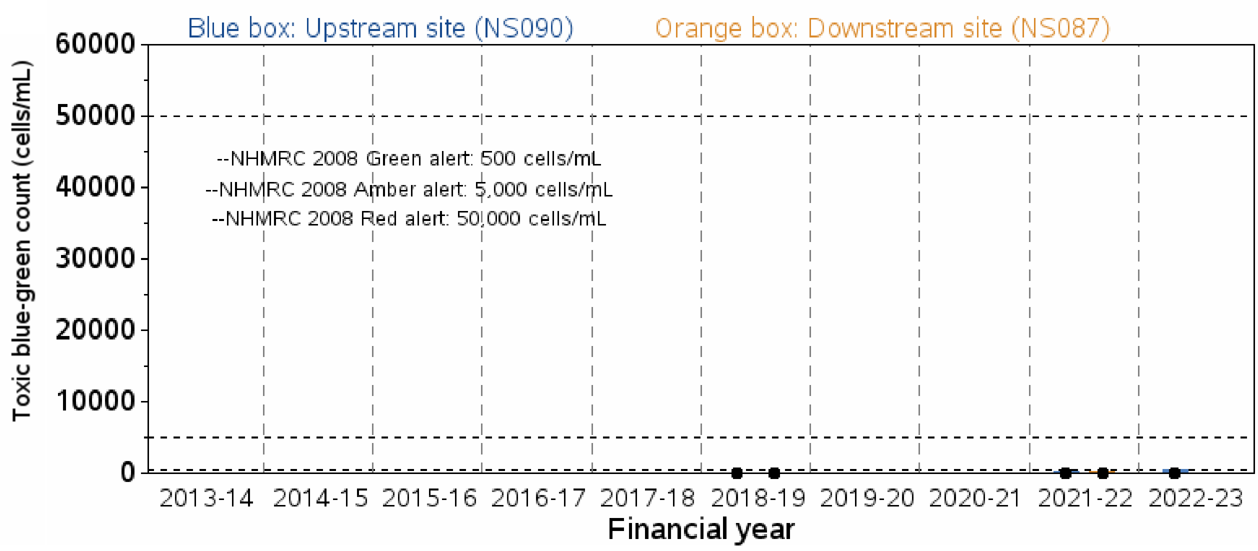
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	0.67	0.4173	NS087	1	3.01	0.0883



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	0.47	0.5098	NS087	Insufficient data		



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	0.53	0.4825	NS087	Insufficient data.		



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS090	1	3.41	0.0948	NS087	Insufficient data.		

A-9.6 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for Breakfast Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1995 and 2022. This comparison suggests downstream stream health was maintained at a level comparable to that of the upstream site indicating wastewater discharge from Quakers Hill WRRF did not have a measurable impact on stream health during 2022-23 (Figure A-29).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under a t-test returned a non-significant test outcome (Table A-39) to reflect SIGNAL-SG scores were overall lower from the upstream site in 2022-23 and confirmed the visual trend of the SIGNAL-SG plot.

As no measurable negative impact on downstream stream health was detected, no further data analysis was undertaken.

Table A-39 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Breakfast Creek near Quakers Hill WRRF

Waterway	Method	Statistic	DF	P value
Breakfast Creek	Welch Two Sample t-test	-0.99	8.7	0.351

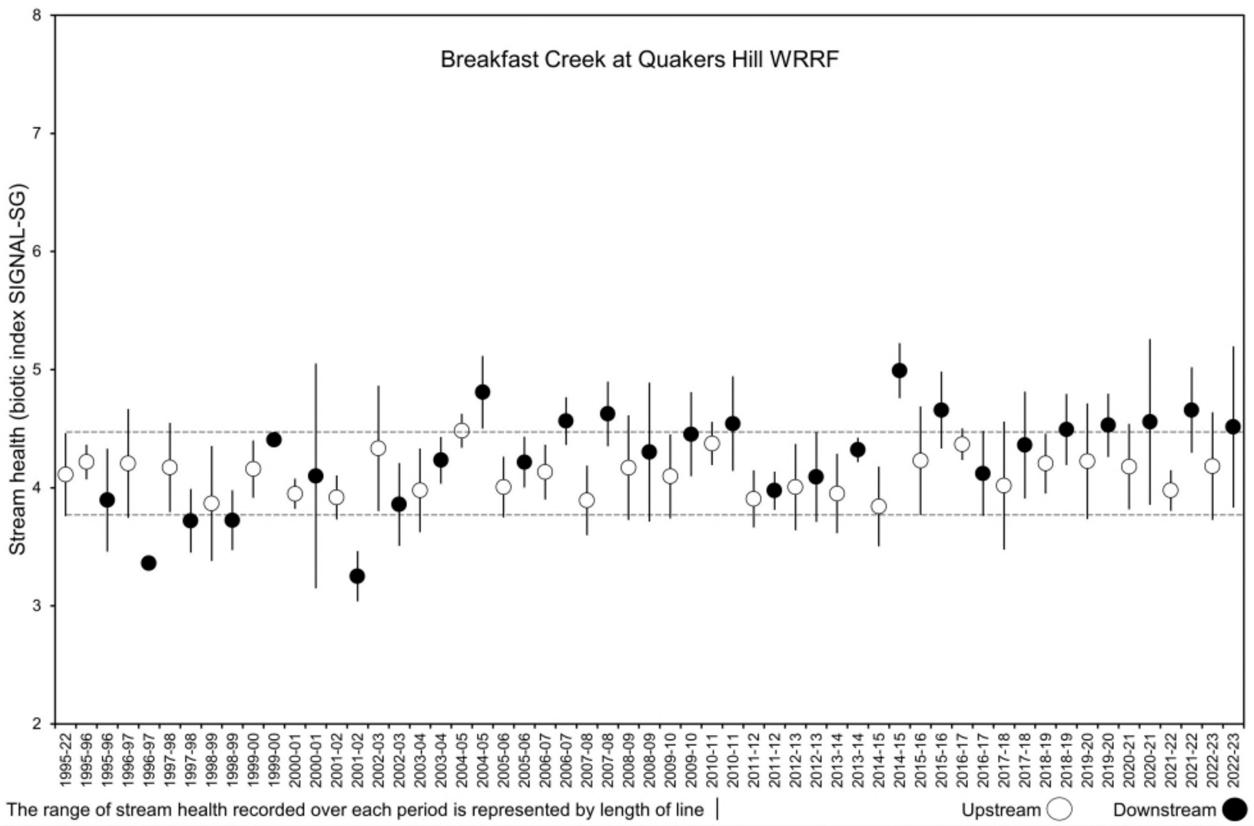
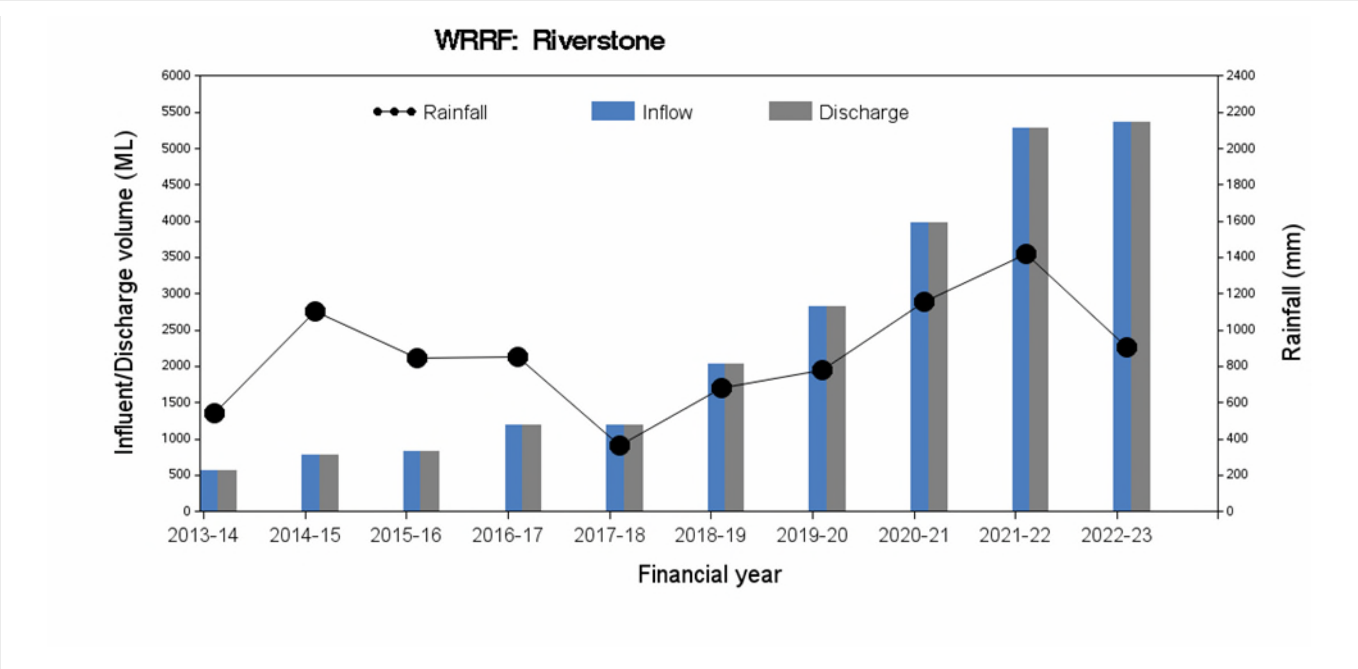


Figure A-29 Stream health of Breakfast Creek near Quakers Hill WRRF

A-10 Riverstone WRRF

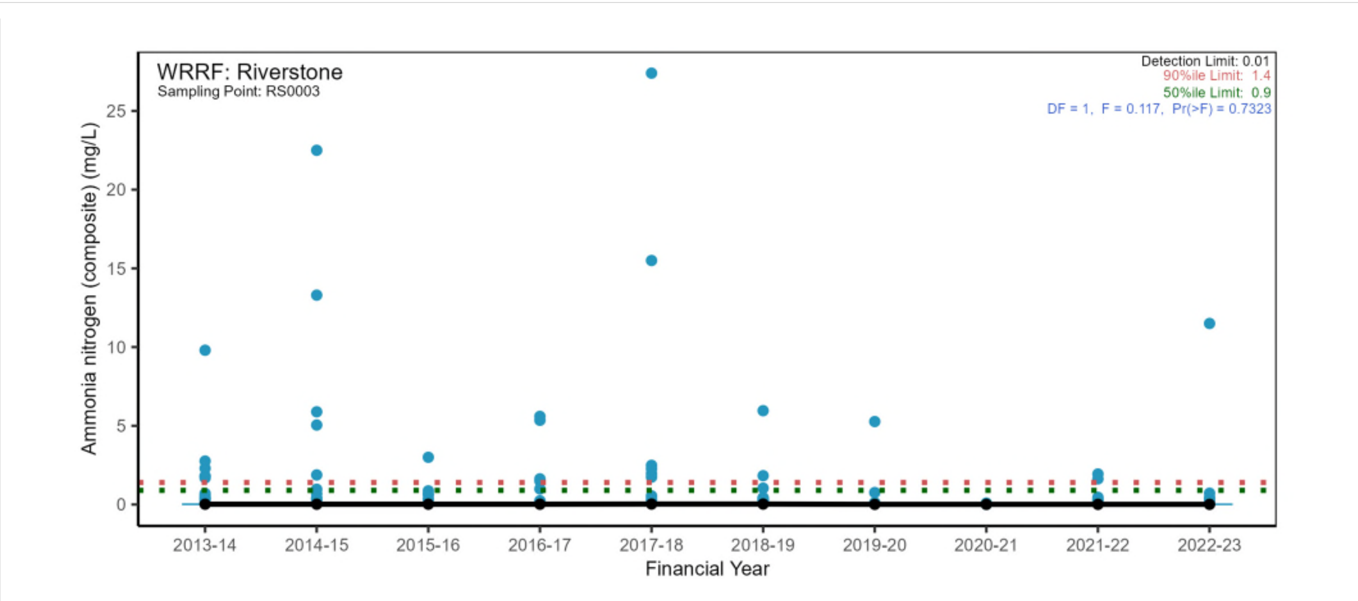
A-10.1 Pressure – Wastewater quantity

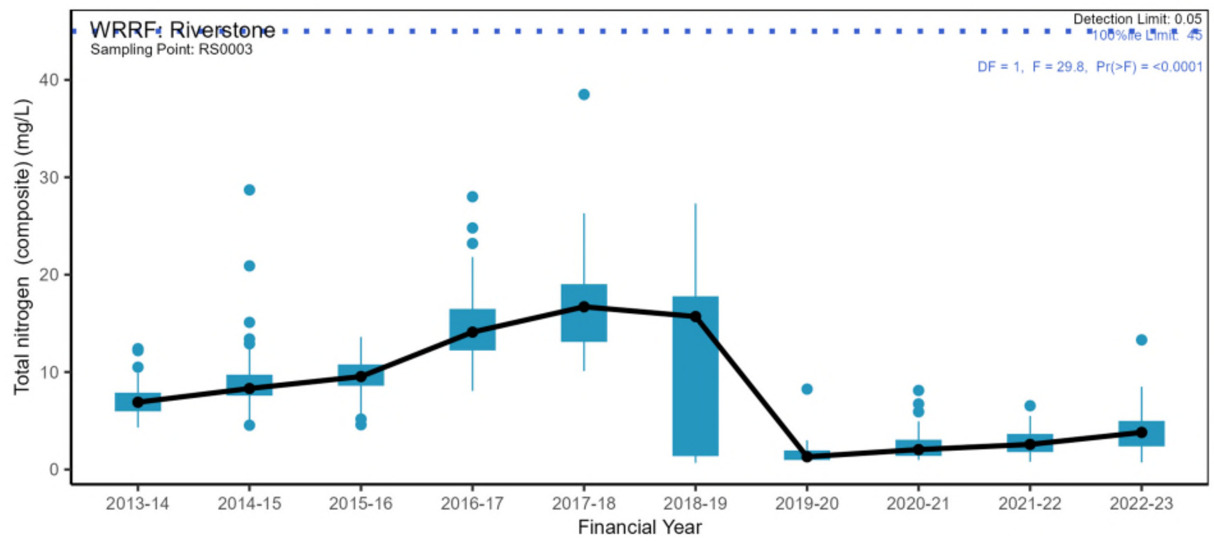
Inflow/ Discharge volume and rainfall

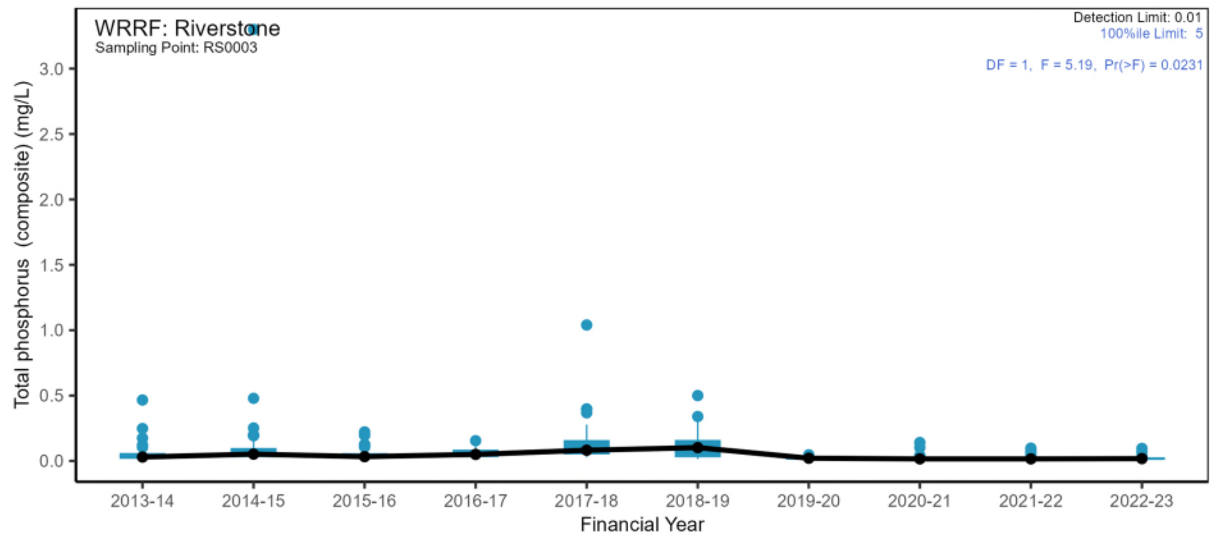


A-10.2 Pressure – Wastewater quality

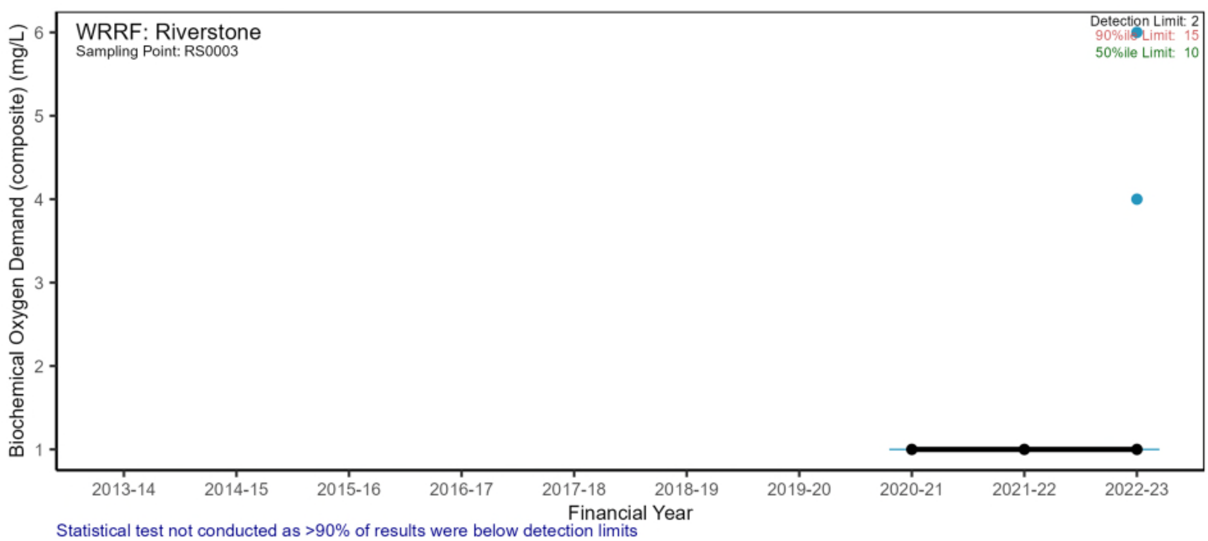
Nutrients

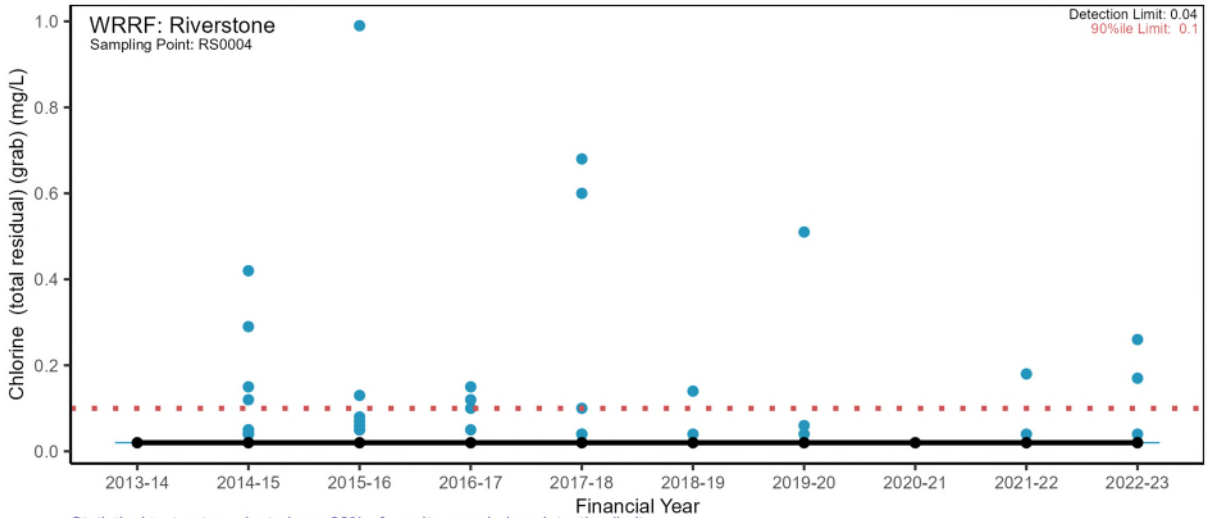




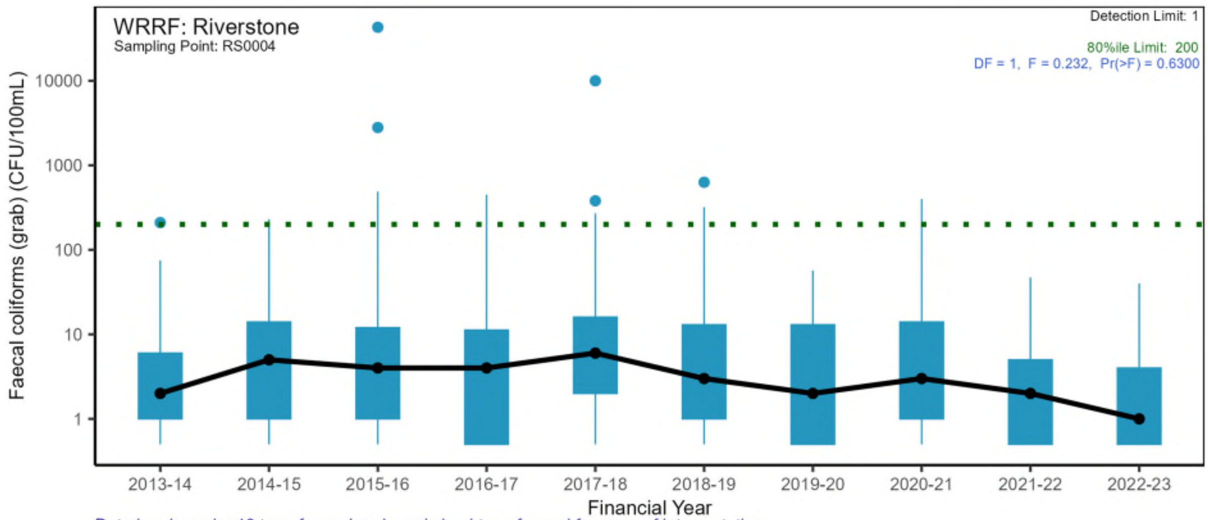


Major conventional analytes

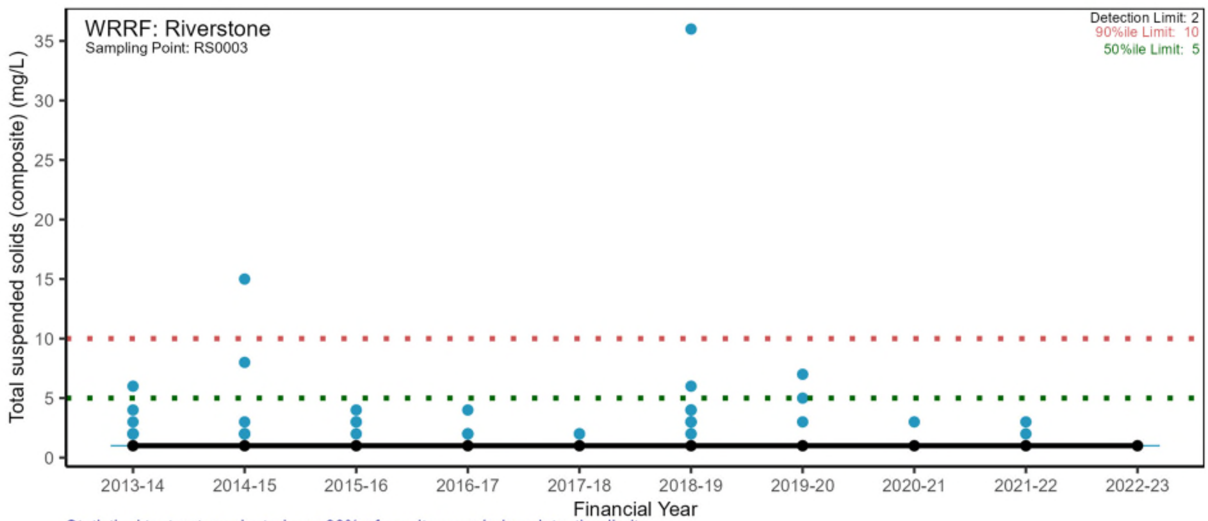




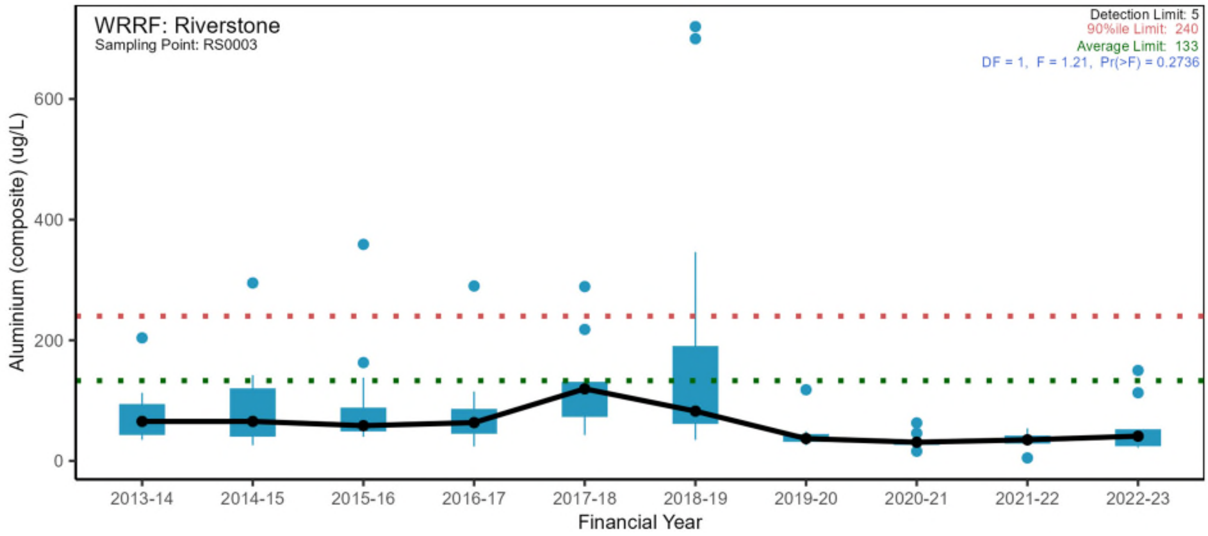
Statistical test not conducted as >90% of results were below detection limits

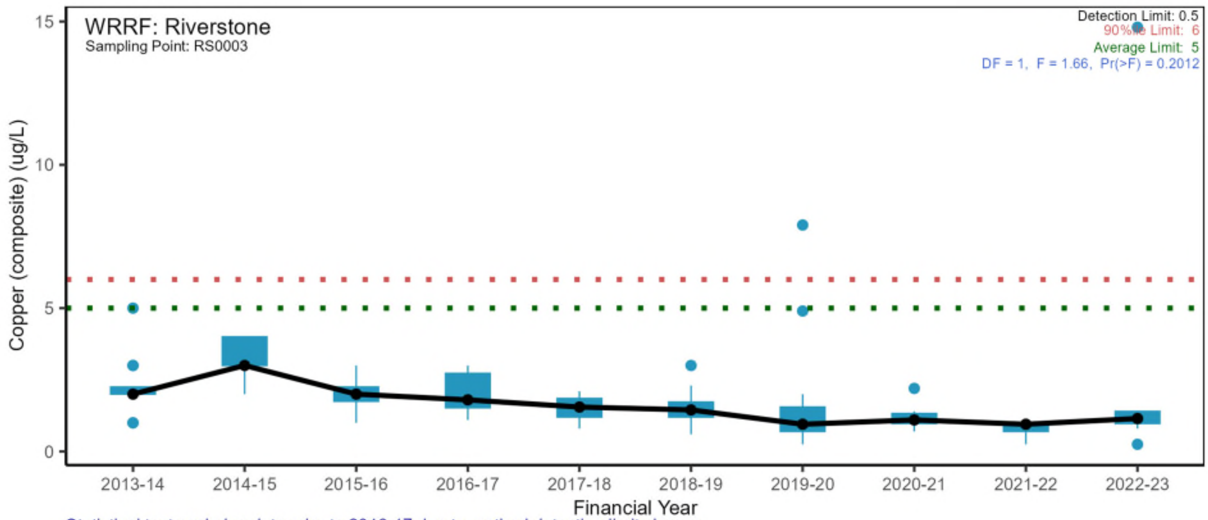


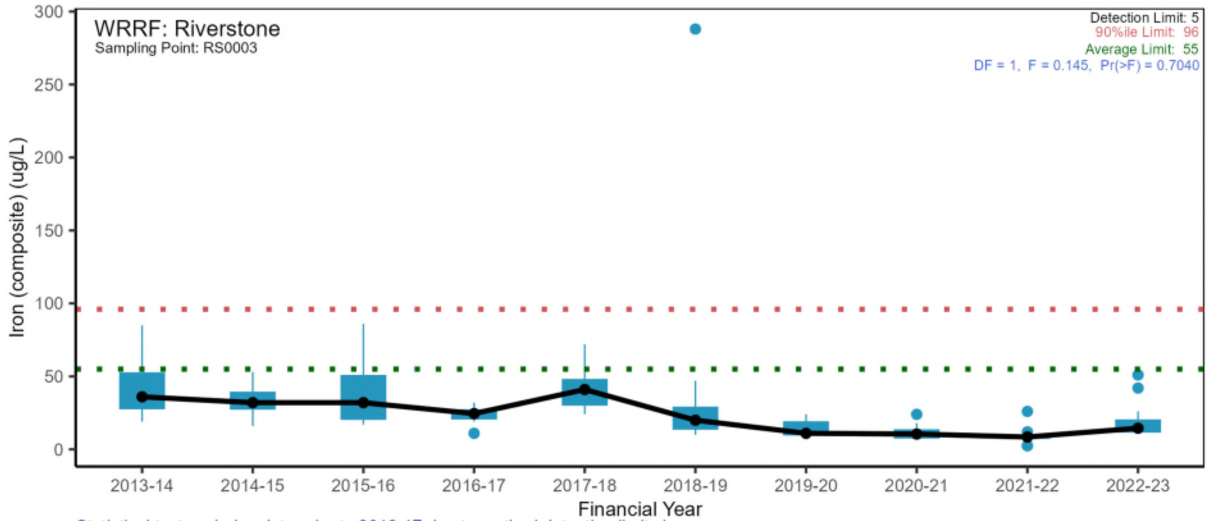
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

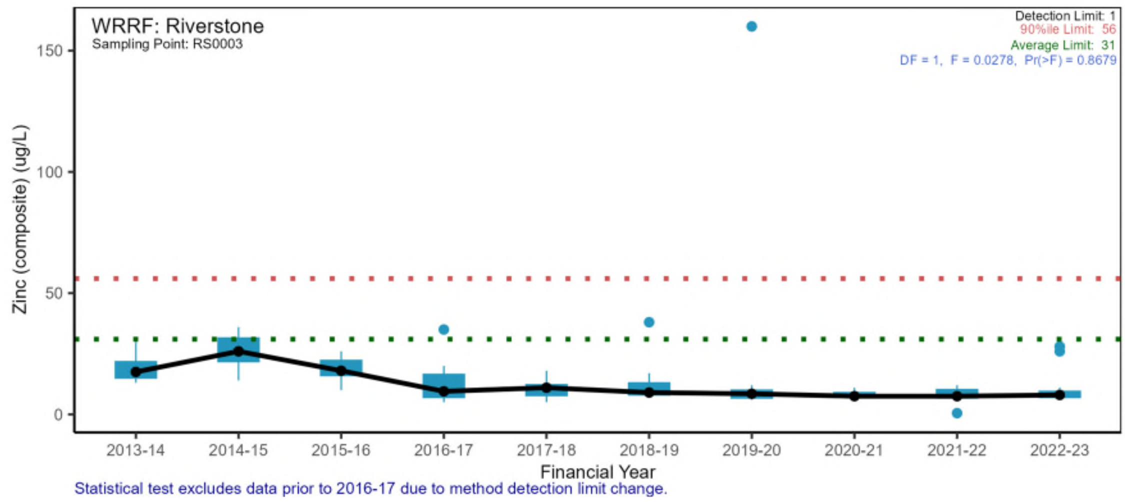


Statistical test not conducted as >90% of results were below detection limits

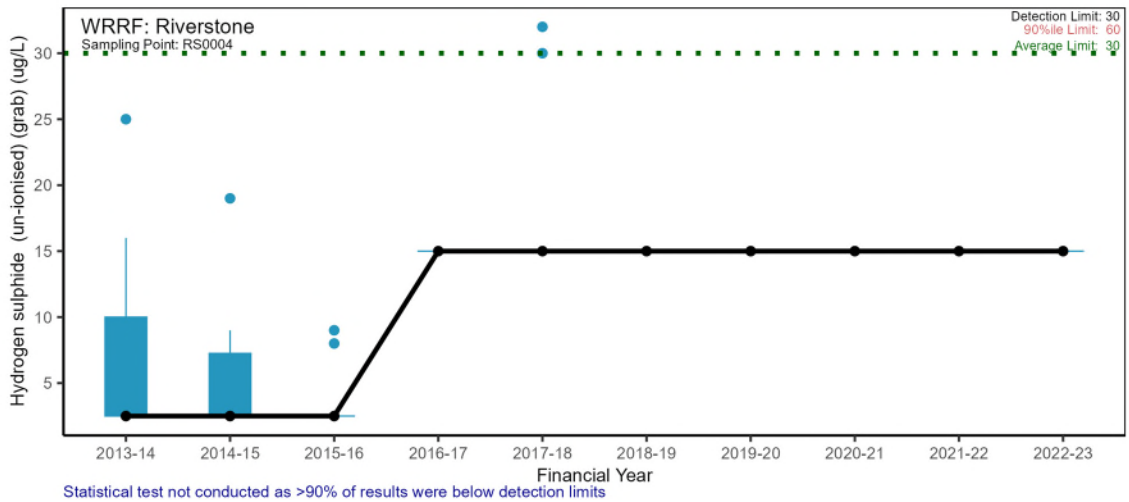

WRRF: Riverstone
Sampling Point: RS0003
Detection Limit: 5
90%ile Limit: 240
Average Limit: 133
DF = 1, F = 1.21, Pr(>F) = 0.2736
Aluminium (composite) (ug/L)
Financial Year
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23


WRRF: Riverstone
Sampling Point: RS0003
Detection Limit: 0.5
90%ile Limit: 6
Average Limit: 5
DF = 1, F = 1.66, Pr(>F) = 0.2012
Copper (composite) (ug/L)
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.

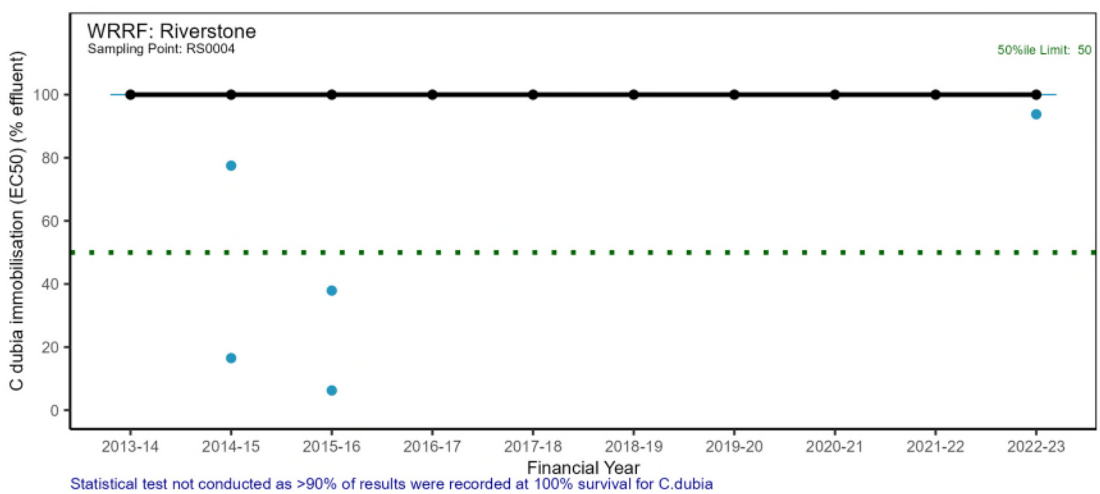

WRRF: Riverstone
Sampling Point: RS0003
Detection Limit: 5
90%ile Limit: 96
Average Limit: 55
DF = 1, F = 0.145, Pr(>F) = 0.7040
Iron (composite) (ug/L)
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.



Other chemicals and organics (including pesticides)

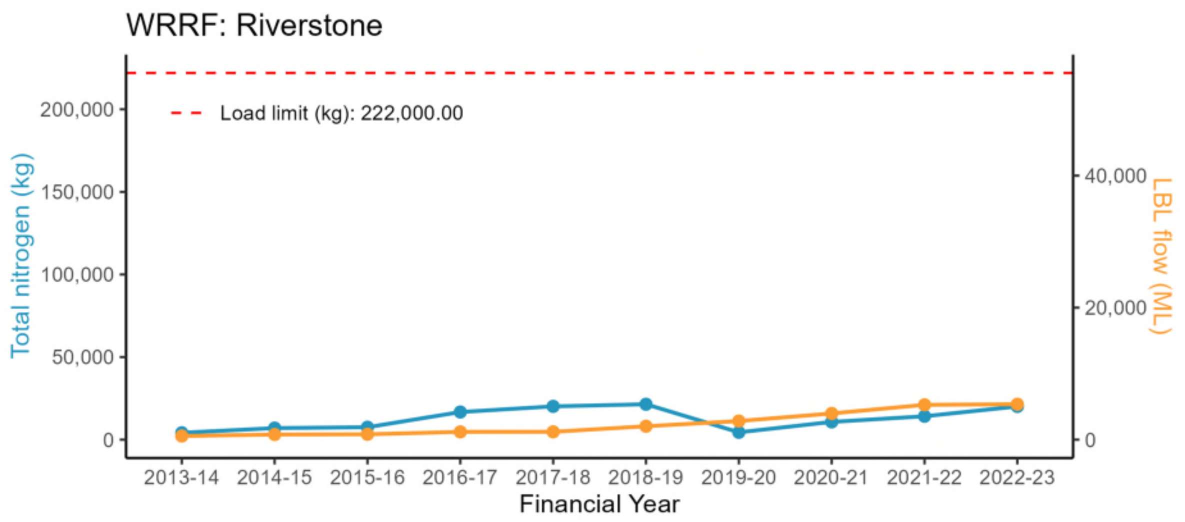


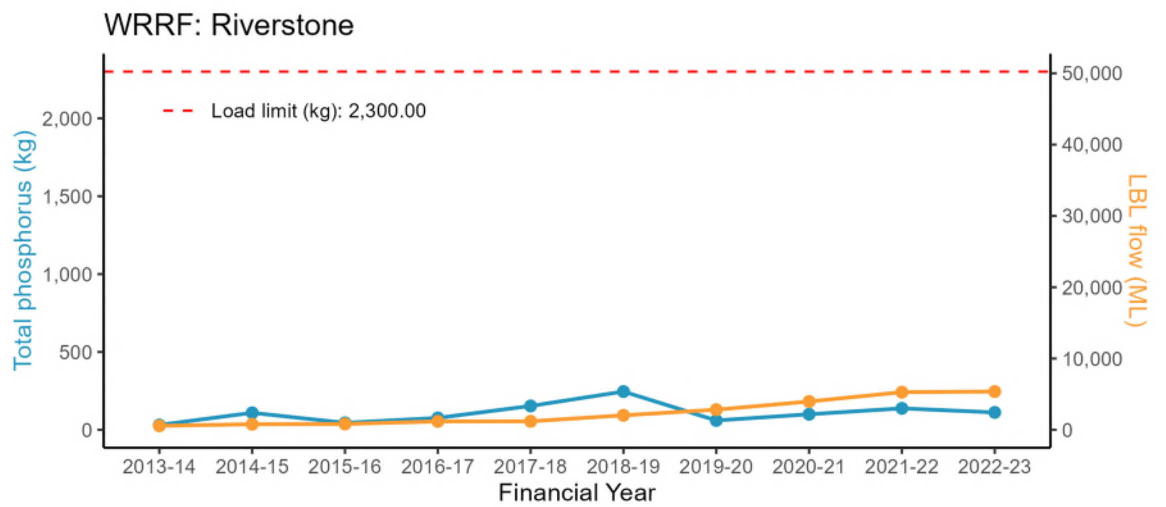
A-10.3 Pressure – Wastewater toxicity



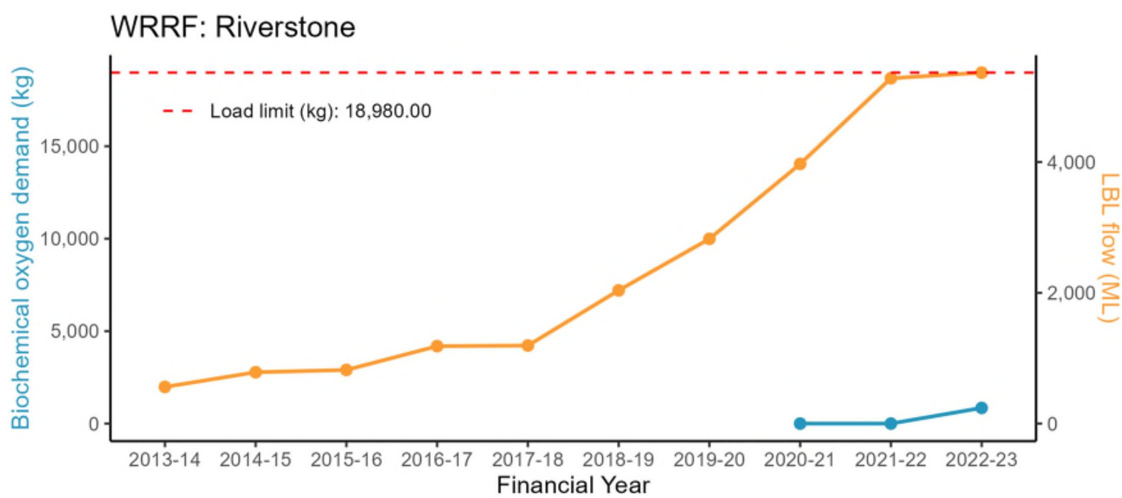
A-10.4 Pressure – Wastewater discharge load

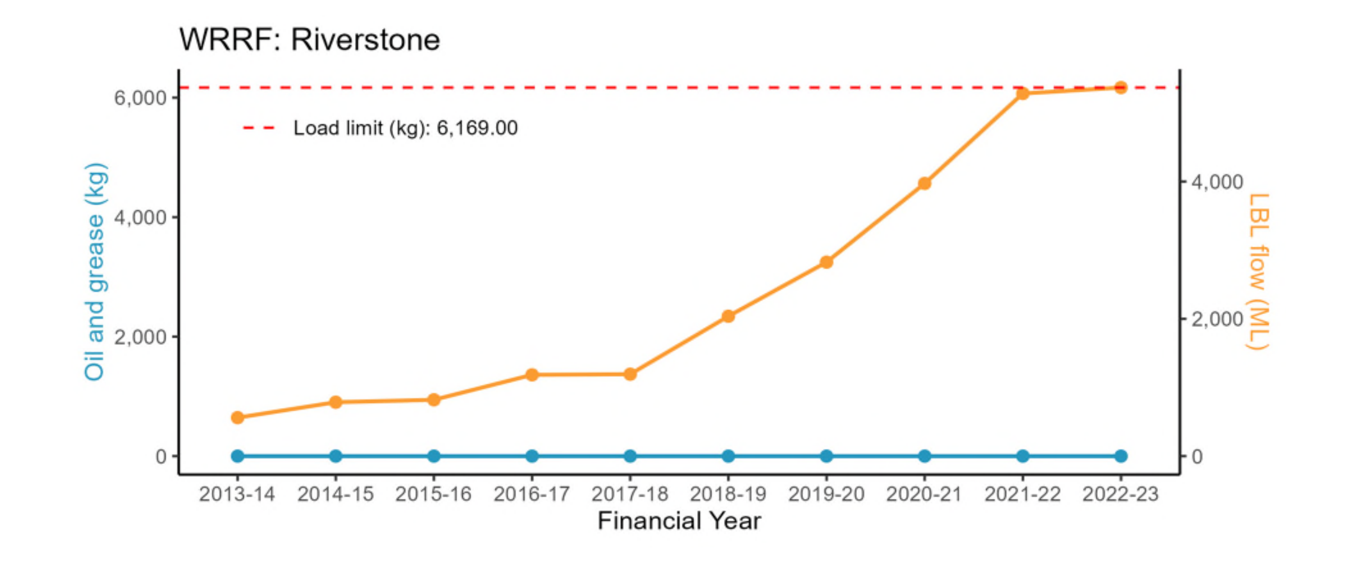
Nutrients

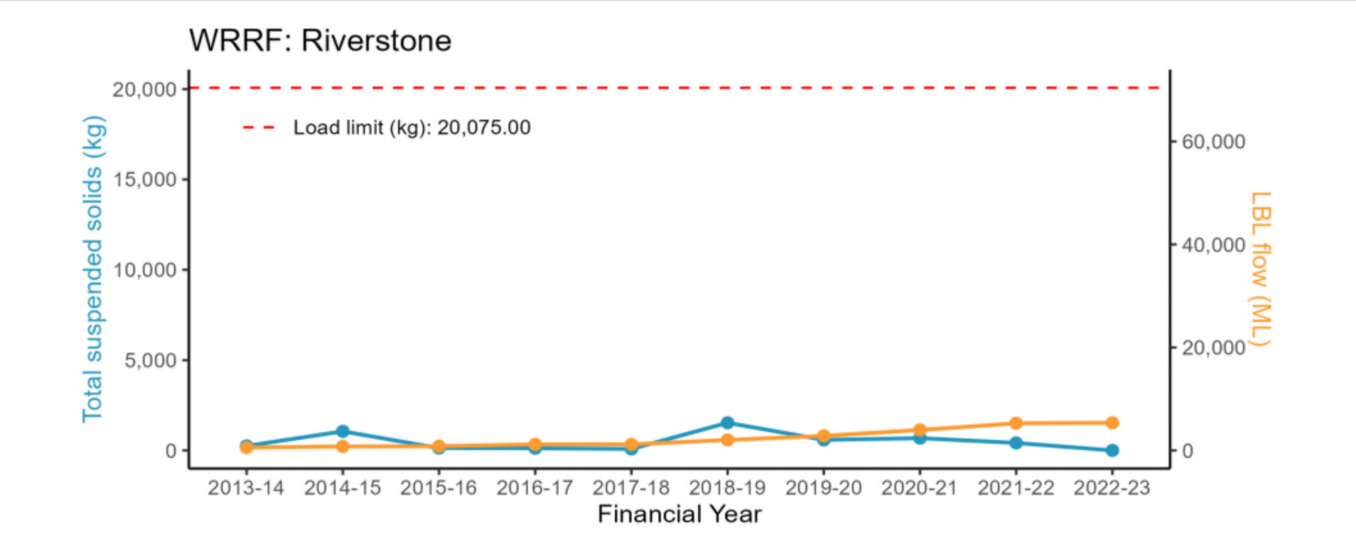




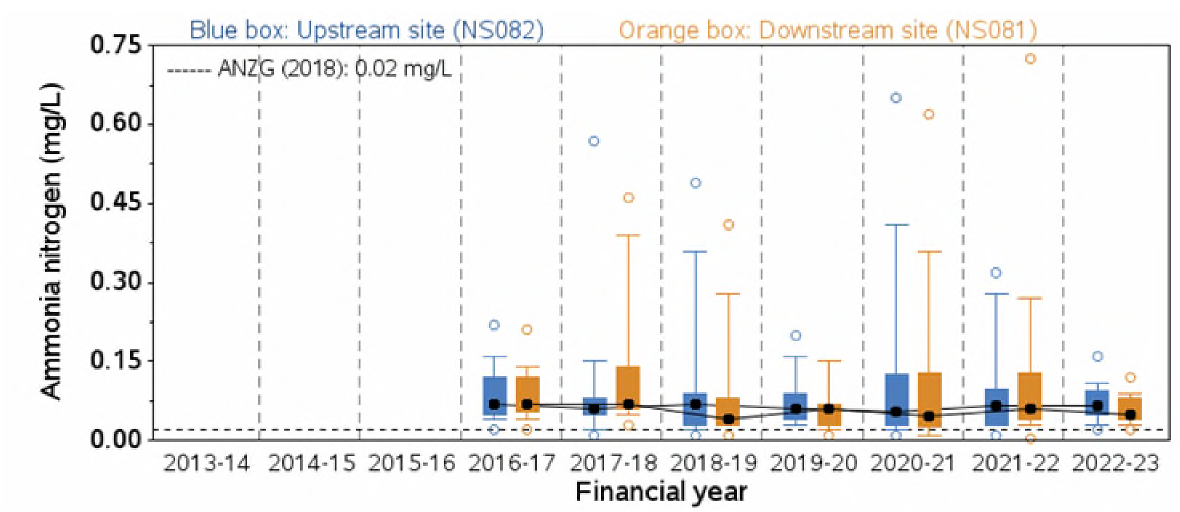
Major conventional analytes



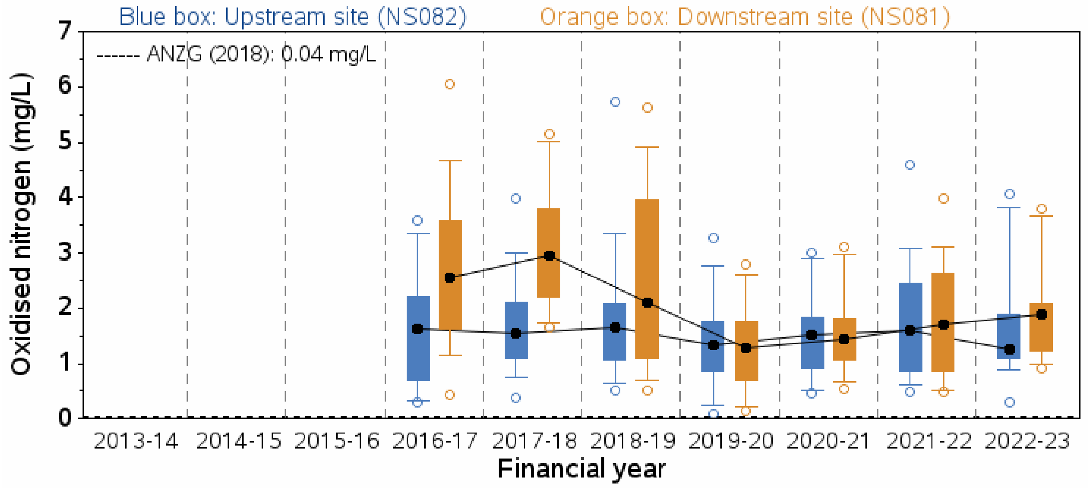




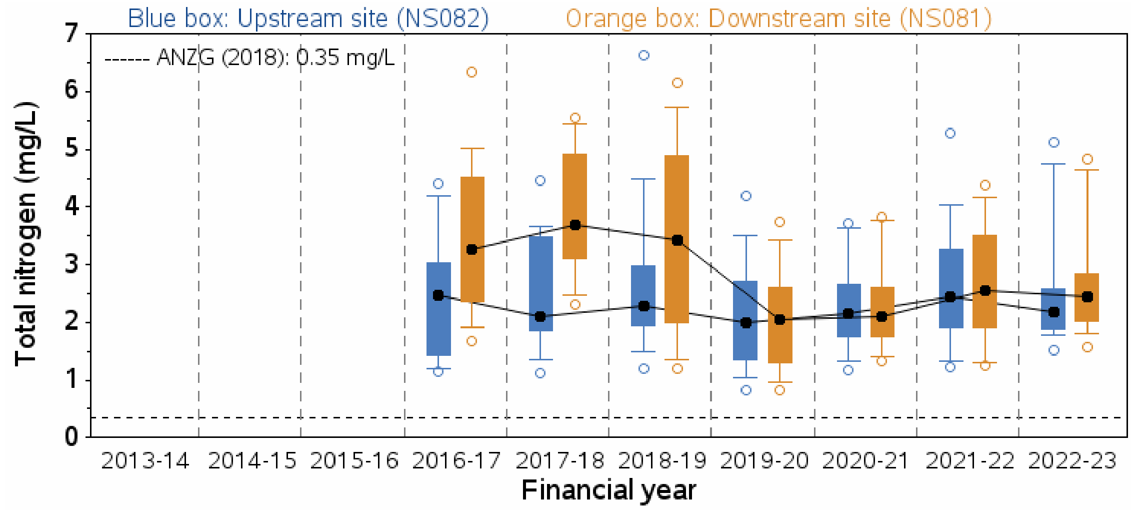
A-10.5 Stressor – Nutrients



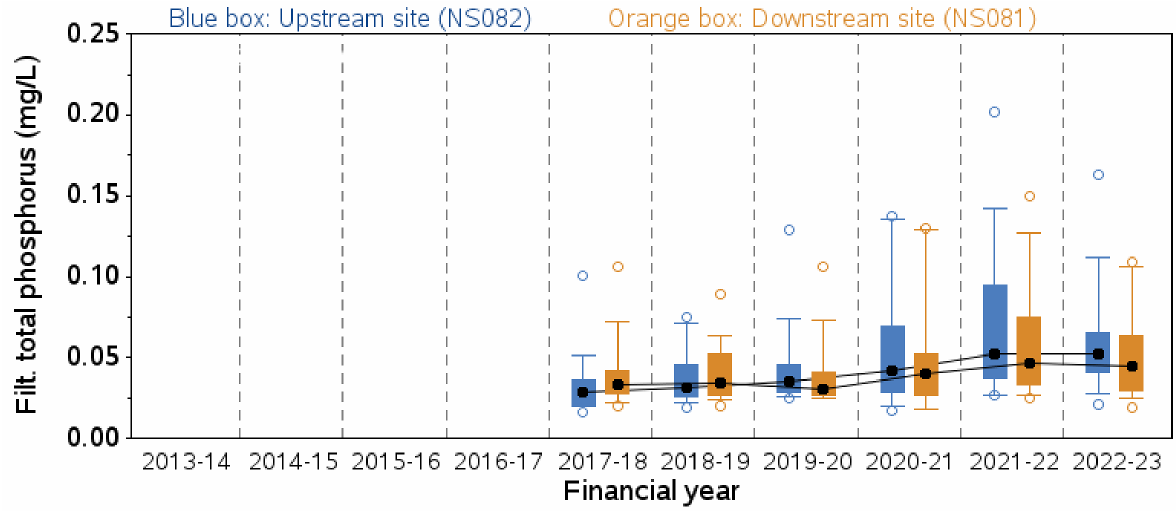
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.63	0.4305	NS081	1	1.79	0.1831



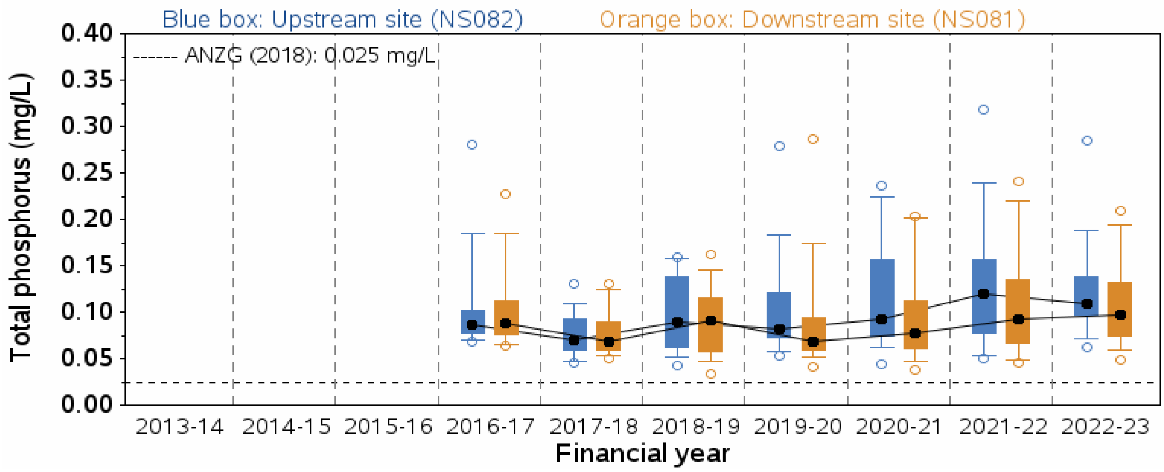
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0	0.9804	NS081	1	0.83	0.3637



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.14	0.7061	NS081	1	0.74	0.3926

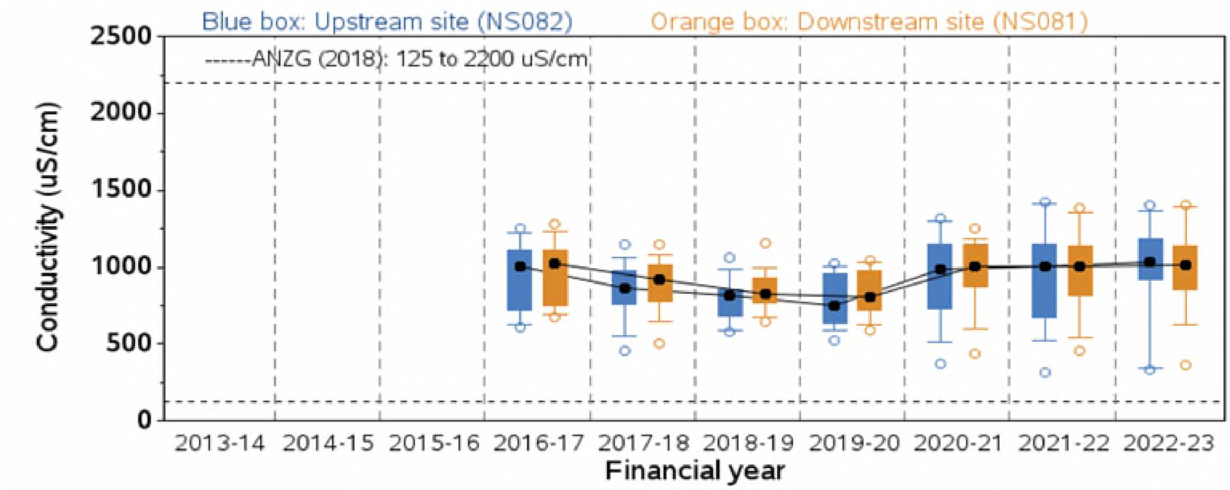


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	1.92	0.1687	NS081	1	0.65	0.4227

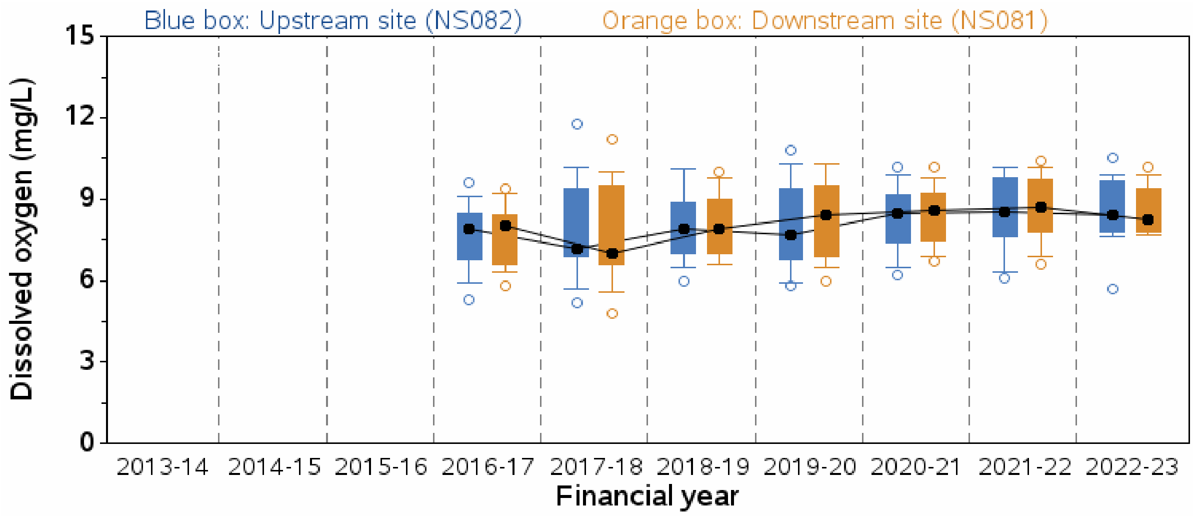


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	1.6	0.2083	NS081	1	0.89	0.3465

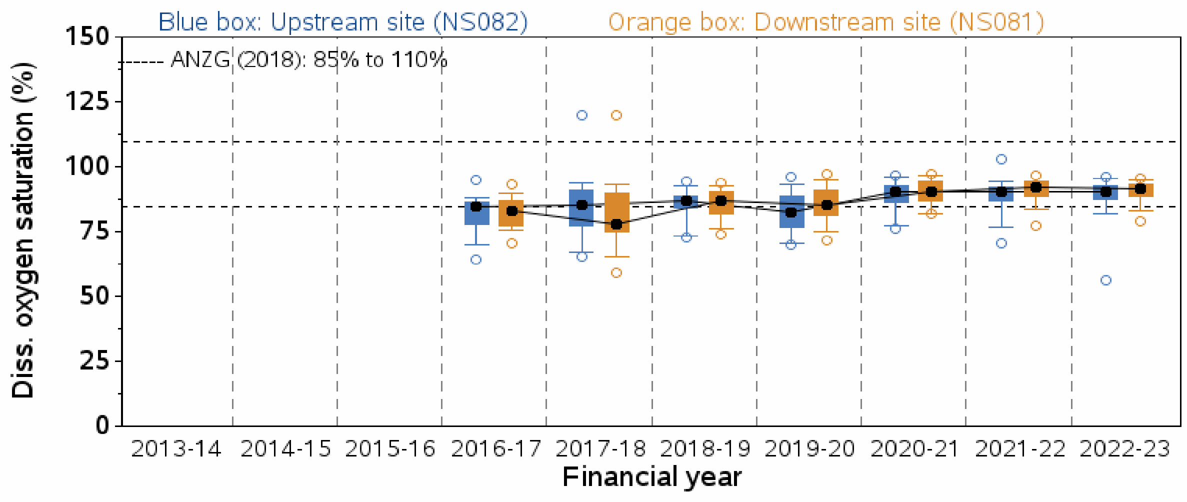
A-10.6 Stressor – Physico-chemical water quality



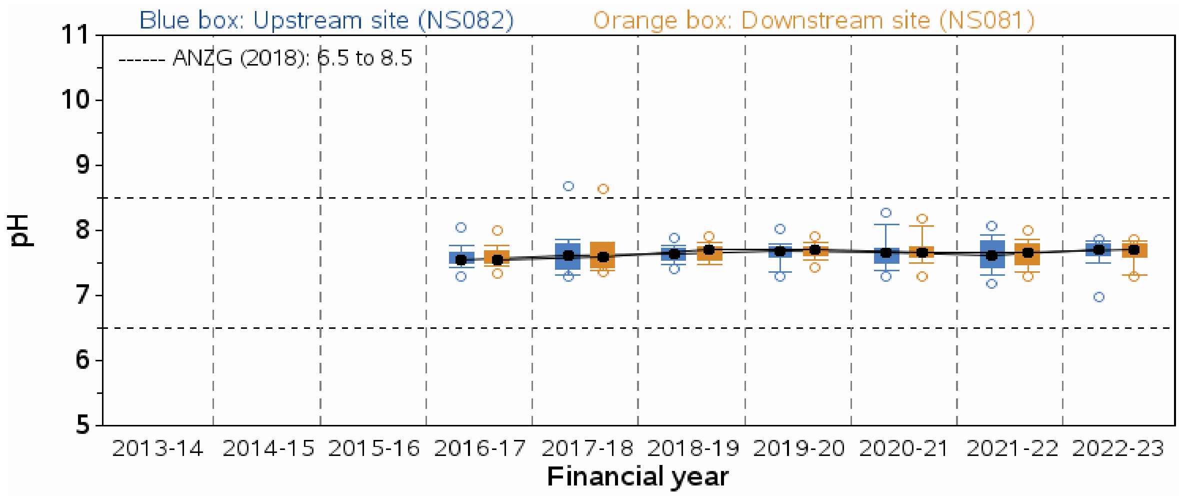
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	3.39	0.0681	NS081	1	1.88	0.173



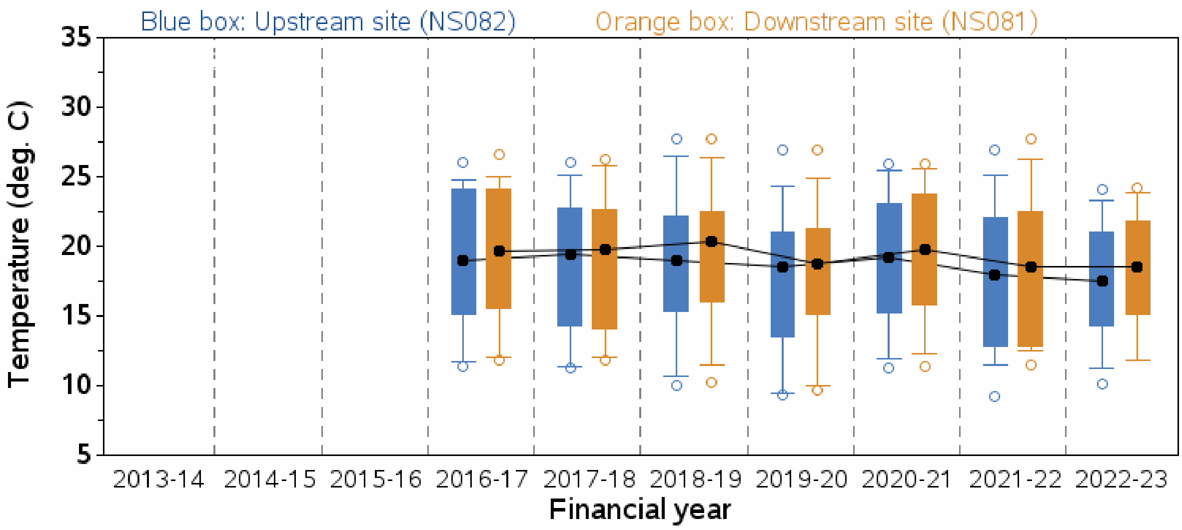
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	1.34	0.2489	NS081	1	2.28	0.1336



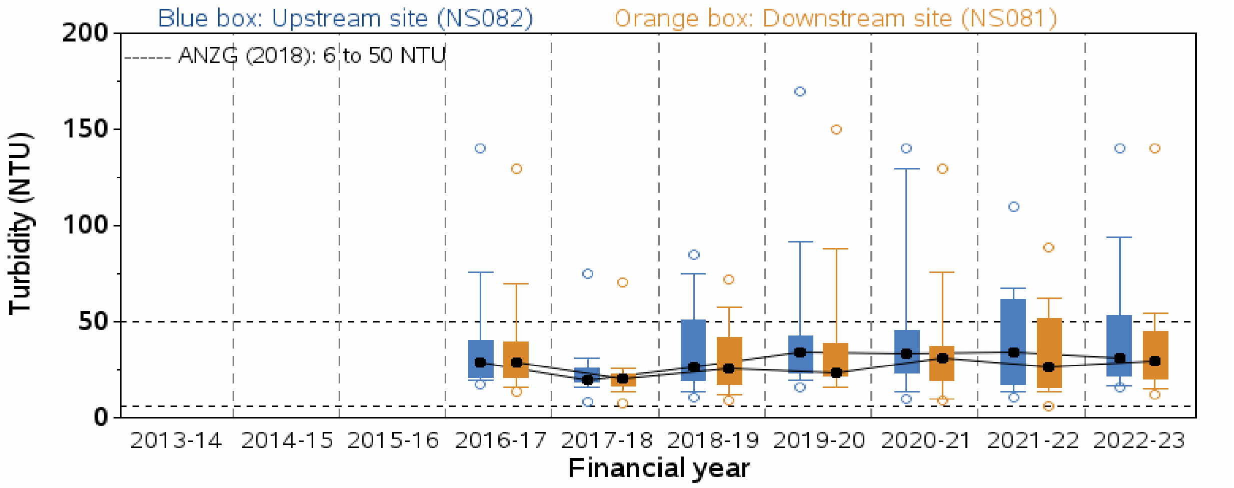
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	1.43	0.2349	NS081	1	4.15	0.0439



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.33	0.5642	NS081	1	0.02	0.8881

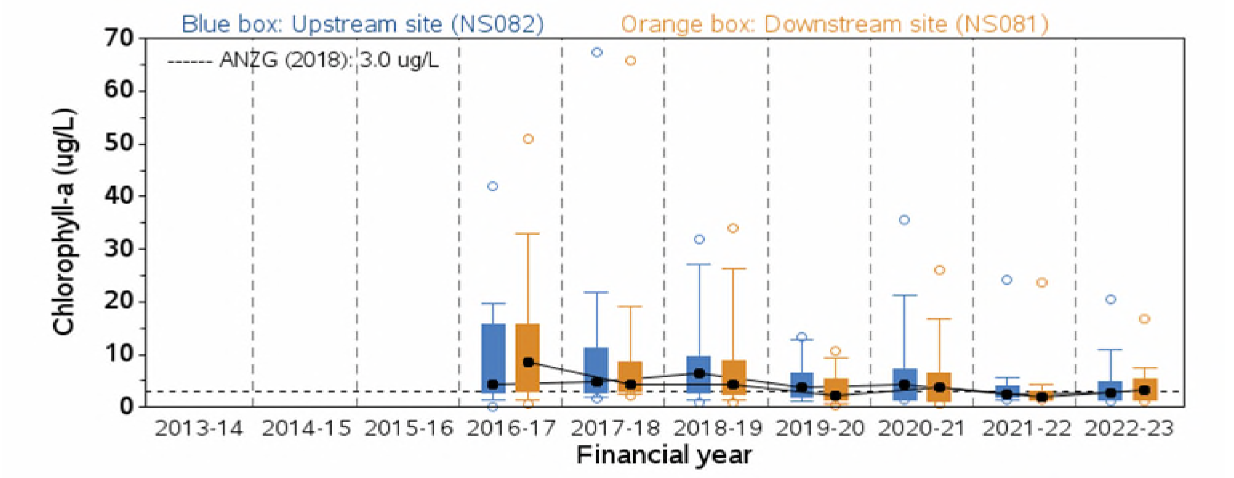


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.59	0.4449	NS081	1	0.38	0.5371

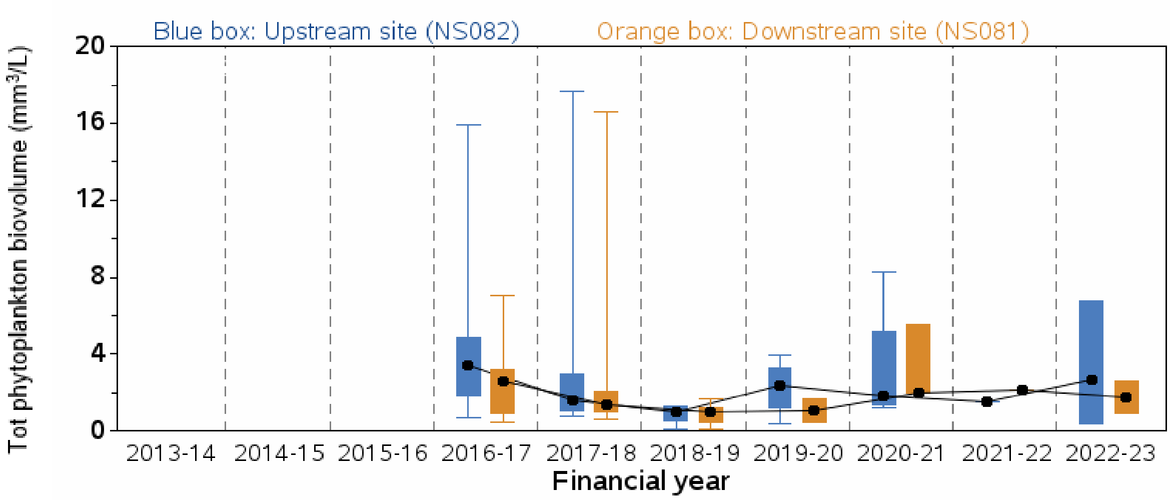


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.51	0.4774	NS081	1	0.3	0.5877

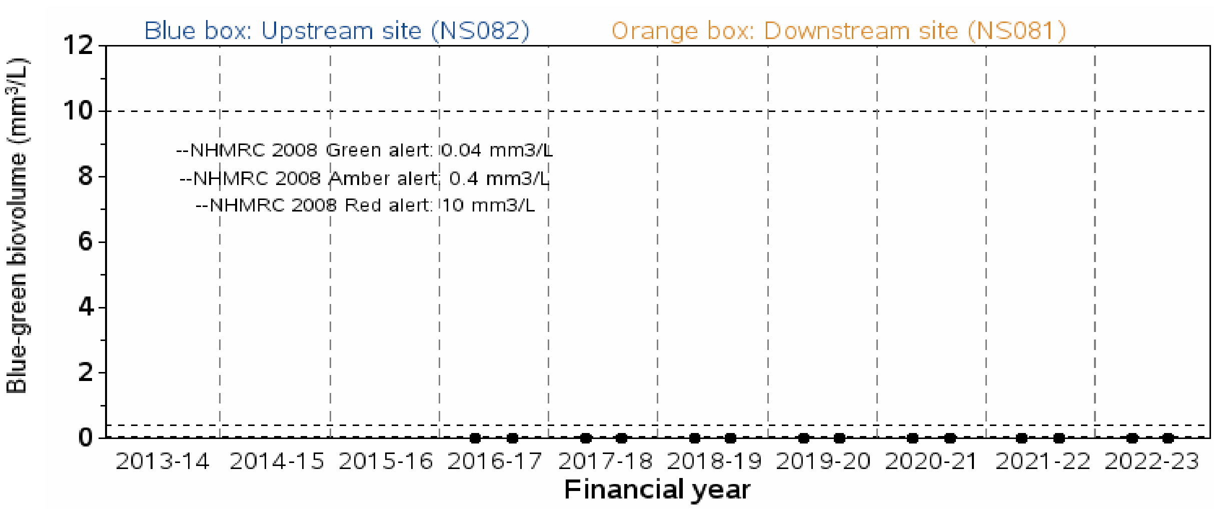
A-10.7 Ecosystem receptor – Phytoplankton



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	1.18	0.2788	NS081	1	1.41	0.2383



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.02	0.8956	NS081	1	0.07	0.7935



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NS082	1	0.03	0.8731	NS081	1	0.08	0.7857

Note: Insufficient data to draw a plot on toxic blue-green count for NS082 and NS081

A-10.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for Eastern Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1995 and 2022. This comparison suggests downstream stream health was maintained at a level comparable to that of the upstream site indicating wastewater discharge from Riverstone WRRF did not have a measurable impact on stream health during 2022-23 (Figure A-30).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under a t-test returned a non-significant test outcome (Table A-40) and confirmed the visual trend.

As no measurable negative impact on downstream stream health was detected, no further data analysis was undertaken.

Table A-40 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Eastern Creek near Riverstone WRRF

Waterway	Method	Statistic	DF	P value
Eastern Creek	Welch Two Sample t-test	-0.23	9.2	0.824

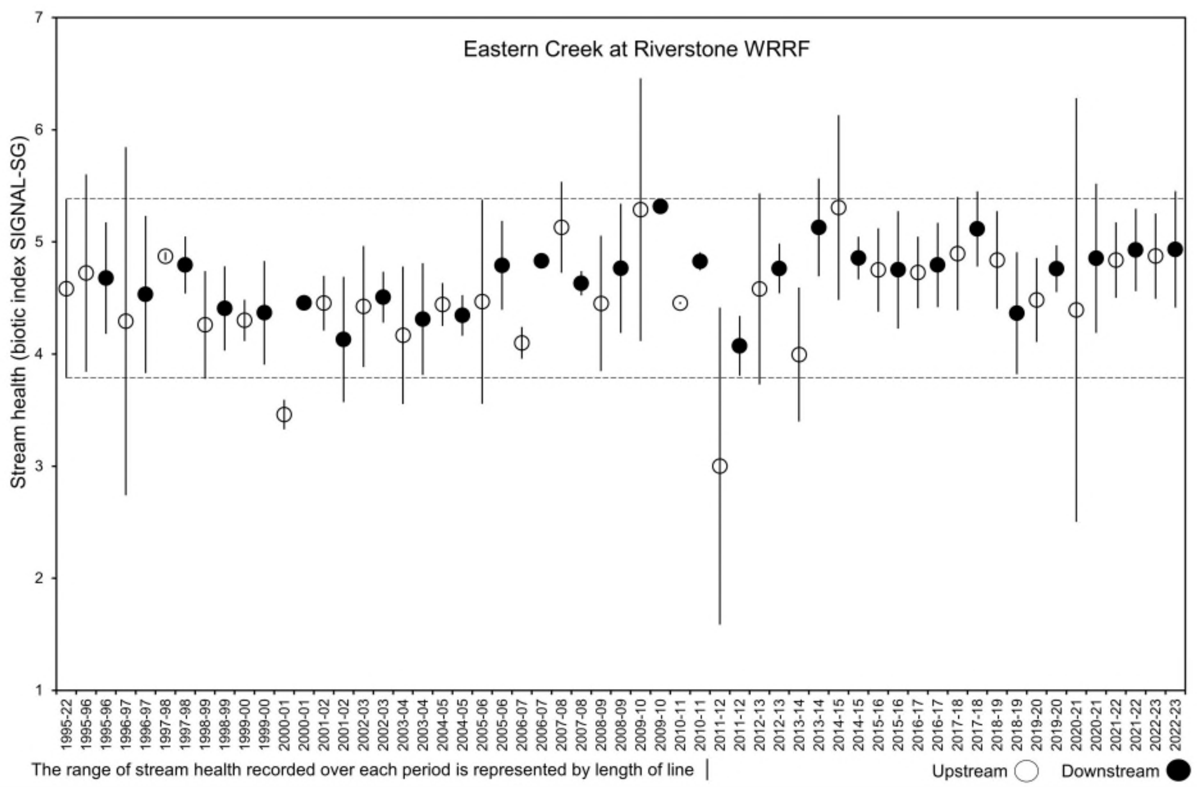
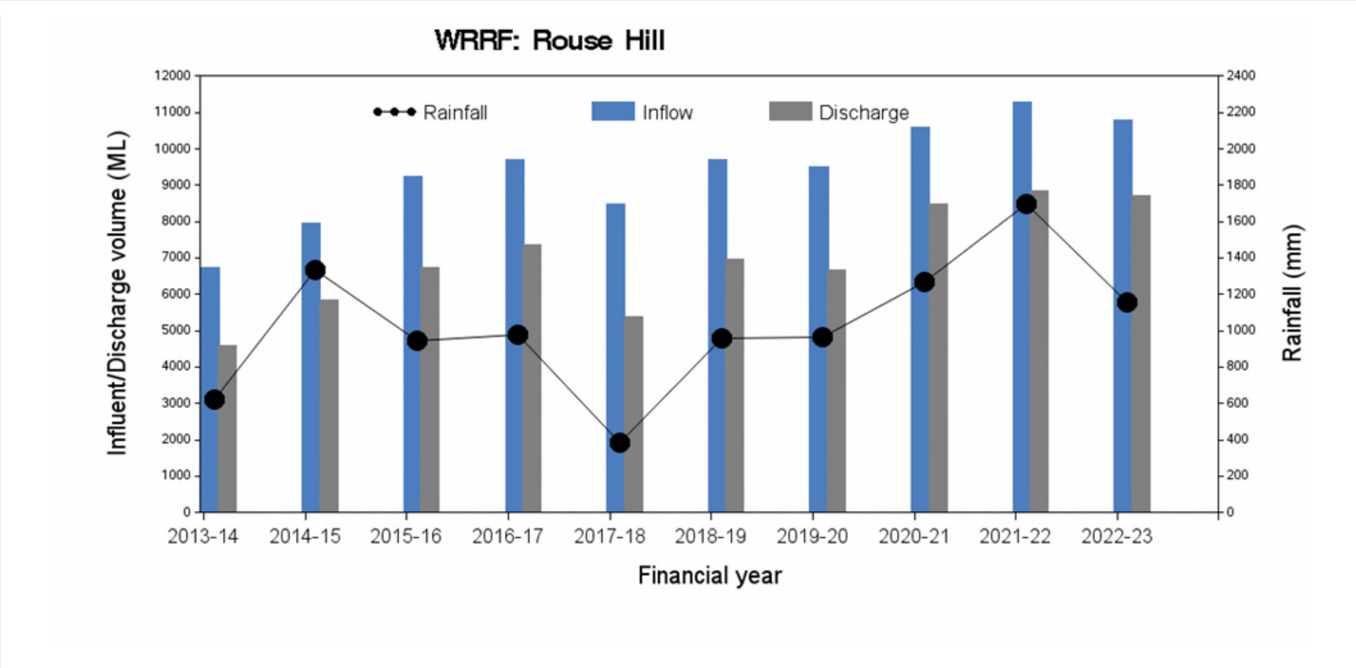


Figure A-30 Stream health of Eastern Creek near Riverstone WRRF

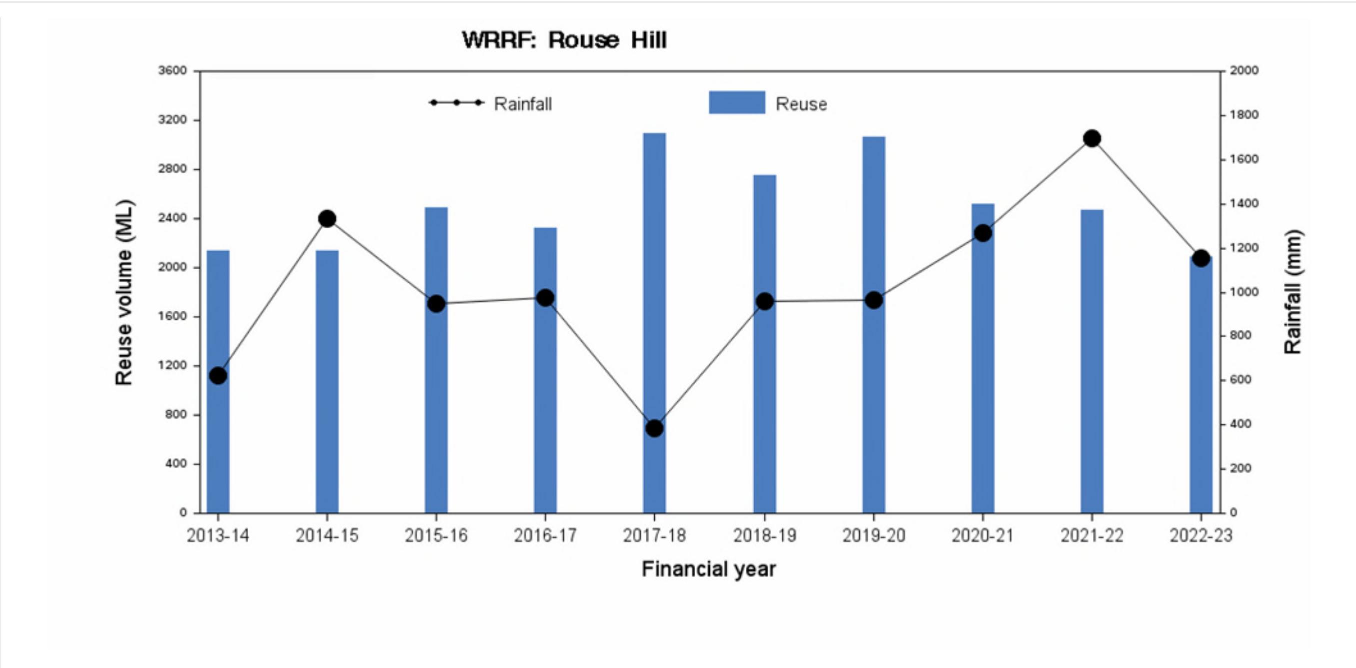
A-11 Rouse Hill WRRF

A-11.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

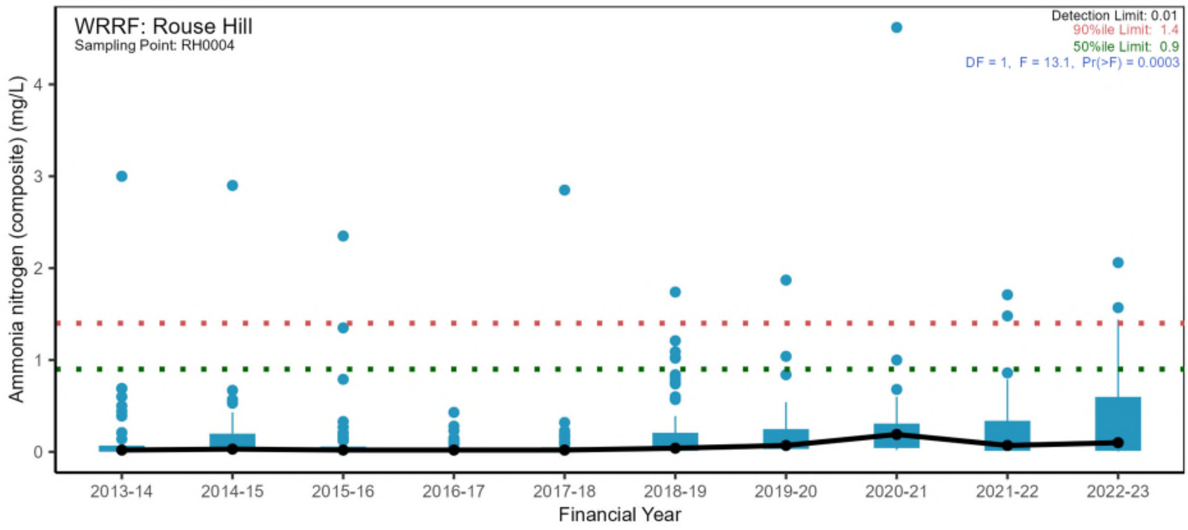


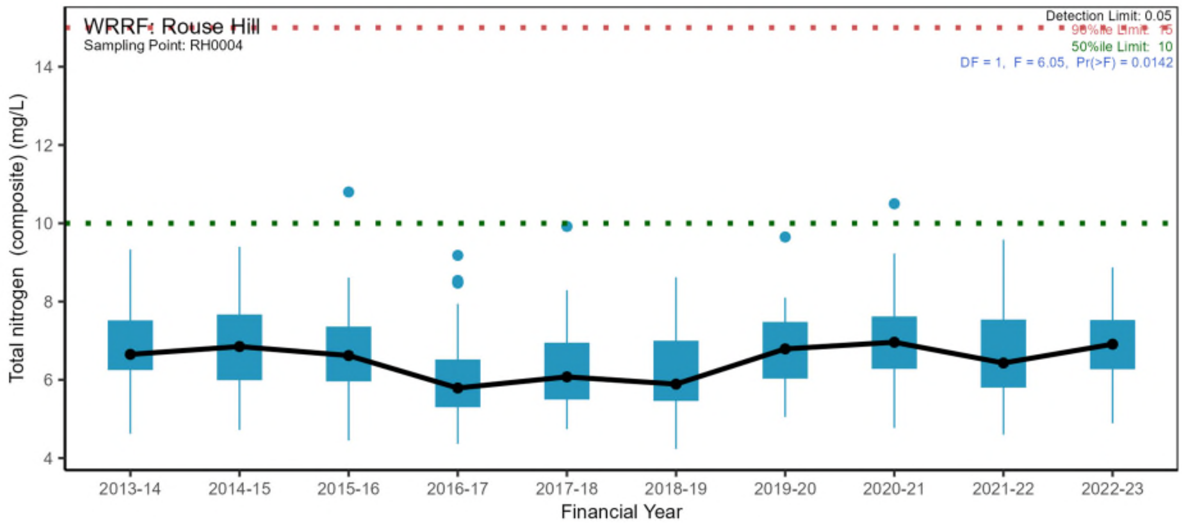
Reuse volume and rainfall

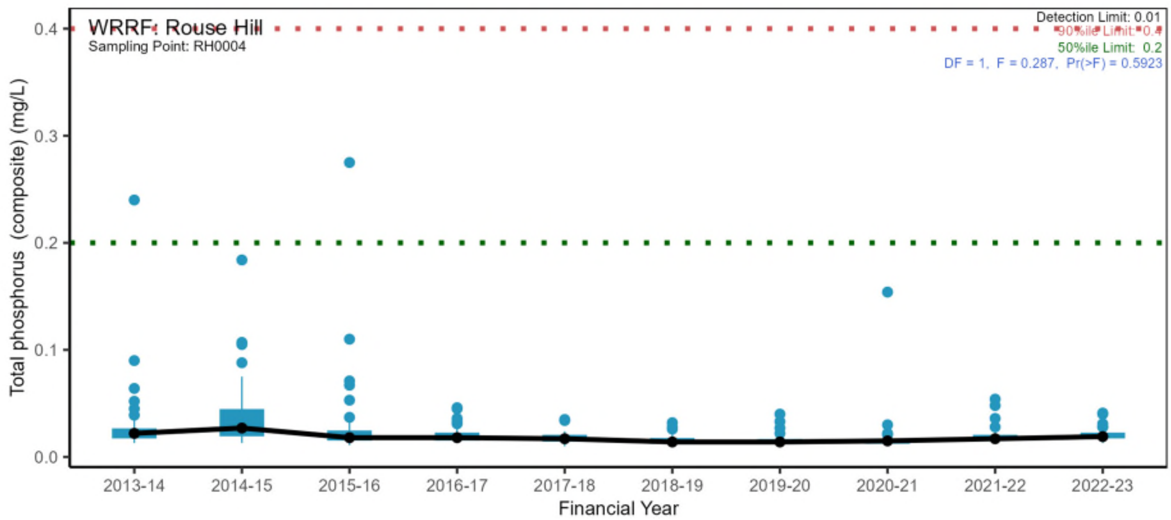


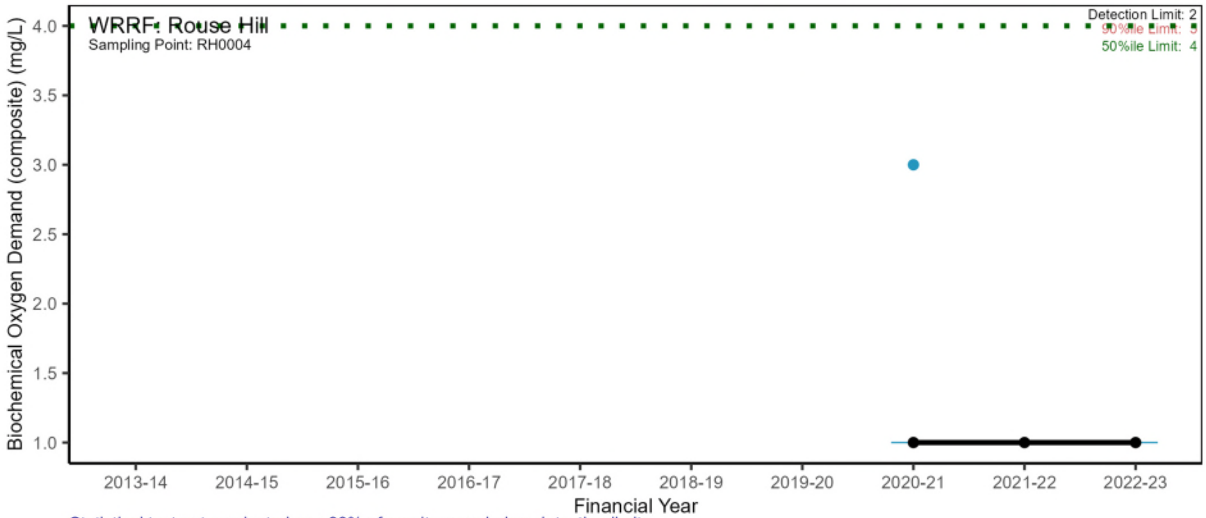
A-11.2 Pressure – Wastewater quality

Nutrients

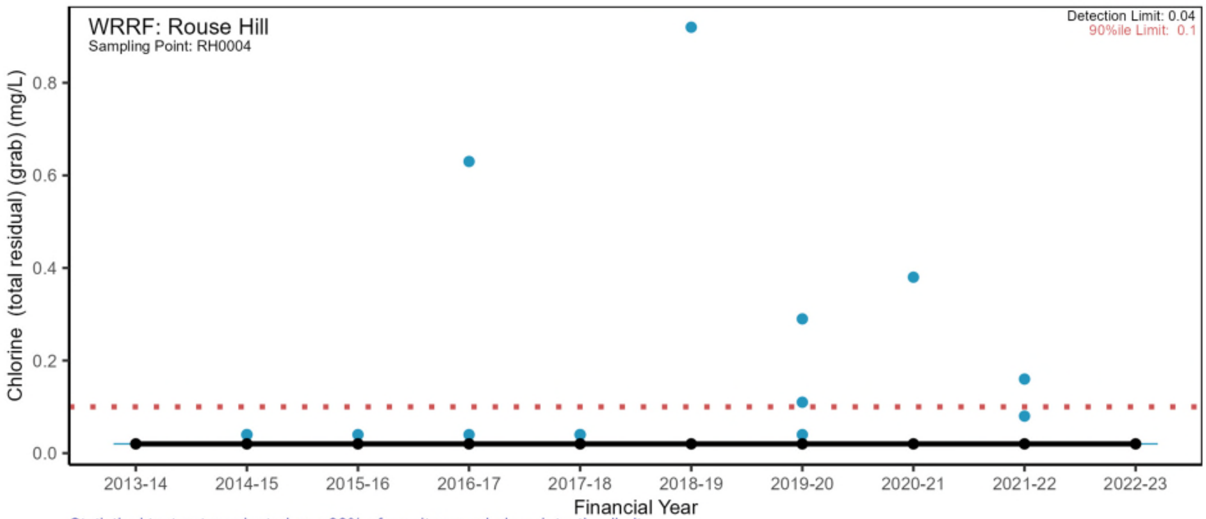




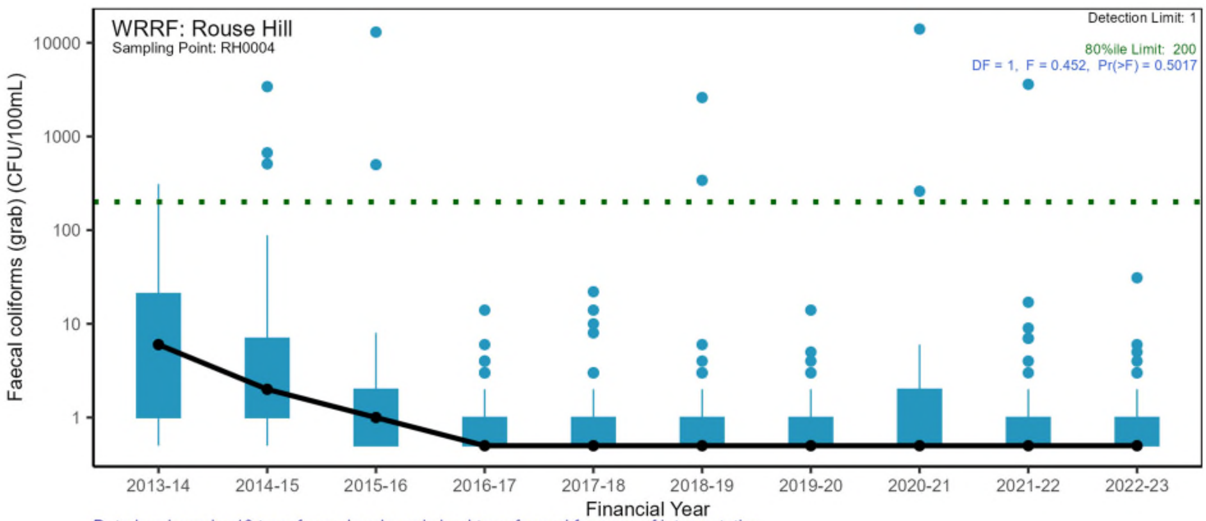




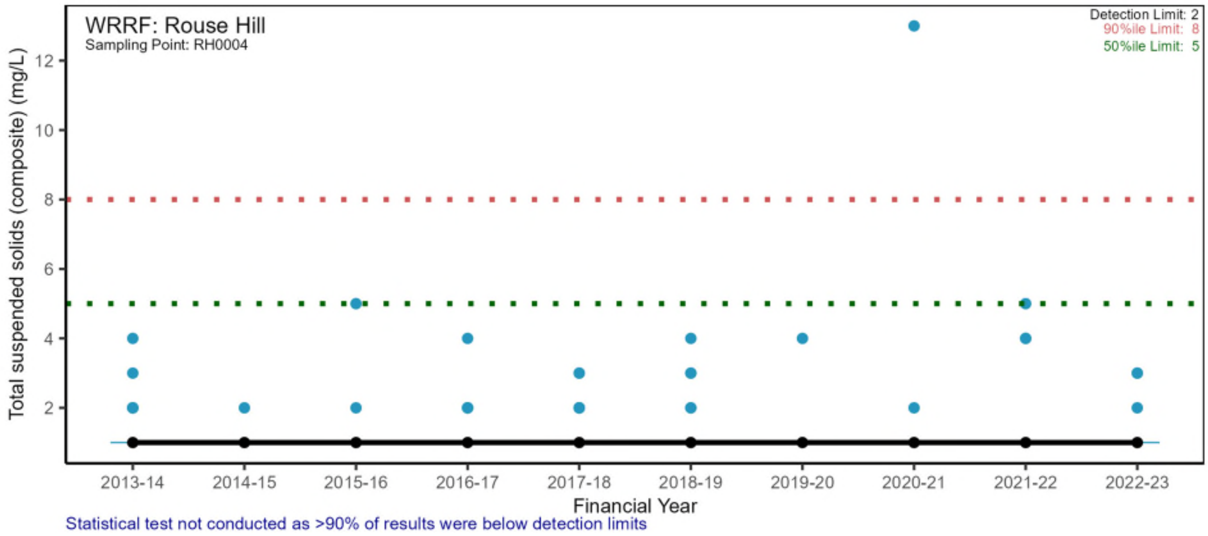
Statistical test not conducted as >90% of results were below detection limits



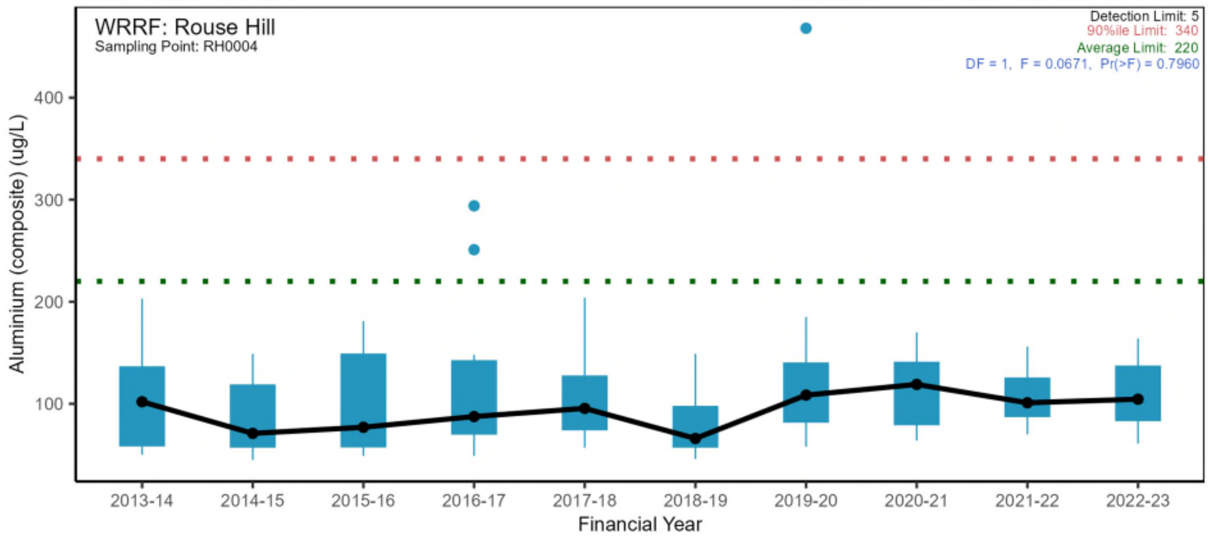
Statistical test not conducted as >90% of results were below detection limits

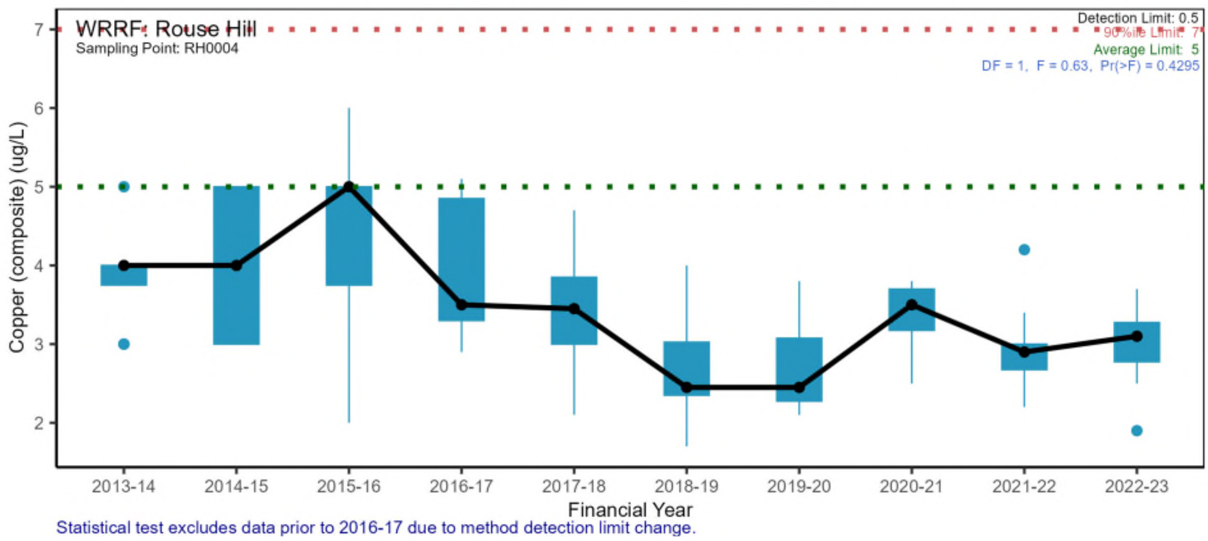


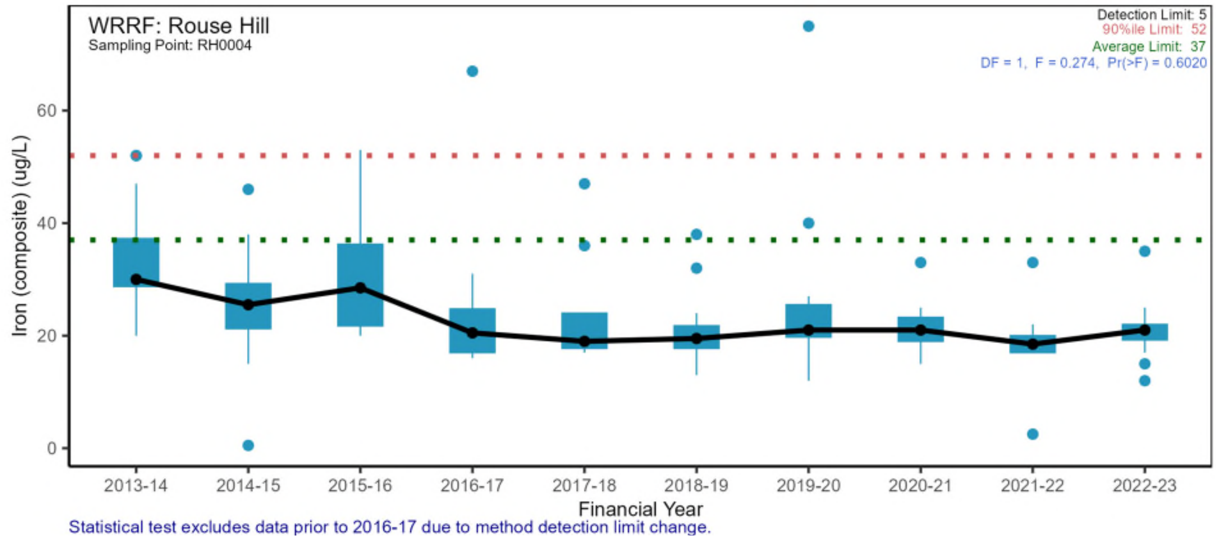
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

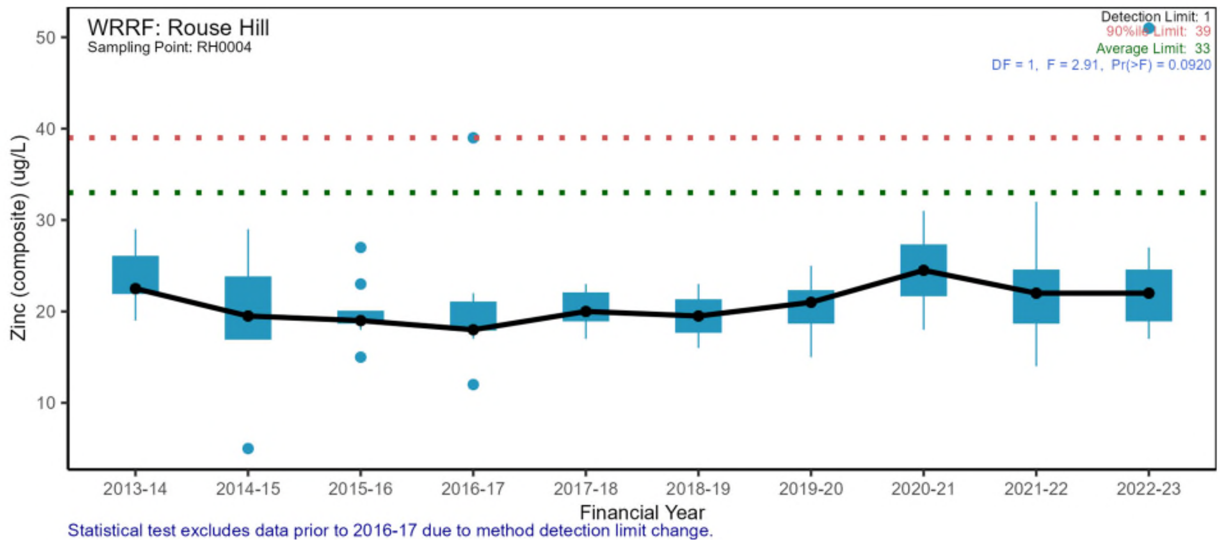


Trace metals

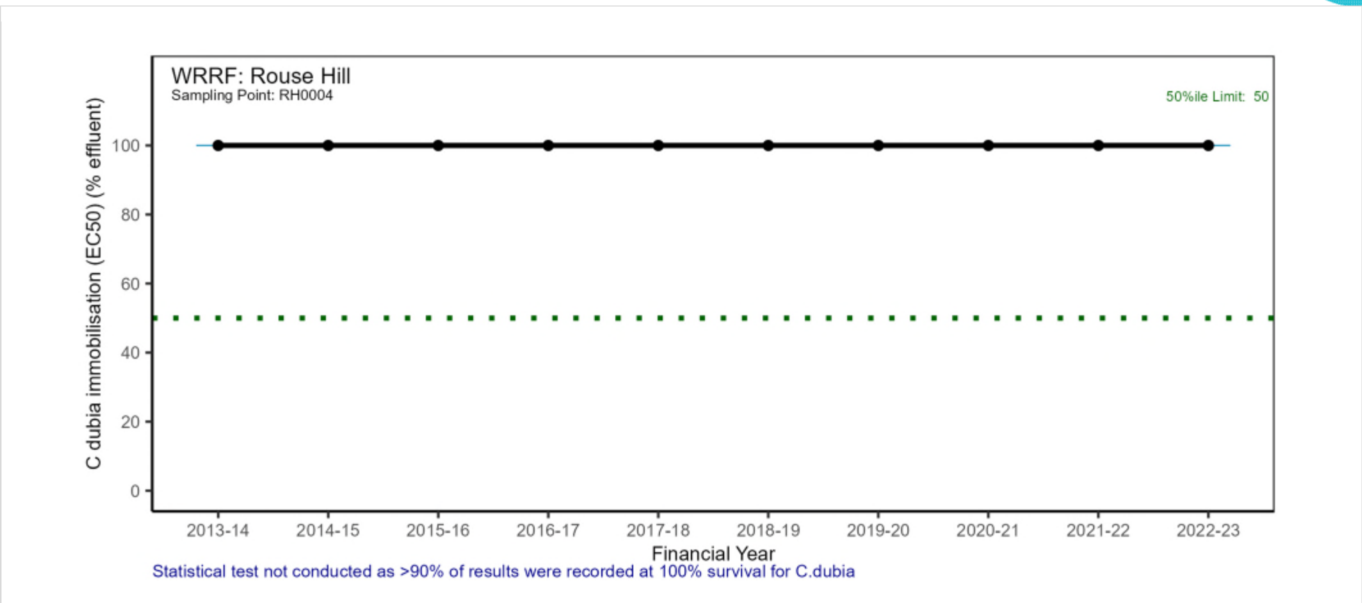





WRRF: Rouse Hill
Sampling Point: RH0004
Detection Limit: 5
90%ile Limit: 52
Average Limit: 37
DF = 1, F = 0.274, Pr(>F) = 0.6020
Iron (composite) (ug/L)
0
20
40
60
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.

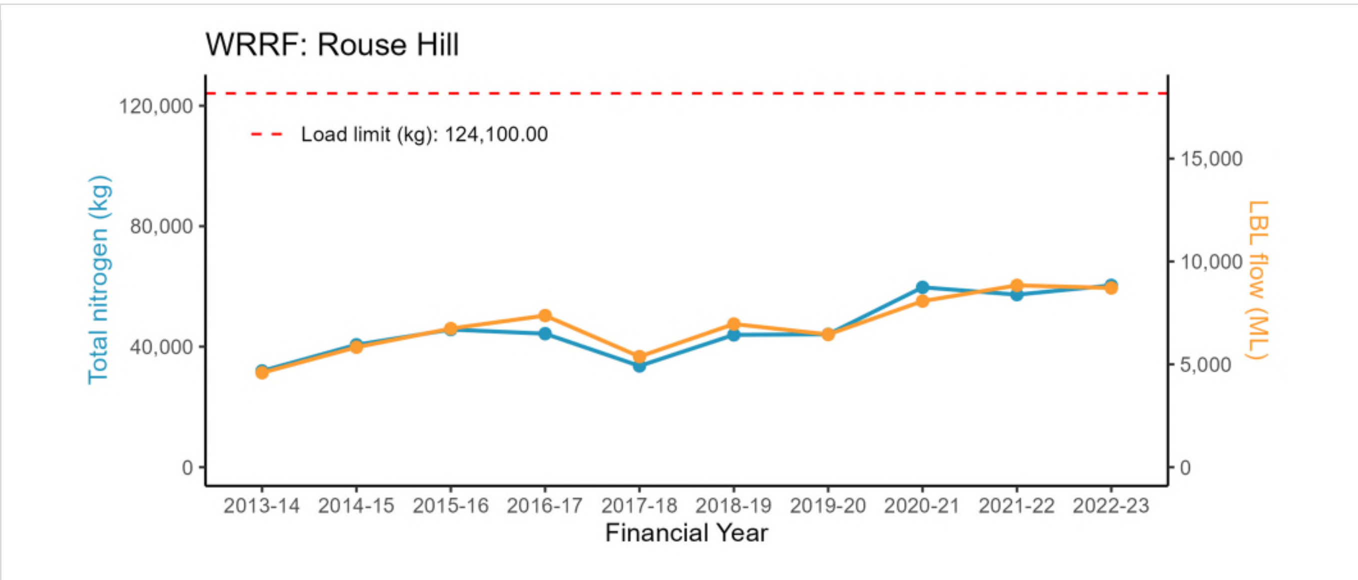

WRRF: Rouse Hill
Sampling Point: RH0004
Detection Limit: 1
90%ile Limit: 39
Average Limit: 33
DF = 1, F = 2.91, Pr(>F) = 0.0920
Zinc (composite) (ug/L)
10
20
30
40
50
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.

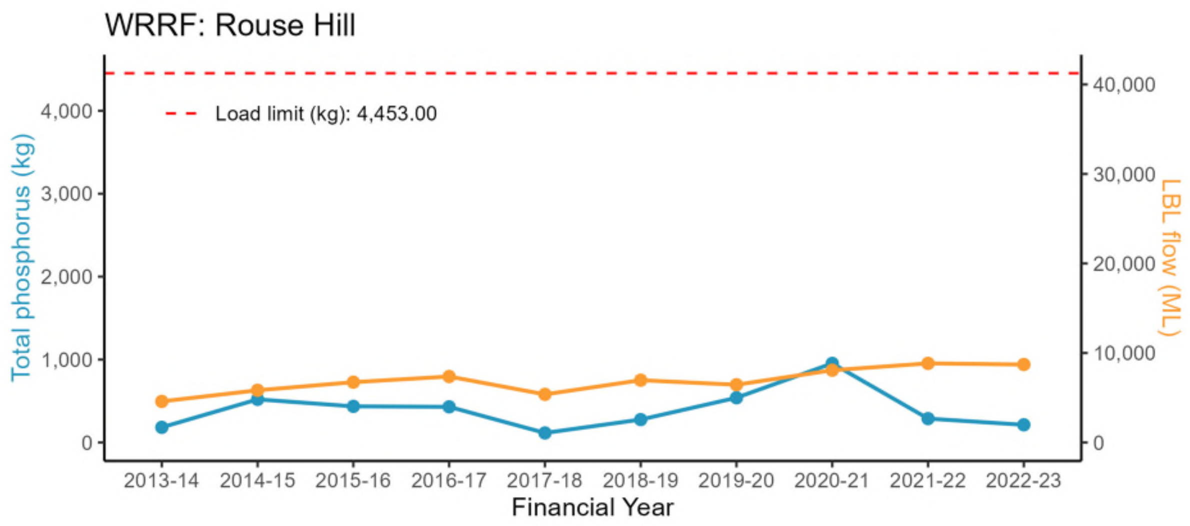
A-11.3 Pressure – Wastewater toxicity



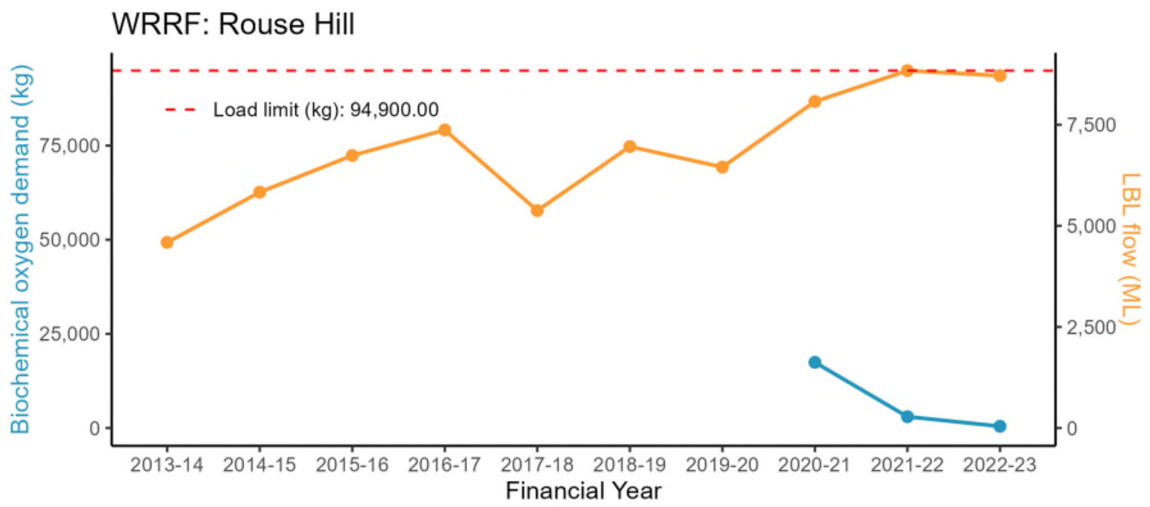
A-11.4 Pressure – Wastewater discharge load

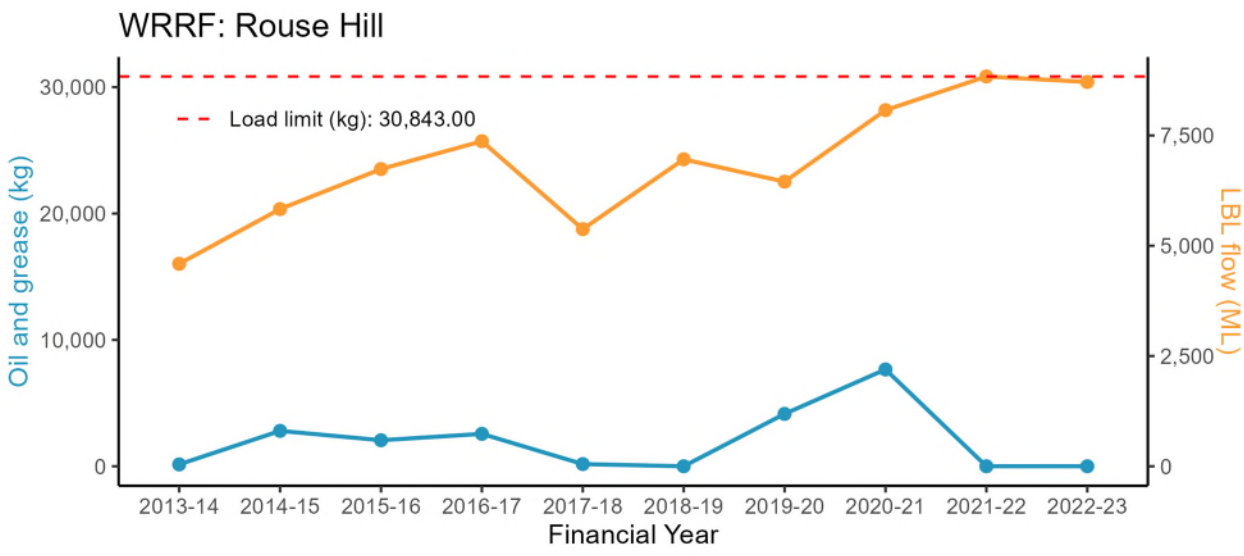
Nutrients

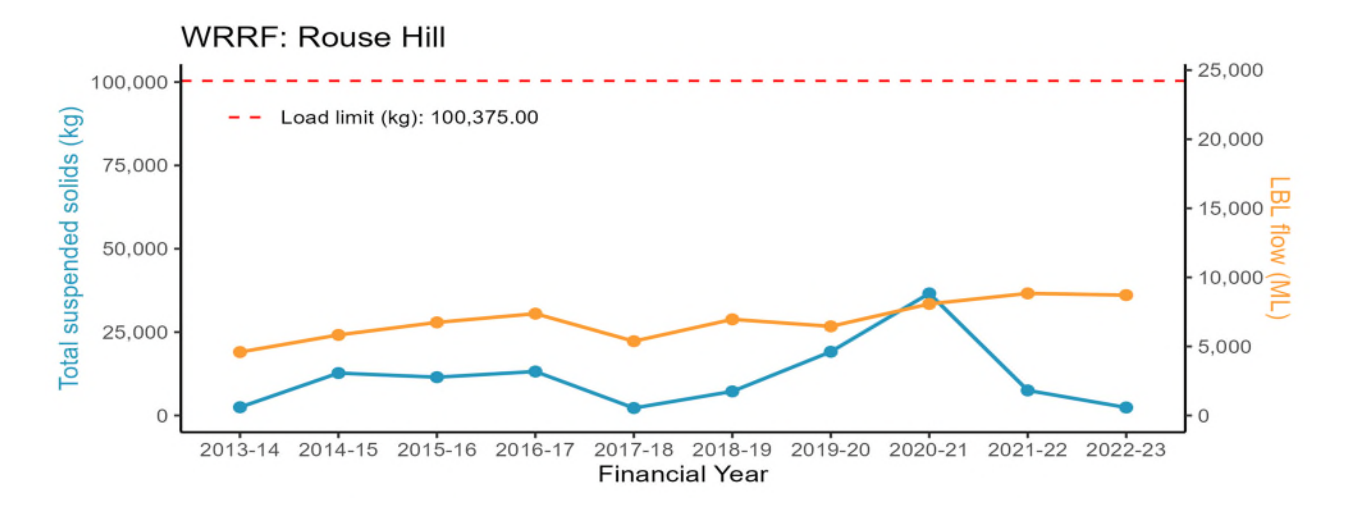




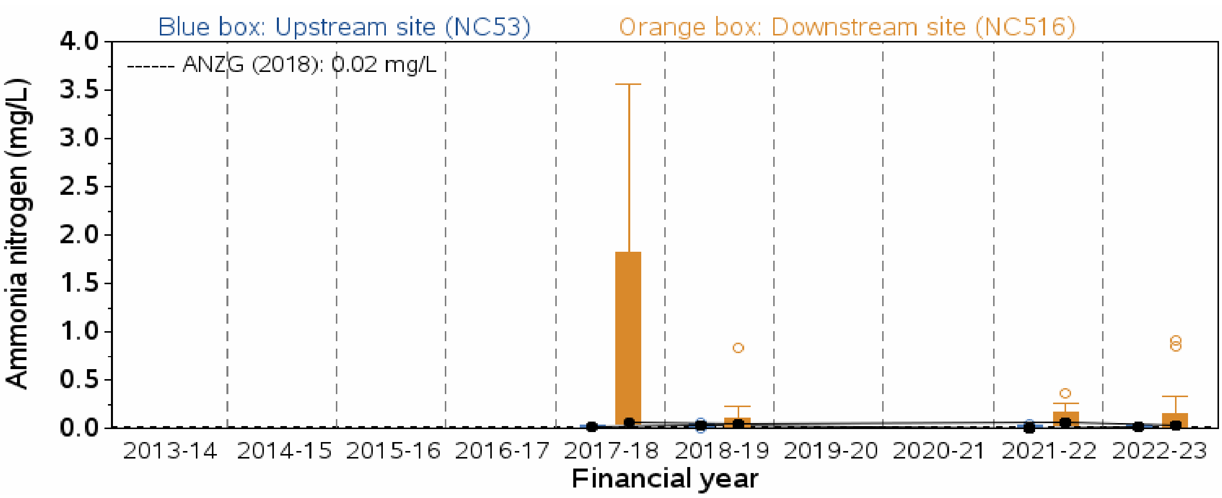
Major conventional analytes



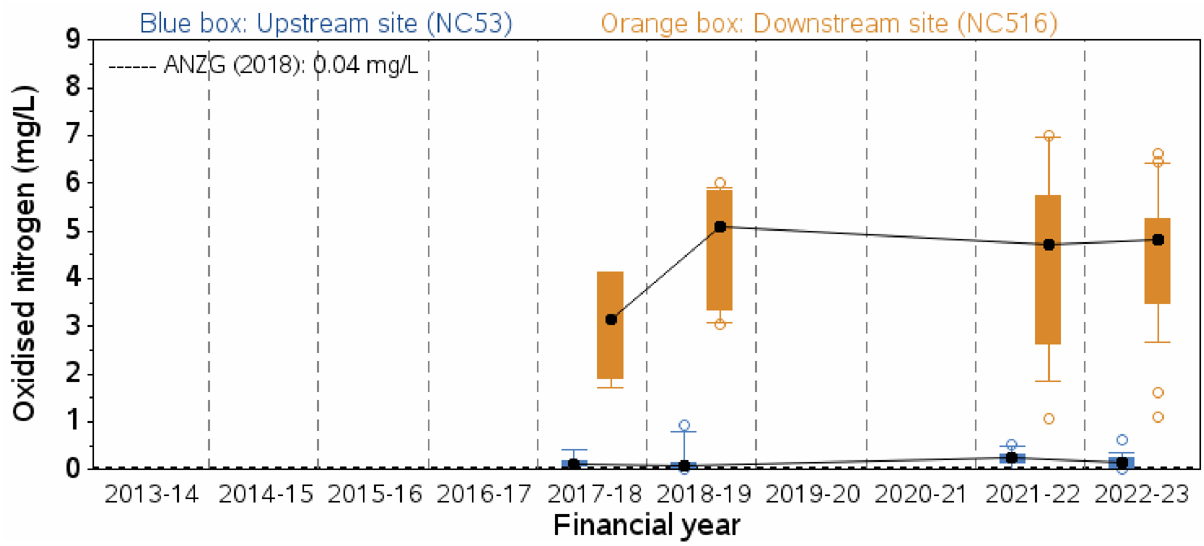




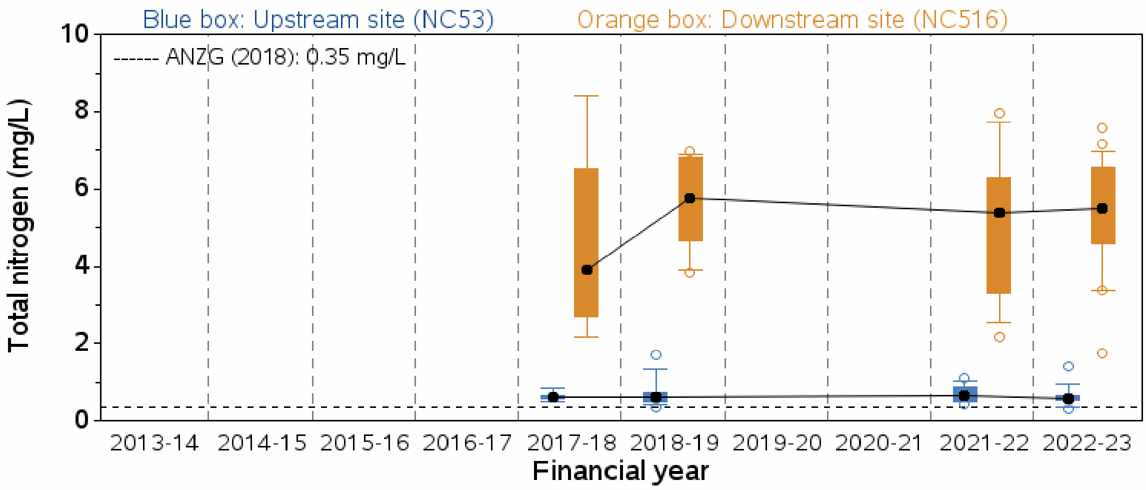
A-11.5 Stressor – Nutrients



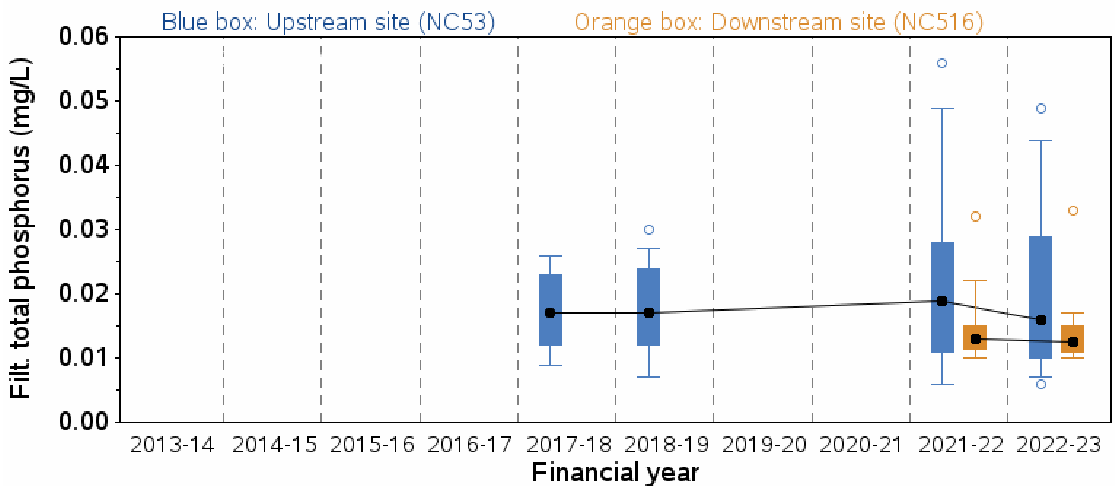
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	2.21	0.1426	NC516	1	0.41	0.5259



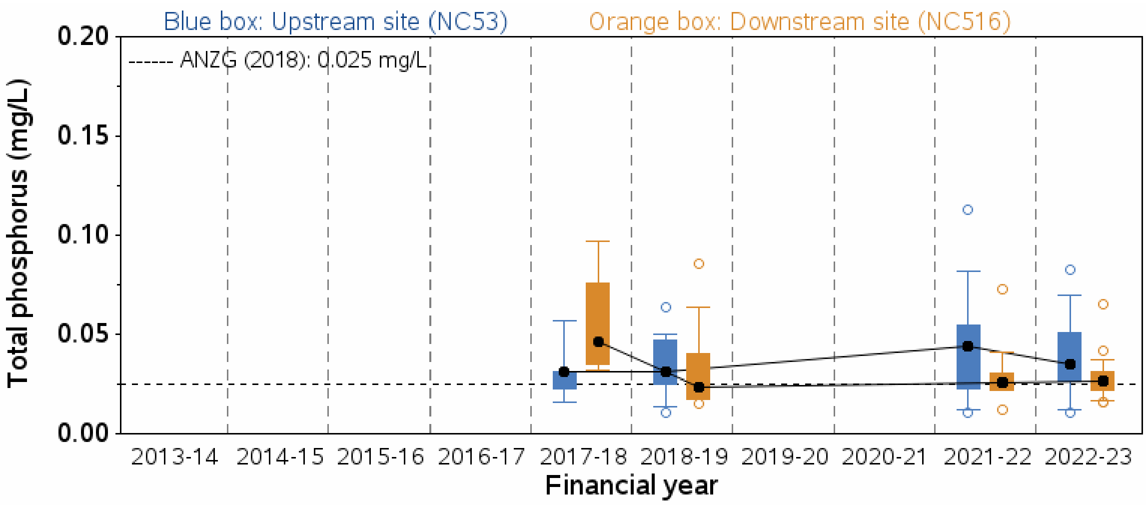
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0.27	0.6065	NC516	1	0.16	0.6918



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	1.06	0.3084	NC516	1	0.19	0.6615

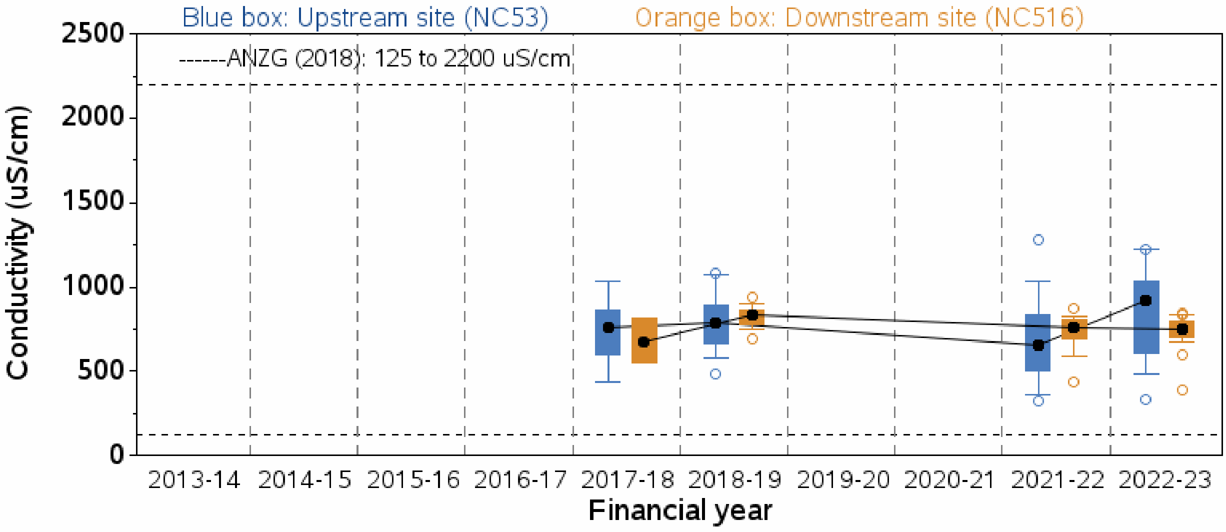


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0	0.9626	NC516	1	0.02	0.884

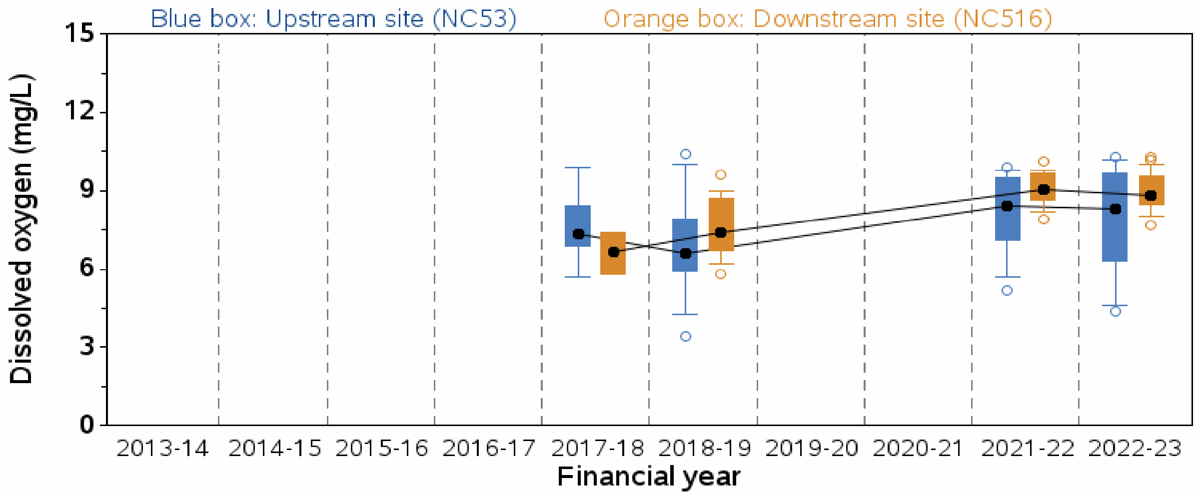


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0.07	0.7965	NC516	1	1.68	0.2012

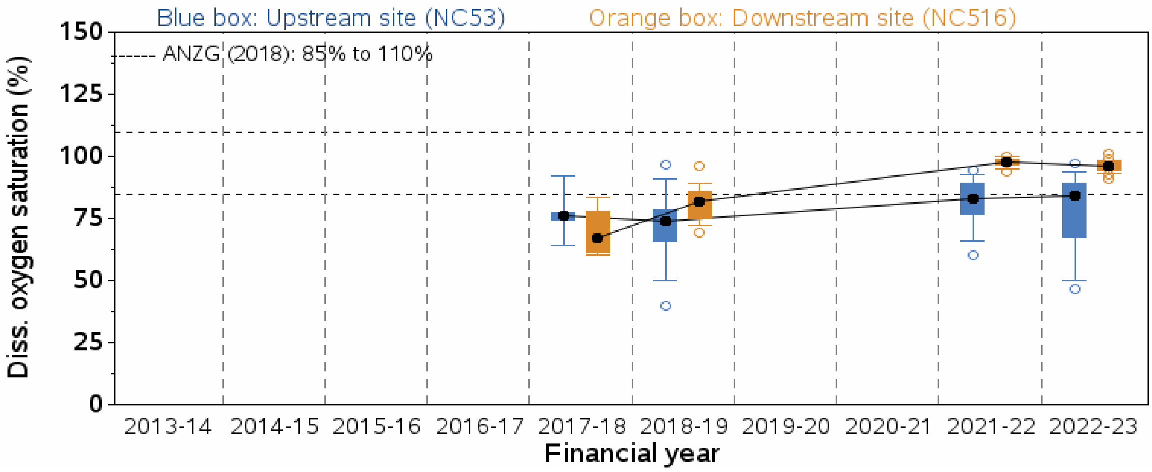
A-11.6 Stressor – Physico-chemical water quality



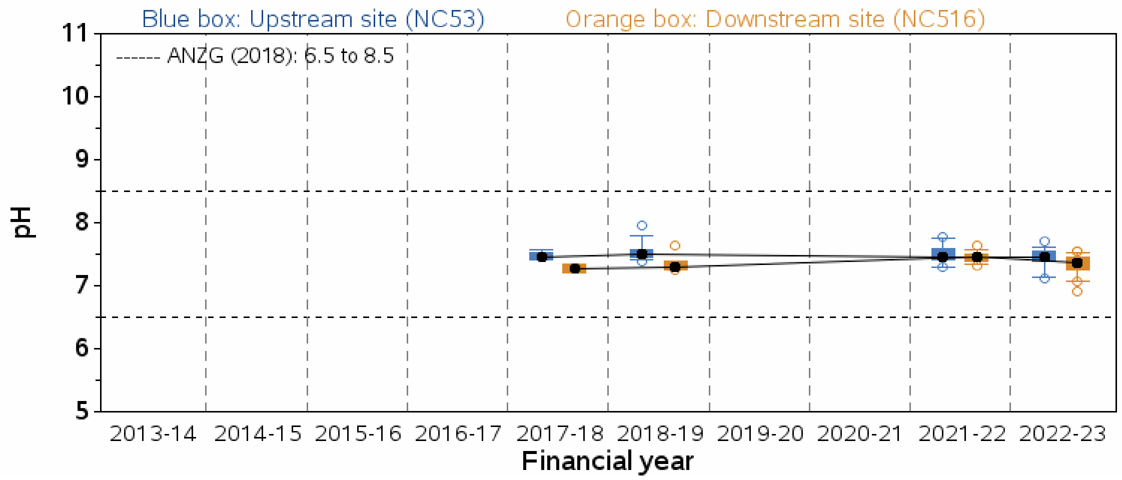
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	2.8	0.0997	NC516	1	0.57	0.4544



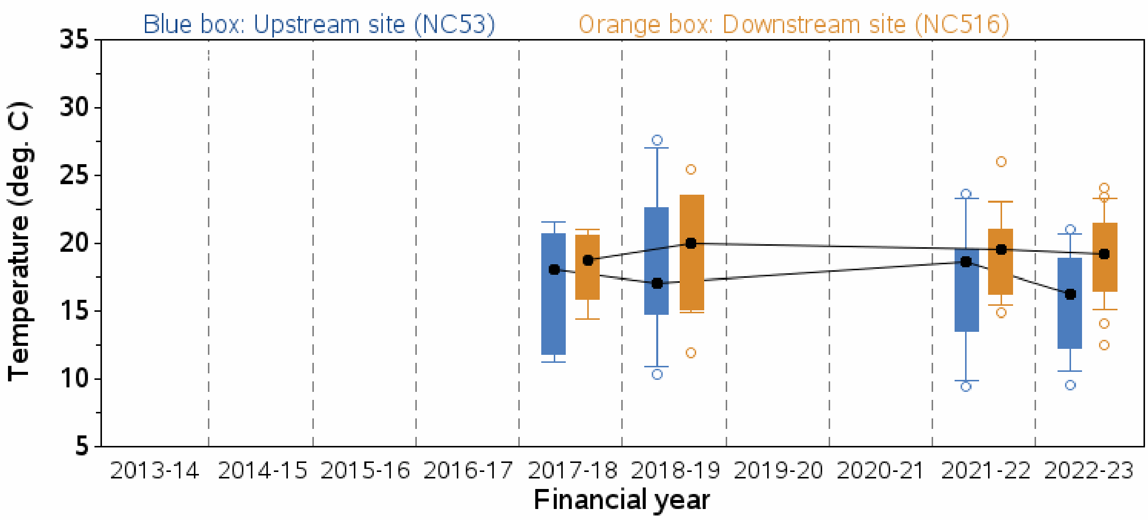
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0.85	0.3595	NC516	1	6.68	0.0125



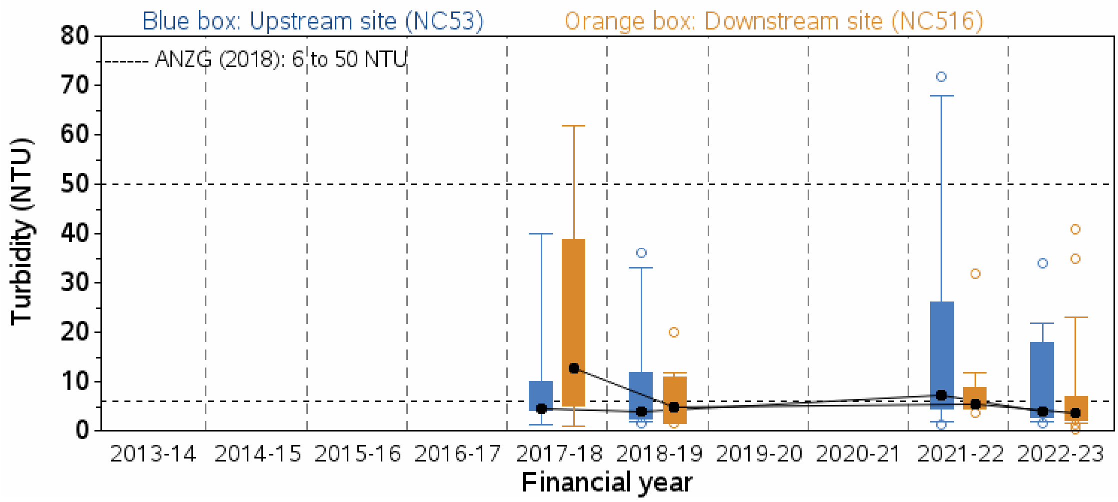
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0.4	0.5295	NC516	1	9.76	0.0029



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	3.62	0.0624	NC516	1	1.89	0.1753

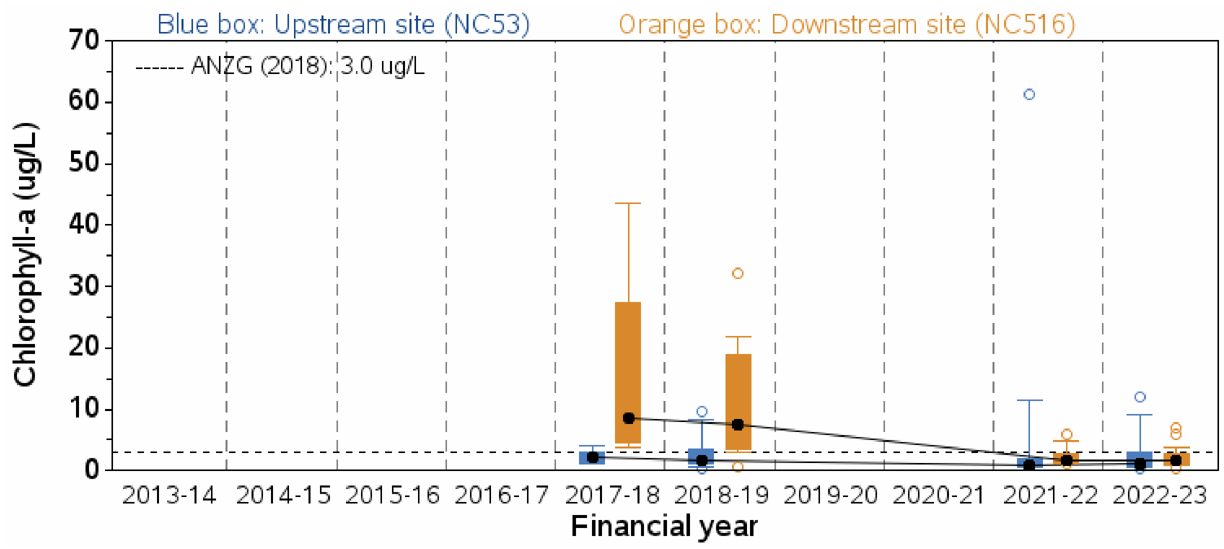


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	1.83	0.1811	NC516	1	0.01	0.9416



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0.9	0.3468	NC516	1	0.19	0.6681

A-11.7 Ecosystem receptor – Phytoplankton



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC53	1	0.28	0.5999	NC516	1	6.27	0.0154

Note: Insufficient data to draw a plot on total phytoplankton biovolume for NC53 and NC516

Note: Insufficient data to draw a plot on blue-green biovolume for NC53 and NC516

Note: Insufficient data to draw a plot on toxic blue-green count for NC53 and NC516

A-11.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for Second Ponds Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1995 and 2022. This comparison suggests downstream stream health was maintained at a level comparable to that of the upstream site indicating wastewater discharge from Rouse Hill WRRF did not have a measurable impact on stream health during 2022-23 (Figure A-31).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under a t-test returned a non-significant test outcome (Table A-41) and confirmed the visual trend.

As no measurable negative impact on downstream stream health was detected, no further data analysis was undertaken.

Table A-41 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Second Ponds Creek near Rouse Hill WRRF

Waterway	Method	Statistic	DF	P value
Second Ponds Creek	Welch Two Sample t-test	-0.81	6.5	0.444

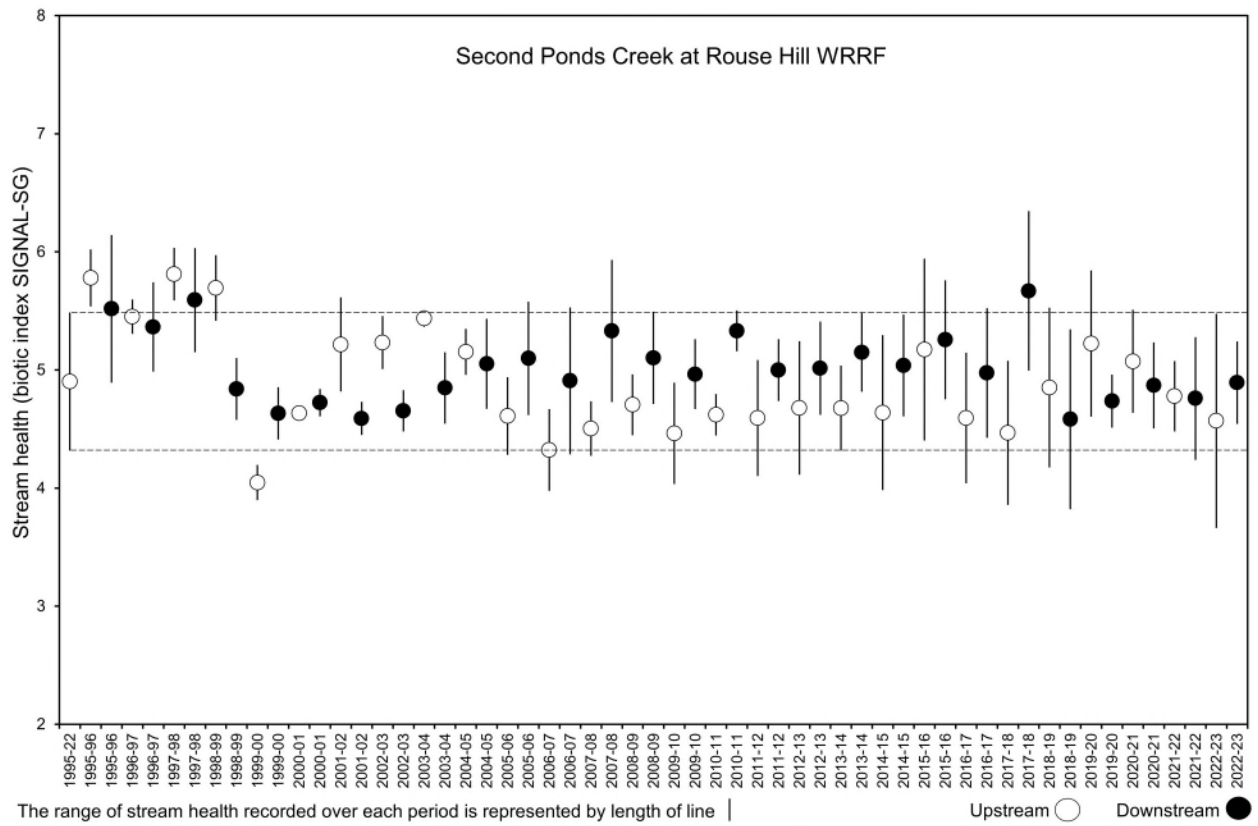
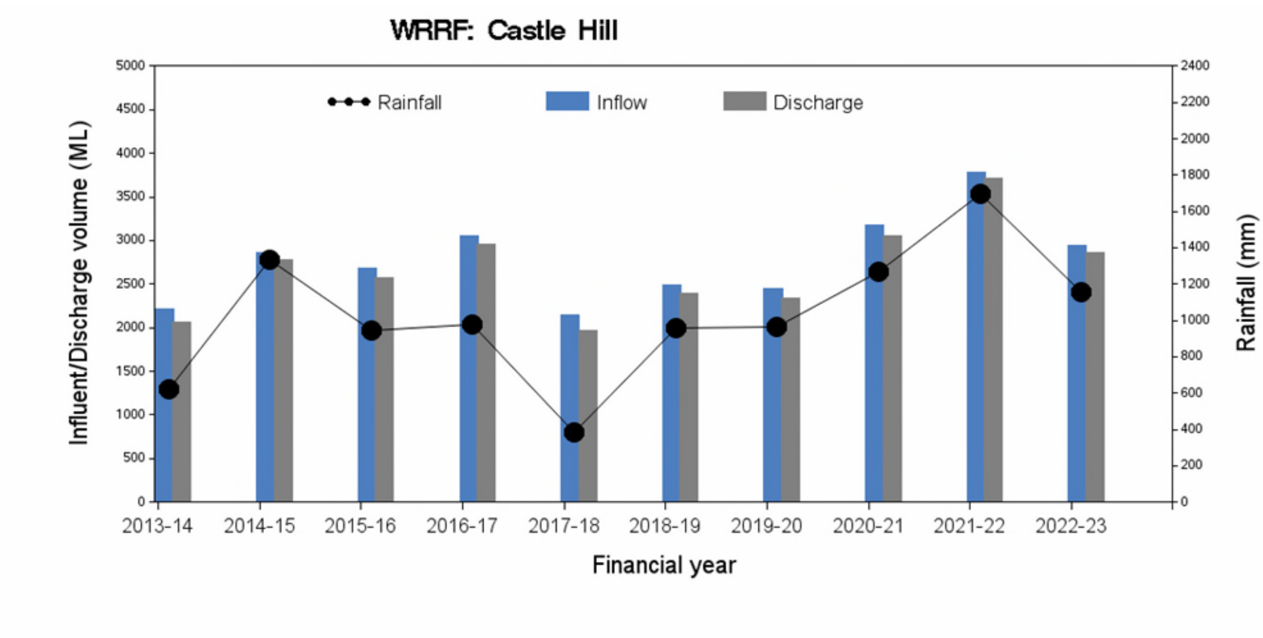


Figure A-31 Stream health of Second Ponds Creek near Rouse Hill WRRF

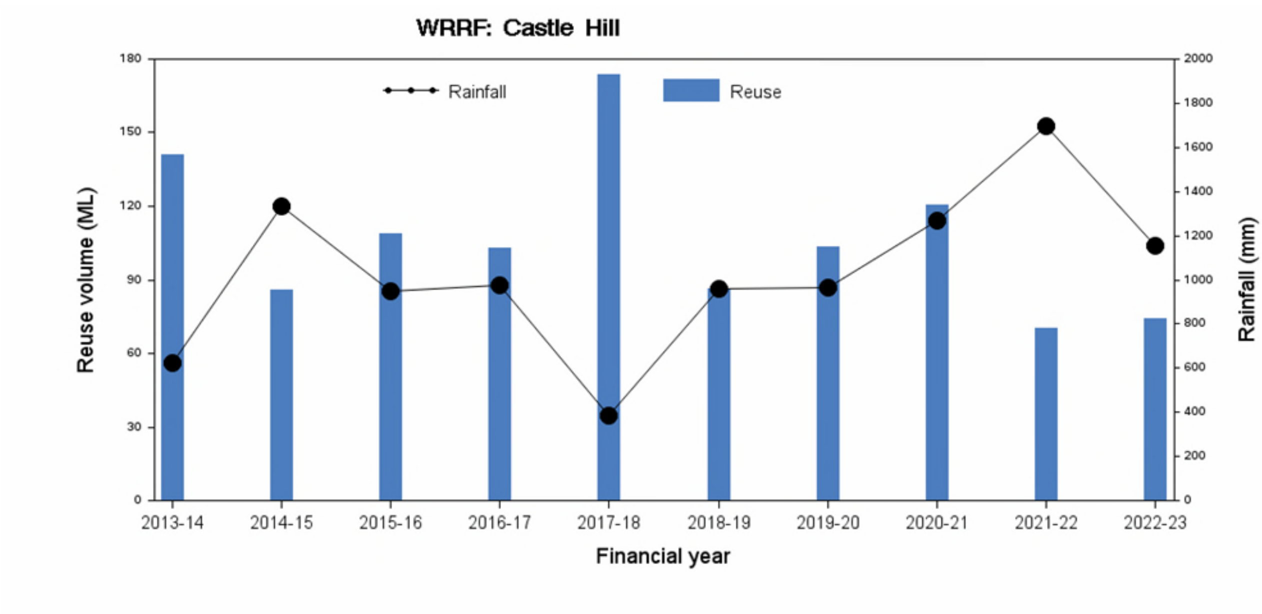
A-12 Castle Hill WRRF

A-12.1 Pressure – Wastewater quantity

Inflow/ Discharge volume and rainfall

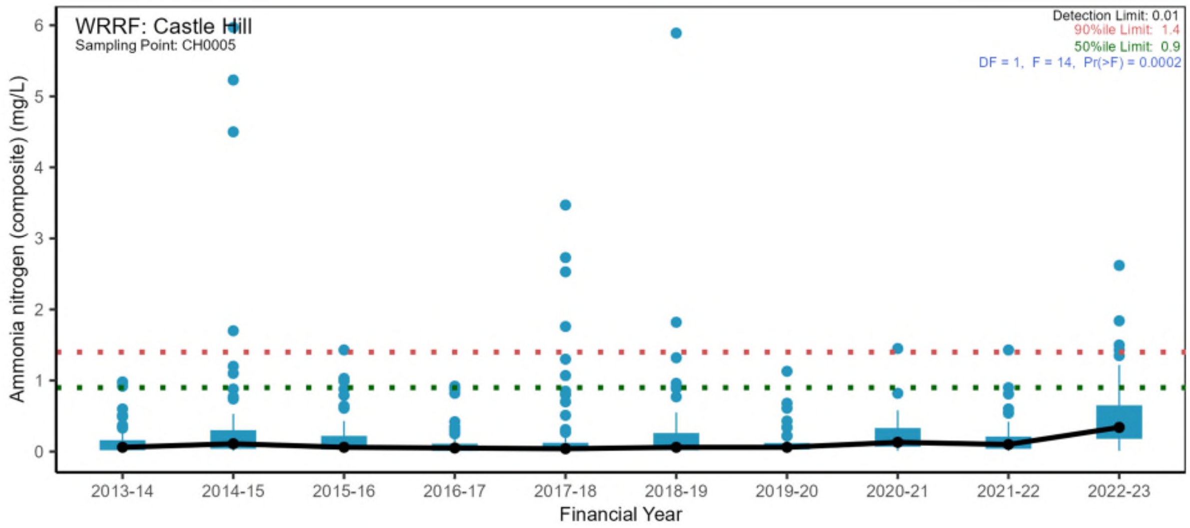


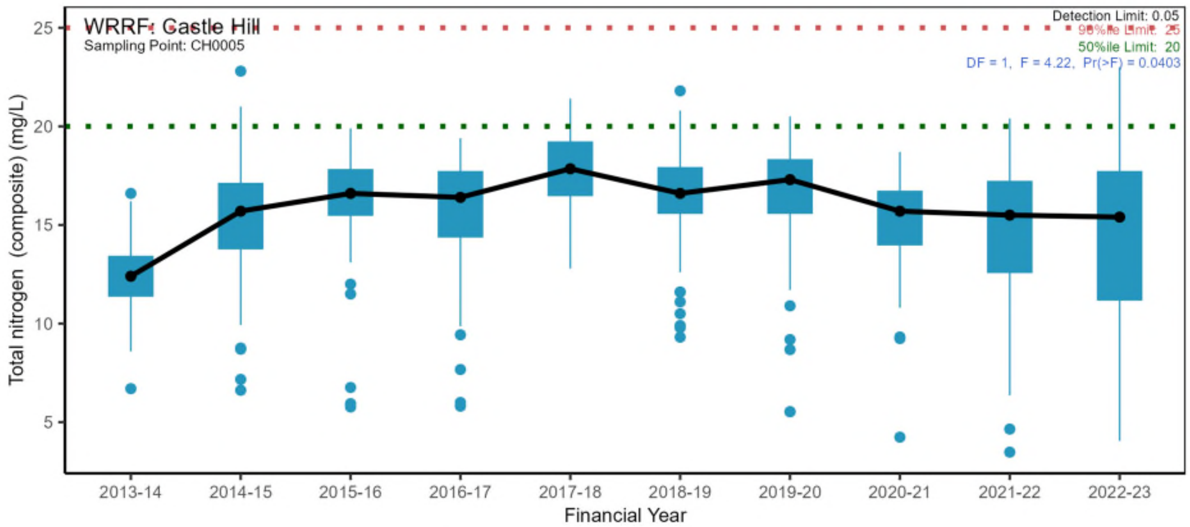
Reuse volume and rainfall

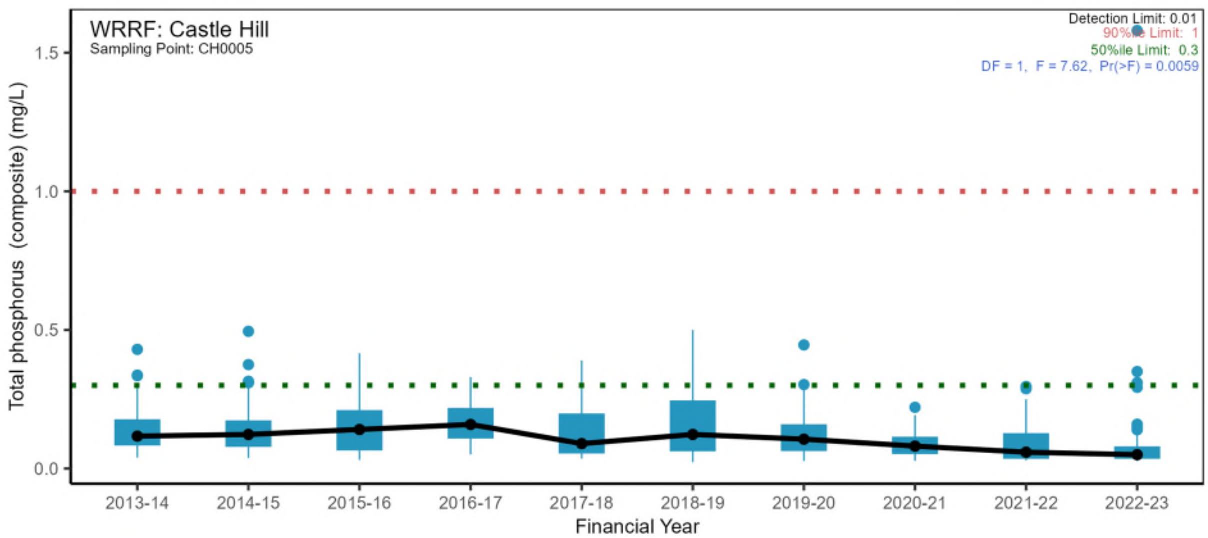


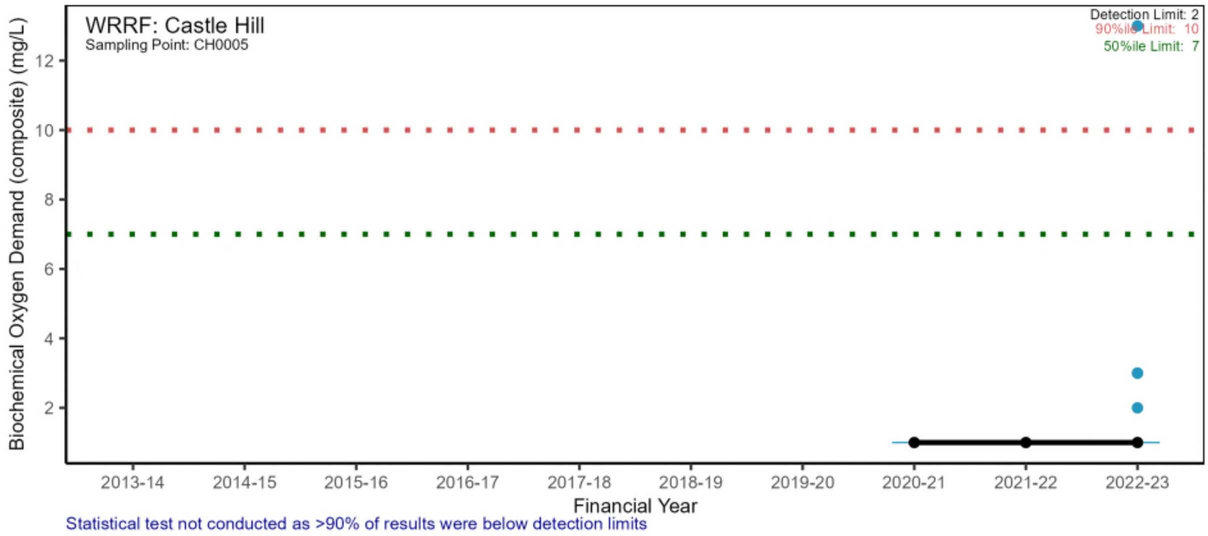
A-12.2 Pressure – Wastewater quality

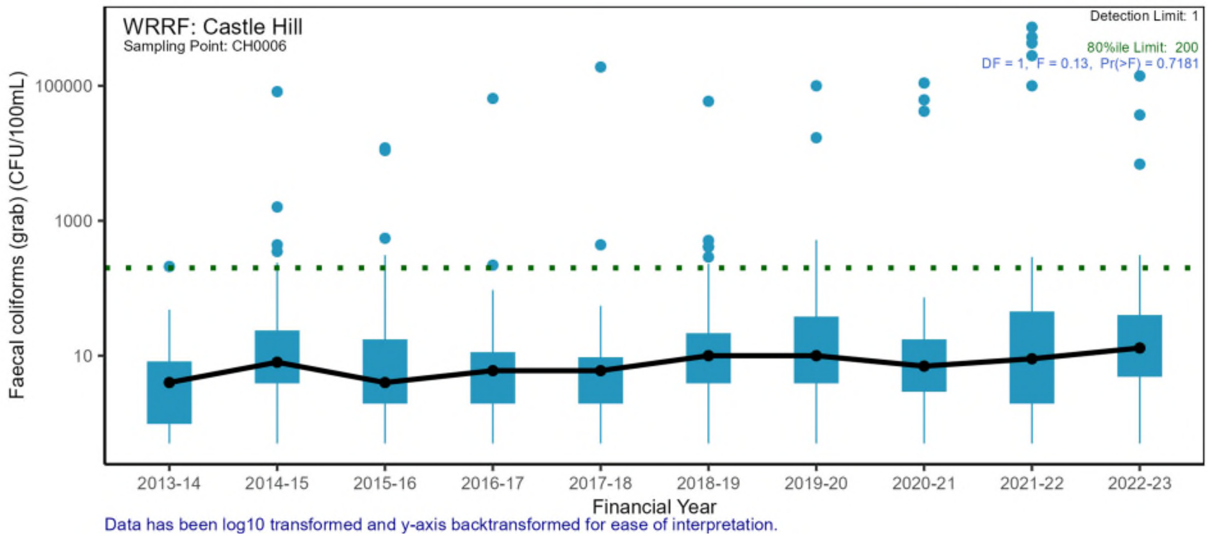
Nutrients

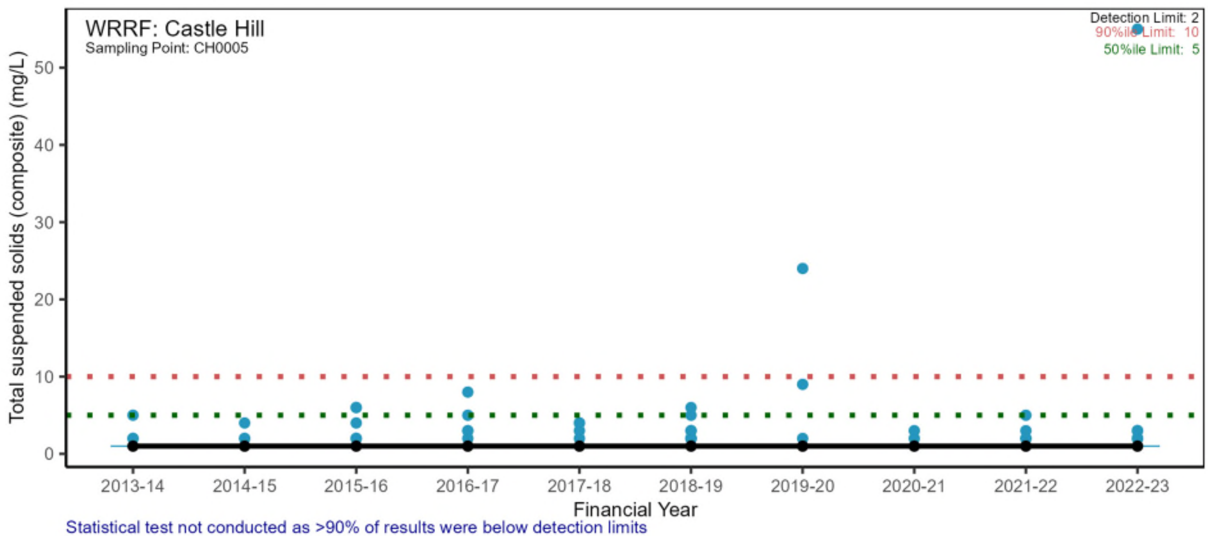




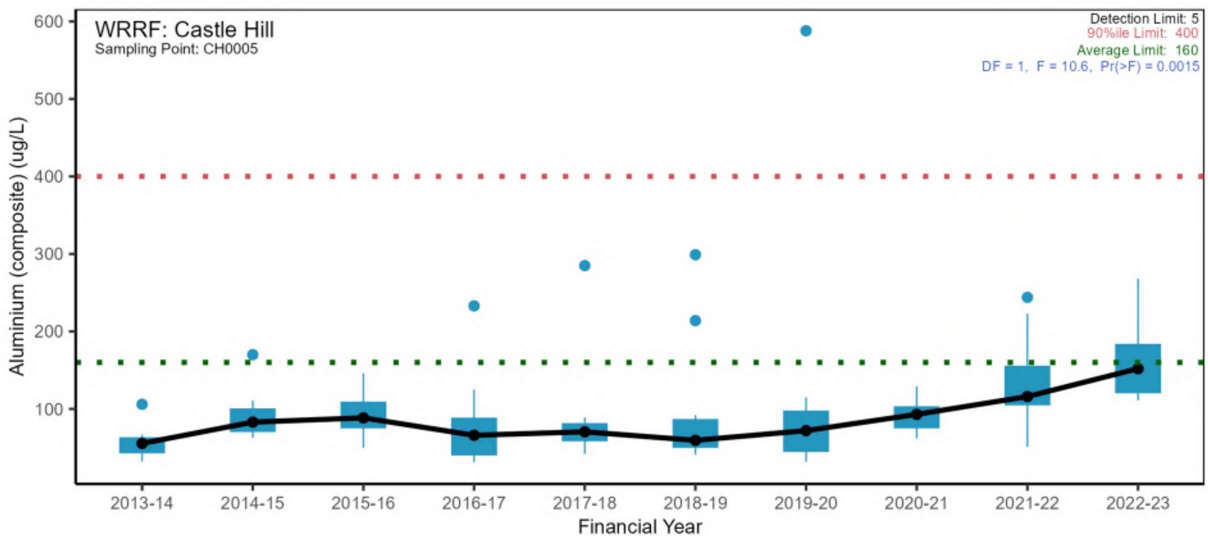


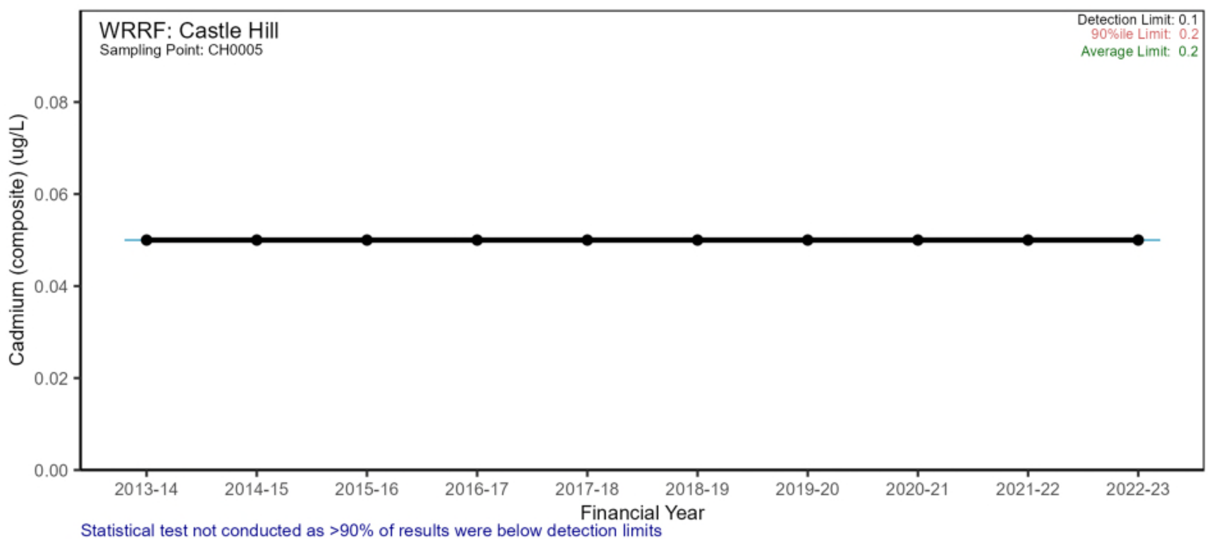

WRRF: Castle Hill
Sampling Point: CH0005
Detection Limit: 2
90%ile Limit: 10
50%ile Limit: 7
Biochemical Oxygen Demand (composite) (mg/L)
12
10
8
6
4
2
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits

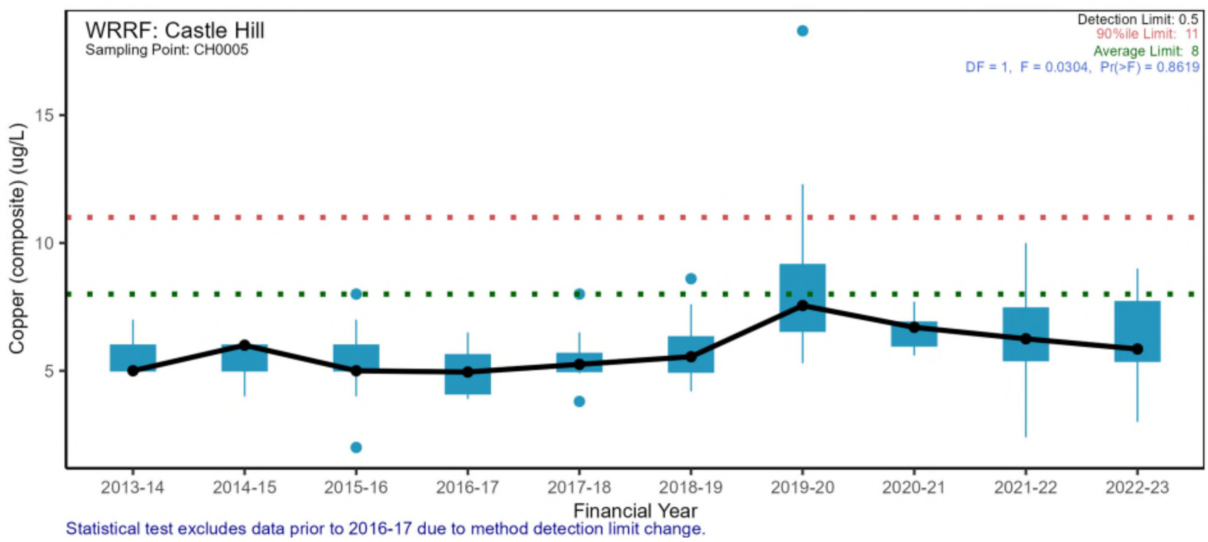

WRRF: Castle Hill
Sampling Point: CH0006
Detection Limit: 1
80%ile Limit: 200
DF = 1, F = 0.13, Pr(>F) = 0.7181
Faecal coliforms (grab) (CFU/100mL)
100000
1000
10
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

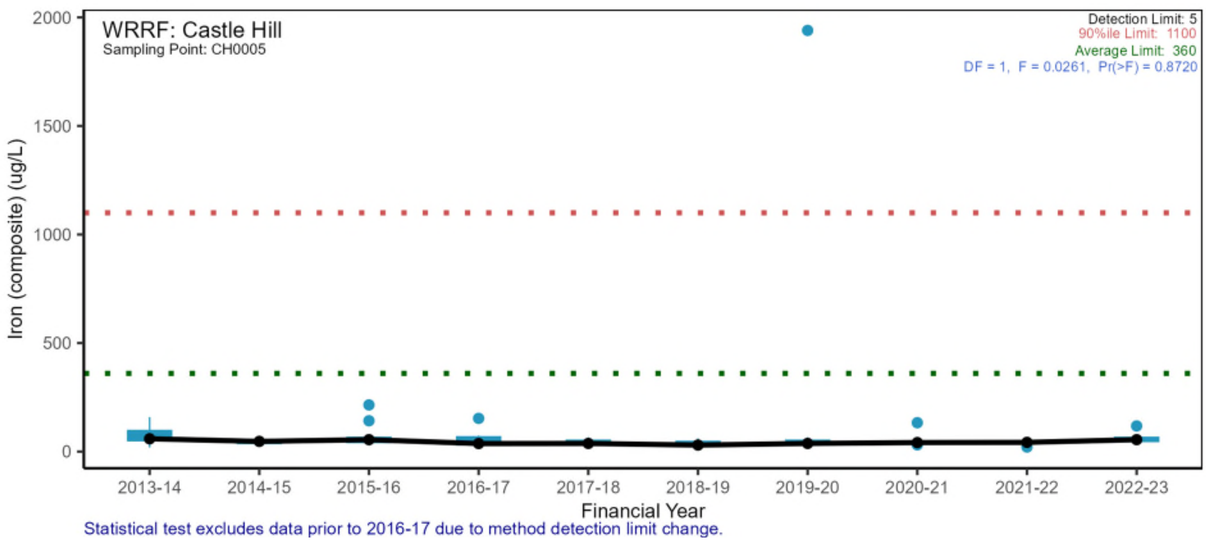

WRRF: Castle Hill
Sampling Point: CH0005
Detection Limit: 2
90%ile Limit: 10
50%ile Limit: 5
Total suspended solids (composite) (mg/L)
50
40
30
20
10
0
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year
Statistical test not conducted as >90% of results were below detection limits

Trace metals

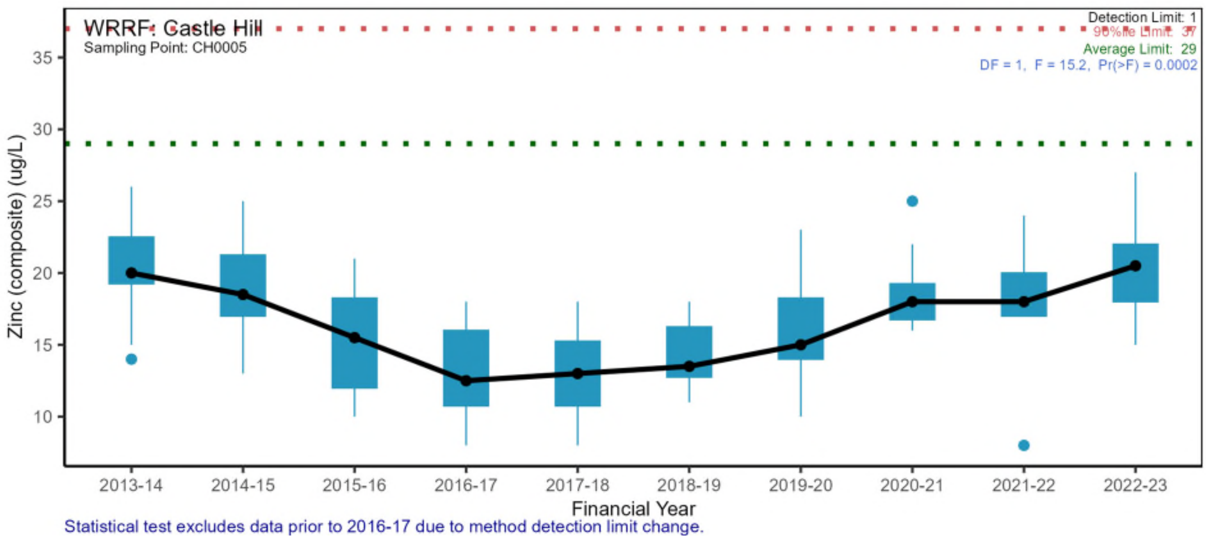






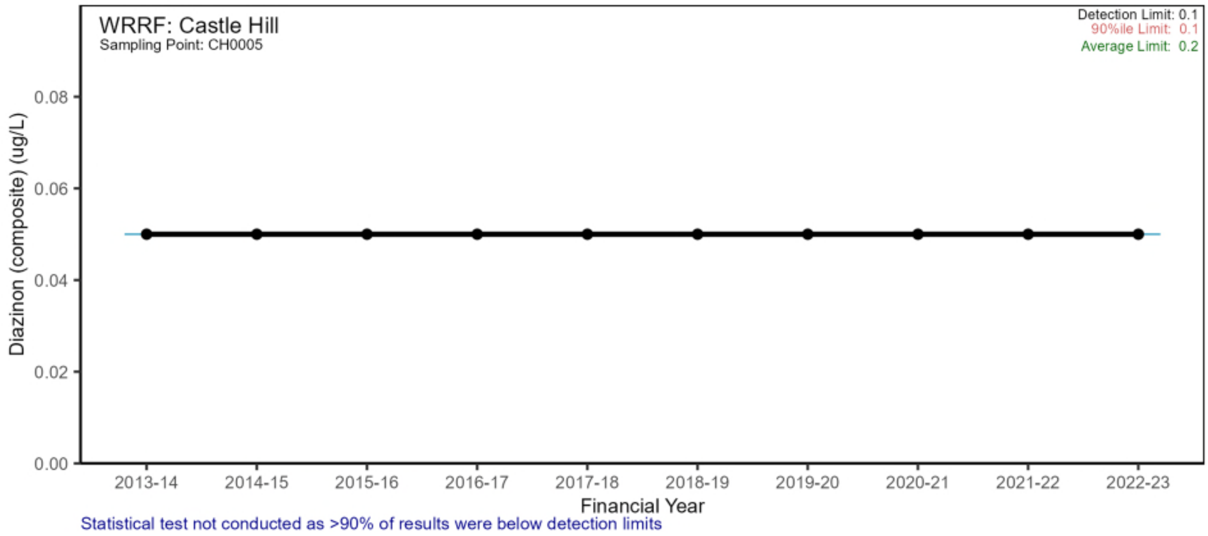


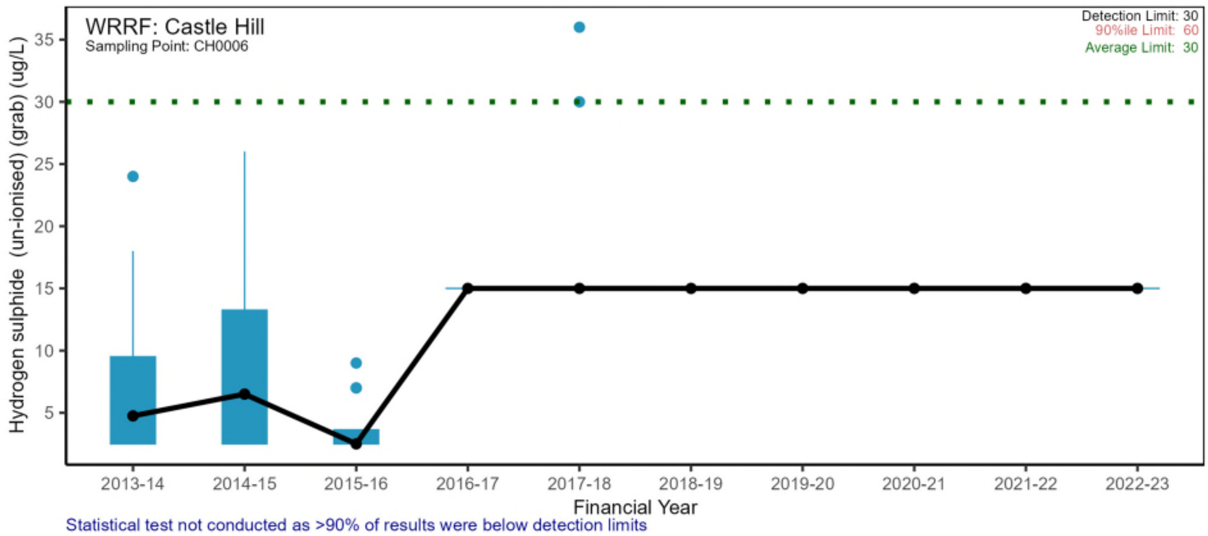
WRRF: Castle Hill
Sampling Point: CH0005
Detection Limit: 5
90%ile Limit: 1100
Average Limit: 360
DF = 1, F = 0.0261, Pr(>F) = 0.8720
Iron (composite) (ug/L)
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.



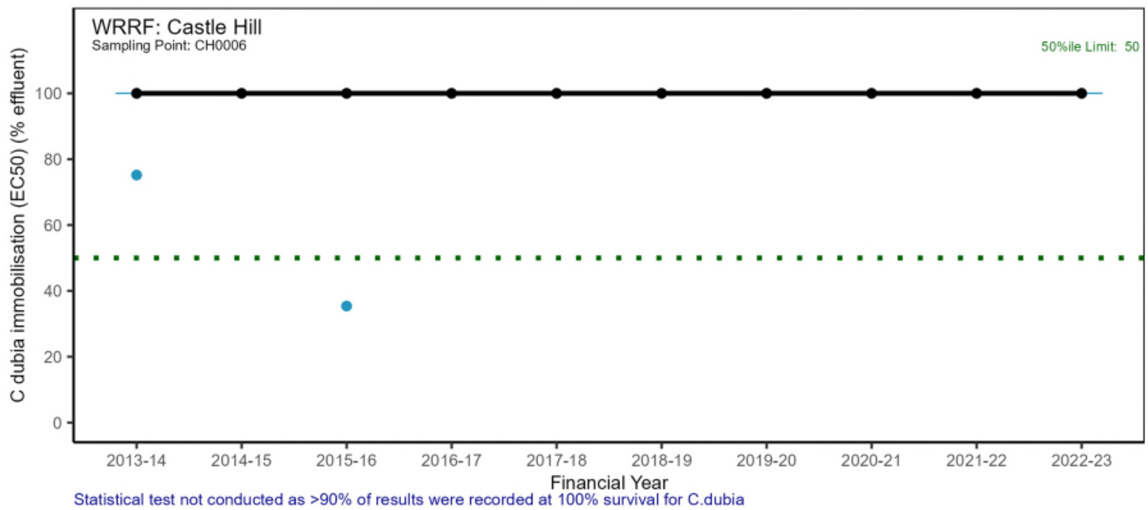
WRRF: Castle Hill
Sampling Point: CH0005
Detection Limit: 1
90%ile Limit: 37
Average Limit: 29
DF = 1, F = 15.2, Pr(>F) = 0.0002
Zinc (composite) (ug/L)
Financial Year
Statistical test excludes data prior to 2016-17 due to method detection limit change.

Other chemicals and organics (including pesticides)



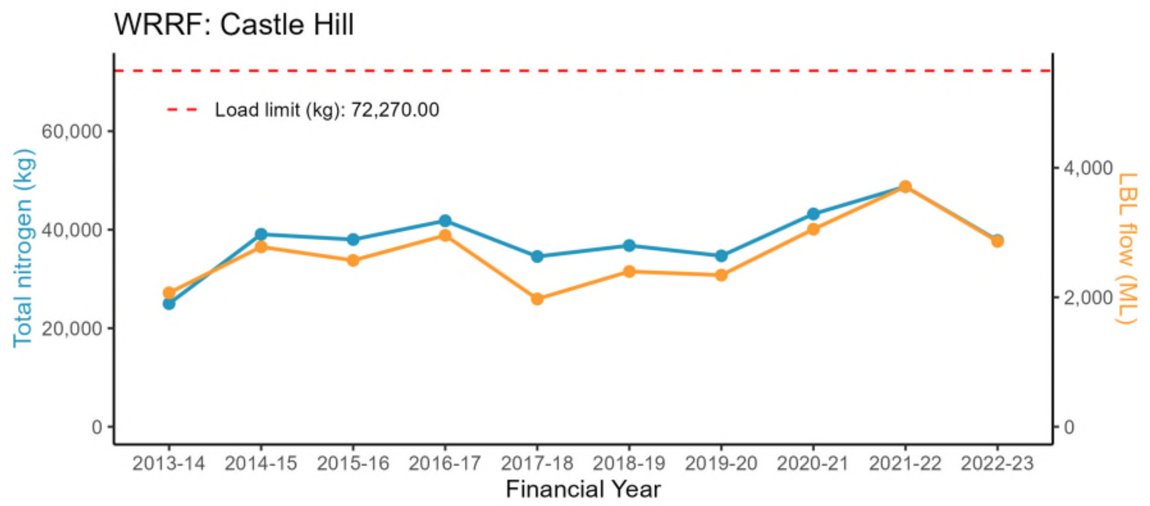


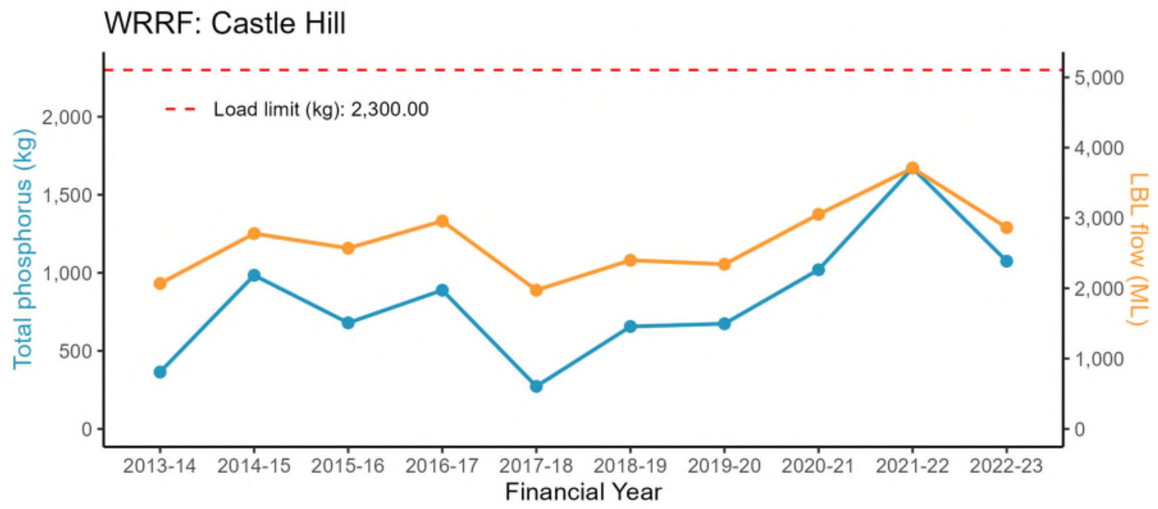
A-12.3 Pressure – Wastewater toxicity



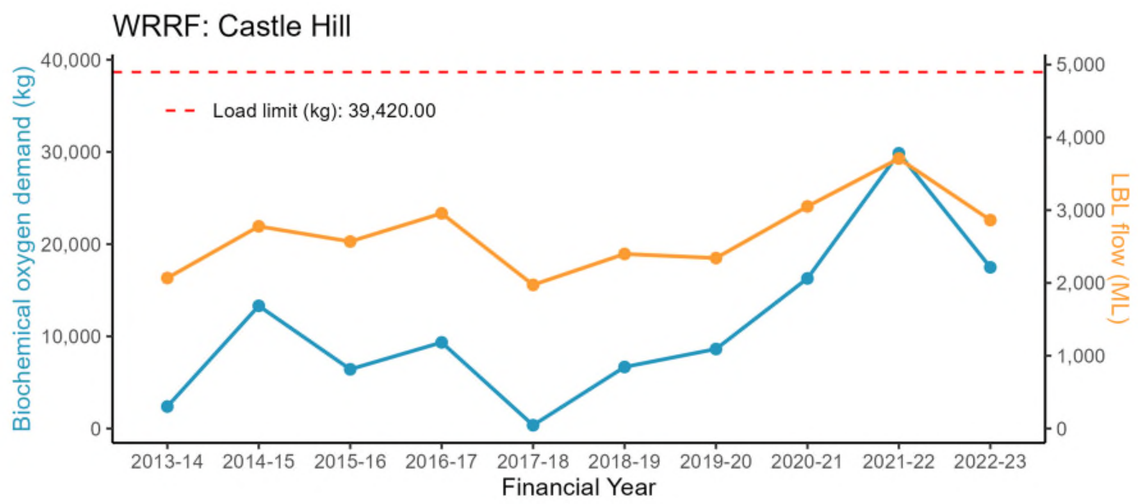
A-12.4 Pressure – Wastewater discharge load

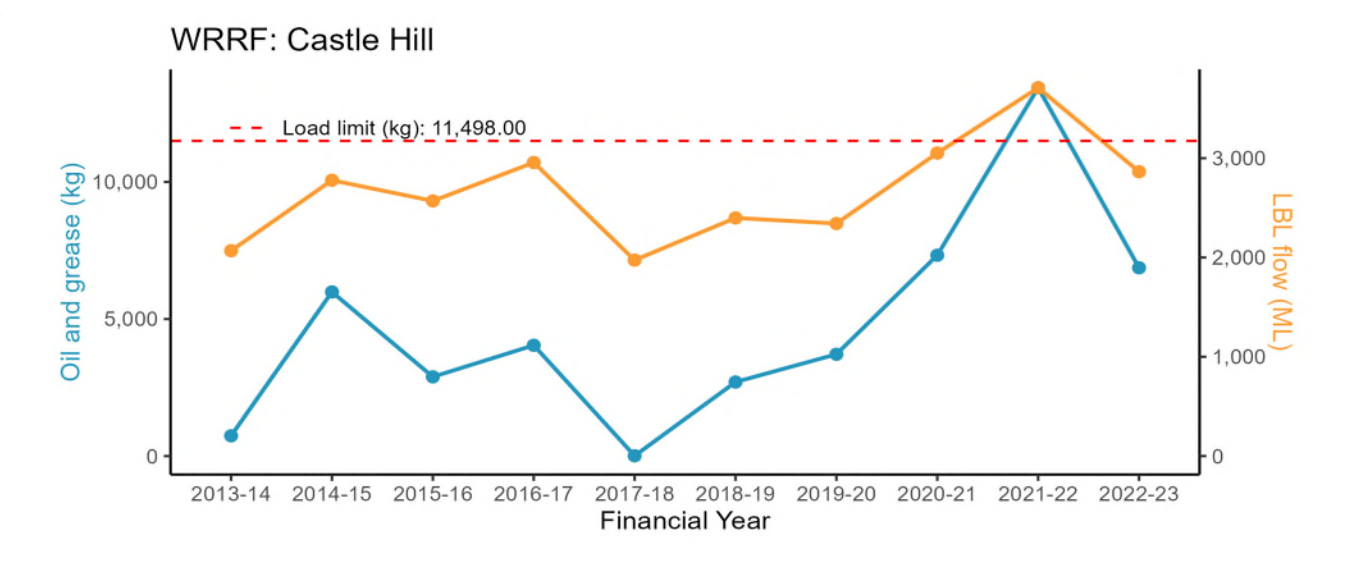
Nutrients

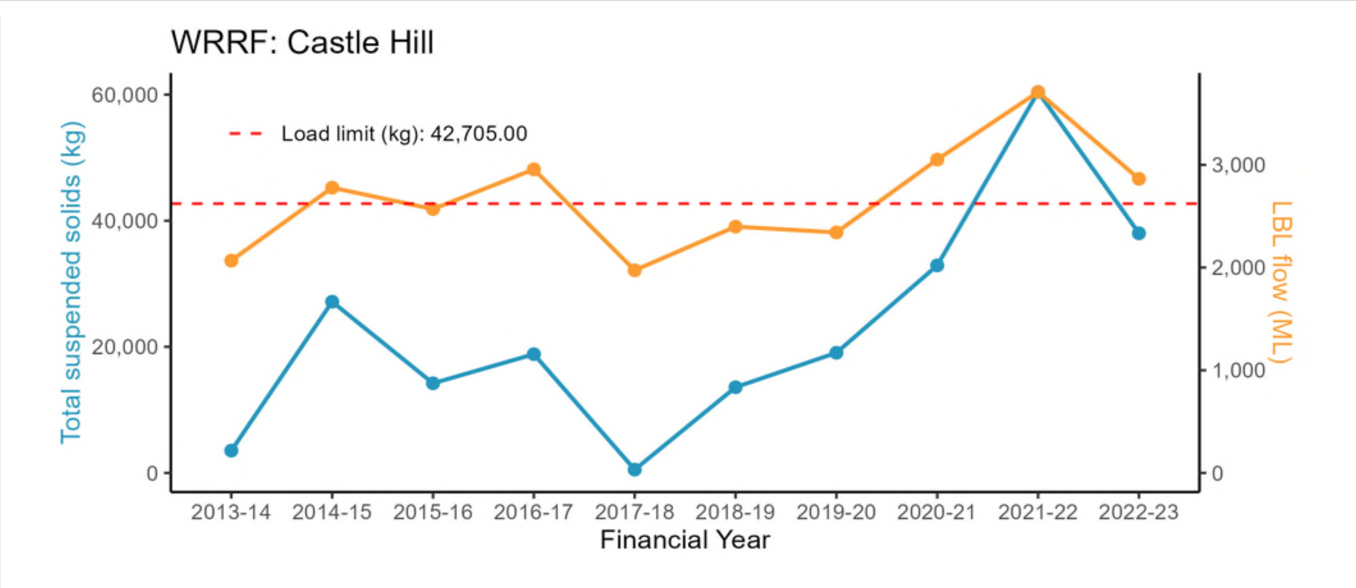




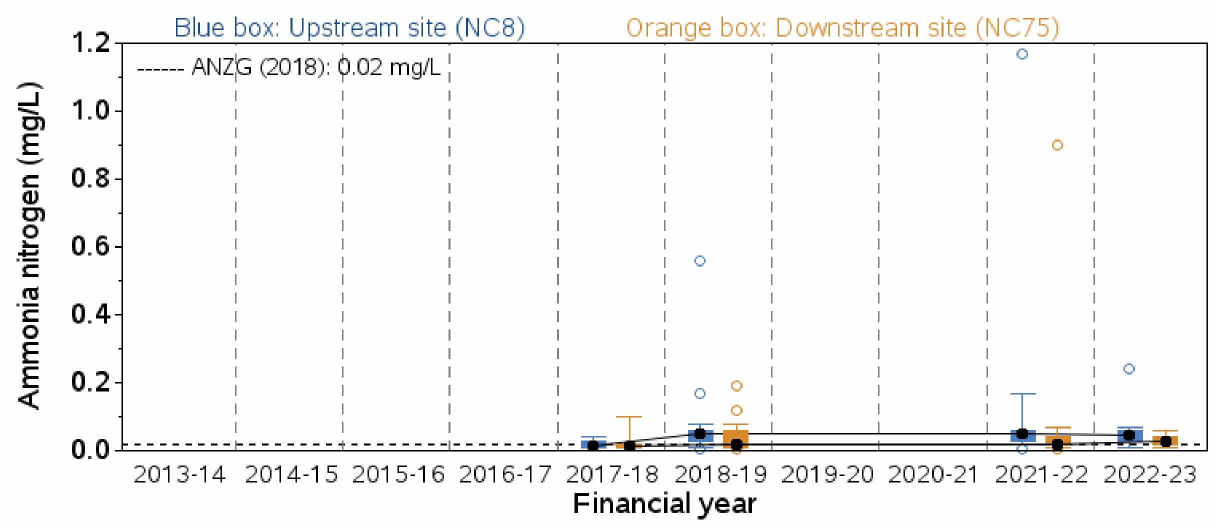
Major conventional analytes



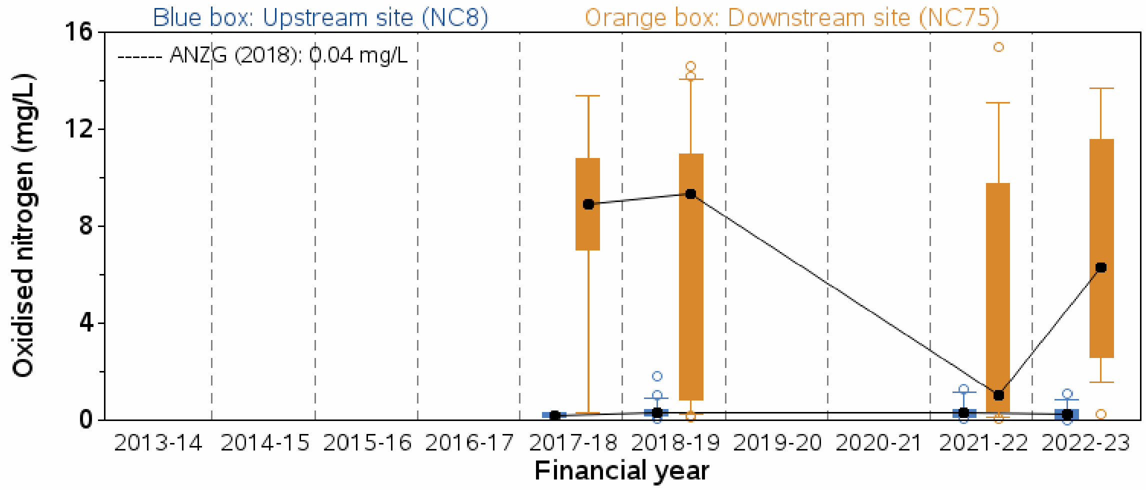




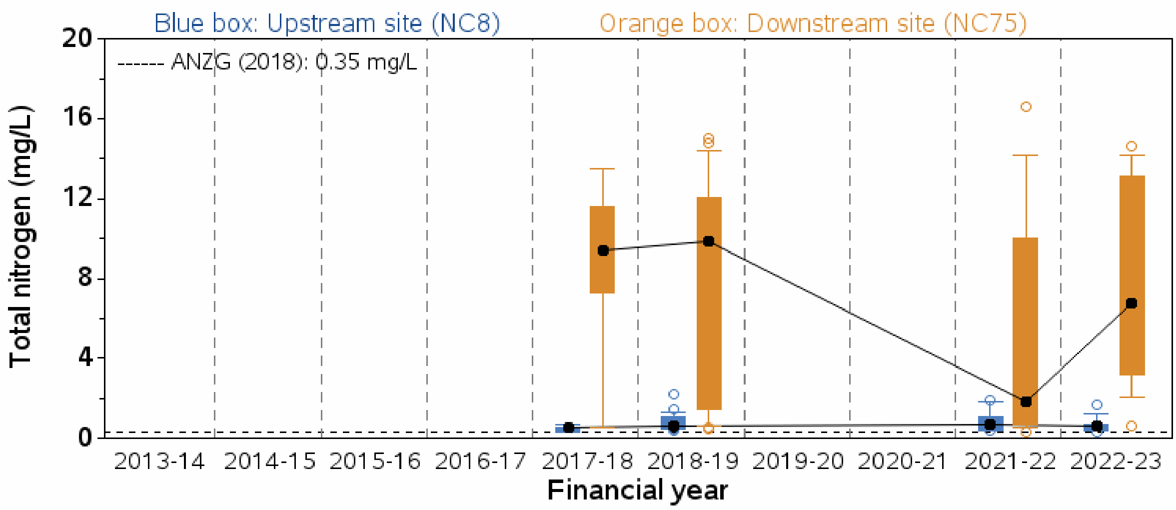
A-12.5 Stressor – Nutrients



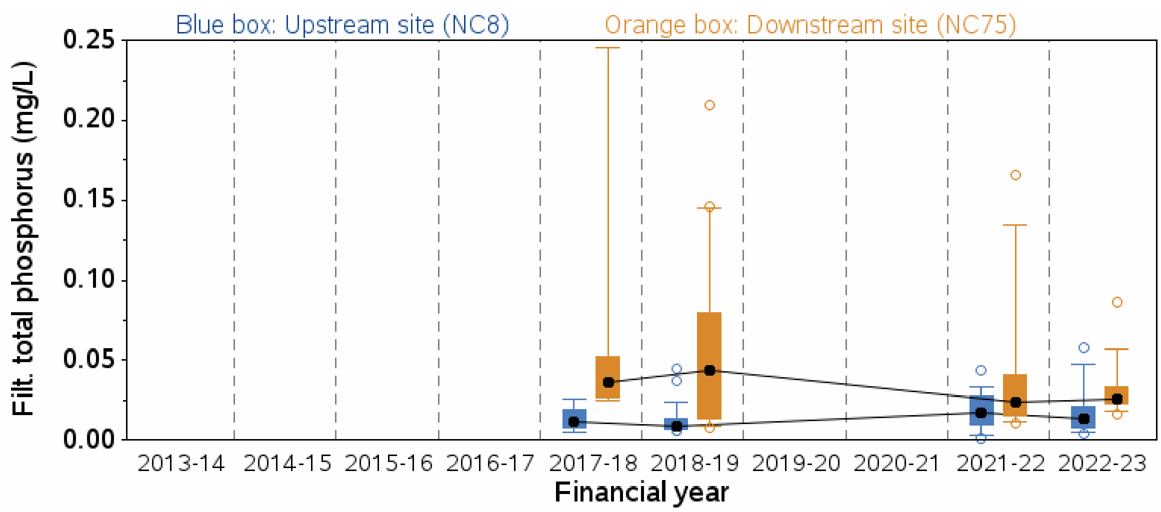
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	0.43	0.5147	NC75	1	0.43	0.5137



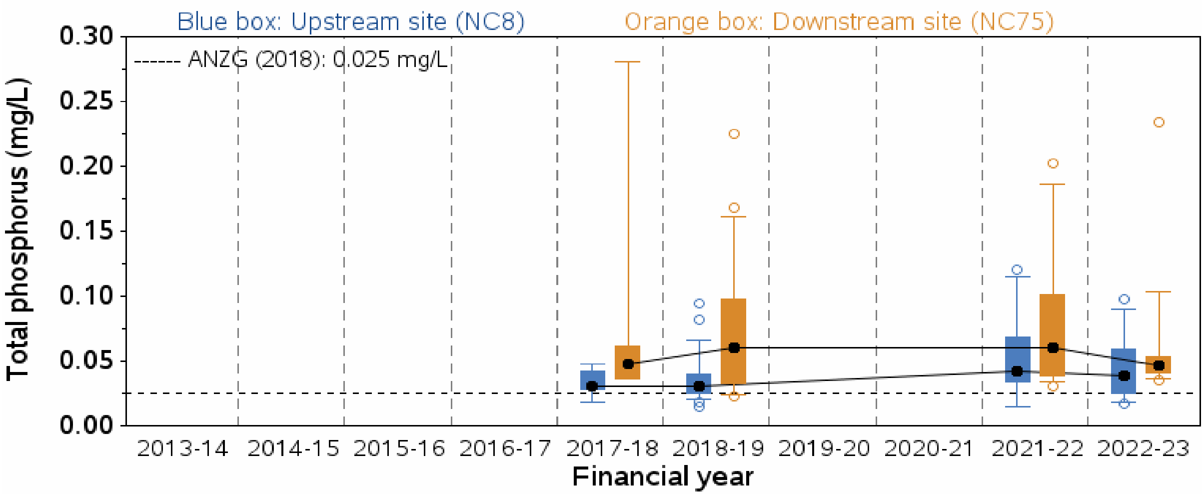
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	0.59	0.4444	NC75	1	0.09	0.7616



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	0.78	0.3803	NC75	1	0.17	0.6783

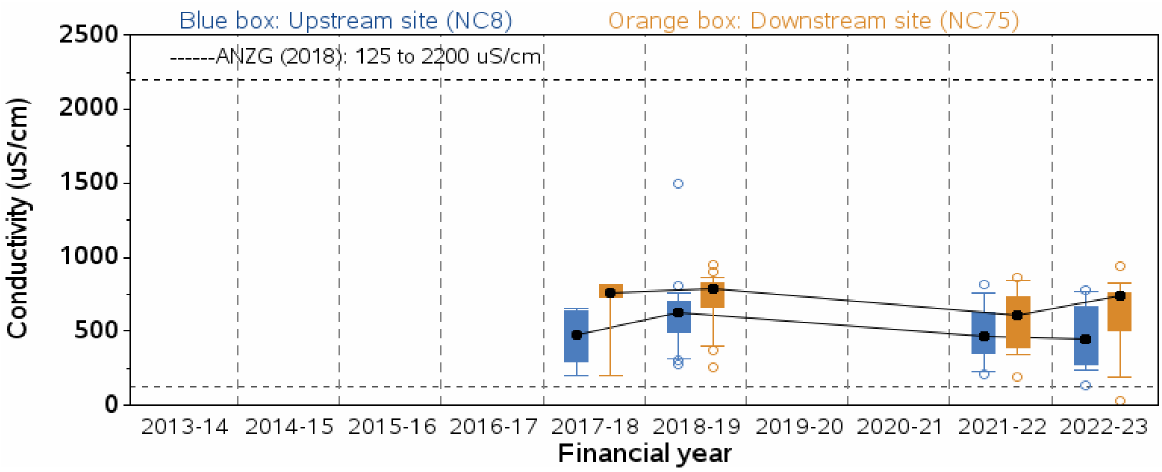


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	1.24	0.27	NC75	1	2.89	0.0937

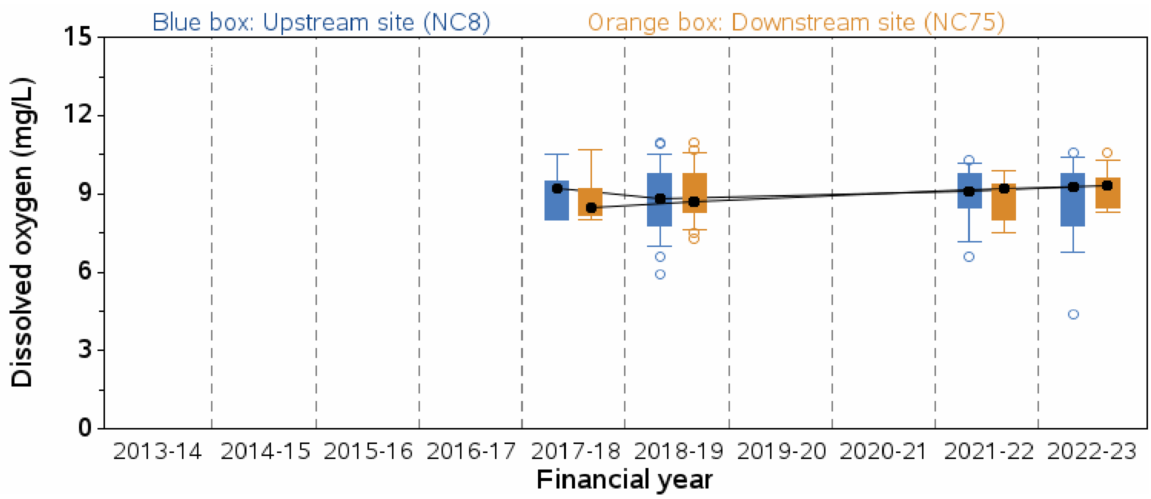


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	0.15	0.7038	NC75	1	1.09	0.2999

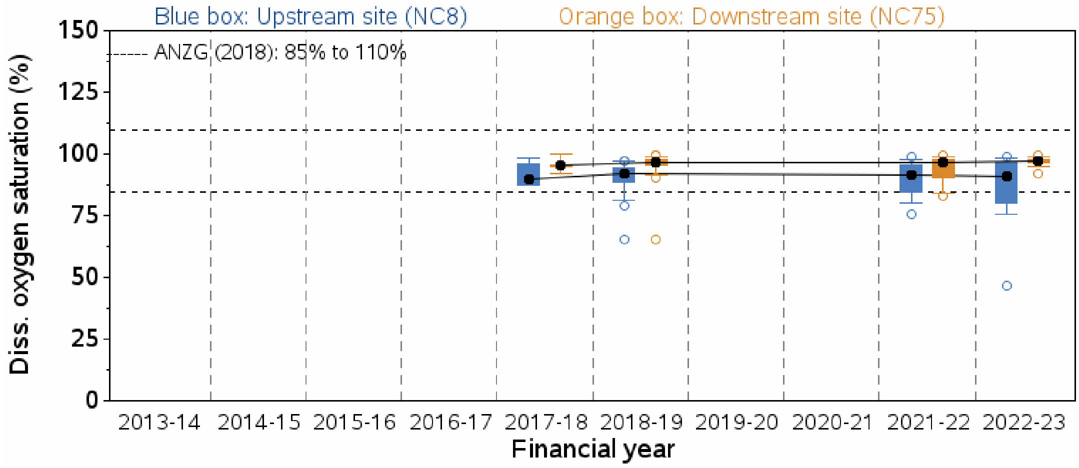
A-12.6 Stressor – Physico-chemical water quality



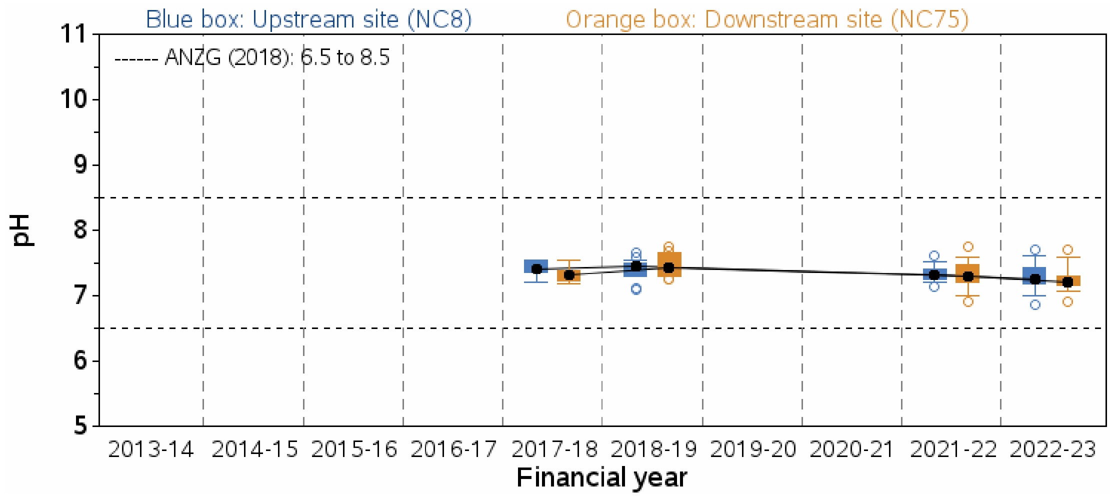
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	1.46	0.2312	NC75	1	0.31	0.5802



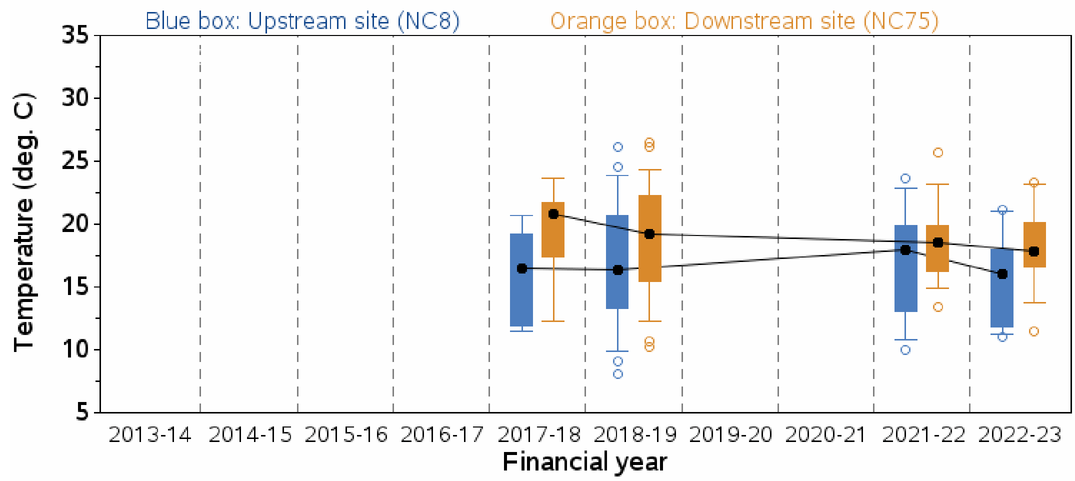
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	0.12	0.7351	NC75	1	1.22	0.2739



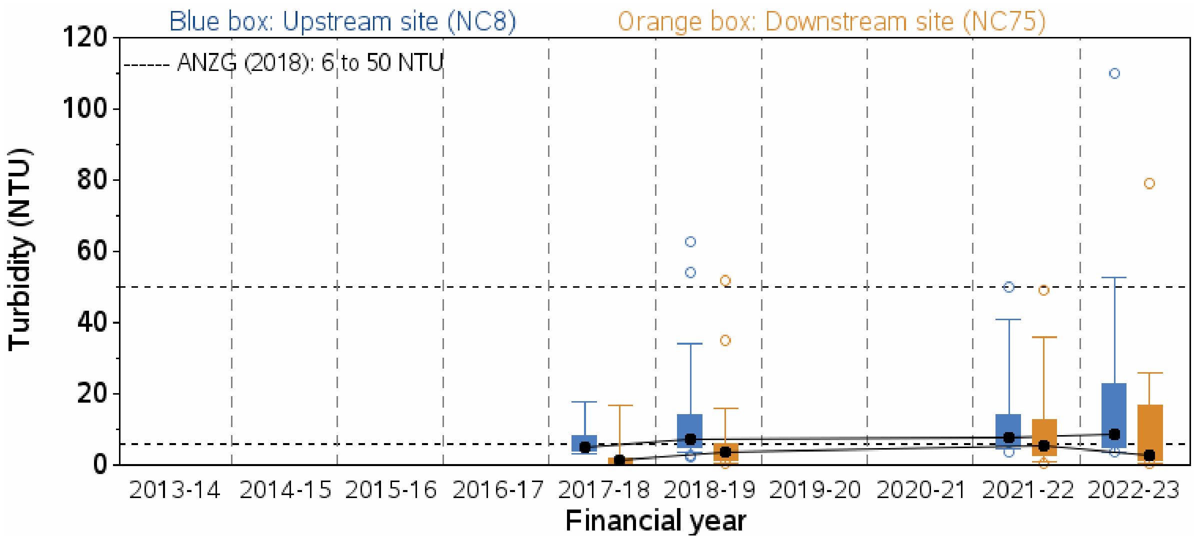
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	1.59	0.2122	NC75	1	2.87	0.095



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	5.3	0.0245	NC75	1	9.1	0.0037

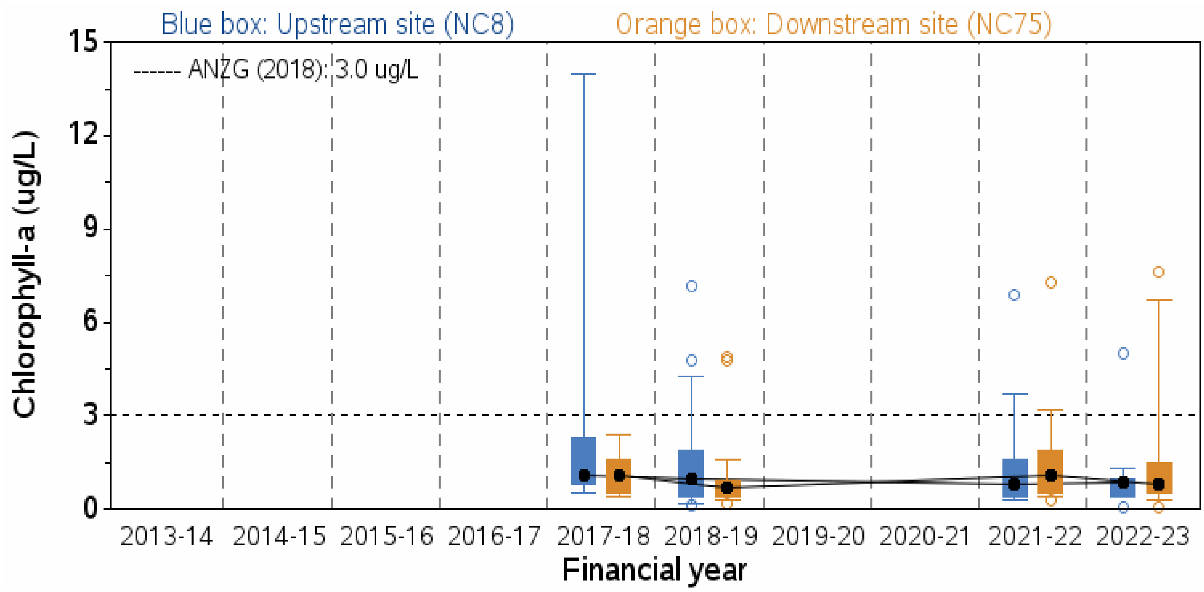


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	0.83	0.3654	NC75	1	0.51	0.4768



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	1.63	0.2062	NC75	1	0.47	0.4943

A-12.7 Ecosystem receptor – Phytoplankton



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NC8	1	1.47	0.2304	NC75	1	0.77	0.3823

Note: Insufficient data to draw a plot on total phytoplankton biovolume for NC8 and NC75

Note: Insufficient data to draw a plot on blue-green biovolume for NC8 and NC75

Note: Insufficient data to draw a plot on toxic blue-green count for NC8 and NC75

A-12.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for Cattai Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022–23 against that collected between 1995 and 2022. This comparison suggests downstream stream health was maintained at a level comparable to that of the upstream site over the historical period but continued to be lower than that of the upstream site in 2022–23, suggesting wastewater discharge from Castle Hill WRRF had a measurable impact on stream health during 2022–23 (Figure A-32).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022–23 samples under a t-test returned a significant test outcome (Table A-42) and confirmed the visual trend of the SIGNAL-SG plot with only minor overlap in the range of stream health between upstream and downstream sites for 2022–23.

As the significant t-test outcome for Cattai Creek was recorded further data analysis was undertaken.

Table A-42 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Cattai Creek

Waterway	Method	Statistic	DF	P value
Cattai Creek	Welch Two Sample t-test	2.96	9.4	0.015

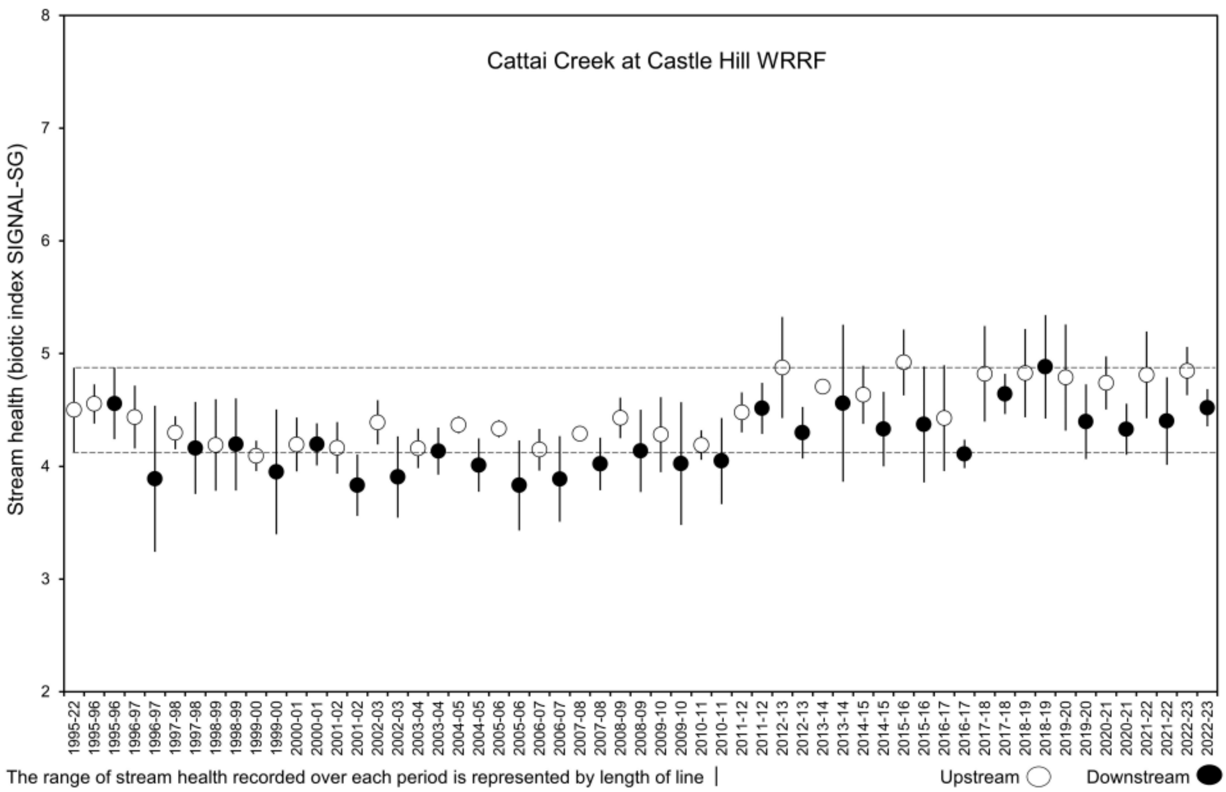


Figure A-32 Stream health of Cattai Creek near Castle Hill WRRF

Both edge and riffle habitats were collected consistently enough at upstream-downstream sites on the same sampling occasions to allow multivariate analysis for the monitoring period of 1995 to 2023. Each habitat (edge and riffle) was analysed separately with comparisons assessed with upstream-downstream sites.

Three-dimensional ordination plots for both edge and riffle habitats had acceptable stress values (0.2 and 0.17) in contrast to those of 2-dimensional summaries (0.27 and 0.25). In the 3-dimensional nMDS ordination plot of the Cattai Creek edge habitat, a partially overlaying pattern of upstream and downstream samples were observed (Figure A-33). This pattern was confirmed in the corresponding tree diagram from cluster analysis with the majority of the upstream and downstream samples separating at a moderate level of similarity (at around 30%) (Figure A-35). The shade plot pattern for the edge habitat upstream downstream sites on Cattai Creek (Figure A-37) displayed a similar suite of taxa suggesting communities between sites were similar. The riffle habitat pattern displayed was even more overlapped compared to the edge habitat, with a relatively interspersed pattern of upstream-downstream samples in the Cattai Creek ordination plot (Figure A-34), tree diagram (Figure A-36) and very similar assemblages shown in the shade plot for upstream and downstream sites (Figure A-38).

The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 33 taxa for the edge habitat (Table A-51) out of 118 taxa, and 20 taxa for the riffle habitat (Table A-52) out of 74 taxa. This subset of taxa formed the main visual pattern in the respective shade plots (Figure A-37 and Figure A-38).

The PERMDISP analysis indicated a similar pattern of dispersion (spacing between same samples) for the upstream and downstream sites of the riffle habitat (Table A-48). This suggests the variability in taxonomic composition of samples collected over time was similar for upstream and downstream riffle sites through the period 1995 to 2023. As such, the subsequent riffle habitat results of ANOSIM tests were focused on community structure differences between sites. In contrast, significant dispersion was shown for the edge habitat samples (Table A-47). This outcome suggests subsequent edge habitat results of ANOSIM tests are describing both the variability in taxonomic composition of samples over time as well as community composition variability between the upstream and downstream sites.

An ANOSIM test was run on the factor ‘Site’. The returned R-values were at a low-range level for both edge (0.244) (Table A-43) and for riffle (0.102) (Table A-44). These R-value results suggest there was a lack of clearly different taxonomic assemblages present at each site.

To further explore community structure, hypothesis testing was conducted using PERMANOVA. This model included the fixed factors ‘Site’ and ‘Year’. ‘Year’ represented samples collected in years between 1995 and 2023 and ‘Site’ had two levels, upstream and downstream. A statistically non-significant ‘Site x Year’ interaction was returned for the edge (Table A-45) and riffle (Table A-46) habitats. These non-significant results allowed us to view the ‘Site’ and ‘Year’ results. Significant results were returned for ‘Site’ and ‘Year’ for both habitats. Looking at the components of variation outputs indicated ‘Year’ and ‘Site’ were fairly similar for the edge habitat, but for the riffle habitat ‘Year’ explained more than twice the variation than explained by ‘Site’.

A second run of ANOSIM based on ‘Site-Period’ groups returned significant global low-range R-values for the edge habitat (0.22) (Table A-49) and the riffle habitat (0.129) (Table A-50). Pairwise test outputs were non-significant for 3 of the 6 edge comparisons, and non-significant for 5 of the 6 riffle comparisons. Returned R-values of significant pairwise tests were returned at levels that may indicate natural spatial change in meso-habitat structure between sites as these values were below R = 0.66 determined by Besley and Chessman (2008) that represents natural habitat differences between sites on the same stream. Taking medium values of subjective within stream values of the edge and riffle substratum did indicate differences within habitats of Cattai Creek for the time periods 1995-2021 and 2021-2023 (Table A-49 and Table A-50).

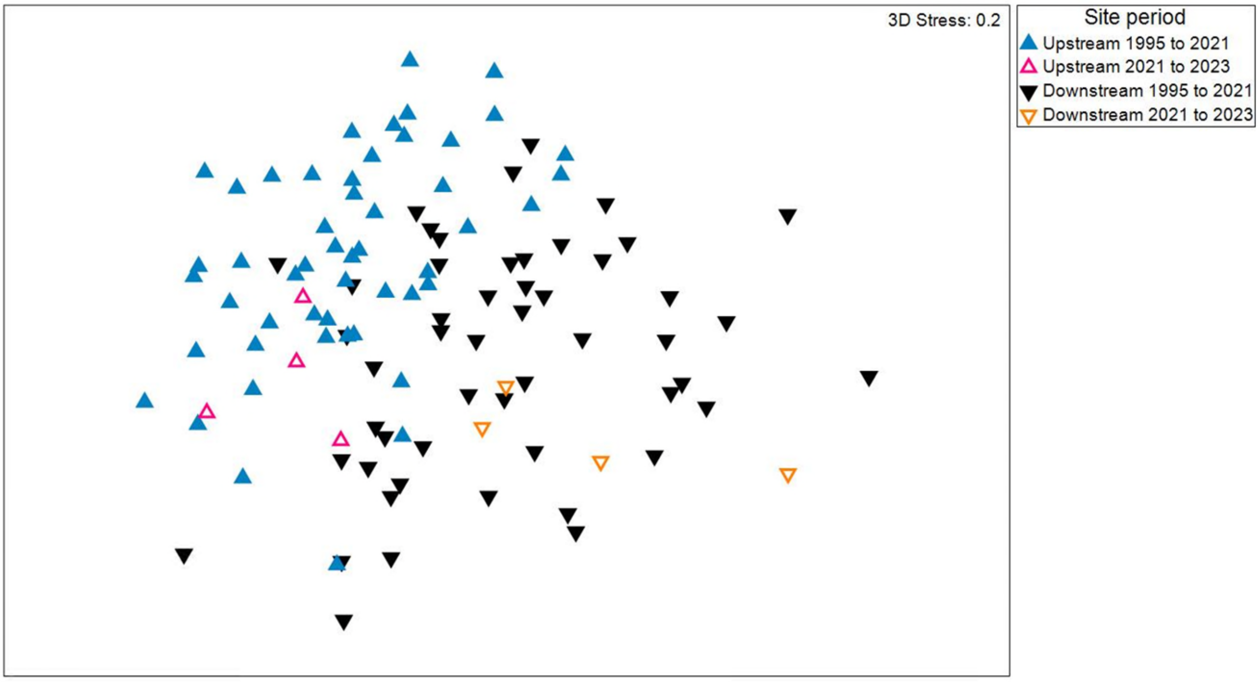


Figure A-33 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Cattai Creek near Castle Hill WRRF

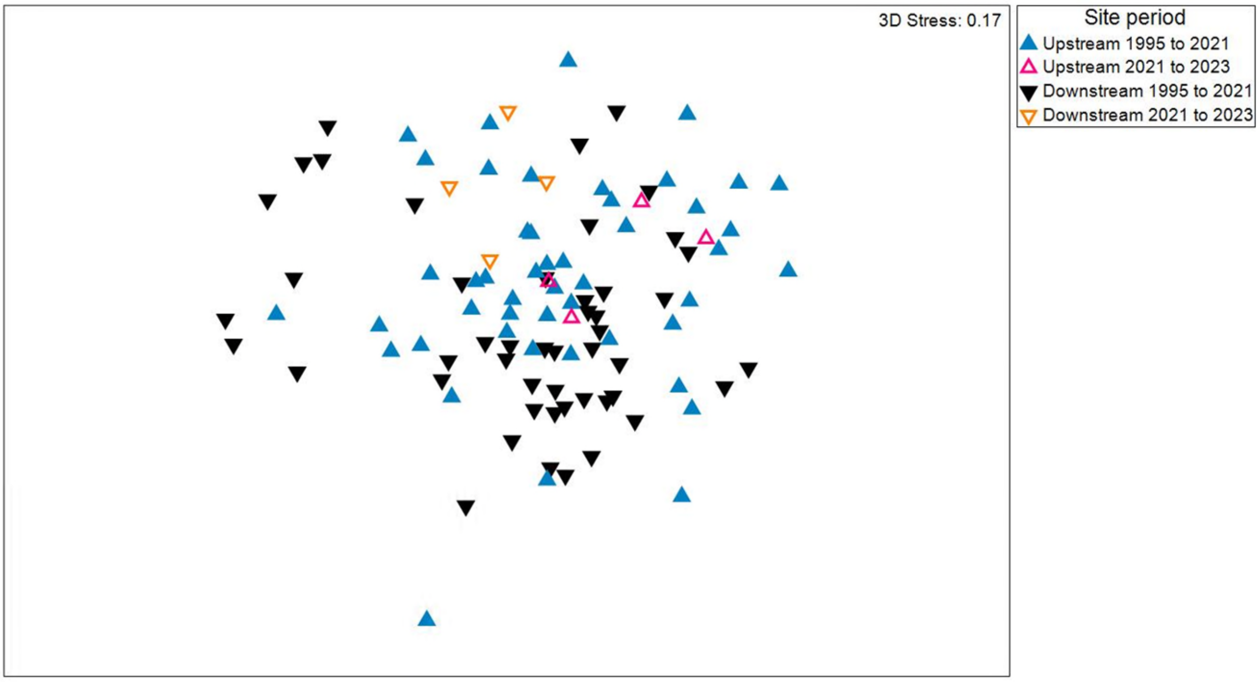


Figure A-34 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate riffle habitat community structure of upstream-downstream sites of Cattai Creek near Castle Hill WRRF

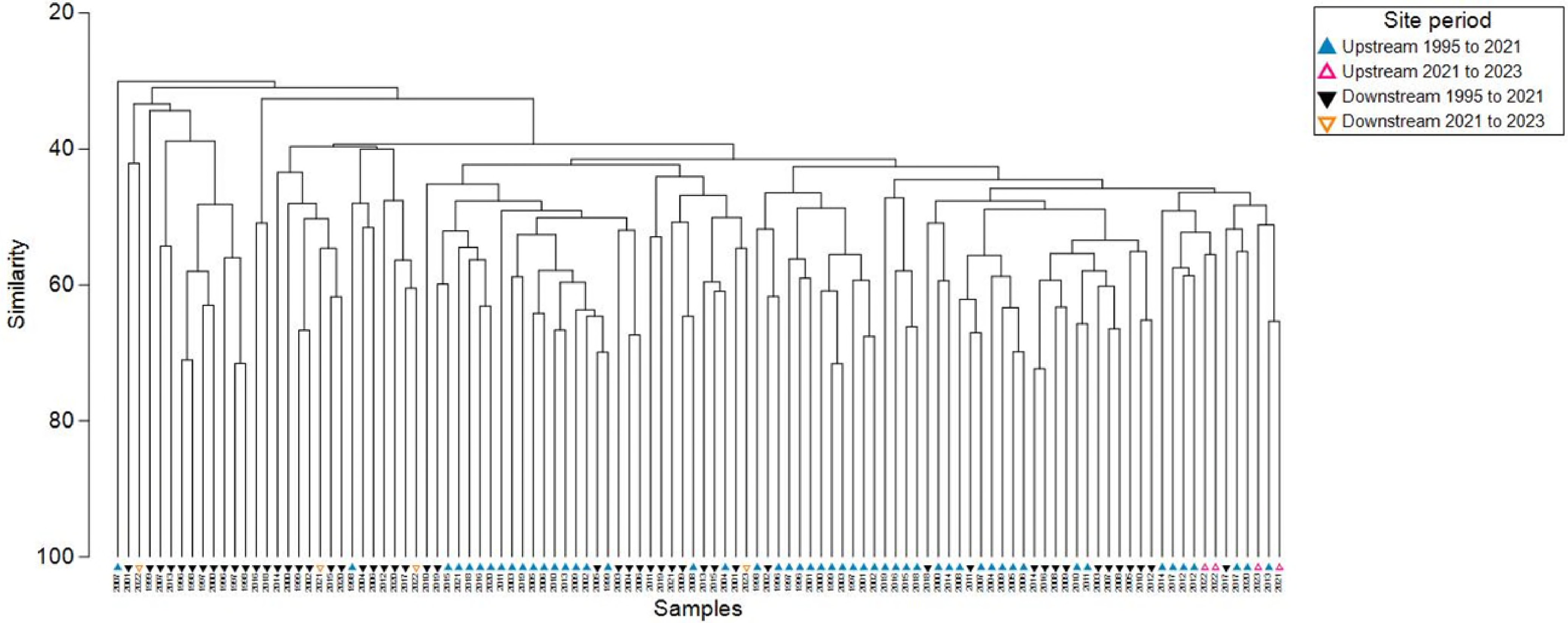


Figure A-35 Tree diagram of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Cattai Creek near Castle Hill WRRF

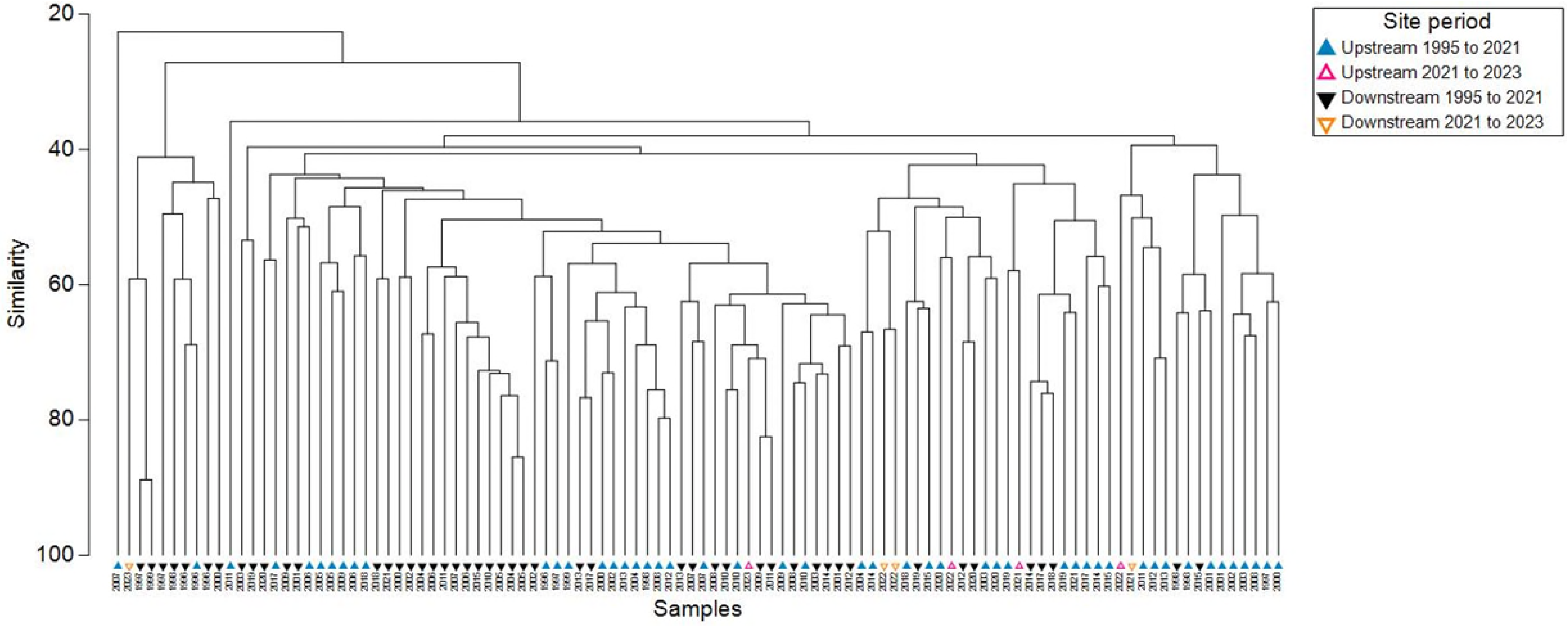


Figure A-36 Tree diagram of freshwater macroinvertebrate riffle habitat community structure of upstream-downstream sites of Cattai Creek near Castle Hill WRRF

Table A-43 ANOSIM test of 'Site' factor for edge habitat of Cattai Creek near Castle Hill WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.244
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-44 ANOSIM test of 'Site' factor for riffle habitat of Cattai Creek near Castle Hill WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.102
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-45 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of Cattai Creek near Castle Hill WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	28

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	15639	15639	10.16	0.0001	9927
Year	27	65687	2432.9	1.5804	0.0001	9672
SitexYear	27	37486	1388.4	0.90193	0.8941	9657
Res	54	83125	1539.3			
Total	109	2.0227E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	260.77	16.149
S(Year)	227.51	15.084
S(SitexYear)	-76.878	-8.768
V(Res)	1539.3	39.234

Table A-46 PERMANOVA test of 'Site' and 'Year' factors for riffle habitat of Cattai Creek near Castle Hill WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	27

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	8741	8741	6.1056	0.0001	9943
Year	26	75758	2913.8	2.0353	0.0001	9755
SitexYear	26	35249	1355.7	0.94698	0.6985	9717
Res	50	71581	1431.6			
Total	103	1.9116E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Stei)	*145.39*	*12.058*
S(Year)	*385.06*	*19.623*
S(SitexYear)	*-39.437*	*-6.2799*
V(Res)	*1431.6*	*37.837*

Table A-47 PERMDISP test of 'Site' factor for edge habitat of Cattai Creek near Castle Hill WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 110

DEVIATIONS FROM CENTROID
F: 11.377 df1: 1 df2: 108
P(perm): 0.0017

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	55	42.579	0.85037
Upstream	55	38.826	0.71721

Table A-48 PERMDISP test of 'Site' factor for riffle habitat of Cattai Creek near Castle Hill WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 104

DEVIATIONS FROM CENTROID
F: 0.01694 df1: 1 df2: 102
P(perm): 0.9046

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	52	40.883	1.2933
Upstream	52	41.106	1.1283

Table A-49 ANOSIM test of ‘Site period’ for edge habitat of Cattai Creek near Castle Hill WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.22
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1995 to 2021, Upstream 1995 to 2021	0.231	0.01	Very large	9999	0
Downstream 1995 to 2021, Downstream 2021 to 2023	-0.026	54.8	341055	9999	5477
Downstream 1995 to 2021, Upstream 2021 to 2023	0.066	30.3	341055	9999	3033
Upstream 1995 to 2021, Downstream 2021 to 2023	0.563	0.1	341055	9999	9
Upstream 1995 to 2021, Upstream 2021 to 2023	0.094	23.2	341055	9999	2322
Downstream 2021 to 2023, Upstream 2021 to 2023	0.531	2.9	35	35	1

Table A-50 ANOSIM test of ‘Site period’ for riffle habitat of Cattai Creek near Castle Hill WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.129
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1995 to 2021, Upstream 1995 to 2021	0.116	0.01	Very large	9999	0
Downstream 1995 to 2021, Downstream 2021 to 2023	0.262	5.3	270725	9999	524
Downstream 1995 to 2021, Upstream 2021 to 2023	0.162	16	270725	9999	1599
Upstream 1995 to 2021, Downstream 2021 to 2023	0.205	9.1	270725	9999	905
Upstream 1995 to 2021, Upstream 2021 to 2023	0.03	40.2	270725	9999	4021
Downstream 2021 to 2023, Upstream 2021 to 2023	0.031	48.6	35	35	17

Table A-51 Genera subset whose multivariate pattern matches full genera set of the edge habitat Cattai Creek near Castle Hill WRRF

Subset of 33 (correlation 0.950) genera from edge habitat whose pattern matches that of the full set of 118 genera identified with the same subset found on 43 runs from 50 random start runs. Each run was based on 3 randomly selected genera. Genera were:

Tateidae Posticobia,Chironomidae Chironomus,Physidae Physella,Planorbidae Helicorbis,Chironomidae Cricotopus,Chironomidae Cryptochironomus,Chironomidae Dicrotendipes,Dugesiidae Cura,Glossiphoniidae Helobdella,Lumbriculidae Lumbriculus,Lymnaeidae Pseudosuccinea,Naididae Branchiura,Naididae Nais,Simuliidae Simulium,Argiolestidae Austroargiolestes,Chironomidae Polypedilum,Chironomidae Procladius,Chironomidae Rheocricotopus,Corduliidae Hemicordulia,Isostictidae Rhadinosticta,Libellulidae Diplacodes,Naididae Pristina,Sphaeriidae Musculium,Tateidae Potamopyrgus,Ceratopogonidae Bezzia,Hydroptilidae Hellyethira,Notonectidae Enithares,Chironomidae Paramerina,Gerridae Tenagogerris,Limnesiidae Limnesia,Psephenidae Sclerocyphon,Chironomidae Tanytarsus,Stratiomyidae Odontomyia

Table A-52 Genera subset whose multivariate pattern matches full genera set of the riffle habitat Cattai Creek near Castle Hill WRRF

Subset of 20 (correlation 0.952) genera from riffle habitat whose pattern matches that of the full set of 74 genera identified with the same subset found on 37 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Tateidae Posticobia,Chironomidae Chironomus,Erpobdellidae Vivabdella,Physidae Physella,Chironomidae Cricotopus,Chironomidae Dicrotendipes,Dugesiidae Cura,Lumbriculidae Lumbriculus,Lymnaeidae Pseudosuccinea,Simuliidae Simulium,Chironomidae Eukiefferiella,Chironomidae Polypedilum,Chironomidae Rheocricotopus,Chironomidae Rheotanytarsus,Chironomidae Thienemanniella,Hydropsychidae Cheumatopsyche,Tateidae Potamopyrgus,Elmidae Simsonia,Hydroptilidae Hellyethira,Chironomidae Paratanytarsus

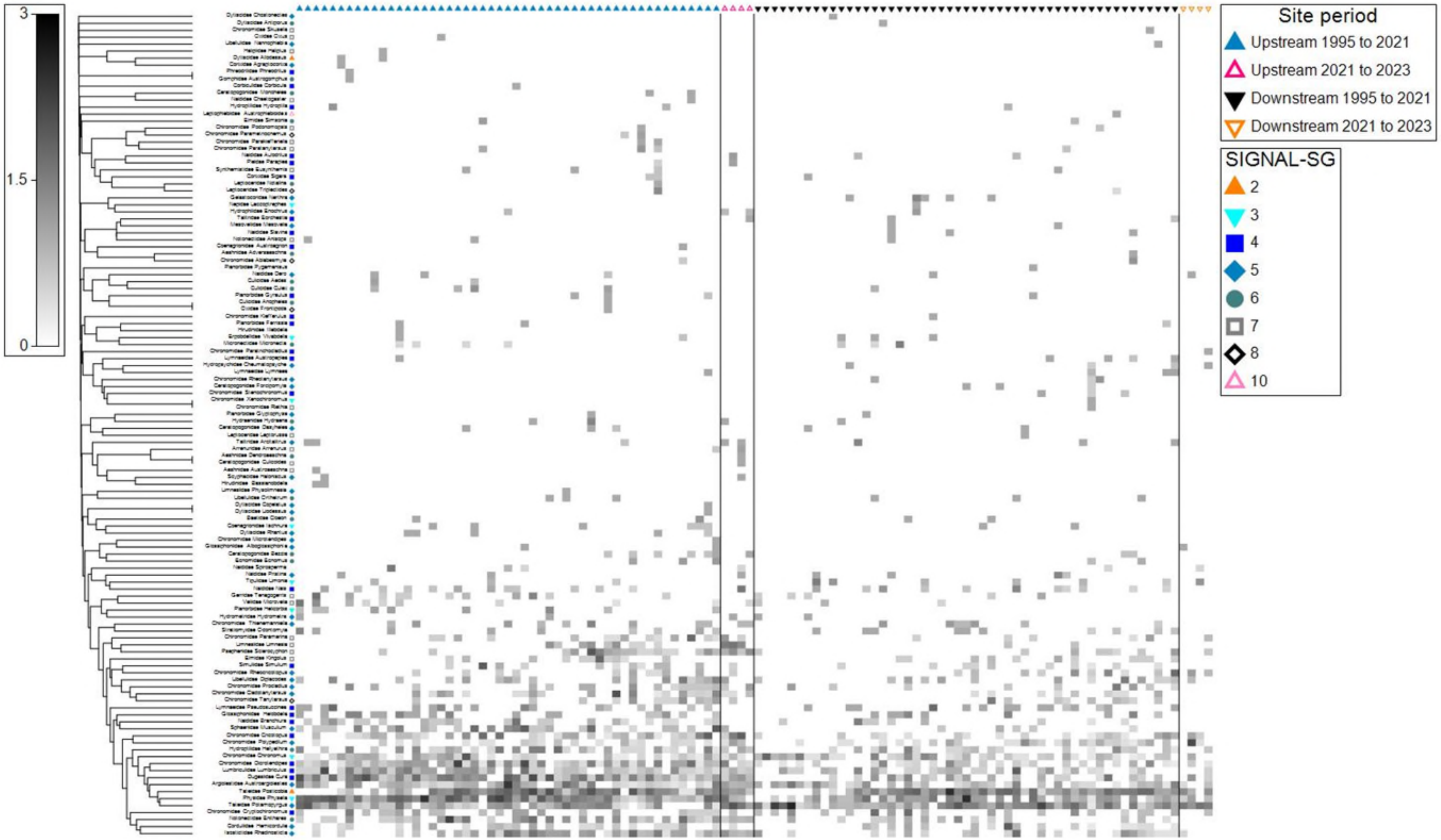


Figure A-37 Shade plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Cattai Creek near Castle Hill WRRF

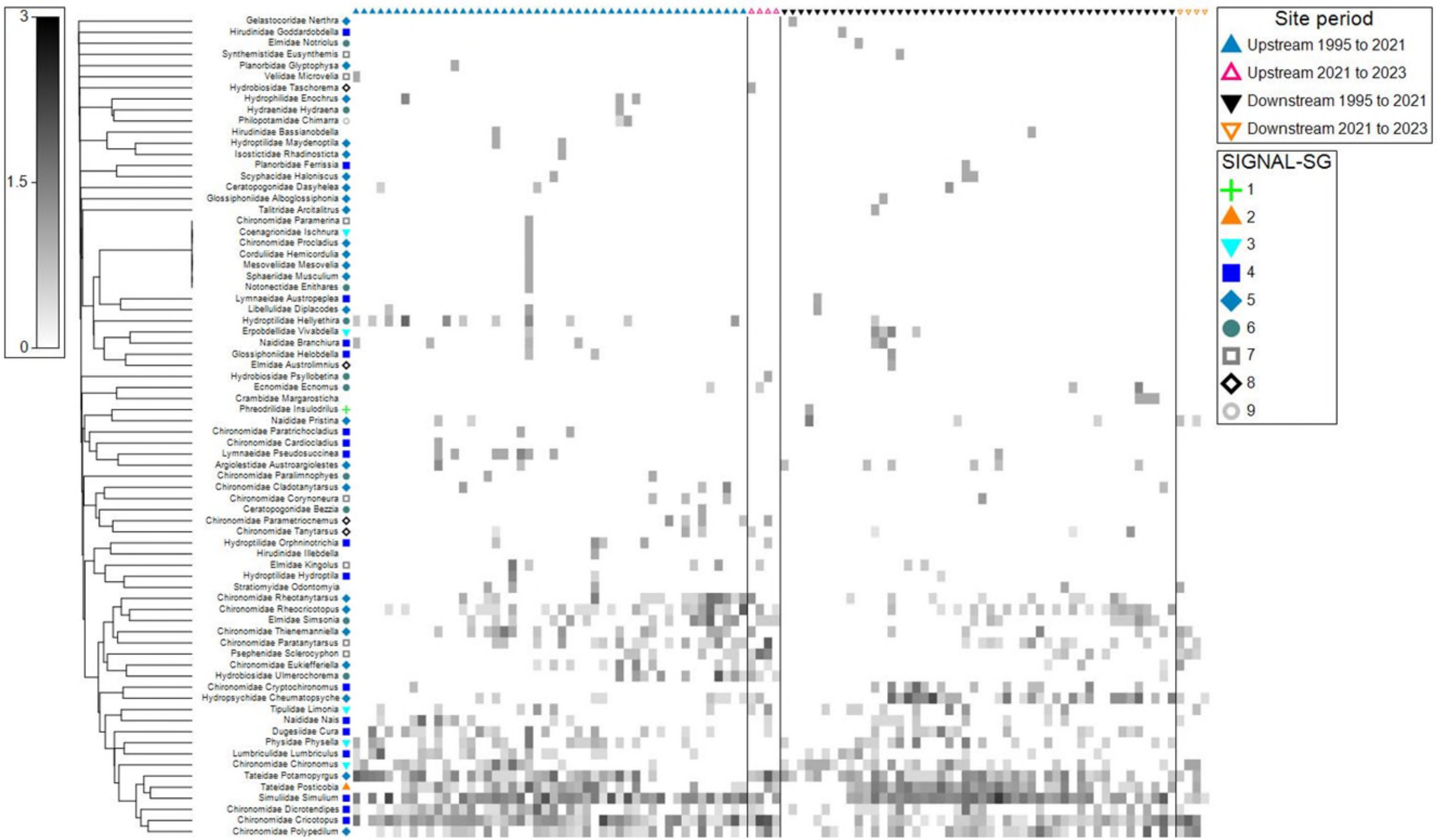
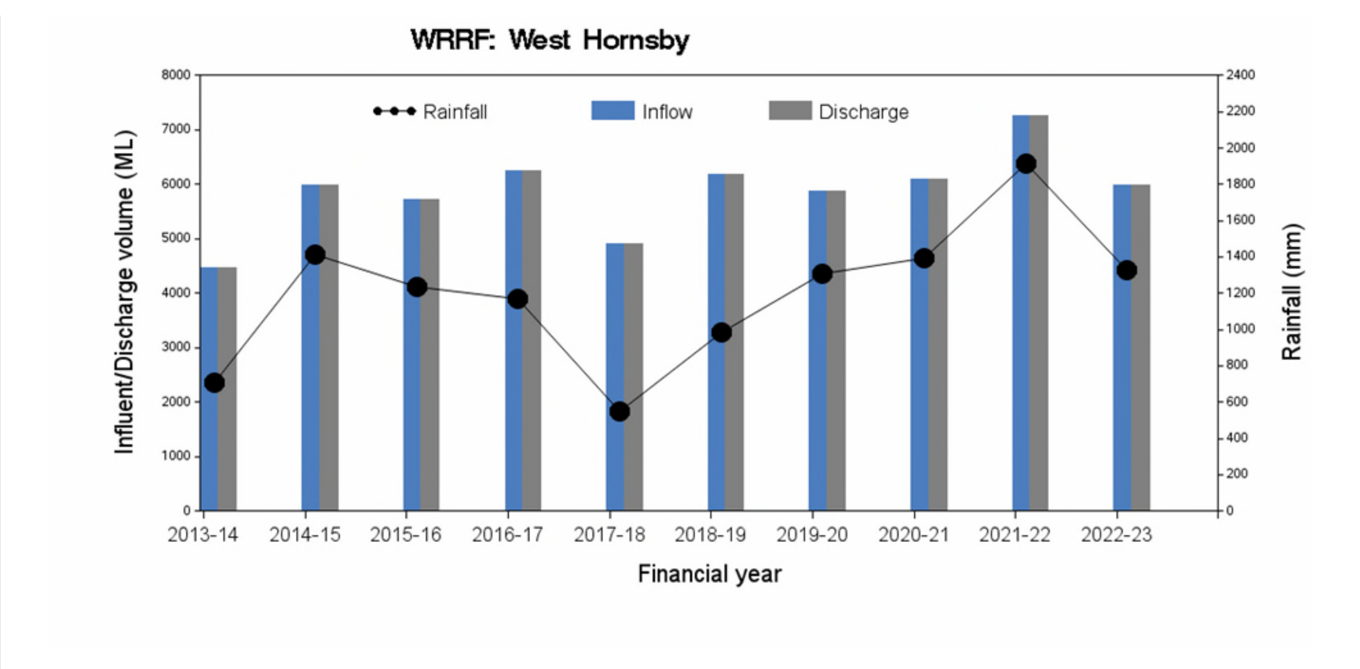


Figure A-38 Shade plot of freshwater macroinvertebrate riffle habitat community structure of upstream-downstream sites of Cattai Creek near Castle Hill WRRF

A-13 West Hornsby WRRF

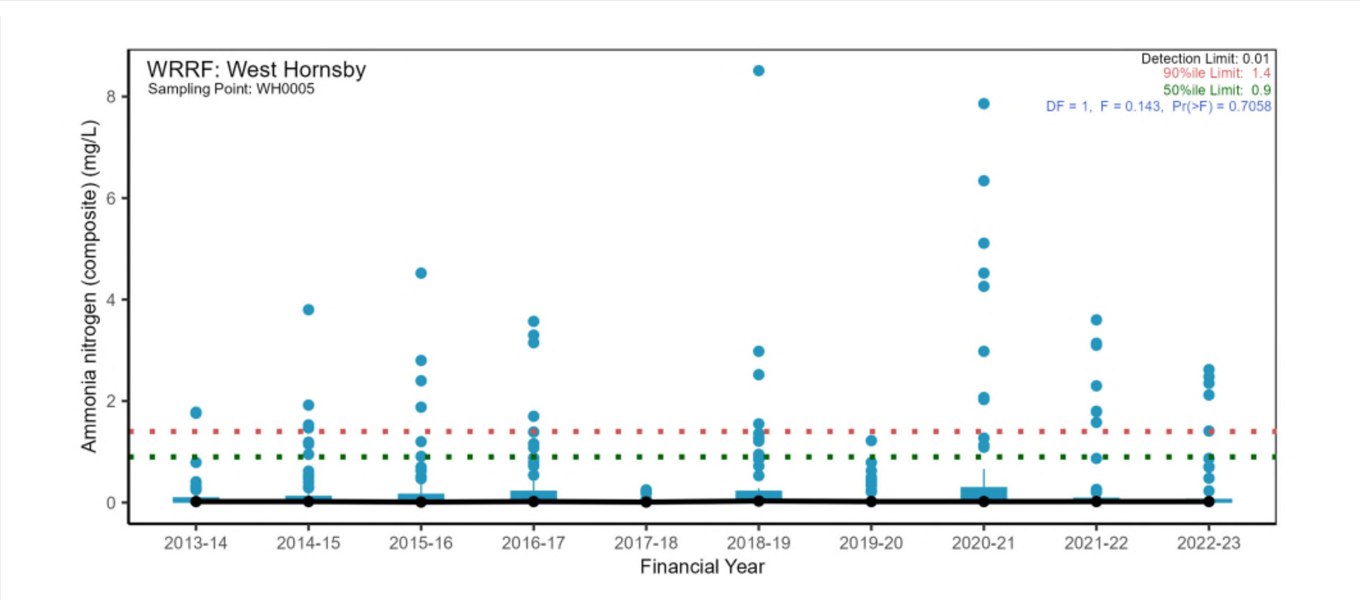
A-13.1 Pressure – Wastewater quantity

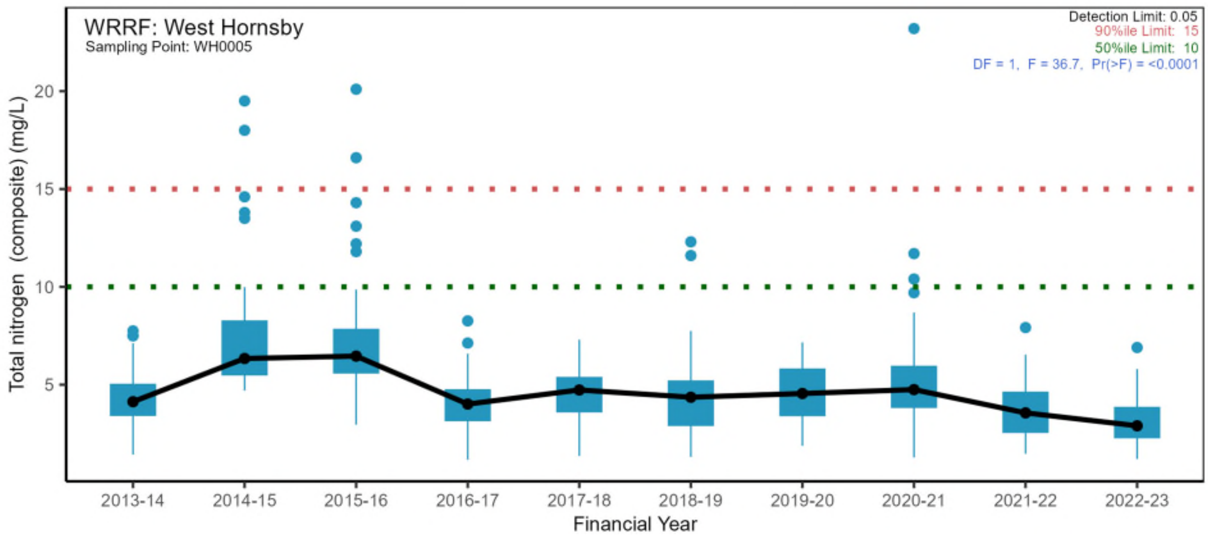
Inflow/ Discharge volume and rainfall

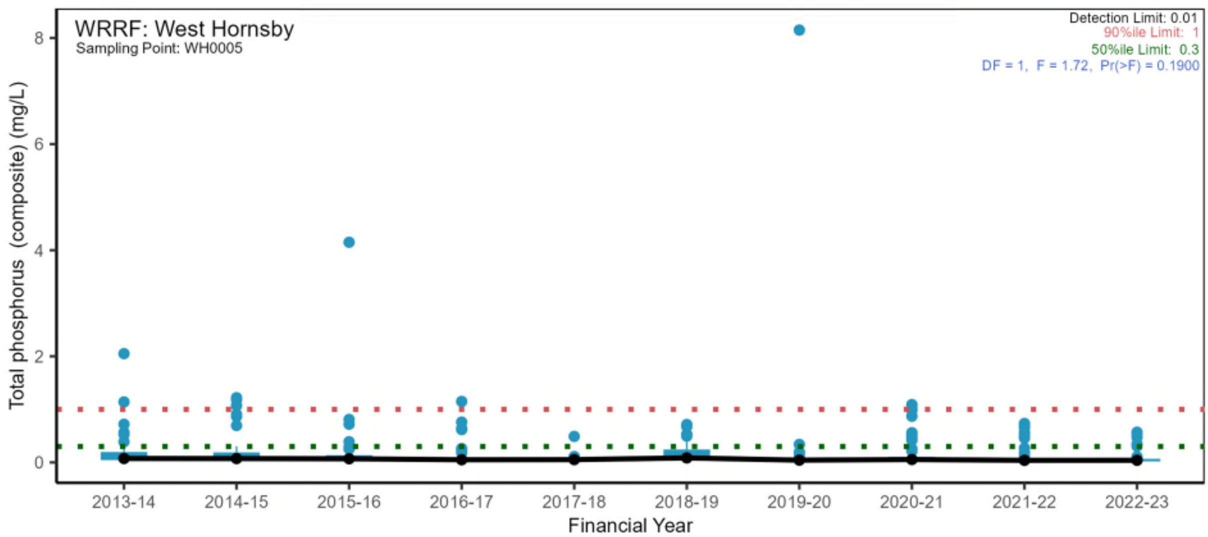


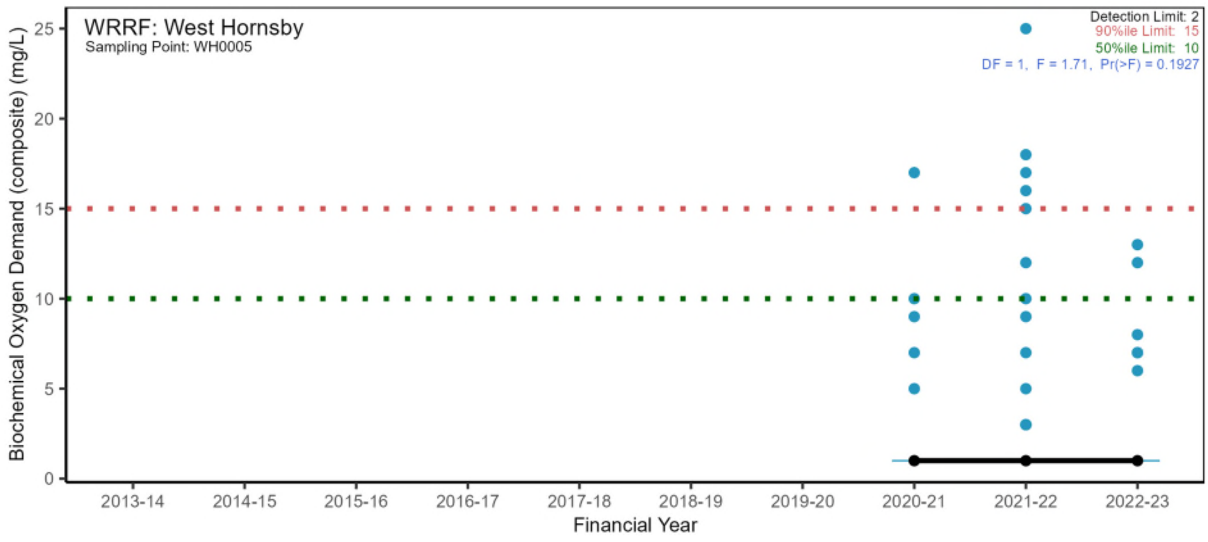
A-13.2 Pressure – Wastewater quality

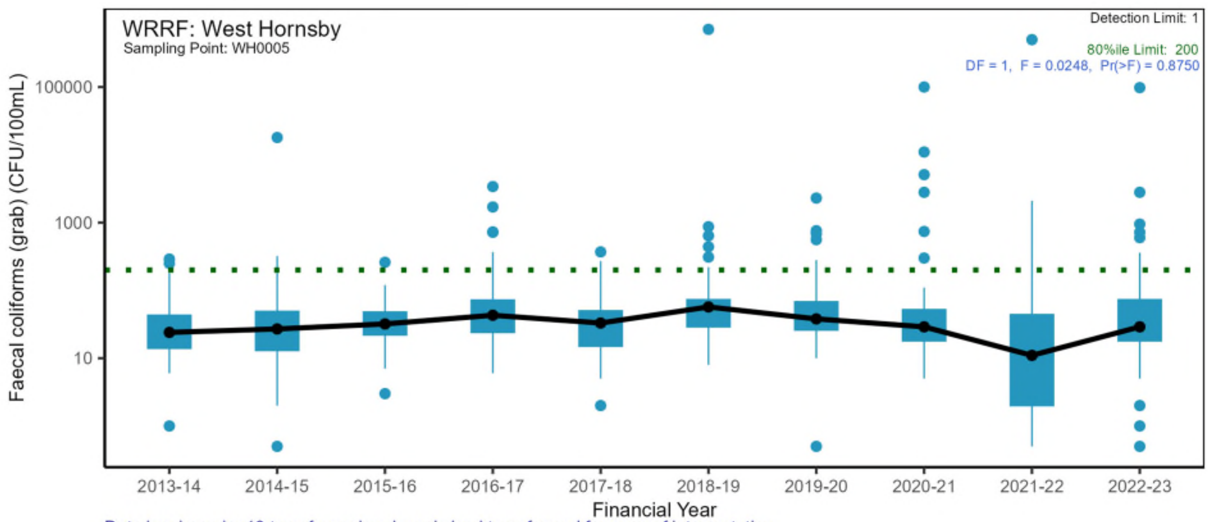
Nutrients



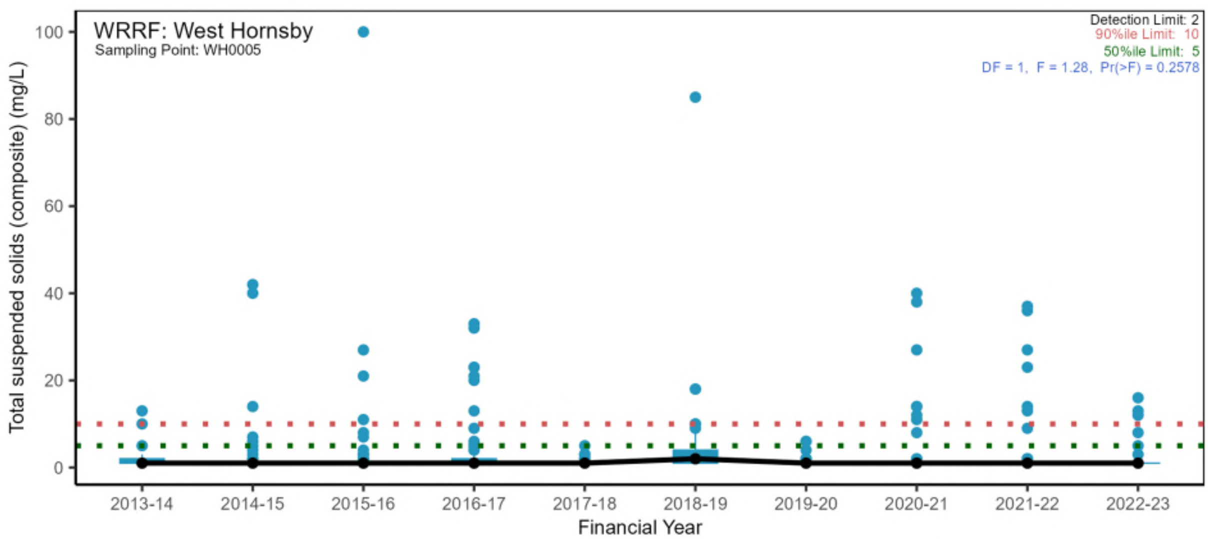

WRRF: West Hornsby
Sampling Point: WH0005
Detection Limit: 0.05
90%ile Limit: 15
50%ile Limit: 10
DF = 1, F = 36.7, Pr(>F) = <0.0001
Total nitrogen (composite) (mg/L)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year


WRRF: West Hornsby
Sampling Point: WH0005
Detection Limit: 0.01
90%ile Limit: 1
50%ile Limit: 0.3
DF = 1, F = 1.72, Pr(>F) = 0.1900
Total phosphorus (composite) (mg/L)
2013-14
2014-15
2015-16
2016-17
2017-18
2018-19
2019-20
2020-21
2021-22
2022-23
Financial Year

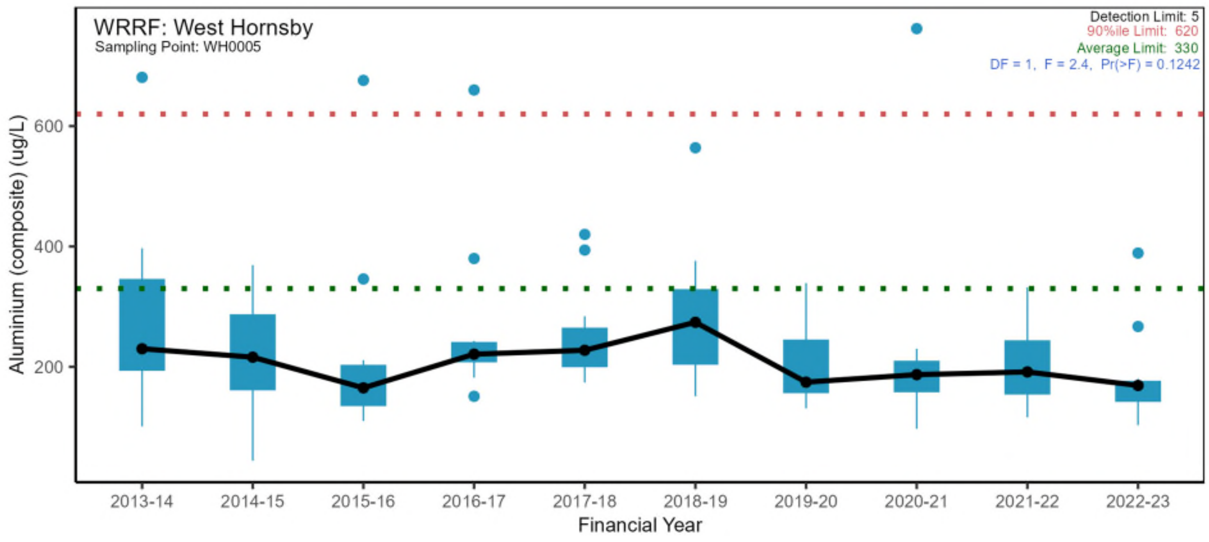


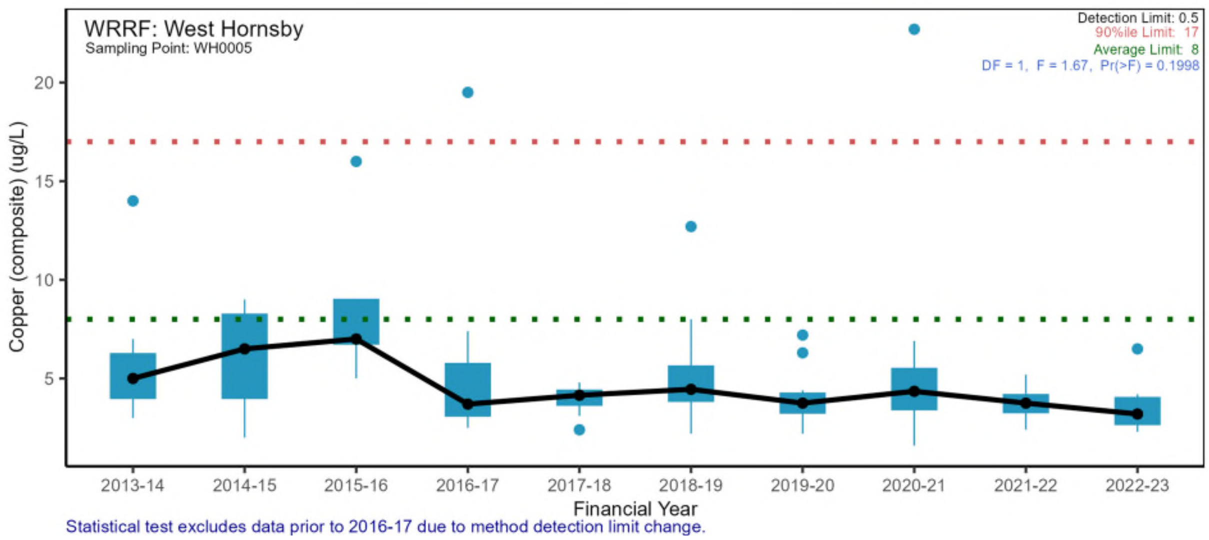


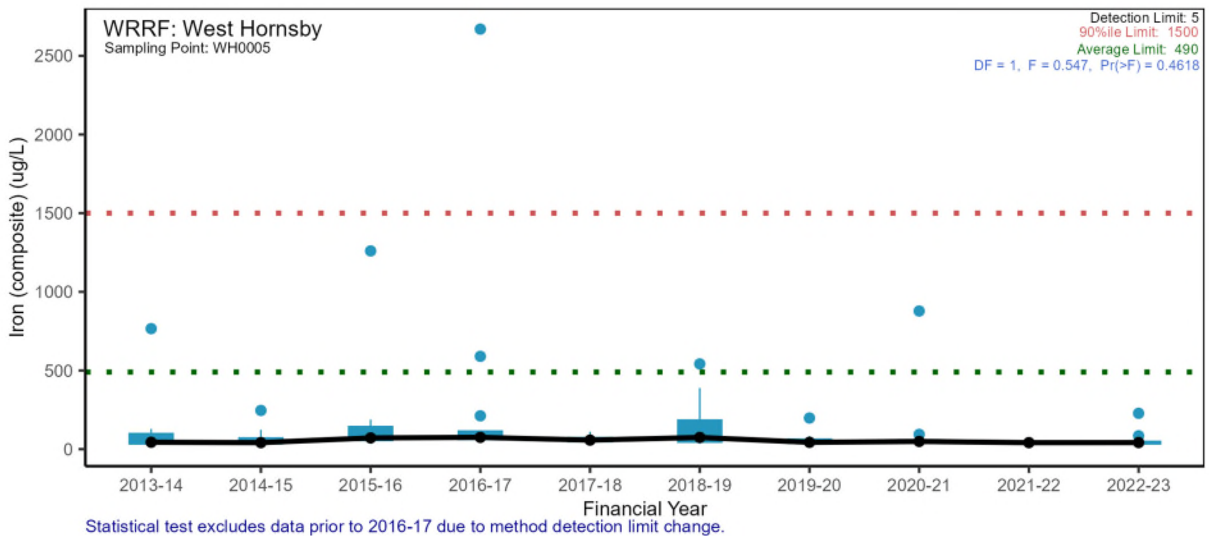
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

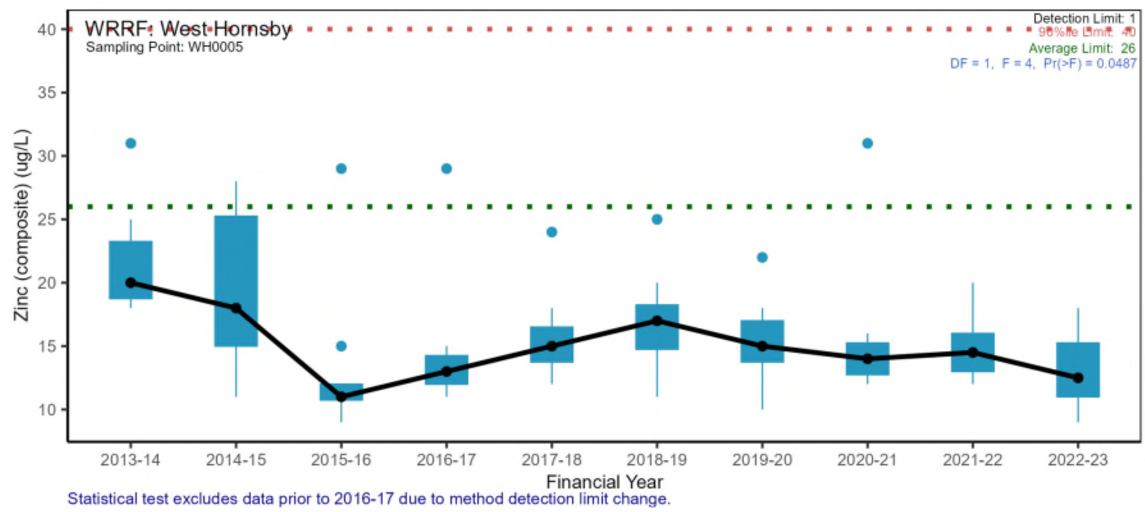


Trace metals

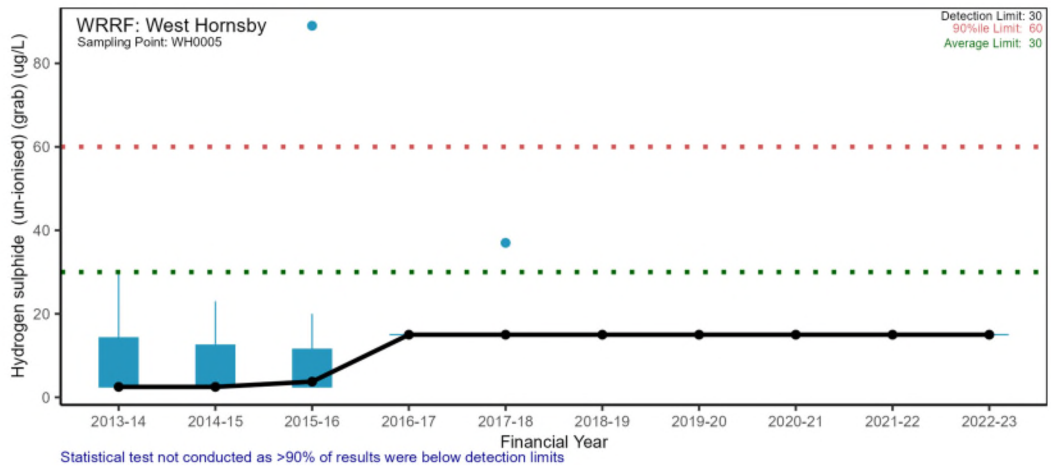




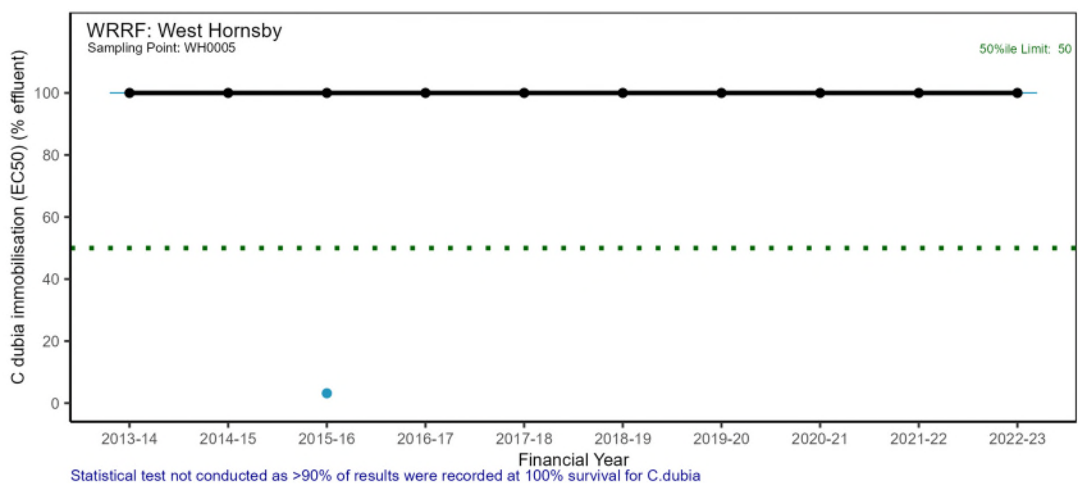




Other chemicals and organics (including pesticides)

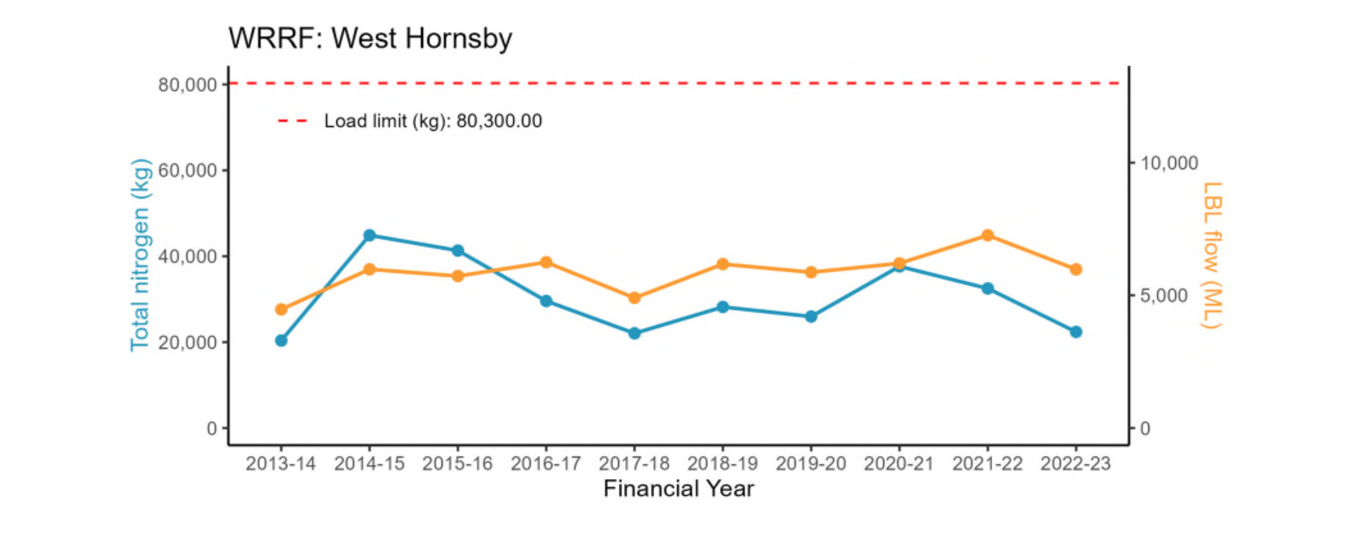


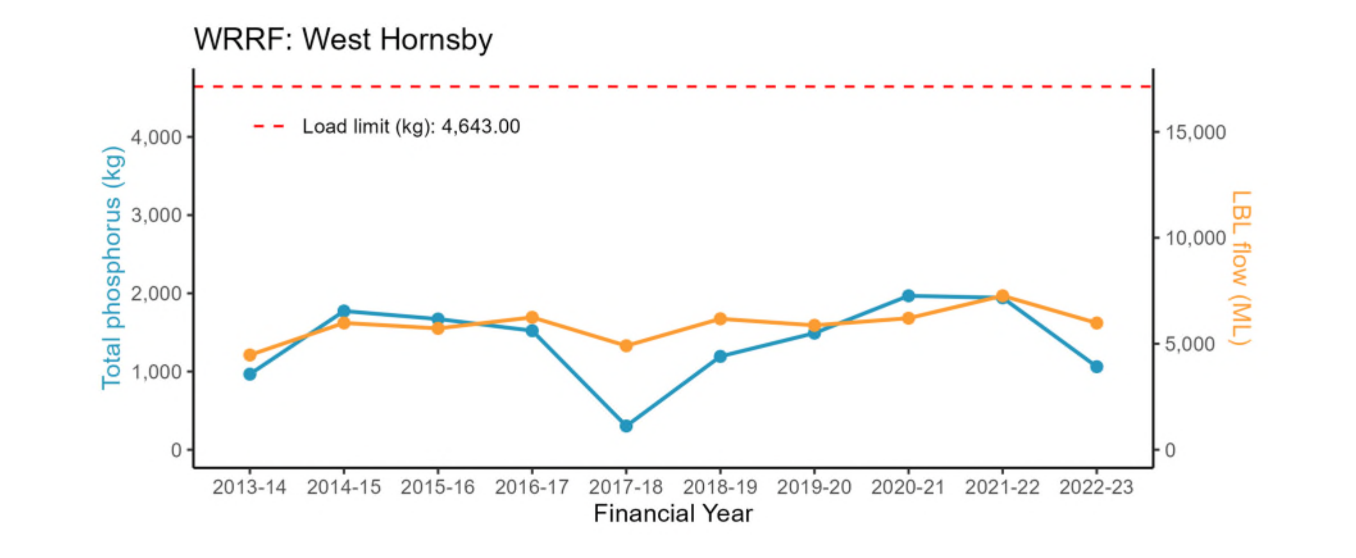
A-13.3 Pressure – Wastewater toxicity



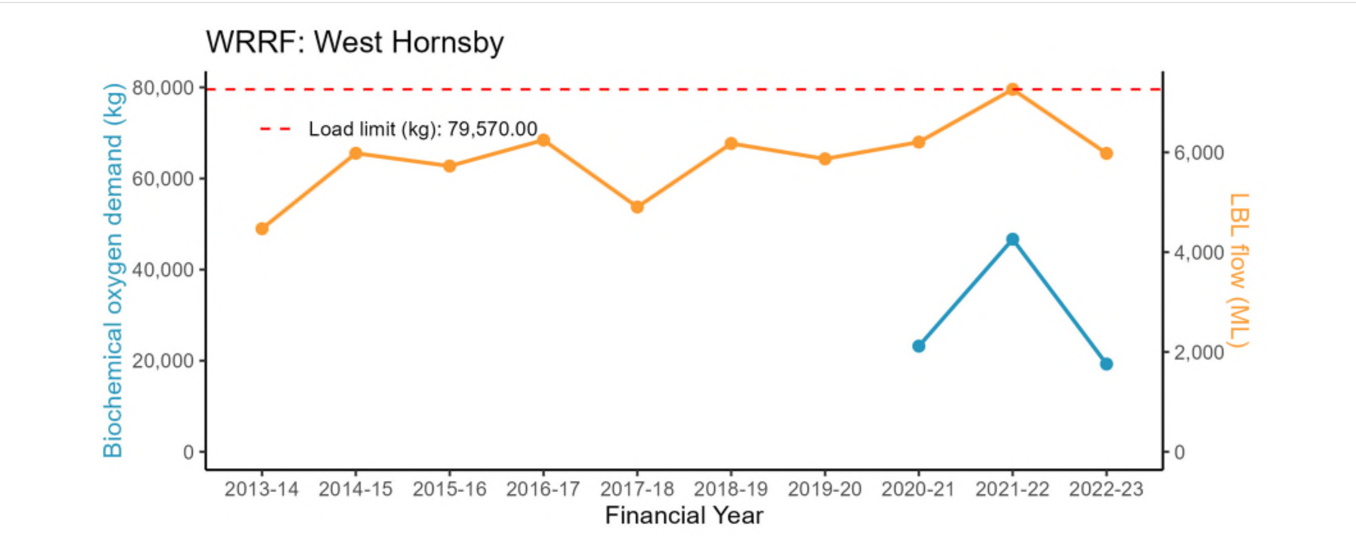
A-13.4 Pressure – Wastewater discharge load

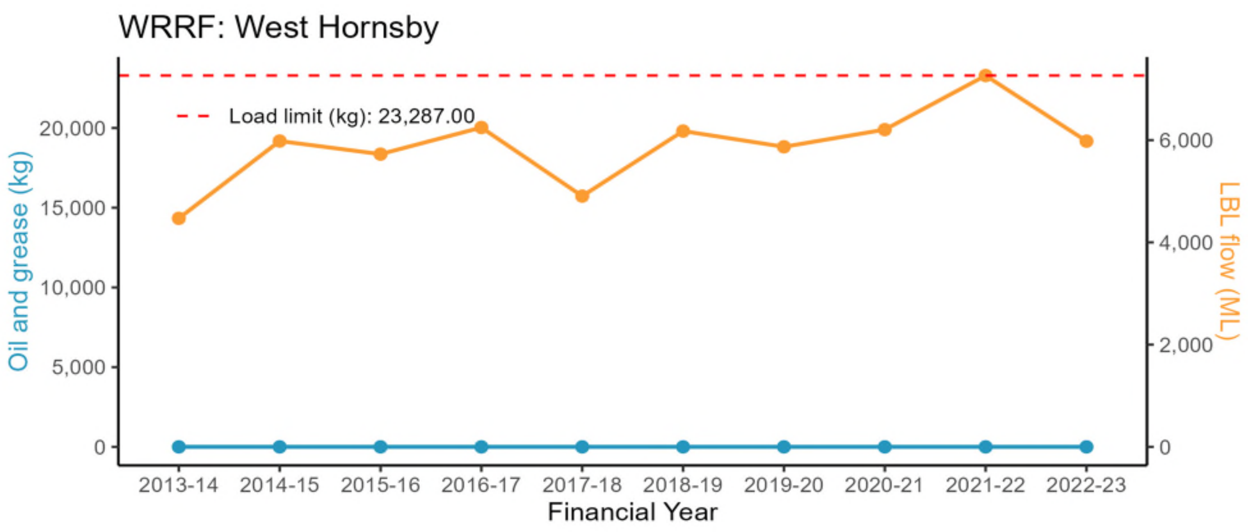
Nutrients

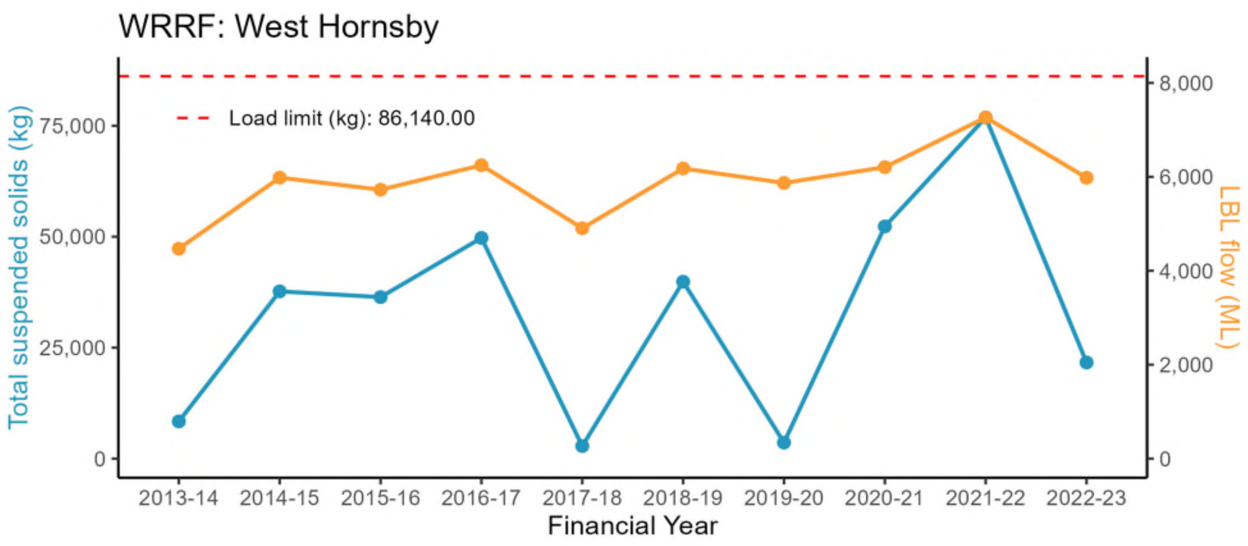




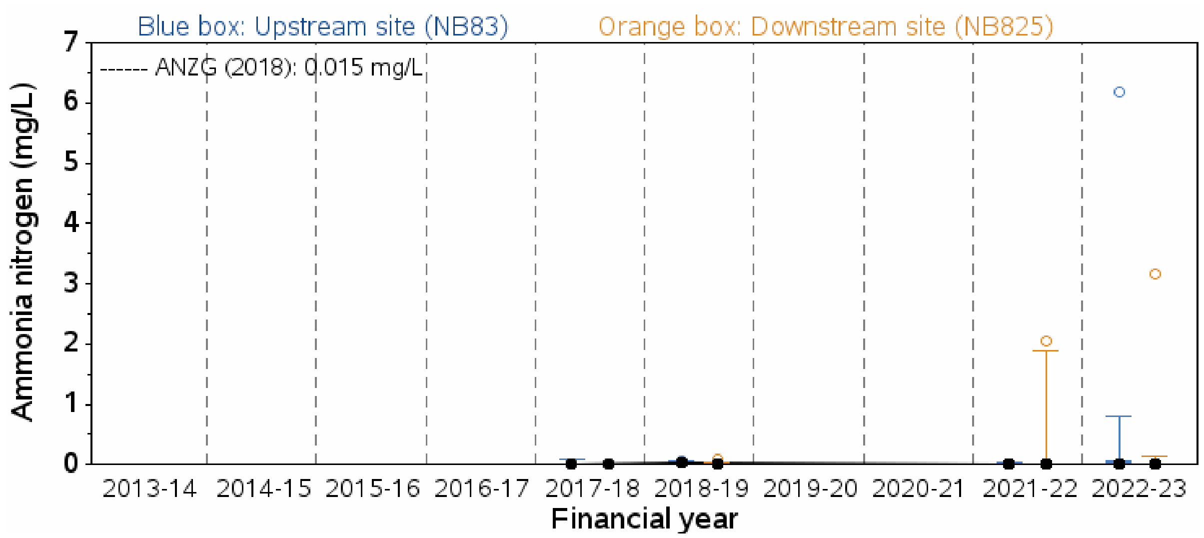
Major conventional analytes



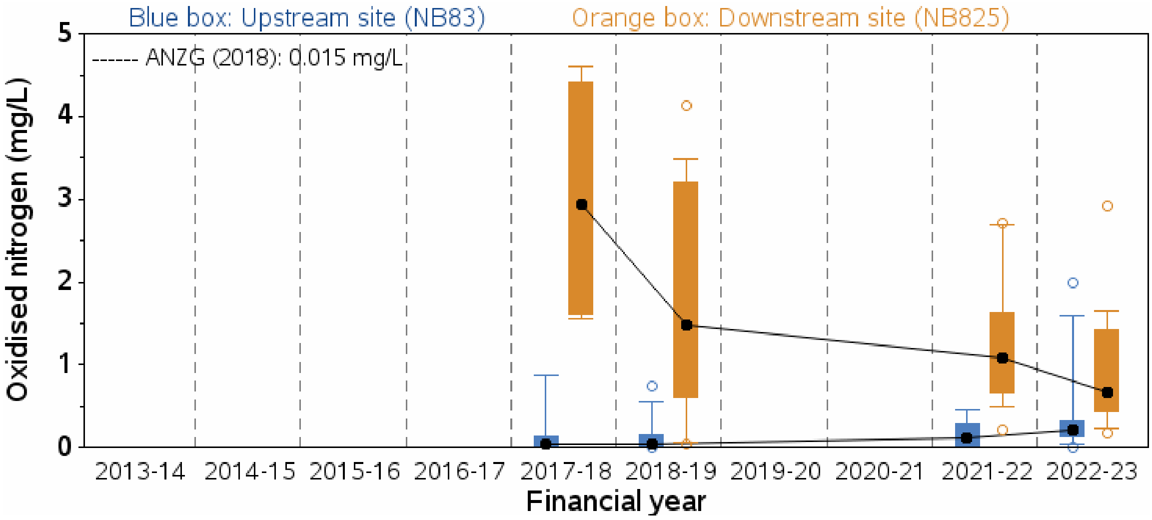




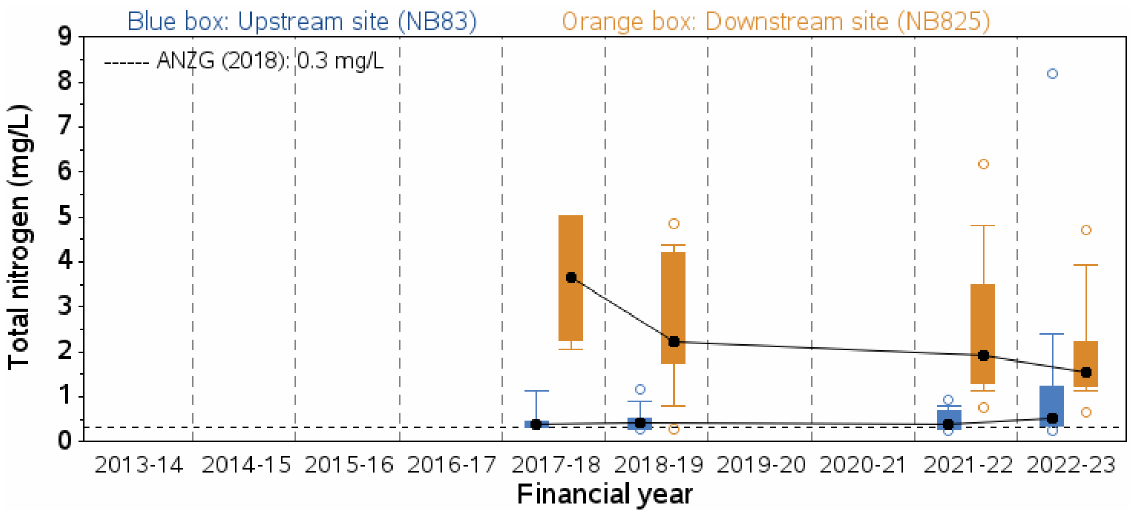
A-13.5 Stressor – Nutrients



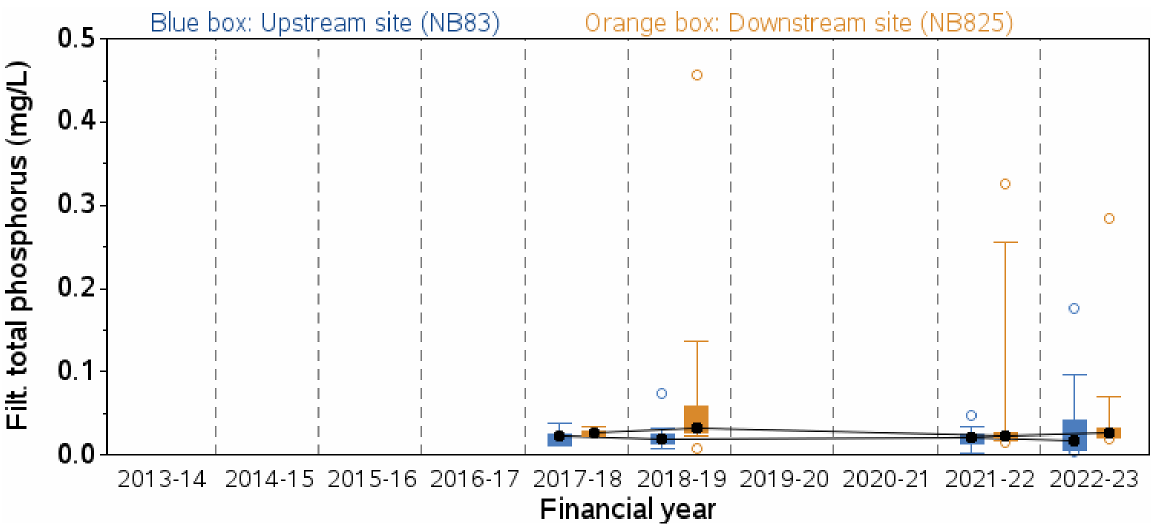
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	3.28	0.0753	NB825	1	0.29	0.5927



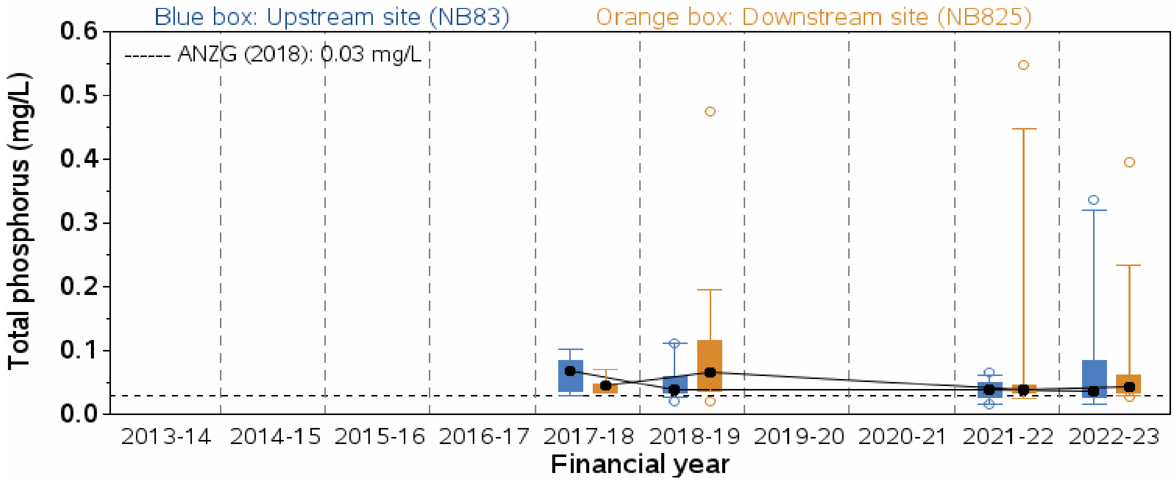
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	6.09	0.0167	NB825	1	6.44	0.014



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	5.32	0.0248	NB825	1	4.64	0.0355

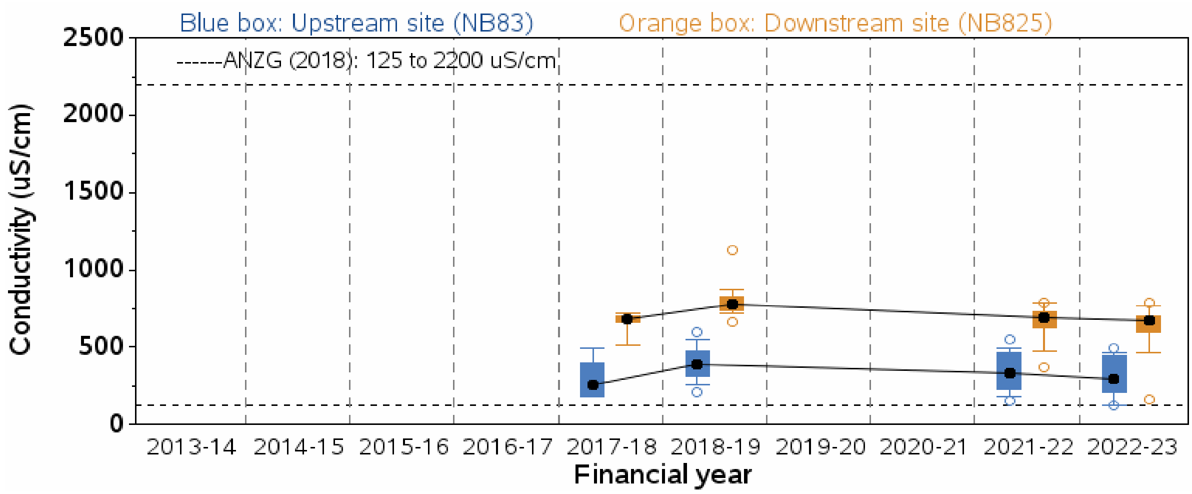


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	3.84	0.0549	NB825	1	0.24	0.6244

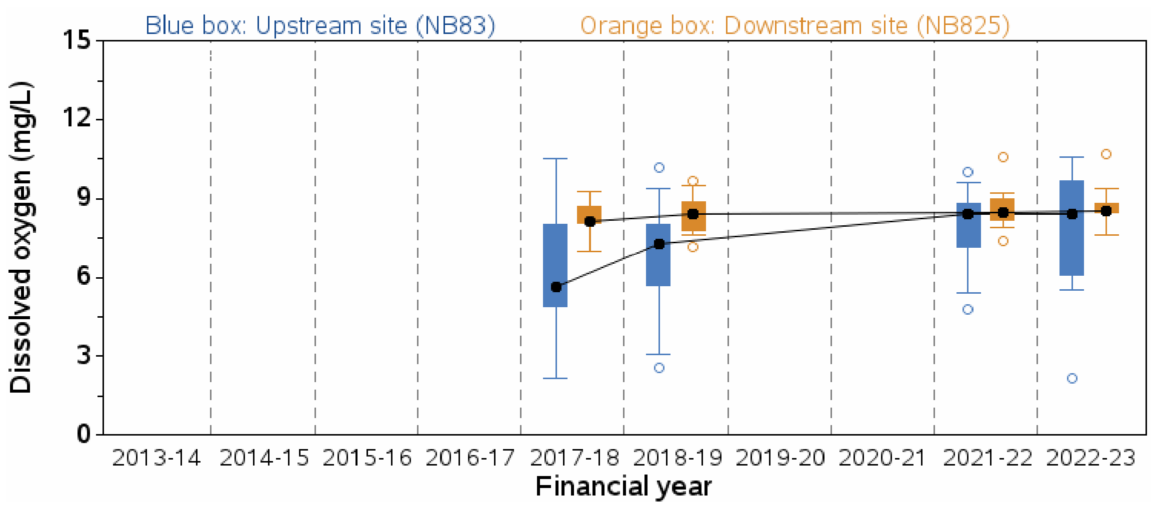


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	4.56	0.0371	NB825	1	0.18	0.6694

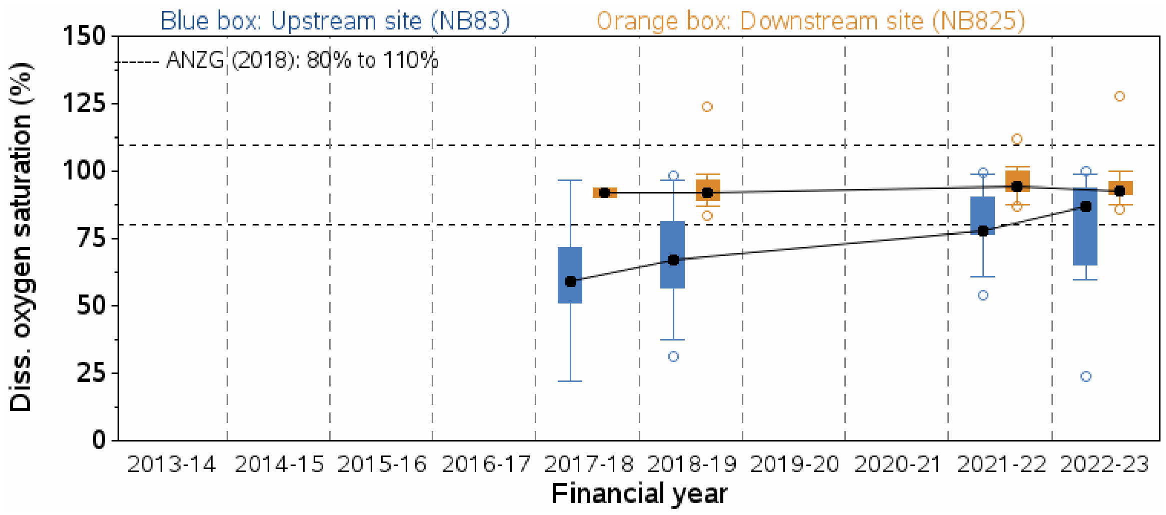
A-13.6 Stressor – Physico-chemical water quality



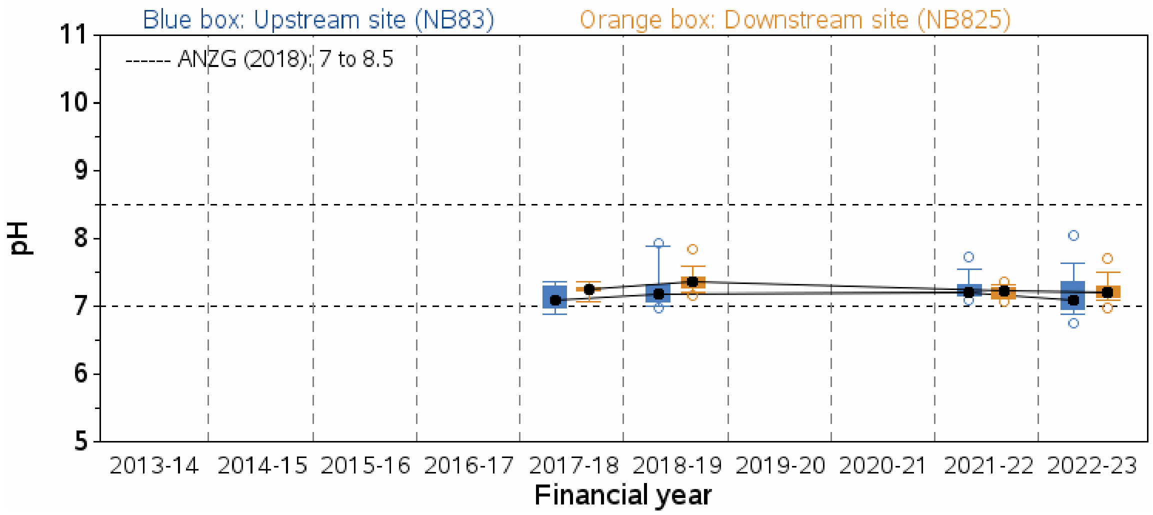
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	1.28	0.2626	NB825	1	5.38	0.024



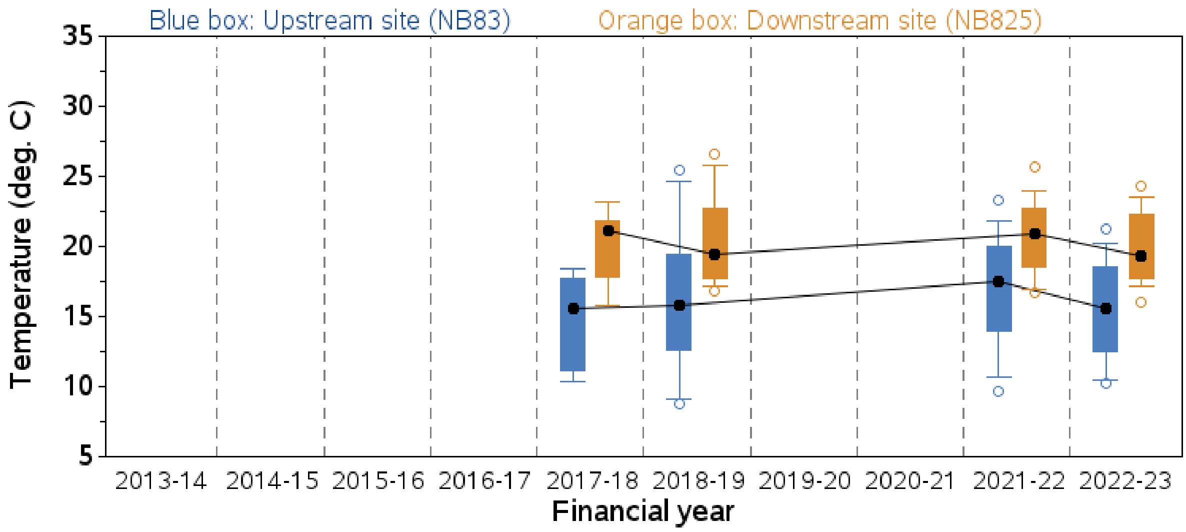
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	1.62	0.208	NB825	1	0.49	0.4859



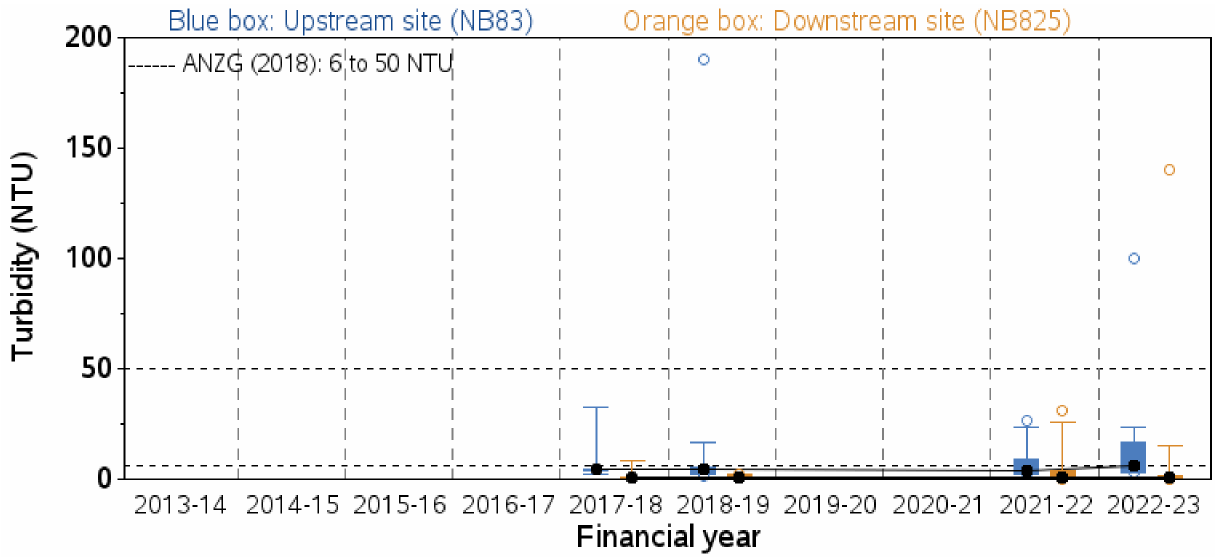
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	1.28	0.2628	NB825	1	0.05	0.8267



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	0.51	0.4766	NB825	1	1.62	0.2089

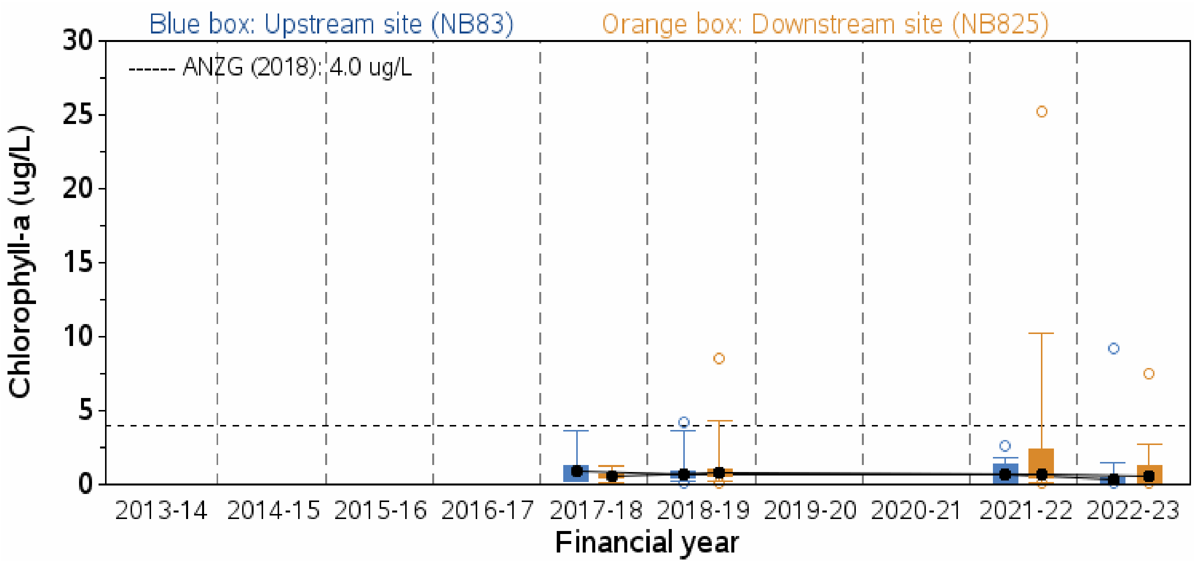


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	0.52	0.4727	NB825	1	0.7	0.4072



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	0.12	0.7331	NB825	1	1.66	0.2023

A-13.7 Ecosystem receptor – Phytoplankton



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB83	1	0.02	0.897	NB825	1	0.62	0.4326

Note: Insufficient data to draw a plot on total phytoplankton biovolume for NB83 and NB825

Note: Insufficient data to draw a plot on blue-green biovolume for NB83 and NB825

Note: Insufficient data to draw a plot on toxic blue-green count for NB83 and N825

A-13.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for Waitara Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1996 and 2022. This comparison suggests downstream stream health has not been maintained a t a level comparable to that of the upstream site suggesting wastewater discharge from West Hor nsby WRRF did have a measurable negative impact on stream health during 2022-23 (Figure A-39).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under a t-test returned a significant test outcome (Table A-53) and confirmed the visual trend of the SIGNAL-SG plots.

As a measurable negative impact on downstream stream health was evident, further data analysis was undertaken.

Table A-53 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Waitara Creek near West Hornsby WRRF

Waterway	Method	Statistic	DF	P value
Waitara Creek	Welch Two Sample t-test	4.56	10.0	0.001

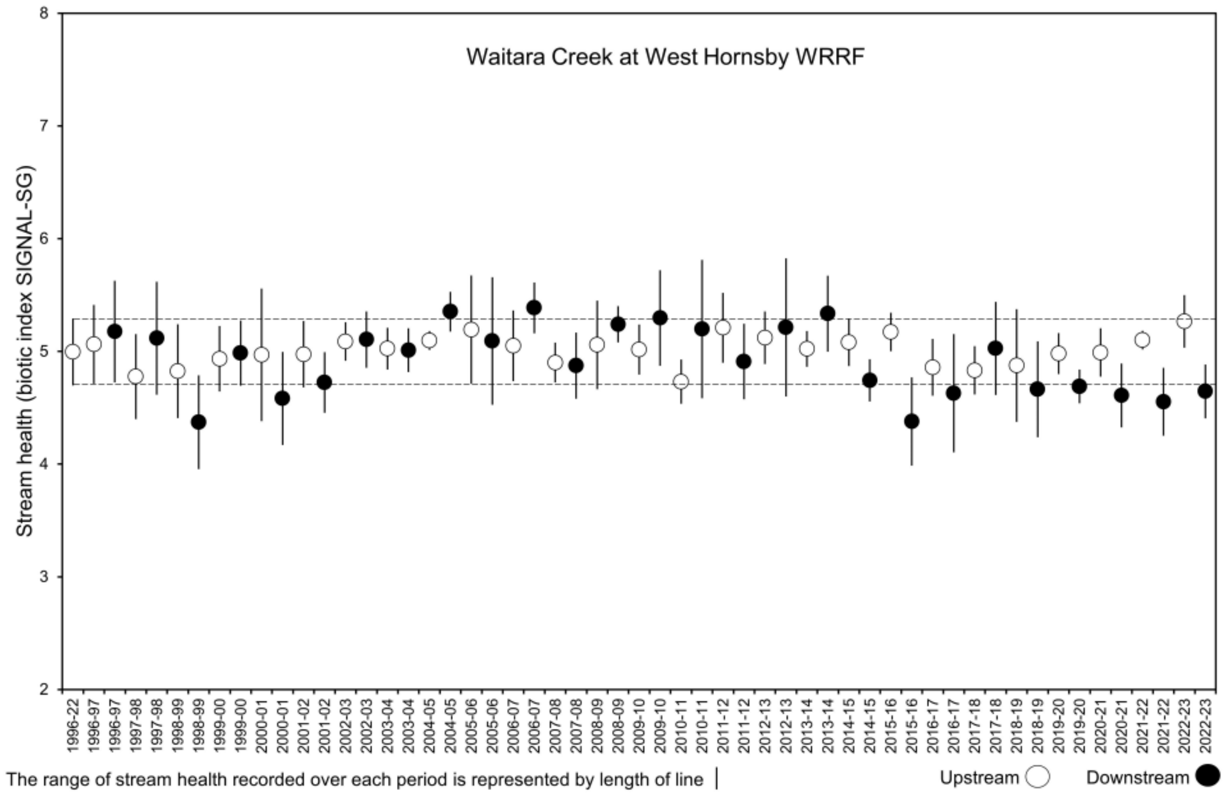


Figure A-39 Stream health of Waitara Creek near West Hornsby WRRF

Both edge and pool rock habitats were collected consistently enough at upstream-downstream sites on the same sampling occasions to allow a multivariate analysis for the monitoring period of 1996 to 2023.

Abutting groups of samples were evident in the 3-dimensional nMDS ordination plot of the Waitara Creek edge habitat (Figure A-40). The ordination pattern was confirmed in the corresponding tree diagram (Figure A-42) from classification analysis where the fifth division separated most of the upstream and downstream samples. The pool rock habitat displayed a slightly overlapping pattern, with more recent (2021-2023) downstream samples grouped with other more disparate downstream samples, and in close proximity to upstream samples from the same period (Figure A-41).

Shade plot patterns display a smaller set of taxa for the edge habitat at the downstream site (Figure A-44). The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 35 taxa identified for the edge habitat (Table A-62) out of 146 taxa, and 28 taxa for the pool rock habitat (Table A-63) out of 158 taxa. These subsets of taxa reflect those taxa which formed the main visual patterns in the respective shade plots.

The PERMDISP analysis indicated a significantly different pattern of dispersion (spacing between same samples) for the upstream and downstream sites of the edge and pool rock habitats (Table A-58 and Table A-59). This suggests the variability in taxonomic composition of samples collected over time was different for upstream and downstream sites through the period 1996 to 2023. This outcome suggests subsequent edge and pool rock habitat results of ANOSIM tests are describing both the variability in taxonomic composition of samples over time as well as community composition variability between the upstream and downstream sites. Inspection of ordination plots reflects variability in samples was evident in downstream samples for both habitats. This data dispersion pattern is also illustrated in Volume 1 for the Blackheath example (Volume 1 Figure 3-5) of a wastewater impact on macroinvertebrate community structure.

An ANOSIM test was run on the factor ‘Site’. The returned R-values were at a mid-range level for edge (0.475) (Table A-54) and at a low-range level for pool rocks (0.30) (Table A-55). These R-value results suggest site specific assemblages were more distinguishable for the edge habitat and less distinguishable for the pool rock habitat.

To further explore community structure, hypothesis testing was conducted with a PERMANOVA model. This model comprised the fixed factors ‘Site’ and ‘Year’ with ‘Year’ representing samples collected between 1996 and 2023 and ‘Site’ having 2 levels, upstream and downstream. A statistically significant ‘Site x Year’ interaction was returned for both edge and pool rock habitats (Table A-56 and Table A-57) suggesting a change through time.

A second run of ANOSIM based on ‘Site-Period’ sample groups displayed in the ordination plots returned a significant global mid-range R-value (0.475) for the edge habitat. In the resulting pairwise comparisons, 1 of the 6 tests returned significant R-values (Table A-60). A slightly lower mid-range global R-value of 0.323 was returned for the pool rock habitat with 2 of 6 tests returning significant R-values (Table A-61). For both habitats the pairwise test for the comparison of samples for the period of 2021 to 2023 downstream site to samples of the period 1996 to 2021 for the upstream site returned a high level R-values of 0.894 and 0.730 (Table A-60 and Table A-61). These test outcomes likely reflect disturbance by wastewater discharge as it is above or close to the 0.66 R-value determined by Besley and Chessman (2008) that represents natural habitat differences between sites on the same stream.

SIGNAL-SG and multivariate testing outcomes suggest downstream community structure in Waitara Creek was altered by wastewater discharge from West Hornsby WRRF in the most recent period.

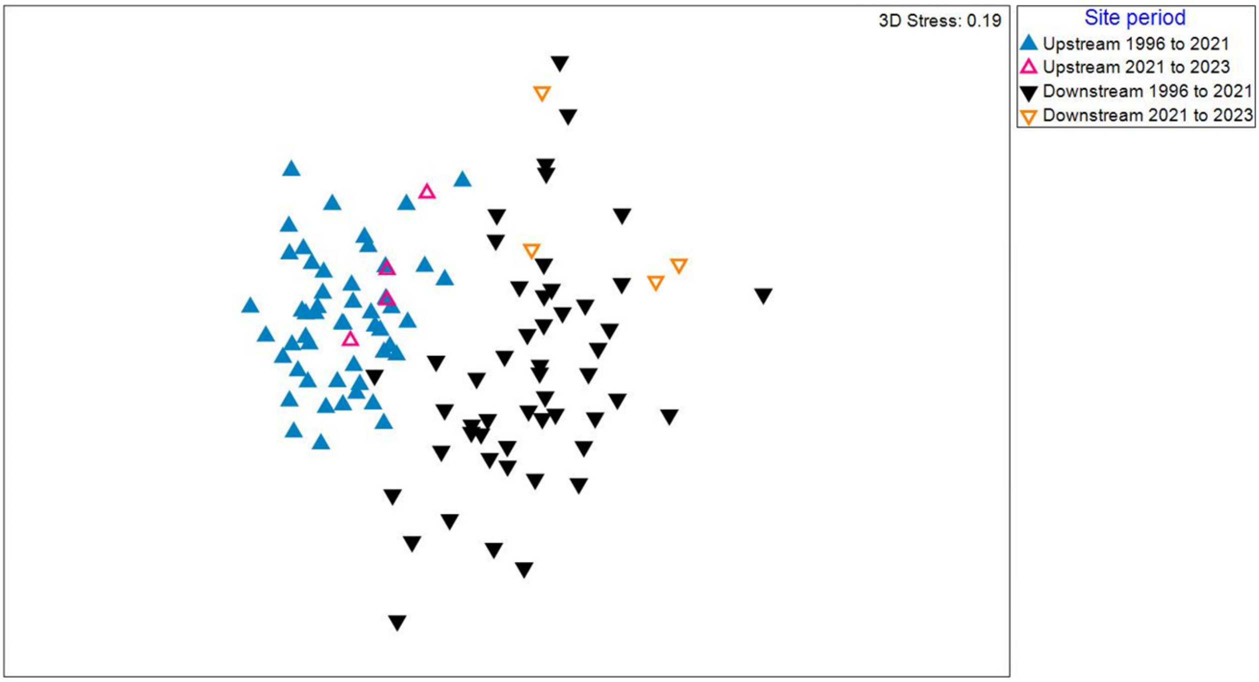


Figure A-40 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Waitara Creek near West Hornsby WRRF

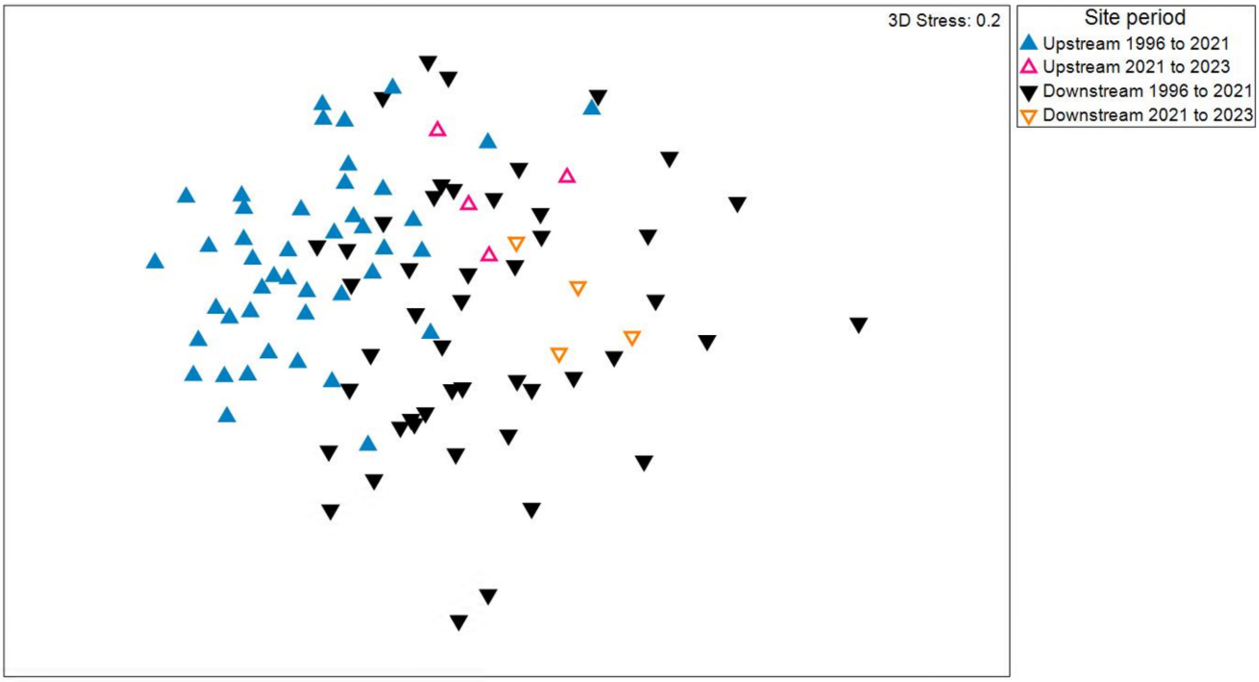


Figure A-41 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate pool rock habitat community structure of upstream-downstream sites of Waitara Creek near West Hornsby WRRF

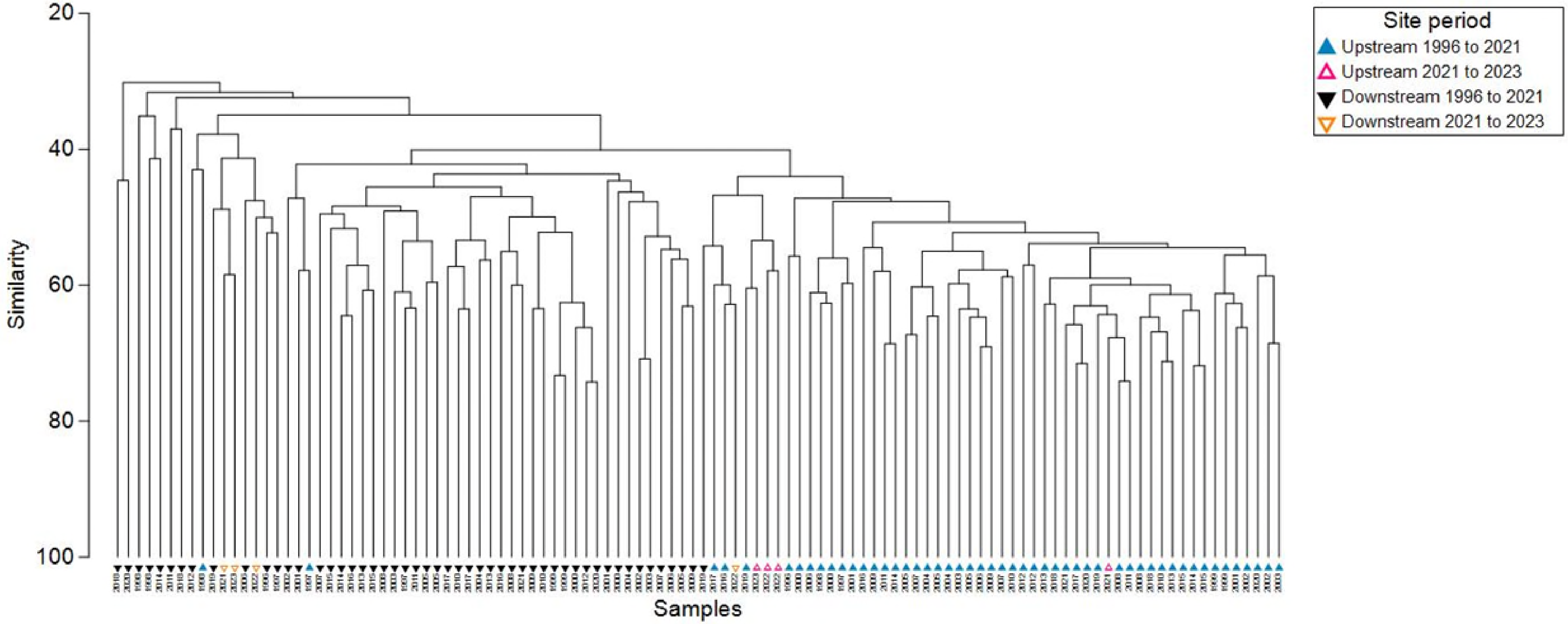


Figure A-42 Tree diagram of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Waitara Creek near West Hornsby WRRF

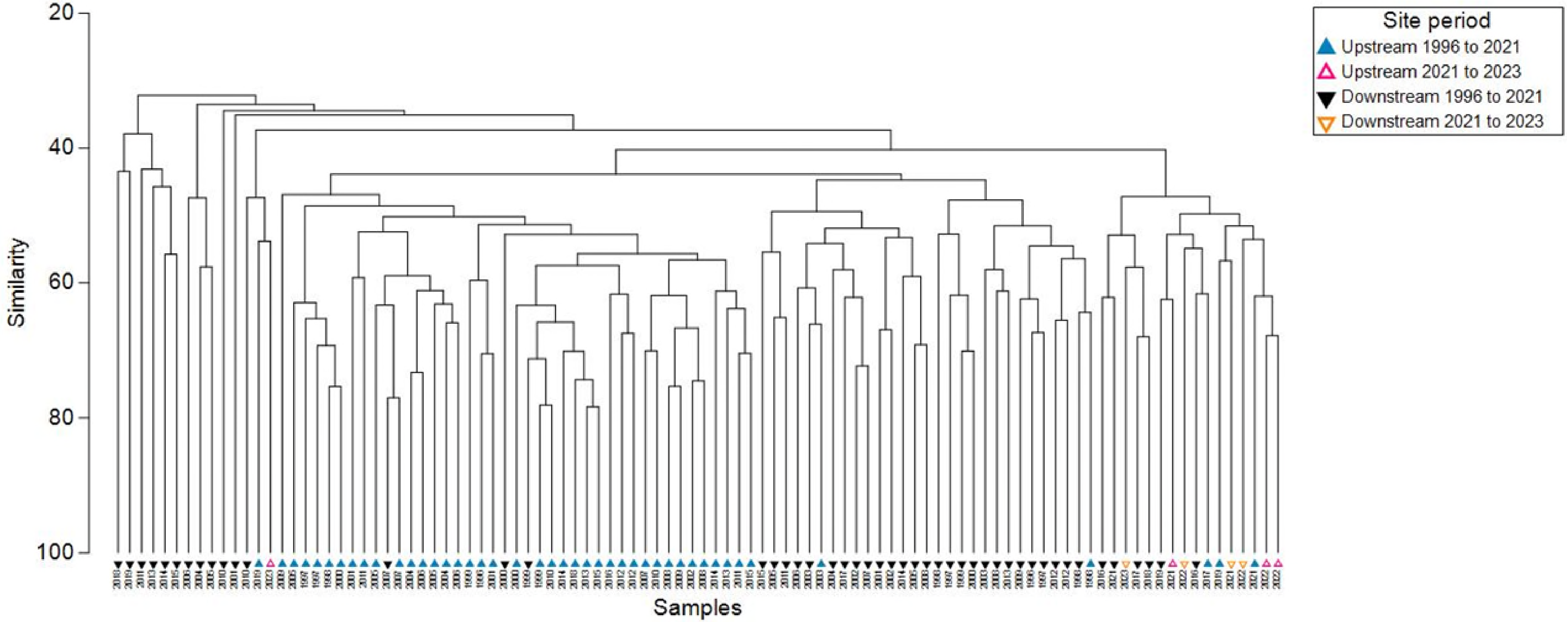


Figure A-43 Tree diagram of freshwater macroinvertebrate pool rock habitat community structure of upstream-downstream sites of Waitara Creek near West Hornsby WRRF

Table A-54 ANOSIM test of 'Site' factor for edge habitat of Waitara Creek near West Hornsby WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.475
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-55 ANOSIM test of 'Site' factor for pool rock habitat of Waitara Creek near West Hornsby WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.3
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-56 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of Waitara Creek near West Hornsby WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	28

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	25443	25443	21.329	0.0001	9922
Year	27	63702	2359.4	1.9779	0.0001	9640
SitexYear	27	36933	1367.9	1.1467	0.031	9628
Res	54	64415	1192.9			
Total	109	1.91E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	458.81	21.42
S(Year)	297.22	17.24
S(SitexYear)	89.183	9.4437
V(Res)	1192.9	34.538

Table A-57 PERMANOVA test of 'Site' and 'Year' factors for pool rock habitat of Waitara Creek near West Hornsby WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	27

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	15671	15671	13.337	0.0001	9927
Year	26	59512	2288.9	1.9481	0.0001	9703
SitexYear	26	35648	1371.1	1.1669	0.0388	9685
Res	46	54049	1175			
Total	99	1.69E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	314.84	17.744
S(Year)	307.53	17.537
S(SitexYear)	108.29	10.406
V(Res)	1175	34.278

Table A-58 PERMDISP test of ‘Site’ factor for edge habitat of Waitara Creek near West Hornsby WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 110

DEVIATIONS FROM CENTROID
F: 37.729 df1: 1 df2: 108
P(perm): 0.0001

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	55	41.631	0.88496
Upstream	55	34.597	0.72684

Table A-59 PERMDISP test of ‘Site’ factor for pool rock habitat of Waitara Creek near West Hornsby WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 100

DEVIATIONS FROM CENTROID
F: 18.706 df1: 1 df2: 98
P(perm): 0.0001

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	52	40.949	0.87042
Upstream	48	35.557	0.89159

Table A-60 ANOSIM test of ‘Site period’ factor for edge habitat of Waitara Creek near West Hornsby WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.475
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1996 to 2021, Upstream 1996 to 2021	0.486	0.01	Very large	9999	0
Downstream 1996 to 2021, Downstream 2021 to 2023	0.177	12.2	341055	9999	1216
Downstream 1996 to 2021, Upstream 2021 to 2023	0.287	4	341055	9999	394
Upstream 1996 to 2021, Downstream 2021 to 2023	0.894	0.01	341055	9999	0
Upstream 1996 to 2021, Upstream 2021 to 2023	0.331	1.6	341055	9999	157
Downstream 2021 to 2023, Upstream 2021 to 2023	0.781	2.9	35	35	1

Table A-61 ANOSIM test of ‘Site period’ factor for pool rock habitat of Waitara Creek near West Hornsby WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.323
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1996 to 2021, Upstream 1996 to 2021	0.322	0.01	Very large	9999	0
Downstream 1996 to 2021, Downstream 2021 to 2023	0.156	13.3	270725	9999	1325
Downstream 1996 to 2021, Upstream 2021 to 2023	0.099	23.2	270725	9999	2320
Upstream 1996 to 2021, Downstream 2021 to 2023	0.73	0.01	194580	9999	0
Upstream 1996 to 2021, Upstream 2021 to 2023	0.399	0.4	194580	9999	42
Downstream 2021 to 2023, Upstream 2021 to 2023	0.458	2.9	35	35	1

Table A-62 Genera subset whose multivariate pattern matches full genera set of the edge habitat of Waitara Creek near West Hornsby WRRF

Subset of 35 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 146 genera identified with the same subset found on 6 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Tateidae Posticobia,Chironomidae Chironomus,Erpobdellidae Vivabdella,Physidae Physella,Planorbidae Helicorbis,Chironomidae Cricotopus,Chironomidae Dicrotendipes,Dugesiidae Cura,Glossiphoniidae Helobdella,Lumbriculidae Lumbriculus,Lymnaeidae Austropeplea,Argiolestidae Austroargiolestes,Chironomidae Polypedilum,Chironomidae Procladius,Chironomidae Rheocricotopus,Chironomidae Rheotanytarsus,Corduliidae Hemicordulia,Hydrophilidae Enochrus,Isostictidae Rhadinosticta,Libellulidae Nannophlebia,Sphaeriidae Musculium,Tateidae Potamopyrgus,Ceratopogonidae Bezzia,Elmidae Simsonia,Gomphidae Austrogomphus,Hydroptilidae Hellyethira,Notonectidae Enithares,Chironomidae Paramerina,Elmidae Kingolus,Limnesiidae Limnesia,Notonectidae Anisops,Psephenidae Sclerocyphon,Veliidae Microvelia,Planorbidae Pygamanisus,Stratiomyidae Odontomyia

Table A-63 Genera subset whose multivariate pattern matches full genera set of the pool rock habitat of Waitara Creek near West Hornsby WRRF

Subset of 28 (correlation 0.952) genera from edge habitat whose pattern matches that of the full set of 158 genera identified with the same subset found on 34 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Tateidae Posticobia,Erpobdellidae Vivabdella,Physidae Physella,Planorbidae Helicorbis,Chironomidae Cricotopus,Chironomidae Cryptochironomus,Chironomidae Dicrotendipes,Dugesiidae Cura,Glossiphoniidae Helobdella,Lumbriculidae Lumbriculus,Naididae Nais,Planorbidae Gyraulus,Argiolestidae Austroargiolestes,Chironomidae Cladotanytarsus,Chironomidae Polypedilum,Chironomidae Procladius,Chironomidae Rheocricotopus,Glossiphoniidae Alboglossiphonia,Hydropsychidae Cheumatopsyche,Sphaeriidae Musculium,Tateidae Potamopyrgus,Ecnomidae Ecnomus,Elmidae Notriolus,Elmidae Simsonia,Hydroptilidae Hellyethira,Corydalidae Archichauliodes,Elmidae Kingolus,Psephenidae Sclerocyphon

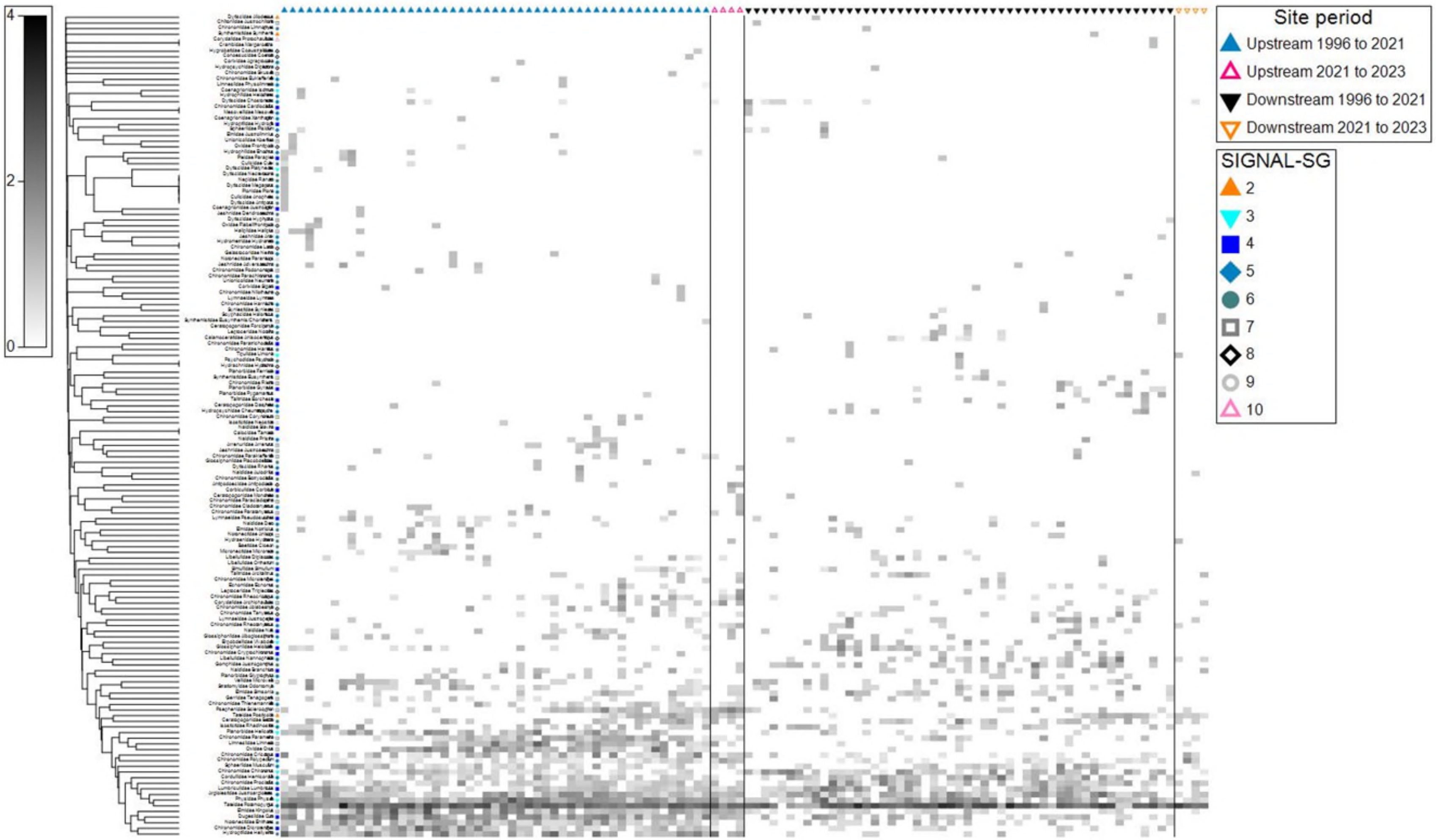


Figure A-44 Shade plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Waitara Creek near West Hornsby WRRF

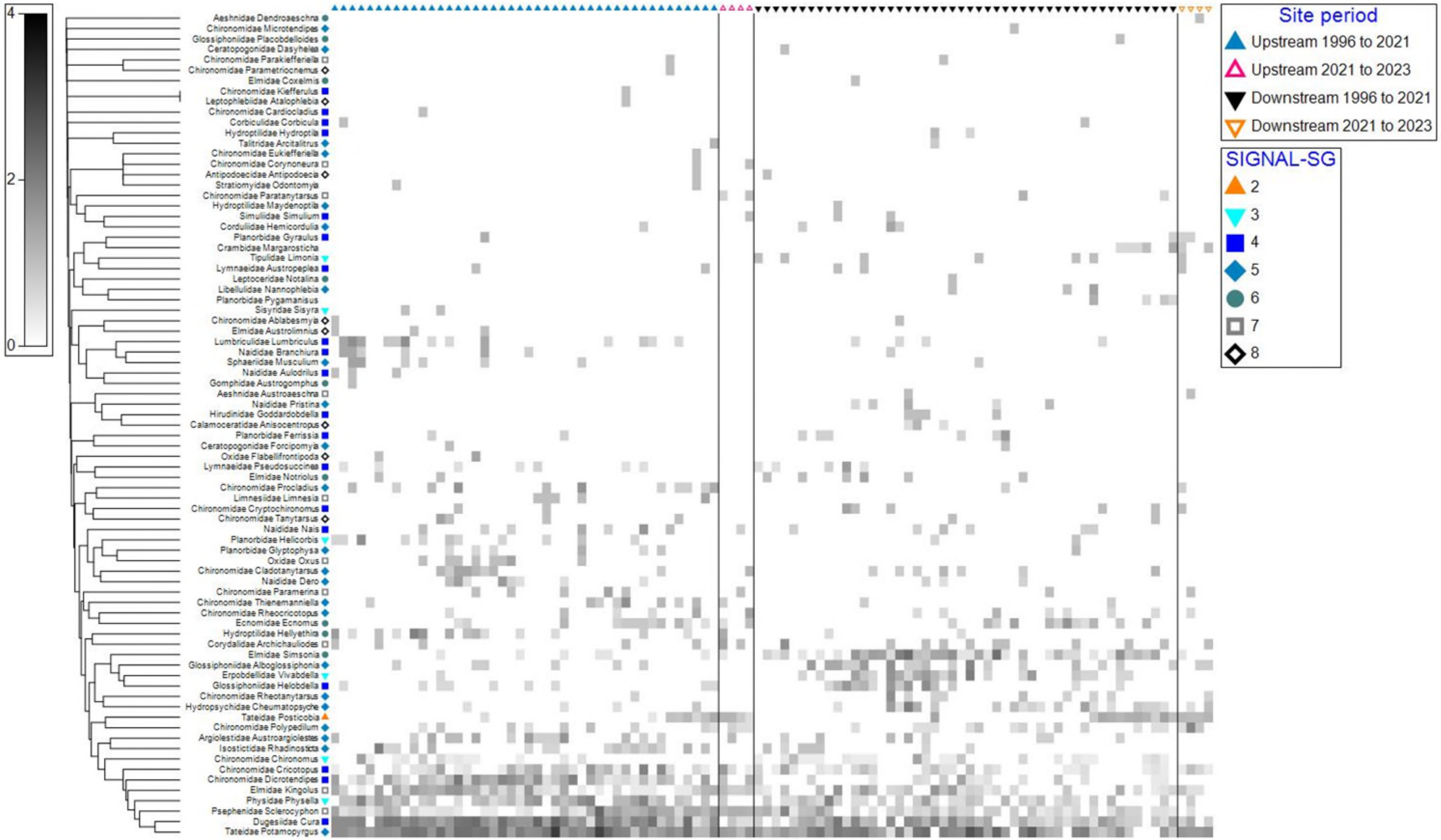
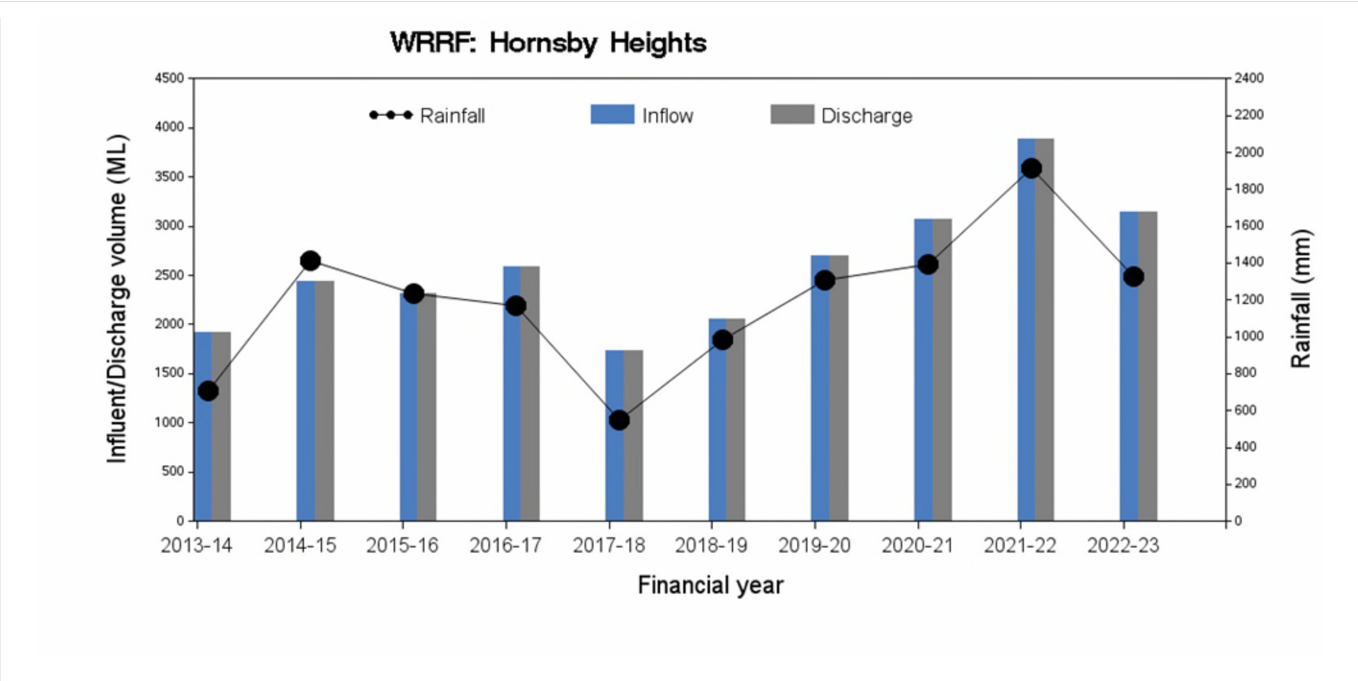


Figure A-45 Shade plot of freshwater macroinvertebrate pool rock habitat community structure of upstream-downstream sites of Waitara Creek near West Hornsby WRRF

A-14 Hornsby Heights WRRF

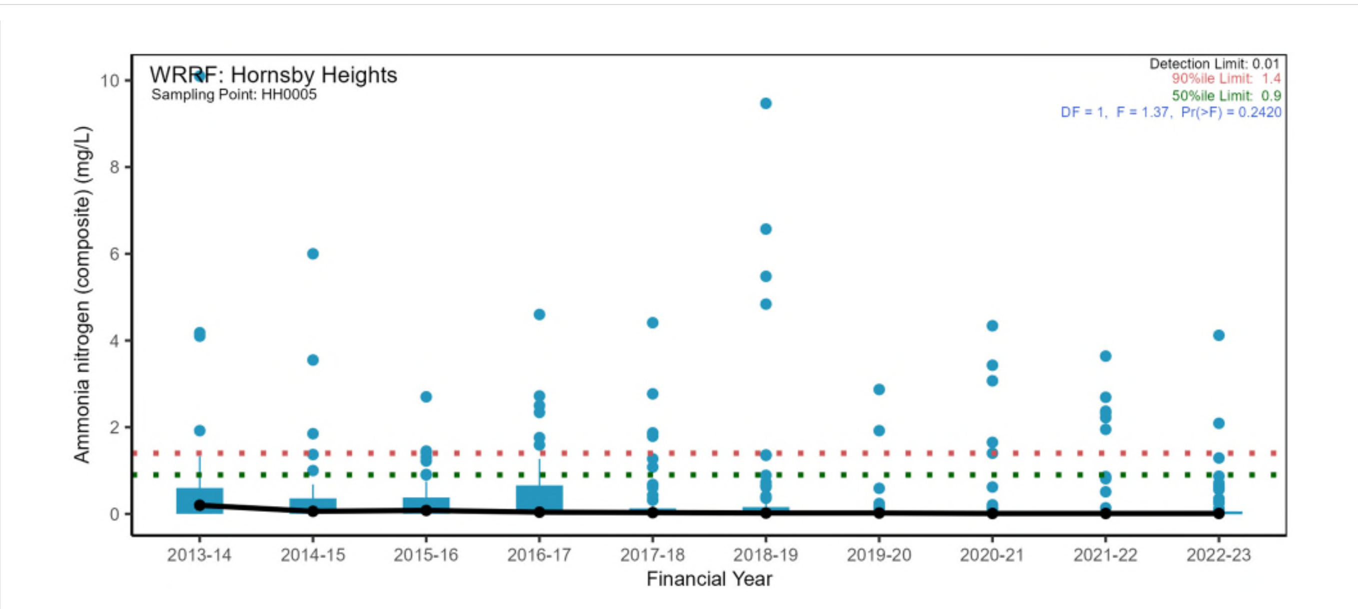
A-14.1 Pressure – Wastewater quantity

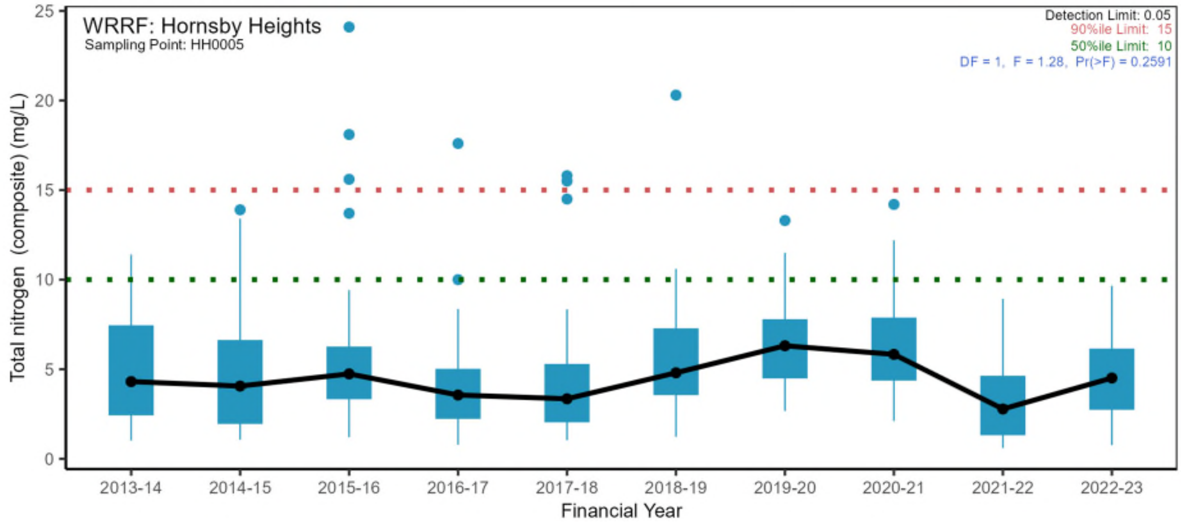
Inflow/ Discharge volume and rainfall

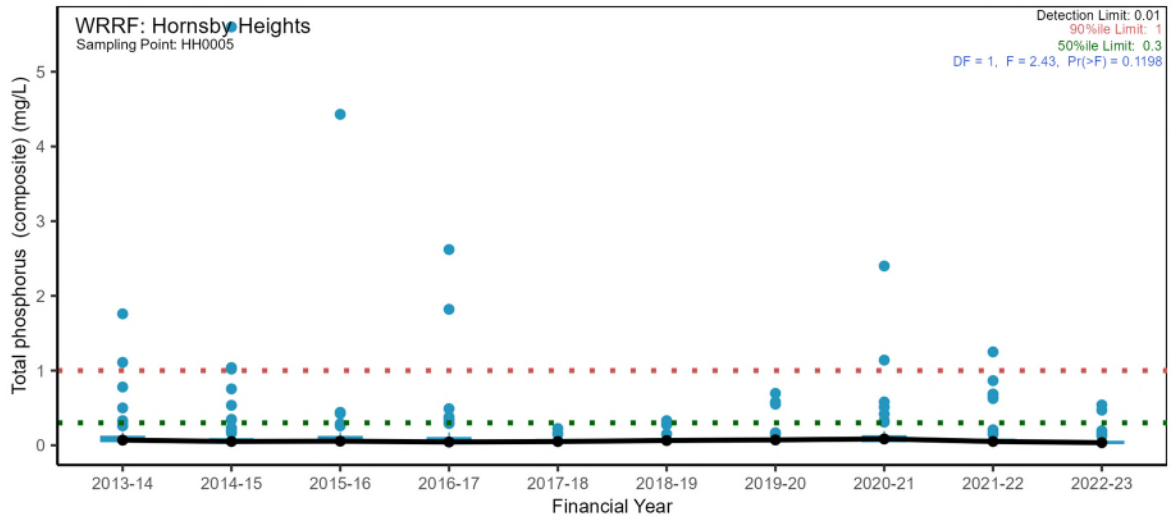


A-14.2 Pressure – Wastewater quality

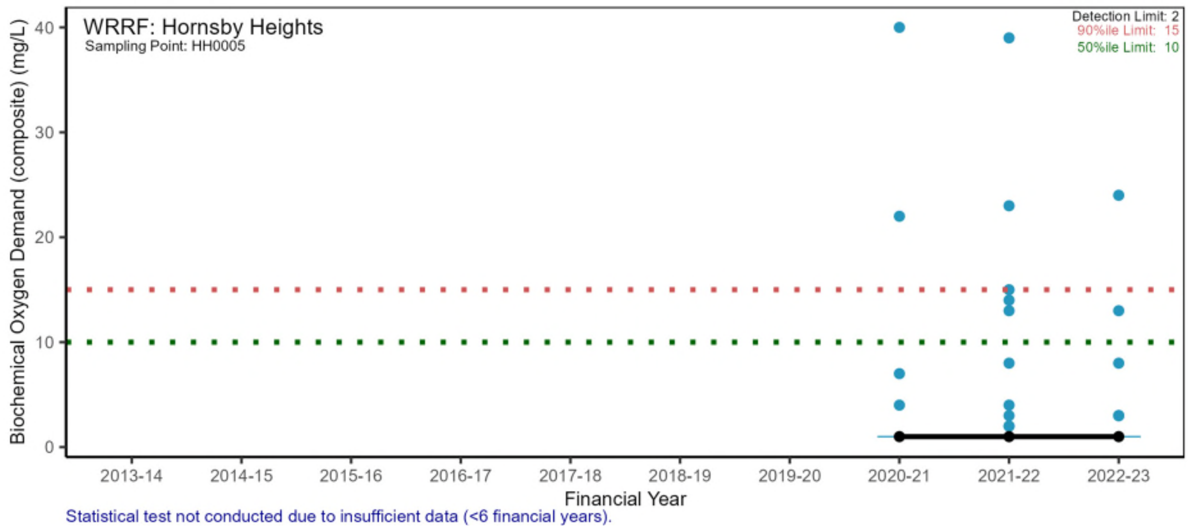
Nutrients

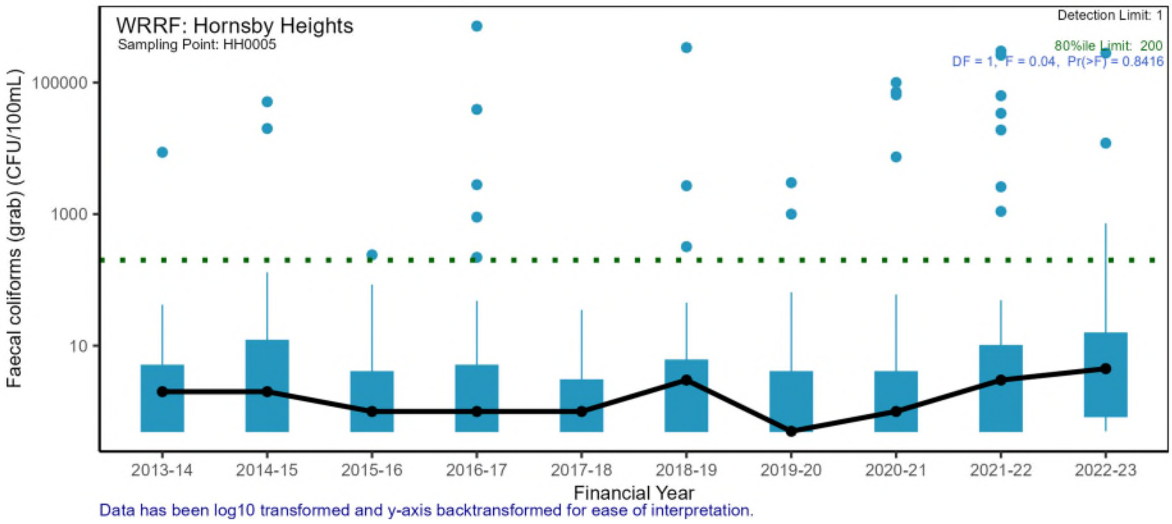


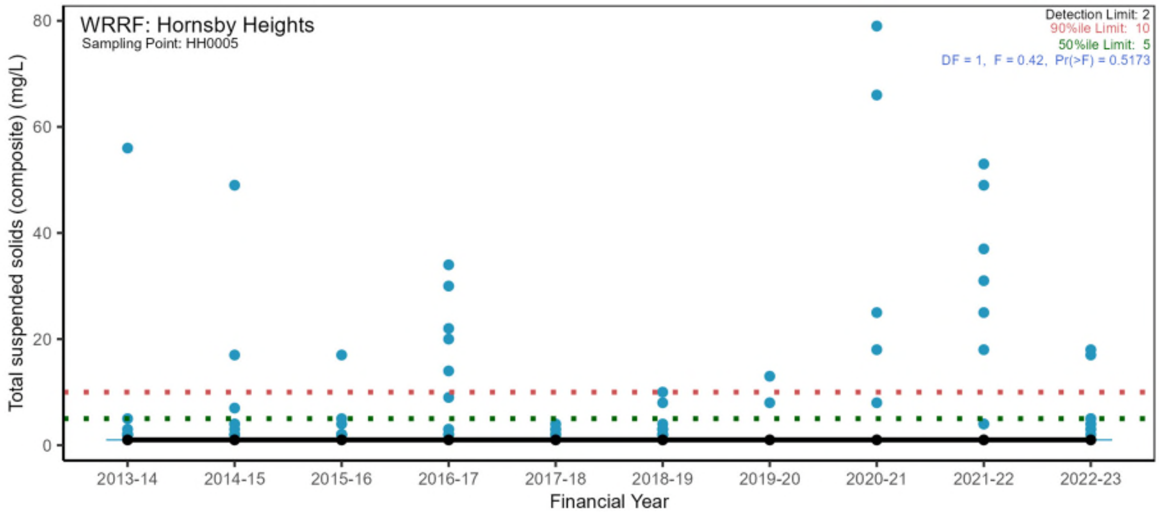




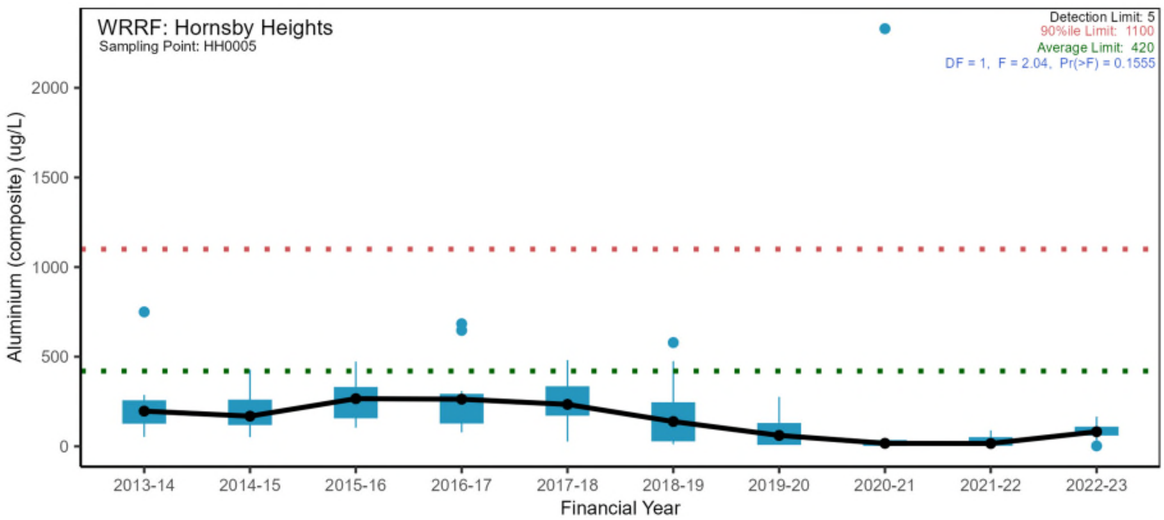
Major conventional analytes

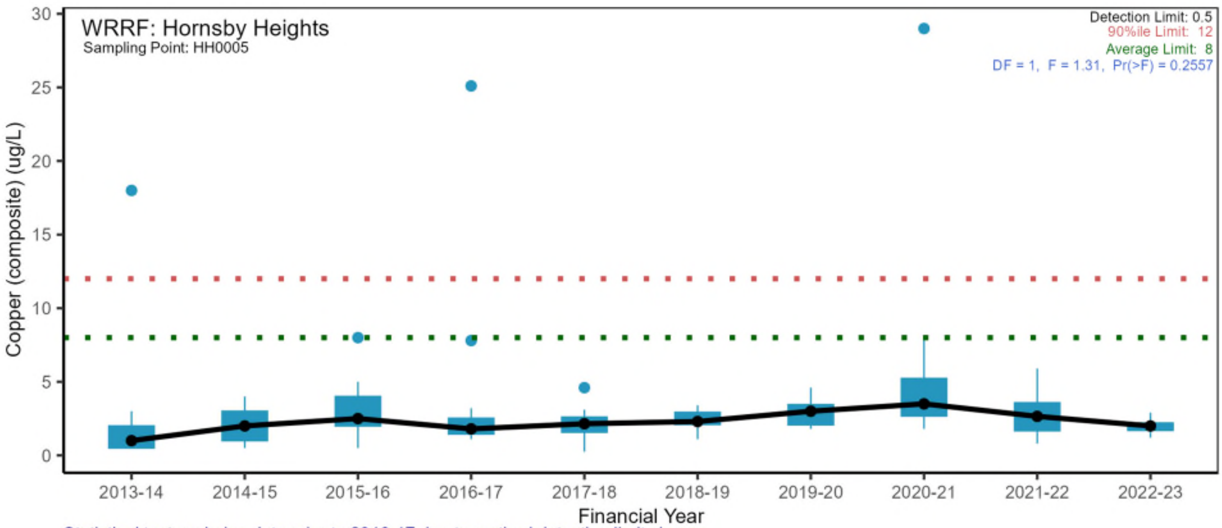




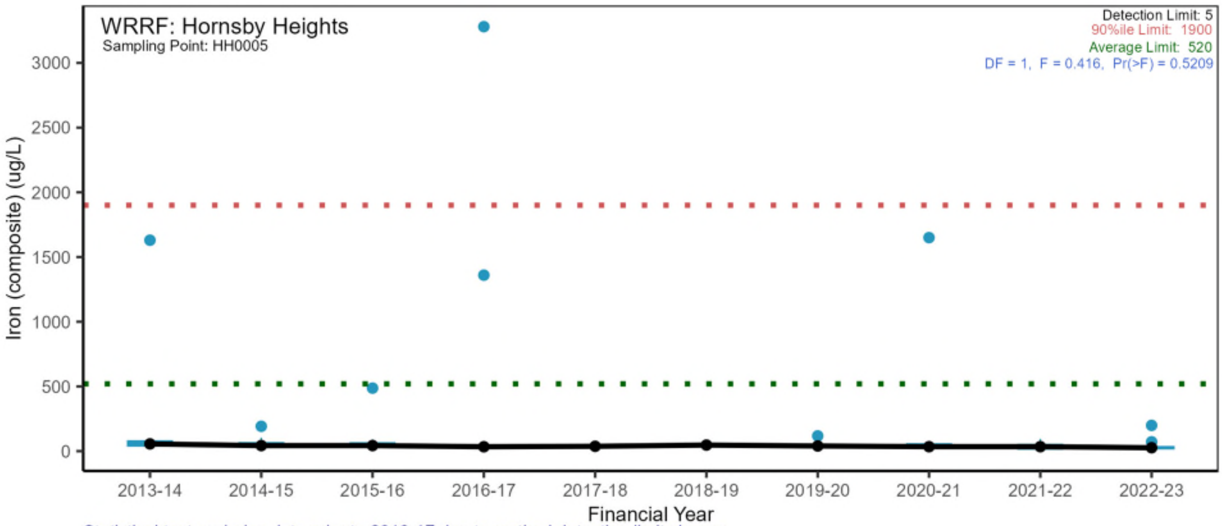


Trace metals

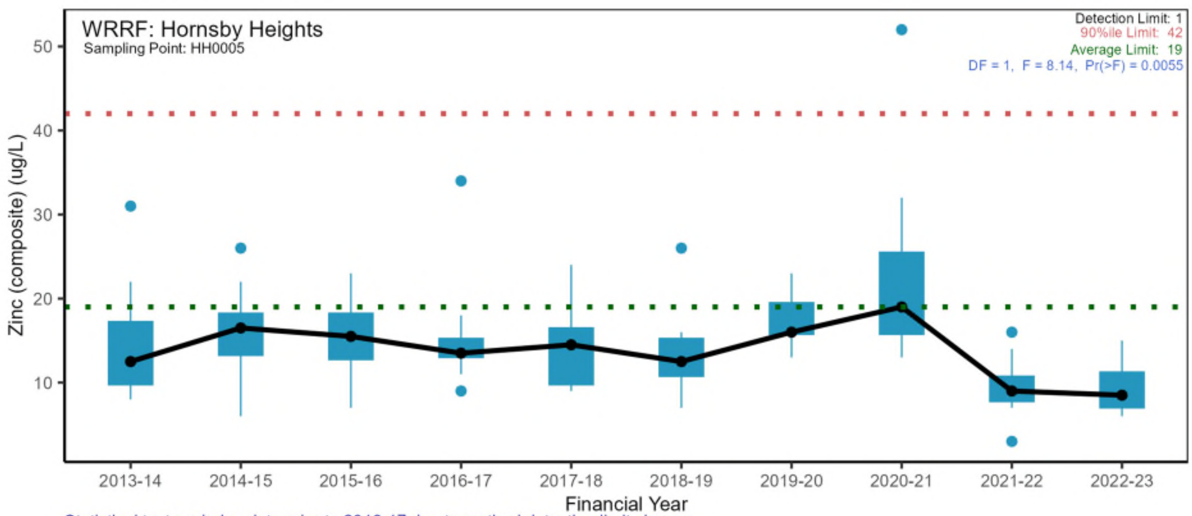




Statistical test excludes data prior to 2016-17 due to method detection limit change.

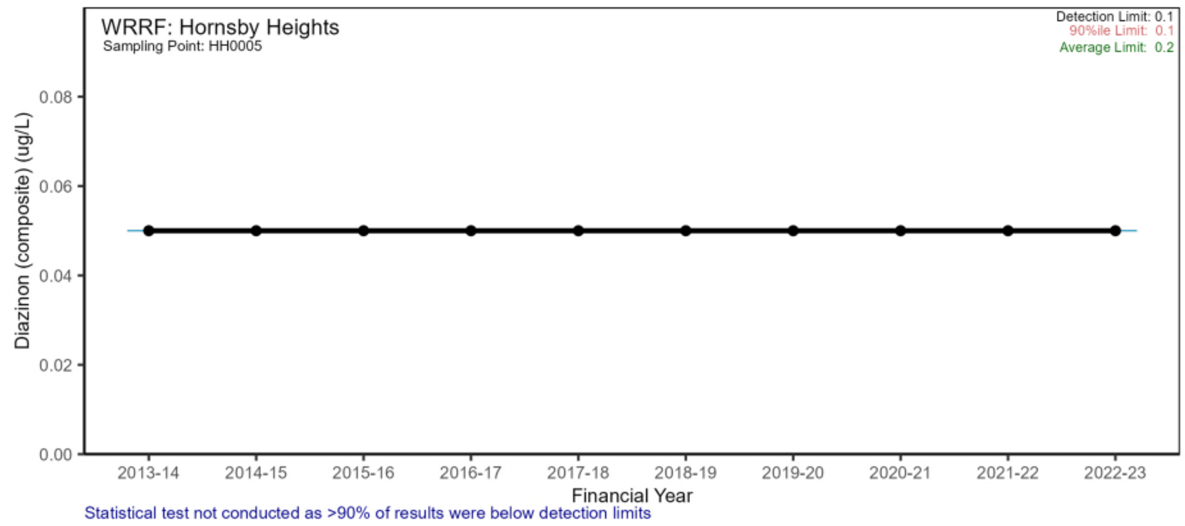


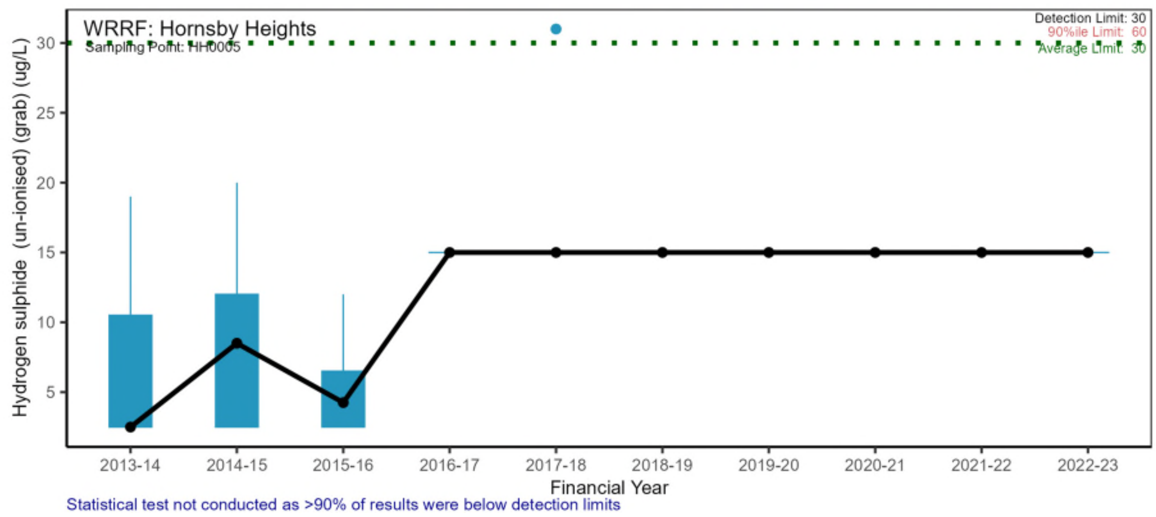
Statistical test excludes data prior to 2016-17 due to method detection limit change.



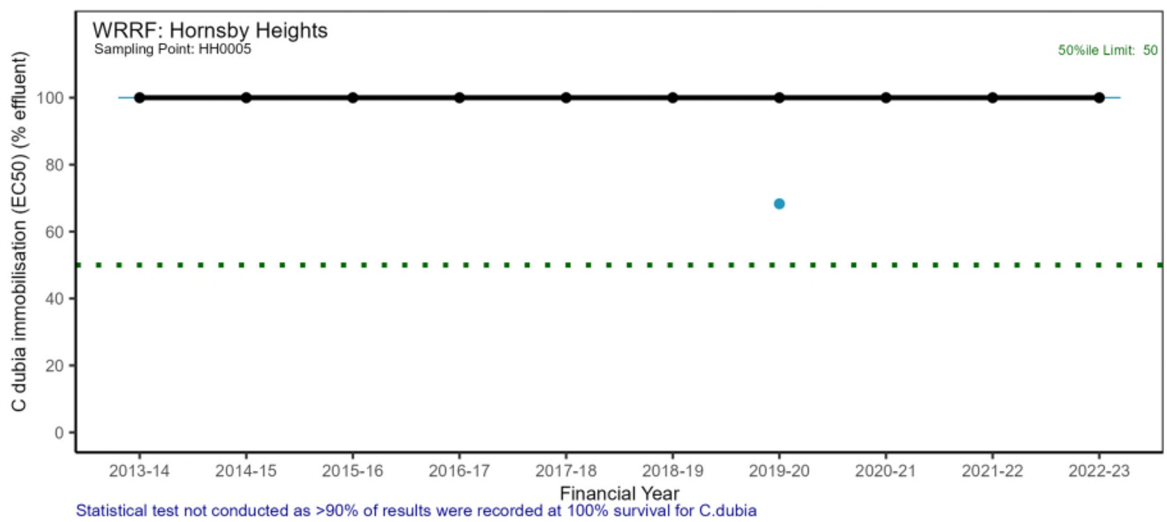
Statistical test excludes data prior to 2016-17 due to method detection limit change.

Other chemicals and organics (including pesticides)



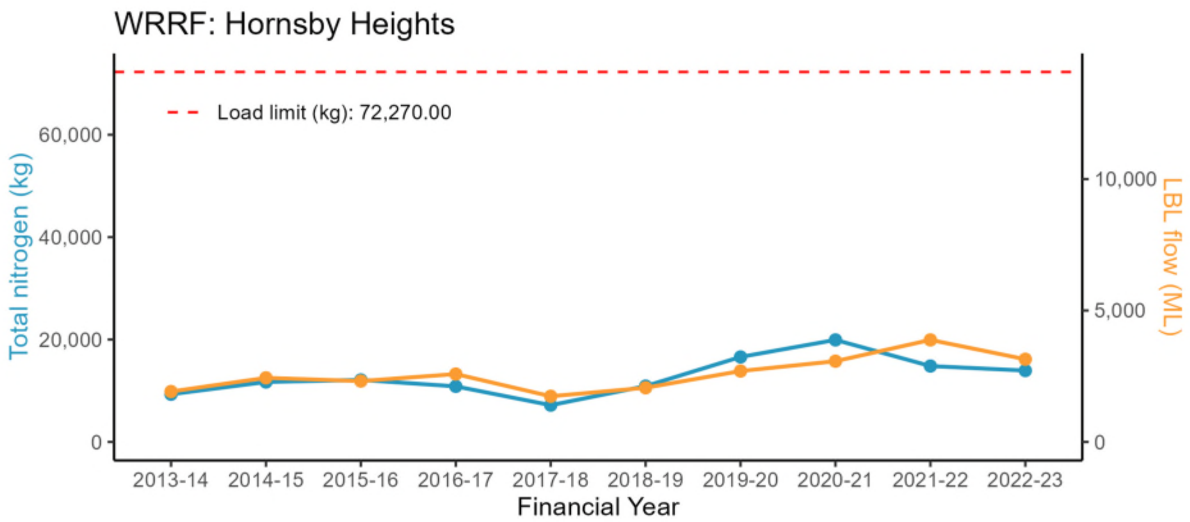


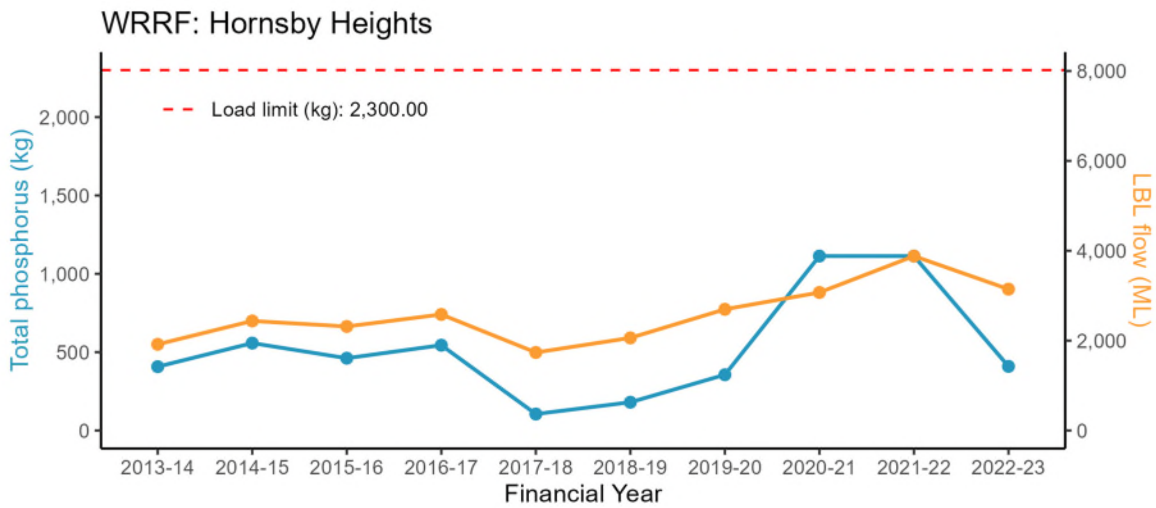
A-14.3Pressure – Wastewater toxicity



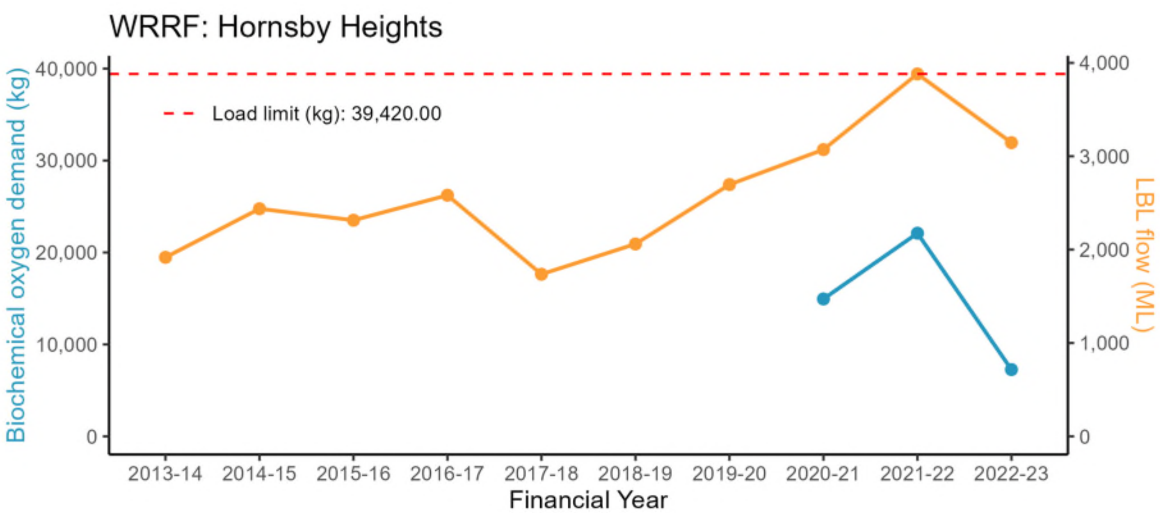
A-14.4Pressure – Wastewater discharge load

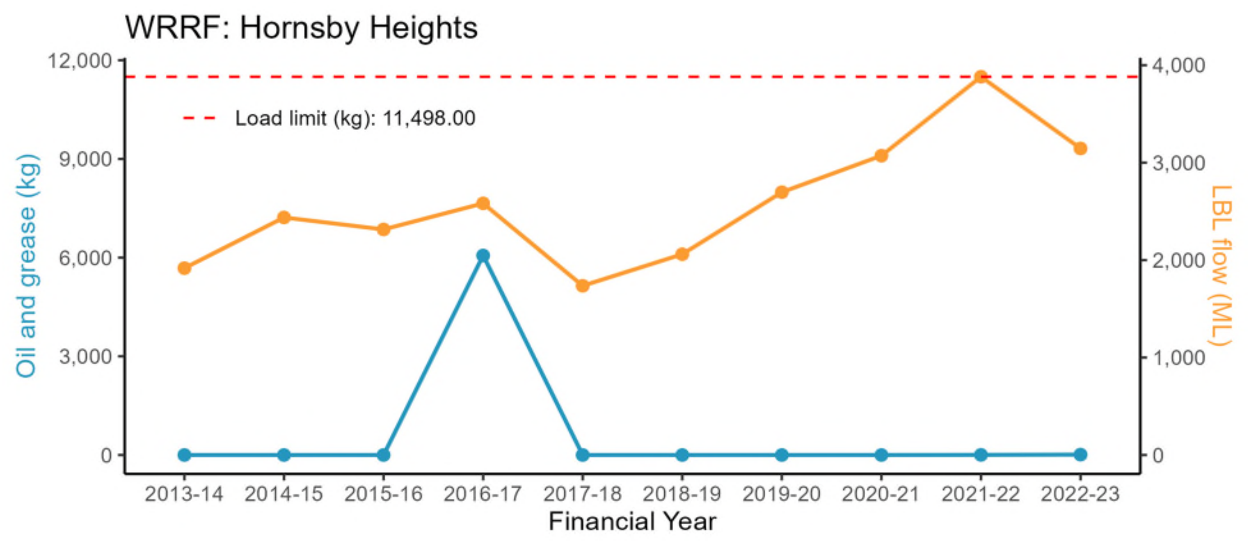
Nutrients

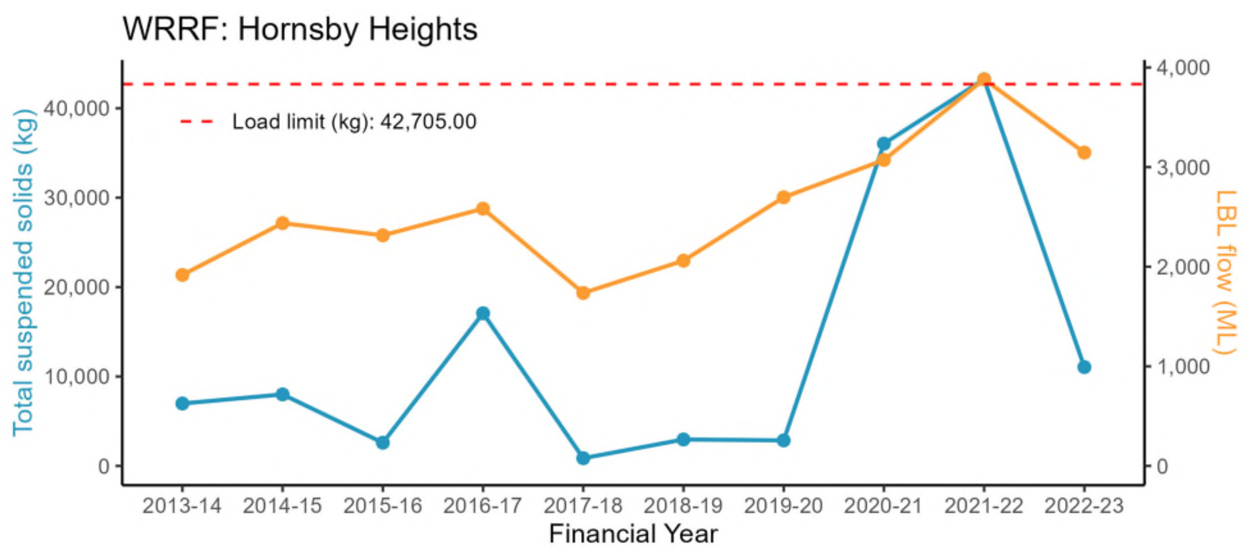




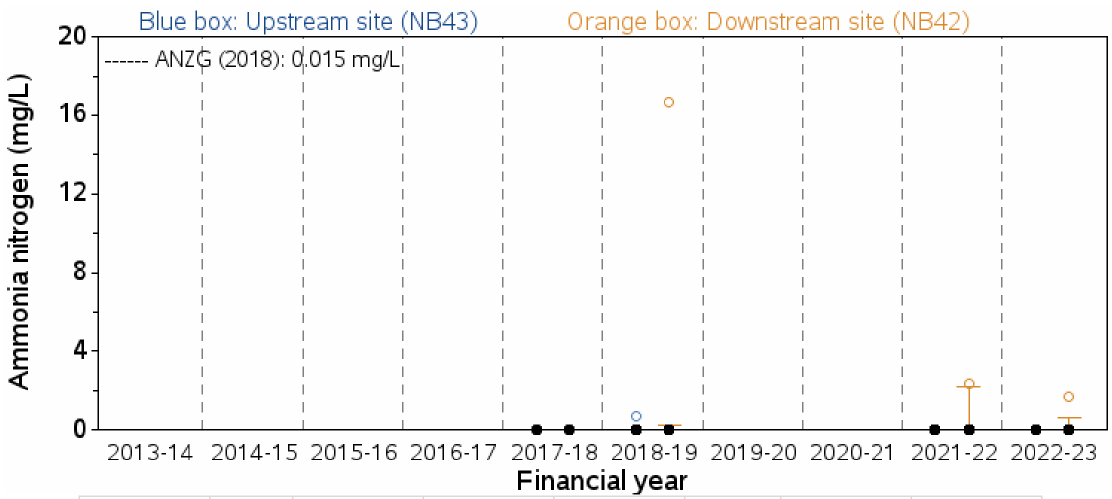
Major conventional analytes



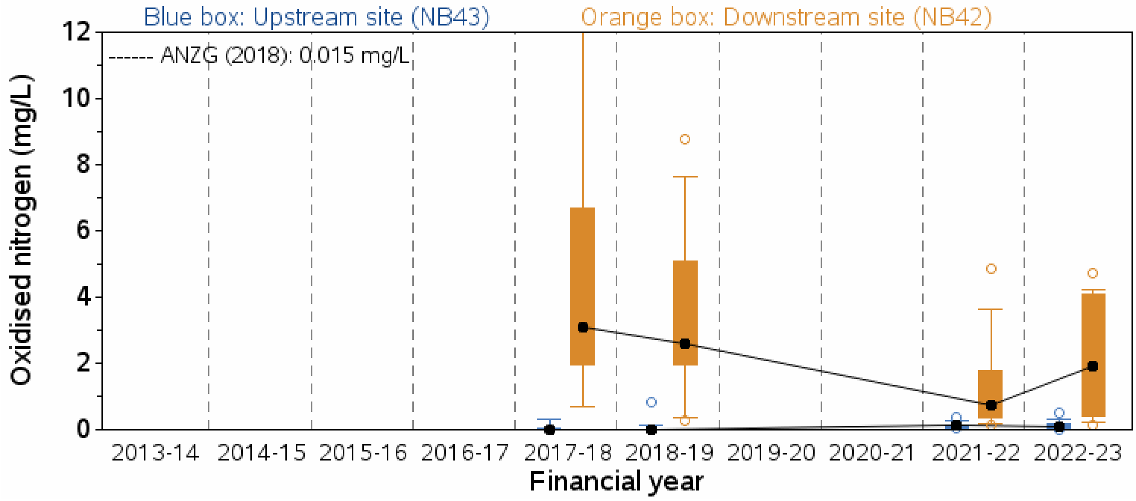




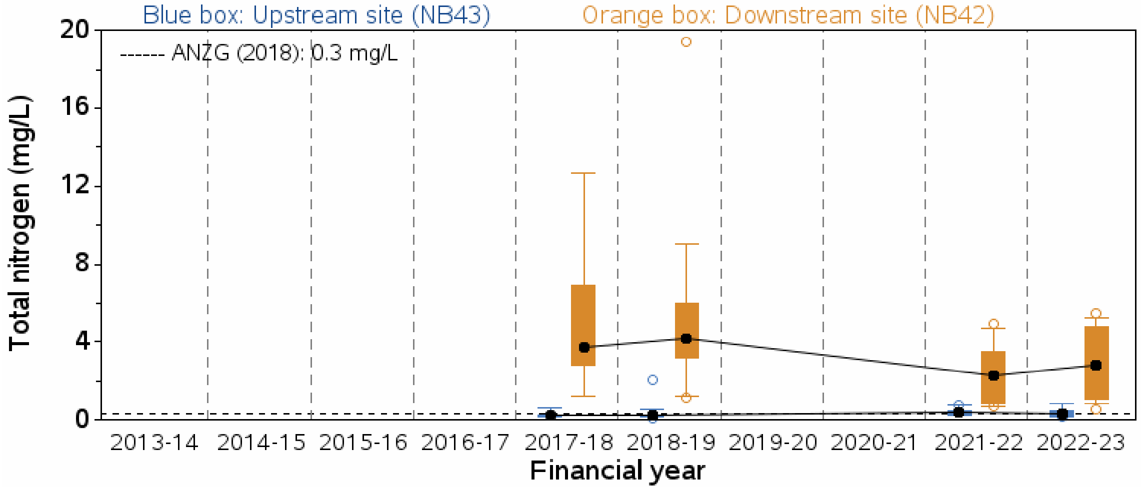
A-14.5 Stressor – Nutrients



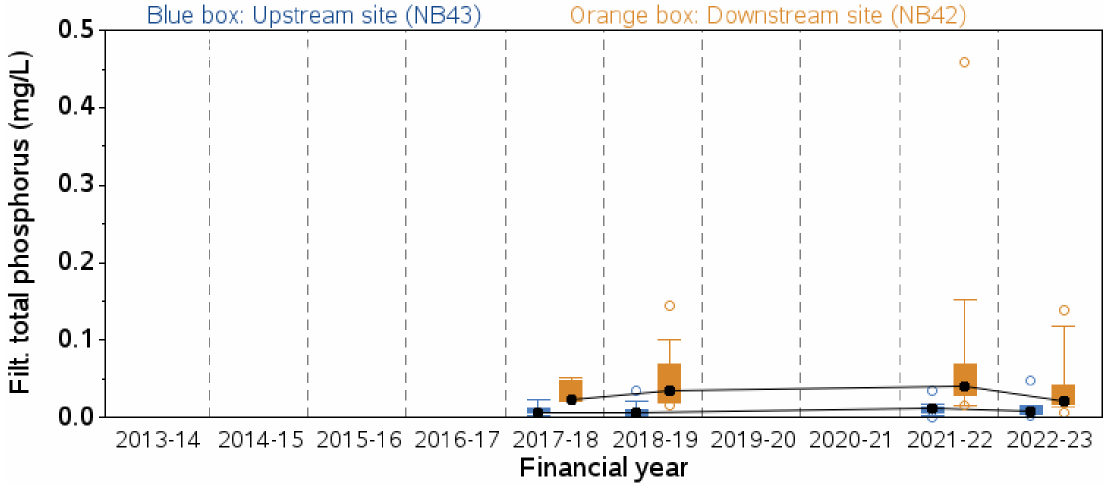
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.35	0.5574	NB42	1	0.36	0.5527



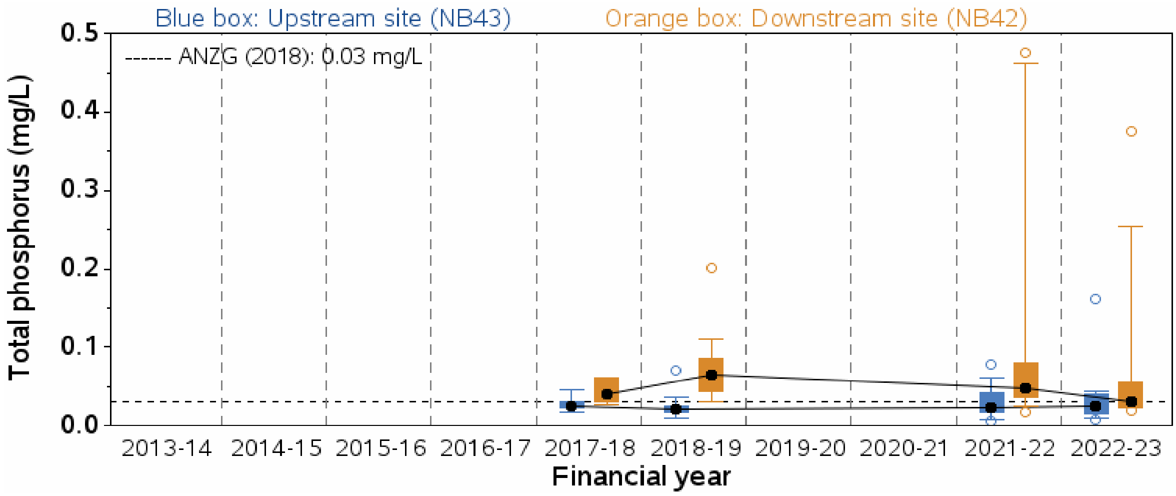
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.66	0.4205	NB42	1	0.94	0.3375



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.08	0.7751	NB42	1	1.49	0.227

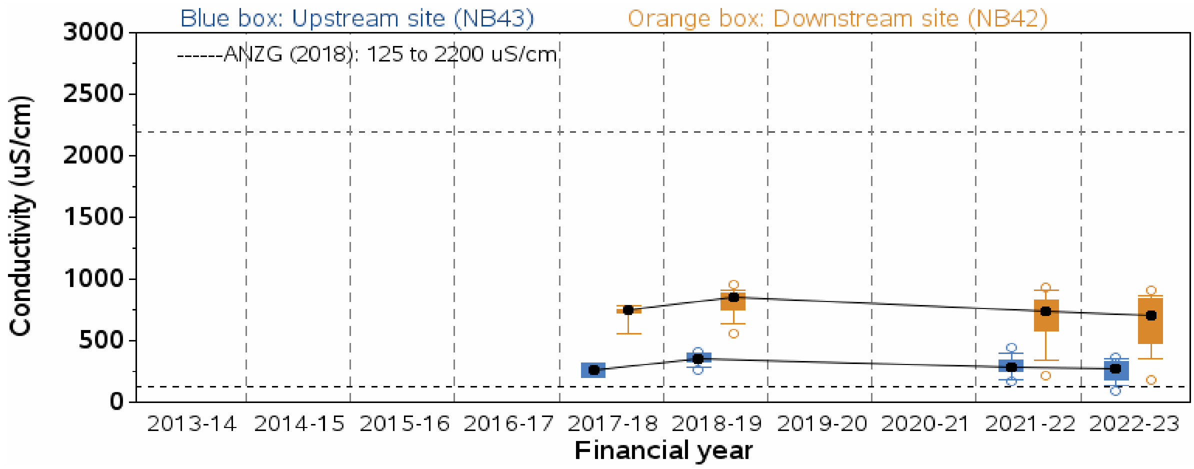


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.06	0.8022	NB42	1	1.08	0.304

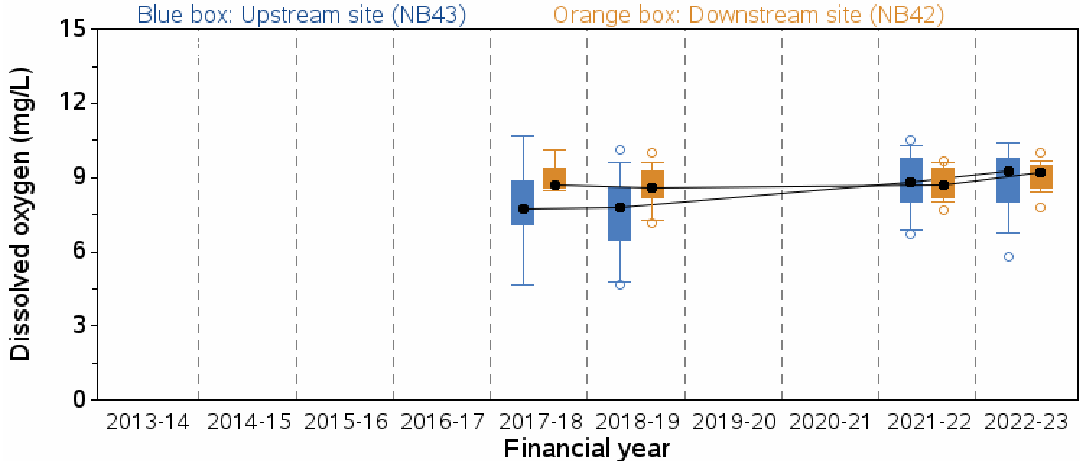


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.44	0.5083	NB42	1	0.21	0.6506

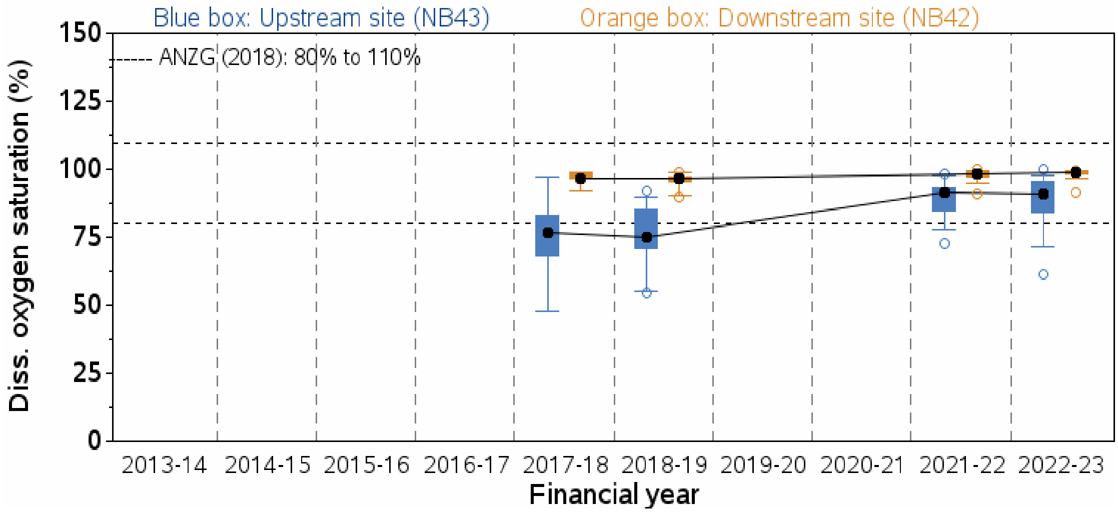
A-14.6 Stressor – Physico-chemical water quality



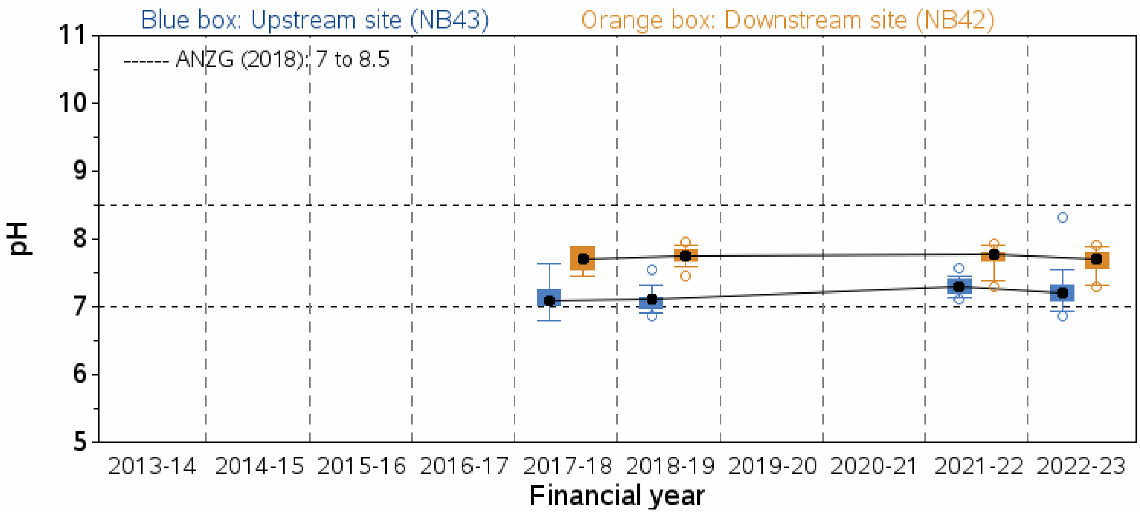
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	5.66	0.0208	NB42	1	1.43	0.2374



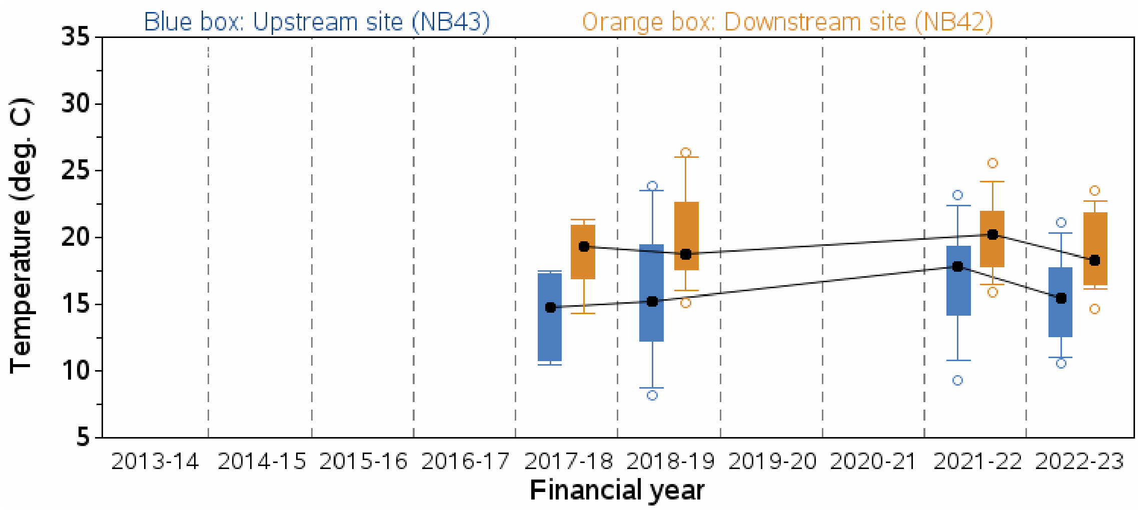
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	3.74	0.0582	NB42	1	3.47	0.0682



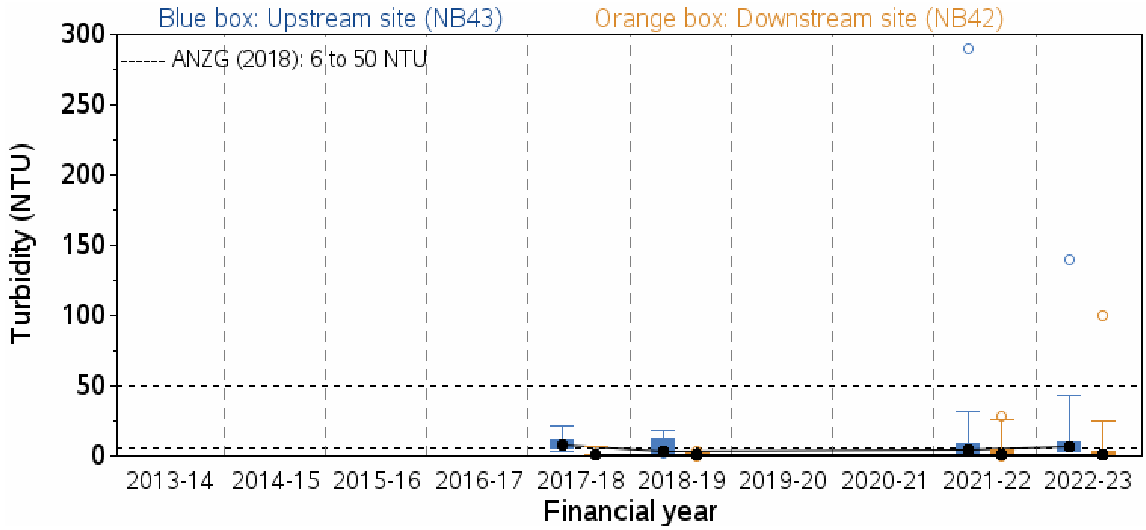
site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	5.53	0.0223	NB42	1	4.47	0.0391



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.64	0.4266	NB42	1	1.57	0.2154

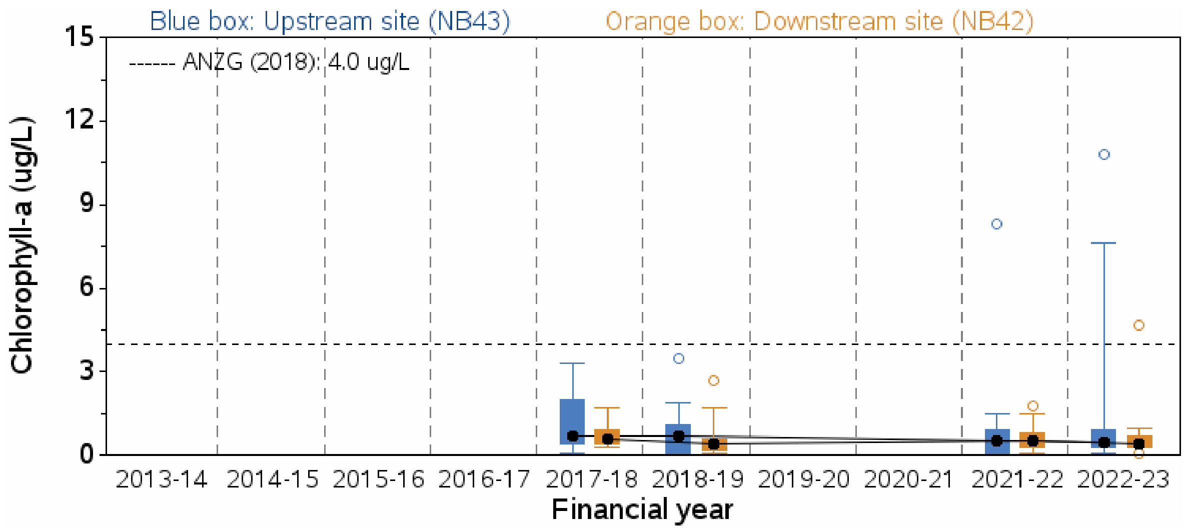


site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.13	0.7237	NB42	1	1.83	0.1822



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.02	0.9019	NB42	1	2.3	0.1353

A-14.7 Ecosystem receptor – Phytoplankton



site	DF	F Value	Pr>F	site	DF	F Value	Pr>F
NB43	1	0.79	0.3781	NB42	1	0.12	0.7303

Note: Insufficient data to draw a plot on total phytoplankton biovolume for NB43 and MB42

Note: Insufficient data to draw a plot on blue-green biovolume for NB43 and MB42

Note: Insufficient data to draw a plot on toxic blue-green count for NB43 and MB42

A-14.8 Ecosystem receptor – Macroinvertebrates

The SIGNAL-SG plot for Calna Creek provided an assessment of stream health. This plot was based on macroinvertebrate identification and counting results expressed as SIGNAL-SG scores and allows a visual comparison of data collected from 2022-23 against that collected between 1996 and 2022. This comparison suggests downstream stream health has not been maintained at a level comparable to that of the upstream site, indicating wastewater discharge from the Hornsby Heights WRRF did have a measurable persistent impact on stream health during 2022-23 (Figure A-46).

A comparison of the upstream-downstream SIGNAL-SG scores for 2022-23 samples under a t-test returned a non-significant test outcome (Table A-64). This test outcome is atypical to more recent years. This test outcome appears to be influenced by a reduction in mean upstream stream health, even though a similar amount of variability in returned sample SIGNAL-SG scores was evident in 2023 to more recent years. To be prudent further analysis was undertaken to explore community structure patterns.

Table A-64 t-test of upstream-downstream SIGNAL-SG scores of 2022-23 samples from Calna Creek near Hornsby Heights WRRF

Waterway	Method	Statistic	DF	P value
Calna Creek	Welch Two Sample t-test	1.84	3.1	0.160

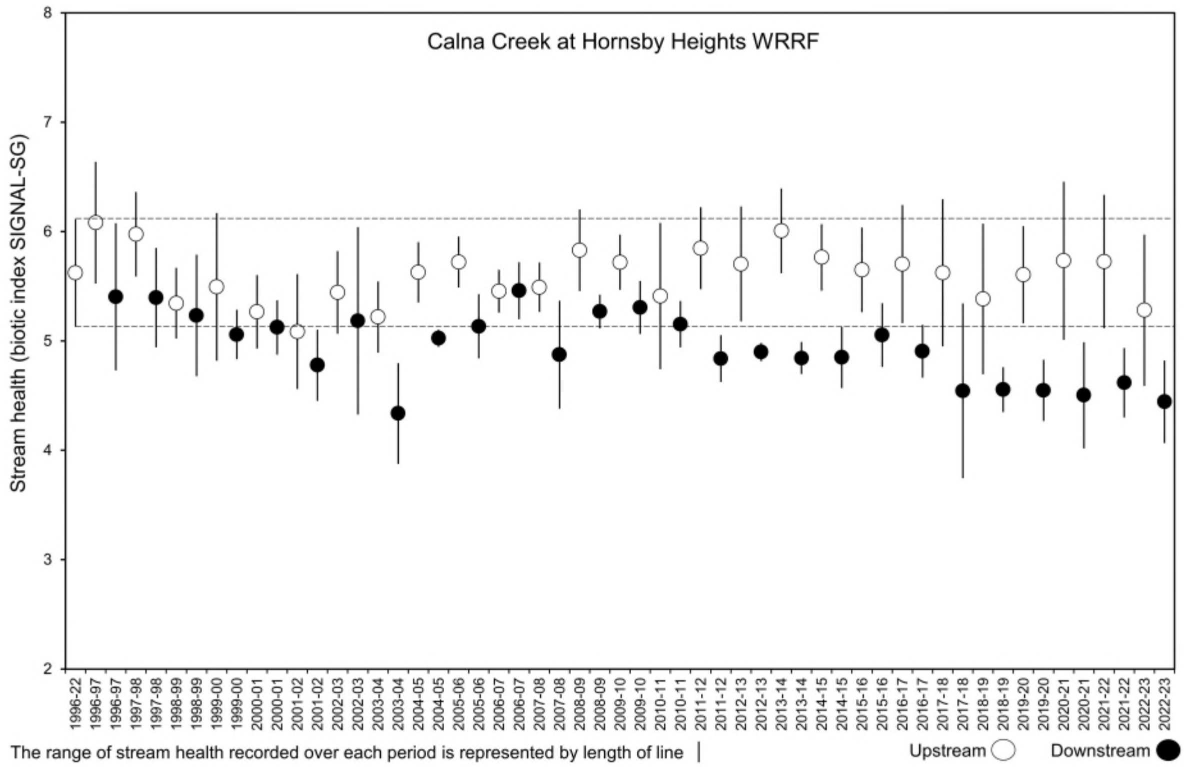


Figure A-46 Stream health of Calna Creek near Hornsby Heights WRRF

Both edge and riffle habitats were collected consistently enough at upstream-downstream sites on the same sampling occasions to allow a multivariate analysis for the monitoring period of 1996 to 2023. Each habitat (edge and riffle) was analysed separately with comparisons assessed with upstream-downstream sites.

In the 3-dimensional nMDS ordination plot of the Calna Creek edge habitat, a relatively interspersed pattern of upstream and downstream samples was observed (Figure A-47). This pattern was confirmed in the corresponding tree diagram from cluster analysis as the first division did not separate a group of upstream samples from another group of downstream samples (Figure A-49). The riffle habitat pattern displayed less overlap of upstream-downstream samples in the Calna Creek ordination plot (Figure A-48) and tree diagram (Figure A-50) compared to the edge habitat.

The PERMDISP analysis indicated a significant pattern of dispersion for the edge and riffle habitat samples (Table A-69 and Table A-70). This outcome suggests subsequent results of ANOSIM tests are describing both the variability in taxonomic composition of samples over time as well as community composition variability between the upstream and downstream sites at each habitat.

An ANOSIM test was run on the factor ‘Site’. The returned R-values were at a low-range level for edge (0.386) (Table A-65) and at a mid-range level for riffle (0.564) (Table A-66). These R-value results suggest site specific assemblages were more distinguishable for the riffle habitat and less distinguishable for the edge habitat. This pattern is reinforced by the shade plots that show a clear difference in sites within the riffle habitat (Figure A-52) and a less distinct pattern within the edge habitat (Figure A-51). These shade plots also show the riffle habitat has a smaller set of taxa (110) compared with the more diverse edge habitat (142) taxa. The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 25 taxa identified for the riffle habitat (Table A-74) and 36 taxa for the edge habitat (Table A-73). These subsets of taxa reflect those taxa which formed the main visual patterns in the respective shade plots.

To further explore community structure, hypothesis testing was conducted with a PERMANOVA model. This model comprised the fixed factors ‘Site’ and ‘Year’ with ‘Year’ representing samples collected between 1996 and 2023 and ‘Site’ having 2 levels, upstream and downstream. A statistically significant ‘Site x Year’ interaction was returned for both the edge and the riffle habitats (Table A-67 and Table A-68) suggesting a change through time at least at one site.

A second run of ANOSIM based on ‘Site-Period’ groups in the 3D ordination plots returned a significant global low-range R-value (0.295) for the edge habitat. Under subsequent upstream-downstream pairwise comparisons, one test returned an R-value at a level (R = 0.938) (Table A-71) that was not expected from natural differences between groups from variation in the substratum composition of the habitats between sites. Besley and Chessman (2008) found R-values up to 0.66 for sites on the same near-pristine stream. A mid-range global R-value (0.449) was returned for the riffle habitat and one of the upstream and downstream pairwise comparisons returned R-values (0.756) (Table A-72) that was at a level that implied more than natural substratum differences between sites. Pairwise comparisons from the ‘Site-period’ ANOSIM suggest that the recent period upstream vs downstream comparison returned an ANOSIM value at levels typical of previous years, suggesting an alteration of wastewater discharge as seen in the past few years.

In summary, the SIGNAL-SG control chart plot showed clear differences between the upstream-downstream sites consistently over the last ten financial years. Variability in the range of stream health levels were also evident for upstream-downstream sites in this SIGNAL-SG control chart.

This variability and difference in assemblage structure suggested by SIGNAL-SG results was also evident in multivariate analysis. Both SIGNAL-SG and multivariate results suggest downstream community structure in Calna Creek has been consistently altered by wastewater discharge from the Hornsby Heights WRRF through the 2011 to 2023 monitoring period.

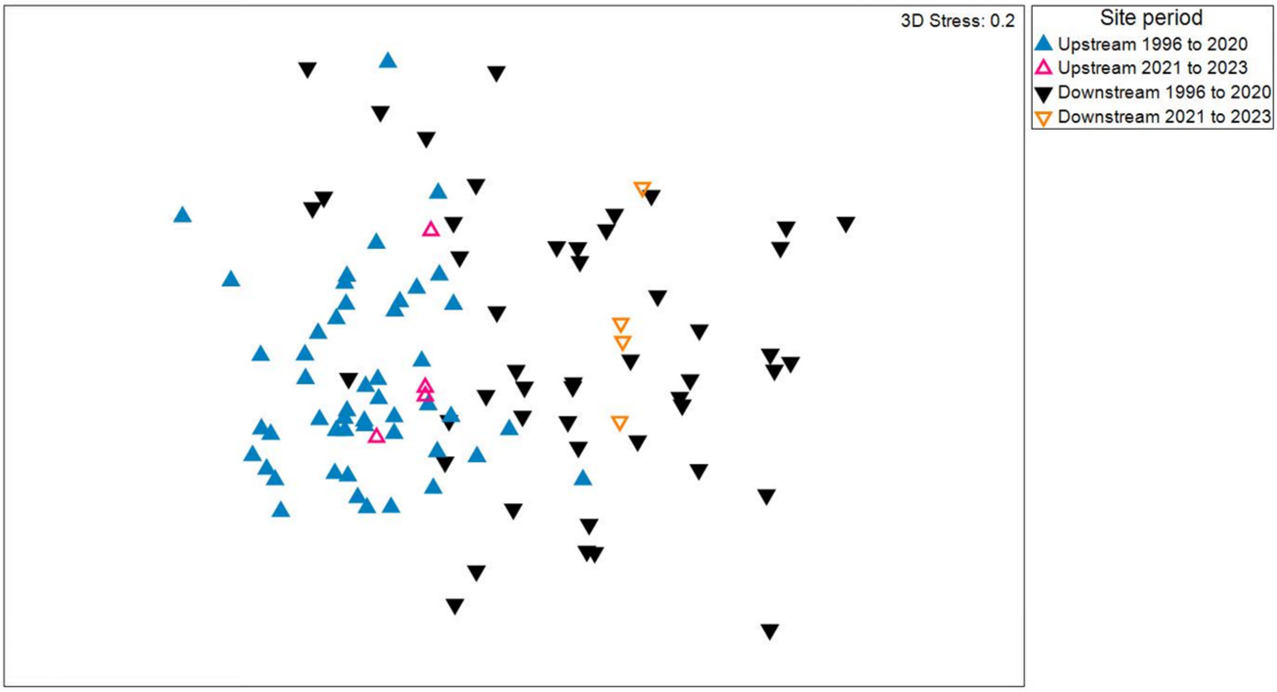


Figure A-47 Dimensions 1 and 3 of 3-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Calna Creek near Hornsby Heights WRRF

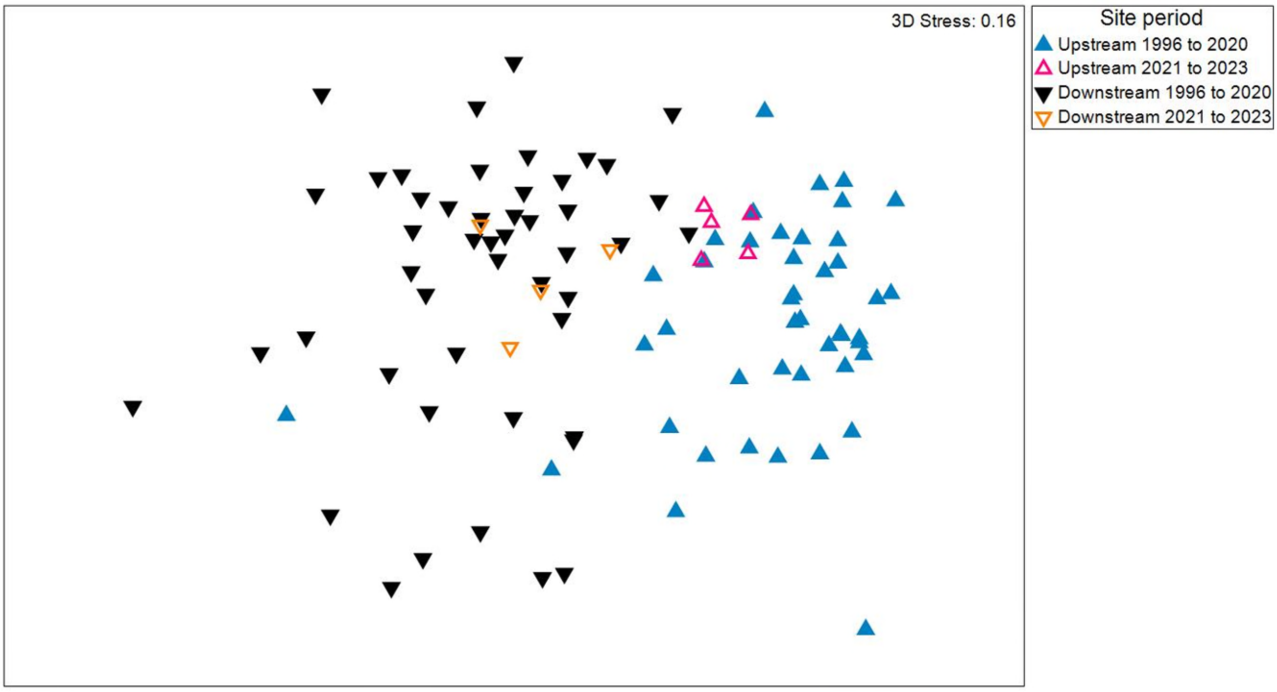


Figure A-48 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate riffle habitat community structure of upstream-downstream sites of Calna Creek near Hornsby Heights WRRF

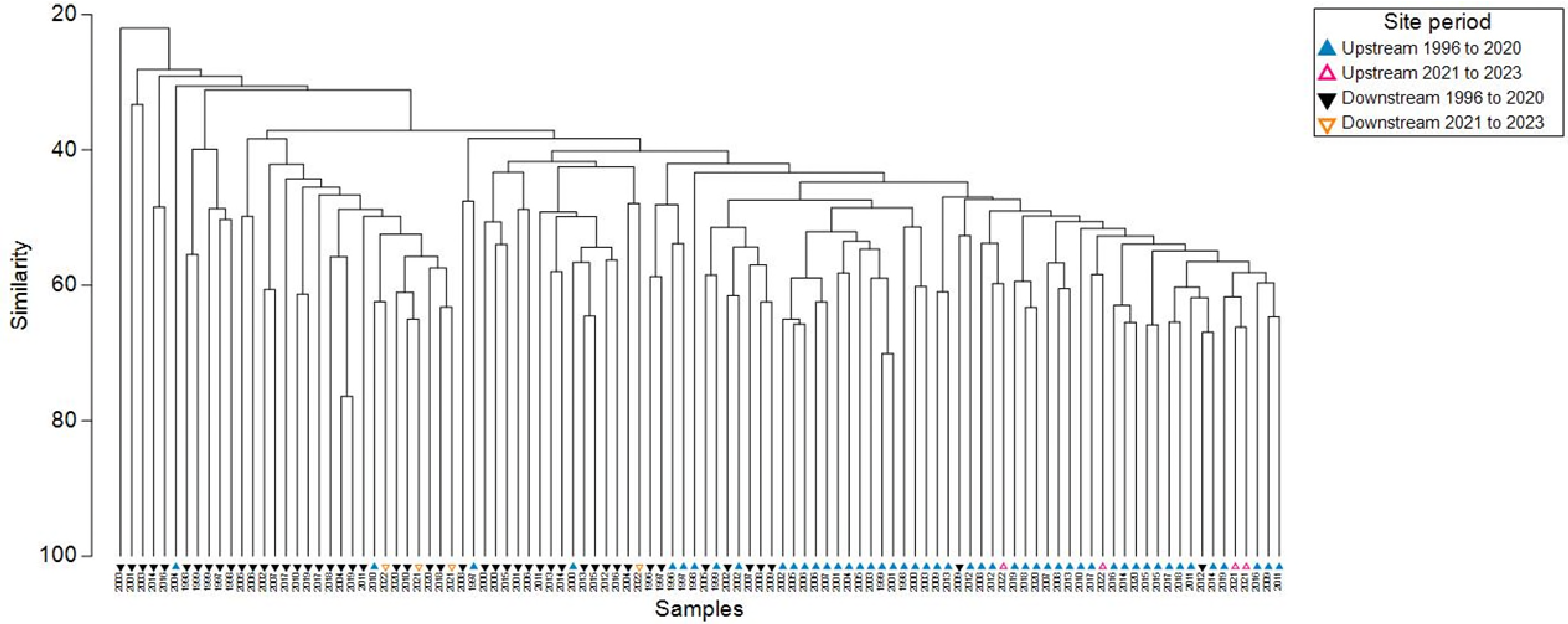


Figure A-49 Tree diagram of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Calna Creek near Hornsby Heights WRRF

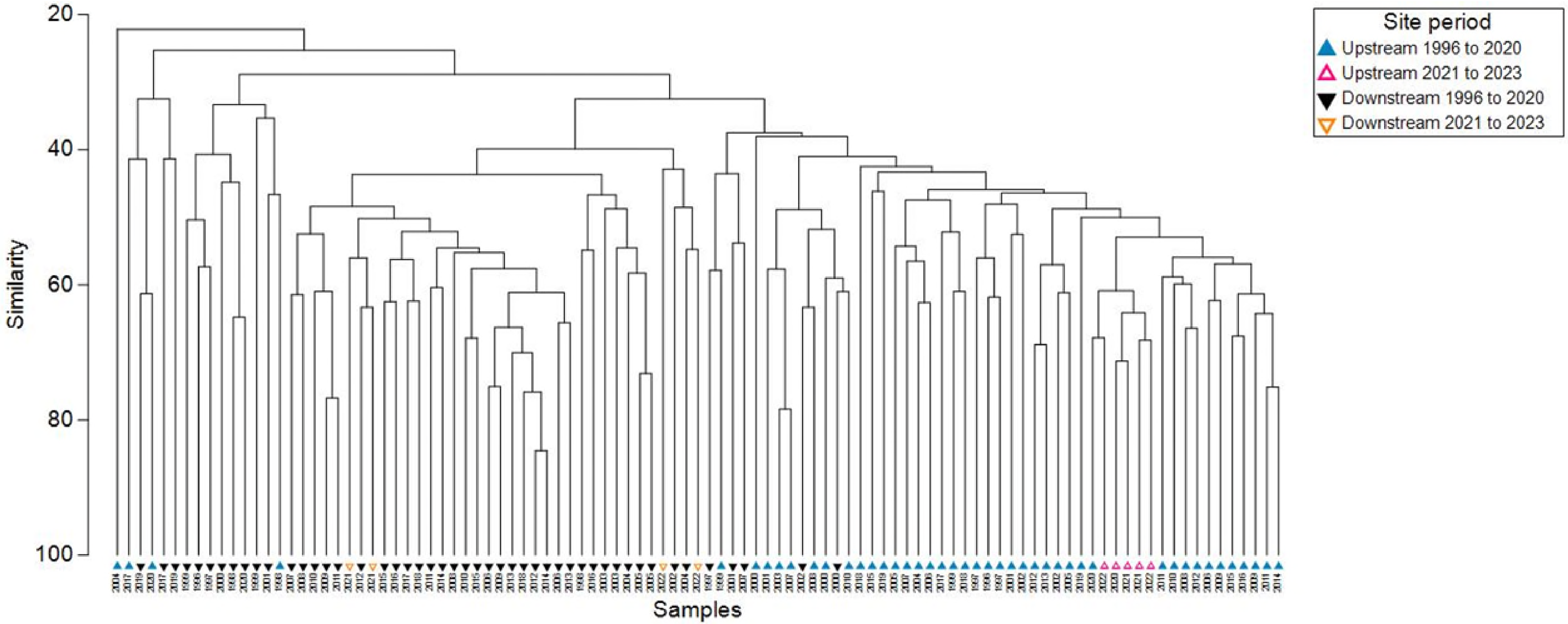


Figure A-50 Tree diagram of freshwater macroinvertebrate riffle habitat community structure of upstream-downstream sites of Calna Creek near Hornsby Heights WRRF

Table A-65 ANOSIM test of 'Site' factor for edge habitat of Calna Creek near Hornsby Heights WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.386
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-66 ANOSIM test of 'Site' factor for riffle habitat of Calna Creek near Hornsby Heights WRRF

Tests for differences between unordered Site groups
Global Test
Sample statistic (R): 0.564
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Table A-67 PERMANOVA test of 'Site' and 'Year' factors for edge habitat of Calna Creek near Hornsby Heights WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	27

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	20512	20512	14.087	0.0001	9924
Year	26	56701	2180.8	1.4977	0.0001	9655
SitexYear	26	43706	1681	1.1544	0.0265	9597
Res	52	75720	1456.2			
Total	105	1.97E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	365.96	19.13
S(Year)	184.65	13.589
S(SitexYear)	114.58	10.704
V(Res)	1456.2	38.16

Table A-68 PERMANOVA test of 'Site' and 'Year' factors for riffle habitat of Calna Creek near Hornsby Heights WRRF

Sums of squares type: Type III (partial)
Fixed effects sum to zero for mixed terms
Permutation method: Permutation of residuals under a reduced model
Number of permutations: 9999

Factors

Name	Type	Levels
Site	Fixed	2
Year	Fixed	27

PERMANOVA table of results

Source	df	SS	MS	Pseudo-F	P(perm)	Unique perms
Site	1	37601	37601	27.32	0.0001	9927
Year	26	59067	2271.8	1.6506	0.0001	9696
SitexYear	26	47846	1840.2	1.337	0.0002	9707
Res	47	64688	1376.3			
Total	100	2.12E+05				

Estimates of components of variation

Source	Estimate	Sq.root
S(Site)	757.79	27.528
S(Year)	243.66	15.61
S(SitexYear)	252.45	15.889
V(Res)	1376.3	37.099

Table A-69 PERMDISP test of ‘Site’ factor for edge habitat of Calna Creek near Hornsby Heights WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 106

DEVIATIONS FROM CENTROID
F: 27.809 df1: 1 df2: 104
P(perm): 0.0001

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	53	43.292	0.92608
Upstream	53	37.117	0.71647

Table A-70 PERMDISP test of ‘Site’ factor for riffle habitat of Calna Creek near Hornsby Heights WRRF

Group factor: Site
Number of permutations: 9999

Number of groups: 2
Number of samples: 101

DEVIATIONS FROM CENTROID
F: 5.0112 df1: 1 df2: 99
P(perm): 0.0427

MEANS AND STANDARD ERRORS

Group	Size	Average	SE
Downstream	53	42.24	1.1728
Upstream	48	38.759	0.99641

Table A-71 ANOSIM test of ‘Site period’ for edge habitat of Calna Creek near Hornsby Heights WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.295
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1996 to 2020, Upstream 1996 to 2020	0.369	0.01	Very large	9999	0
Downstream 1996 to 2020, Downstream 2021 to 2023	-0.271	98.5	292825	9999	9851
Downstream 1996 to 2020, Upstream 2021 to 2023	0.042	36.2	292825	9999	3621
Upstream 1996 to 2020, Downstream 2021 to 2023	0.587	0.02	292825	9999	1
Upstream 1996 to 2020, Upstream 2021 to 2023	-0.114	79	292825	9999	7897
Downstream 2021 to 2023, Upstream 2021 to 2023	0.938	2.9	35	35	1

Table A-72 ANOSIM test of ‘Site period’ for riffle habitat of Calna Creek near Hornsby Heights WRRF

Tests for differences between unordered Site period groups
Global Test
Sample statistic (R): 0.449
Significance level of sample statistic: 0.01%
Number of permutations: 9999 (Random sample from a large number)
Number of permuted statistics greater than or equal to R: 0

Pairwise Tests

Groups	R Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Downstream 1996 to 2020, Upstream 1996 to 2020	0.551	0.01	Very large	9999	0
Downstream 1996 to 2020, Downstream 2021 to 2023	0.058	34.1	270725	9999	3407
Downstream 1996 to 2020, Upstream 2021 to 2023	0.279	3.8	2869685	9999	381
Upstream 1996 to 2020, Downstream 2021 to 2023	0.562	0.2	194580	9999	16
Upstream 1996 to 2020, Upstream 2021 to 2023	-0.084	69.7	1906884	9999	6964
Downstream 2021 to 2023, Upstream 2021 to 2023	0.756	0.8	126	126	1

Table A-73 Genera subset whose multivariate pattern matches full genera set of the edge habitat Calna Creek near Hornsby Heights WRRF

Subset of 36 (correlation 0.950) genera from edge habitat whose pattern matches that of the full set of 142 genera identified with the same subset found on 35 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Chironomus,Physidae Physella,Chironomidae Cricotopus,Chironomidae Cryptochironomus,Chironomidae Dicrotendipes,Coenagrionidae Austroagrion,Dugesiidae Cura,Glossiphoniidae Helobdella,Lumbriculidae Lumbriculus,Lymnaeidae Pseudosuccinea,Naididae Branchiura,Planorbidae Ferrissia,Argiolestidae Austroargiolestes,Chironomidae Microtendipes,Chironomidae Polypedilum,Chironomidae Procladius,Corduliidae Hemicordulia,Talitridae Arcitalitrus,Tateidae Potamopyrgus,Ceratopogonidae Bezzia,Elmidae Notriolus,Elmidae Simsonia,Gomphidae Austrogomphus,Hydroptilidae Hellyethira,Notonectidae Enithares,Chironomidae Paramerina,Chironomidae Riethia,Corydalidae Archichauliodes,Elmidae Kingolus,Gerridae Tenagogerris,Notonectidae Anisops,Oxidae Oxus,Psephenidae Sclerocyphon,Veliidae Microvelia,Chironomidae Tanytarsus,Stratiomyidae Odontomyia

Table A-74 Genera subset whose multivariate pattern matches full genera set of the riffle habitat Calna Creek near Hornsby Heights WRRF

Subset of 25 (correlation 0.953) genera from edge habitat whose pattern matches that of the full set of 110 genera identified with the same subset found on 30 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Chironomus,Physidae Physella,Chironomidae Cricotopus,Dugesiidae Cura,Lumbriculidae Lumbriculus,Simuliidae Simulium,Argiolestidae Austroargiolestes,Chironomidae Microtendipes,Chironomidae Polypedilum,Chironomidae Procladius,Chironomidae Rheocricotopus,Chironomidae Rheotanytarsus,Gelastocoridae Nerthra,Hydropsychidae Cheumatopsyche,Tateidae Potamopyrgus,Elmidae Notriolus,Elmidae Simsonia,Aeshnidae Austroaeschna,Corydalidae Archichauliodes,Elmidae Kingolus,Psephenidae Sclerocyphon,Calamoceratidae Anisocentropus,Gomphidae Hemigomphus,Philopotamidae Chimarra,Stratiomyidae Odontomyia

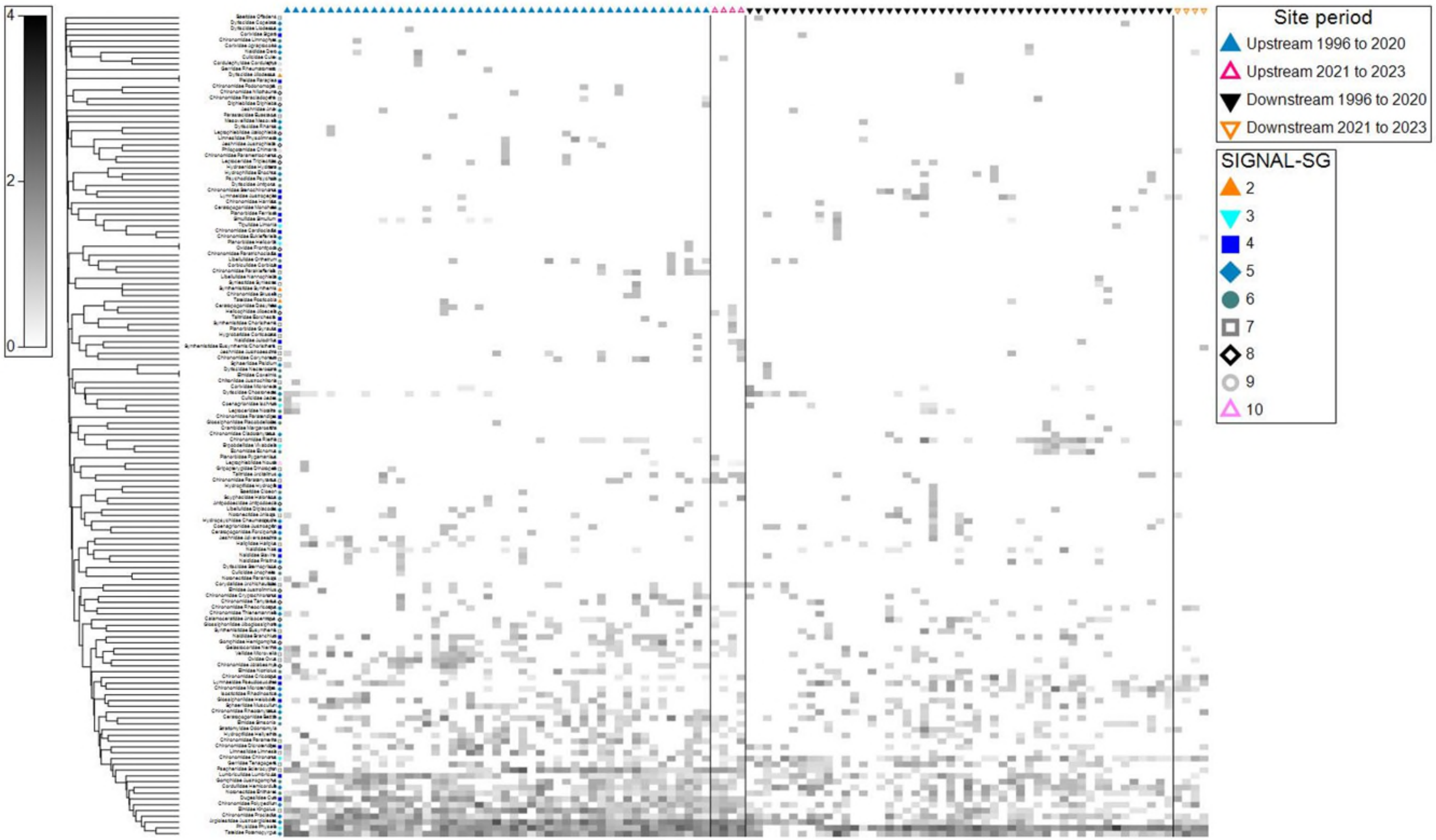


Figure A-51 Shade plot of freshwater macroinvertebrate edge habitat community structure of upstream-downstream sites of Calna Creek near Hornsby Heights WRRF

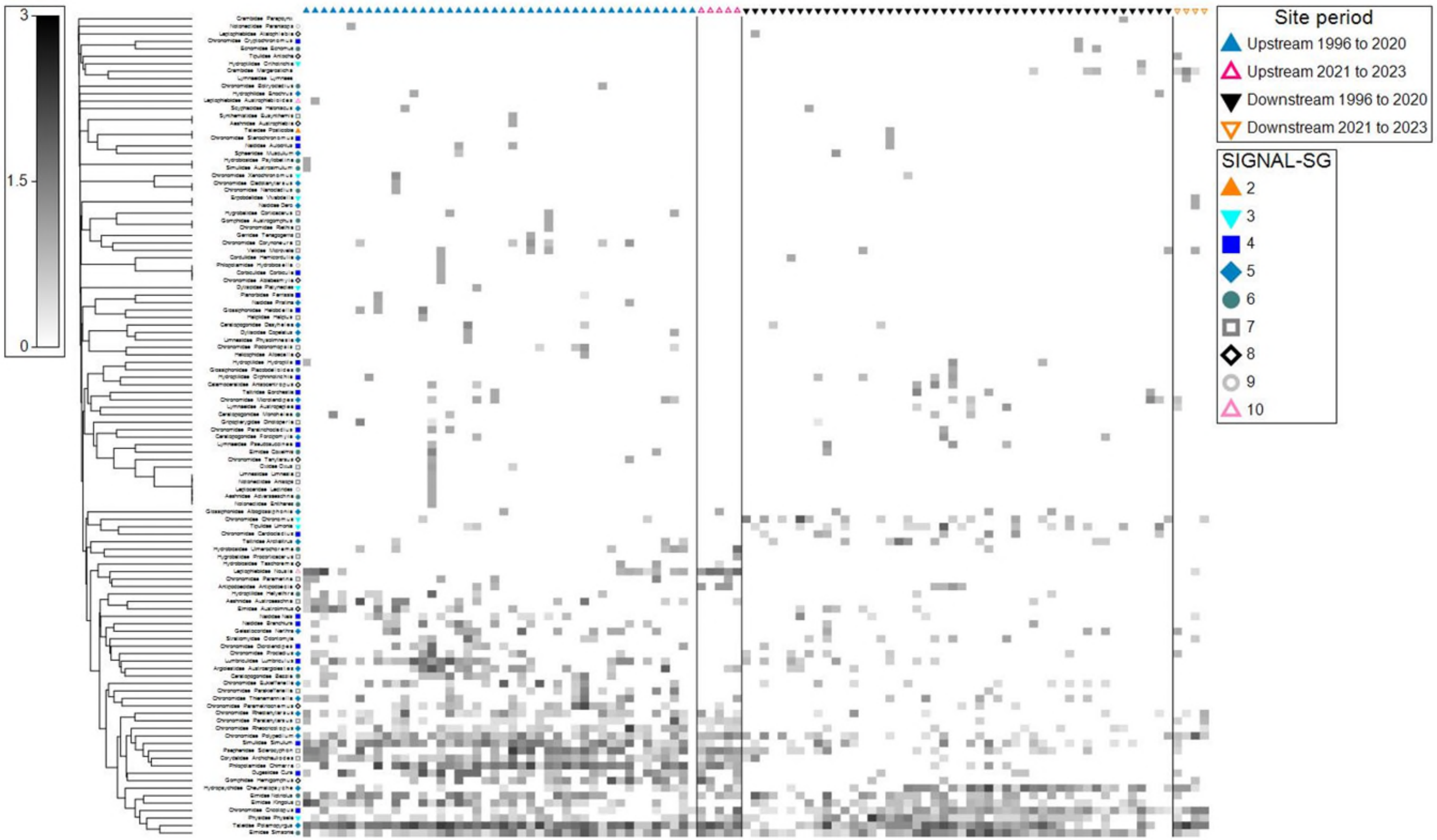
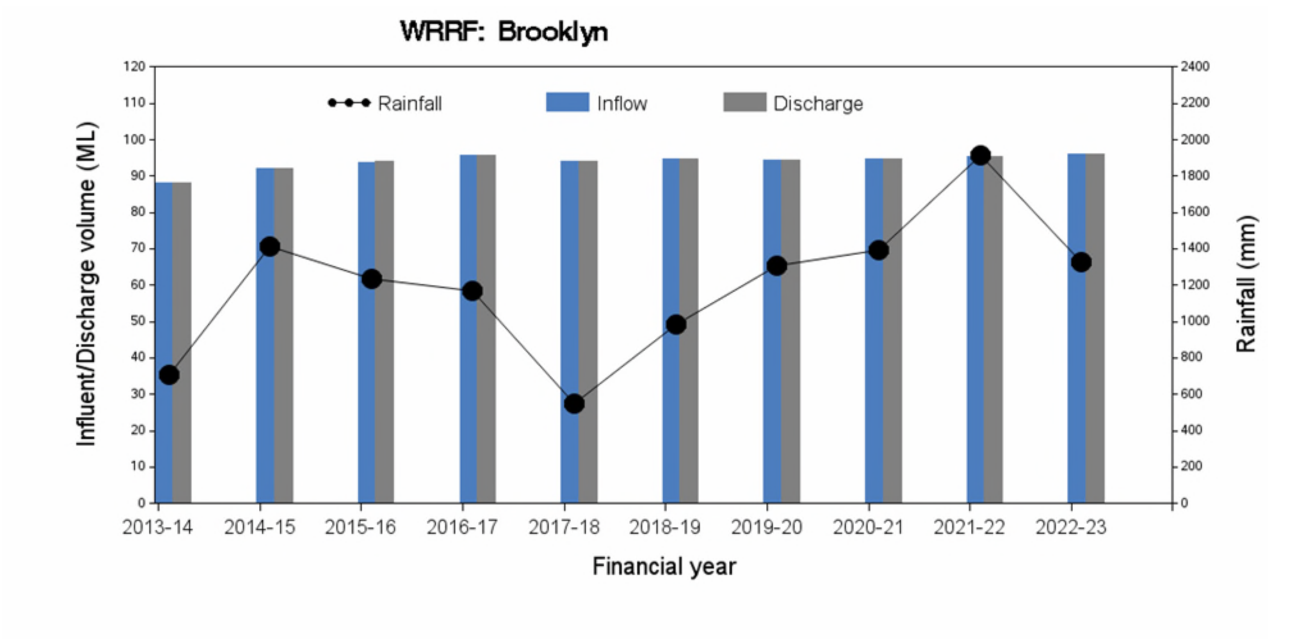


Figure A-52 Shade plot of freshwater macroinvertebrate riffle habitat community structure of upstream-downstream sites of Calna Creek near Hornsby Heights WRRF

A-15 Brooklyn WRRF

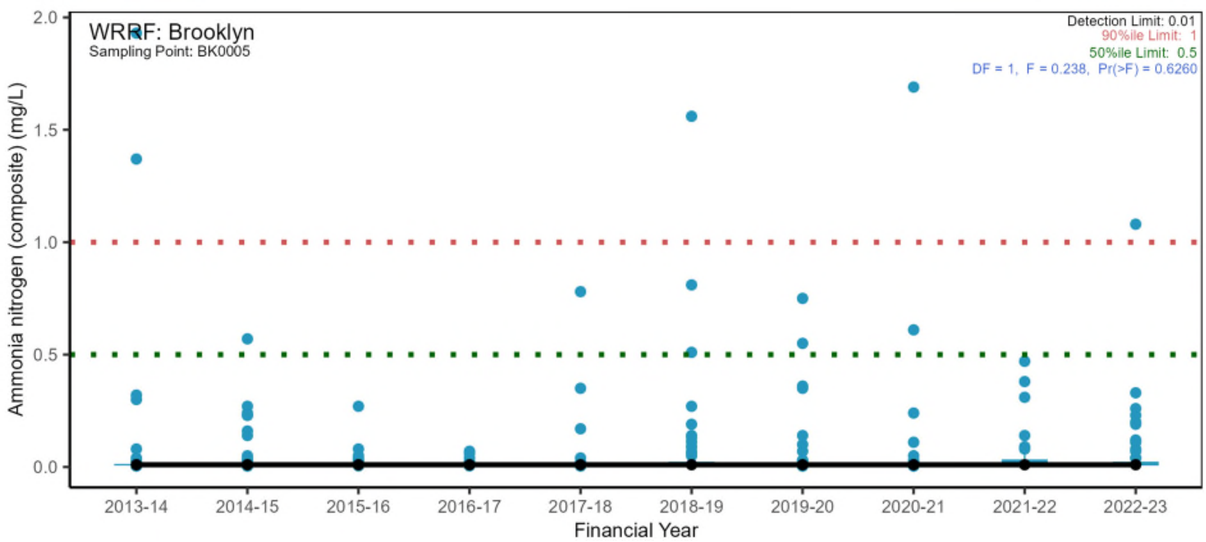
A-15.1 Pressure – Wastewater quantity

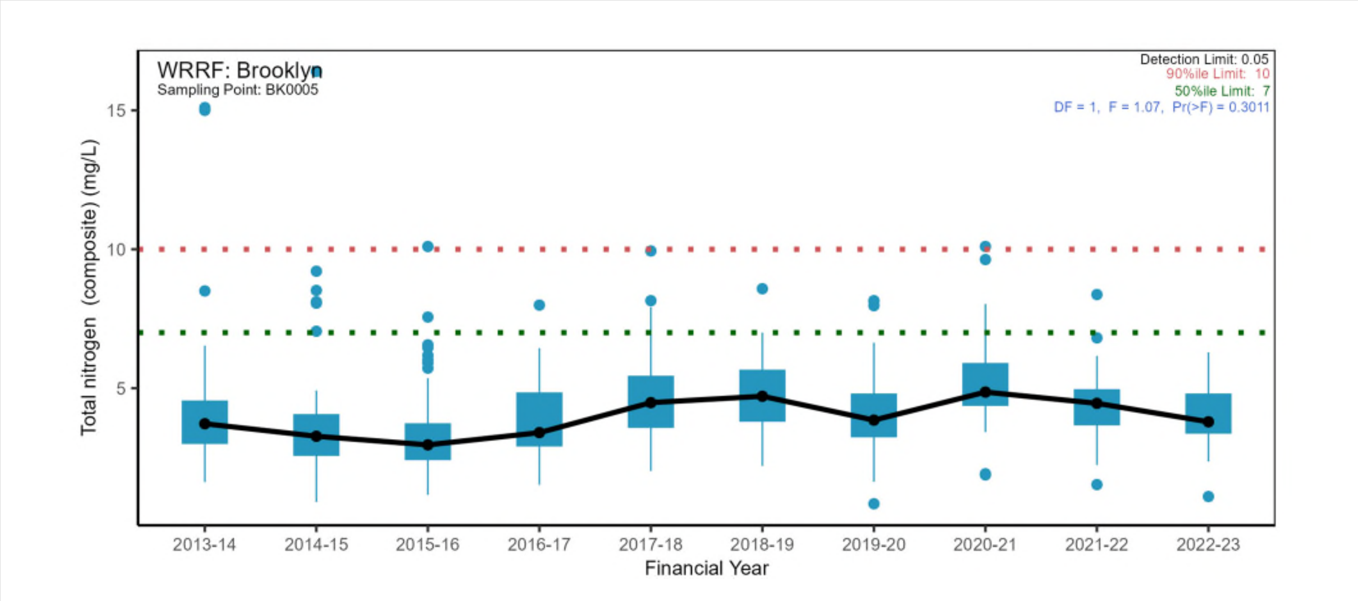
Inflow/ Discharge volume and rainfall

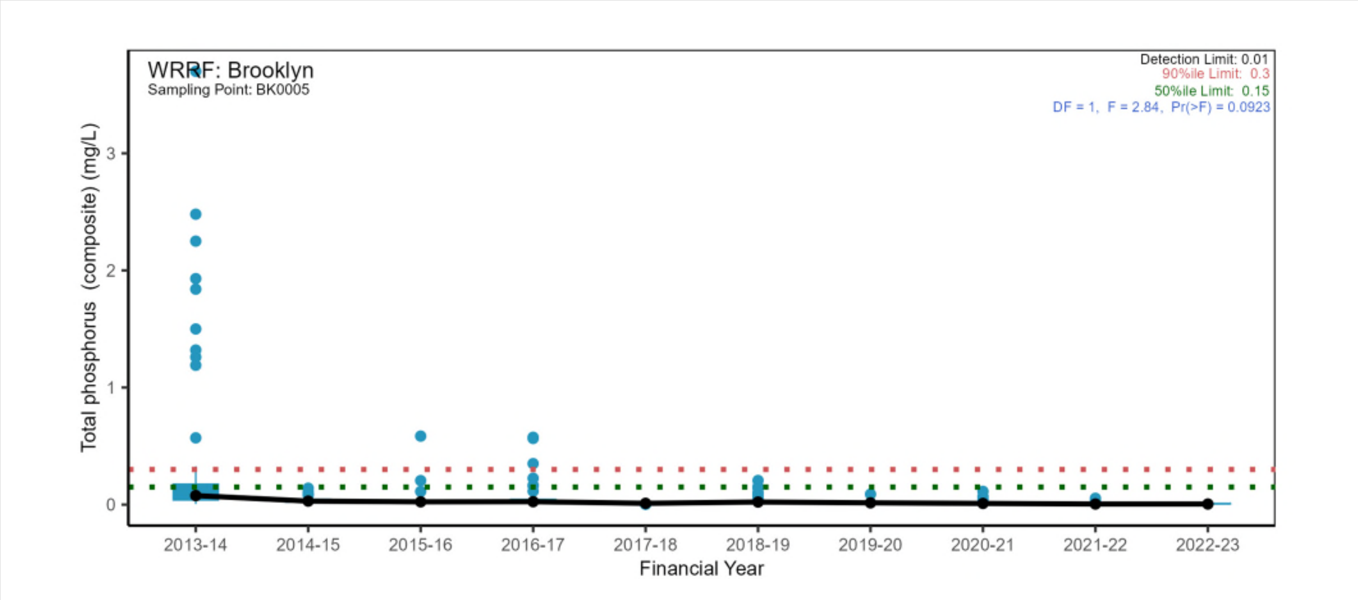


A-15.2 Pressure – Wastewater quality

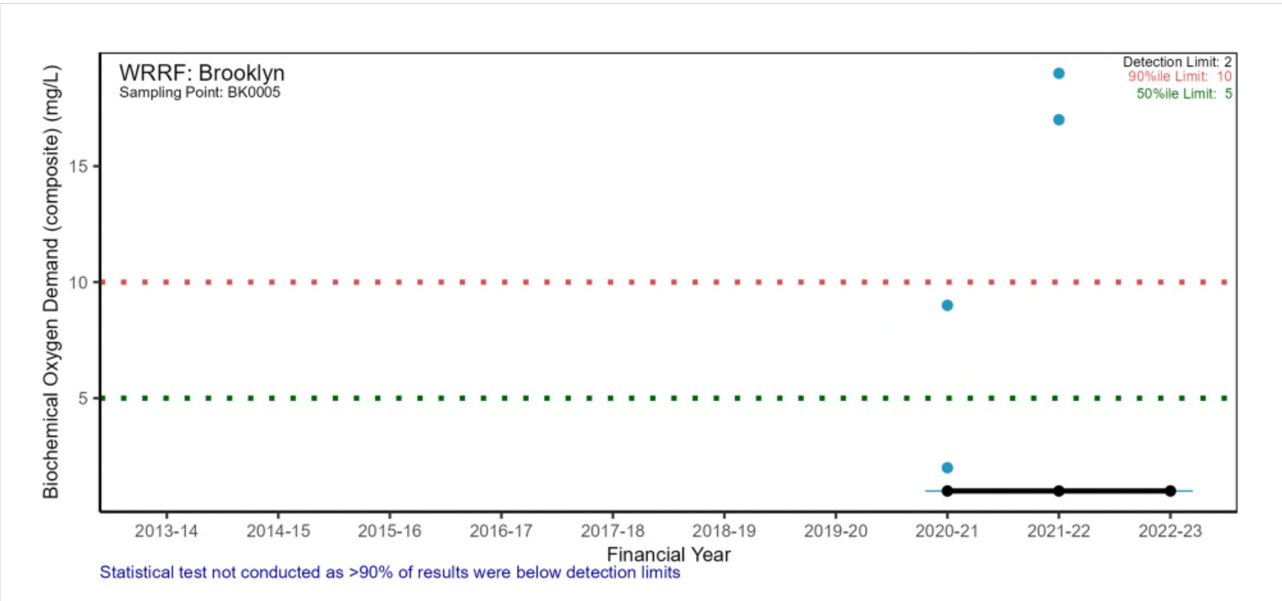
Nutrients

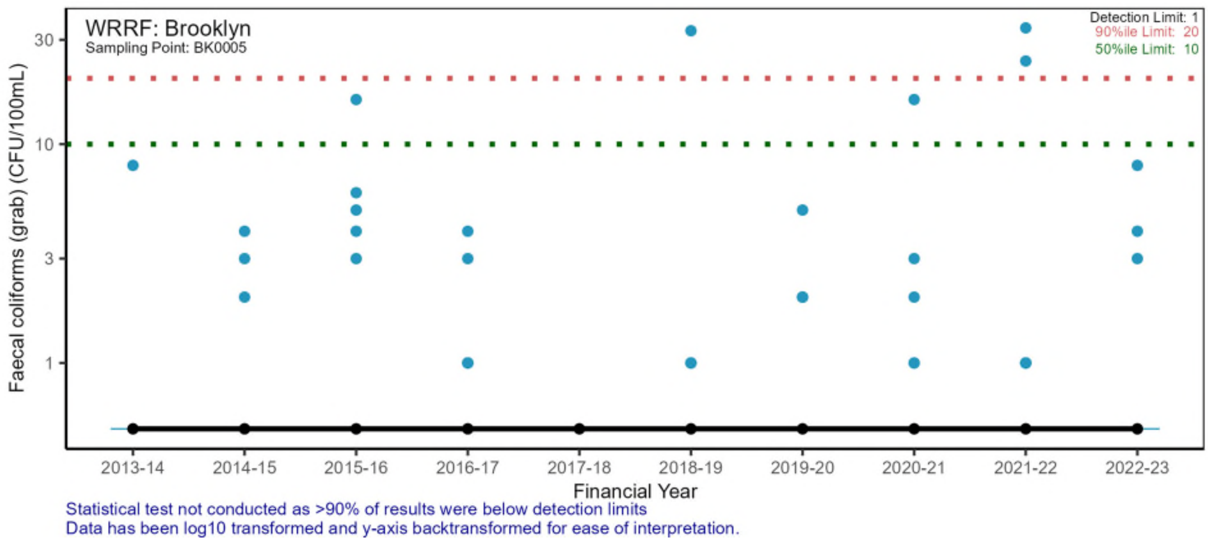


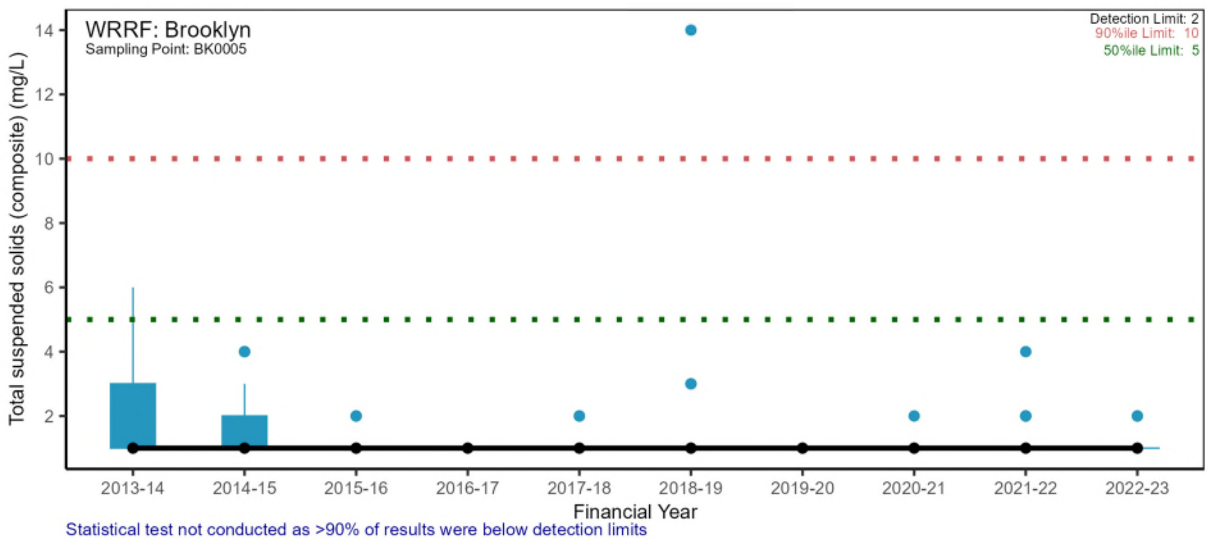




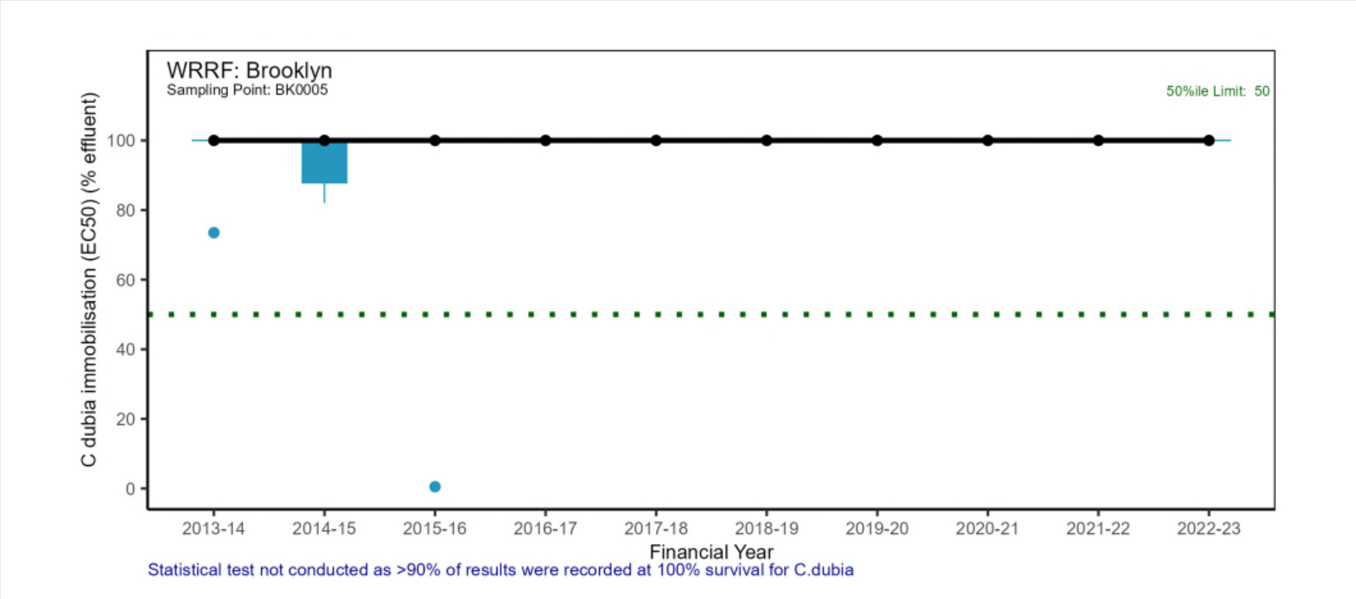
Major conventional analytes




WRRF: Brooklyn
Sampling Point: BK0005
Detection Limit: 1
90%ile Limit: 20
50%ile Limit: 10
Faecal coliforms (grab) (CFU/100mL)
Financial Year
Statistical test not conducted as >90% of results were below detection limits
Data has been log10 transformed and y-axis backtransformed for ease of interpretation.

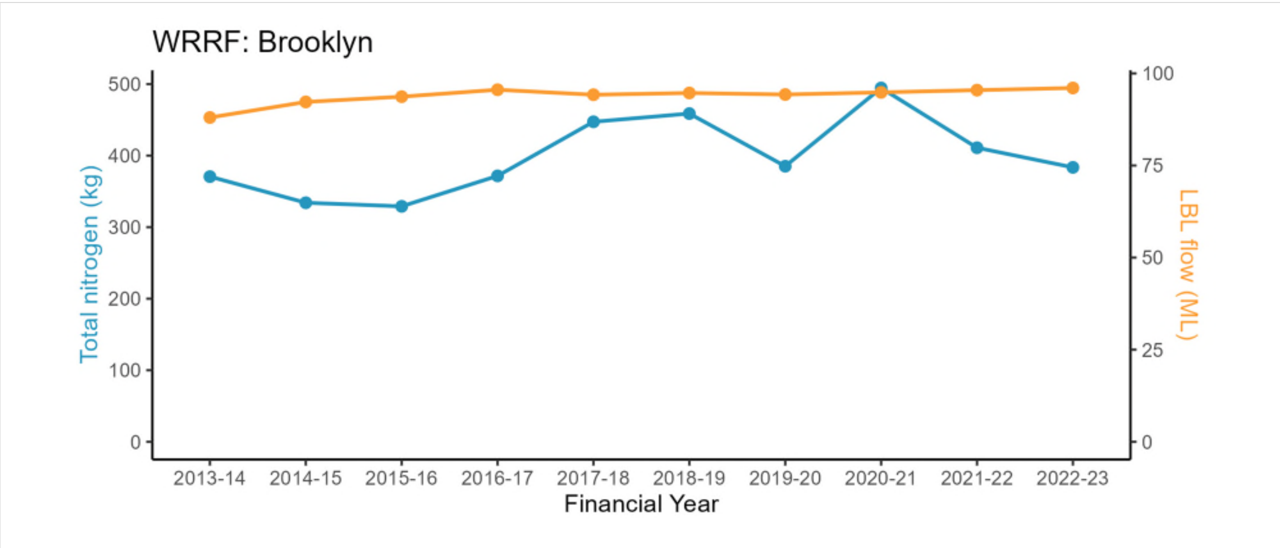

WRRF: Brooklyn
Sampling Point: BK0005
Detection Limit: 2
90%ile Limit: 10
50%ile Limit: 5
Total suspended solids (composite) (mg/L)
Financial Year
Statistical test not conducted as >90% of results were below detection limits

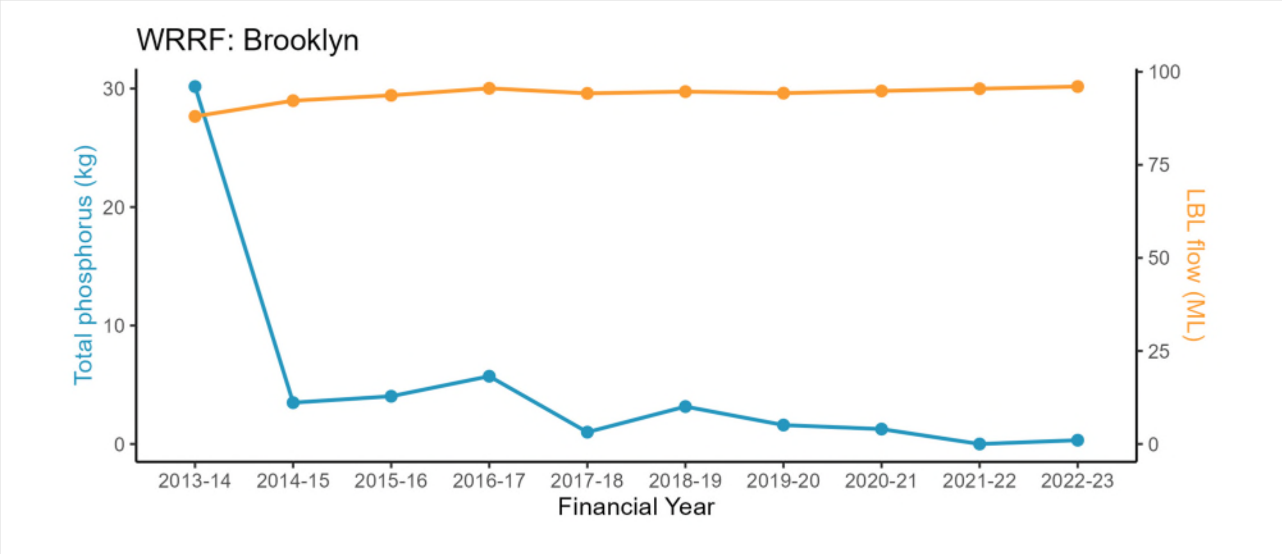
A-15.3 Pressure – Wastewater toxicity



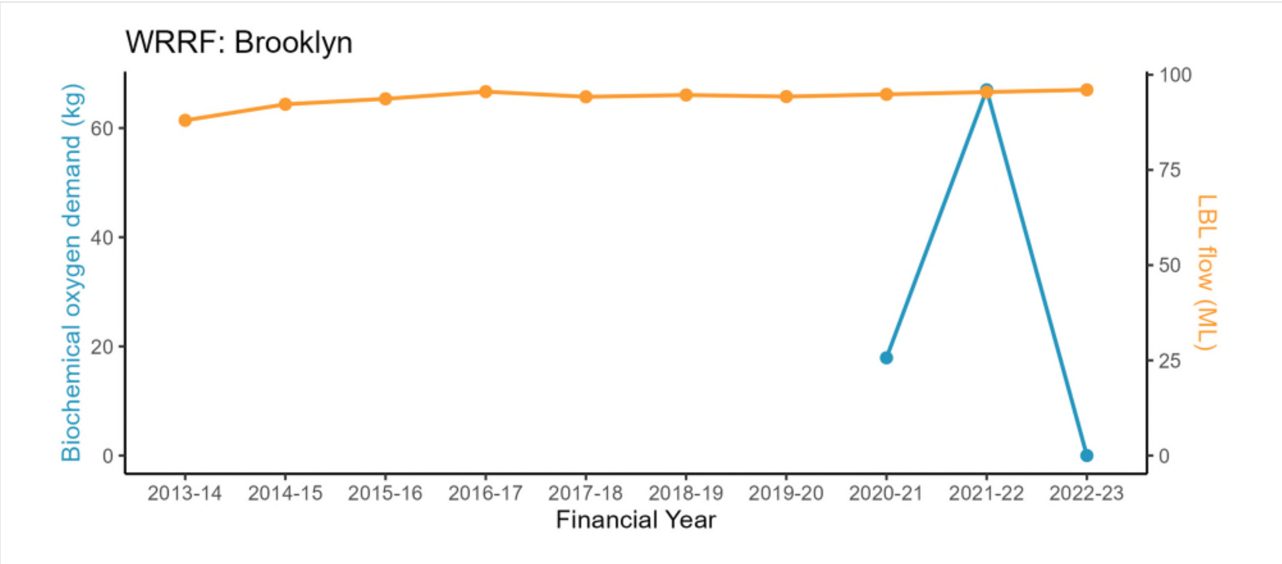
A-15.4 Pressure – Wastewater discharge load

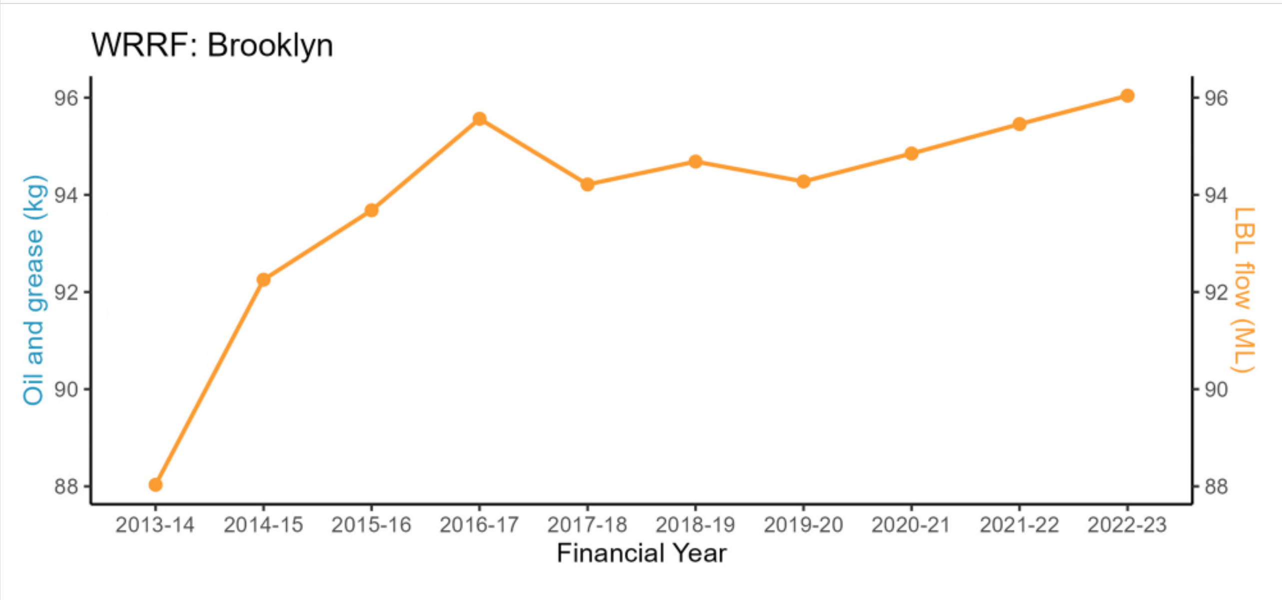
Nutrients

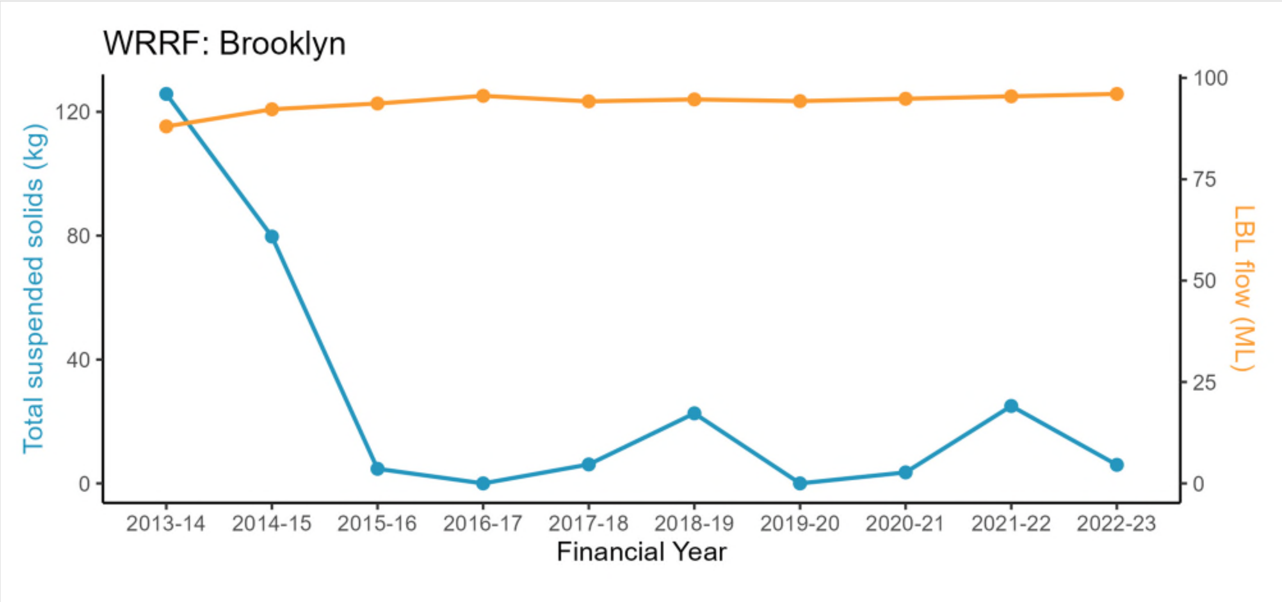




Major conventional analytes







A-15.5 Stressor – Nutrients

No previous monitoring data, Brooklyn outfalls are not recommended for regular monitoring in the revised STSIMP given treatment level, receiving environment, mixing and dilution, but this decision should be regularly reviewed.

A-15.6Stressor – Physico-chemical water quality

No previous monitoring data, Brooklyn outfalls are not recommended for regular monitoring in the revised STSIMP given treatment level, receiving environment, mixing and dilution, but this decision should be regularly reviewed

A-15.7 Ecosystem receptor – Phytoplankton

No previous monitoring data, Brooklyn outfalls are not recommended for regular monitoring in the revised STSIMP given treatment level, receiving environment, mixing and dilution, but this decision should be regularly reviewed

A-15.8 Ecosystem receptor – Macroinvertebrates

Brooklyn WRRF lies in the Hawkesbury estuary, where freshwater macroinvertebrate monitoring is not applicable due to factors such as tidal conditions, depth, and extremely high dilution of discharge (within 30 m) due to relatively high tidal currents in this lower reach of the estuary (see STSIMP Recommendations Report for further information).

A-16 EPL limits of the Hawkesbury-Nepean River WRRFs

Table A-75 EPL concentration limits for the Hawkesbury-Nepean River WRRFs (2022-23)

WRRF	Sampling Points	Nitrogen (Ammonia) (mg/L)		Total Nitrogen (mg/L)			Total Phosphorus (mg/L)			Biochemical Oxygen Demand (mg/L)		Chlorine (Total Residual) (mg/L)	Faecal Coliform (cfu/100mL)			pH (pH units)	Total Suspended Solids (mg/L)		*Ceriodaphnia dubia* (% effluent)
		50th %-ile	90th %-ile	50th %-ile	90th %-ile	100th %-ile	50th %-ile	90th %-ile	100th %-ile	50th %-ile	90th %-ile	90th %-ile	50th %-ile	80th %-ile	90th %-ile	50th %-ile	50th %-ile	90th %-ile	50th %-ile
Picton	PI0001 – discharge (G)	0.5	1	4.5	7		0.15	0.3		2	5			200			5	10	
	PI0011 – irrigation (G)	2	5	10	15		8	9		10	15		2000		10000	6.5 to 9.5	120	480	
	PI0013 – irrigation (G)	0.5	1	6	10		0.2	0.4		7	10			200		6.5 to 9.5	7	15	
West Camden	WC0005 (C), (G)	1[a]	3.5[a]	10	15		0.3	1		10	15	0.1		200			10	15	50
Wallacia	WL0004 (C), (G)	0.5	1	7.5	10		0.15	0.3		5	10			200			5	10	50
Penrith	PR0005 (C), (G)	1[b]	5[b]	10	15		0.2	0.4		10	15			200			5	10	
	PR0021 (G)											0.1							
	PR0022 (G)																		50
Winmalee[c]	WM0004 (C), (G)	2[c]	5[c]	15[c]	20[c]		2	3		10	15	0.1		200			10[c]	15[c]	50
North Richmond	NR0004 (C), NR0005 (G)	0.9	1.4	10	15		2	5		10	15			200			5	10	50
Richmond	RM0016 – discharge (G)	0.9	1.4	10	15		0.3	1		10	15	0.1		200			5	10	50
	RM0017 (C), (G)	1	5	10	15		0.3	1		10	15	5	10				10	15	
St Marys	SM0005 (C), (G)	0.9	1.4			45			5	10	15	0.1		200			5	10	50
Quakers Hill	QH0004 (C), QH0005 (G)	0.9	1.4			45			5	10	15	0.1		200			5	10	50
Riverstone	RS0003 (C), RS0004 (G)	0.9	1.4			45			5	10	15	0.1		200			5	10	50
Castle Hill	CH0005 (C), CH0006 (G)	0.9	1.4	20	25		0.3	1		7	10			200			5	10	50
Rouse Hill	RH0004 (C), (G)	0.9	1.4	10	15		0.2	0.4		4	5	0.1		200			5	8	50
Hornsby Heights	HH0005 (C), (G)	0.9	1.4	10	15		0.3	1		10	15			200			5	10	50
West Hornsby	WH0005 (C), (G)	0.9	1.4	10	15		0.3	1		10	15			200			5	10	50
Brooklyn	BK0005 (C), (G)	0.5	1	7	10		0.15	0.3		5	10		10		20		5	10	50

Note: Sample collection method (C) = Composite, (G) = Grab

[a] Values shown are West Camden WRRF's temporary ammonia nitrogen limits effective from 1 April 2022. Prior to this date the ammonia nitrogen 50th and 90th percentile limits were 0.9 and 1.4, respectively.

[b] Values shown are Penrith WRRF's temporary ammonia nitrogen limits effective from 19 May 2023. Prior to this date the ammonia nitrogen 50th and 90th percentile limits were 0.9 and 1.4, respectively.

[c] Values shown are Winmalee WRRF limits during facility upgrades. These were effective from 7 April 2021 (Clause L3.9 in the licence).

WRRF	Sampling Points	Aluminium (µg/L)		Cadmium (µg/L)		Chromium (µg/L)		Copper (µg/L)		Iron (µg/L)		Nickel (µg/L)		Zinc (µg/L)		Diazinon (µg/L)		Un-ionised H_2S (µg/L)		Nonylphenol ethoxylates (µg/L)	
		90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average	90th %-ile	Average
Picton	PI0001 – discharge (G)																				
	PI0011 – irrigation (G)																				
	PI0013 – irrigation (G)																				
West Camden	WC0005 (C), (G)	500	130					5	4	240	170			37	31	0.1	0.2	60	30		
Wallacia	WL0004 (C), (G)	85	81					31	18					26	20			60	30	580	64
Penrith	PR0005 (C), (G)	270	200	0.2	0.2			9	8	350	330			180	60			60	30		
	PR0021 (G)																				
	PR0022 (G)																				
Winmalee	WM0004 (C), (G)	270	190					9	7	880	650			33	25	0.1	0.2				
North Richmond	NR0004 (C), NR0005 (G)	873	500					7	5	180	95			57	44	0.1	0.2	60	30		
Richmond	RM0016 – discharge (G)																				
	RM0017 (C), (G)																				
St Marys	SM0005 (C), (G)	200	120					8	6	96	156	16.9	12.3	46	37	0.1	0.2	60	30		
Quakers Hill	QH0004 (C), QH0005 (G)	190	120	0.3	0.2	4	3	6	5					41	34			60	30		
Riverstone	RS0003 (C), RS0004 (G)	240	133					6	5	96	55			56	31			60	30		
Castle Hill	CH0005 (C), CH0006 (G)	400	160	0.2	0.2			11	8	1100	360			37	29	0.1	0.2	60	30		
Rouse Hill	RH0004 (C), (G)	340	220					7	5	52	37			39	33						
Hornsby Heights	HH0005 (C), (G)	1100	420					12	8	1900	520			42	19	0.1	0.2	60	30		
West Hornsby	WH0005 (C), (G)	620	330					17	8	1500	490			40	26			60	30		
Brooklyn	BK0005 (C), (G)																				

Note: Sample collection method (C) = Composite, (G) = Grab

Table A-76 EPL load limits for the Hawkesbury-Nepean River WRRFs (2022-23)

Load limits (kg) 2022-23	Picton	West Camden	Wallacia	Penrith	Winmalee	North Richmond	Richmond	St Marys	Quakers Hill	Riverstone	Castle Hill	Rouse Hill	Hornsby Heights	West Hornsby	Brooklyn
Total Suspended Solids	2,400	39,420	8,760	144,540	67,160	10,585	37,595	195,275	96,360	20,075	42,705	100,375	42,705	86,140	-
Biological Oxygen Demand	2,400	37,230	8,395	136,510	67,160	7,300	26,280	184,325	96,360	18,980	39,420	94,900	39,420	79,570	-
Total Nitrogen	4,400	91,980	12,410	176,660	110,595	7,118	43,800	222,000	222,000	222,000	72,270	124,100	72,270	80,300	-
Total Phosphorus	80	2,190	1,606	8,030	6,687	803	10,877	2,300	2,300	2,300	2,300	4,453	2,300	4,643	-
Oil & Grease	292	12,045	1,132	44,165	28,762	3,650	6,388	59,495	40,150	6,169	11,498	30,843	11,498	23,287	-
Cadmium				5.03				0.76	2.21						
Chromium				6.58				18.42	96.36						
Copper				154.8				559.36	349.14						
Lead				48.18				31.58	48.18						
Mercury				0.44				0.43	4.82						
Selenium				240.9				339.45	240.9						
Zinc				2,312.83				1,893.32	1,953.97						
Pesticides				7				6.88	7.5						