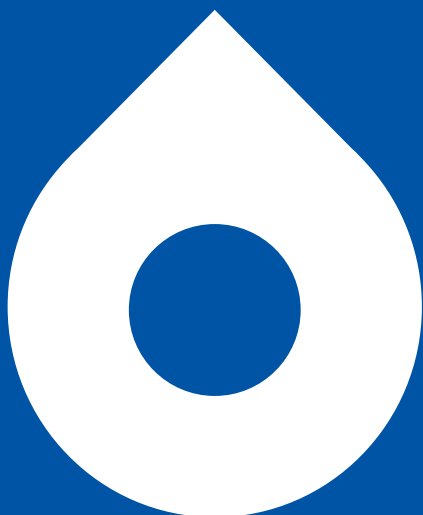


Sydney Water Aquatic Monitoring Program

Volume 2: Appendix A
Interpretive Report 2024-25



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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.

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. Trend plots on other supplementary data are also included to improve our understanding on:

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

Wastewater quality and load plots are included in the following four sub-groups, and then within each sub-group, analytes are 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. Summary statistics are included as electronic appendices sent to the EPA.

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 the mainstream river (if any).

Statistical analysis outcome tables on paired sites for all monitoring analytes are presented first before the plots for each WRRF section e.g. A.1.5 Stressor and Ecosystem receptor – Statistical analysis outcomes for Picton WRRF.

- Upstream vs downstream (current period) contrast outcomes for paired tributary and/or mainstream river sites, e.g. upstream vs downstream Stonequarry Creek (N911B vs N911) and Nepean River (N92 vs N91) at Picton WRRF.
- Current period vs previous period comparison for each individual site, e.g. current period (2024-25) vs past period (2015-16 to 2023-24) for Nepean River site N91 at Picton WRRF.

The previous data period varies from nine years for most sites and analytes, with the exception of total and filterable metals and soluble reactive phosphorus (two years) and some paired tributary sites (two to six years).



Other supplementary outcomes from statistical analysis on e.g. ANOVA and estimated marginal means on paired and SoE waterway sites are included as electronic appendices sent to the EPA.

Paired boxplots and needle plots for each site are presented in the following three sub-groups and order:

- Nutrients
 - Ammonia nitrogen
 - Oxidised nitrogen
 - Total nitrogen
 - Soluble reactive phosphorus
 - Total phosphorus
- Physico-chemical analytes
 - Conductivity
 - Dissolved oxygen (mg/L)
 - Dissolved oxygen saturation (%)
 - pH
 - Water temperature
 - Turbidity
- Trace metals
 - Filterable aluminium
 - Total aluminium
 - Filterable cobalt
 - Total cobalt
 - Filterable copper
 - Total copper
 - Filterable nickel
 - Total nickel
 - Filterable zinc
 - Total zinc

Analytes included for the receiving water quality are in accordance with Sydney Water Aquatic Monitoring (SWAM, Sydney Water 2023).

For the ecosystem receptor, the following two approaches were taken:

- Phytoplankton (paired boxplots and needle plots)
 - Chlorophyll-a

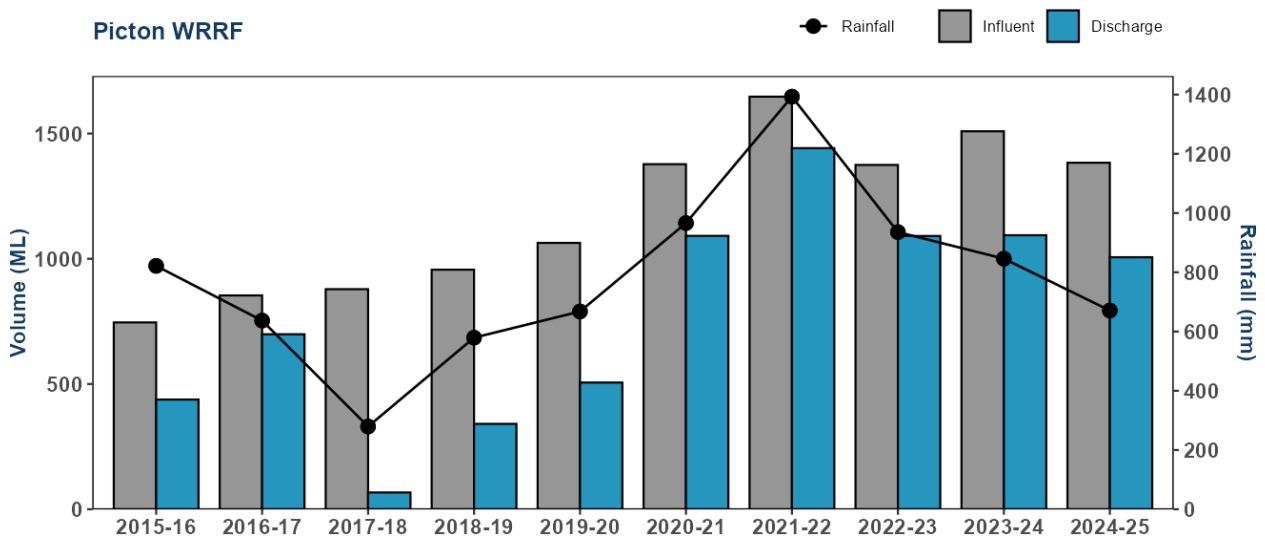
- Macroinvertebrates
 - Univariate statistical analysis outcomes

Water quality trend plots and needle plots for two macroinvertebrate monitoring sites (N92A and N57A) are presented as a separate sub-section at the end of Appendix C-2. The sequence on these box plots and needle plots of are same as those described above for the paired sites.

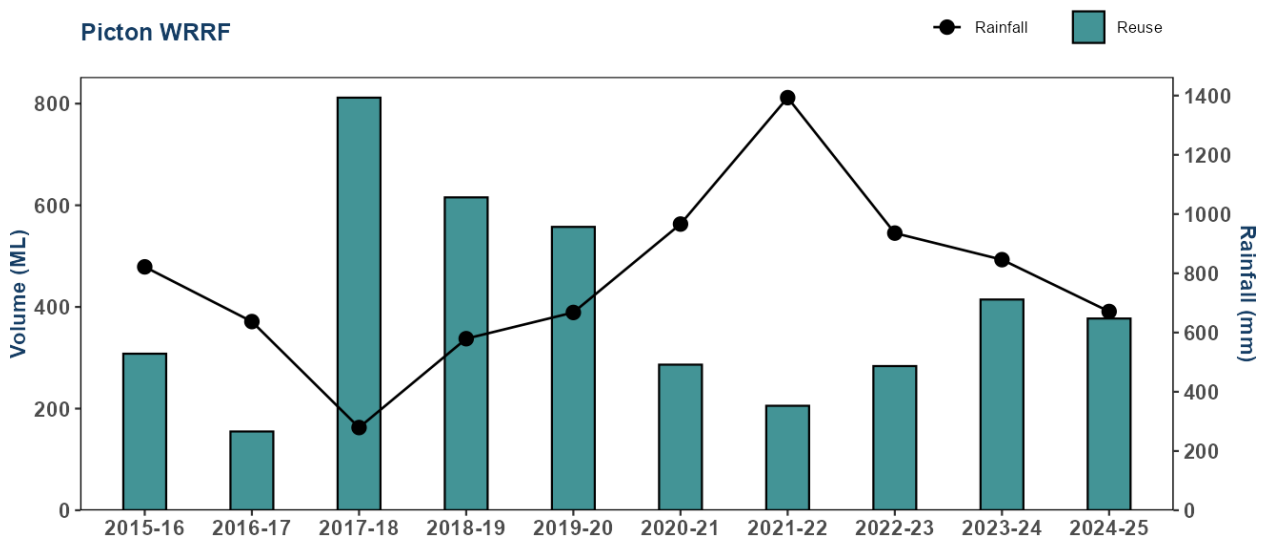
A.1. Picton WRRF

A.1.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



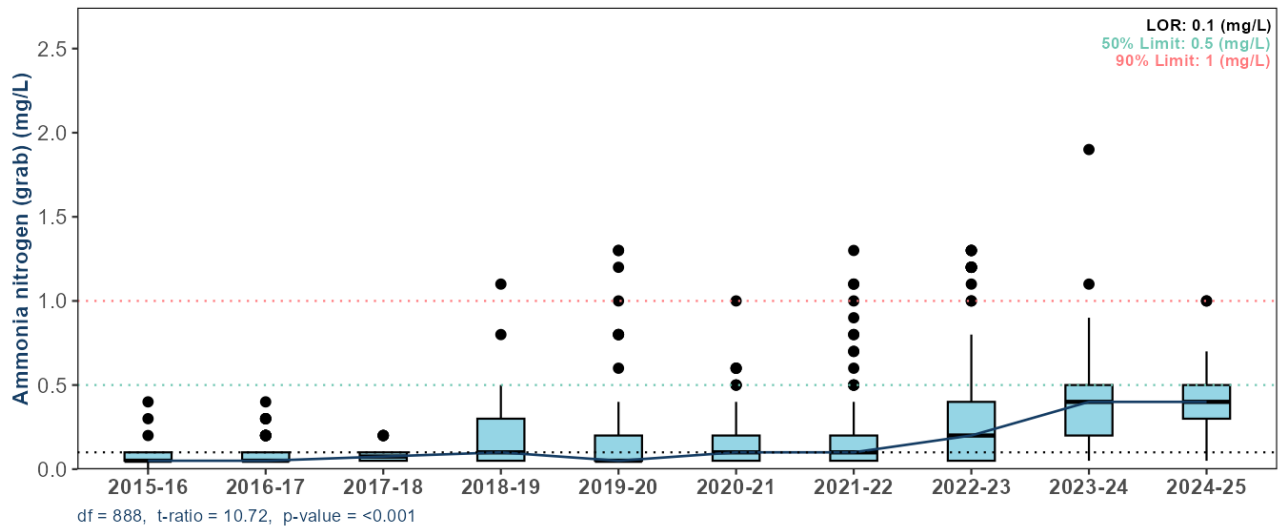
Reuse volume and rainfall



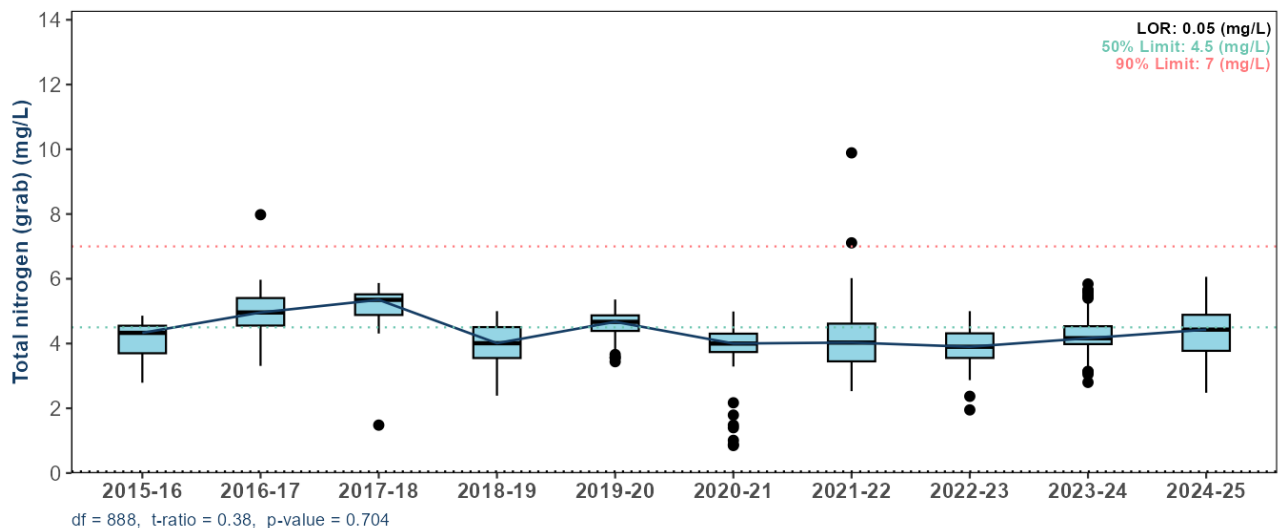
A.1.2. Pressure – Wastewater quality

Nutrients: PI0001 Precautionary discharge

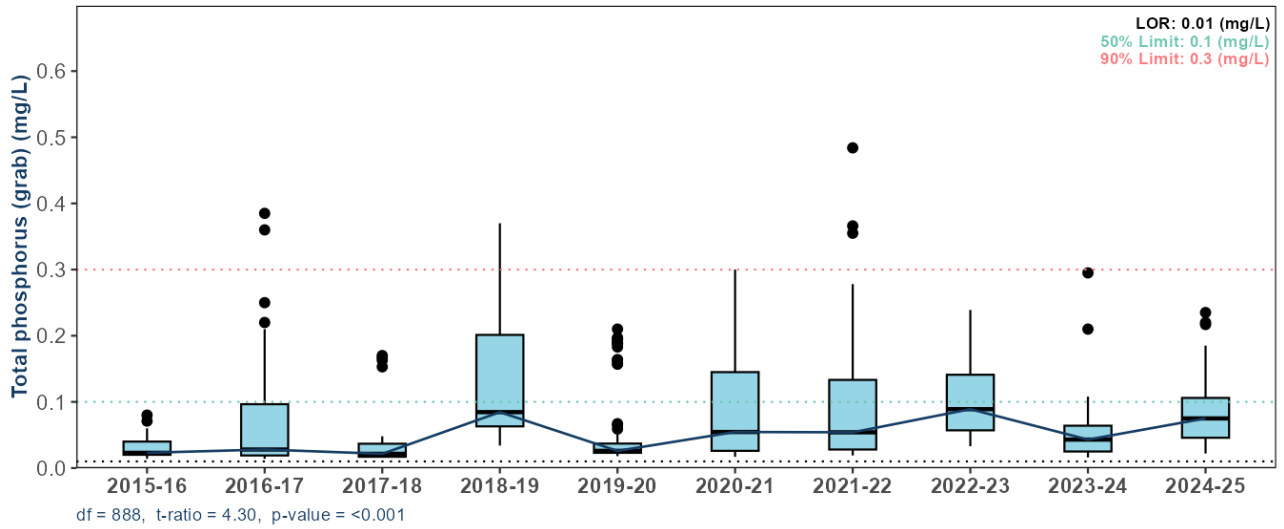
PI0001 at Picton WRRF



PI0001 at Picton WRRF

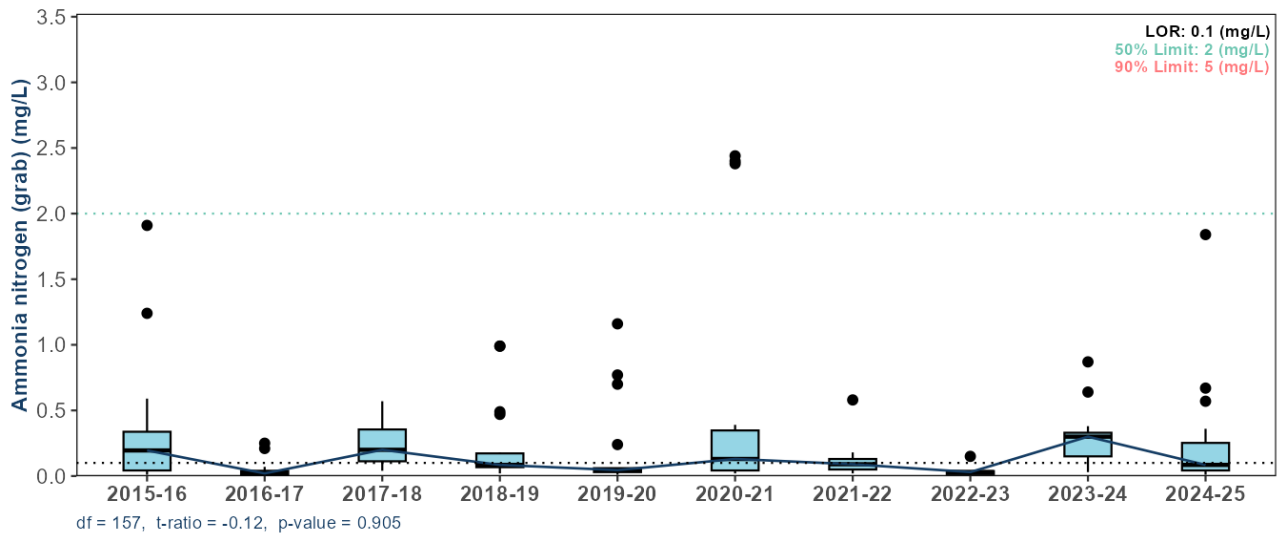


PI0001 at Picton WRRF

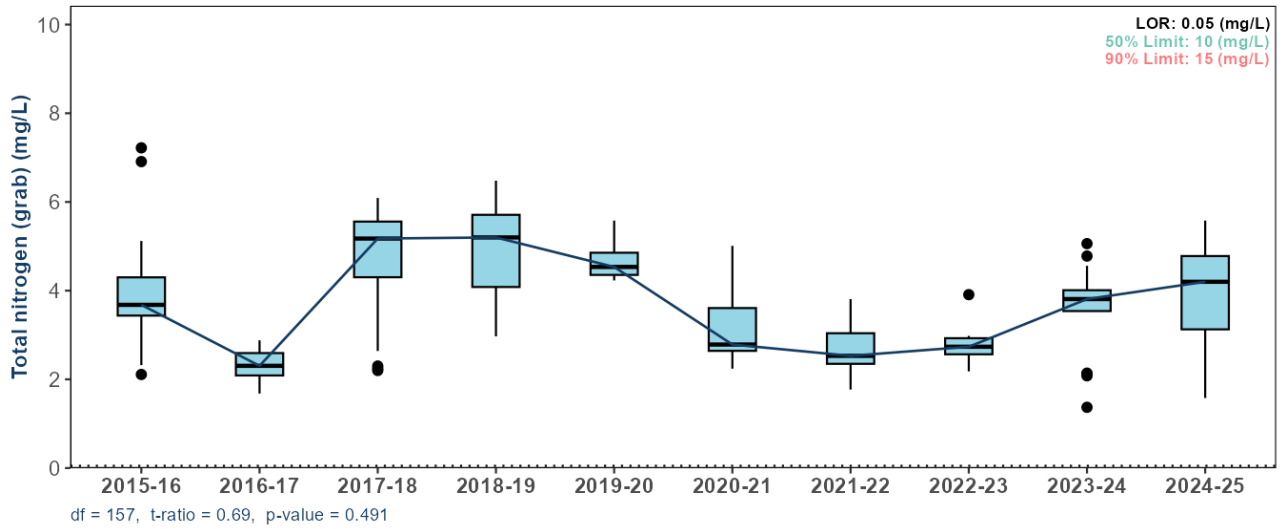


Nutrients: PI0011 Irrigation

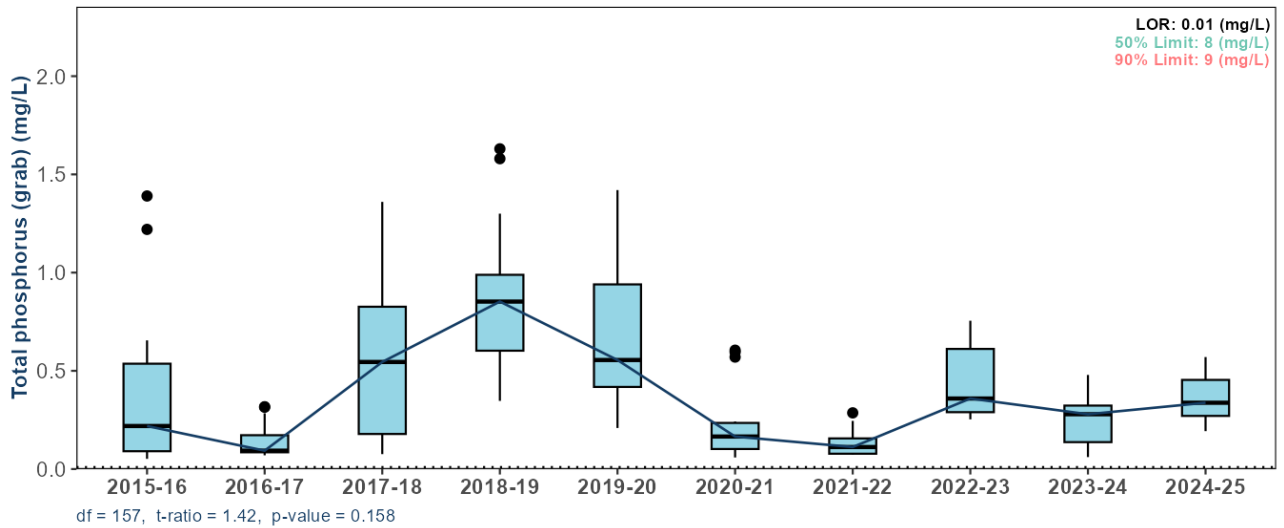
PI0011 at Picton WRRF



PI0011 at Picton WRRF

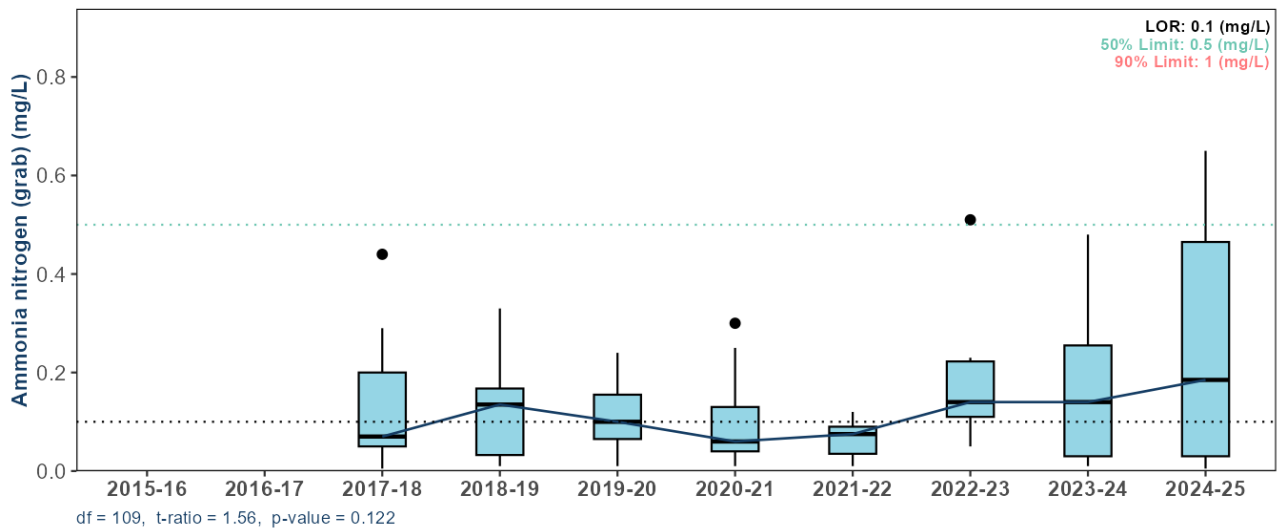


PI0011 at Picton WRRF

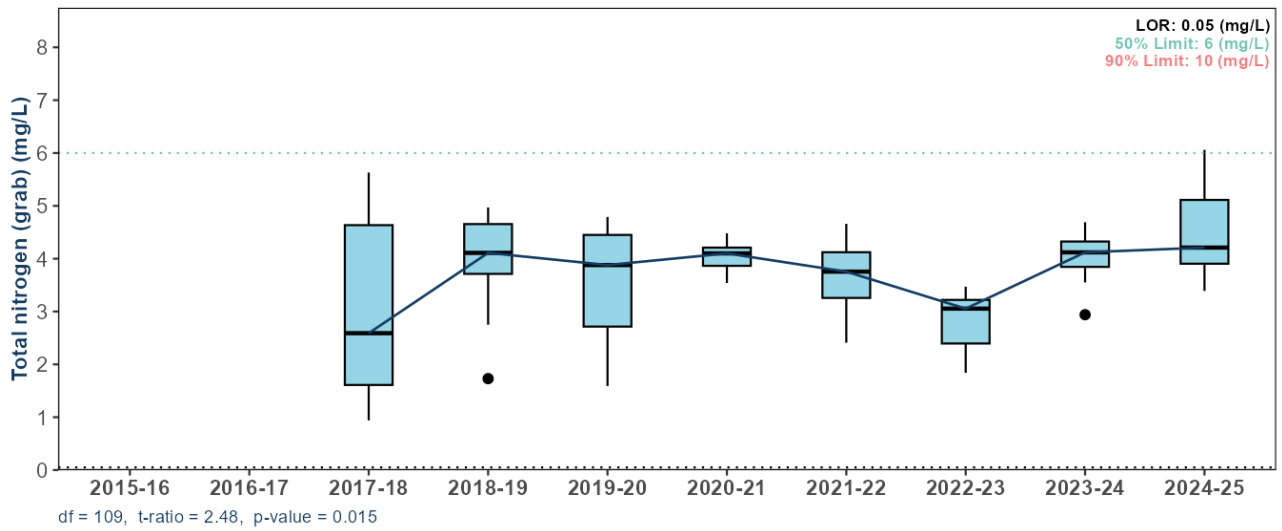


Nutrients: PI0013 Irrigation

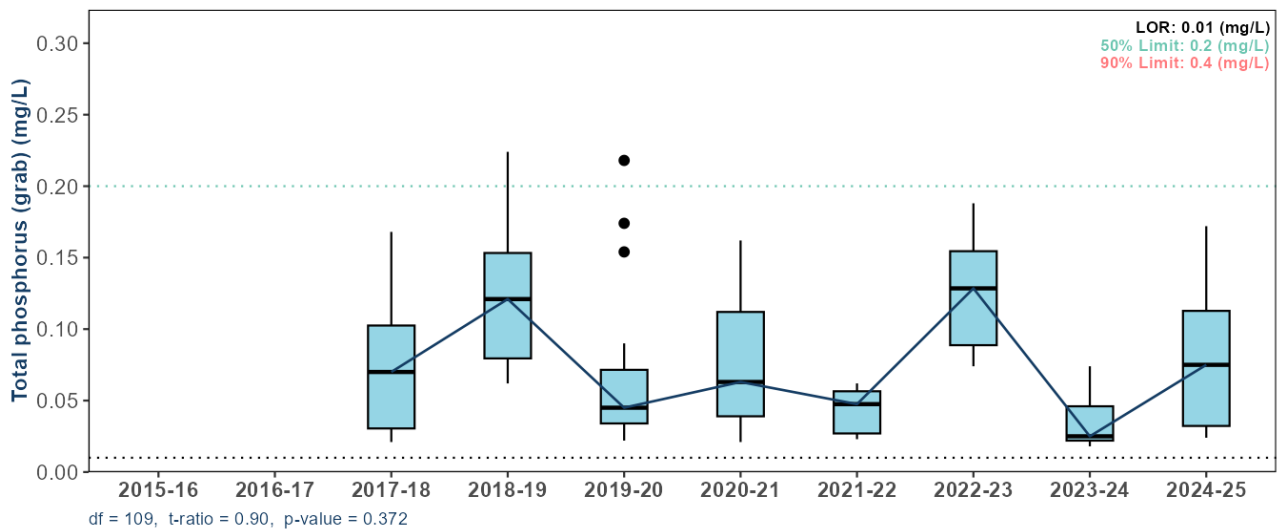
PI0013 at Picton WRRF



PI0013 at Picton WRRF

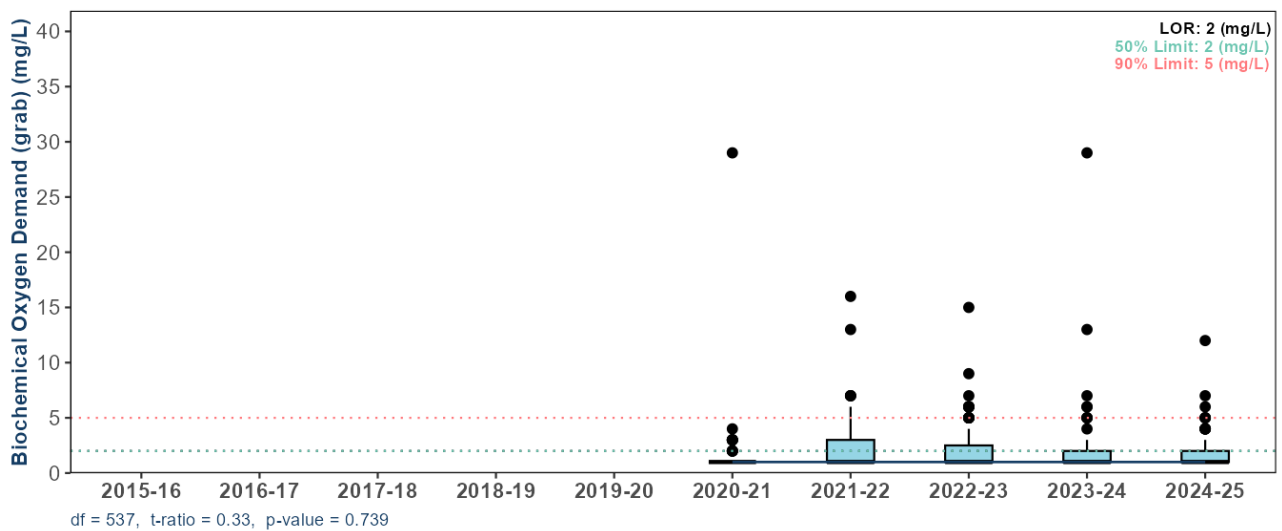


PI0013 at Picton WRRF

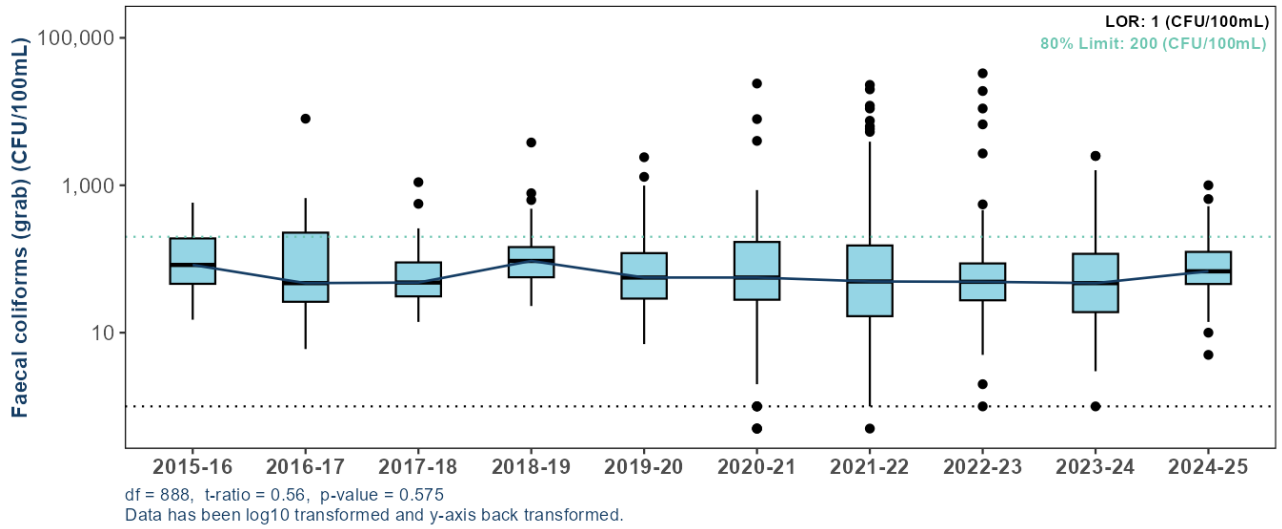


Major conventional analytes: PI0001 Precautionary discharge

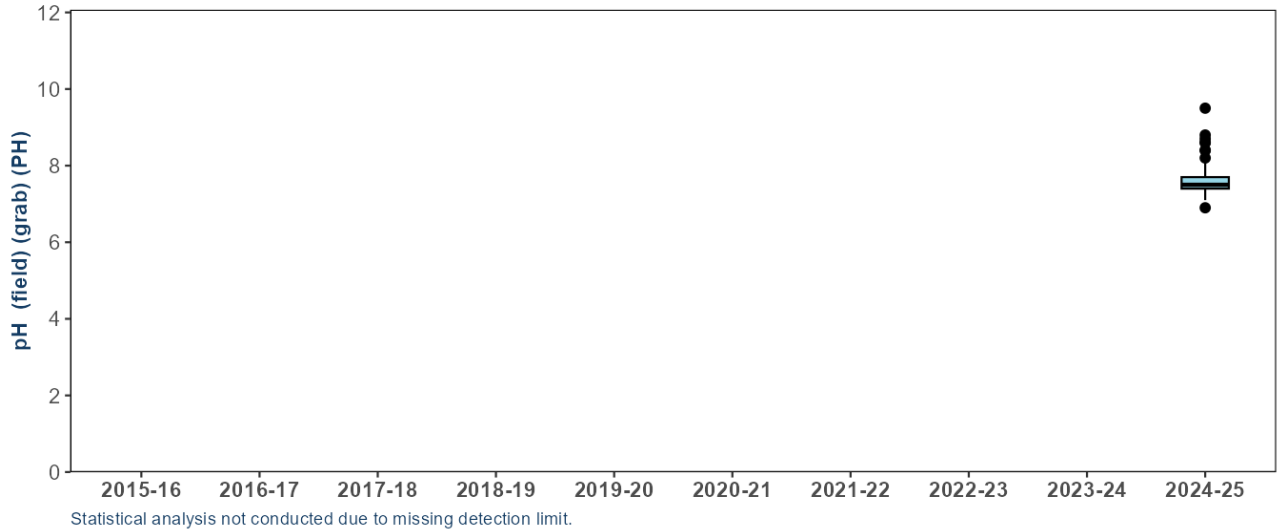
PI0001 at Picton WRRF



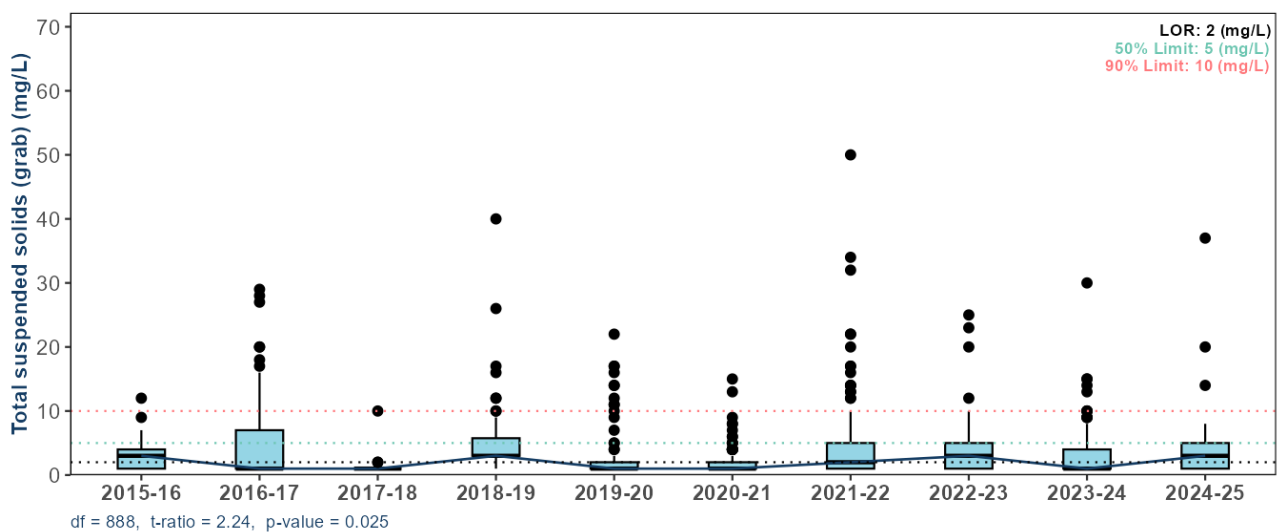
PI0001 at Picton WRRF



PI0001 at Picton WRRF

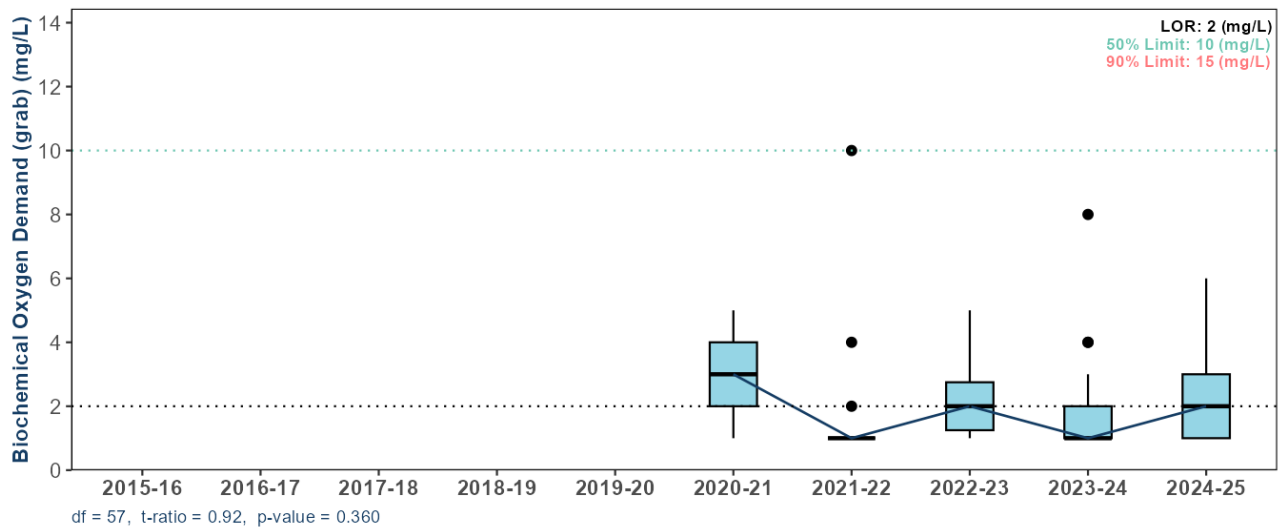


PI0001 at Picton WRRF

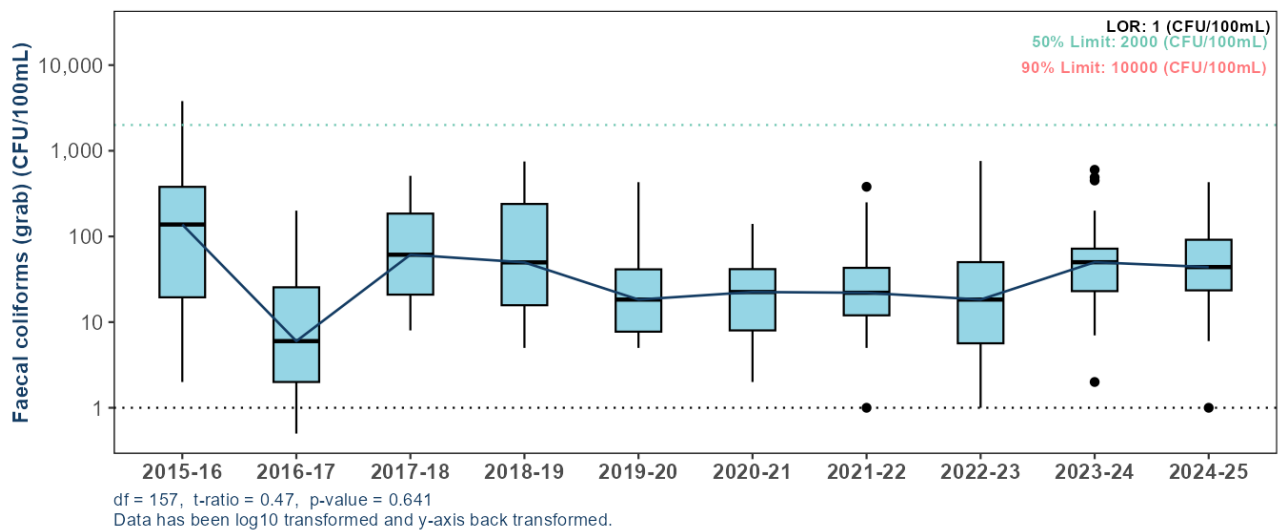


Major conventional analytes: PI0011 Irrigation

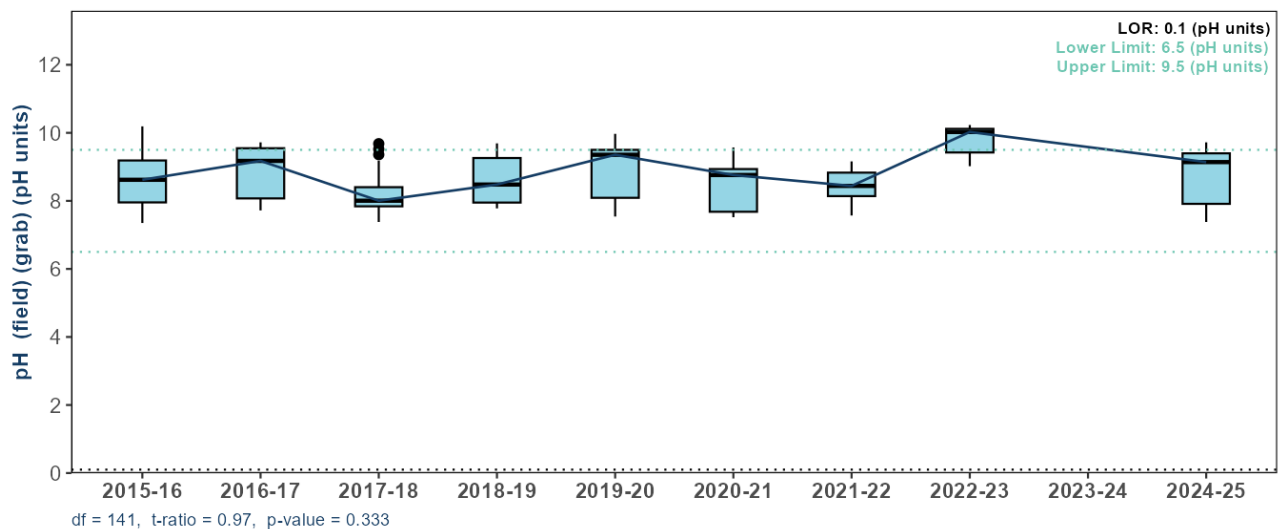
PI0011 at Picton WRRF



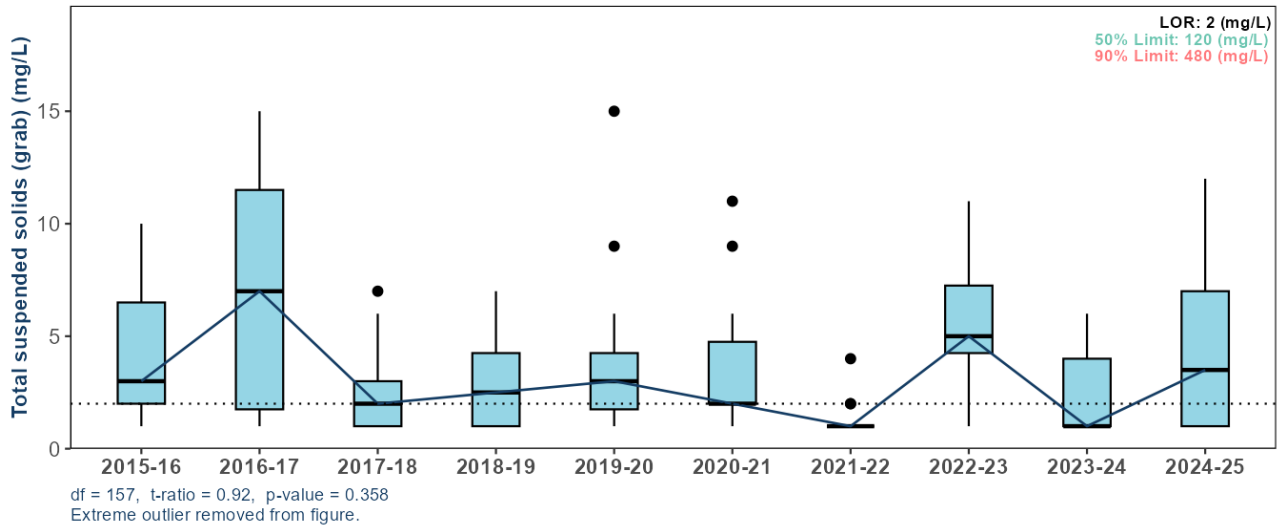
PI0011 at Picton WRRF



PI0011 at Picton WRRF

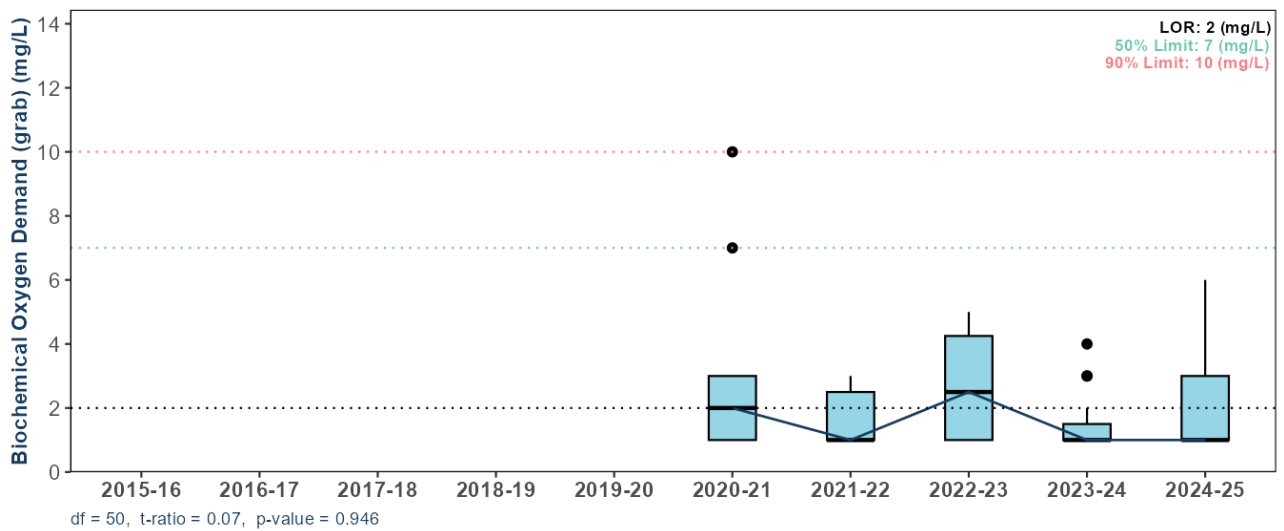


PI0011 at Picton WRRF

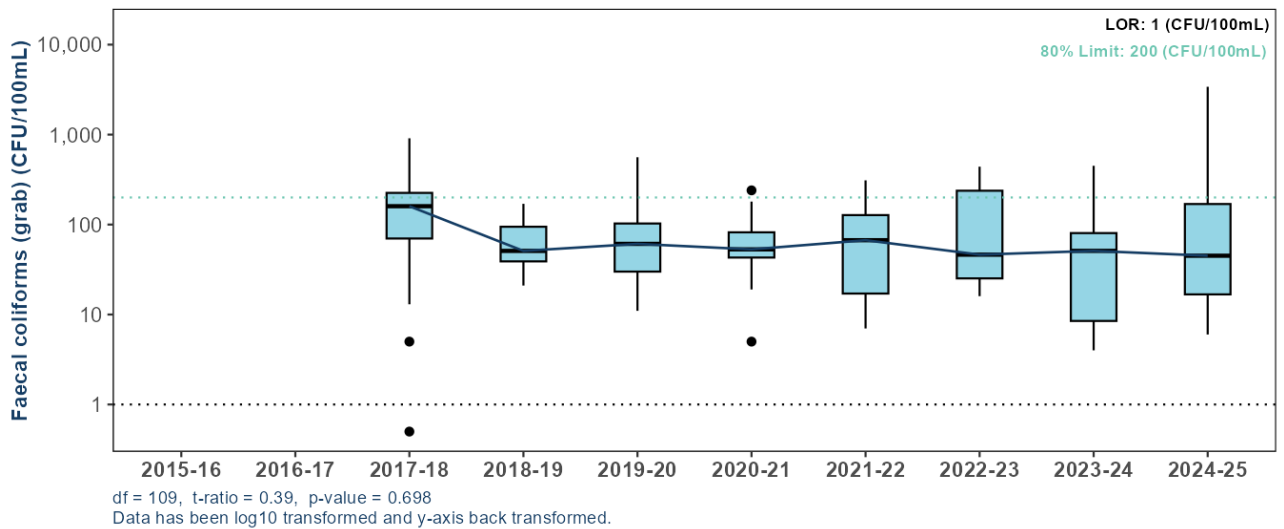


Major conventional analytes: PI0013 Irrigation

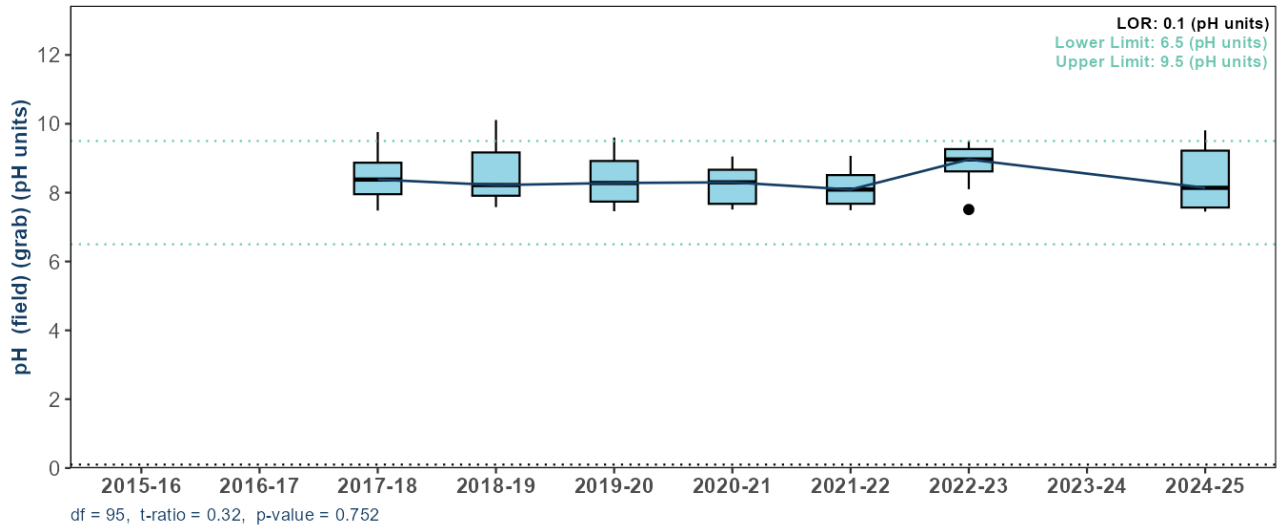
PI0013 at Picton WRRF



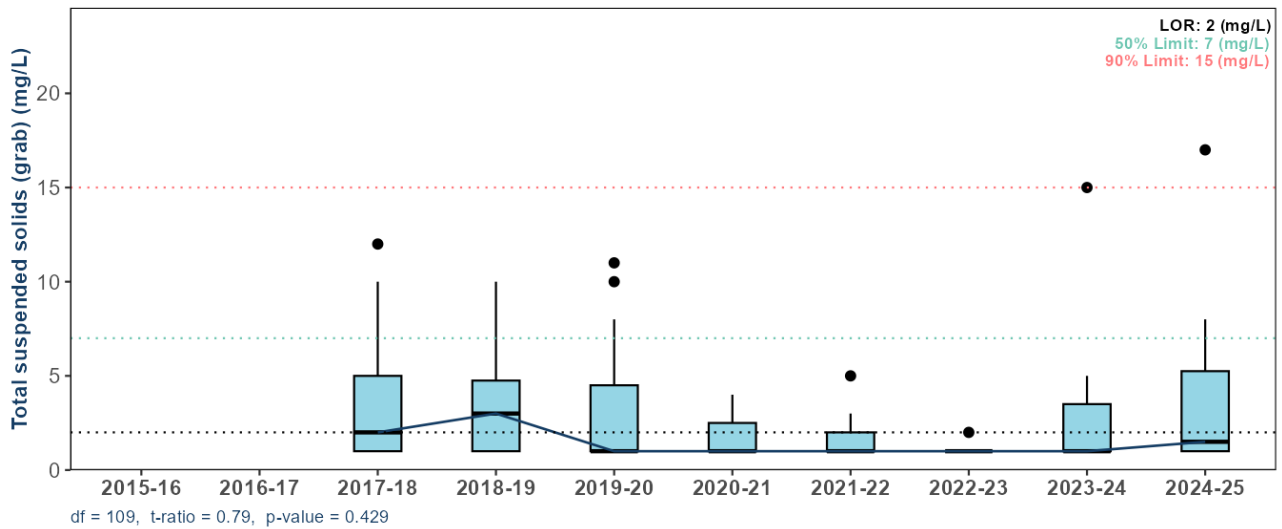
PI0013 at Picton WRRF



PI0013 at Picton WRRF



PI0013 at Picton WRRF

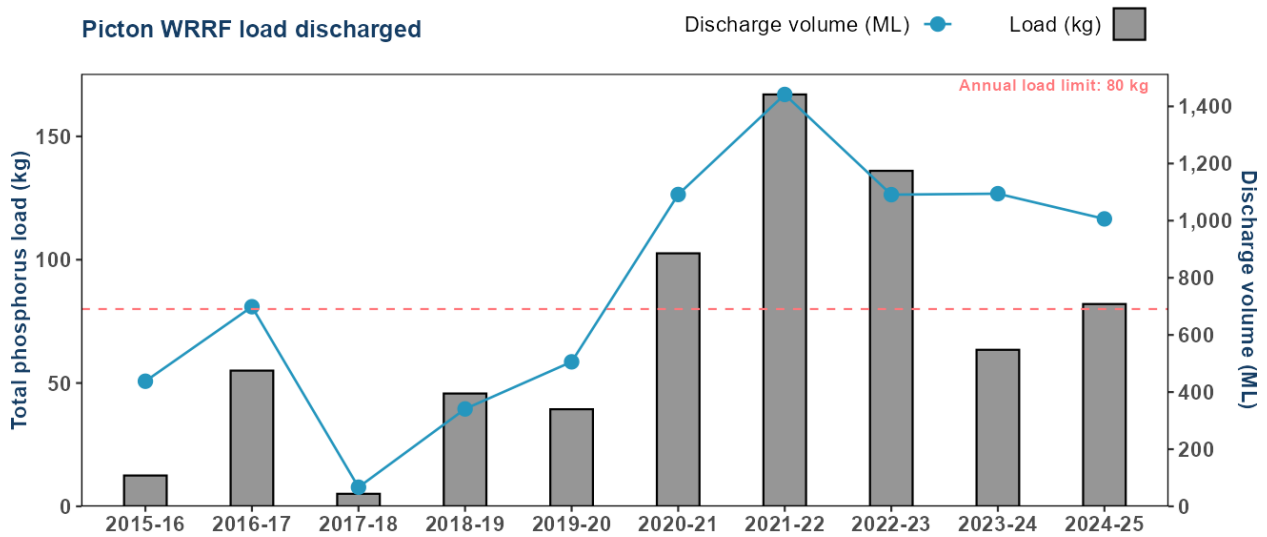
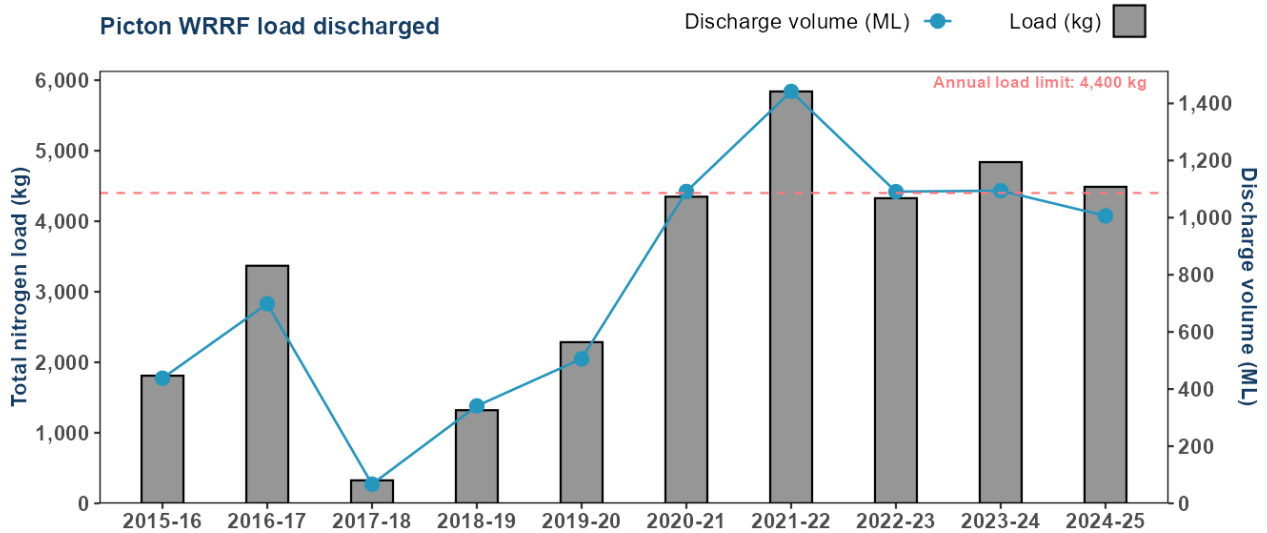


A.1.3. Pressure – Wastewater toxicity

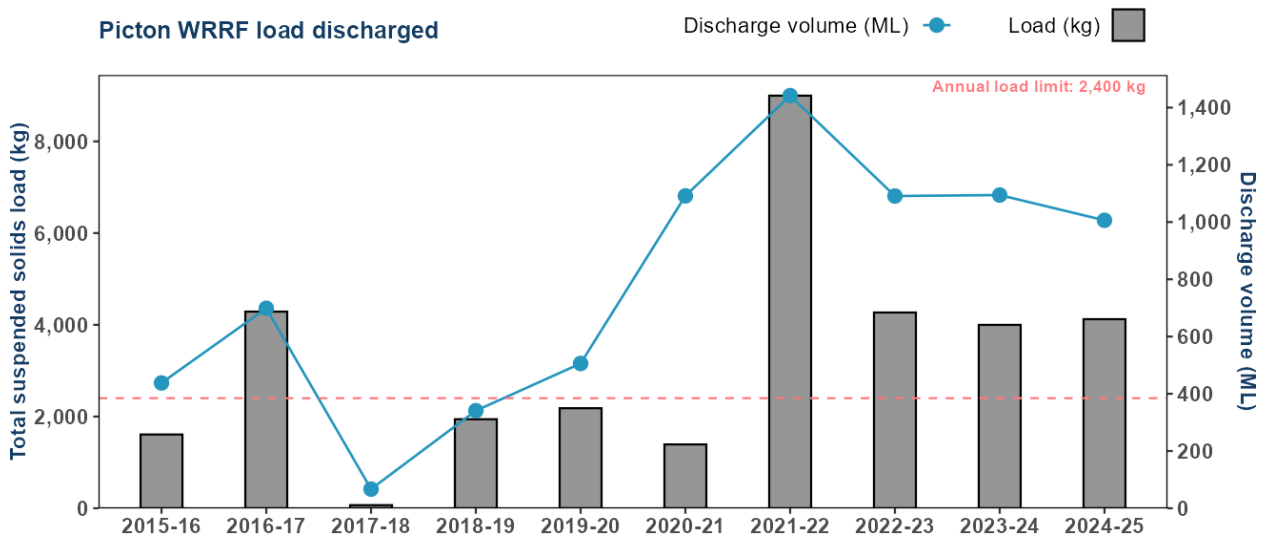
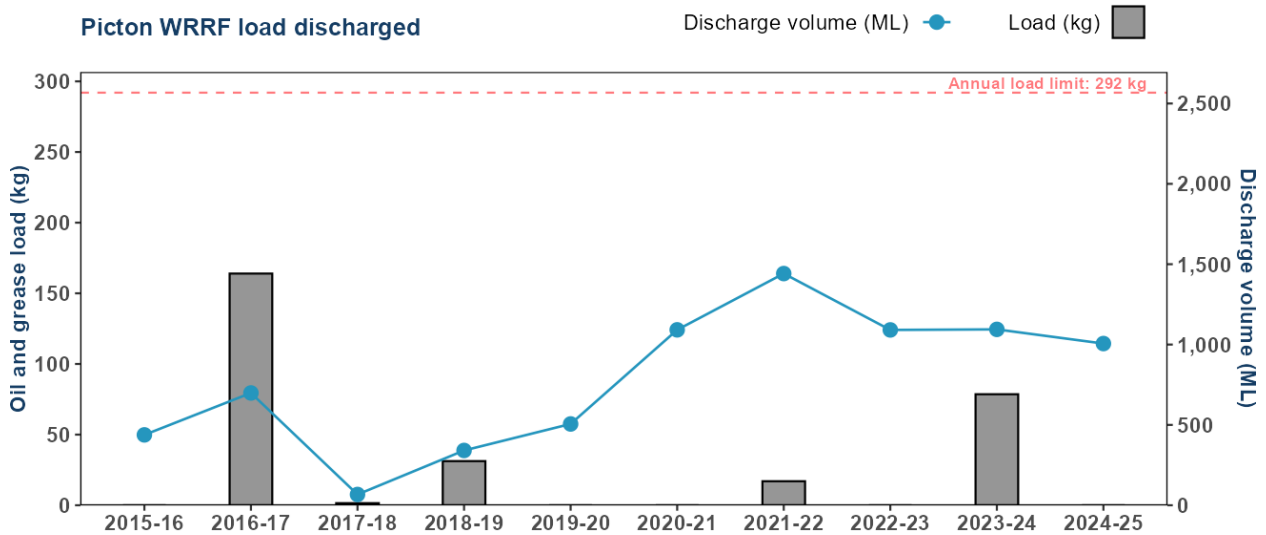
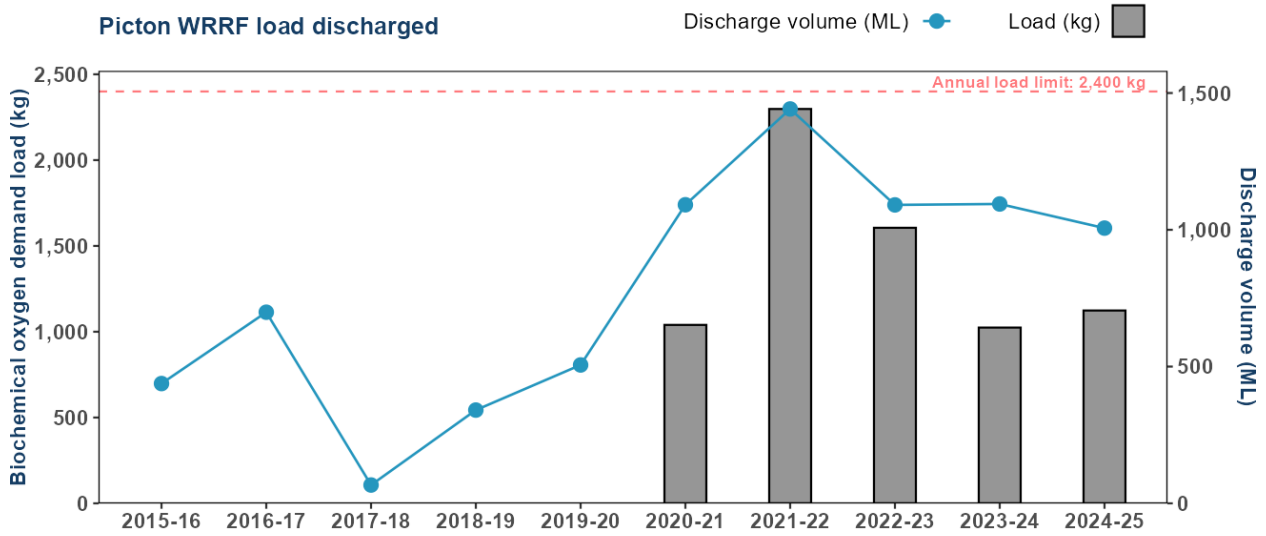
No toxicity monitoring requirement at Picton WRRF.

A.1.4. Pressure – Wastewater discharge load

Nutrients



Major conventional analytes



A.1.5. Stressor – Statistical analysis outcomes

Table A-1 Upstream vs downstream comparison (2024-25 reporting period) for Stonequarry Creek at Picton WRRF

Stonequarry Creek at Picton WRRF: N911B vs N911 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.73	0.49	133	1.94	0.217
Oxidised nitrogen	1.39	0.66	133	0.69	0.900
Total nitrogen	1.27	0.30	133	0.99	0.758
Soluble reactive phosphorus	1.22	0.33	66	0.74	0.882
Total phosphorus	1.15	0.29	133	0.58	0.938
Physico-chemical					
Conductivity	1.02	0.11	133	0.20	0.997
Dissolved oxygen	1.00	0.06	129	0.03	>0.999
Dissolved oxygen saturation	0.56	1.85	129	0.30	0.990
pH	-0.01	0.06	133	-0.09	>0.999
Water temperature	1.00	0.13	133	0.01	>0.999
Turbidity	0.85	0.26	133	-0.54	0.949
Trace Metals					
Filterable aluminium	1.12	0.35	66	0.37	0.983
Total aluminium	0.78	0.37	66	-0.53	0.952
Filterable cobalt	1.10	0.23	66	0.47	0.965
Total cobalt	0.86	0.25	66	-0.52	0.955
Filterable copper	1.08	0.16	66	0.54	0.950
Total copper	0.97	0.27	66	-0.11	>0.999
Filterable nickel	1.01	0.18	66	0.07	>0.999
Total nickel	0.96	0.20	66	-0.22	0.996
Filterable zinc	0.74	0.19	64	-1.18	0.642
Total zinc	0.78	0.23	66	-0.85	0.832

	not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-2 Upstream current period (2024-25) vs previous period comparison (single site) for Stonequarry Creek at Picton WRRF

Stonequarry Creek at Picton WRRF: N911B (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.76	0.18	133	-1.20	0.625
Oxidised nitrogen	0.75	0.30	133	-0.72	0.887
Total nitrogen	0.84	0.17	133	-0.86	0.827
Soluble reactive phosphorus	0.87	0.24	66	-0.52	0.953
Total phosphorus	0.70	0.14	133	-1.73	0.314
Physico-chemical					
Conductivity	1.07	0.09	133	0.80	0.855
Dissolved oxygen	0.99	0.05	129	-0.14	>0.999
Dissolved oxygen saturation	-1.27	1.50	129	-0.84	0.833
pH	-0.06	0.05	133	-1.08	0.703
Water temperature	1.02	0.11	133	0.21	0.997
Turbidity	0.76	0.19	133	-1.11	0.686
Trace Metals					
Filterable aluminium	0.62	0.20	66	-1.52	0.431
Total aluminium	0.55	0.27	66	-1.23	0.613
Filterable cobalt	0.89	0.19	66	-0.56	0.944
Total cobalt	0.87	0.25	66	-0.50	0.959
Filterable copper	0.93	0.14	66	-0.47	0.966
Total copper	0.89	0.25	66	-0.42	0.974
Filterable nickel	0.81	0.14	66	-1.18	0.641
Total nickel	0.78	0.16	66	-1.18	0.639
Filterable zinc	1.30	0.34	64	0.99	0.754
Total zinc	0.79	0.23	66	-0.78	0.862

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-3 Downstream current period (2024-25) vs previous period comparison (single site) for Stonequarry Creek at Picton WRRF

Stonequarry Creek at Picton WRRF: N911 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.60	0.14	133	-2.20	0.129
Oxidised nitrogen	0.32	0.12	133	-2.92	0.021
Total nitrogen	0.46	0.09	133	-3.91	<0.001
Soluble reactive phosphorus	0.68	0.19	66	-1.41	0.496
Total phosphorus	0.57	0.12	133	-2.73	0.036
Physico-chemical					
Conductivity	1.10	0.10	133	1.15	0.660
Dissolved oxygen	1.00	0.05	129	0.09	>0.999
Dissolved oxygen saturation	-1.15	1.50	129	-0.77	0.867
pH	-0.05	0.05	133	-0.92	0.796
Water temperature	0.99	0.10	133	-0.14	>0.999
Turbidity	0.78	0.19	133	-1.00	0.750
Trace Metals					
Filterable aluminium	0.27	0.09	66	-4.10	<0.001
Total aluminium	0.35	0.17	66	-2.16	0.145
Filterable cobalt	0.65	0.14	66	-1.99	0.202
Total cobalt	0.62	0.18	66	-1.64	0.363
Filterable copper	0.91	0.14	66	-0.64	0.920
Total copper	0.47	0.13	66	-2.68	0.044
Filterable nickel	0.63	0.11	66	-2.59	0.056
Total nickel	0.58	0.12	66	-2.63	0.051
Filterable zinc	0.47	0.13	64	-2.83	0.031
Total zinc	0.41	0.12	66	-3.04	0.017

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-4 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at Picton WRRF

Nepean River at Picton WRRF: N92 vs N91 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.99	0.38	325	3.62	0.002
Oxidised nitrogen	1.78	0.59	325	1.75	0.301
Total nitrogen	1.16	0.13	325	1.31	0.556
Soluble reactive phosphorus	2.24	0.53	66	3.41	0.006
Total phosphorus	1.63	0.25	325	3.14	0.010
Physico-chemical					
Conductivity	1.35	0.25	323	1.66	0.346
Dissolved oxygen	1.00	0.05	323	0.04	>0.999
Dissolved oxygen saturation	0.21	3.00	321	0.07	>0.999
pH	0.06	0.16	323	0.41	0.977
Water temperature	1.02	0.11	325	0.18	0.998
Turbidity	1.54	0.38	325	1.76	0.296
Trace Metals					
Filterable aluminium	0.83	0.21	66	-0.74	0.882
Total aluminium	1.31	0.48	66	0.74	0.882
Filterable cobalt	1.15	0.42	66	0.39	0.979
Total cobalt	1.49	0.44	66	1.35	0.537
Filterable copper	1.24	0.21	66	1.24	0.605
Total copper	1.32	0.25	66	1.47	0.464
Filterable nickel	0.94	0.29	66	-0.21	0.997
Total nickel	0.93	0.28	66	-0.25	0.994
Filterable zinc	1.02	0.20	66	0.08	>0.999
Total zinc	1.22	0.24	66	1.02	0.736

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-5 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Picton WRRF

Nepean River at Picton WRRF: N92 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.87	0.12	325	-0.95	0.780
Oxidised nitrogen	0.59	0.14	325	-2.17	0.134
Total nitrogen	0.89	0.07	325	-1.35	0.532
Soluble reactive phosphorus	1.04	0.25	66	0.17	0.998
Total phosphorus	1.16	0.13	325	1.30	0.562
Physico-chemical					
Conductivity	0.67	0.09	323	-2.91	0.020
Dissolved oxygen	1.01	0.04	323	0.27	0.993
Dissolved oxygen saturation	1.81	2.25	321	0.80	0.852
pH	-0.25	0.12	323	-2.14	0.144
Water temperature	1.04	0.09	325	0.45	0.970
Turbidity	1.11	0.20	325	0.57	0.941
Trace Metals					
Filterable aluminium	1.49	0.37	66	1.58	0.398
Total aluminium	1.44	0.53	66	0.99	0.755
Filterable cobalt	0.16	0.06	66	-4.95	<0.001
Total cobalt	0.17	0.05	66	-5.96	<0.001
Filterable copper	0.98	0.17	66	-0.12	>0.999
Total copper	0.99	0.19	66	-0.03	>0.999
Filterable nickel	0.31	0.10	66	-3.66	0.003
Total nickel	0.32	0.10	66	-3.69	0.002
Filterable zinc	0.54	0.11	66	-3.07	0.016
Total zinc	0.55	0.11	66	-3.07	0.016

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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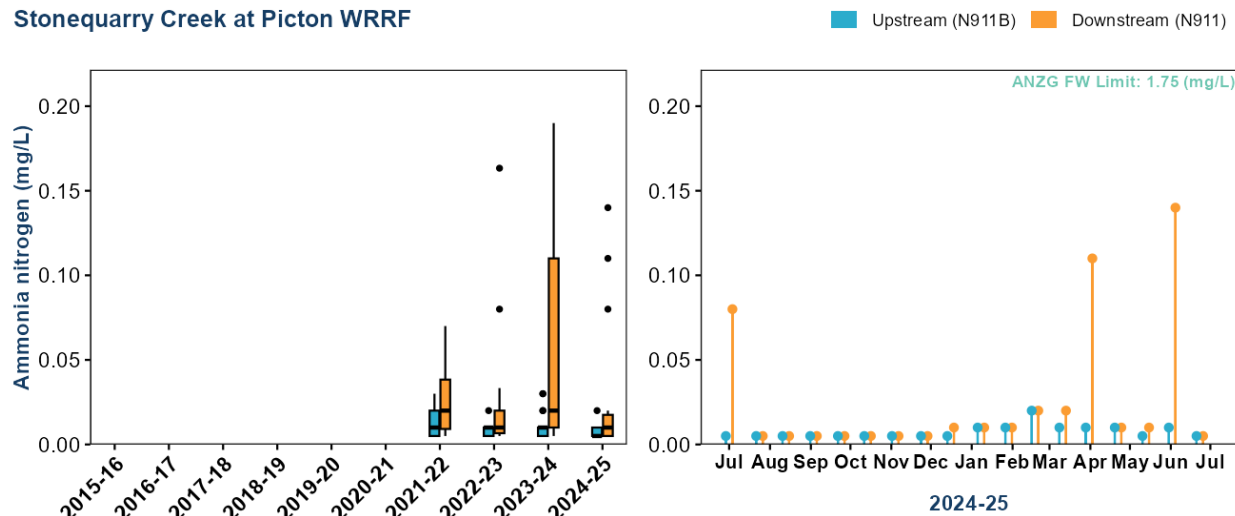
Table A-6 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Picton WRRF

Nepean River at Picton WRRF: N91 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.16	0.17	325	1.06	0.713
Oxidised nitrogen	0.77	0.19	325	-1.08	0.699
Total nitrogen	0.90	0.07	325	-1.24	0.599
Soluble reactive phosphorus	1.47	0.35	66	1.61	0.379
Total phosphorus	1.51	0.18	325	3.58	0.002
Physico-chemical					
Conductivity	0.81	0.11	323	-1.54	0.416
Dissolved oxygen	1.01	0.04	323	0.33	0.988
Dissolved oxygen saturation	1.81	2.25	321	0.81	0.851
pH	-0.20	0.12	323	-1.71	0.319
Water temperature	1.04	0.09	325	0.51	0.957
Turbidity	1.31	0.24	325	1.46	0.461
Trace Metals					
Filterable aluminium	1.21	0.30	66	0.76	0.873
Total aluminium	1.34	0.50	66	0.79	0.859
Filterable cobalt	0.17	0.06	66	-4.72	<0.001
Total cobalt	0.28	0.08	66	-4.30	<0.001
Filterable copper	0.89	0.15	66	-0.69	0.900
Total copper	0.92	0.18	66	-0.44	0.971
Filterable nickel	0.33	0.10	66	-3.51	0.004
Total nickel	0.33	0.10	66	-3.65	0.003
Filterable zinc	0.60	0.12	66	-2.54	0.062
Total zinc	0.67	0.13	66	-2.03	0.186

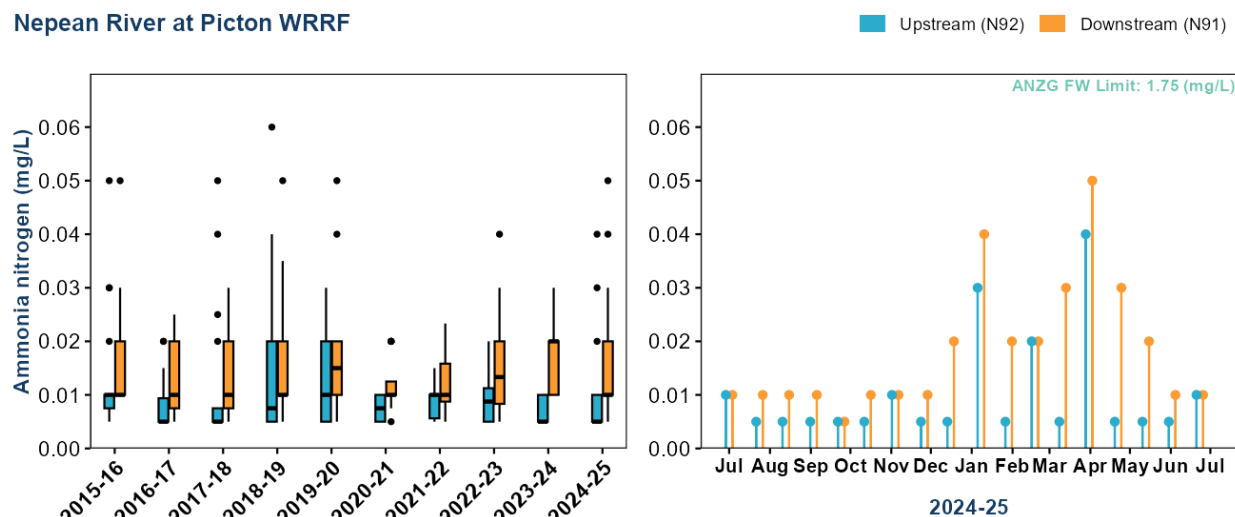
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.1.6. Stressor – Nutrients

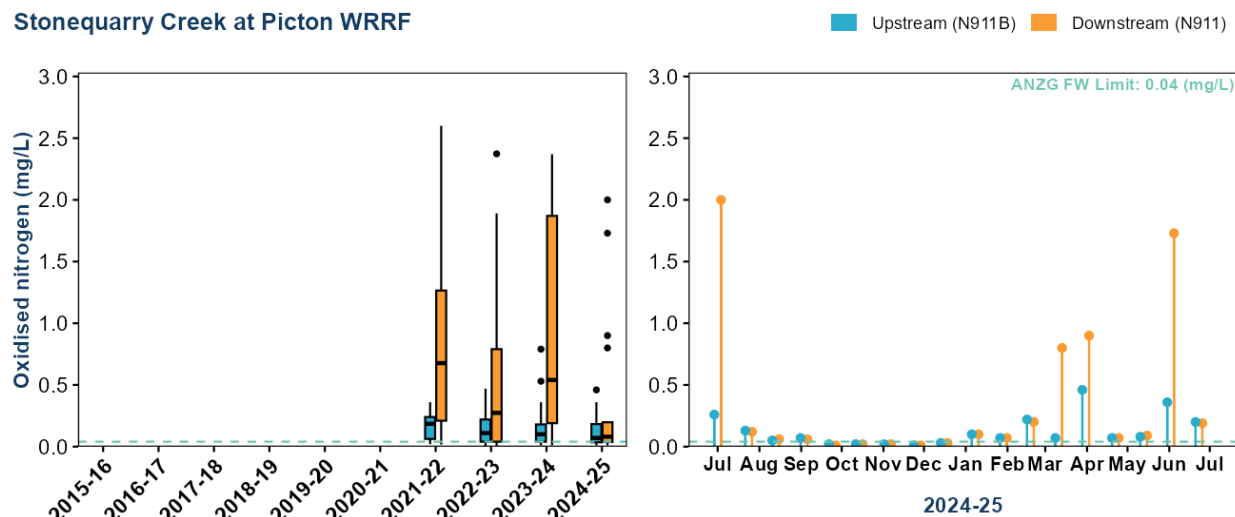
Stonequarry Creek at Picton WRRF



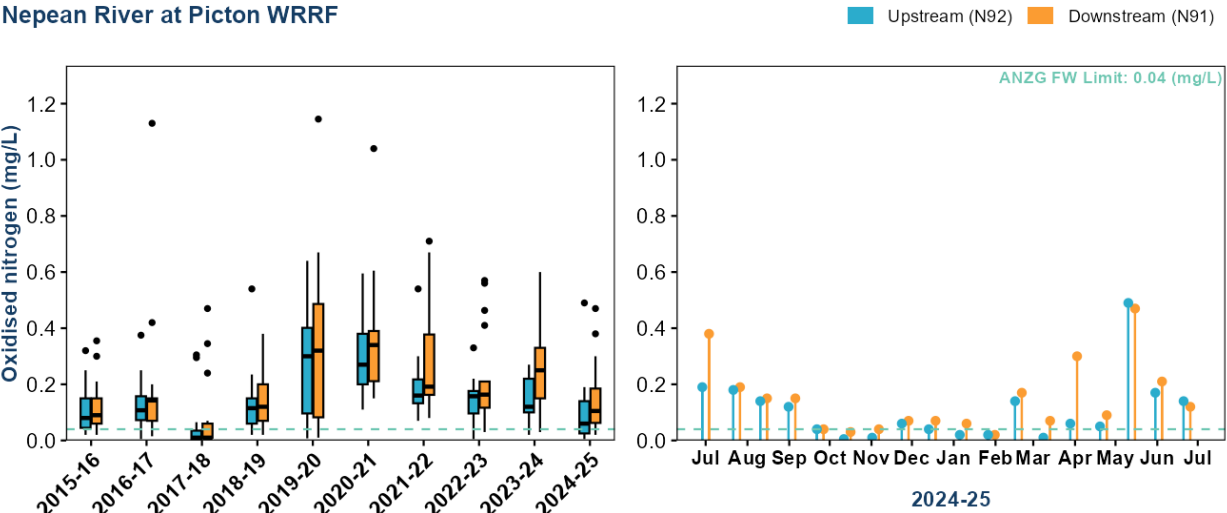
Nepean River at Picton WRRF



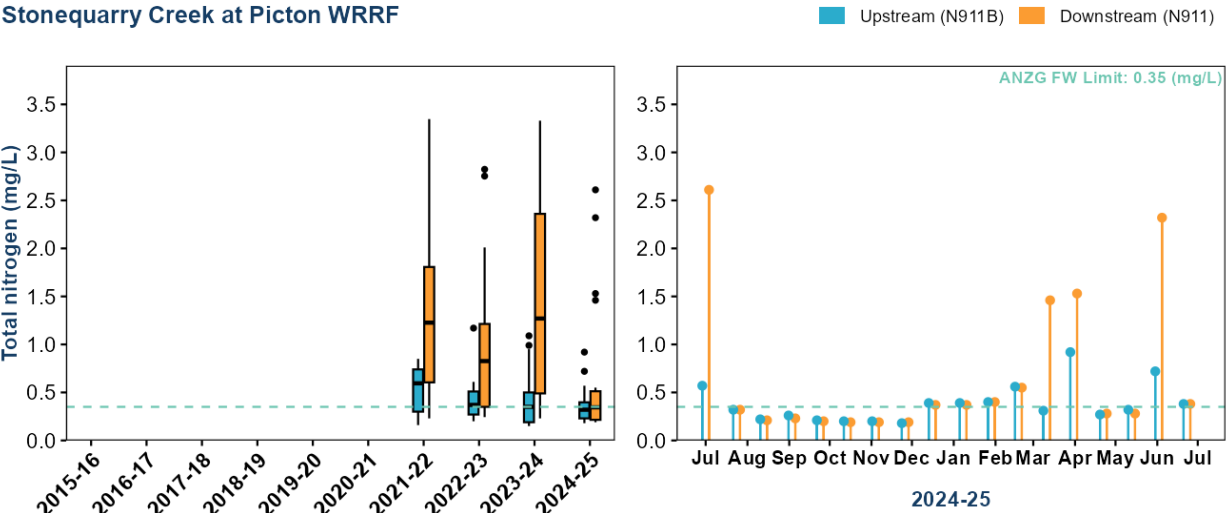
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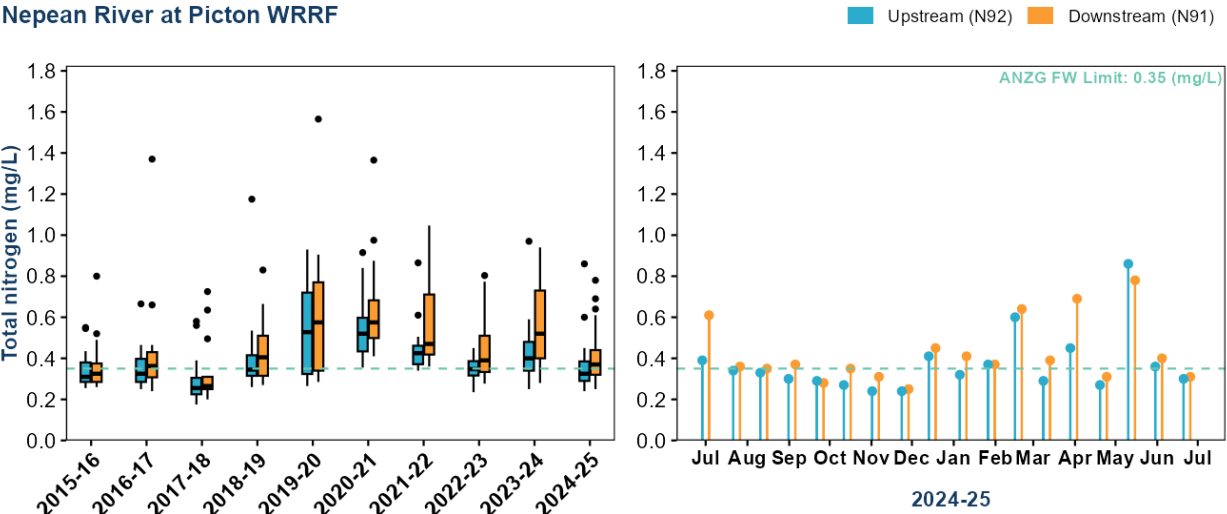
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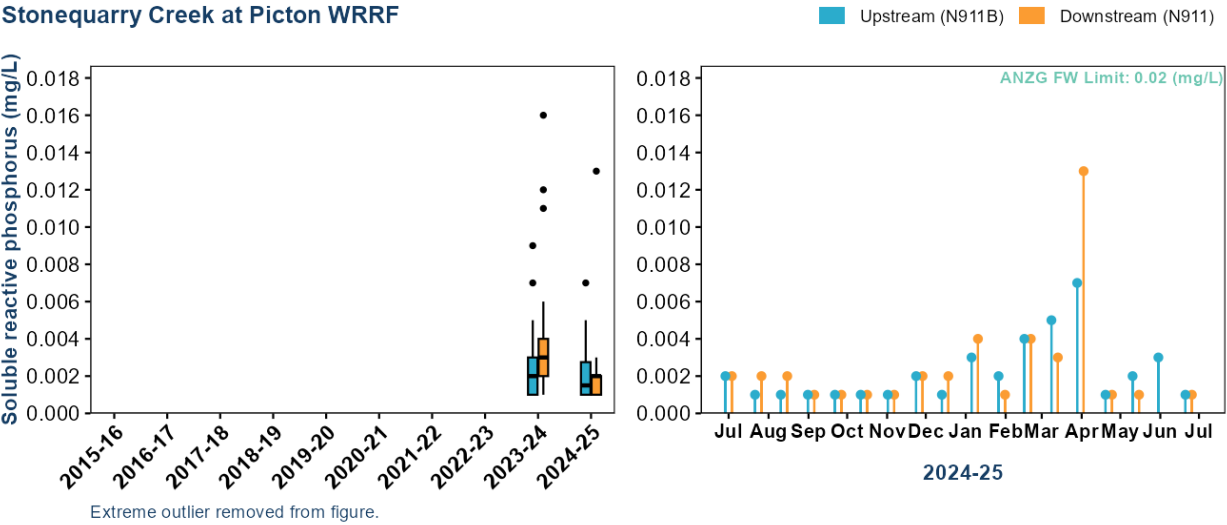
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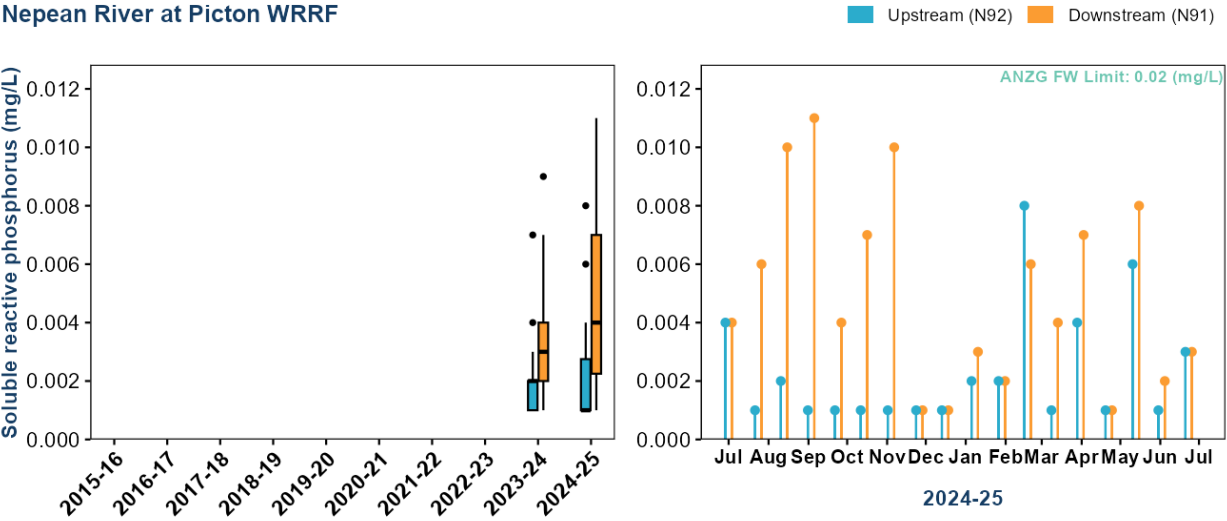
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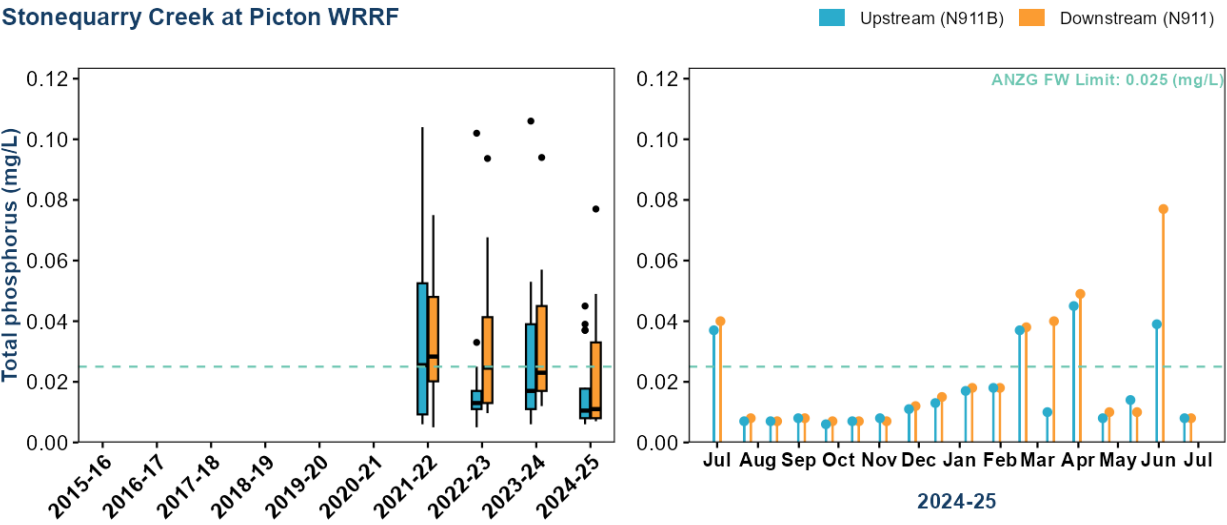
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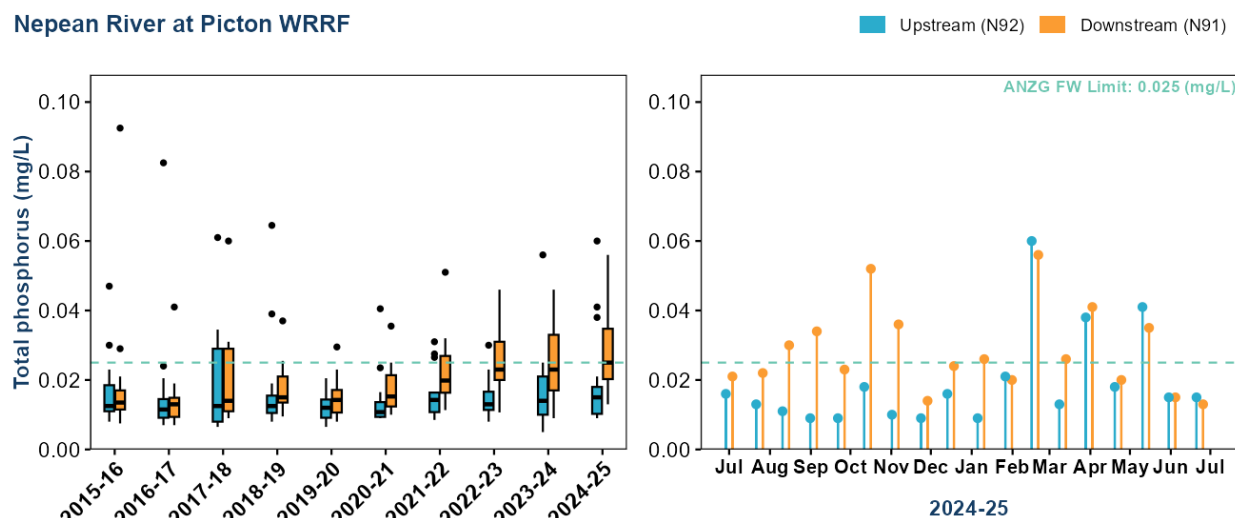
Nepean River at Picton WRRF



Stonequarry Creek at Picton WRRF

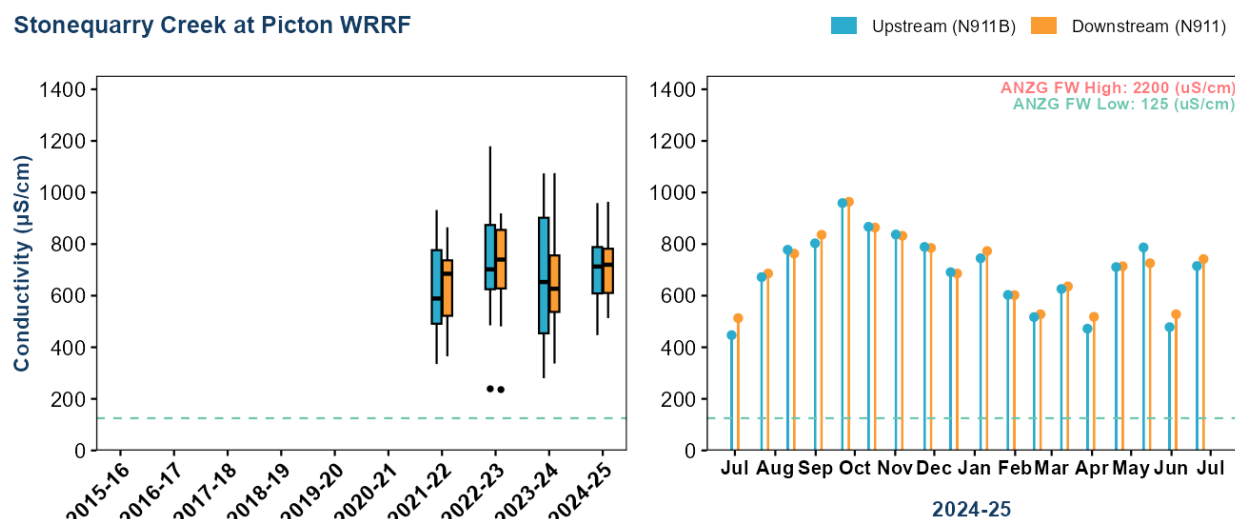


Nepean River at Picton WRRF

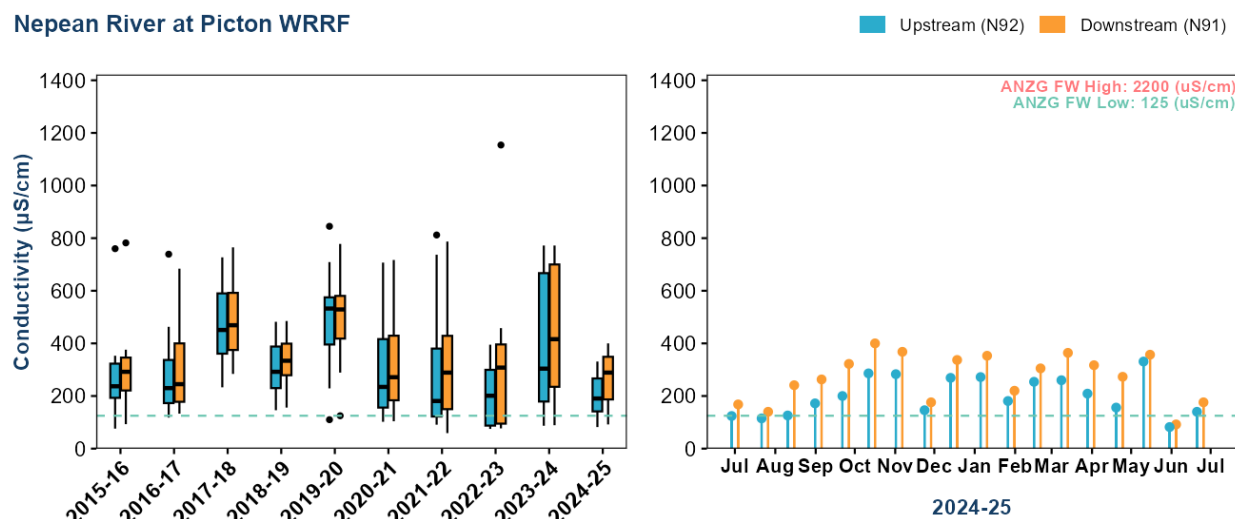


A.1.7. Stressor – Physico-chemical water quality

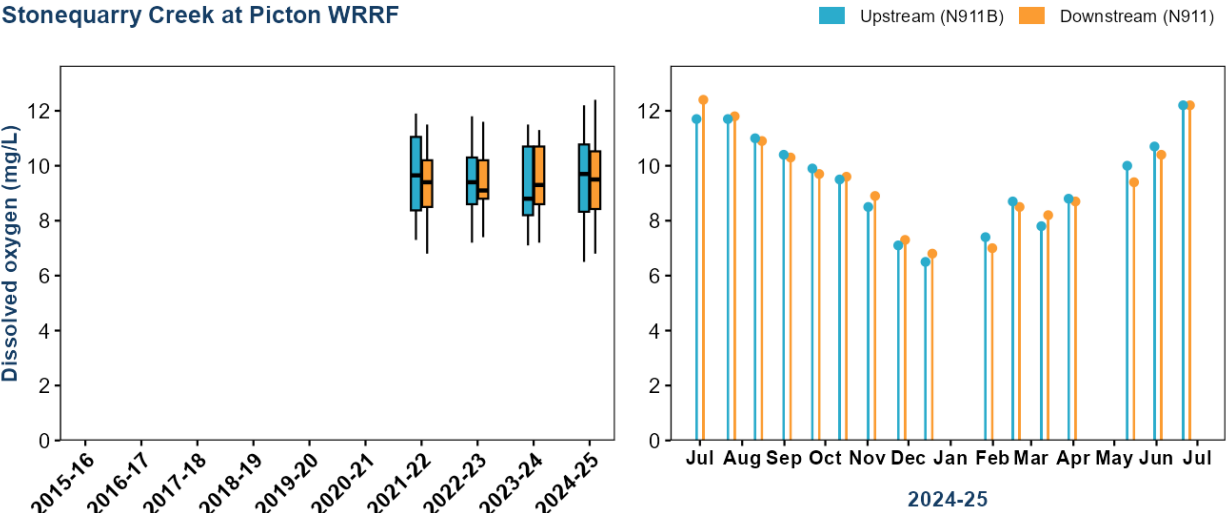
Stonequarry Creek at Picton WRRF



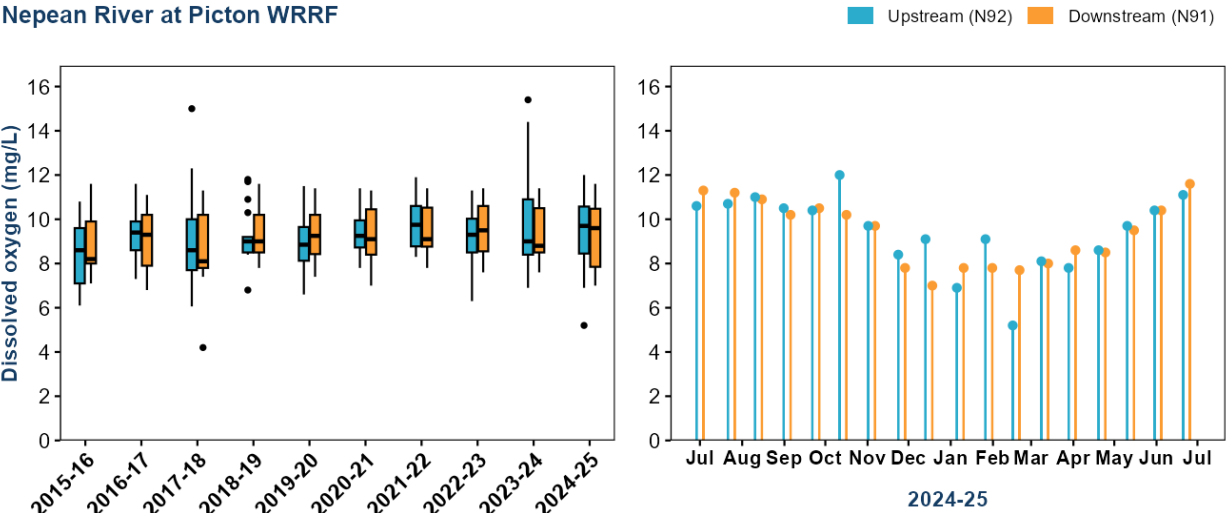
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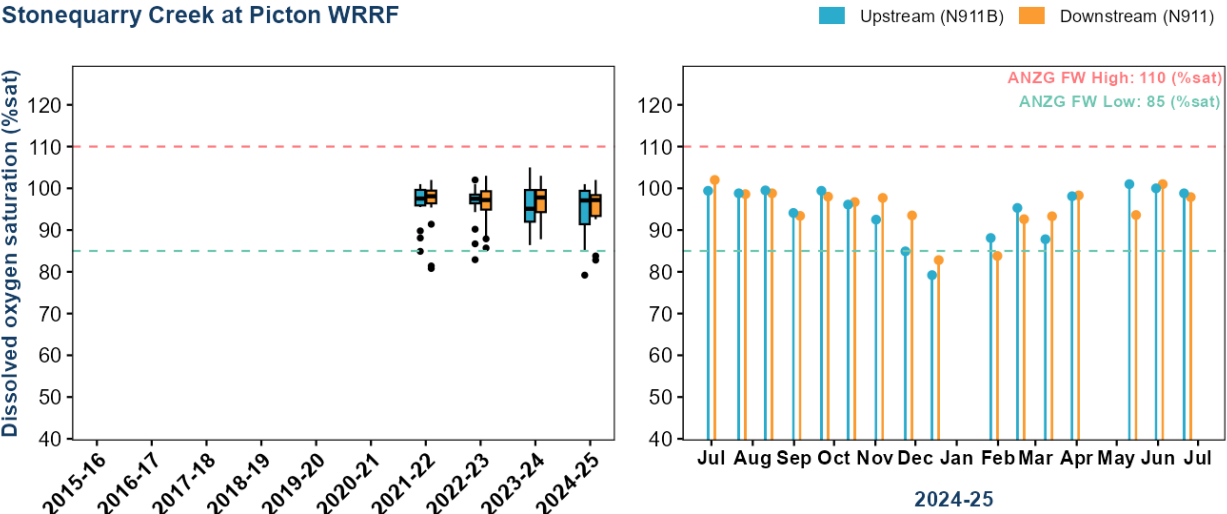
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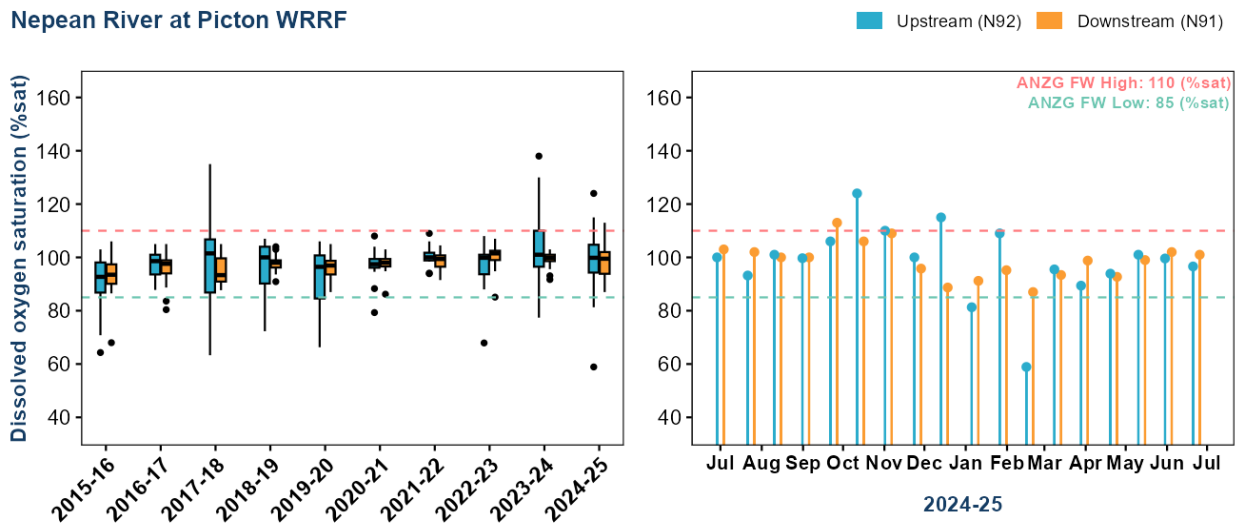
Nepean River at Picton WRRF



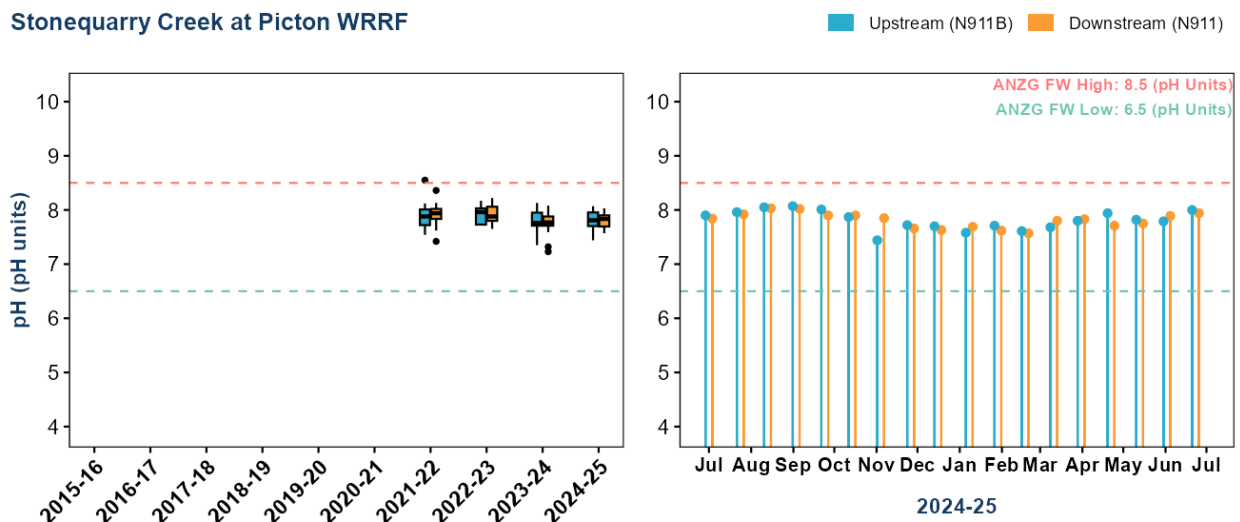
Stonequarry Creek at Picton WRRF



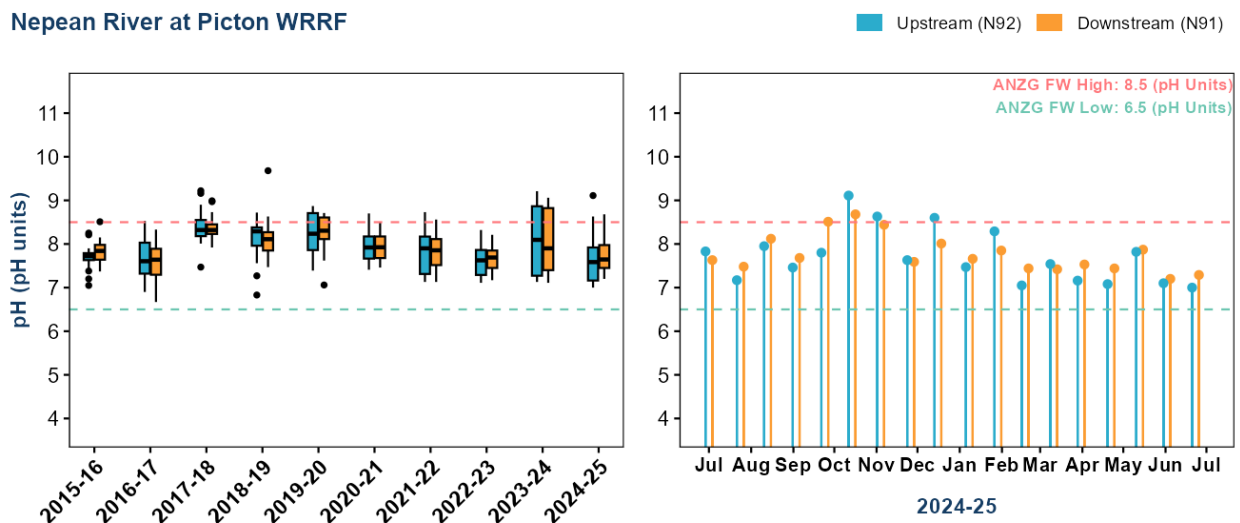
Nepean River at Picton WRRF



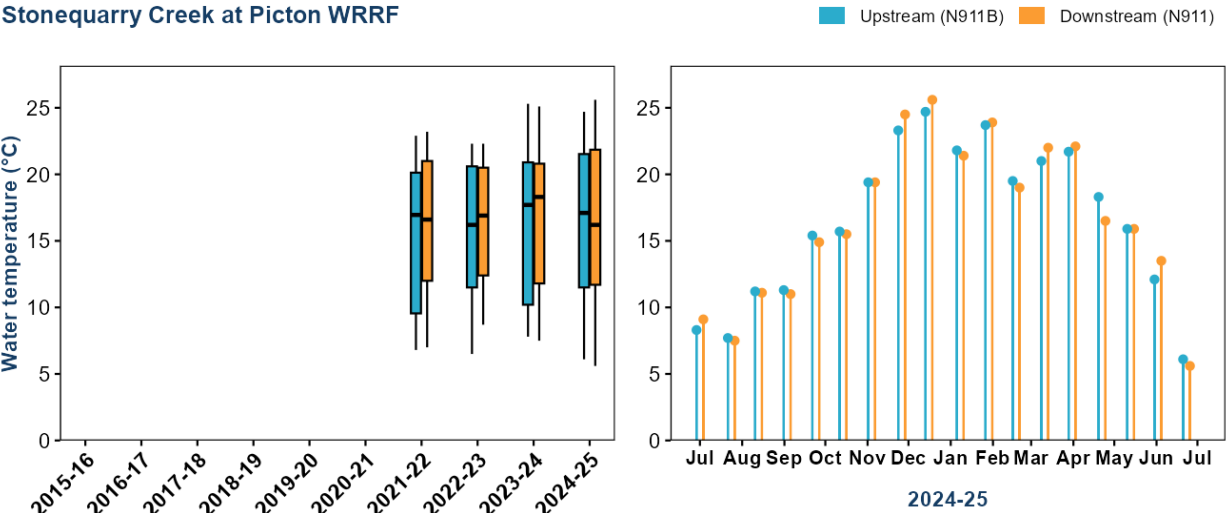
Stonequarry Creek at Picton WRRF



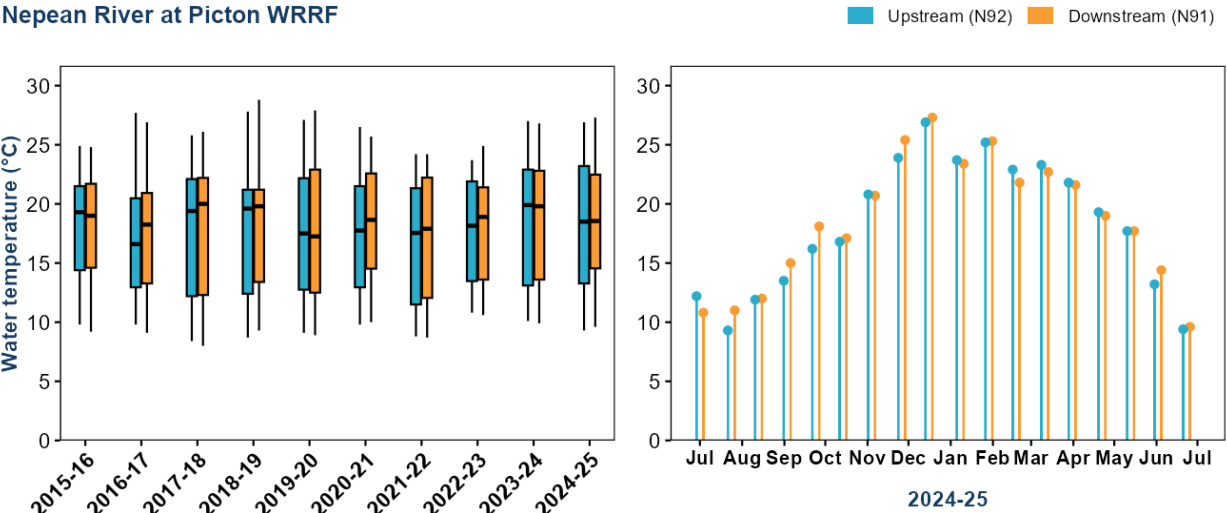
Nepean River at Picton WRRF



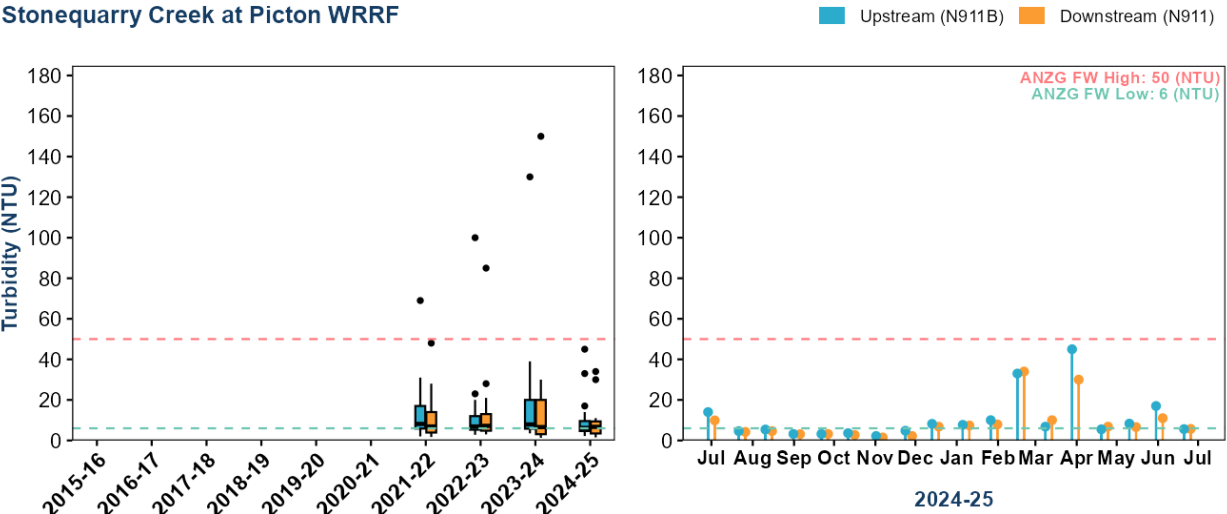
Stonequarry Creek at Picton WRRF



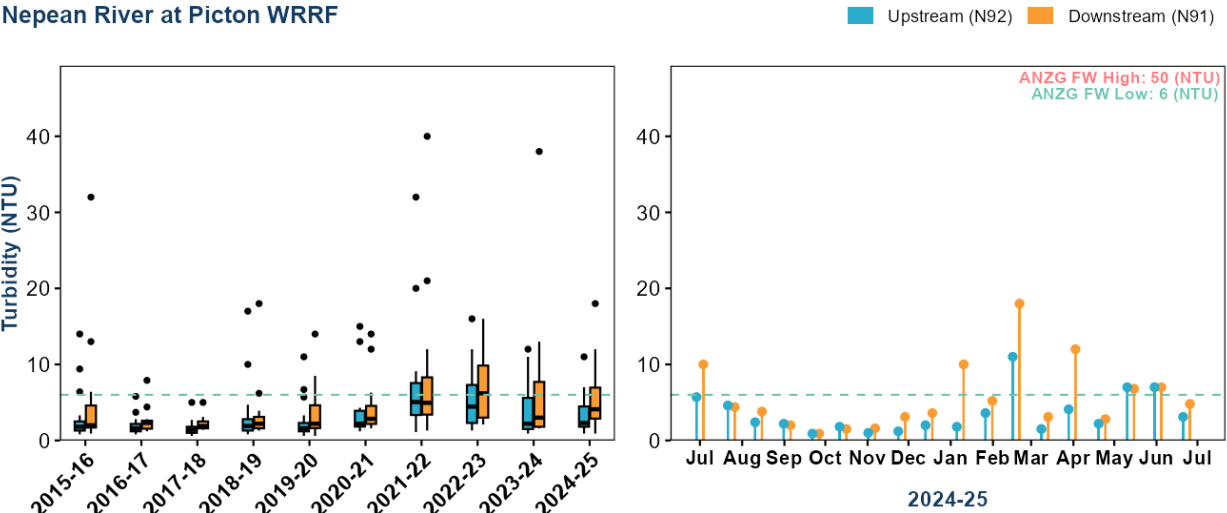
Nepean River at Picton WRRF



Stonequarry Creek at Picton WRRF

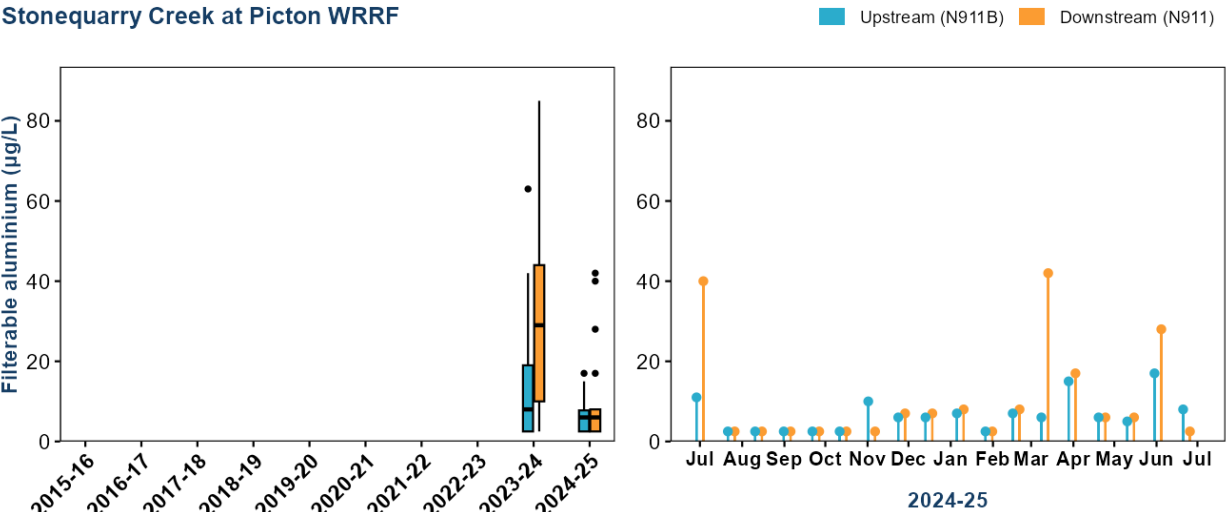


Nepean River at Picton WRRF

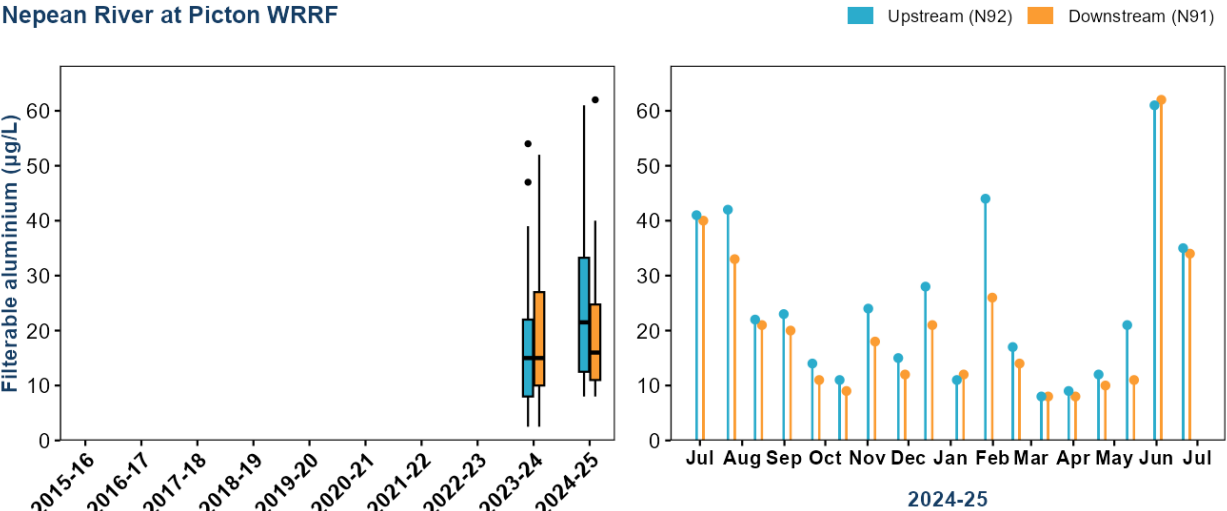


A.1.8. Stressor - Trace metals

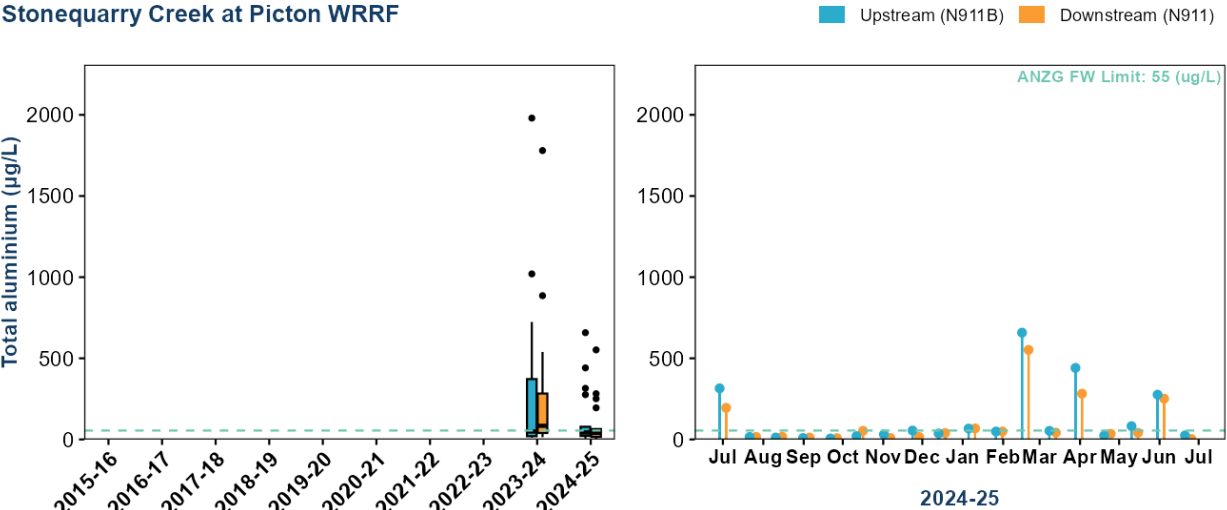
Stonequarry Creek at Picton WRRF



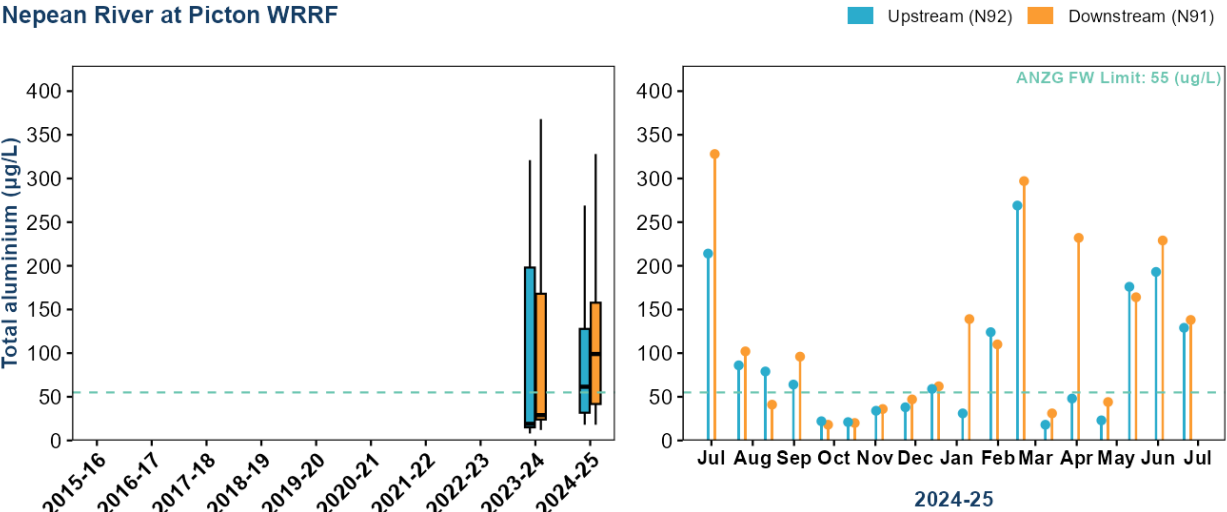
Nepean River at Picton WRRF



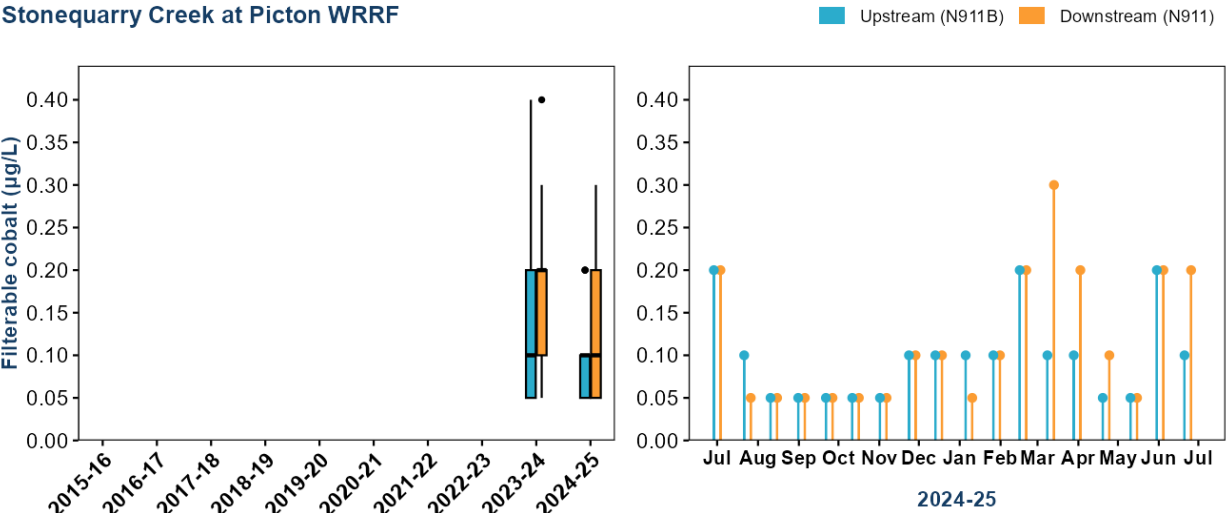
Stonequarry Creek at Picton WRRF



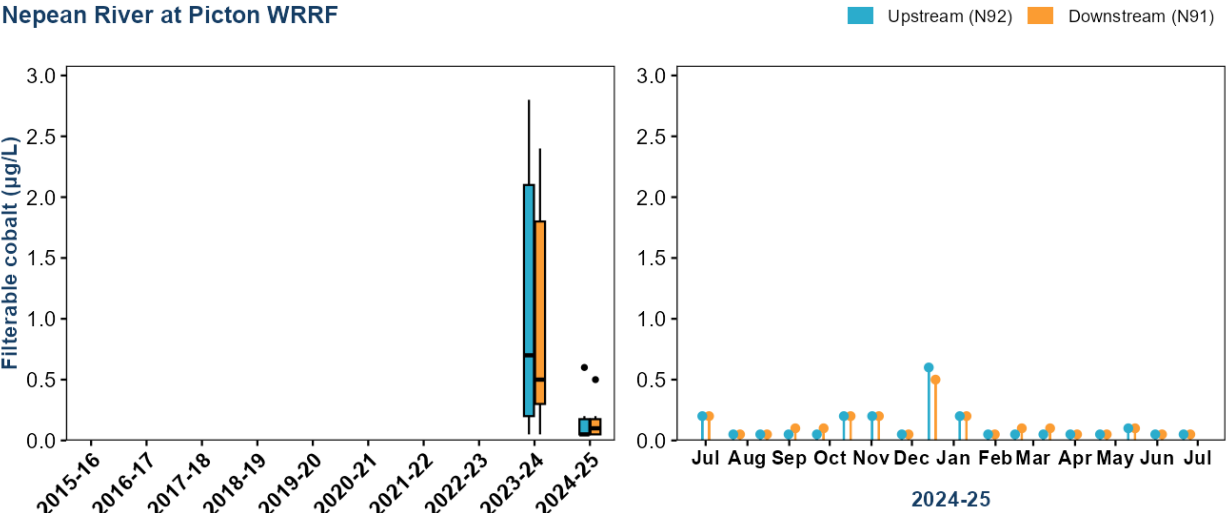
Nepean River at Picton WRRF



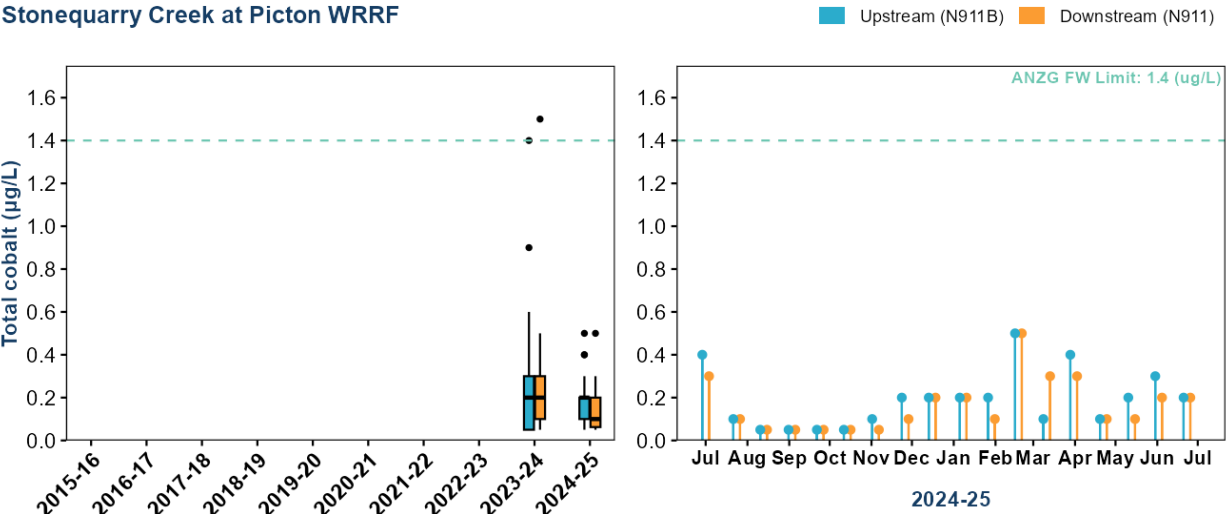
Stonequarry Creek at Picton WRRF



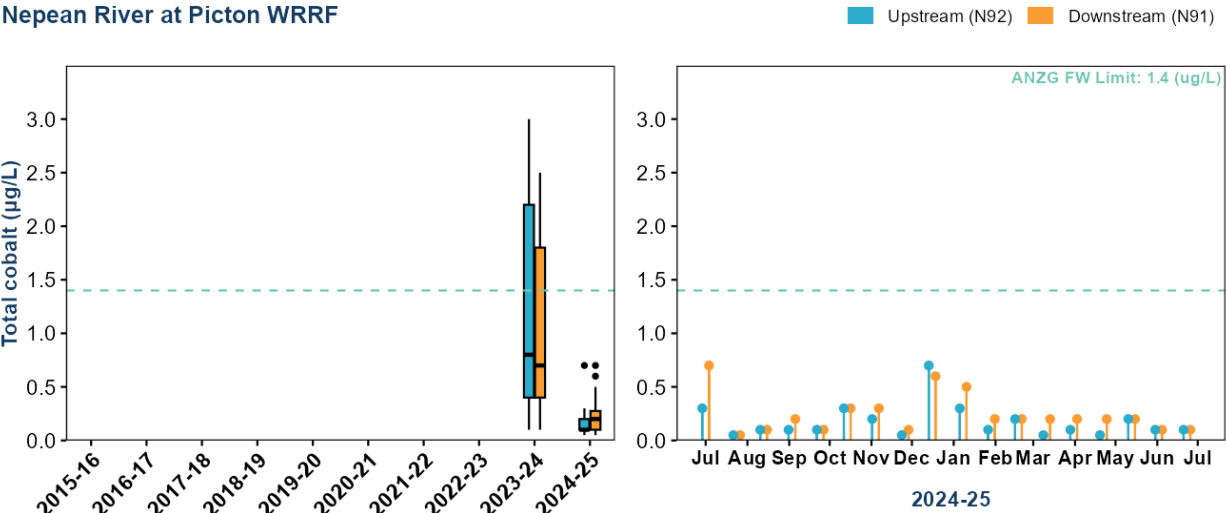
Nepean River at Picton WRRF



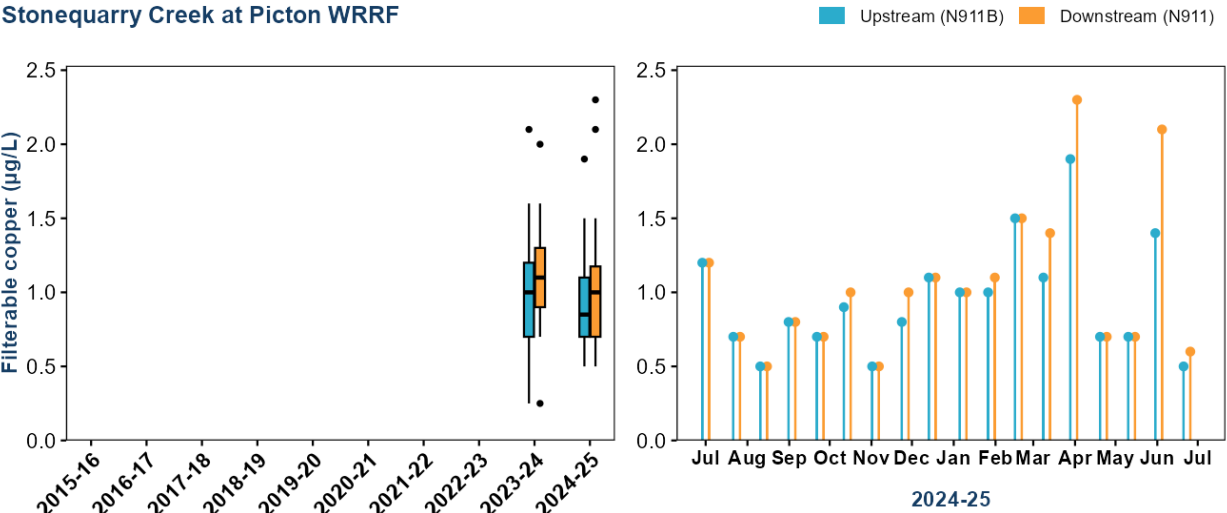
Stonequarry Creek at Picton WRRF



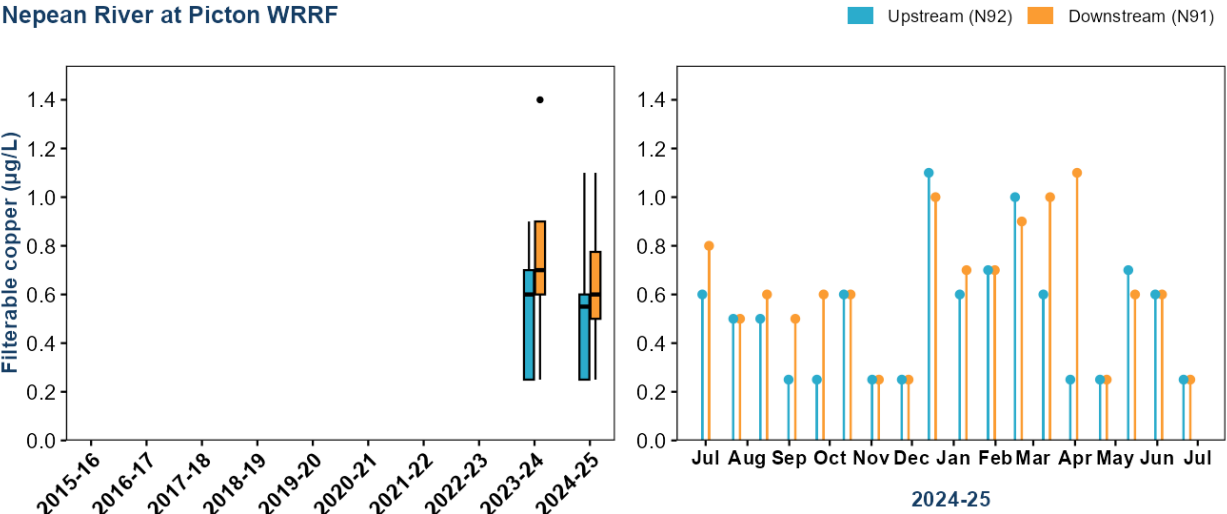
Nepean River at Picton WRRF



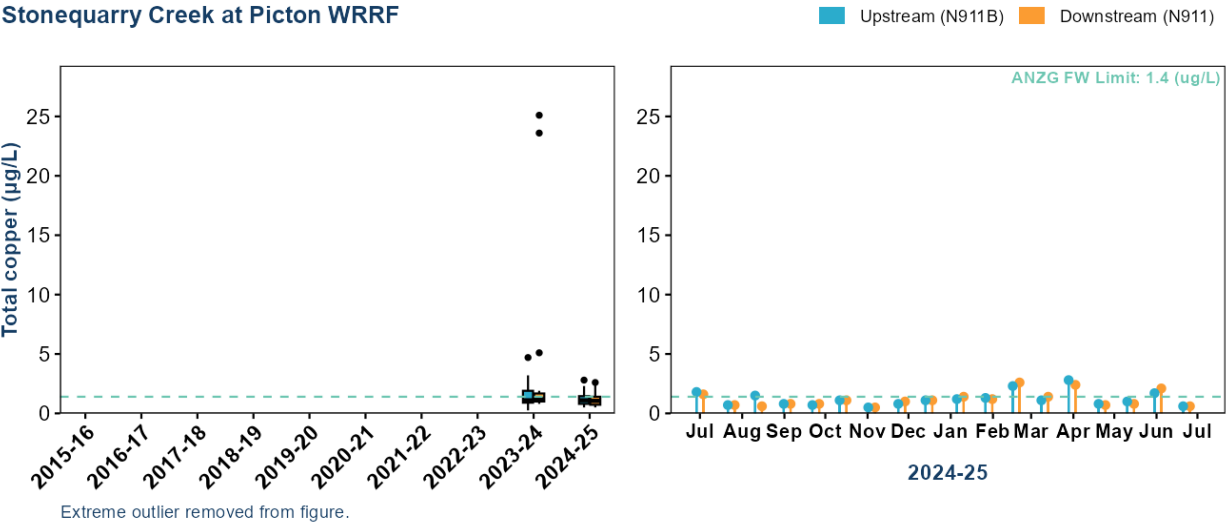
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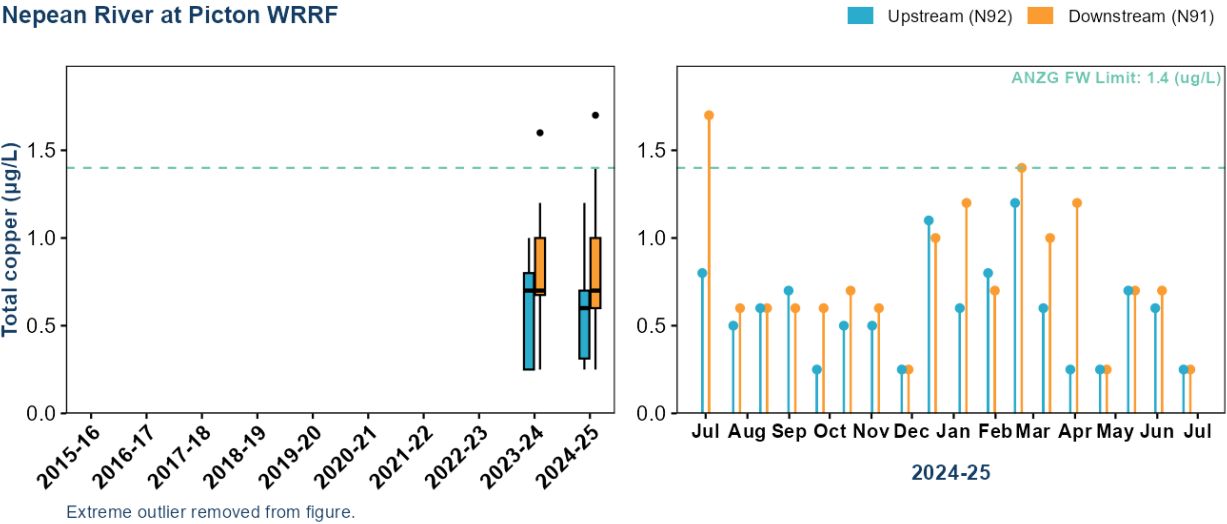
Nepean River at Picton WRRF



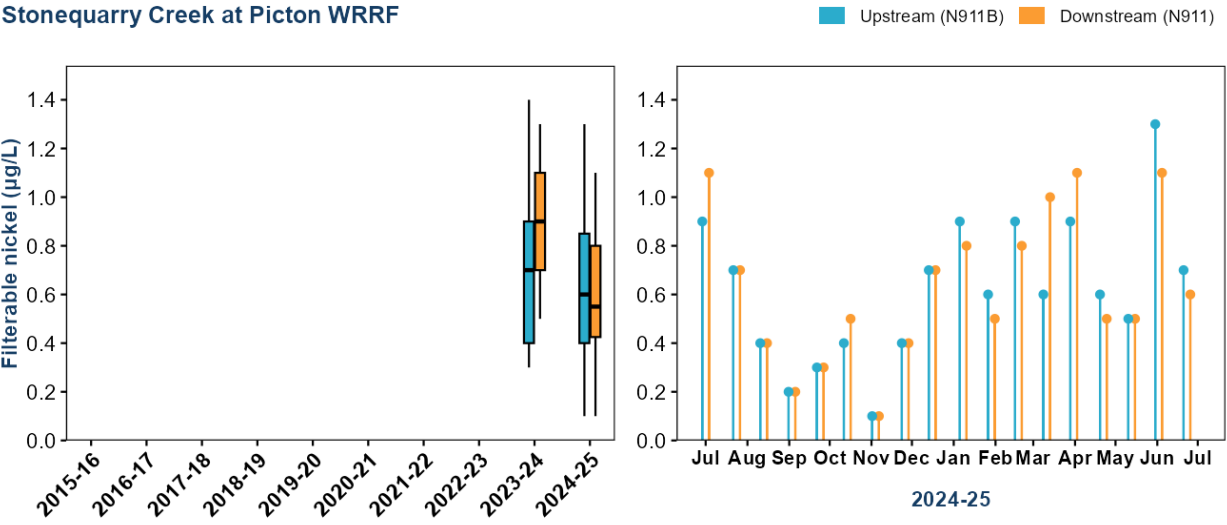
Stonequarry Creek at Picton WRRF



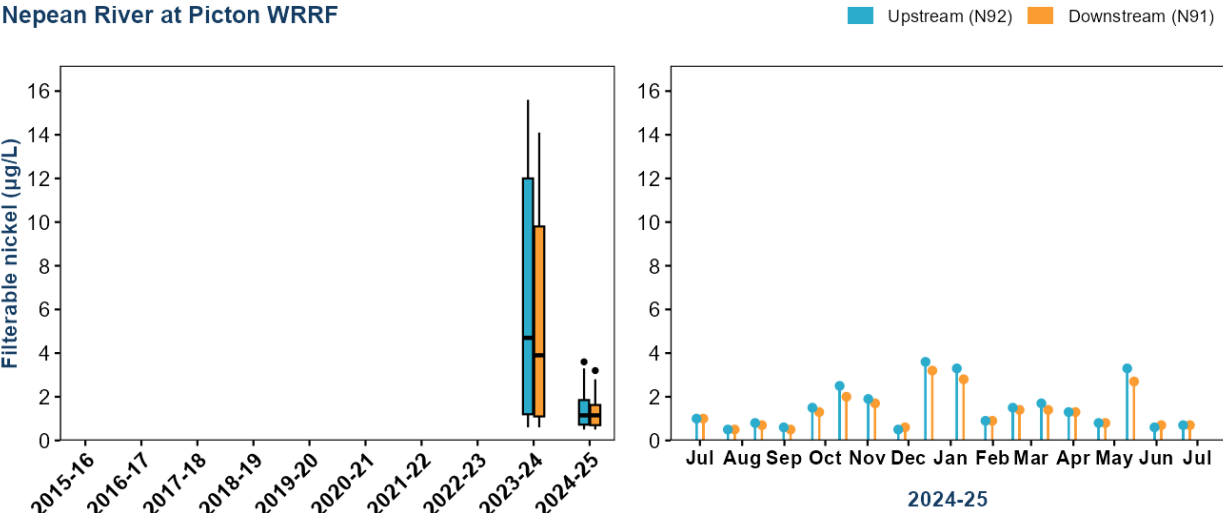
Nepean River at Picton WRRF



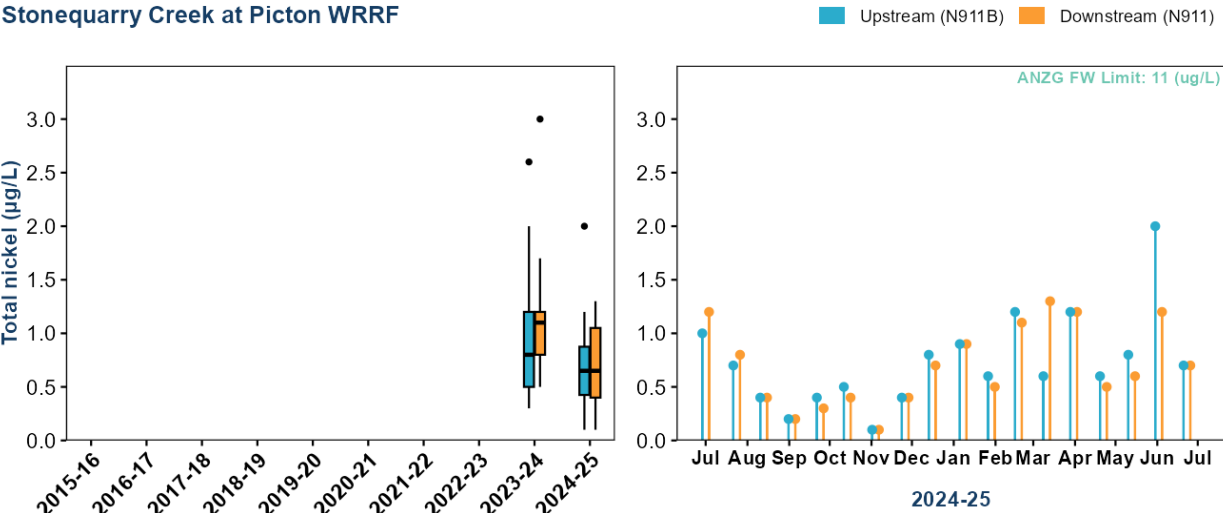
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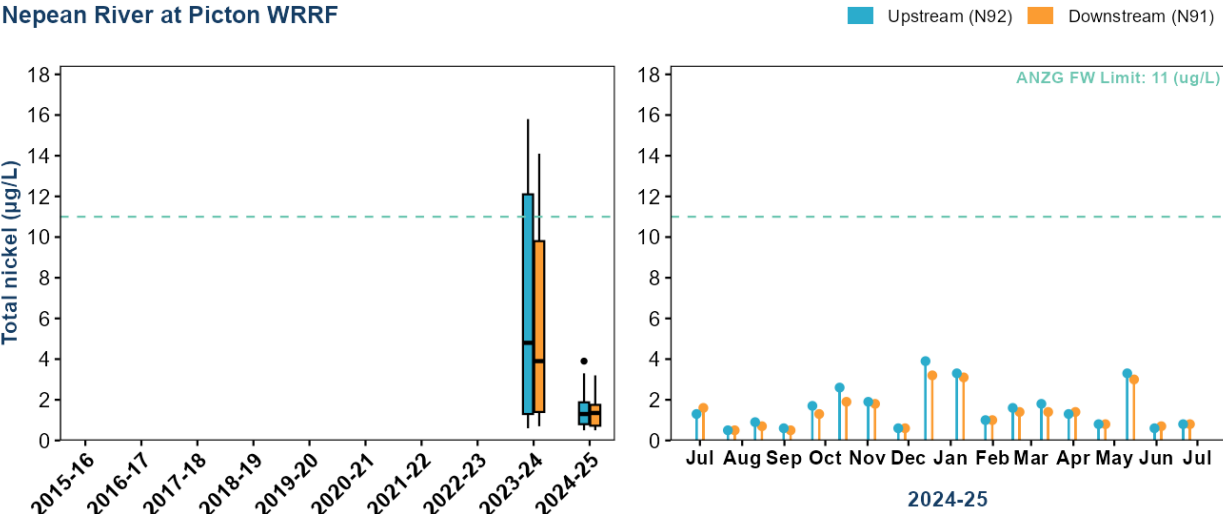
Nepean River at Picton WRRF



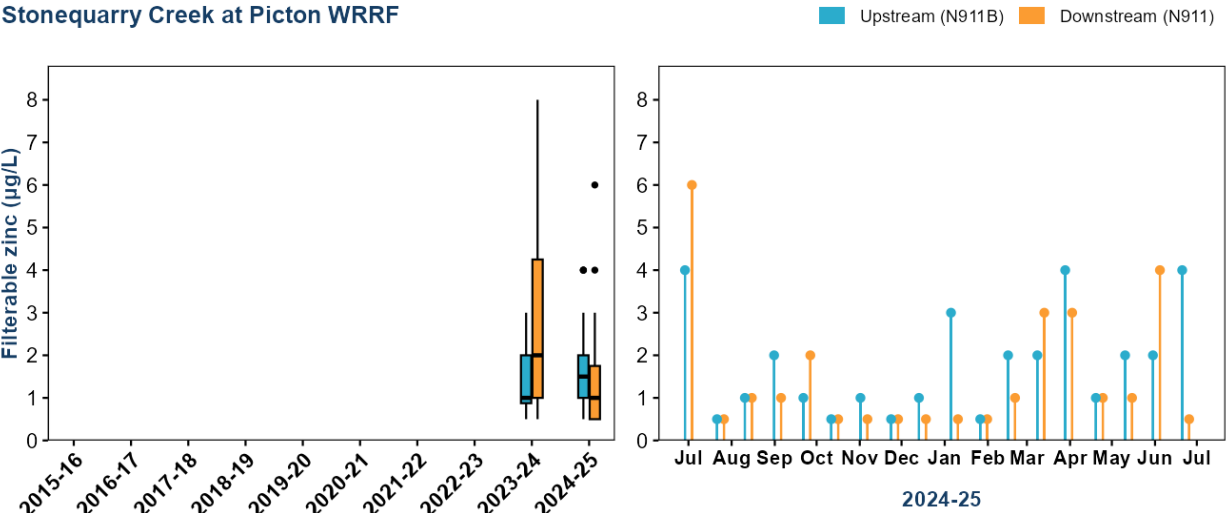
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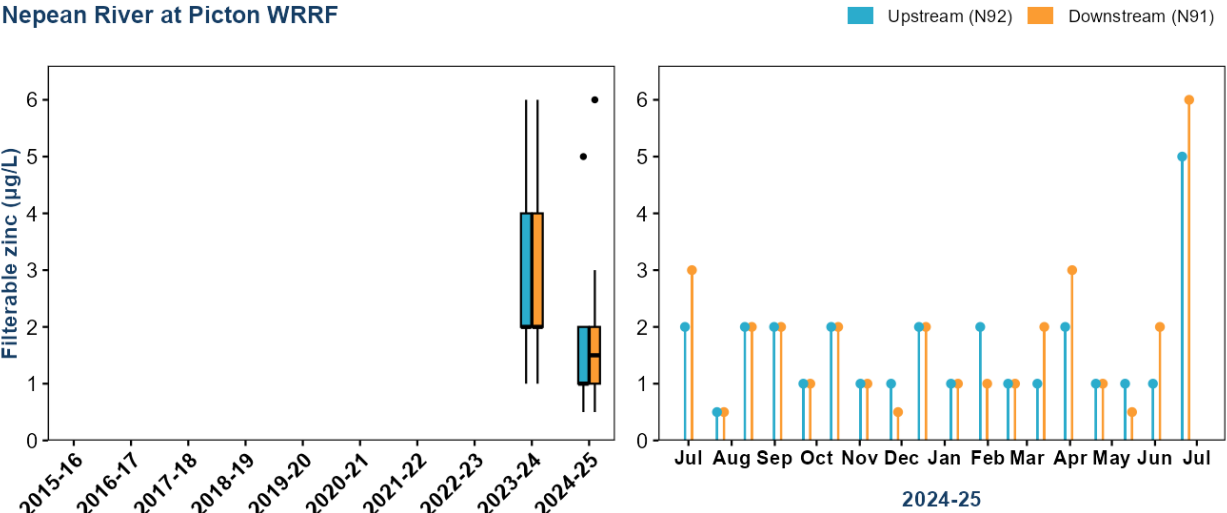
Nepean River at Picton WRRF



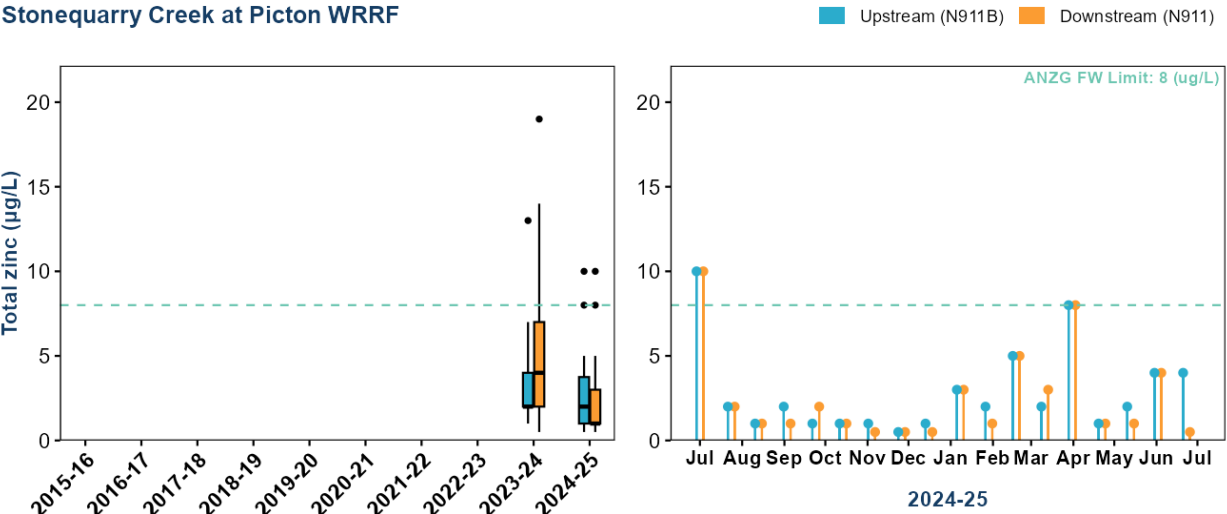
Stonequarry Creek at Picton WRRF



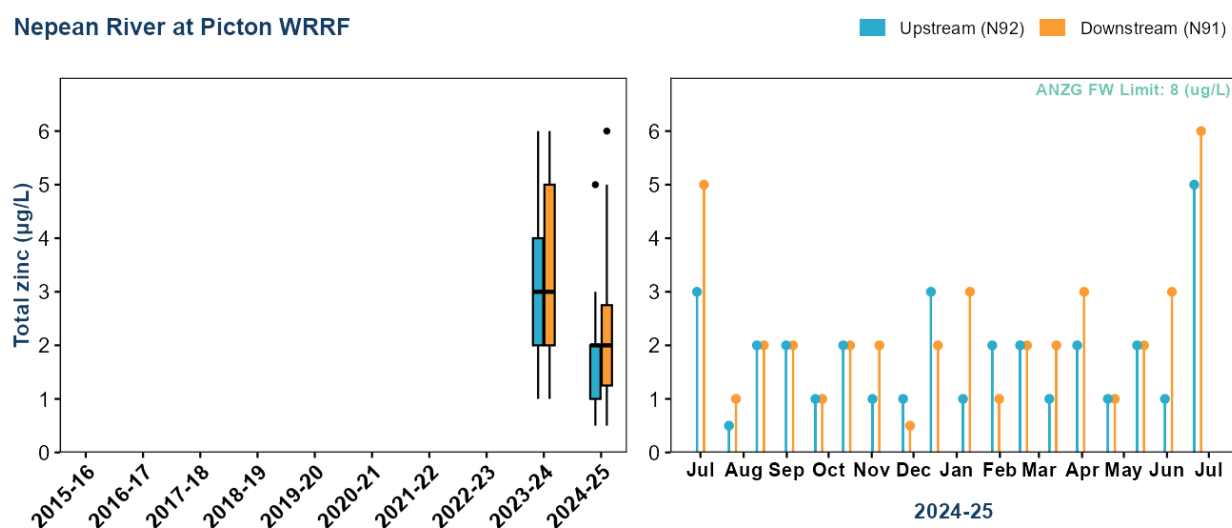
Nepean River at Picton WRRF



Stonequarry Creek at Picton WRRF



Nepean River at Picton WRRF



A.1.9. Ecosystem receptor – Statistical analysis outcomes

Table A-7 Upstream vs downstream comparison (2024-25 reporting period) for Stonequarry Creek at Picton WRRF

Stonequarry Creek at Picton WRRF: N911B vs N911 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.90	0.30	131	-0.31	0.990

not significant (p>0.05)
p <0.05 and >=0.01
p <0.01 and >=0.001
p <0.001

Table A-8 Upstream current period (2024-25) vs previous period comparison (single site) for Stonequarry Creek at Picton WRRF

Stonequarry Creek at Picton WRRF: N911B (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.82	0.23	131	-0.70	0.897

not significant (p>0.05)
p <0.05 and >=0.01
p <0.01 and >=0.001
p <0.001

Table A-9 Downstream current period (2024-25) vs previous period comparison (single site) for Stonequarry Creek at Picton WRRF

Stonequarry Creek at Picton WRRF: N911 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.43	0.12	131	-3.05	0.014

not significant (p>0.05)
p <0.05 and >=0.01
p <0.01 and >=0.001
p <0.001

Table A-10 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at Picton WRRF

Nepean River at Picton WRRF: N92 vs N91 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.82	0.27	323	-0.61	0.930

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-11 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Picton WRRF

Nepean River at Picton WRRF: N92 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.13	0.27	323	0.49	0.961

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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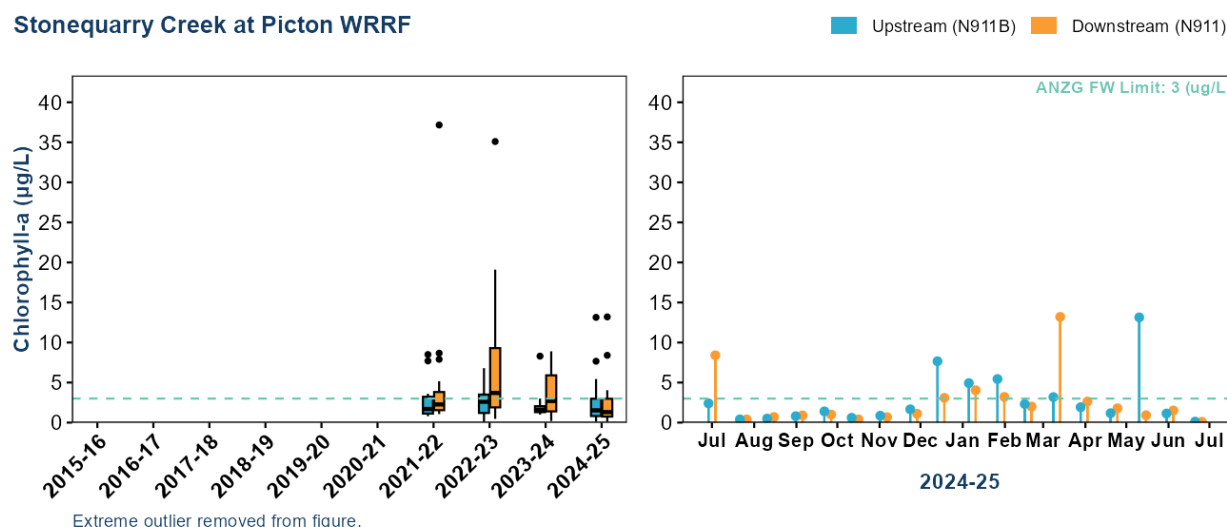
Table A-12 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Picton WRRF

Nepean River at Picton WRRF: N91 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.09	0.26	323	0.35	0.986

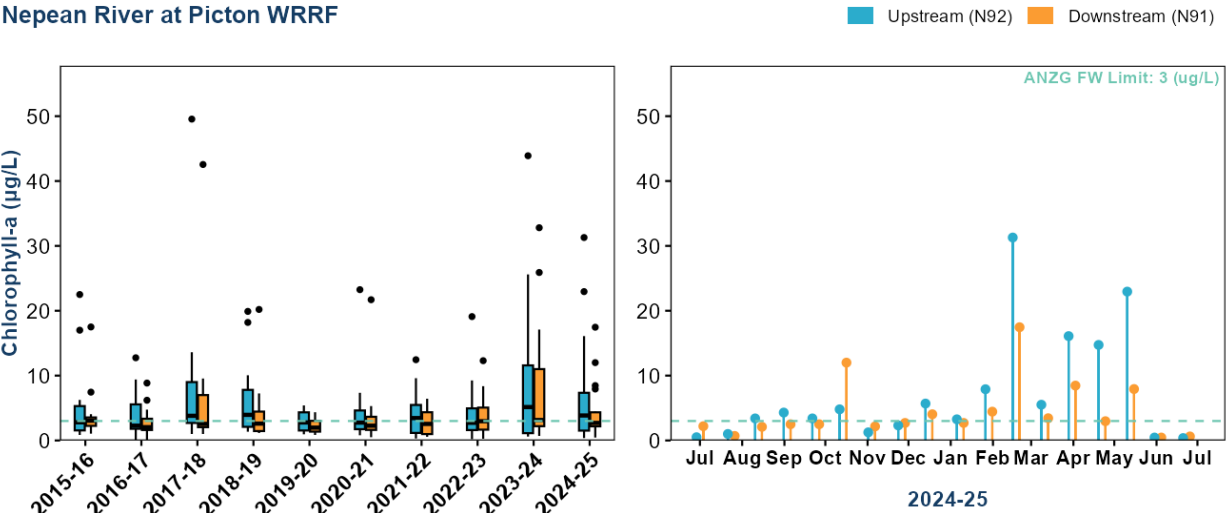
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.1.10. Ecosystem receptor – Phytoplankton

Stonequarry Creek at Picton WRRF



Nepean River at Picton WRRF

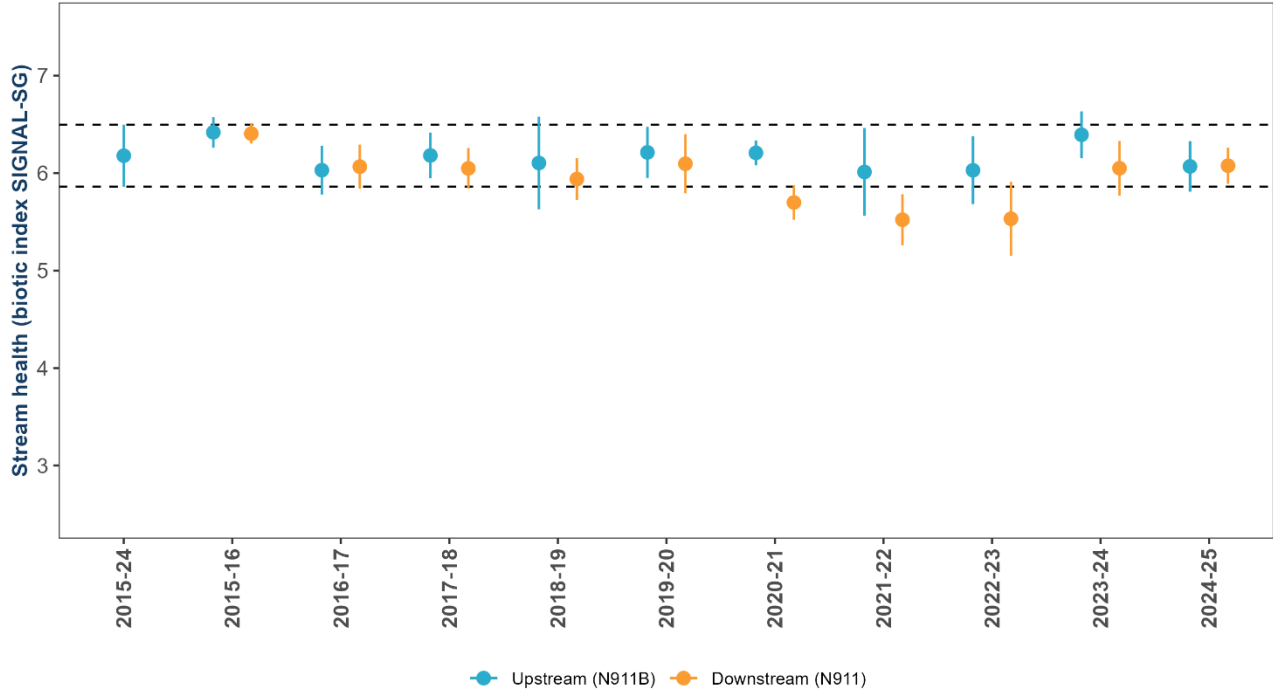


A.1.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Stonequarry Creek	Tributary (N911B vs N911)	Welch Two Sample t-test	-0.01	-0.06	12.0	0.951
Nepean River	River (N92A vs N91)	Welch Two Sample t-test	0.09	0.87	8.7	0.407

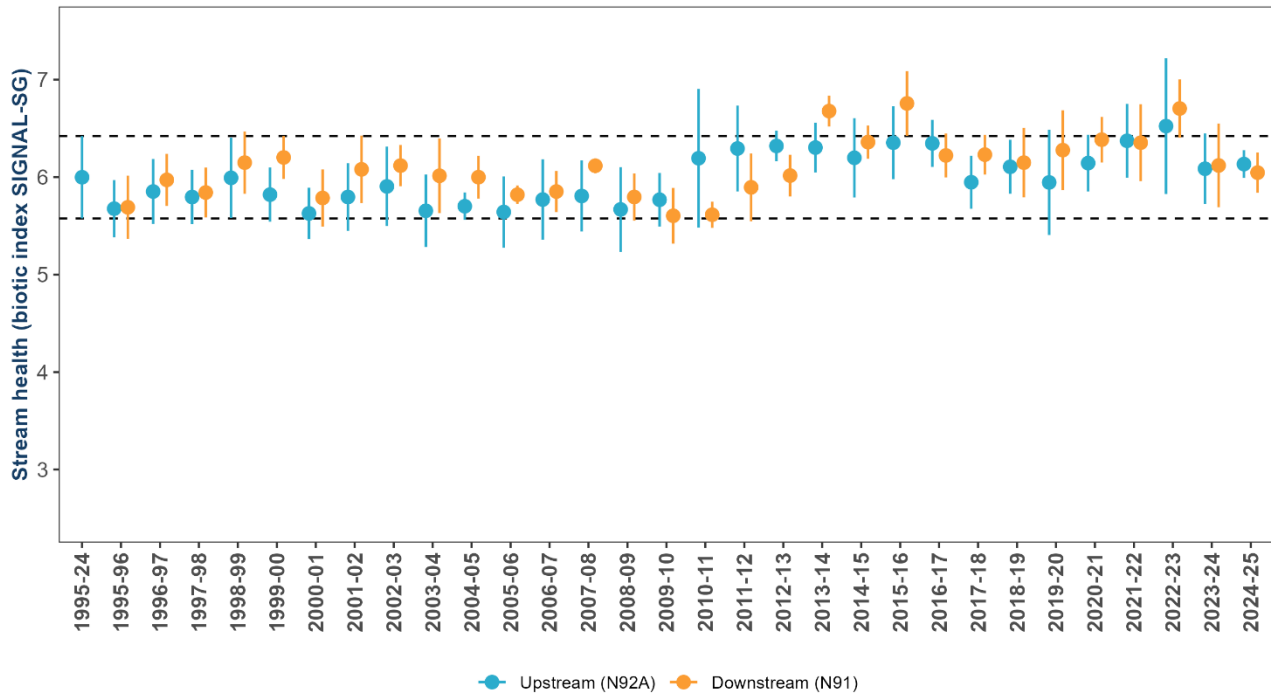
not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Stonequarry Creek at Picton WRRF



The range of stream health recorded over each period is represented by length of line

Nepean River at Picton WRRF

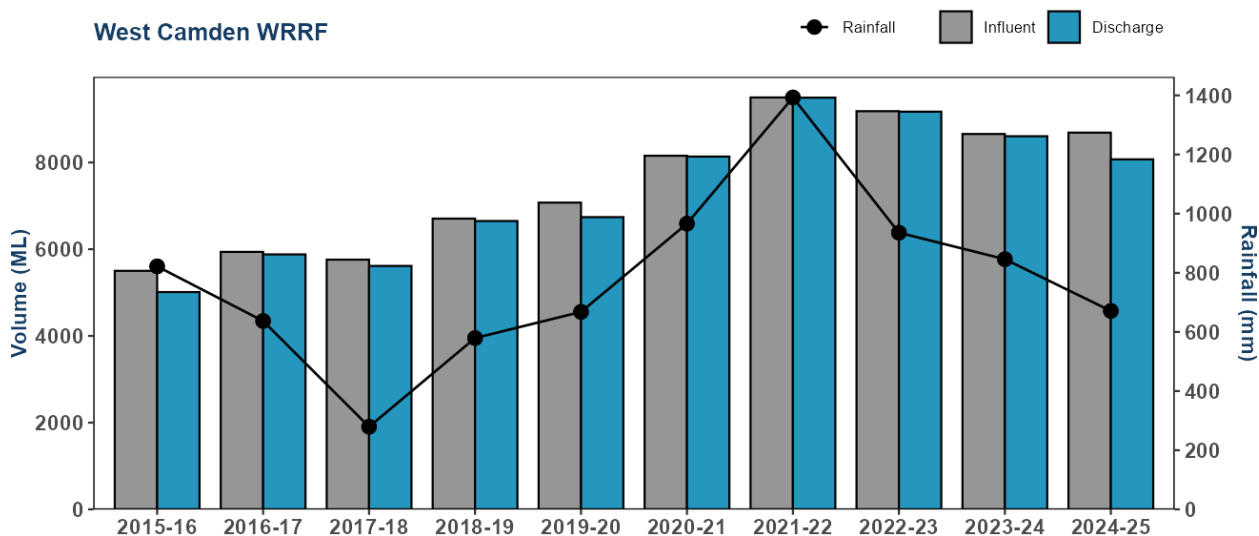


The range of stream health recorded over each period is represented by length of line

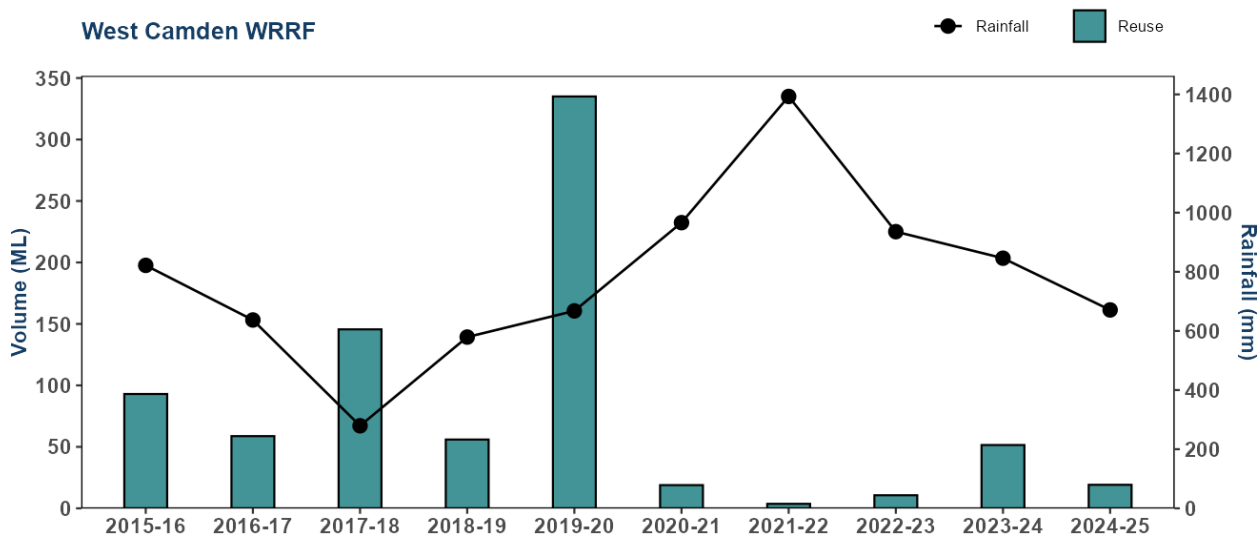
A.2. West Camden WRRF

A.2.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



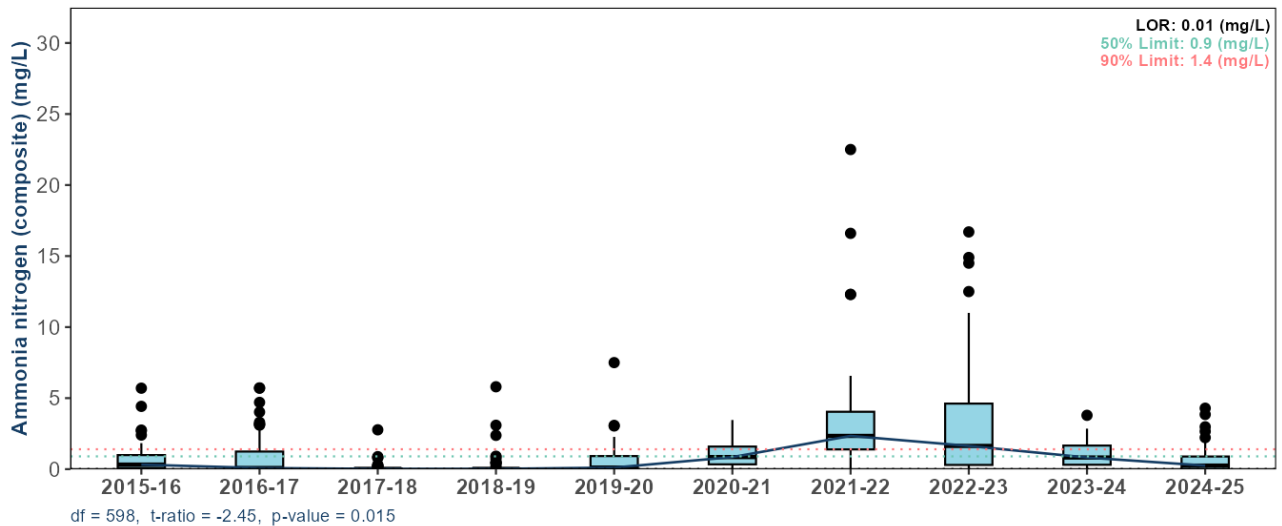
Reuse volume and rainfall



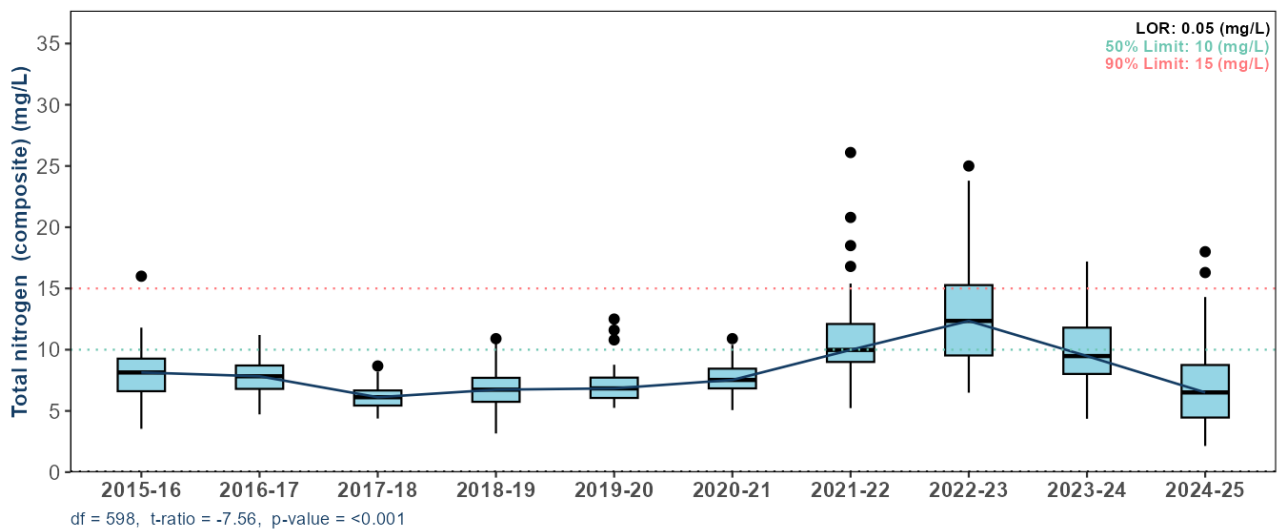
A.2.2. Pressure – Wastewater quality

Nutrients

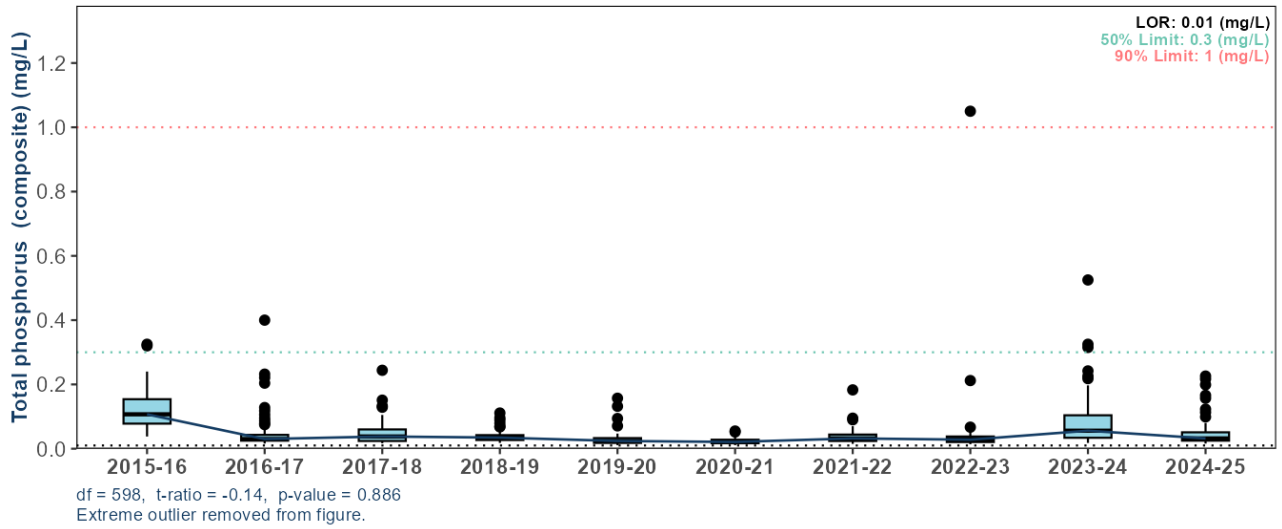
WC0015 (WC0005) at West Camden WRRF



WC0015 (WC0005) at West Camden WRRF

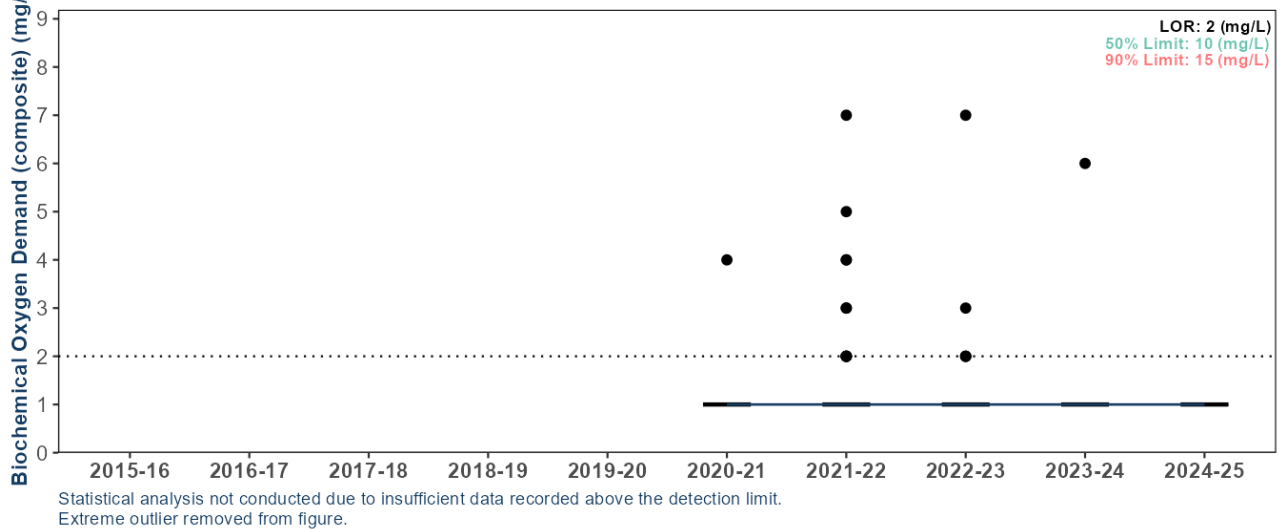


WC0015 (WC0005) at West Camden WRRF

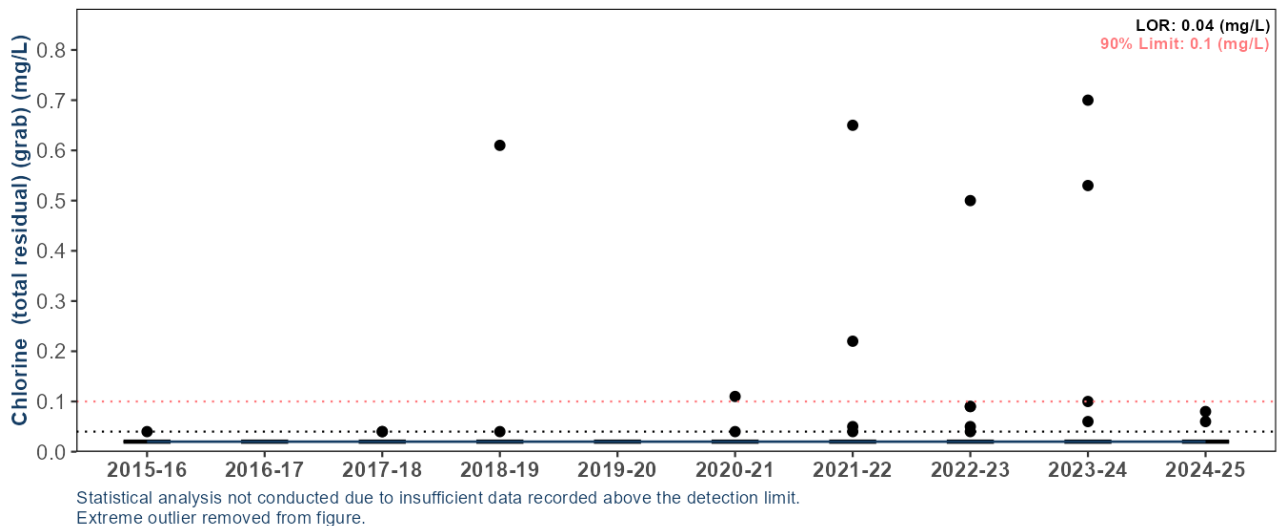


Major conventional analytes

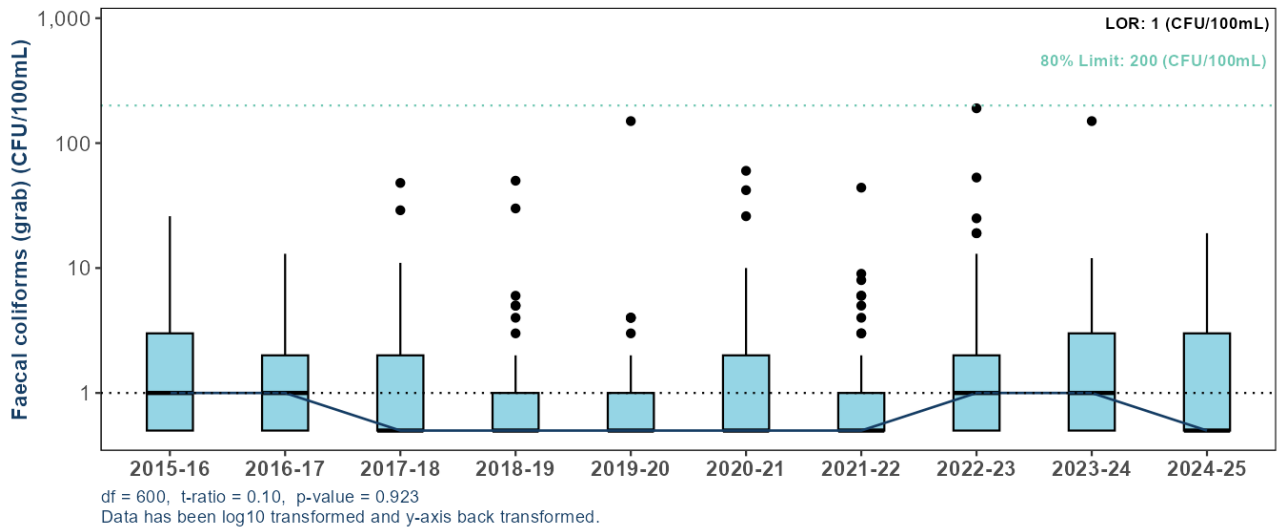
WC0015 (WC0005) at West Camden WRRF



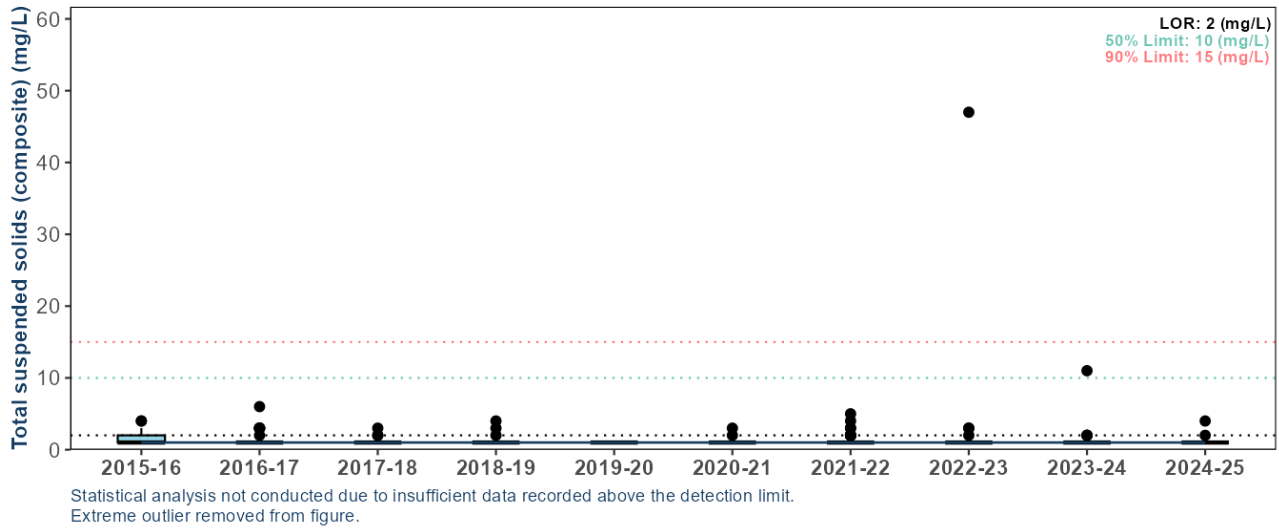
WC0015 (WC0005) at West Camden WRRF



WC0015 (WC0005) at West Camden WRRF

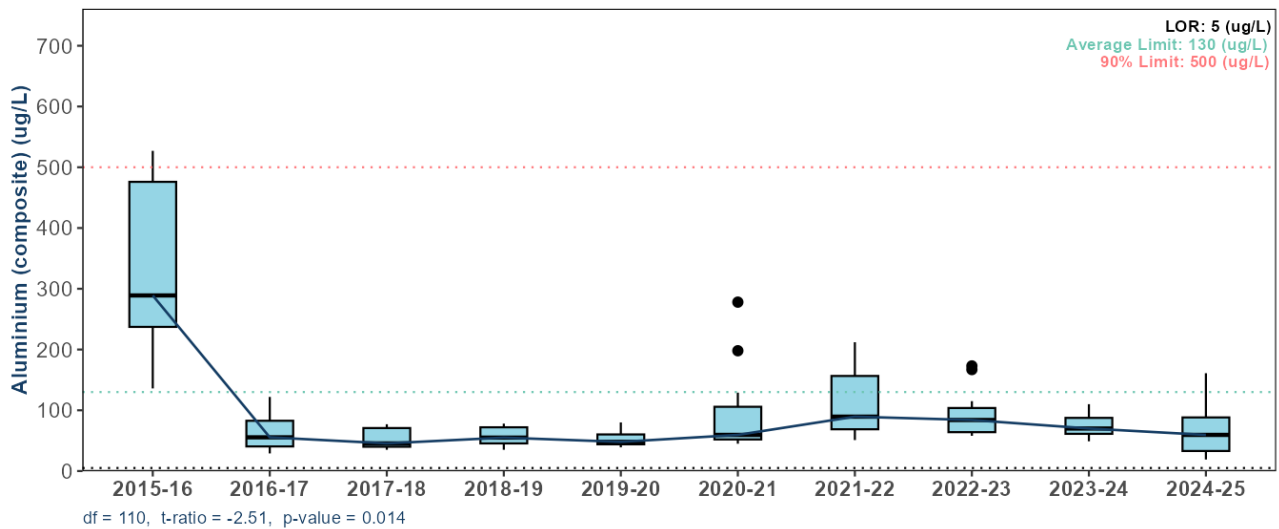


WC0015 (WC0005) at West Camden WRRF

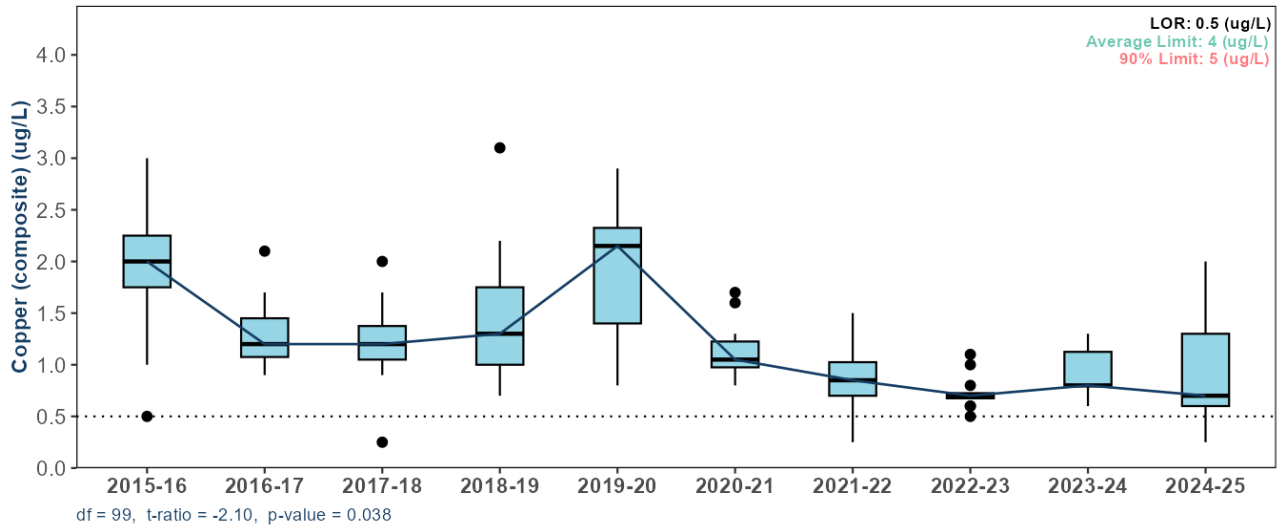


Trace metals

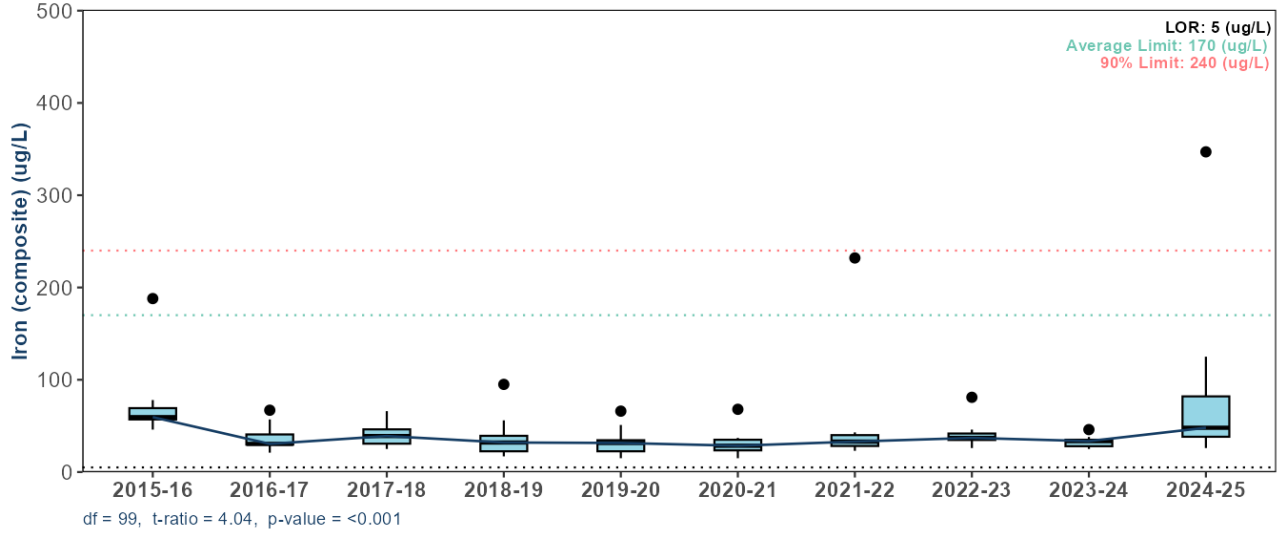
WC0015 (WC0005) at West Camden WRRF



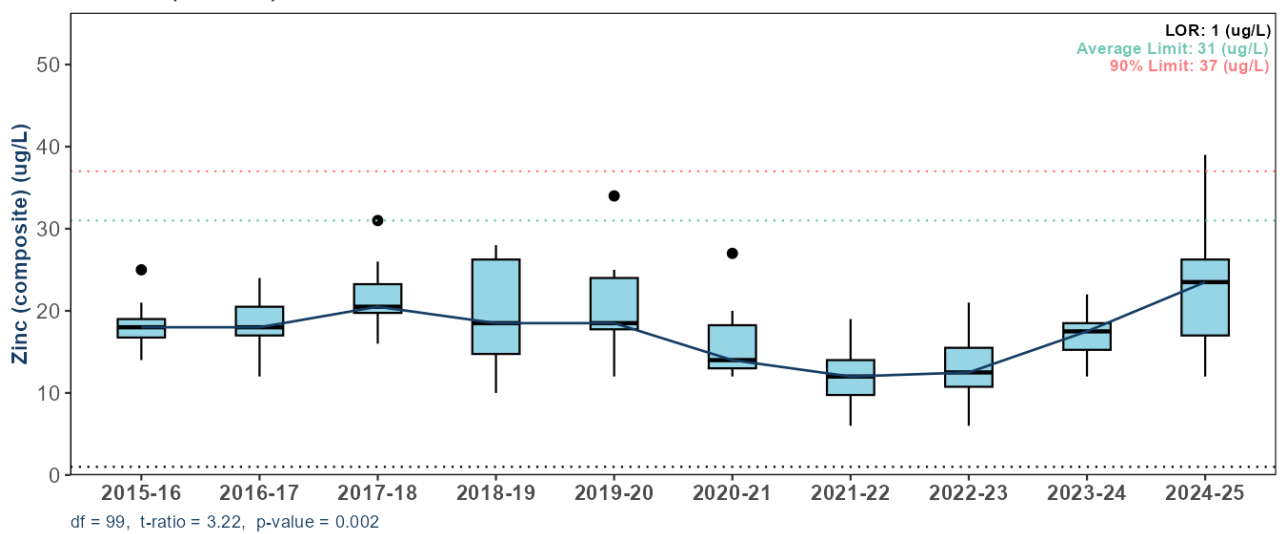
WC0015 (WC0005) at West Camden WRRF



WC0015 (WC0005) at West Camden WRRF

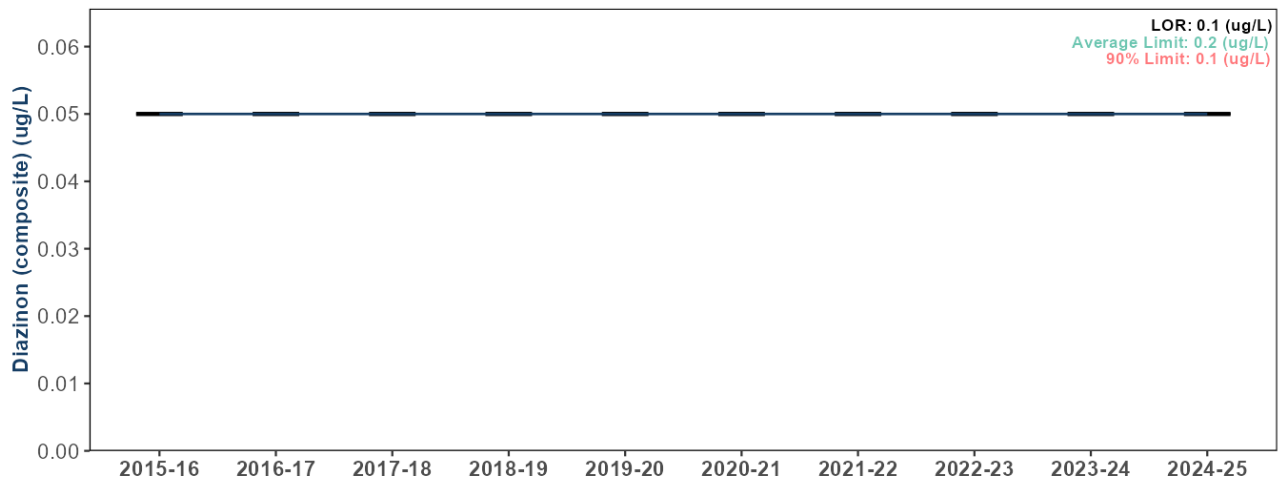


WC0015 (WC0005) at West Camden WRRF



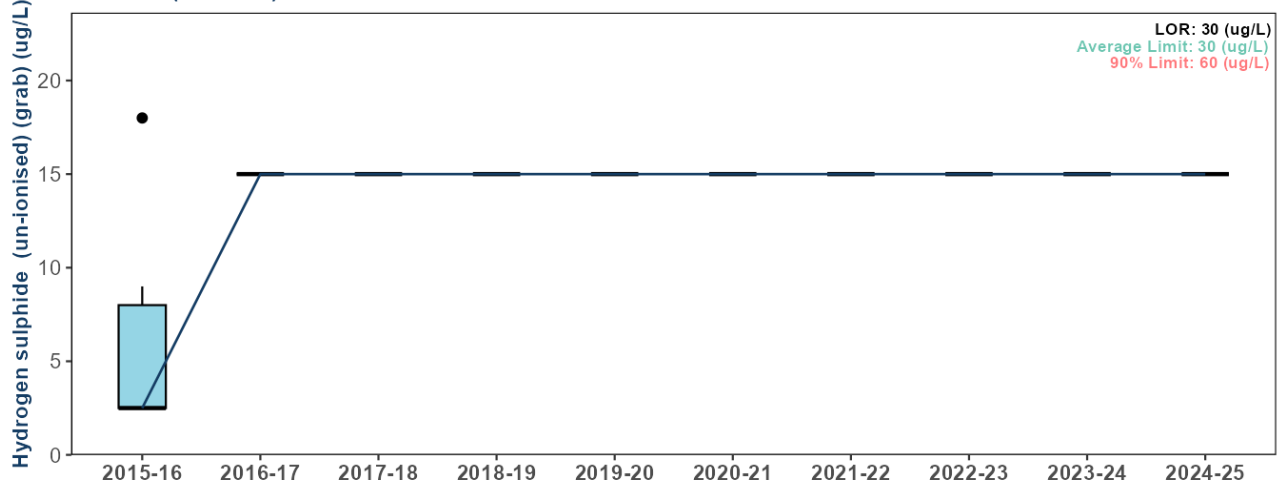
Other chemicals and organics (including pesticides)

WC0015 (WC0005) at West Camden WRRF



Statistical analysis not conducted due to insufficient data recorded above the detection limit.
Extreme outlier removed from figure.

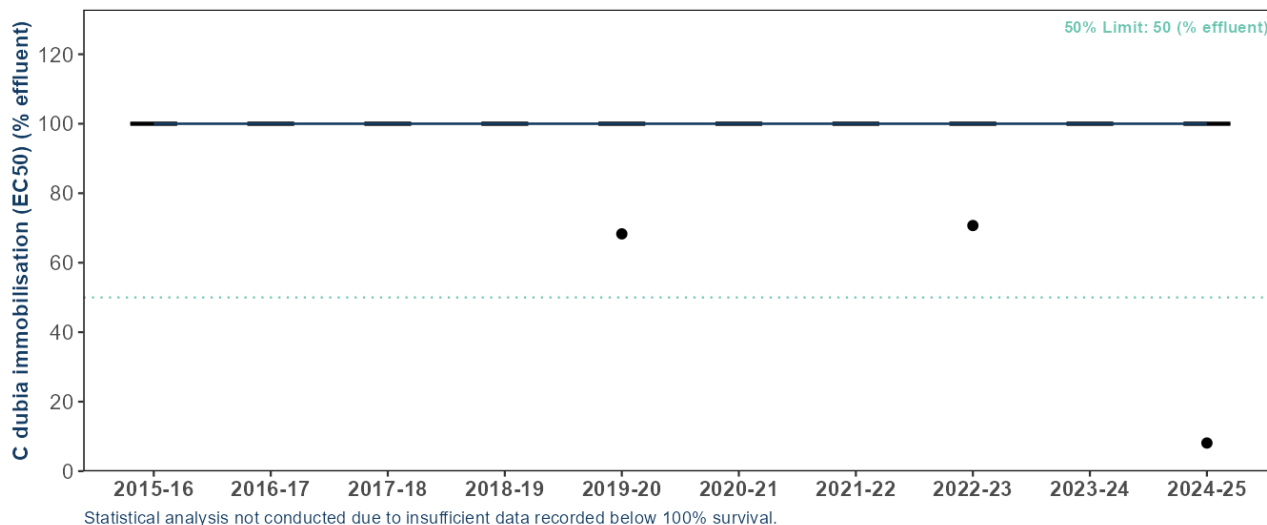
WC0015 (WC0005) at West Camden WRRF



Statistical analysis not conducted due to insufficient data recorded above the detection limit.
Extreme outlier removed from figure.

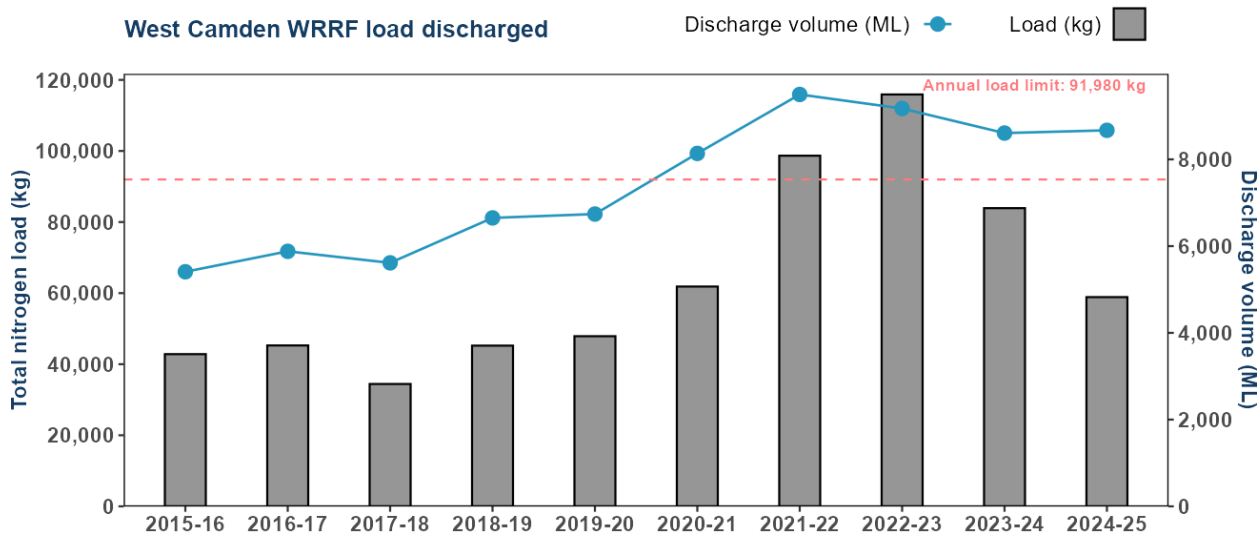
A.2.3. Pressure – Wastewater toxicity

WC0015 (WC0005) at West Camden WRRF



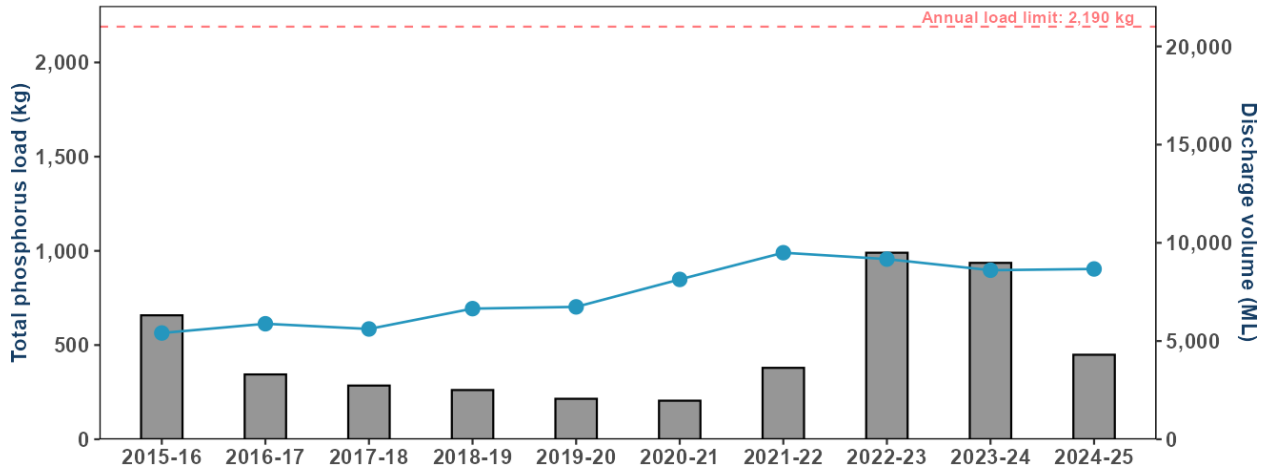
A.2.4. Pressure – Wastewater discharge load

Nutrients



West Camden WRRF load discharged

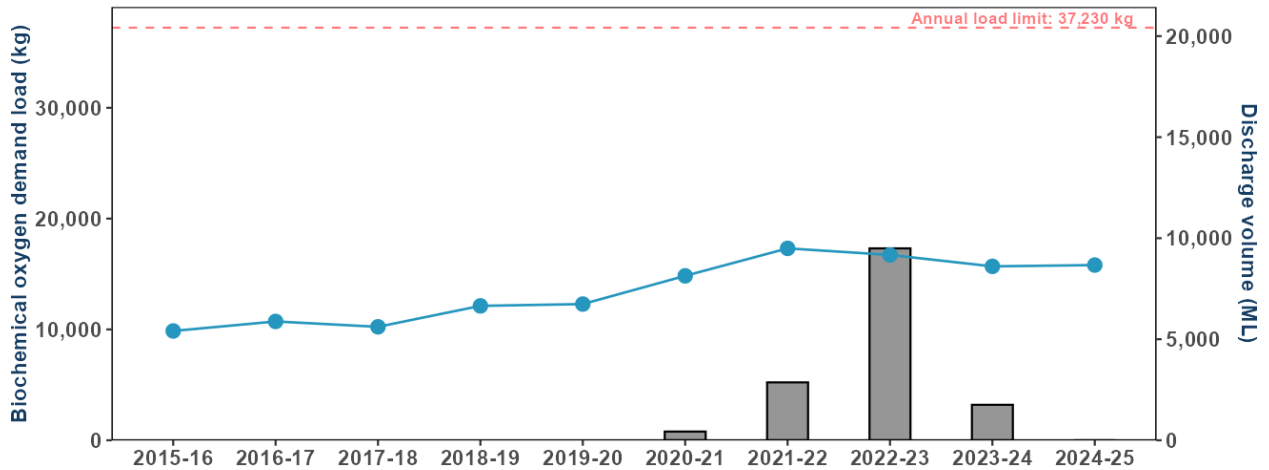
Discharge volume (ML) ● Load (kg) ■



Major conventional analytes

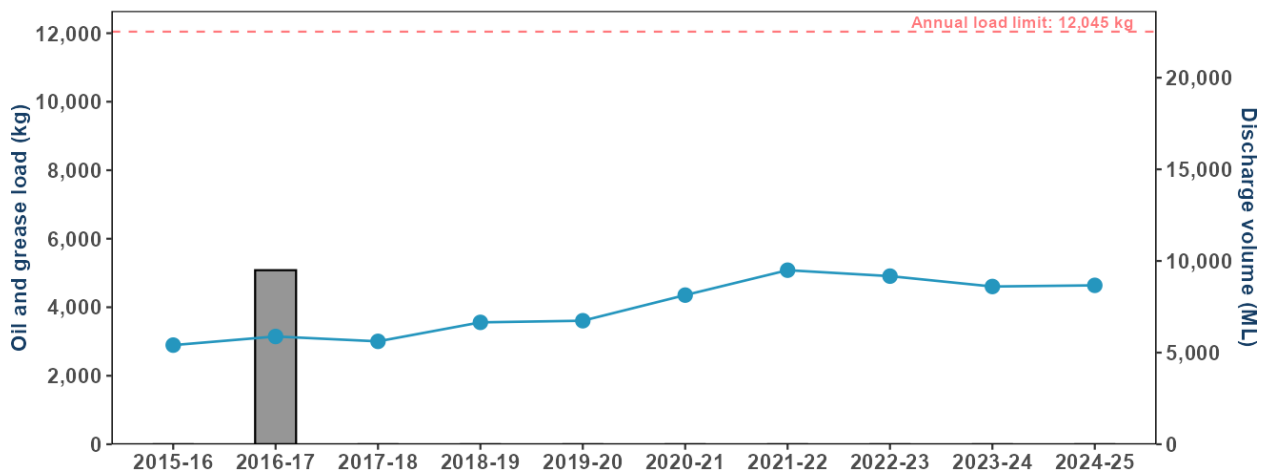
West Camden WRRF load discharged

Discharge volume (ML) ● Load (kg) ■

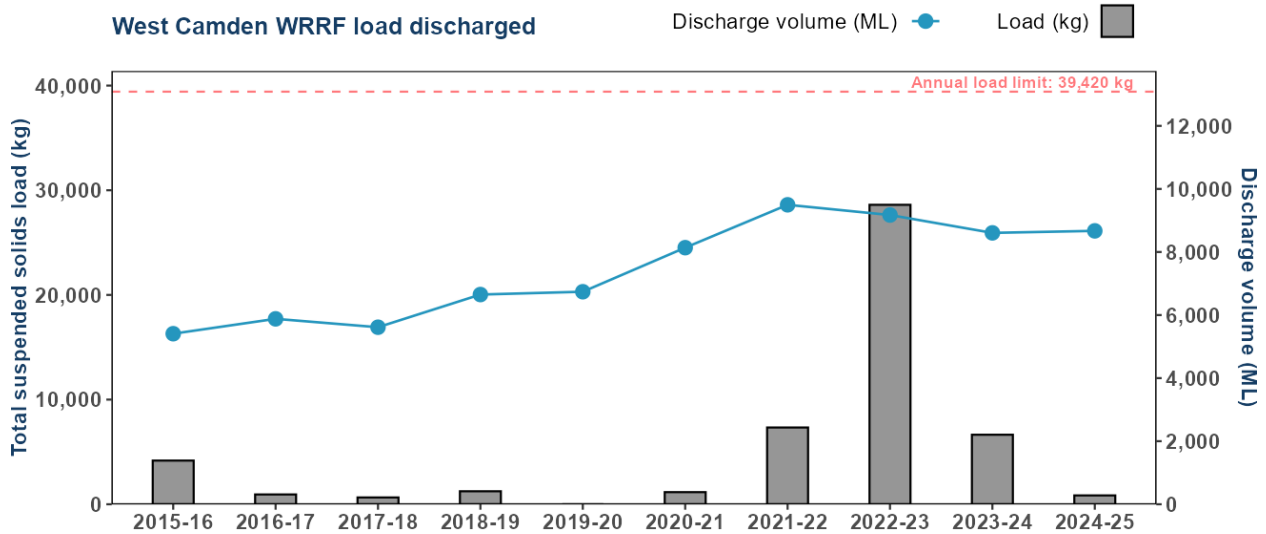


West Camden WRRF load discharged

Discharge volume (ML) ● Load (kg) ■



West Camden WRRF load discharged



A.2.5. Stressor – Statistical analysis outcomes

Table A-13 Upstream vs downstream comparison (2024-25 reporting period) for Matahil Creek at West Camden WRRF

Matahil Creek at West Camden WRRF: N7824A vs N7824 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	6.45	4.47	138	2.69	0.040
Oxidised nitrogen	237.54	77.72	138	16.72	<0.001
Total nitrogen	4.36	0.78	138	8.24	<0.001
Soluble reactive phosphorus	2.16	0.93	56	1.78	0.293
Total phosphorus	0.85	0.21	138	-0.66	0.914
Physico-chemical					
Conductivity	0.23	0.04	138	-8.10	<0.001
Dissolved oxygen	1.20	0.08	138	2.83	0.027
Dissolved oxygen saturation	24.38	3.28	135	7.44	<0.001
pH	-0.20	0.07	136	-2.68	0.040
Water temperature	1.47	0.14	138	4.00	<0.001
Turbidity	0.07	0.02	138	-8.59	<0.001
Trace Metals					
Filterable aluminium	9.37	2.13	56	9.85	<0.001
Total aluminium	0.39	0.10	56	-3.62	0.003
Filterable cobalt	0.57	0.09	56	-3.49	0.005
Total cobalt	0.46	0.08	56	-4.60	<0.001
Filterable copper	0.68	0.14	56	-1.96	0.216
Total copper	0.53	0.10	56	-3.27	0.010
Filterable nickel	2.13	0.25	56	6.53	<0.001
Total nickel	1.88	0.24	56	4.94	<0.001
Filterable zinc	12.06	2.58	55	11.66	<0.001
Total zinc	7.06	1.27	56	10.85	<0.001

not significant (p>0.05)
p <0.05 and >=0.01
p <0.01 and >=0.001
p <0.001

Table A-14 Upstream current period (2024-25) vs previous period comparison (single site) for Matajhu Creek at West Camden WRRF

Matahil Creek at West Camden WRRF: N7824A (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.21	0.73	138	0.31	0.989
Oxidised nitrogen	0.56	0.16	138	-2.01	0.189
Total nitrogen	0.83	0.13	138	-1.22	0.617
Soluble reactive phosphorus	0.80	0.37	56	-0.48	0.962
Total phosphorus	0.80	0.17	138	-1.04	0.728
Physico-chemical					
Conductivity	1.28	0.20	138	1.56	0.403
Dissolved oxygen	0.94	0.05	138	-1.19	0.634
Dissolved oxygen saturation	-8.14	2.86	135	-2.84	0.026
pH	-0.04	0.07	136	-0.58	0.939
Water temperature	0.89	0.07	138	-1.38	0.516
Turbidity	0.62	0.17	138	-1.75	0.300
Trace Metals					
Filterable aluminium	0.89	0.22	56	-0.47	0.965
Total aluminium	0.37	0.10	56	-3.54	0.004
Filterable cobalt	1.14	0.20	56	0.76	0.872
Total cobalt	0.89	0.16	56	-0.63	0.921
Filterable copper	0.52	0.11	56	-3.04	0.019
Total copper	0.48	0.10	56	-3.54	0.004
Filterable nickel	0.89	0.11	56	-0.93	0.790
Total nickel	0.74	0.10	56	-2.24	0.124
Filterable zinc	0.74	0.17	55	-1.27	0.585
Total zinc	0.53	0.10	56	-3.27	0.010
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-15 Downstream current period (2024-25) vs previous period comparison (single site) for Matahil Creek at West Camden WRRF

Matahil Creek at West Camden WRRF: N7824 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.22	0.11	138	-2.96	0.019
Oxidised nitrogen	0.33	0.08	138	-4.66	<0.001
Total nitrogen	0.33	0.04	138	-8.50	<0.001
Soluble reactive phosphorus	0.65	0.25	56	-1.10	0.691
Total phosphorus	1.05	0.19	138	0.27	0.993
Physico-chemical					
Conductivity	0.97	0.13	138	-0.25	0.995
Dissolved oxygen	0.98	0.05	138	-0.45	0.970
Dissolved oxygen saturation	-0.41	2.30	135	-0.18	0.998
pH	-0.01	0.06	136	-0.18	0.998
Water temperature	1.05	0.07	138	0.65	0.914
Turbidity	0.63	0.15	138	-1.99	0.197
Trace Metals					
Filterable aluminium	0.89	0.18	56	-0.54	0.949
Total aluminium	0.76	0.18	56	-1.15	0.660
Filterable cobalt	0.82	0.12	56	-1.36	0.527
Total cobalt	0.83	0.13	56	-1.22	0.618
Filterable copper	0.79	0.14	56	-1.29	0.574
Total copper	0.81	0.14	56	-1.18	0.644
Filterable nickel	0.84	0.09	56	-1.62	0.378
Total nickel	0.84	0.10	56	-1.48	0.458
Filterable zinc	1.09	0.21	55	0.42	0.974
Total zinc	1.09	0.18	56	0.55	0.946

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-16 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at West Camden WRRF

Nepean River at West Camden WRRF: N78 vs N75 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	2.92	1.03	243	3.04	0.014
Oxidised nitrogen	6.87	2.12	243	6.25	<0.001
Total nitrogen	2.48	0.33	243	6.82	<0.001
Soluble reactive phosphorus	1.48	0.35	66	1.66	0.351
Total phosphorus	1.49	0.19	243	3.13	0.011
Physico-chemical					
Conductivity	1.37	0.16	243	2.72	0.035
Dissolved oxygen	1.00	0.04	243	0.08	>0.999
Dissolved oxygen saturation	1.13	2.57	240	0.44	0.972
pH	0.08	0.09	241	0.80	0.854
Water temperature	1.02	0.10	243	0.17	0.998
Turbidity	0.90	0.19	243	-0.51	0.956
Trace Metals					
Filterable aluminium	1.09	0.21	66	0.43	0.973
Total aluminium	0.83	0.21	66	-0.74	0.879
Filterable cobalt	1.06	0.26	66	0.22	0.996
Total cobalt	0.80	0.12	66	-1.44	0.477
Filterable copper	1.27	0.18	66	1.68	0.340
Total copper	1.07	0.14	66	0.50	0.959
Filterable nickel	1.44	0.25	66	2.09	0.169
Total nickel	1.25	0.19	66	1.52	0.430
Filterable zinc	2.55	0.53	66	4.54	<0.001
Total zinc	1.77	0.39	66	2.64	0.050

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-17 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at West Camden WRRF

Nepean River at West Camden WRRF: N78 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.59	0.17	243	-1.89	0.236
Oxidised nitrogen	0.89	0.22	243	-0.50	0.960
Total nitrogen	0.90	0.09	243	-1.03	0.731
Soluble reactive phosphorus	0.84	0.20	66	-0.73	0.883
Total phosphorus	0.80	0.08	243	-2.15	0.141
Physico-chemical					
Conductivity	0.85	0.08	243	-1.72	0.317
Dissolved oxygen	1.00	0.03	243	0.00	>0.999
Dissolved oxygen saturation	0.70	2.03	240	0.34	0.986
pH	-0.12	0.07	241	-1.61	0.375
Water temperature	1.03	0.08	243	0.40	0.978
Turbidity	0.74	0.13	243	-1.78	0.284
Trace Metals					
Filterable aluminium	1.31	0.26	66	1.40	0.504
Total aluminium	0.75	0.20	66	-1.11	0.684
Filterable cobalt	0.72	0.18	66	-1.31	0.562
Total cobalt	0.66	0.10	66	-2.67	0.046
Filterable copper	0.75	0.11	66	-2.00	0.197
Total copper	0.82	0.11	66	-1.47	0.462
Filterable nickel	0.47	0.08	66	-4.24	<0.001
Total nickel	0.50	0.08	66	-4.63	<0.001
Filterable zinc	0.76	0.16	66	-1.29	0.575
Total zinc	0.87	0.19	66	-0.62	0.926

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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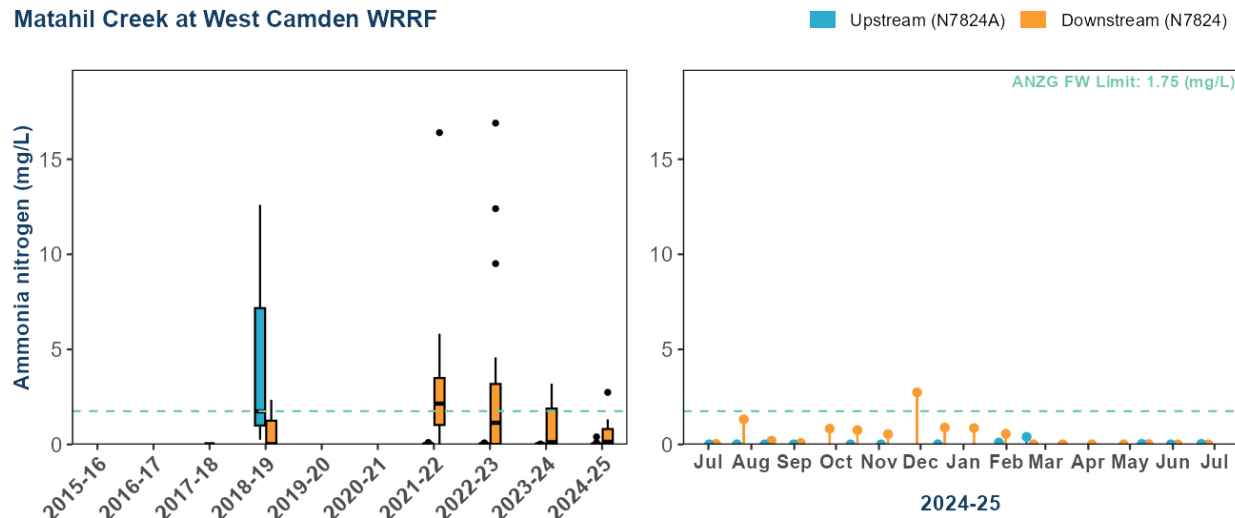
Table A-18 Downstream current period (2024-250 vs previous period comparison (single site) for the Nepean River at West Camden WRRF

Nepean River at West Camden WRRF: N75 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.49	0.14	243	-2.57	0.052
Oxidised nitrogen	0.66	0.16	243	-1.71	0.321
Total nitrogen	0.75	0.08	243	-2.66	0.041
Soluble reactive phosphorus	1.13	0.27	66	0.50	0.959
Total phosphorus	1.02	0.10	243	0.19	0.998
Physico-chemical					
Conductivity	0.94	0.09	243	-0.62	0.926
Dissolved oxygen	1.01	0.03	243	0.43	0.973
Dissolved oxygen saturation	1.71	2.04	240	0.84	0.835
pH	-0.11	0.08	241	-1.42	0.489
Water temperature	1.03	0.08	243	0.36	0.984
Turbidity	0.79	0.13	243	-1.40	0.500
Trace Metals					
Filterable aluminium	1.11	0.22	66	0.55	0.947
Total aluminium	0.83	0.22	66	-0.70	0.898
Filterable cobalt	0.65	0.16	66	-1.70	0.334
Total cobalt	0.61	0.09	66	-3.19	0.011
Filterable copper	0.86	0.13	66	-1.02	0.737
Total copper	0.85	0.11	66	-1.22	0.614
Filterable nickel	0.57	0.10	66	-3.18	0.012
Total nickel	0.56	0.08	66	-3.84	0.002
Filterable zinc	0.90	0.19	66	-0.49	0.961
Total zinc	0.75	0.17	66	-1.30	0.567

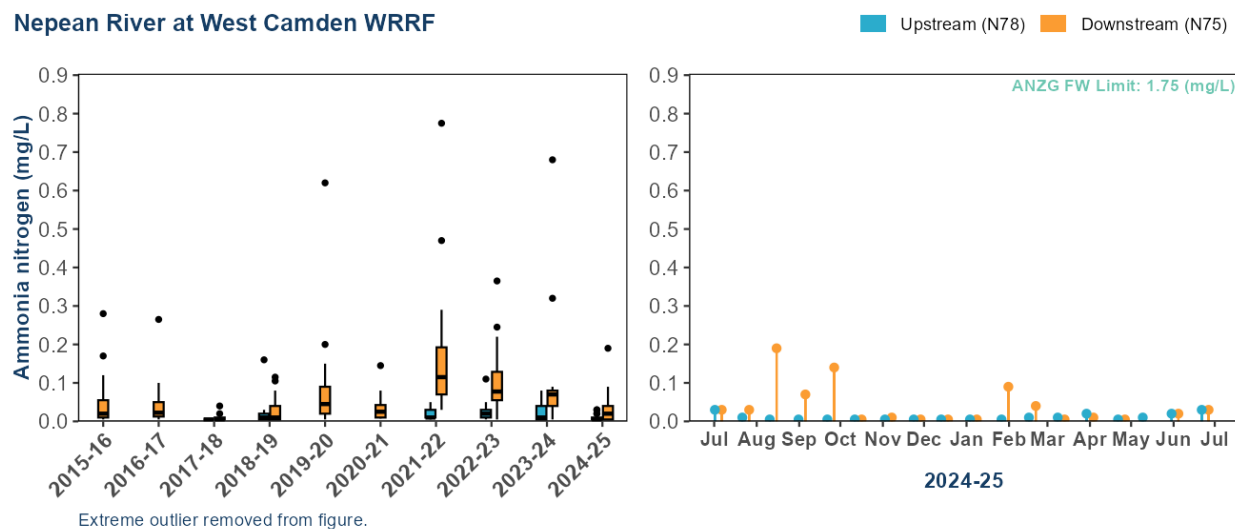
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.2.6. Stressor – Nutrients

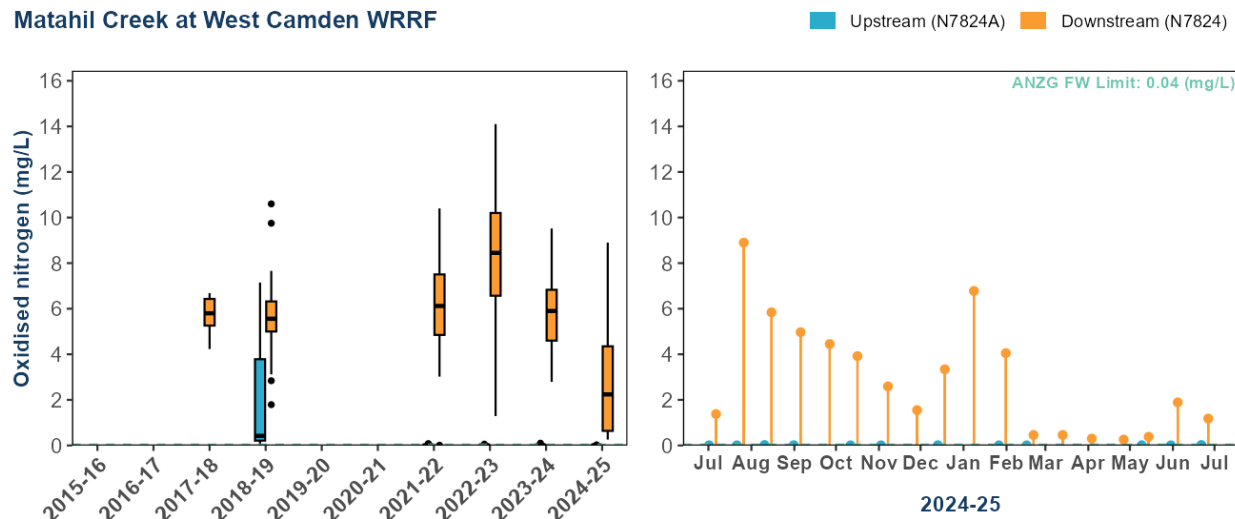
Matahil Creek at West Camden WRRF



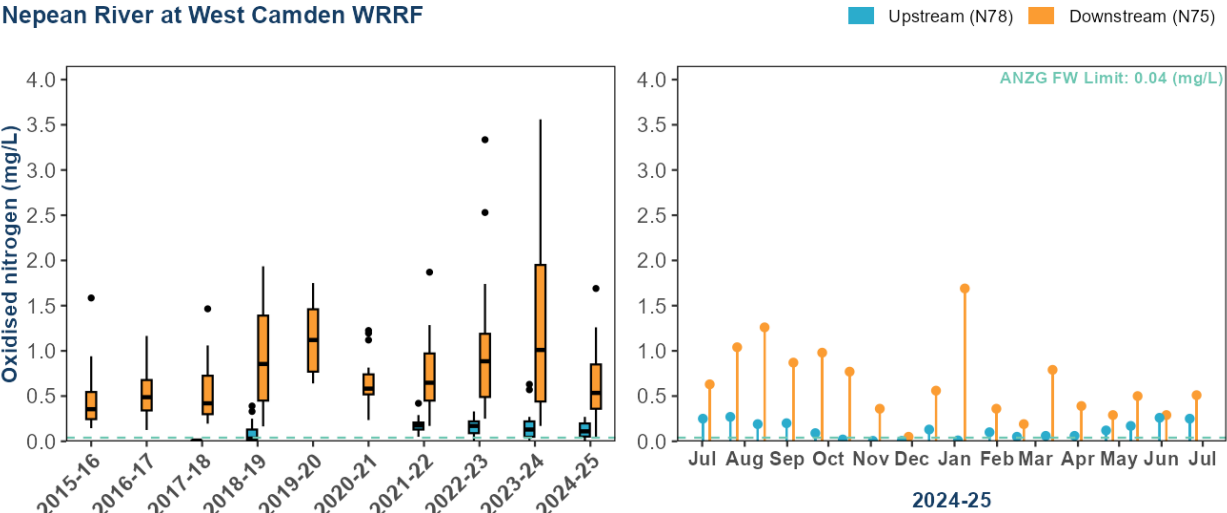
Nepean River at West Camden WRRF



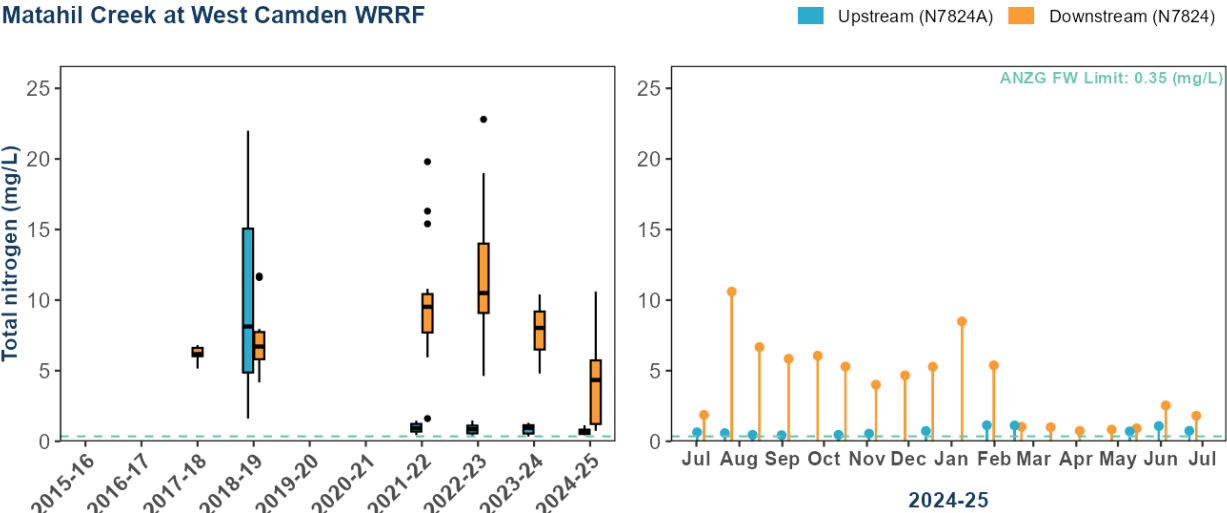
Matahil Creek at West Camden WRRF



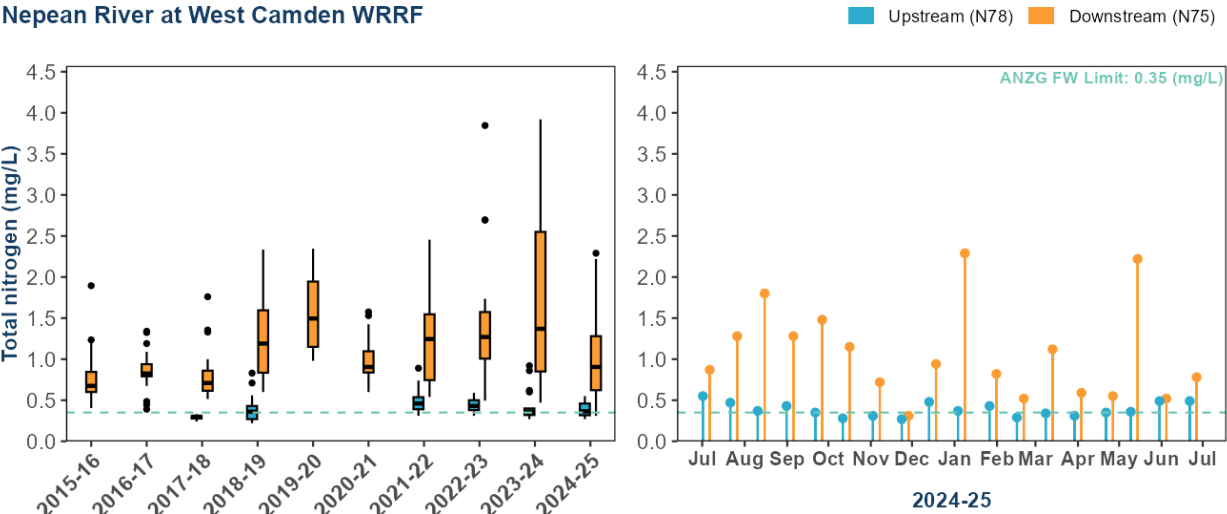
Nepean River at West Camden WRRF



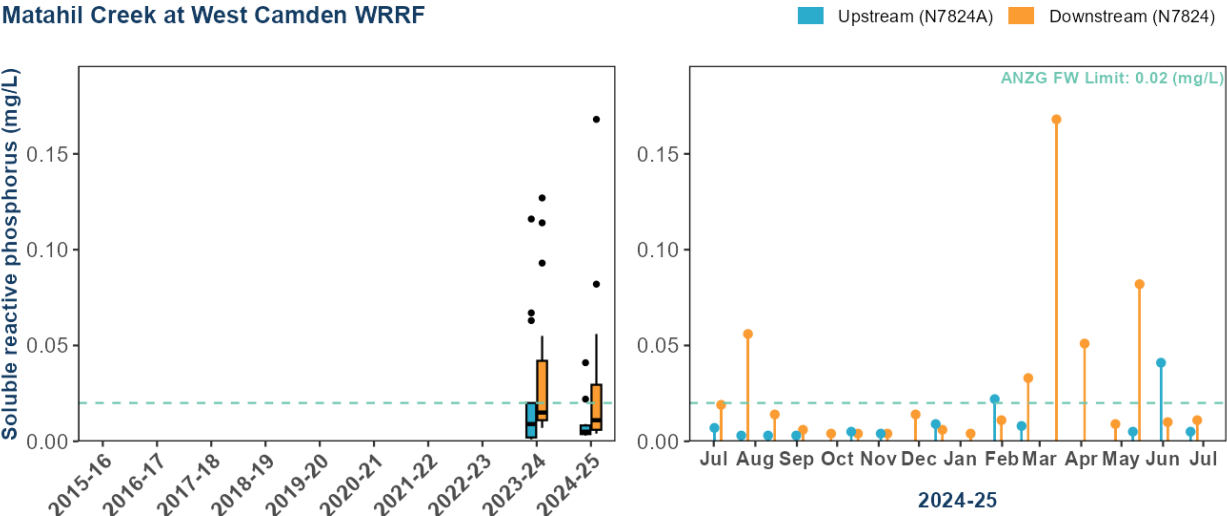
Matahil Creek at West Camden WRRF



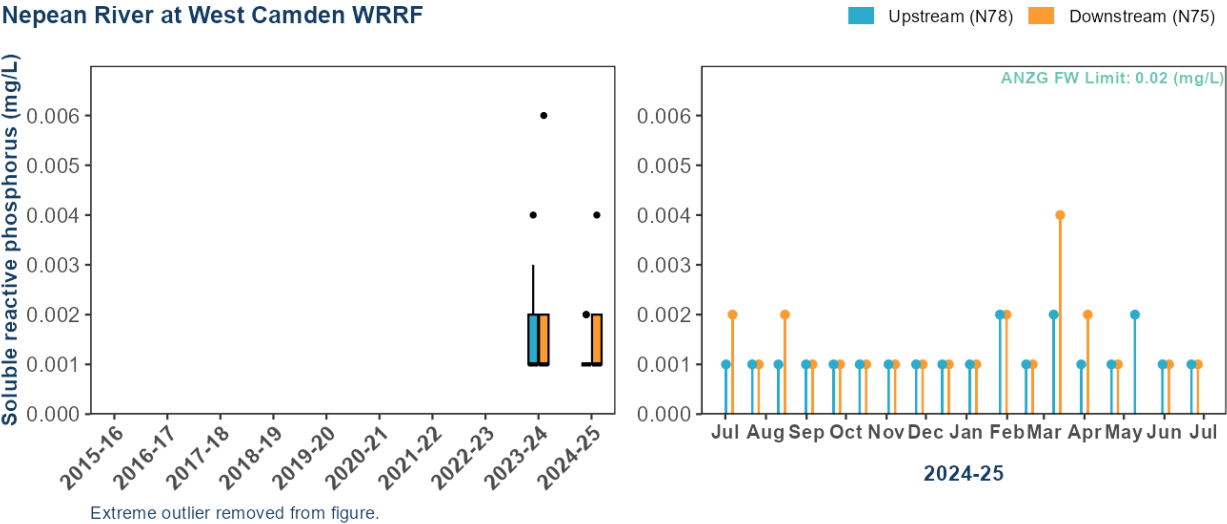
Nepean River at West Camden WRRF



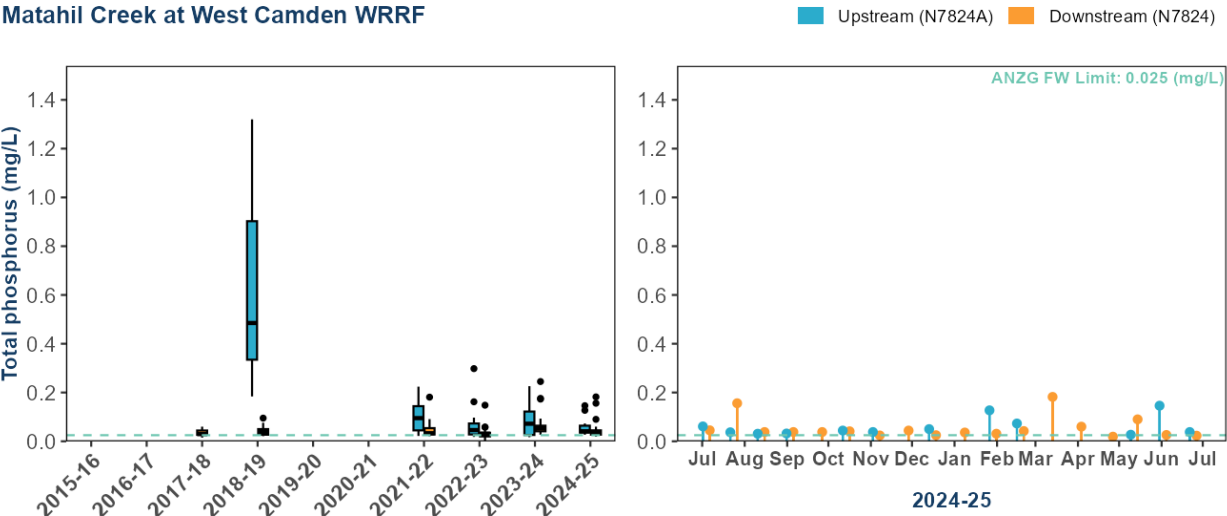
Matahil Creek at West Camden WRRF



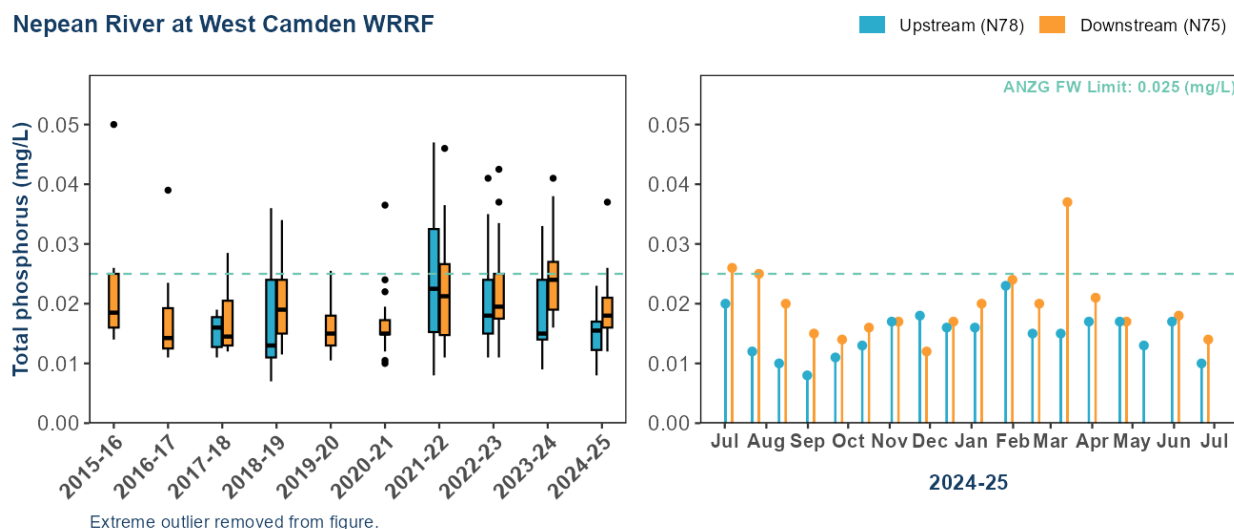
Nepean River at West Camden WRRF



Matahil Creek at West Camden WRRF

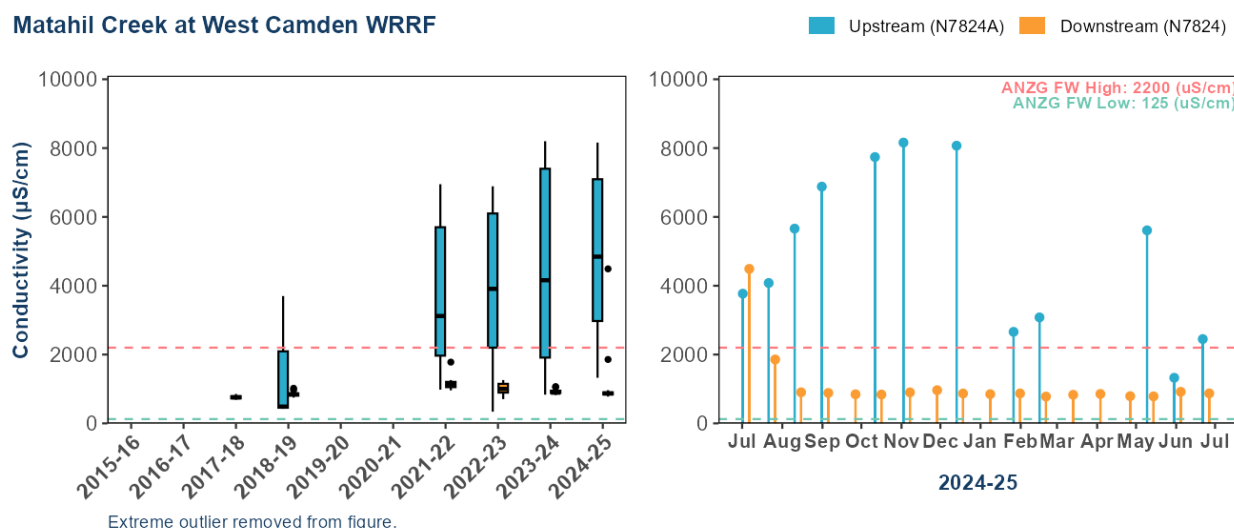


Nepean River at West Camden WRRF

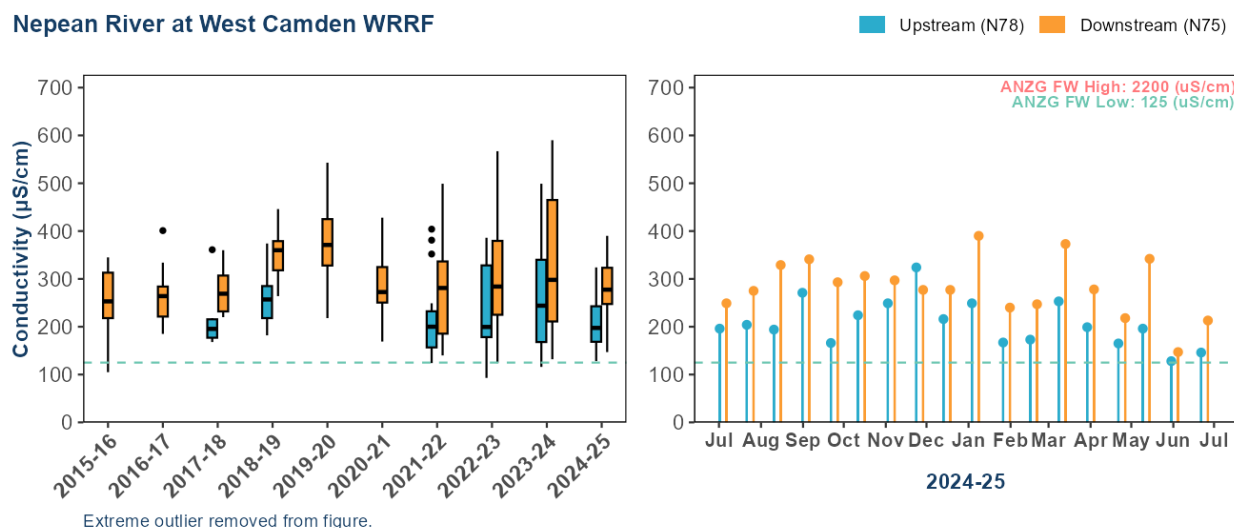


A.2.7. Stressor – Physico-chemical water quality

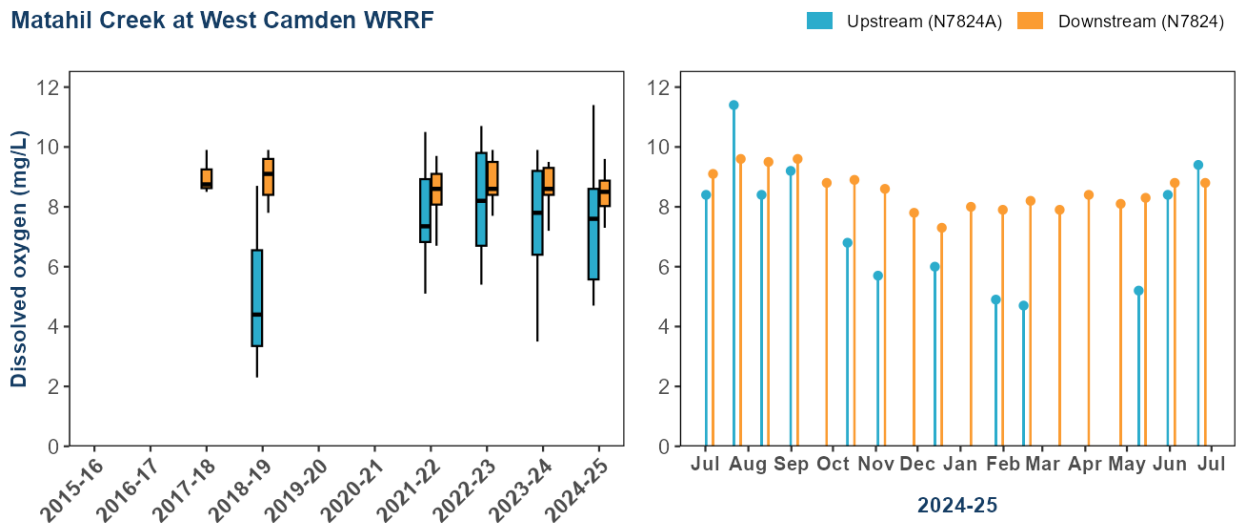
Matahil Creek at West Camden WRRF



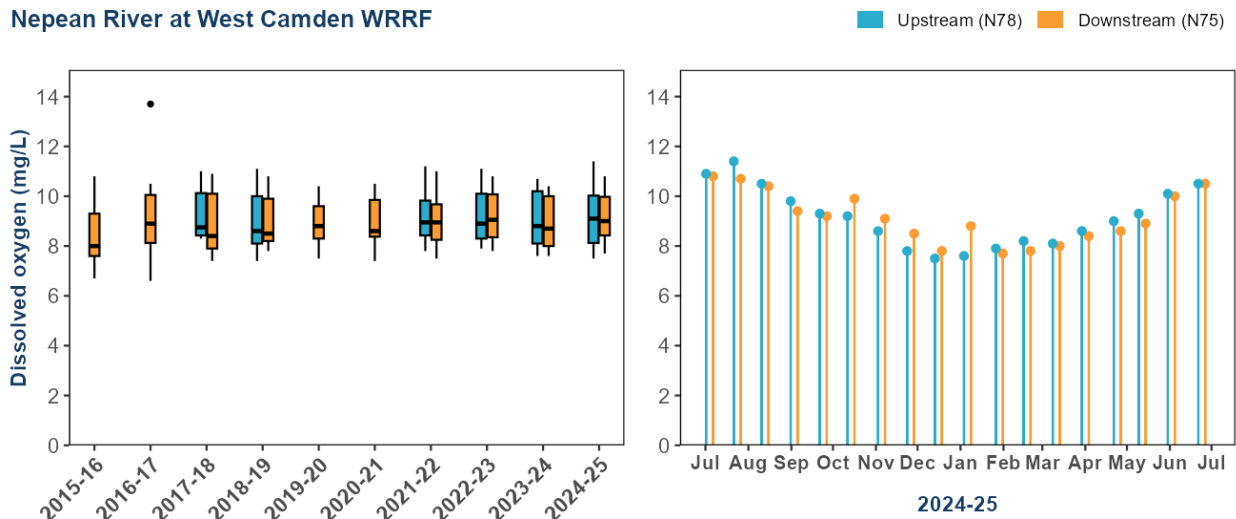
Nepean River at West Camden WRRF



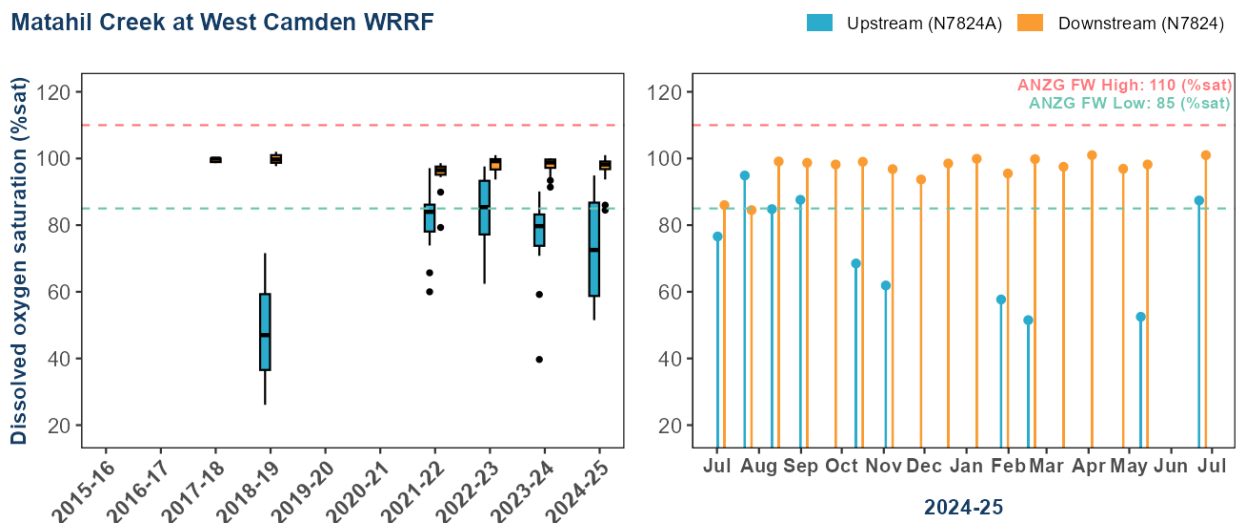
Matahil Creek at West Camden WRRF



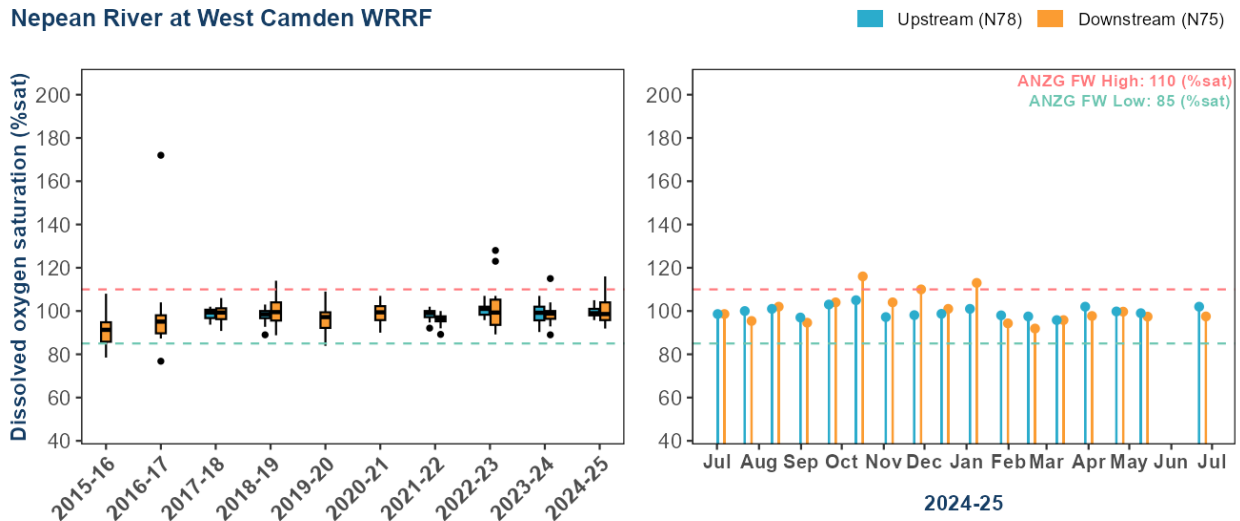
Nepean River at West Camden WRRF



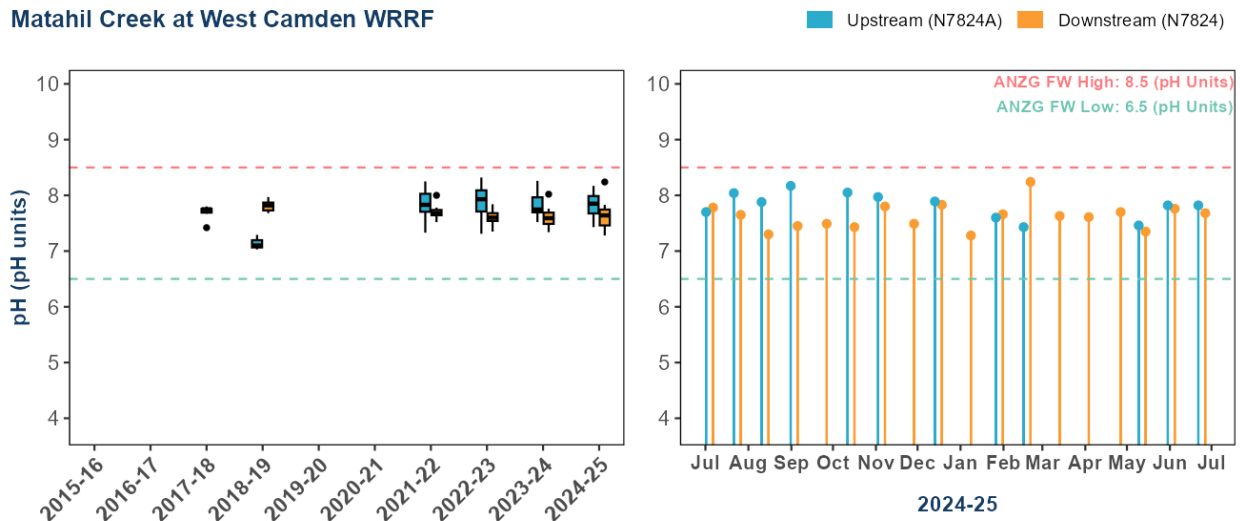
Matahil Creek at West Camden WRRF



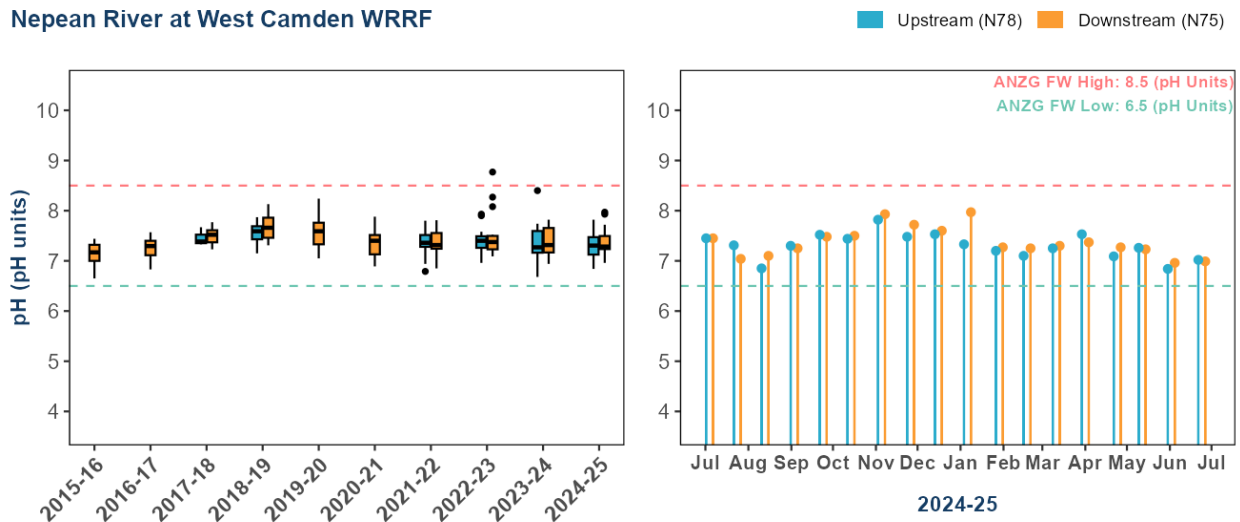
Nepean River at West Camden WRRF



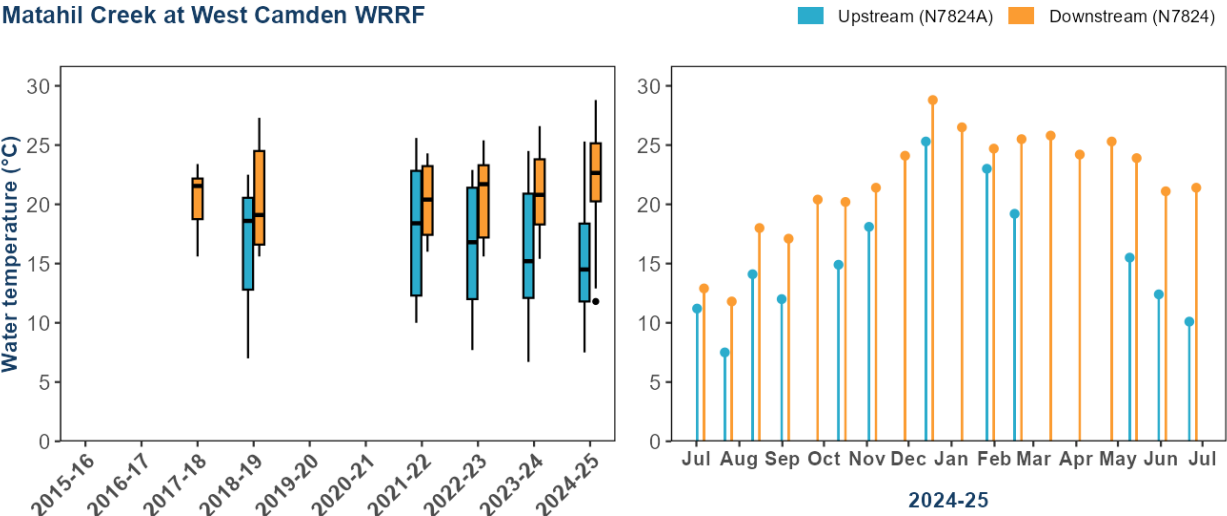
Matahil Creek at West Camden WRRF



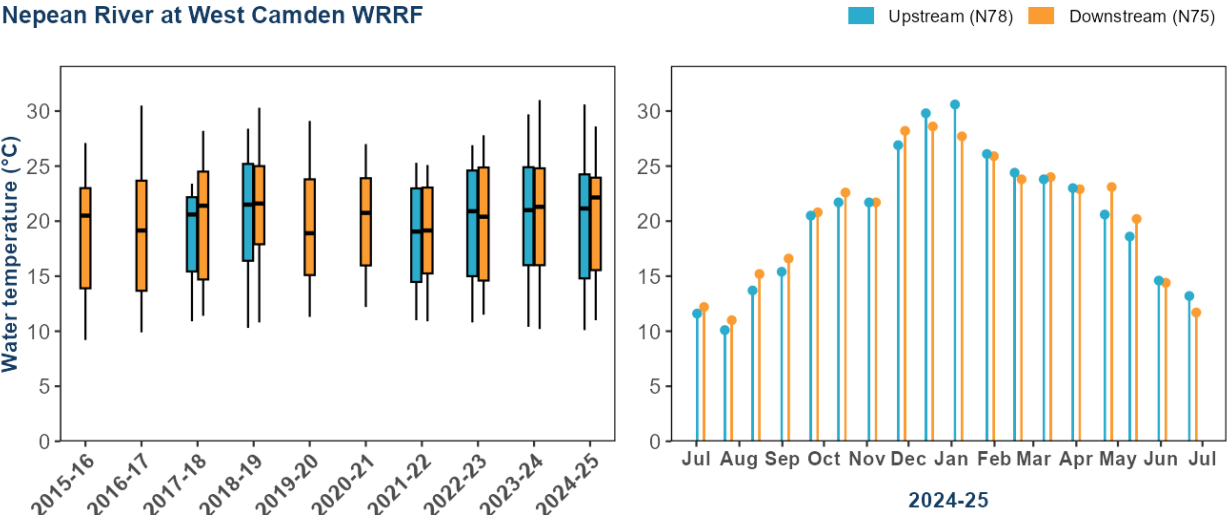
Nepean River at West Camden WRRF



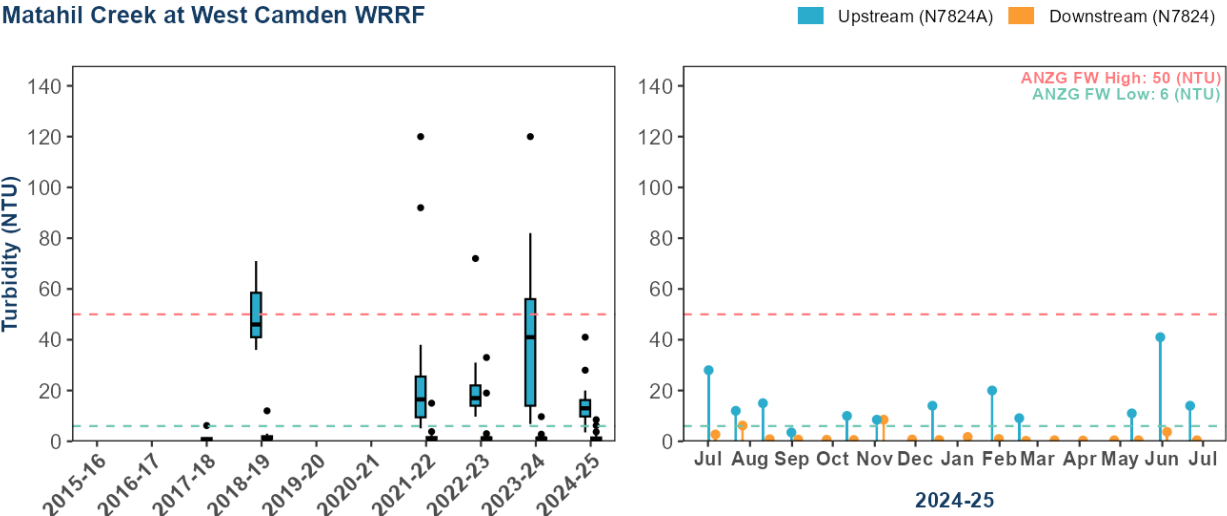
Matahil Creek at West Camden WRRF



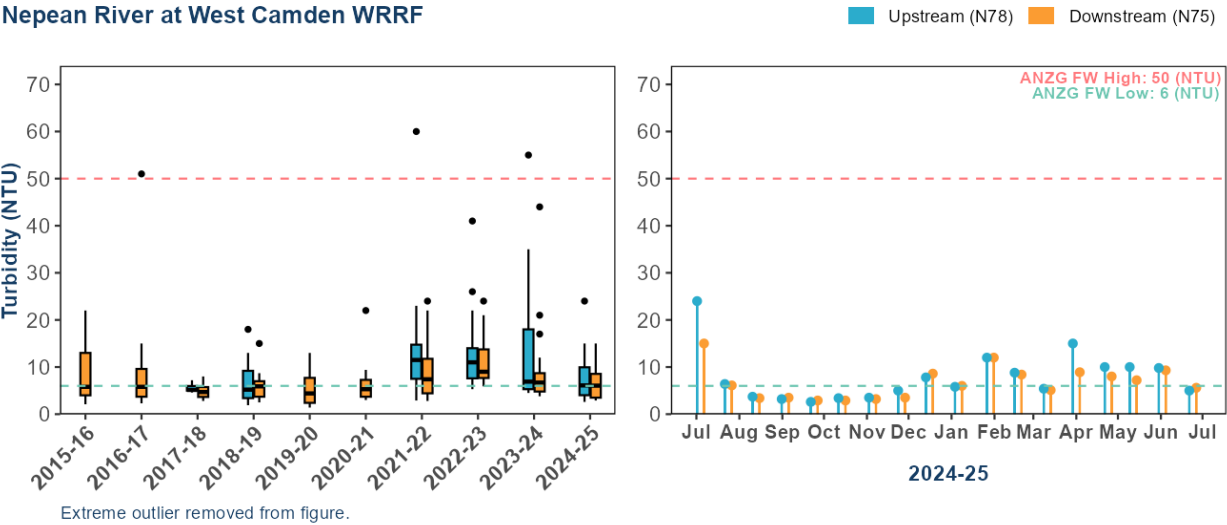
Nepean River at West Camden WRRF



Matahil Creek at West Camden WRRF

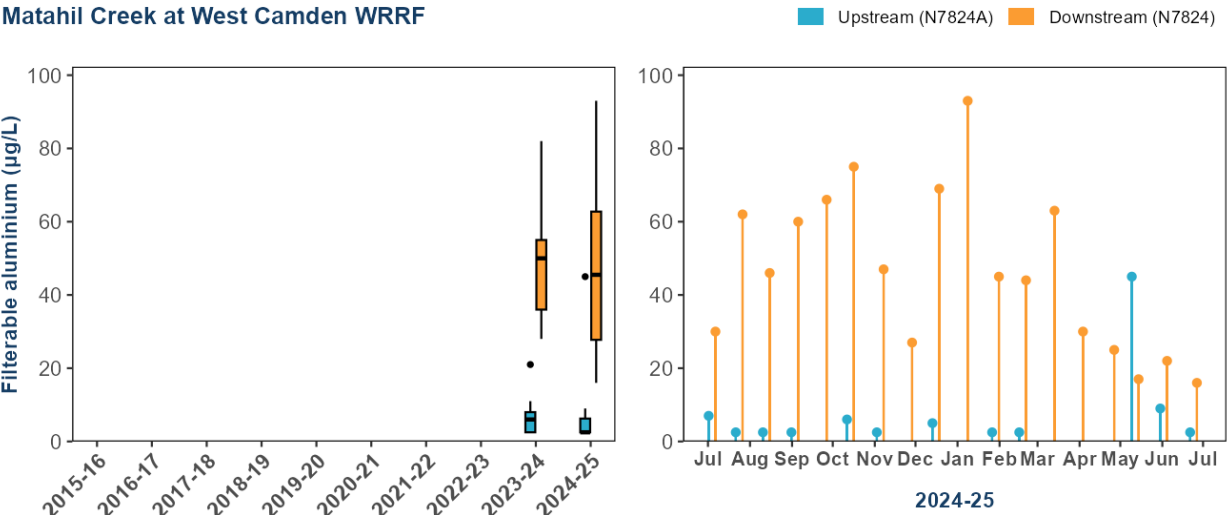


Nepean River at West Camden WRRF

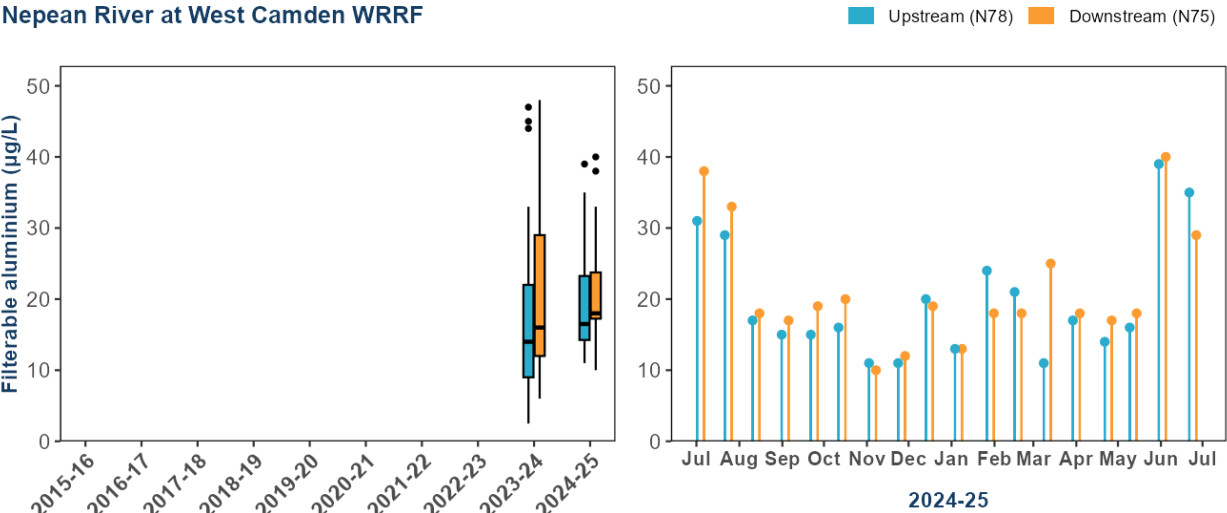


A.2.8. Stressor – Trace metals

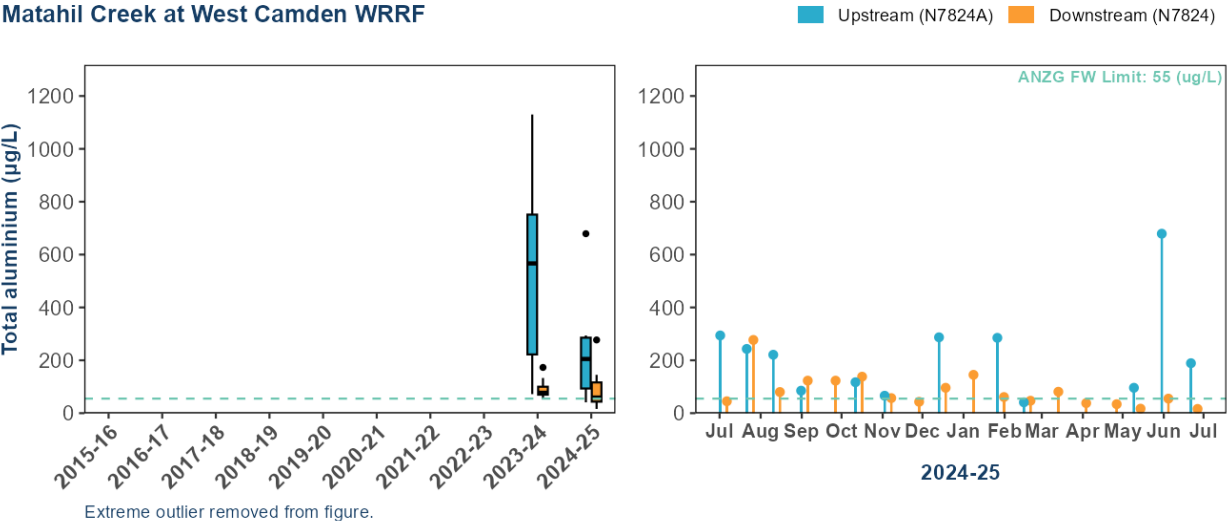
Matahil Creek at West Camden WRRF



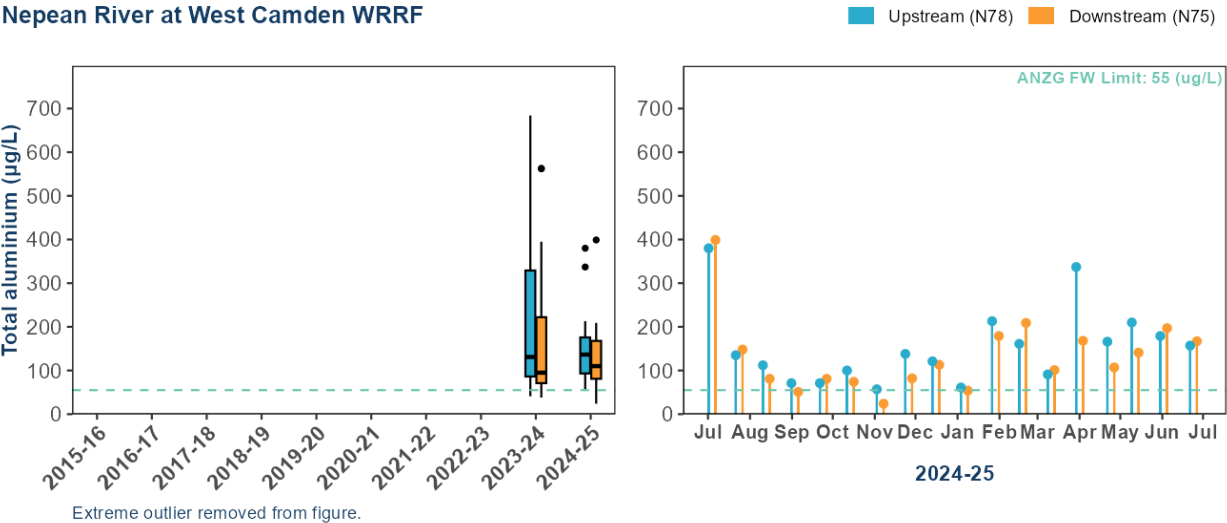
Nepean River at West Camden WRRF



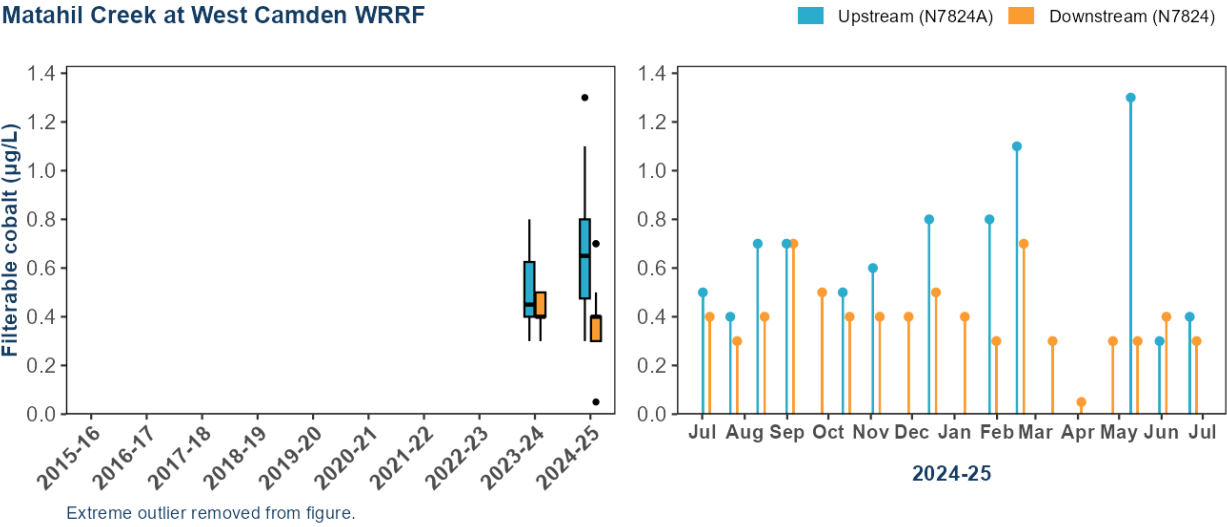
Matahil Creek at West Camden WRRF



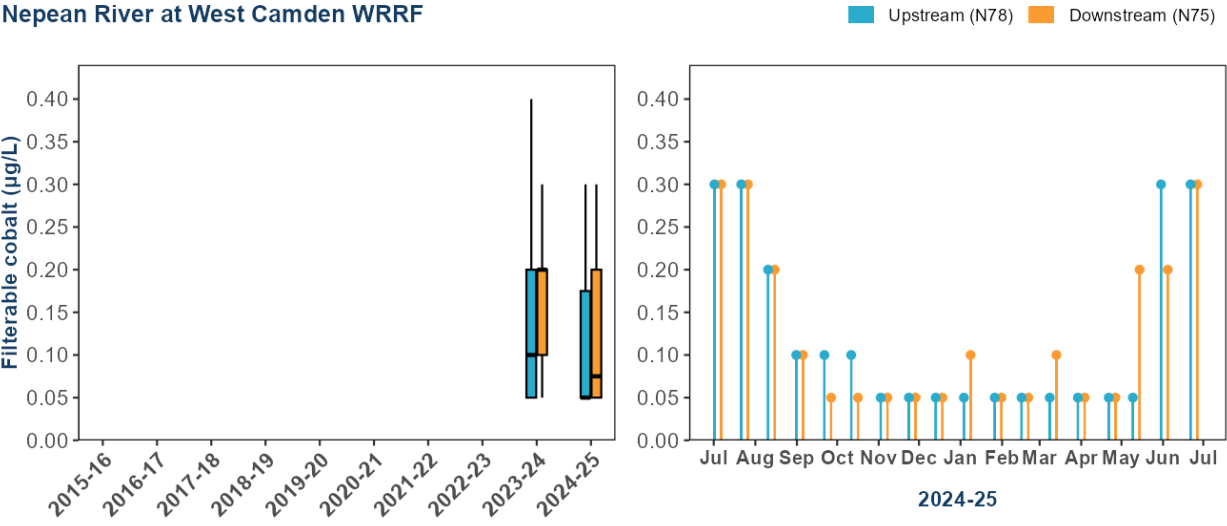
Nepean River at West Camden WRRF



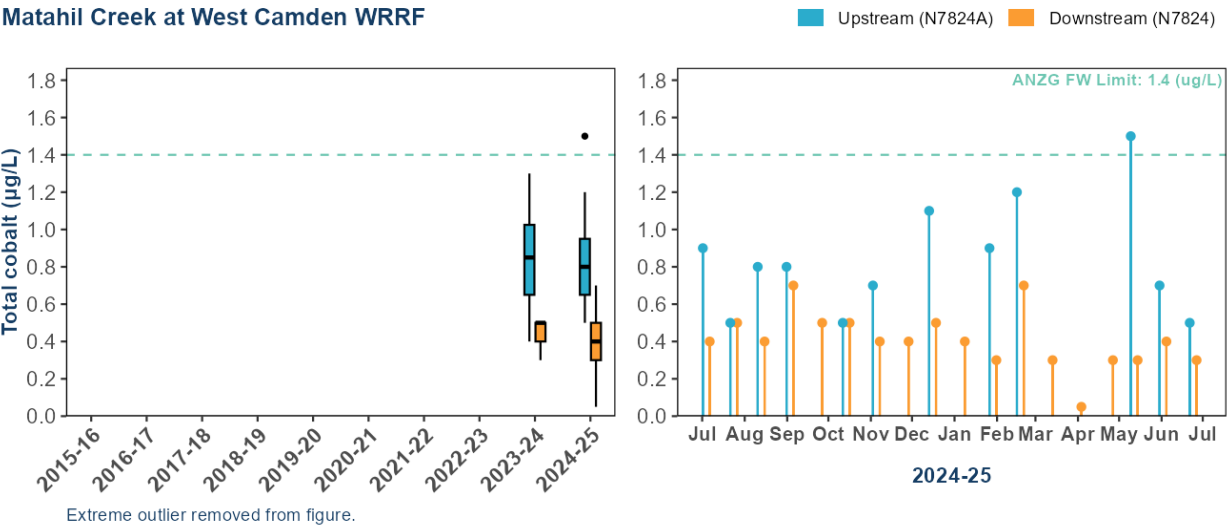
Matahil Creek at West Camden WRRF



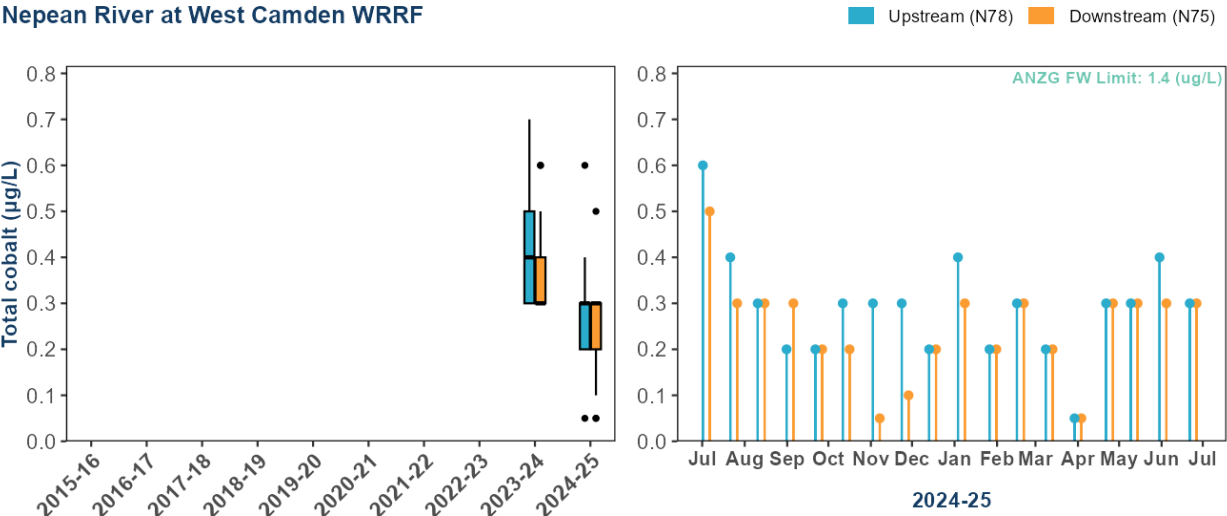
Nepean River at West Camden WRRF



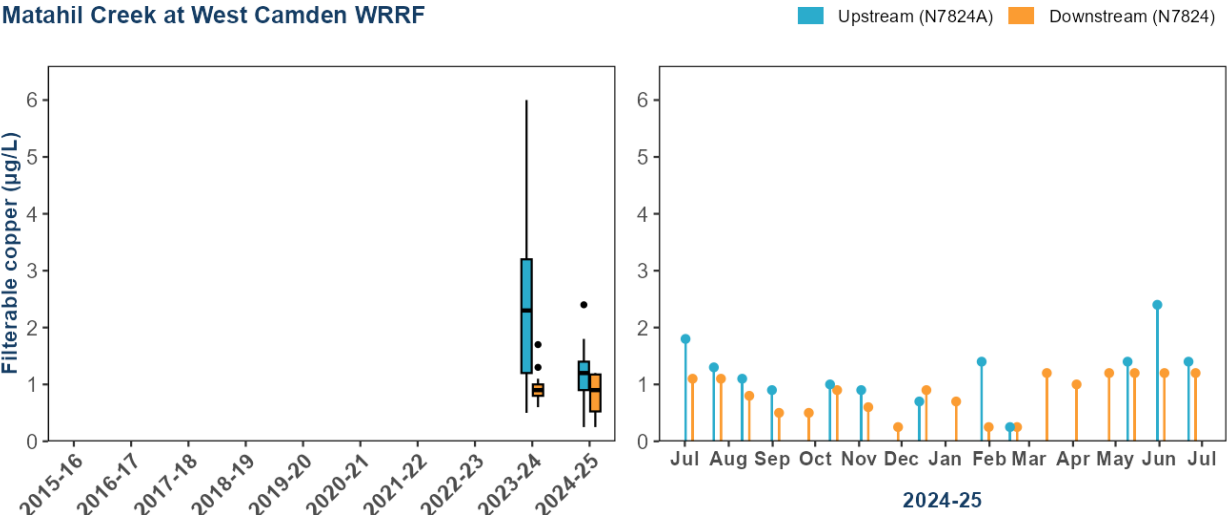
Matahil Creek at West Camden WRRF



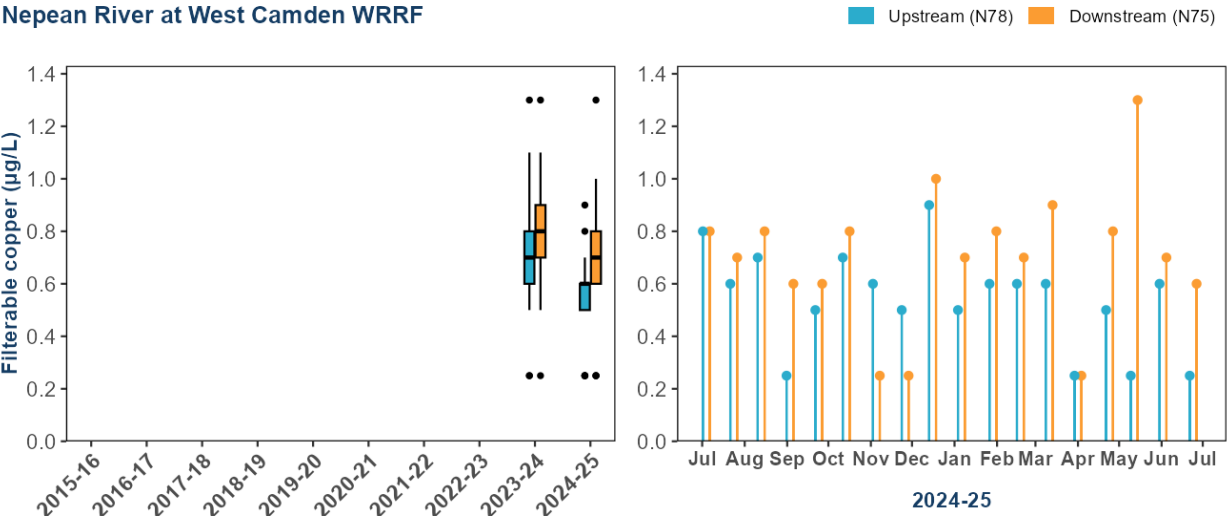
Nepean River at West Camden WRRF



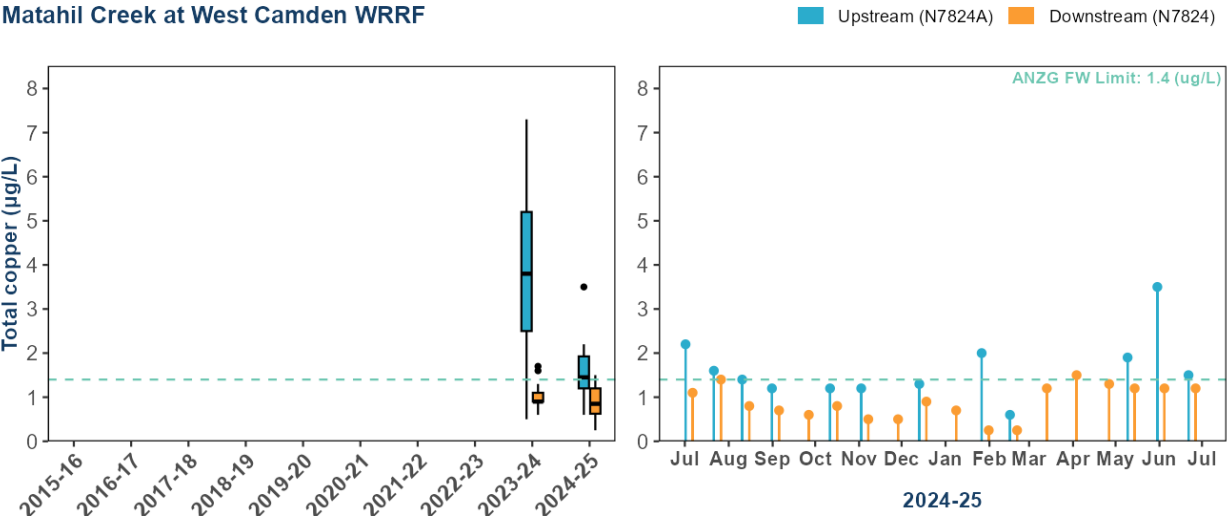
Matahil Creek at West Camden WRRF



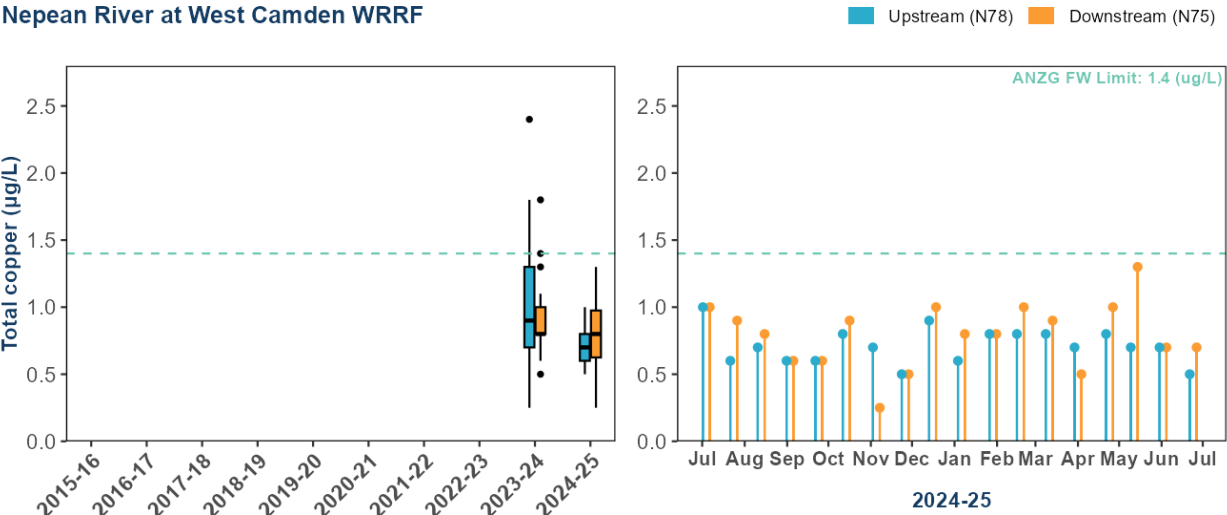
Nepean River at West Camden WRRF



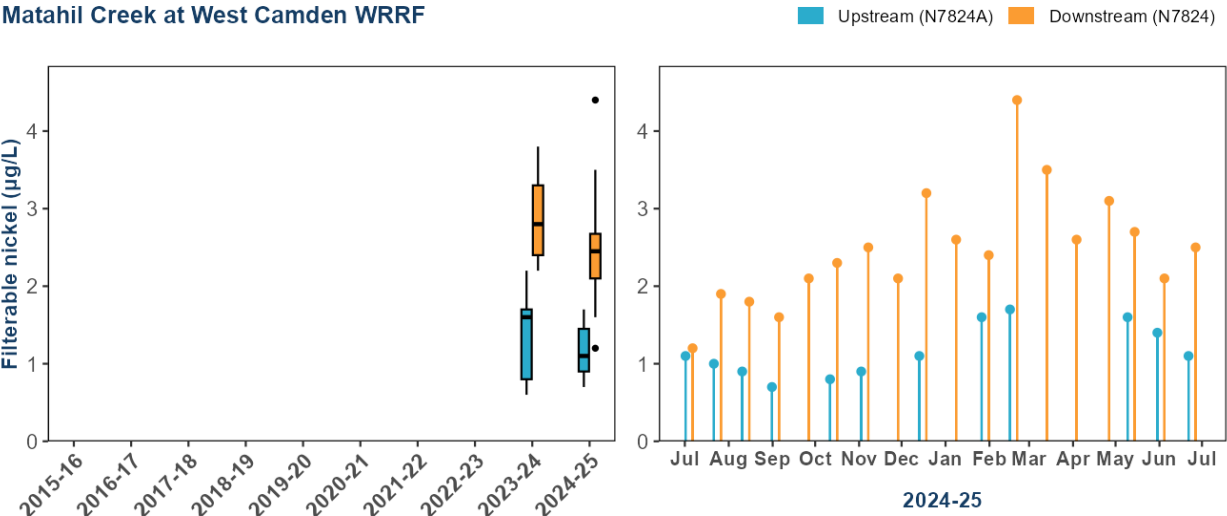
Matahil Creek at West Camden WRRF



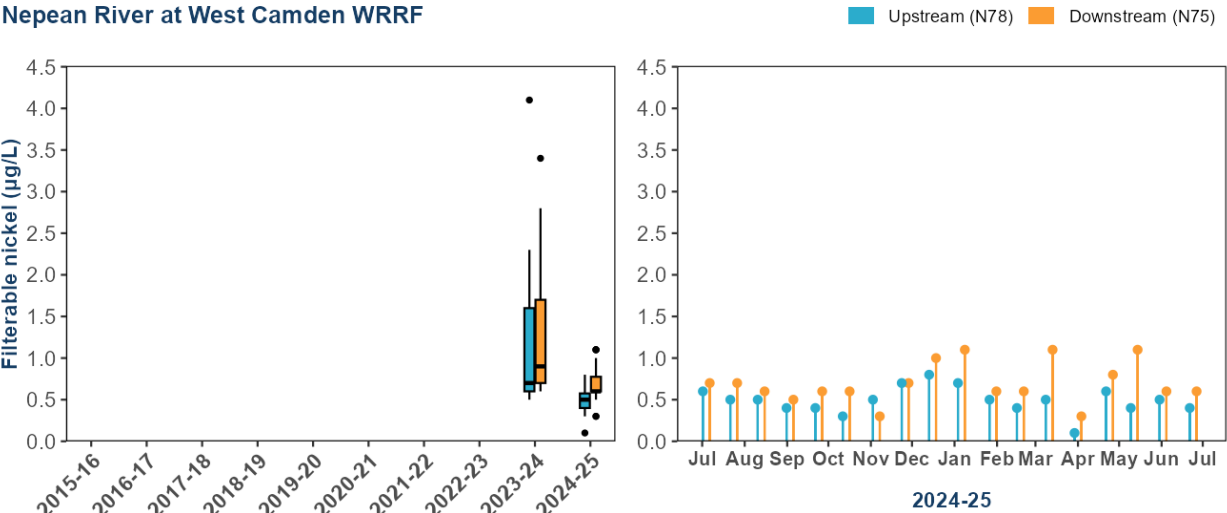
Nepean River at West Camden WRRF



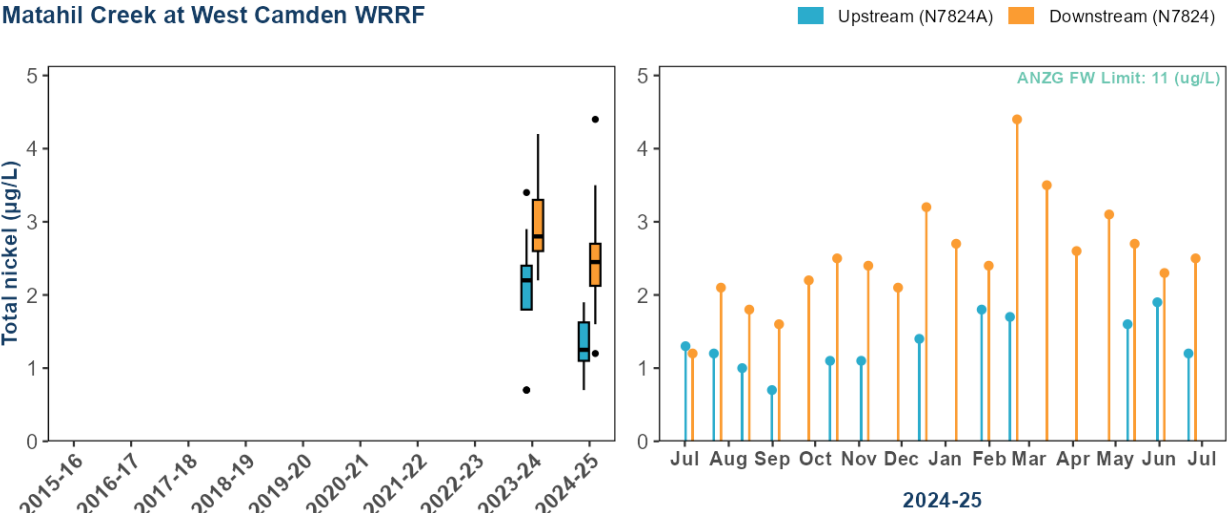
Matahil Creek at West Camden WRRF



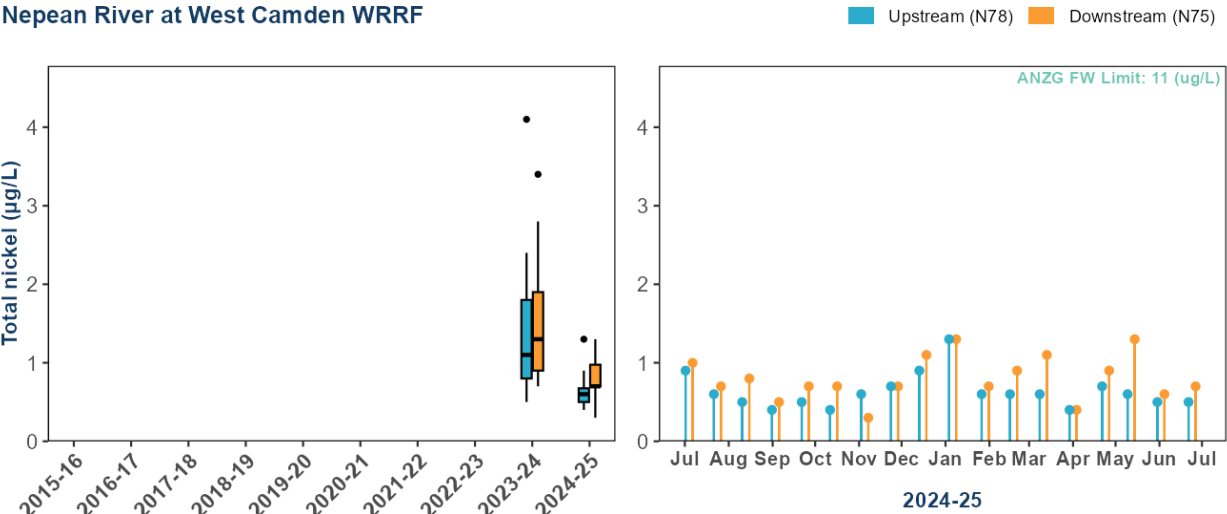
Nepean River at West Camden WRRF



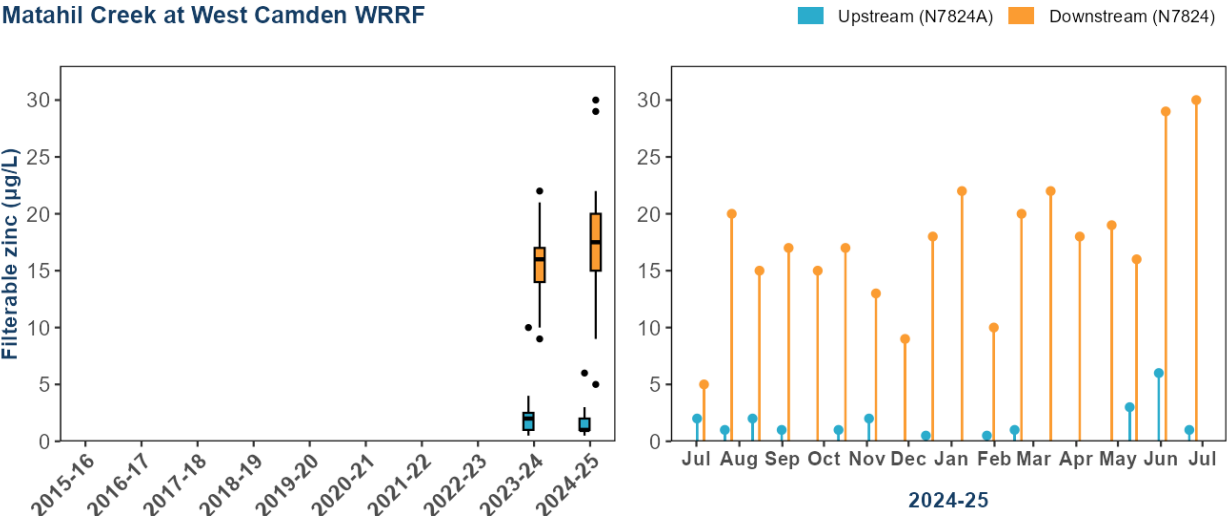
Matahil Creek at West Camden WRRF



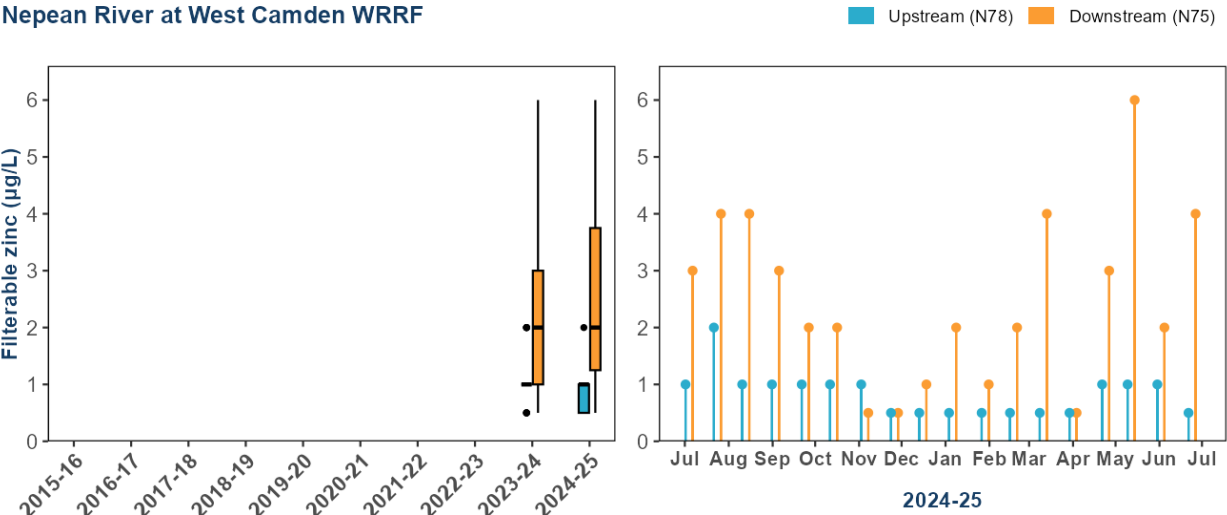
Nepean River at West Camden WRRF



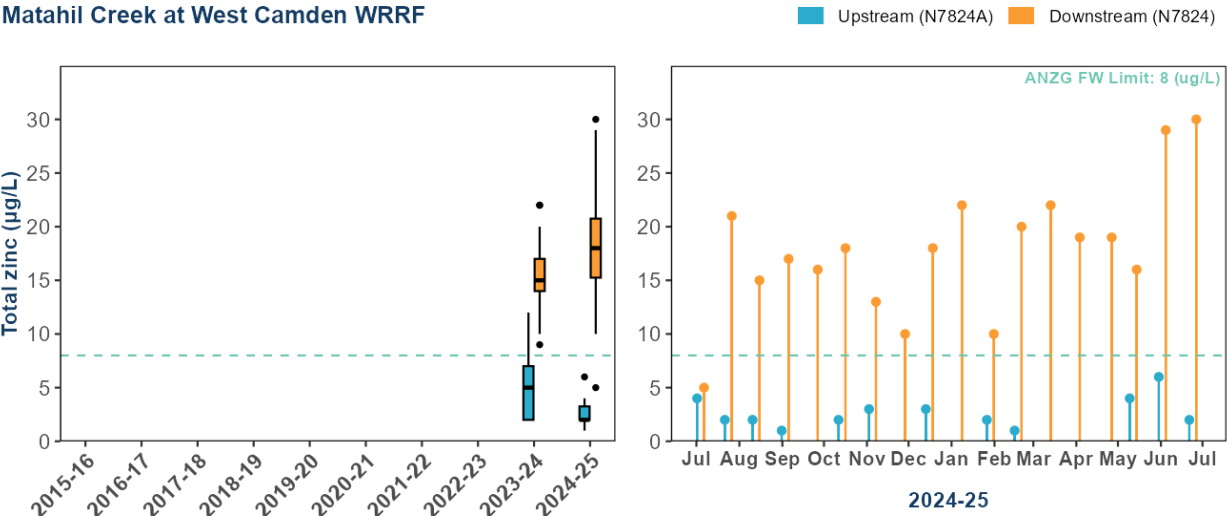
Matahil Creek at West Camden WRRF



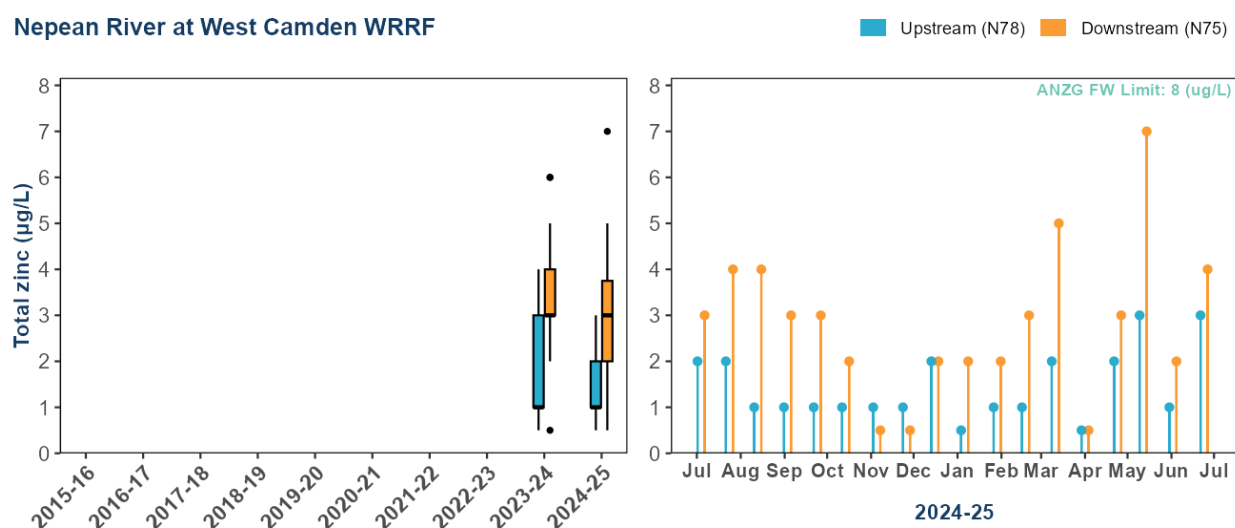
Nepean River at West Camden WRRF



Matahil Creek at West Camden WRRF



Nepean River at West Camden WRRF



A.2.9. Ecosystem receptor – Statistical analysis outcomes

Table A-19 Upstream vs downstream comparison (2024-25 reporting period) for Matahil Creek at West Camden WRRF

Matahil Creek at West Camden WRRF: N7824A vs N7824 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.04	0.01	136	-9.47	<0.001
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-20 Upstream current period (2024-25) vs previous period comparison (single site) for Matahil Creek at West Camden WRRF

Matahil Creek at West Camden WRRF: N7824A (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.21	0.36	136	0.62	0.925
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-21 Downstream current period (2024-25) vs previous period comparison (single site) for Matahil Creek at West Camden WRRF

Matahil Creek at West Camden WRRF: N7824 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.59	0.15	136	-2.10	0.158
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-22 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at West Camden WRRF

Nepean River at West Camden WRRF: N78 vs N75 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.44	0.42	242	1.25	0.596

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-23 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at West Camden WRRF

Nepean River at West Camden WRRF: N78 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.94	0.22	242	-0.28	0.992

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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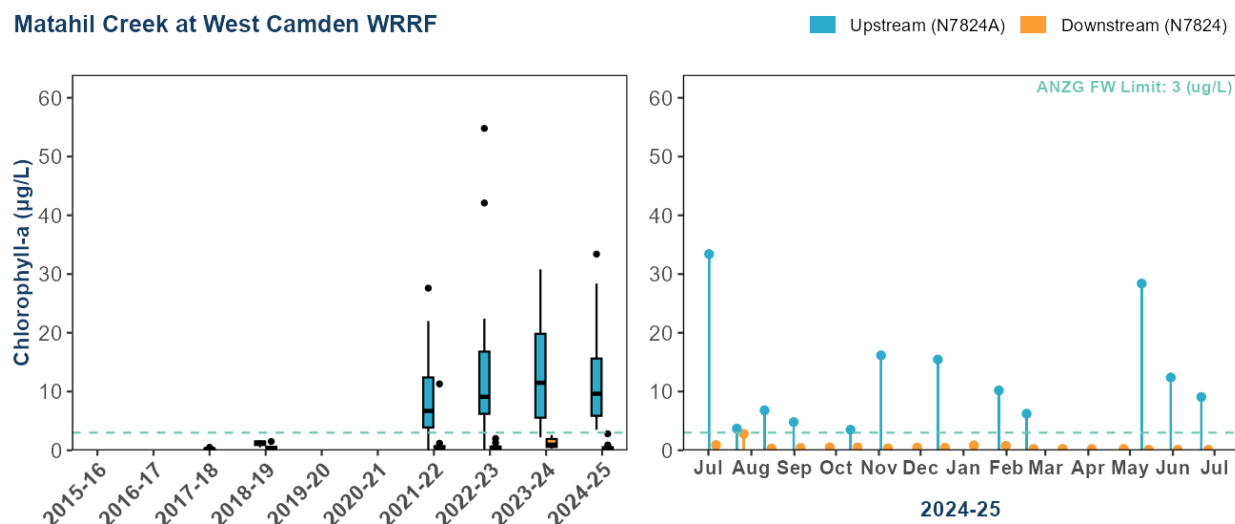
Table A-24 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at West Camden WRRF

Nepean River at West Camden WRRF: N75 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.05	0.24	242	0.21	0.997

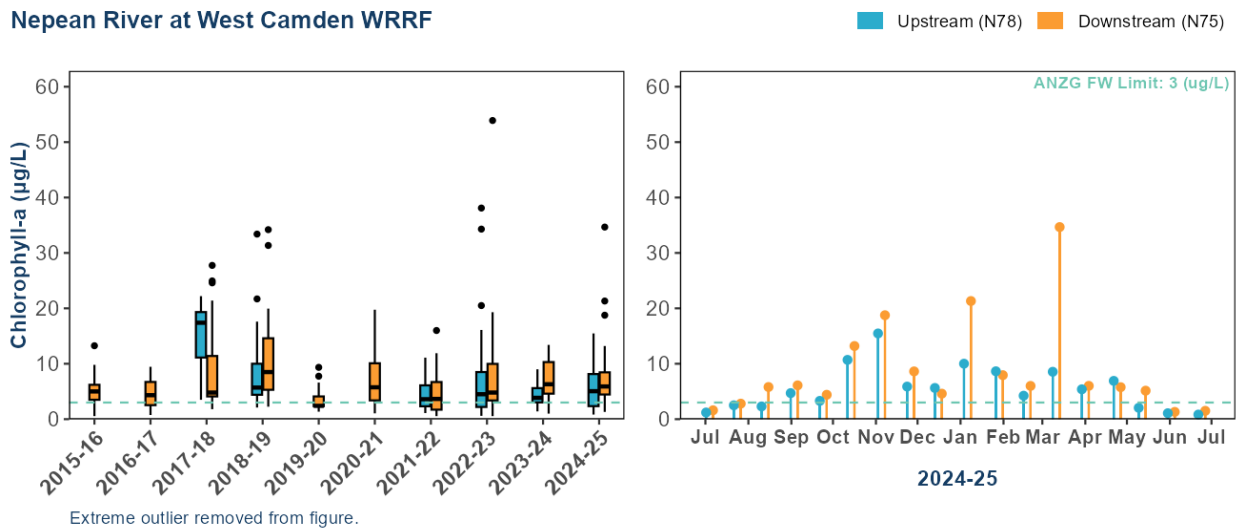
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.2.10. Ecosystem receptor – Phytoplankton

Matahil Creek at West Camden WRRF



Nepean River at West Camden WRRF

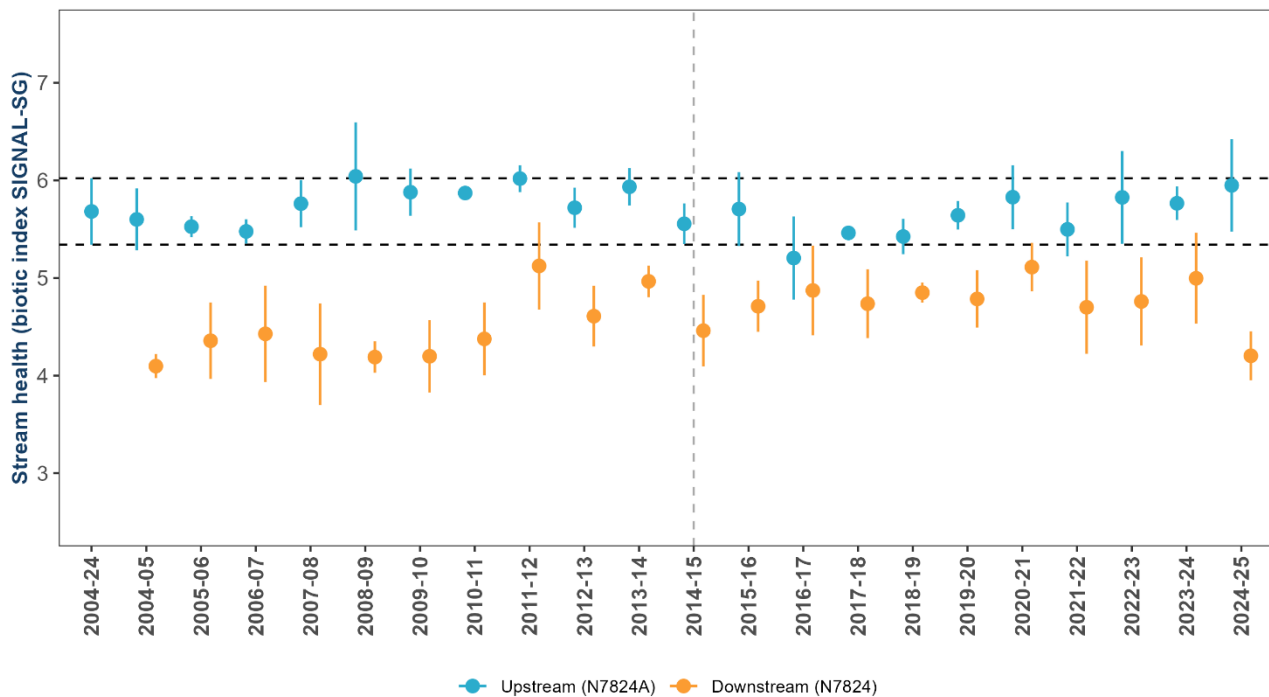


A.2.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Matahil Creek	Tributary (N7824A vs N7824)	Welch Two Sample t-test	1.75	7.97	7.6	<0.001
Nepean River	River (N78 vs N75)	Welch Two Sample t-test	-0.04	-0.13	7.6	0.899

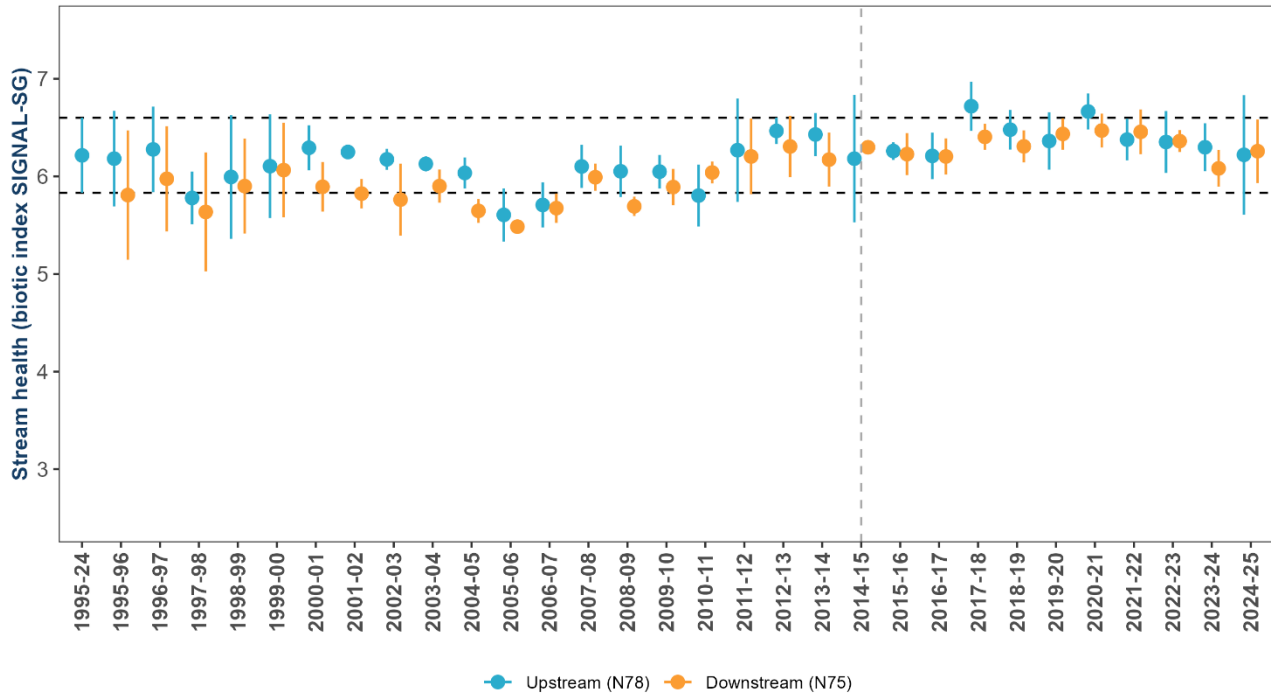
not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Matahil Creek at West Camden WRRF



The range of stream health recorded over each period is represented by length of line

Nepean River at West Camden WRRF



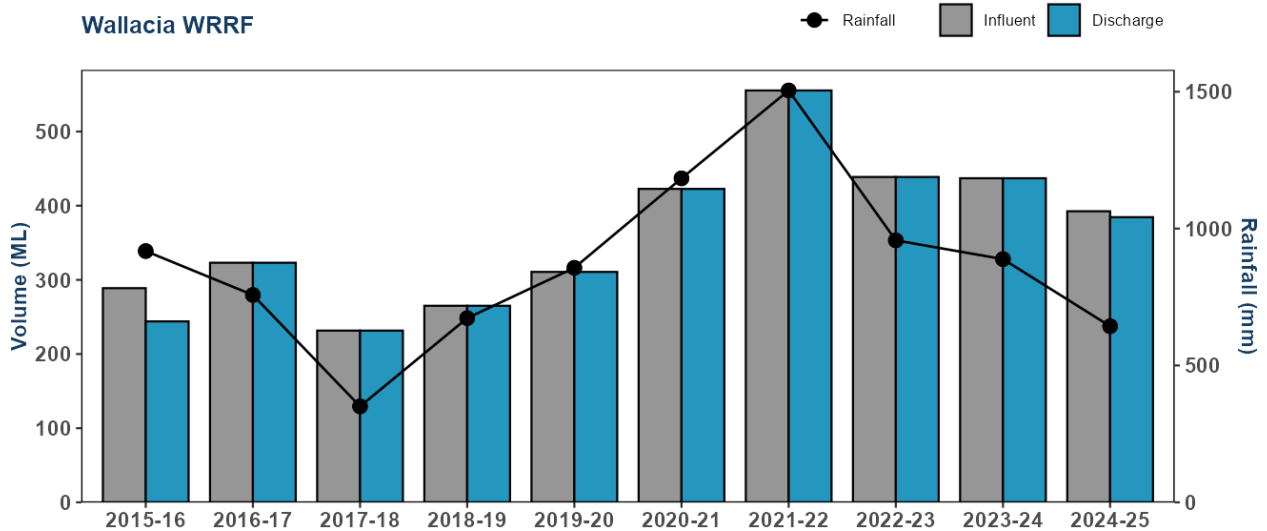
The range of stream health recorded over each period is represented by length of line

*Grey line indicates beginning of WRRF upgrade

A.3. Wallacia WRRF

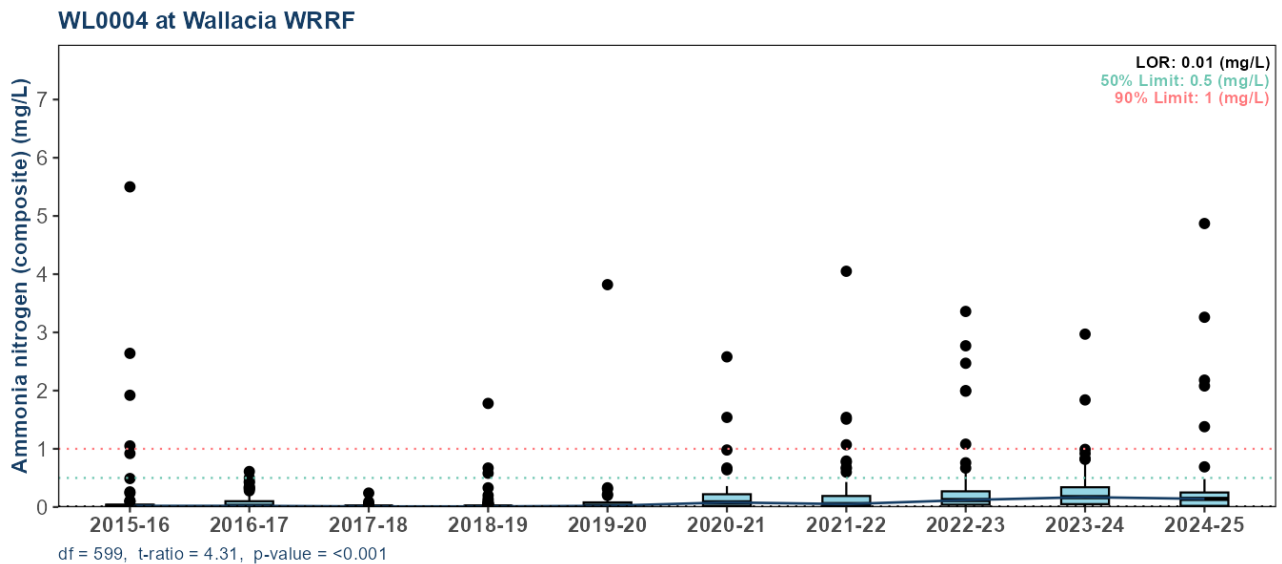
A.3.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall

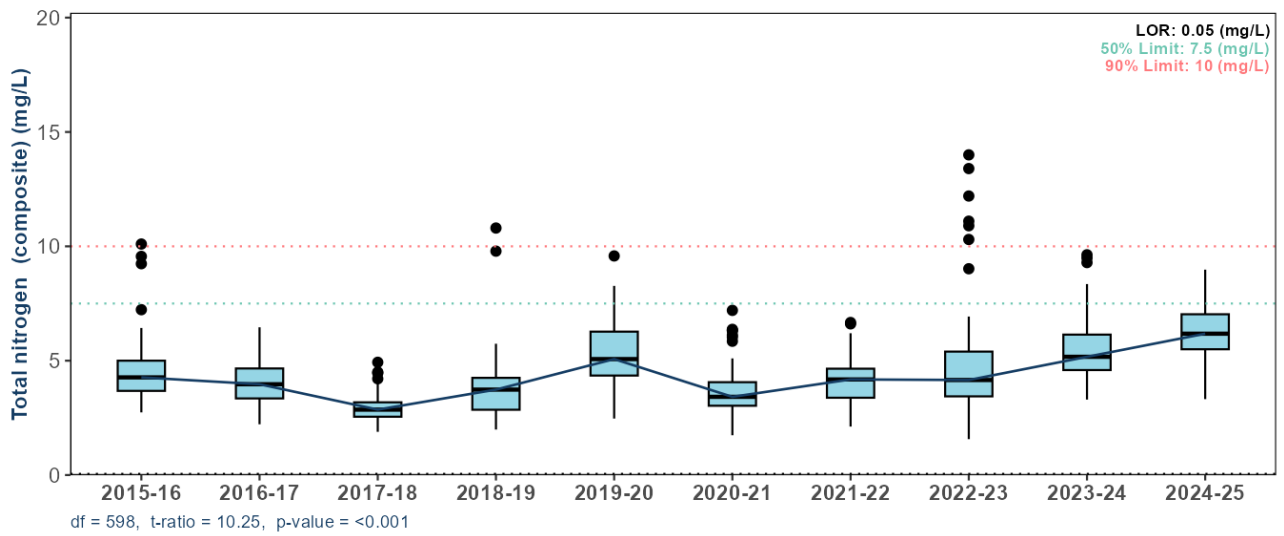


A.3.2. Pressure – Wastewater quality

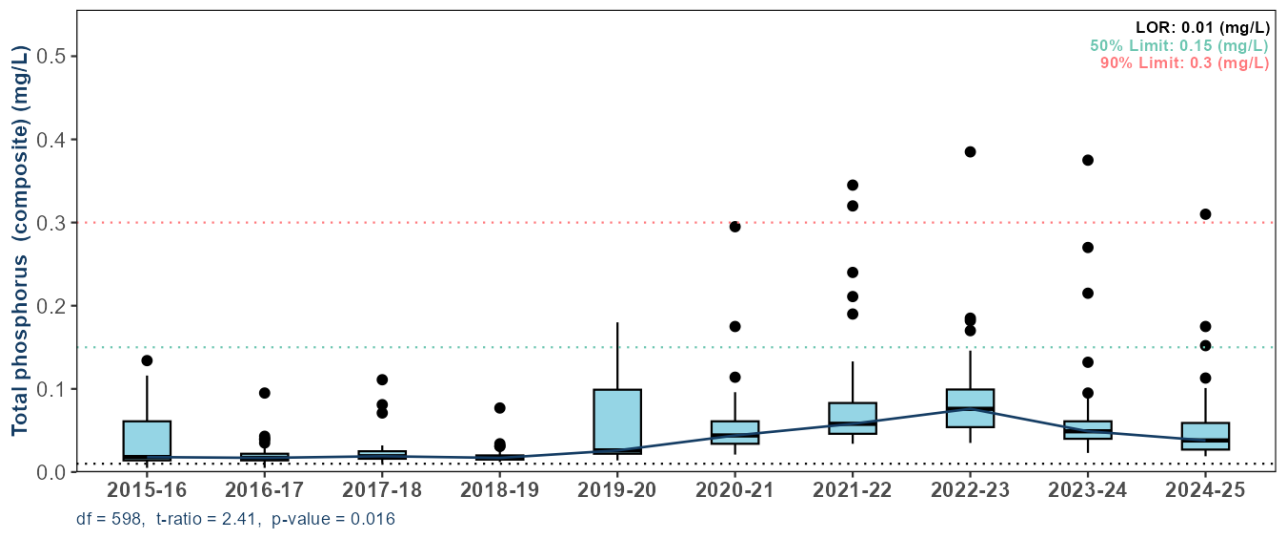
Nutrients



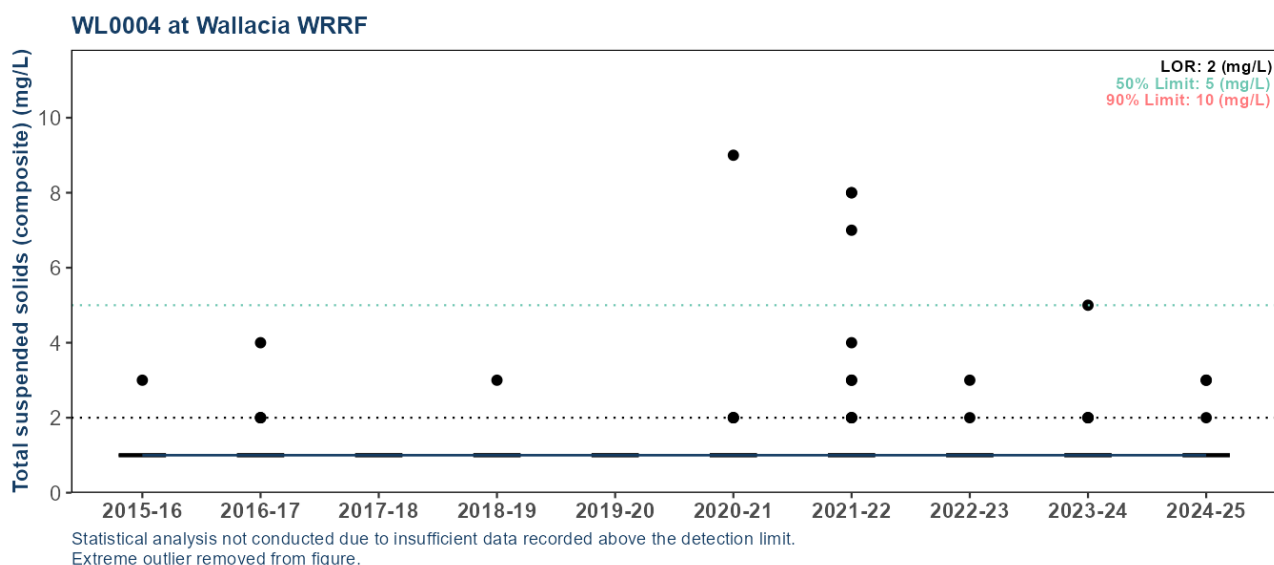
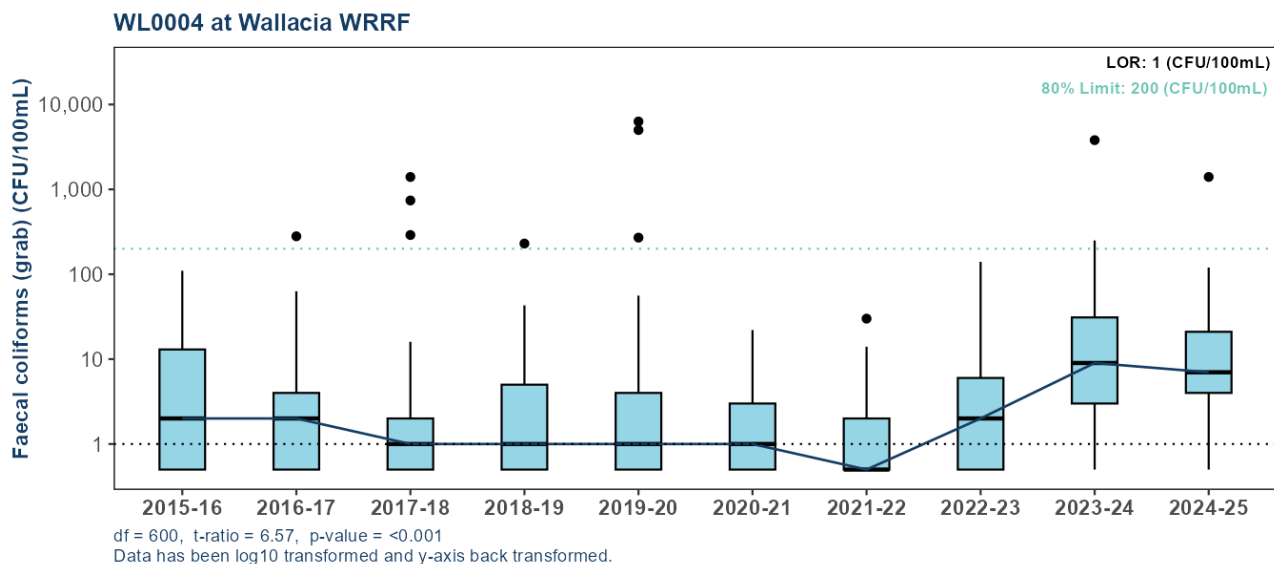
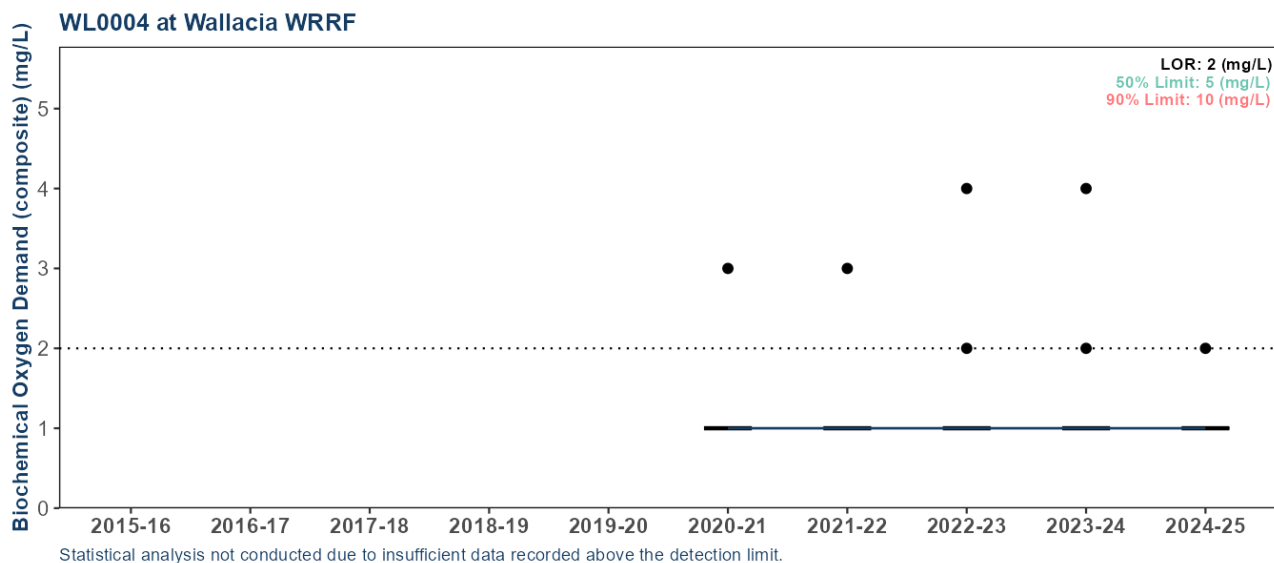
WL0004 at Wallacia WRRF



WL0004 at Wallacia WRRF

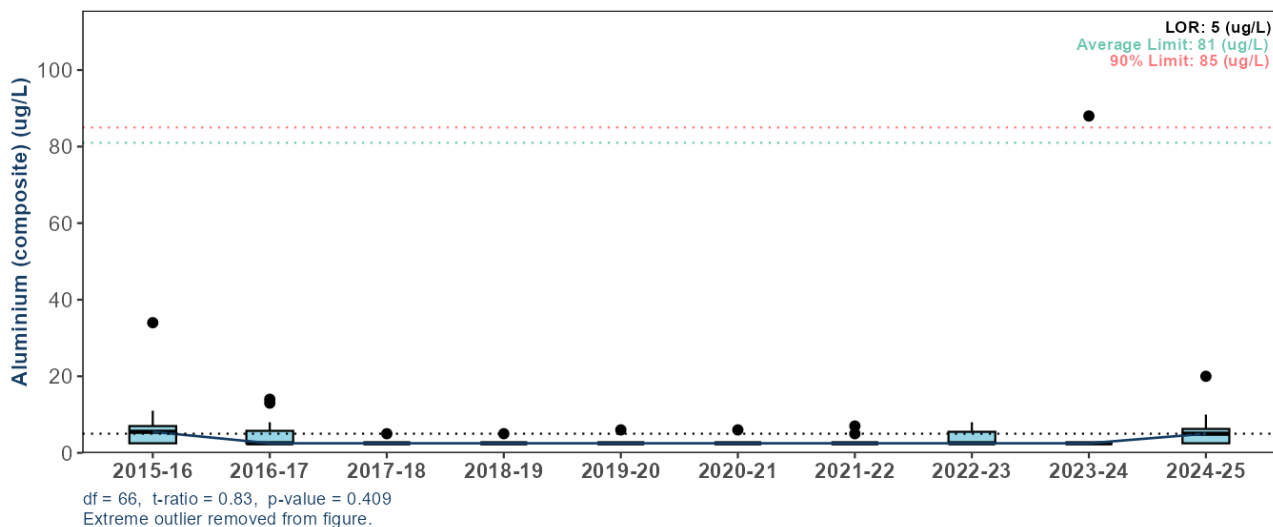


Major conventional analytes

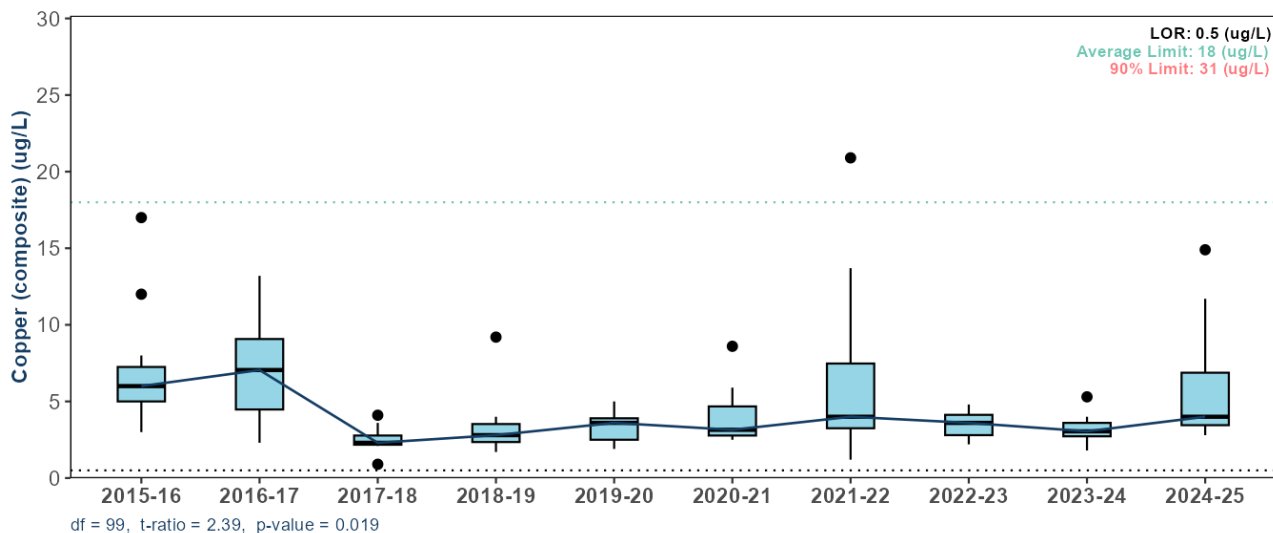


Trace metals

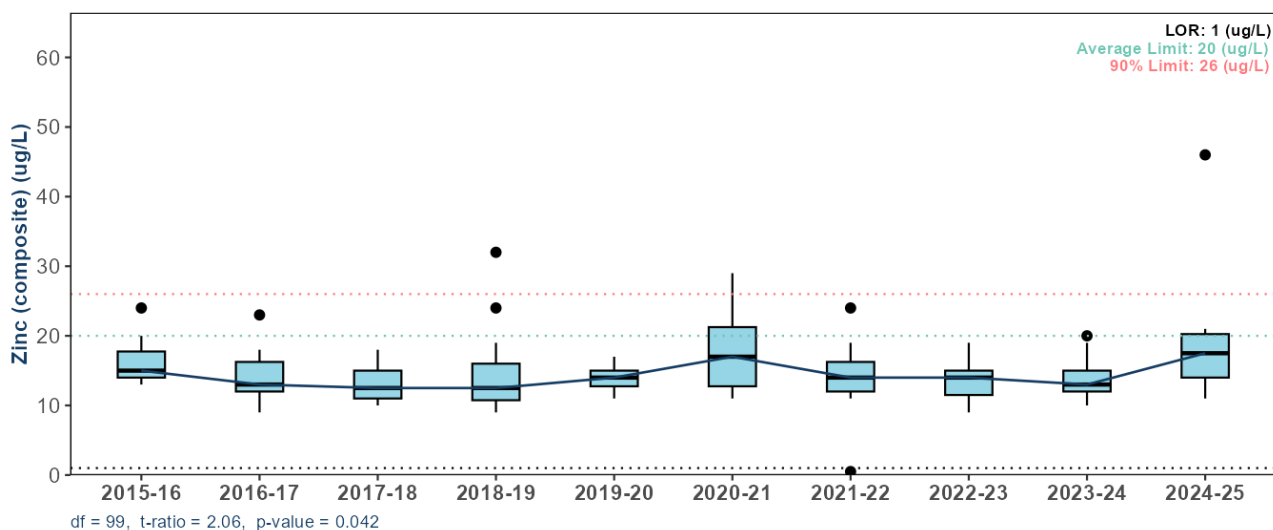
WL0004 at Wallacia WRRF



WL0004 at Wallacia WRRF

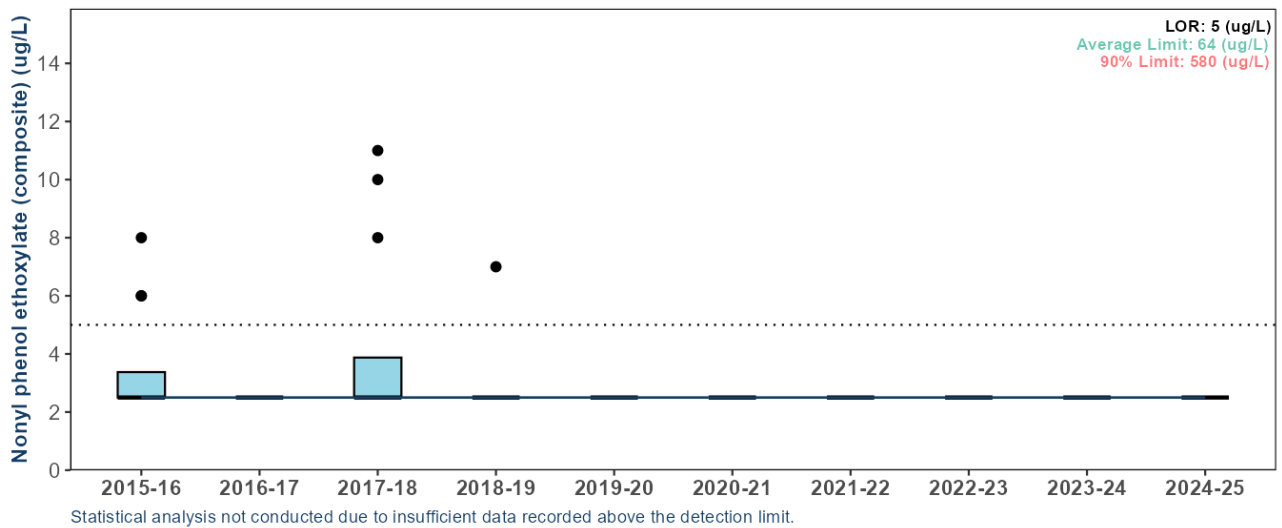


WL0004 at Wallacia WRRF

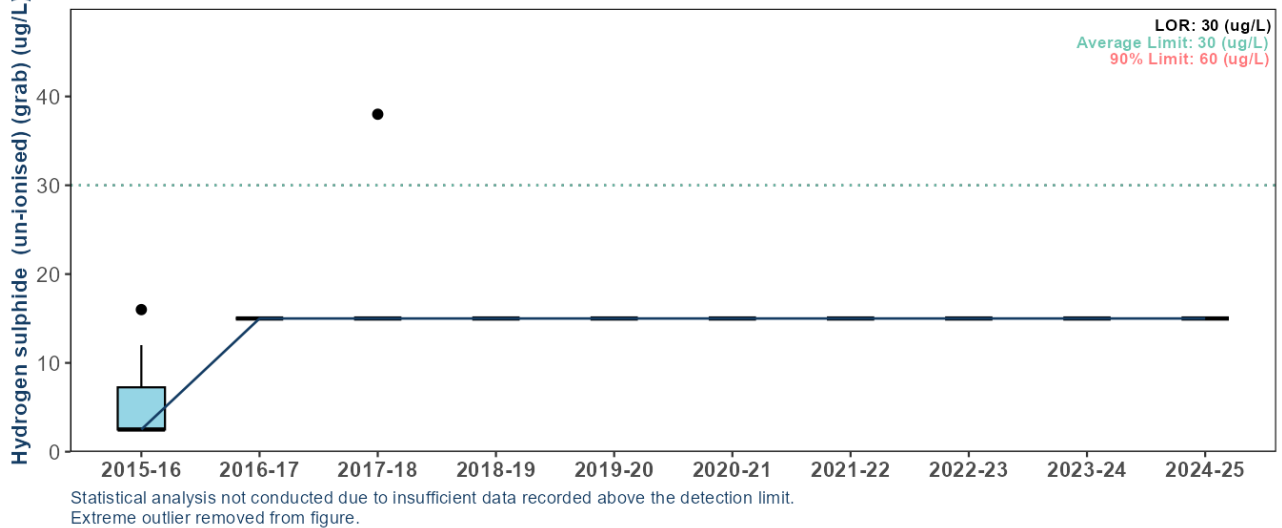


Other chemicals and organics (including pesticides)

WL0004 at Wallacia WRRF

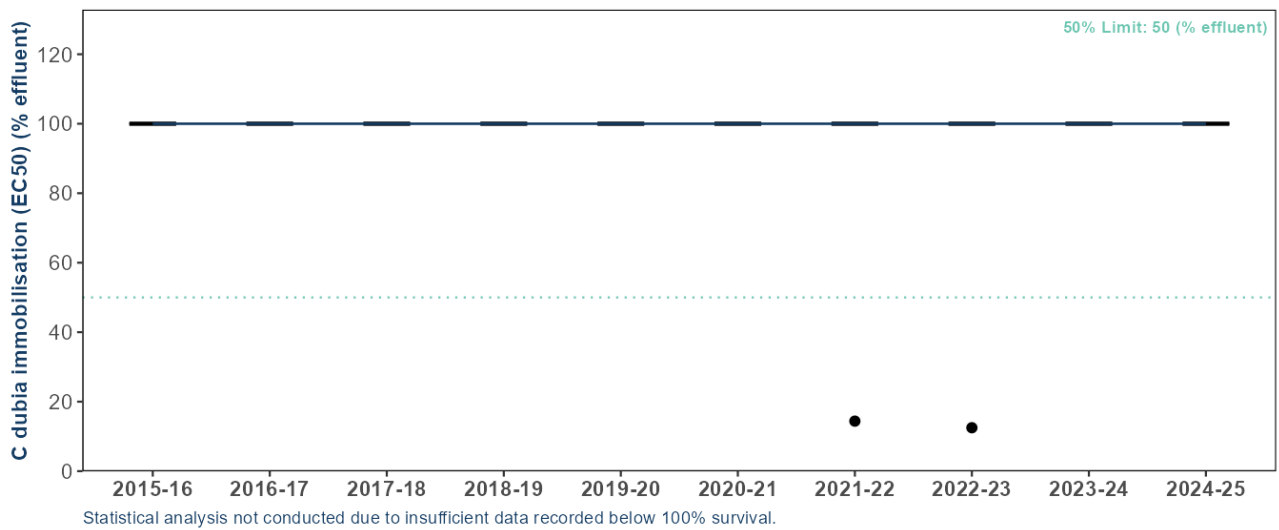


WL0004 at Wallacia WRRF



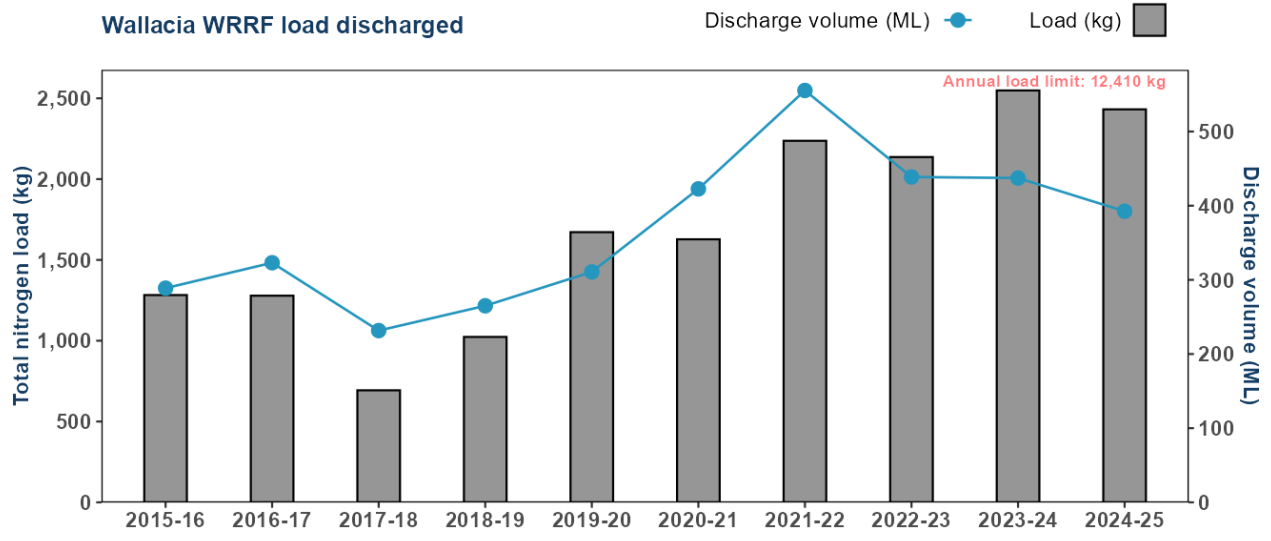
A.3.3. Pressure – Wastewater toxicity

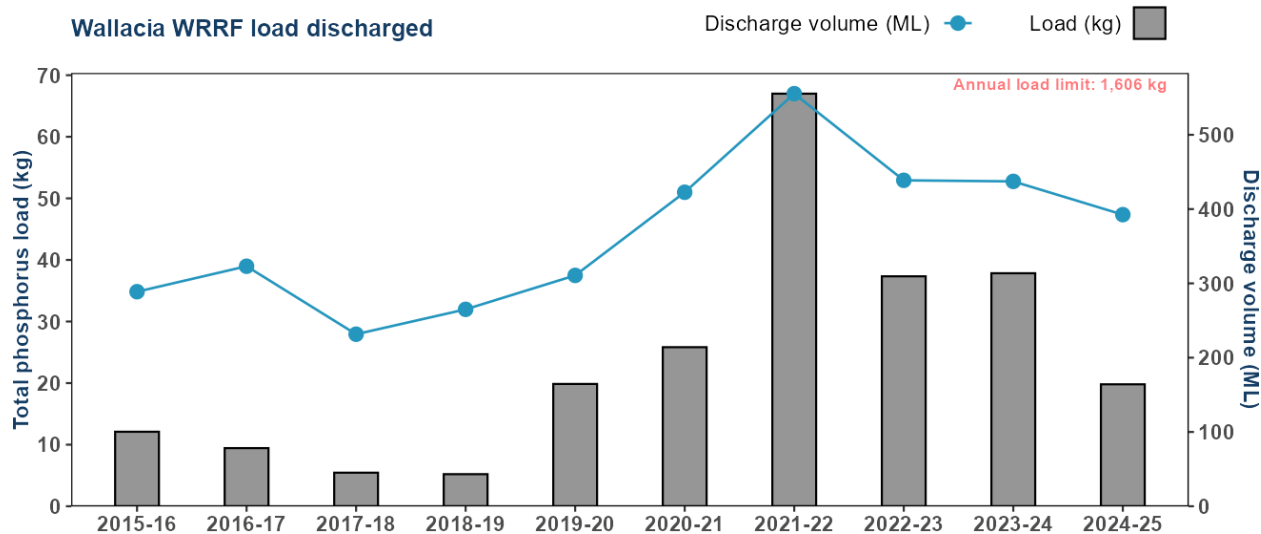
WL0004 at Wallacia WRRF



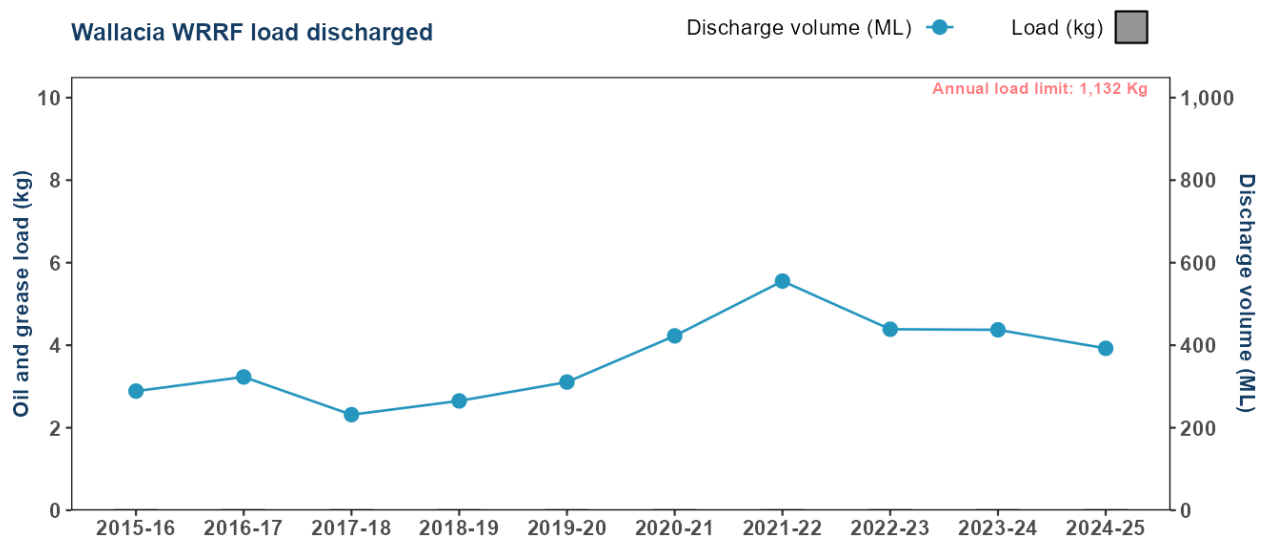
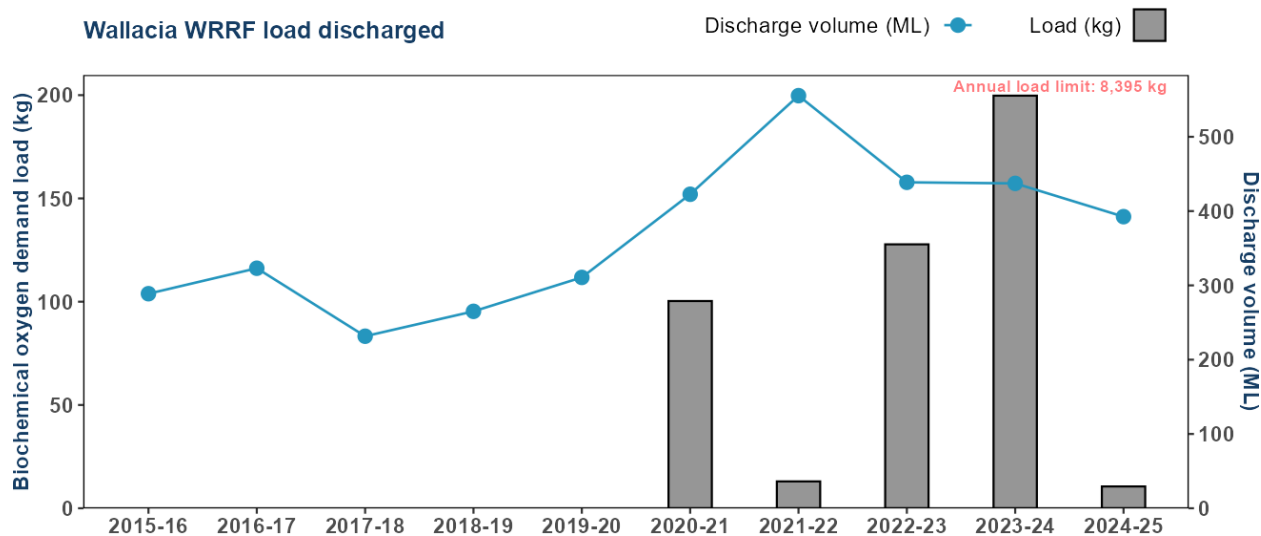
A.3.4. Pressure – Wastewater discharge load

Nutrients

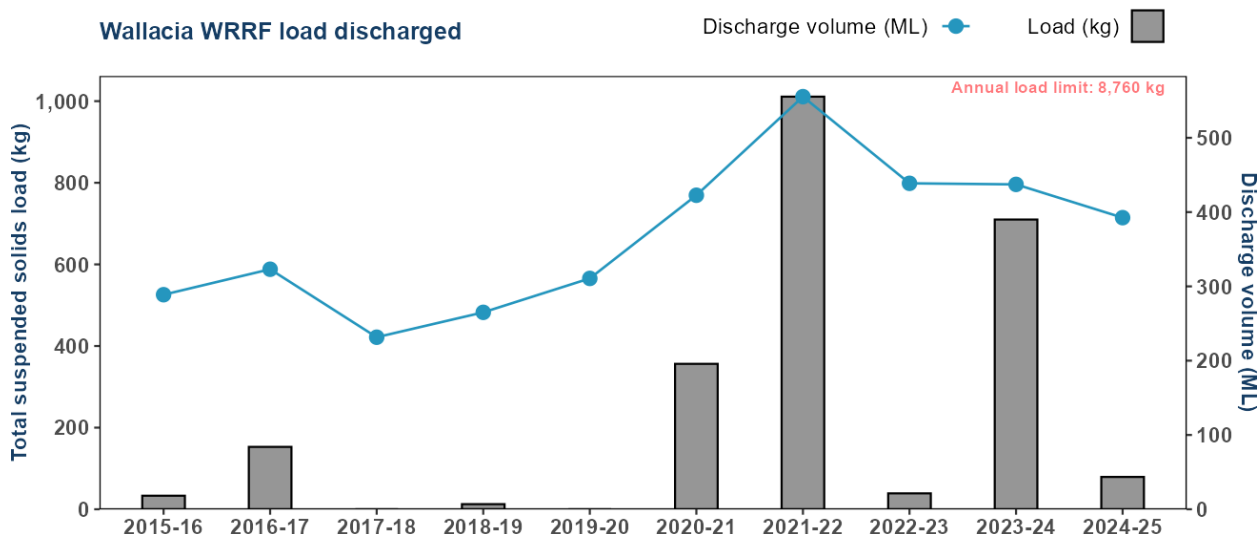




Major conventional analytes



Wallacia WRRF load discharged



A.3.5. Stressor – Statistical analysis outcomes

Table A-25 Upstream vs downstream comparison (2024-25 reporting period) for the Warragamba and Nepean River at Wallacia WRRF

Warragamba River at Wallacia WRRF: N67 vs N641 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.79	0.25	239	-0.74	0.883
Oxidised nitrogen	0.55	0.11	239	-2.90	0.021
Total nitrogen	0.70	0.08	239	-3.14	0.010
Soluble reactive phosphorus	1.20	0.29	66	0.76	0.871
Total phosphorus	0.74	0.13	239	-1.68	0.334
Physico-chemical					
Conductivity	0.73	0.07	239	-3.27	0.007
Dissolved oxygen	1.04	0.05	239	0.86	0.825
Dissolved oxygen saturation	3.61	2.71	237	1.33	0.544
pH	0.23	0.09	237	2.51	0.061
Water temperature	0.94	0.10	238	-0.56	0.945
Turbidity	0.74	0.15	239	-1.51	0.436
Trace Metals					
Filterable aluminium	0.96	0.21	66	-0.18	0.998
Total aluminium	0.94	0.24	66	-0.24	0.995
Filterable cobalt	0.55	0.12	66	-2.75	0.038
Total cobalt	0.31	0.05	66	-6.80	<0.001
Filterable copper	1.45	0.20	66	2.69	0.043
Total copper	1.14	0.15	66	0.98	0.759
Filterable nickel	1.36	0.18	66	2.36	0.095
Total nickel	1.37	0.16	66	2.72	0.040
Filterable zinc	0.81	0.18	65	-0.97	0.767
Total zinc	0.90	0.17	66	-0.54	0.949

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-26 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River near Wallacia WRRF

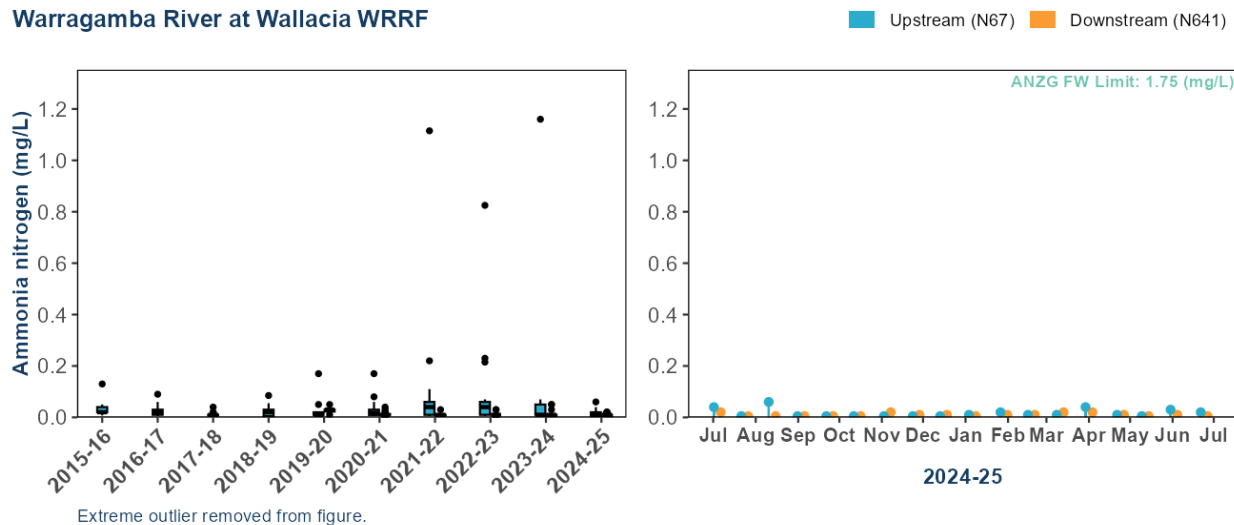
Warragamba River at Wallacia WRRF: N67 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.41	0.11	239	-3.43	0.004
Oxidised nitrogen	0.78	0.13	239	-1.48	0.449
Total nitrogen	0.74	0.07	239	-3.37	0.005
Soluble reactive phosphorus	0.57	0.14	66	-2.27	0.116
Total phosphorus	0.65	0.09	239	-3.00	0.016
Physico-chemical					
Conductivity	0.95	0.07	239	-0.62	0.924
Dissolved oxygen	0.99	0.04	239	-0.12	>0.999
Dissolved oxygen saturation	0.89	2.15	237	0.42	0.976
pH	-0.04	0.07	237	-0.56	0.943
Water temperature	1.04	0.09	238	0.50	0.959
Turbidity	0.73	0.12	239	-1.90	0.229
Trace Metals					
Filterable aluminium	1.34	0.30	66	1.33	0.548
Total aluminium	0.79	0.21	66	-0.91	0.802
Filterable cobalt	0.65	0.14	66	-1.98	0.205
Total cobalt	0.63	0.11	66	-2.59	0.057
Filterable copper	0.76	0.11	66	-1.95	0.219
Total copper	0.66	0.09	66	-3.08	0.016
Filterable nickel	0.58	0.08	66	-4.18	<0.001
Total nickel	0.55	0.06	66	-5.05	<0.001
Filterable zinc	0.83	0.19	65	-0.80	0.854
Total zinc	0.63	0.12	66	-2.40	0.088
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-27 Downstream current period (2024-25) vs previous period comparison (single site) for the Warragamba River at Wallacia WRRF

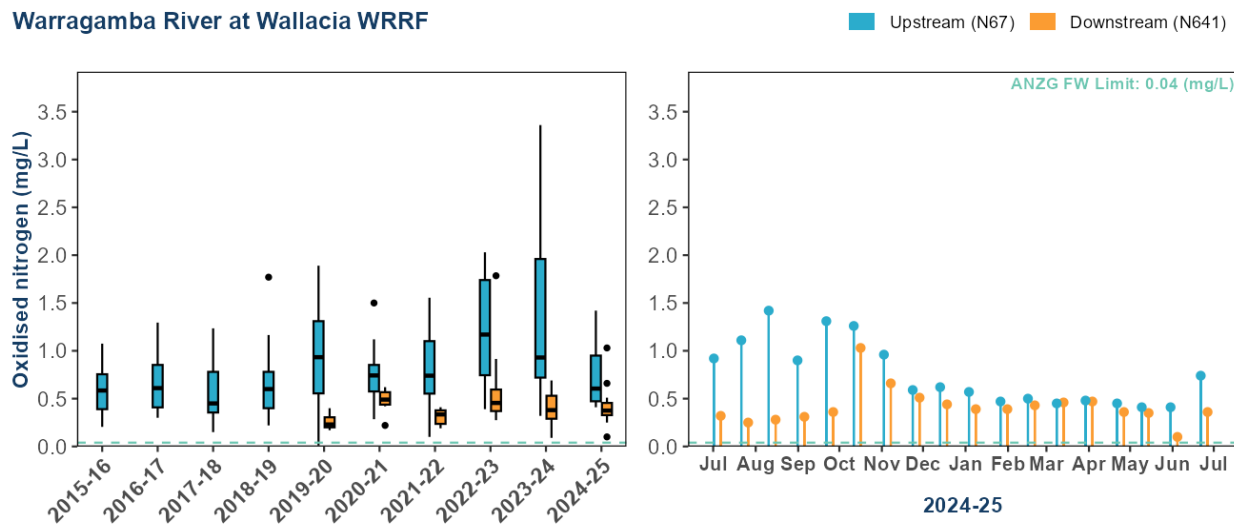
Warragamba River at Wallacia WRRF: N641 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.87	0.22	239	-0.56	0.945
Oxidised nitrogen	0.96	0.16	239	-0.25	0.994
Total nitrogen	0.94	0.08	239	-0.73	0.885
Soluble reactive phosphorus	0.88	0.22	66	-0.54	0.950
Total phosphorus	0.84	0.12	239	-1.24	0.601
Physico-chemical					
Conductivity	1.09	0.08	239	1.14	0.664
Dissolved oxygen	0.96	0.04	239	-1.03	0.734
Dissolved oxygen saturation	-1.47	2.16	237	-0.68	0.904
pH	0.02	0.07	237	0.27	0.993
Water temperature	1.02	0.09	238	0.29	0.992
Turbidity	0.70	0.11	239	-2.15	0.141
Trace Metals					
Filterable aluminium	1.12	0.25	66	0.51	0.957
Total aluminium	0.67	0.18	66	-1.53	0.424
Filterable cobalt	0.85	0.19	66	-0.74	0.880
Total cobalt	0.56	0.10	66	-3.31	0.008
Filterable copper	0.81	0.11	66	-1.50	0.442
Total copper	0.80	0.11	66	-1.68	0.345
Filterable nickel	0.70	0.09	66	-2.72	0.040
Total nickel	0.72	0.08	66	-2.79	0.034
Filterable zinc	0.97	0.22	65	-0.15	0.999
Total zinc	0.89	0.17	66	-0.61	0.928
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.3.6. Stressor – Nutrients

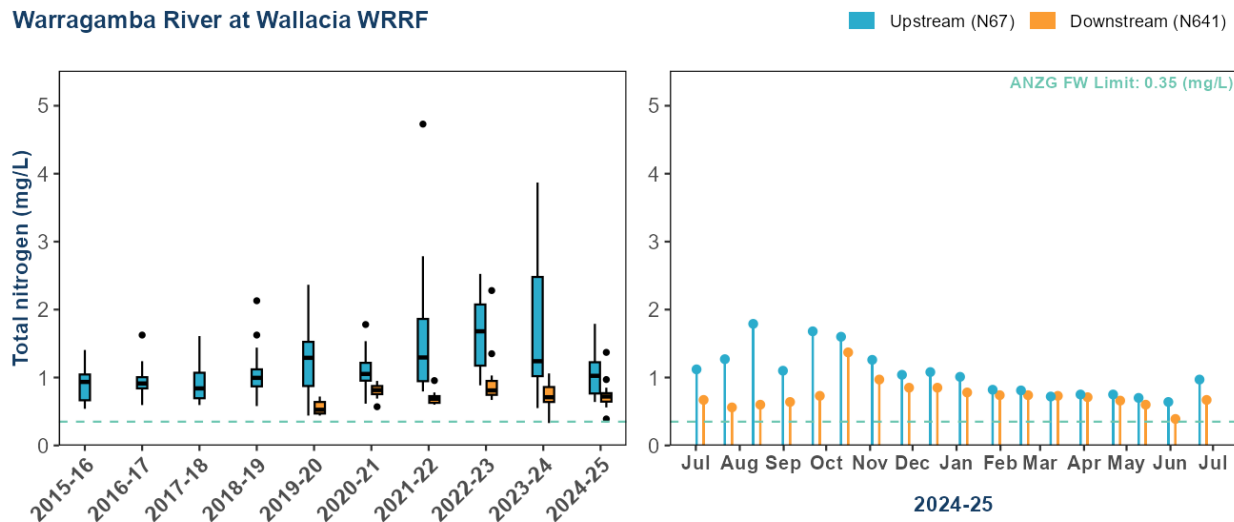
Warragamba River at Wallacia WRRF



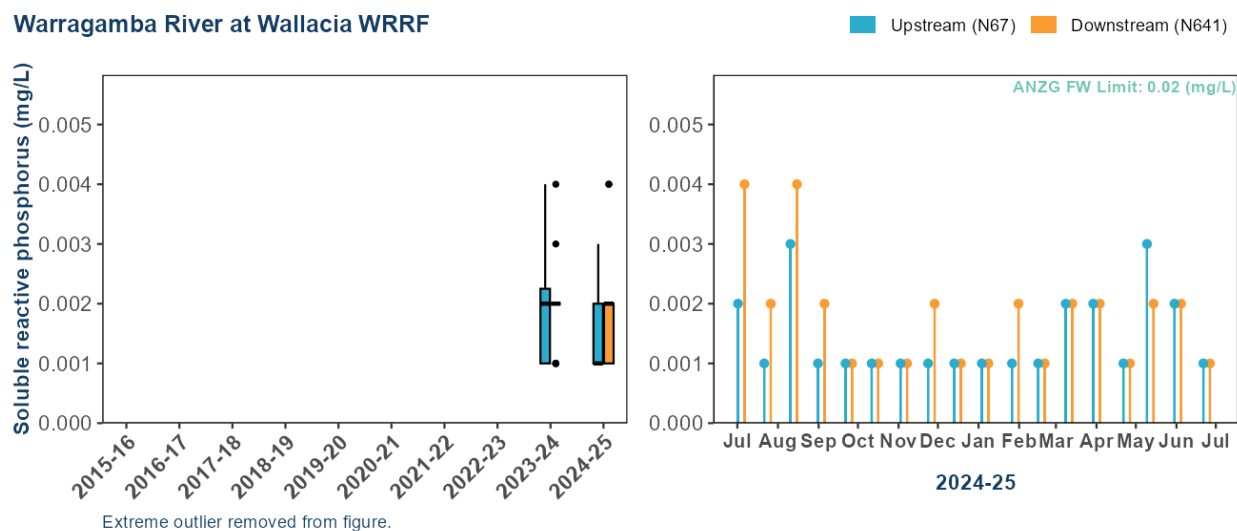
Warragamba River at Wallacia WRRF



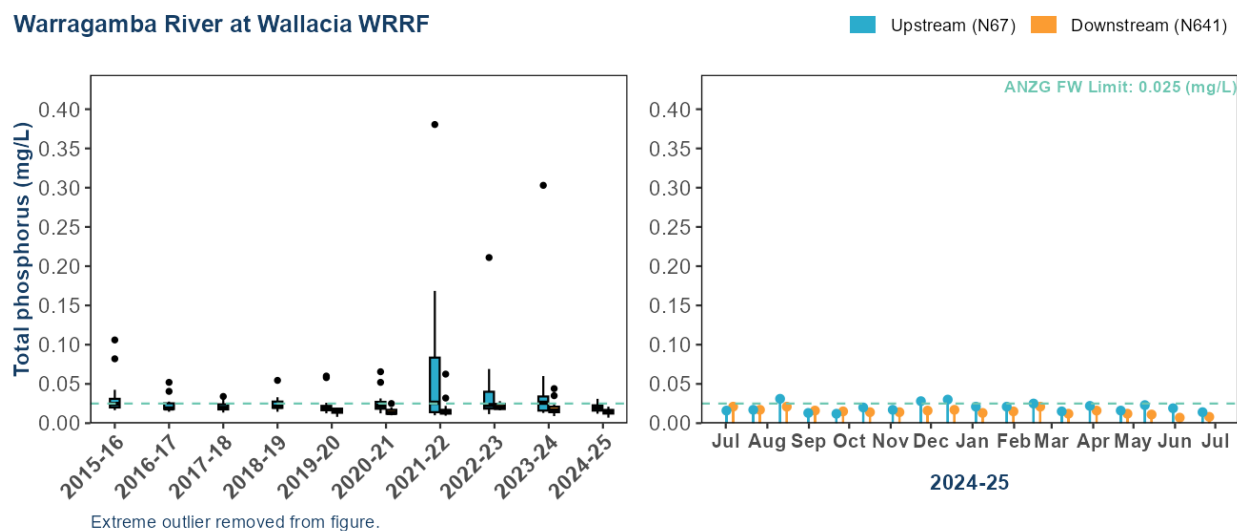
Warragamba River at Wallacia WRRF



Warragamba River at Wallacia WRRF

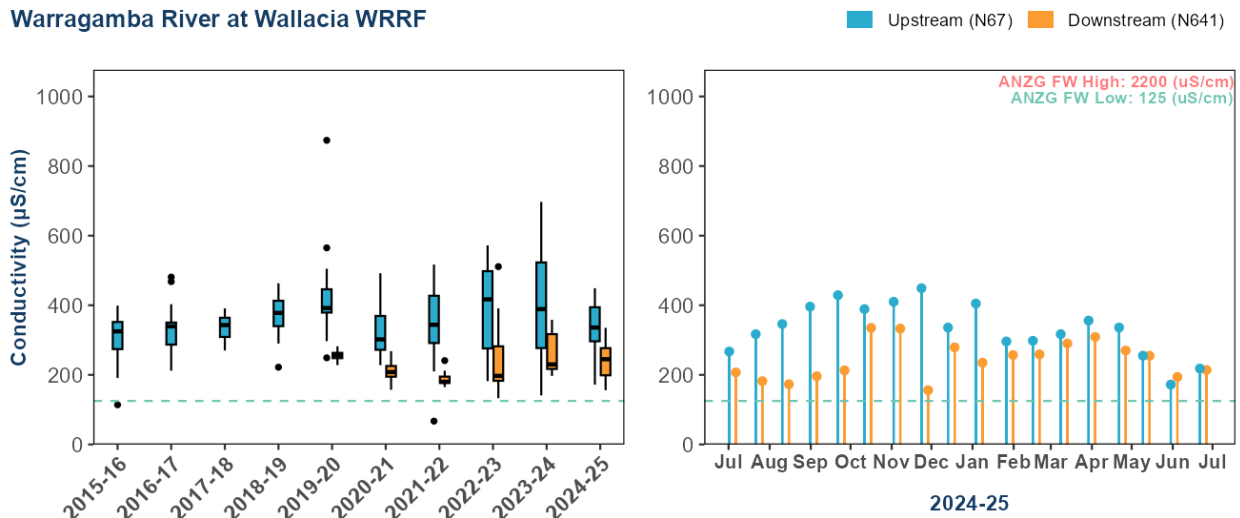


Warragamba River at Wallacia WRRF

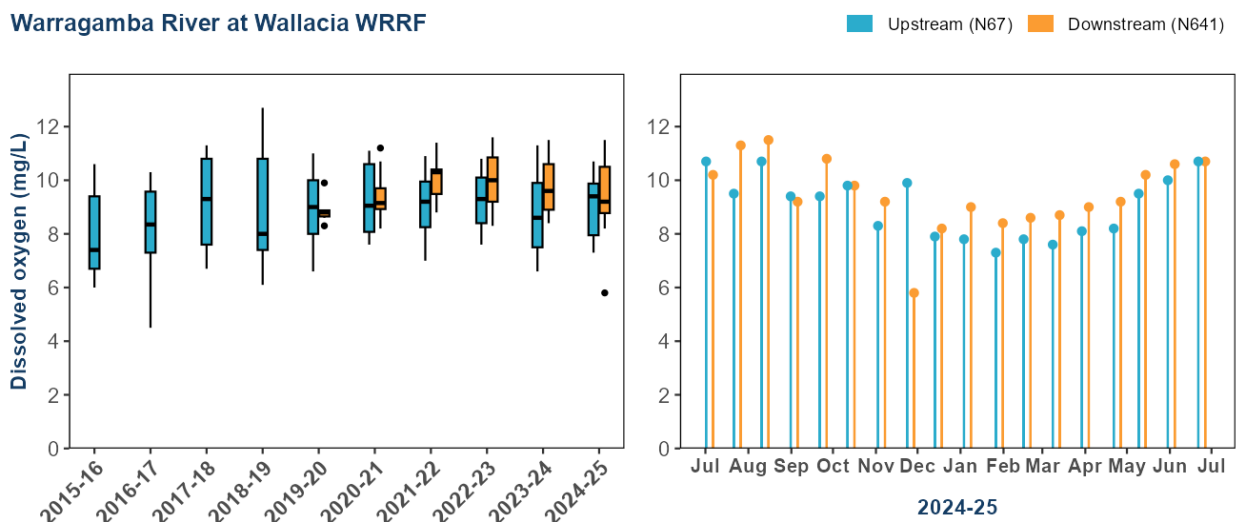


A.3.7. Stressor – Physico-chemical water quality

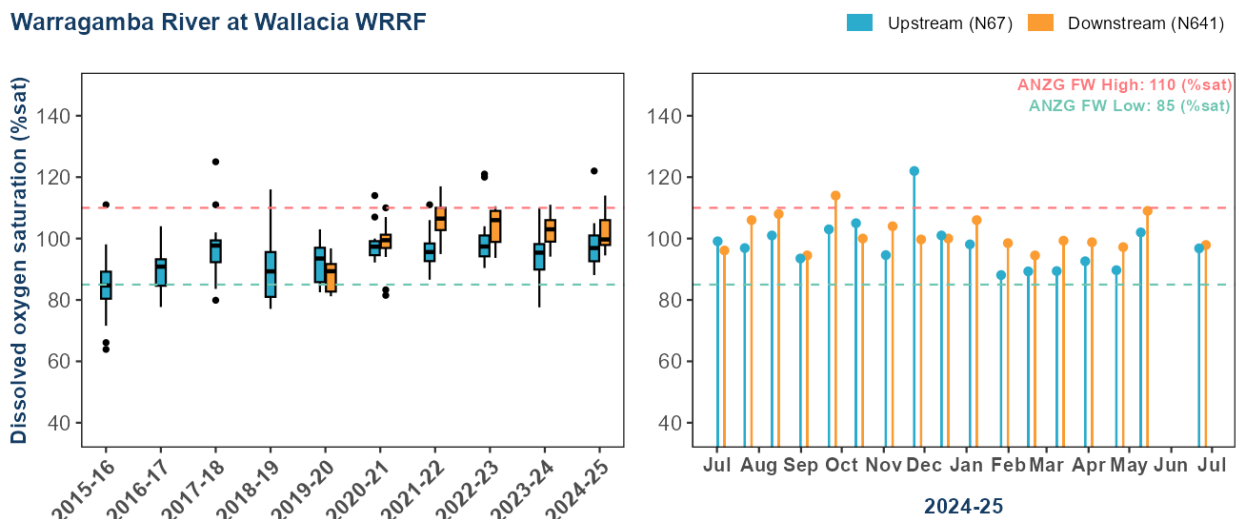
Warragamba River at Wallacia WRRF



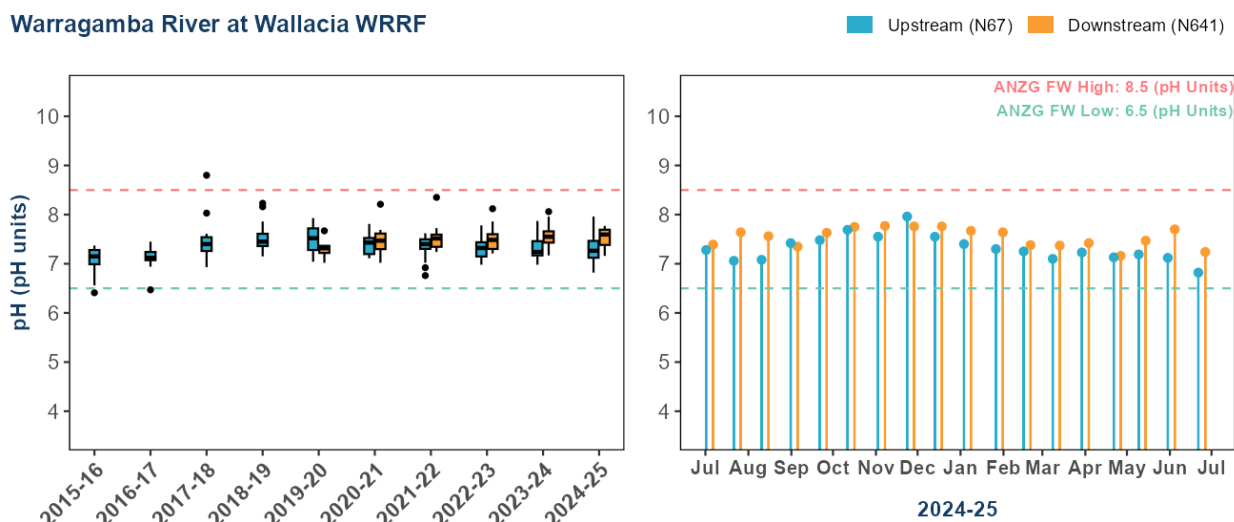
Warragamba River at Wallacia WRRF



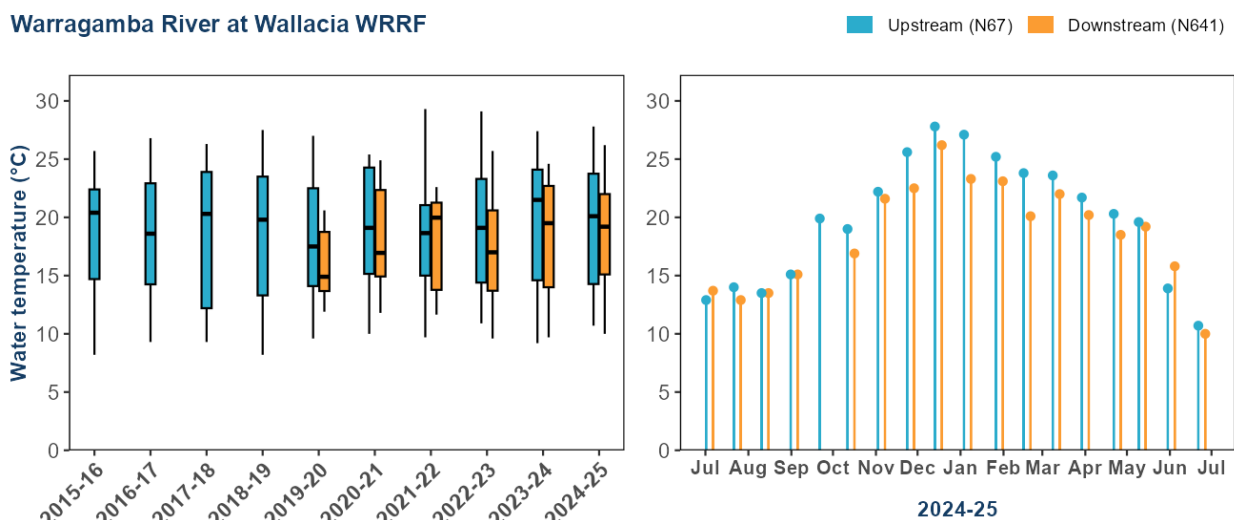
Warragamba River at Wallacia WRRF



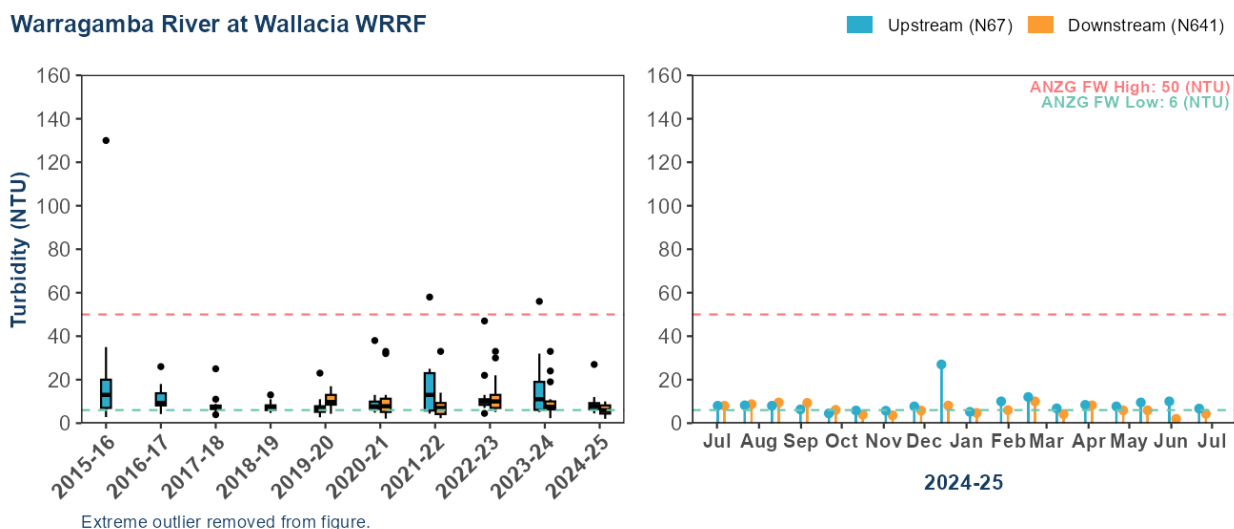
Warragamba River at Wallacia WRRF



Warragamba River at Wallacia WRRF

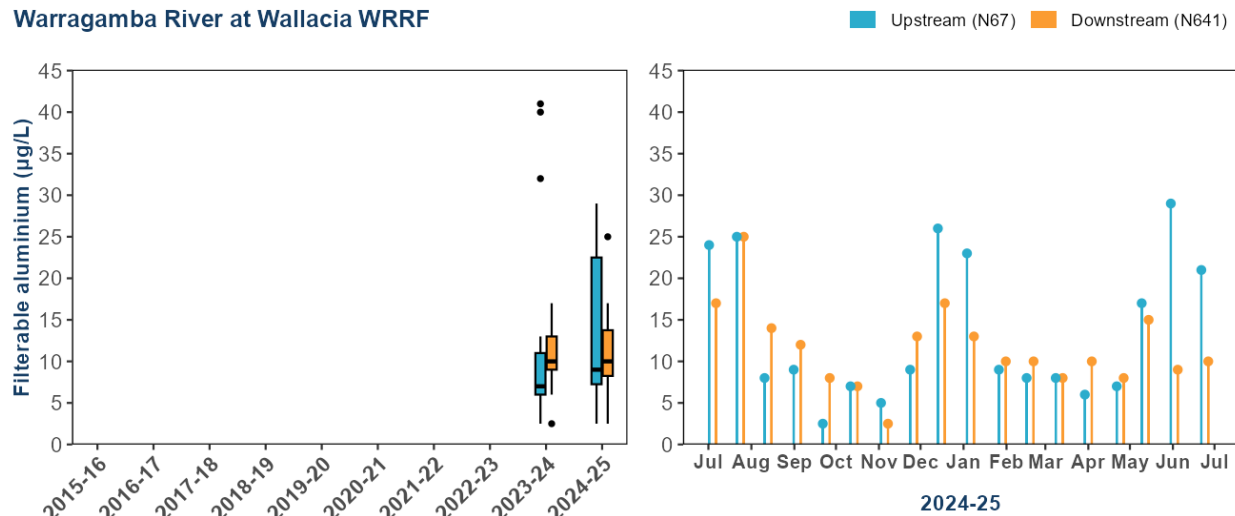


Warragamba River at Wallacia WRRF

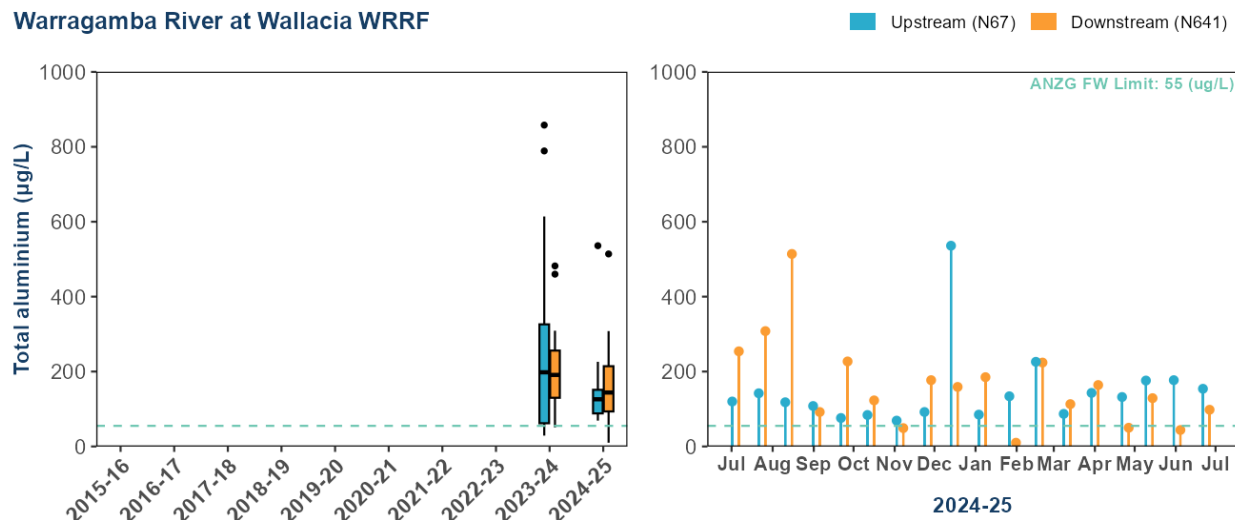


A.3.8. Stressor – Trace metals

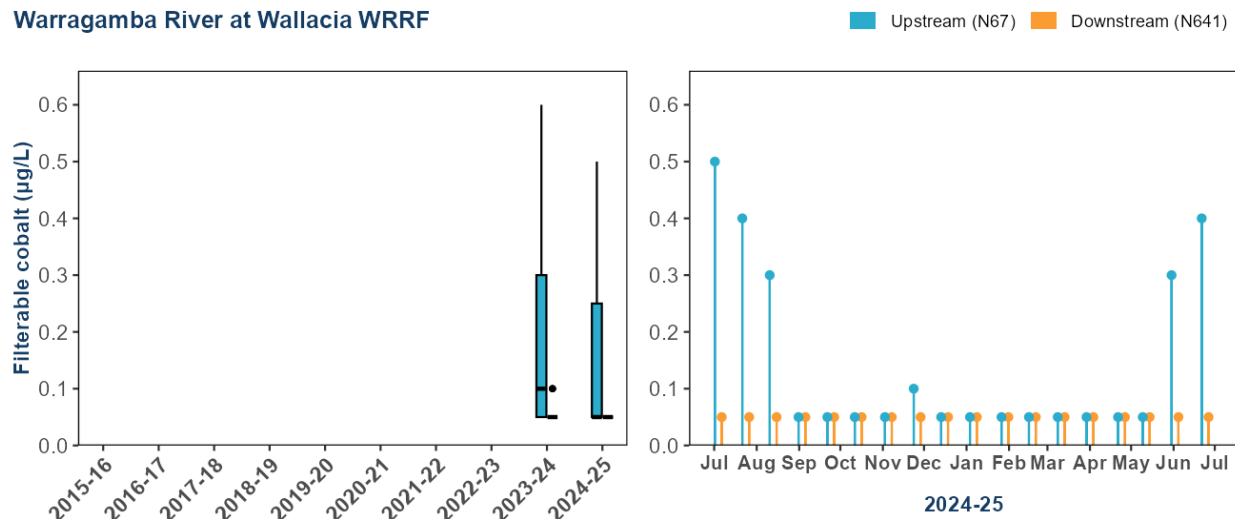
Warragamba River at Wallacia WRRF



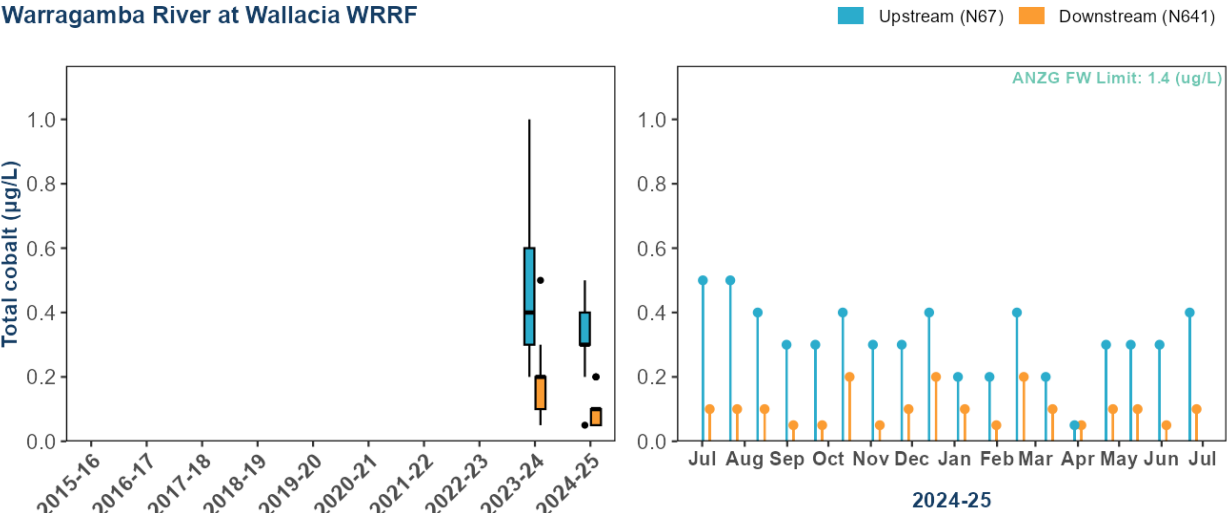
Warragamba River at Wallacia WRRF



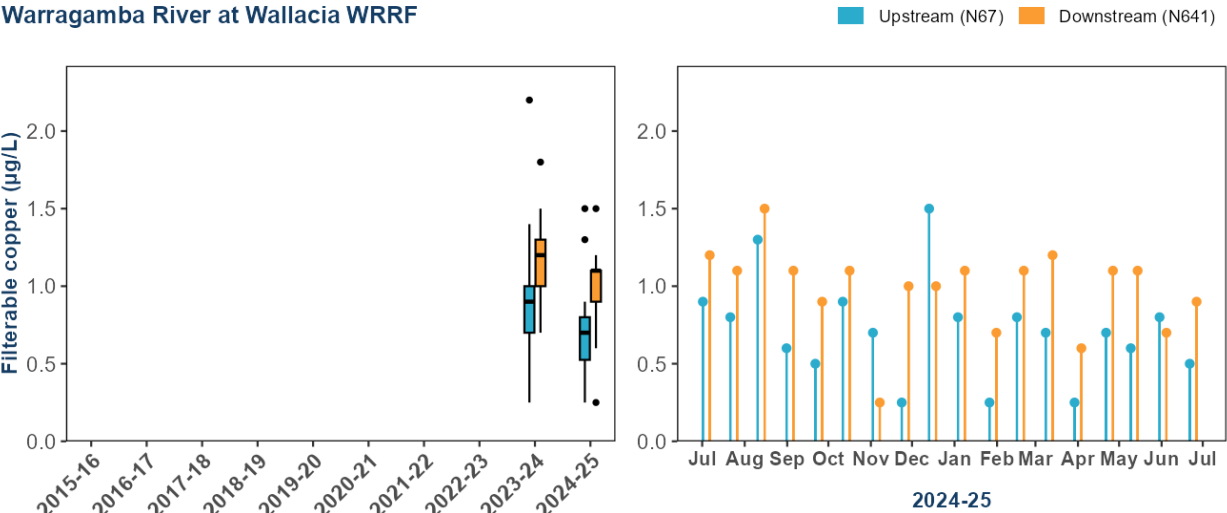
Warragamba River at Wallacia WRRF



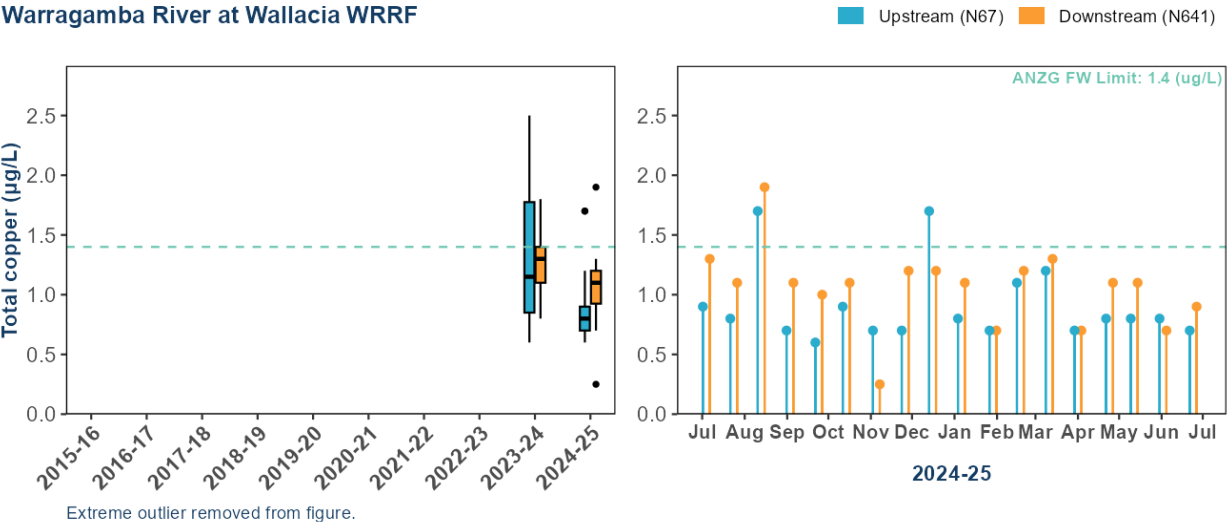
Warragamba River at Wallacia WRRF



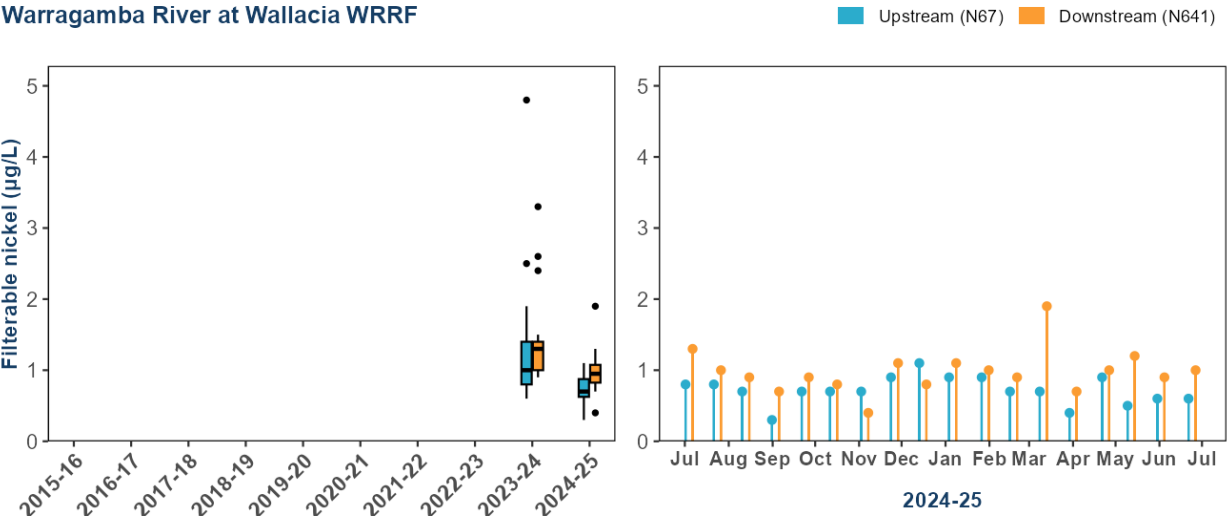
Warragamba River at Wallacia WRRF



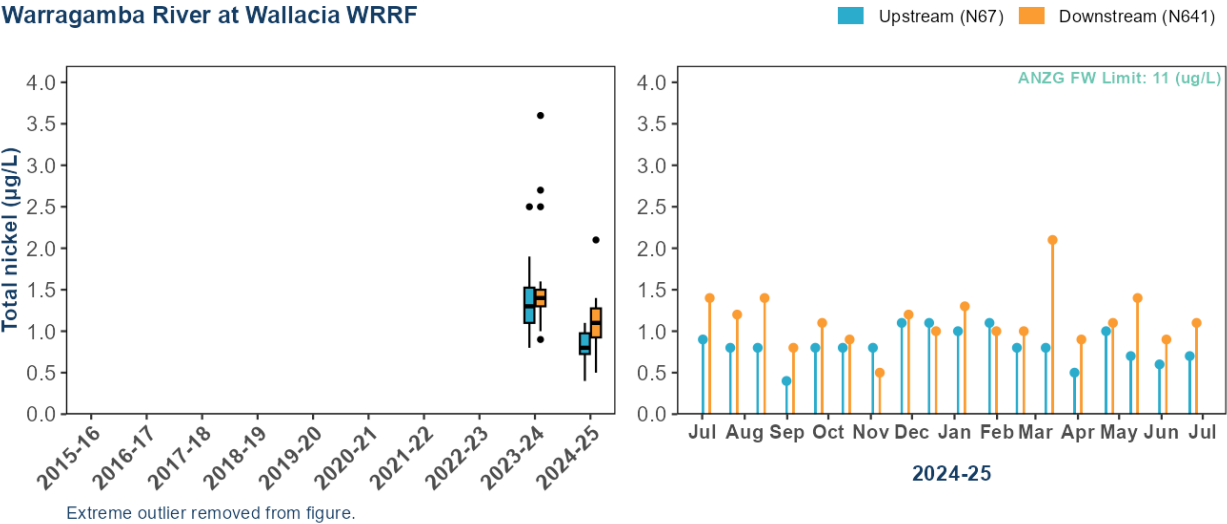
Warragamba River at Wallacia WRRF



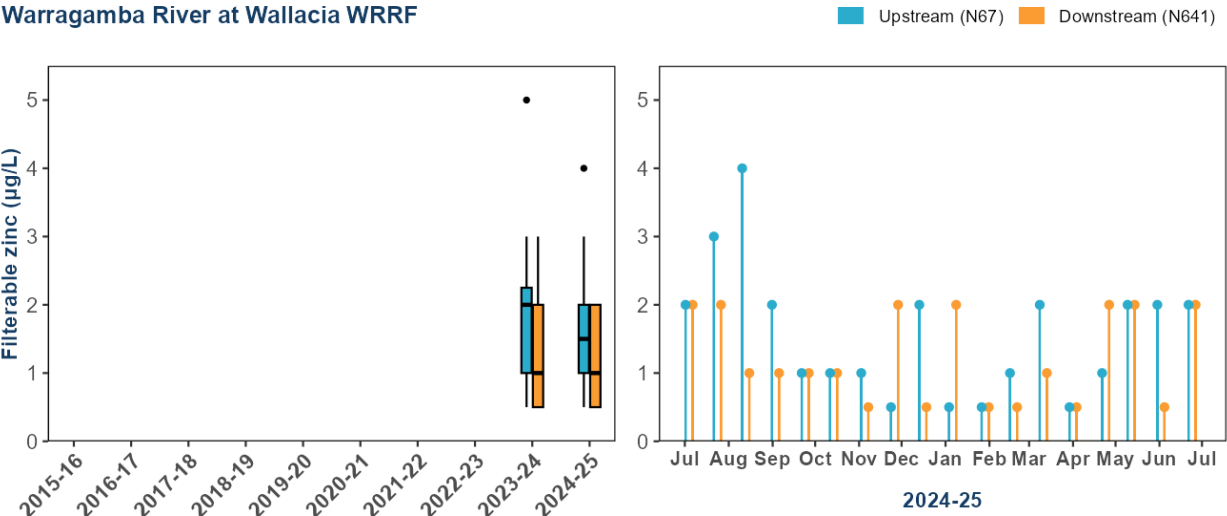
Warragamba River at Wallacia WRRF



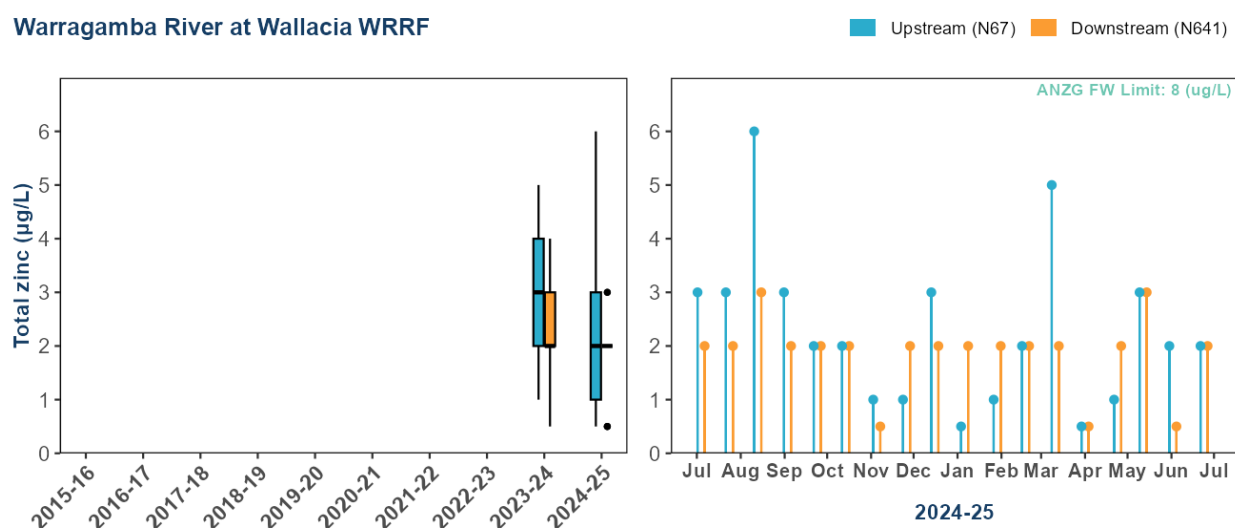
Warragamba River at Wallacia WRRF



Warragamba River at Wallacia WRRF



Warragamba River at Wallacia WRRF



A.3.9. Ecosystem receptor – Statistical analysis outcomes

Table A-28 Upstream vs downstream comparison (2024-25 reporting period) for the Warragamba River at Wallacia WRRF

Warragamba River at Wallacia WRRF: N67 vs N641 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.47	0.13	239	-2.69	0.038
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-29 Upstream current period (2024-25) vs previous period comparison (single site) for the Warragamba River at Wallacia WRRF

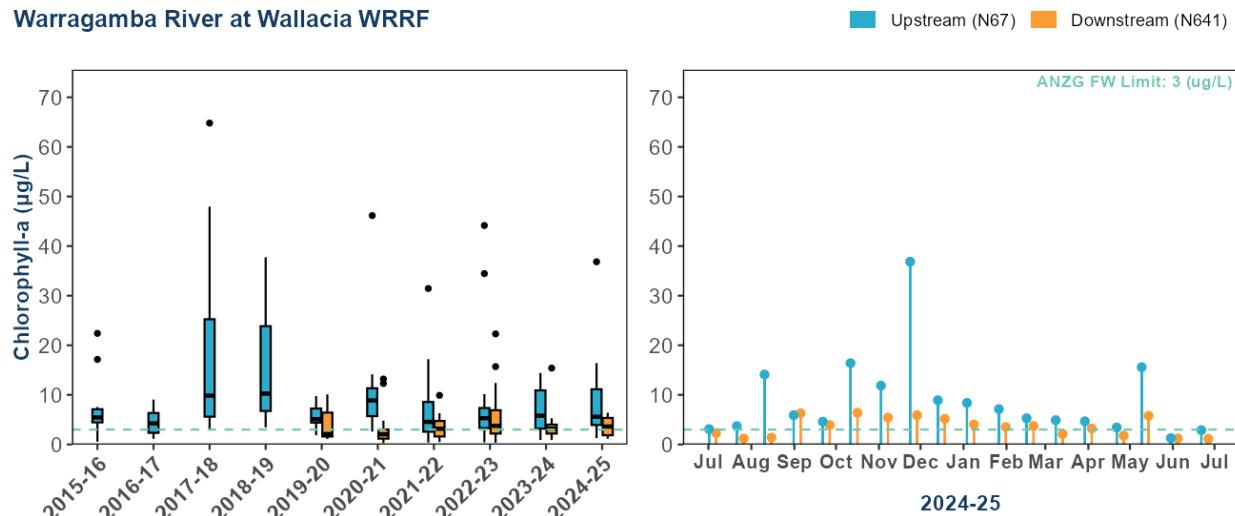
Warragamba River at Wallacia WRRF: N67 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.17	0.26	239	0.70	0.895
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-30 Downstream current period (2024-25) vs previous period comparison (single site) for the Warragamba River at Wallacia WRRF

Warragamba River at Wallacia WRRF: N641 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.10	0.25	239	0.42	0.974
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.3.10. Ecosystem receptor – Phytoplankton

Warragamba River at Wallacia WRRF

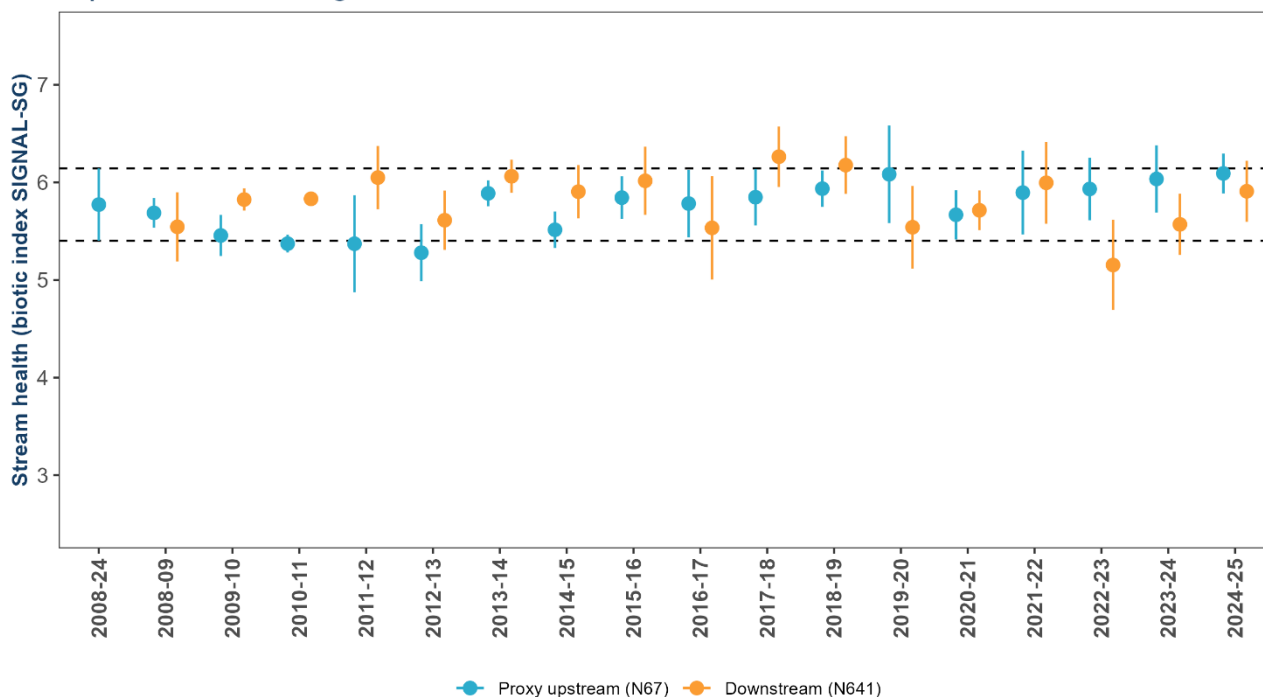


A.3.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Warragamba / Nepean Rivers	River (N67 vs N641)	Welch Two Sample t-test	0.18	1.32	10.1	0.216

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Nepean River and Warragamba River at Wallacia WRRF

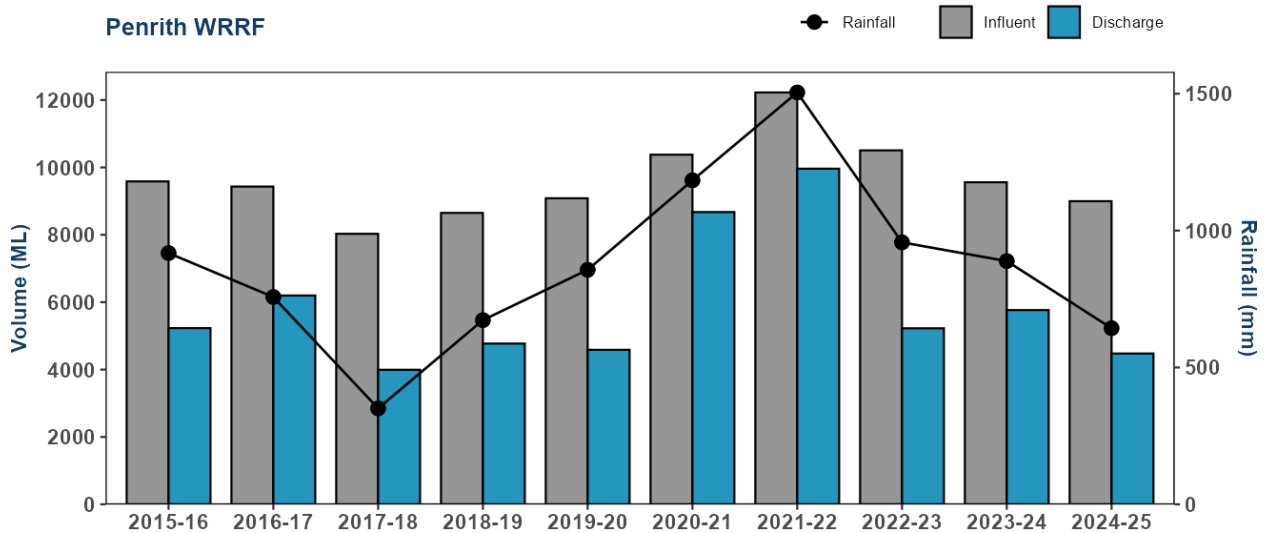


The range of stream health recorded over each period is represented by length of line

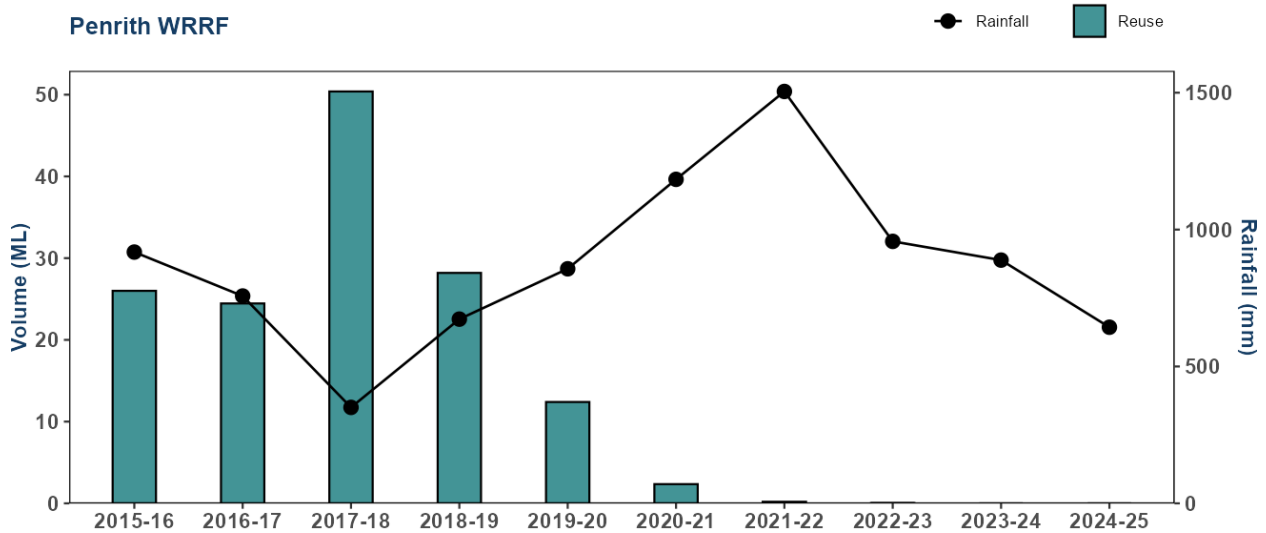
A.4. Penrith WRRF

A.4.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



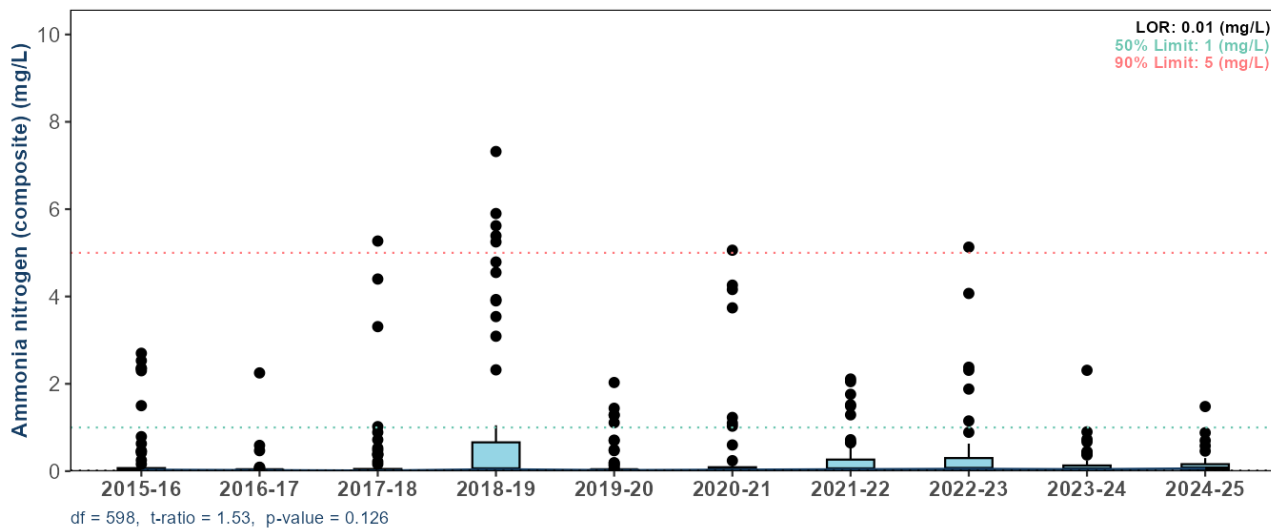
Reuse volume and rainfall



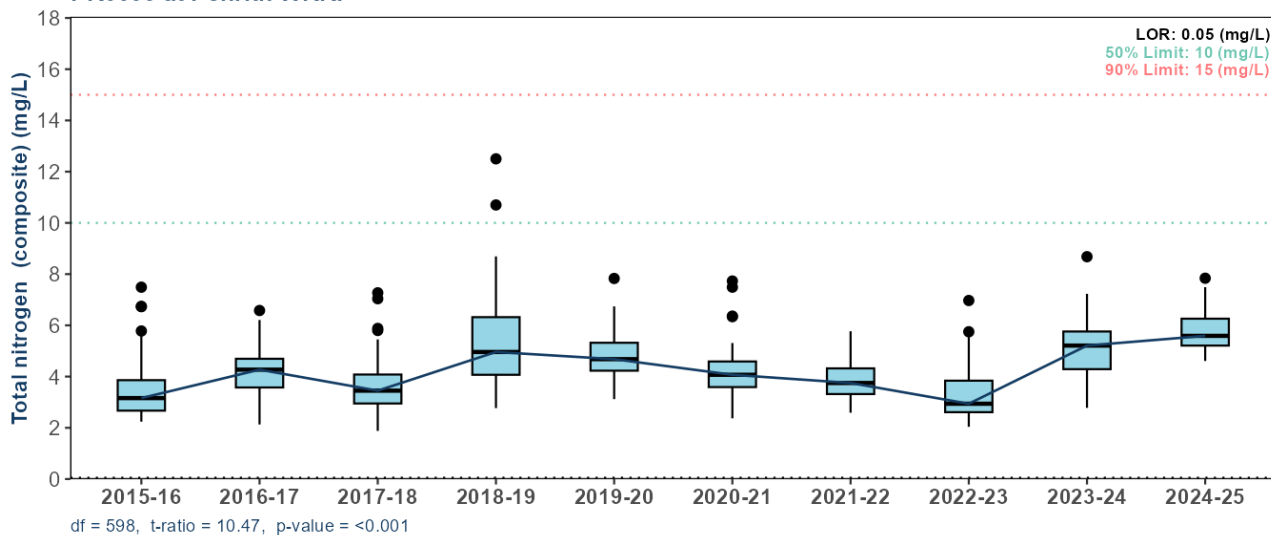
A.4.2. Pressure – Wastewater quality

Nutrients: PR0005

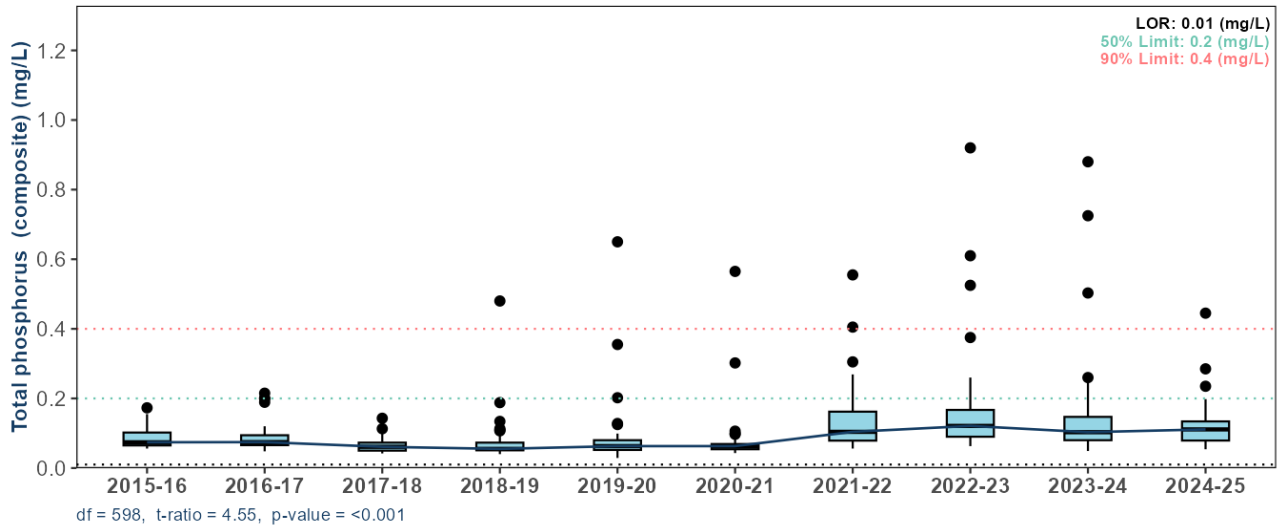
PR0005 at Penrith WRRF



PR0005 at Penrith WRRF

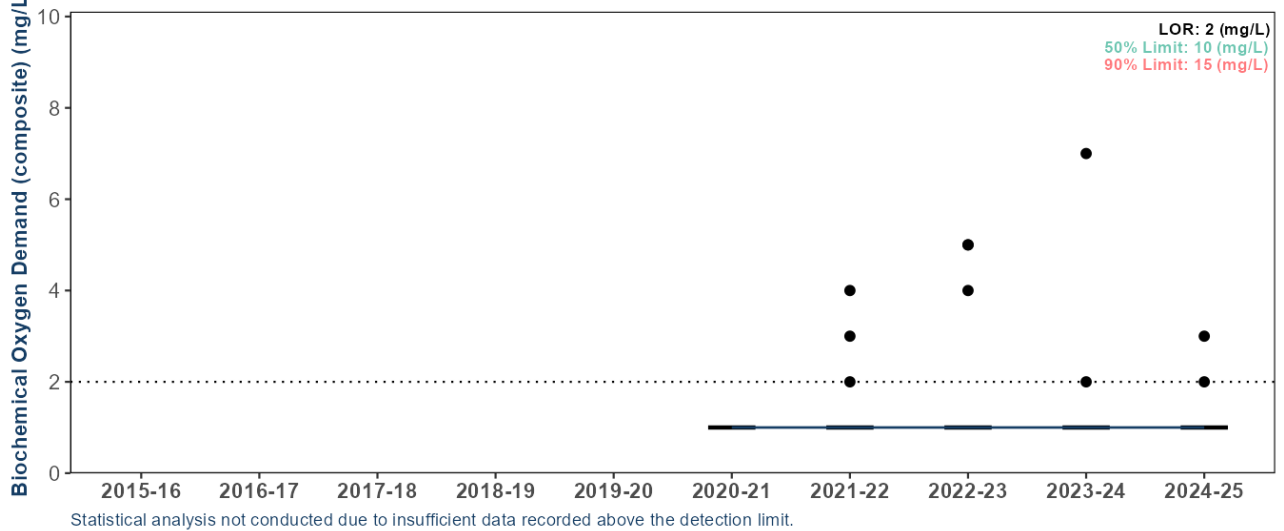


PR0005 at Penrith WRRF

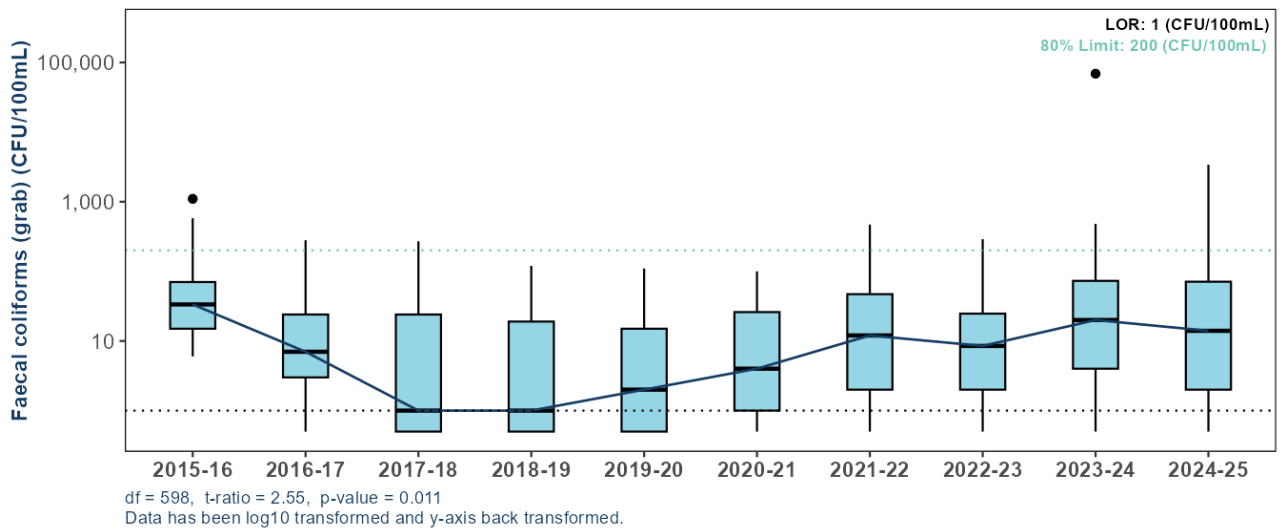


Major conventional analytes: PR0005

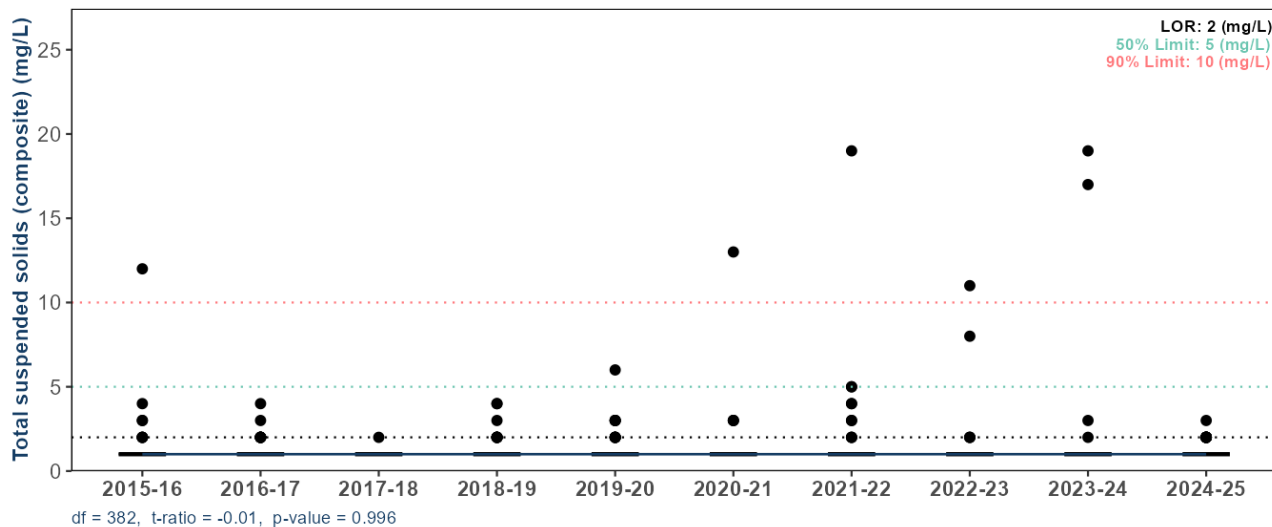
PR0005 at Penrith WRRF



PR0005 at Penrith WRRF

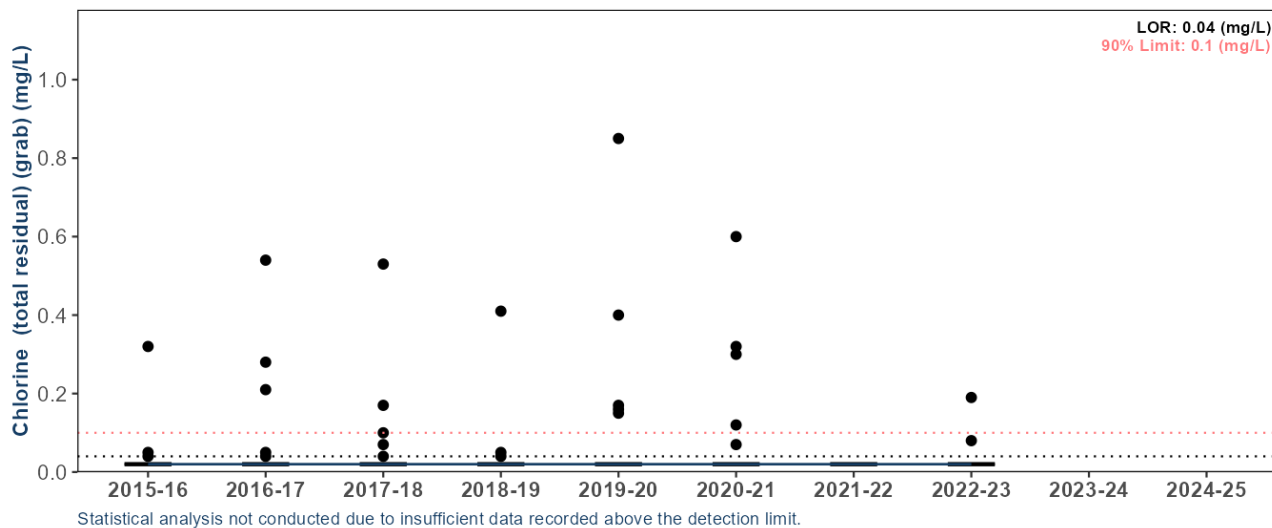


PR0005 at Penrith WRRF



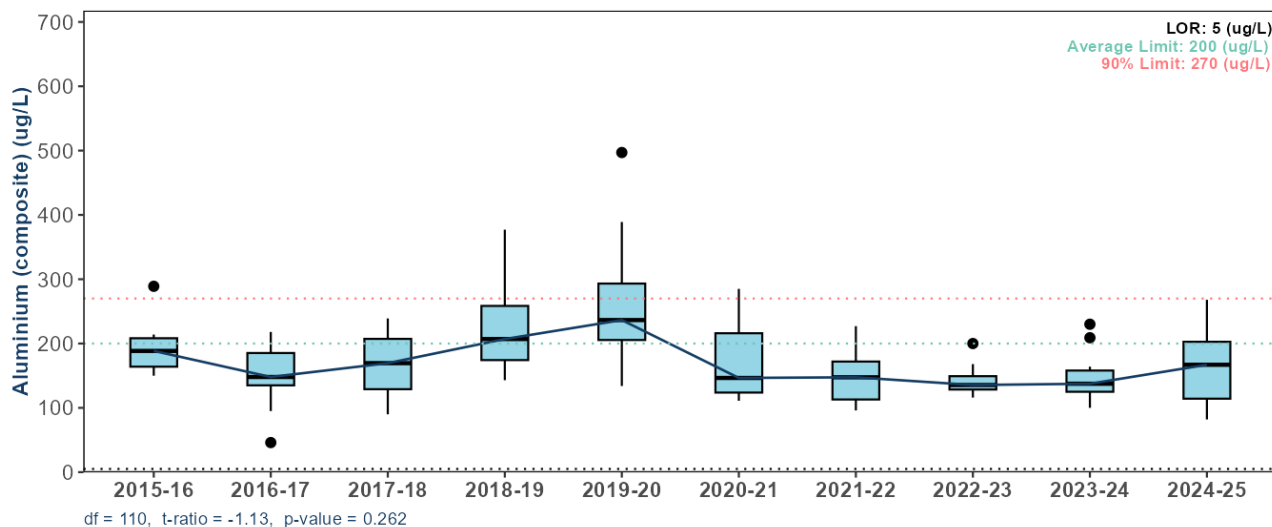
Major conventional analytes: PR0021

PR0021 at Penrith WRRF

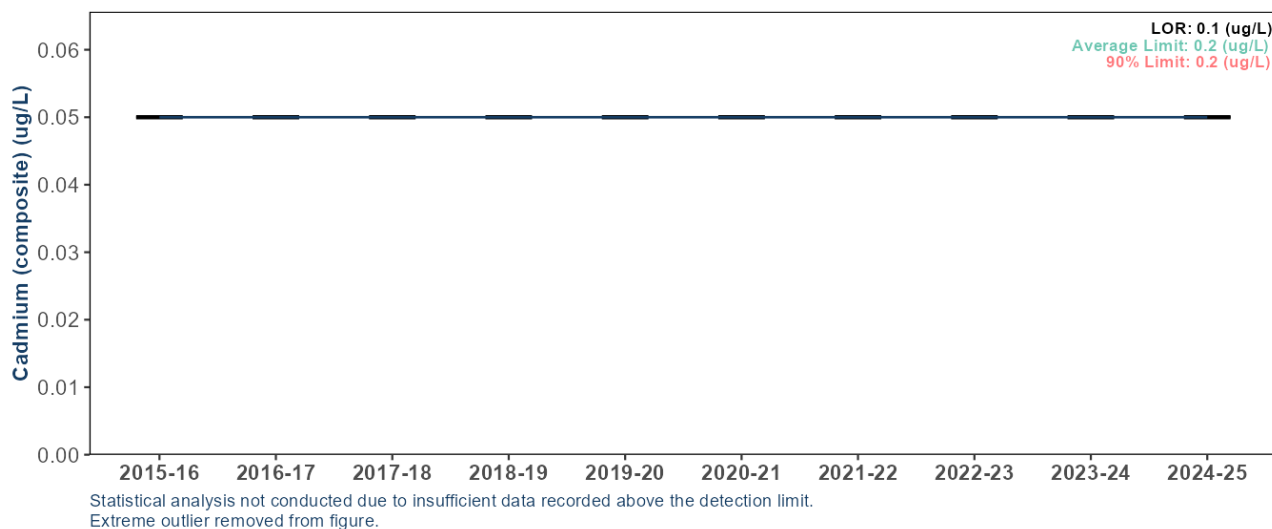


Trace metals: PR0005

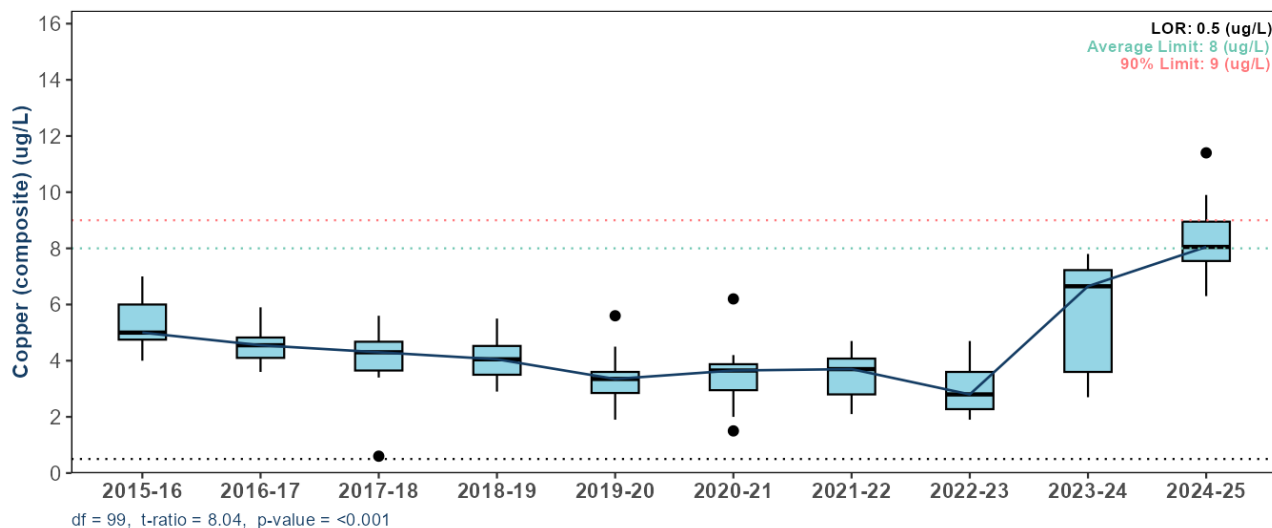
PR0005 at Penrith WRRF



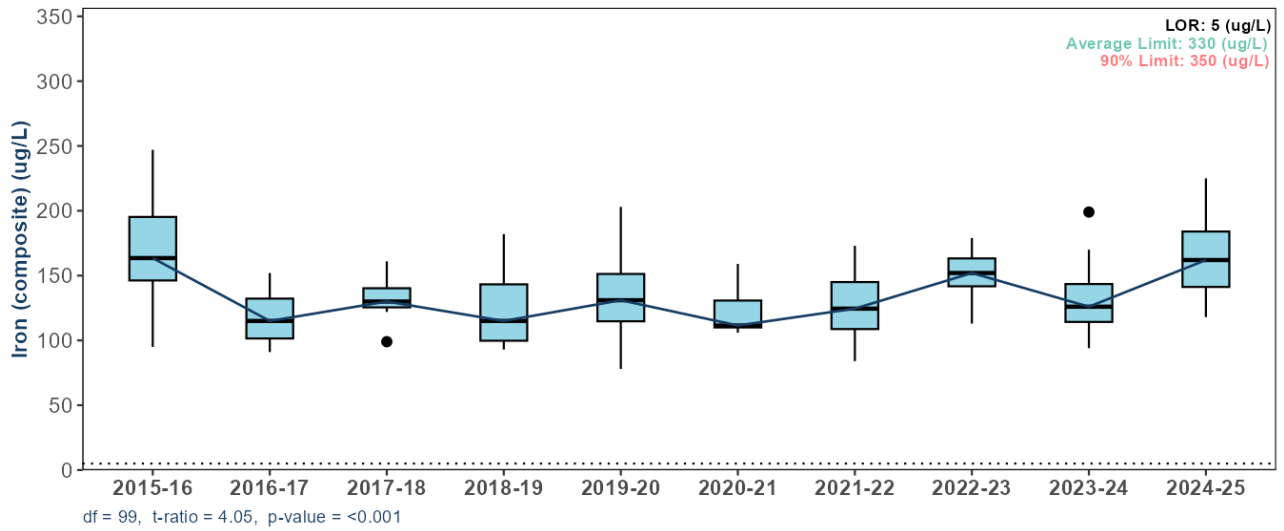
PR0005 at Penrith WRRF



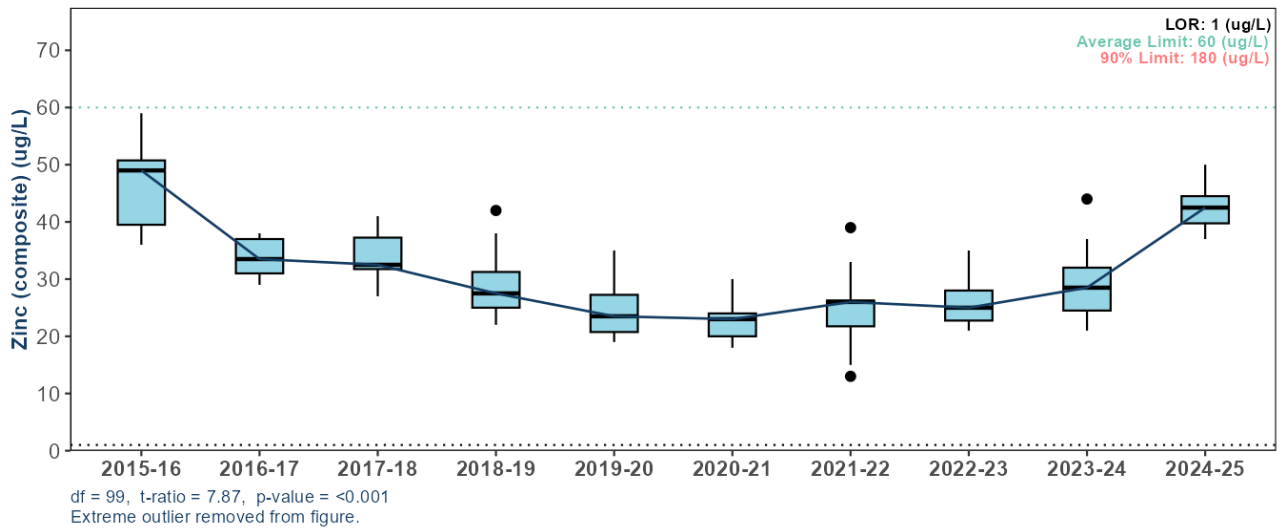
PR0005 at Penrith WRRF



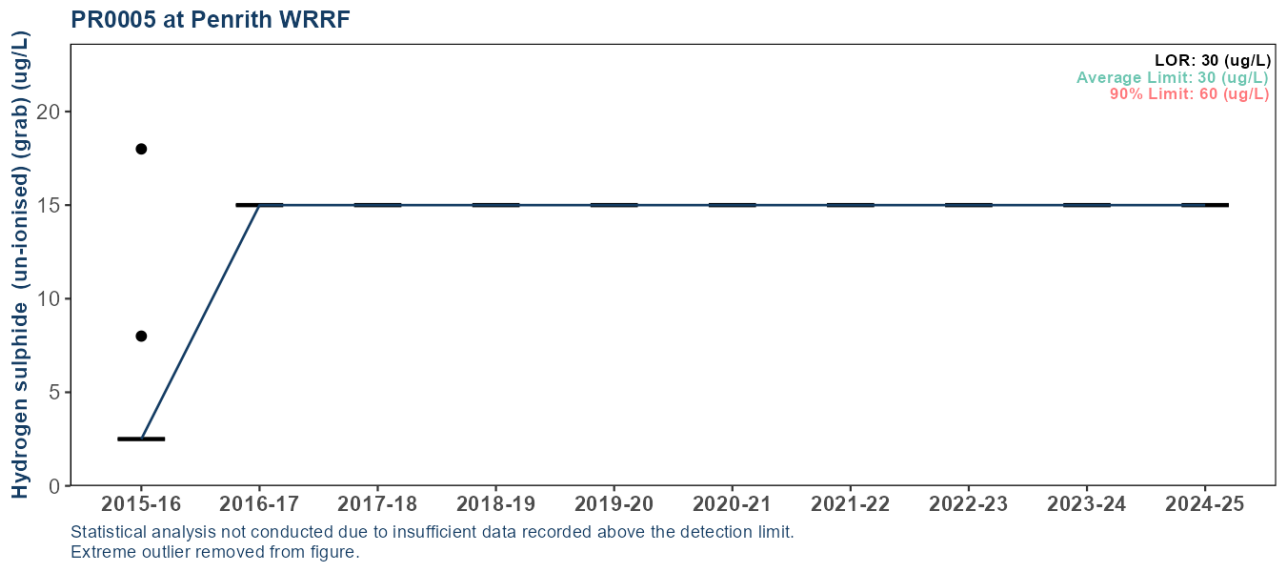
PR0005 at Penrith WRRF



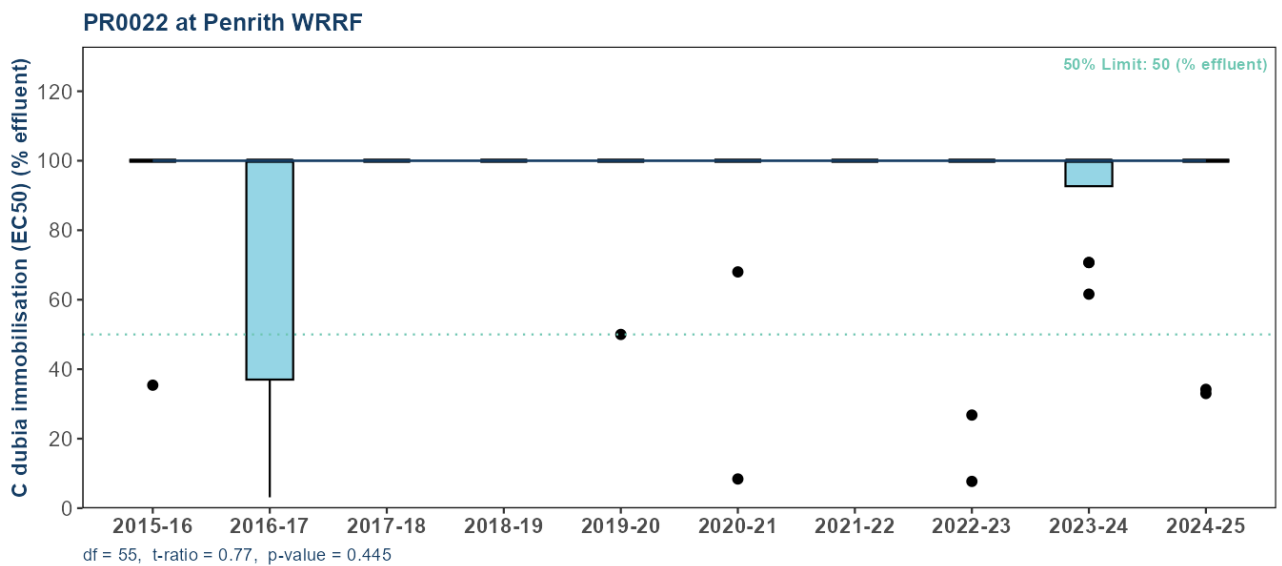
PR0005 at Penrith WRRF



Other chemicals and organics (including pesticides): PR0005

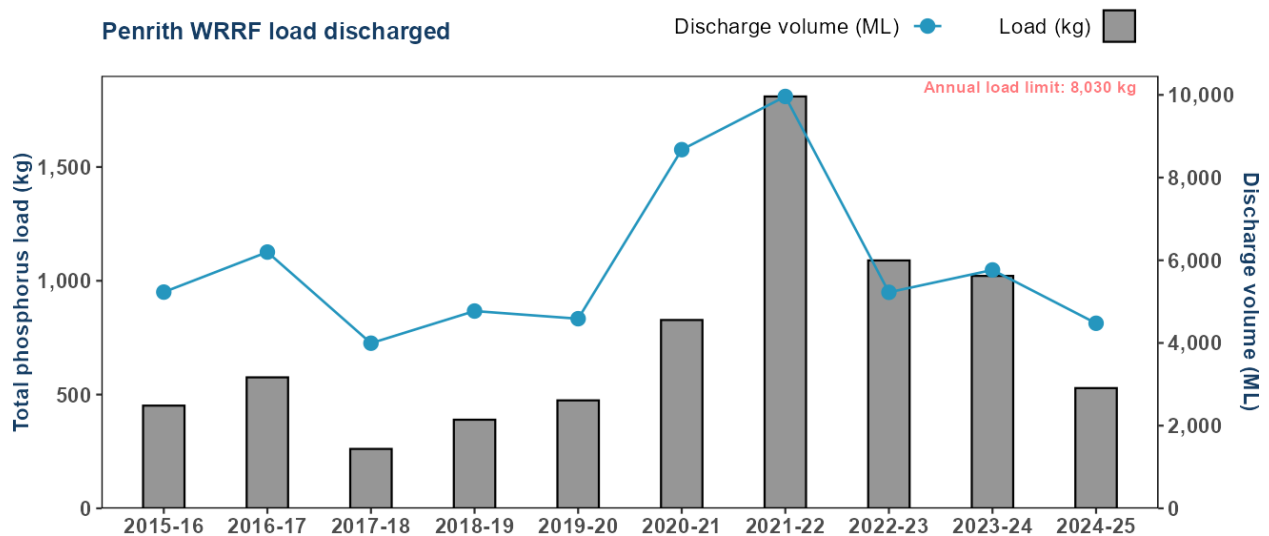
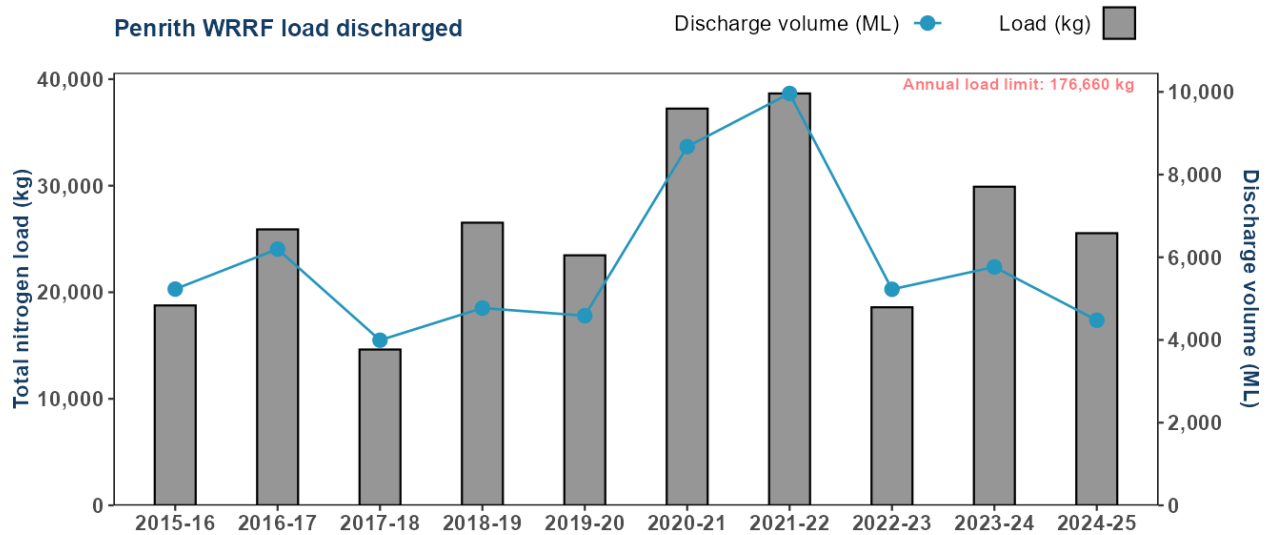


A.4.3. Pressure – Wastewater toxicity

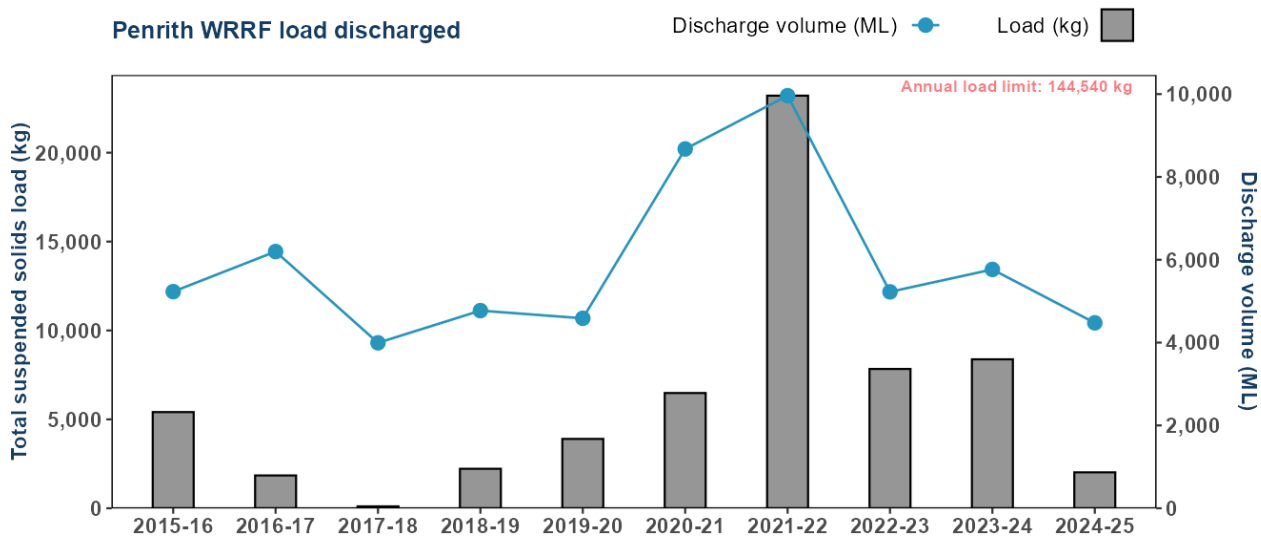
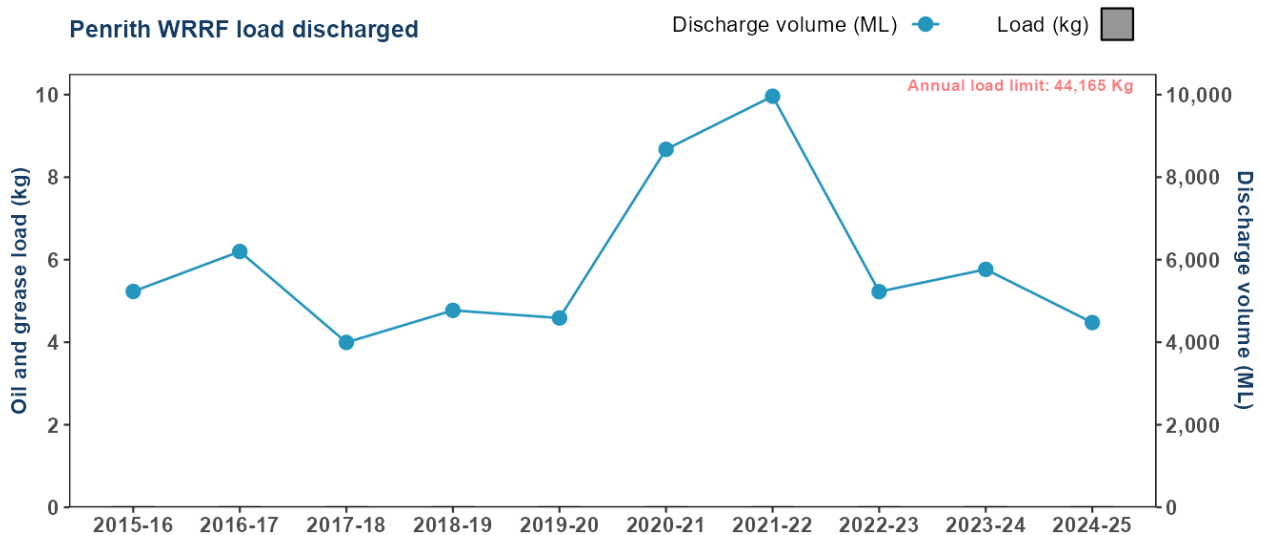
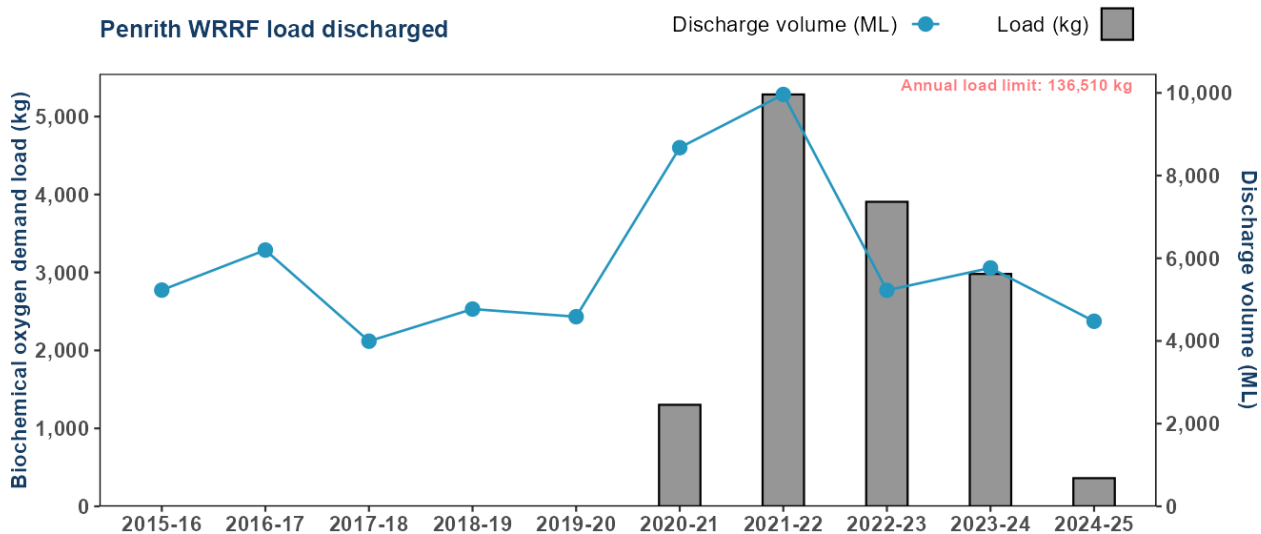


A.4.4. Pressure – Wastewater discharge load

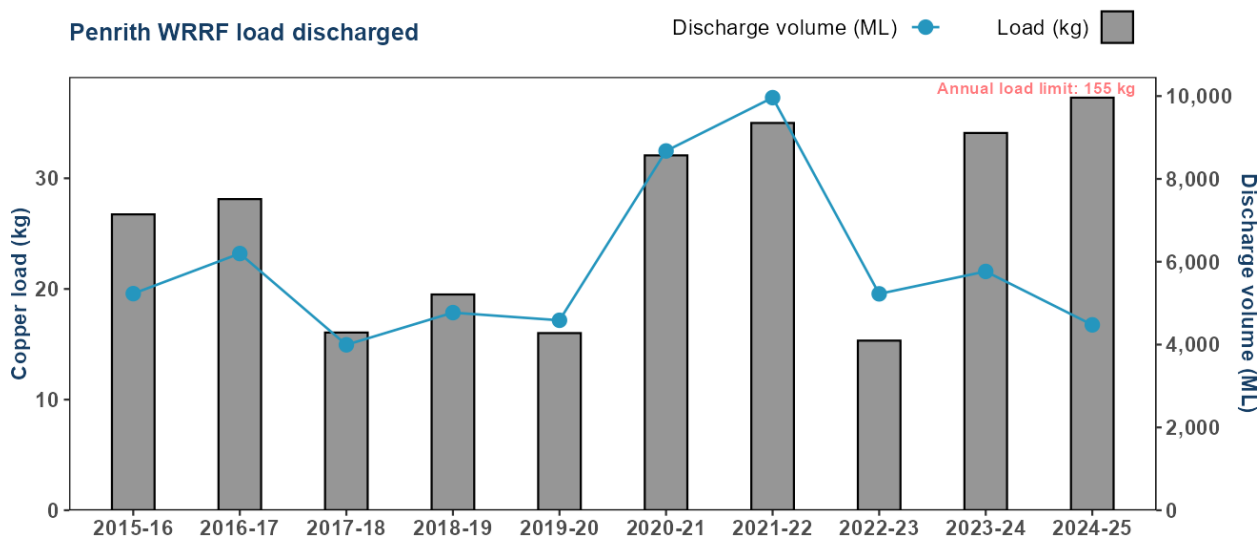
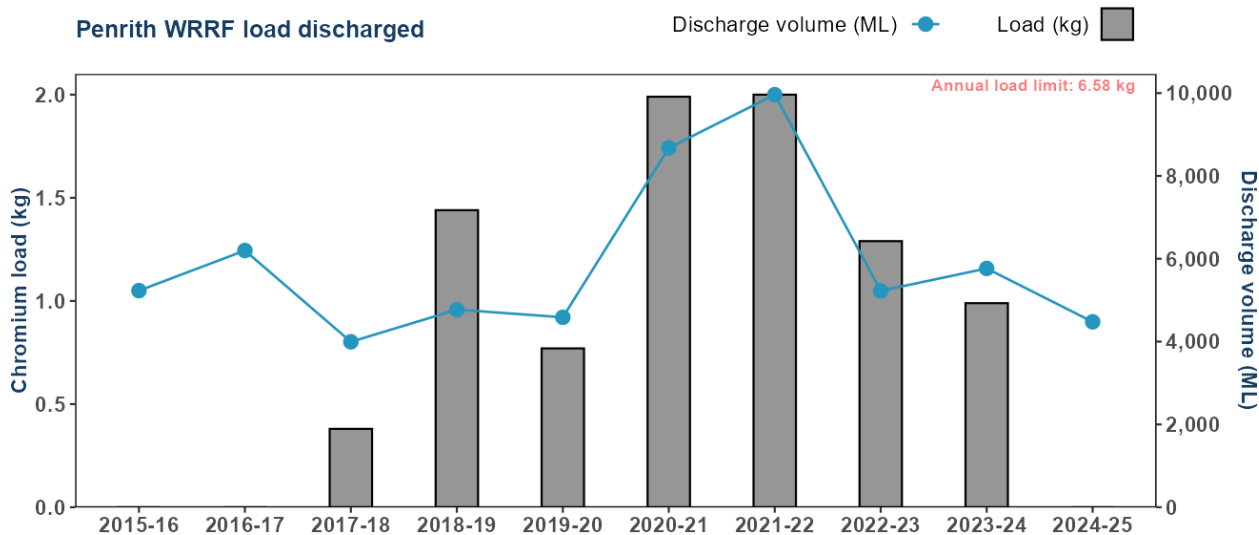
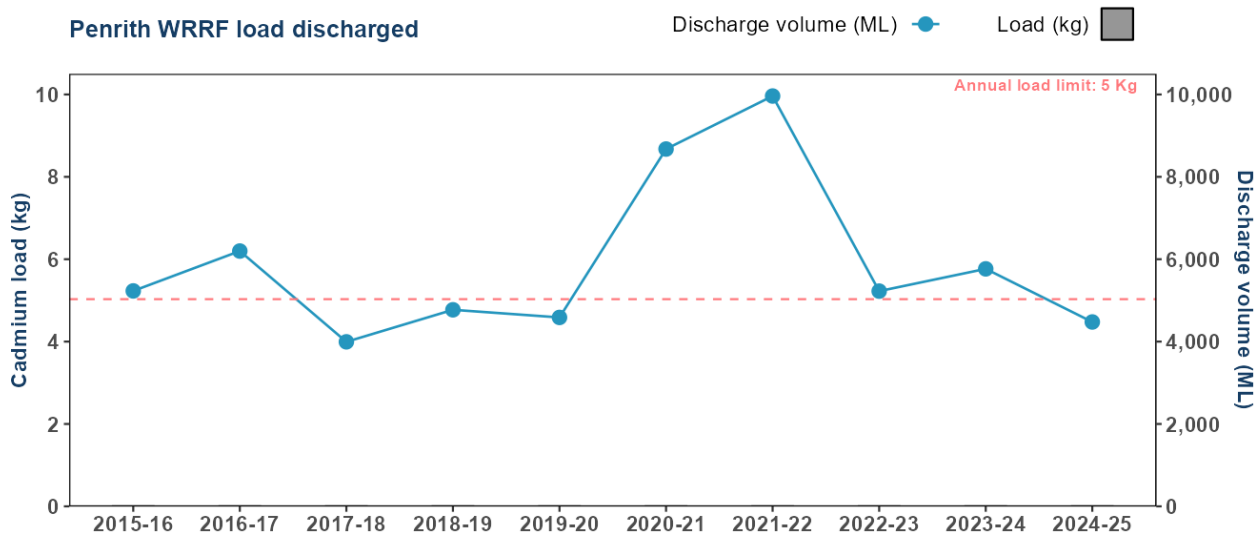
Nutrients

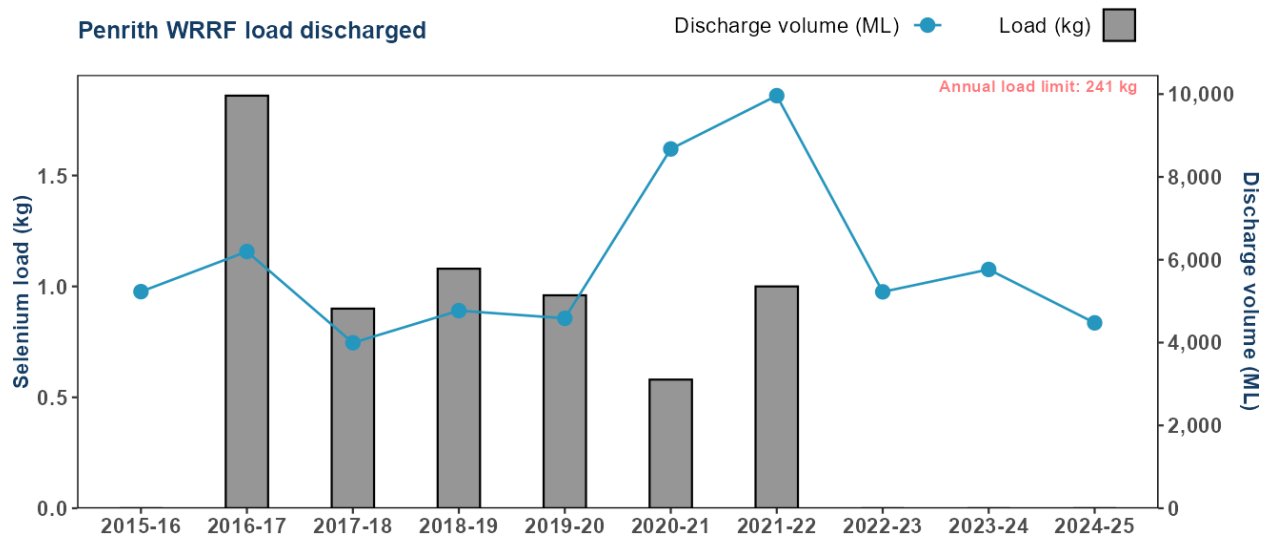
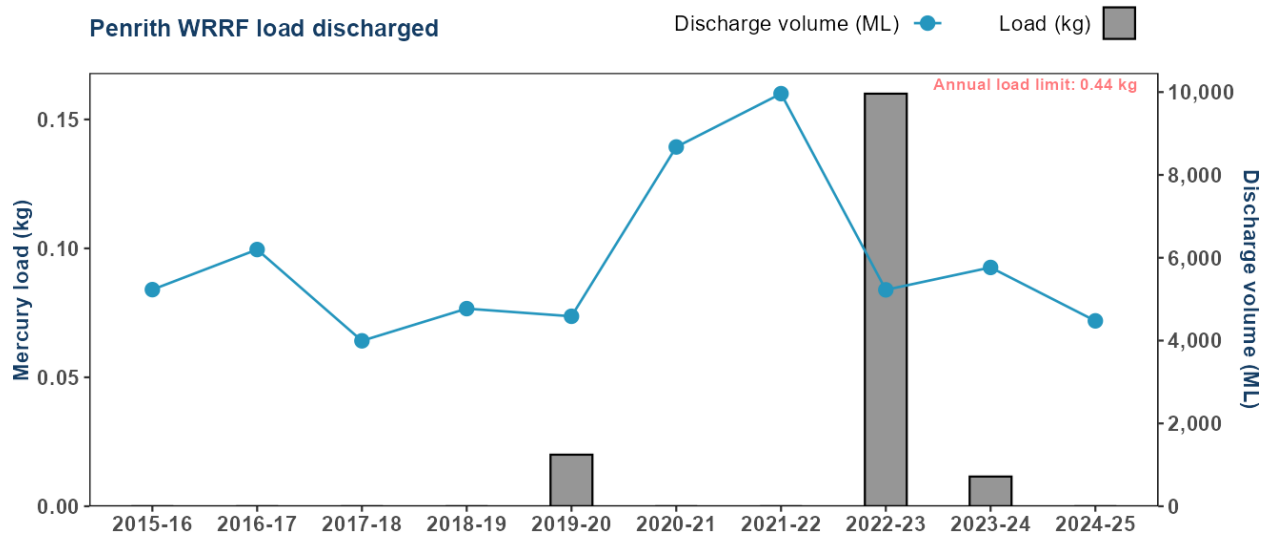
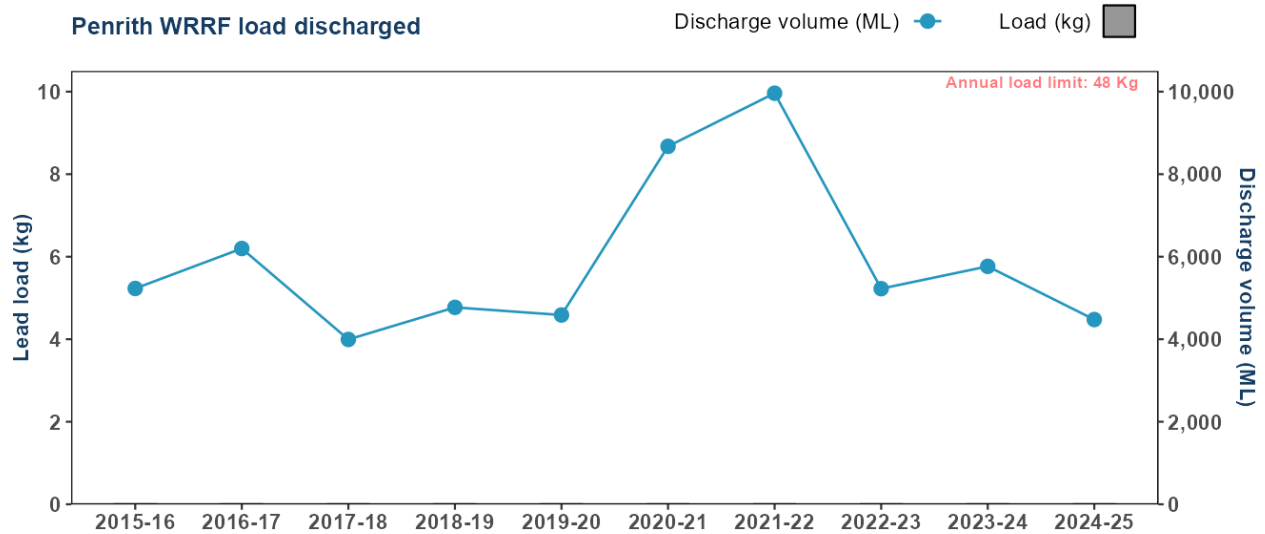


Major conventional analytes

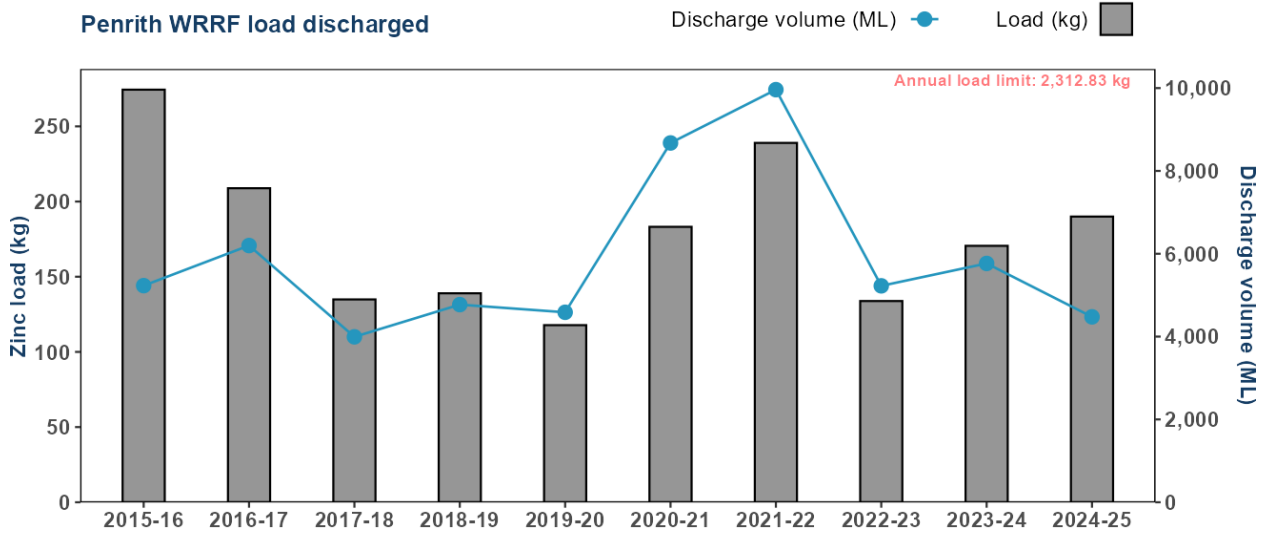


Trace metals



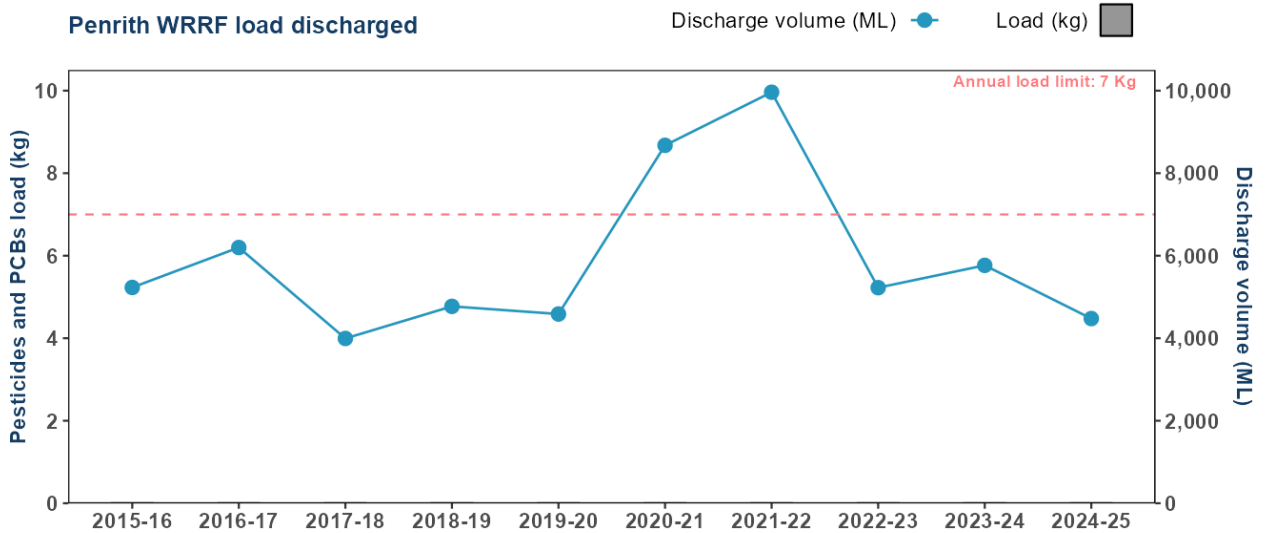


Penrith WRRF load discharged



Other chemical and organics (including pesticides)

Penrith WRRF load discharged



A.4.5. Stressor – Statistical analysis outcomes

Table A-31 Upstream vs downstream comparison (2024-25 reporting period) for Boundary Creek at Penrith WRRF

Boundary Creek at Penrith WRRF: N542 vs N541 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.30	0.14	164	-2.49	0.065
Oxidised nitrogen	33.10	15.18	164	7.63	<0.001
Total nitrogen	3.25	0.98	164	3.92	<0.001
Soluble reactive phosphorus	0.44	0.16	66	-2.21	0.130
Total phosphorus	0.65	0.22	164	-1.26	0.588
Physico-chemical					
Conductivity	0.64	0.21	163	-1.38	0.511
Dissolved oxygen	1.38	0.23	164	1.87	0.244
Dissolved oxygen saturation	13.08	9.83	162	1.33	0.545
pH	-0.28	0.18	164	-1.53	0.420
Water temperature	1.15	0.09	164	1.87	0.246
Turbidity	0.82	0.26	164	-0.61	0.928
Trace Metals					
Filterable aluminium	3.13	0.79	66	4.52	<0.001
Total aluminium	2.15	0.63	66	2.61	0.054
Filterable cobalt	1.31	0.33	66	1.06	0.717
Total cobalt	1.17	0.28	66	0.65	0.916
Filterable copper	4.25	1.25	66	4.92	<0.001
Total copper	1.99	0.59	66	2.31	0.105
Filterable nickel	2.63	0.62	66	4.13	<0.001
Total nickel	2.41	0.57	66	3.70	0.002
Filterable zinc	5.18	1.53	66	5.58	<0.001
Total zinc	2.62	0.71	66	3.52	0.004

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-32 Upstream current period (2024-25) vs previous period comparison (single site) for Boundary Creek at at Penrith WRRF

Boundary Creek at Penrith WRRF: N542 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.71	0.66	164	1.39	0.507
Oxidised nitrogen	0.53	0.19	164	-1.74	0.304
Total nitrogen	0.80	0.19	164	-0.92	0.794
Soluble reactive phosphorus	0.57	0.22	66	-1.48	0.458
Total phosphorus	0.83	0.23	164	-0.68	0.906
Physico-chemical					
Conductivity	0.69	0.18	163	-1.44	0.479
Dissolved oxygen	0.56	0.08	164	-4.27	<0.001
Dissolved oxygen saturation	-45.32	7.82	162	-5.79	<0.001
pH	-0.87	0.14	164	-6.00	<0.001
Water temperature	0.97	0.06	164	-0.48	0.964
Turbidity	0.53	0.13	164	-2.54	0.057
Trace Metals					
Filterable aluminium	1.12	0.29	66	0.43	0.974
Total aluminium	0.54	0.16	66	-2.06	0.177
Filterable cobalt	0.65	0.17	66	-1.68	0.345
Total cobalt	0.53	0.13	66	-2.67	0.046
Filterable copper	0.64	0.19	66	-1.49	0.449
Total copper	0.69	0.21	66	-1.23	0.609
Filterable nickel	0.69	0.16	66	-1.57	0.403
Total nickel	0.65	0.16	66	-1.80	0.281
Filterable zinc	0.89	0.27	66	-0.38	0.982
Total zinc	0.81	0.22	66	-0.78	0.865

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-33 Downstream current period (2024-25) vs previous period comparison (single site) for Boundary Creek at Penrith WRRF

Boundary Creek at Penrith WRRF: N541 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.86	0.33	164	-0.39	0.980
Oxidised nitrogen	4.62	1.68	164	4.21	<0.001
Total nitrogen	4.26	1.02	164	6.08	<0.001
Soluble reactive phosphorus	2.38	0.90	66	2.30	0.109
Total phosphorus	3.82	1.05	164	4.88	<0.001
Physico-chemical					
Conductivity	3.84	0.98	163	5.25	<0.001
Dissolved oxygen	0.77	0.10	164	-1.98	0.199
Dissolved oxygen saturation	-21.21	7.82	162	-2.71	0.037
pH	-0.14	0.14	164	-0.97	0.769
Water temperature	1.00	0.06	164	-0.08	>0.999
Turbidity	2.65	0.67	164	3.88	<0.001
Trace Metals					
Filterable aluminium	2.65	0.68	66	3.81	0.002
Total aluminium	2.50	0.75	66	3.06	0.016
Filterable cobalt	4.20	1.09	66	5.55	<0.001
Total cobalt	4.27	1.03	66	6.04	<0.001
Filterable copper	6.26	1.87	66	6.15	<0.001
Total copper	5.65	1.71	66	5.72	<0.001
Filterable nickel	6.29	1.49	66	7.74	<0.001
Total nickel	5.95	1.44	66	7.38	<0.001
Filterable zinc	6.66	1.99	66	6.33	<0.001
Total zinc	5.92	1.64	66	6.42	<0.001

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-34 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at Penrith WRRF

Nepean River at Penrith WRRF: N57 vs N53 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	2.06	0.53	239	2.80	0.028
Oxidised nitrogen	1.34	0.40	239	1.01	0.746
Total nitrogen	1.21	0.13	239	1.76	0.295
Soluble reactive phosphorus	1.20	0.24	64	0.94	0.784
Total phosphorus	1.49	0.20	239	3.03	0.014
Physico-chemical					
Conductivity	1.08	0.09	239	0.93	0.787
Dissolved oxygen	0.99	0.05	239	-0.23	0.995
Dissolved oxygen saturation	0.87	2.95	239	0.30	0.991
pH	-0.02	0.11	239	-0.16	0.999
Water temperature	1.05	0.10	239	0.47	0.966
Turbidity	1.17	0.25	239	0.77	0.867
Trace Metals					
Filterable aluminium	1.45	0.37	64	1.49	0.451
Total aluminium	1.44	0.37	64	1.39	0.508
Filterable cobalt	1.10	0.12	64	0.82	0.844
Total cobalt	1.51	0.31	64	2.05	0.181
Filterable copper	1.54	0.17	64	3.92	0.001
Total copper	1.71	0.22	64	4.21	<0.001
Filterable nickel	1.27	0.17	64	1.81	0.278
Total nickel	1.17	0.13	64	1.35	0.538
Filterable zinc	2.32	0.54	64	3.61	0.003
Total zinc	1.93	0.43	64	2.96	0.022

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-35 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Penrith WRRF

Nepean River at Penrith WRRF: N57 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.58	0.12	239	-2.73	0.034
Oxidised nitrogen	1.05	0.24	239	0.20	0.997
Total nitrogen	0.88	0.07	239	-1.45	0.470
Soluble reactive phosphorus	0.84	0.16	64	-0.90	0.803
Total phosphorus	0.69	0.07	239	-3.68	0.002
Physico-chemical					
Conductivity	1.05	0.06	239	0.75	0.876
Dissolved oxygen	1.00	0.04	239	-0.11	>0.999
Dissolved oxygen saturation	-0.71	2.28	239	-0.31	0.990
pH	-0.05	0.09	239	-0.54	0.948
Water temperature	1.01	0.07	239	0.15	0.999
Turbidity	0.67	0.11	239	-2.49	0.065
Trace Metals					
Filterable aluminium	1.22	0.30	64	0.80	0.856
Total aluminium	0.72	0.18	64	-1.29	0.574
Filterable cobalt	0.88	0.10	64	-1.14	0.668
Total cobalt	0.69	0.14	64	-1.89	0.241
Filterable copper	0.80	0.09	64	-2.08	0.171
Total copper	0.73	0.09	64	-2.55	0.062
Filterable nickel	0.59	0.08	64	-4.15	<0.001
Total nickel	0.61	0.07	64	-4.31	<0.001
Filterable zinc	1.09	0.25	64	0.36	0.984
Total zinc	0.81	0.18	64	-0.97	0.770

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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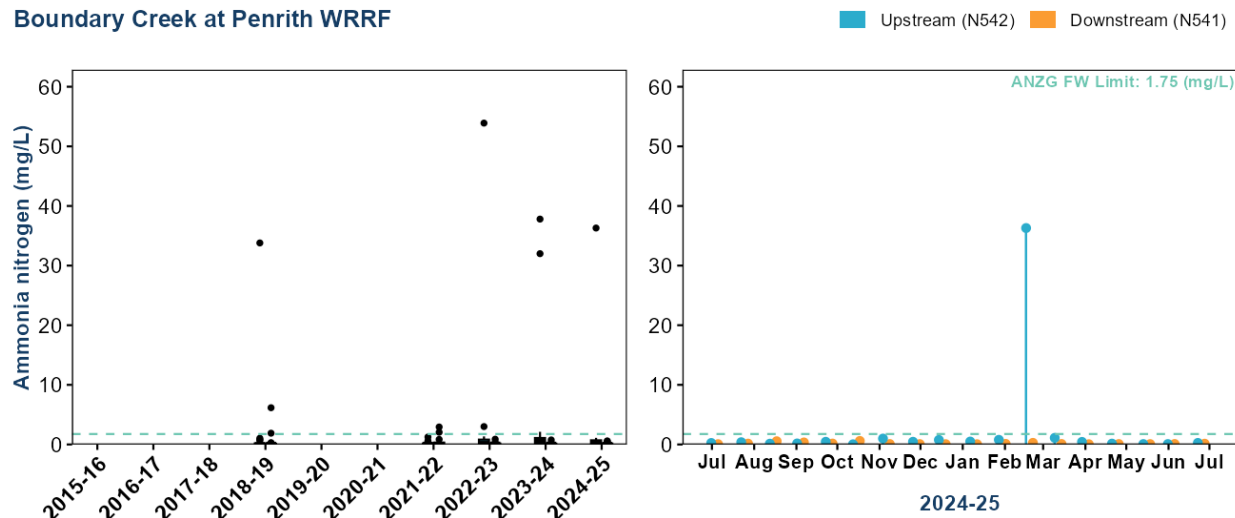
Table A-36 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Penrith WRRF

Nepean River at Penrith WRRF: N53 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.50	0.10	239	-3.32	0.006
Oxidised nitrogen	0.95	0.23	239	-0.21	0.997
Total nitrogen	0.90	0.08	239	-1.16	0.653
Soluble reactive phosphorus	0.74	0.15	64	-1.50	0.441
Total phosphorus	0.81	0.09	239	-1.91	0.226
Physico-chemical					
Conductivity	1.08	0.07	239	1.26	0.588
Dissolved oxygen	0.99	0.04	239	-0.21	0.997
Dissolved oxygen saturation	2.18	2.40	239	0.91	0.801
pH	0.00	0.09	239	0.04	>0.999
Water temperature	1.08	0.08	239	0.95	0.778
Turbidity	0.73	0.12	239	-1.86	0.249
Trace Metals					
Filterable aluminium	1.48	0.38	64	1.53	0.423
Total aluminium	0.83	0.22	64	-0.69	0.899
Filterable cobalt	0.93	0.10	64	-0.66	0.913
Total cobalt	0.84	0.17	64	-0.87	0.819
Filterable copper	1.07	0.12	64	0.56	0.942
Total copper	1.09	0.14	64	0.64	0.920
Filterable nickel	0.78	0.10	64	-1.83	0.270
Total nickel	0.78	0.09	64	-2.18	0.141
Filterable zinc	1.18	0.28	64	0.70	0.897
Total zinc	0.97	0.22	64	-0.12	>0.999

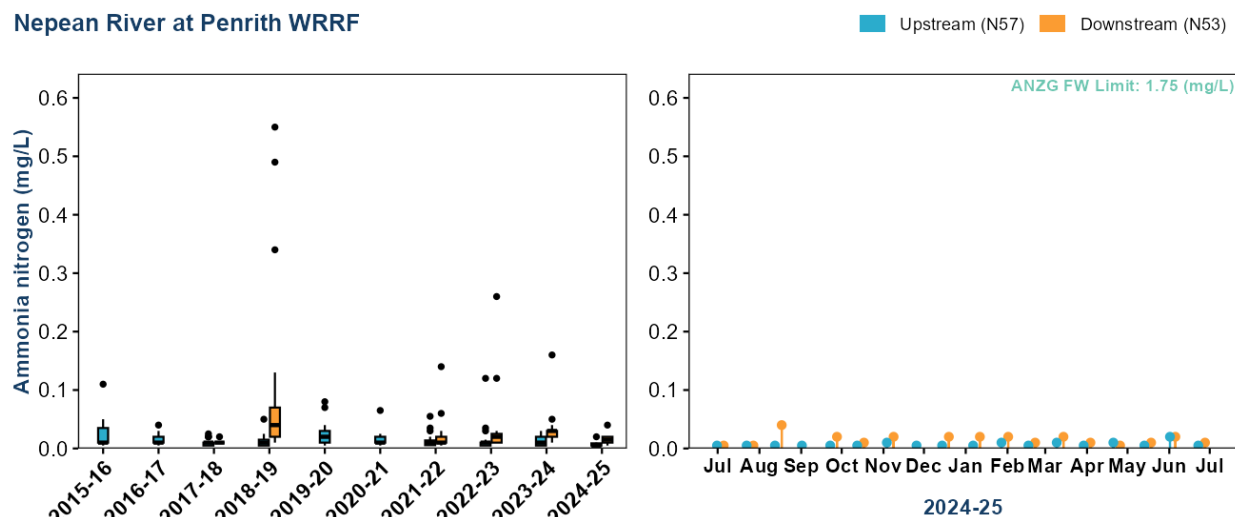
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.4.6. Stressor – Nutrients

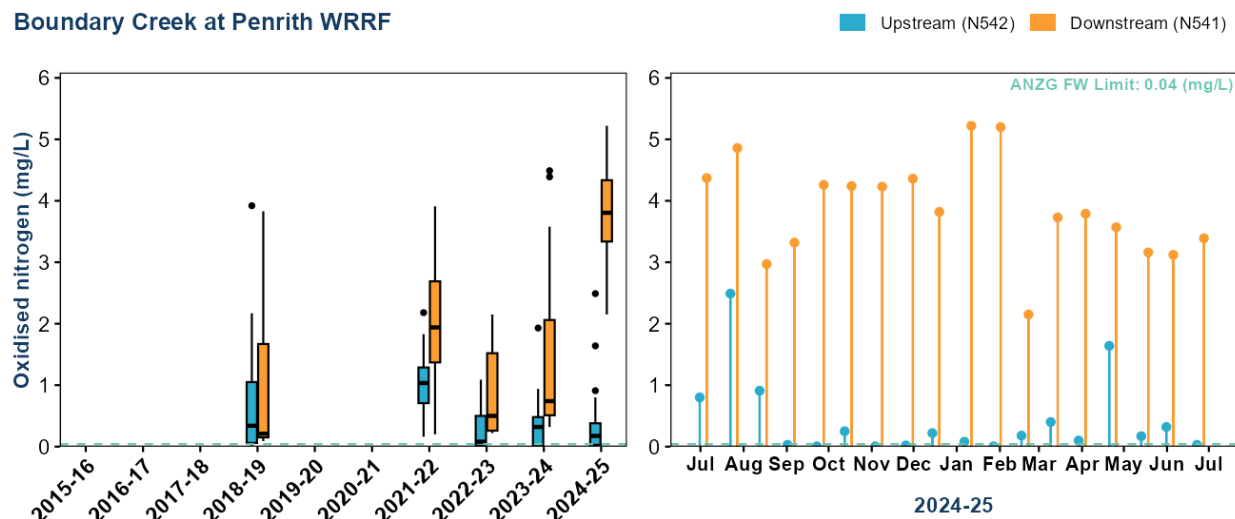
Boundary Creek at Penrith WRRF



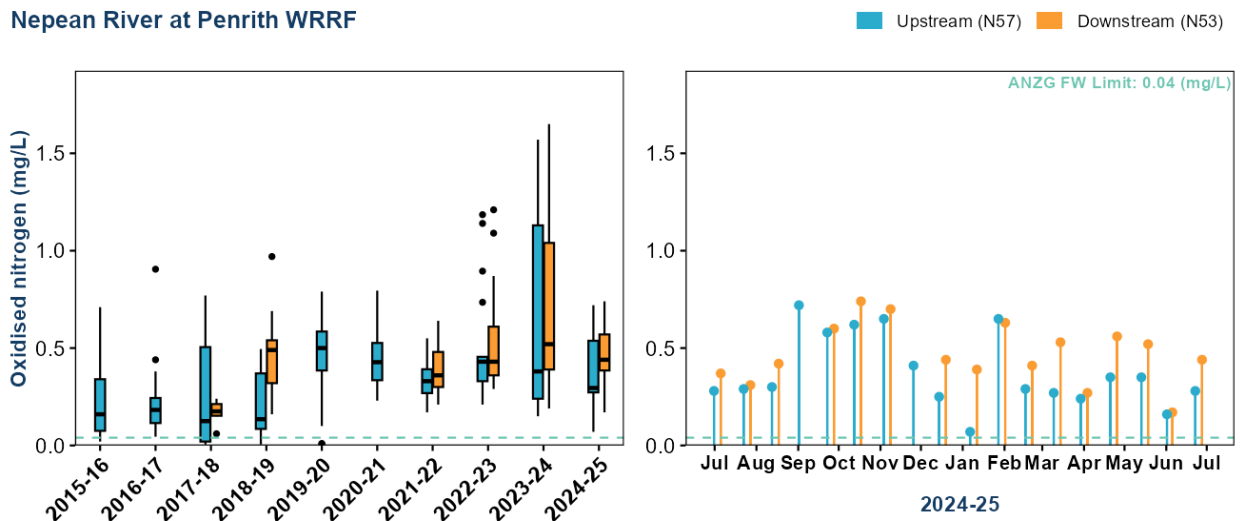
Nepean River at Penrith WRRF



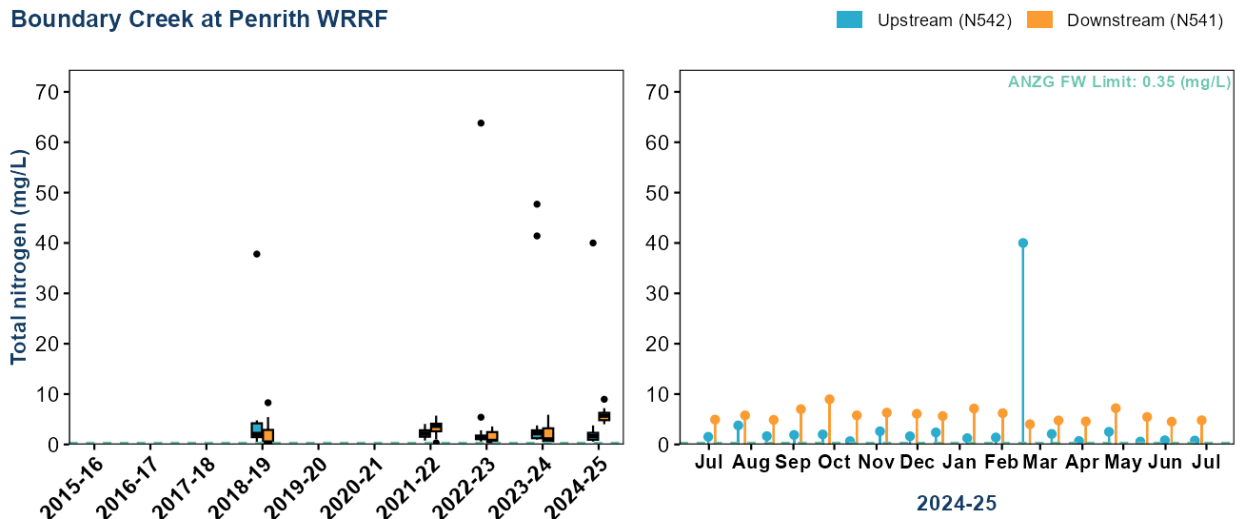
Boundary Creek at Penrith WRRF



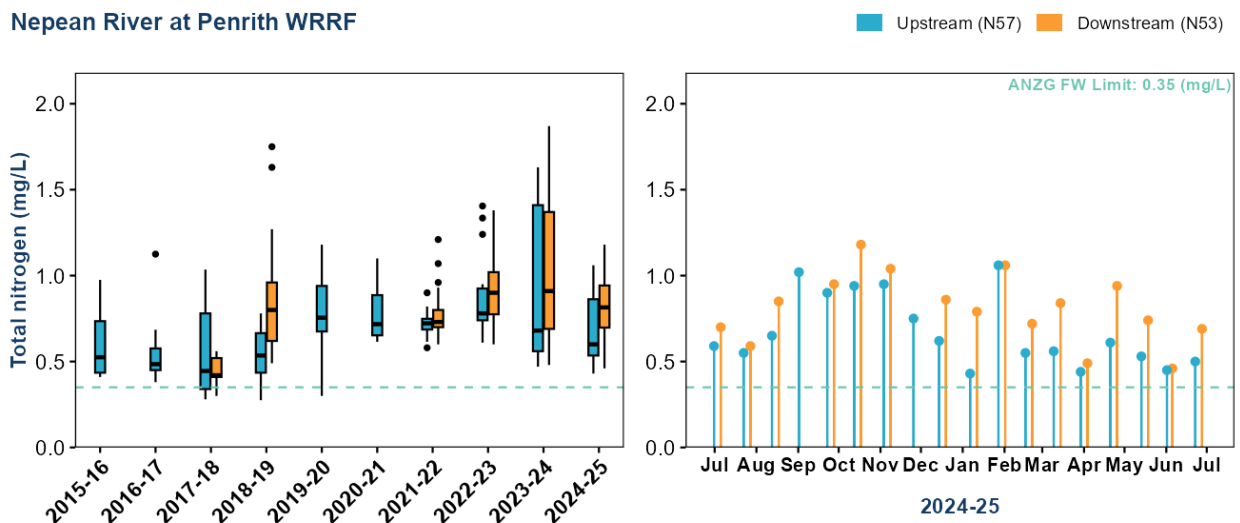
Nepean River at Penrith WRRF



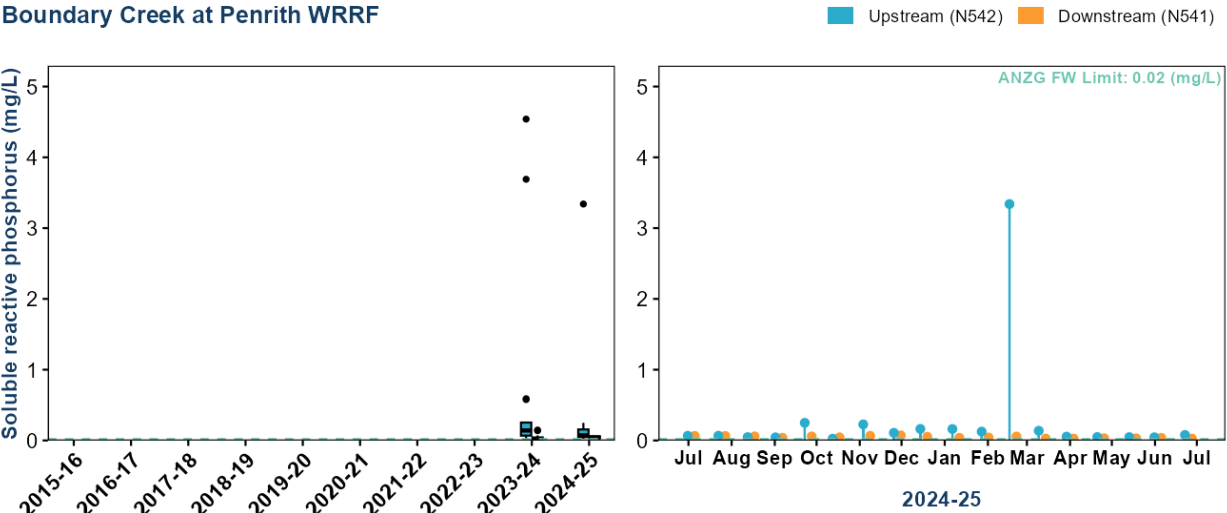
Boundary Creek at Penrith WRRF



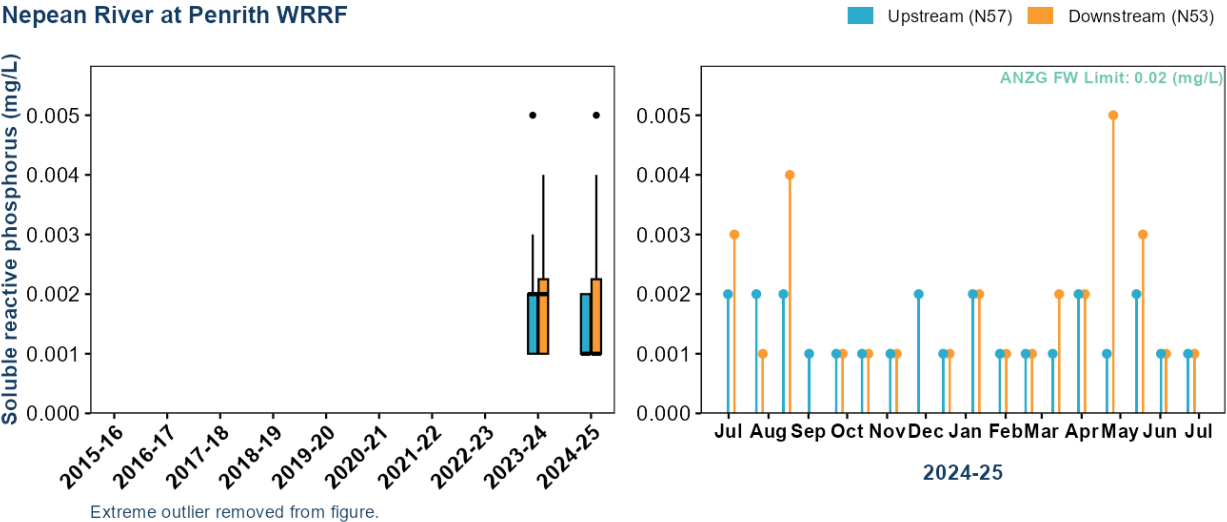
Nepean River at Penrith WRRF



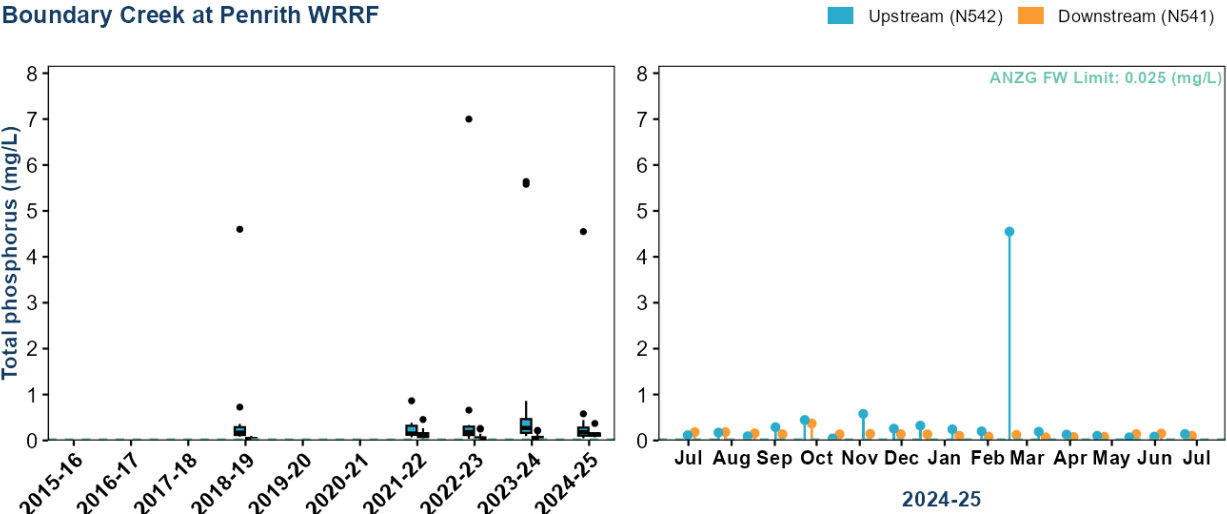
Boundary Creek at Penrith WRRF



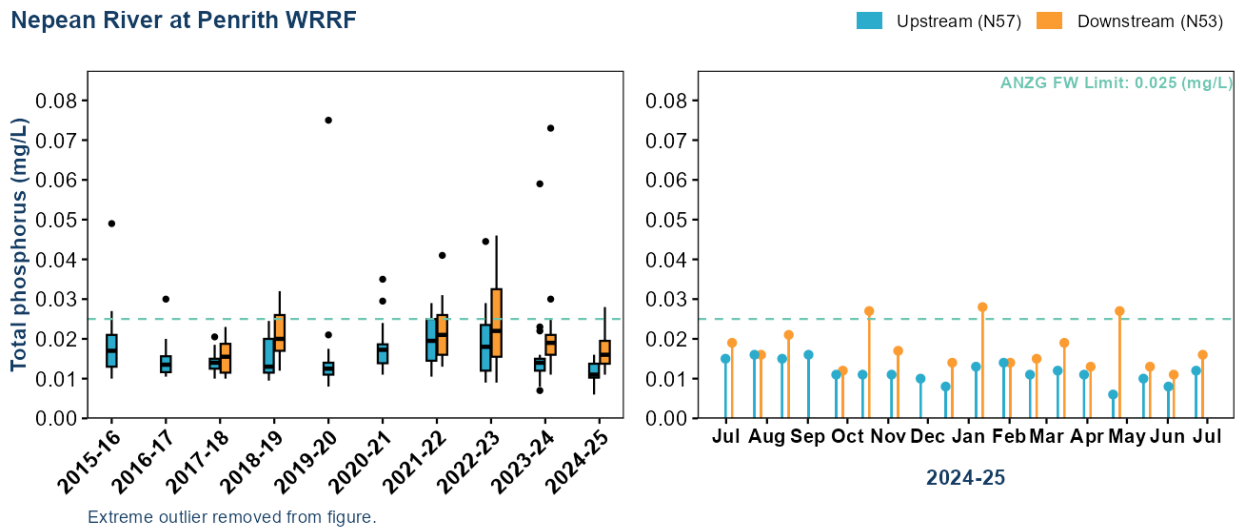
Nepean River at Penrith WRRF



Boundary Creek at Penrith WRRF

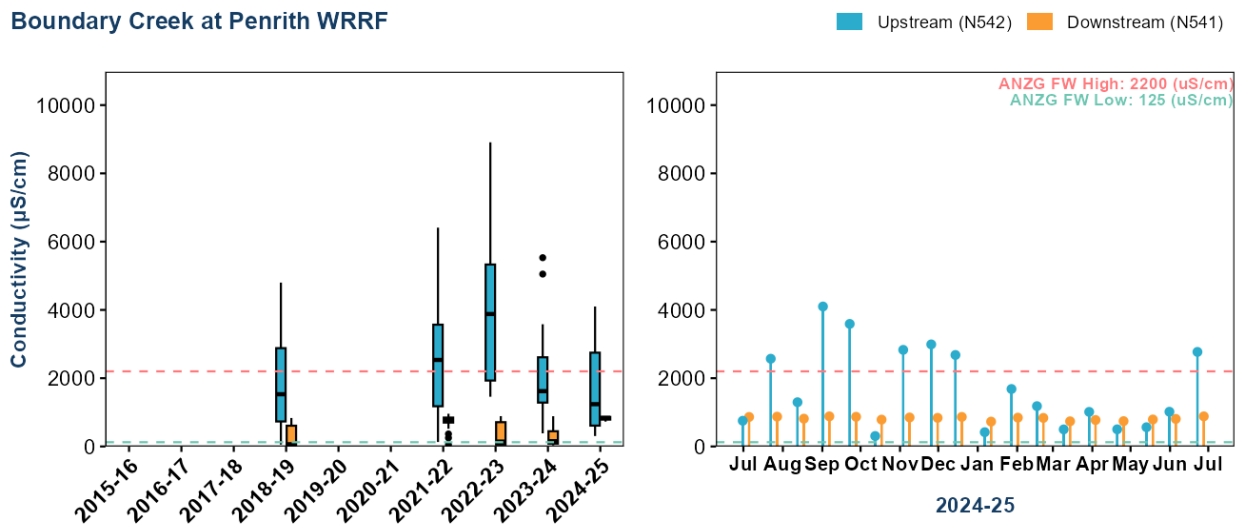


Nepean River at Penrith WRRF

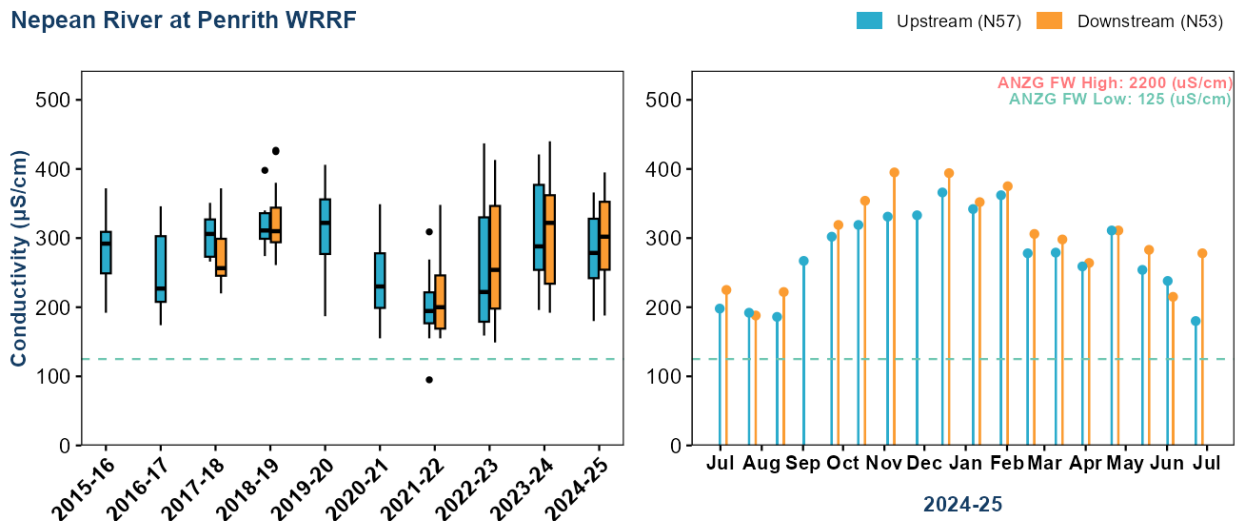


A.4.7. Stressor – Physico-chemical water quality

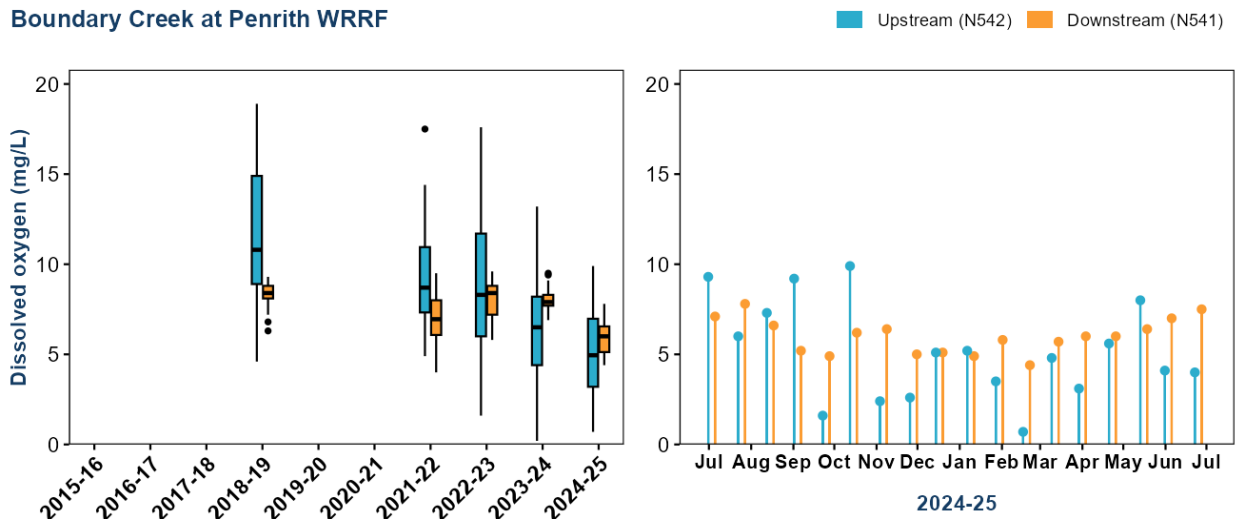
Boundary Creek at Penrith WRRF



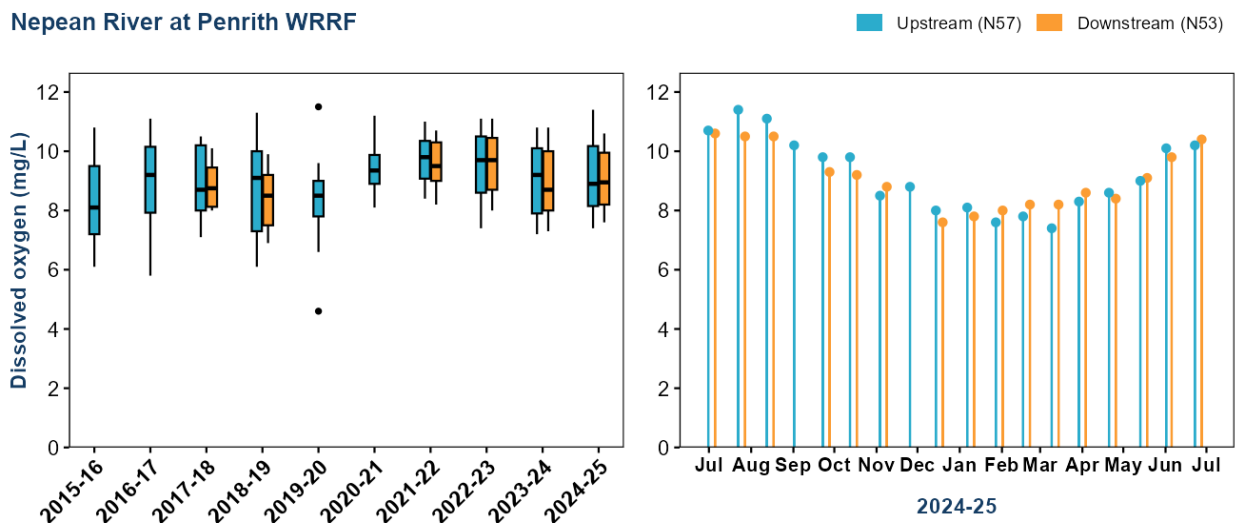
Nepean River at Penrith WRRF



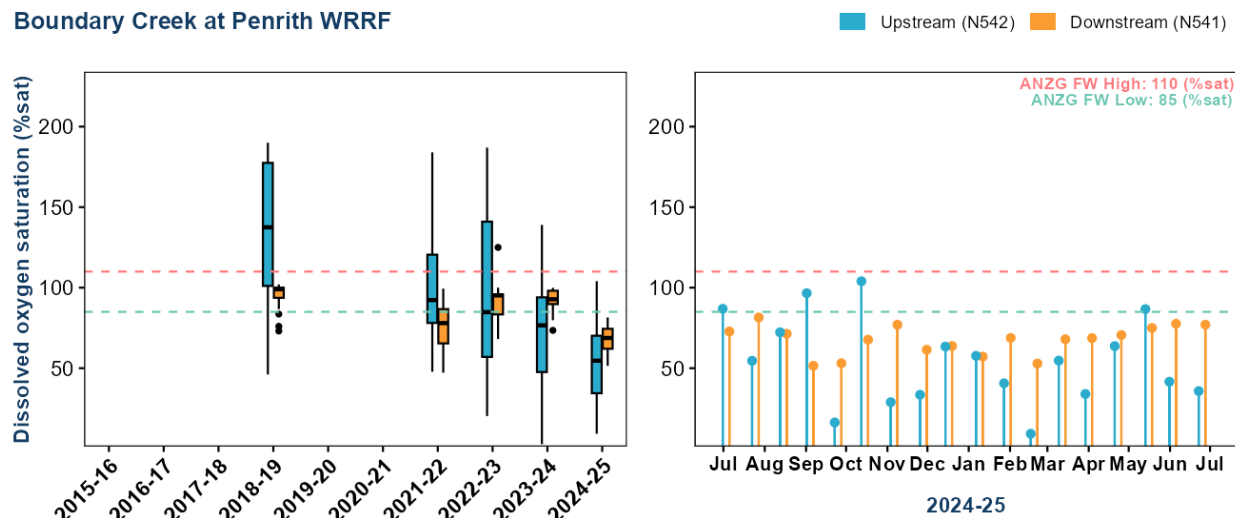
Boundary Creek at Penrith WRRF



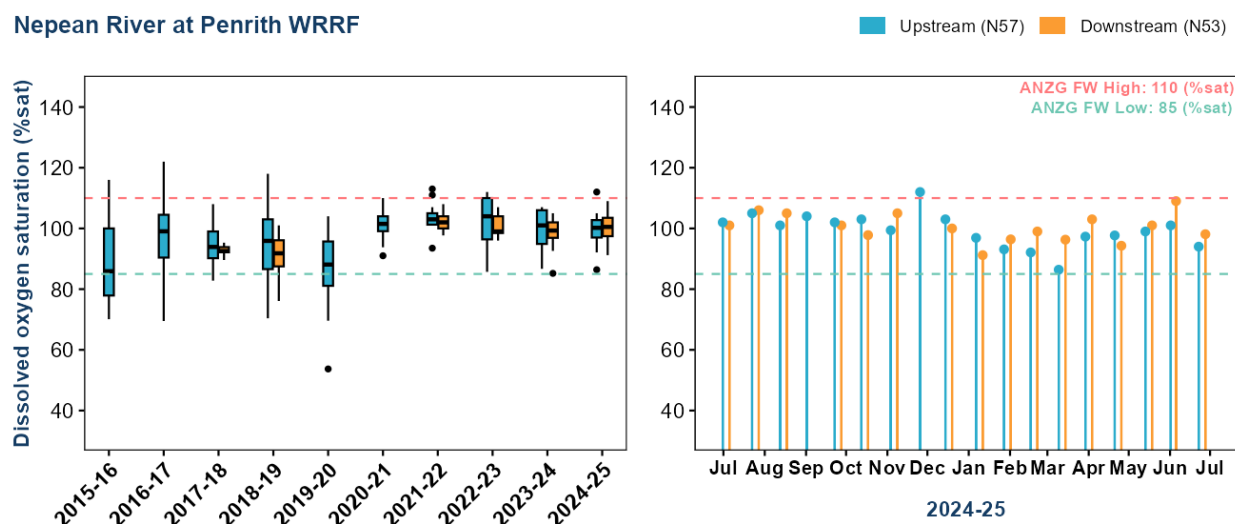
Nepean River at Penrith WRRF



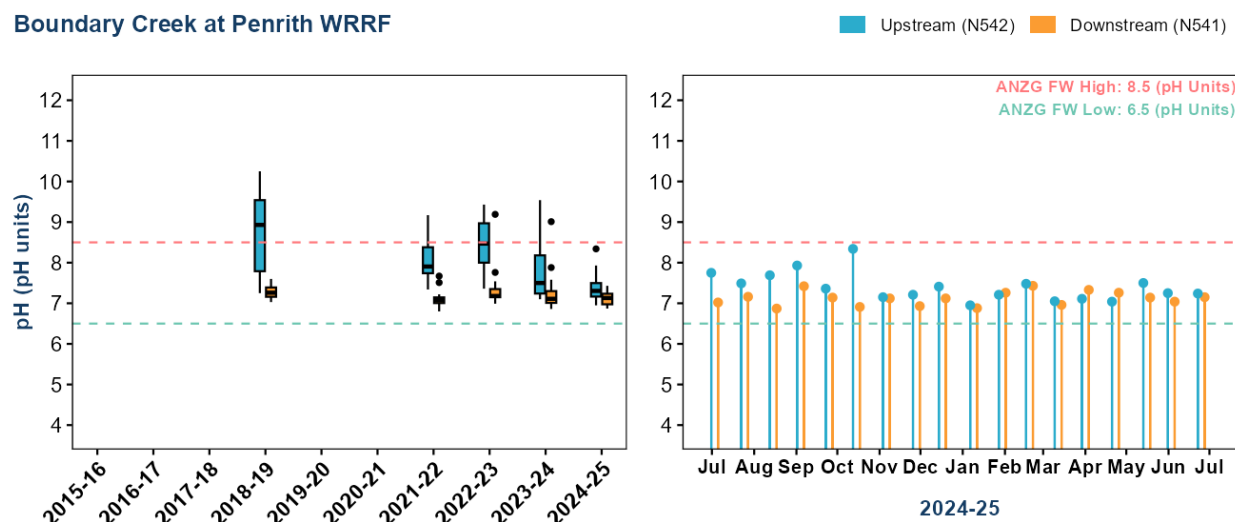
Boundary Creek at Penrith WRRF



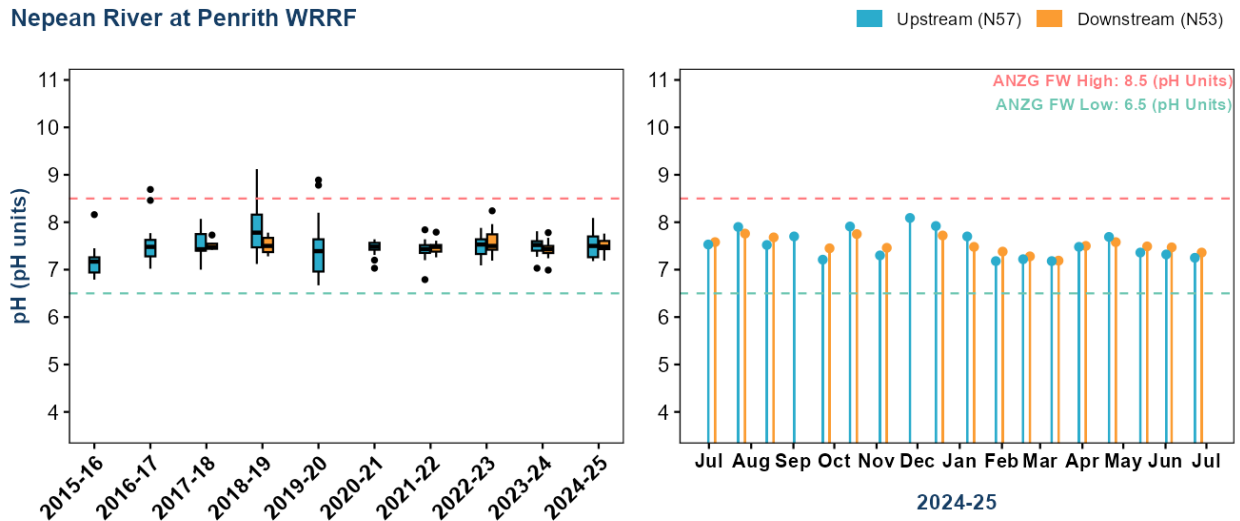
Nepean River at Penrith WRRF



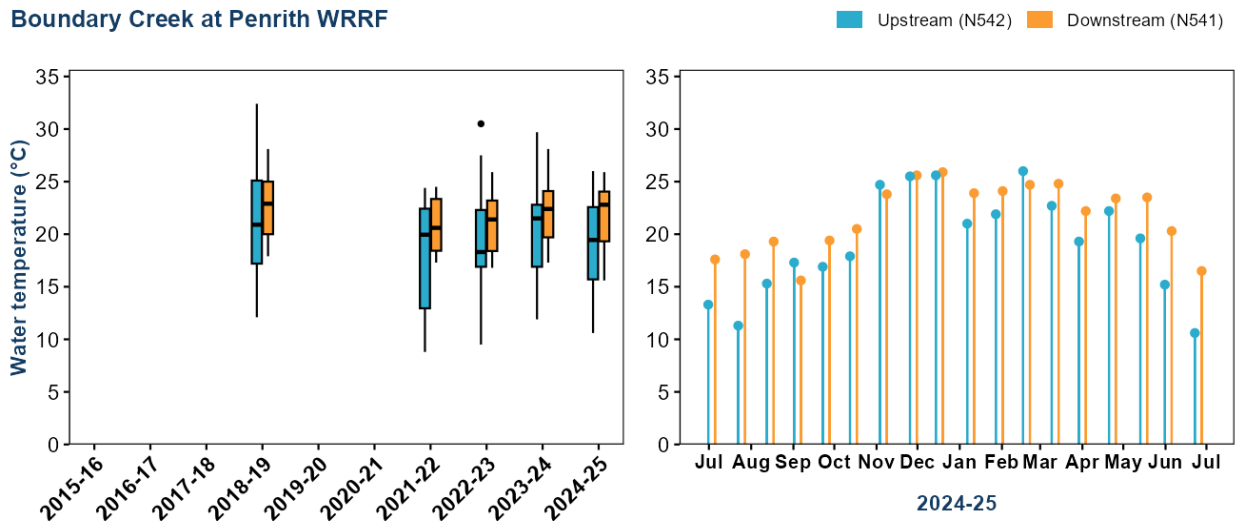
Boundary Creek at Penrith WRRF



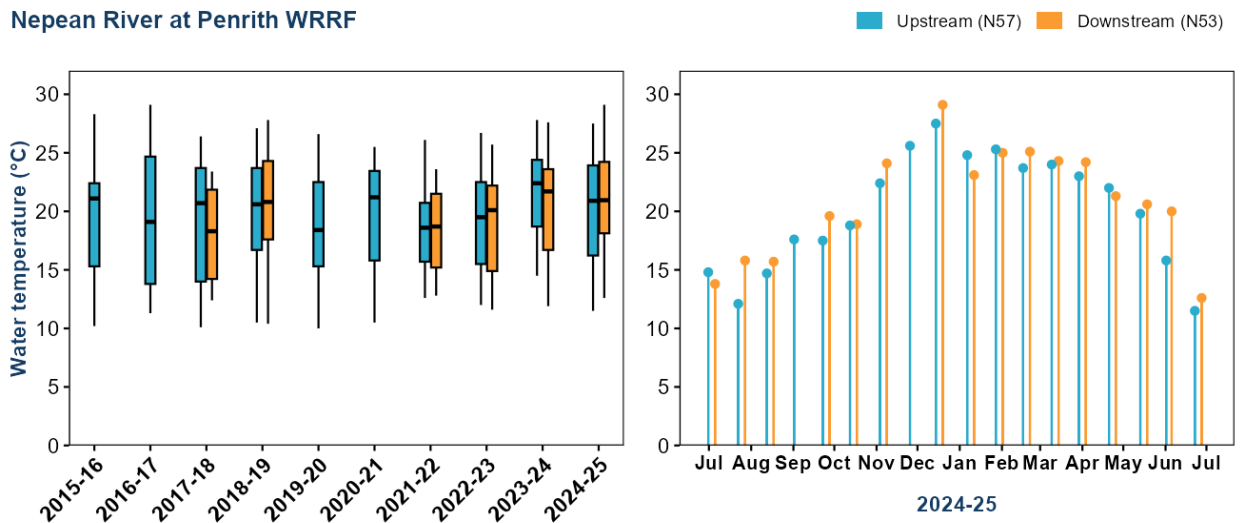
Nepean River at Penrith WRRF



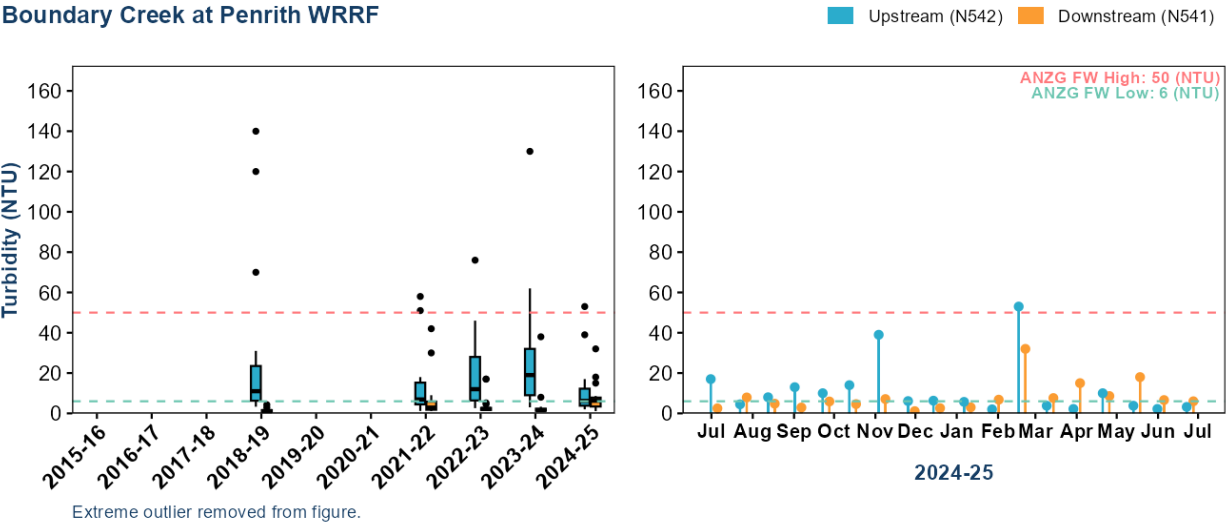
Boundary Creek at Penrith WRRF



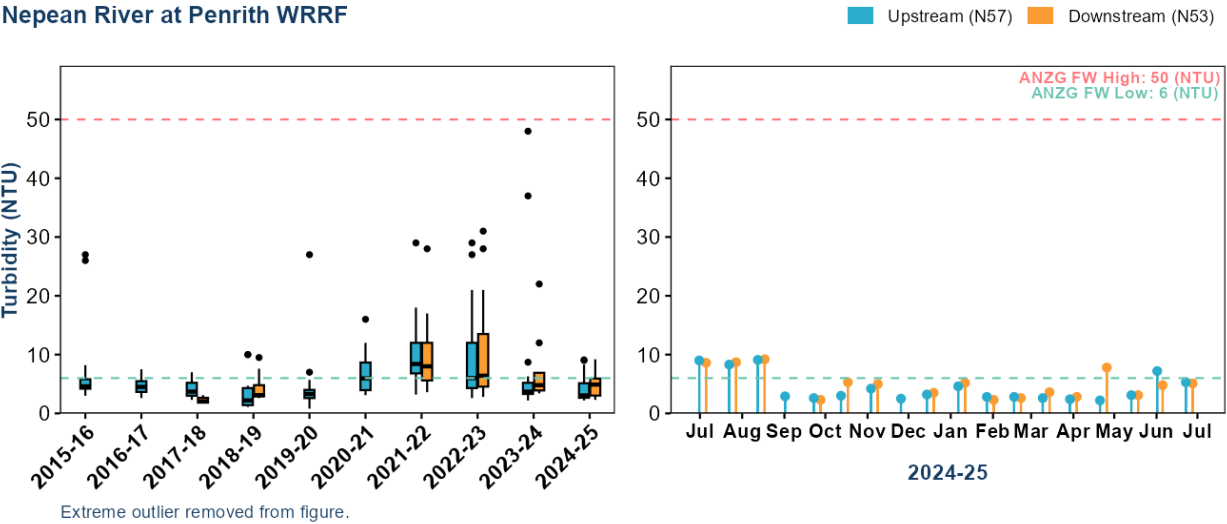
Nepean River at Penrith WRRF



Boundary Creek at Penrith WRRF

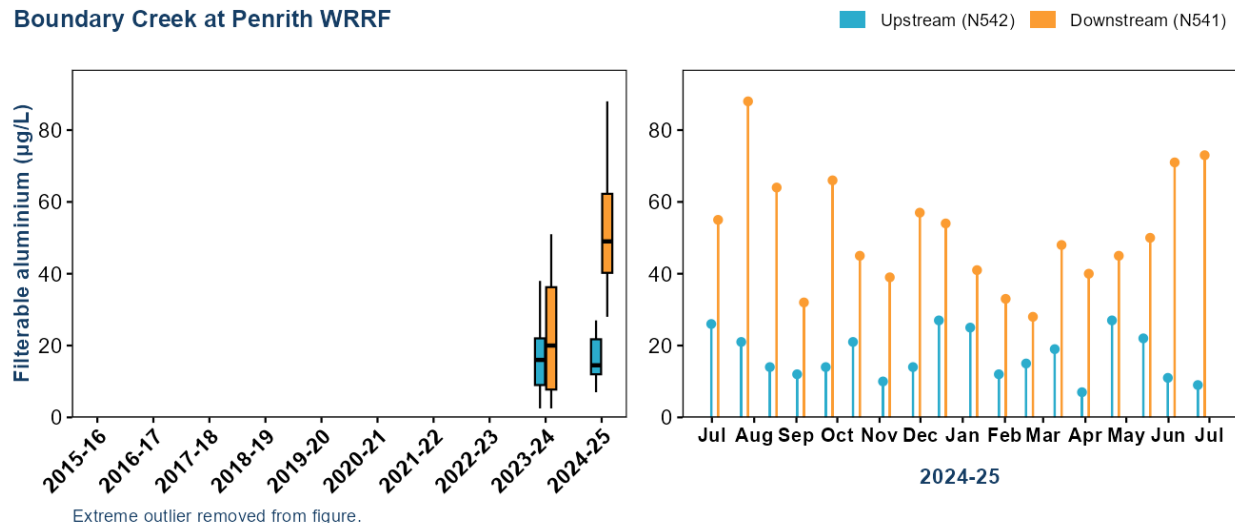


Nepean River at Penrith WRRF

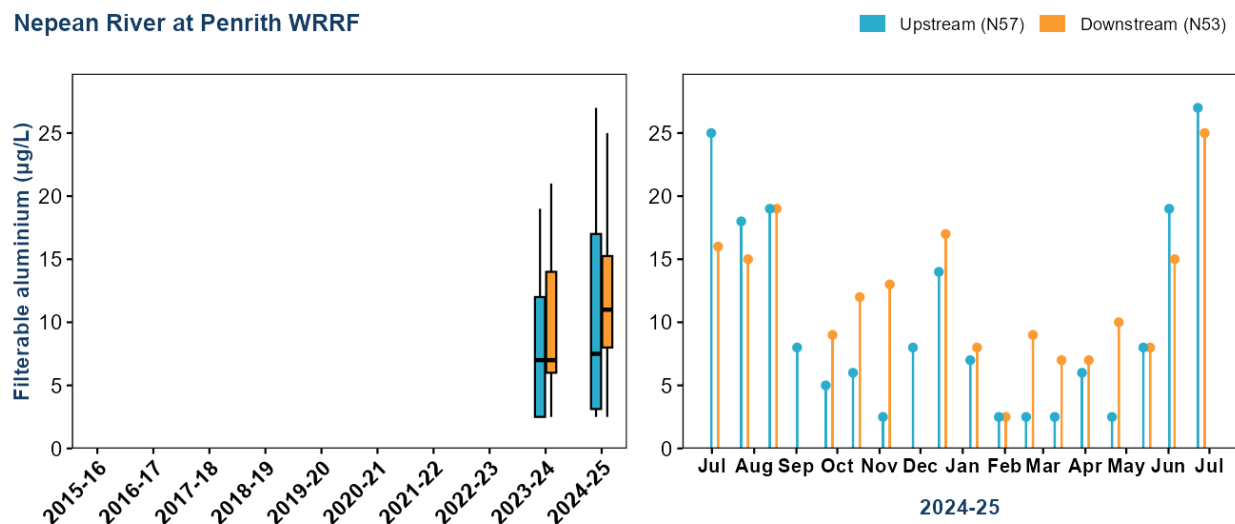


A.4.8. Stressor – Trace metals

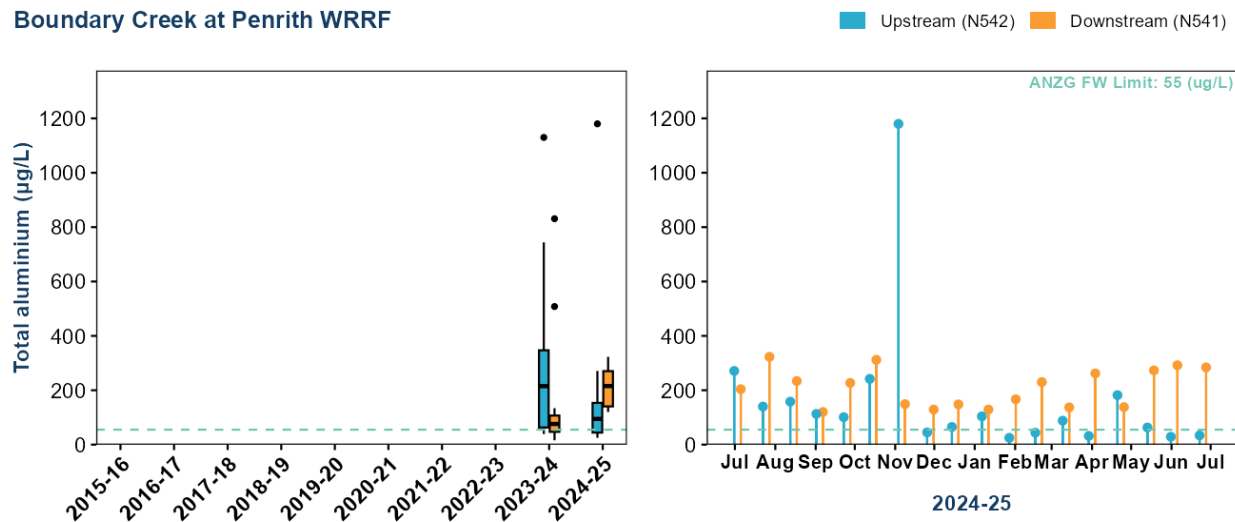
Boundary Creek at Penrith WRRF



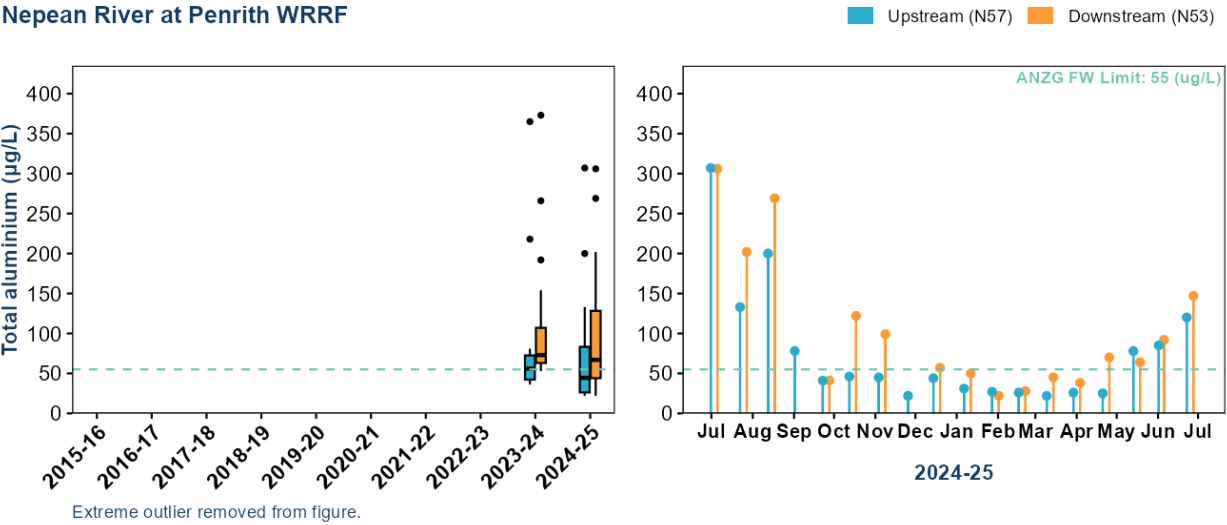
Nepean River at Penrith WRRF



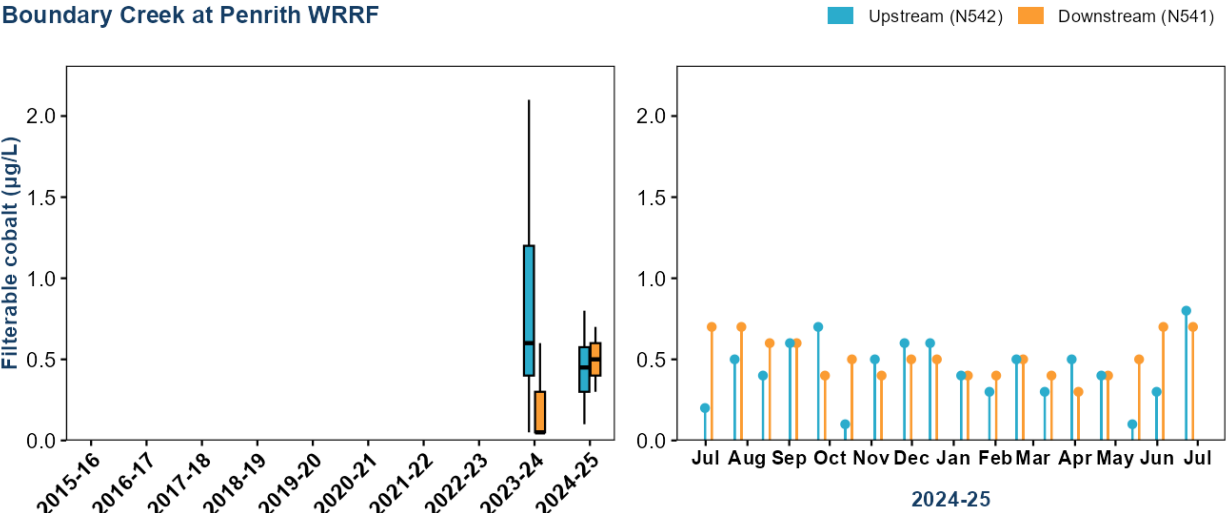
Boundary Creek at Penrith WRRF



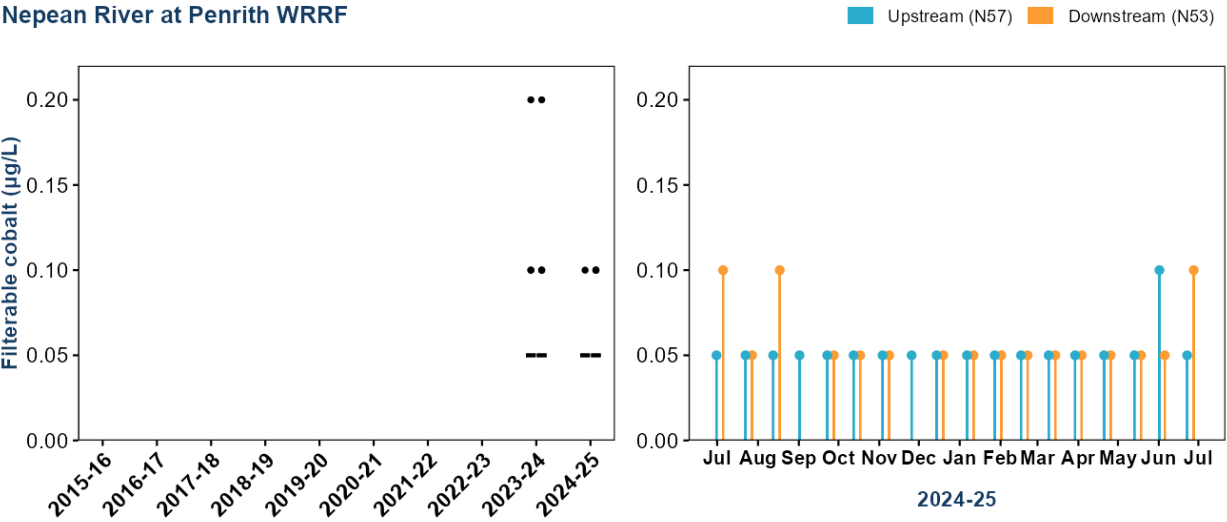
Nepean River at Penrith WRRF



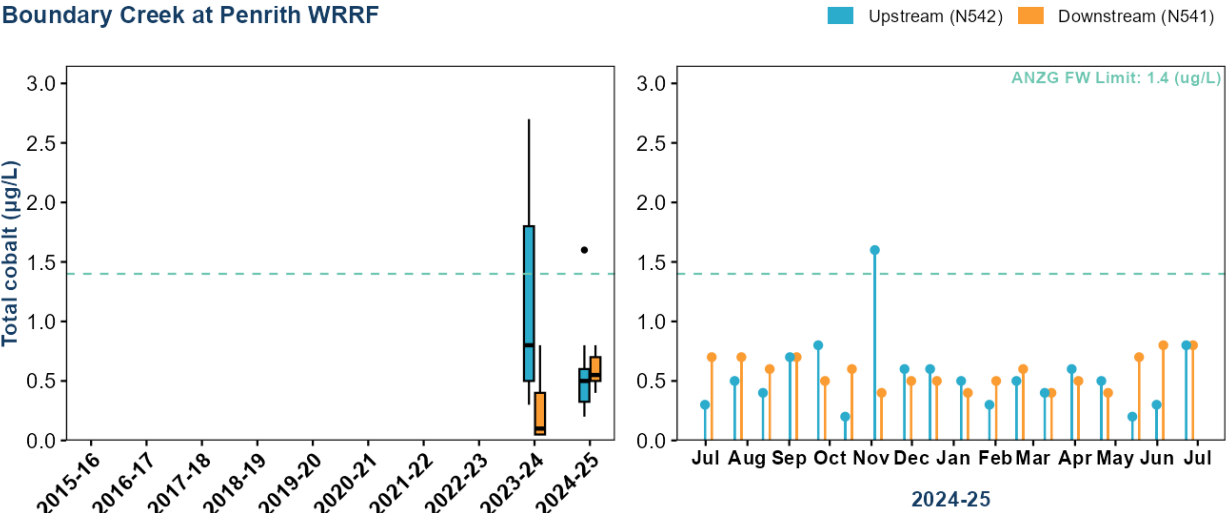
Boundary Creek at Penrith WRRF



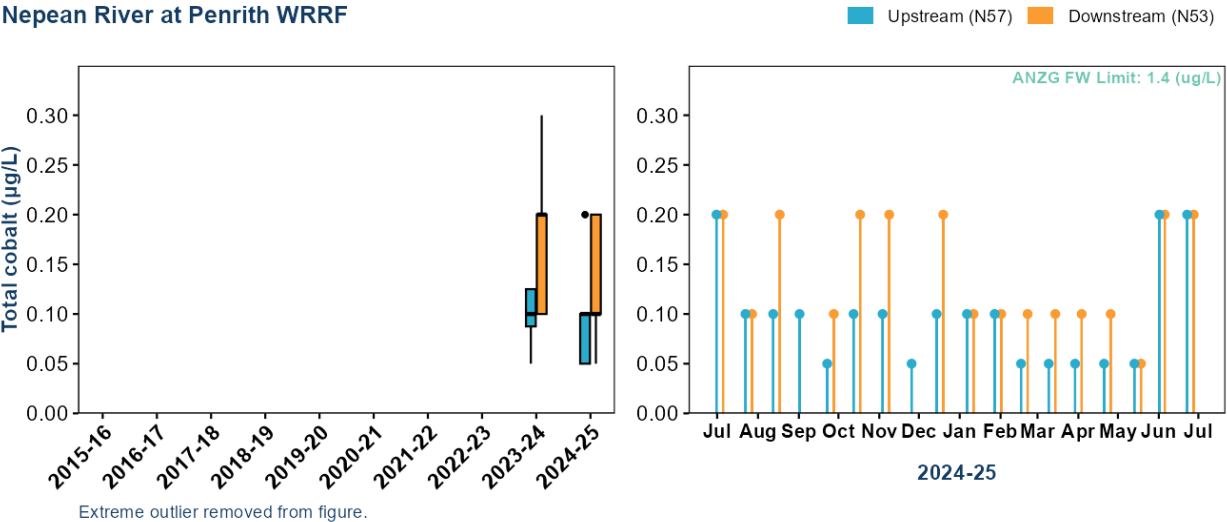
Nepean River at Penrith WRRF



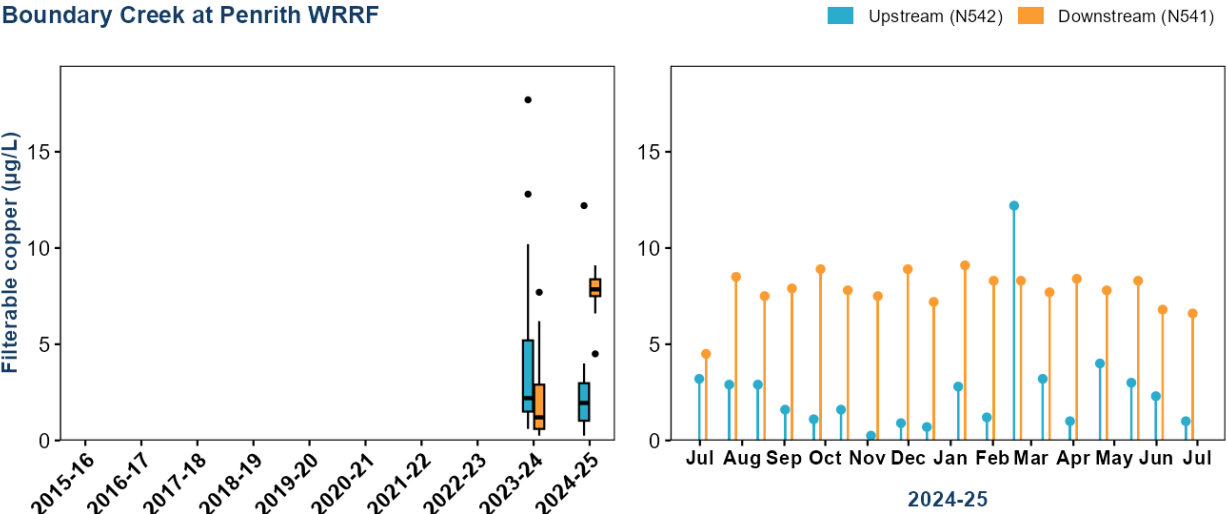
Boundary Creek at Penrith WRRF



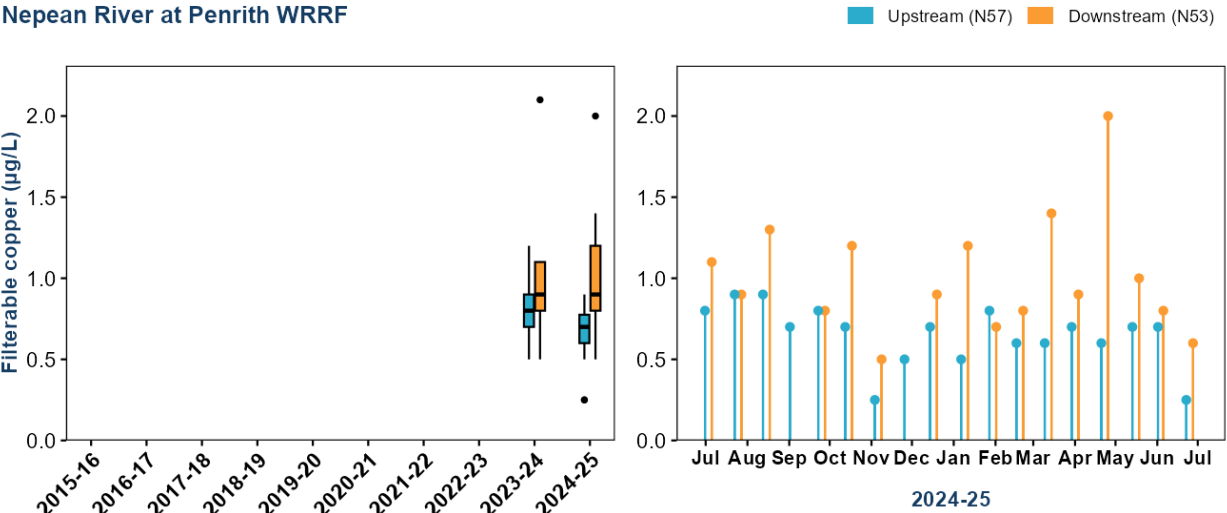
Nepean River at Penrith WRRF



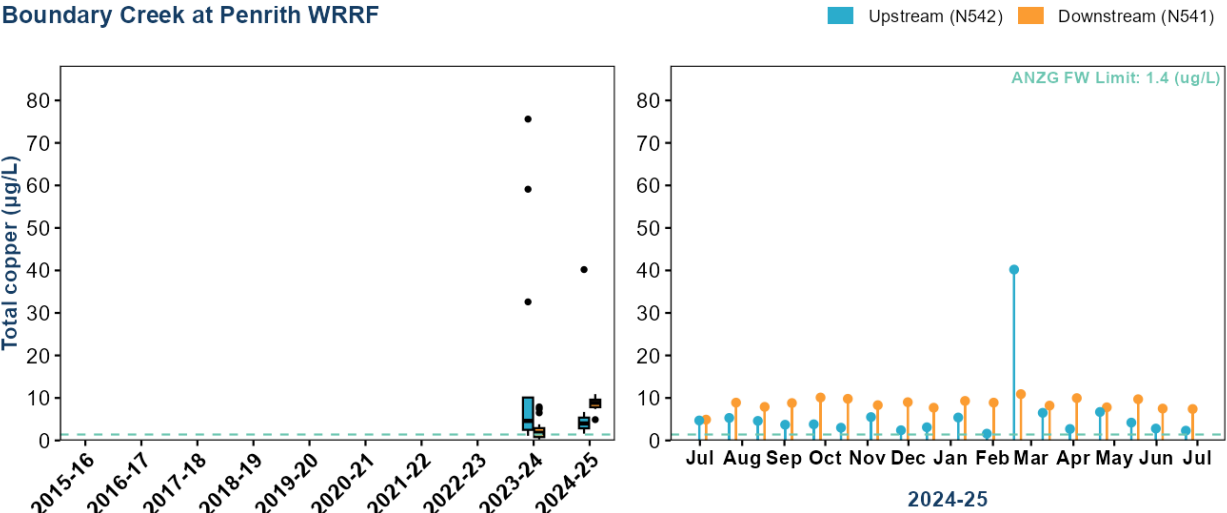
Boundary Creek at Penrith WRRF



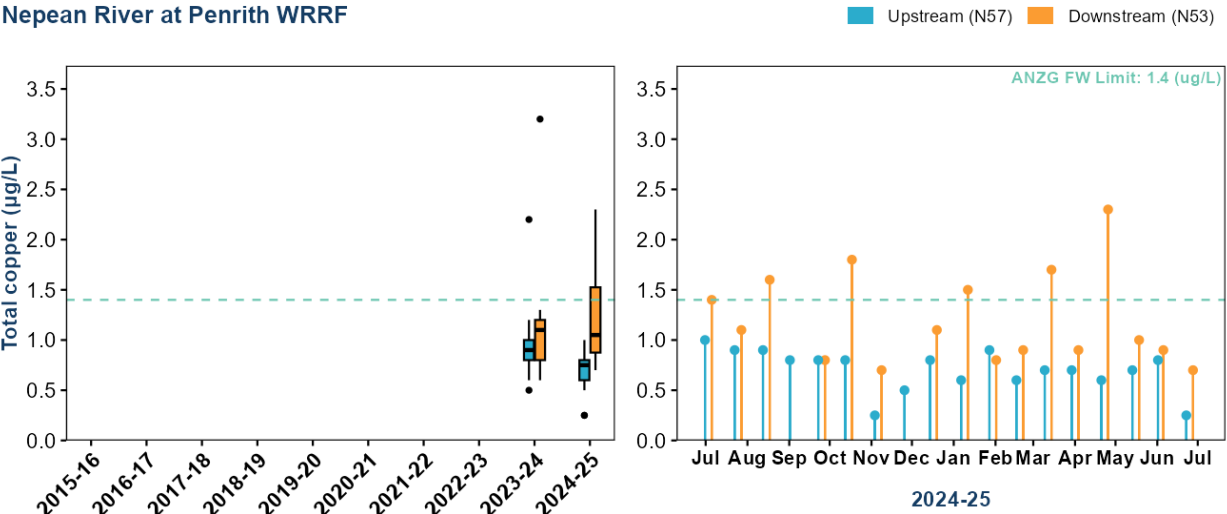
Nepean River at Penrith WRRF



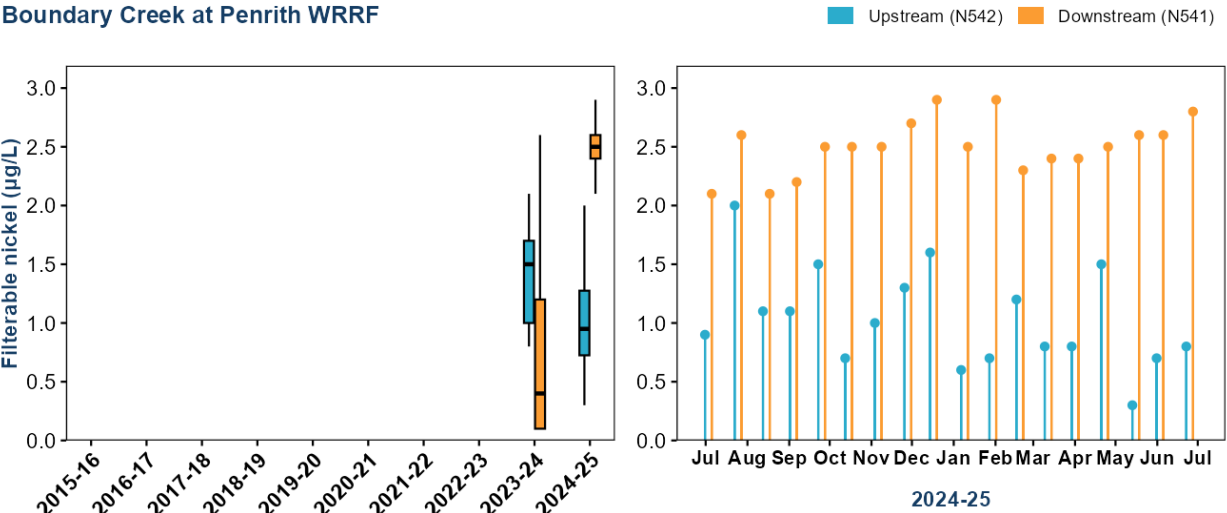
Boundary Creek at Penrith WRRF



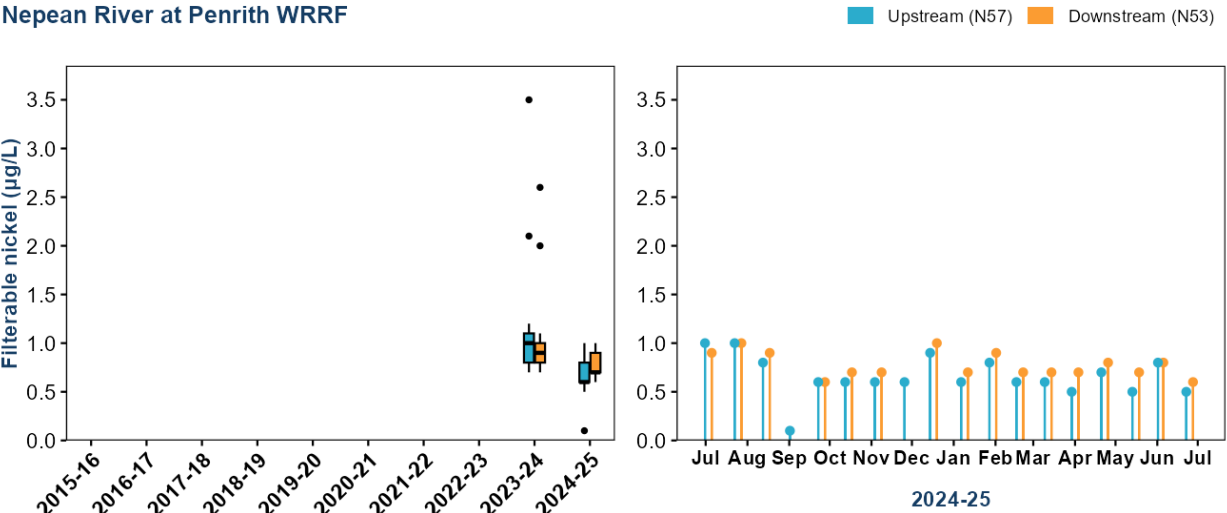
Nepean River at Penrith WRRF



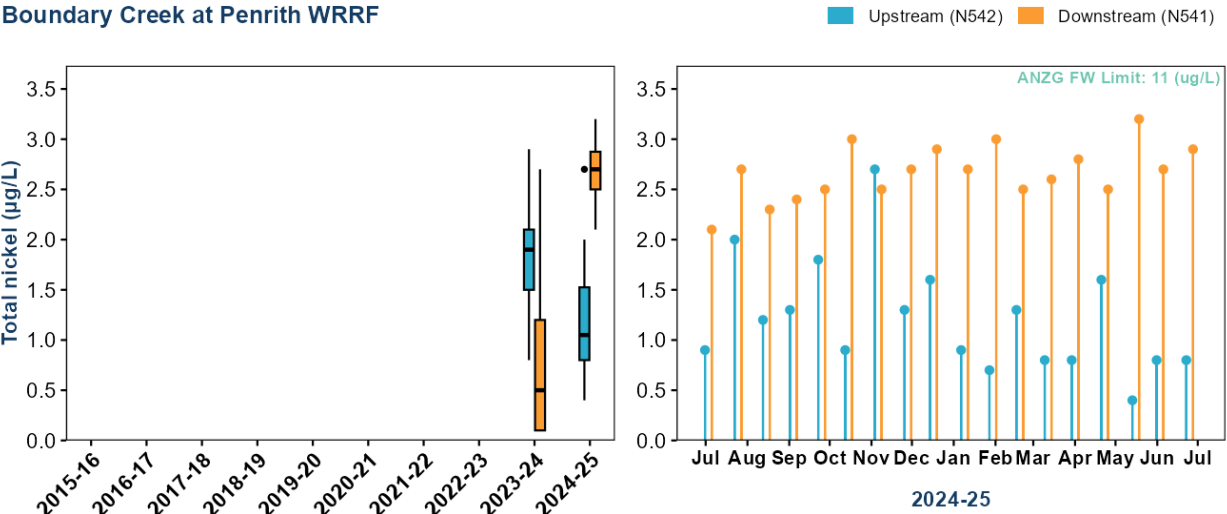
Boundary Creek at Penrith WRRF



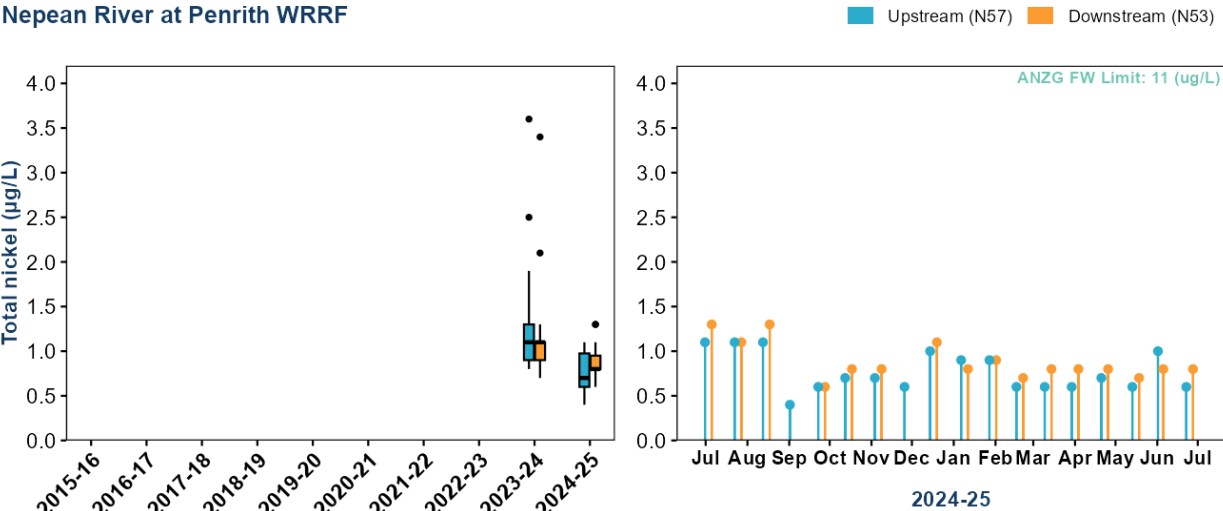
Nepean River at Penrith WRRF



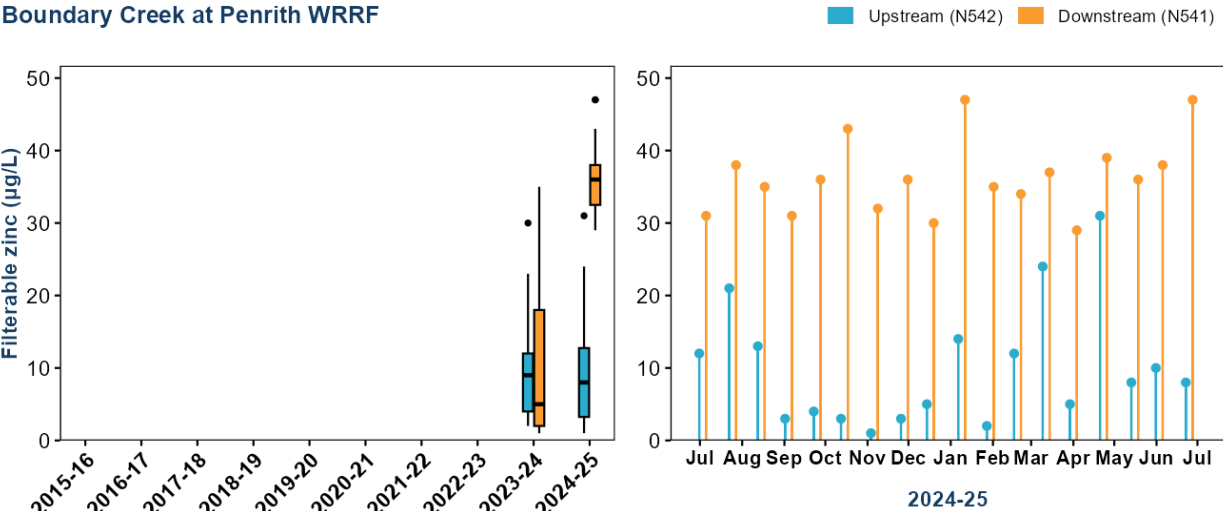
Boundary Creek at Penrith WRRF



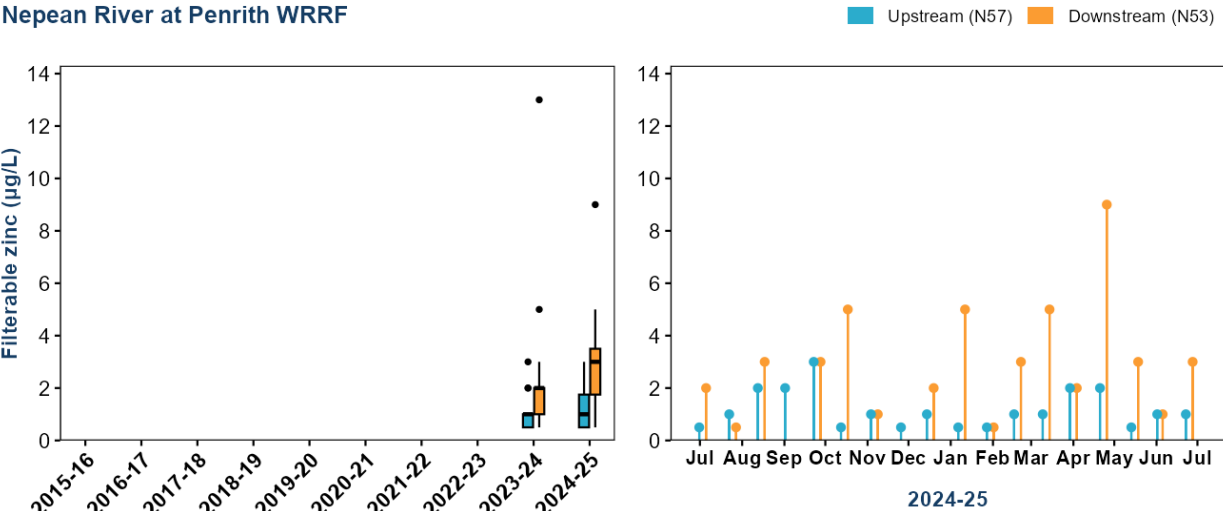
Nepean River at Penrith WRRF



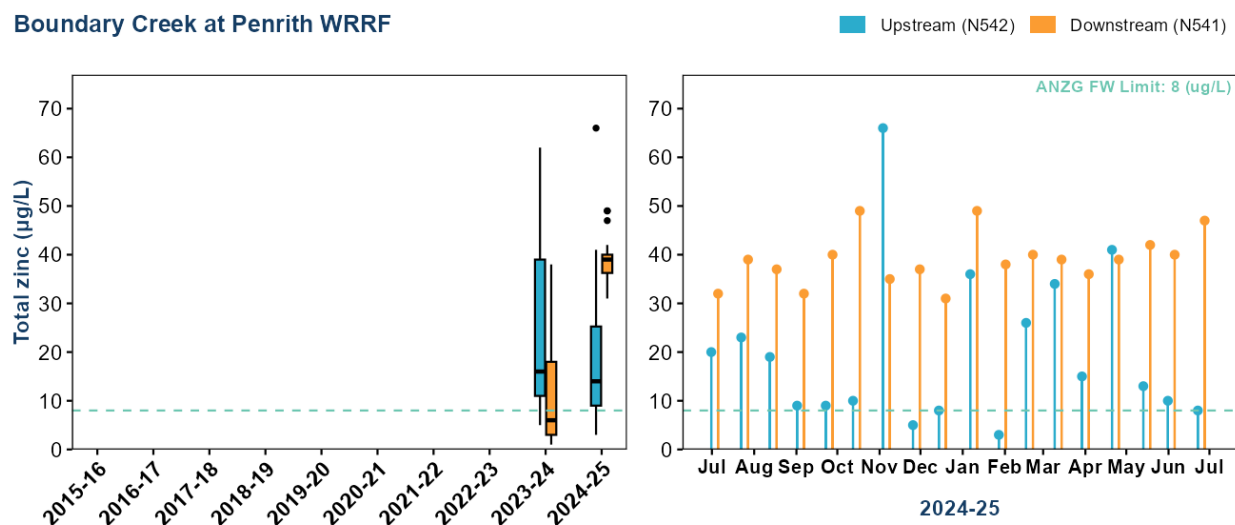
Boundary Creek at Penrith WRRF



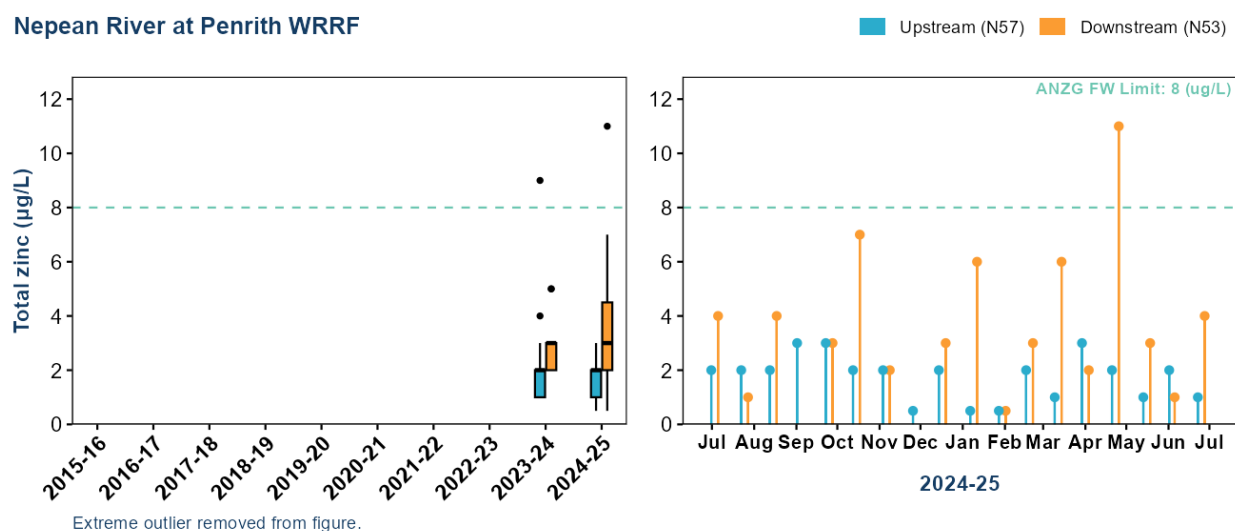
Nepean River at Penrith WRRF



Boundary Creek at Penrith WRRF



Nepean River at Penrith WRRF



A.4.9. Ecosystem receptor – Statistical analysis outcomes

Table A-37 Upstream vs downstream comparison (2024-25 reporting period) for Boundary Creek at Penrith WRRF

Boundary Creek at Penrith WRRF: N542 vs N541 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.17	0.07	164	-4.49	<0.001
not significant ($p > 0.05$) $p < 0.05$ and ≥ 0.01 $p < 0.01$ and ≥ 0.001 $p < 0.001$					

Table A-38 Upstream current period (2024-25) vs previous period comparison (single site) for Boundary Creek at Penrith WRRF

Boundary Creek at Penrith WRRF: N542 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.49	0.15	164	-2.30	0.101
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-39 Downstream current period (2024-25) vs previous period comparison (single site) for Boundary Creek at Penrith WRRF

Boundary Creek at Penrith WRRF: N541 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.38	0.43	164	1.03	0.730
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-40 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at Penrith WRRF

Nepean River at Penrith WRRF: N57 vs N53 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.68	0.16	238	-1.65	0.352
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-41 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Penrith WRRF

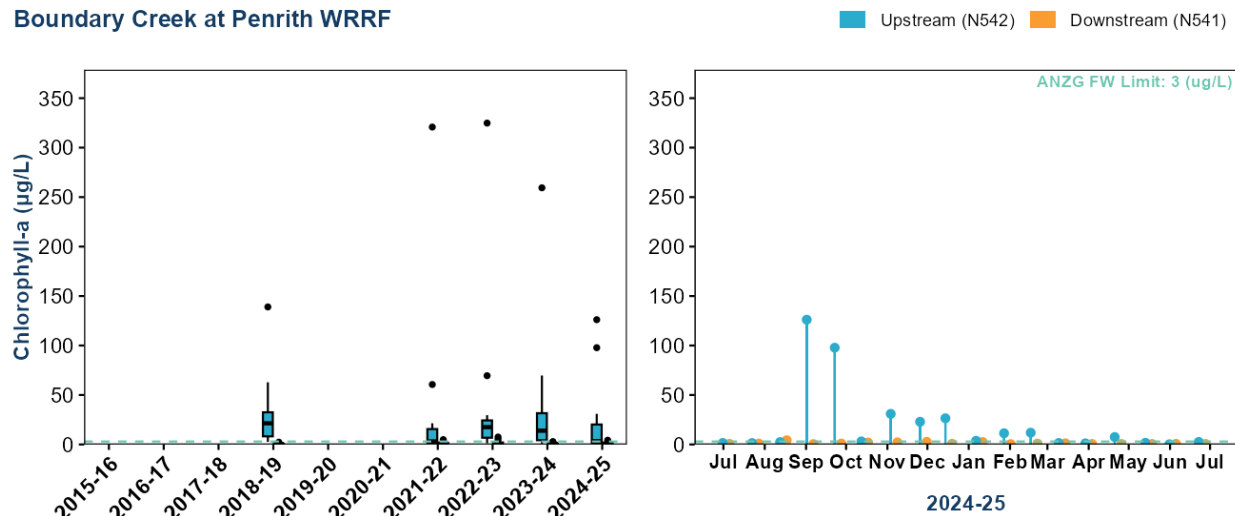
Nepean River at Penrith WRRF: N57 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.33	0.24	238	1.58	0.392
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-42 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Penrith WRRF

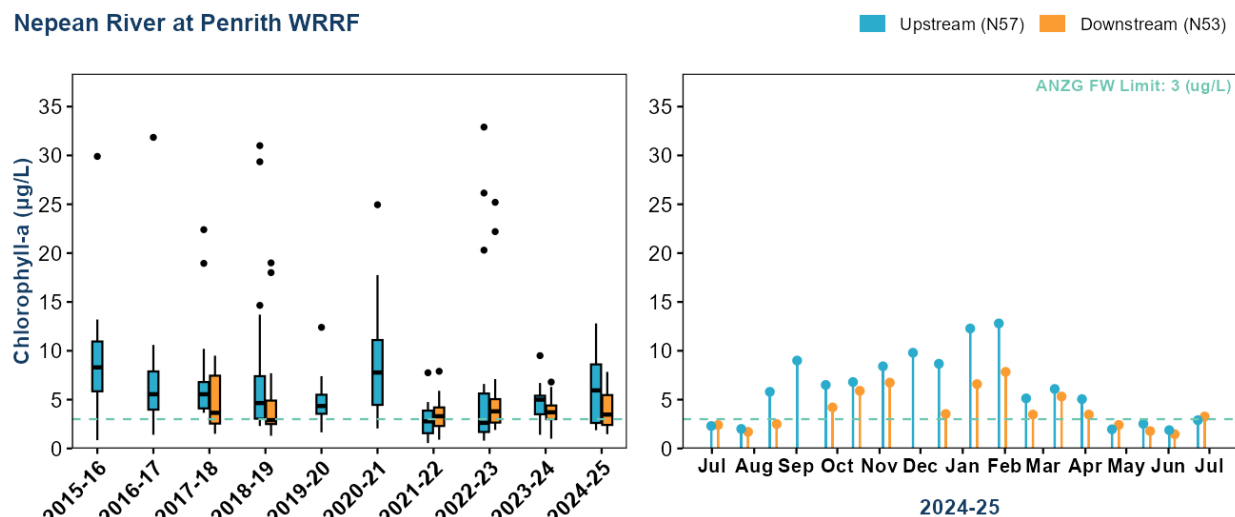
Nepean River at Penrith WRRF: N53 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.95	0.18	238	-0.28	0.992
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.4.10. Ecosystem receptor – Phytoplankton

Boundary Creek at Penrith WRRF



Nepean River at Penrith WRRF

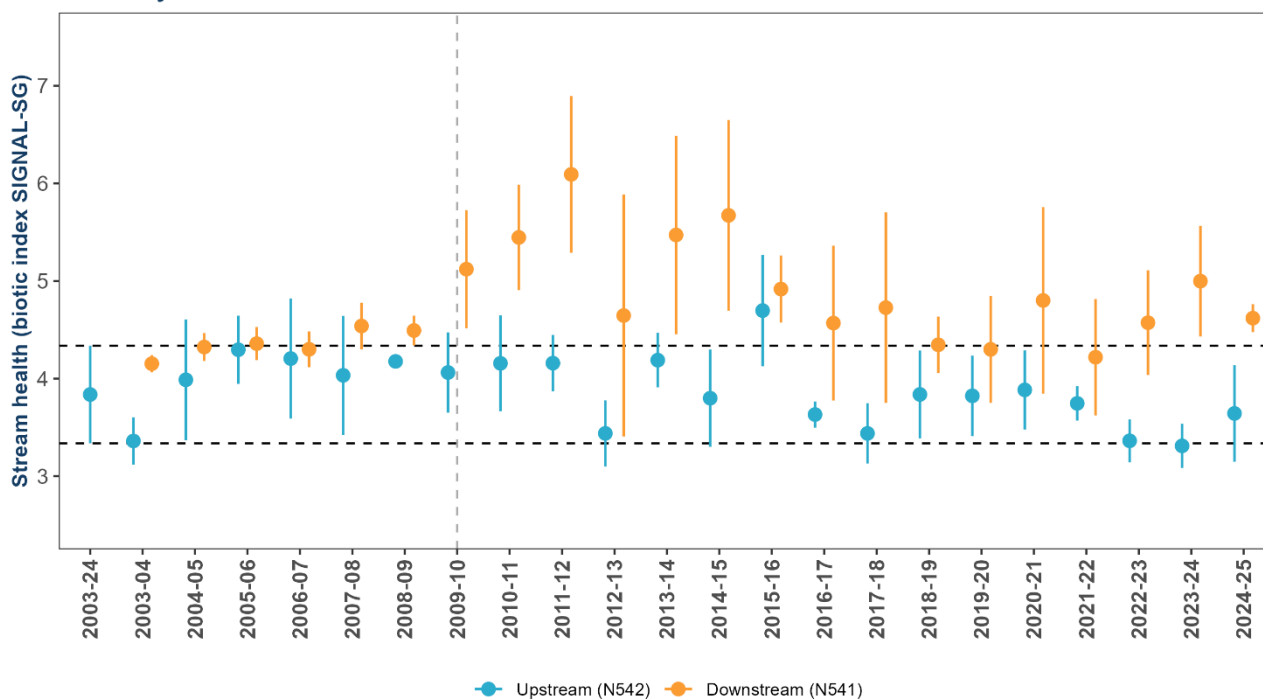


A.4.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Boundary Creek	Tributary (N542 vs N541)	Welch Two Sample t-test	-0.98	-4.64	5.8	0.004
Nepean River	River (N57A vs N53)	Welch Two Sample t-test	-0.22	-1.16	10.0	0.272

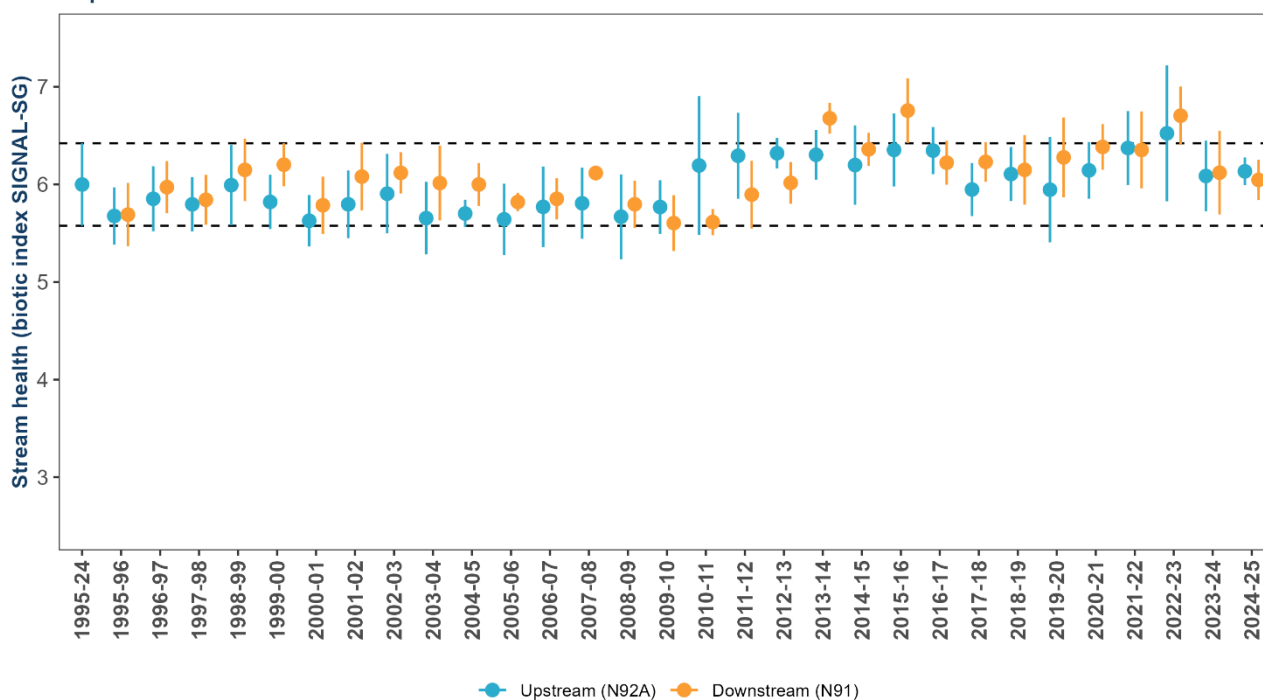
not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Boundary Creek at Penrith WRRF



The range of stream health recorded over each period is represented by length of line

Nepean River at Picton WRRF

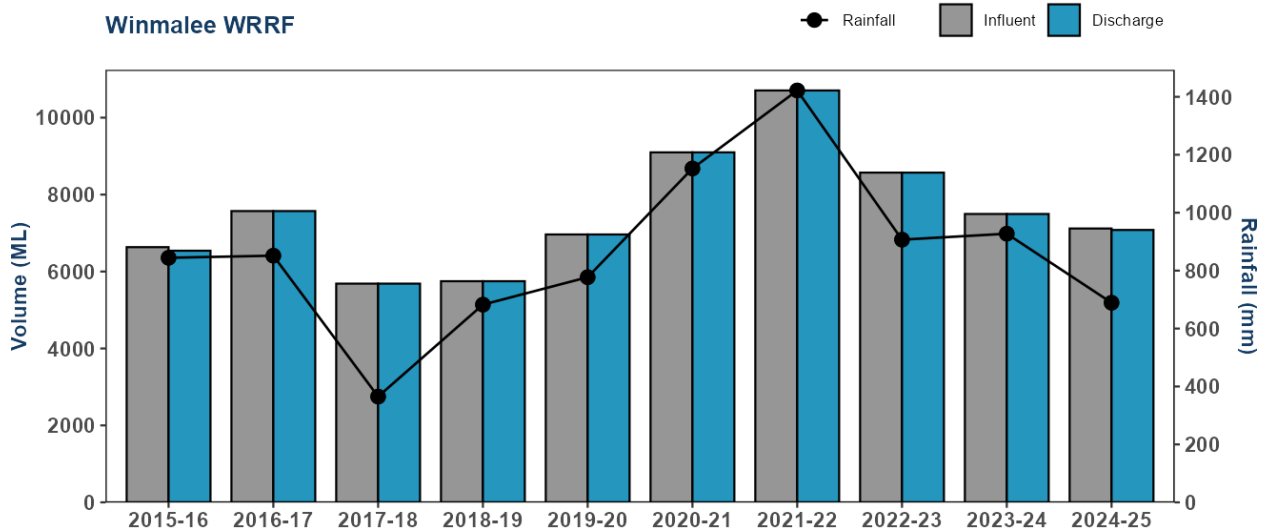


The range of stream health recorded over each period is represented by length of line

A.5. Winmalee WRRF

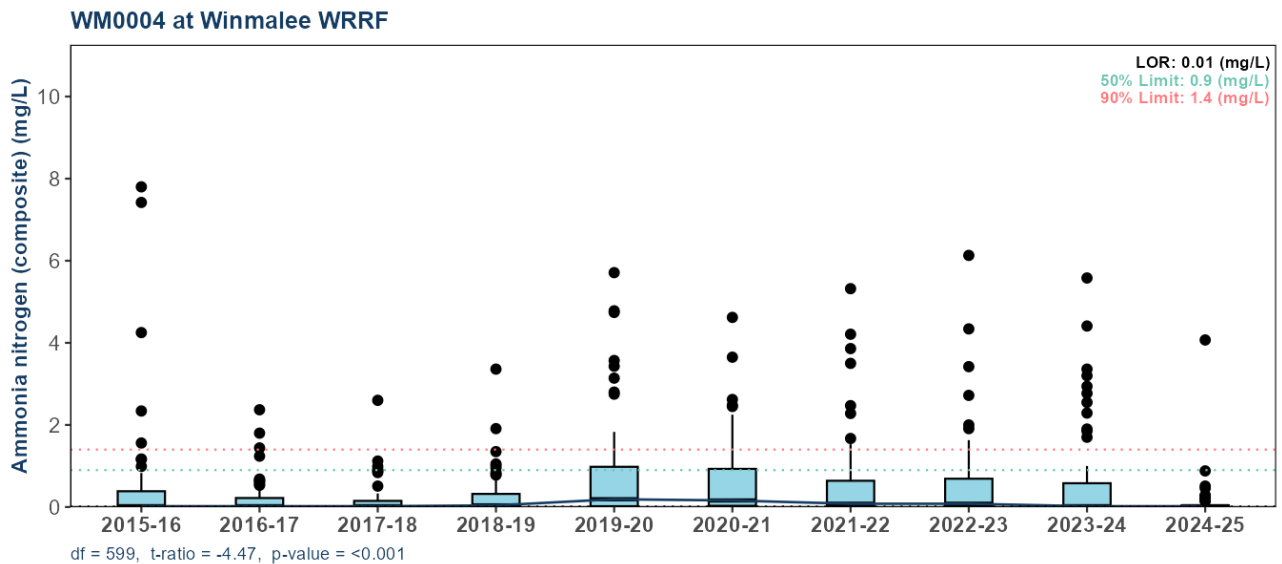
A.5.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall

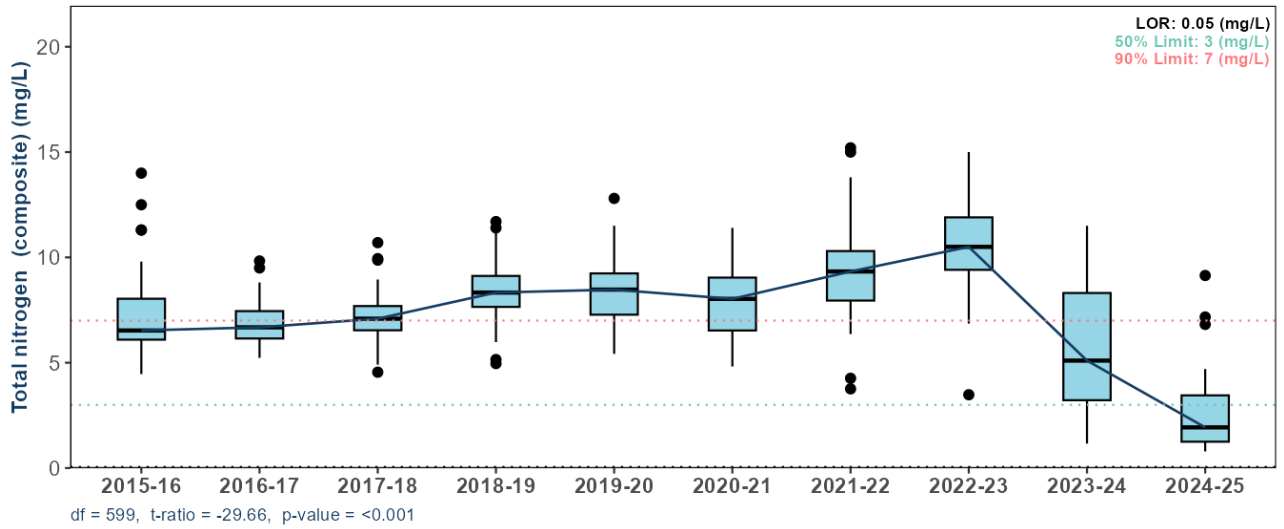


A.5.2. Pressure – Wastewater quality

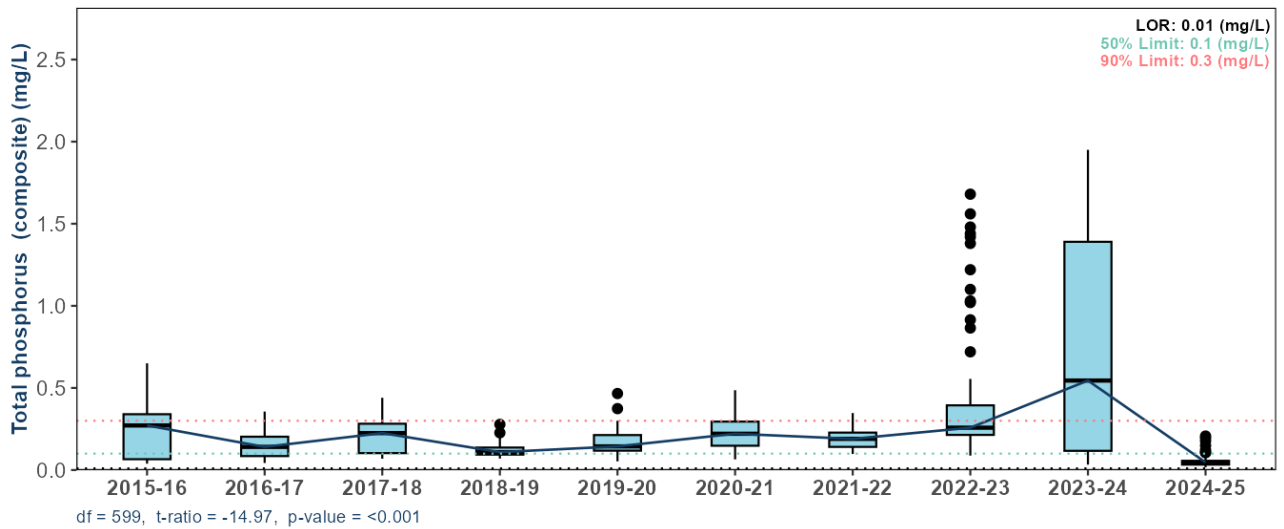
Nutrients



WM0004 at Winmalee WRRF

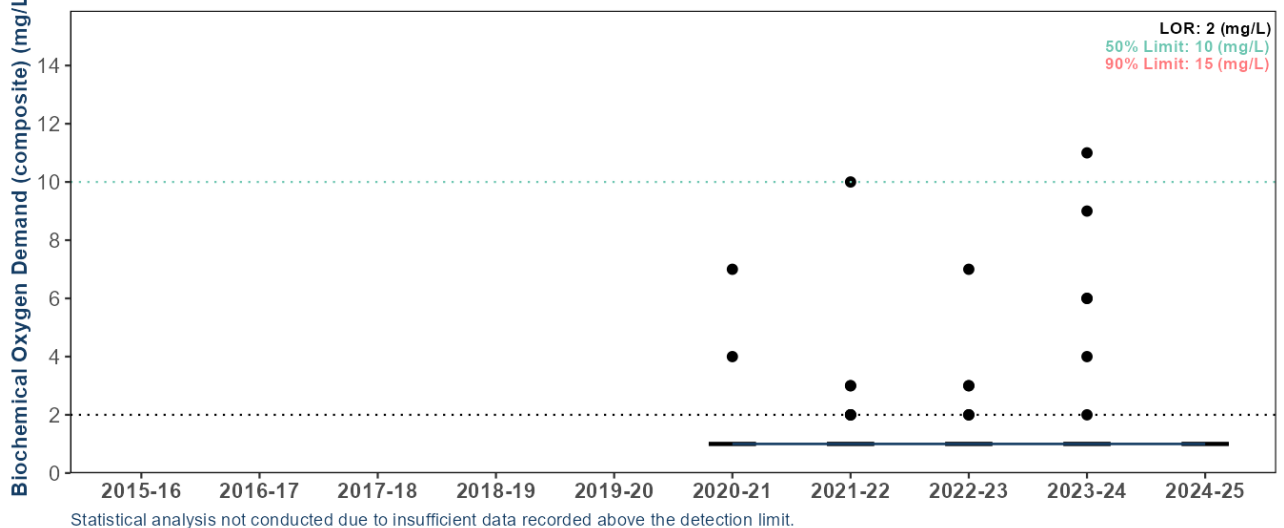


WM0004 at Winmalee WRRF

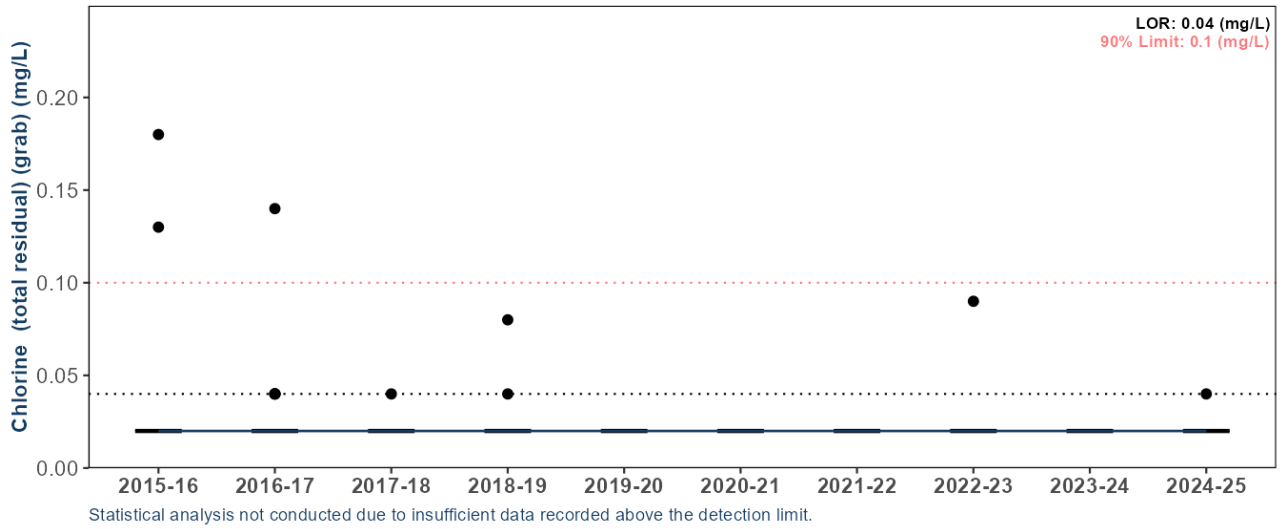


Major conventional analytes

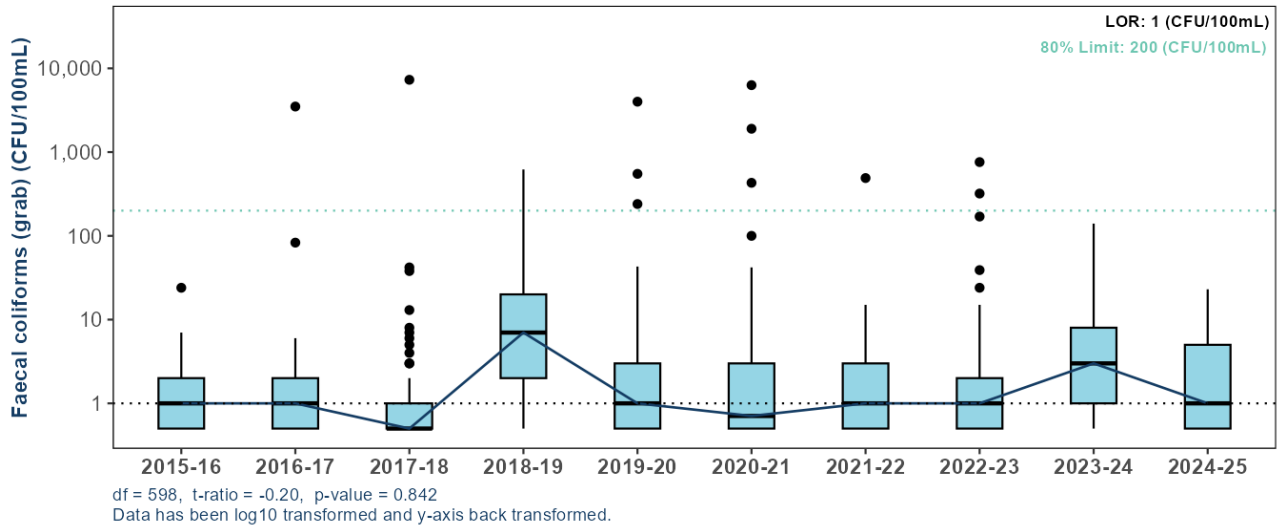
WM0004 at Winmalee WRRF



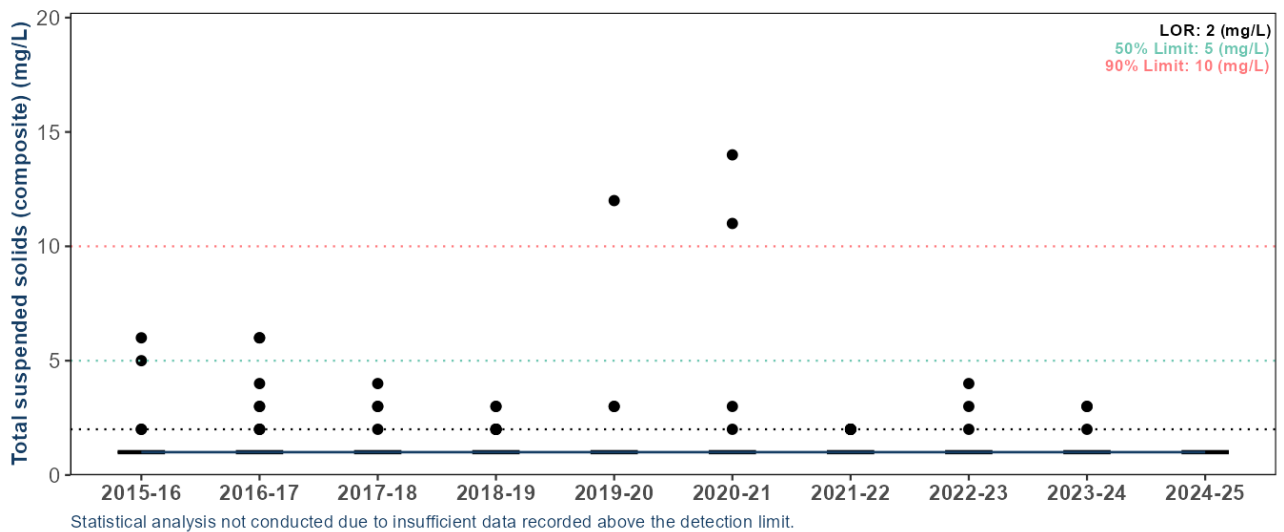
WM0004 at Winmalee WRRF



WM0004 at Winmalee WRRF

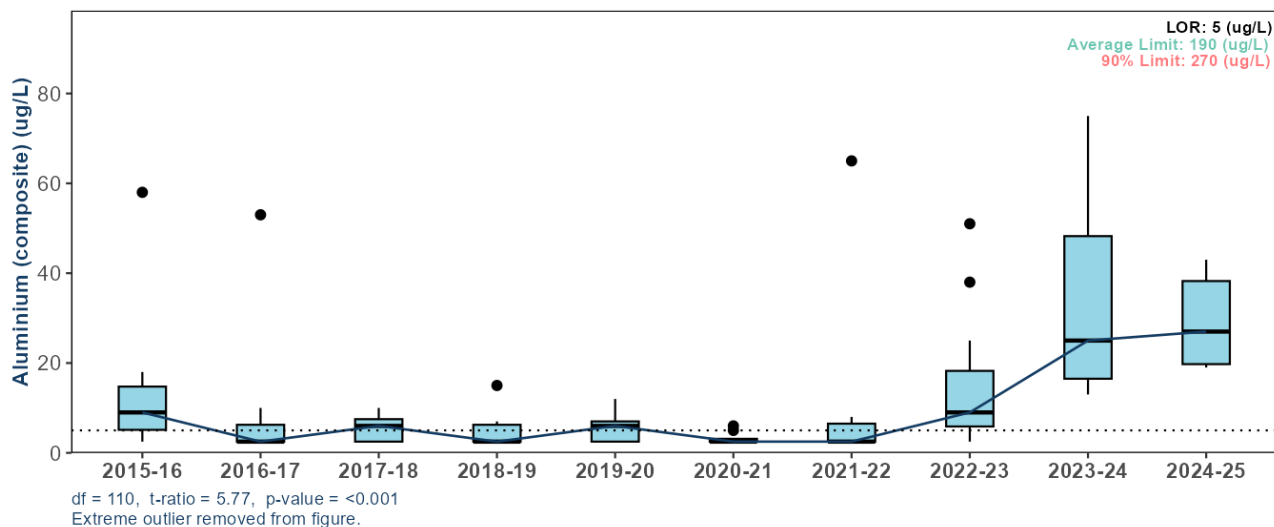


WM0004 at Winmalee WRRF

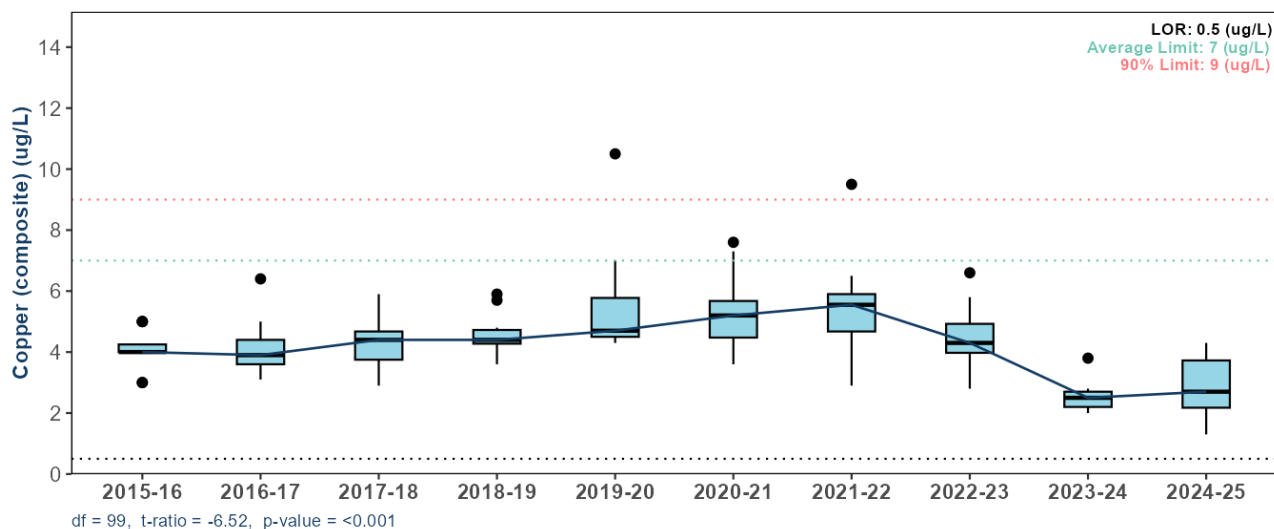


Trace metals

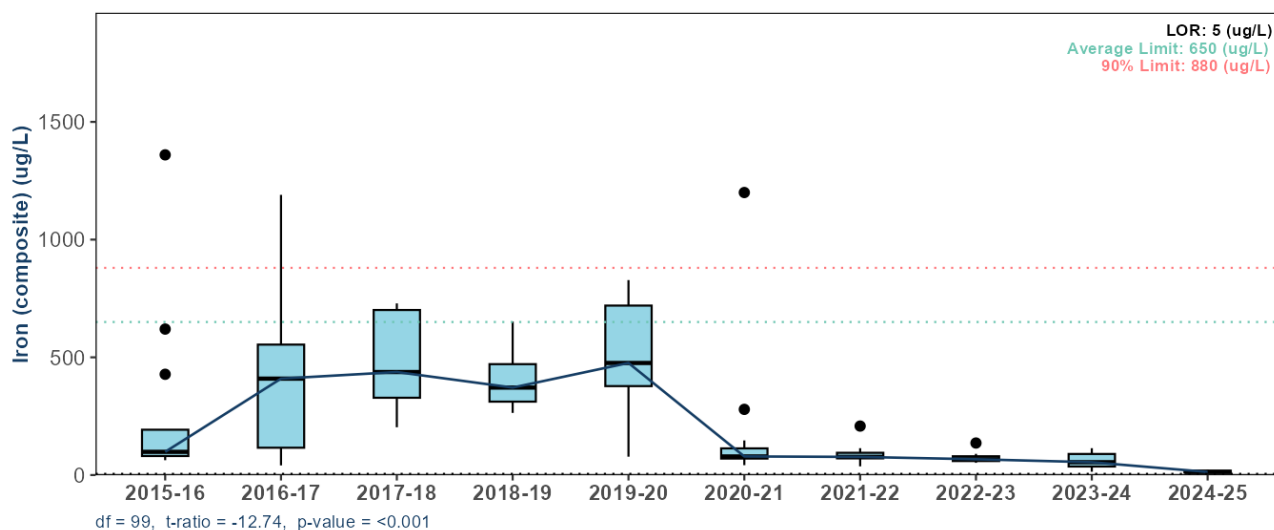
WM0004 at Winmalee WRRF



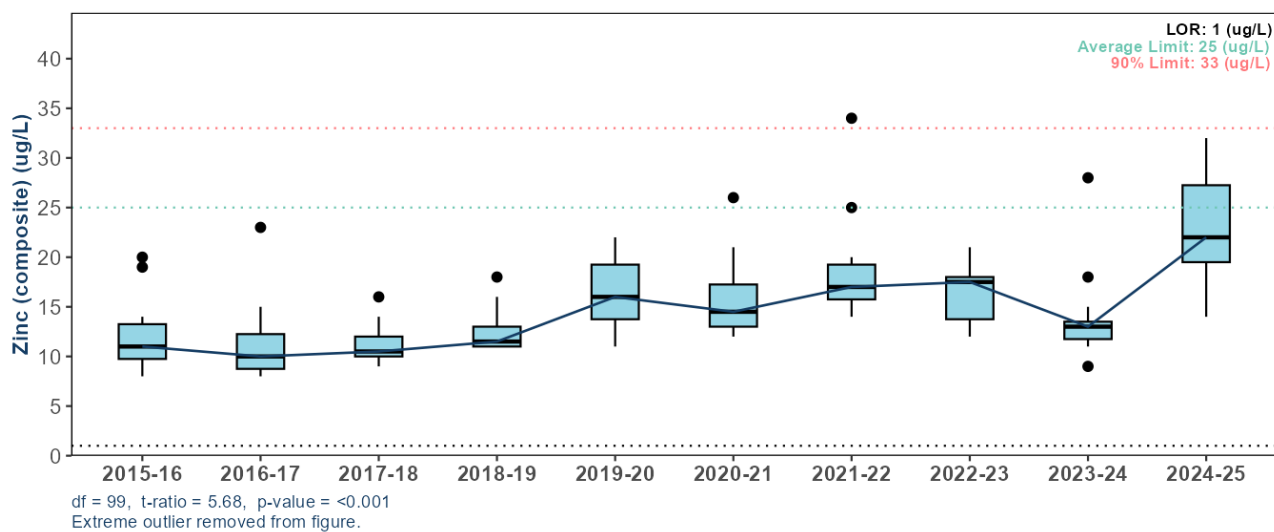
WM0004 at Winmalee WRRF



WM0004 at Winmalee WRRF

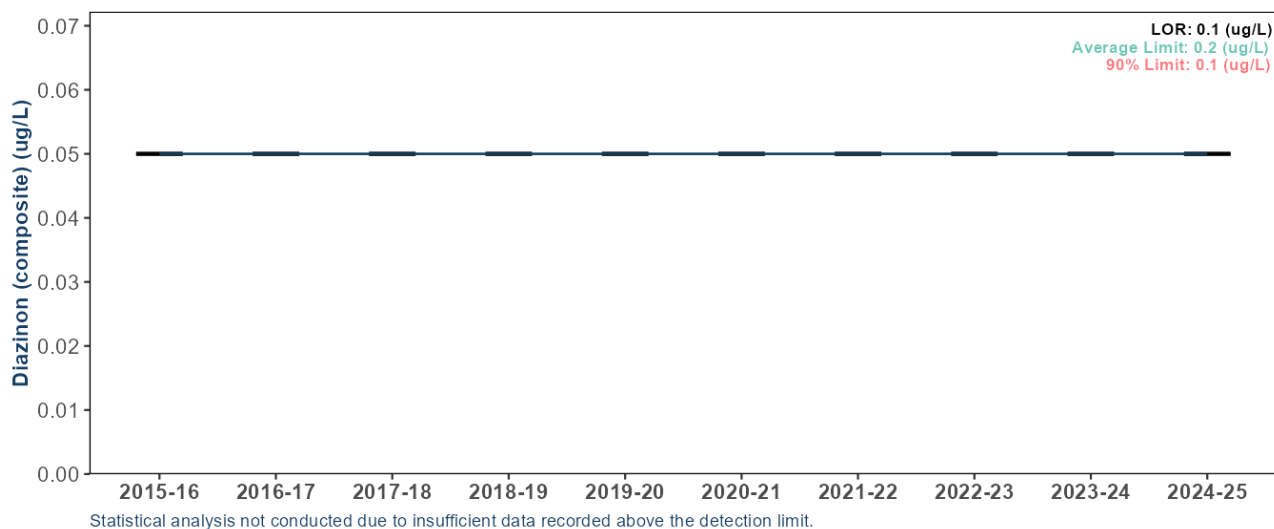


WM0004 at Winmalee WRRF



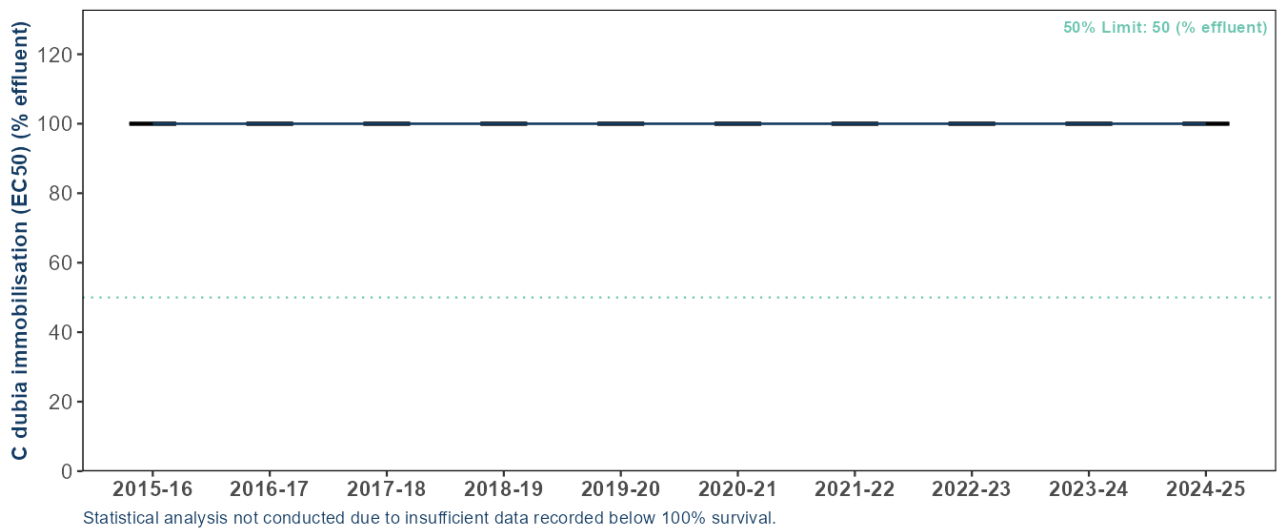
Other chemicals and organics (including pesticides)

WM0004 at Winmalee WRRF



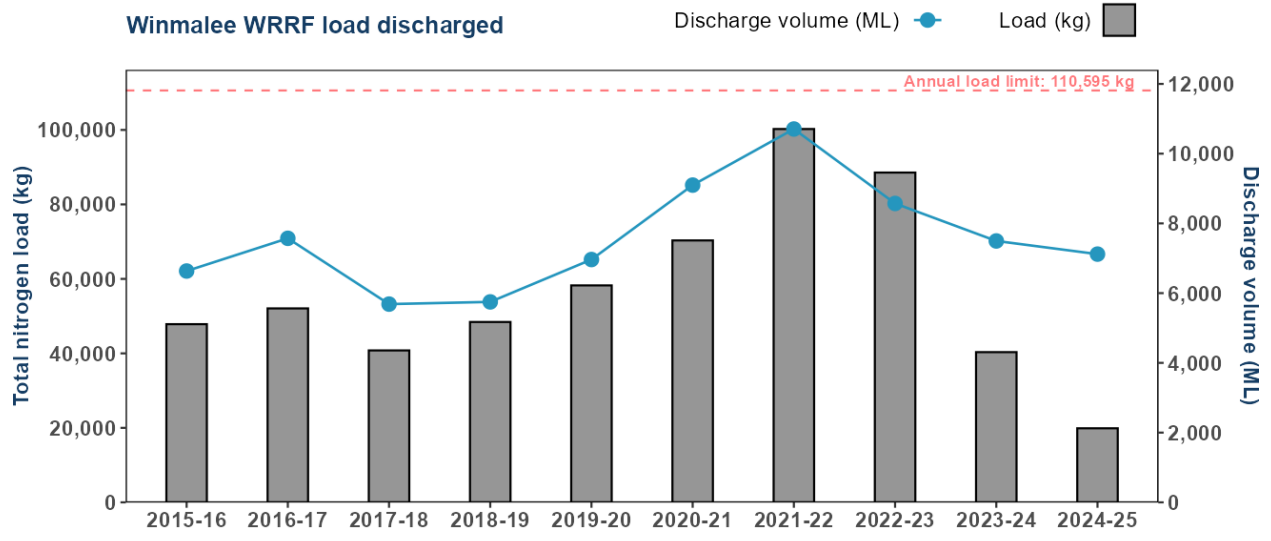
A.5.3. Pressure – Wastewater toxicity

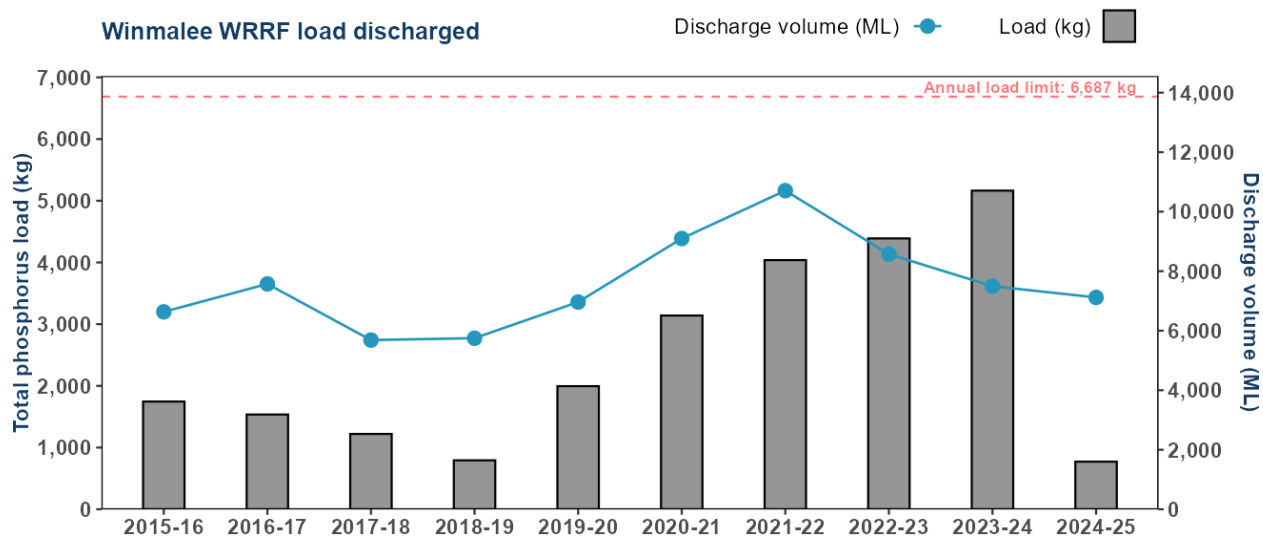
WM0004 at Winmalee WRRF



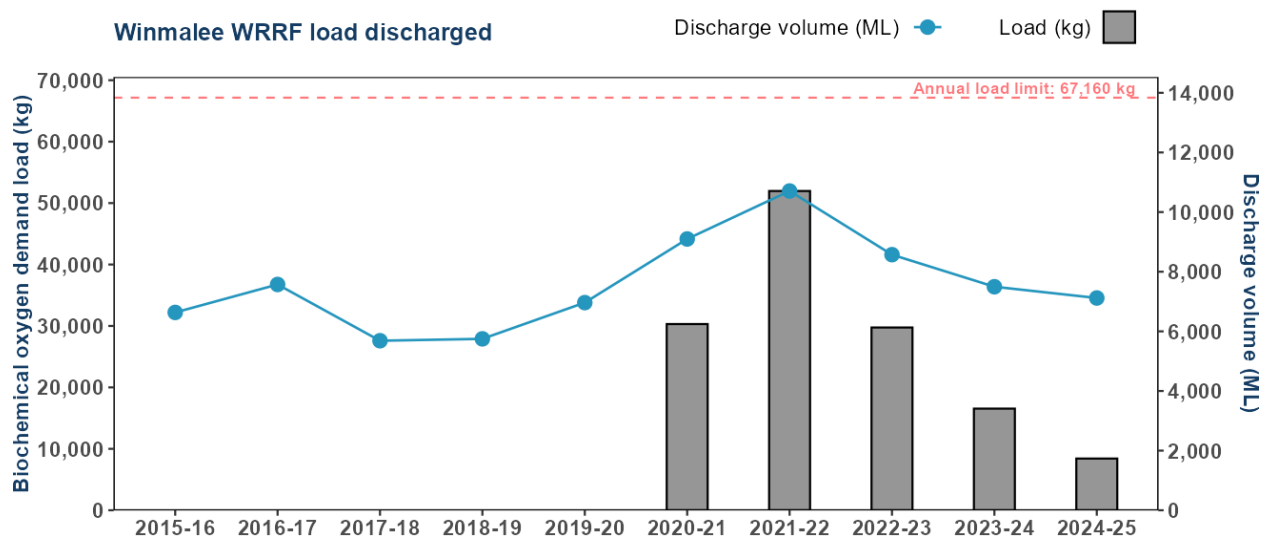
A.5.4. Pressure – Wastewater discharge load

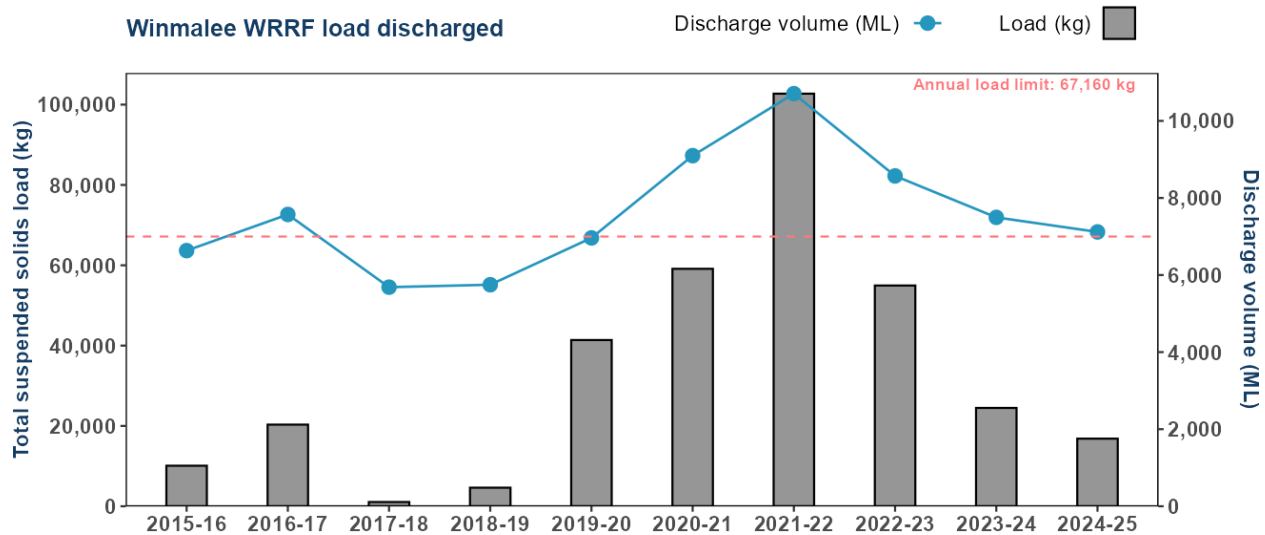
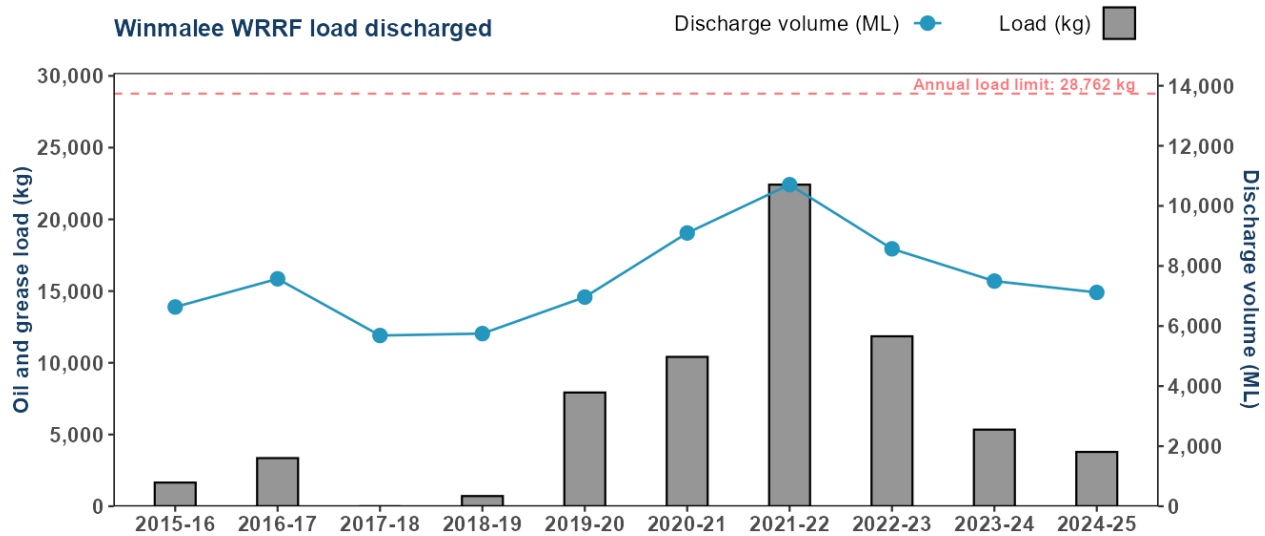
Nutrients





Major conventional analytes





A.5.5. Stressor – Statistical analysis outcomes

Table A-43 Upstream vs downstream comparison (2024-25 reporting period) for the unnamed creek at Winmalee WRRF

Unnamed Creek at Winmalee WRRF: N461 vs N462 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	2.29	1.04	66	1.83	0.270
Oxidised nitrogen	0.45	0.18	66	-2.02	0.190
Total nitrogen	0.61	0.14	66	-2.16	0.145
Soluble reactive phosphorus	0.80	0.26	66	-0.68	0.904
Total phosphorus	0.87	0.26	66	-0.46	0.967
Physico-chemical					
Conductivity	1.01	0.05	66	0.11	>0.999
Dissolved oxygen	0.98	0.03	66	-0.83	0.841
Dissolved oxygen saturation	1.68	1.97	66	0.85	0.830
pH	-0.31	0.06	66	-5.34	<0.001
Water temperature	1.04	0.06	66	0.68	0.905
Turbidity	0.46	0.09	66	-3.94	0.001
Trace Metals					
Filterable aluminium	1.28	0.15	66	2.13	0.156
Total aluminium	0.70	0.11	66	-2.32	0.105
Filterable cobalt	1.48	0.19	66	2.96	0.021
Total cobalt	1.37	0.19	66	2.32	0.103
Filterable copper	1.14	0.08	66	1.77	0.297
Total copper	1.08	0.08	66	1.08	0.704
Filterable nickel	1.14	0.08	66	1.87	0.251
Total nickel	1.12	0.08	66	1.67	0.349
Filterable zinc	1.82	0.19	66	5.77	<0.001
Total zinc	1.63	0.16	66	5.01	<0.001

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-44 Upstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at Winmalee WRRF

Unnamed Creek at Winmalee WRRF: N461 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.38	0.18	66	-2.09	0.168
Oxidised nitrogen	0.75	0.30	66	-0.71	0.894
Total nitrogen	0.59	0.14	66	-2.25	0.122
Soluble reactive phosphorus	0.13	0.04	66	-6.19	<0.001
Total phosphorus	0.14	0.04	66	-6.34	<0.001
Physico-chemical					
Conductivity	1.06	0.05	66	1.23	0.608
Dissolved oxygen	0.99	0.03	66	-0.44	0.971
Dissolved oxygen saturation	-0.26	2.00	66	-0.13	>0.999
pH	-0.01	0.06	66	-0.14	0.999
Water temperature	1.02	0.06	66	0.25	0.995
Turbidity	0.61	0.12	66	-2.46	0.075
Trace Metals					
Filterable aluminium	0.85	0.10	66	-1.32	0.554
Total aluminium	0.64	0.10	66	-2.82	0.032
Filterable cobalt	0.73	0.10	66	-2.35	0.097
Total cobalt	0.66	0.09	66	-2.94	0.023
Filterable copper	1.10	0.08	66	1.29	0.571
Total copper	1.07	0.08	66	0.88	0.815
Filterable nickel	0.78	0.05	66	-3.59	0.003
Total nickel	0.77	0.05	66	-3.83	0.002
Filterable zinc	1.37	0.15	66	3.01	0.019
Total zinc	1.29	0.13	66	2.59	0.055
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-45 Downstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at Winmalee WRRF

Unnamed Creek at Winmalee WRRF: N462 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.27	0.13	66	-2.82	0.031
Oxidised nitrogen	0.23	0.09	66	-3.68	0.003
Total nitrogen	0.34	0.08	66	-4.68	<0.001
Soluble reactive phosphorus	0.11	0.03	66	-6.85	<0.001
Total phosphorus	0.13	0.04	66	-6.69	<0.001
Physico-chemical					
Conductivity	1.04	0.05	66	0.75	0.876
Dissolved oxygen	1.08	0.03	66	2.74	0.039
Dissolved oxygen saturation	9.12	2.00	66	4.56	<0.001
pH	0.19	0.06	66	3.22	0.010
Water temperature	1.03	0.06	66	0.53	0.952
Turbidity	0.65	0.13	66	-2.17	0.142
Trace Metals					
Filterable aluminium	1.27	0.15	66	2.01	0.196
Total aluminium	0.79	0.12	66	-1.52	0.434
Filterable cobalt	0.78	0.10	66	-1.84	0.262
Total cobalt	0.65	0.09	66	-3.13	0.014
Filterable copper	1.15	0.08	66	1.96	0.215
Total copper	1.11	0.08	66	1.36	0.530
Filterable nickel	0.80	0.06	66	-3.18	0.012
Total nickel	0.78	0.05	66	-3.49	0.005
Filterable zinc	1.59	0.17	66	4.40	<0.001
Total zinc	1.49	0.15	66	4.02	<0.001
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-46 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at Winmalee WRRF

Nepean River at Winmalee WRRF: N48A vs N464 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.85	0.18	309	-0.74	0.880
Oxidised nitrogen	1.20	0.32	309	0.68	0.903
Total nitrogen	1.11	0.13	309	0.92	0.792
Soluble reactive phosphorus	1.16	0.35	65	0.49	0.961
Total phosphorus	1.23	0.17	309	1.55	0.410
Physico-chemical					
Conductivity	1.09	0.08	309	1.15	0.660
Dissolved oxygen	1.03	0.04	308	0.75	0.875
Dissolved oxygen saturation	1.79	2.51	308	0.72	0.891
pH	0.02	0.11	309	0.20	0.997
Water temperature	0.96	0.09	309	-0.41	0.977
Turbidity	1.03	0.20	309	0.17	0.998
Trace Metals					
Filterable aluminium	1.39	0.26	65	1.73	0.317
Total aluminium	1.35	0.31	65	1.31	0.560
Filterable cobalt	1.12	0.16	65	0.80	0.854
Total cobalt	1.41	0.24	65	2.05	0.181
Filterable copper	1.19	0.09	65	2.43	0.081
Total copper	1.19	0.10	65	2.00	0.198
Filterable nickel	1.00	0.11	65	0.00	>0.999
Total nickel	0.99	0.11	65	-0.11	>0.999
Filterable zinc	1.53	0.28	64	2.33	0.103
Total zinc	1.45	0.27	65	2.00	0.199

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-47 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Winmalee WRRF

Nepean River at Winmalee WRRF: N48A (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.69	0.11	309	-2.24	0.114
Oxidised nitrogen	1.45	0.29	309	1.85	0.251
Total nitrogen	1.02	0.09	309	0.27	0.993
Soluble reactive phosphorus	0.76	0.24	65	-0.87	0.818
Total phosphorus	0.75	0.08	309	-2.82	0.026
Physico-chemical					
Conductivity	1.09	0.06	309	1.68	0.336
Dissolved oxygen	1.01	0.03	308	0.21	0.997
Dissolved oxygen saturation	1.82	1.89	308	0.97	0.769
pH	0.04	0.08	309	0.44	0.972
Water temperature	1.03	0.07	309	0.40	0.978
Turbidity	0.88	0.13	309	-0.88	0.817
Trace Metals					
Filterable aluminium	0.84	0.16	65	-0.88	0.816
Total aluminium	0.53	0.13	65	-2.64	0.050
Filterable cobalt	0.95	0.14	65	-0.36	0.984
Total cobalt	0.77	0.13	65	-1.47	0.460
Filterable copper	0.76	0.06	65	-3.60	0.003
Total copper	0.76	0.07	65	-3.03	0.018
Filterable nickel	0.74	0.08	65	-2.71	0.041
Total nickel	0.74	0.08	65	-2.68	0.045
Filterable zinc	0.71	0.14	64	-1.80	0.283
Total zinc	0.58	0.11	65	-2.87	0.028

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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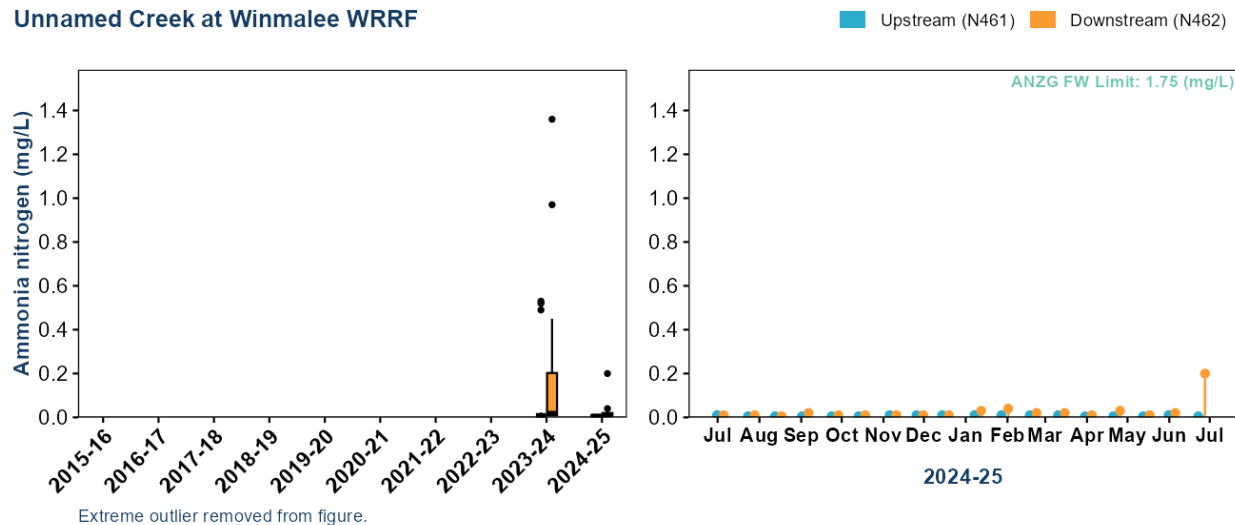
Table A-48 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Winmalee WRRF

Nepean River at Winmalee WRRF: N464 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.55	0.09	309	-3.70	0.001
Oxidised nitrogen	0.52	0.10	309	-3.24	0.007
Total nitrogen	0.66	0.06	309	-4.86	<0.001
Soluble reactive phosphorus	0.11	0.03	65	-7.28	<0.001
Total phosphorus	0.55	0.06	309	-5.98	<0.001
Physico-chemical					
Conductivity	1.14	0.06	309	2.41	0.077
Dissolved oxygen	1.00	0.03	308	0.16	0.998
Dissolved oxygen saturation	0.86	1.87	308	0.46	0.968
pH	-0.02	0.08	309	-0.24	0.995
Water temperature	1.02	0.07	309	0.33	0.988
Turbidity	0.86	0.12	309	-1.05	0.720
Trace Metals					
Filterable aluminium	1.01	0.19	65	0.05	>0.999
Total aluminium	0.62	0.15	65	-2.02	0.190
Filterable cobalt	0.74	0.11	65	-2.03	0.189
Total cobalt	0.79	0.14	65	-1.35	0.538
Filterable copper	0.86	0.06	65	-1.98	0.205
Total copper	0.87	0.08	65	-1.55	0.417
Filterable nickel	0.72	0.08	65	-3.07	0.016
Total nickel	0.64	0.07	65	-3.92	0.001
Filterable zinc	0.99	0.18	64	-0.07	>0.999
Total zinc	0.80	0.15	65	-1.18	0.639

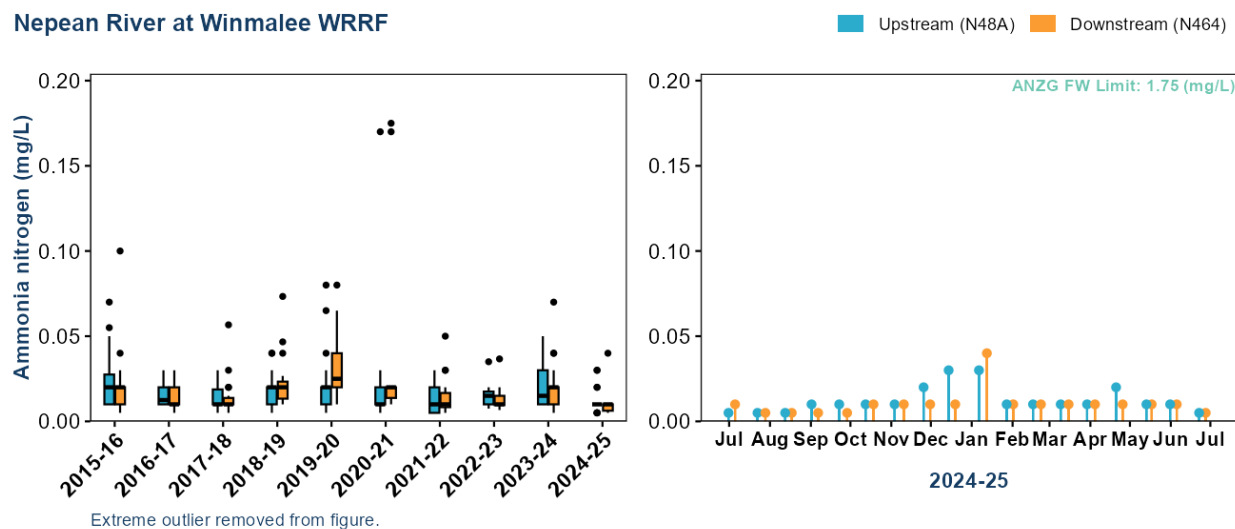
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.5.6. Stressor – Nutrients

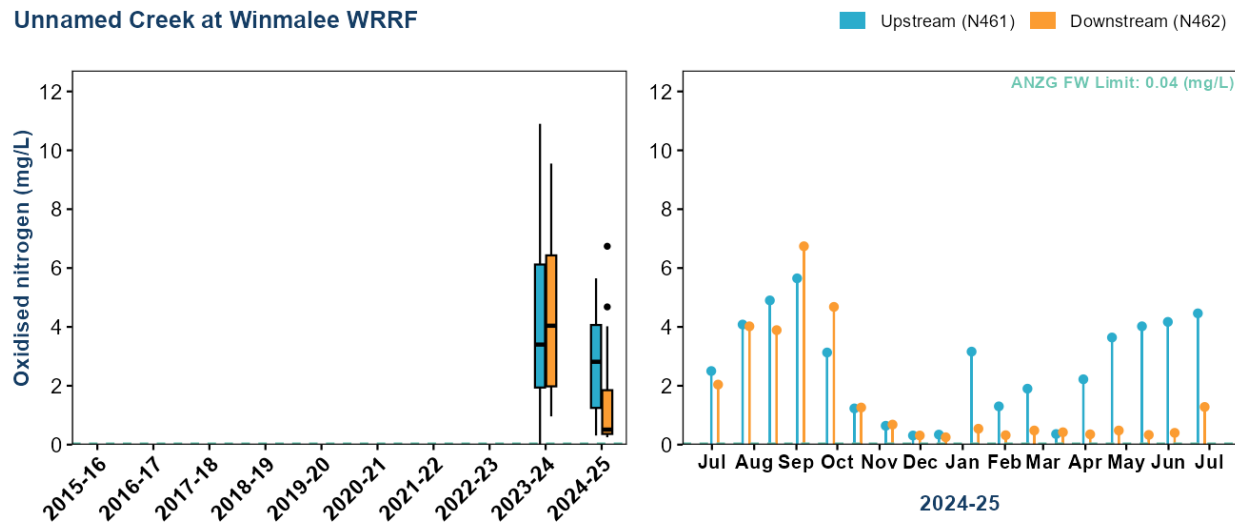
Unnamed Creek at Winmalee WRRF



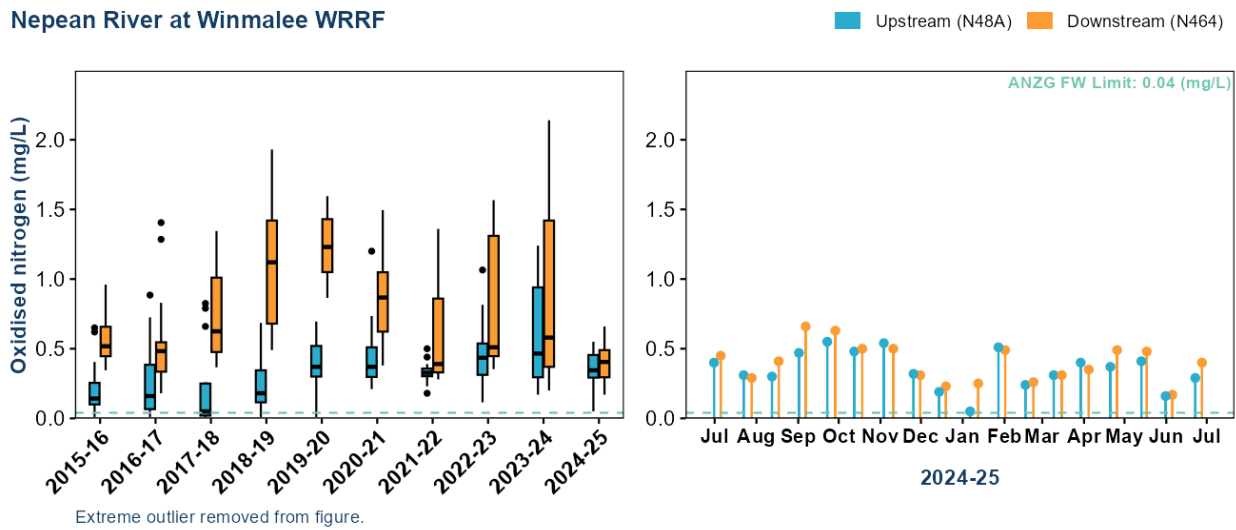
Nepean River at Winmalee WRRF



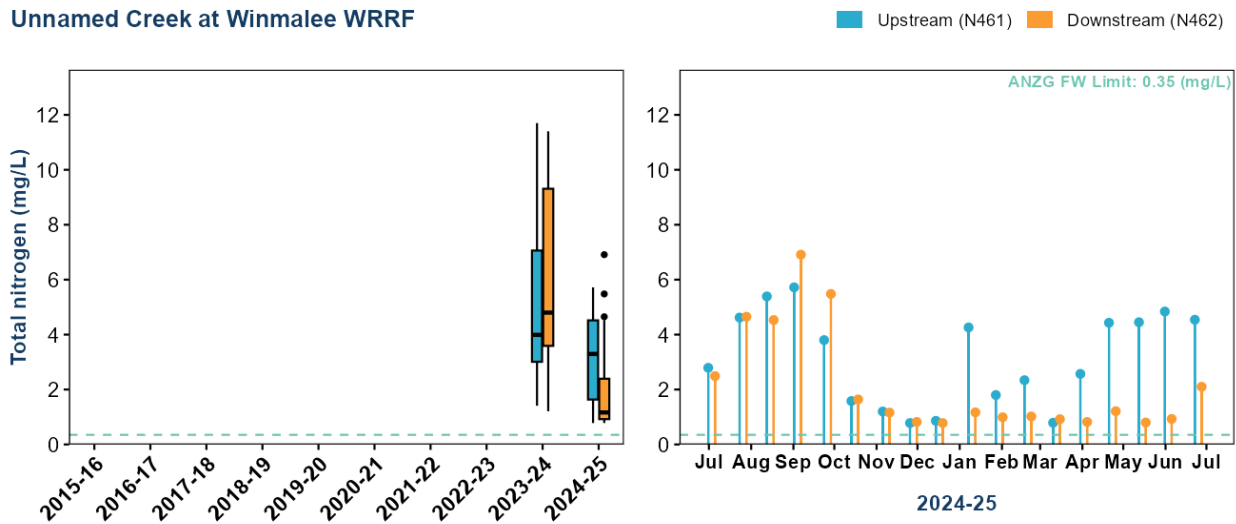
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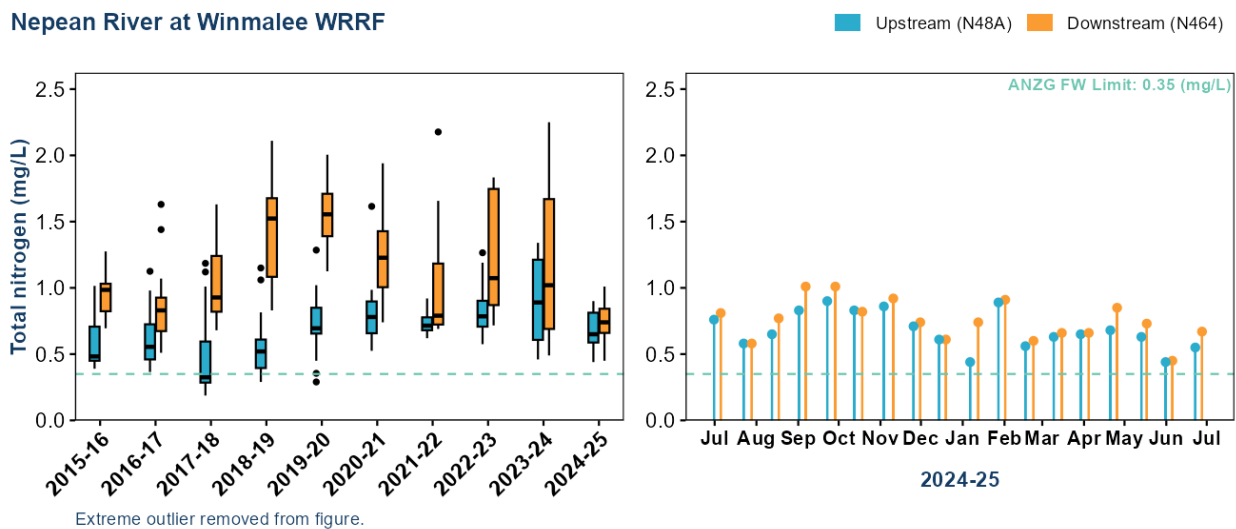
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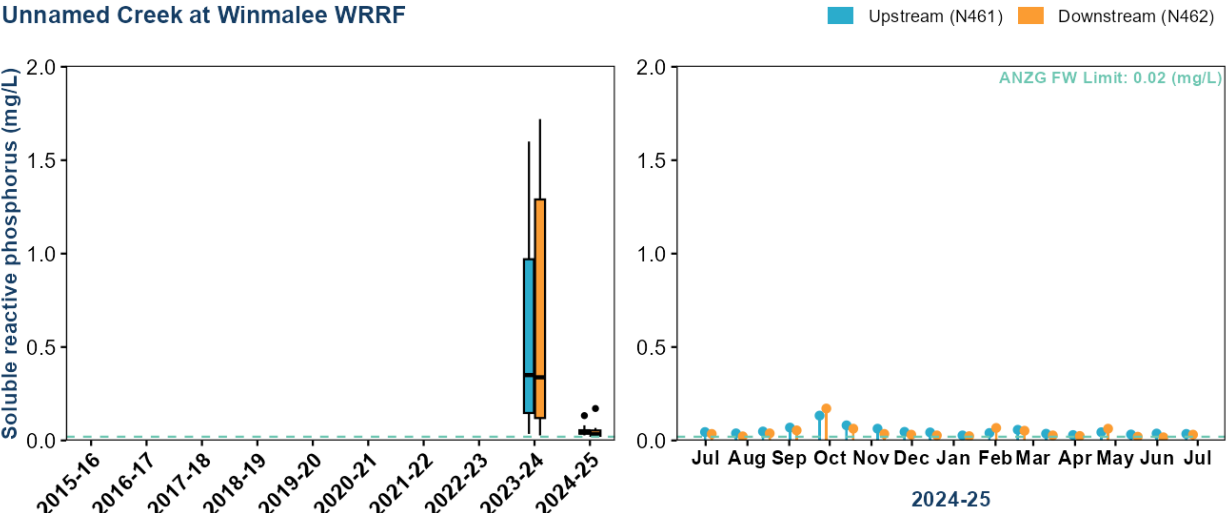
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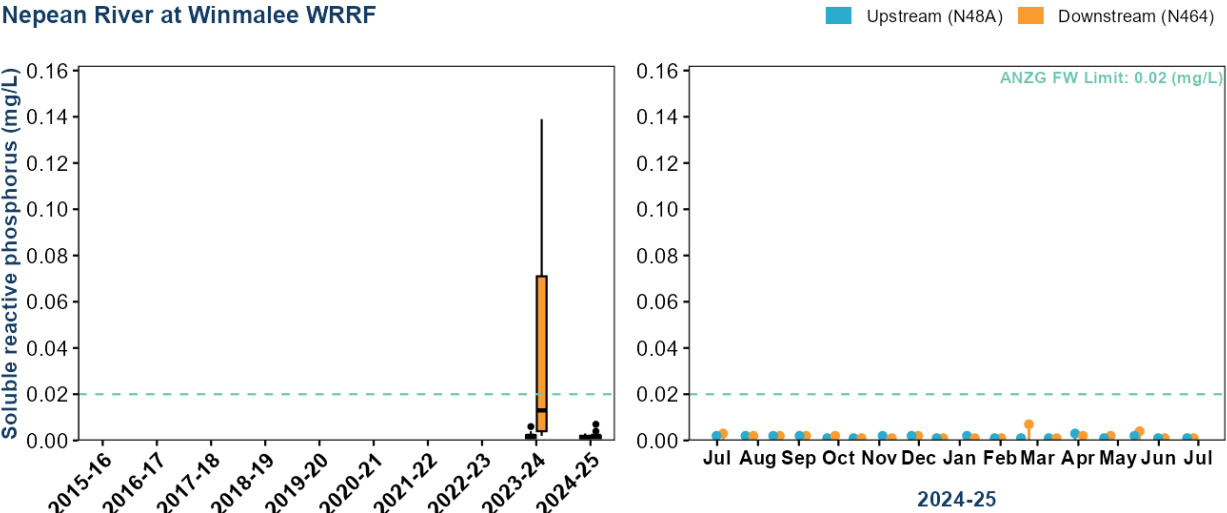
Nepean River at Winmalee WRRF



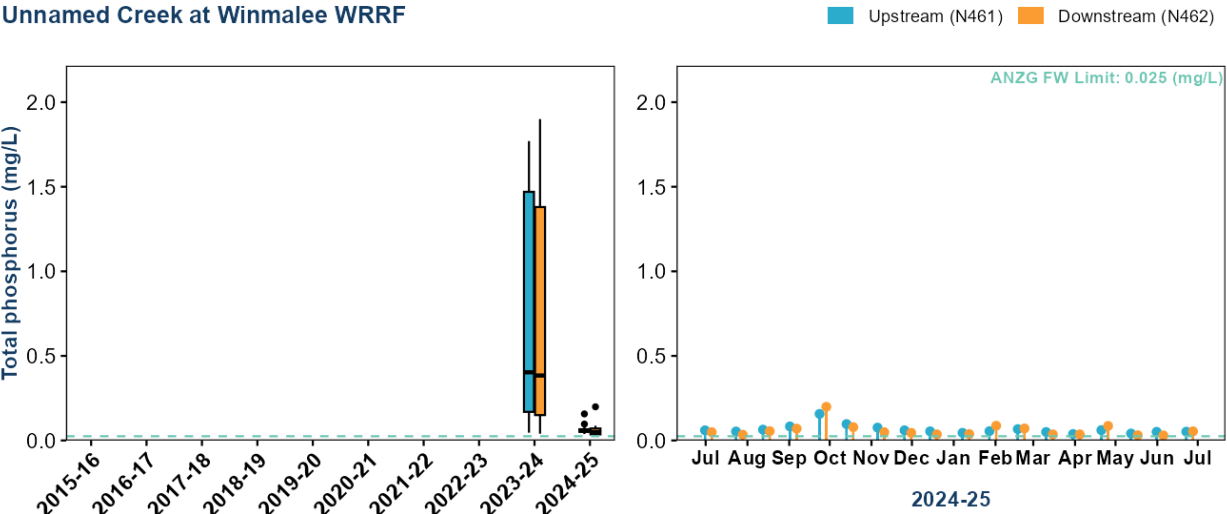
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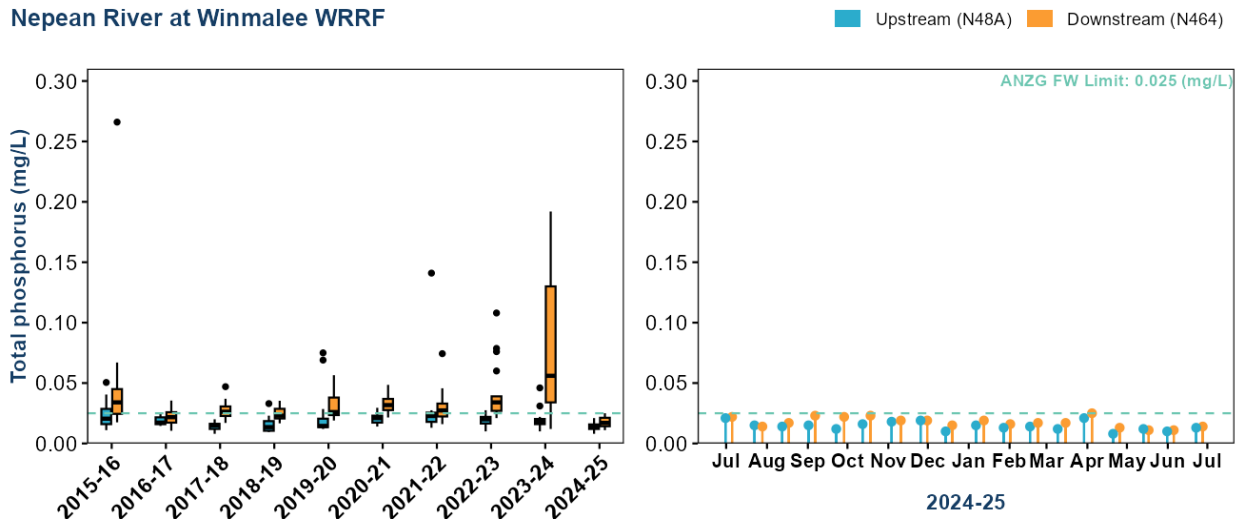
Nepean River at Winmalee WRRF



Unnamed Creek at Winmalee WRRF

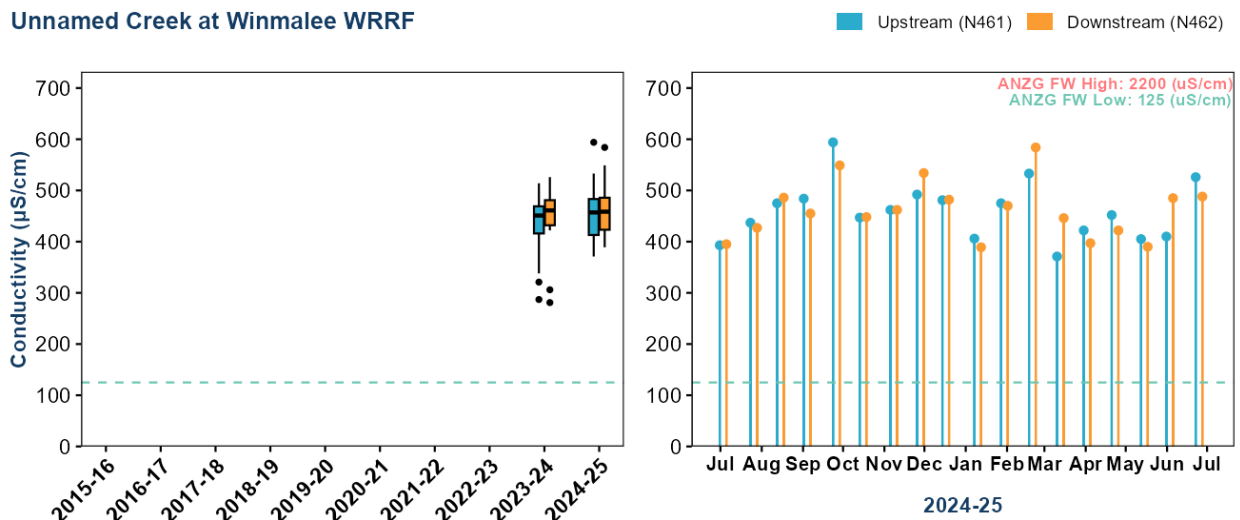


Nepean River at Winmalee WRRF

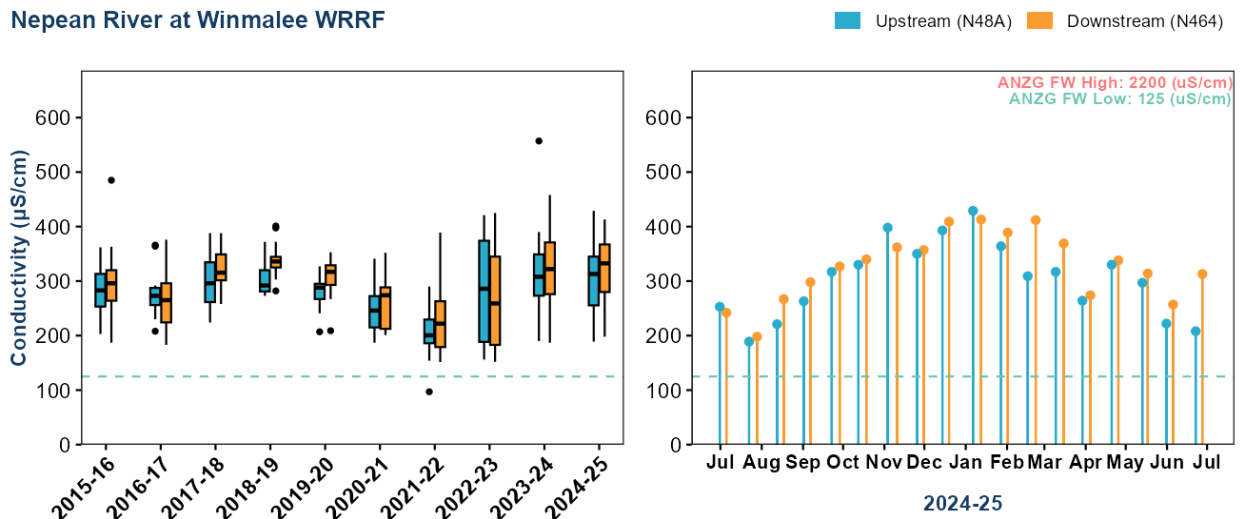


A.5.7. Stressor – Physico-chemical water quality

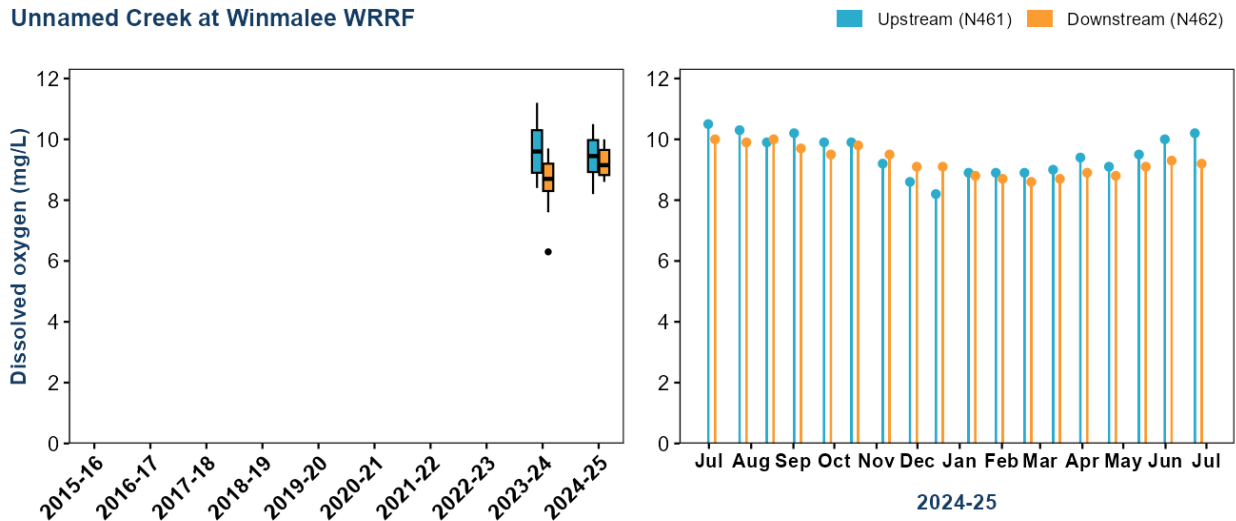
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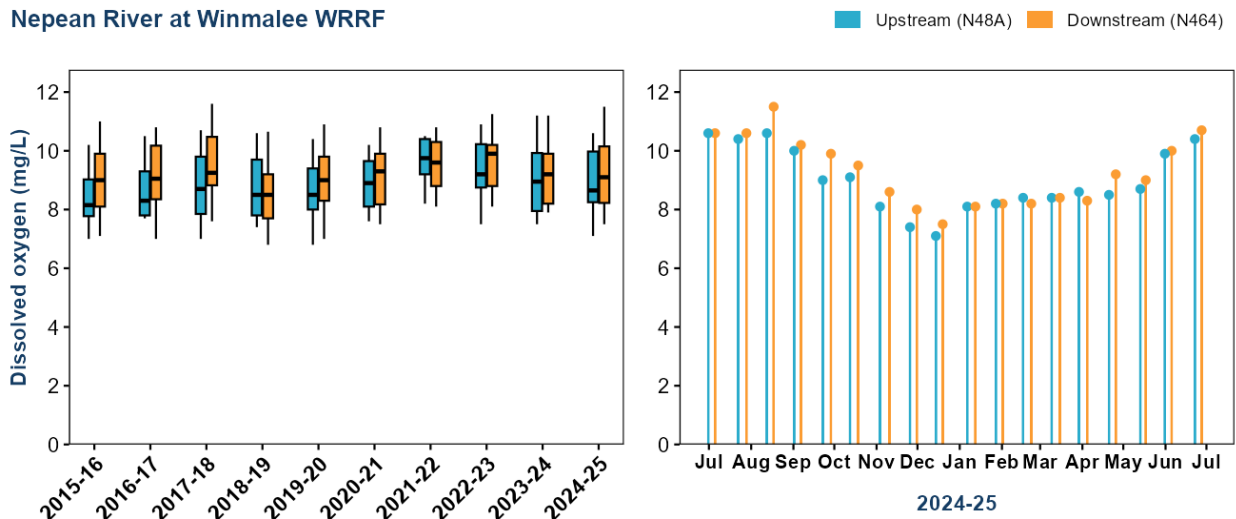
Nepean River at Winmalee WRRF



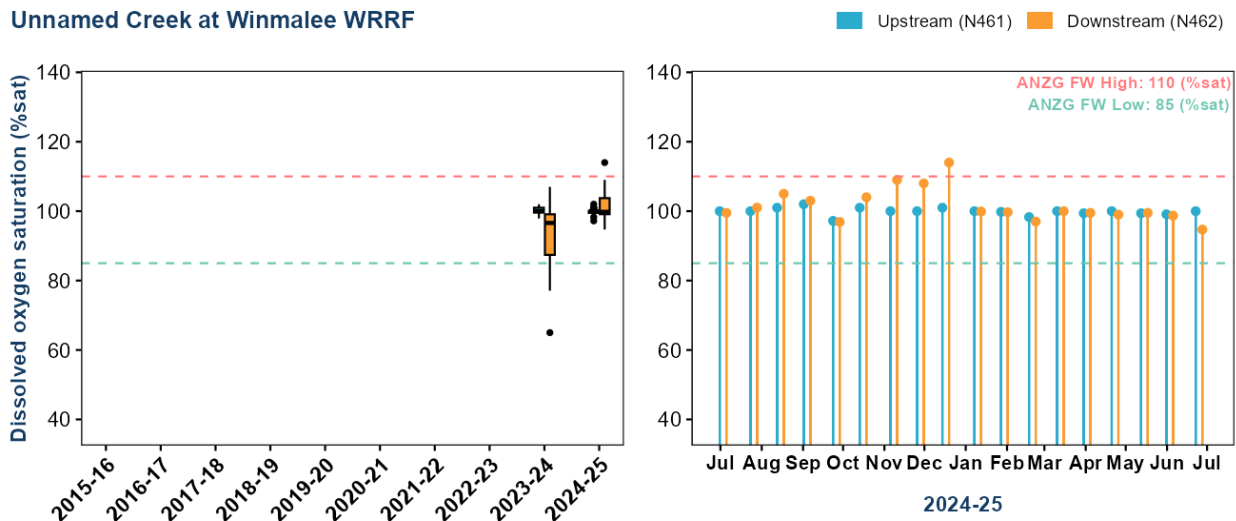
Unnamed Creek at Winmalee WRRF



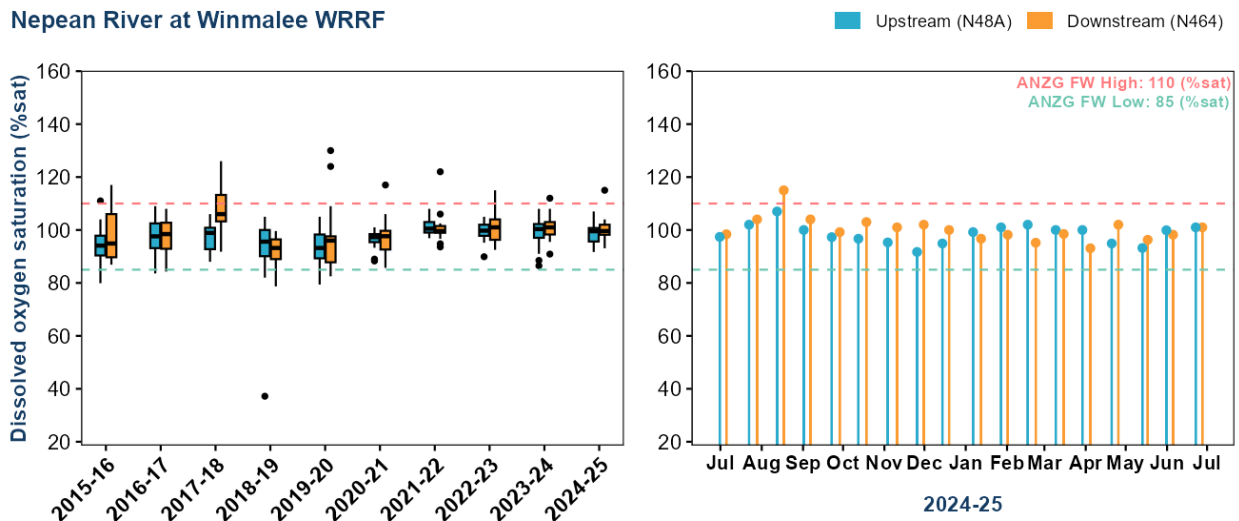
Nepean River at Winmalee WRRF



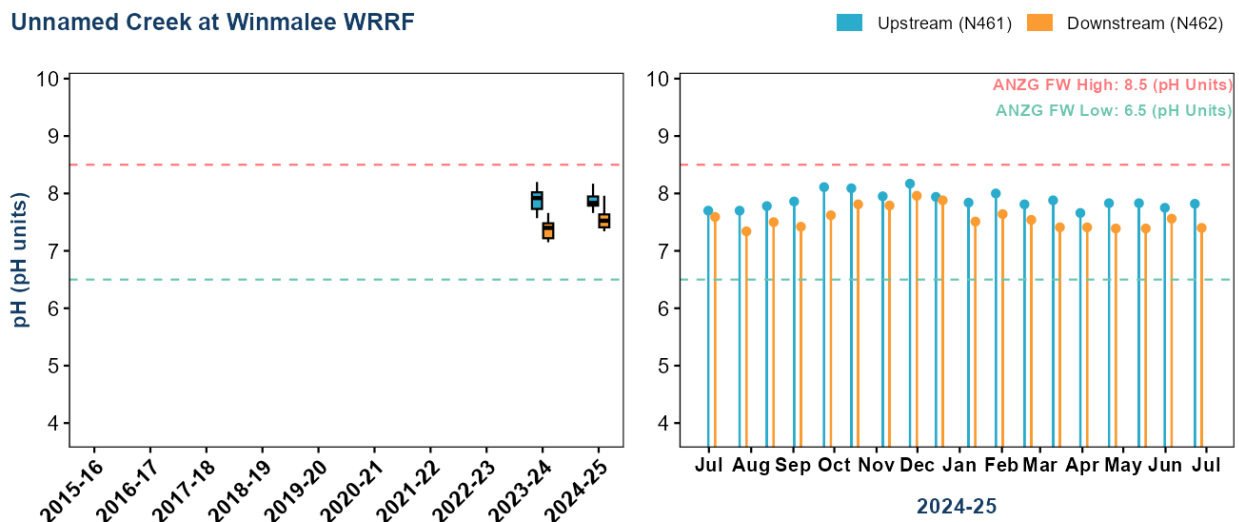
Unnamed Creek at Winmalee WRRF



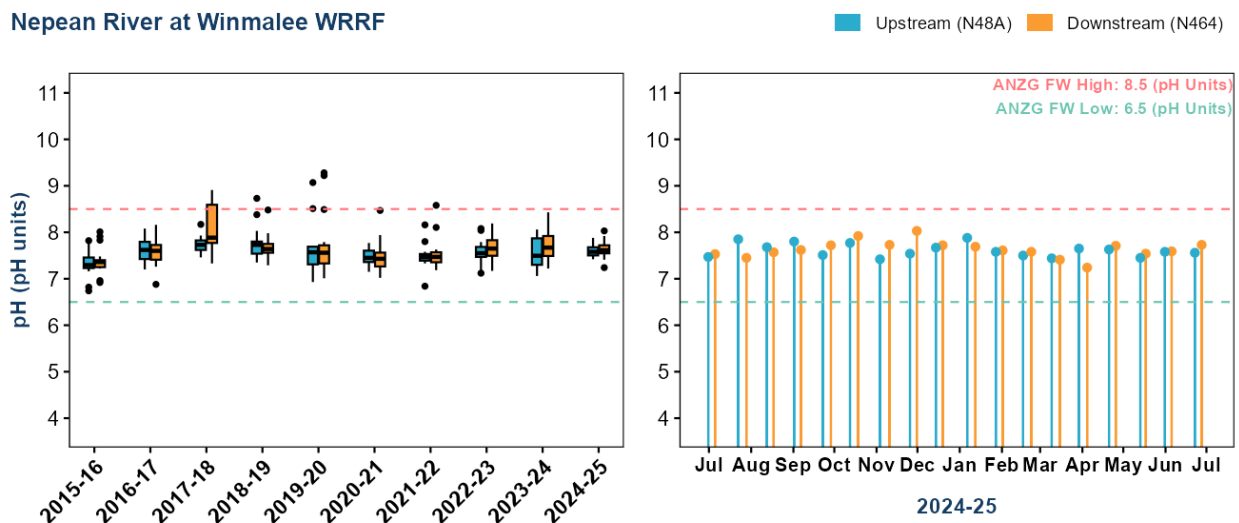
Nepean River at Winmalee WRRF



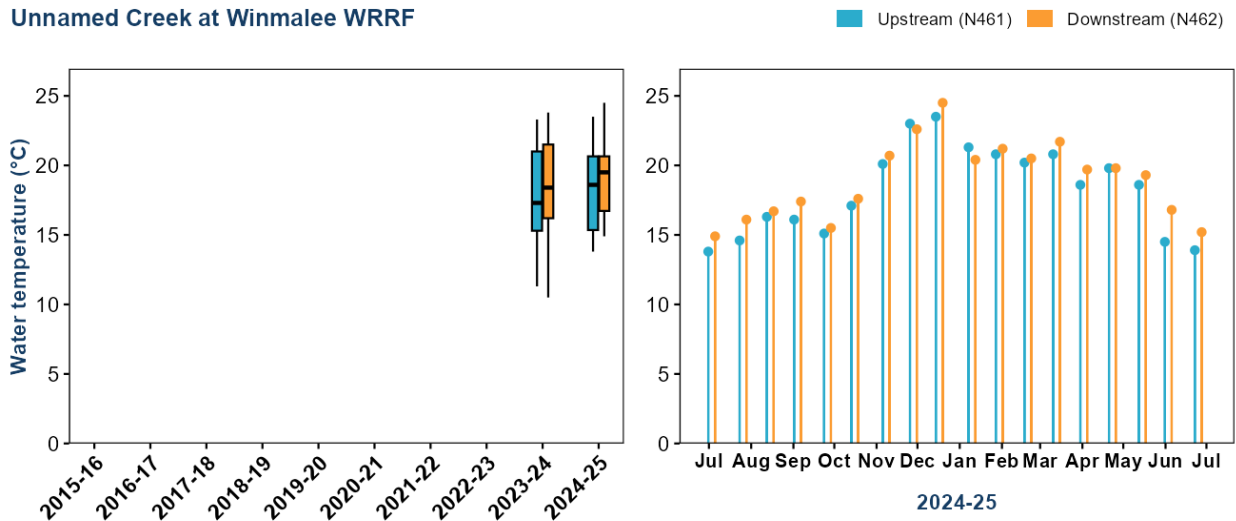
Unnamed Creek at Winmalee WRRF



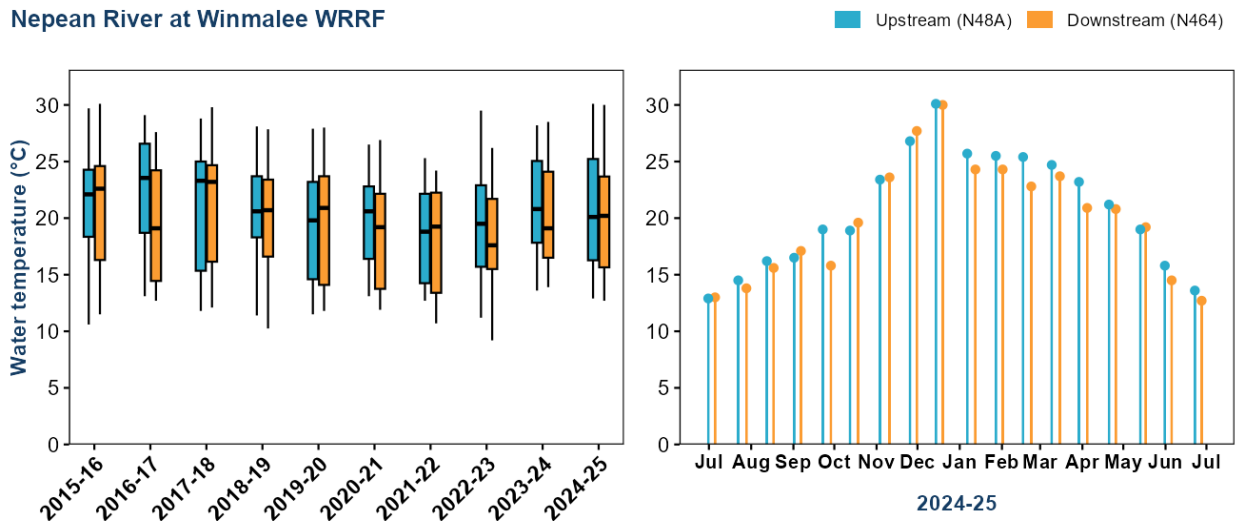
Nepean River at Winmalee WRRF



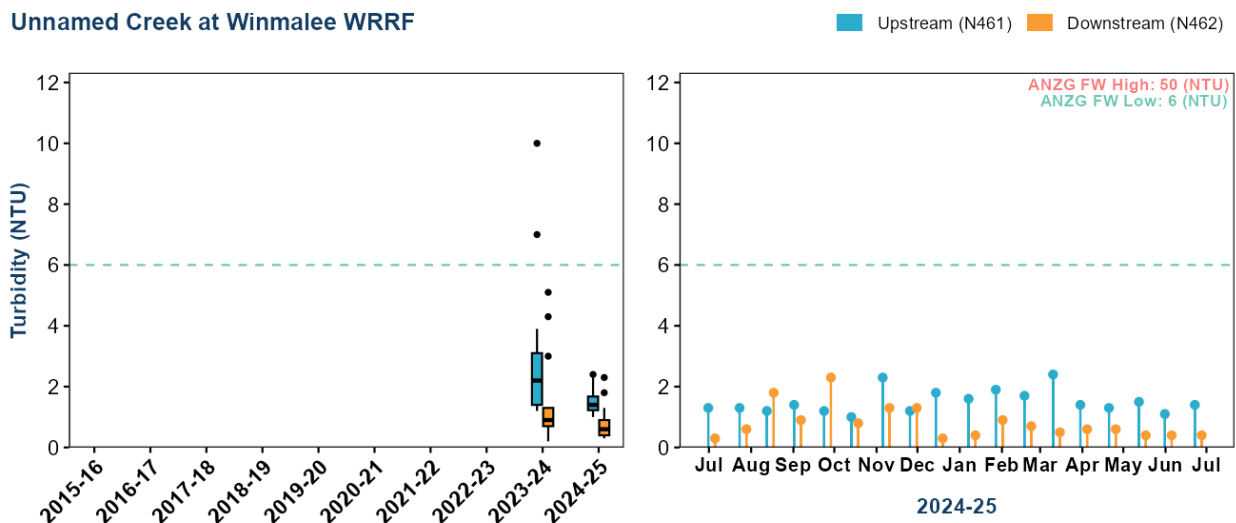
Unnamed Creek at Winmalee WRRF



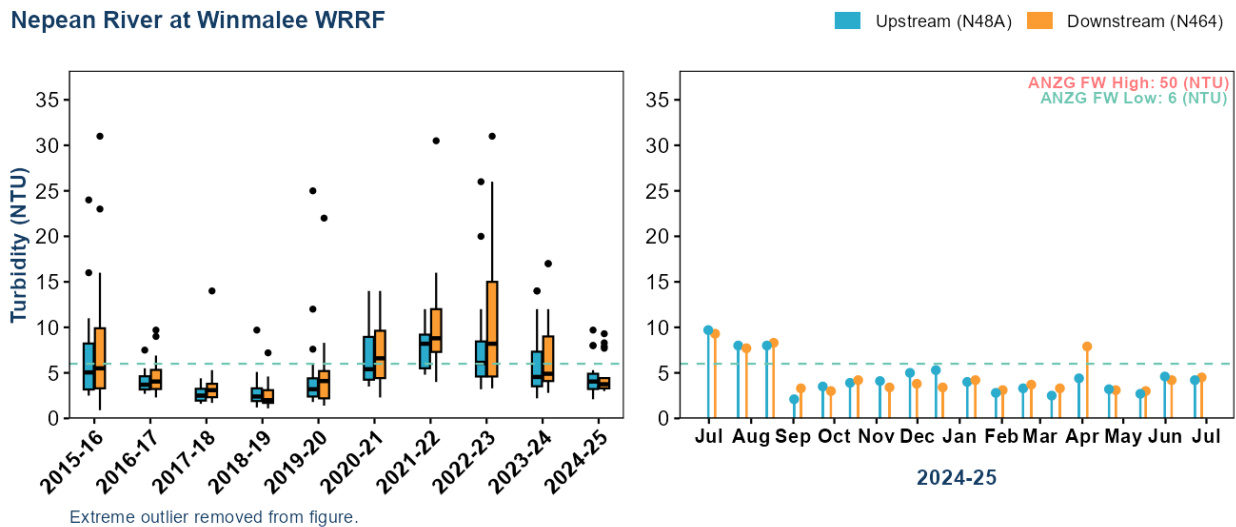
Nepean River at Winmalee WRRF



Unnamed Creek at Winmalee WRRF

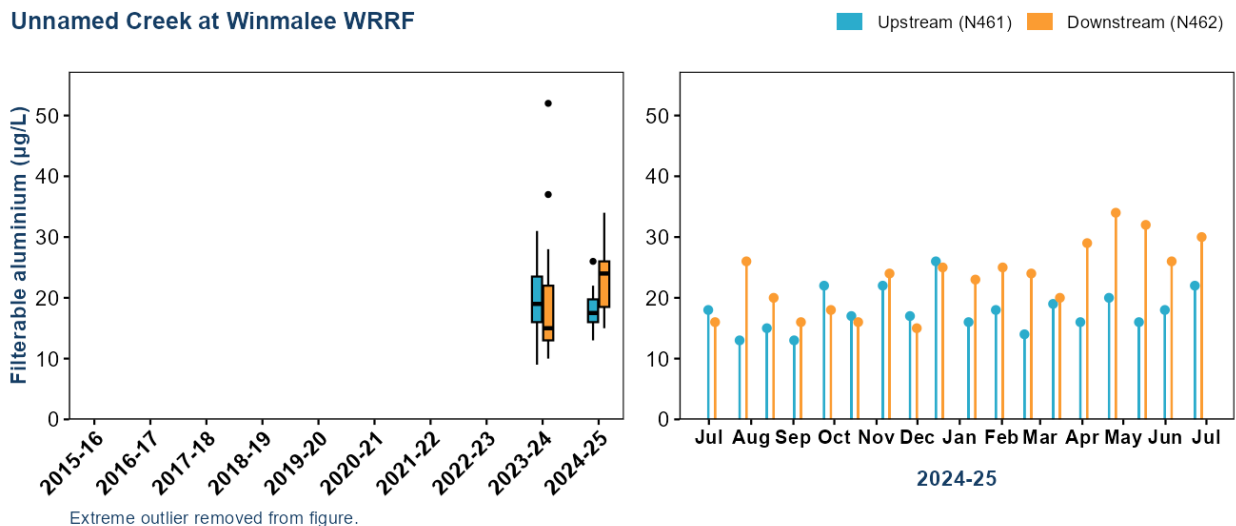


Nepean River at Winmalee WRRF

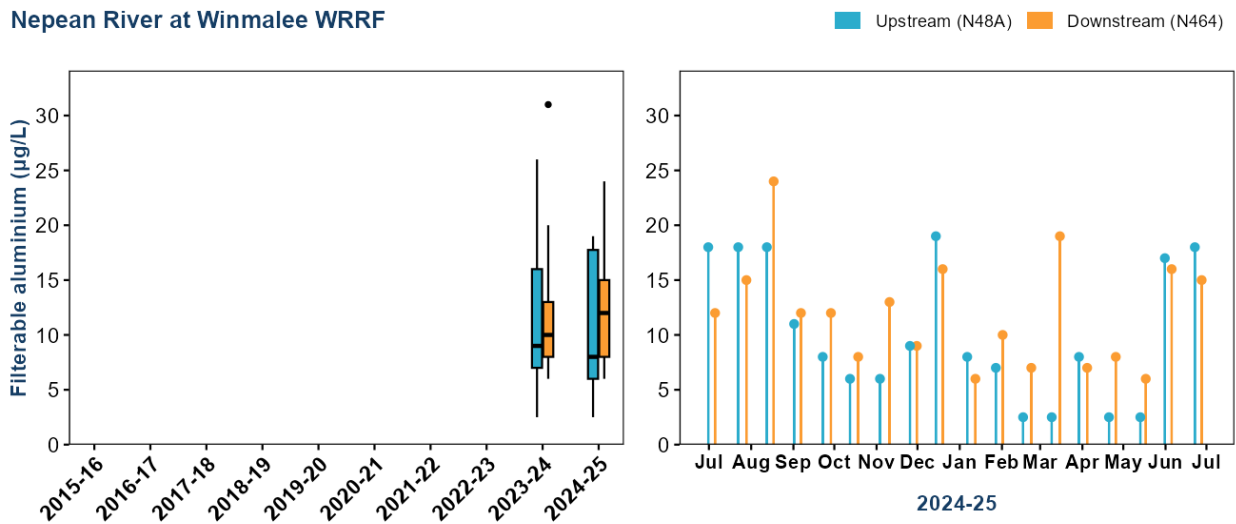


A.5.8. Stressor – Trace metals

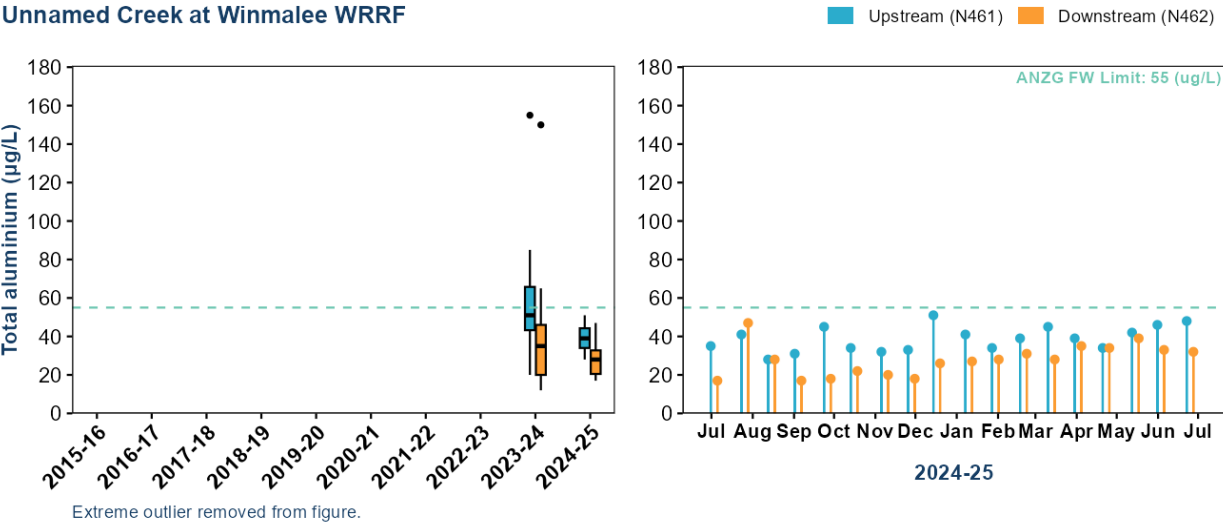
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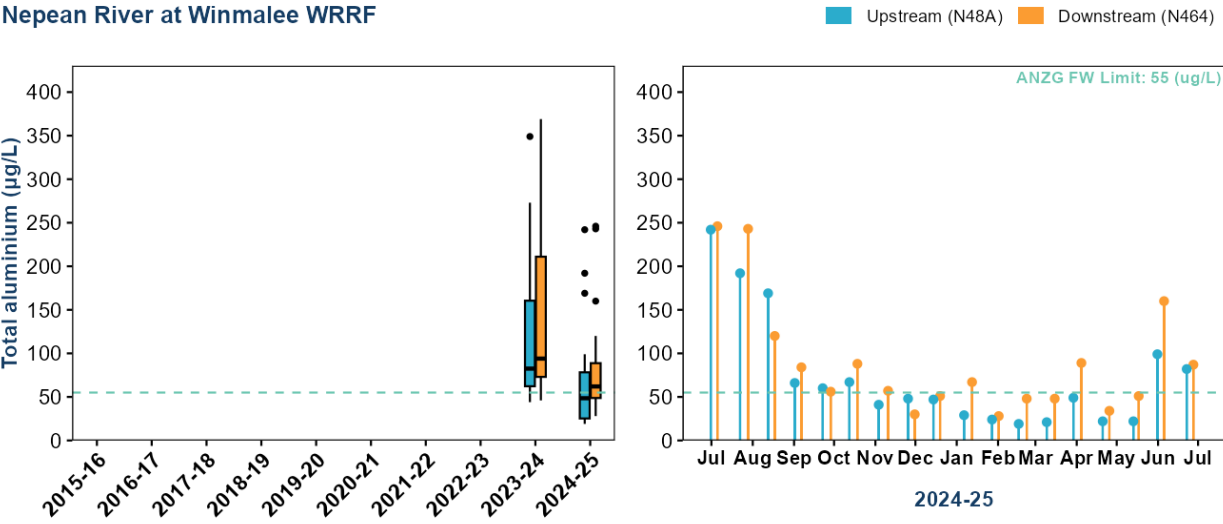
Nepean River at Winmalee WRRF



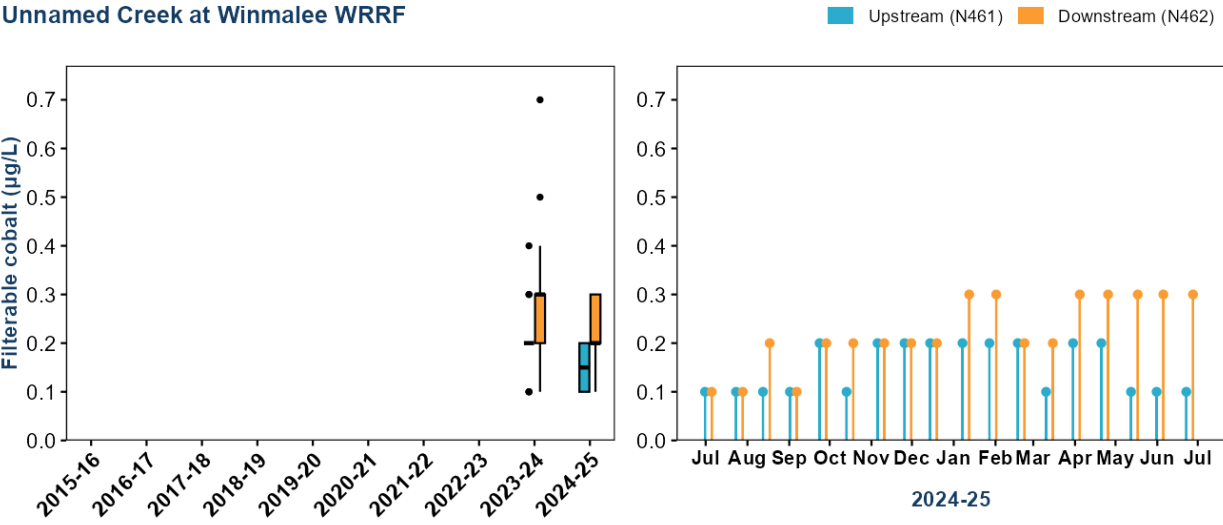
Unnamed Creek at Winmalee WRRF



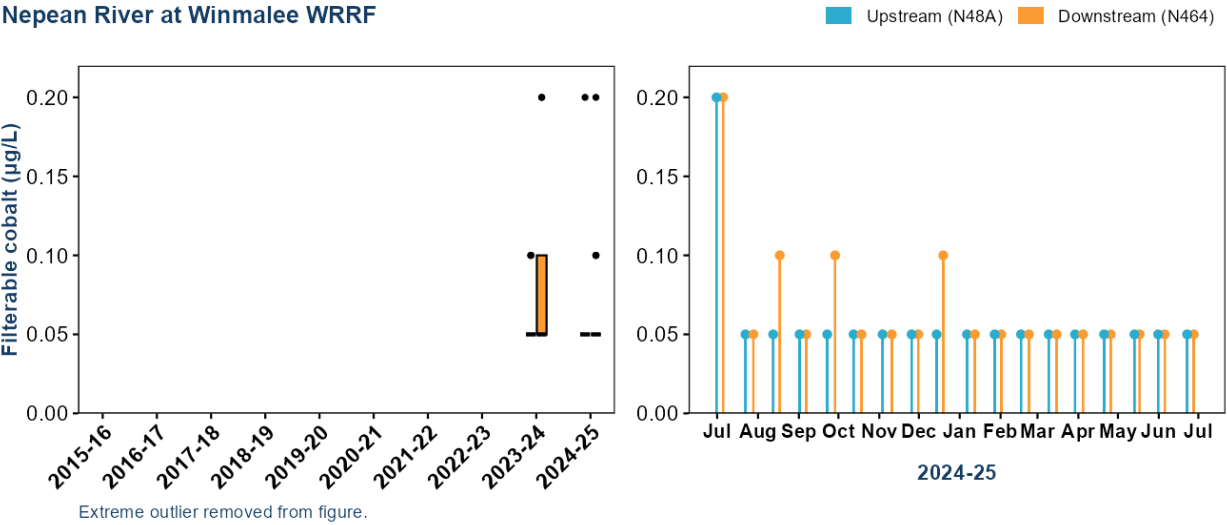
Nepean River at Winmalee WRRF



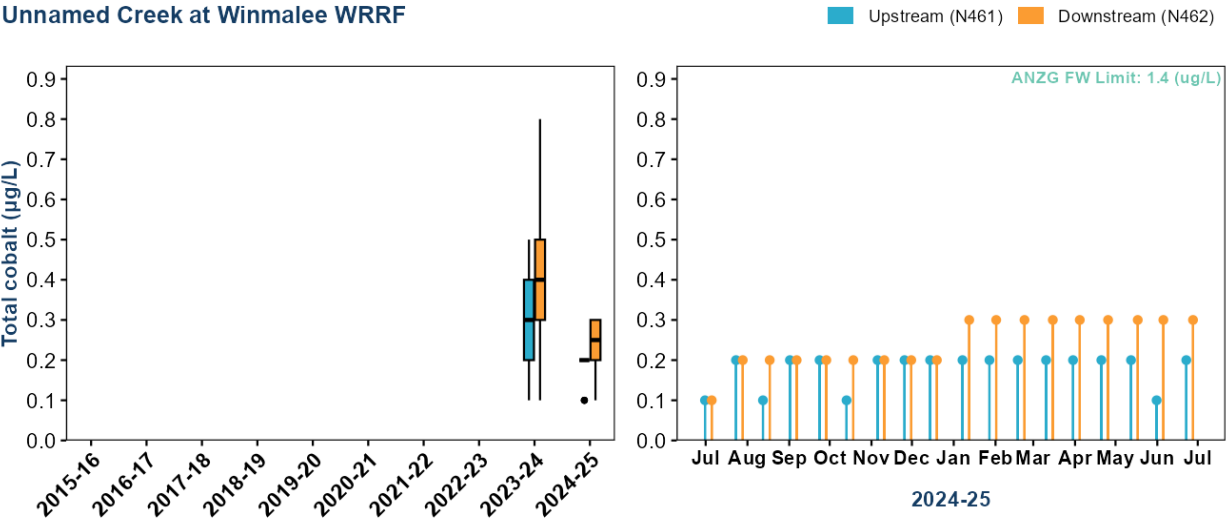
Unnamed Creek at Winmalee WRRF



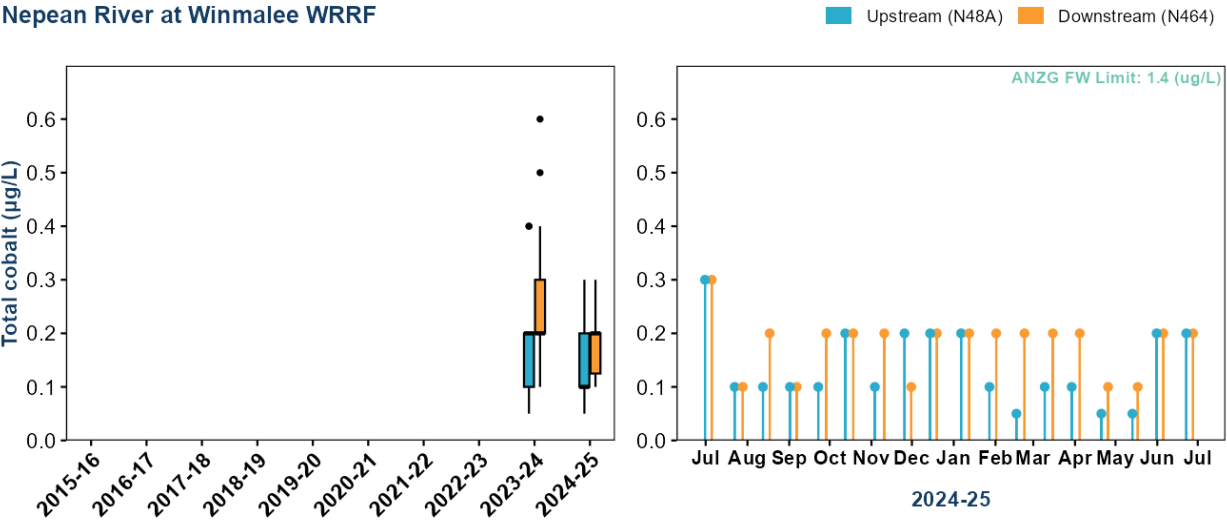
Nepean River at Winmalee WRRF



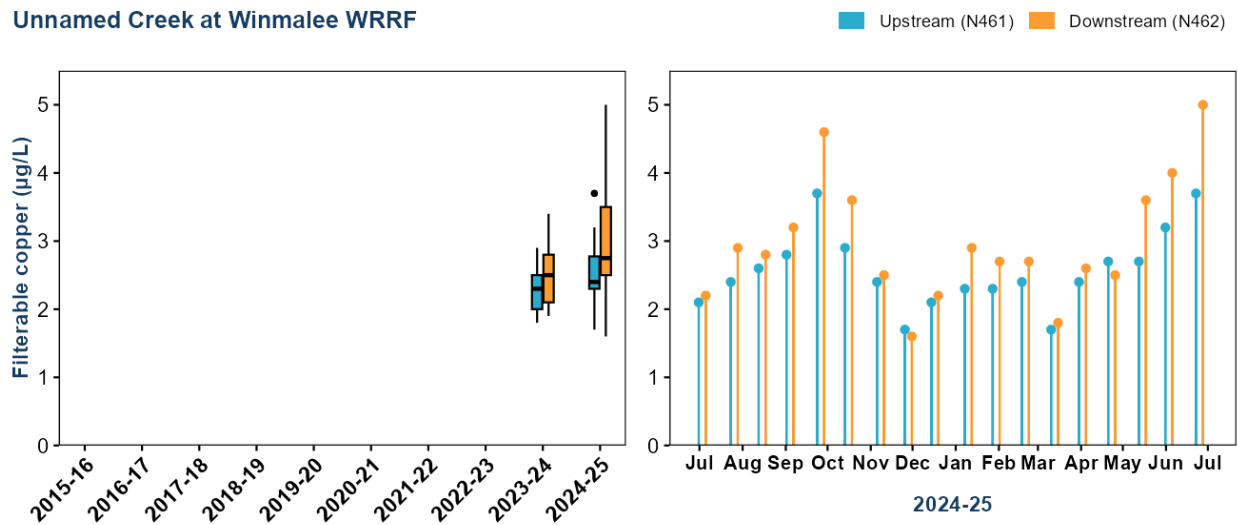
Unnamed Creek at Winmalee WRRF



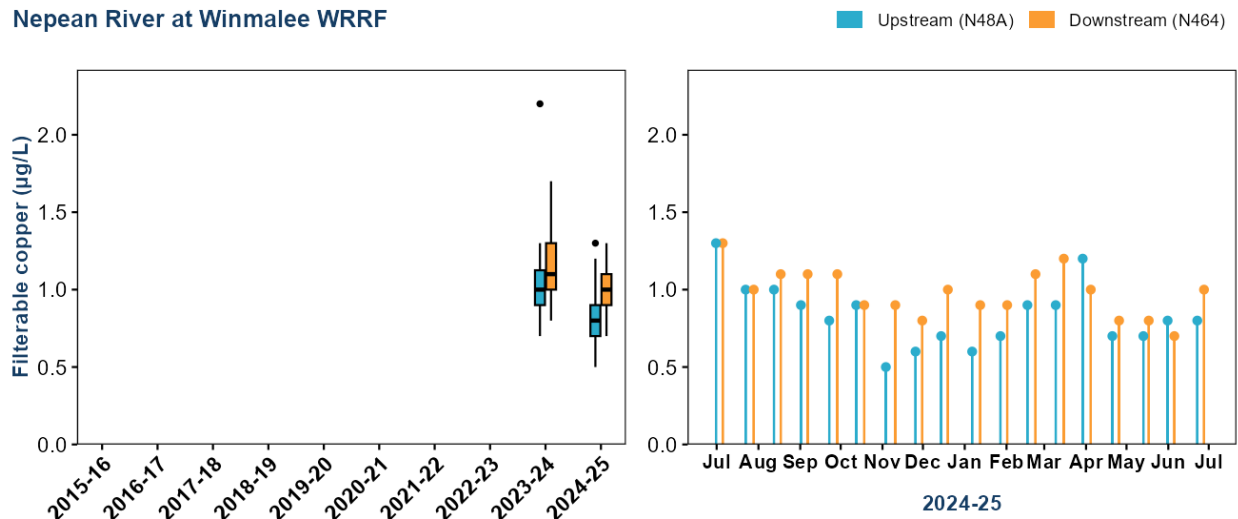
Nepean River at Winmalee WRRF



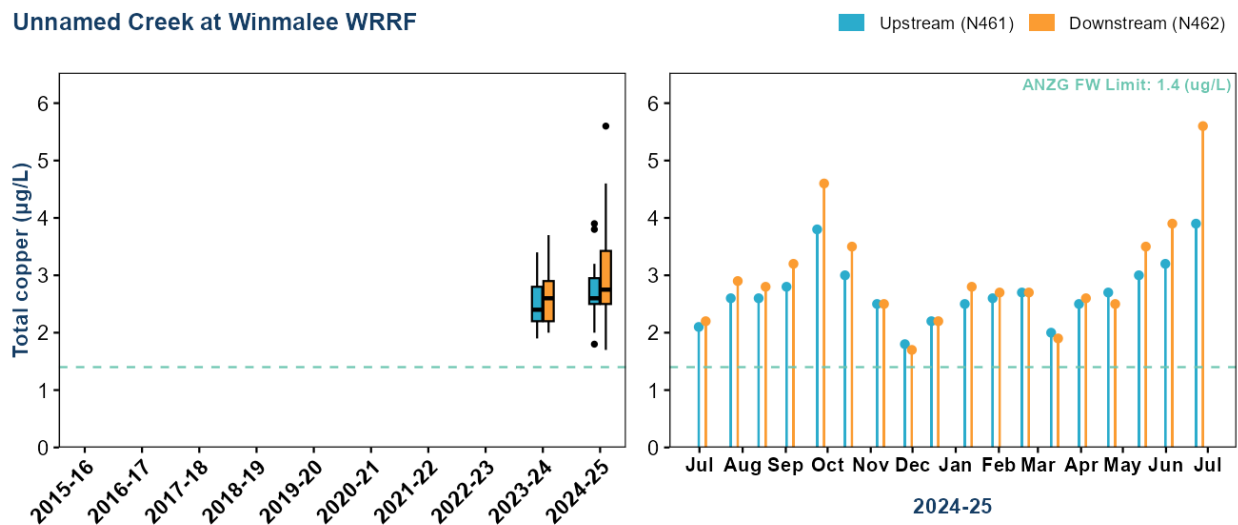
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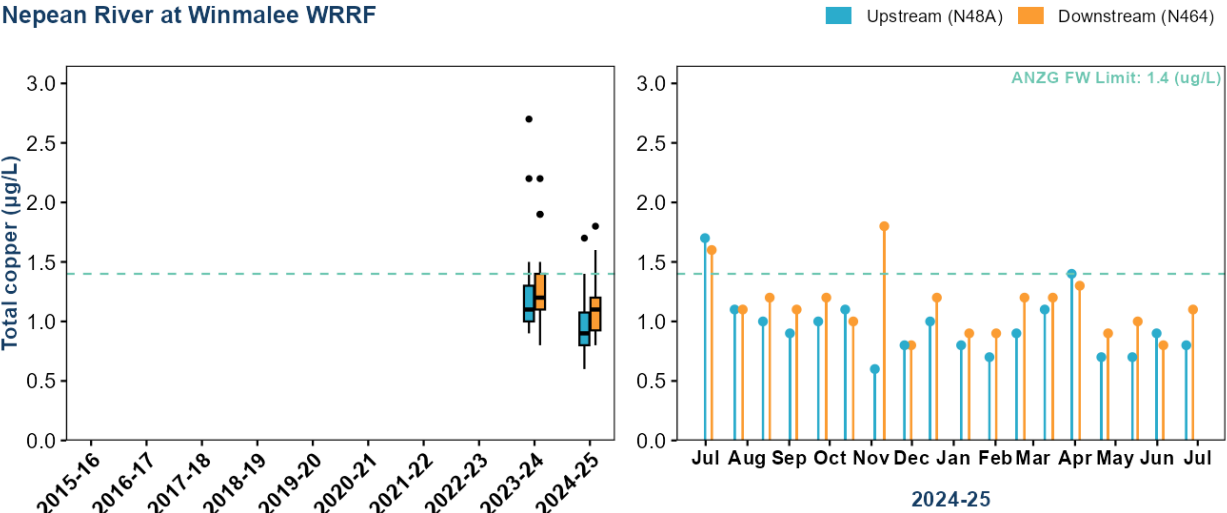
Nepean River at Winmalee WRRF



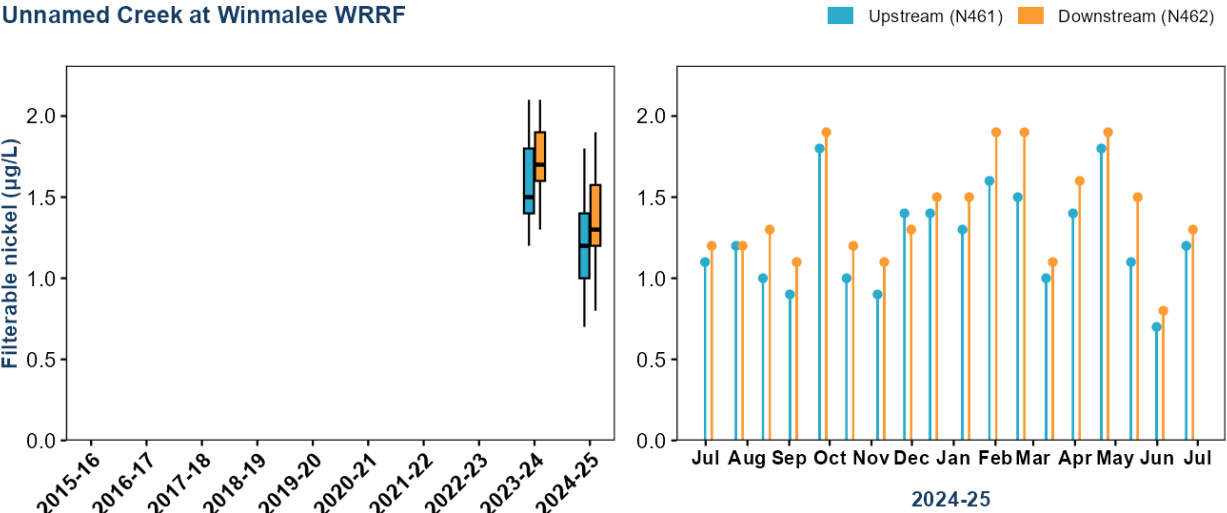
Unnamed Creek at Winmalee WRRF



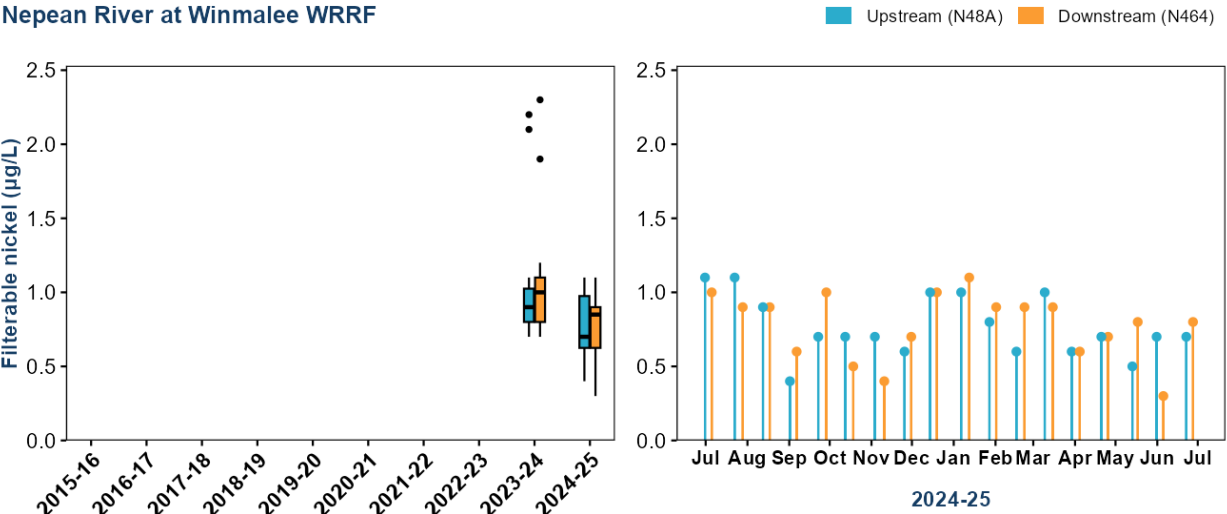
Nepean River at Winmalee WRRF



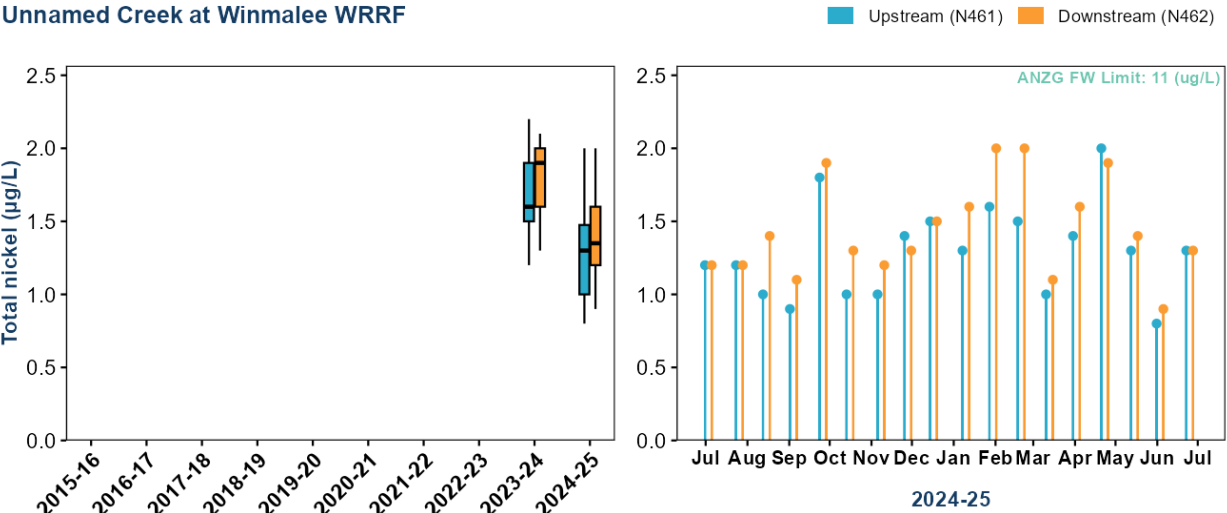
Unnamed Creek at Winmalee WRRF



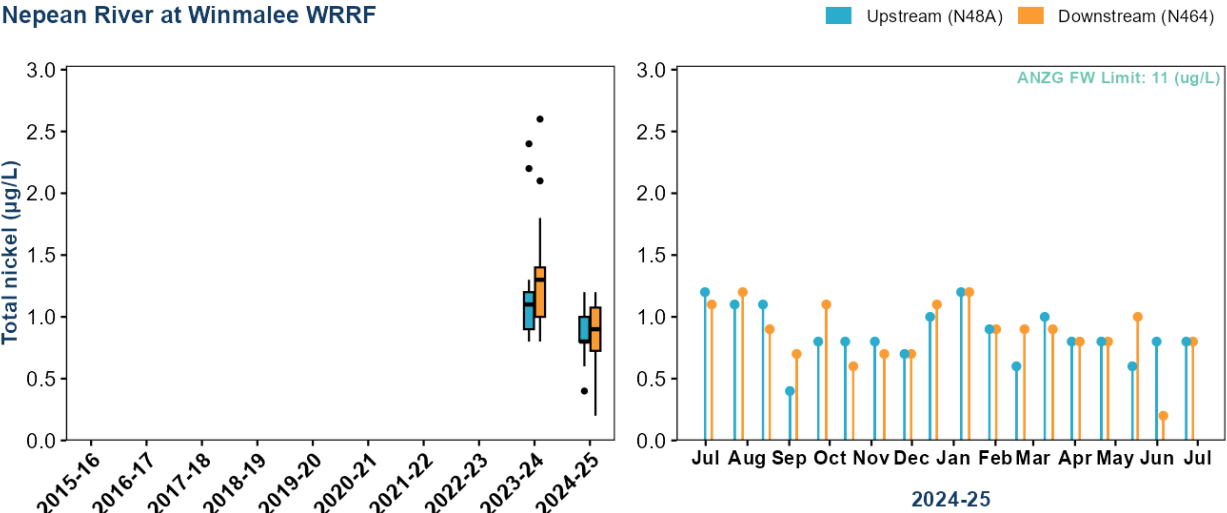
Nepean River at Winmalee WRRF



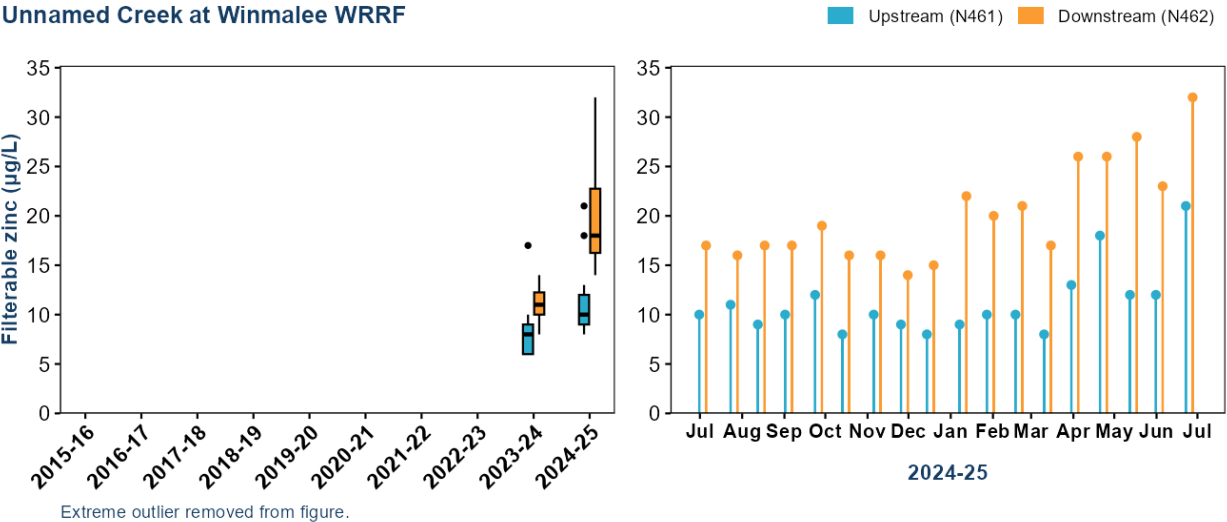
Unnamed Creek at Winmalee WRRF



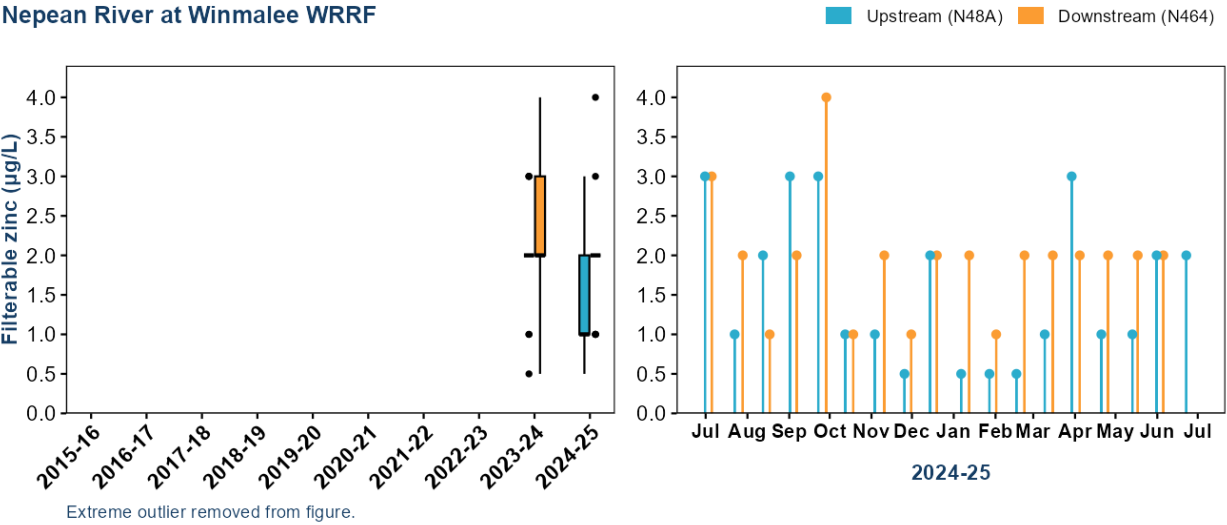
Nepean River at Winmalee WRRF



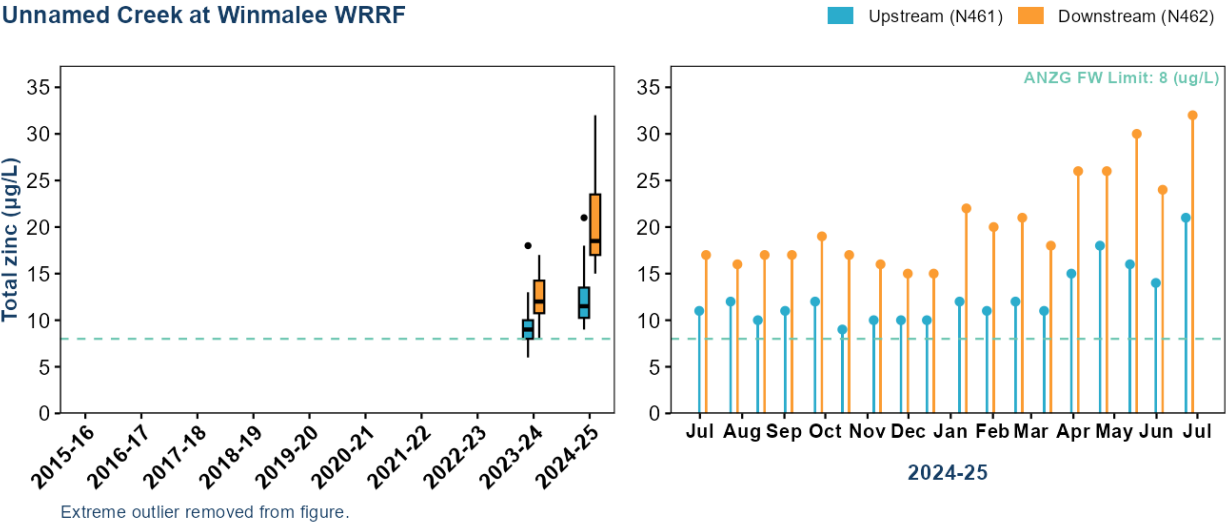
Unnamed Creek at Winmalee WRRF



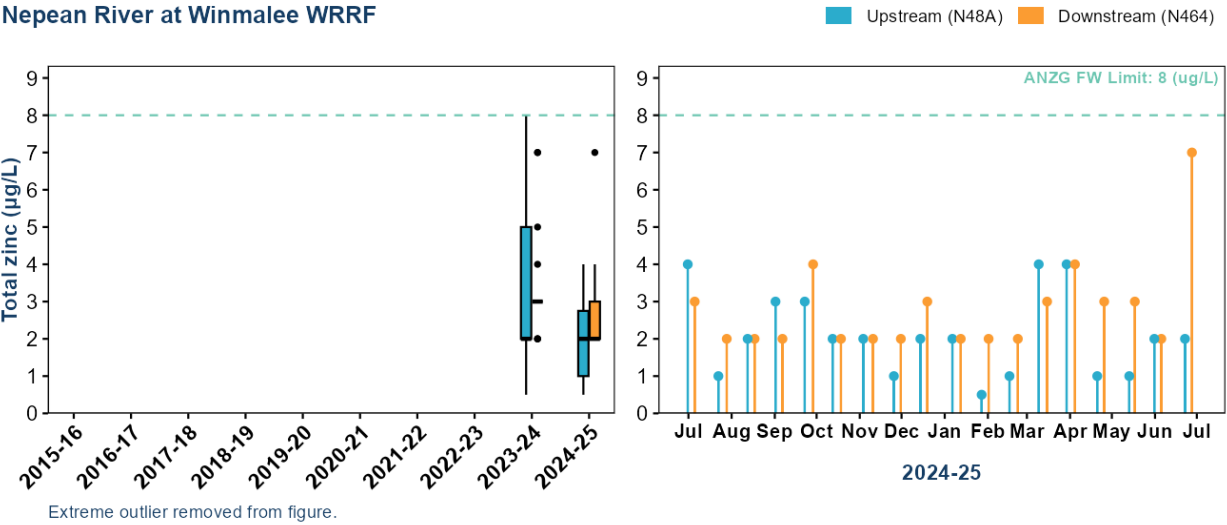
Nepean River at Winmalee WRRF



Unnamed Creek at Winmalee WRRF



Nepean River at Winmalee WRRF



A.5.9. Ecosystem receptor – Statistical analysis outcomes

Table A-49 Upstream vs downstream comparison (2024-25 reporting period) for the unnamed creek tributary at Winmalee WRRF

Unnamed Creek at Winmalee WRRF: N461 vs N462 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.84	0.49	64	2.29	0.112
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-50 Upstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at Winmalee WRRF

Unnamed Creek at Winmalee WRRF: N461 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.02	0.28	64	0.09	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-51 Downstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at Winmalee WRRF

Unnamed Creek at Winmalee WRRF: N462 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.85	0.23	64	-0.61	0.929
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-52 Upstream vs downstream comparison (2024-25 reporting period) for the Nepean River at Winmalee WRRF

Nepean River at Winmalee WRRF: N48A vs N464 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.02	0.24	304	0.10	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-53 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Winmalee WRRF

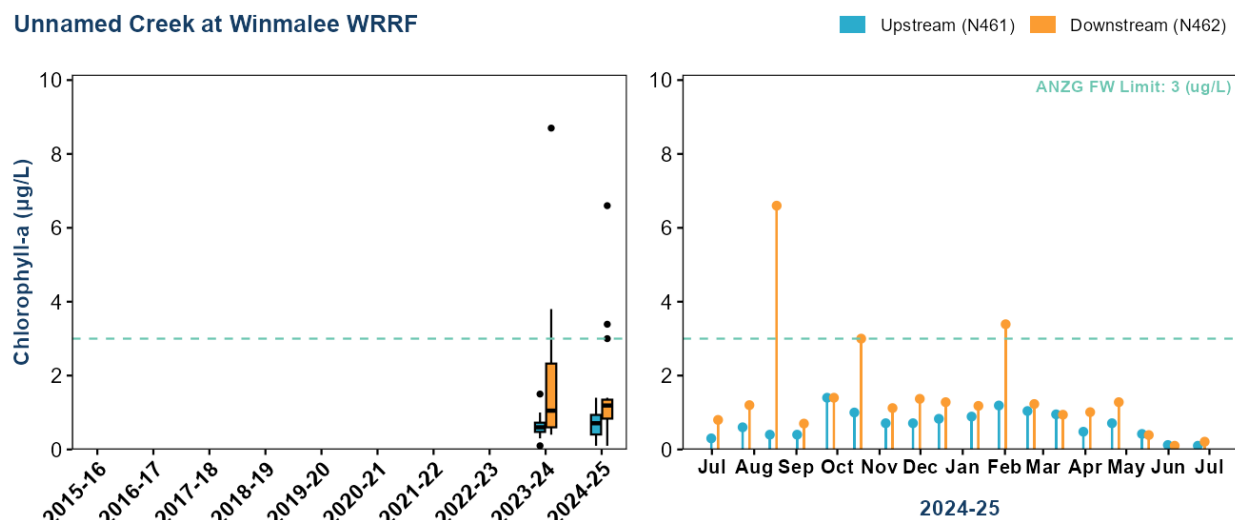
Nepean River at Winmalee WRRF: N48A (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.92	0.16	304	-0.49	0.960
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-54 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at Winmalee WRRF

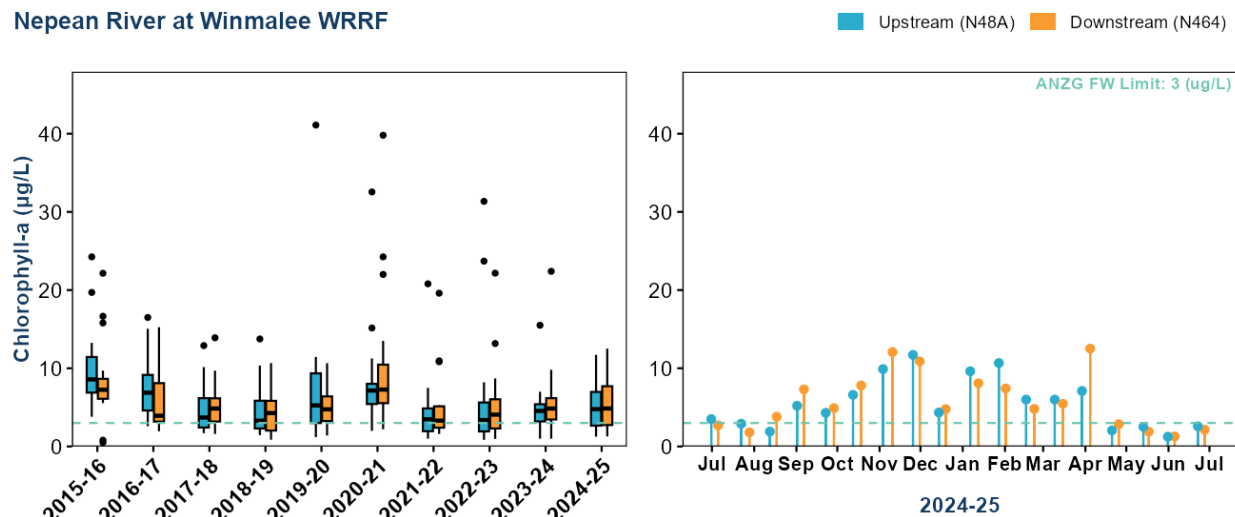
Nepean River at Winmalee WRRF: N464 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.98	0.17	304	-0.12	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.5.10. Ecosystem receptor – Phytoplankton

Unnamed Creek at Winmalee WRRF



Nepean River at Winmalee WRRF

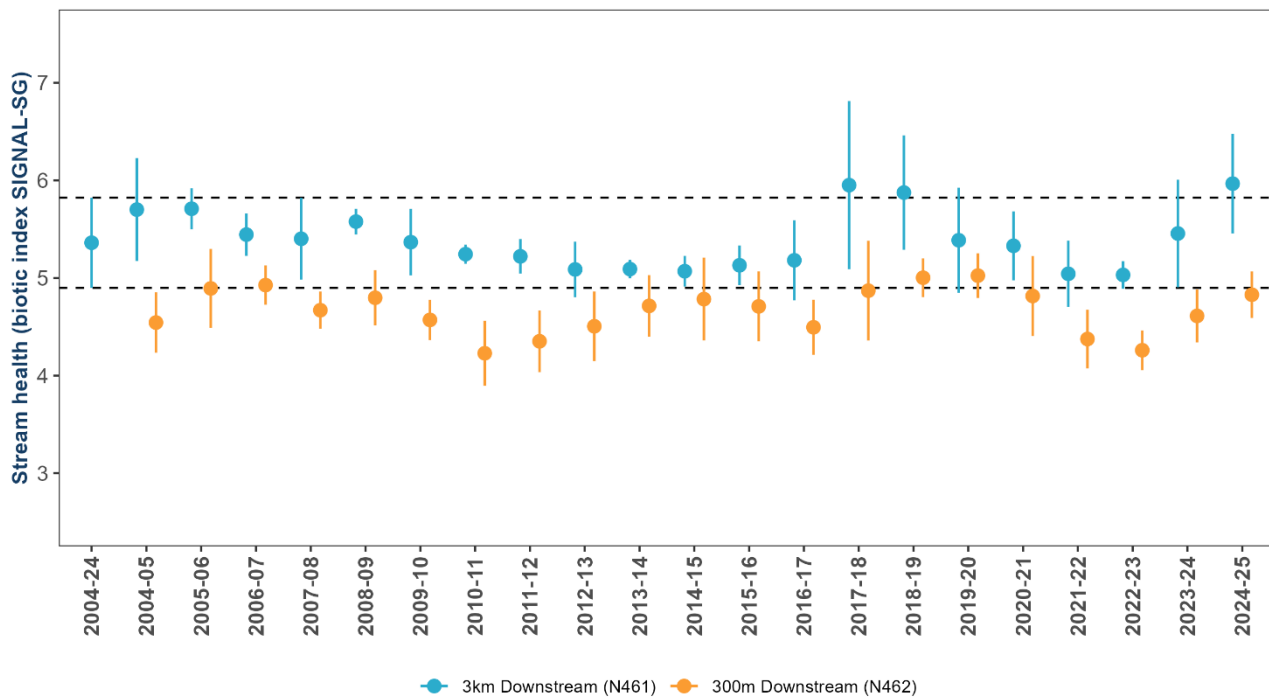


A.5.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Unnamed Creek	Tributary (N461 vs N462)	Welch Two Sample t-test	1.14	4.94	7.1	0.002
Nepean River	River (N48A vs N44)	Welch Two Sample t-test	-0.09	-0.35	7.5	0.737

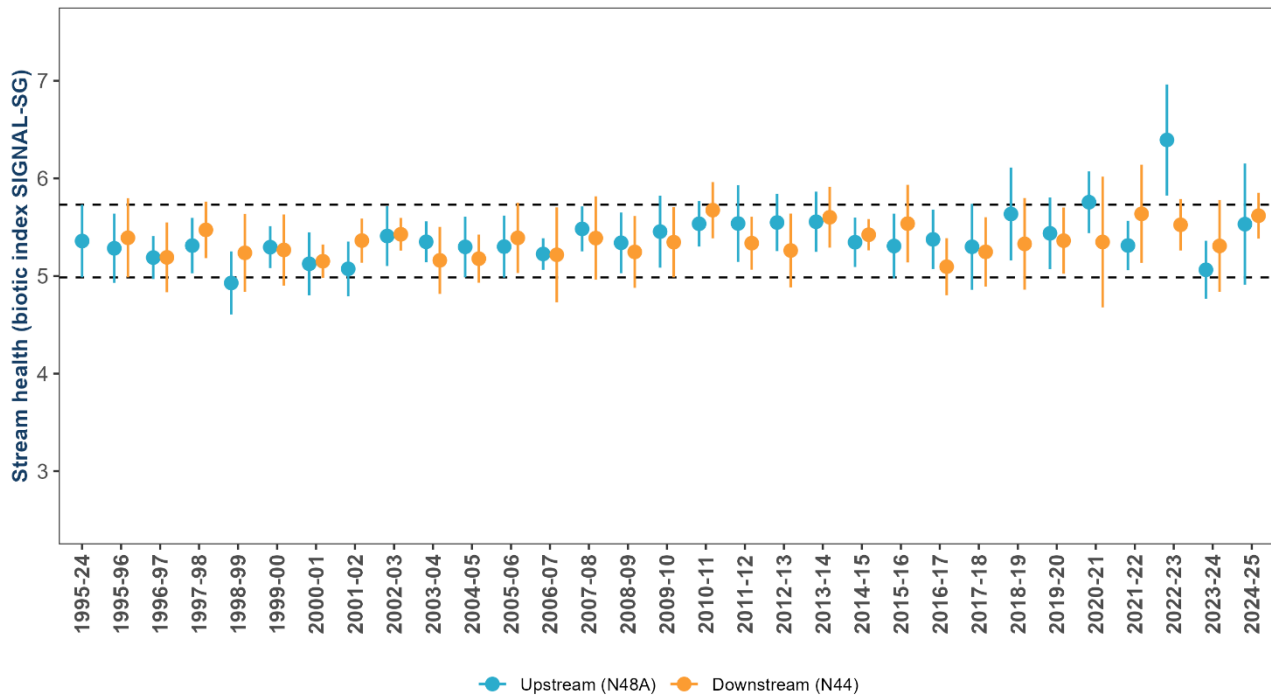
not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Unnamed Creek at Winmalee WRRF



The range of stream health recorded over each period is represented by length of line

Nepean River at Winmalee WRRF



The range of stream health recorded over each period is represented by length of line

A.5.12. Gate 3 investigation for Winmalee WRRF

The gate 2 synthesis identified that the ecosystem health in terms of macroinvertebrates has remained impacted downstream in the unnamed creek, resembling previous years. Increased zinc concentrations in the Winmalee WRRF discharge were reflected with elevated levels in the downstream receiving waters of the unnamed creek compared to previous years. The gate 3 analysis focused on investigating the potential influences of the impacted stream health at downstream site of the unnamed creek as indicated by the macroinvertebrate (SIGNAL-SG) score.

Stage 1: Multivariate analysis of macroinvertebrate community data

Sampling in the unnamed creek covered the period from 2004 to 2025 for both edge and riffle habitats, and from 1995 to 2025 for the Nepean River edge habitat, allowing for both spatial and temporal comparisons to be made for all reaches.

Visual ordination patterns (nMDS and cluster diagrams, Figure A-1 to Figure A-3) suggested clear site separation between upstream and downstream sites in the unnamed creek, with the strongest clustering and separation evident at the edge habitat relative to the riffle habitat. Separations could not be discerned visually for the Nepean River edge sites.

Multivariate statistical results are summarised in Table A-55 for the unnamed creek and Table A-56 for the Nepean River. PERMDISP analysis for all habitats across the unnamed creek and Nepean River reaches returned non-significant outcomes, indicating similar dispersion within individual sites. This enables interpretation of between-site differences without confounding variability. In the unnamed creek, ANOSIM tests were significant for both site and site-period combinations. R values for 'site' tests (0.539 and 0.470) and 'site-period' tests (0.566 and 0.495) for edge and riffle



habitats were all in the mid-range, suggesting a moderate level of dissimilarity. Pairwise comparisons (Table A-57) confirmed separation between upstream and downstream locations across time, particularly between the sites in the current 2023-2025 period (edge: 0.720; riffle: 0.606), suggesting stronger differences in taxonomic assemblages between these sites in recent years relative to what was observed historically. Pairwise ANOSIM tests for the Nepean River (Table A-58) showed greater levels of similarity between sites both recently and historically, with R values ranging from 0.097 to 0.303.

PERMANOVA results for the unnamed creek habitats further support these findings, with a significant site-year interaction observed in the edge habitat, suggesting a difference between sites as well as a change through time. Conversely, the site-year interaction in the riffle habitat was non-significant, allowing interpretation of individual factors of 'site' and 'year', which both suggested significant differences. Estimates of components of variation indicate that site effects dominate at both habitats (edge: 644.44; riffle: 582.5) (Table A-59). PERMANOVA results for the Nepean River do suggest significant site and year differences, however estimates of components of variation indicate that the greatest contributing factor was 'year', suggesting a temporal change.

Shade plots for the unnamed creek (Figure A-7 and Figure A-8) 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 *Parametrioctenemys* 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 outcomes (Table A-60) identified 29 and 23 taxon for the edge and riffle habitats respectively, which formed the main visual patterns in their respective shade plots. Conversely, taxonomic assemblage appeared similar between Nepean River sites.

These multivariate analysis results suggested alteration of taxonomic assemblage from wastewater discharge in the unnamed creek and was most evident in within the edge habitat. These impacts appear to be localised within the unnamed creek and do not appear to extend to the Nepean River.

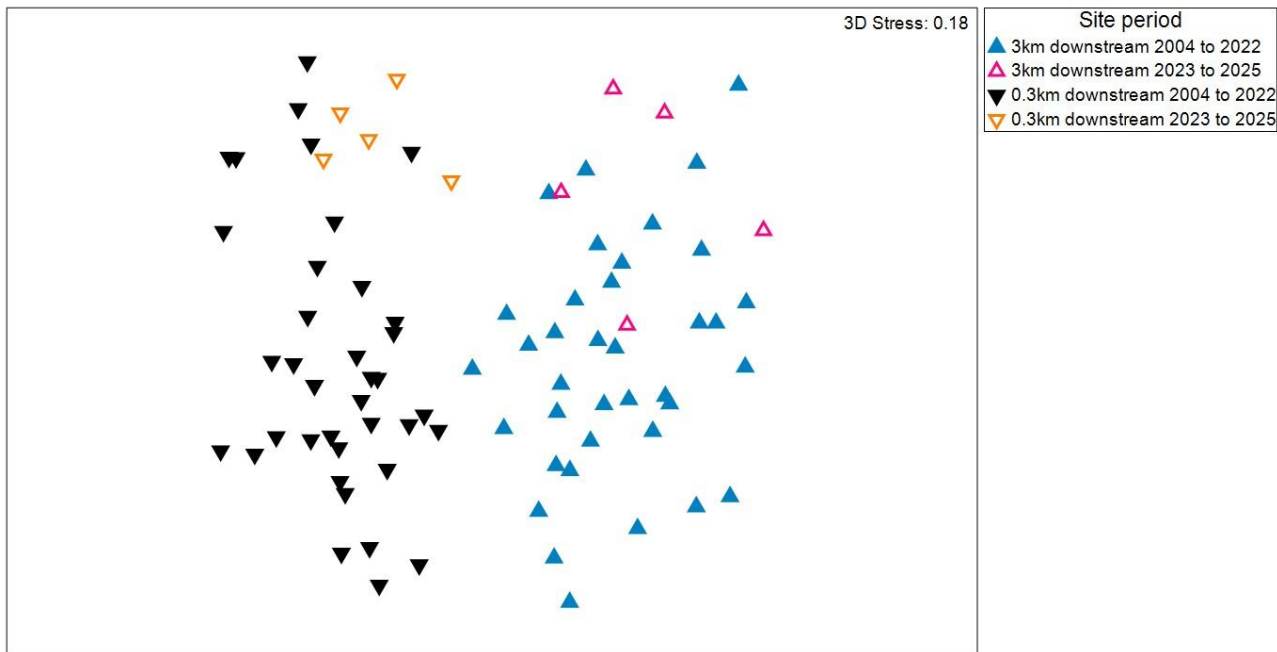


Figure A-1 Dimensions 1 and 2 of 2-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of proxy upstream and downstream sites in the unnamed creek near Winmalee WRRF

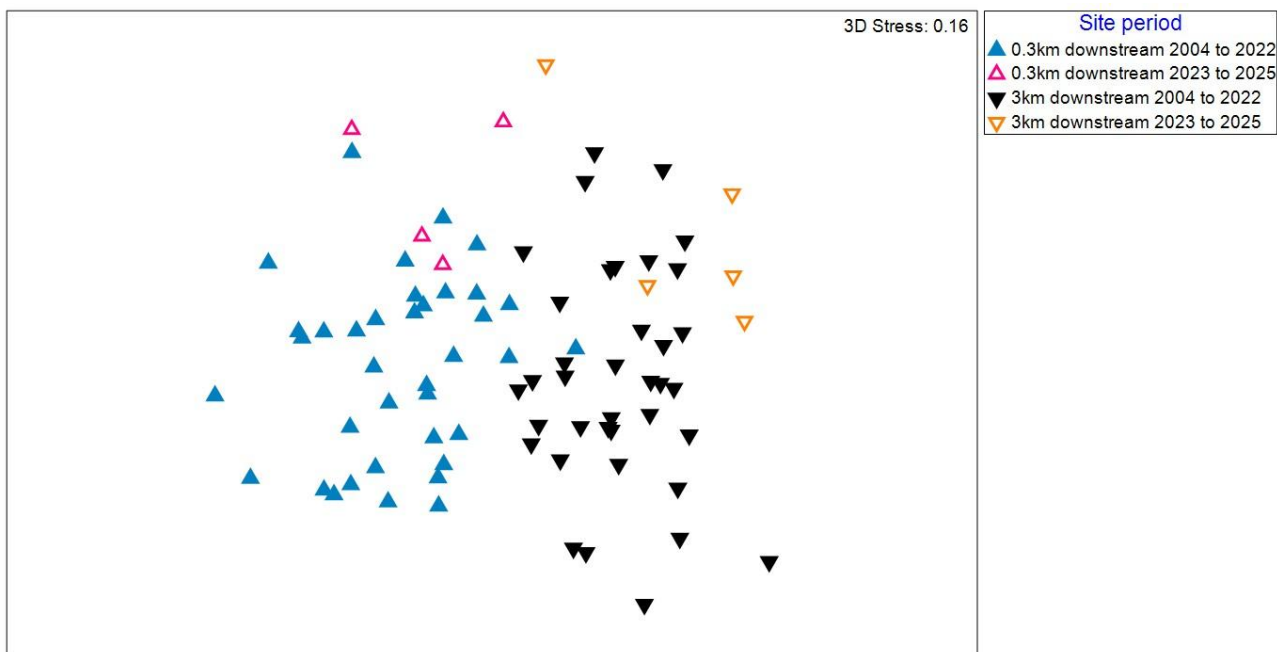


Figure A-2 Dimensions 1 and 2 of 2-dimensional ordination plot of freshwater macroinvertebrate riffle habitat community structure of proxy upstream and downstream sites in the unnamed creek near Winmalee WRRF

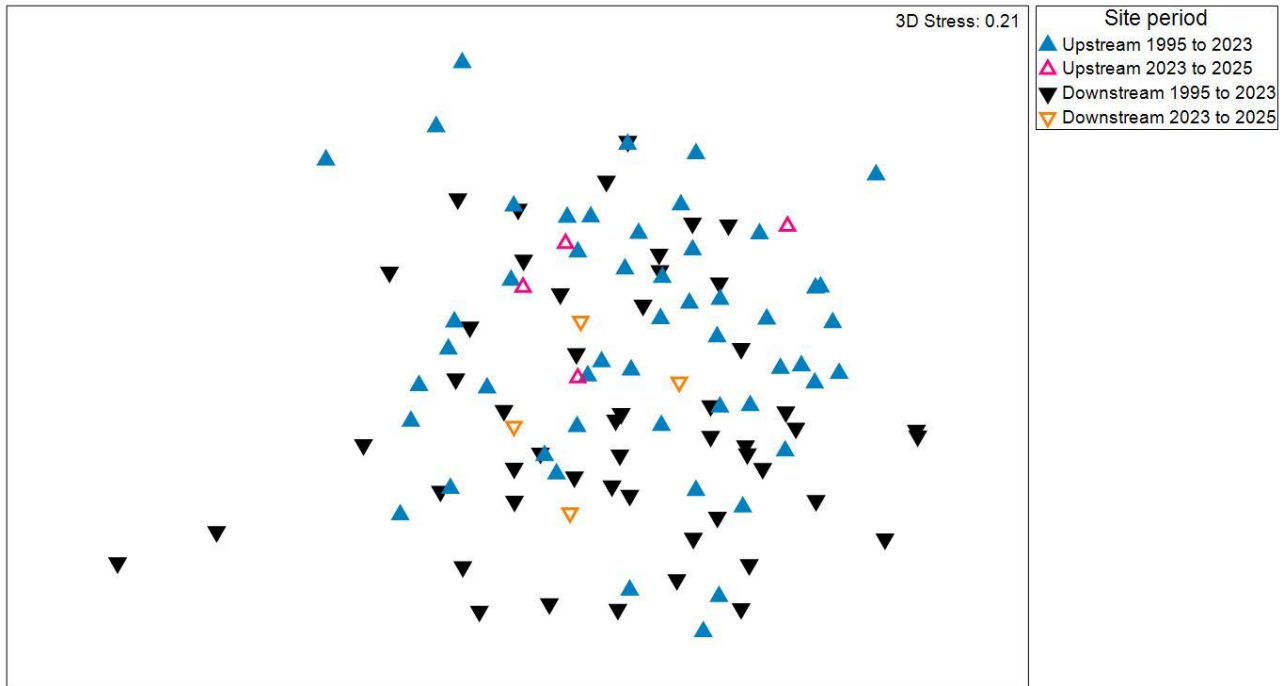


Figure A-3 Dimensions 1 and 2 of 2-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites in the Nepean River near Winmalee WRRF

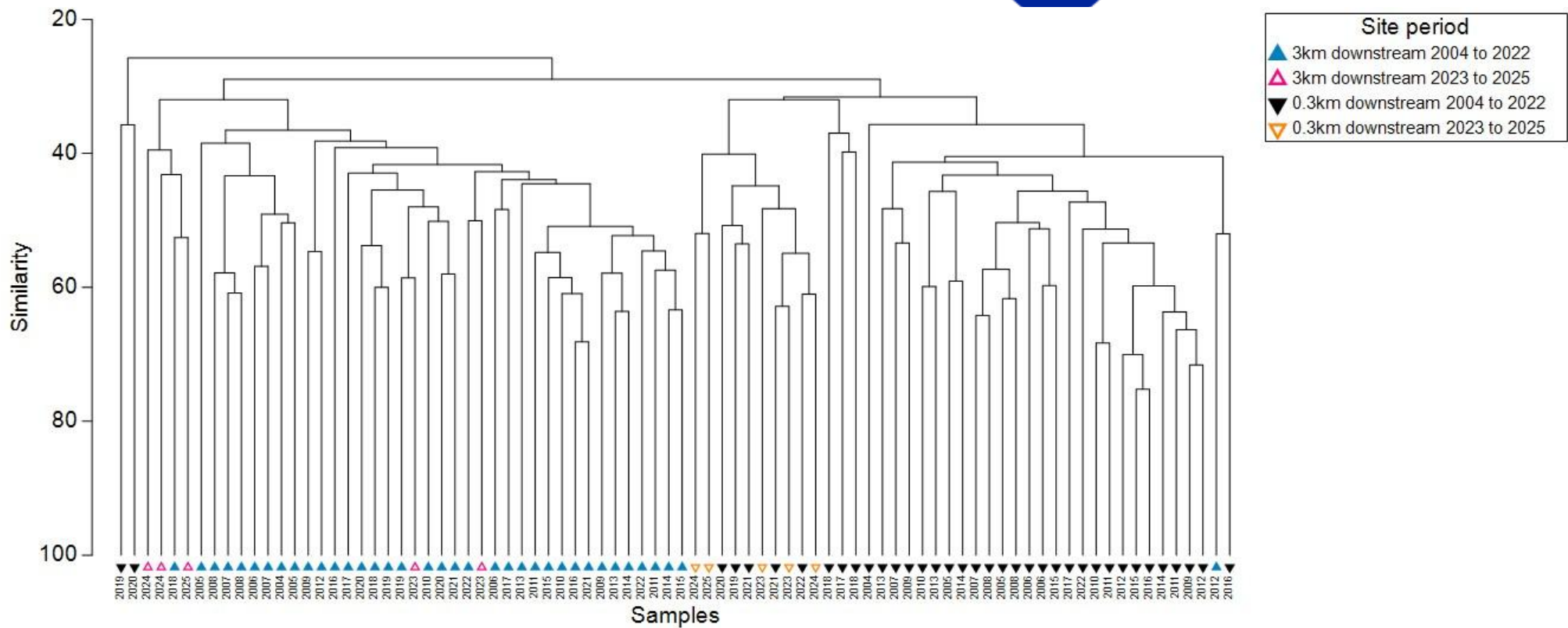


Figure A-4 Cluster diagram of freshwater macroinvertebrate edge habitat community structure of proxy upstream and downstream sites in the unnamed creek near Winmalee WRRF

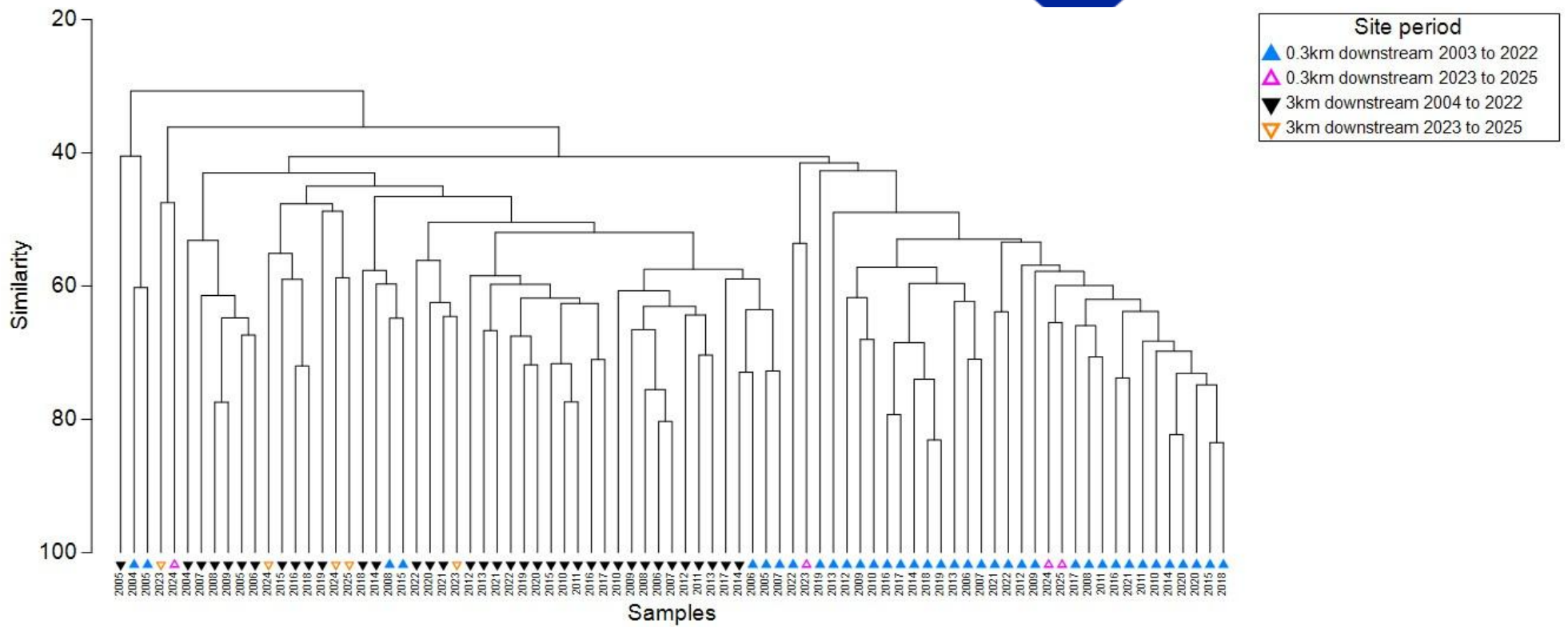


Figure A-5 Cluster diagram of freshwater macroinvertebrate riffle habitat community structure of proxy upstream and downstream sites in the unnamed creek near Winmalee WRRF

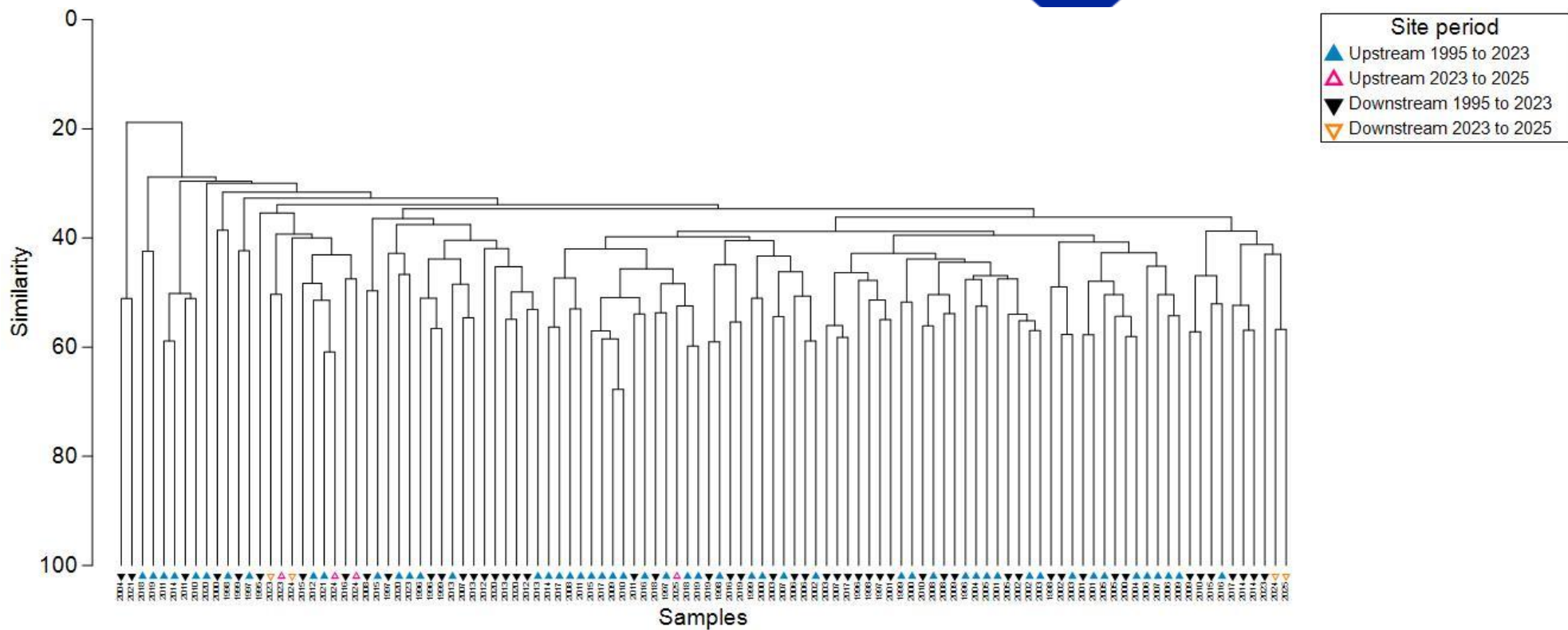


Figure A-6 Cluster diagram of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites in the Nepean River near Winmalee WRRF

Table A-55 Macroinvertebrate multivariate statistical test summary for the unnamed creek near Winmalee WRRF

Winmalee Unnamed Creek		Edge			Riffle		
		df	Sample Statistic (Pseudo-F/R)	p-value	df	Sample Statistic (Pseudo-F/R)	p-value
PERMDISP	Site	1 (82)	0.801	0.3987	1 (81)	0.838	0.3917
ANOSIM	Site	-	0.539	<0.001	-	0.470	<0.001
	SitexPeriod	-	0.566	<0.001	-	0.495	<0.001
PERMANOVA	Site	1 (83)	18.910	<0.001	1 (82)	20.909	<0.001
	Year	21 (83)	2.071	<0.001	21 (82)	1.677	<0.001
	SitexYear	21 (83)	1.234	0.0092	21 (82)	0.964	0.6158

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-56 Macroinvertebrate multivariate statistical test summary for the Nepean River near Winmalee WRRF

Winmalee Nepean River		Edge		
		df	Sample Statistic (Pseudo-F/R)	p-value
PERMDISP	Site	1 (108)	0.038	0.8548
ANOSIM	Site	-	0.084	<0.001
	SitexPeriod	-	0.134	<0.001
PERMANOVA	Site	1 (109)	3.473	<0.001
	Year	29 (109)	1.735	<0.001
	SitexYear	28 (109)	1.052	0.2198

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-57 ANOSIM pairwise comparisons of 'Site period' test for edge and riffle habitats for the unnamed creek near Winmalee WRRF

Winmalee Unnamed Creek		Edge		Riffle	
		R Statistic	p-value	R Statistic	p-value
3km downstream 2004 to 2022, 0.3km downstream 2004 to 2022		0.571	<0.001	0.491	<0.001
3km downstream 2004 to 2022, 3km downstream 2023 to 2025		0.271	0.024	0.345	0.009
3km downstream 2004 to 2022, 0.3km downstream 2023 to 2025		0.766	<0.001	0.566	0.0003
0.3km downstream 2004 to 2022, 3km downstream 2023 to 2025		0.712	<0.001	0.745	<0.001
0.3km downstream 2004 to 2022, 0.3km downstream 2023 to 2025		0.459	0.001	0.307	0.048
3km downstream 2023 to 2025, 0.3km downstream 2023 to 2025		0.720	0.008	0.606	0.016

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-58 ANOSIM pairwise comparisons of 'Site period' test for the edge habitat for the Nepean River near Winmalee WRRF

Winmalee Nepean River	Edge	
	R Statistic	p-value
Downstream 1995 to 2022, Upstream 1995 to 2022	0.097	<0.001
Downstream 1995 to 2022, Downstream 2022 to 2025	0.195	0.064
Downstream 1995 to 2022, Upstream 2022 to 2025	0.171	0.098
Upstream 1995 to 2022, Downstream 2022 to 2025	0.303	0.009
Upstream 1995 to 2022, Upstream 2022 to 2025	0.232	0.034
Downstream 2022 to 2025, Upstream 2022 to 2025	0.156	0.135

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-59 Estimates of components of variation from PERMANOVA tests for the unnamed creek and Nepean River habitats

Winmalee Unnamed Creek	Edge	Riffle	Winmalee Nepean River	Edge
S(Site)	644.44	582.5	S(Site)	82.336
S(Year)	407.64	208.58	S(Year)	349.1
S(SitexYear)	177.98	-22.04	S(SitexYear)	48.471
V(Res)	1451.3	1156	V(Res)	1722.8

Table A-60 Genera subset whose multivariate pattern matches full genera set of the habitats for the unnamed creek and the Nepean River near Winmalee WRRF

The unnamed creek edge

Subset of 29 (correlation 0.956) genera from the unnamed creek edge habitat whose pattern matches that of the full set of 147 genera identified with the same subset found on 33 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Chironomus, Physidae Physella, Chironomidae Cricotopus, Dugesidae Cura, Lumbriculidae Lumbriculus, Lymnaeidae Pseudosuccinea, 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, Leptoceridae Triplectides, Tateidae Posticobia

The unnamed creek riffle

Subset of 23 (correlation 0.951) genera from the unnamed creek riffle habitat whose pattern matches that of the full set of 68 genera identified with the same subset found on 3 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Coenagrionidae Ischnura, Physidae Physella, Chironomidae Cardiocladius, Chironomidae Cricotopus, Dugesidae Cura, Naididae Nais, Simuliidae Simulium, Atyidae Australatya, Chironomidae Eukiefferiella, Chironomidae Microtendipes, Chironomidae Polypedilum, Chironomidae Rheocricotopus, Chironomidae Rheotanytarsus, Chironomidae Thienemanniella, Hydropsychidae Cheumatopsyche, Scyphacidae Haloniscus, Tateidae Potamopyrgus, Elmidae Notriolus, Elmidae Simsonia, Aeshnidae Austroaeschna, Chironomidae Parametriocnemus, Crambidae Margarosticha, Tateidae Posticobia

Nepean River edge

Subset of 64 (correlation 0.942) genera from Nepean River edge habitat whose pattern matches that of the full set of 154 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 Chironomus, Chironomidae Xenochironomus, Coenagrionidae Ischnura, Physidae Physella, Planorbidae Helicorbis, Belostomatidae Diplonychus, Chironomidae Cardiocladius, Chironomidae Cricotopus, Chironomidae Cryptochironomus, Chironomidae Dicrotendipes, Coenagrionidae Austroagrion, Corbiculidae Corbicula, Dugesidae Cura, Glossiphoniidae Helobdella, Lumbriculidae Lumbriculus, Lymnaeidae Pseudosuccinea, Naididae Nais, Naucoridae Naucoris, Planorbidae Ferrissia, Planorbidae Gyraulus, Platycnemididae Nososticta, Simuliidae Simulium, Chironomidae Cladotanytarsus, Chironomidae Microtendipes, Chironomidae Polypedilum, Chironomidae Rheocricotopus, Chironomidae Rheotanytarsus, Coenagrionidae Pseudagrion, Corduliidae Hemicordulia, Hydrophilidae Helochares, Hydropsychidae Cheumatopsyche, Isostictidae Rhadinosticta, Libellulidae Diplacodes, Libellulidae Nannophlebia, Limnesiidae Physolimnesia, Mesoveliidae Mesovelia, Atyidae Paratya, Baetidae Cloeon, Caenidae Tasmanocoenis, Ceratopogonidae Bezzia, Culicidae Anopheles, Ecnomidae Ecnomus, Elmidae Coxelmis, Hydroptilidae Hellyethira, Leptoceridae Notalina, Libellulidae Orthetrum, Micronectidae Micronecta, Notonectidae Enithares, Baetidae Offadens, Chironomidae Corynoneura, Chironomidae Paratanytarsus, Chironomidae Skusella, Hydrodromidae Hydrodroma, Hydrophilidae Berosus, Leptoceridae Oecetis, Unionicolidae Koenikea, Unionicolidae Recifella, Veliidae Microvelia, Calamoceratidae Anisocentropus, Chironomidae Ablabesmyia, Chironomidae Larsia, Chironomidae Tanytarsus, Dytiscidae Sternopriscus, Leptoceridae Triplectides

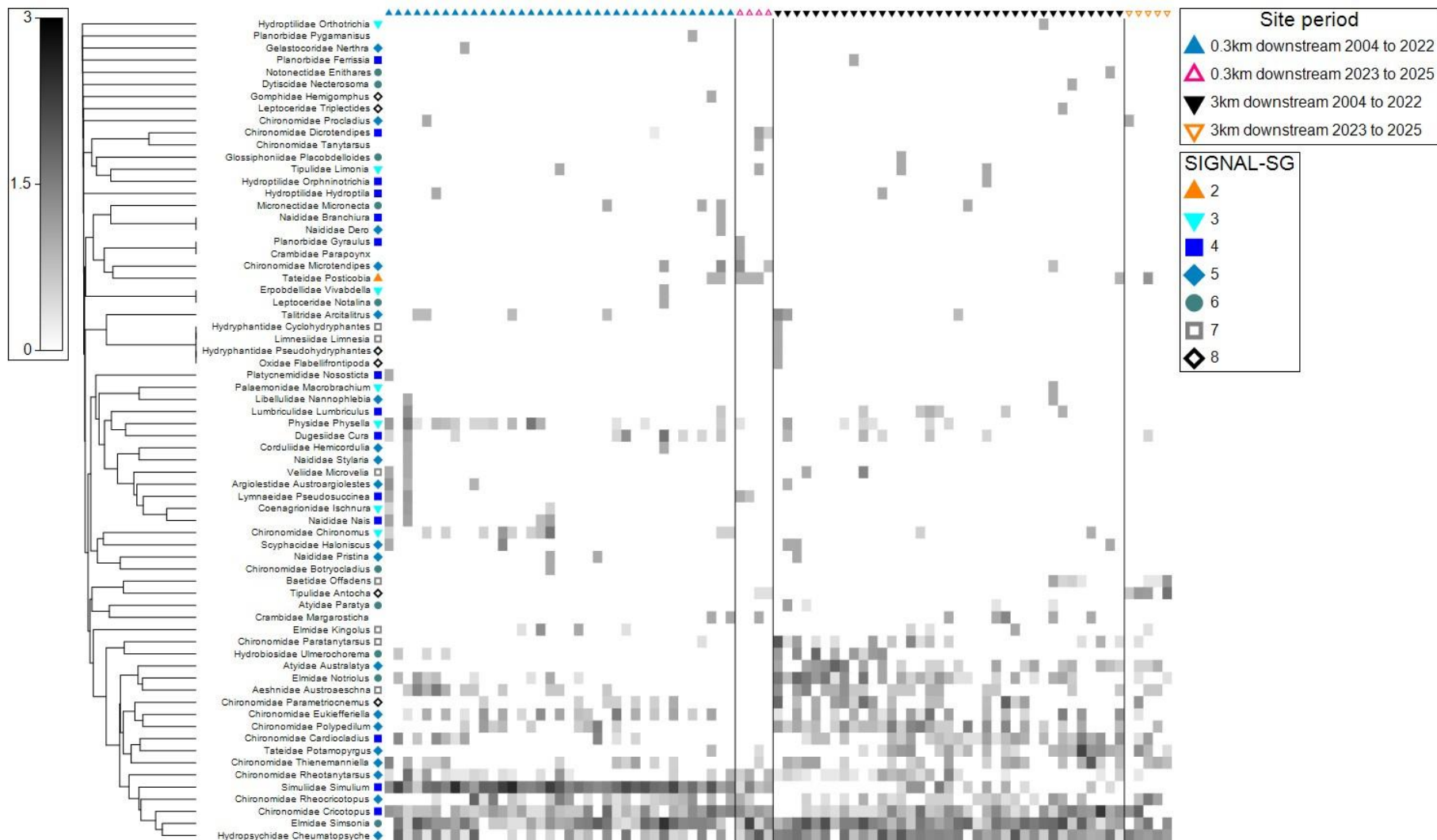


Figure A-8 Shade plot of freshwater macroinvertebrate riffle habitat community structure of proxy upstream and downstream sites in the unnamed creek near Winmalee WRRF

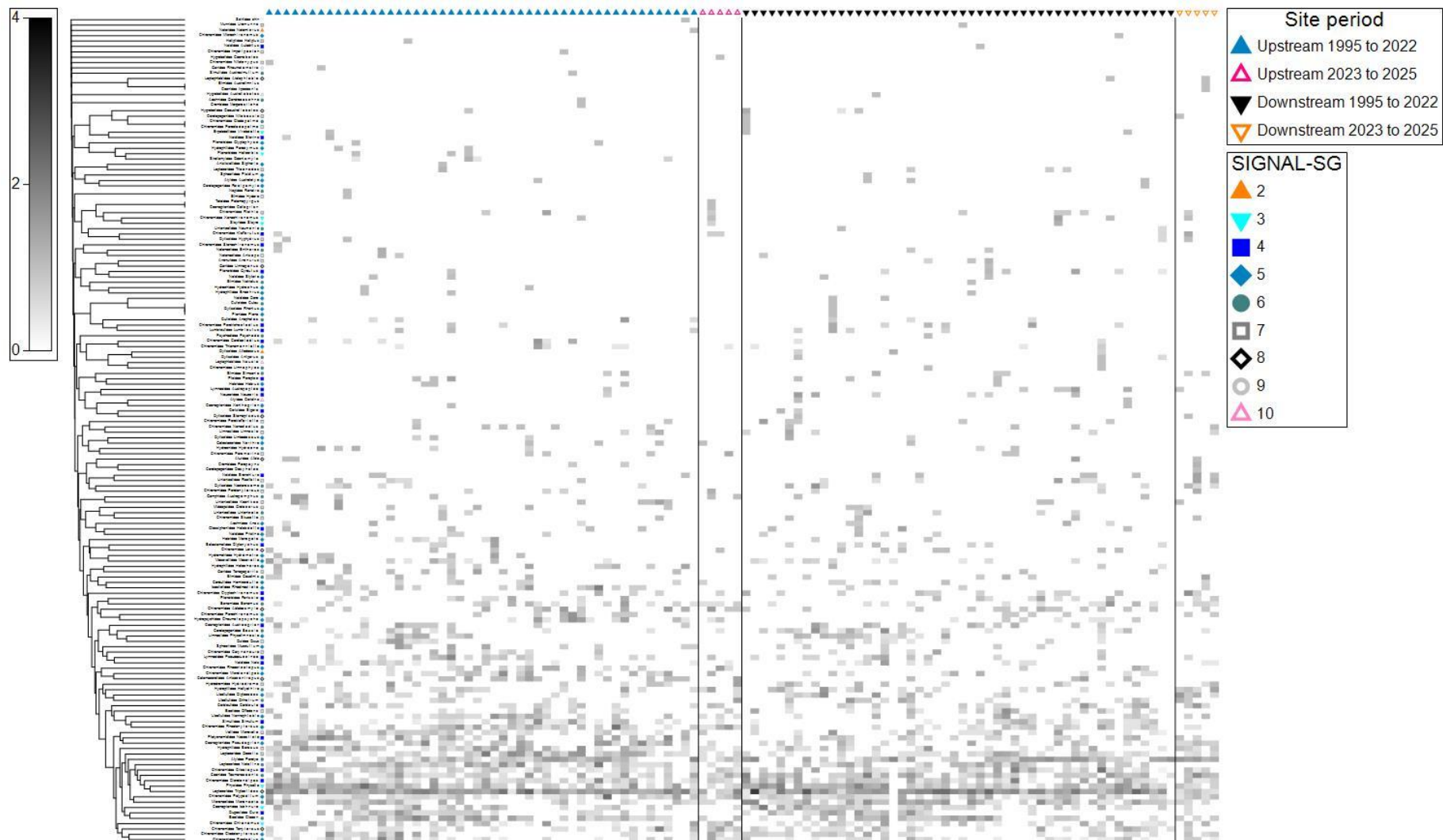


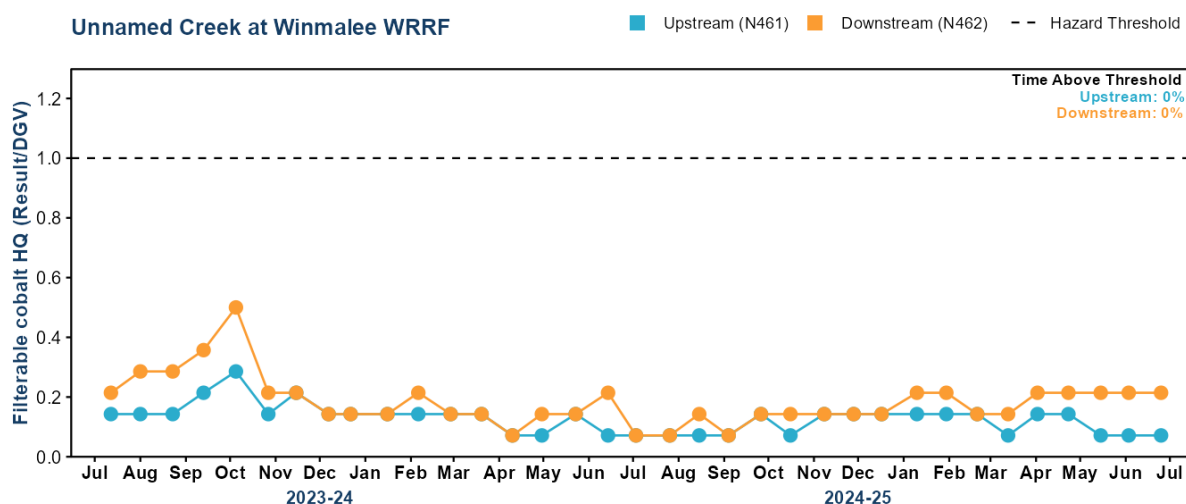
Figure A-9 Shade plot of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites for the Nepean River near Winmalee WRRF

Stage 2: Multivariate regression linking water quality and ecosystem receptors

Monitoring of water quality parameters in the unnamed creek as a receiving water tributary of the Winmalee WRRF commenced in the 2023-24 financial year. Therefore, there is currently insufficient data to conduct a multivariate regression to explore the relationships between the monitored water quality parameters and the downstream impacted macroinvertebrate community.

Stage 3: Hazard quotient metric to evaluate the potential risks of filterable metal exposure to organisms

The hazard quotient calculations identified that the increased concentrations of filterable cobalt in the downstream receiving tributary did not exceed the hazard threshold (Figure A-10). Downstream filterable zinc concentrations exceeded the hazard threshold on most occasions (94% of samples), while a reduced number of sampling events exceeded the hazard threshold at the proxy upstream site (60% of samples; Figure A-10). In addition, filterable copper was found to exceed the hazard threshold at the proxy upstream and downstream monitoring locations in the unnamed creek on all occasions (100% of samples; Figure A-10). Ammonia nitrogen returned a hazard quotient above 1 on a singular occasion at the downstream site in August 2023, indicating a possible processing issue at the Winmalee WRRF (Table A-61).



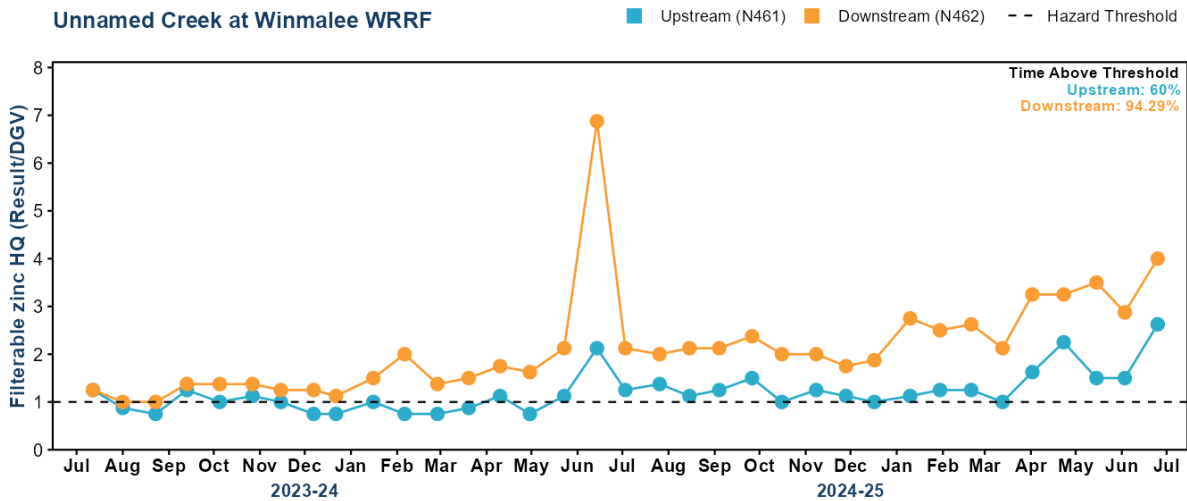
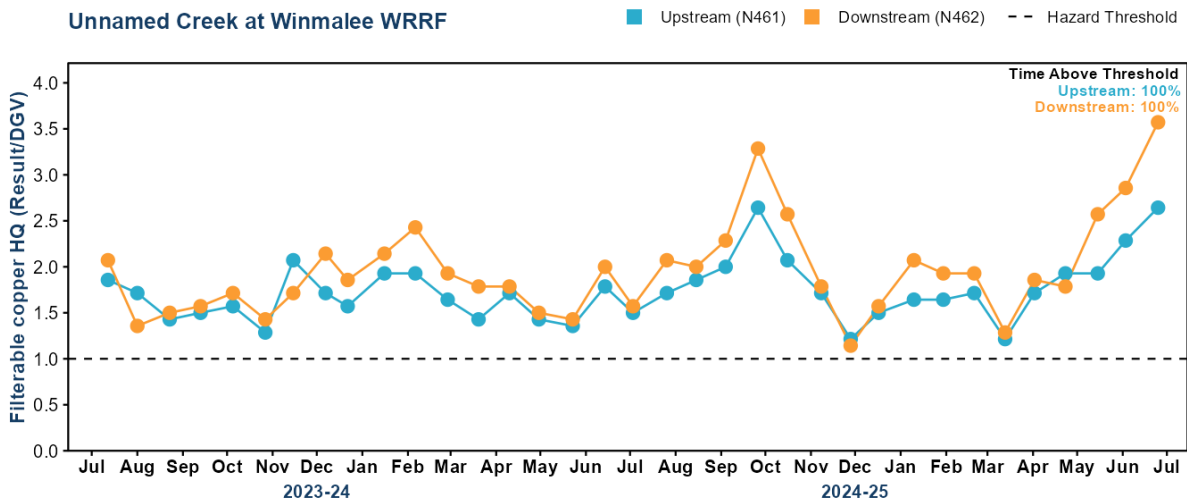


Figure A-10 Hazard quotients for filterable cobalt, copper, and zinc concentrations between 2023 and 2025 for an unnamed creek situated both downstream and proxy upstream of the discharge from Winmalee WRRF

Table A-61 Hazard quotients of metal and ammonia nitrogen concentrations between 2023 and 2025 for unnamed creek situated downstream and proxy upstream of the discharge from Winmalee WRRF

Unnamed creek at Winmalee WRRF: Hazard Quotient (Result/DGV)												
Collection date	Ammonia nitrogen		Filterable aluminium		Filterable cobalt		Filterable copper		Filterable nickel		Filterable zinc	
	N461 (US)	N462 (DS)	N461 (US)	N462 (DS)	N461 (US)	N462 (DS)	N461 (US)	N462 (DS)	N461 (US)	N462 (DS)	N461 (US)	N462 (DS)
2023-07-12	0.00	0.10	0.31	0.31	0.14	0.21	1.86	2.07	0.17	0.17	1.25	1.25
2023-08-01	0.28	2.41	0.24	0.27	0.14	0.29	1.71	1.36	0.18	0.17	0.88	1.00
2023-08-23	0.01	0.15	0.49	0.67	0.14	0.29	1.43	1.50	0.15	0.16	0.75	1.00
2023-09-13	0.01	0.04	0.45	0.40	0.21	0.36	1.50	1.57	0.16	0.19	1.25	1.38
2023-10-05	0.01	0.26	0.42	0.51	0.29	0.50	1.57	1.71	0.17	0.18	1.00	1.38
2023-10-27	0.01	0.01	0.29	0.22	0.14	0.21	1.29	1.43	0.14	0.15	1.12	1.38
2023-11-15	0.01	0.01	0.29	0.18	0.21	0.21	2.07	1.71	0.19	0.17	1.00	1.25
2023-12-07	0.01	0.01	0.31	0.22	0.14	0.14	1.71	2.14	0.14	0.15	0.75	1.25
2023-12-22	0.01	0.01	0.45	0.36	0.14	0.14	1.57	1.86	0.15	0.15	0.75	1.12
2024-01-16	0.30	0.55	1.44	0.95	0.14	0.14	1.93	2.14	0.11	0.12	1.00	1.50
2024-02-06	0.01	0.01	0.42	0.27	0.14	0.21	1.93	2.43	0.13	0.16	0.75	2.00
2024-02-28	0.01	0.01	0.38	0.24	0.14	0.14	1.64	1.93	0.13	0.15	0.75	1.38
2024-03-20	0.01	0.01	0.33	0.27	0.14	0.14	1.43	1.79	0.11	0.13	0.88	1.50
2024-04-10	0.01	0.01	0.56	0.49	0.07	0.07	1.71	1.79	0.12	0.13	1.12	1.75
2024-04-30	0.01	0.01	0.36	0.24	0.07	0.14	1.43	1.50	0.13	0.15	0.75	1.62
2024-05-23	0.00	0.01	0.27	0.25	0.14	0.14	1.36	1.43	0.13	0.15	1.12	2.12
2024-06-14	0.30	0.78	0.16	0.25	0.07	0.21	1.79	2.00	0.14	0.19	2.12	6.88
2024-07-03	0.01	0.01	0.33	0.29	0.07	0.07	1.50	1.57	0.10	0.11	1.25	2.12
2024-07-26	0.00	0.01	0.24	0.47	0.07	0.07	1.71	2.07	0.11	0.11	1.38	2.00
2024-08-15	0.00	0.00	0.27	0.36	0.07	0.14	1.86	2.00	0.09	0.12	1.12	2.12
2024-09-04	0.00	0.01	0.24	0.29	0.07	0.07	2.00	2.29	0.08	0.10	1.25	2.12
2024-09-26	0.00	0.01	0.40	0.33	0.14	0.14	2.64	3.29	0.16	0.17	1.50	2.38
2024-10-16	0.00	0.01	0.31	0.29	0.07	0.14	2.07	2.57	0.09	0.11	1.00	2.00
2024-11-08	0.01	0.01	0.40	0.44	0.14	0.14	1.71	1.79	0.08	0.10	1.25	2.00
2024-11-28	0.01	0.01	0.31	0.27	0.14	0.14	1.21	1.14	0.13	0.12	1.12	1.75
2024-12-17	0.01	0.01	0.47	0.45	0.14	0.14	1.50	1.57	0.13	0.14	1.00	1.88
2025-01-10	0.01	0.02	0.29	0.42	0.14	0.21	1.64	2.07	0.12	0.14	1.12	2.75
2025-01-30	0.01	0.02	0.33	0.45	0.14	0.21	1.64	1.93	0.15	0.17	1.25	2.50
2025-02-20	0.01	0.01	0.25	0.44	0.14	0.14	1.71	1.93	0.14	0.17	1.25	2.62
2025-03-13	0.01	0.01	0.35	0.36	0.07	0.14	1.21	1.29	0.09	0.10	1.00	2.12
2025-04-02	0.00	0.01	0.29	0.53	0.14	0.21	1.71	1.86	0.13	0.15	1.62	3.25
2025-04-23	0.00	0.02	0.36	0.62	0.14	0.21	1.93	1.79	0.16	0.17	2.25	3.25
2025-05-15	0.00	0.01	0.29	0.58	0.07	0.21	1.93	2.57	0.10	0.14	1.50	3.50
2025-06-03	0.01	0.01	0.33	0.47	0.07	0.21	2.29	2.86	0.06	0.07	1.50	2.88
2025-06-25	0.00	0.11	0.40	0.55	0.07	0.21	2.64	3.57	0.11	0.12	2.62	4.00
% Above Threshold	0.00	2.86	2.86	0.00	0.00	0.00	100.00	100.00	0.00	0.00	60.00	94.29

Stage 4: Synthesis of gate 3 results and recommendation for future investigations

Winmalee WRRF discharges treated effluent into an unnamed creek that originates adjacent to the facility. The monitoring sites in the receiving waters of the Winmalee WRRF are unique, as sampling upstream of the discharge point is not possible due to the ephemeral nature of the unnamed creek. Instead, two sampling points are monitored downstream of the discharge point, with one site 300 m downstream (N462) and a proxy upstream site 3km downstream (N461). In addition, a secondary pair of monitoring sites are sampled upstream (N48A) and downstream (N464) of the confluence of the unnamed creek and the Nepean River. The absence of an ecological health impact found in the Nepean River suggests that the localised impact in the unnamed creek did not extend to the Nepean River.

Multivariate analysis from gate 3 stage 1 suggested that the community structure alteration from wastewater discharge was most evident in the macroinvertebrate taxonomic assemblages within the edge habitat in the unnamed creek. The differences in taxonomic assemblages between the downstream and proxy upstream locations were found to be stronger in recent years relative to what was historically observed. The more consistent presence of non-biting midge larvae (Chironomidae *Parametrioctenemys*) and caddisfly (*Leptoceridae Triplectides*) at the proxy upstream site (N461) suggests recovery in the water quality with distance from the WRRF.

Hazard quotient calculations found that copper and zinc concentrations were consistently above the hazard quotient threshold at both the unnamed creek monitoring sites. Previous studies have attributed Australian households as a source of metal contamination to domestic wastewater, primarily due to lead, zinc, and copper. Major sources of zinc were traced back to the bathroom, while copper inputs were attributed to plumbing and water supplies (Besley et al., 2023; Tjadraatmadja and Diaper, 2006). There were less sampling events where filterable zinc concentrations were above the hazard quotient threshold at the proxy upstream site further downstream (N461), compared to the site directly downstream (N462). This further supports the findings of the stage 1 analysis that there is recovery with distance down the unnamed creek.

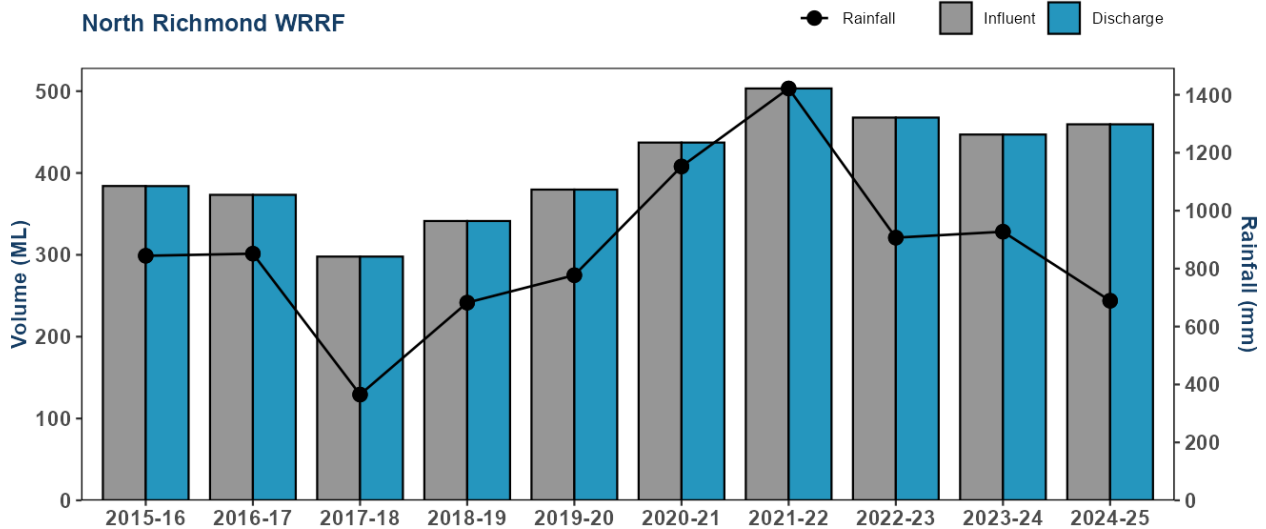
The reduction in filterable metal concentrations corresponds with the improved stream health further downstream of the WRRF discharge point. Trace metals (specifically copper and zinc) influencing macroinvertebrate communities has been previously documented. Liess et al (2017) found strong correlations between dissolved metal toxicity and invertebrate communities within streams and waterways across Australia. More recently, a 30-year dataset across 1457 sites compiled by Johnson et al (2025), also found copper and zinc to be strongly associated with changes in macroinvertebrate communities.

Current available data and supporting literature indicates that the localised impacts to stream health (as indicated by the macroinvertebrate SIGNAL-SG index scores) in the unnamed creek downstream of Winmalee WRRF could be due to the levels of dissolved copper and zinc concentrations in the waterway. However, there appears to be recovery with distance down the unnamed creek, with potential impacts mitigated prior to the confluence with the Nepean River. Ongoing water quality and macroinvertebrate monitoring in the unnamed creek will allow for a more comprehensive assessment through a multivariate regression in future years.

A.6. North Richmond WRRF

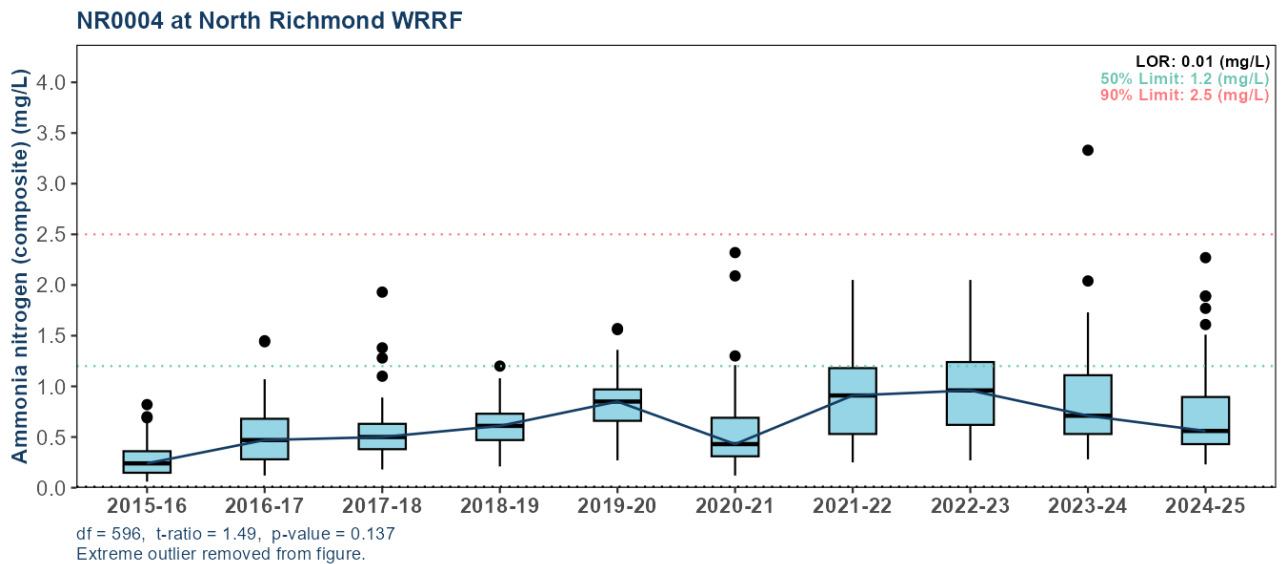
A.6.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall

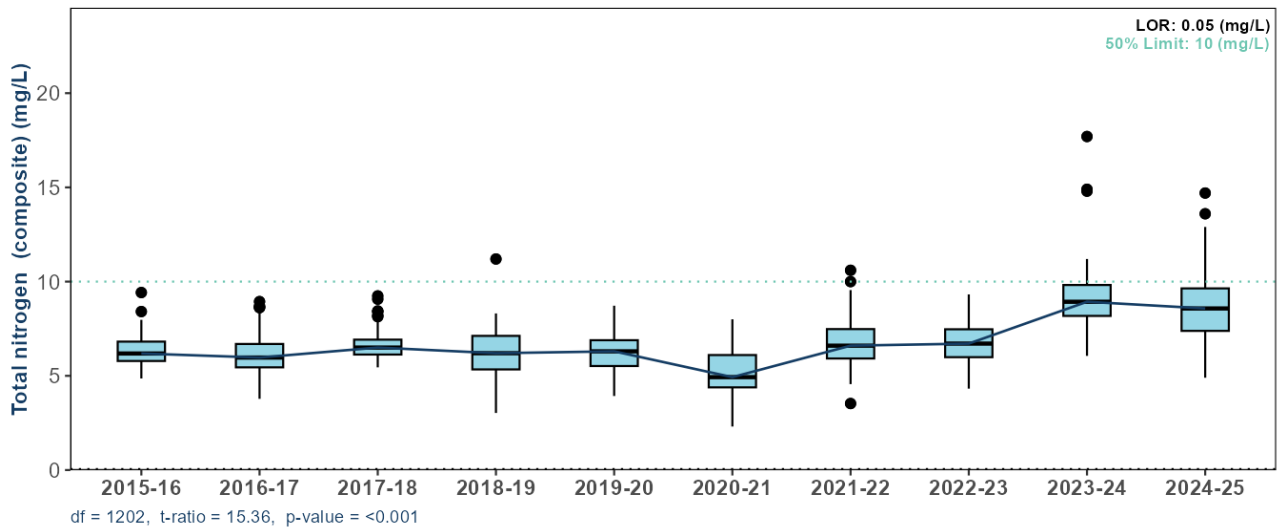


A.6.2. Pressure – Wastewater quality

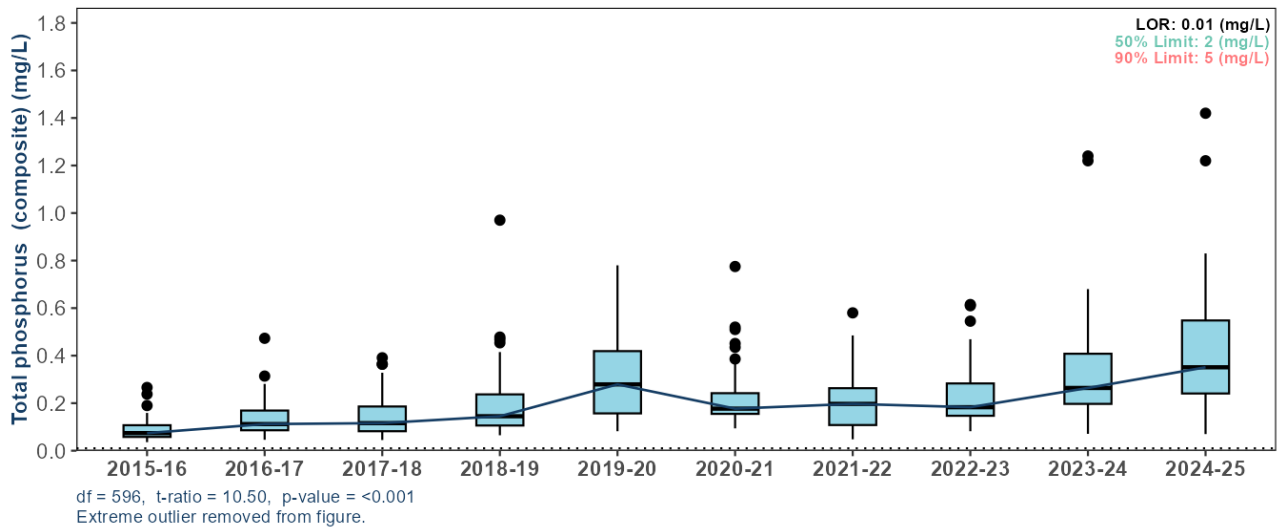
Nutrients



NR0004 at North Richmond WRRF

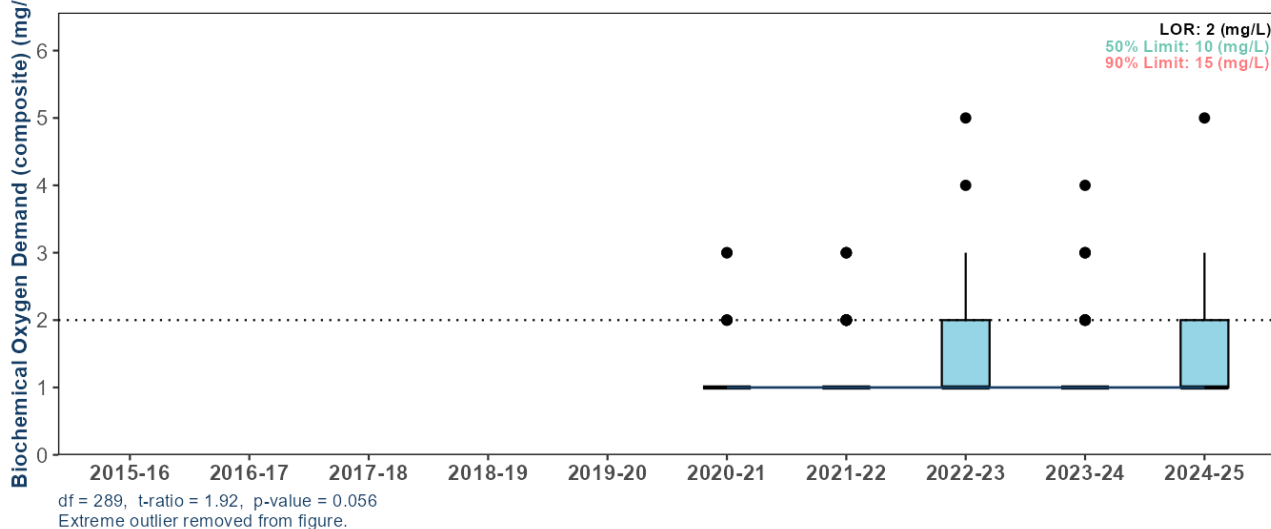


NR0004 at North Richmond WRRF

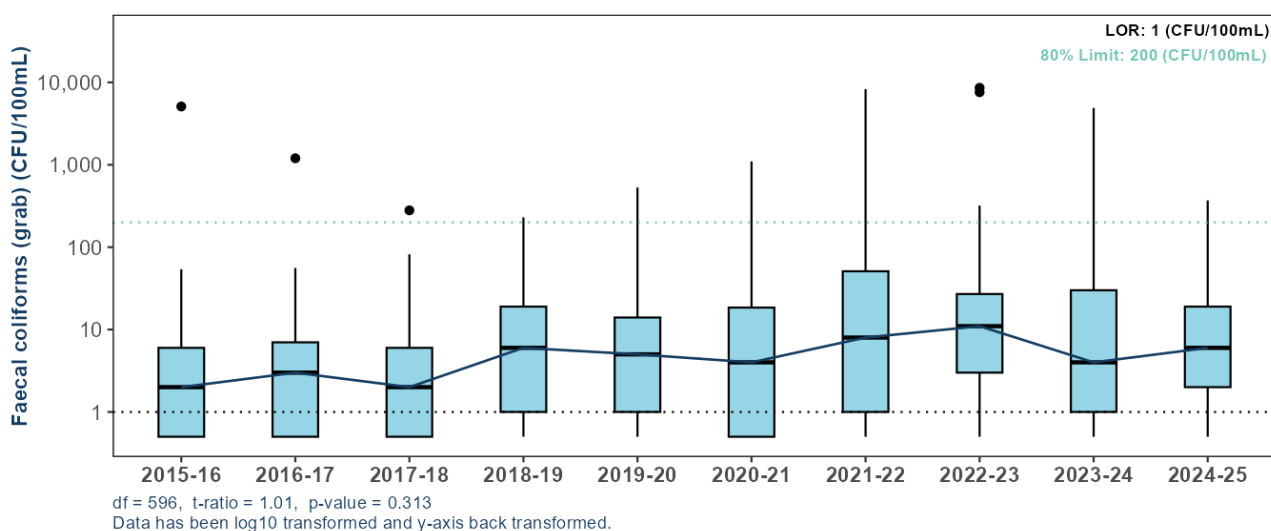


Major conventional analytes

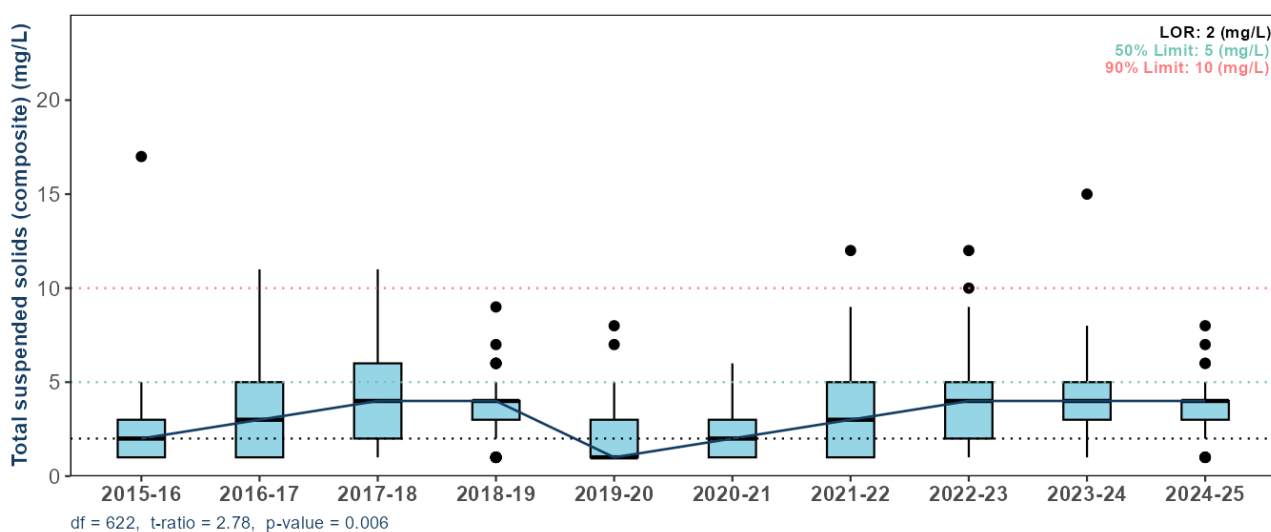
NR0004 at North Richmond WRRF



NR0005 at North Richmond WRRF

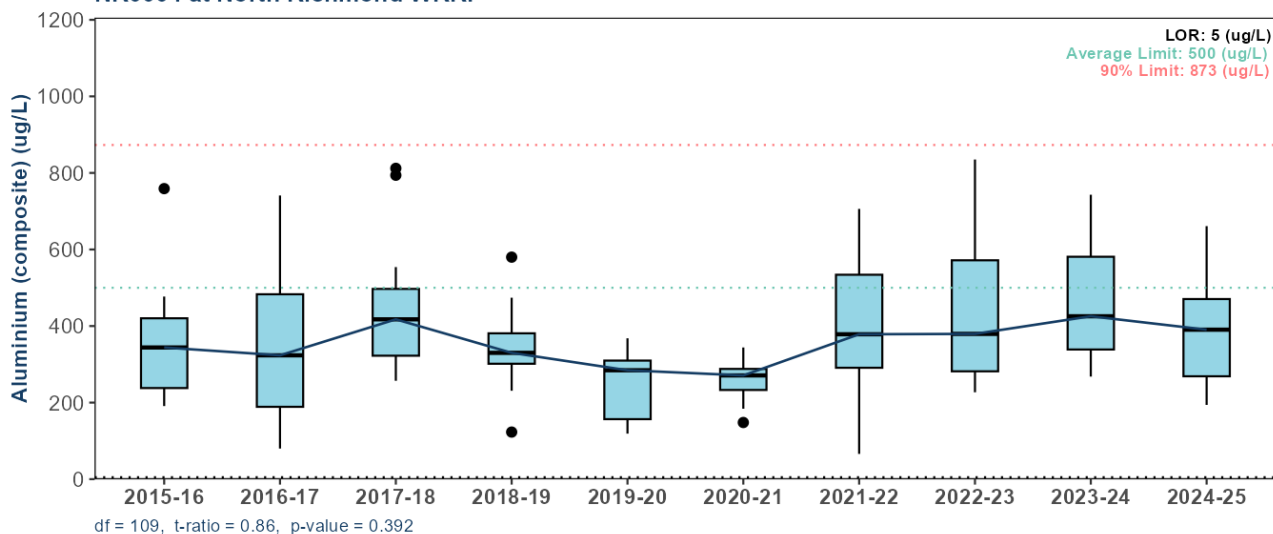


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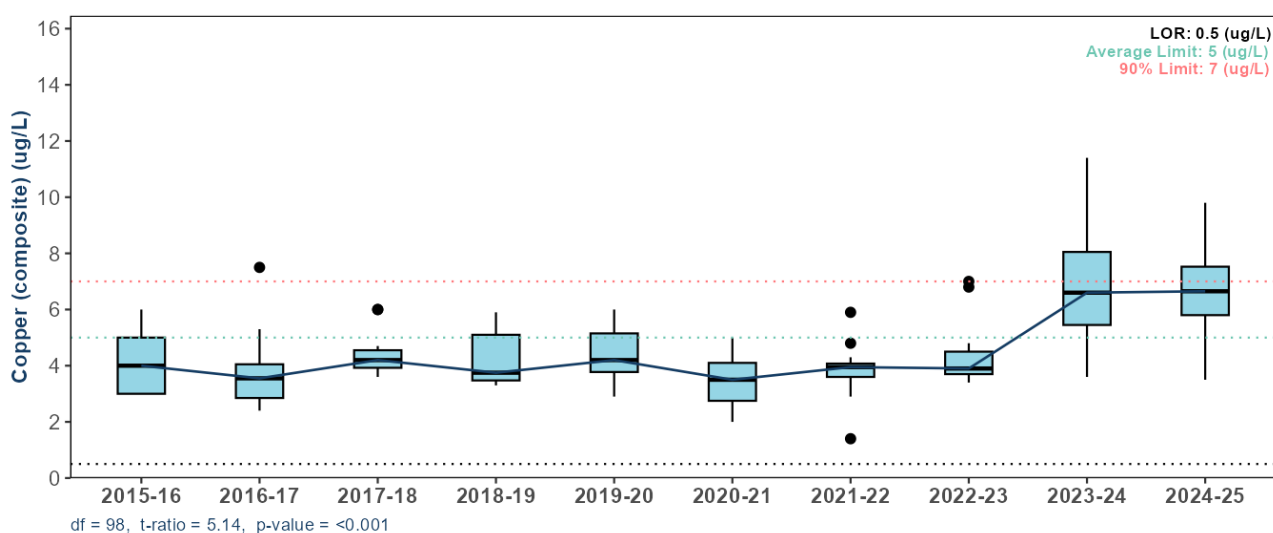


Trace metals

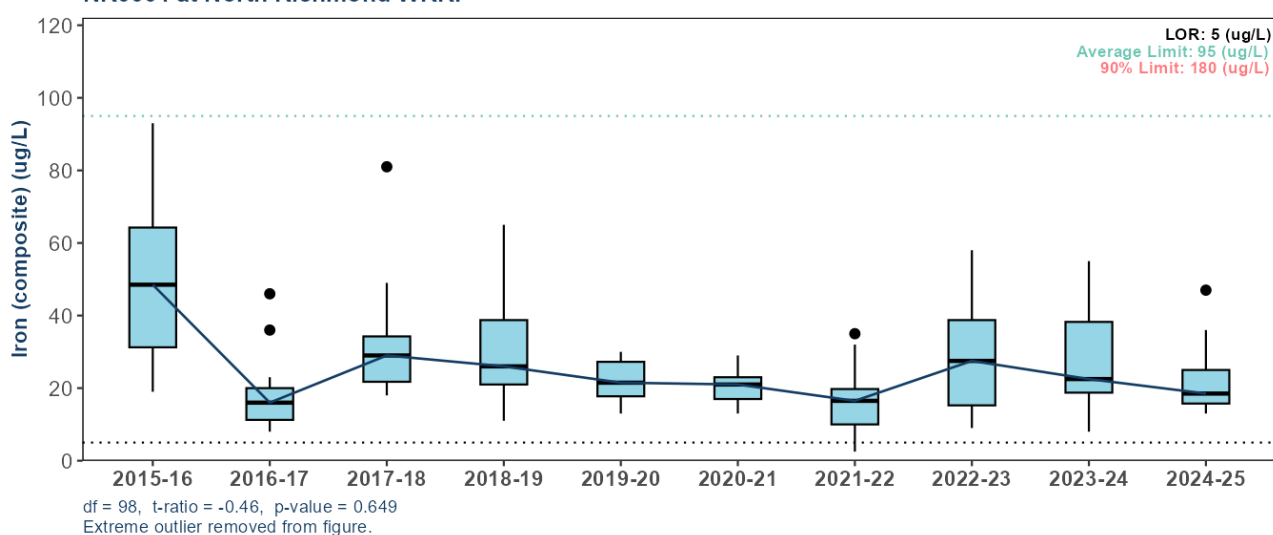
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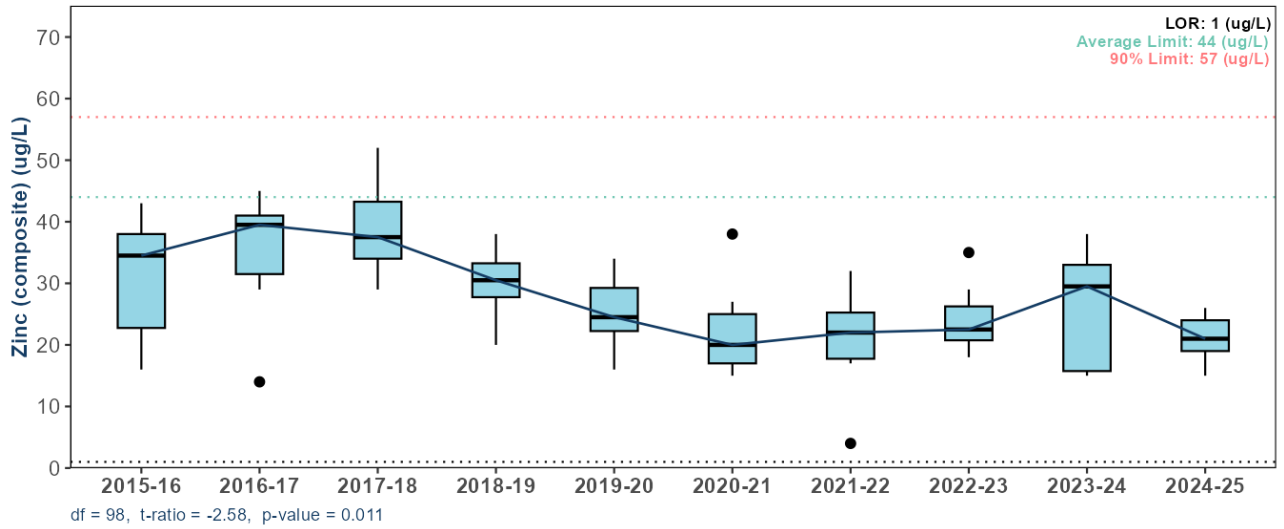
NR0004 at North Richmond WRRF



NR0004 at North Richmond WRRF

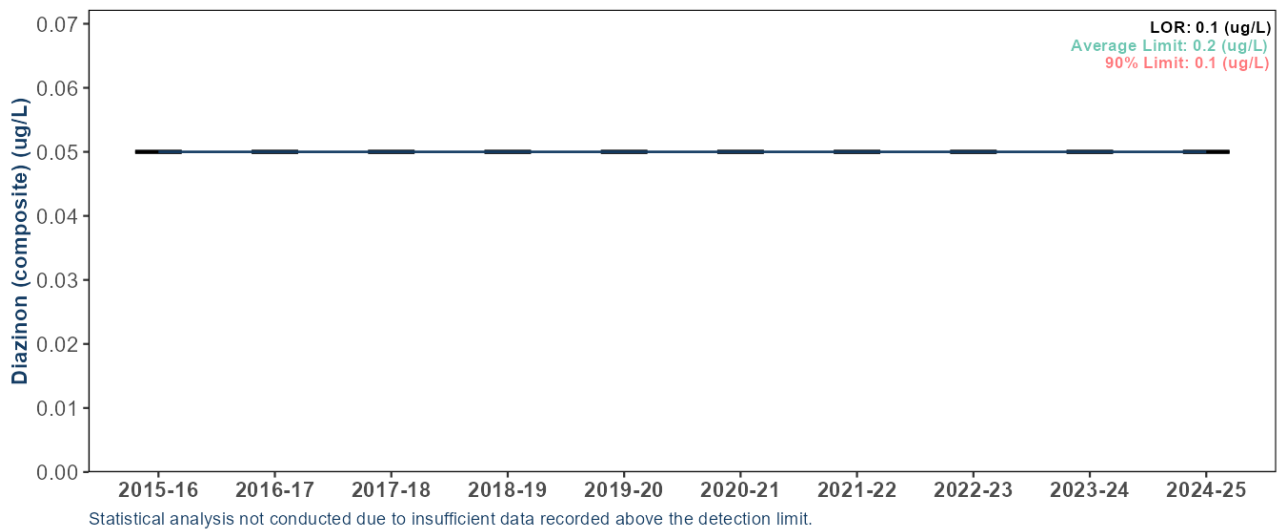


NR0004 at North Richmond WRRF

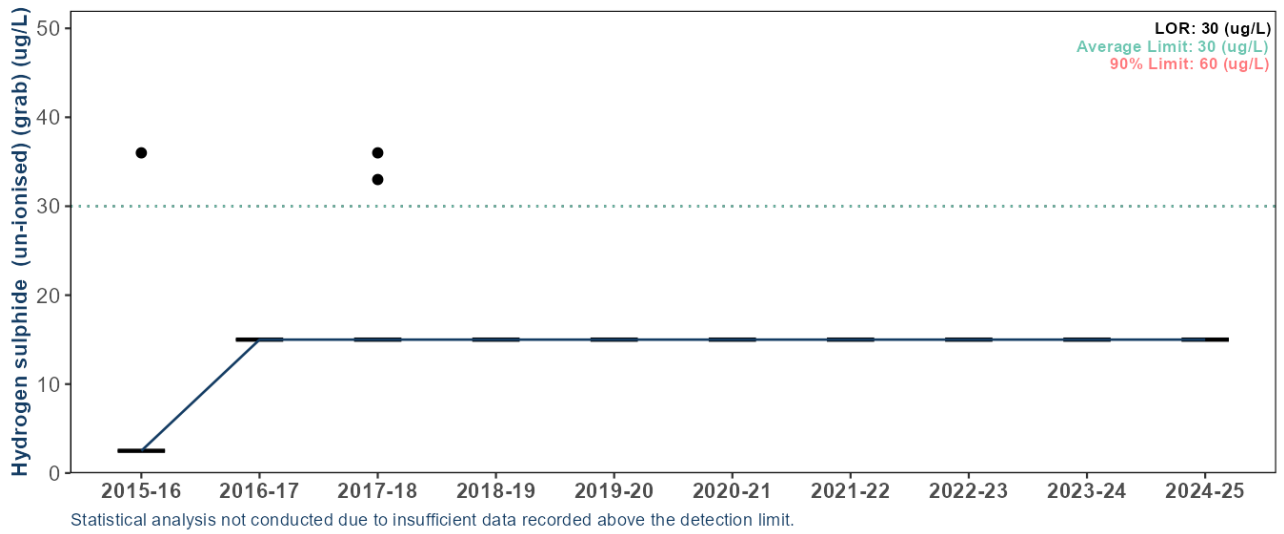


Other chemicals and organics (including pesticides)

NR0004 at North Richmond WRRF

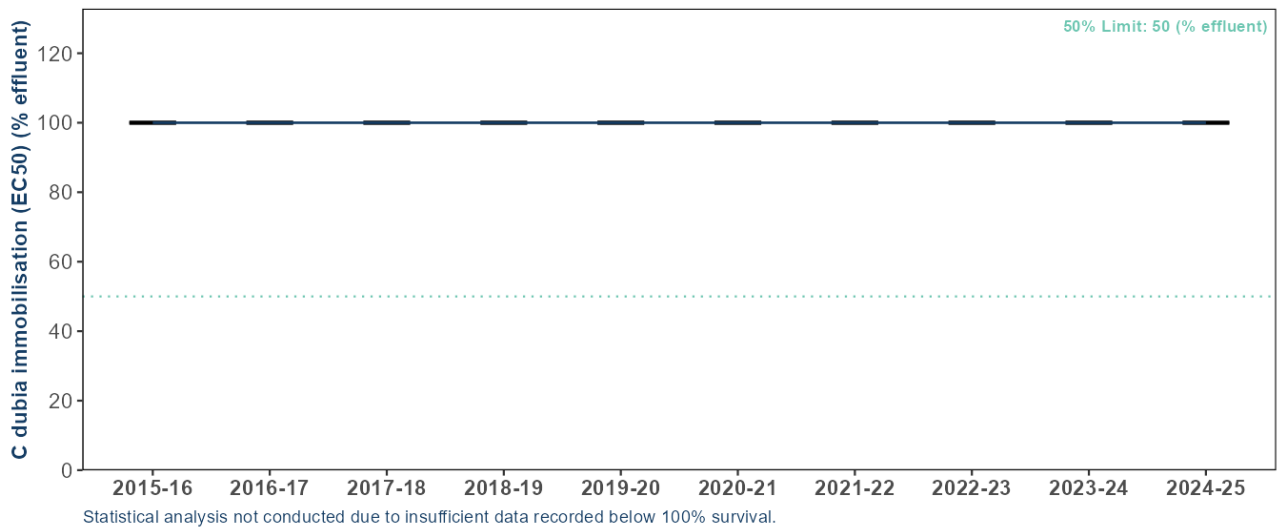


NR0005 at North Richmond WRRF



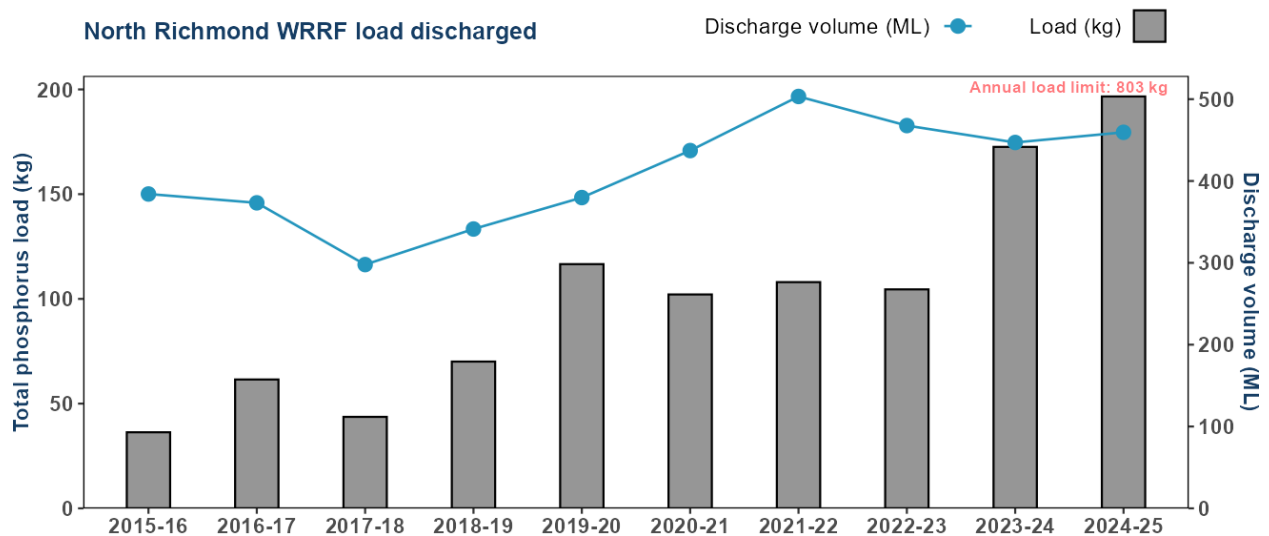
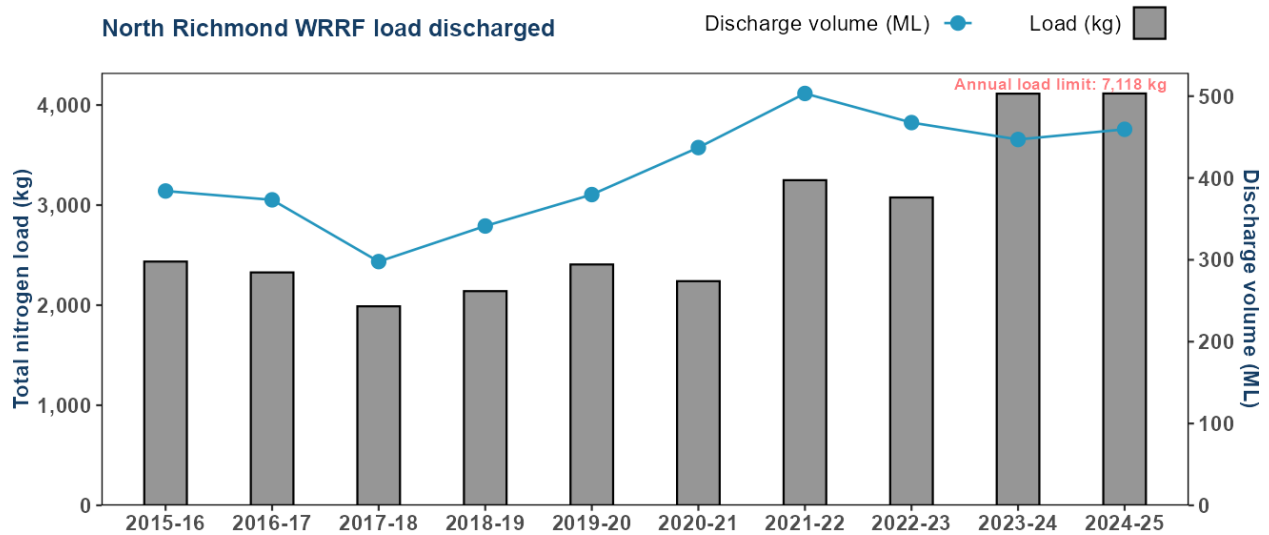
A.6.3. Pressure – Wastewater toxicity

NR0005 at North Richmond WRRF

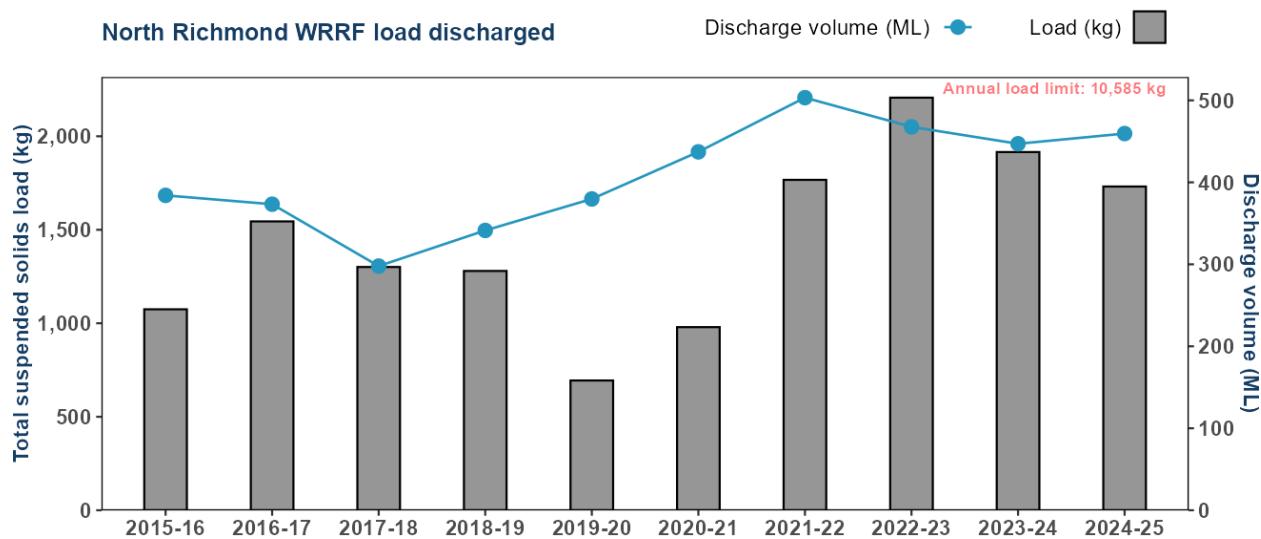
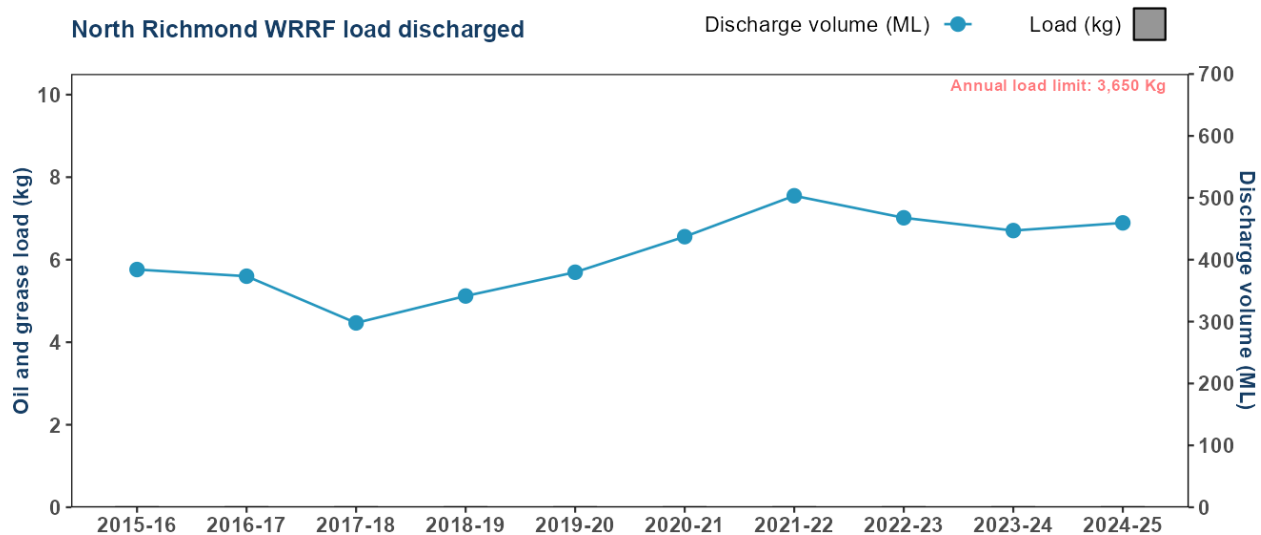
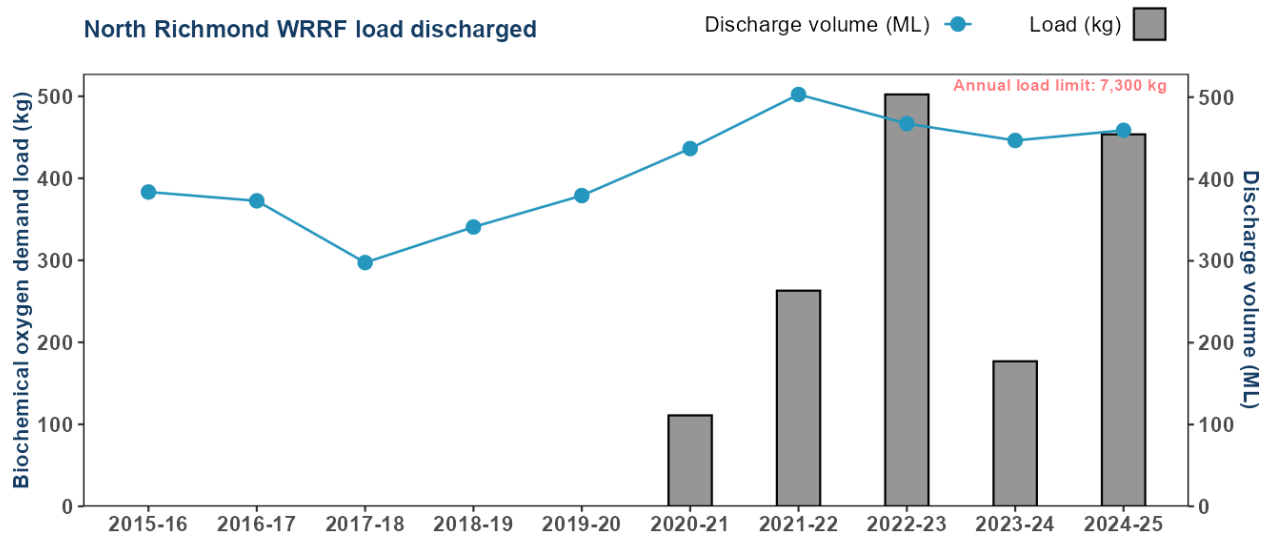


A.6.4. Pressure – Wastewater discharge load

Nutrients



Major conventional analytes



A.6.5. Stressor – Statistical analysis outcomes

Table A-62 Upstream vs downstream comparison (2024-25 reporting period) for Redbank Creek at North Richmond WRRF

Redbank Creek at North Richmond WRRF: N412 vs N411 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	4.35	1.28	160	4.98	<0.001
Oxidised nitrogen	15.54	3.55	160	12.00	<0.001
Total nitrogen	6.36	0.93	160	12.64	<0.001
Soluble reactive phosphorus	15.49	5.86	66	7.24	<0.001
Total phosphorus	6.67	1.31	160	9.69	<0.001
Physico-chemical					
Conductivity	1.29	0.11	160	3.05	0.014
Dissolved oxygen	1.11	0.07	158	1.72	0.315
Dissolved oxygen saturation	11.48	3.18	158	3.61	0.002
pH	-0.01	0.06	154	-0.20	0.997
Water temperature	1.09	0.11	160	0.88	0.816
Turbidity	0.76	0.29	158	-0.71	0.893
Trace Metals					
Filterable aluminium	5.37	1.19	66	7.57	<0.001
Total aluminium	2.39	0.95	66	2.19	0.136
Filterable cobalt	2.36	0.45	66	4.52	<0.001
Total cobalt	1.94	0.36	66	3.57	0.004
Filterable copper	4.09	0.67	66	8.57	<0.001
Total copper	3.57	0.60	66	7.53	<0.001
Filterable nickel	1.70	0.17	66	5.39	<0.001
Total nickel	1.63	0.17	66	4.74	<0.001
Filterable zinc	4.09	0.73	63	7.91	<0.001
Total zinc	3.53	0.62	66	7.13	<0.001
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-63 Upstream current period (2024-25) vs previous period comparison (single site) for Redbank Creek at North Richmond WRRF

Redbank Creek at North Richmond WRRF: N412 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.79	0.18	160	-1.03	0.732
Oxidised nitrogen	0.99	0.18	160	-0.03	>0.999
Total nitrogen	0.80	0.09	160	-1.94	0.216
Soluble reactive phosphorus	0.95	0.37	66	-0.13	>0.999
Total phosphorus	0.85	0.13	160	-1.06	0.716
Physico-chemical					
Conductivity	0.99	0.07	160	-0.18	0.998
Dissolved oxygen	1.05	0.05	158	0.92	0.796
Dissolved oxygen saturation	3.35	2.54	158	1.32	0.551
pH	0.05	0.05	154	1.07	0.708
Water temperature	1.06	0.08	160	0.73	0.886
Turbidity	0.73	0.22	158	-1.02	0.740
Trace Metals					
Filterable aluminium	0.88	0.20	66	-0.57	0.941
Total aluminium	1.11	0.45	66	0.25	0.994
Filterable cobalt	1.04	0.20	66	0.18	0.998
Total cobalt	1.20	0.23	66	0.99	0.753
Filterable copper	0.65	0.11	66	-2.62	0.052
Total copper	0.76	0.13	66	-1.58	0.399
Filterable nickel	0.79	0.08	66	-2.31	0.106
Total nickel	0.81	0.08	66	-2.03	0.188
Filterable zinc	0.97	0.18	63	-0.18	0.998
Total zinc	1.00	0.18	66	0.02	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-64 Downstream current period (2024-25) vs previous period comparison (single site) for Redbank Creek at North Richmond WRRF

Redbank Creek at North Richmond WRRF: N411 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.90	0.21	160	-0.47	0.965
Oxidised nitrogen	1.38	0.25	160	1.76	0.297
Total nitrogen	1.18	0.14	160	1.41	0.496
Soluble reactive phosphorus	2.94	1.13	66	2.81	0.032
Total phosphorus	1.96	0.31	160	4.33	<0.001
Physico-chemical					
Conductivity	0.99	0.07	160	-0.09	>0.999
Dissolved oxygen	1.01	0.05	158	0.17	0.998
Dissolved oxygen saturation	0.75	2.54	158	0.30	0.991
pH	-0.01	0.05	154	-0.10	>0.999
Water temperature	1.03	0.08	160	0.33	0.988
Turbidity	0.76	0.23	158	-0.90	0.803
Trace Metals					
Filterable aluminium	0.95	0.21	66	-0.23	0.996
Total aluminium	0.72	0.29	66	-0.82	0.844
Filterable cobalt	0.91	0.18	66	-0.49	0.962
Total cobalt	0.93	0.17	66	-0.37	0.982
Filterable copper	0.99	0.17	66	-0.05	>0.999
Total copper	1.01	0.17	66	0.09	>0.999
Filterable nickel	0.76	0.08	66	-2.74	0.039
Total nickel	0.77	0.08	66	-2.55	0.061
Filterable zinc	0.95	0.17	63	-0.30	0.990
Total zinc	0.90	0.16	66	-0.58	0.939
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-65 Upstream vs downstream comparison (2024-25 reporting period) Redbank Creek for the Nepean River at North Richmond WRRF

Hawkesbury River at North Richmond WRRF: N42 vs N39 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.08	0.27	314	0.32	0.989
Oxidised nitrogen	1.16	0.26	314	0.70	0.899
Total nitrogen	1.09	0.10	314	0.90	0.807
Soluble reactive phosphorus	0.83	0.15	62	-1.06	0.716
Total phosphorus	1.01	0.11	314	0.13	>0.999
Physico-chemical					
Conductivity	1.04	0.08	314	0.59	0.936
Dissolved oxygen	0.99	0.05	312	-0.18	0.998
Dissolved oxygen saturation	-0.62	3.49	311	-0.18	0.998
pH	-0.13	0.14	310	-0.94	0.784
Water temperature	1.00	0.10	314	0.01	>0.999
Turbidity	1.06	0.22	314	0.26	0.994
Trace Metals					
Filterable aluminium	0.86	0.20	62	-0.64	0.917
Total aluminium	1.17	0.27	62	0.68	0.905
Filterable cobalt	1.35	0.33	62	1.22	0.617
Total cobalt	1.11	0.21	62	0.55	0.946
Filterable copper	0.83	0.08	62	-1.89	0.244
Total copper	0.97	0.11	62	-0.23	0.996
Filterable nickel	1.06	0.10	62	0.64	0.920
Total nickel	1.16	0.12	62	1.42	0.490
Filterable zinc	0.73	0.15	58	-1.53	0.427
Total zinc	0.99	0.28	62	-0.03	>0.999

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-66 Upstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at North Richmond WRRF

Hawkesbury River at North Richmond WRRF: N42 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.88	0.16	314	-0.67	0.909
Oxidised nitrogen	0.77	0.13	314	-1.57	0.399
Total nitrogen	0.79	0.06	314	-3.33	0.005
Soluble reactive phosphorus	0.60	0.11	62	-2.78	0.035
Total phosphorus	0.76	0.06	314	-3.39	0.004
Physico-chemical					
Conductivity	1.02	0.06	314	0.30	0.991
Dissolved oxygen	0.98	0.04	312	-0.53	0.952
Dissolved oxygen saturation	-1.02	2.61	311	-0.39	0.980
pH	-0.14	0.10	310	-1.35	0.530
Water temperature	1.05	0.08	314	0.65	0.915
Turbidity	1.07	0.16	314	0.47	0.965
Trace Metals					
Filterable aluminium	1.04	0.24	62	0.15	0.999
Total aluminium	0.79	0.19	62	-0.96	0.774
Filterable cobalt	0.81	0.21	62	-0.83	0.840
Total cobalt	0.91	0.18	62	-0.46	0.968
Filterable copper	0.87	0.09	62	-1.34	0.540
Total copper	0.88	0.10	62	-1.10	0.689
Filterable nickel	0.78	0.07	62	-2.60	0.055
Total nickel	0.79	0.09	62	-2.18	0.140
Filterable zinc	1.13	0.24	58	0.57	0.940
Total zinc	0.97	0.28	62	-0.12	>0.999

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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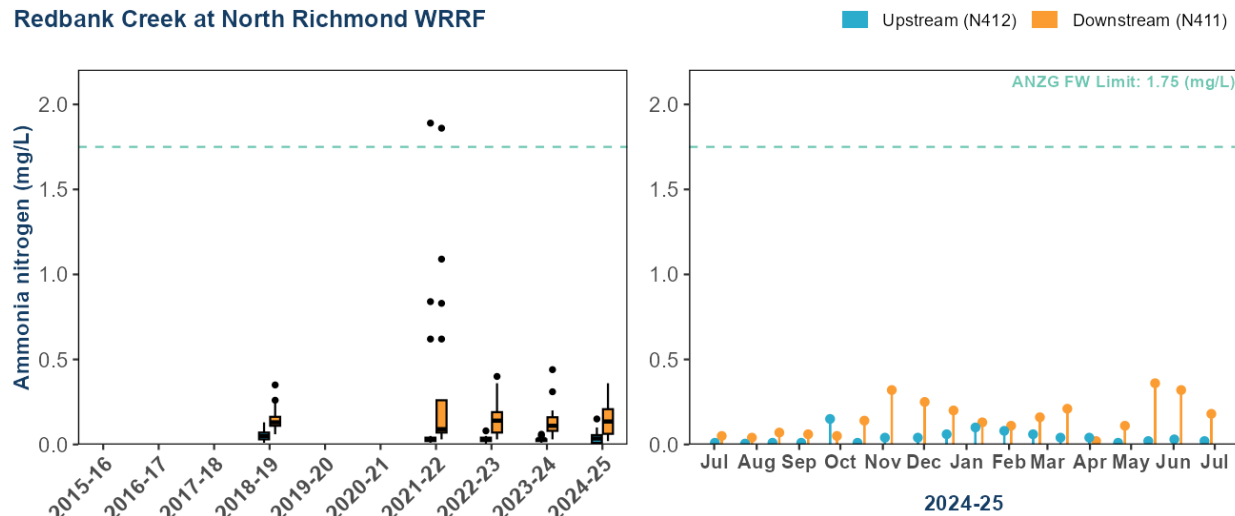
Table A-67 Downstream current period (2024-25) vs previous period comparison (single site) for the Nepean River at North Richmond WRRF

Hawkesbury River at North Richmond WRRF: N39 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.82	0.15	314	-1.08	0.700
Oxidised nitrogen	0.92	0.15	314	-0.52	0.955
Total nitrogen	0.84	0.06	314	-2.49	0.063
Soluble reactive phosphorus	0.72	0.13	62	-1.89	0.244
Total phosphorus	0.80	0.07	314	-2.72	0.034
Physico-chemical					
Conductivity	1.04	0.06	314	0.81	0.852
Dissolved oxygen	0.96	0.03	312	-1.15	0.657
Dissolved oxygen saturation	-5.00	2.60	311	-1.92	0.221
pH	-0.23	0.10	310	-2.30	0.100
Water temperature	1.00	0.07	314	0.03	>0.999
Turbidity	1.07	0.16	314	0.45	0.970
Trace Metals					
Filterable aluminium	0.91	0.21	62	-0.42	0.975
Total aluminium	0.82	0.19	62	-0.84	0.834
Filterable cobalt	0.80	0.20	62	-0.88	0.816
Total cobalt	0.96	0.18	62	-0.20	0.997
Filterable copper	0.86	0.09	62	-1.55	0.413
Total copper	0.94	0.11	62	-0.52	0.955
Filterable nickel	0.82	0.07	62	-2.26	0.120
Total nickel	0.91	0.10	62	-0.87	0.818
Filterable zinc	0.83	0.17	58	-0.89	0.809
Total zinc	0.95	0.27	62	-0.18	0.998

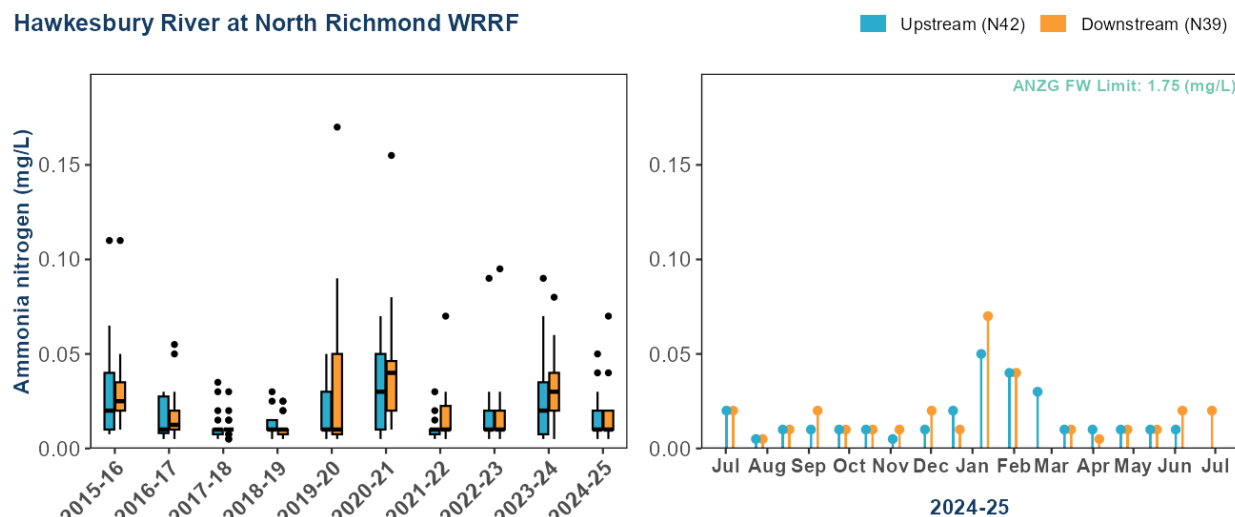
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.6.6. Stressor – Nutrients

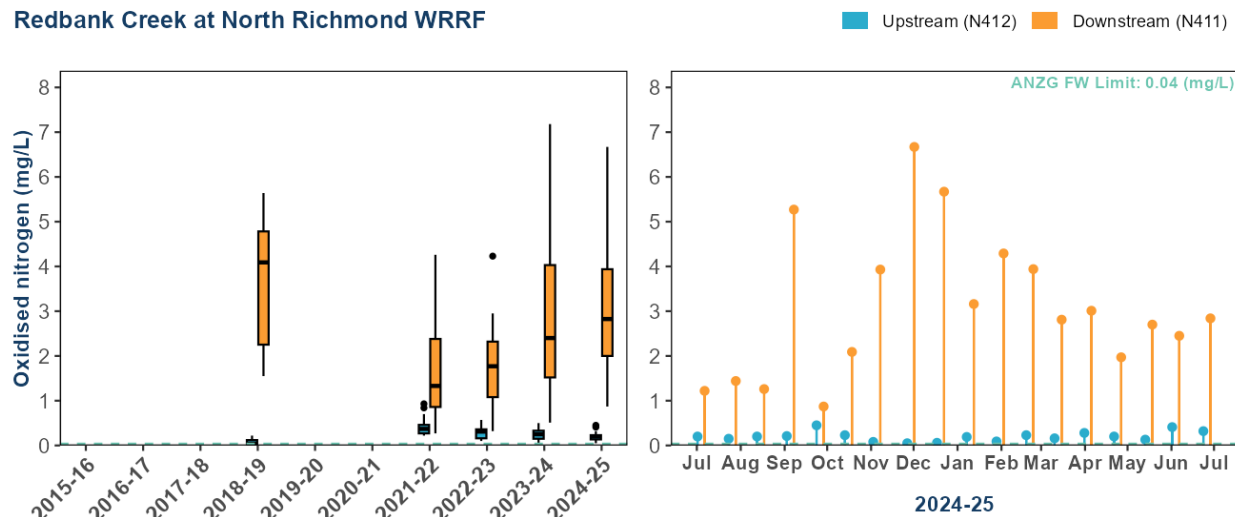
Redbank Creek at North Richmond WRRF



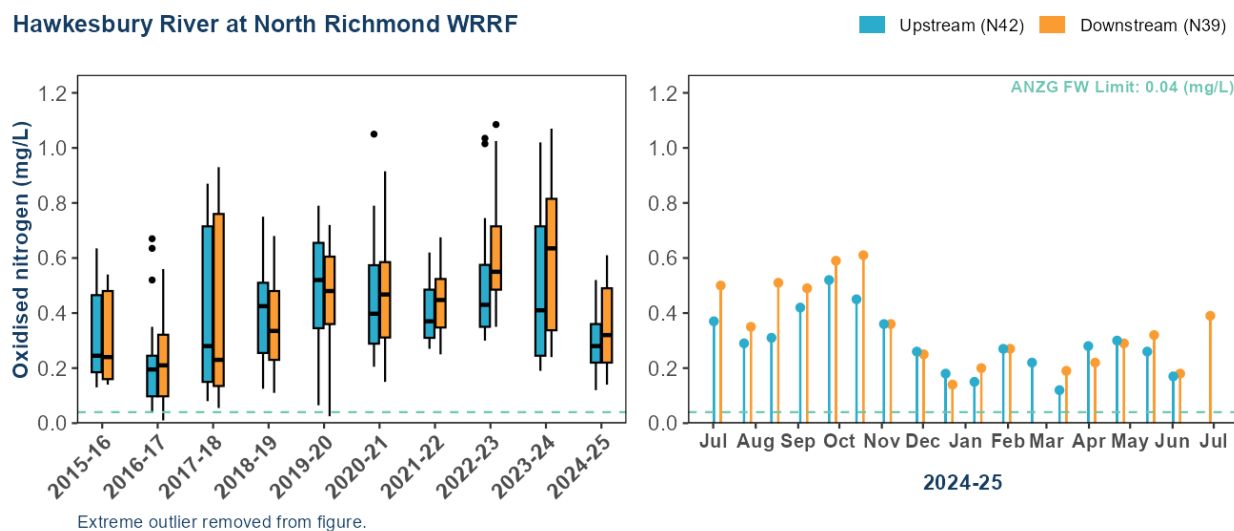
Hawkesbury River at North Richmond WRRF



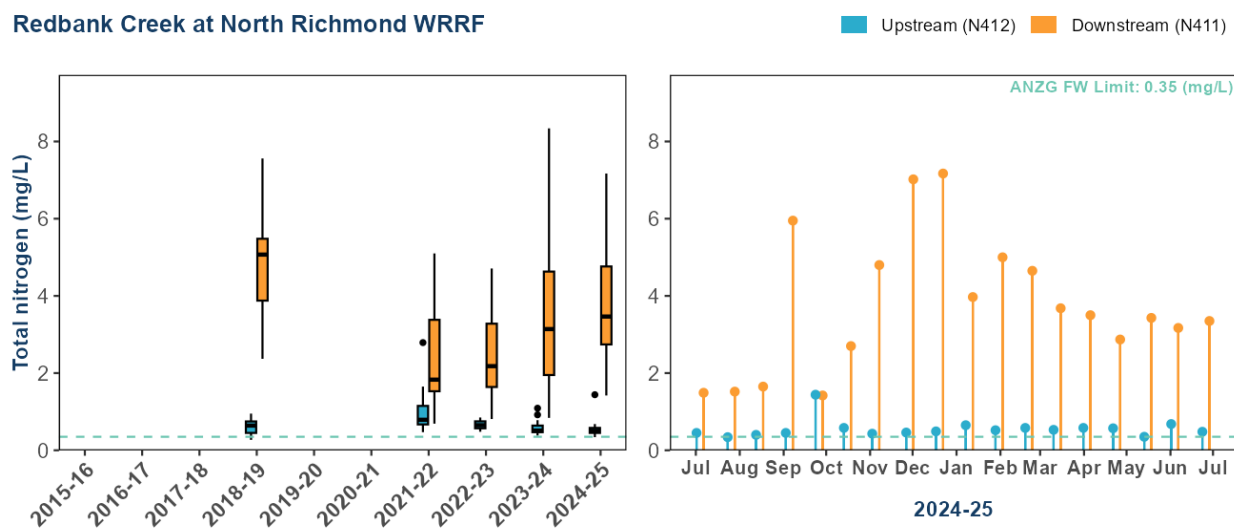
Redbank Creek at North Richmond WRRF



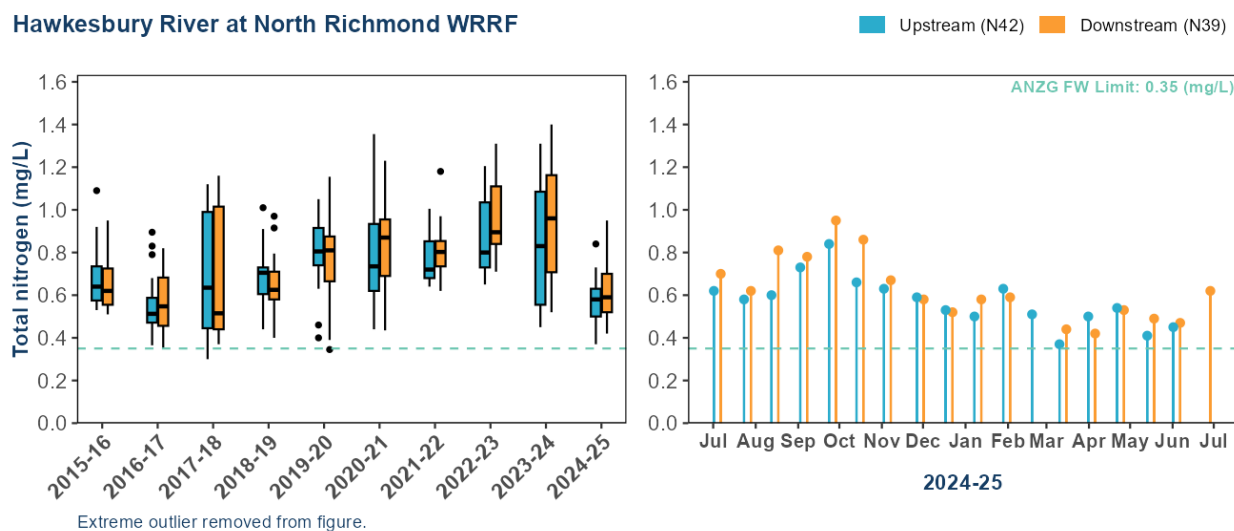
Hawkesbury River at North Richmond WRRF



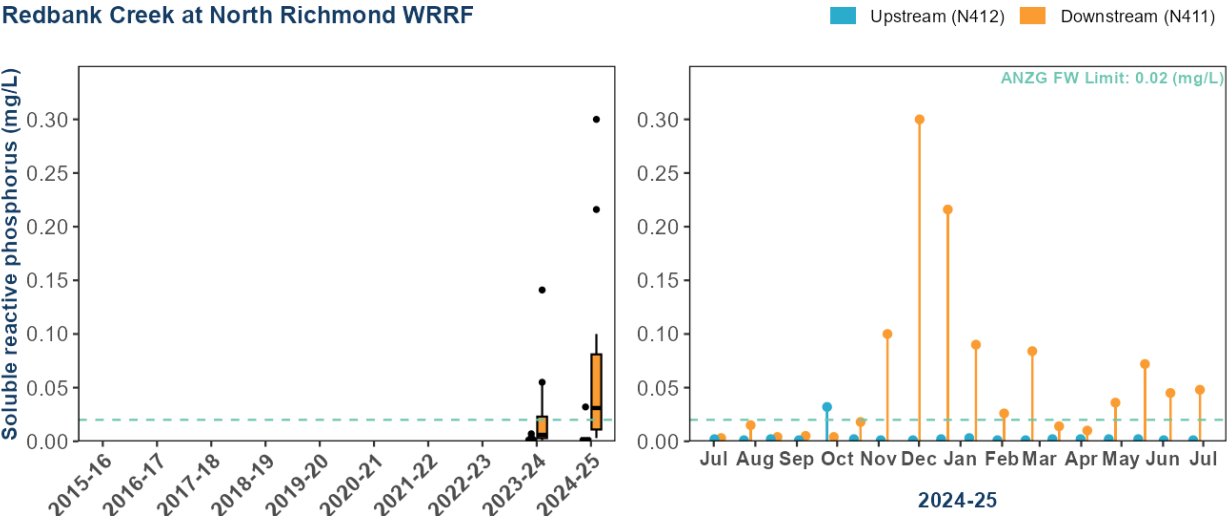
Redbank Creek at North Richmond WRRF



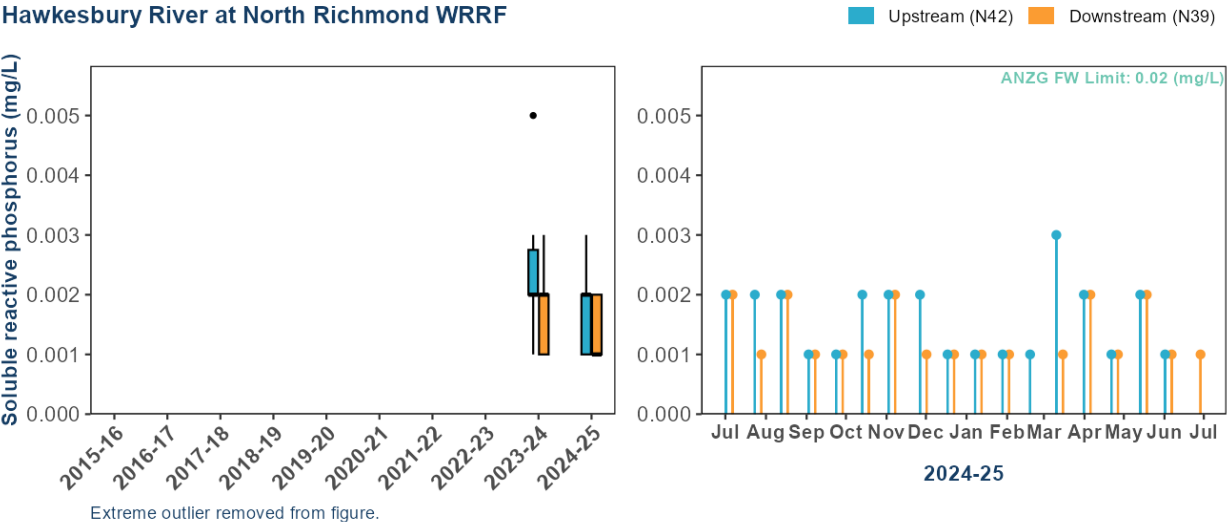
Hawkesbury River at North Richmond WRRF



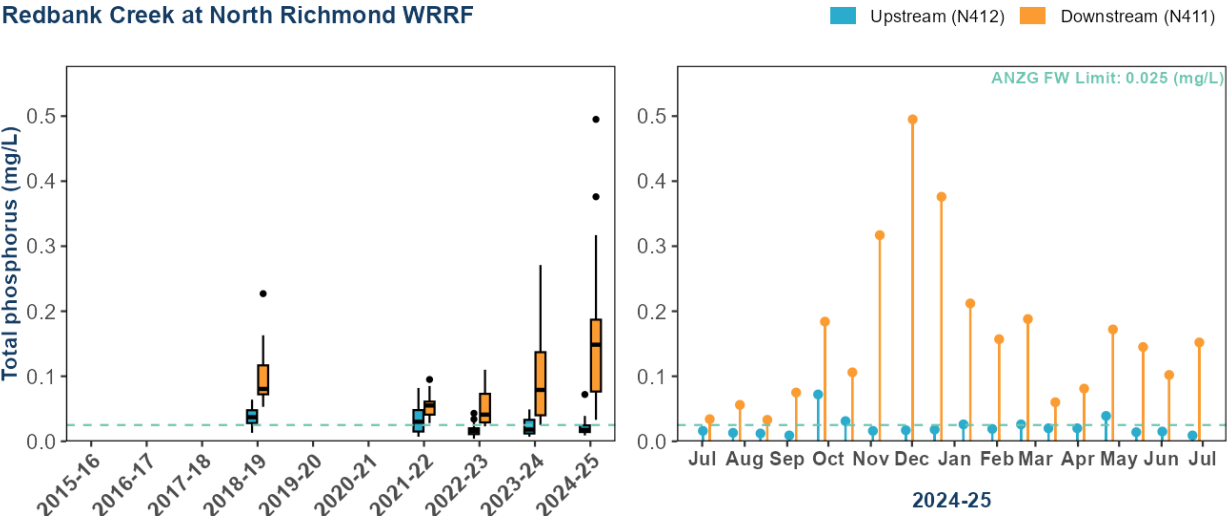
Redbank Creek at North Richmond WRRF



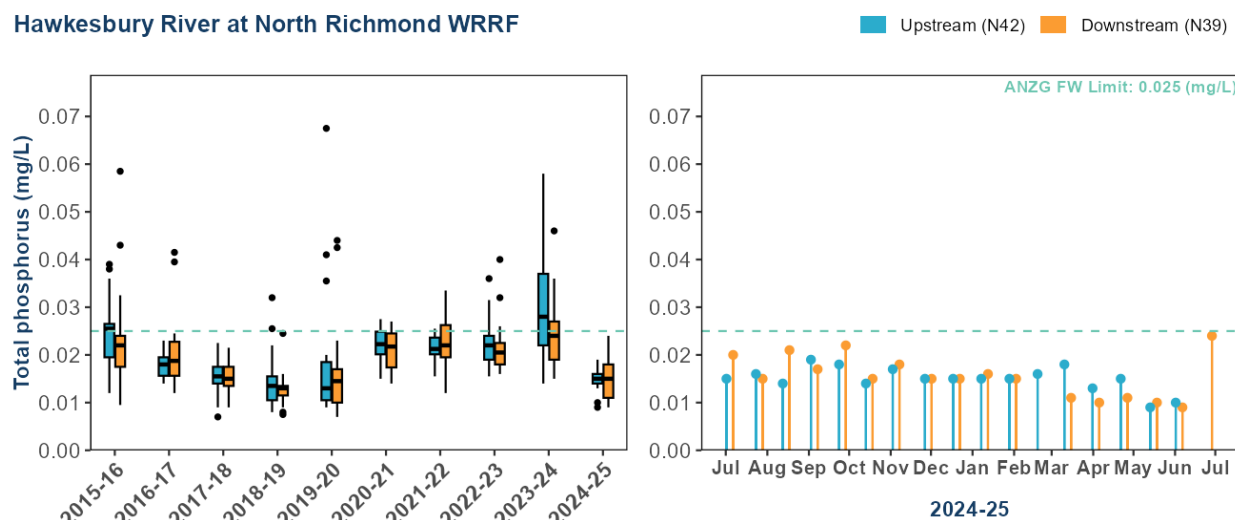
Hawkesbury River at North Richmond WRRF



Redbank Creek at North Richmond WRRF

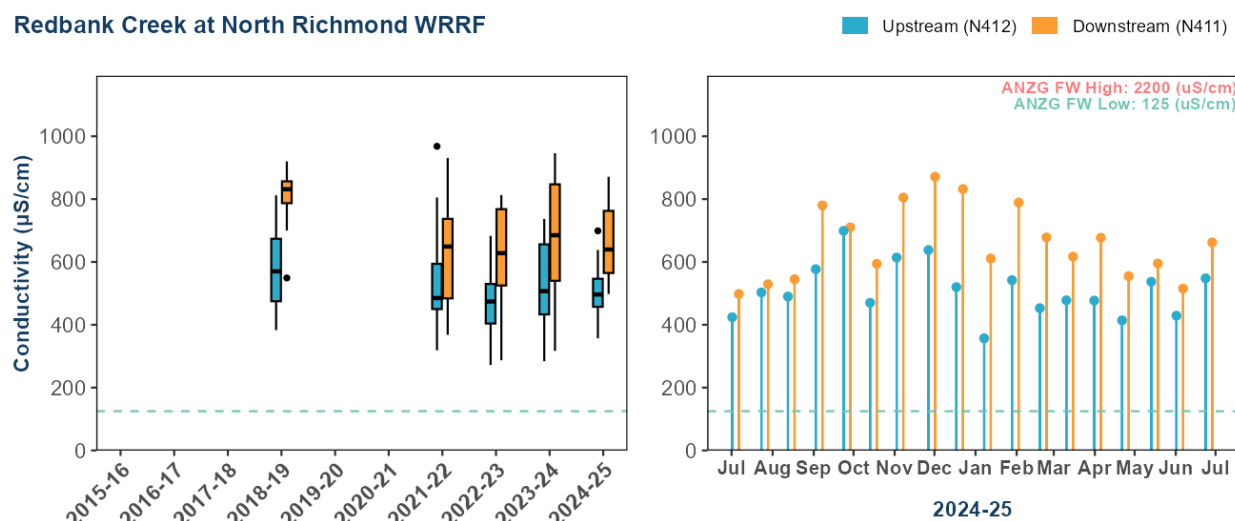


Hawkesbury River at North Richmond WRRF

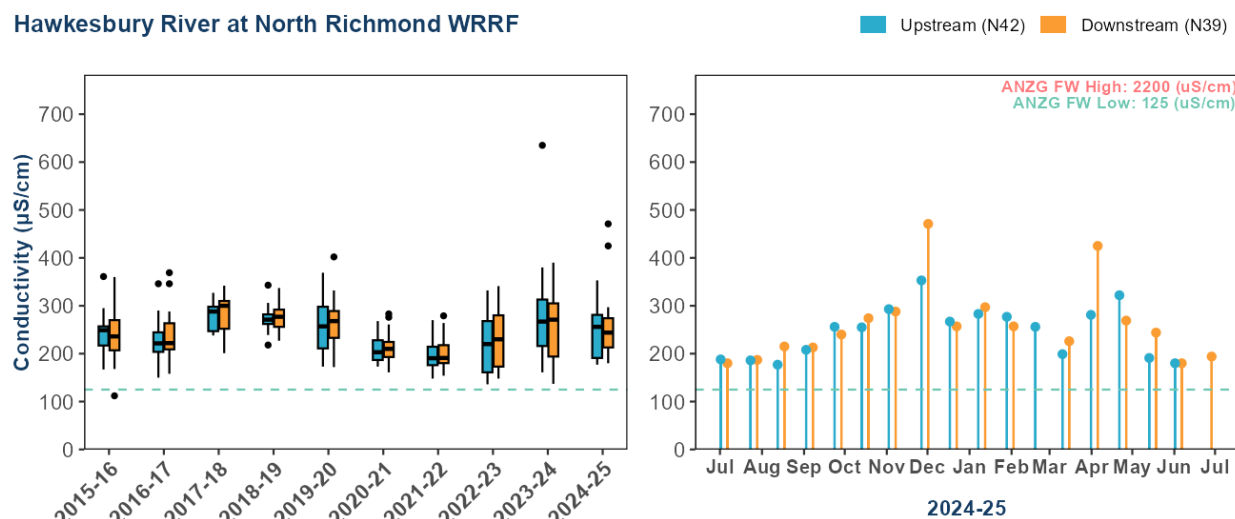


A.6.7. Stressor – Physico-chemical water quality

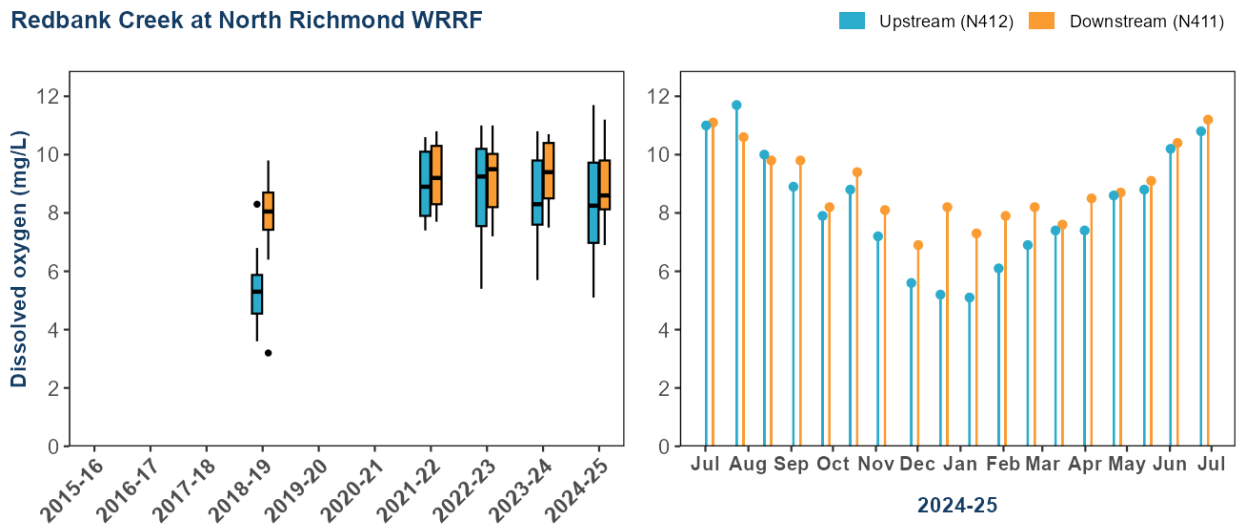
Redbank Creek at North Richmond WRRF



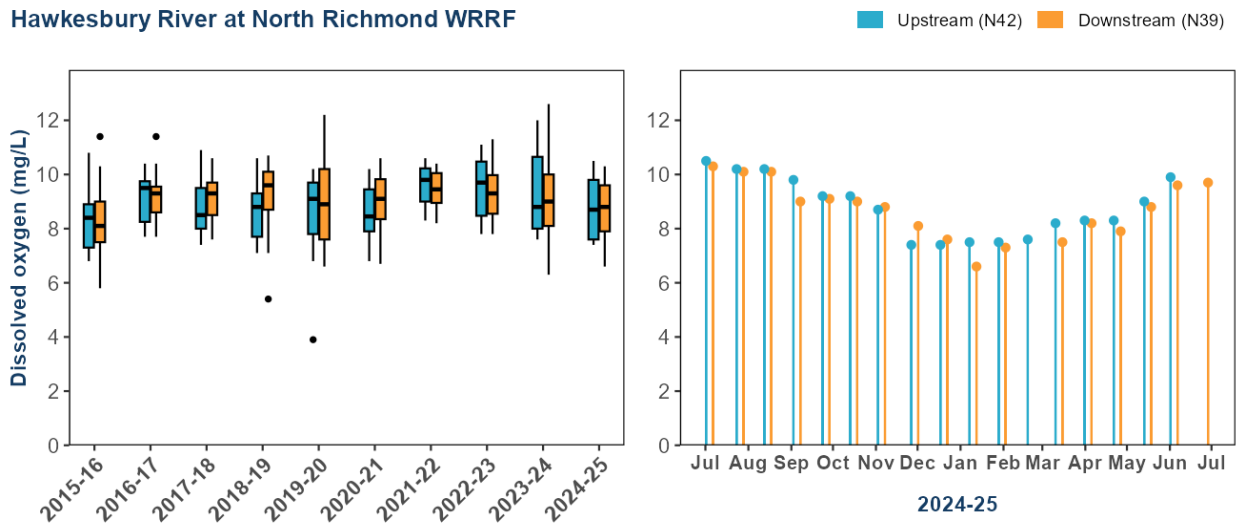
Hawkesbury River at North Richmond WRRF



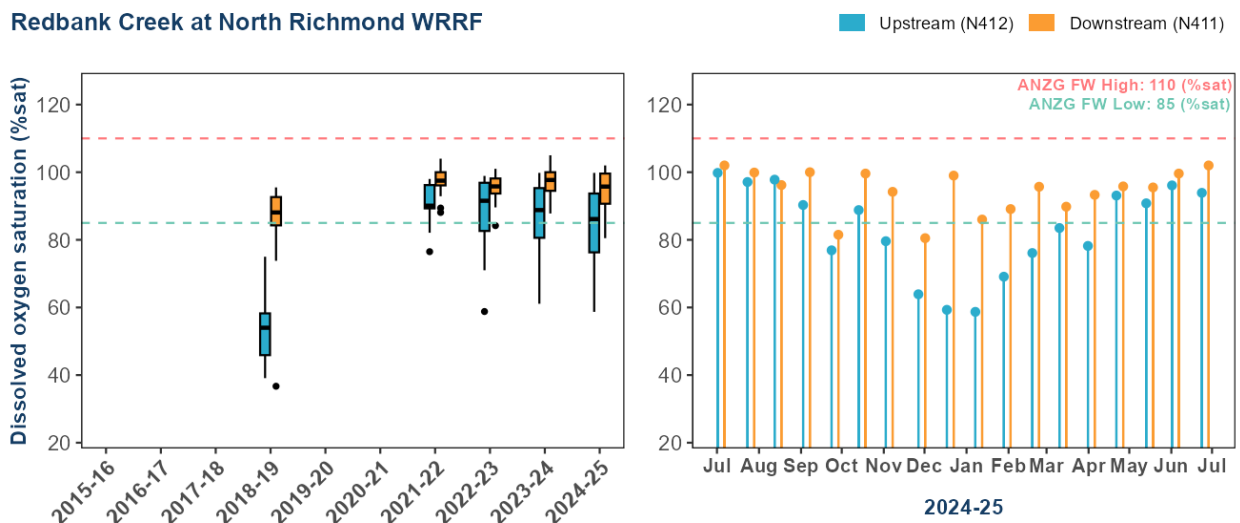
Redbank Creek at North Richmond WRRF



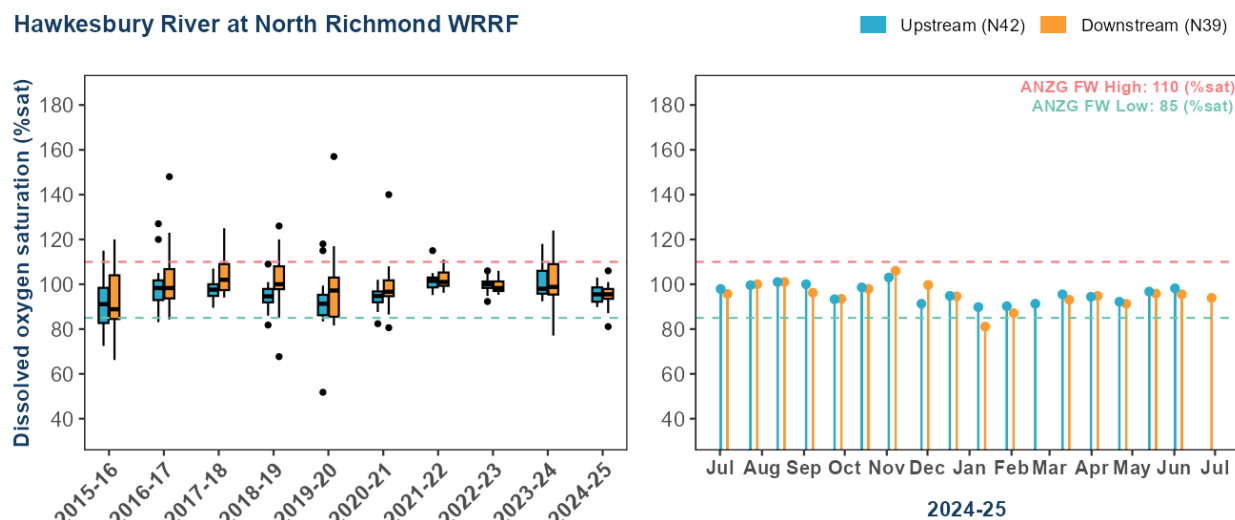
Hawkesbury River at North Richmond WRRF



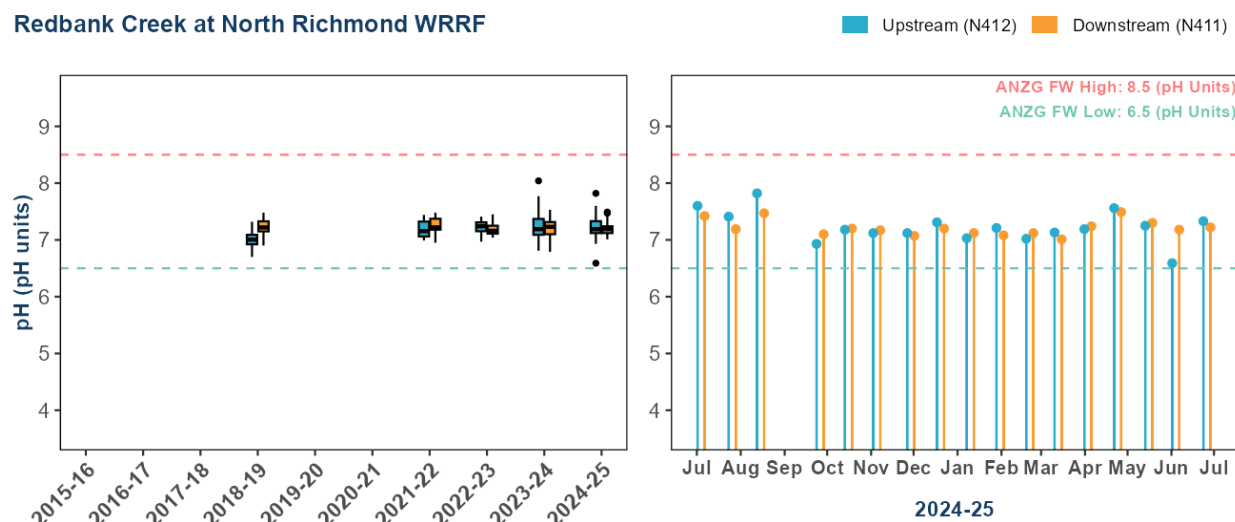
Redbank Creek at North Richmond WRRF



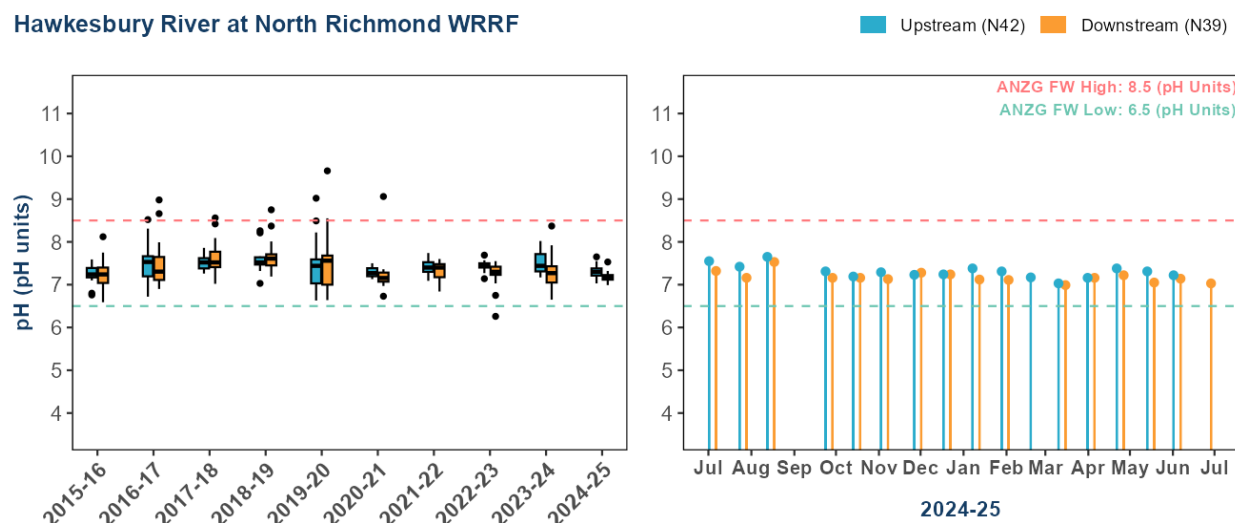
Hawkesbury River at North Richmond WRRF



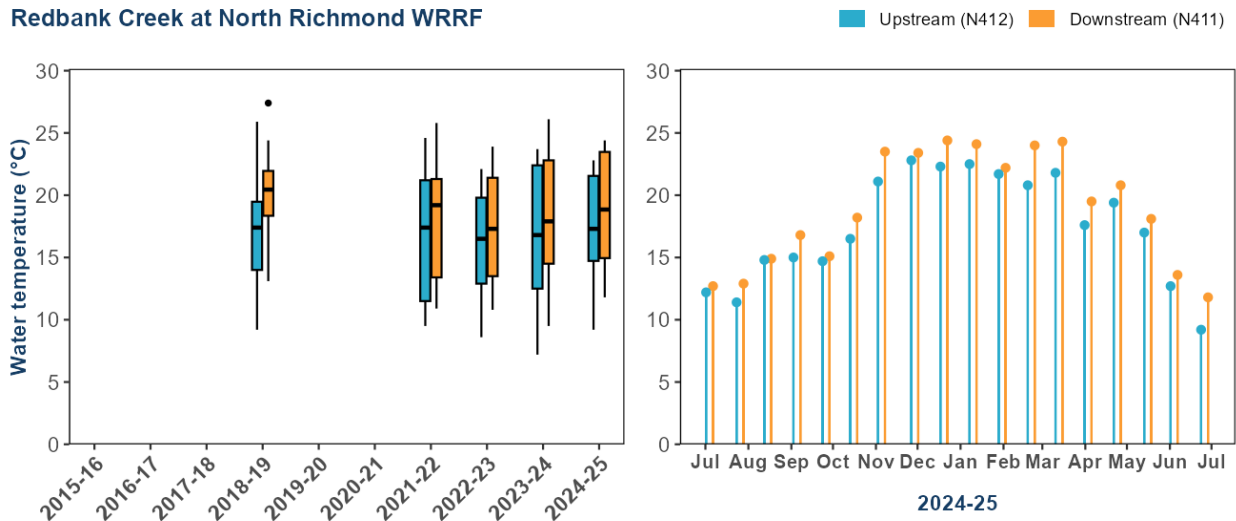
Redbank Creek at North Richmond WRRF



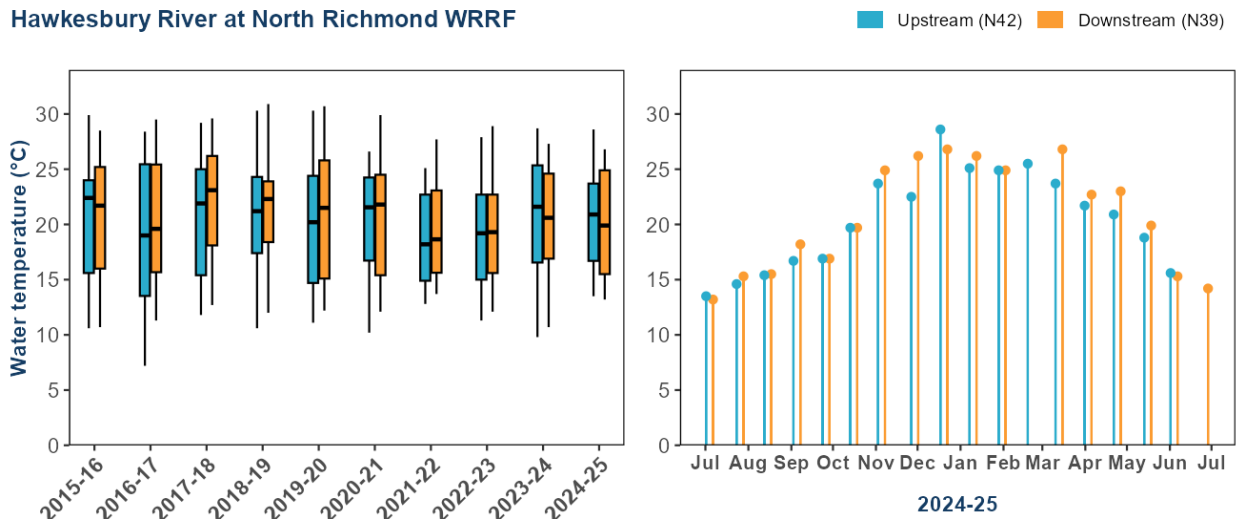
Hawkesbury River at North Richmond WRRF



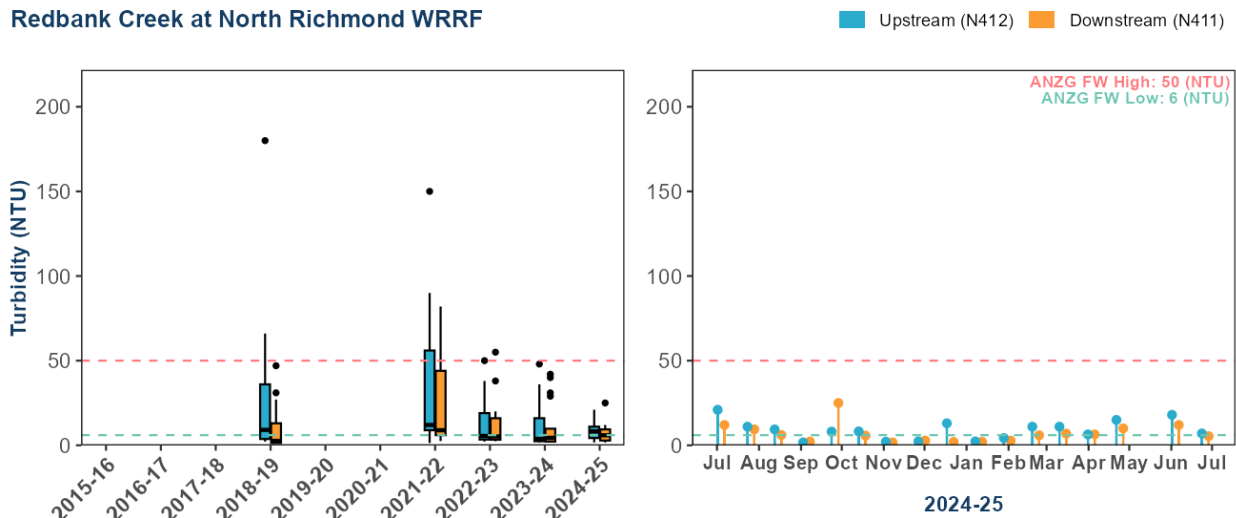
Redbank Creek at North Richmond WRRF



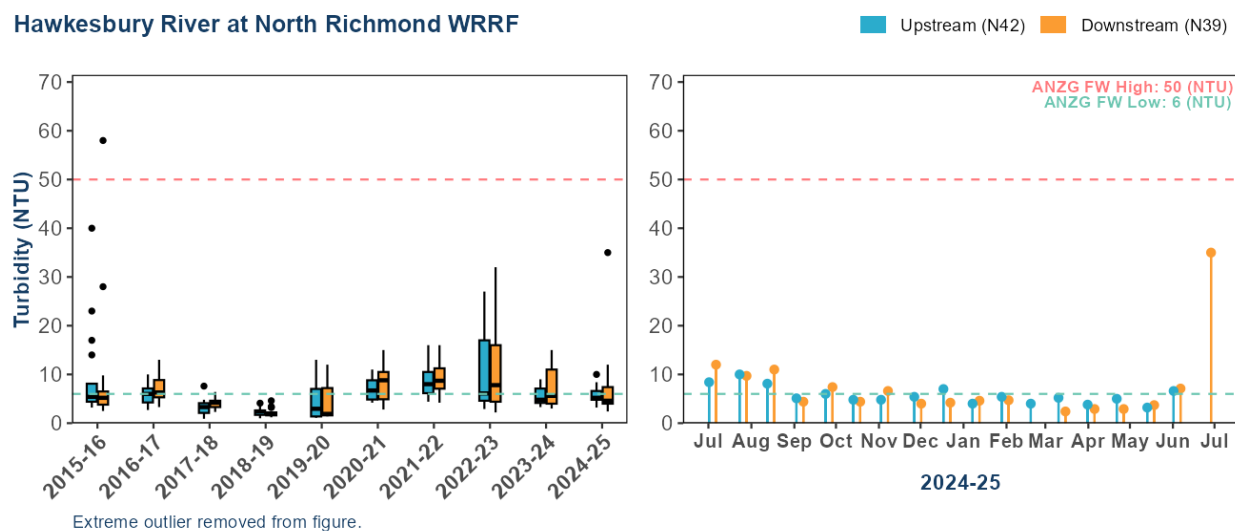
Hawkesbury River at North Richmond WRRF



Redbank Creek at North Richmond WRRF

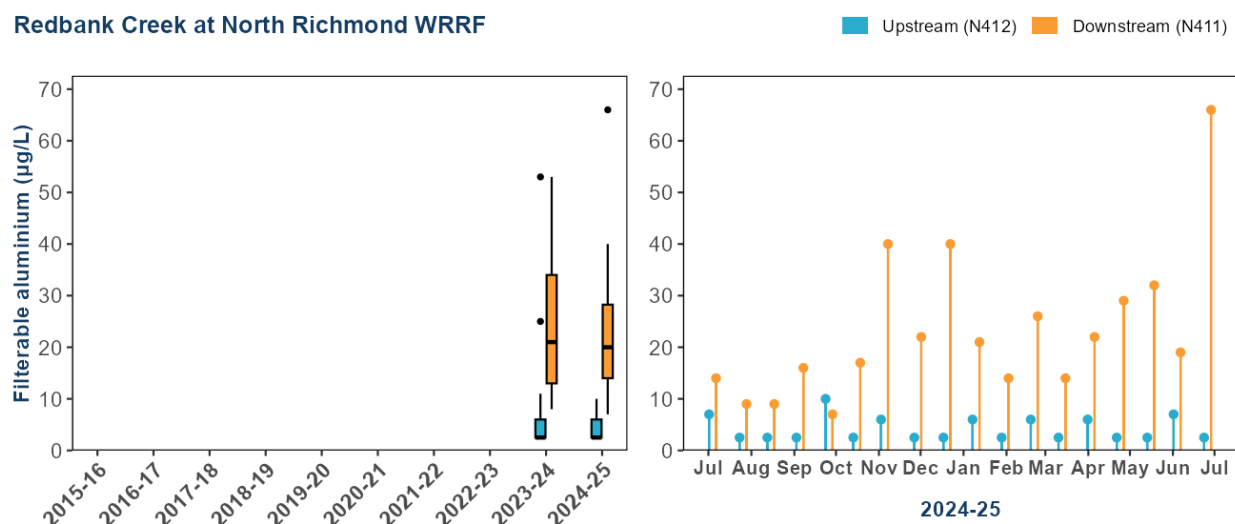


Hawkesbury River at North Richmond WRRF

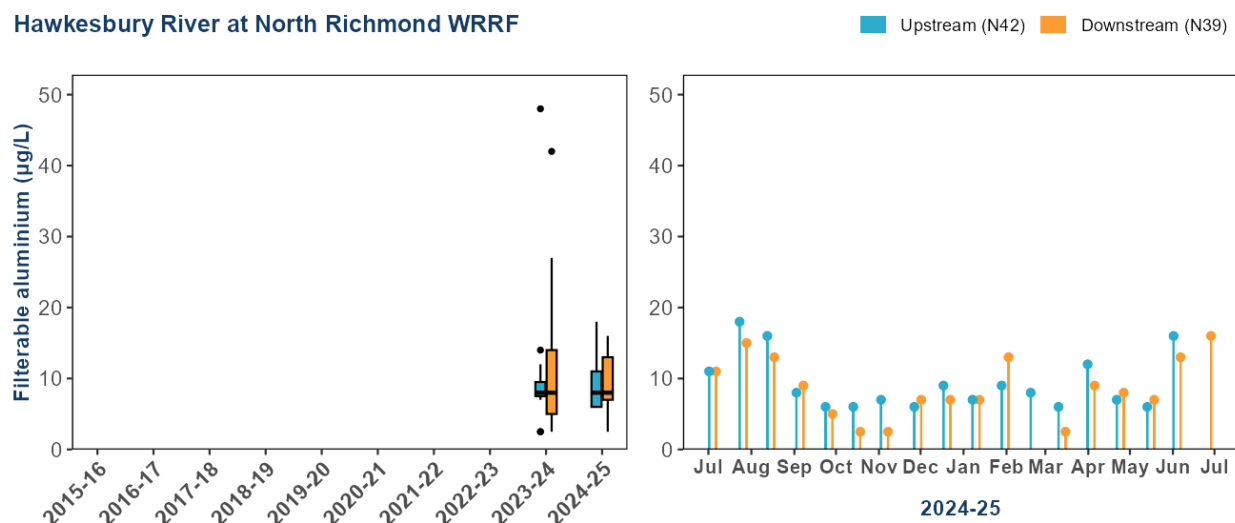


A.6.8. Stressor – Trace metals

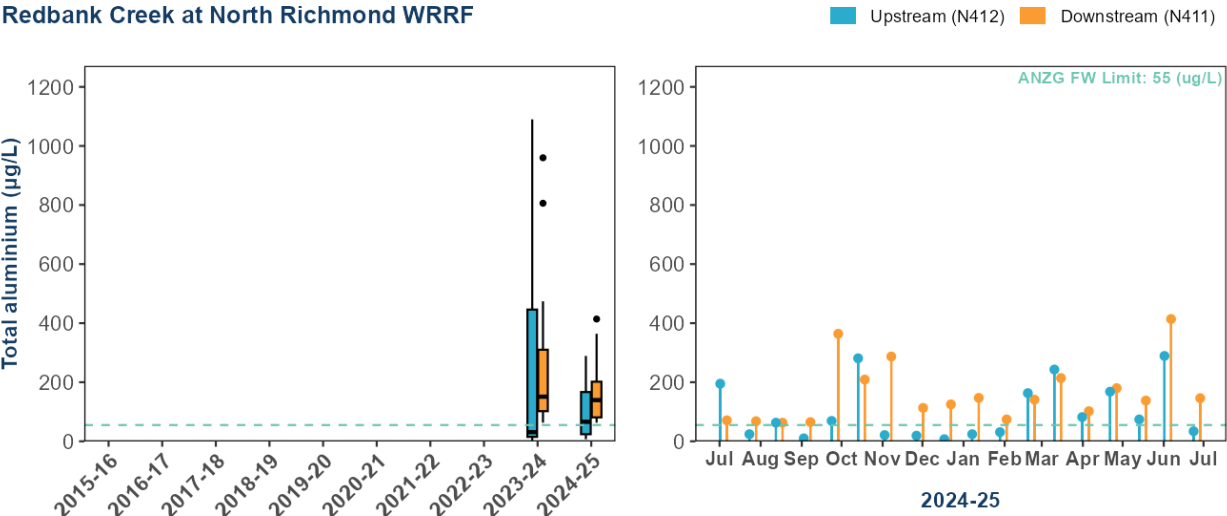
Redbank Creek at North Richmond WRRF



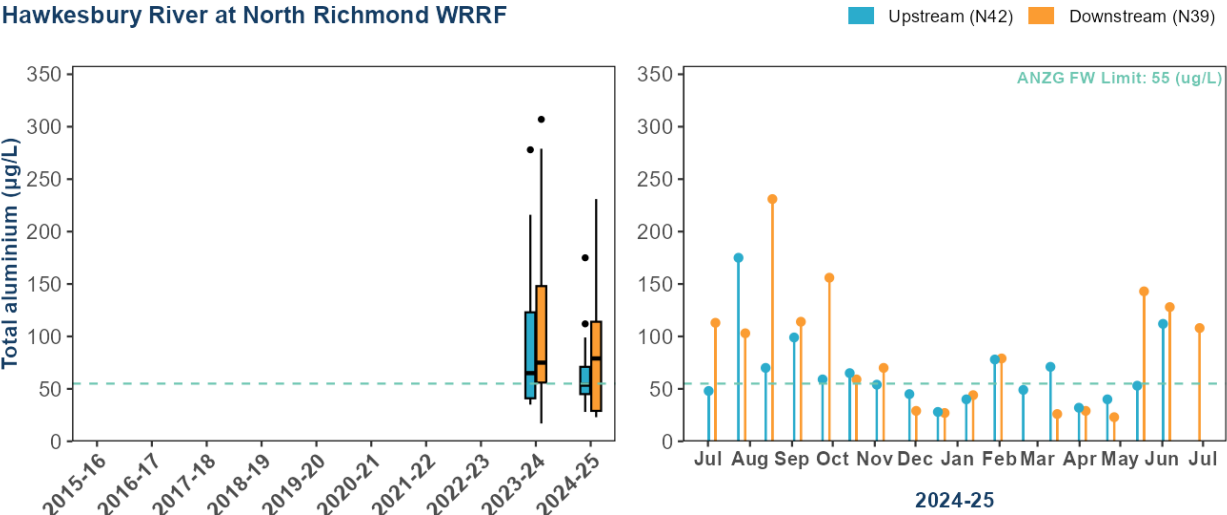
Hawkesbury River at North Richmond WRRF



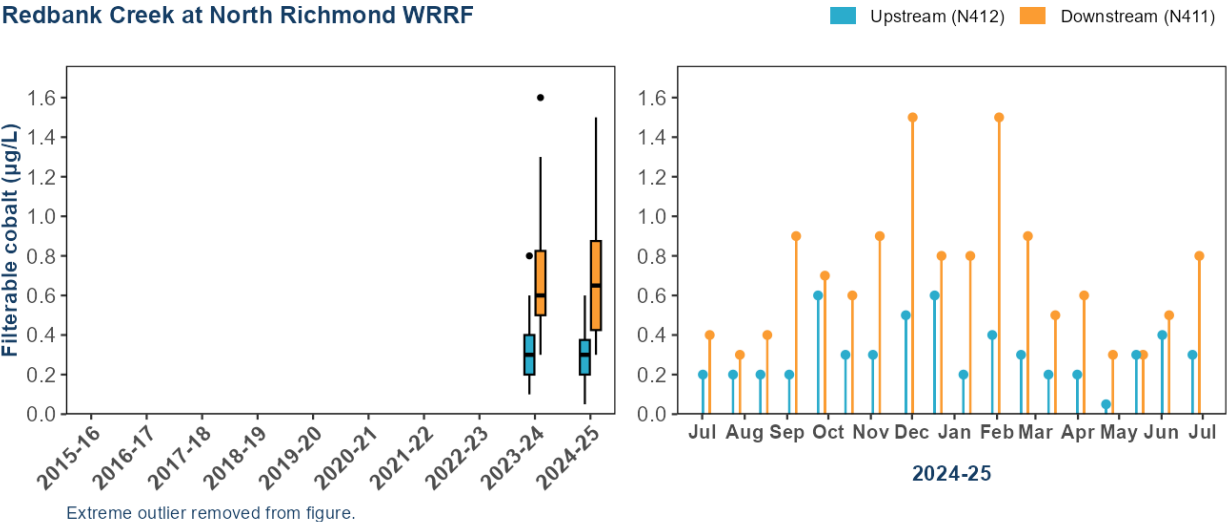
Redbank Creek at North Richmond WRRF



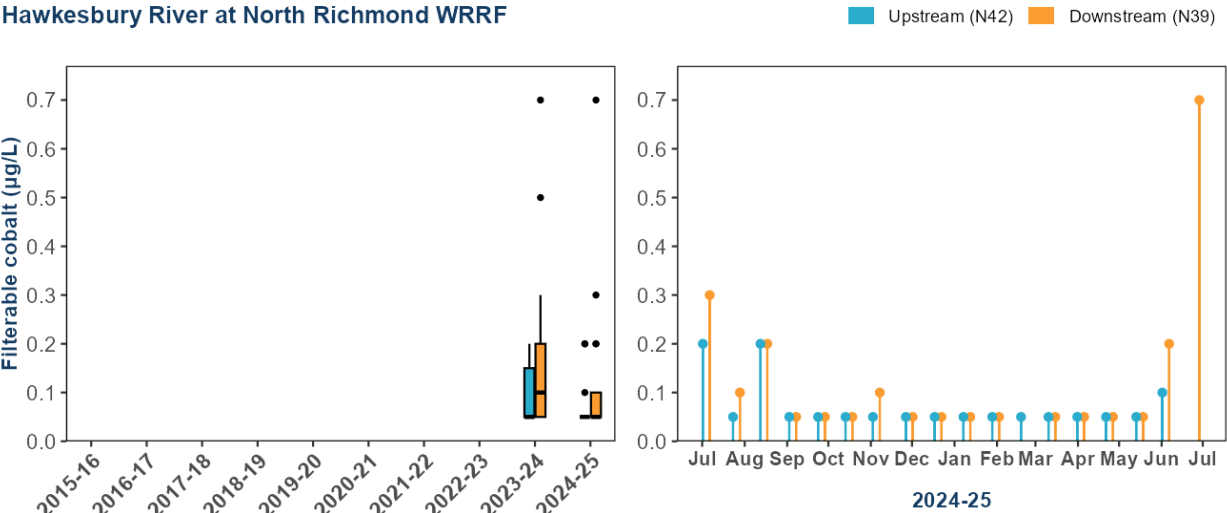
Hawkesbury River at North Richmond WRRF



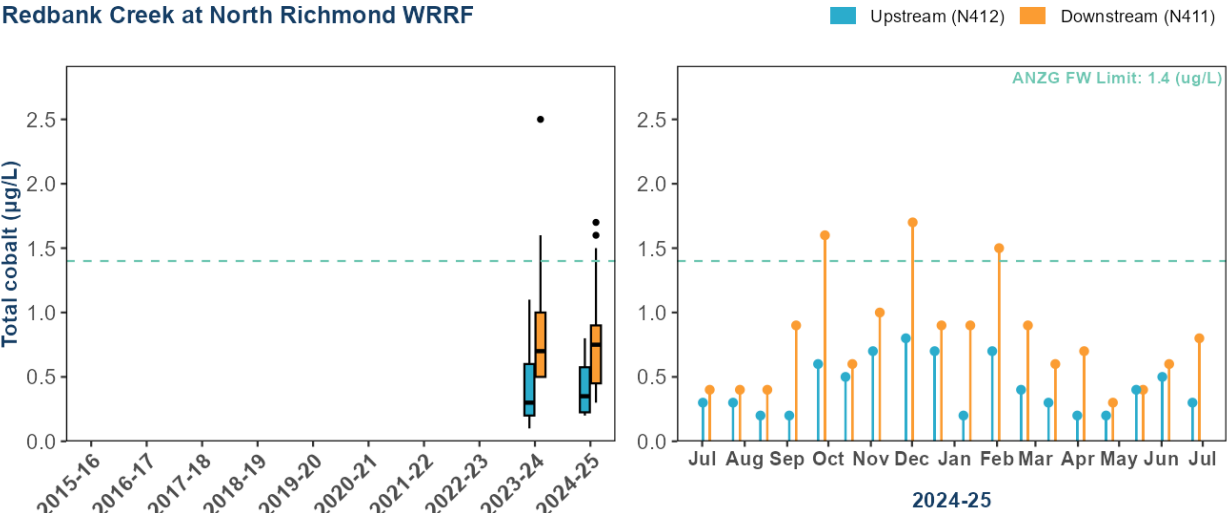
Redbank Creek at North Richmond WRRF



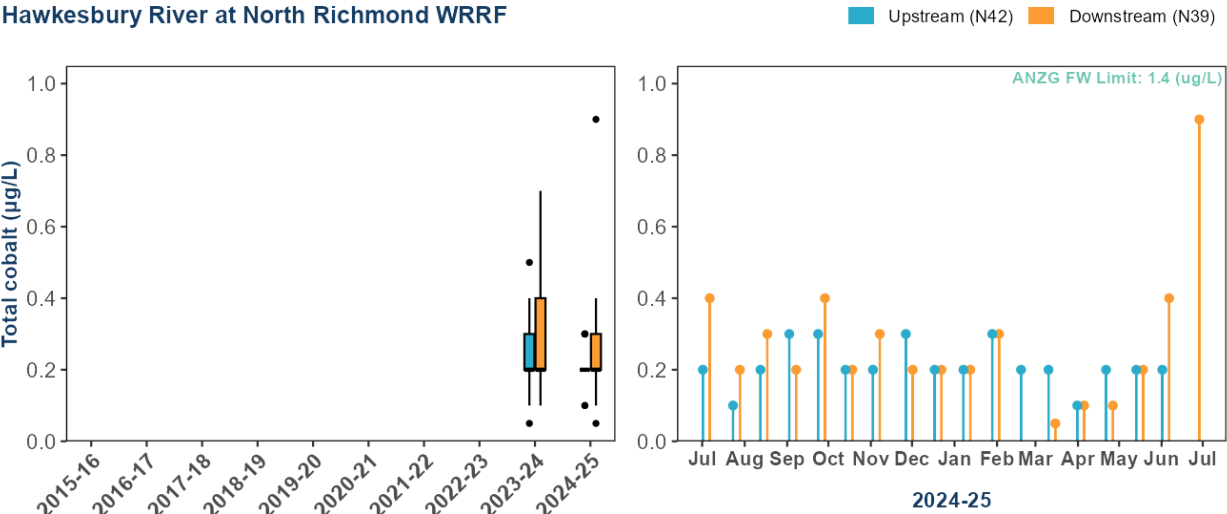
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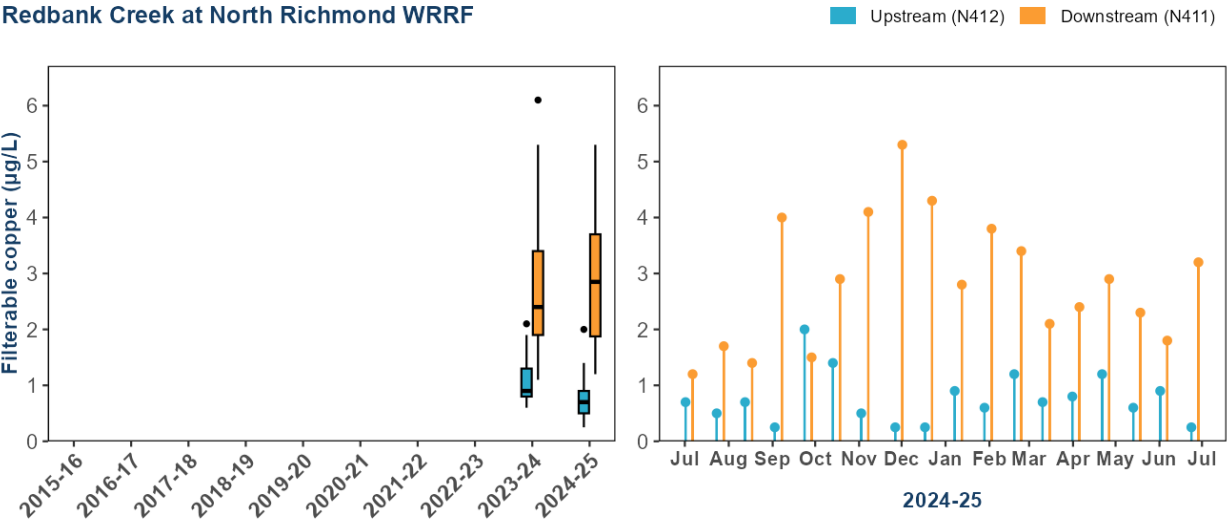
Redbank Creek at North Richmond WRRF



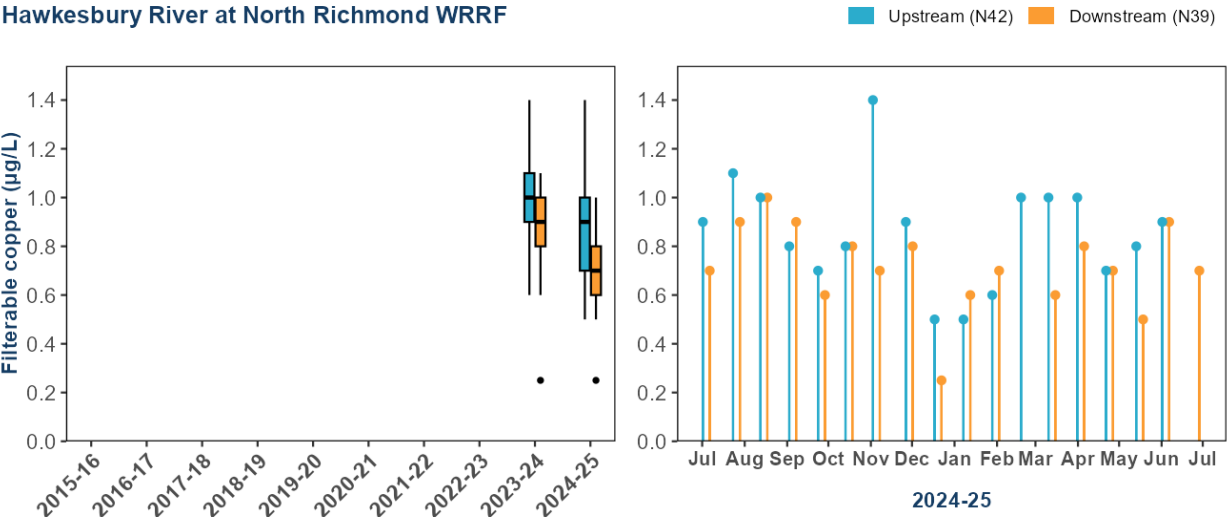
Hawkesbury River at North Richmond WRRF



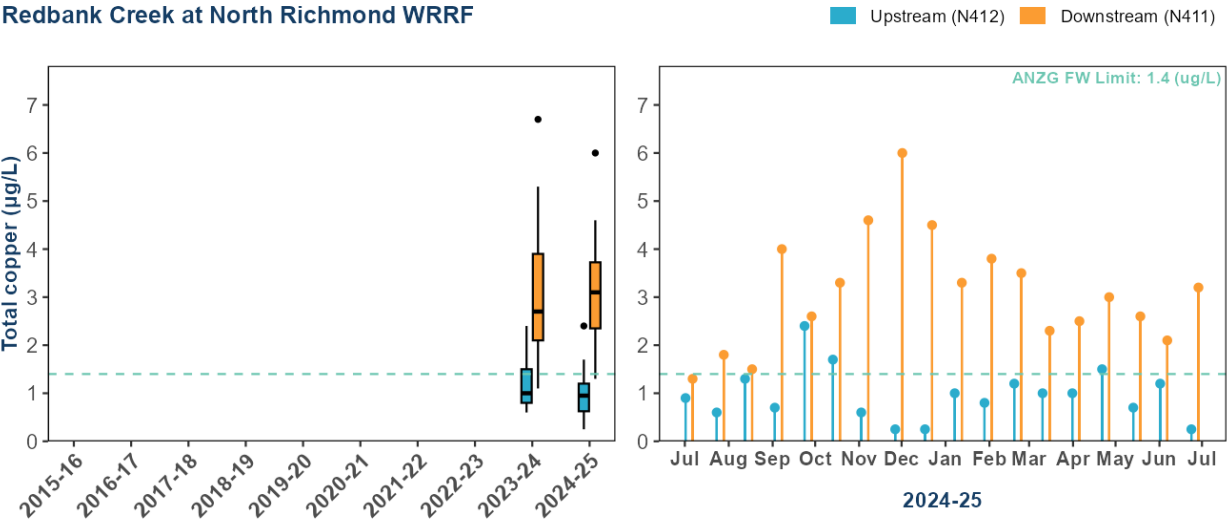
Redbank Creek at North Richmond WRRF



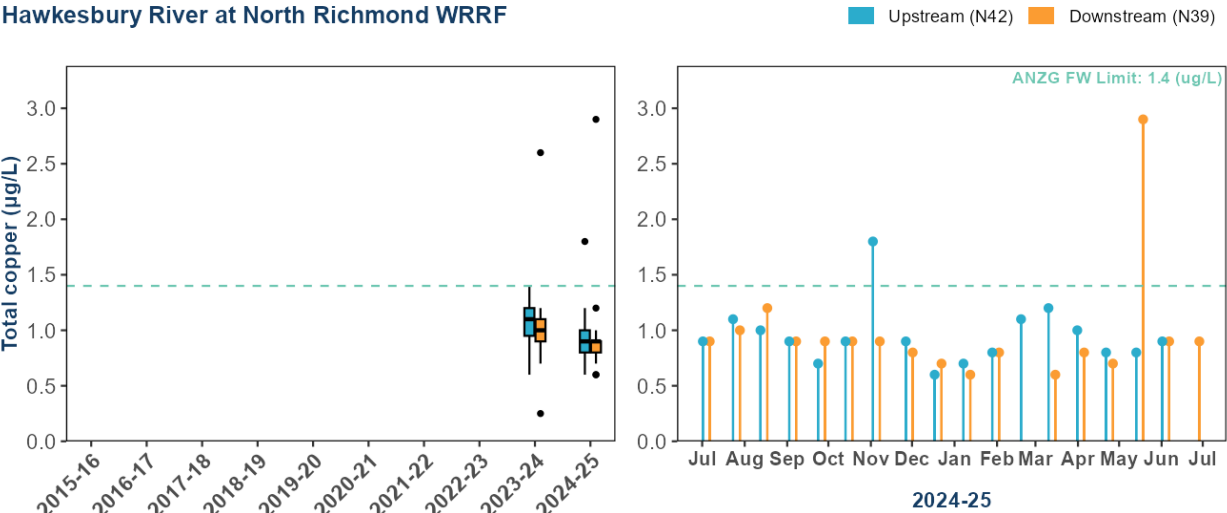
Hawkesbury River at North Richmond WRRF



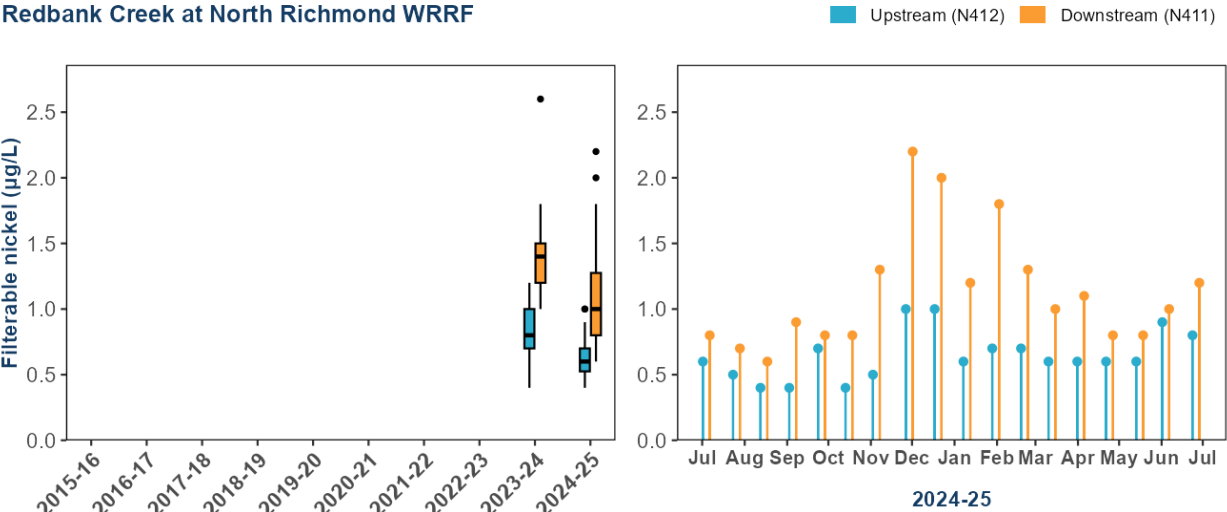
Redbank Creek at North Richmond WRRF



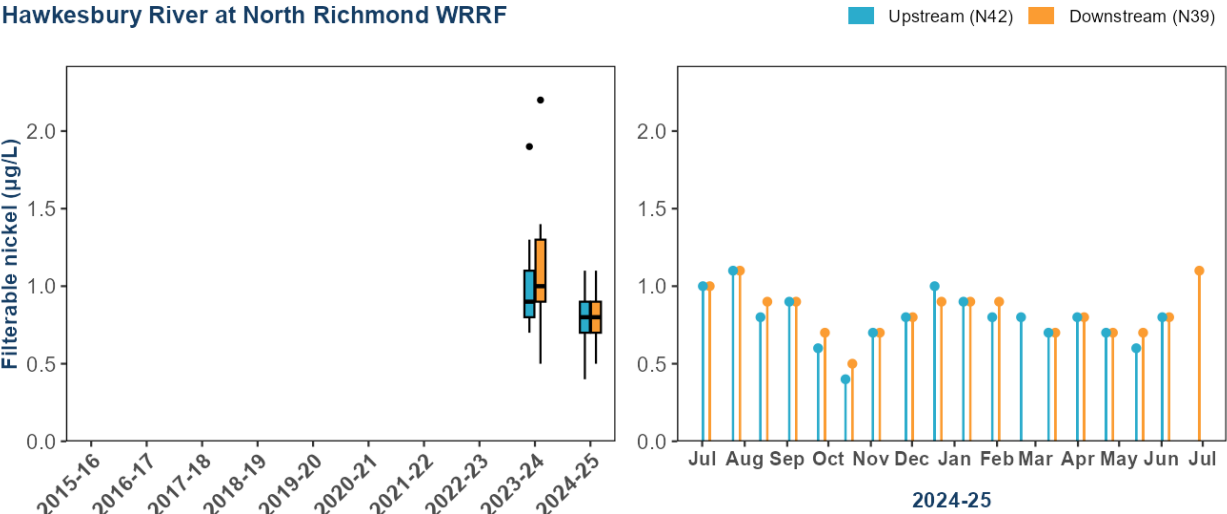
Hawkesbury River at North Richmond WRRF



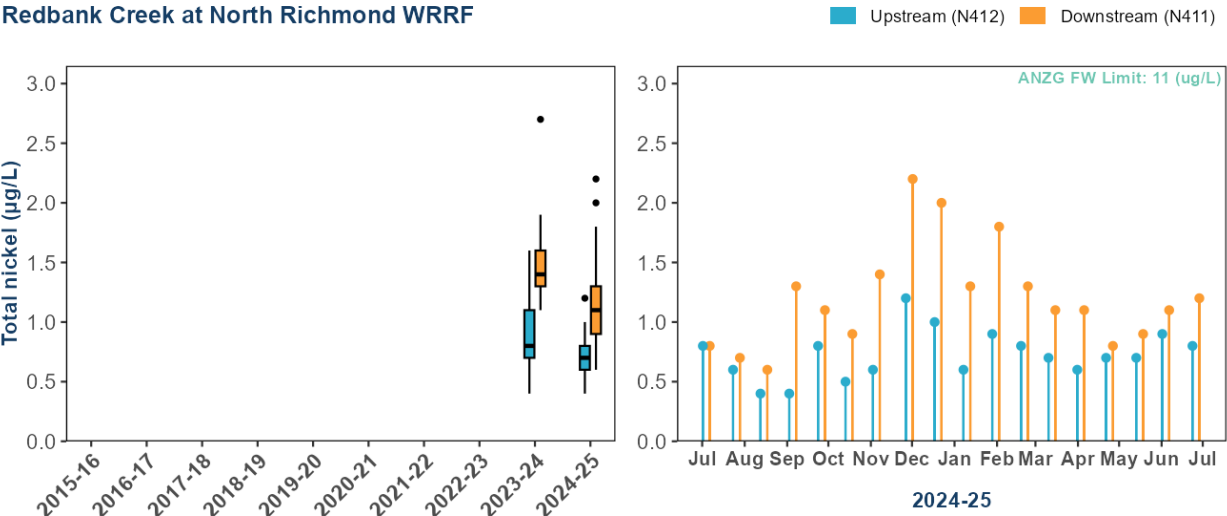
Redbank Creek at North Richmond WRRF



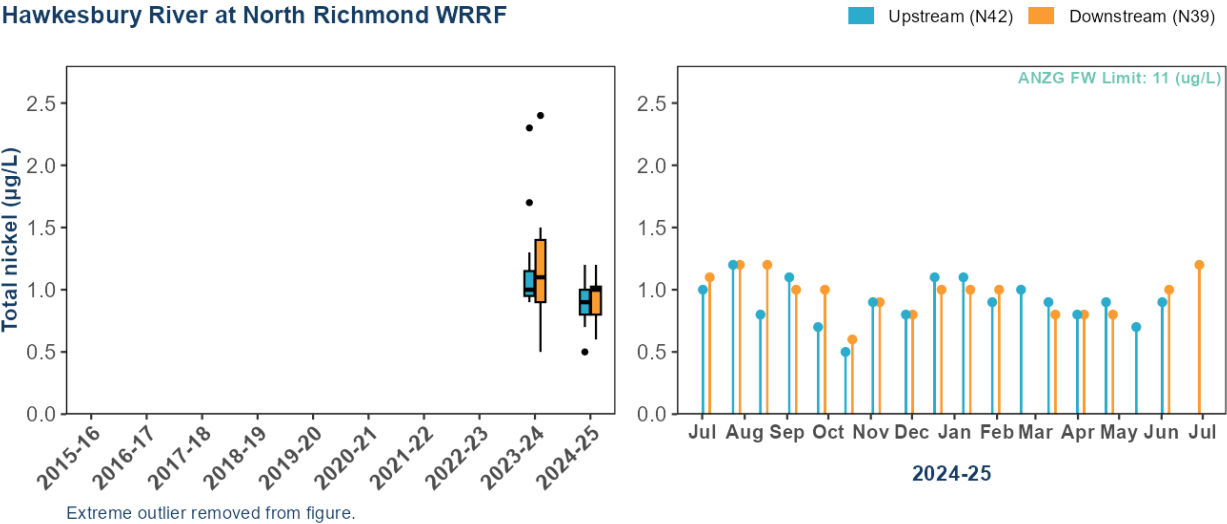
Hawkesbury River at North Richmond WRRF



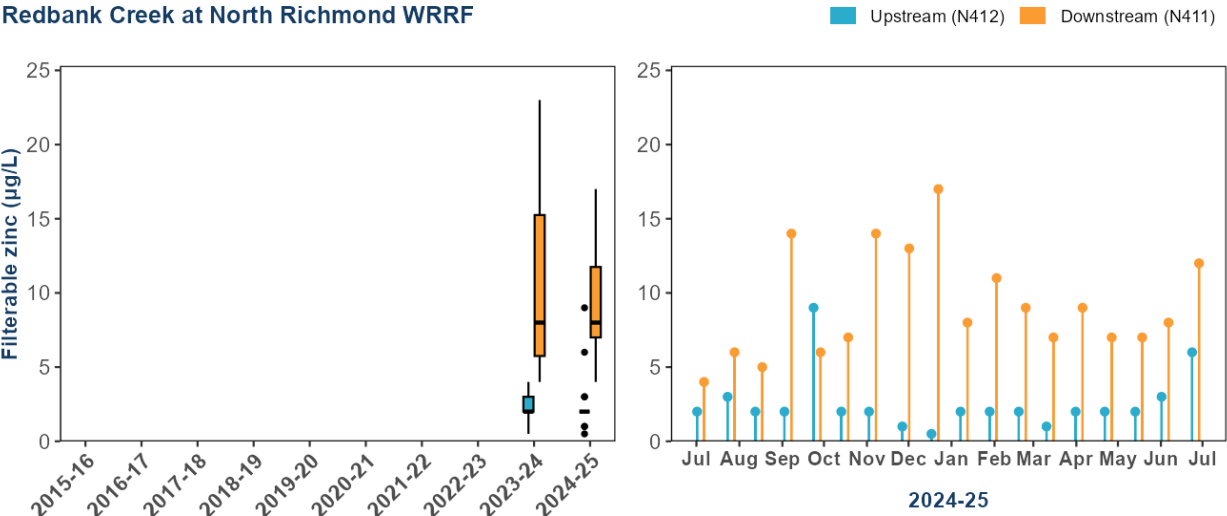
Redbank Creek at North Richmond WRRF



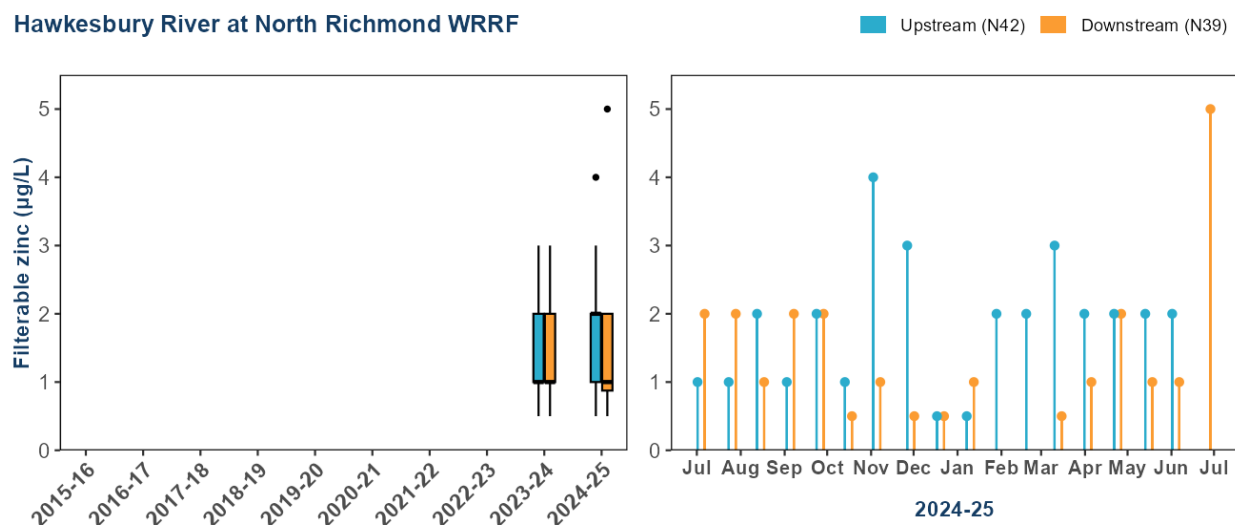
Hawkesbury River at North Richmond WRRF



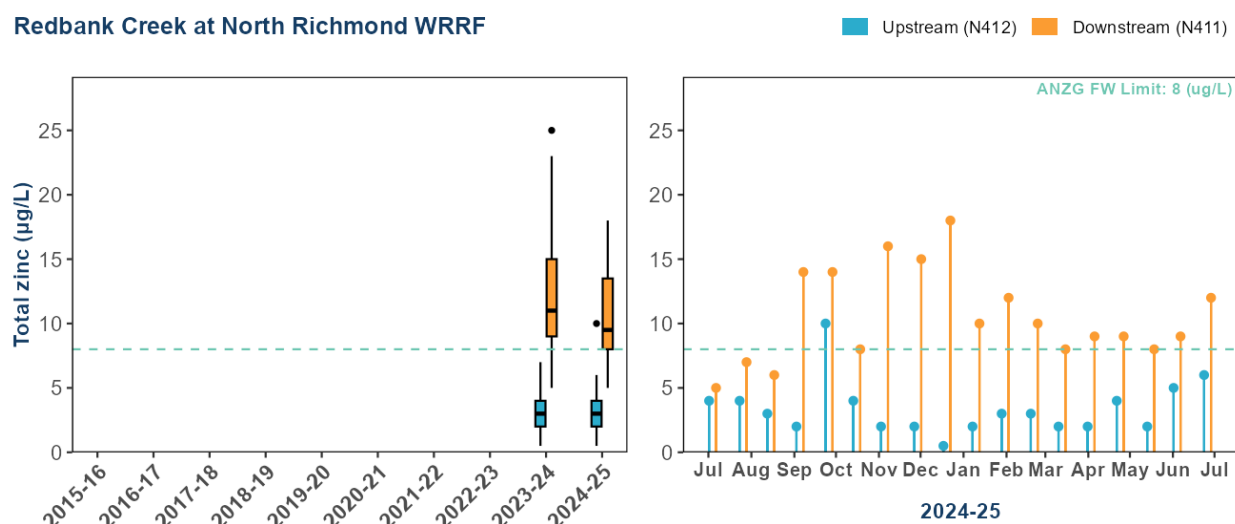
Redbank Creek at North Richmond WRRF



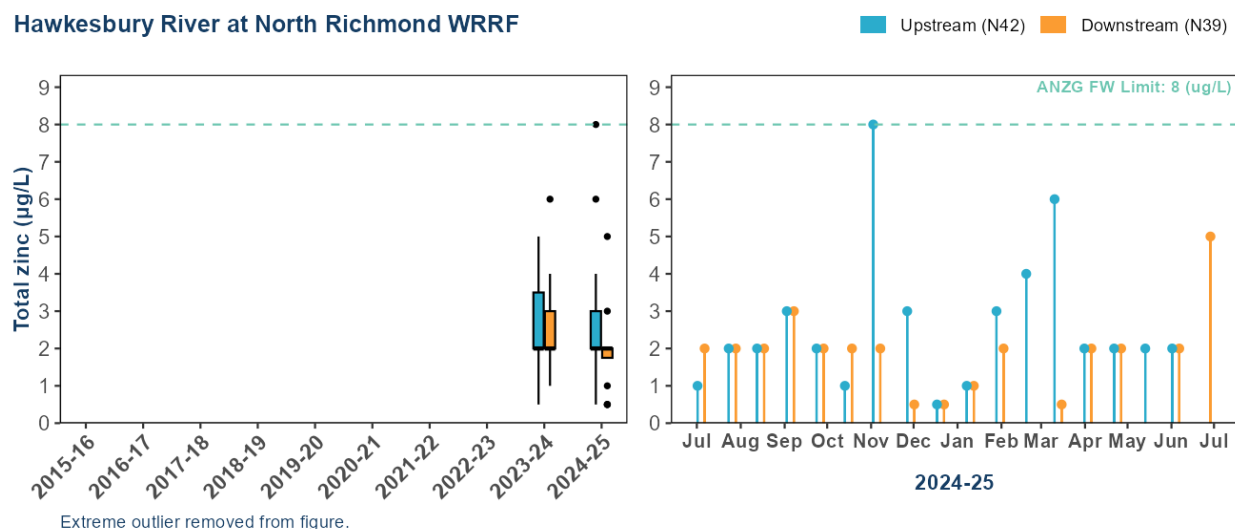
Hawkesbury River at North Richmond WRRF



Redbank Creek at North Richmond WRRF



Hawkesbury River at North Richmond WRRF



A.6.9. Ecosystem receptor – Statistical analysis outcomes

Table A-68 Upstream vs downstream comparison (2024-25 reporting period) for Redbank Creek at North Richmond WRRF

Redbank Creek at North Richmond WRRF: N412 vs N411 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.50	0.47	160	1.28	0.578
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-69 Upstream current period (2024-25) vs previous period comparison (single site) for Redbank Creek at North Richmond WRRF

Redbank Creek at North Richmond WRRF: N412 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.10	0.28	160	0.36	0.984
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-70 Downstream current period (2024-25) vs previous period comparison (single site) for Redbank Creek at North Richmond WRRF

Redbank Creek at North Richmond WRRF: N411 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.36	0.34	160	1.23	0.606
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-71 Upstream vs downstream comparison (2024-25 reporting period) for the Hawkesbury River at North Richmond WRRF

Hawkesbury River at North Richmond WRRF: N42 vs N39 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.05	0.28	314	0.17	0.998
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-72 Upstream current period (2024-25) vs previous period comparison (single site) for the Hawkesbury River at North Richmond WRRF

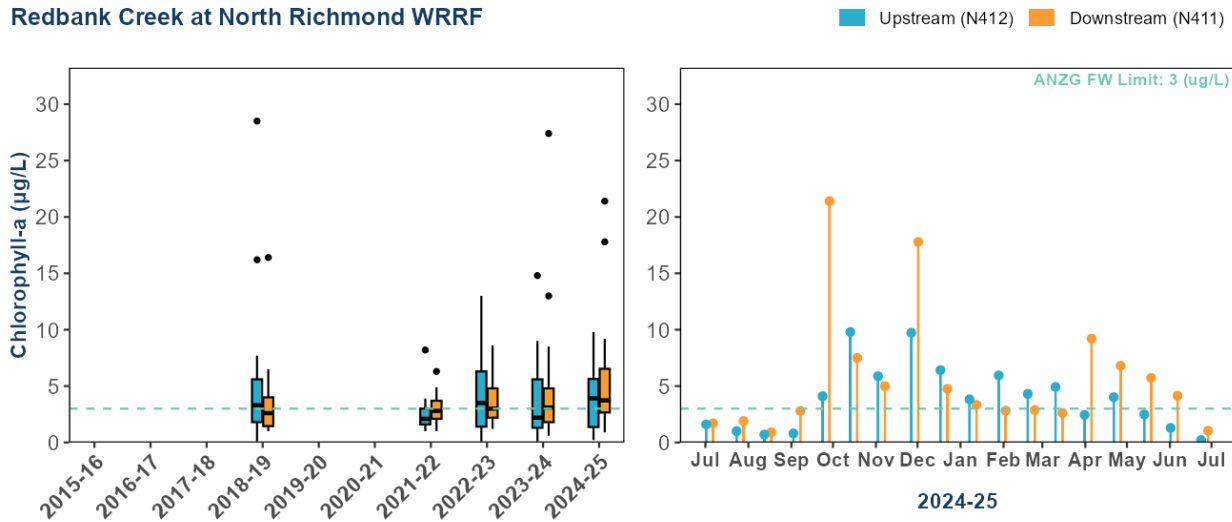
Hawkesbury River at North Richmond WRRF: N42 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.85	0.17	314	-0.81	0.847
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-73 Downstream current period (2024-25) vs previous period comparison (single site) for the Hawkesbury River at North Richmond WRRF

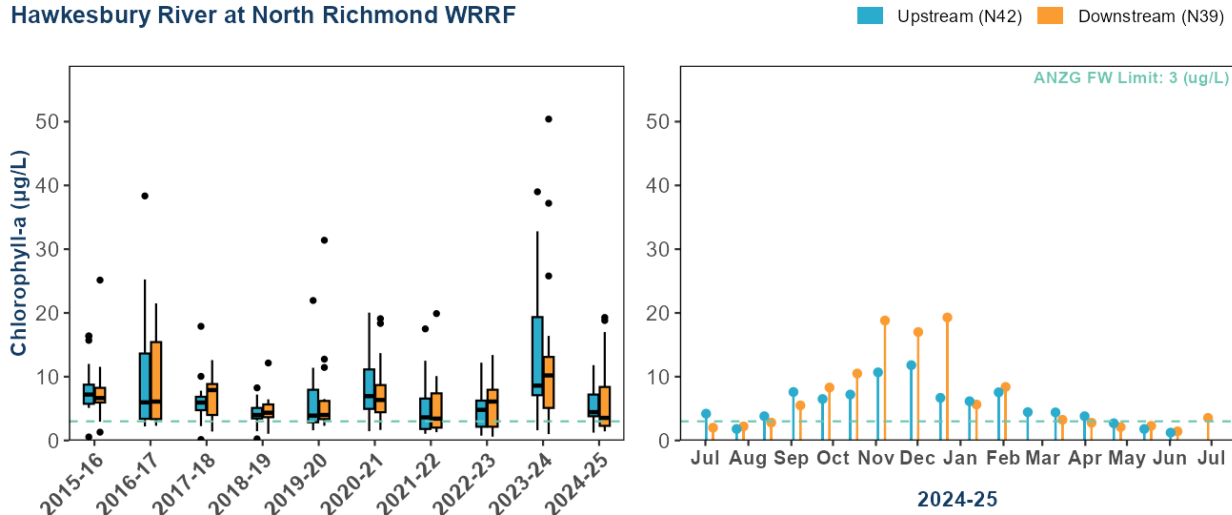
Hawkesbury River at North Richmond WRRF: N39 (River)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.87	0.17	314	-0.68	0.905
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.6.10. Ecosystem receptor – Phytoplankton

Redbank Creek at North Richmond WRRF



Hawkesbury River at North Richmond WRRF

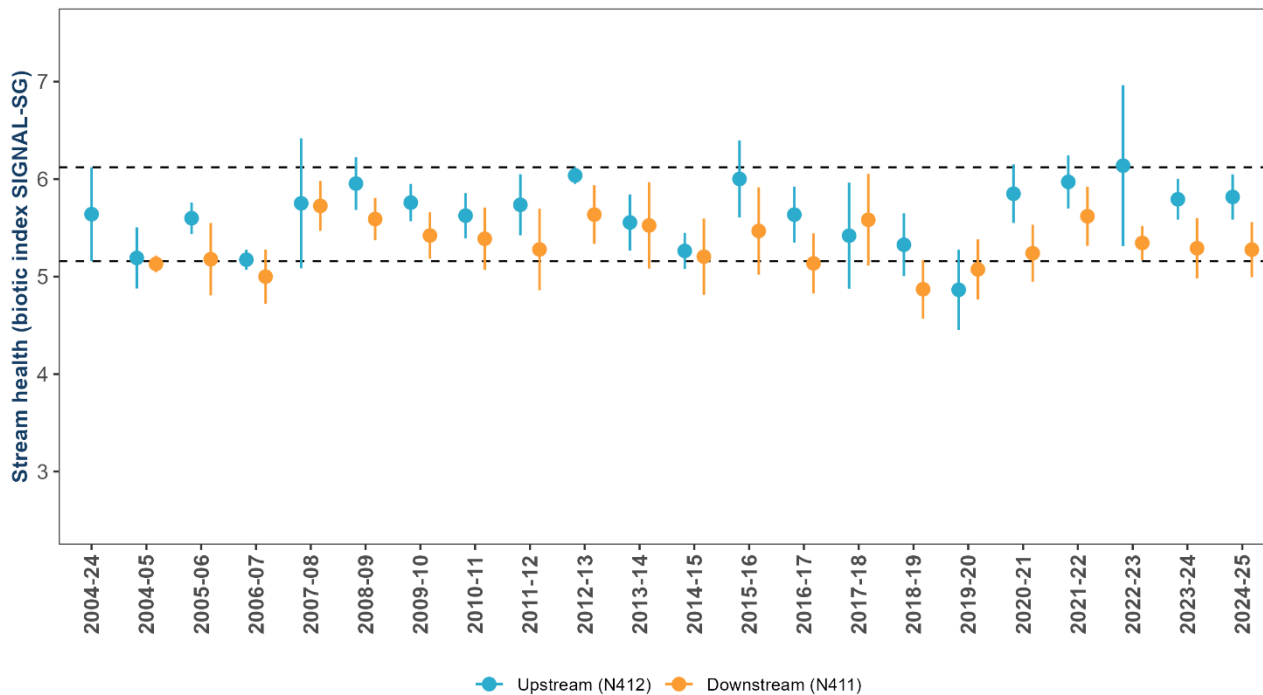


A.6.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Redbank Creek	Tributary (N412 vs N411)	Welch Two Sample t-test	0.54	3.62	9.6	0.005
Hawkesbury River	River (N42 vs N39)	Welch Two Sample t-test	0.61	1.09	8.7	0.304

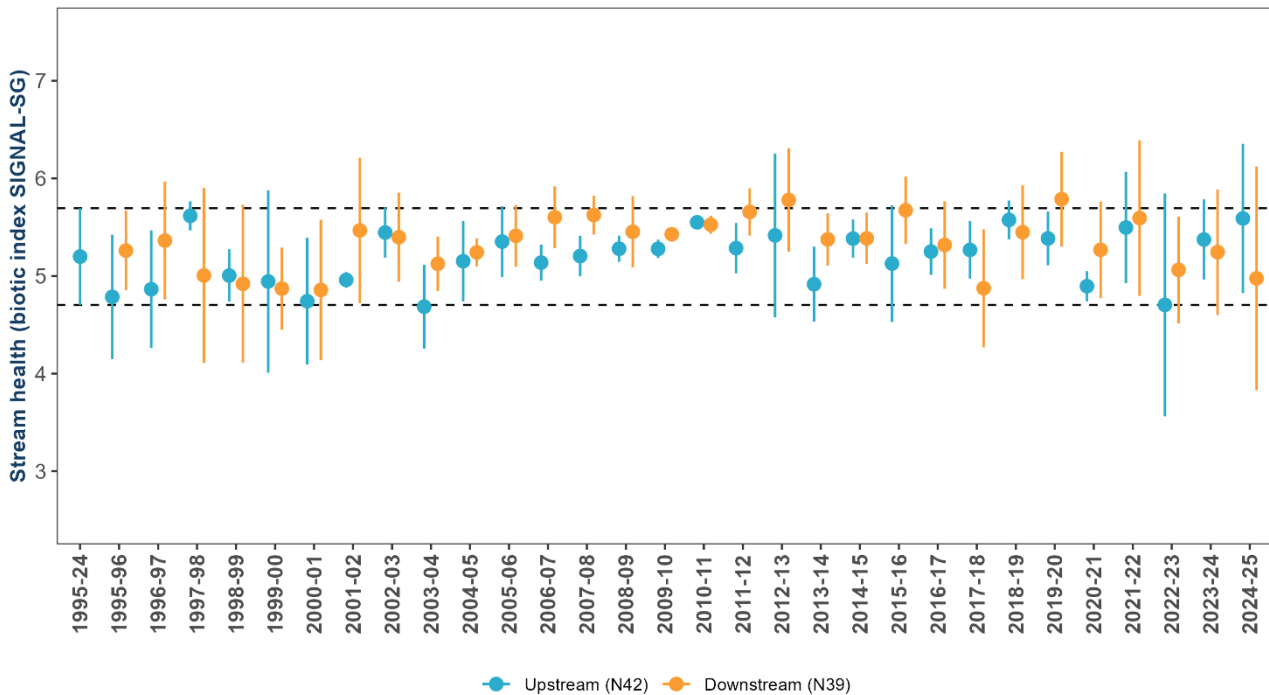
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Redbank Creek at North Richmond WRRF



The range of stream health recorded over each period is represented by length of line

Hawkesbury River at North Richmond WRRF



The range of stream health recorded over each period is represented by length of line

A.6.12. Gate 3 investigation for North Richmond WRRF

The increased total nitrogen and phosphorus concentrations in the North Richmond WRRF discharge were reflected in the downstream receiving waters with significantly higher nutrient concentrations in Redbank Creek compared to the upstream site. Filterable metal concentrations were also significantly higher at the downstream site (N411). The gate 3 analysis focused on investigating the potential influence of these parameters on the downstream ecosystem health impact found at Redbank Creek, as indicated by a significant difference in the macroinvertebrate SIGNAL-SG score.

Stage 1: Multivariate analysis of macroinvertebrate community data

Edge habitat samples were collected consistently from Redbank Creek, enabling multivariate analysis for the monitoring period 2005 to 2025. At the Hawkesbury River upstream and downstream of the confluence with Redbank Creek sites, sampling of macrophyte and edge habitats was highly imbalanced between sites. As such, it was not appropriate to perform multivariate analyses on the North Richmond Hawkesbury River sites.

Visual ordination patterns (nMDS and cluster diagrams, Figure A-11 and Figure A-12) showed a moderate separation between upstream and downstream sites. Cluster analysis confirmed this pattern, with most upstream and downstream samples not separating until the fourth or fifth division.

Multivariate statistical results are summarised in Table A-74. PERMDISP analysis returned a non-significant outcome, indicating similar dispersion within sites and allowing interpretation of between-site differences without confounding variability. ANOSIM tests on the factor 'site' returned

a low-range R value (0.237), suggesting taxonomic assemblage was similar between sites. ANOSIM based on site-period groups returned a significant global R value (0.239), with pairwise tests showing similar low to mid-range R values for all comparisons (0.129 to 0.426, Table A-75). PERMANOVA confirmed significant effects for both site and year, but the site-year interaction was non-significant, indicating temporal variation alongside weak spatial differences. Shade plots and BVSTEP outcomes suggest that taxonomic assemblage was not largely dissimilar between sites, with 46 genera forming the main visual patterns in the shade plot (Figure A-13 and Table A-76). These multivariate results suggest that there isn't strong evidence supporting the claim that downstream taxonomic assemblage in Redbank Creek has been altered by wastewater discharge from North Richmond WRRF in 2024-25.

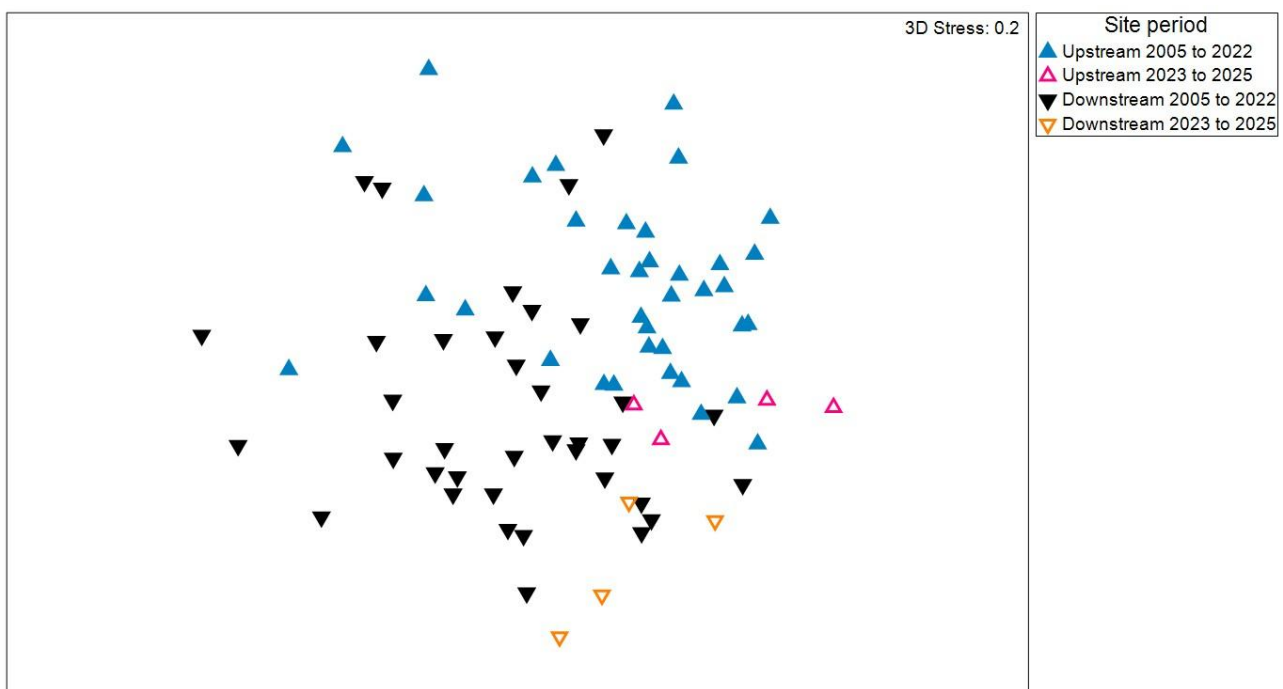


Figure A-11 Dimensions 1 and 2 of 2-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites of Redbank Creek near North Richmond WRRF

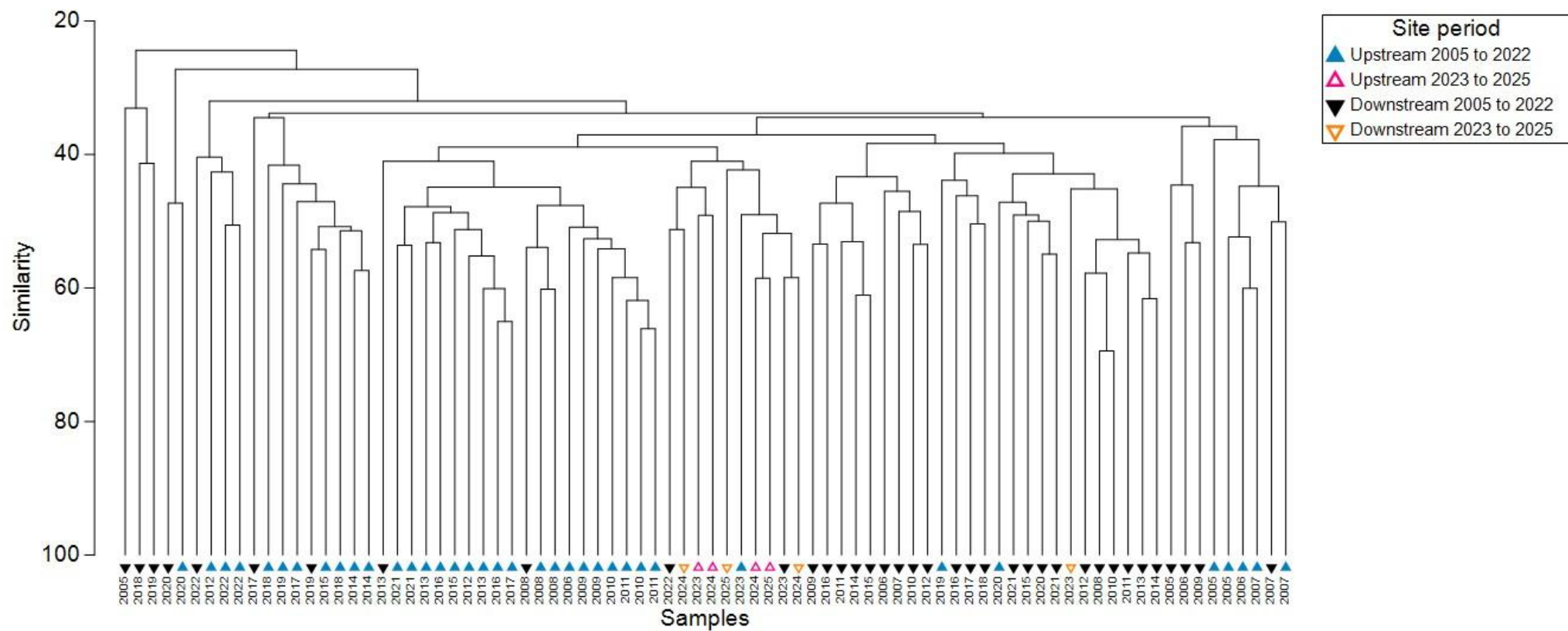


Figure A-12 Cluster diagram of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites of Redbank Creek near North Richmond WRRF

Table A-74 Macroinvertebrate multivariate statistical test summary for Redbank Creek near North Richmond WRRF

North Richmond Redbank Creek		Edge		
		df	Sample Statistic (Pseudo-F/R)	p-value
PERMDISP	Site	1 (80)	1.252	0.300
ANOSIM	Site	-	0.237	<0.001
	SitexPeriod	-	0.239	<0.001
PERMANOVA	Site	1 (81)	6.923	0.001
	Year	20 (81)	2.048	0.001
	SitexYear	20 (81)	0.866	0.964

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-75 ANOSIM pairwise comparisons of 'Site period' test for the edge habitat of the Redbank Creek near North Richmond WRRF

North Richmond Redbank Creek	Edge	
	R Statistic	p-value
Downstream 2005 to 2022, Upstream 2005 to 2022	0.246	<0.001
Downstream 2005 to 2022, Downstream 2023 to 2025	0.140	0.193
Downstream 2005 to 2022, Upstream 2023 to 2025	0.213	0.097
Upstream 2005 to 2022, Downstream 2023 to 2025	0.426	0.008
Upstream 2005 to 2022, Upstream 2023 to 2025	0.129	0.202
Downstream 2023 to 2025, Upstream 2023 to 2025	0.292	0.171

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-76 Estimates of components of variation from PERMANOVA tests for Redbank Creek

North Richmond Redbank Creek	Edge
S(Site)	239.93
S(Year)	436.02
S(SitexYear)	-111.32
V(Res)	1624.1

Table A-77 Genera subset whose multivariate pattern matches full genera set of the edge habitat of Redbank Creek near North Richmond WRRF

Subset of 46 (correlation 0.950) genera from Redbank Creek edge habitat whose pattern matches that of the full set of 193 genera identified with the same subset found on 4 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Chironomidae Chironomus, Coenagrionidae Ischnura, Physidae Physella, Chironomidae Cricotopus, Chironomidae Cryptochironomus, Coenagrionidae Austroagrion, Dugesiiidae Cura, Glossiphoniidae Helobdella, Lumbriculidae Lumbriculus, Lymnaeidae Pseudosuccinea, Naididae Branchiura, Pleidae Paraplea, Simuliidae Simulium, Argiolestidae Austroargiolestes, Chironomidae Polypedilum, Chironomidae Procladius, Chironomidae Rheocricotopus, Corduliidae Hemicordulia, Dytiscidae Chostonectes, Dytiscidae Liodessus, Gelastocoridae Nerthra, Isostictidae Rhadinosticta, Libellulidae Diplacodes, Libellulidae Nannophlebia, Planorbidae Glyptophysa, Sphaeriidae Musculium, Atyidae Paratya, Baetidae Cloeon, Ceratopogonidae Bezzia, Dytiscidae Necterosoma, Ecnomidae Ecnomus, Gomphidae Austrogomphus, Chironomidae Paratanytarsus, Chironomidae Riethia, Dytiscidae Hyphydrus, Haliplidae Haliphus, Hydrophilidae Berosus, Leptoceridae Oecetis, Limnesiidae Limnesia, Oxidae Oxus, Veliidae Microvelia, Chironomidae Ablabesmyia, Chironomidae Tanytarsus, Leptoceridae Triplectides, Leptophlebiidae Atalophlebia, Scirtidae shin

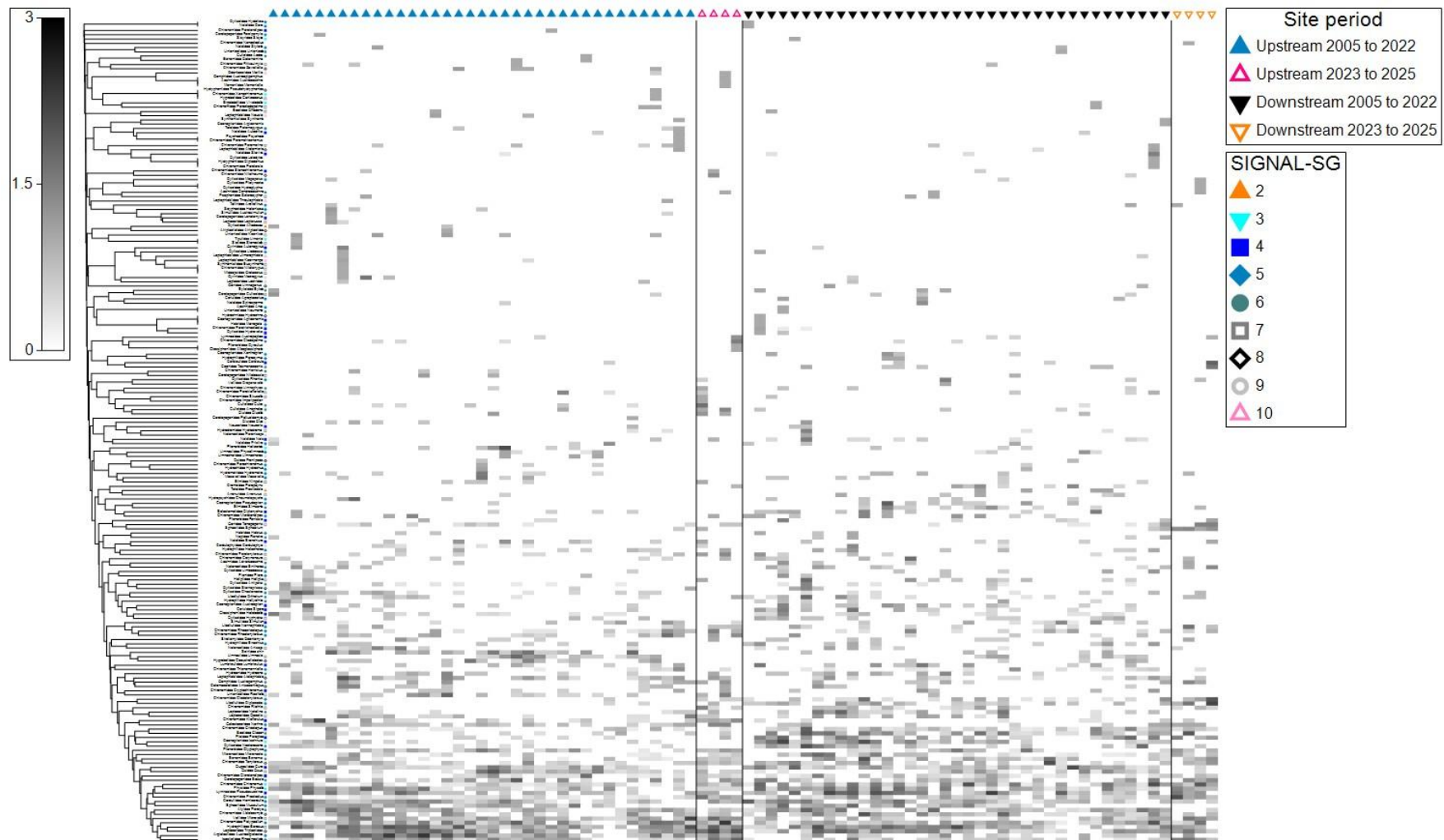


Figure A-13 Shade plot of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites of Redbank Creek near North Richmond WRRF

Stage 2: Multivariate regression linking water quality and ecosystem receptors

A visual upstream and downstream comparison of the modelled parameters indicated potential increased concentrations of ammonia nitrogen, conductivity, and total phosphorus at the downstream site (Figure A-14). The sequential tests of the model suggested that conductivity was the best fit predictor of macroinvertebrate variation as an ecosystem receptor ($AICc = -27.20$). However, the contribution of conductivity as a predictor of SIGNAL-SG score was found to be not significant during the marginal testing (Table A-78). A fitted and total variation of 0% indicated that the cause of variation in SIGNAL-SG score is likely an unaccounted measure (not monitored or insufficient data), outside of the water quality parameters included in the model. Monitoring of the upstream and downstream sites within Redbank Creek commenced in the 2018-19 financial year, and therefore, there is no available historic data to present long-term trend boxplots.

Redbank Creek at North Richmond WRRF (2019-25)

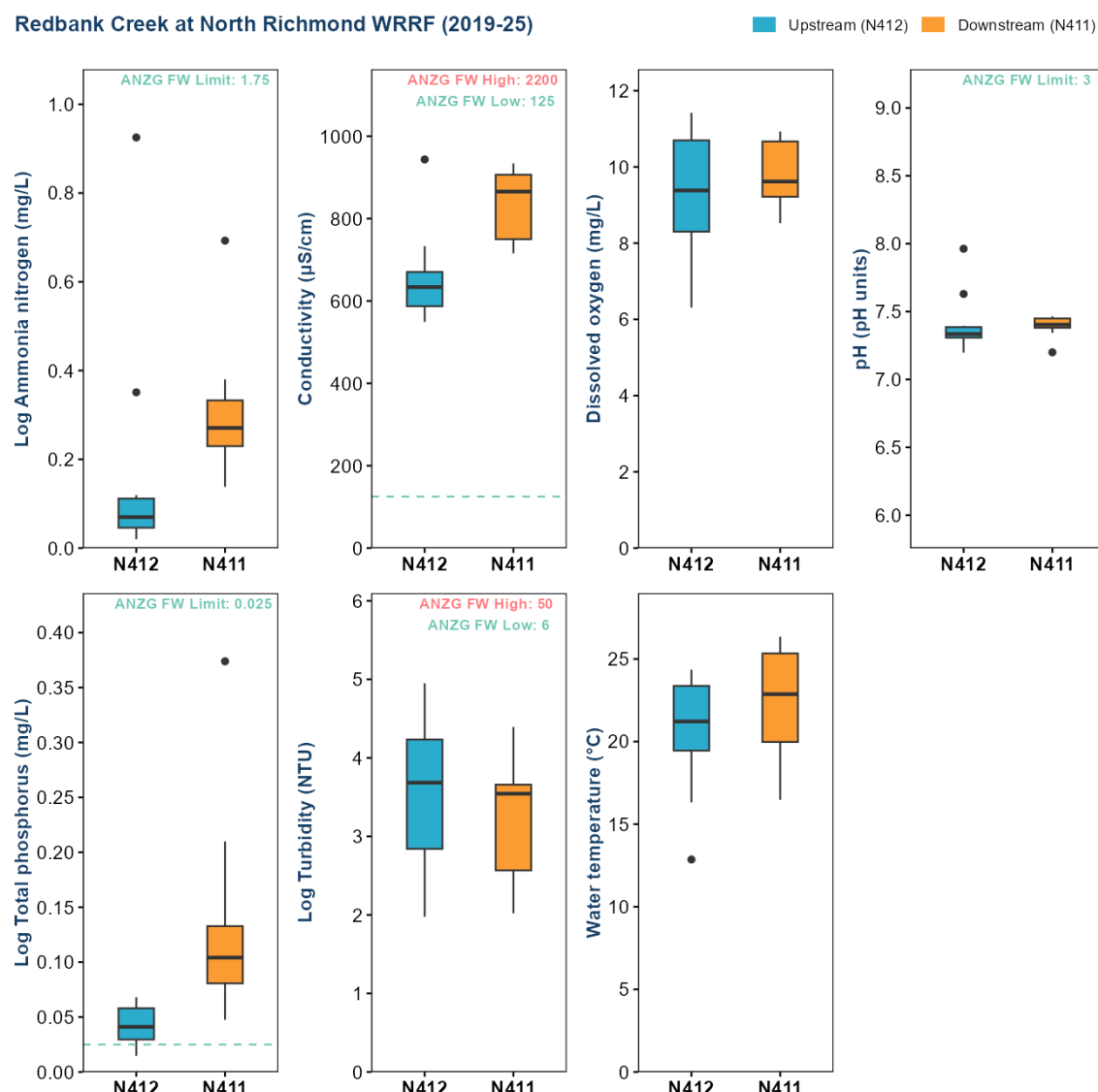


Figure A-14 Boxplots of the modelled parameters from 2019 to 2025 for the sites upstream and downstream of North Richmond WRRF in the Redbank Creek

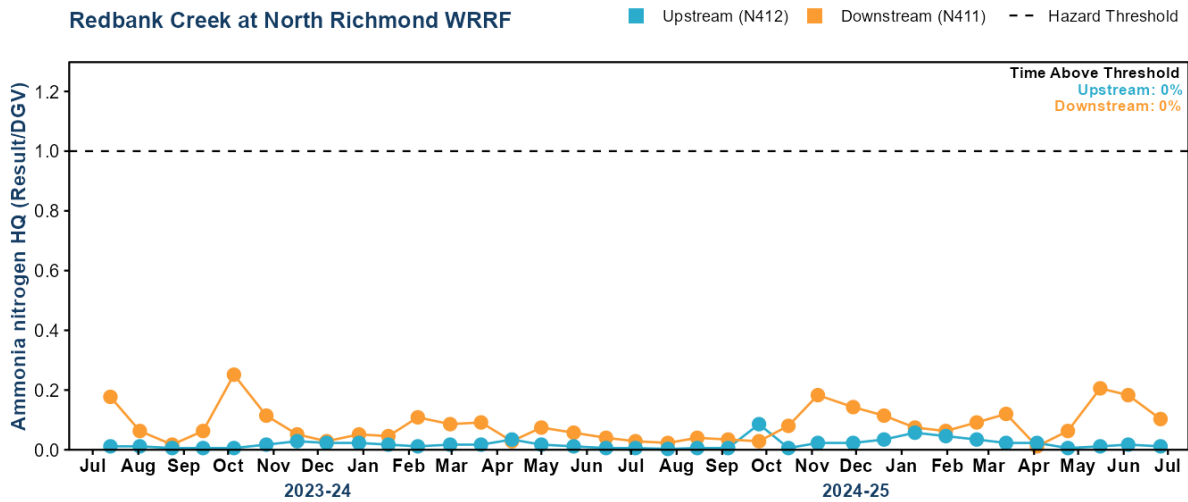
Table A-78 Results from the marginal tests of the DISTLM for Redbank Creek. Parameters are listed in order of their contribution in explaining variation in the SIGNAL-SG score (% Variation). * Represents a log(x+1) transformation; ns = non-significant.

Redbank Creek at North Richmond WRRF (2019-25)				
Modelled Parameters	SS	Pseudo-F	p	% Variation
Conductivity	0.35	1.47	ns	7.54
Total phosphorus *	0.28	1.19	ns	6.19
Ammonia nitrogen *	0.25	1.05	ns	5.50
Dissolved oxygen	0.08	0.33	ns	1.78
pH	0.06	0.24	ns	1.30
Turbidity *	0.02	0.06	ns	0.33
Water temperature	0.00	0.01	ns	0.07

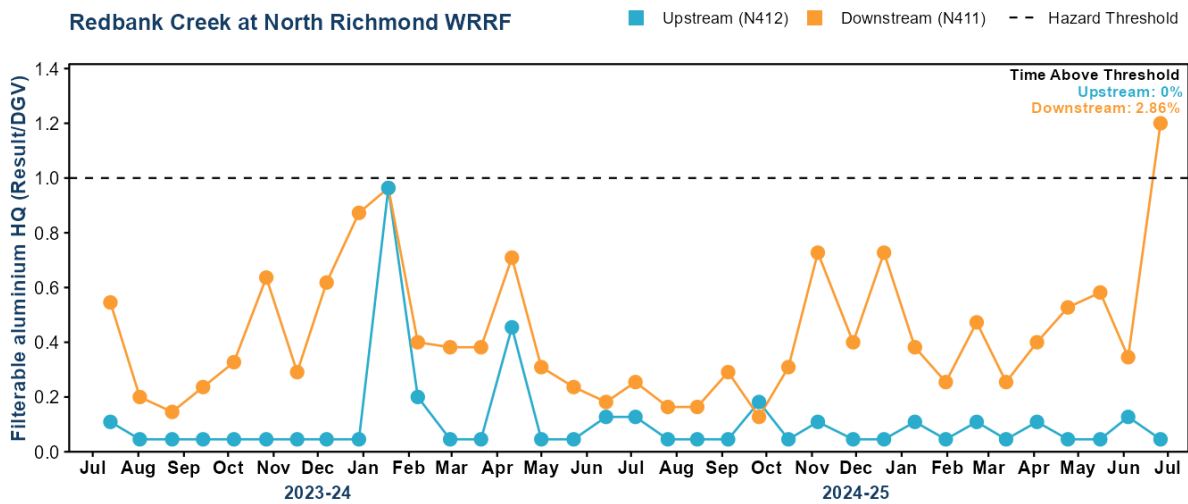
Stage 3: Hazard quotient metric to evaluate the potential risks of filterable metal exposure to organisms

Ammonia nitrogen and all filterable trace metals (aluminium, cobalt, copper, nickel and zinc) were identified during the Gate 2 synthesis to be higher at the downstream Redbank Creek site (N411). Hazard quotient calculations indicated that the concentrations of ammonia nitrogen (Figure A-15) and filterable nickel (Figure A-15) were consistently below the hazard quotient threshold. There were four downstream sampling events where filterable cobalt (Figure A-15) was above the hazard threshold, and one instance for filterable aluminium (Figure A-15). These infrequent exceedances could indicate possible processing issues at the North Richmond WRRF. Downstream of the discharge point in Redbank Creek, both filterable copper and zinc exceeded the hazard quotient threshold for 91% and 47% of samples, respectively (Figure A-15). Filterable trace metals exceeding the hazard quotient threshold at the upstream site (N412) were uncommon (Table A-79).

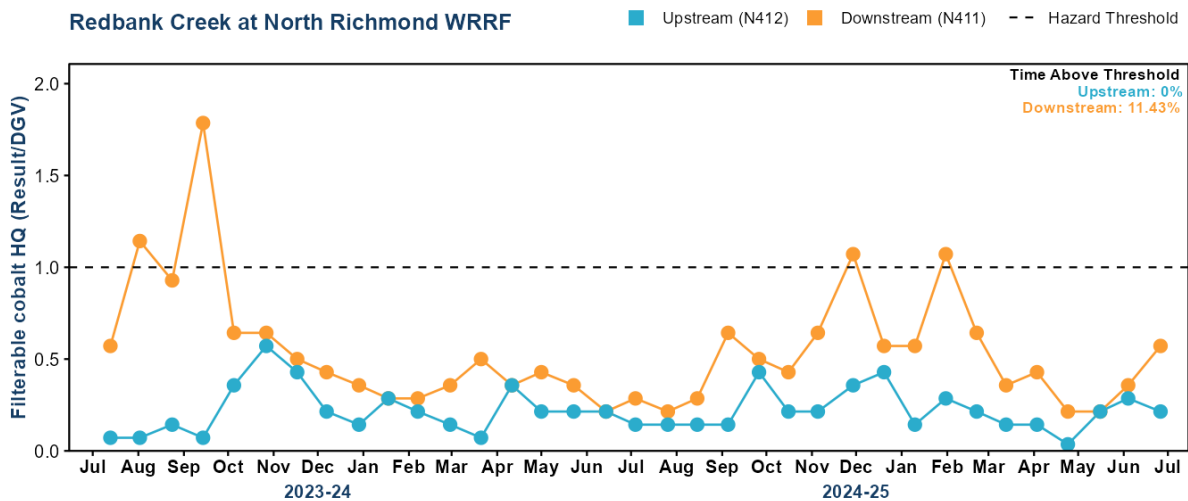
Redbank Creek at North Richmond WRRF



Redbank Creek at North Richmond WRRF



Redbank Creek at North Richmond WRRF



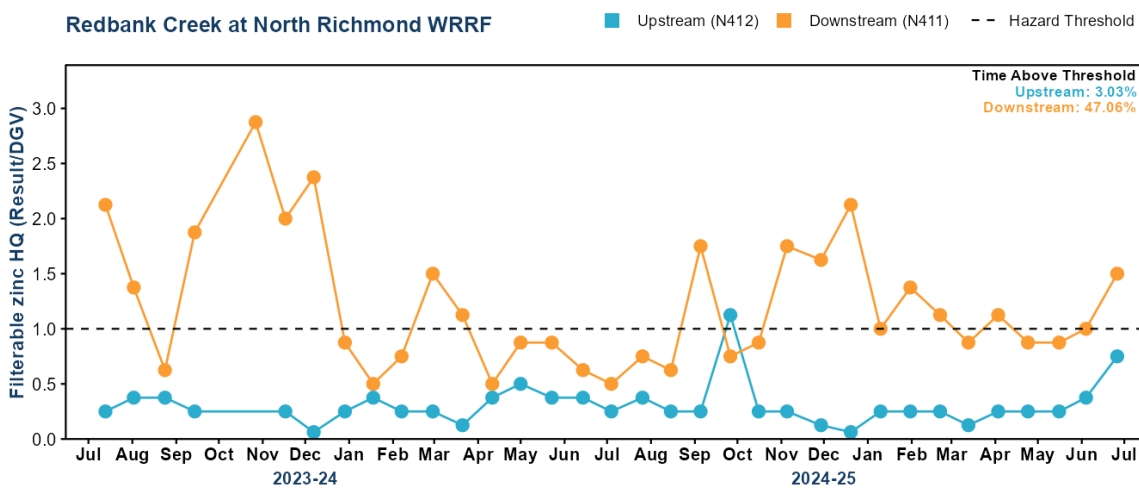
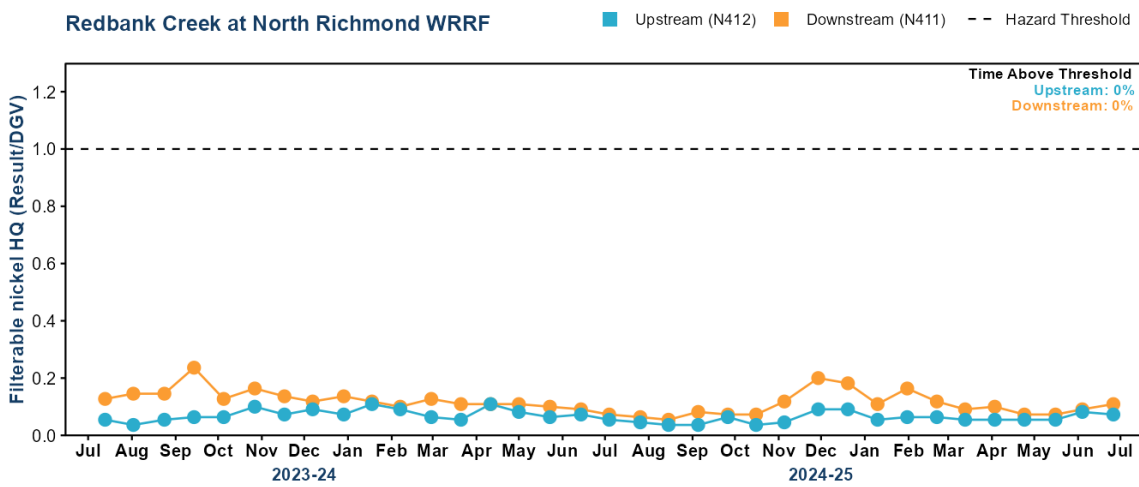
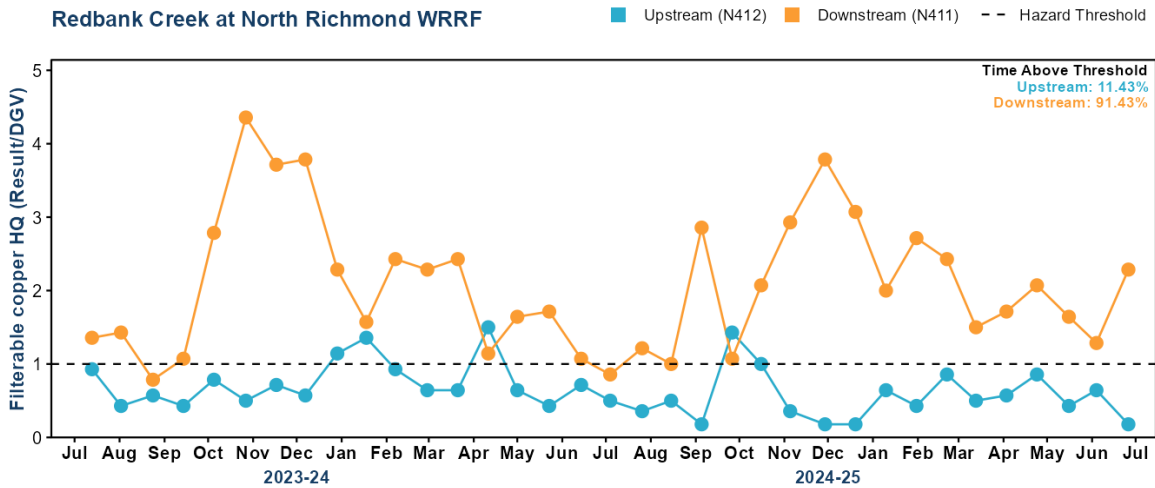


Figure A-15 Hazard quotients for ammonia nitrogen, filterable aluminium, cobalt, copper, nickel, and zinc concentrations between 2023 and 2025 for the Redbank Creek situated both upstream and downstream of the discharge from North Richmond WRRF

Table A-79 Hazard quotients for metal and ammonia nitrogen concentrations between 2023 and 2025 at Redbank Creek upstream and downstream of the discharge from North Richmond WRRF

Redbank Creek at North Richmond WRRF: Hazard Quotient (Result/DGV)												
Collection date	Ammonia nitrogen		Filterable aluminium		Filterable cobalt		Filterable copper		Filterable nickel		Filterable zinc	
	N412 (US)	N411 (DS)	N412 (US)	N411 (DS)	N412 (US)	N411 (DS)	N412 (US)	N411 (DS)	N412 (US)	N411 (DS)	N412 (US)	N411 (DS)
2023-07-13	0.01	0.18	0.11	0.55	0.07	0.57	0.93	1.36	0.05	0.13	0.25	2.12
2023-08-02	0.01	0.06	0.05	0.20	0.07	1.14	0.43	1.43	0.04	0.15	0.38	1.38
2023-08-24	0.01	0.02	0.05	0.15	0.14	0.93	0.57	0.79	0.05	0.15	0.38	0.62
2023-09-14	0.01	0.06	0.05	0.24	0.07	1.79	0.43	1.07	0.06	0.24	0.25	1.88
2023-10-05	0.01	0.25	0.05	0.33	0.36	0.64	0.79	2.79	0.06	0.13	-	-
2023-10-27	0.02	0.11	0.05	0.64	0.57	0.64	0.50	4.36	0.10	0.16	-	2.88
2023-11-17	0.03	0.05	0.05	0.29	0.43	0.50	0.71	3.71	0.07	0.14	0.25	2.00
2023-12-07	0.02	0.03	0.05	0.62	0.21	0.43	0.57	3.79	0.09	0.12	0.06	2.38
2023-12-29	0.02	0.05	0.05	0.87	0.14	0.36	1.14	2.29	0.07	0.14	0.25	0.88
2024-01-18	0.02	0.05	0.96	0.96	0.29	0.29	1.36	1.57	0.11	0.12	0.38	0.50
2024-02-07	0.01	0.11	0.20	0.40	0.21	0.29	0.93	2.43	0.09	0.10	0.25	0.75
2024-02-29	0.02	0.09	0.05	0.38	0.14	0.36	0.64	2.29	0.06	0.13	0.25	1.50
2024-03-21	0.02	0.09	0.05	0.38	0.07	0.50	0.64	2.43	0.05	0.11	0.12	1.12
2024-04-11	0.03	0.03	0.45	0.71	0.36	0.36	1.50	1.14	0.11	0.11	0.38	0.50
2024-05-01	0.02	0.07	0.05	0.31	0.21	0.43	0.64	1.64	0.08	0.11	0.50	0.88
2024-05-23	0.01	0.06	0.05	0.24	0.21	0.36	0.43	1.71	0.06	0.10	0.38	0.88
2024-06-14	0.01	0.04	0.13	0.18	0.21	0.21	0.71	1.07	0.07	0.09	0.38	0.62
2024-07-04	0.01	0.03	0.13	0.25	0.14	0.29	0.50	0.86	0.05	0.07	0.25	0.50
2024-07-26	0.00	0.02	0.05	0.16	0.14	0.21	0.36	1.21	0.05	0.06	0.38	0.75
2024-08-15	0.01	0.04	0.05	0.16	0.14	0.29	0.50	1.00	0.04	0.05	0.25	0.62
2024-09-05	0.01	0.03	0.05	0.29	0.14	0.64	0.18	2.86	0.04	0.08	0.25	1.75
2024-09-26	0.09	0.03	0.18	0.13	0.43	0.50	1.43	1.07	0.06	0.07	1.12	0.75
2024-10-16	0.01	0.08	0.05	0.31	0.21	0.43	1.00	2.07	0.04	0.07	0.25	0.88
2024-11-05	0.02	0.18	0.11	0.73	0.21	0.64	0.36	2.93	0.05	0.12	0.25	1.75
2024-11-29	0.02	0.14	0.05	0.40	0.36	1.07	0.18	3.79	0.09	0.20	0.12	1.62
2024-12-20	0.03	0.11	0.05	0.73	0.43	0.57	0.18	3.07	0.09	0.18	0.06	2.12
2025-01-10	0.06	0.07	0.11	0.38	0.14	0.57	0.64	2.00	0.05	0.11	0.25	1.00
2025-01-31	0.05	0.06	0.05	0.25	0.29	1.07	0.43	2.71	0.06	0.16	0.25	1.38
2025-02-21	0.03	0.09	0.11	0.47	0.21	0.64	0.86	2.43	0.06	0.12	0.25	1.12
2025-03-13	0.02	0.12	0.05	0.25	0.14	0.36	0.50	1.50	0.05	0.09	0.12	0.88
2025-04-03	0.02	0.01	0.11	0.40	0.14	0.43	0.57	1.71	0.05	0.10	0.25	1.12
2025-04-24	0.01	0.06	0.05	0.53	0.04	0.21	0.86	2.07	0.05	0.07	0.25	0.88
2025-05-16	0.01	0.21	0.05	0.58	0.21	0.21	0.43	1.64	0.05	0.07	0.25	0.88
2025-06-04	0.02	0.18	0.13	0.35	0.29	0.36	0.64	1.29	0.08	0.09	0.38	1.00
2025-06-26	0.01	0.10	0.05	1.20	0.21	0.57	0.18	2.29	0.07	0.11	0.75	1.50
% Above Threshold	0.00	0.00	0.00	2.86	0.00	11.43	11.43	91.43	0.00	0.00	3.03	47.06

Stage 4: Synthesis of gate 3 results and recommendation for future investigations

North Richmond WRRF discharges into an unnamed creek that connects to the Redbank Creek (N411) and continues to flow into a confluence with the Hawkesbury River (N39). The upstream control sites for Redbank Creek and Hawkesbury River are N412 and N42, respectively. A localised impact to stream health (as described by the macroinvertebrate SIGNAL-SG biotic index) was identified at the Redbank Creek downstream site but did not extend further to the Hawkesbury River.

Multivariate analysis of the macroinvertebrate community data for that there was a weak spatial difference in taxonomic assemblages found between the upstream and downstream sites. The extent the two sites differed in taxonomic assemblages was likely reduced by a small number of sampling event with similar taxonomic assemblages. These findings indicate that despite significant differences in SIGNAL-SG scores, there is little evidence to confirm that the wastewater discharge from North Richmond WRRF is impacting the downstream macroinvertebrate stream health in Redbank Creek.

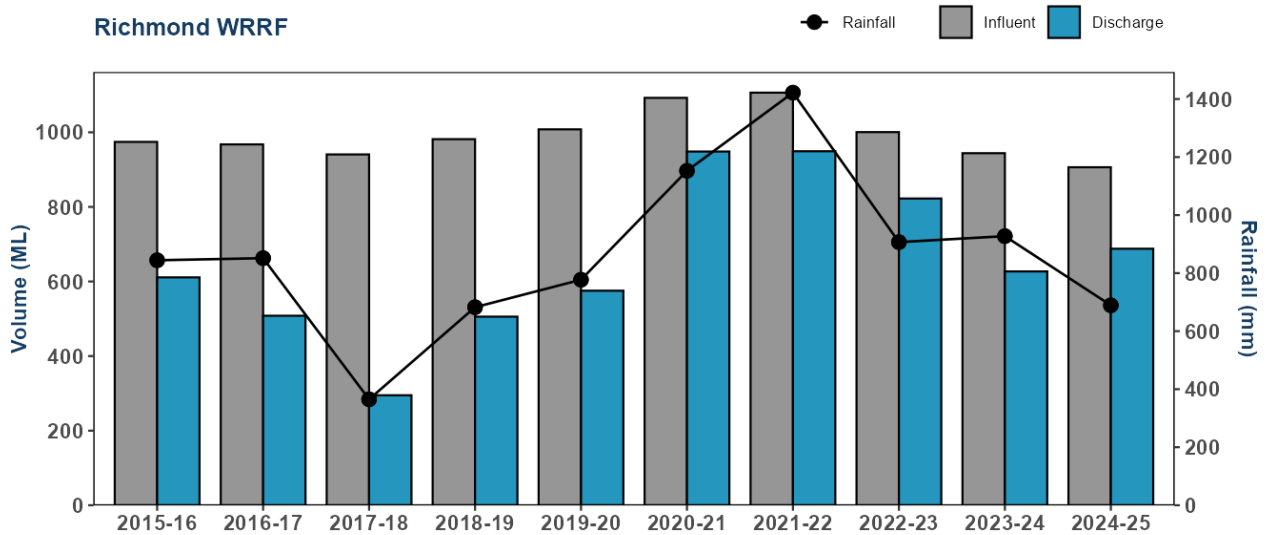
Outcomes from the DISTLM indicated that the source of variation in the macroinvertebrate biotic index (SIGNAL-SG) score was from an unaccounted measure, and not a water quality parameter that was included in the model. Hazard quotient calculations identified filterable copper and zinc as the two key trace metals above the hazard quotient threshold at the downstream Redbank Creek site that could be influencing stream health. Previous studies have identified two potential sources for copper and zinc contamination in Australian waterways. One is due to domestic wastewater, where zinc levels have been linked to bathroom products, and sources of copper have been attributed to plumbing and water supply leaching (Besley et al., 2023; Tjadraatmadja and Diaper, 2006). Secondly, road-derived metals have been reported as a key contributor to stormwater contamination, with Birch (2024) stating that roads in urban environments generate a considerable trace metal output that is transported directly to any adjacent receiving waterways.

However, as the upstream site had a significantly lower hazard threshold exceedance for filterable copper and zinc concentrations than the downstream site, it is unlikely that stormwater is the major contributor to the trace metal contamination. An EPL limit exceedance and significantly higher concentration of total copper in the effluent compared to the past years, could offer a possible source of metal contamination from the wastewater pipework coming through the North Richmond WRRF discharge that is influencing stream health downstream. Ongoing monitoring will enable a more comprehensive assessment of the relationship between filterable trace metals and the suspected downstream impact to stream health through a multivariate regression in future years.

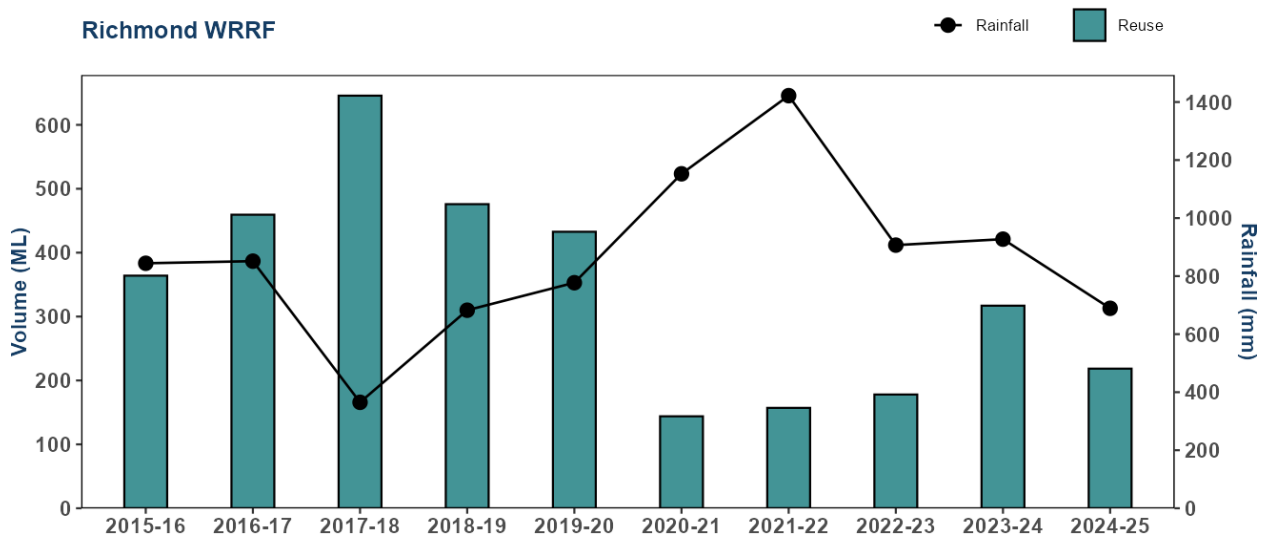
A.7. Richmond WRRF

A.7.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



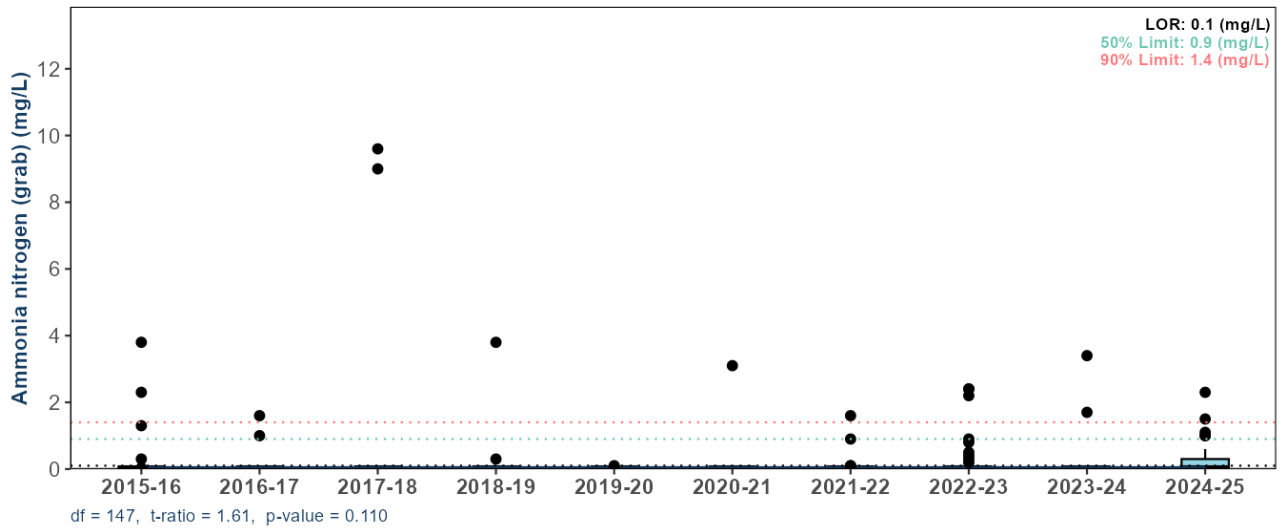
Reuse volume and rainfall



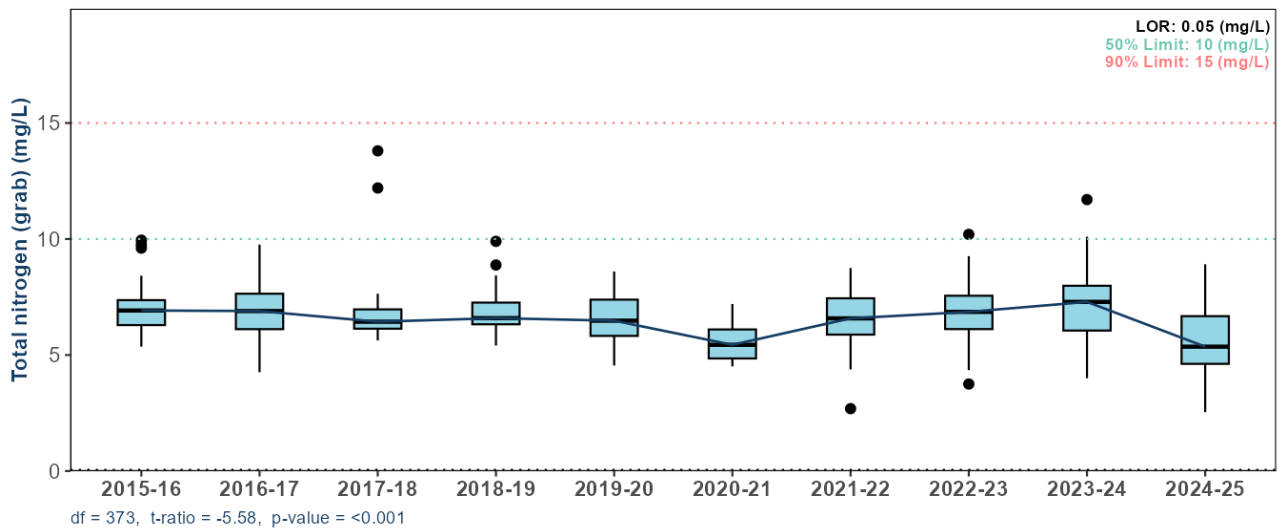
A.7.2. Pressure – Wastewater quality

Nutrients (RM0016 Bypass effluent)

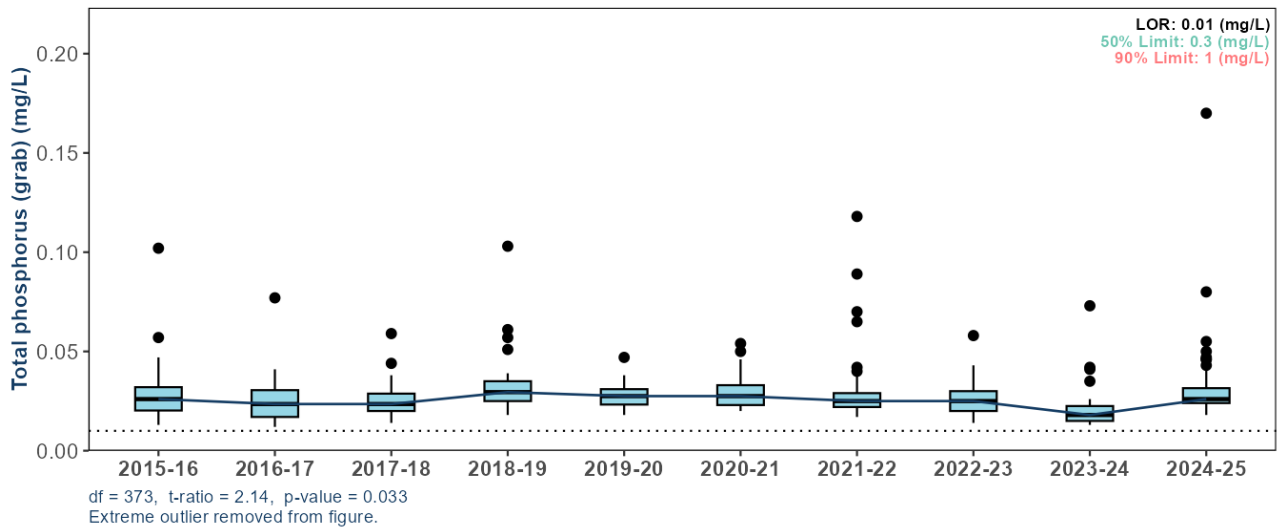
RM0016 at Richmond WRRF



RM0016 at Richmond WRRF

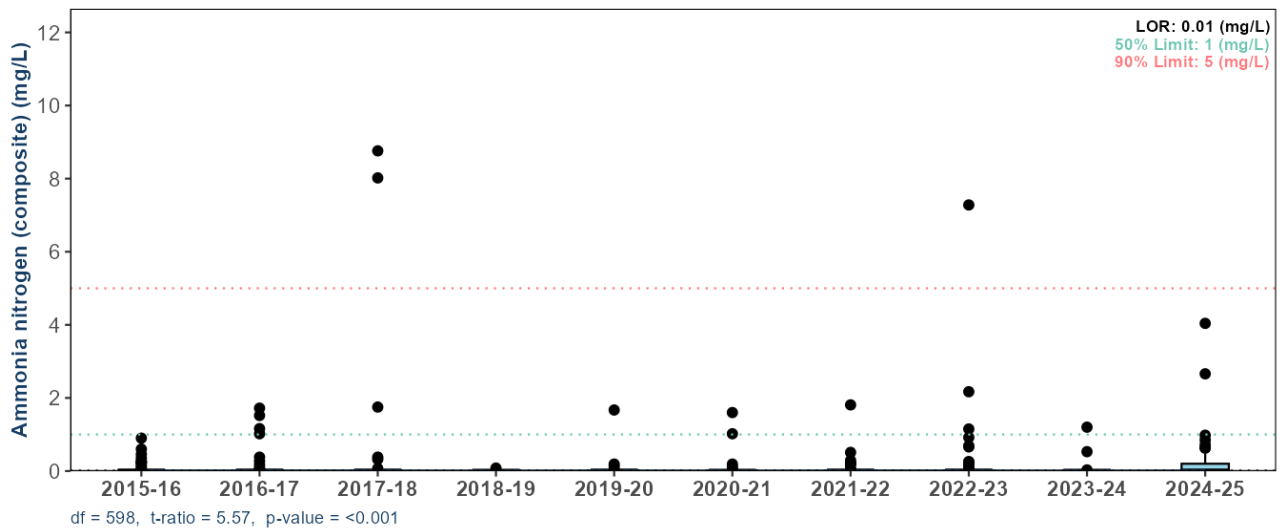


RM0016 at Richmond WRRF

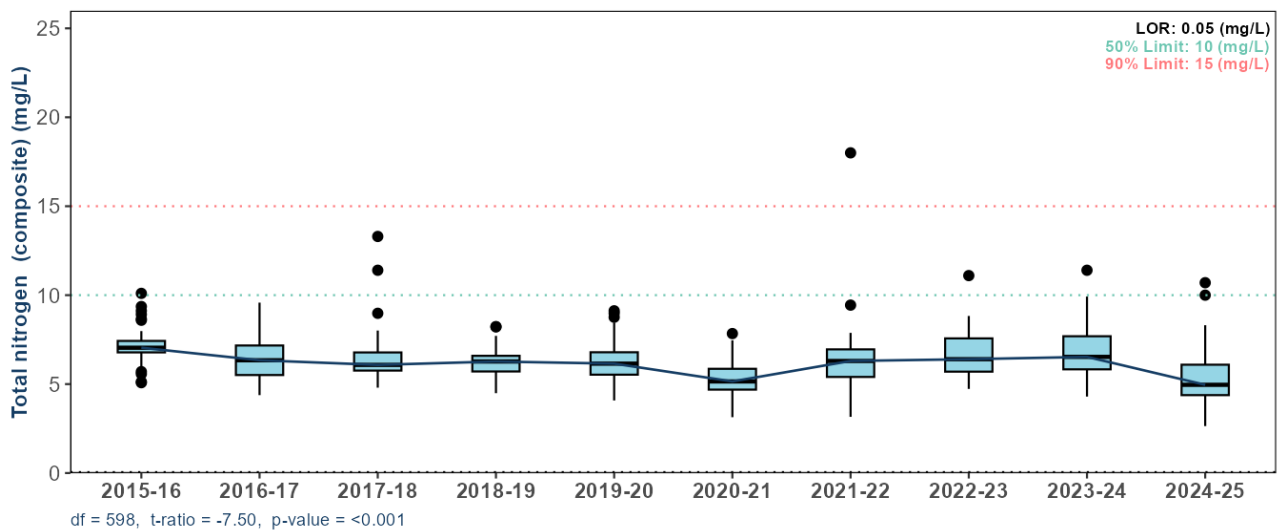


Nutrients (RM0017 Effluent)

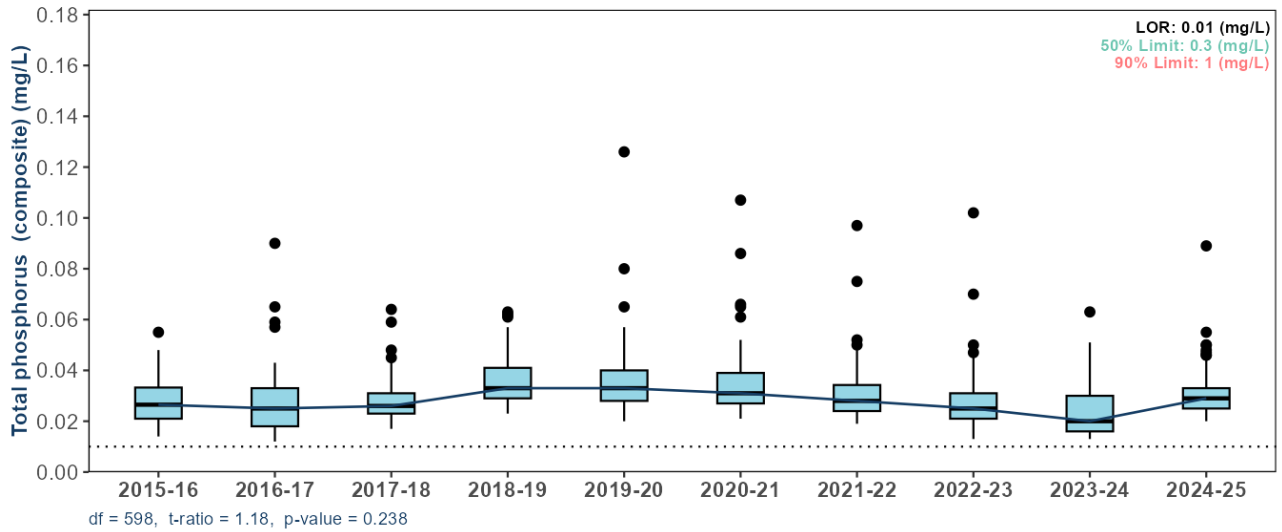
RM0017 at Richmond WRRF



RM0017 at Richmond WRRF

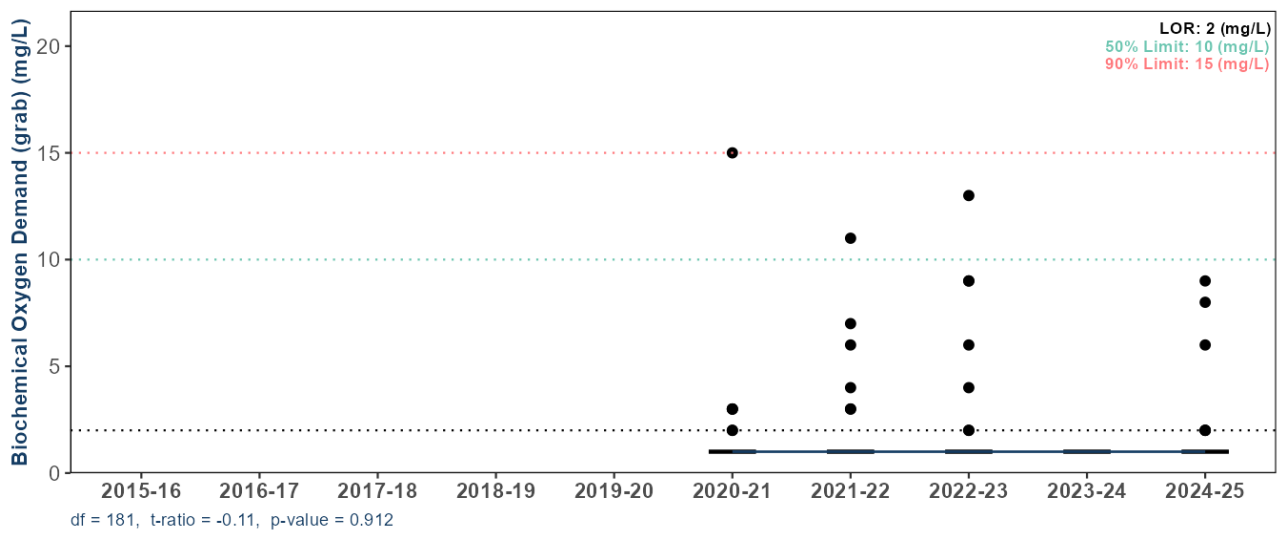


RM0017 at Richmond WRRF

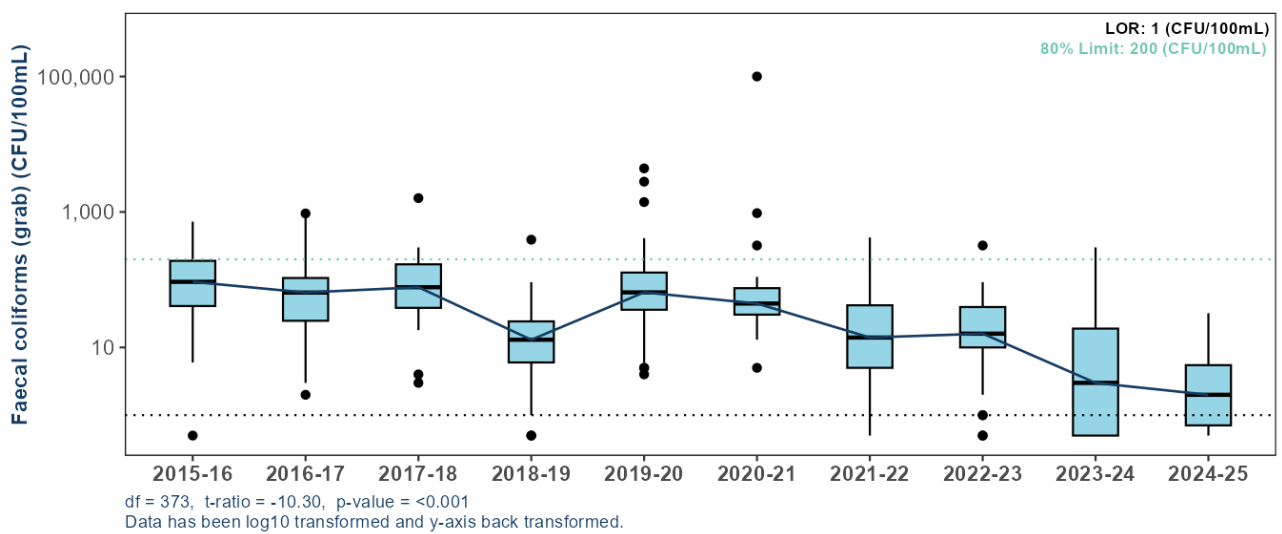


Major conventional analytes (RM0016 Bypass effluent)

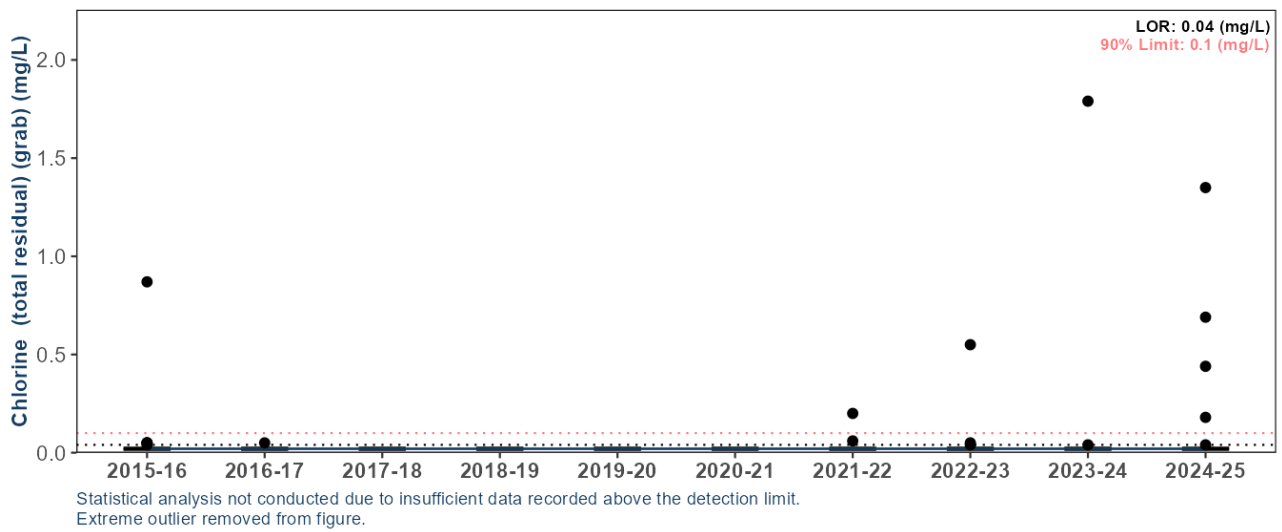
RM0016 at Richmond WRRF



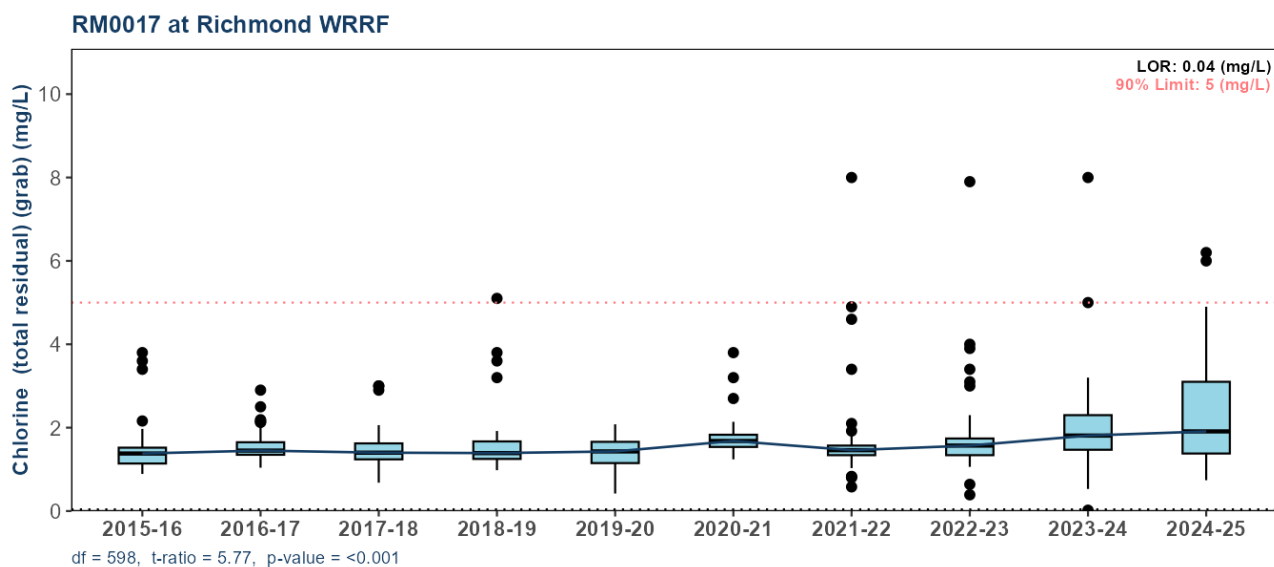
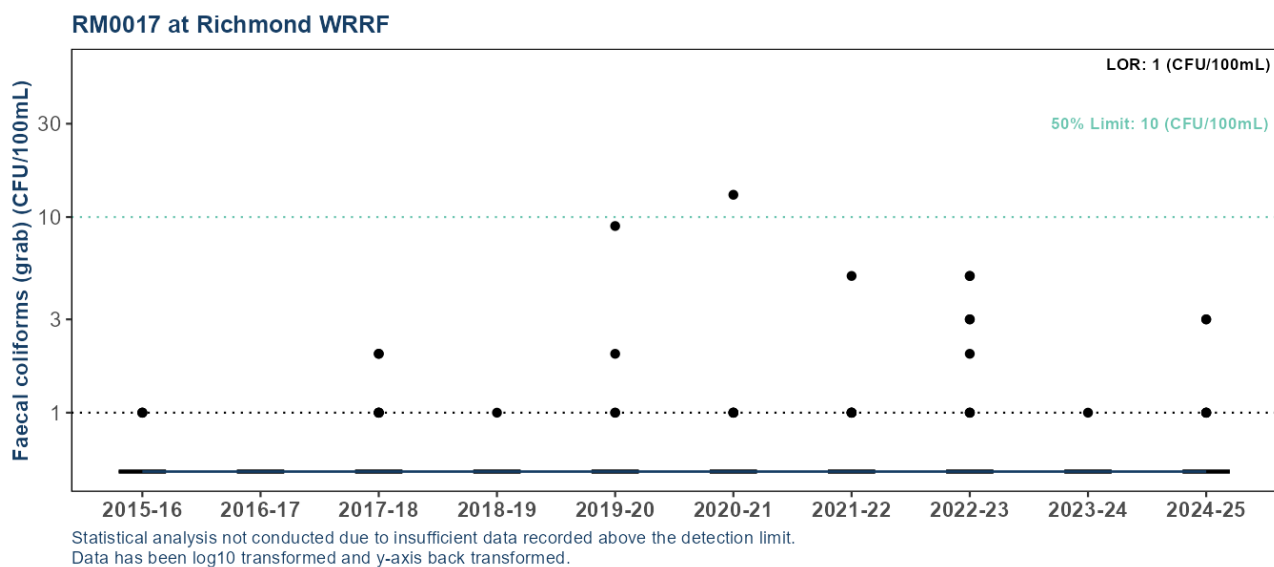
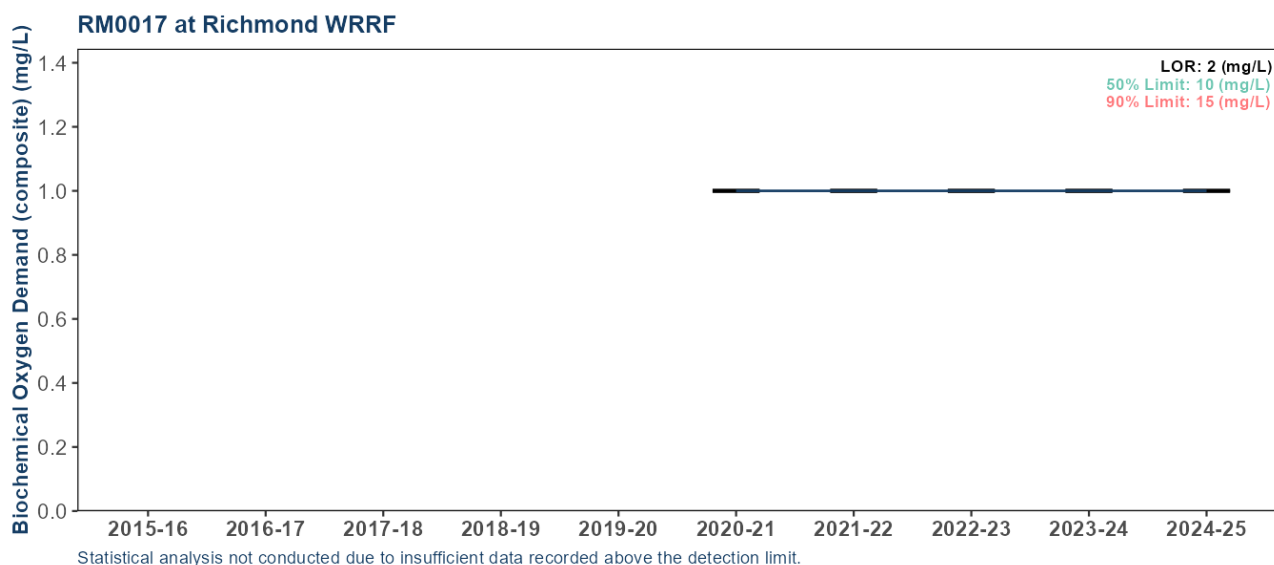
RM0016 at Richmond WRRF



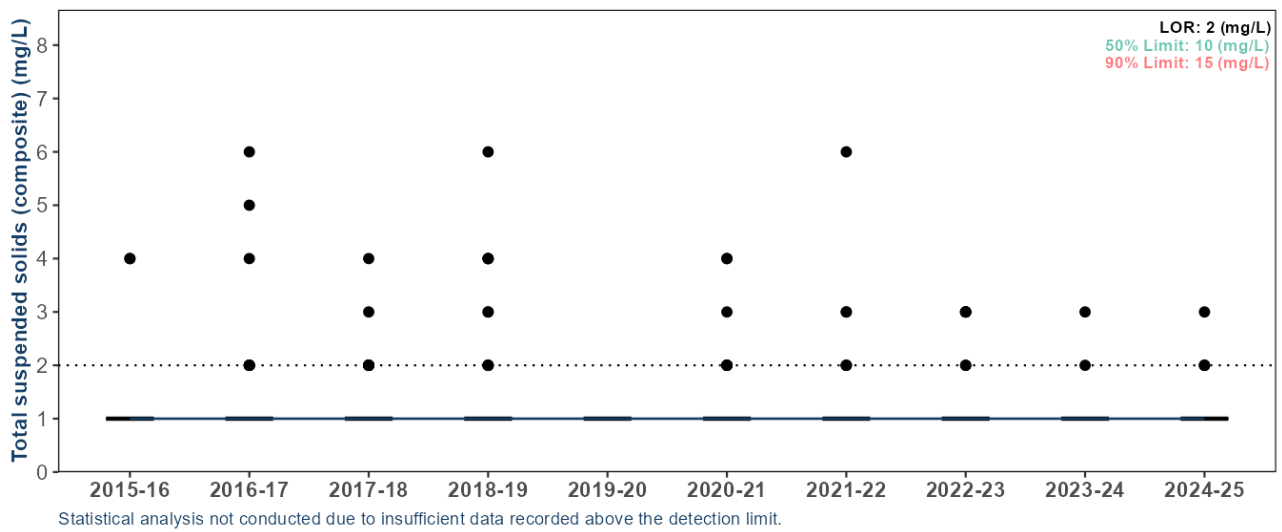
RM0016 at Richmond WRRF



Major conventional analytes (RM0017 Effluent)

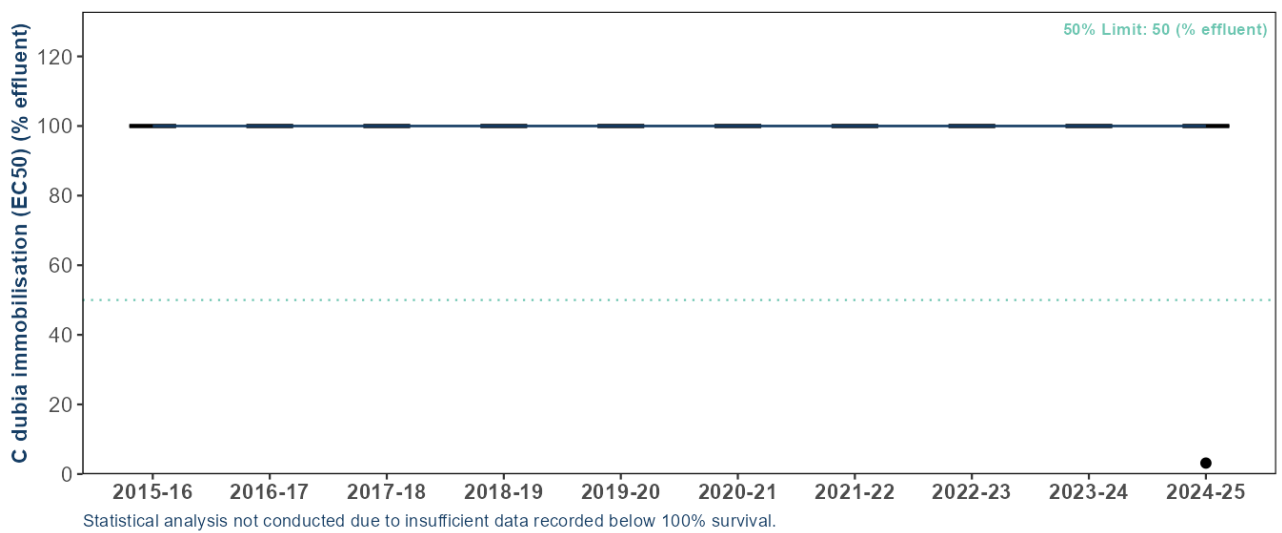


RM0017 at Richmond WRRF



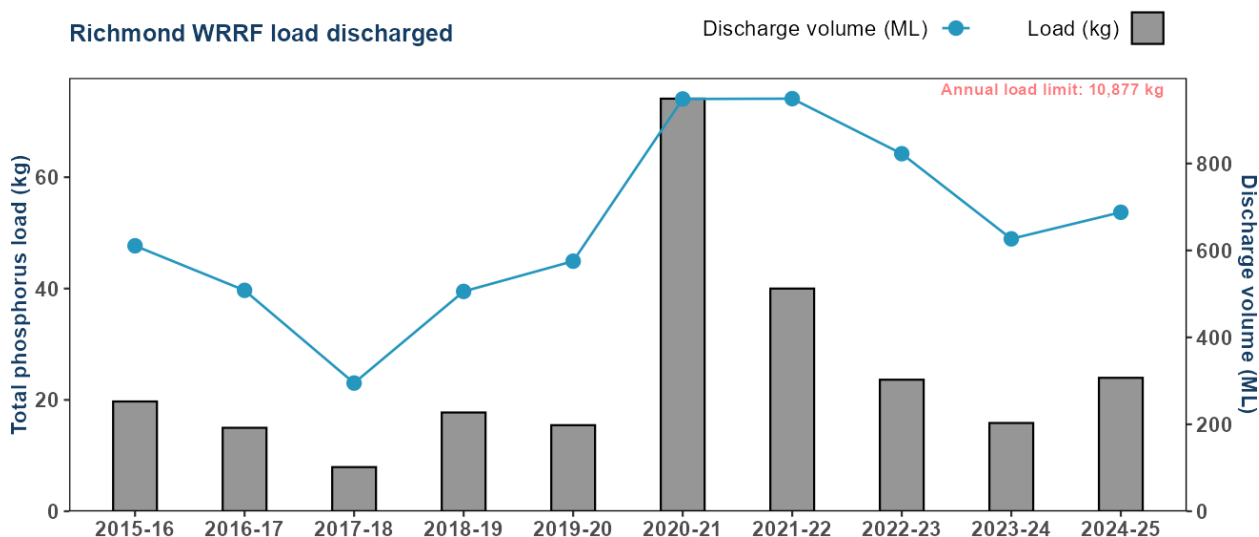
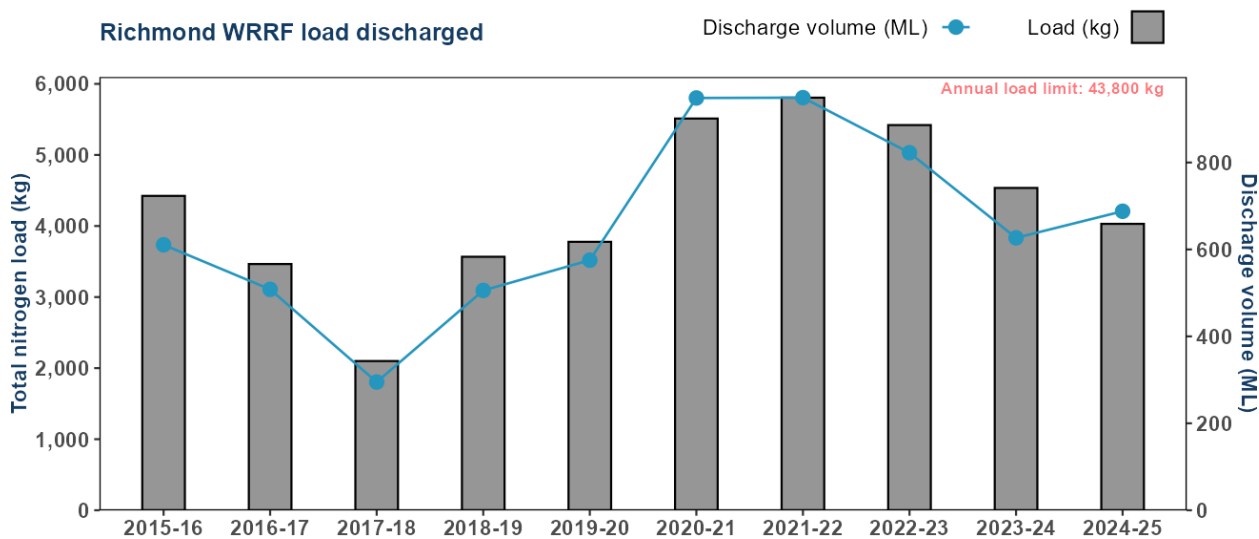
A.7.3. Pressure – Wastewater toxicity

RM0016 at Richmond WRRF

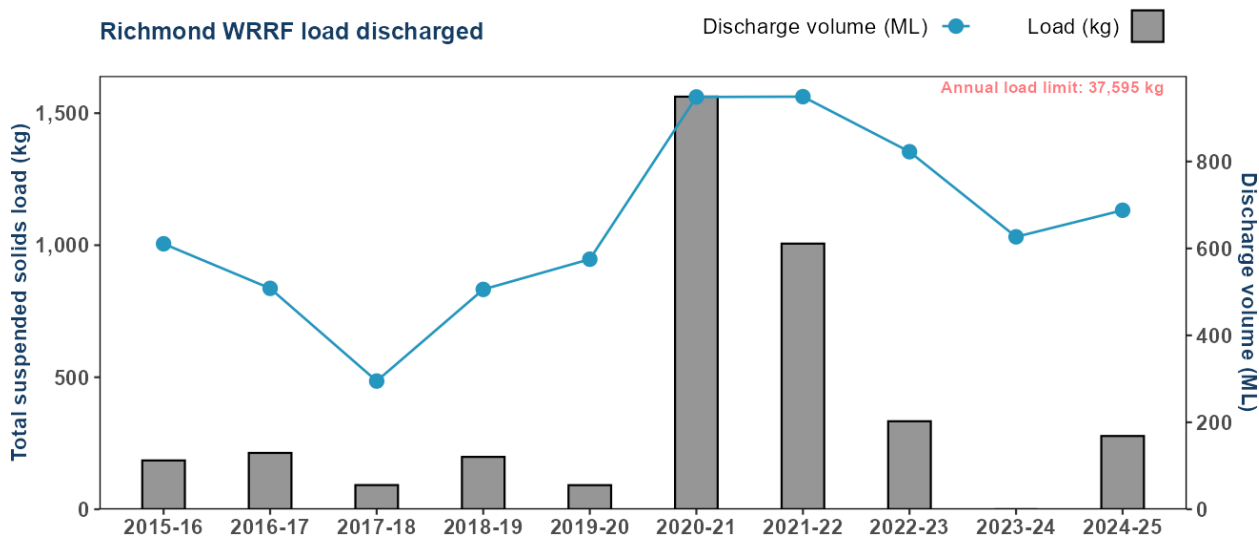
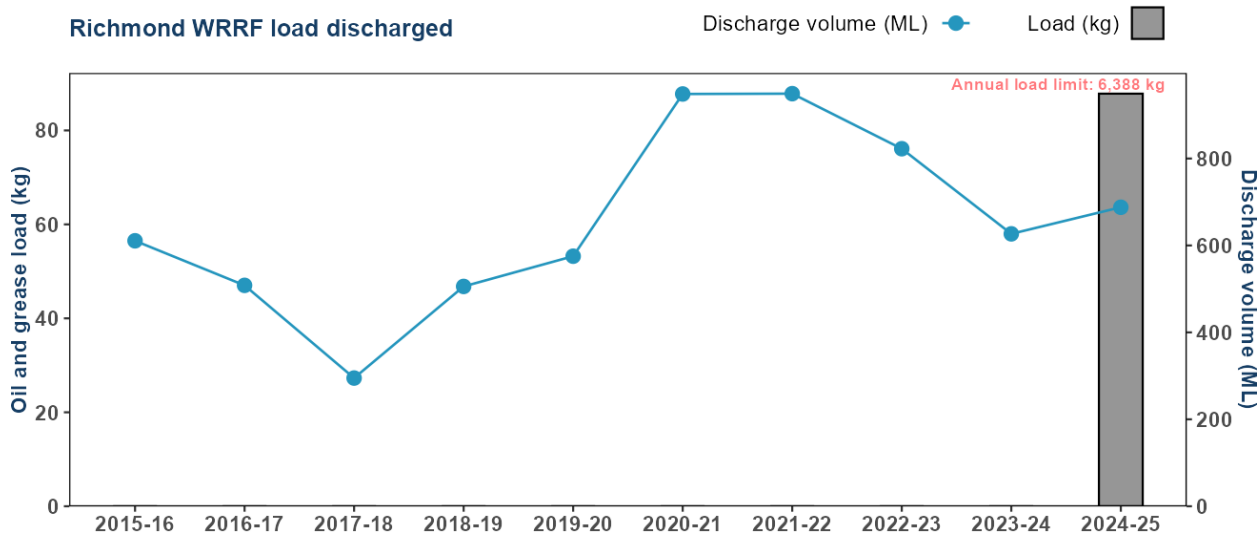
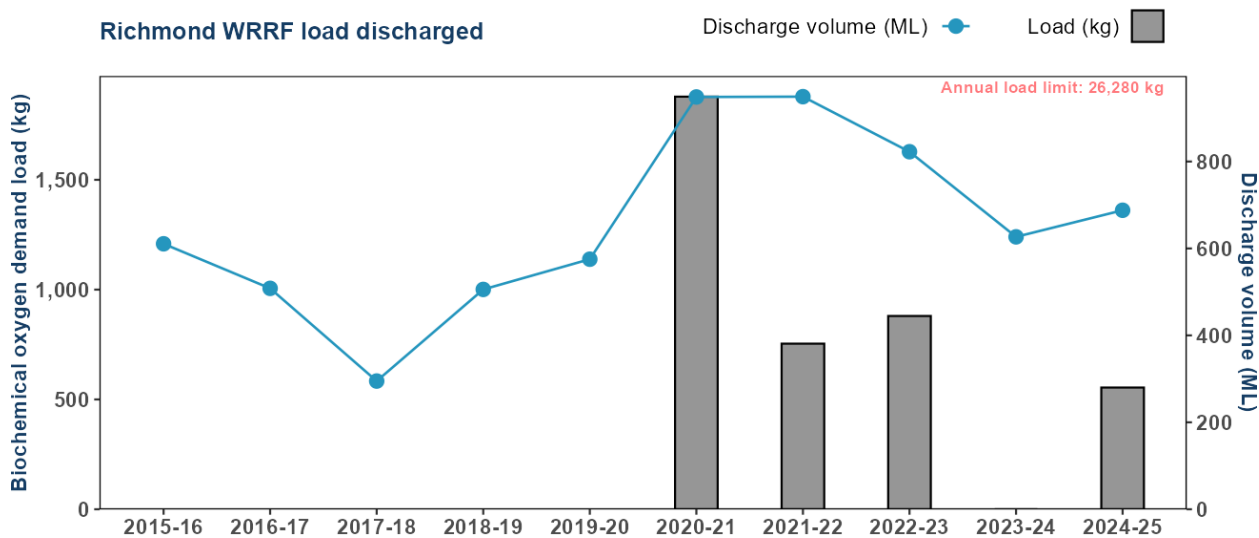


A.7.4. Pressure – Wastewater discharge load

Nutrients



Major conventional analytes



A.7.5. Stressor – Statistical analysis outcomes

Table A-80 Upstream vs downstream comparison (2024-25 reporting period) for Rickabys Creek at Richmond WRRF

Rickabys Creek at Richmond WRRF: N389 vs N388 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.73	0.36	117	-0.63	0.921
Oxidised nitrogen	5.32	3.18	117	2.80	0.030
Total nitrogen	1.41	0.23	117	2.10	0.160
Soluble reactive phosphorus	1.86	0.92	66	1.26	0.590
Total phosphorus	0.83	0.23	117	-0.67	0.908
Physico-chemical					
Conductivity	0.62	0.15	116	-1.99	0.199
Dissolved oxygen	1.49	0.12	117	4.98	<0.001
Dissolved oxygen saturation	27.27	4.76	117	5.73	<0.001
pH	0.25	0.12	115	2.14	0.146
Water temperature	1.03	0.11	117	0.24	0.995
Turbidity	1.29	0.23	117	1.44	0.476
Trace Metals					
Filterable aluminium	0.99	0.35	66	-0.03	>0.999
Total aluminium	2.71	0.90	66	3.01	0.019
Filterable cobalt	0.56	0.12	66	-2.75	0.037
Total cobalt	0.73	0.14	66	-1.64	0.366
Filterable copper	1.33	0.30	66	1.26	0.595
Total copper	1.38	0.34	66	1.32	0.551
Filterable nickel	1.01	0.08	66	0.07	>0.999
Total nickel	1.14	0.11	66	1.30	0.568
Filterable zinc	1.28	0.38	57	0.85	0.829
Total zinc	1.32	0.34	66	1.06	0.714
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-81 Upstream current period (2024-25) vs previous period comparison (single site) for Rickabys Creek at Richmond WRRF

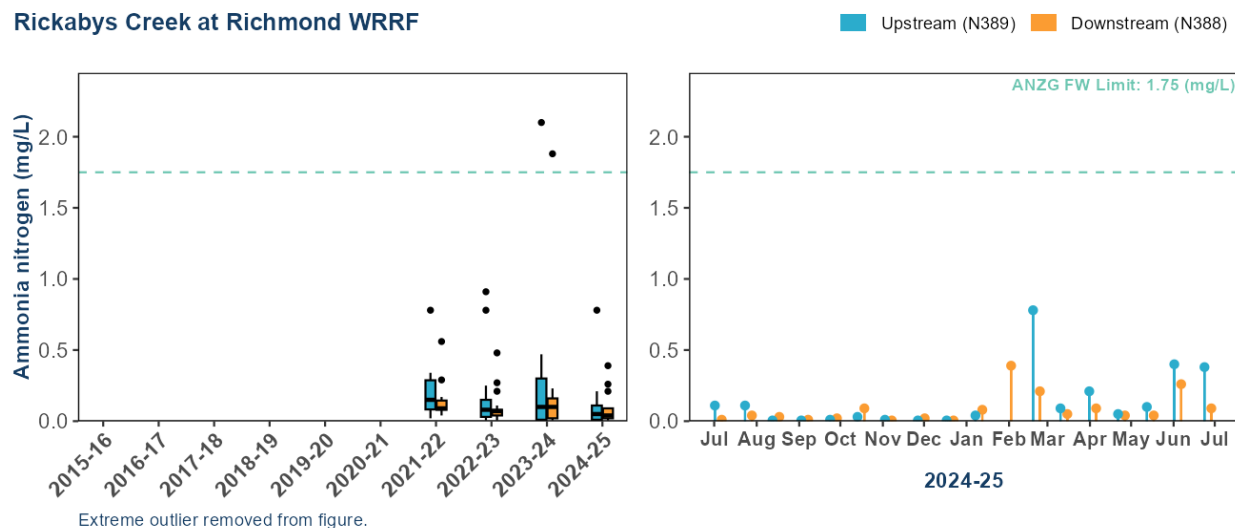
Rickabys Creek at Richmond WRRF: N389 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.66	0.28	117	-0.99	0.753
Oxidised nitrogen	1.35	0.68	117	0.59	0.936
Total nitrogen	1.08	0.15	117	0.58	0.938
Soluble reactive phosphorus	0.92	0.46	66	-0.17	0.998
Total phosphorus	1.29	0.30	117	1.11	0.685
Physico-chemical					
Conductivity	1.24	0.25	116	1.06	0.715
Dissolved oxygen	0.93	0.06	117	-1.03	0.735
Dissolved oxygen saturation	-4.55	4.03	117	-1.13	0.673
pH	0.13	0.10	115	1.29	0.573
Water temperature	0.98	0.09	117	-0.28	0.993
Turbidity	0.89	0.13	117	-0.78	0.862
Trace Metals					
Filterable aluminium	0.62	0.22	66	-1.32	0.552
Total aluminium	0.52	0.17	66	-1.94	0.220
Filterable cobalt	1.07	0.23	66	0.32	0.988
Total cobalt	1.00	0.19	66	-0.03	>0.999
Filterable copper	0.60	0.14	66	-2.19	0.136
Total copper	0.65	0.16	66	-1.74	0.313
Filterable nickel	0.85	0.07	66	-2.00	0.198
Total nickel	0.81	0.08	66	-2.06	0.178
Filterable zinc	0.61	0.18	57	-1.63	0.368
Total zinc	0.73	0.19	66	-1.21	0.624
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-82 Downstream current period (2024-25) vs previous period comparison (single site) for Rickabys Creek at Richmond WRRF

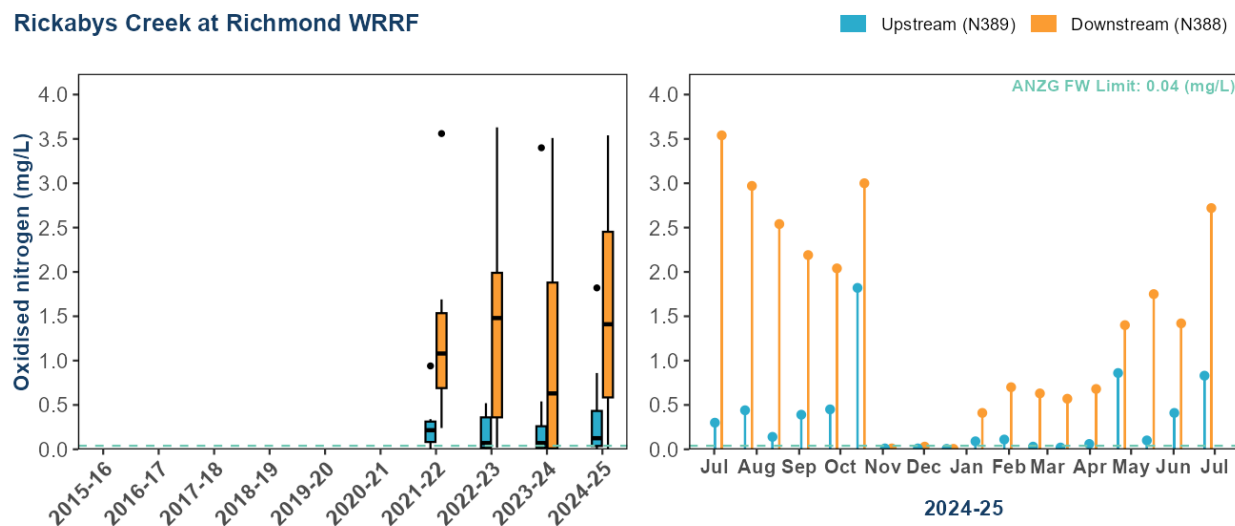
Rickabys Creek at Richmond WRRF: N388 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.55	0.23	117	-1.46	0.464
Oxidised nitrogen	1.32	0.67	117	0.56	0.945
Total nitrogen	1.01	0.14	117	0.08	>0.999
Soluble reactive phosphorus	0.78	0.39	66	-0.50	0.959
Total phosphorus	0.71	0.16	117	-1.51	0.438
Physico-chemical					
Conductivity	1.25	0.25	116	1.11	0.687
Dissolved oxygen	1.00	0.07	117	0.03	>0.999
Dissolved oxygen saturation	-0.38	4.01	117	-0.10	>0.999
pH	-0.01	0.10	115	-0.08	>0.999
Water temperature	0.99	0.09	117	-0.12	>0.999
Turbidity	1.27	0.19	117	1.61	0.378
Trace Metals					
Filterable aluminium	0.68	0.24	66	-1.06	0.715
Total aluminium	1.18	0.40	66	0.49	0.962
Filterable cobalt	0.78	0.17	66	-1.16	0.655
Total cobalt	0.86	0.16	66	-0.80	0.855
Filterable copper	0.78	0.18	66	-1.10	0.692
Total copper	0.80	0.20	66	-0.88	0.816
Filterable nickel	0.93	0.08	66	-0.94	0.784
Total nickel	0.96	0.10	66	-0.36	0.984
Filterable zinc	0.91	0.28	57	-0.31	0.989
Total zinc	1.00	0.27	66	0.01	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.7.6. Stressor – Nutrients

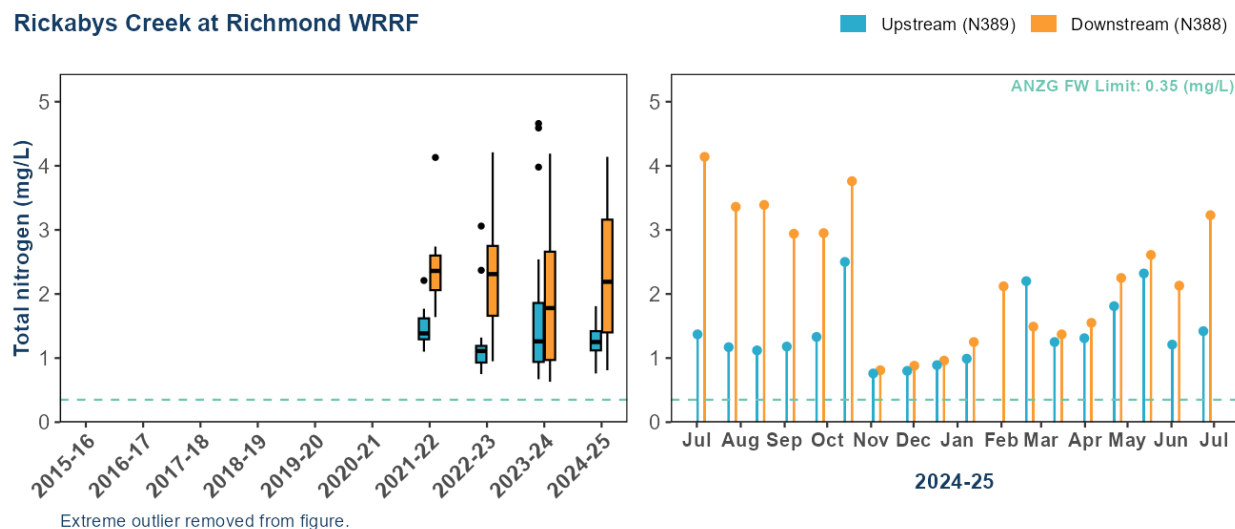
Rickabys Creek at Richmond WRRF



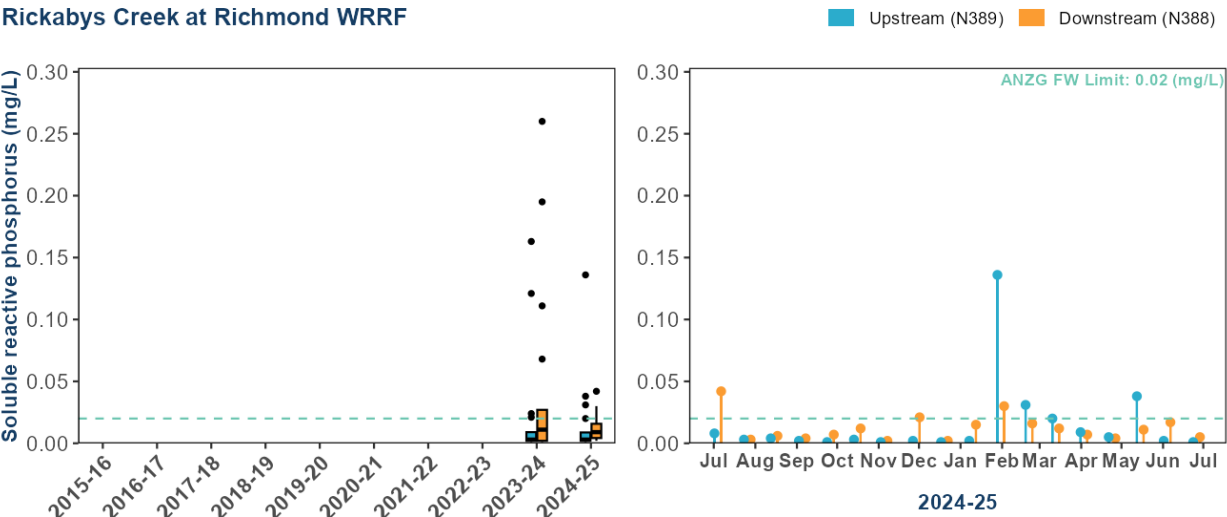
Rickabys Creek at Richmond WRRF



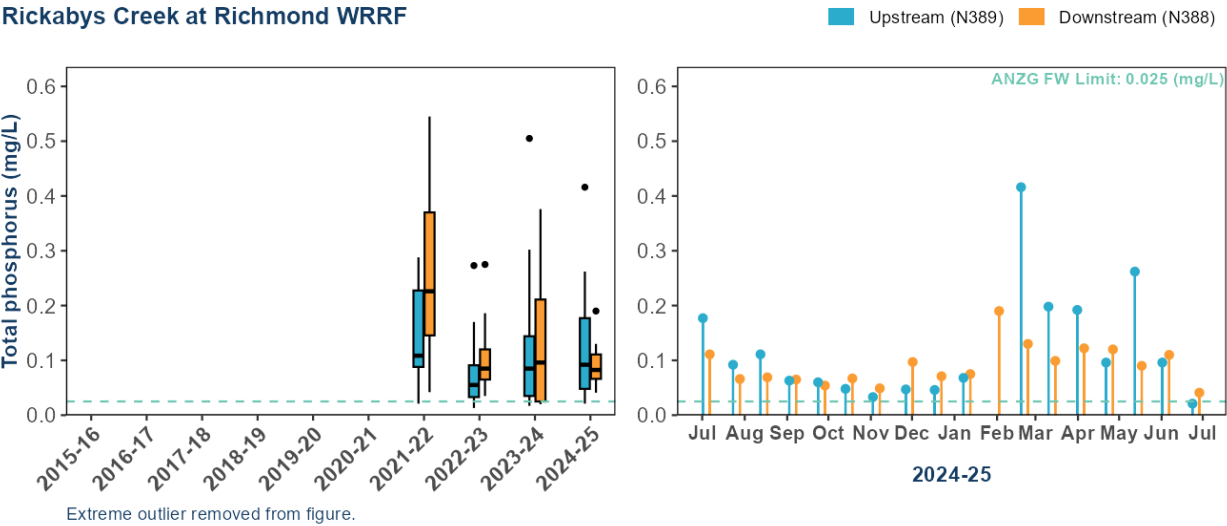
Rickabys Creek at Richmond WRRF



Rickabys Creek at Richmond WRRF

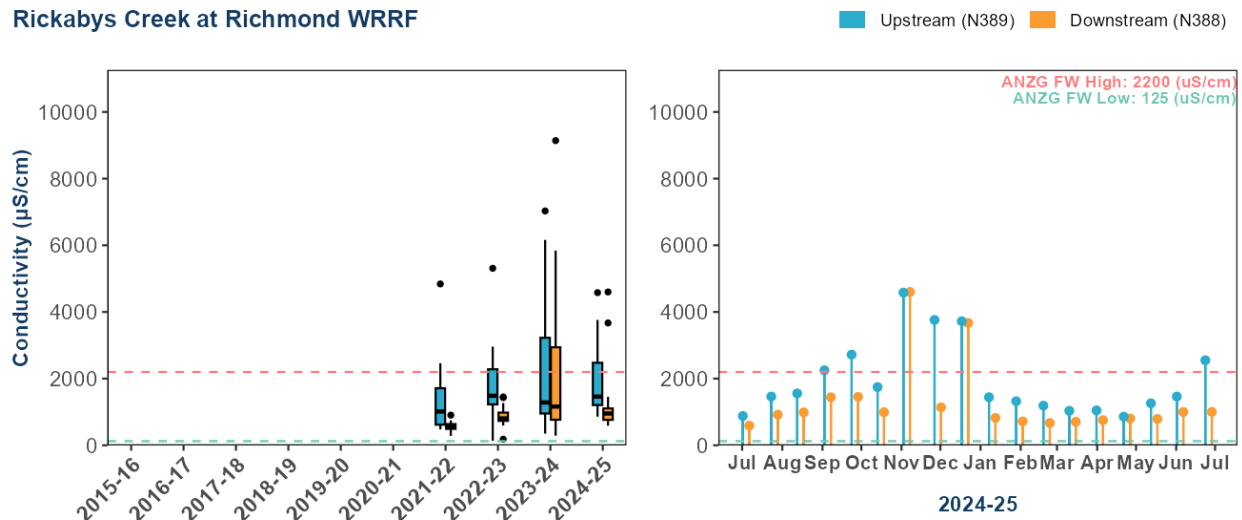


Rickabys Creek at Richmond WRRF

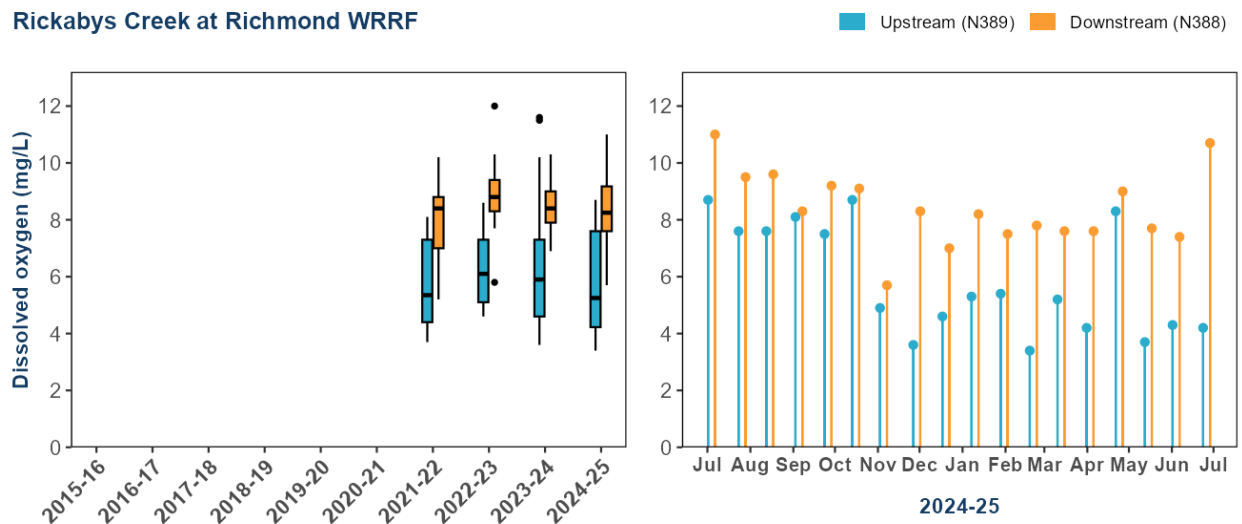


A.7.7. Stressor – Physico-chemical water quality

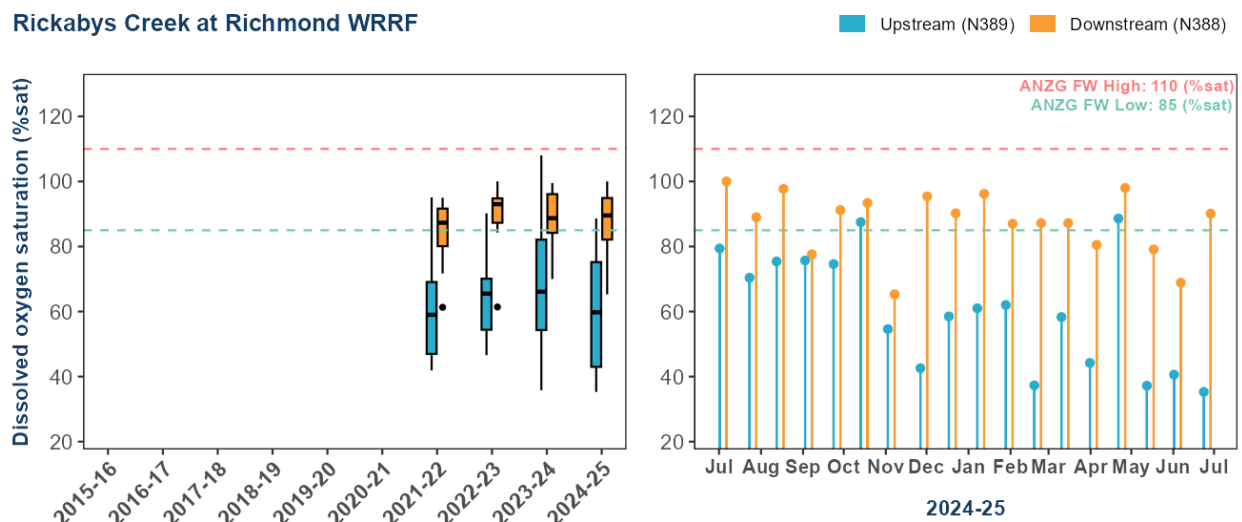
Rickabys Creek at Richmond WRRF



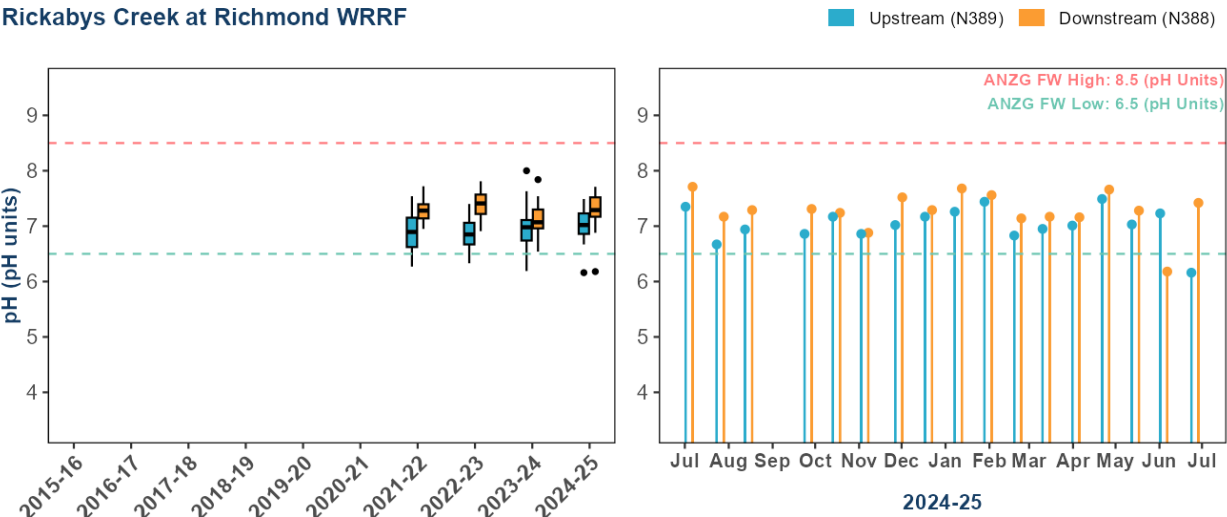
Rickabys Creek at Richmond WRRF



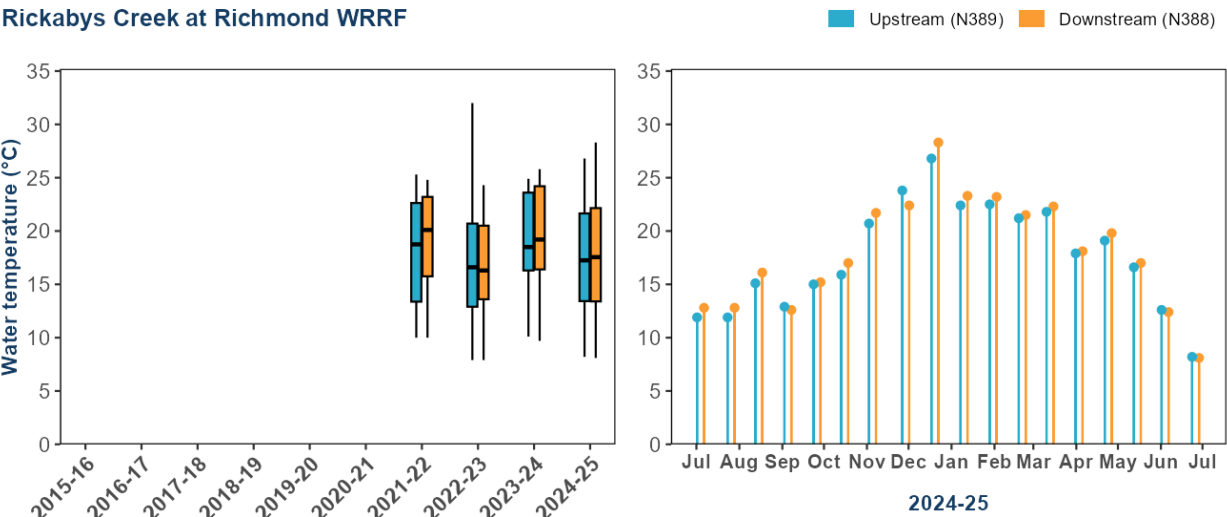
Rickabys Creek at Richmond WRRF



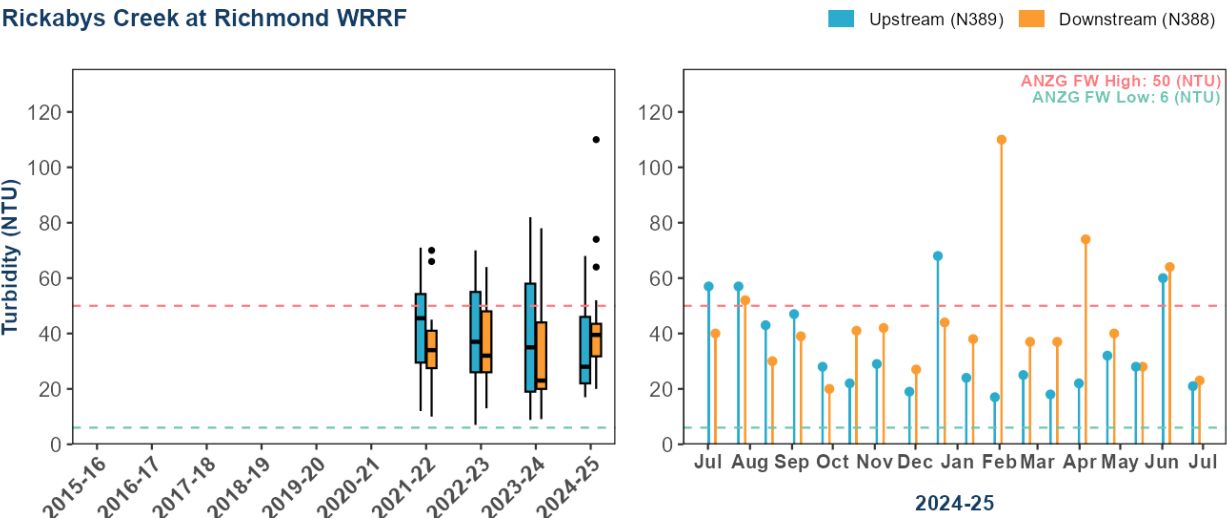
Rickabys Creek at Richmond WRRF



Rickabys Creek at Richmond WRRF

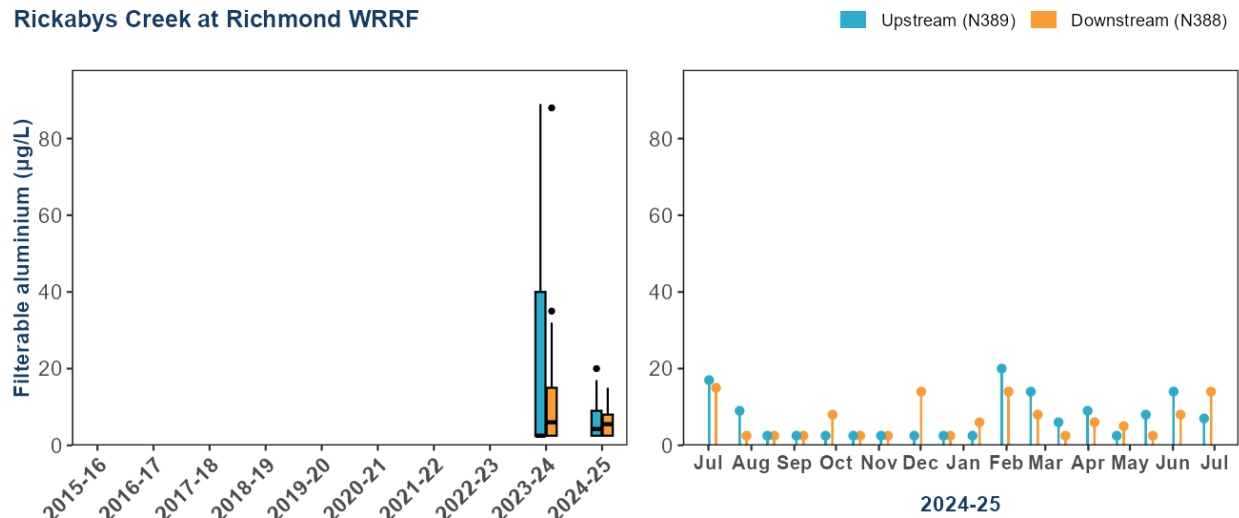


Rickabys Creek at Richmond WRRF

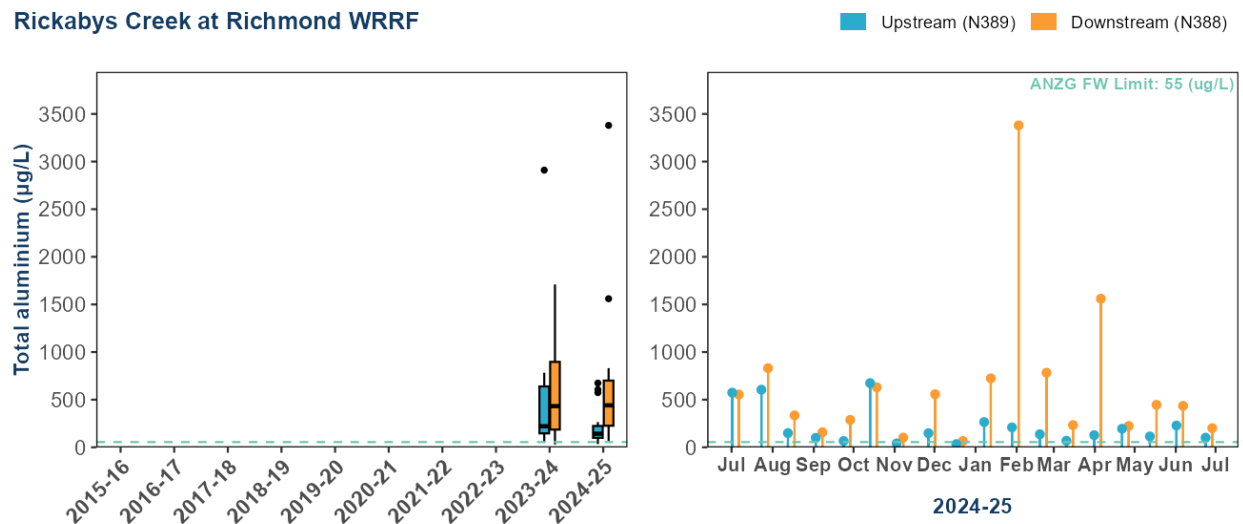


A.7.8. Stressor – Trace metals

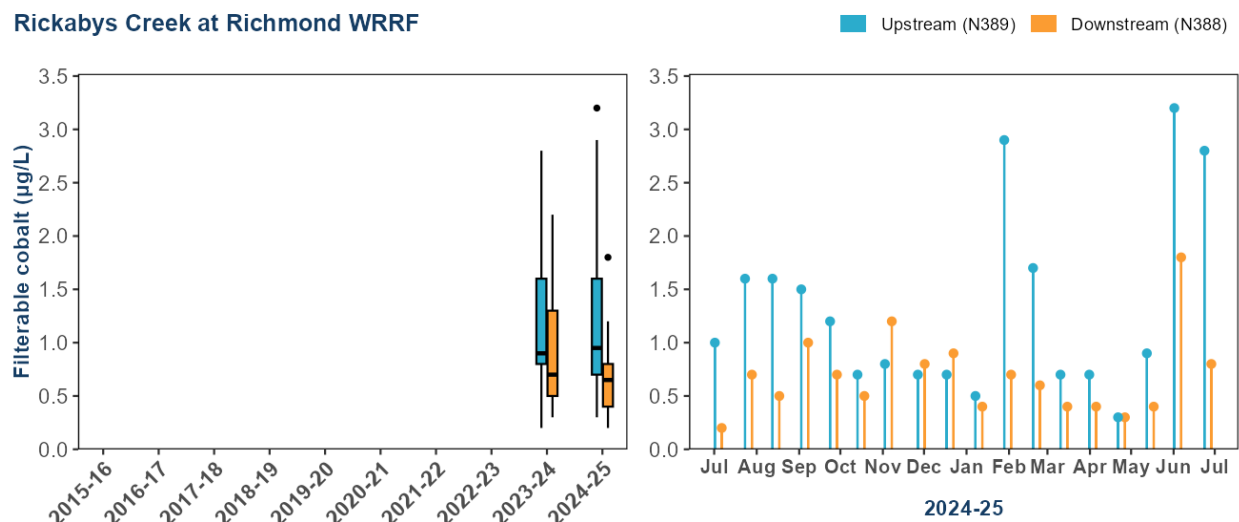
Rickabys Creek at Richmond WRRF



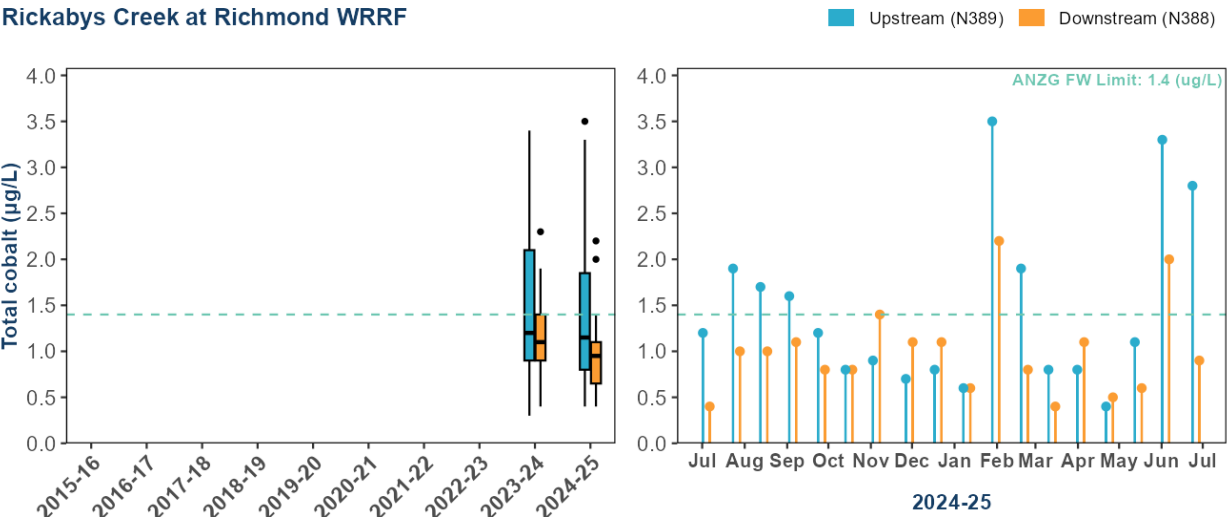
Rickabys Creek at Richmond WRRF



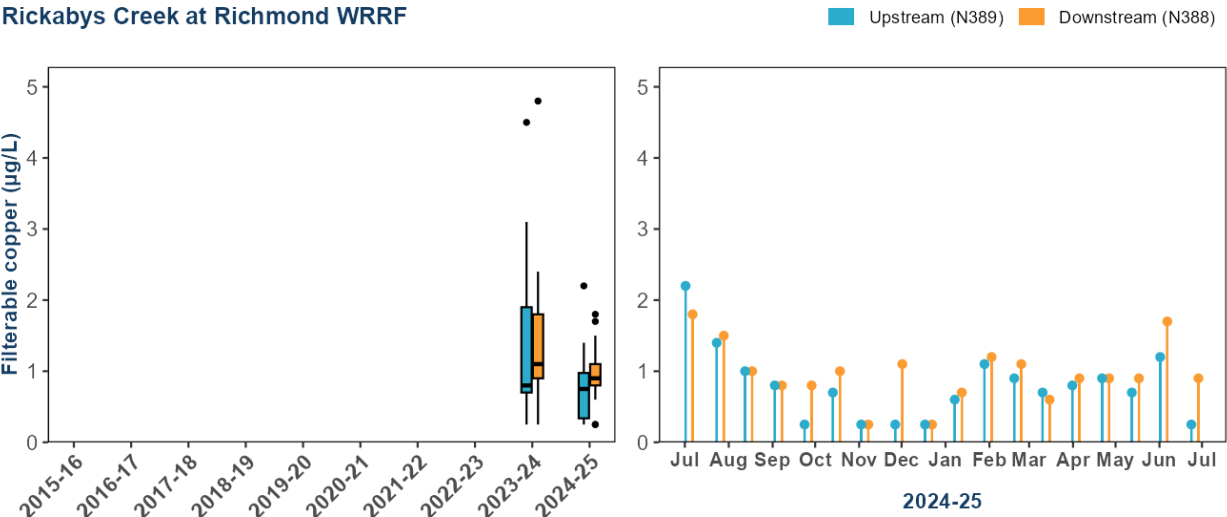
Rickabys Creek at Richmond WRRF



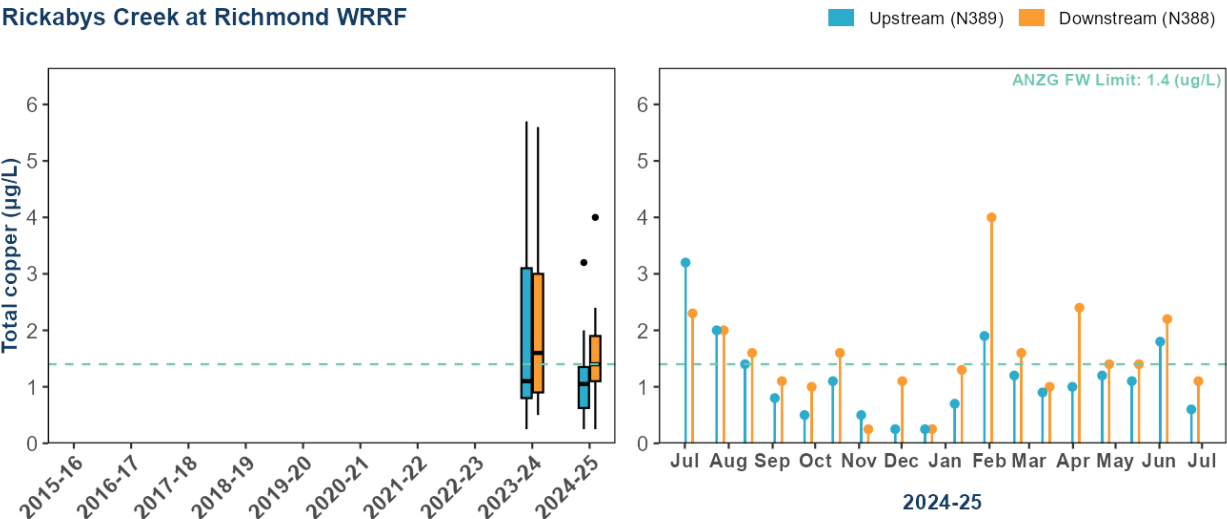
Rickabys Creek at Richmond WRRF



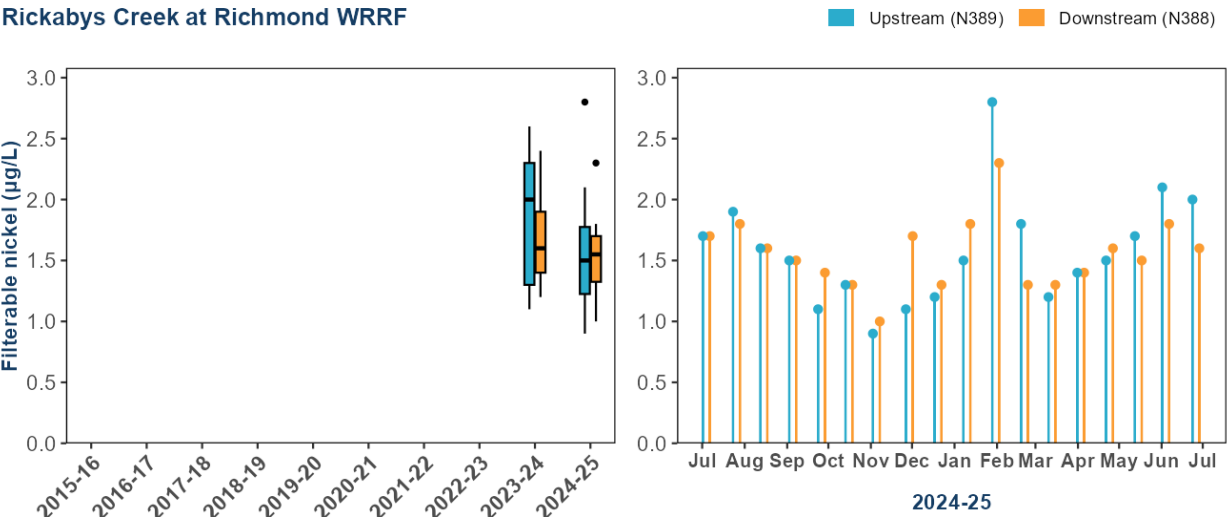
Rickabys Creek at Richmond WRRF



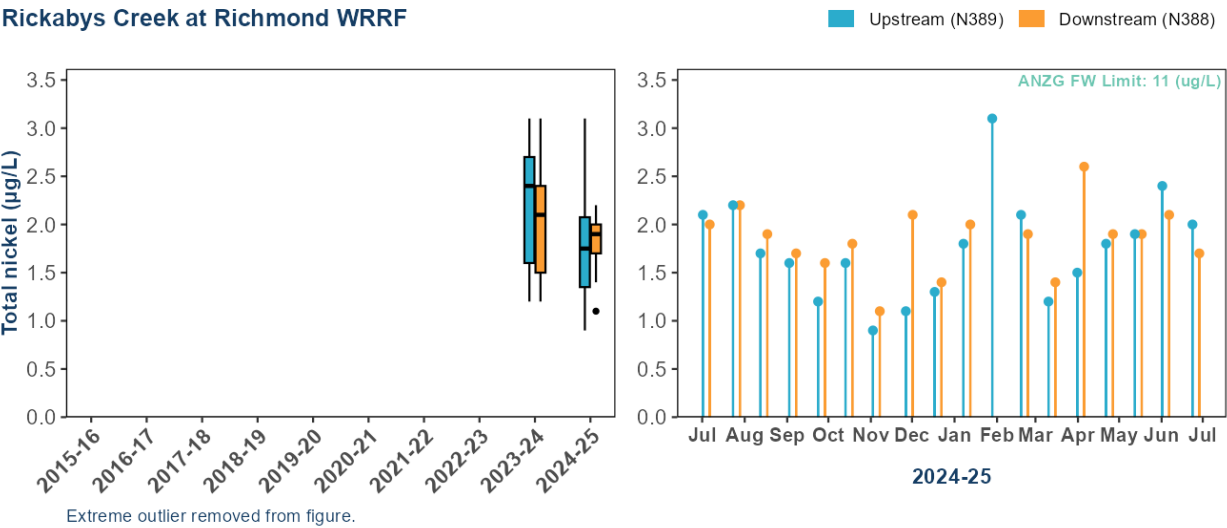
Rickabys Creek at Richmond WRRF



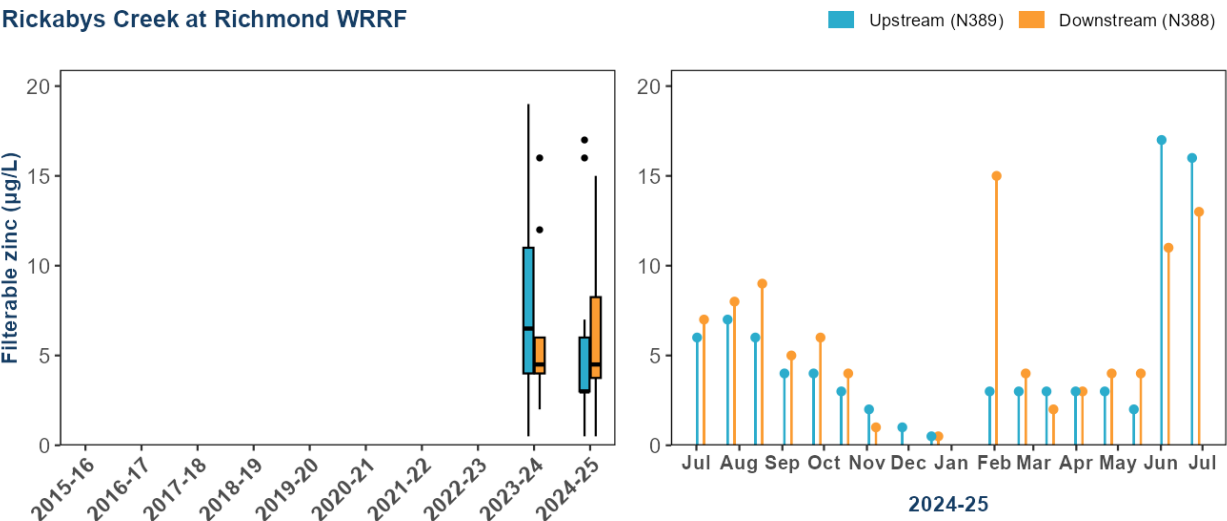
Rickabys Creek at Richmond WRRF



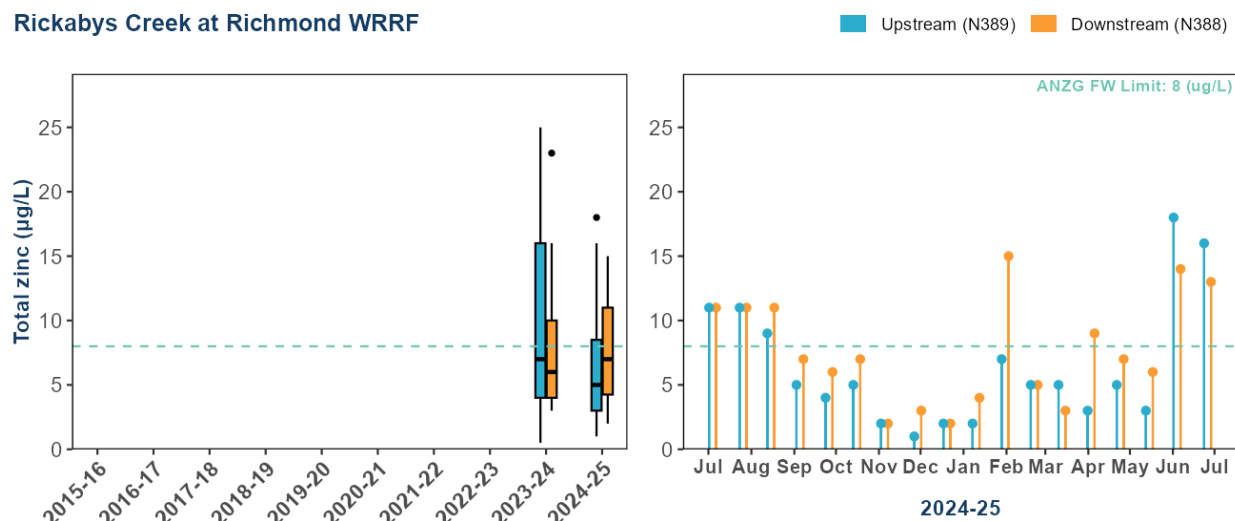
Rickabys Creek at Richmond WRRF



Rickabys Creek at Richmond WRRF



Rickabys Creek at Richmond WRRF



A.7.9. Ecosystem receptor – Statistical analysis outcomes

Table A-83 Upstream vs downstream comparison (2024-25 reporting period) for Rickabys Creek at Richmond WRRF

Rickabys Creek at Richmond WRRF: N389 vs N388 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.58	0.20	117	-1.58	0.397
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-84 Upstream current period (2024-25) vs previous period comparison (single site) for Rickabys Creek at Richmond WRRF

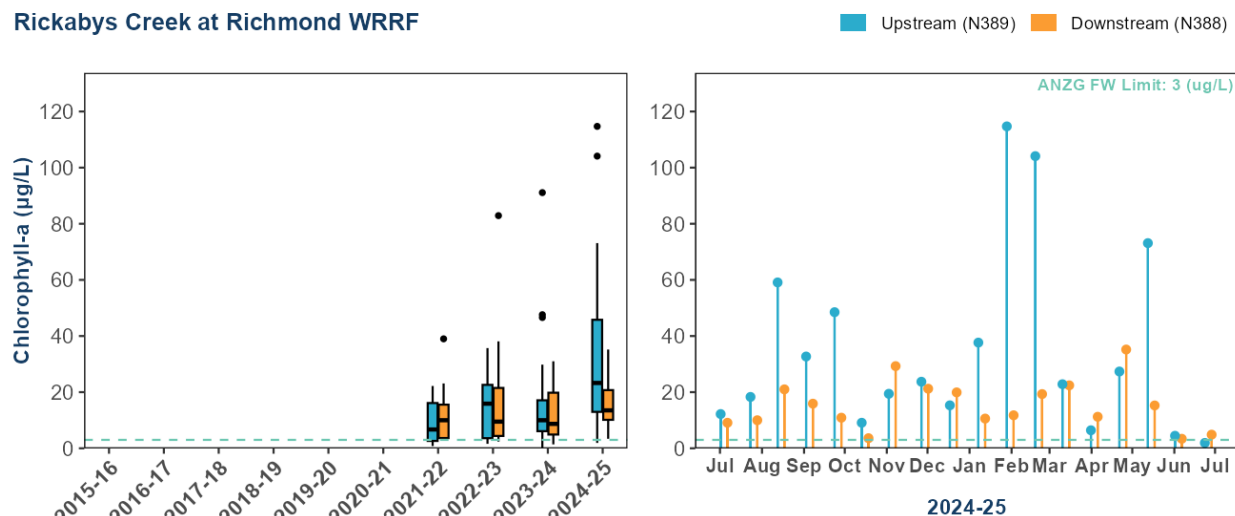
Rickabys Creek at Richmond WRRF: N389 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	2.68	0.79	117	3.34	0.006
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-85 Downstream current period (2024-25) vs previous period comparison (single site) for Rickabys Creek at Richmond WRRF

Rickabys Creek at Richmond WRRF: N388 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.40	0.41	117	1.16	0.656
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.7.10. Ecosystem receptor – Phytoplankton

Rickabys Creek at Richmond WRRF

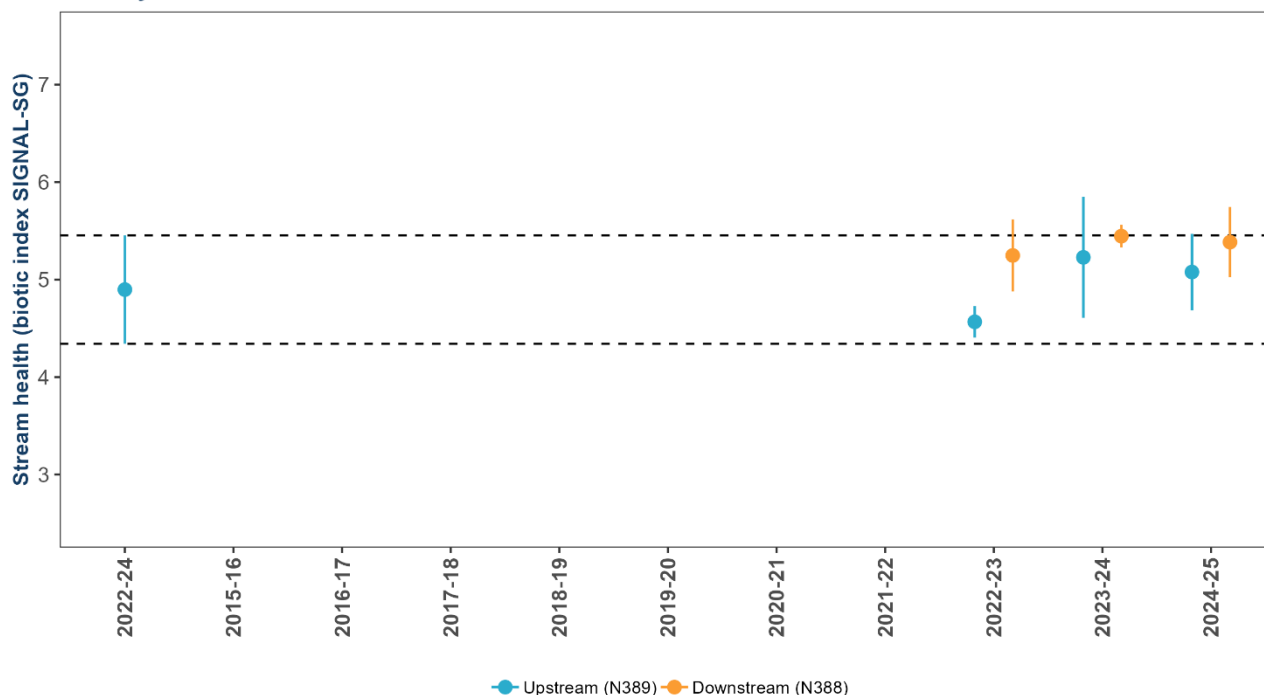


A.7.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Rickabys Creek	Tributary (N389 vs N388)	Welch Two Sample t-test	-0.31	-1.63	13.9	0.126

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Rickabys Creek at Richmond WRRF

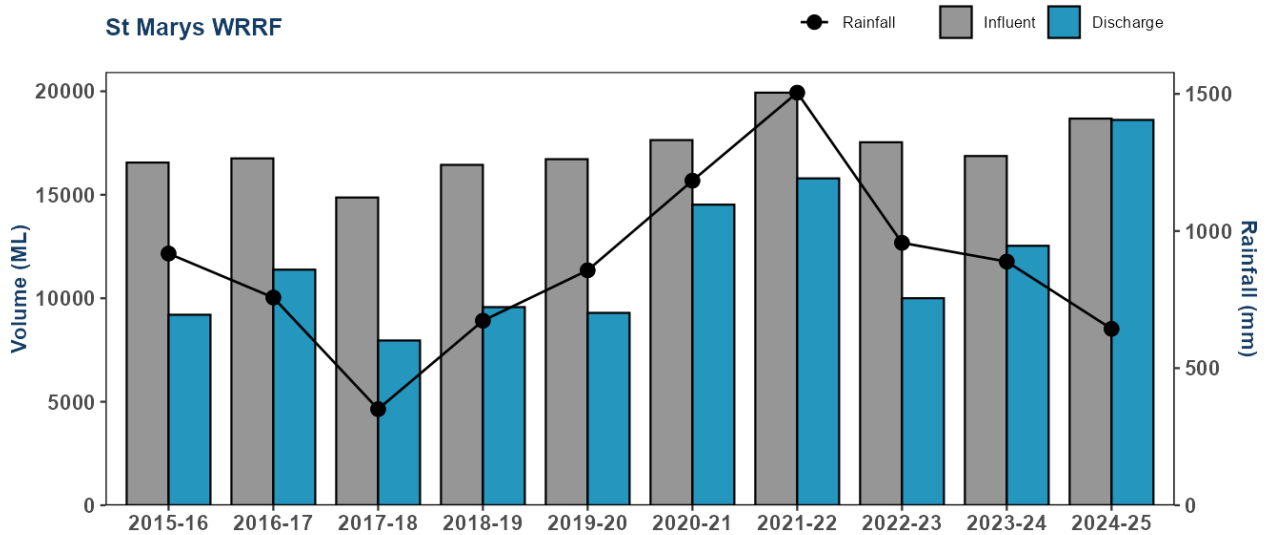


The range of stream health recorded over each period is represented by length of line

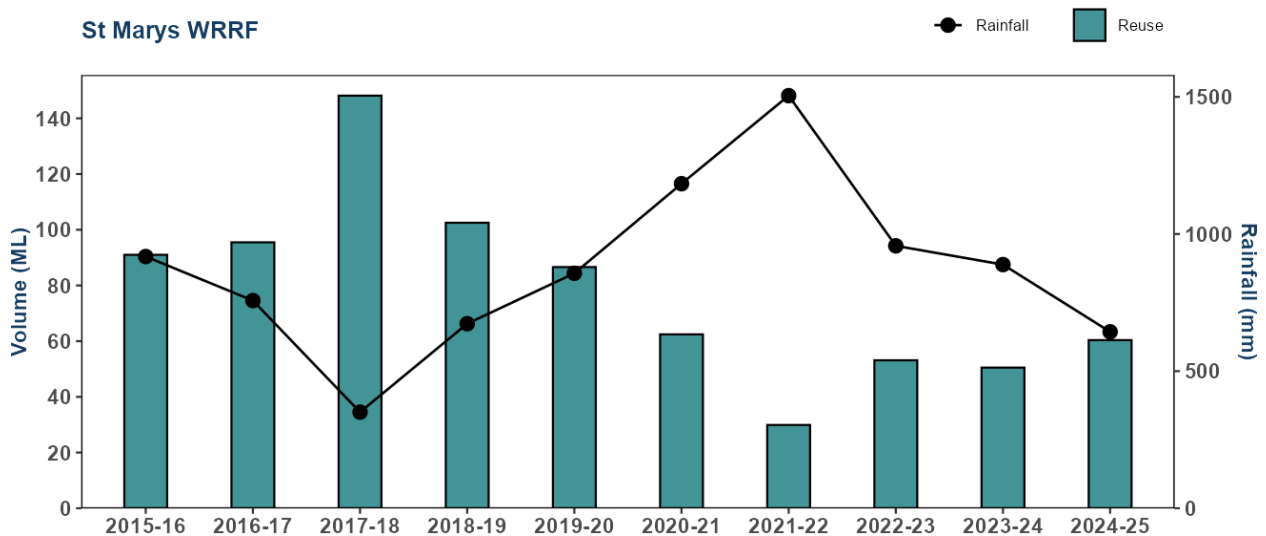
A.8. St Marys WRRF

A.8.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



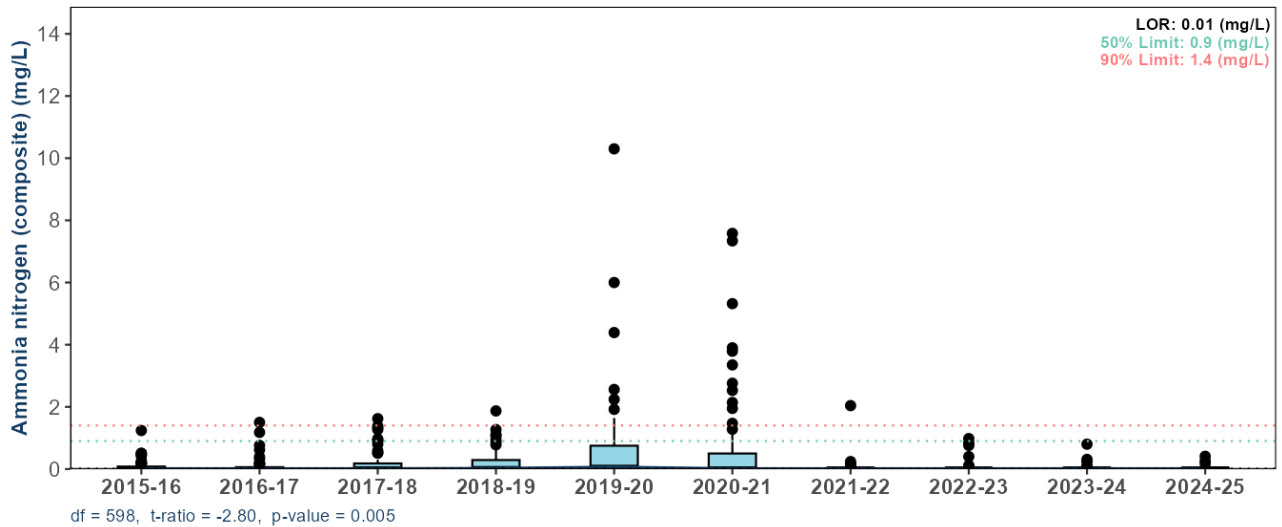
Reuse volume and rainfall



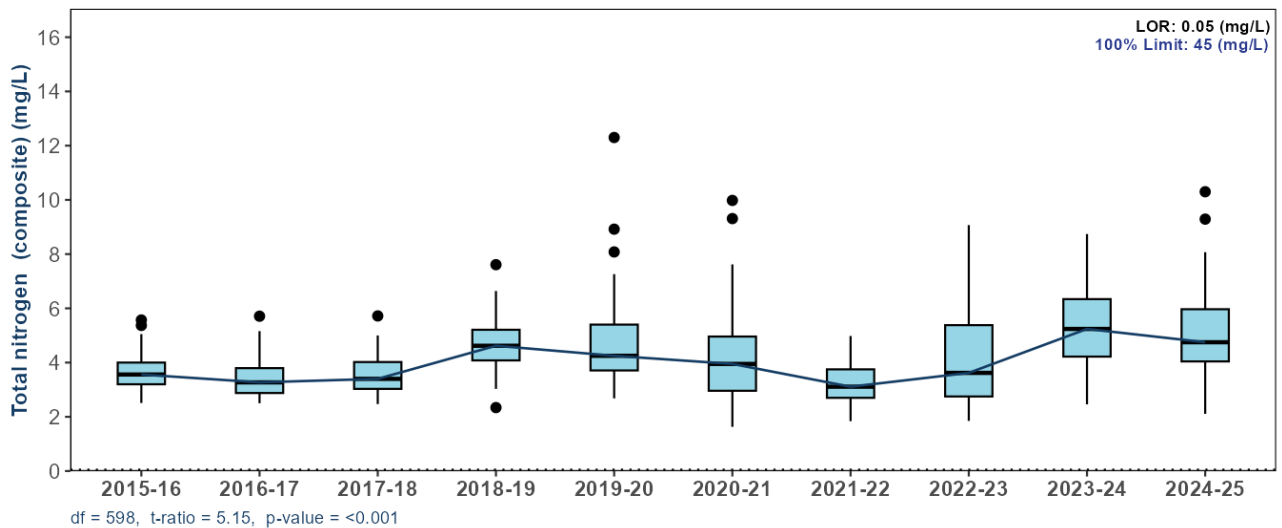
A.8.2. Pressure – Wastewater quality

Nutrients

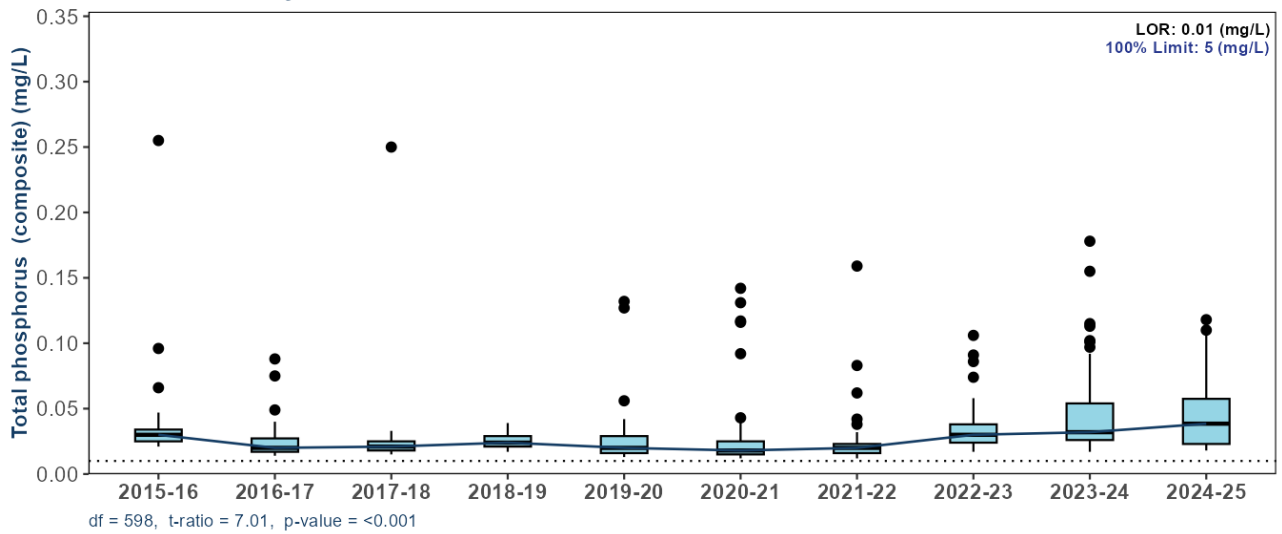
SM0005 at St Marys WRRF



SM0005 at St Marys WRRF

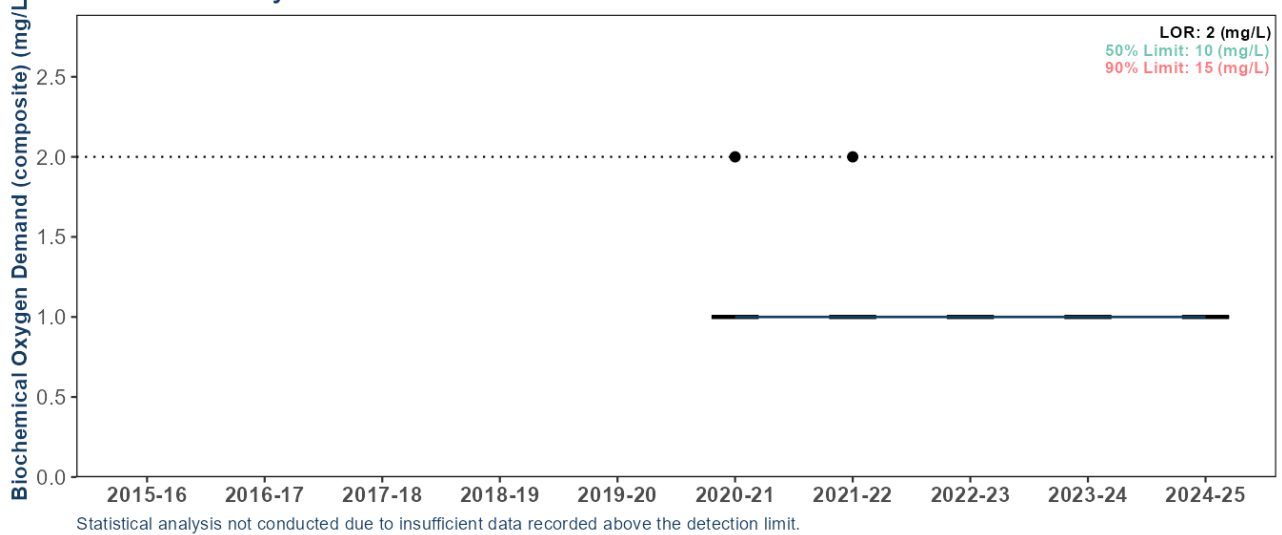


SM0005 at St Marys WRRF

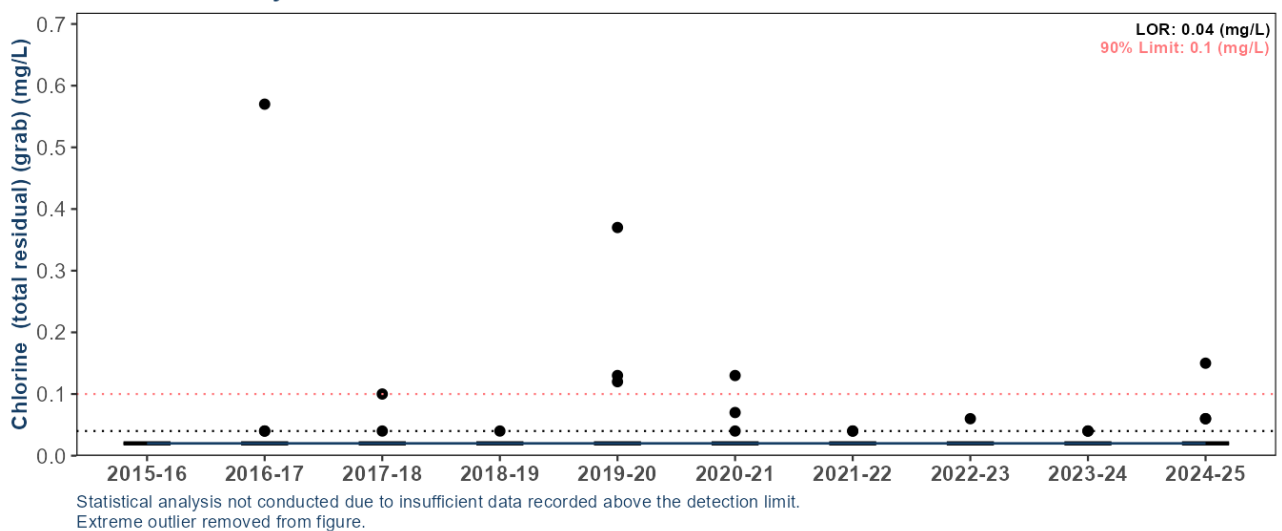


Major conventional analytes

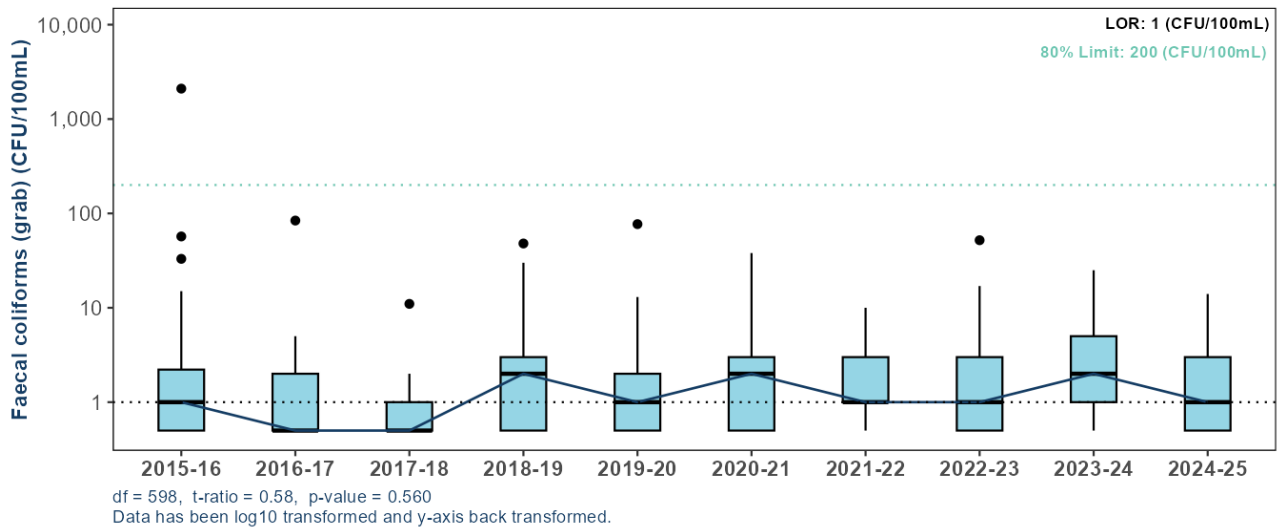
SM0005 at St Marys WRRF



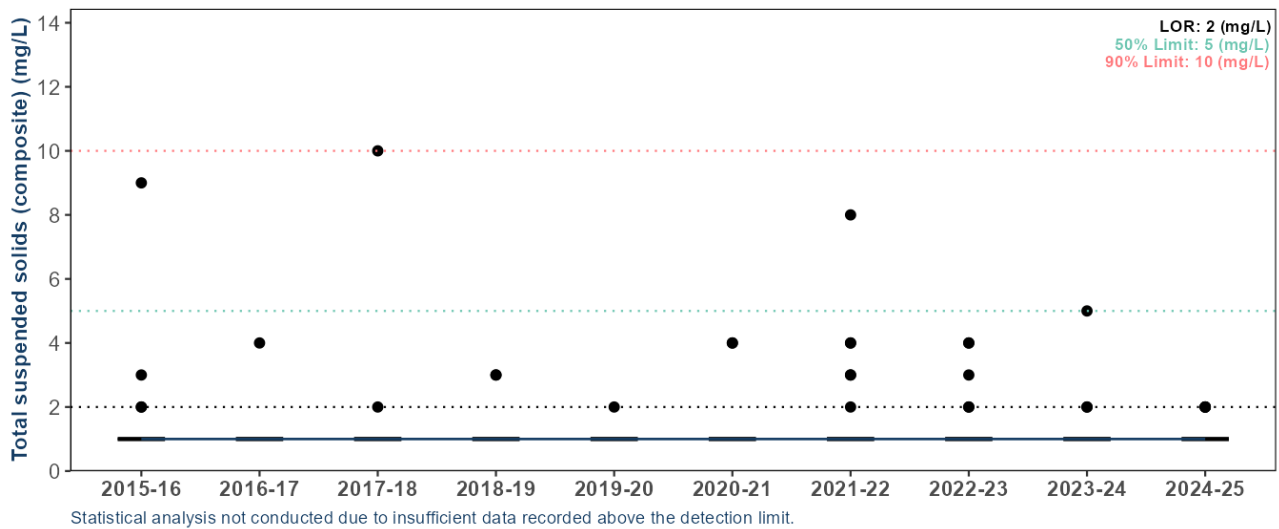
SM0005 at St Marys WRRF



SM0005 at St Marys WRRF

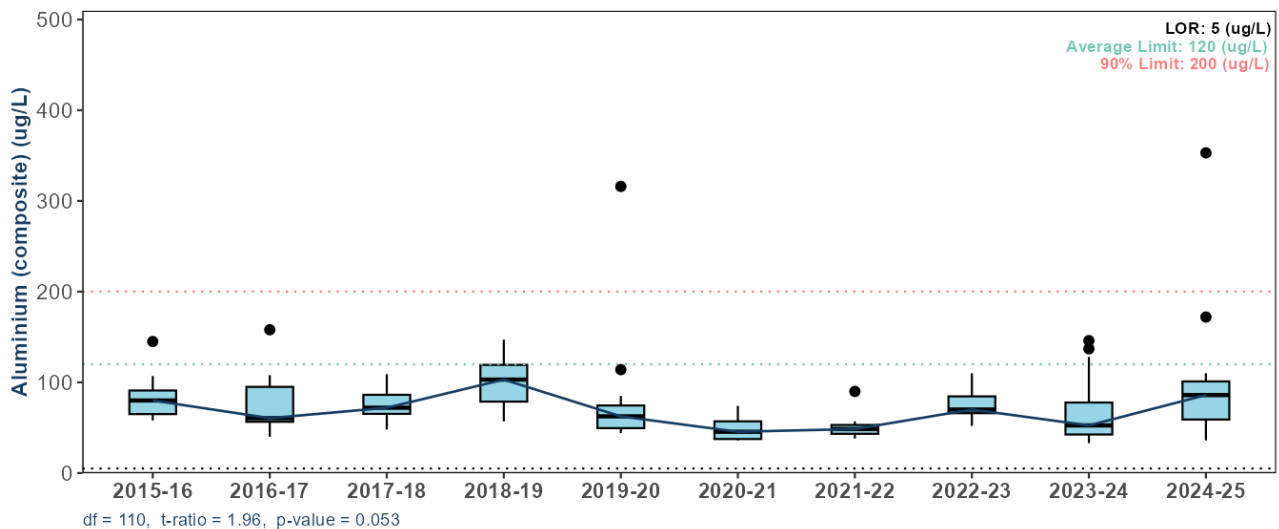


SM0005 at St Marys WRRF

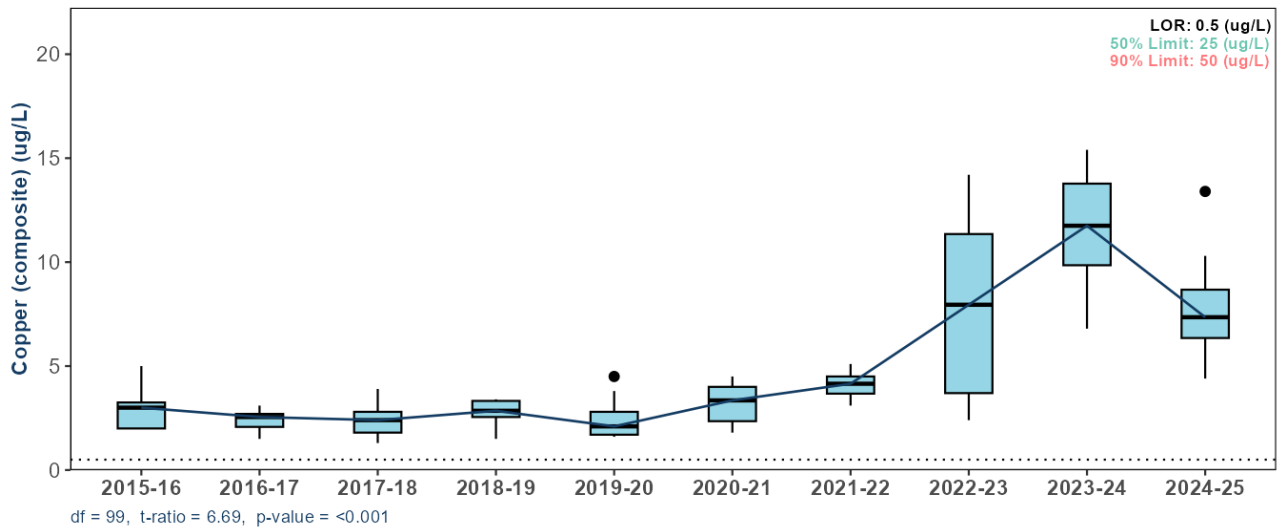


Trace metals

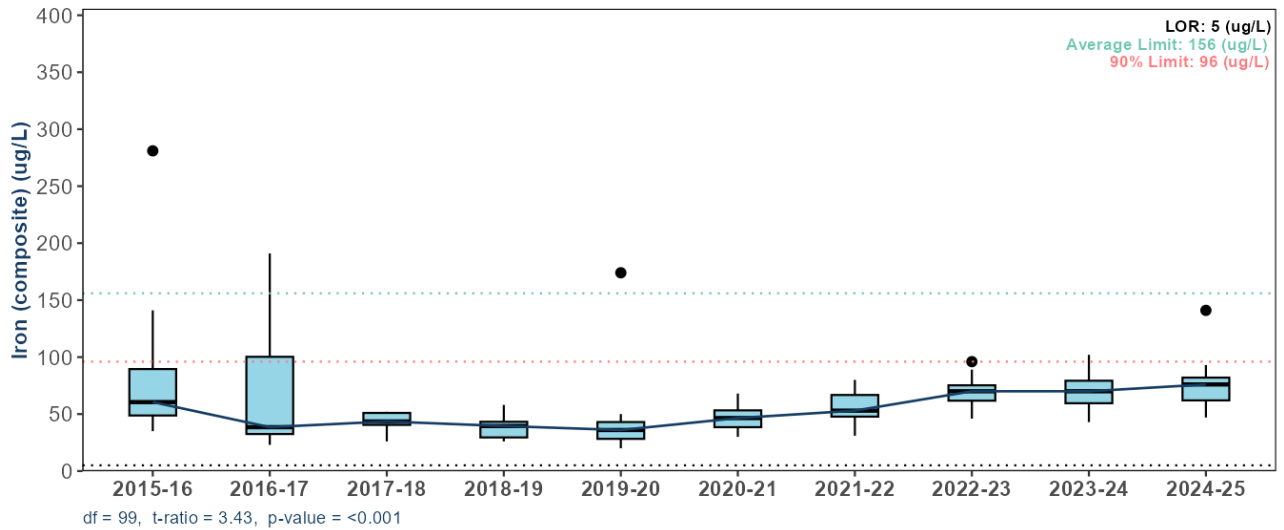
SM0005 at St Marys WRRF



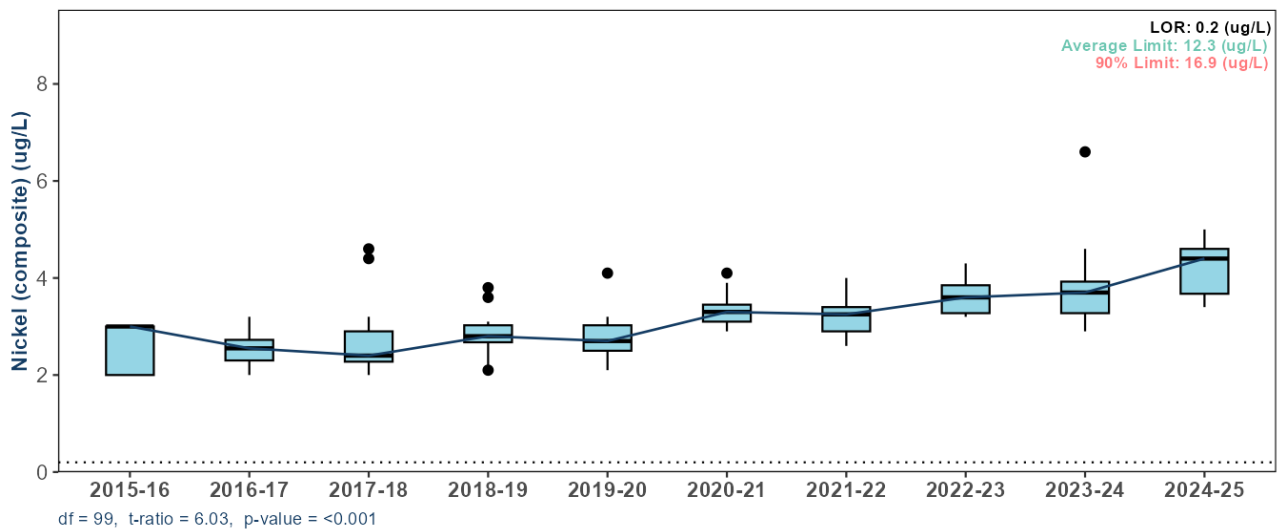
SM0005 at St Marys WRRF



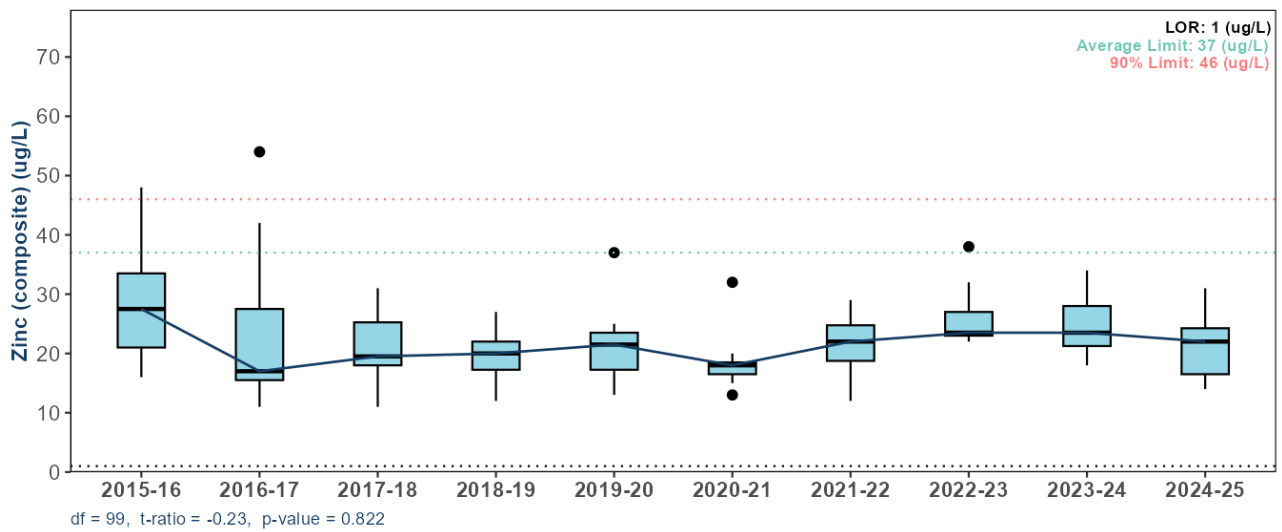
SM0005 at St Marys WRRF



SM0005 at St Marys WRRF

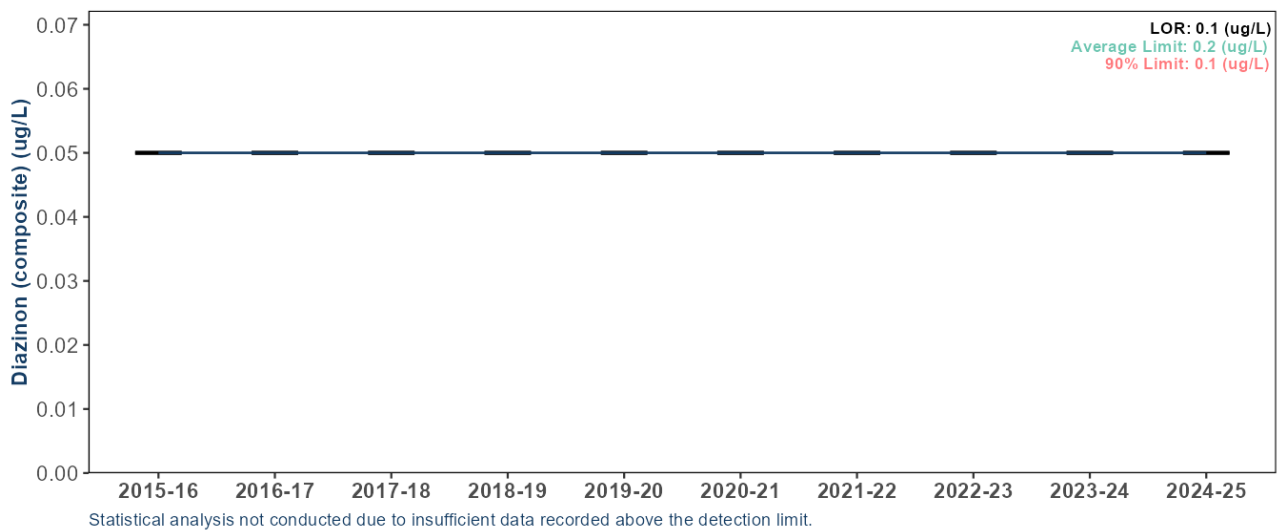


SM0005 at St Marys WRRF

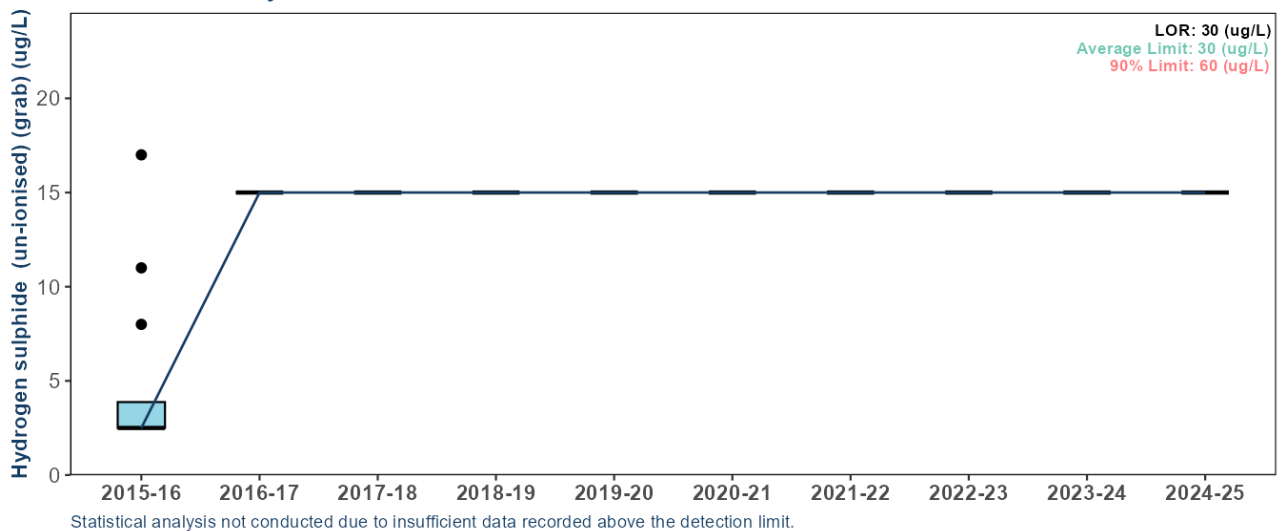


Other chemicals and organics (including pesticides)

SM0005 at St Marys WRRF

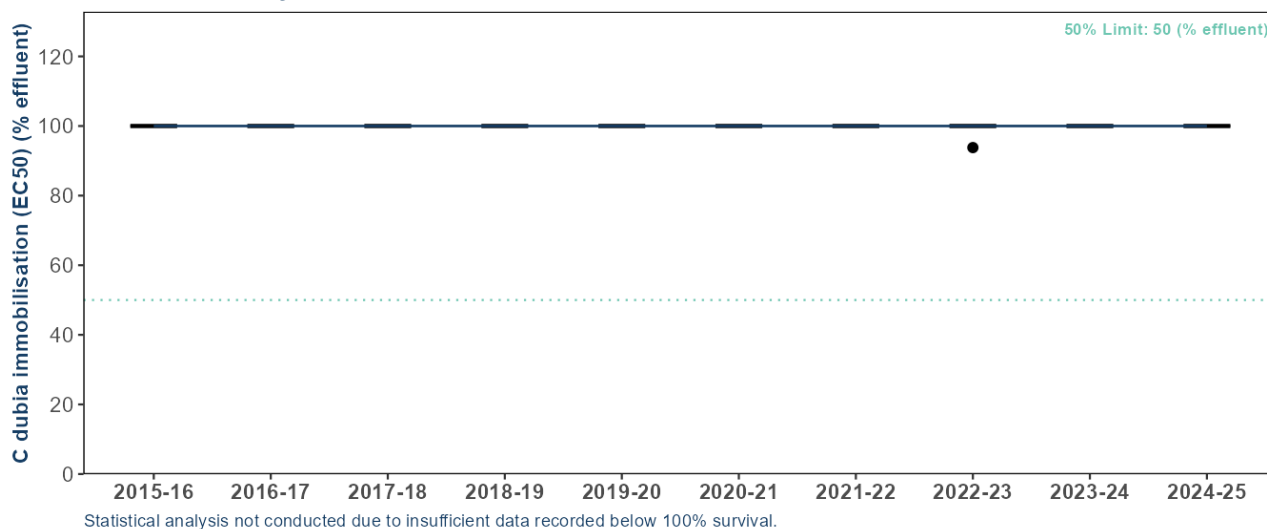


SM0005 at St Marys WRRF



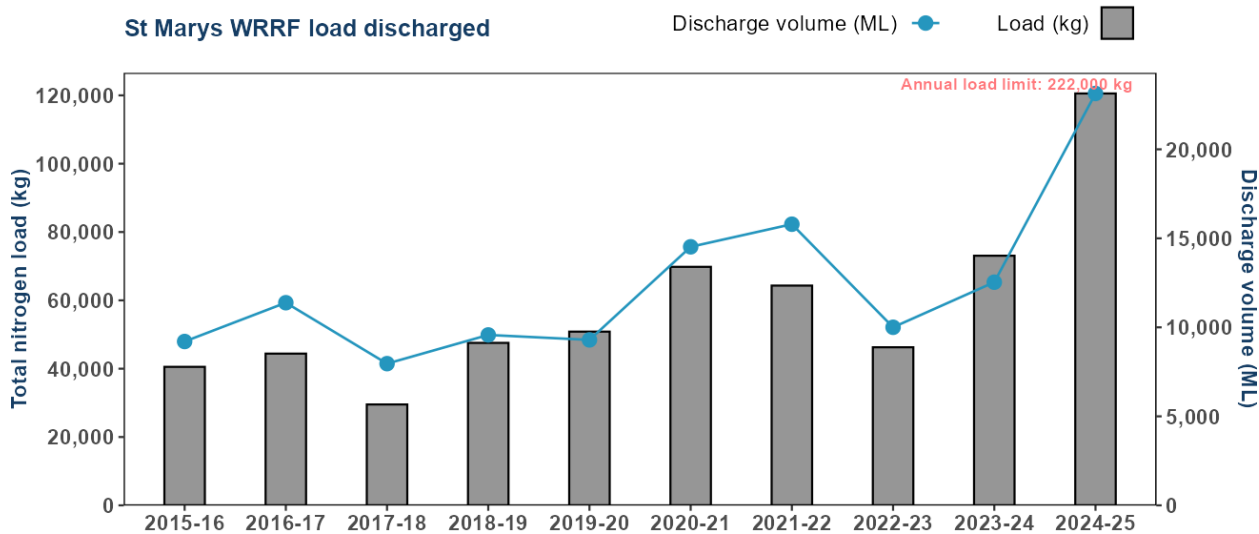
A.8.3. Pressure – Wastewater toxicity

SM0005 at St Marys WRRF

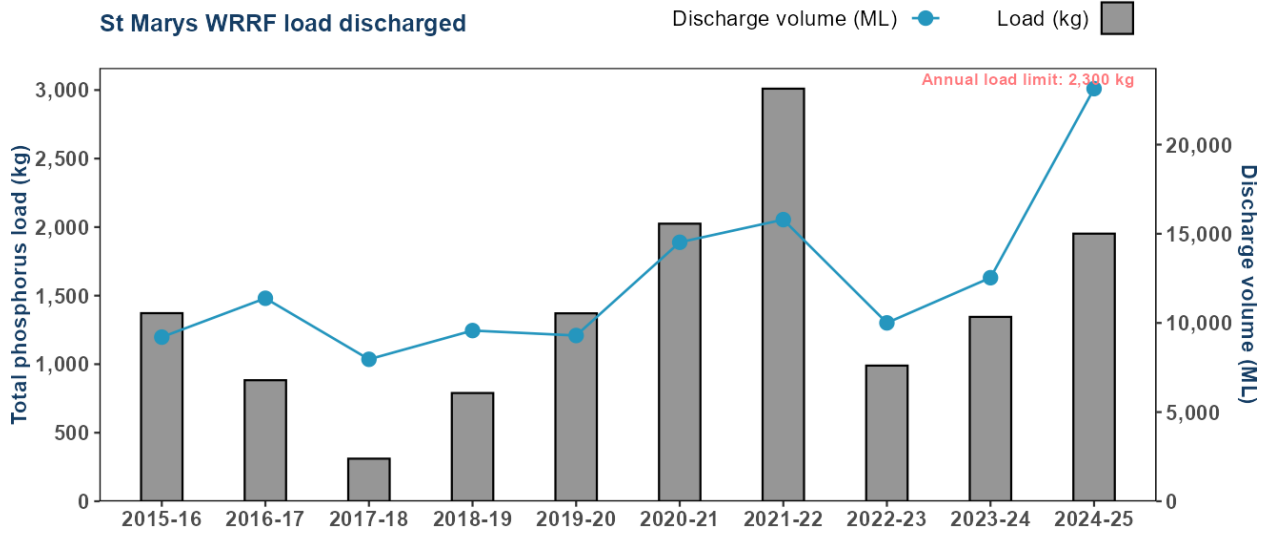


A.8.4. Pressure – Wastewater discharge load

Nutrients

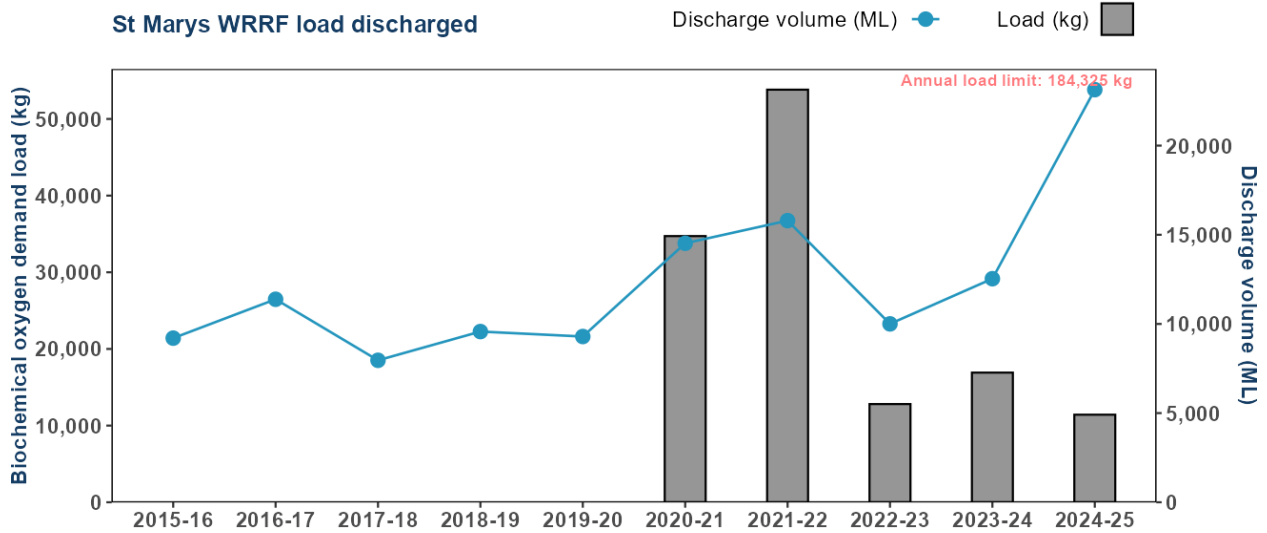


St Marys WRRF load discharged

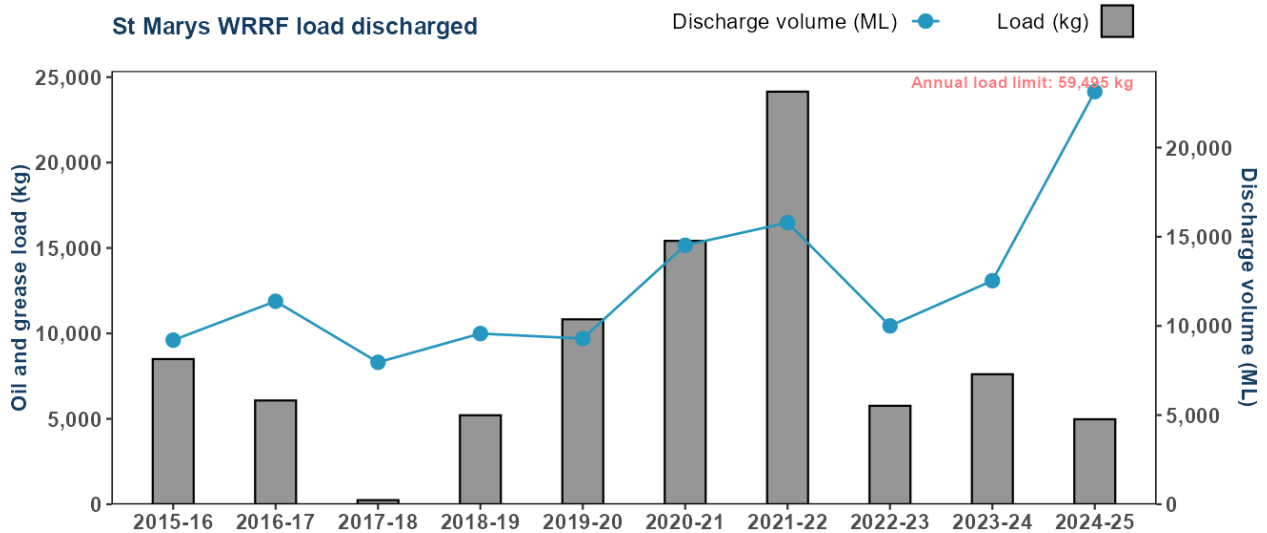


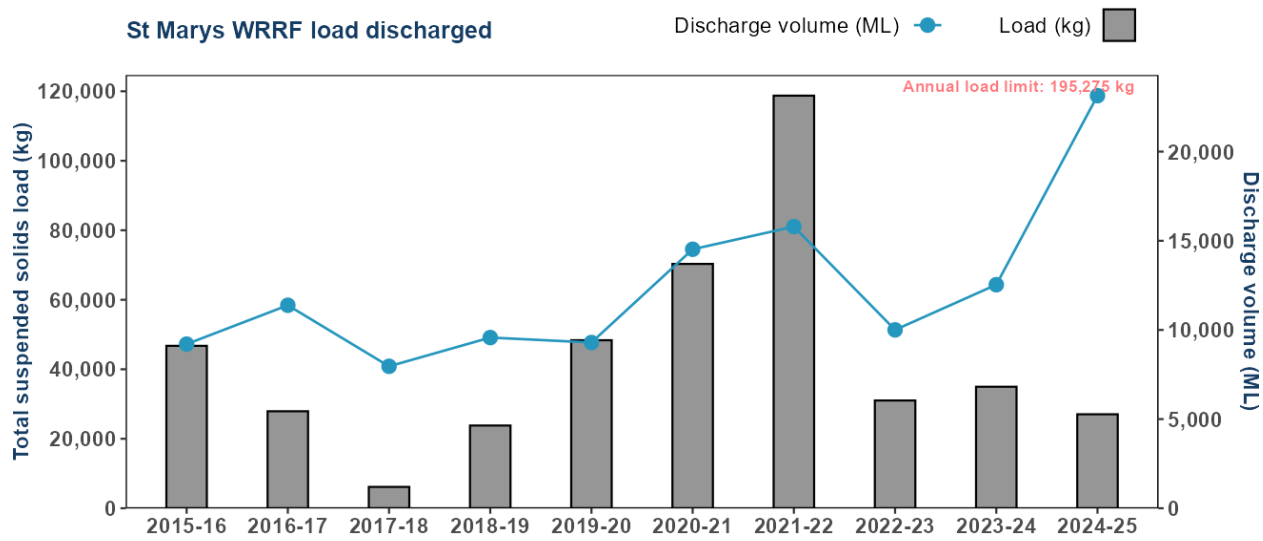
Major conventional analytes

St Marys WRRF load discharged

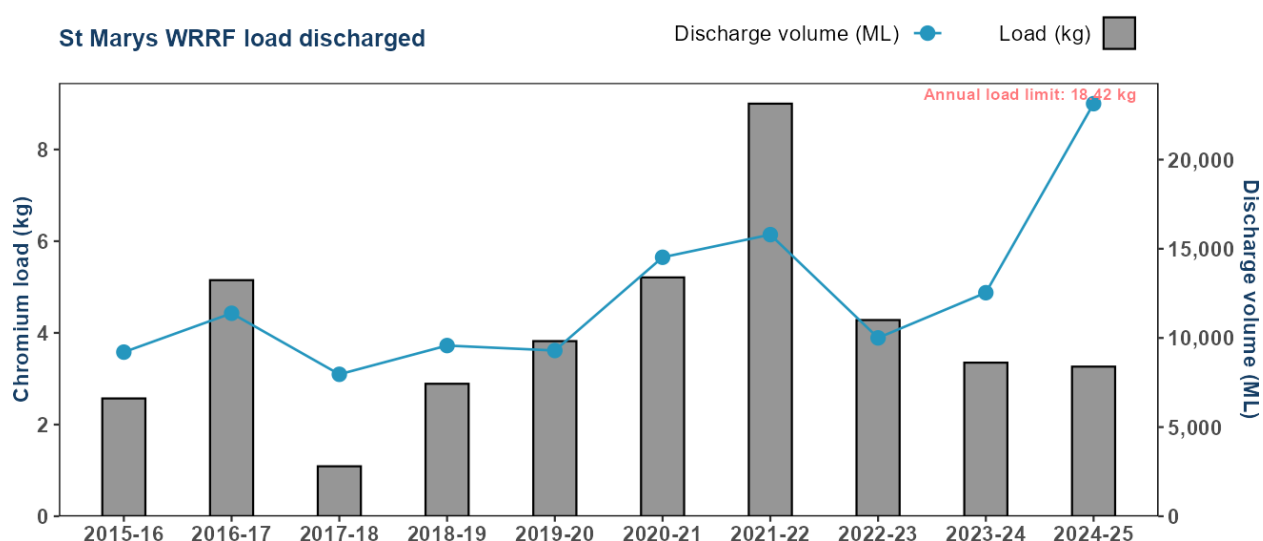
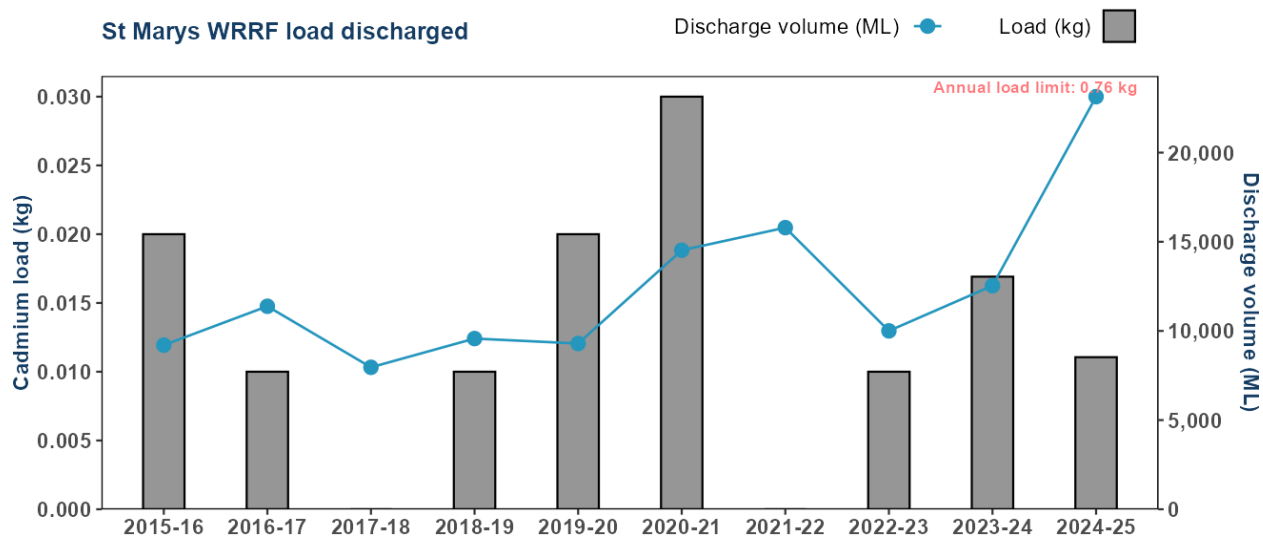


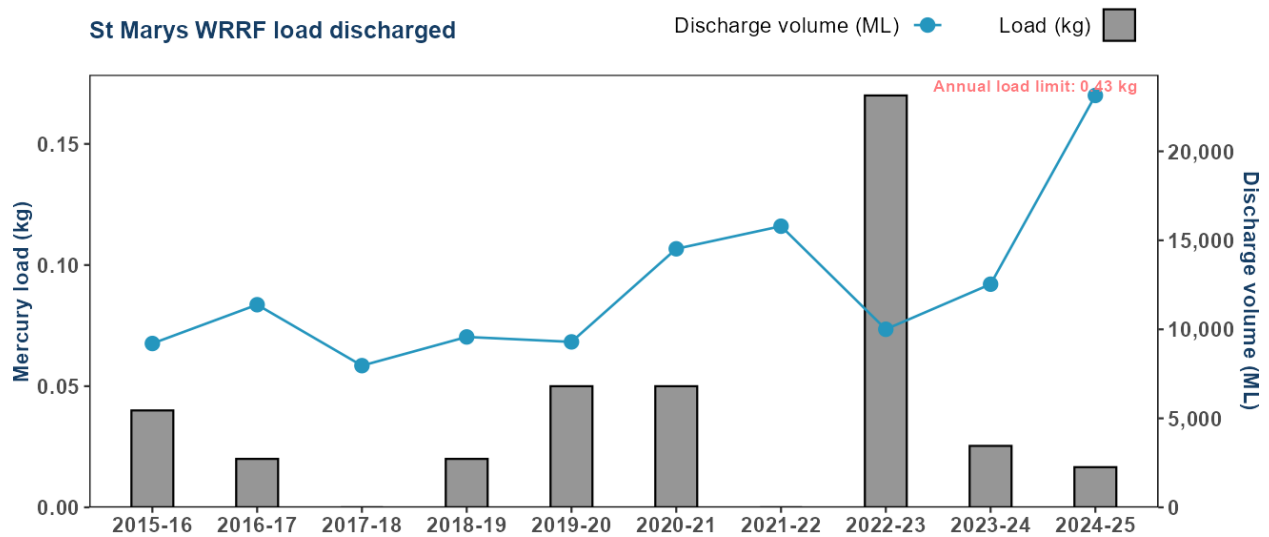
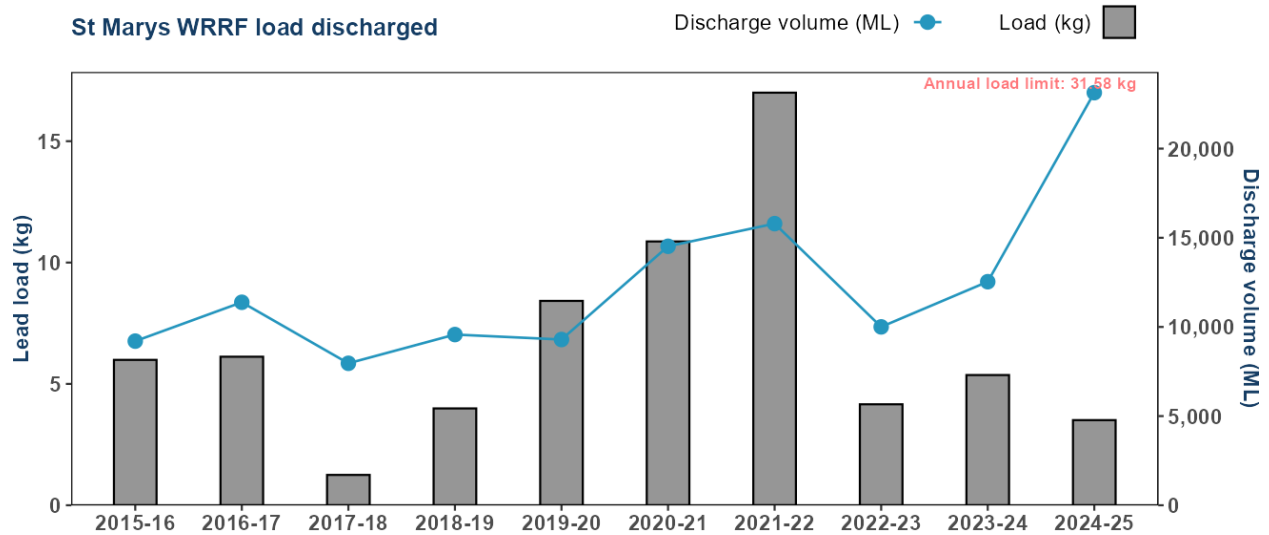
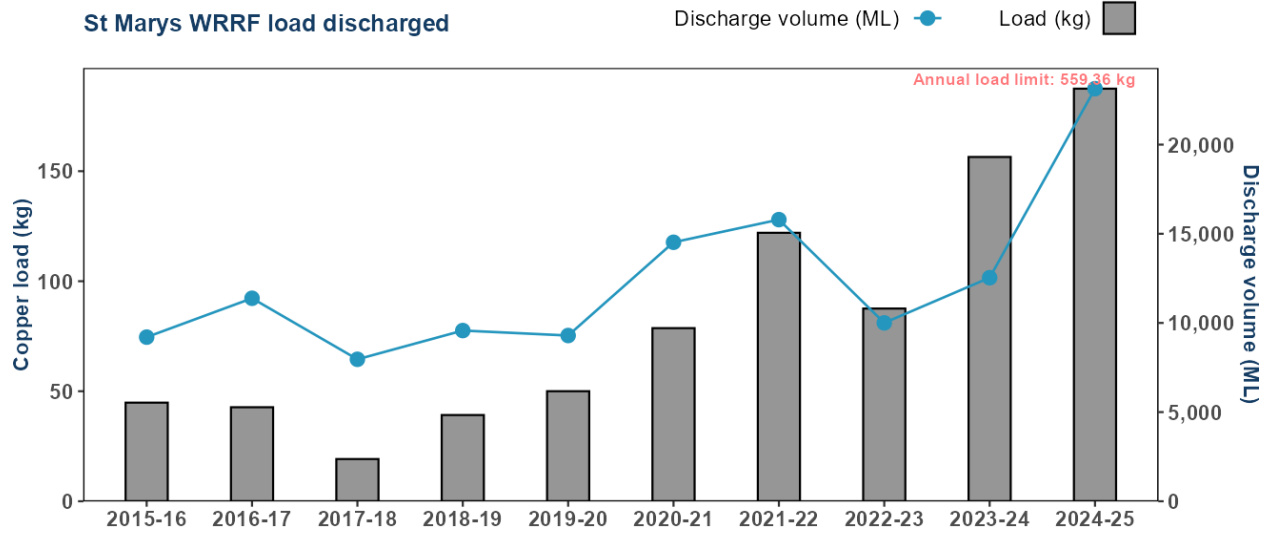
St Marys WRRF load discharged



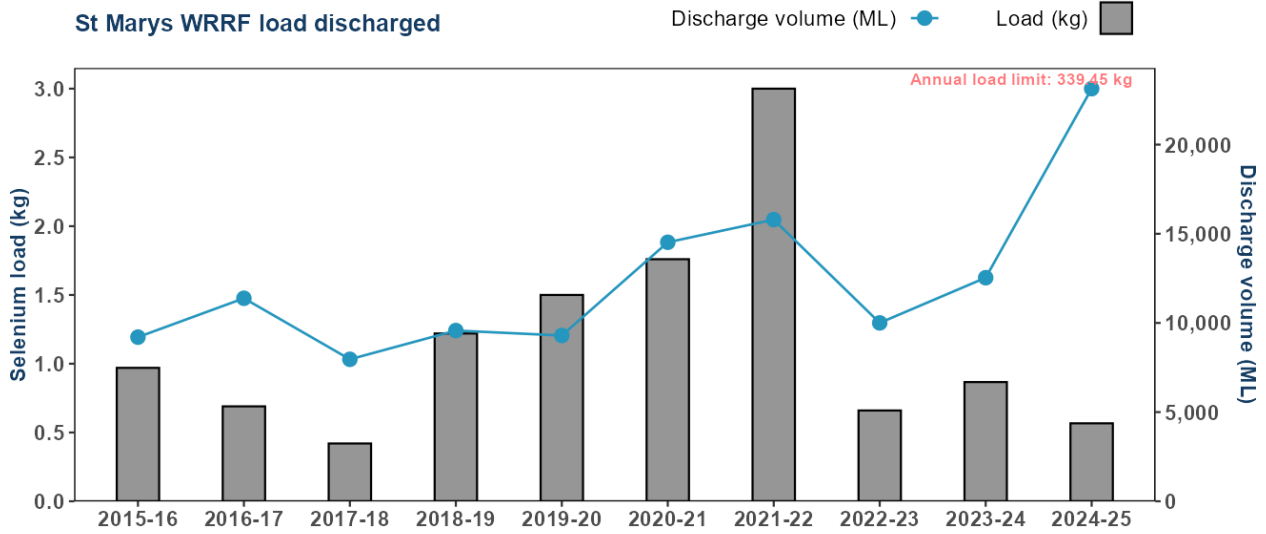


Trace metals

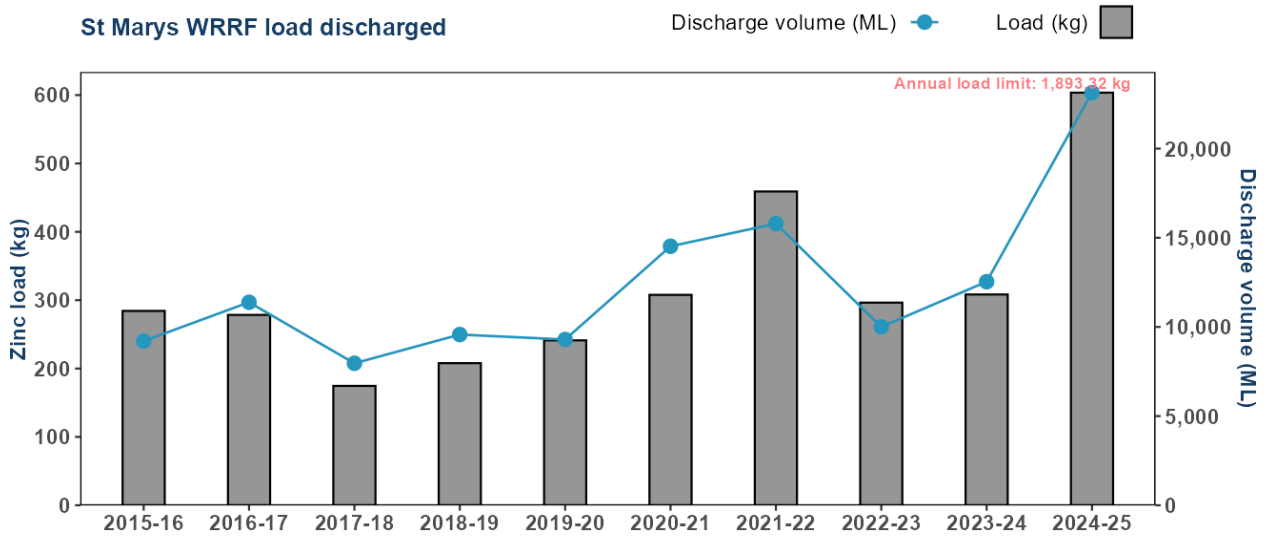




St Marys WRRF load discharged

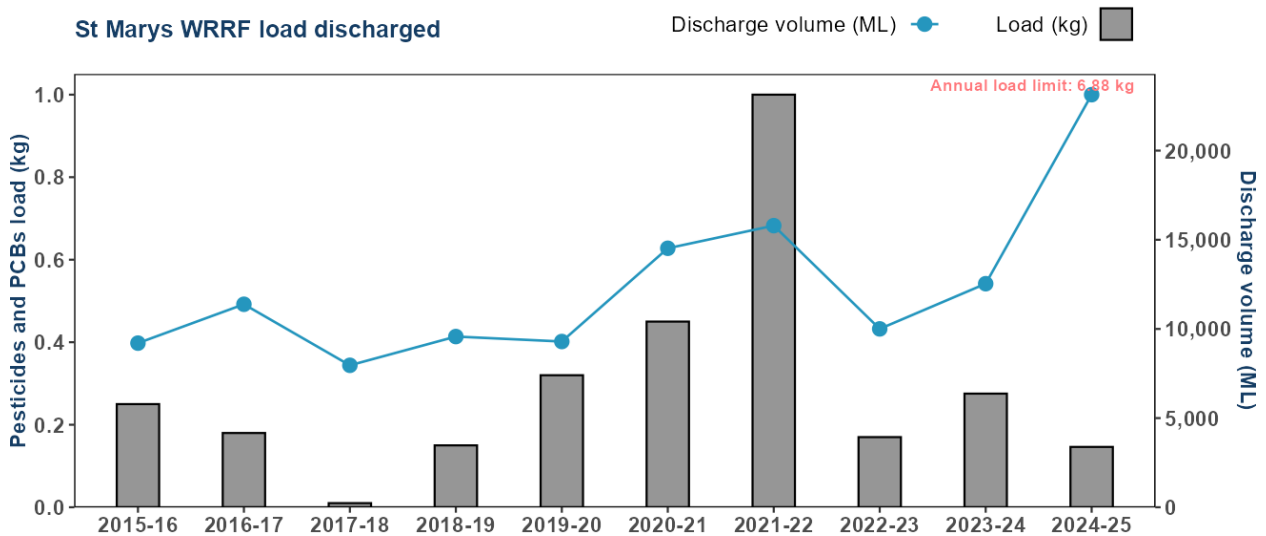


St Marys WRRF load discharged



Other chemicals and organics (including pesticides)

St Marys WRRF load discharged



A.8.5. Stressor – Statistical analysis outcomes

Table A-86 Upstream vs downstream comparison (2024-25 reporting period) for the unnamed creek at St Marys WRRF

Unnamed Creek at St Marys WRRF: NS242 vs NS241 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.01	0.00	53	-10.68	<0.001
Oxidised nitrogen	30.32	12.79	53	8.09	<0.001
Total nitrogen	0.66	0.20	53	-1.38	0.516
Soluble reactive phosphorus	0.15	0.04	53	-6.57	<0.001
Total phosphorus	0.24	0.05	53	-6.45	<0.001
Physico-chemical					
Conductivity	1.15	0.18	54	0.89	0.808
Dissolved oxygen	2.19	0.22	53	7.74	<0.001
Dissolved oxygen saturation	54.11	4.25	53	12.74	<0.001
pH	0.01	0.08	54	0.09	>0.999
Water temperature	1.34	0.10	54	3.90	0.001
Turbidity	0.20	0.07	54	-4.35	<0.001
Trace Metals					
Filterable aluminium	6.83	1.42	54	9.26	<0.001
Total aluminium	1.31	0.52	54	0.66	0.910
Filterable cobalt	1.53	0.25	54	2.63	0.052
Total cobalt	1.34	0.21	54	1.90	0.242
Filterable copper	8.96	2.45	54	8.01	<0.001
Total copper	3.50	0.95	54	4.61	<0.001
Filterable nickel	4.13	0.36	54	16.22	<0.001
Total nickel	3.56	0.41	54	10.93	<0.001
Filterable zinc	1.34	0.38	53	1.04	0.724
Total zinc	0.73	0.18	54	-1.26	0.592
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-87 Upstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at St Marys WRRF

Unnamed Creek at St Marys WRRF: NS242 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	4.39	2.42	53	2.68	0.047
Oxidised nitrogen	0.81	0.39	53	-0.43	0.974
Total nitrogen	3.18	1.09	53	3.39	0.007
Soluble reactive phosphorus	1.92	0.63	53	1.97	0.214
Total phosphorus	1.26	0.32	53	0.91	0.797
Physico-chemical					
Conductivity	1.41	0.25	54	1.94	0.223
Dissolved oxygen	0.80	0.09	53	-1.97	0.214
Dissolved oxygen saturation	-13.03	4.74	53	-2.75	0.039
pH	0.11	0.09	54	1.16	0.654
Water temperature	0.87	0.07	54	-1.65	0.358
Turbidity	0.71	0.29	54	-0.84	0.838
Trace Metals					
Filterable aluminium	0.61	0.14	54	-2.12	0.160
Total aluminium	0.46	0.21	54	-1.74	0.314
Filterable cobalt	0.89	0.16	54	-0.63	0.922
Total cobalt	0.70	0.12	54	-2.09	0.170
Filterable copper	0.66	0.20	54	-1.38	0.517
Total copper	0.64	0.20	54	-1.46	0.469
Filterable nickel	0.79	0.08	54	-2.41	0.086
Total nickel	0.64	0.08	54	-3.40	0.007
Filterable zinc	0.65	0.21	53	-1.34	0.545
Total zinc	0.72	0.20	54	-1.18	0.645
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-88 Downstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at St Marys WRRF

Unnamed Creek at St Marys WRRF: NS241 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.72	0.41	53	-0.58	0.939
Oxidised nitrogen	1.08	0.54	53	0.15	0.999
Total nitrogen	1.08	0.38	53	0.23	0.996
Soluble reactive phosphorus	0.35	0.12	53	-3.06	0.017
Total phosphorus	0.70	0.18	53	-1.38	0.516
Physico-chemical					
Conductivity	1.13	0.21	54	0.67	0.909
Dissolved oxygen	1.03	0.12	53	0.26	0.994
Dissolved oxygen saturation	0.43	4.95	53	0.09	>0.999
pH	-0.19	0.10	54	-1.95	0.221
Water temperature	0.98	0.09	54	-0.28	0.992
Turbidity	0.50	0.22	54	-1.60	0.388
Trace Metals					
Filterable aluminium	1.91	0.47	54	2.63	0.053
Total aluminium	0.87	0.41	54	-0.30	0.990
Filterable cobalt	1.31	0.25	54	1.42	0.491
Total cobalt	1.04	0.19	54	0.20	0.997
Filterable copper	0.78	0.25	54	-0.75	0.874
Total copper	0.69	0.22	54	-1.13	0.670
Filterable nickel	1.30	0.13	54	2.55	0.063
Total nickel	1.15	0.16	54	0.99	0.755
Filterable zinc	1.41	0.47	53	1.02	0.739
Total zinc	0.99	0.30	54	-0.03	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-89 Upstream vs downstream comparison (2024-25 reporting period) for South Creek at St Marys WRRF

South Creek at St Marys WRRF: NS26 vs NS23A (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.77	0.63	156	1.61	0.374
Oxidised nitrogen	8.23	2.72	156	6.36	<0.001
Total nitrogen	2.98	0.43	156	7.52	<0.001
Soluble reactive phosphorus	1.34	0.39	66	0.98	0.759
Total phosphorus	0.86	0.18	156	-0.72	0.890
Physico-chemical					
Conductivity	0.85	0.09	155	-1.60	0.383
Dissolved oxygen	1.10	0.07	156	1.48	0.455
Dissolved oxygen saturation	10.16	3.08	156	3.30	0.007
pH	-0.02	0.06	156	-0.30	0.990
Water temperature	1.16	0.11	156	1.51	0.433
Turbidity	0.47	0.14	156	-2.63	0.045
Trace Metals					
Filterable aluminium	4.67	0.85	66	8.46	<0.001
Total aluminium	0.58	0.17	66	-1.84	0.262
Filterable cobalt	1.00	0.11	66	-0.02	>0.999
Total cobalt	0.79	0.11	66	-1.73	0.316
Filterable copper	2.64	0.30	66	8.55	<0.001
Total copper	1.82	0.23	66	4.72	<0.001
Filterable nickel	1.66	0.15	66	5.44	<0.001
Total nickel	1.39	0.13	66	3.42	0.006
Filterable zinc	4.40	0.74	66	8.84	<0.001
Total zinc	1.99	0.31	66	4.39	<0.001
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-90 Upstream current period (2024-25) vs previous period comparison (single site) for South Creek at St Marys WRRF

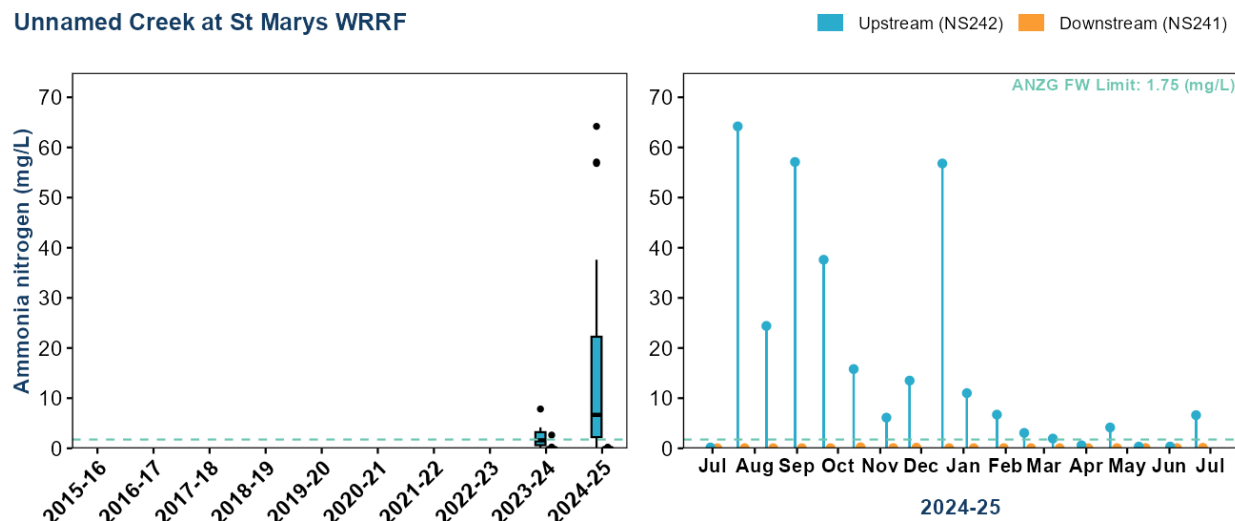
South Creek at St Marys WRRF: NS26 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.64	0.18	156	-1.57	0.399
Oxidised nitrogen	1.08	0.28	156	0.27	0.993
Total nitrogen	1.07	0.12	156	0.62	0.925
Soluble reactive phosphorus	0.74	0.22	66	-1.01	0.743
Total phosphorus	0.96	0.16	156	-0.23	0.996
Physico-chemical					
Conductivity	1.33	0.11	155	3.43	0.004
Dissolved oxygen	1.04	0.05	156	0.70	0.897
Dissolved oxygen saturation	3.11	2.47	156	1.26	0.588
pH	0.05	0.05	156	1.13	0.670
Water temperature	1.01	0.08	156	0.13	>0.999
Turbidity	0.89	0.21	156	-0.50	0.959
Trace Metals					
Filterable aluminium	1.00	0.18	66	-0.02	>0.999
Total aluminium	0.67	0.20	66	-1.34	0.543
Filterable cobalt	1.29	0.14	66	2.29	0.111
Total cobalt	0.96	0.13	66	-0.32	0.988
Filterable copper	0.93	0.11	66	-0.64	0.920
Total copper	0.81	0.10	66	-1.61	0.381
Filterable nickel	1.09	0.10	66	0.96	0.774
Total nickel	0.94	0.09	66	-0.66	0.911
Filterable zinc	0.75	0.13	66	-1.67	0.350
Total zinc	0.75	0.12	66	-1.81	0.276
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-91 Downstream current period (2024-25) vs previous period comparison (single site) for South Creek at St Marys WRRF

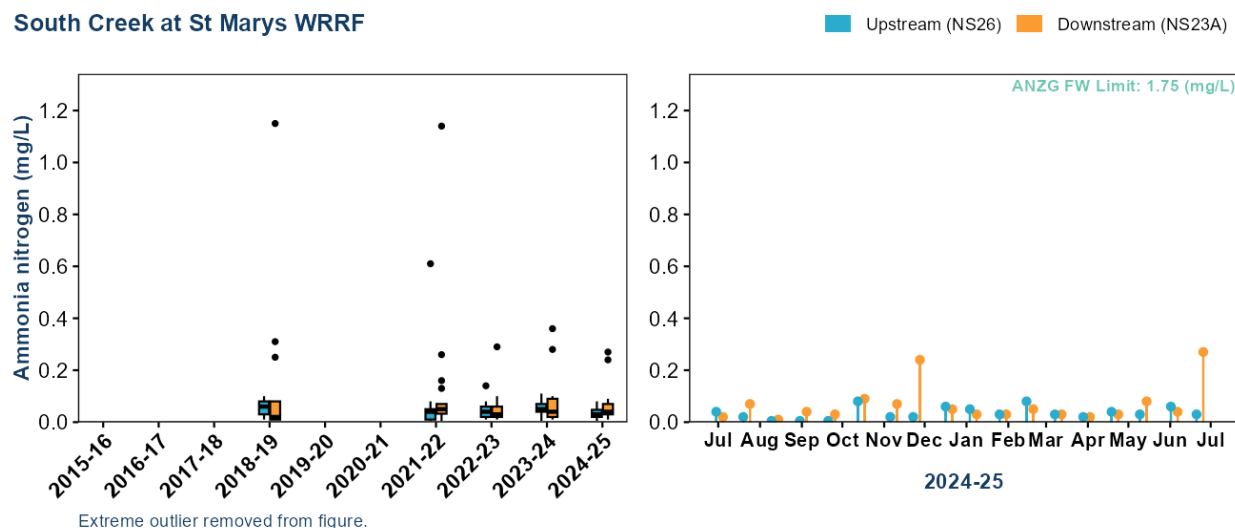
South Creek at St Marys WRRF: NS23A (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.08	0.31	156	0.27	0.993
Oxidised nitrogen	1.85	0.49	156	2.33	0.096
Total nitrogen	1.57	0.18	156	3.90	<0.001
Soluble reactive phosphorus	0.86	0.26	66	-0.51	0.958
Total phosphorus	1.03	0.17	156	0.16	0.998
Physico-chemical					
Conductivity	1.14	0.09	155	1.59	0.386
Dissolved oxygen	1.02	0.05	156	0.35	0.985
Dissolved oxygen saturation	3.49	2.47	156	1.42	0.491
pH	-0.03	0.05	156	-0.67	0.909
Water temperature	1.07	0.08	156	0.86	0.823
Turbidity	0.61	0.14	156	-2.11	0.153
Trace Metals					
Filterable aluminium	1.94	0.36	66	3.57	0.004
Total aluminium	0.54	0.16	66	-2.09	0.167
Filterable cobalt	1.19	0.13	66	1.55	0.416
Total cobalt	0.84	0.12	66	-1.24	0.605
Filterable copper	0.99	0.11	66	-0.05	>0.999
Total copper	0.86	0.11	66	-1.13	0.674
Filterable nickel	1.24	0.12	66	2.25	0.121
Total nickel	1.06	0.10	66	0.59	0.935
Filterable zinc	1.37	0.23	66	1.87	0.250
Total zinc	0.96	0.15	66	-0.24	0.995
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.8.6. Stressor – Nutrients

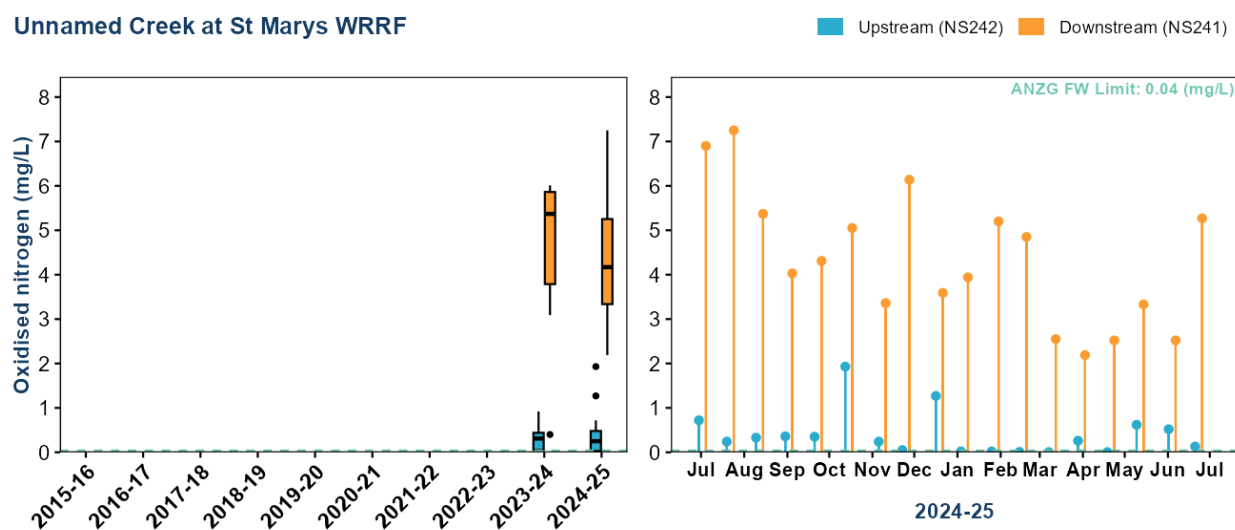
Unnamed Creek at St Marys WRRF



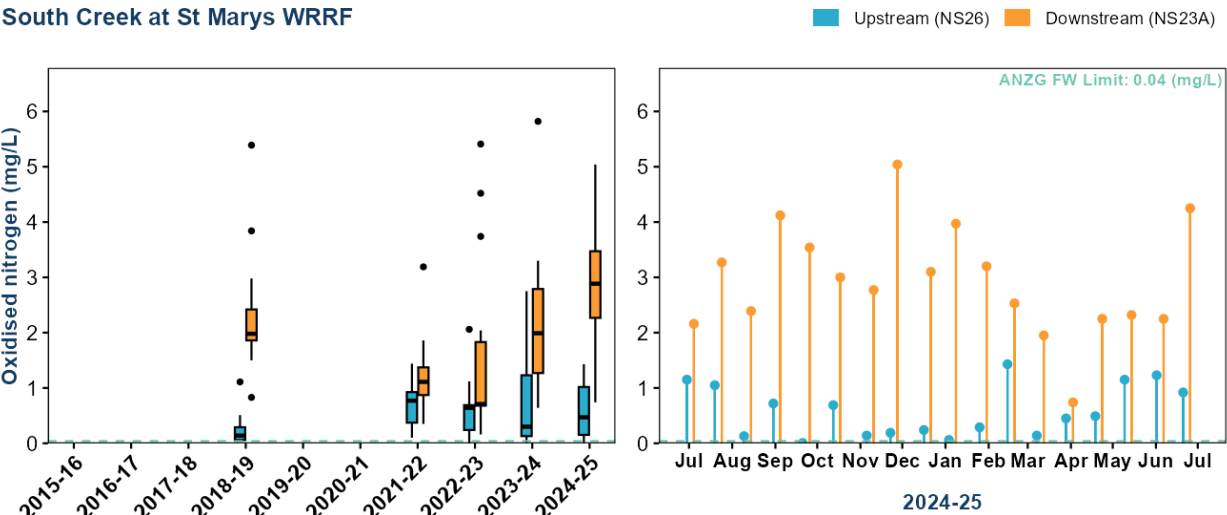
South Creek at St Marys WRRF



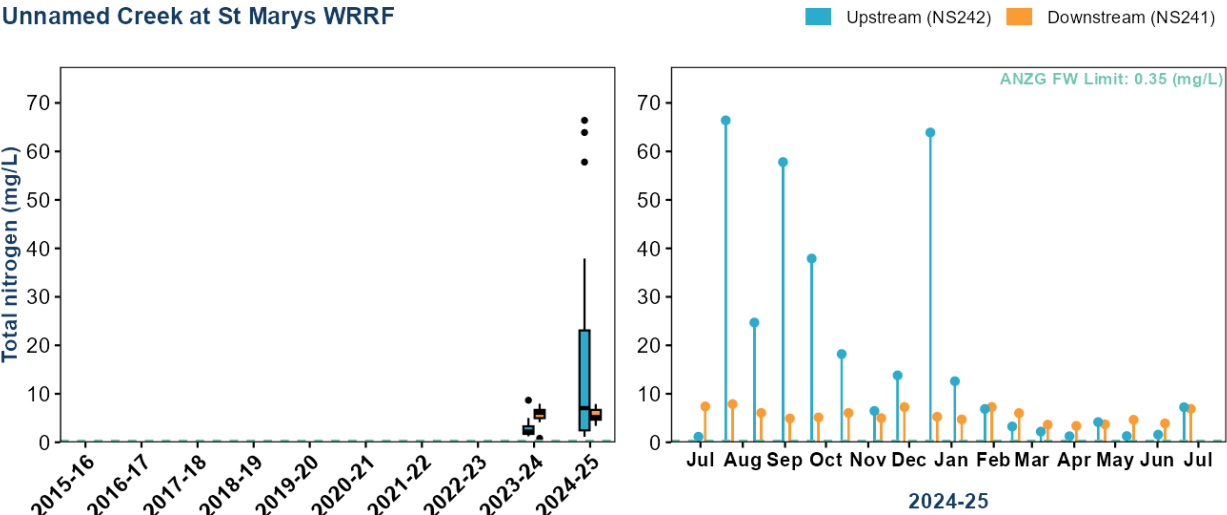
Unnamed Creek at St Marys WRRF



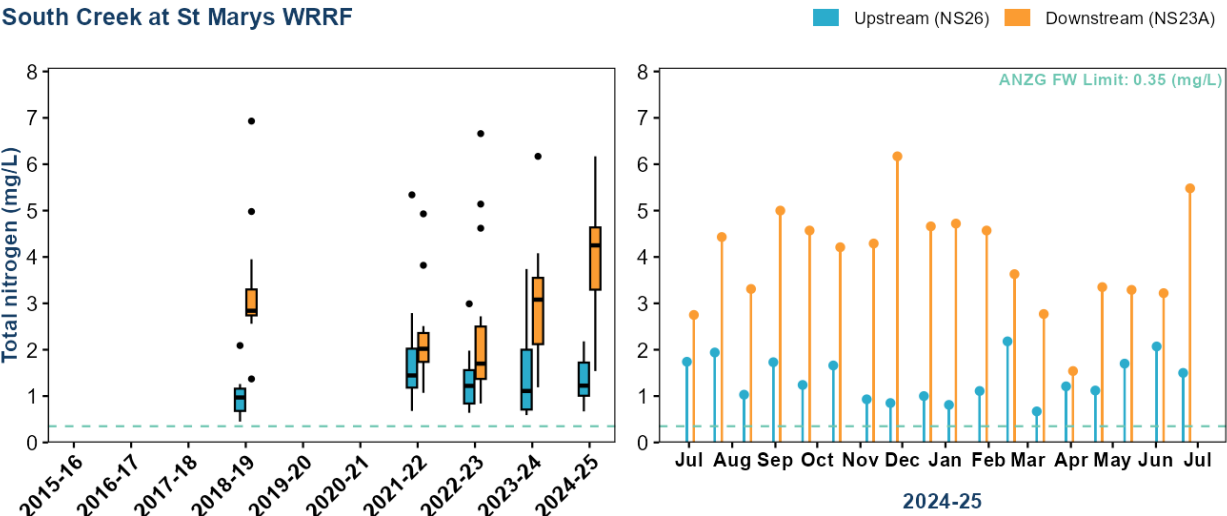
South Creek at St Marys WRRF



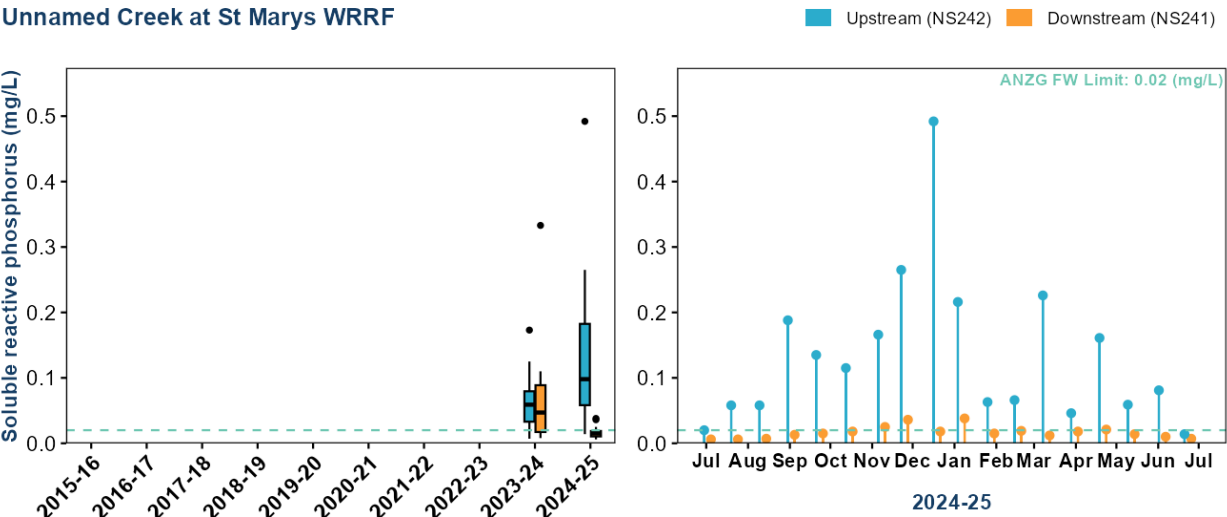
Unnamed Creek at St Marys WRRF



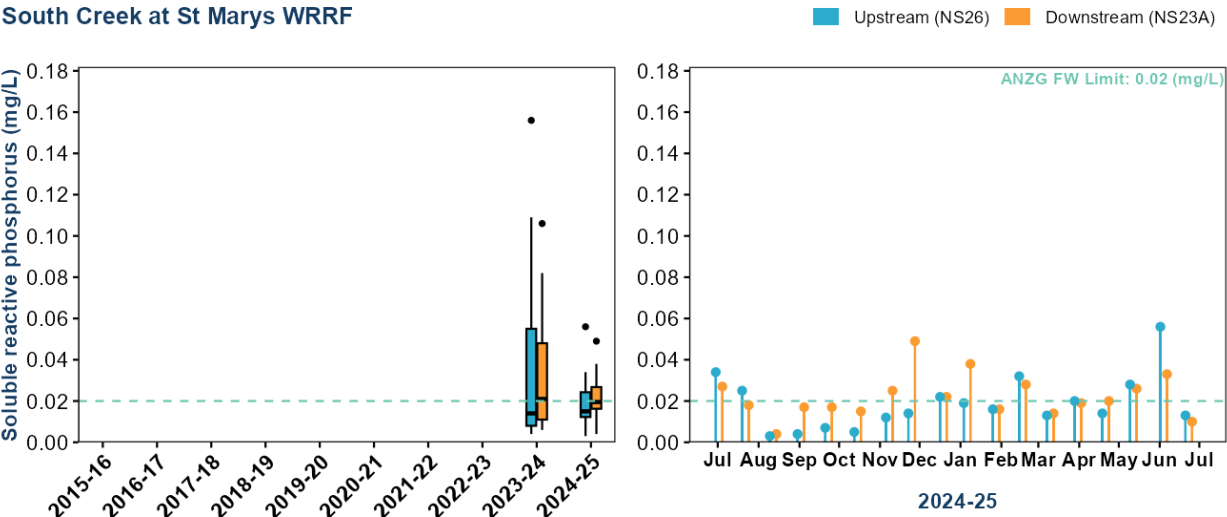
South Creek at St Marys WRRF



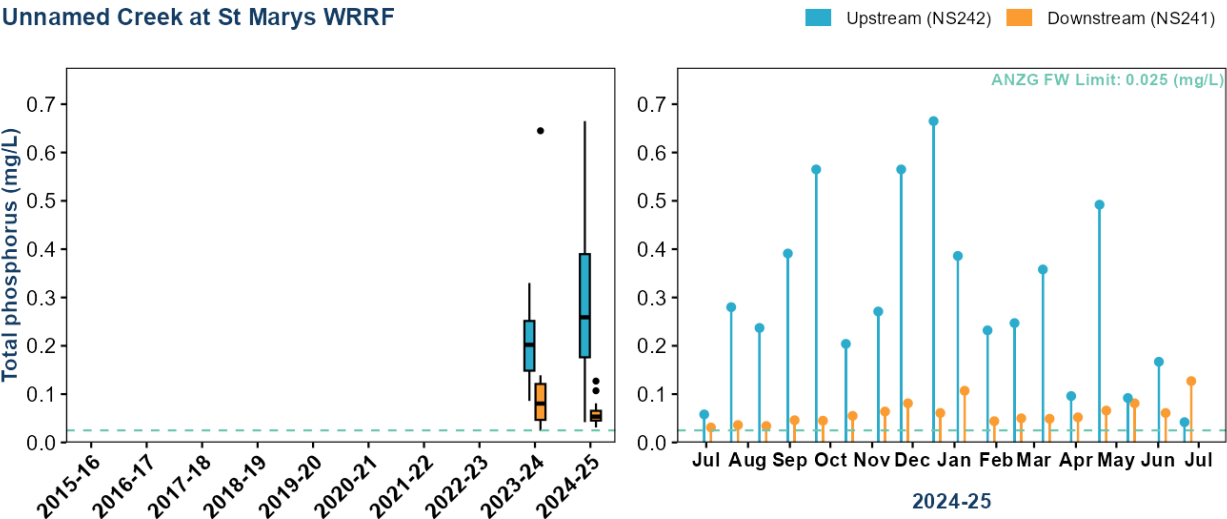
Unnamed Creek at St Marys WRRF



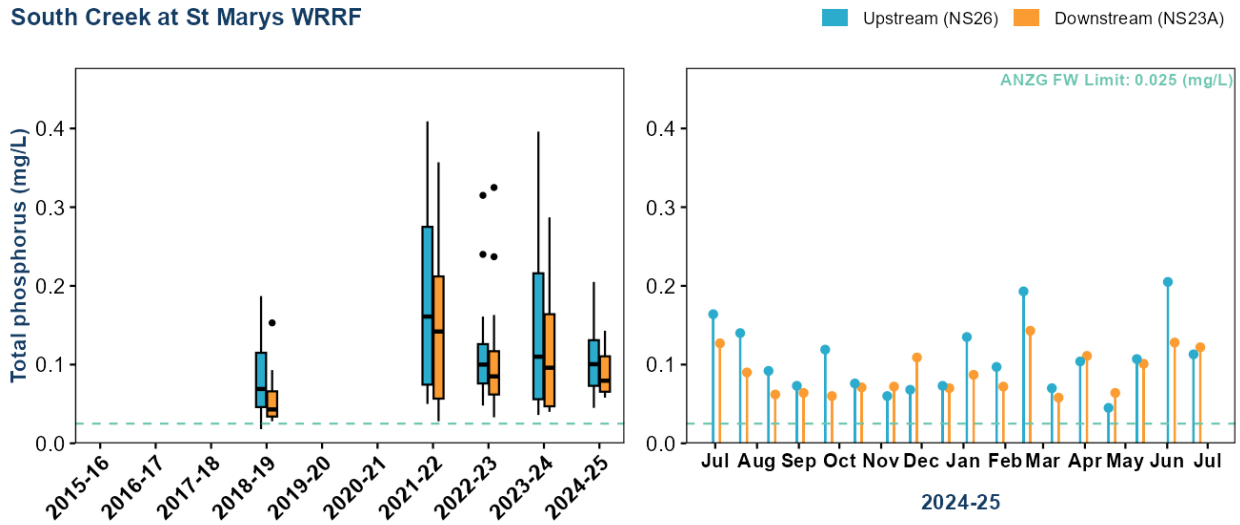
South Creek at St Marys WRRF



Unnamed Creek at St Marys WRRF

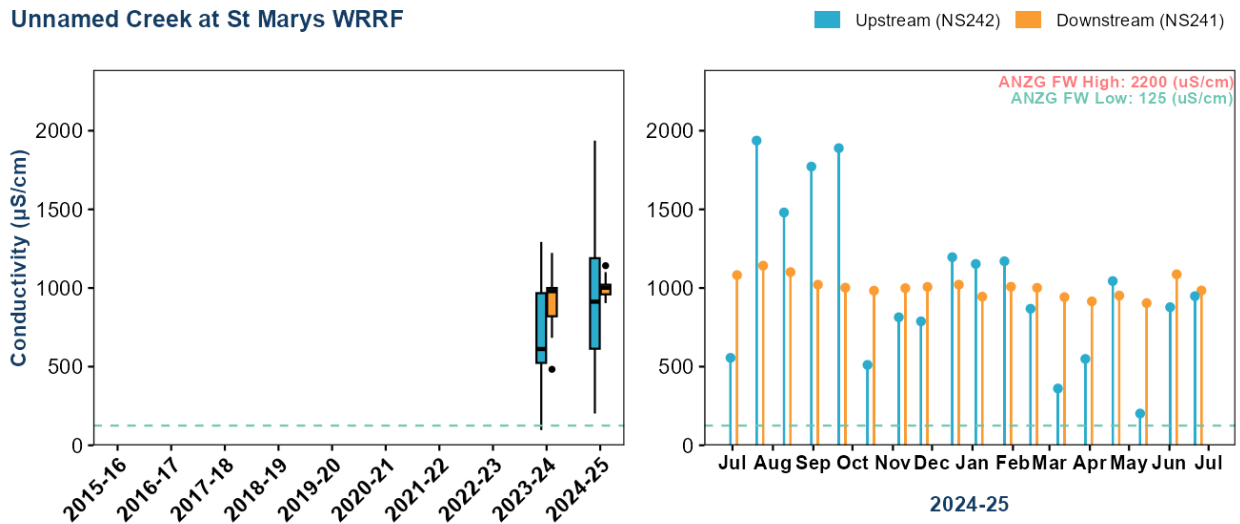


South Creek at St Marys WRRF

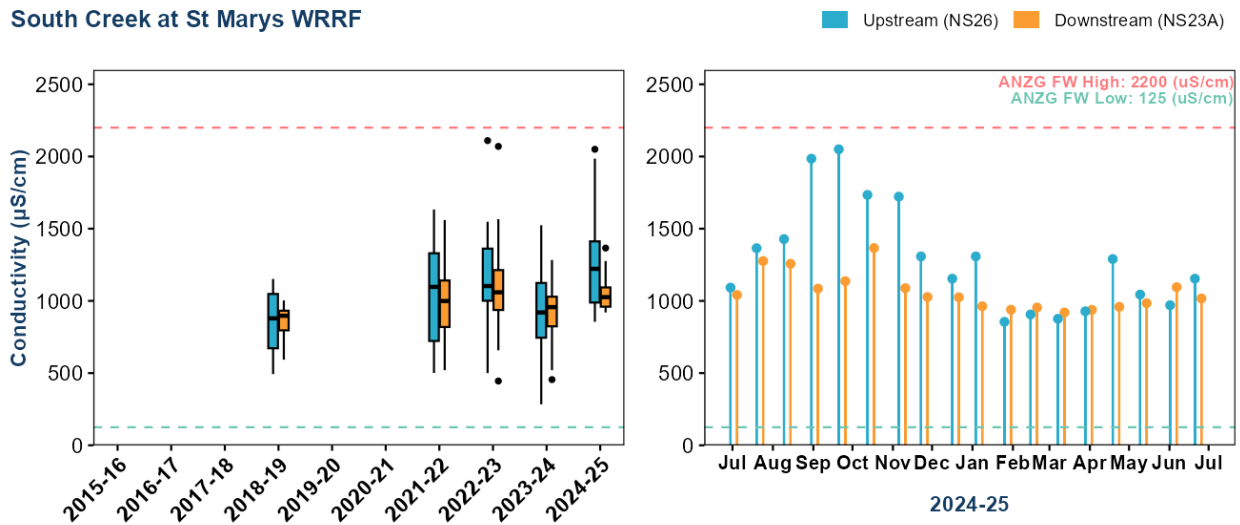


A.8.7. Stressor – Physico-chemical water quality

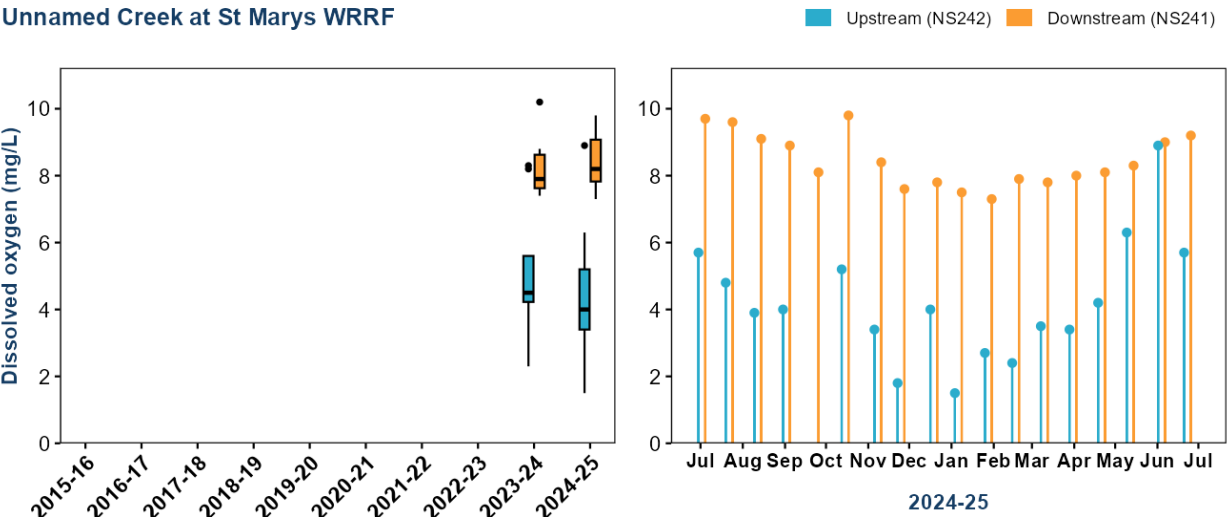
Unnamed Creek at St Marys WRRF



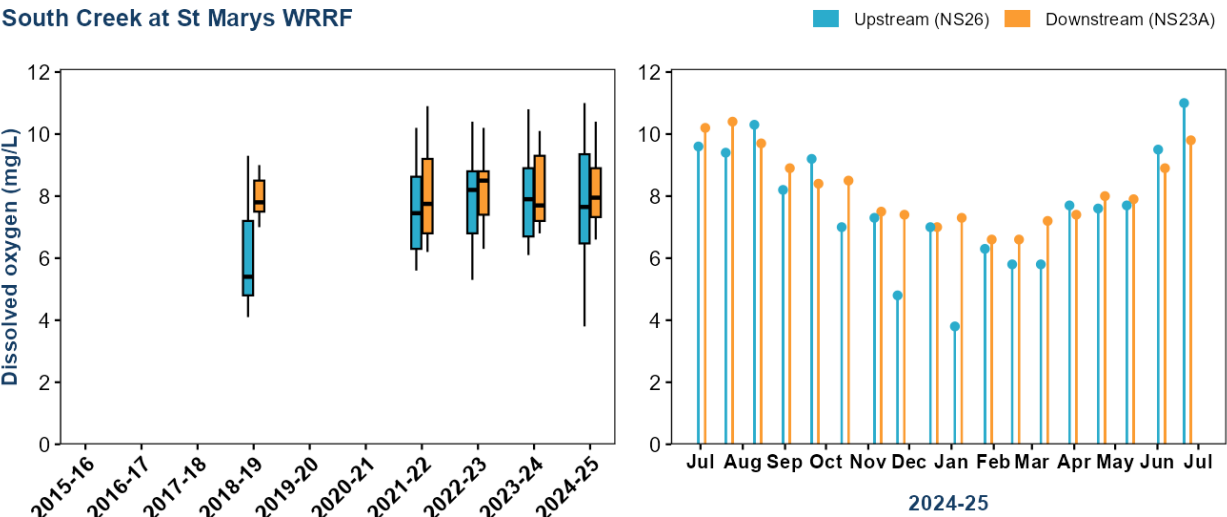
South Creek at St Marys WRRF



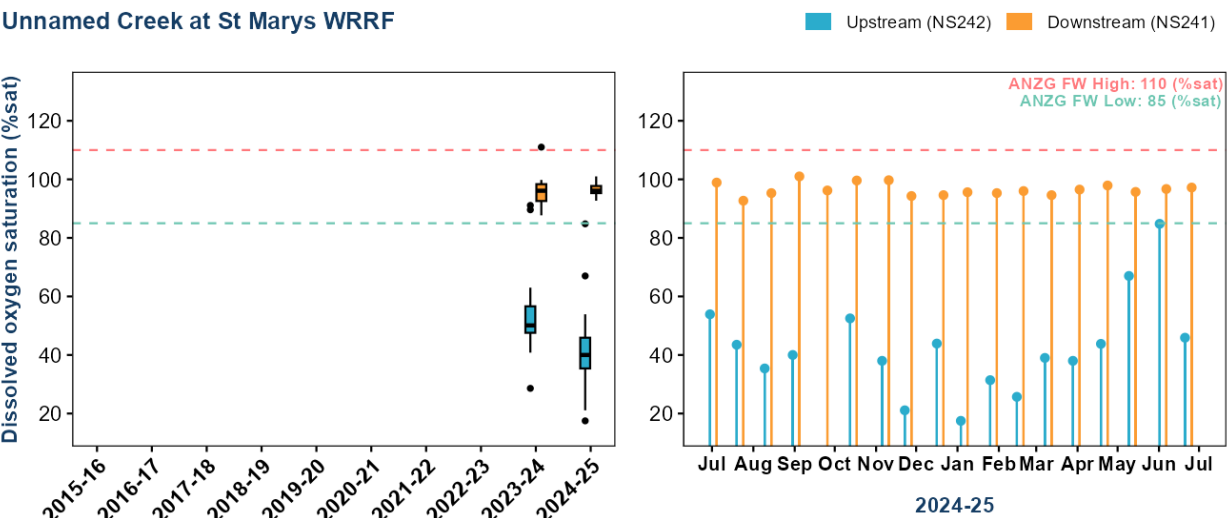
Unnamed Creek at St Marys WRRF



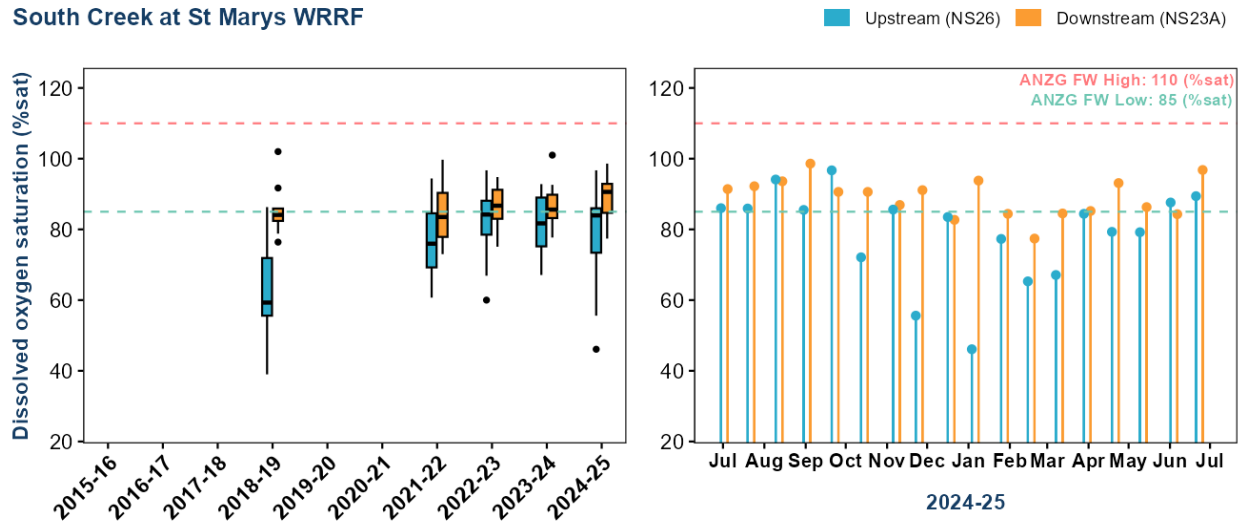
South Creek at St Marys WRRF



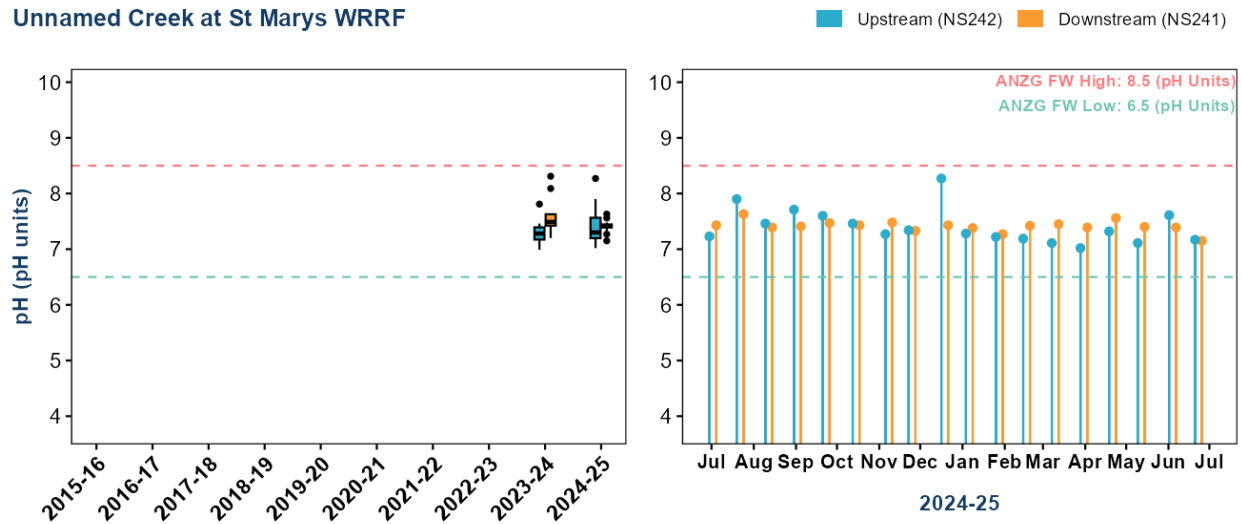
Unnamed Creek at St Marys WRRF



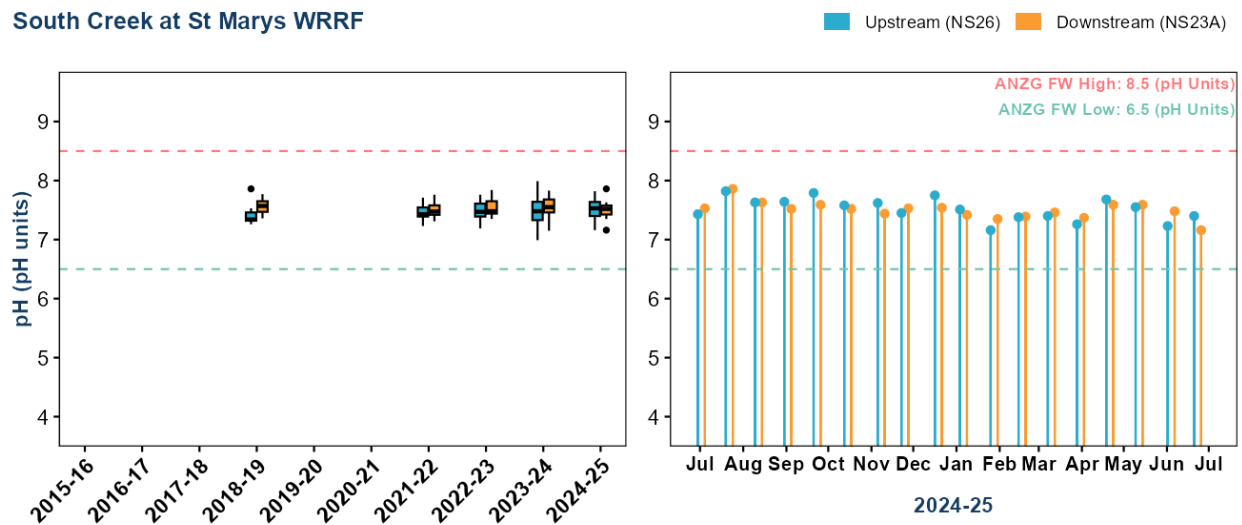
South Creek at St Marys WRRF



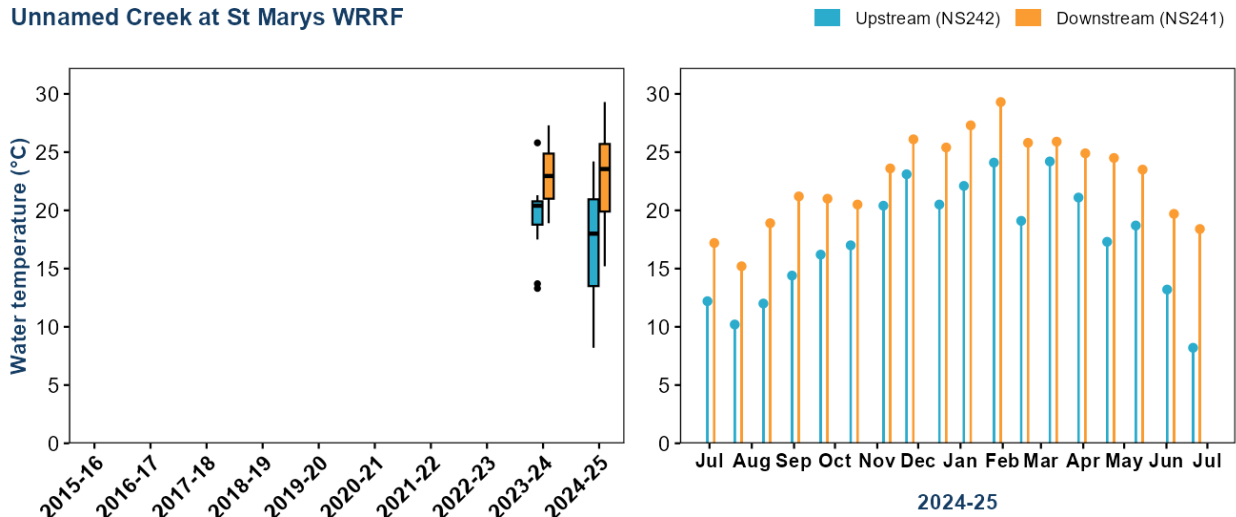
Unnamed Creek at St Marys WRRF



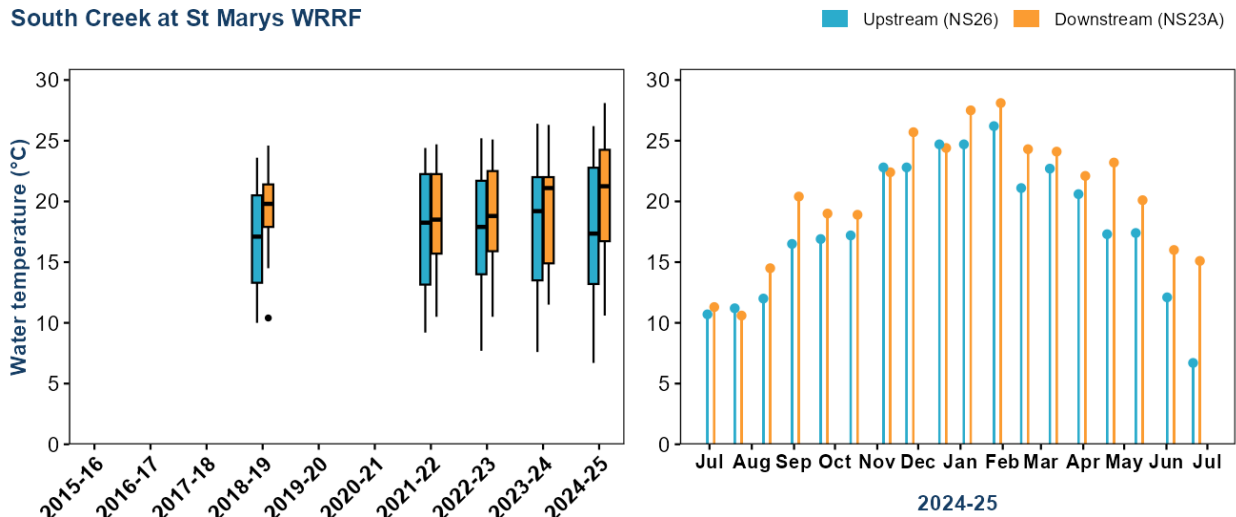
South Creek at St Marys WRRF



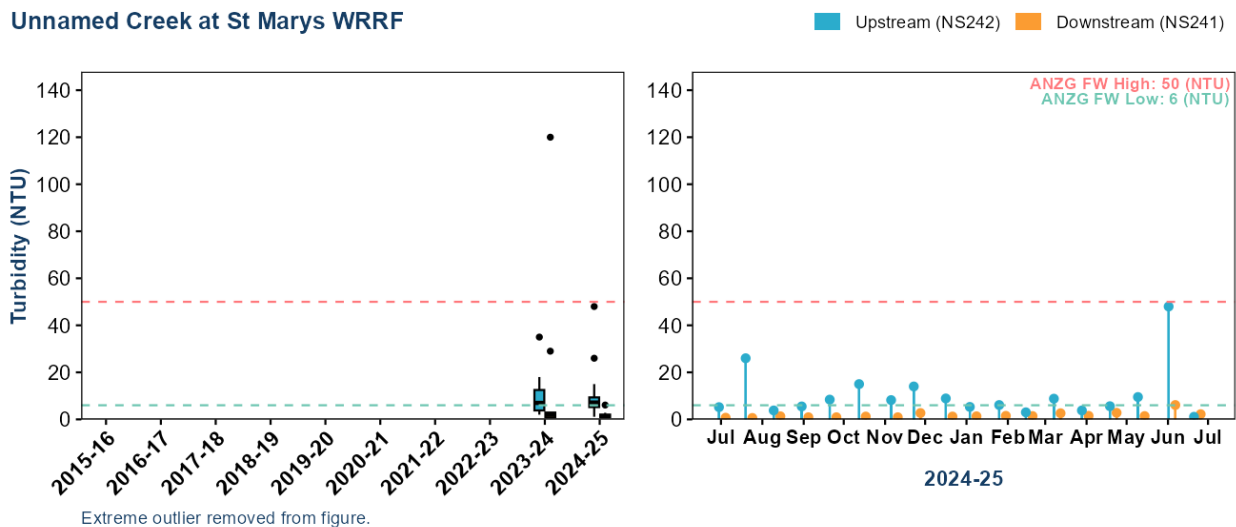
Unnamed Creek at St Marys WRRF



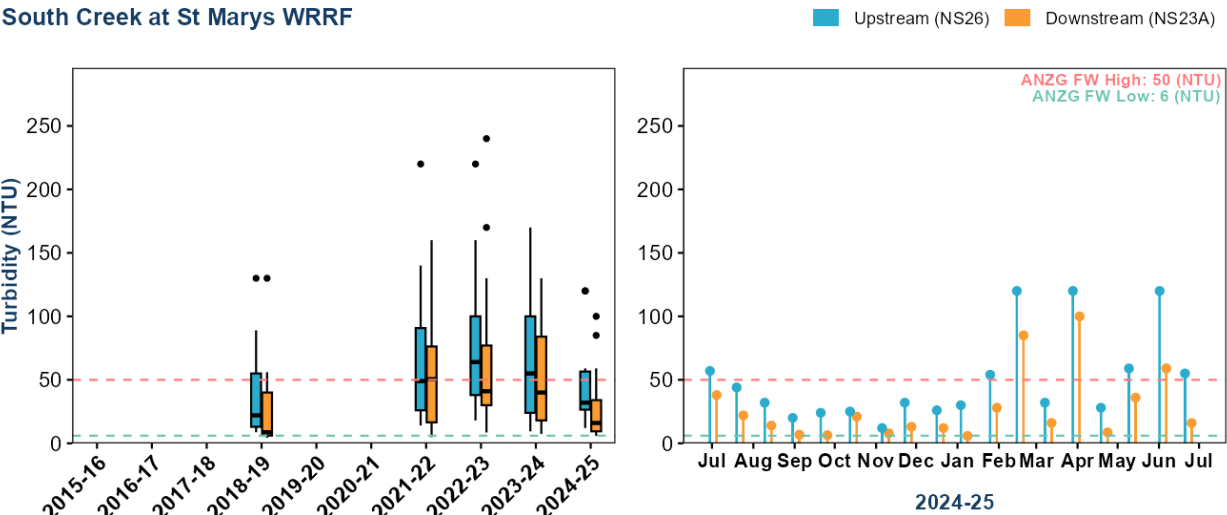
South Creek at St Marys WRRF



Unnamed Creek at St Marys WRRF

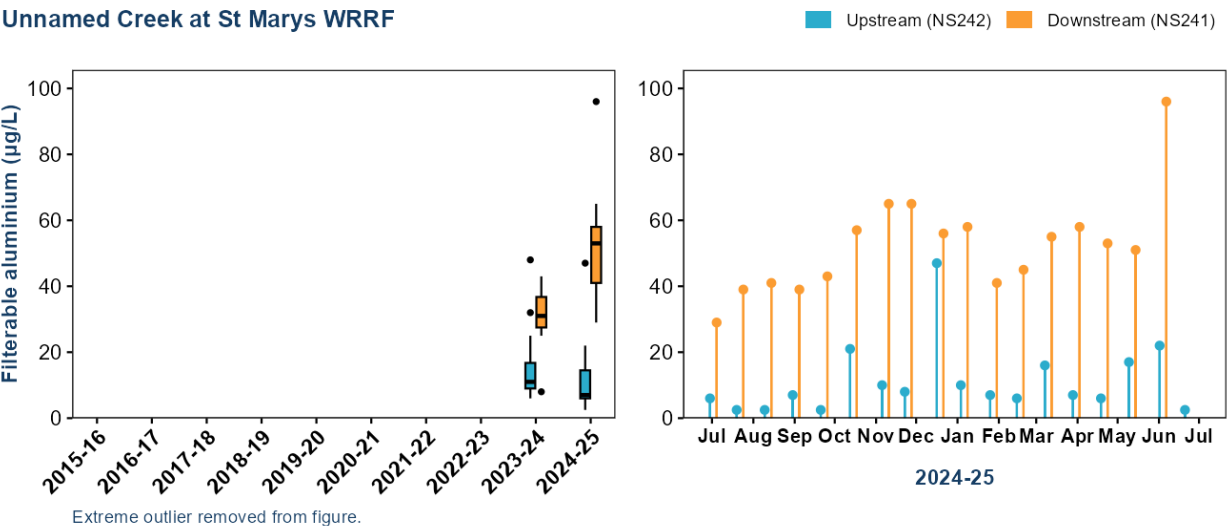


South Creek at St Marys WRRF

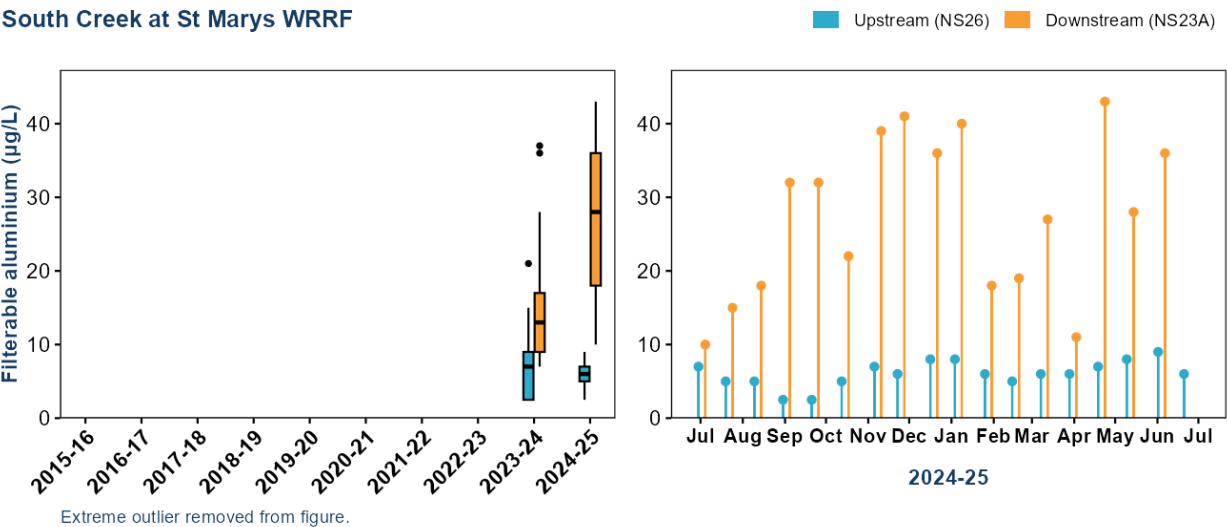


A.8.8. Stressor – Trace metals

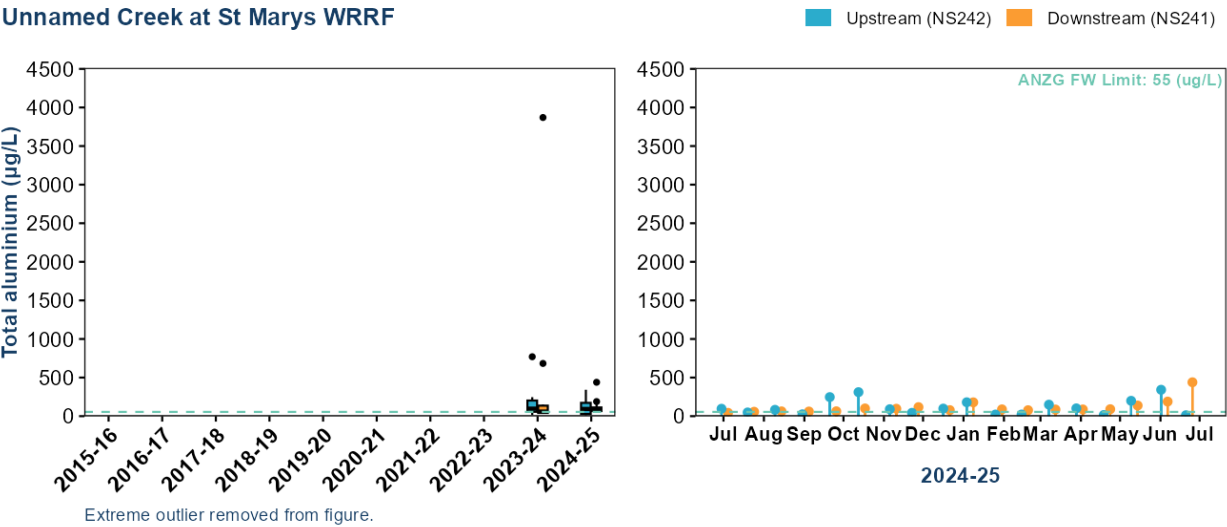
Unnamed Creek at St Marys WRRF



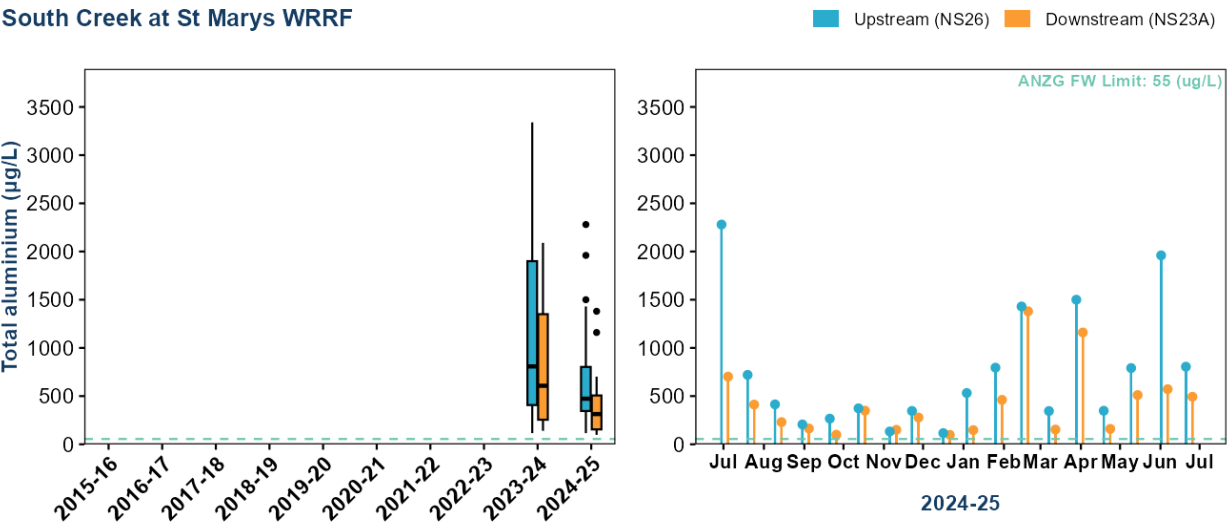
South Creek at St Marys WRRF



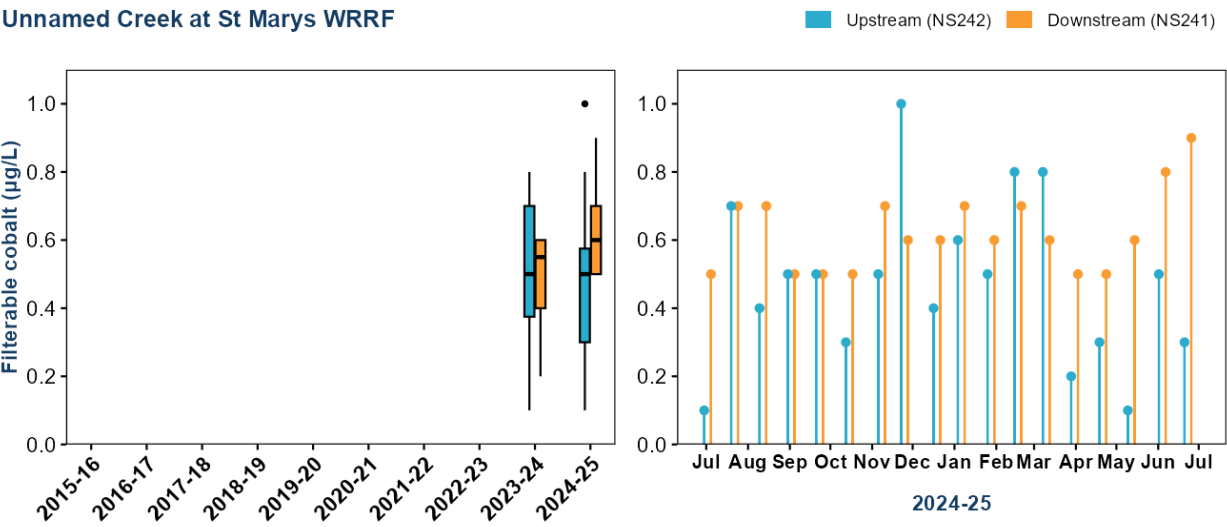
Unnamed Creek at St Marys WRRF



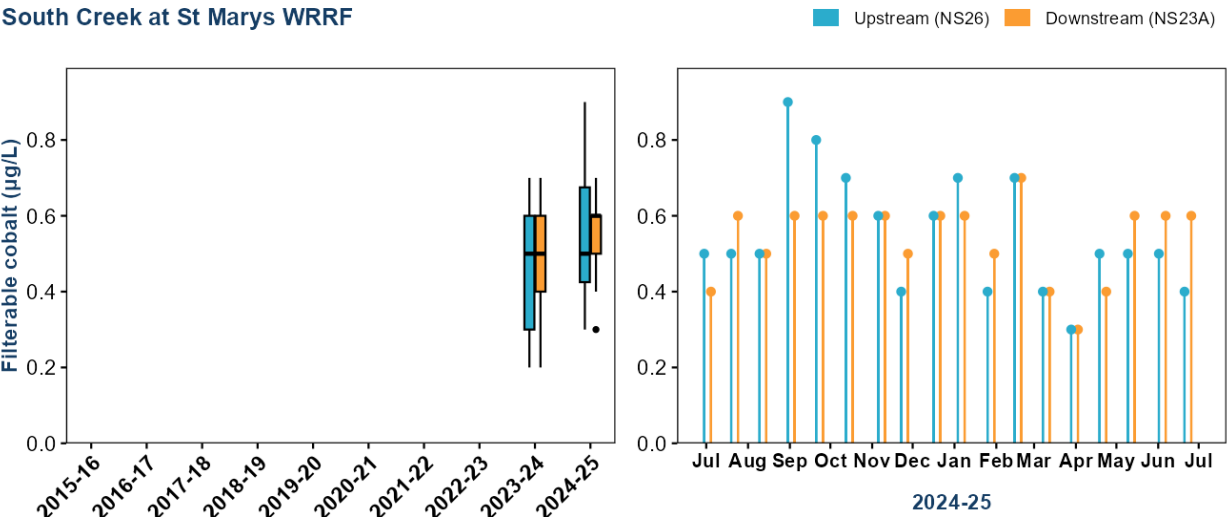
South Creek at St Marys WRRF



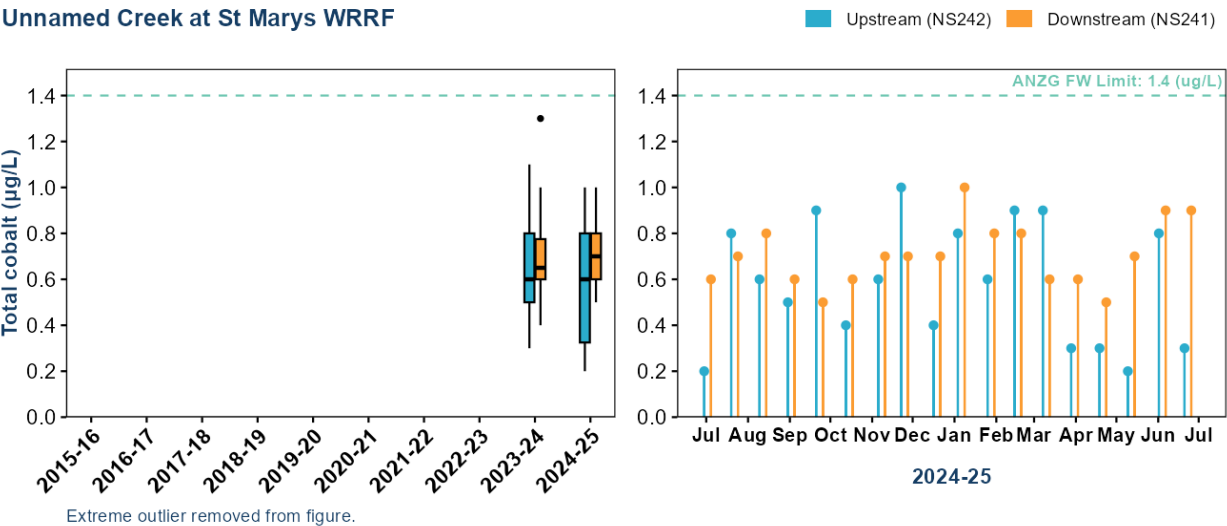
Unnamed Creek at St Marys WRRF



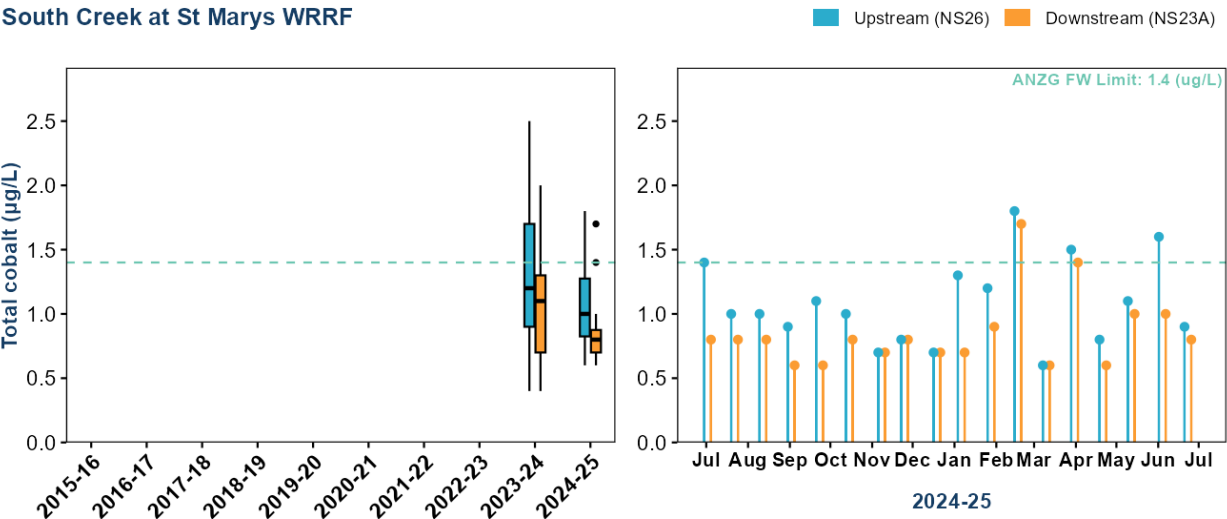
South Creek at St Marys WRRF



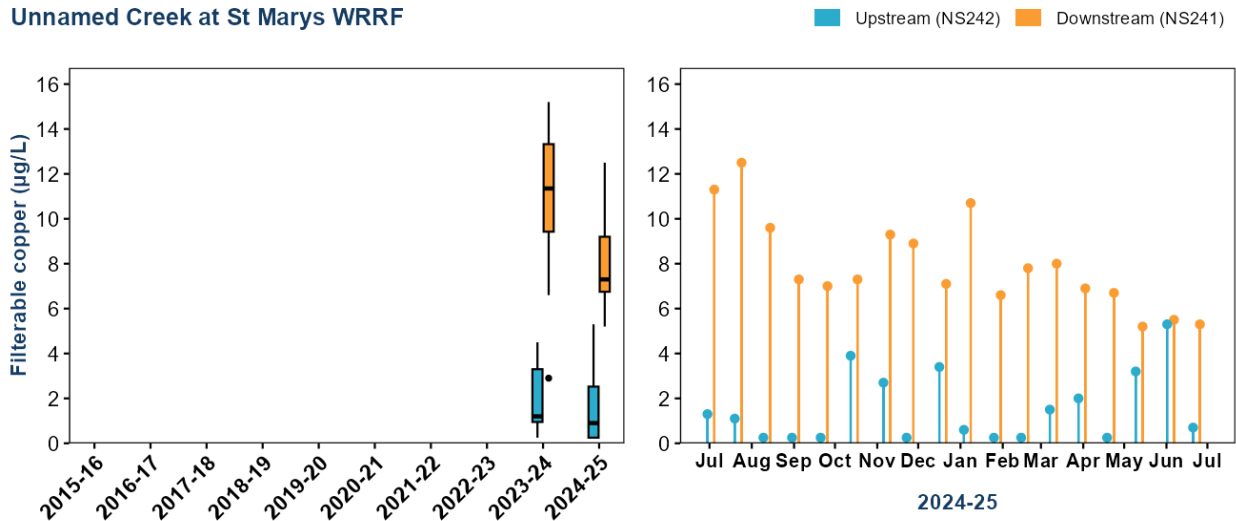
Unnamed Creek at St Marys WRRF



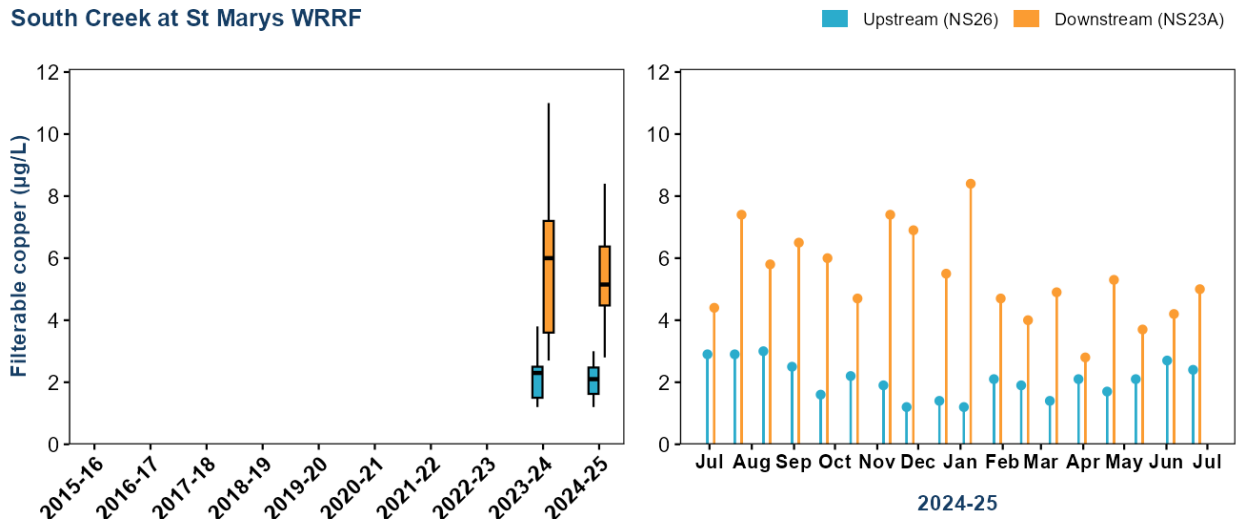
South Creek at St Marys WRRF



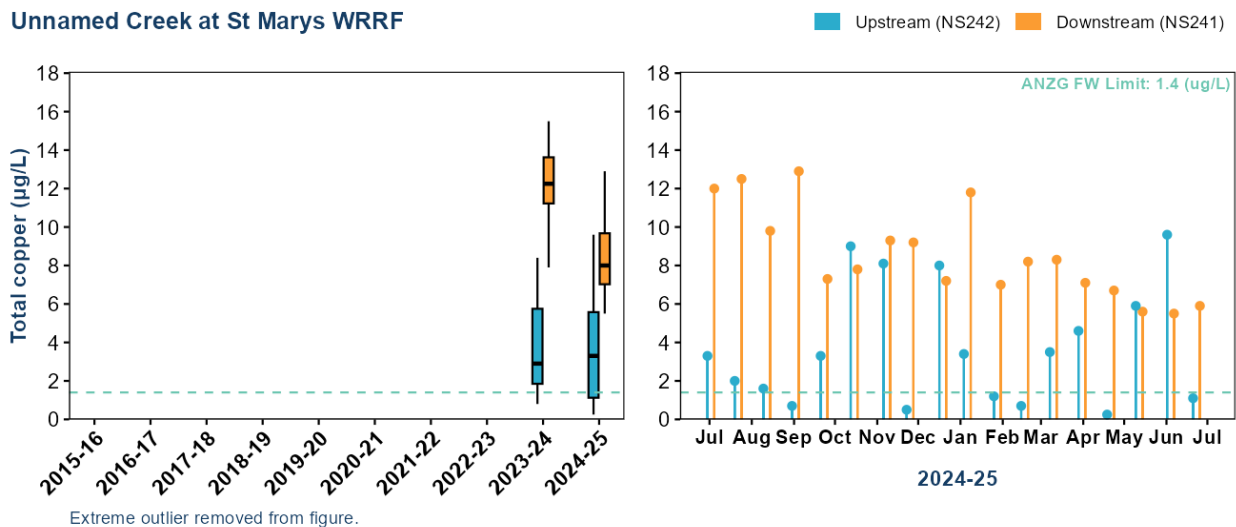
Unnamed Creek at St Marys WRRF



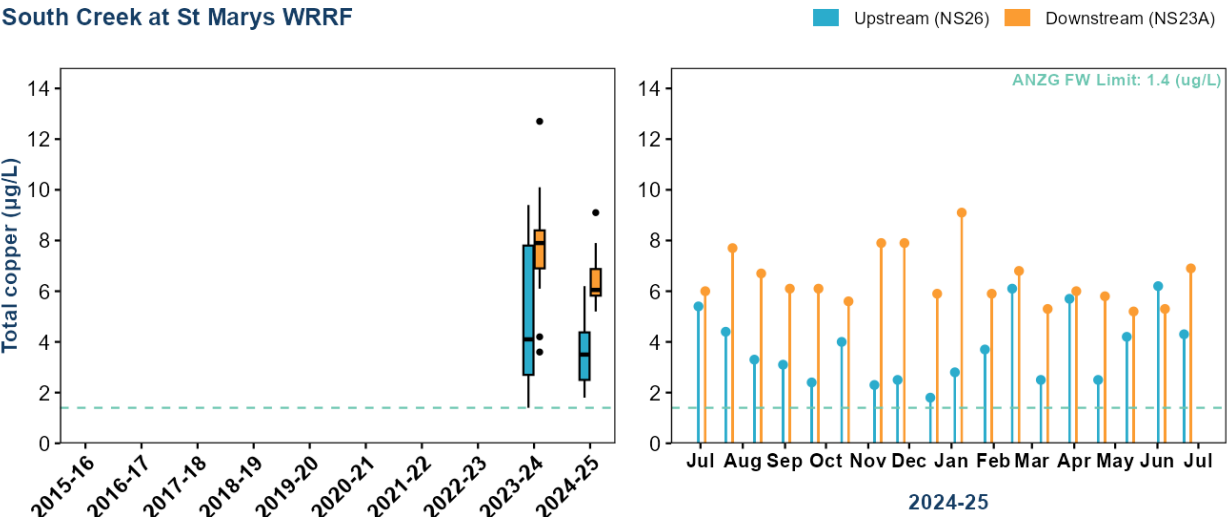
South Creek at St Marys WRRF



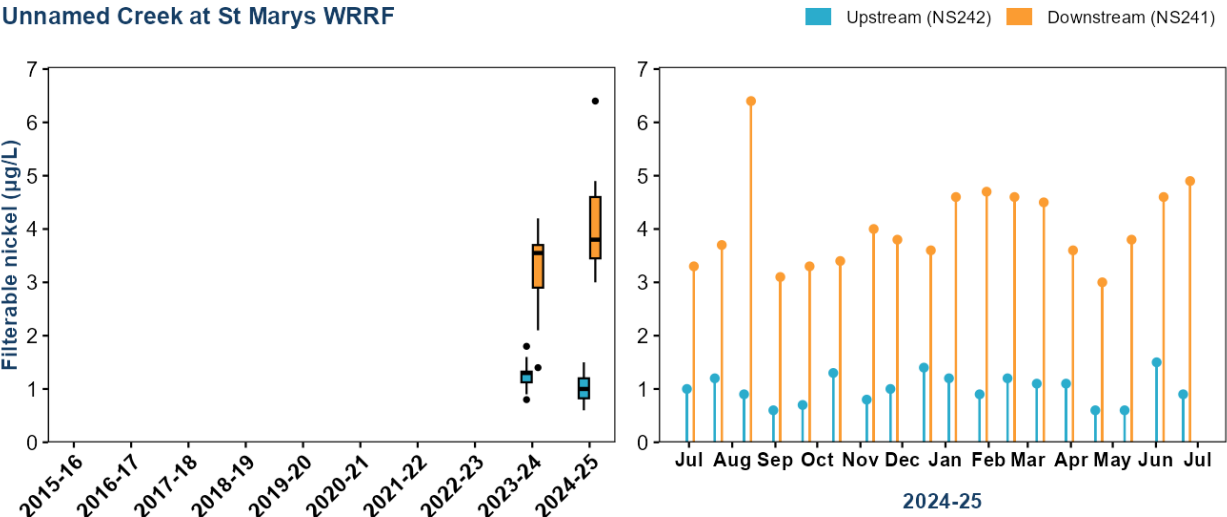
Unnamed Creek at St Marys WRRF



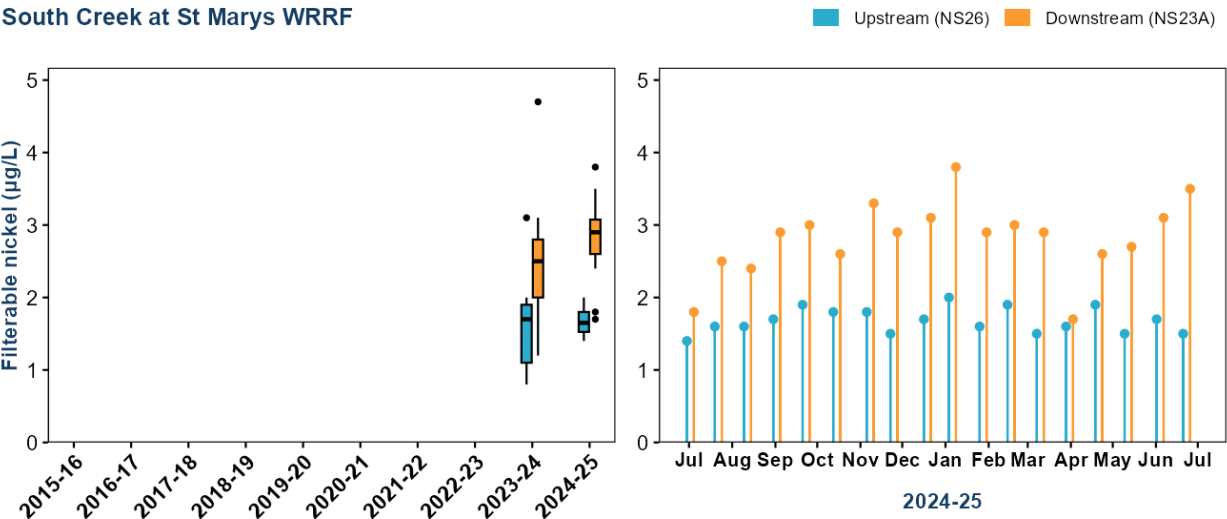
South Creek at St Marys WRRF



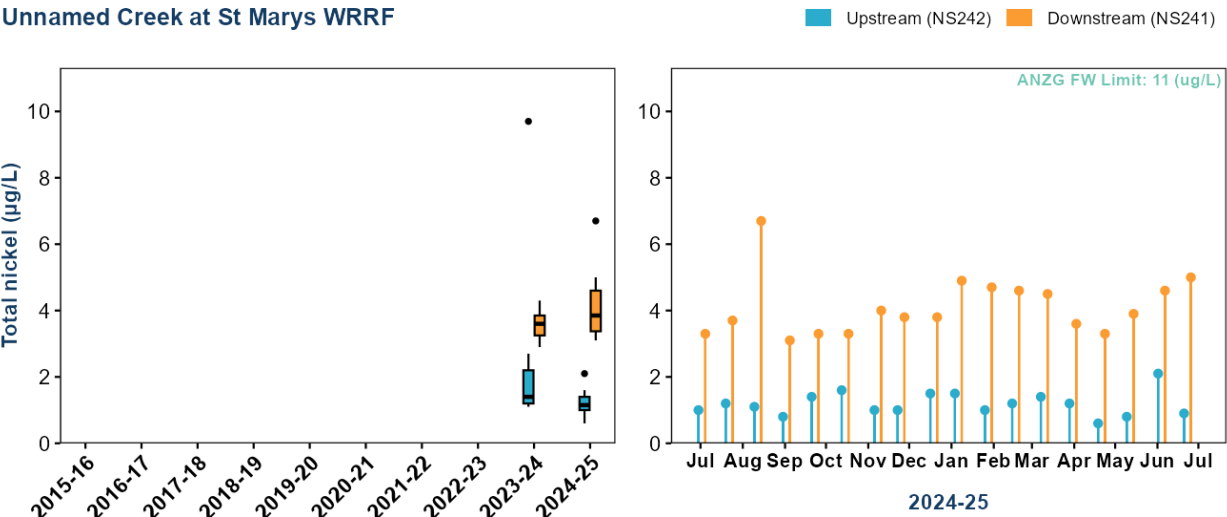
Unnamed Creek at St Marys WRRF



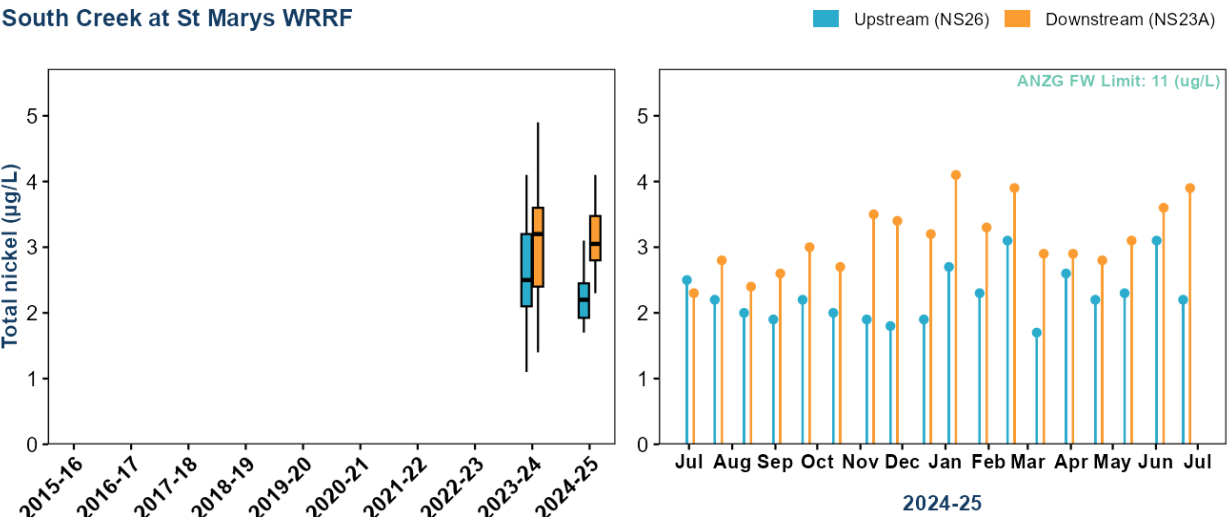
South Creek at St Marys WRRF



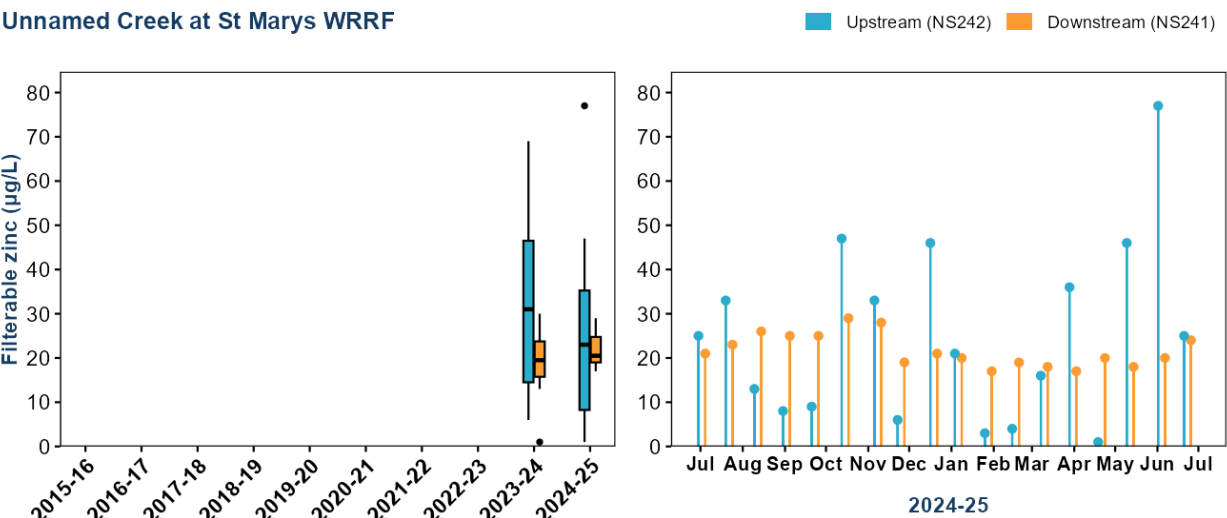
Unnamed Creek at St Marys WRRF



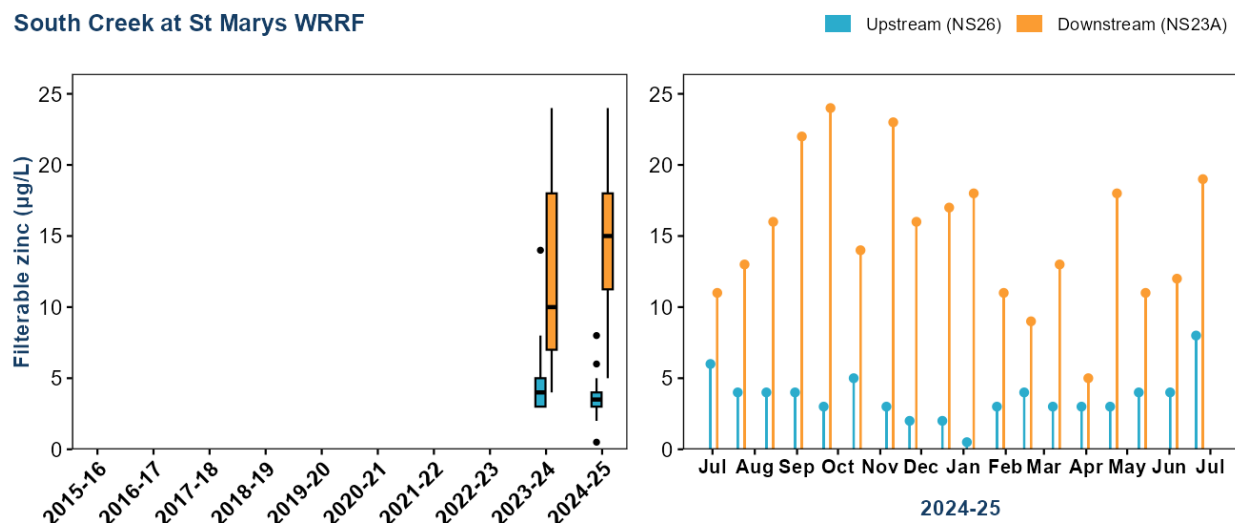
South Creek at St Marys WRRF



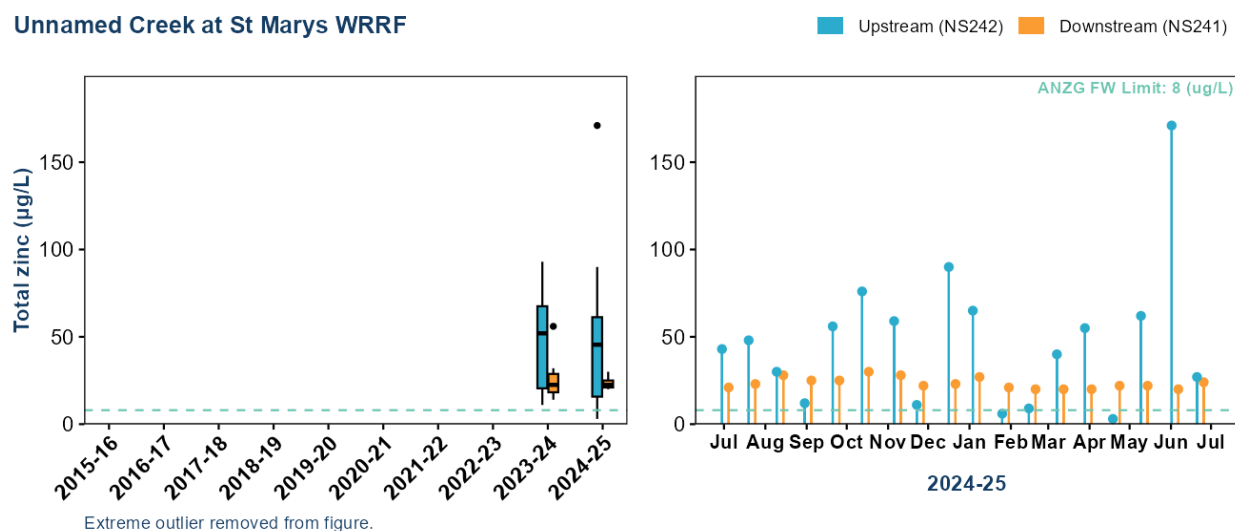
Unnamed Creek at St Marys WRRF



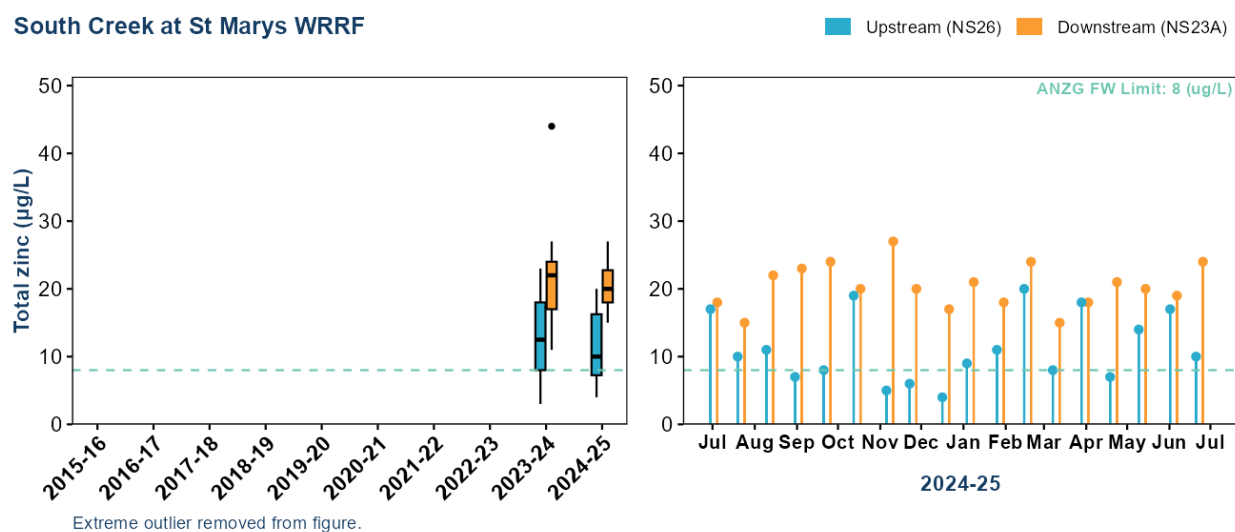
South Creek at St Marys WRRF



Unnamed Creek at St Marys WRRF



South Creek at St Marys WRRF



A.8.9. Ecosystem receptor – Statistical analysis outcomes

Table A-92 Upstream vs downstream comparison (2024-25 reporting period) for the unnamed creek at St Marys WRRF

Unnamed Creek at St Marys WRRF: NS242 vs NS241 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.37	0.10	54	-3.62	0.003
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-93 Upstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at St Marys WRRF

Unnamed Creek at St Marys WRRF: NS242 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.20	0.36	54	0.59	0.934
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-94 Downstream current period (2024-25) vs previous period comparison (single site) for the unnamed creek at St Marys WRRF

Unnamed Creek at St Marys WRRF: NS241 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.72	0.23	54	-1.04	0.727
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-95 Upstream vs downstream comparison (2024-25 reporting period) for South Creek at St Marys WRRF

South Creek at St Marys WRRF: NS26 vs NS23A (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.42	0.14	156	-2.58	0.053
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-96 Upstream current period (2024-25) vs previous period comparison (single site) for South Creek at St Marys WRRF

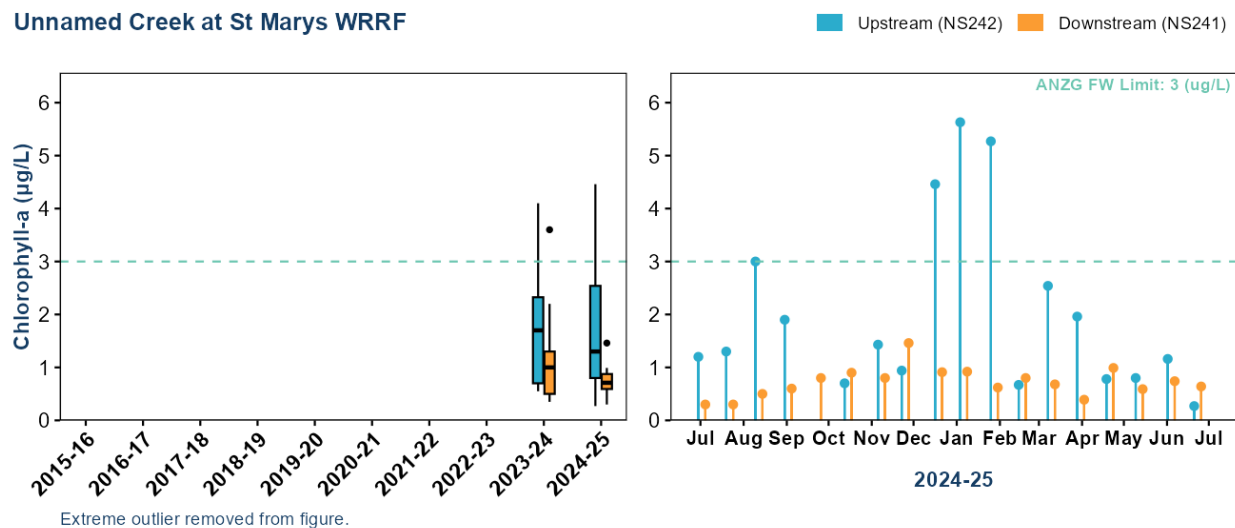
South Creek at St Marys WRRF: NS26 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.99	0.27	156	-0.05	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-97 Downstream current period (2024-25) vs previous period comparison (single site) for South Creek at St Marys WRRF

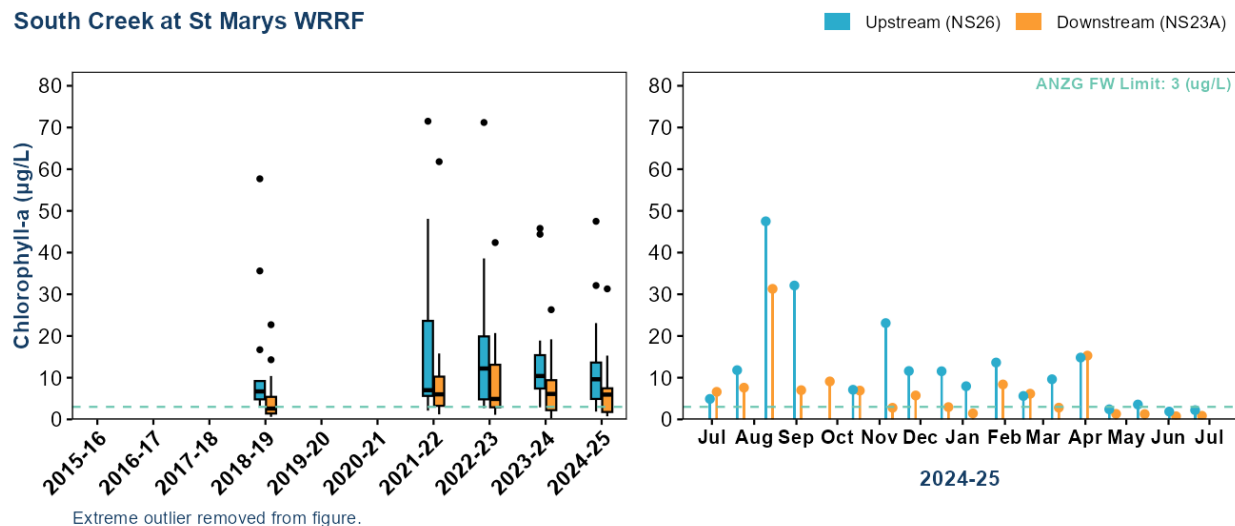
South Creek at St Marys WRRF: NS23A (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.87	0.23	156	-0.53	0.951
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.8.10. Ecosystem receptor – Phytoplankton

Unnamed Creek at St Marys WRRF



South Creek at St Marys WRRF

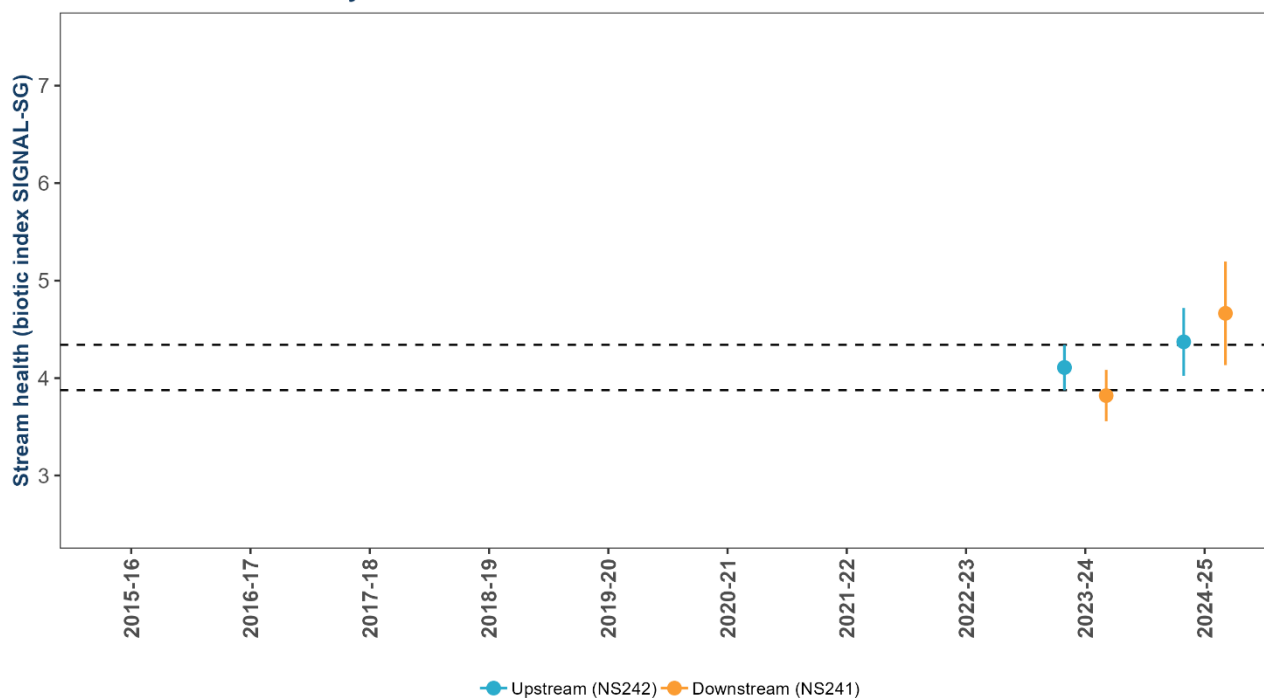


A.8.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Unnamed Creek	Tributary (NS242 vs NS241)	Welch Two Sample t-test	-0.29	-1.30	12.1	0.217
South Creek	River (NS26 vs NS23)	Welch Two Sample t-test	-1.23	-5.96	9.7	<0.001

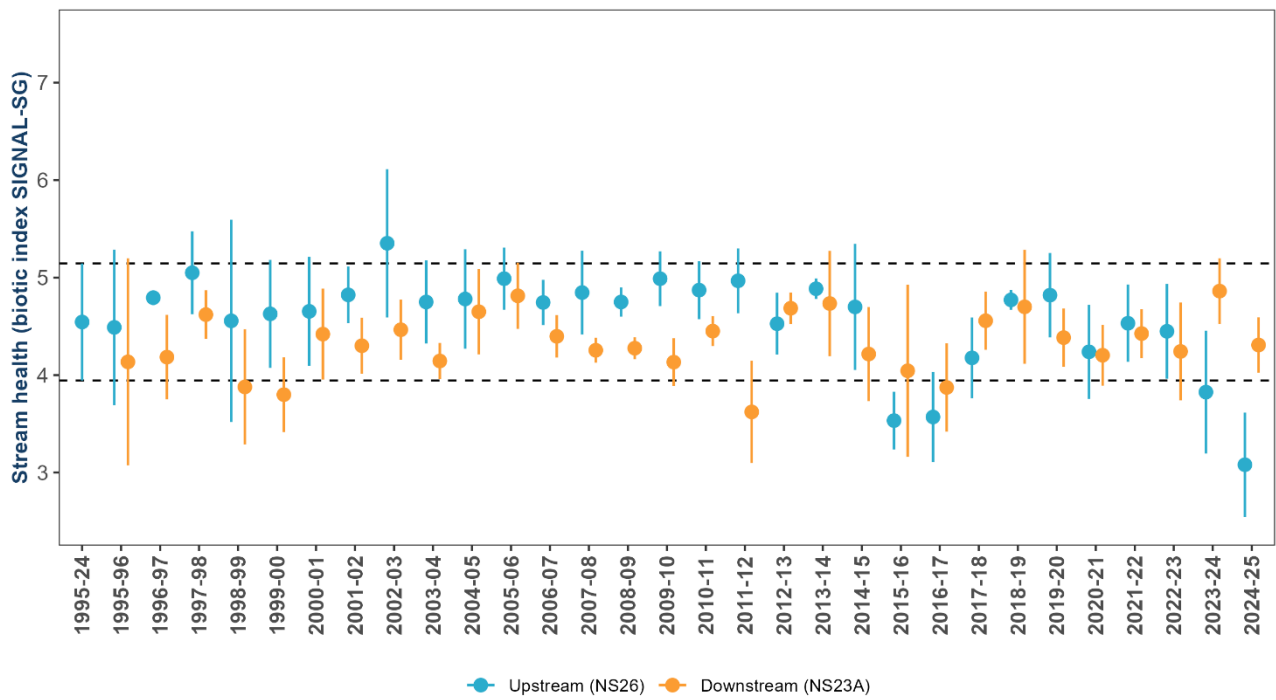
	not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Unnamed Creek at St Marys WRRF



The range of stream health recorded over each period is represented by length of line

South Creek at St Marys WRRF

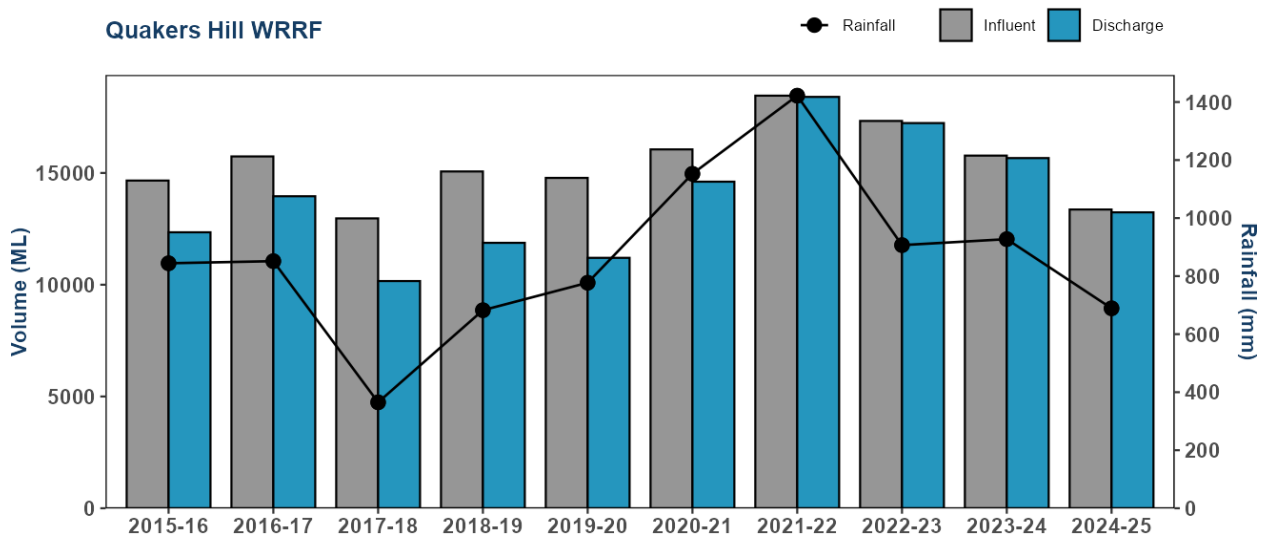


The range of stream health recorded over each period is represented by length of line

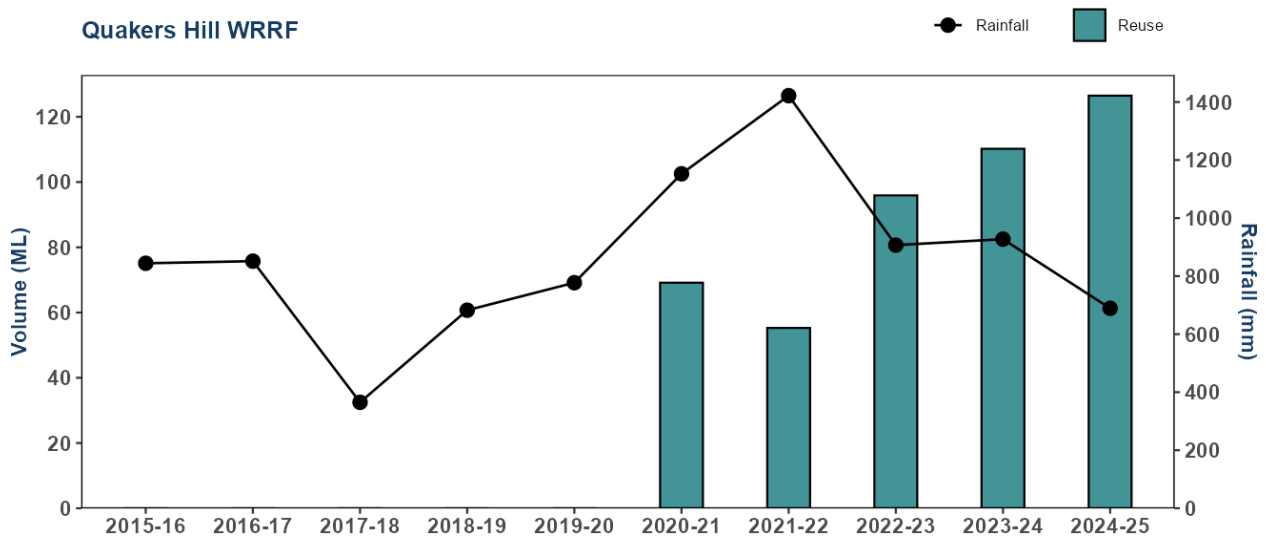
A.9. Quakers Hill WRRF

A.9.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



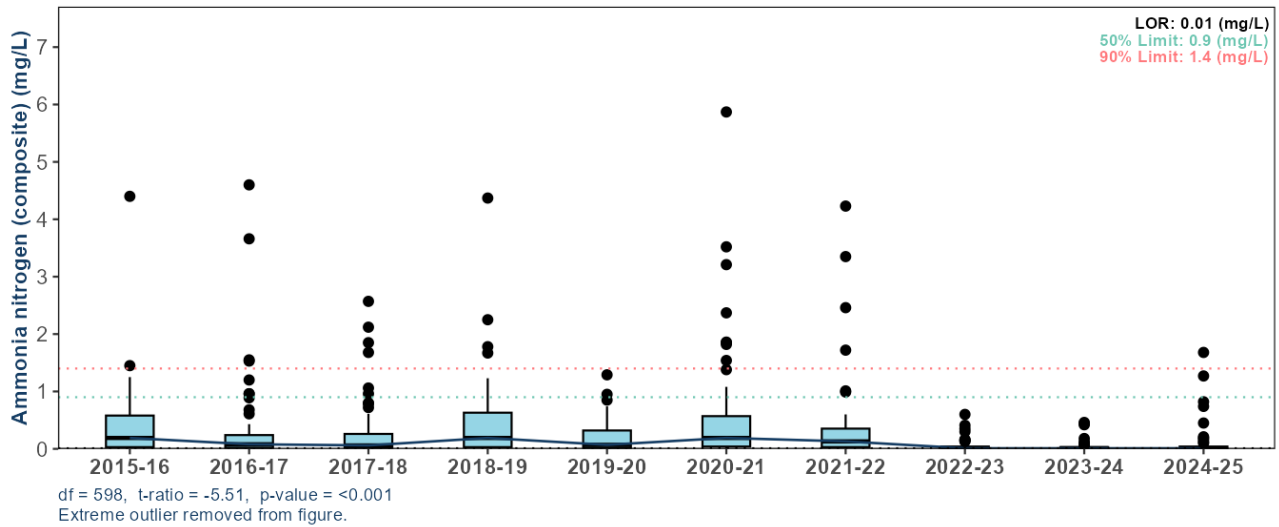
Reuse volume and rainfall



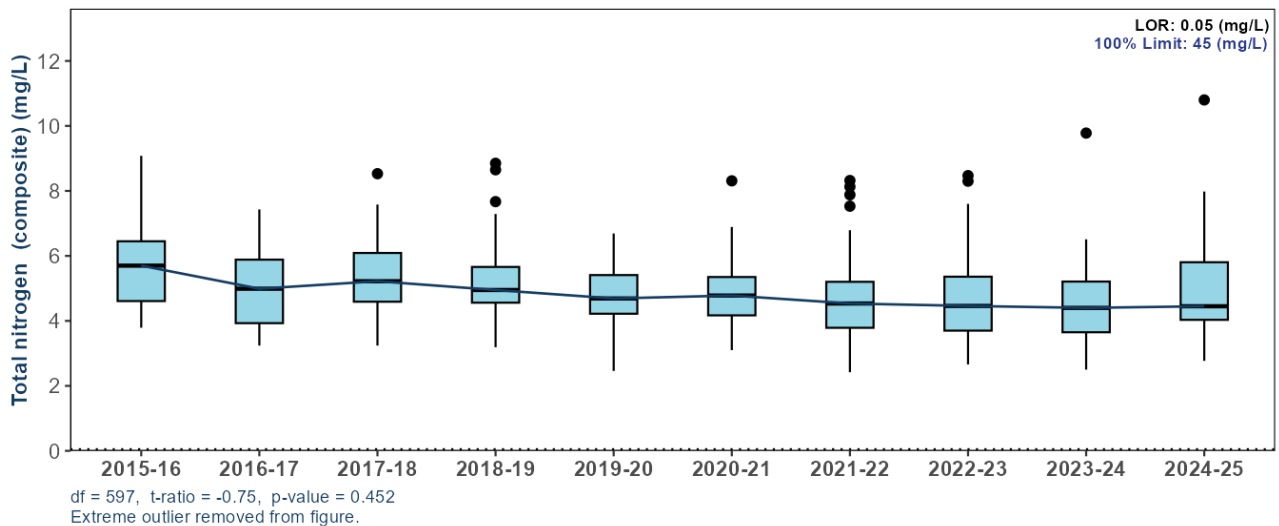
A.9.2. Pressure - Wastewater quality

Nutrients

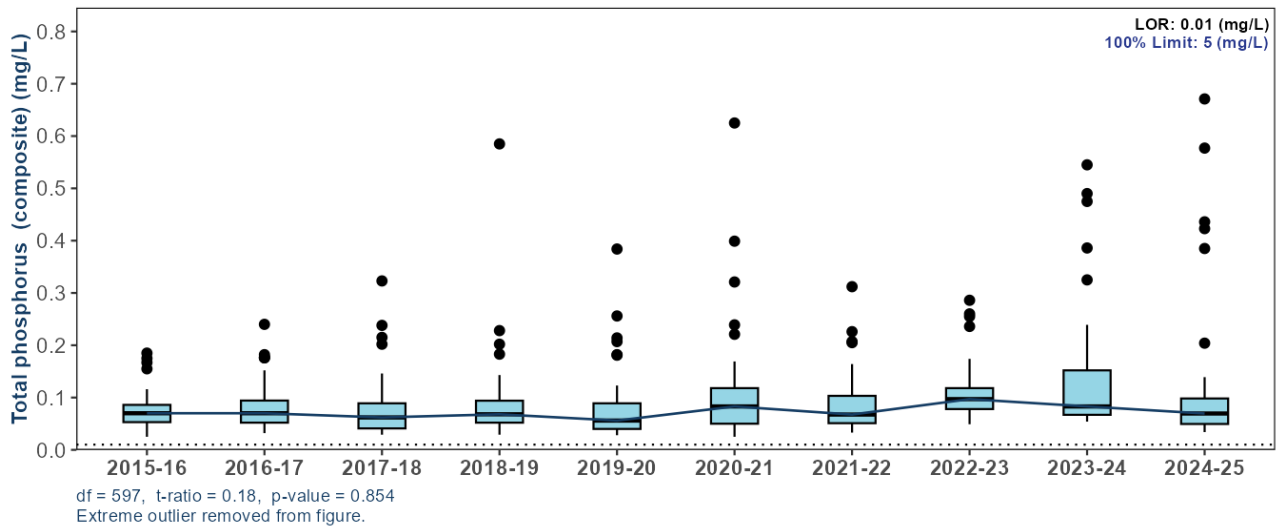
QH0004 at Quakers Hill WRRF



QH0004 at Quakers Hill WRRF

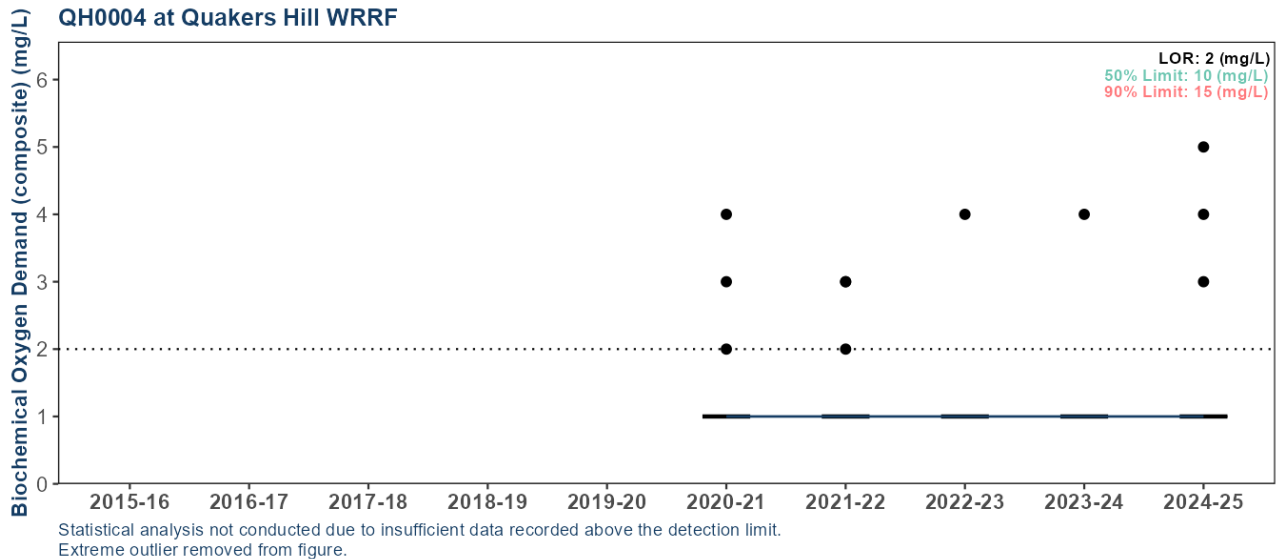


QH0004 at Quakers Hill WRRF

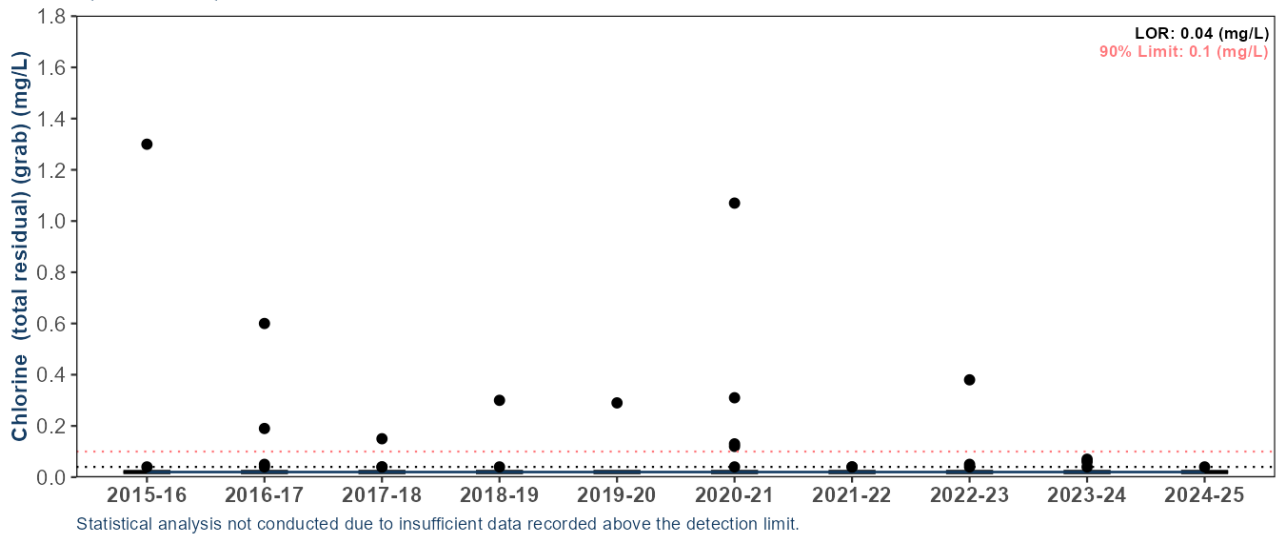


Major conventional analytes

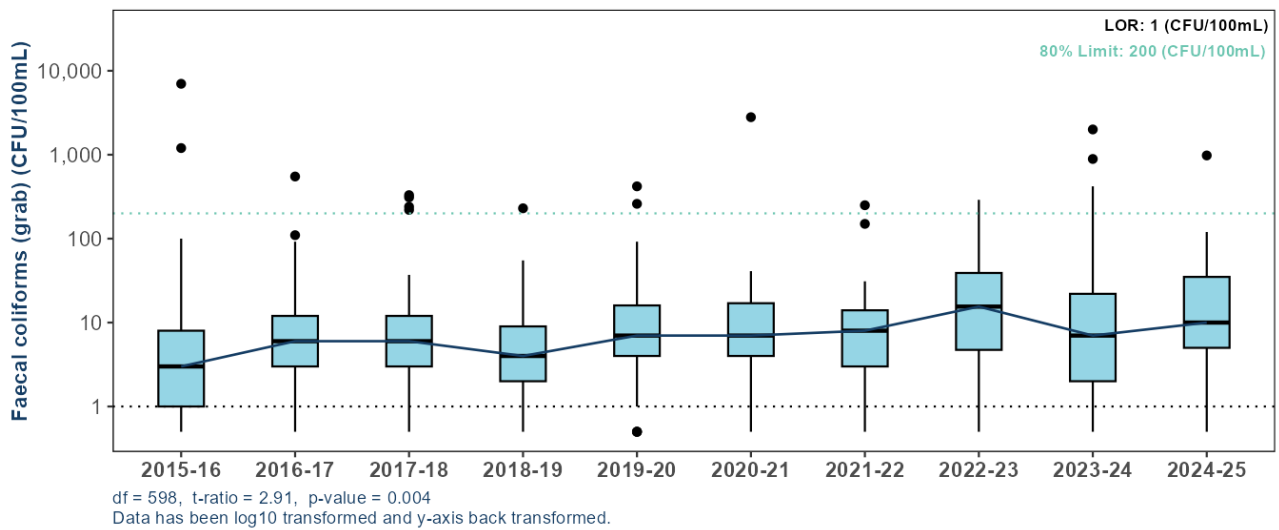
QH0004 at Quakers Hill WRRF



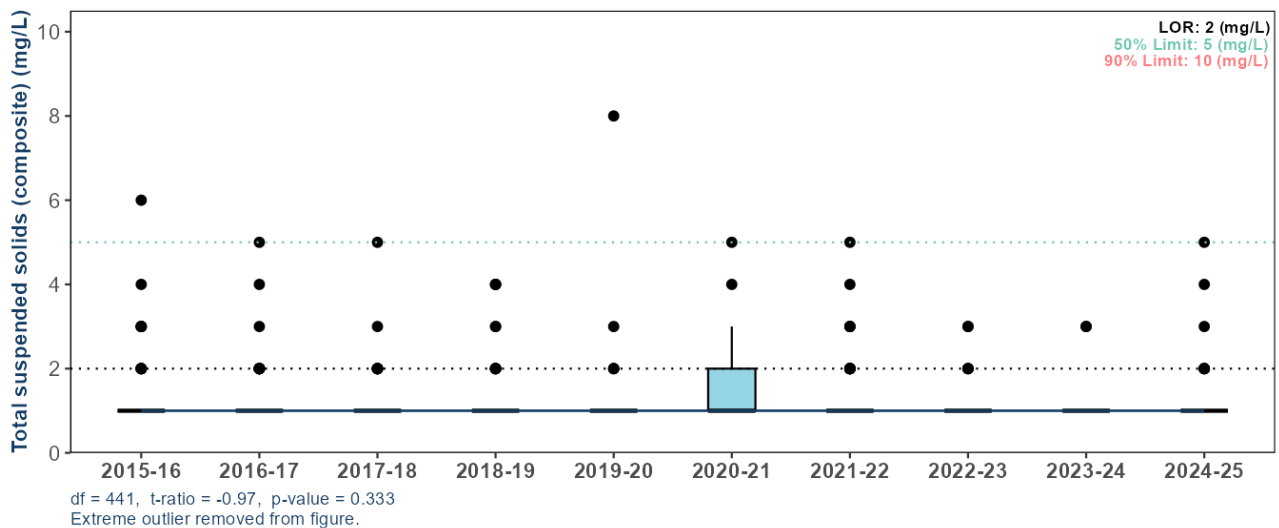
QH0005 at Quakers Hill WRRF



QH0005 at Quakers Hill WRRF

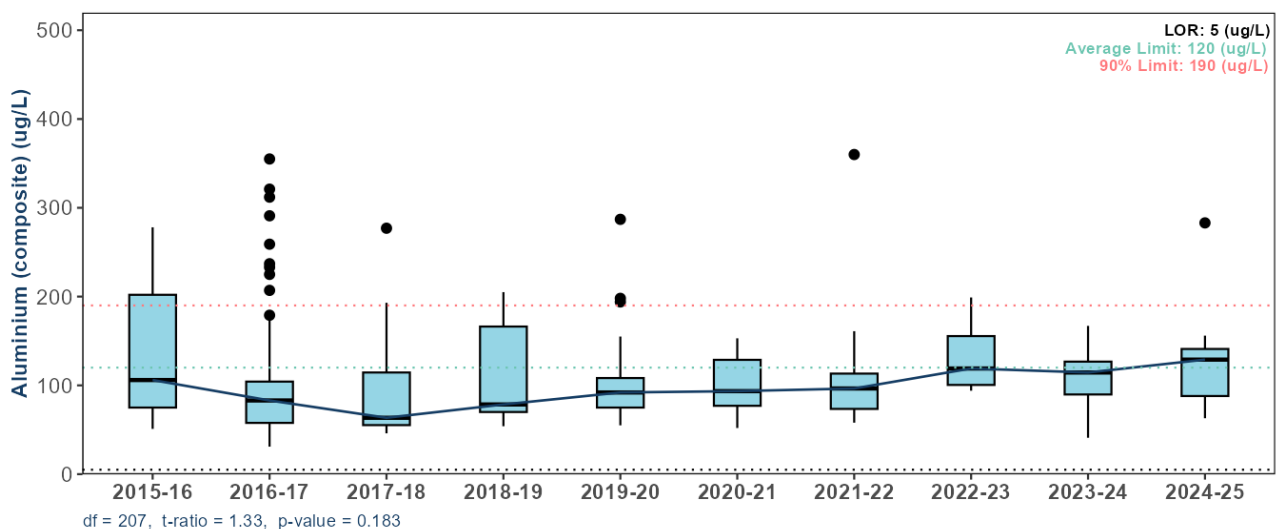


QH0004 at Quakers Hill WRRF

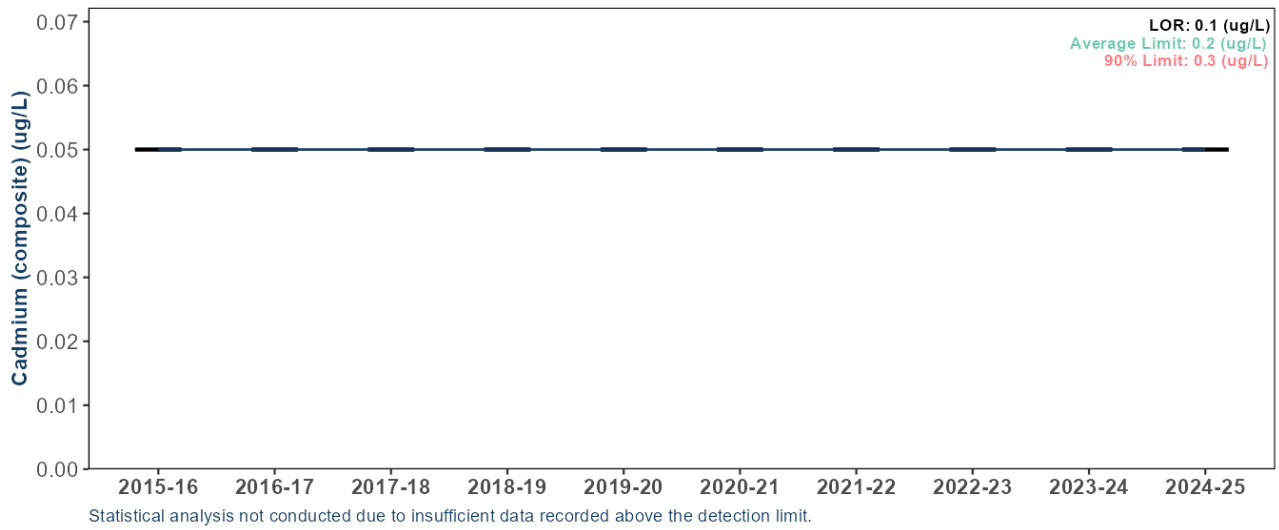


Trace metals

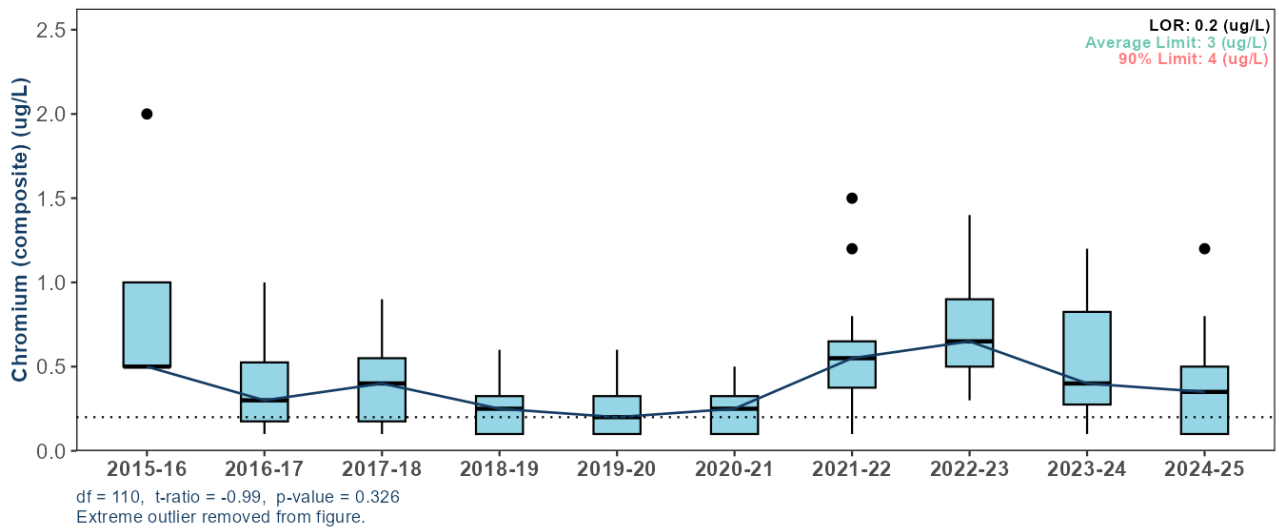
QH0004 at Quakers Hill WRRF



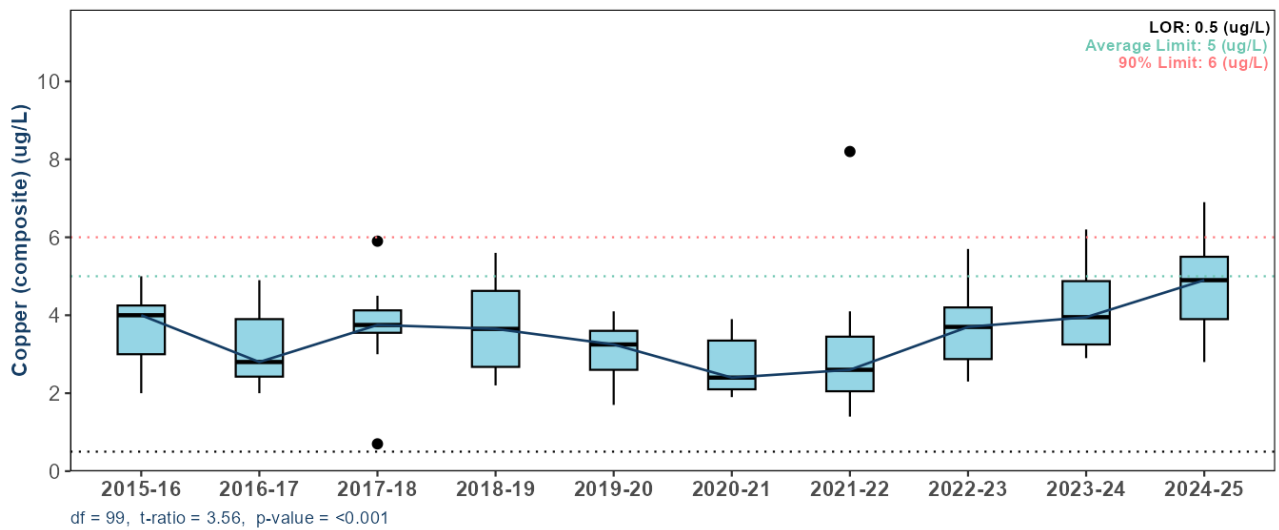
QH0004 at Quakers Hill WRRF



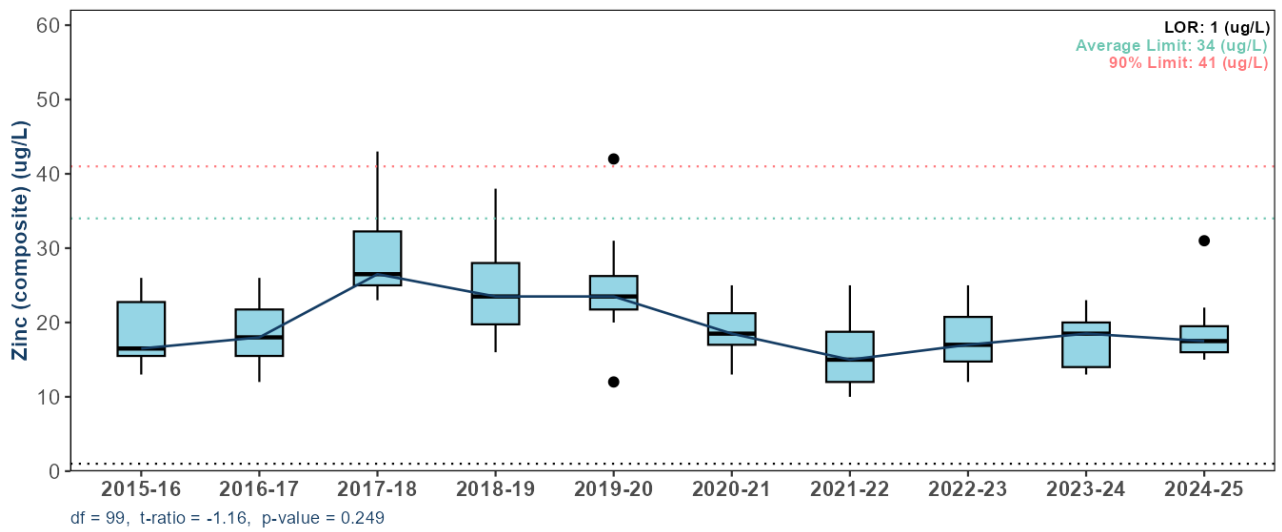
QH0004 at Quakers Hill WRRF



QH0004 at Quakers Hill WRRF

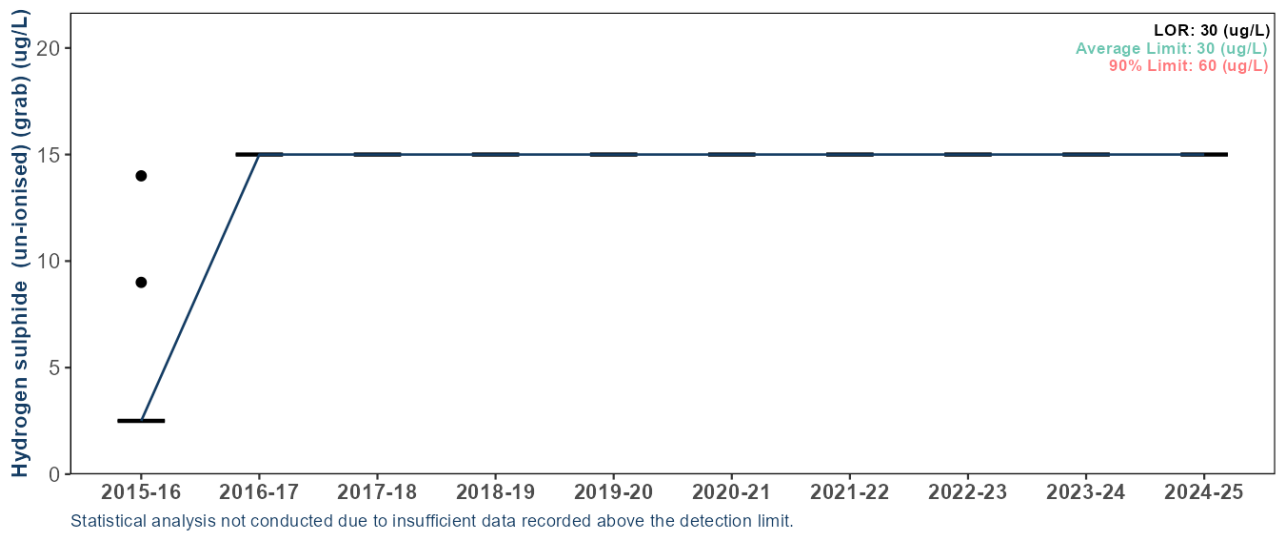


QH0004 at Quakers Hill WRRF



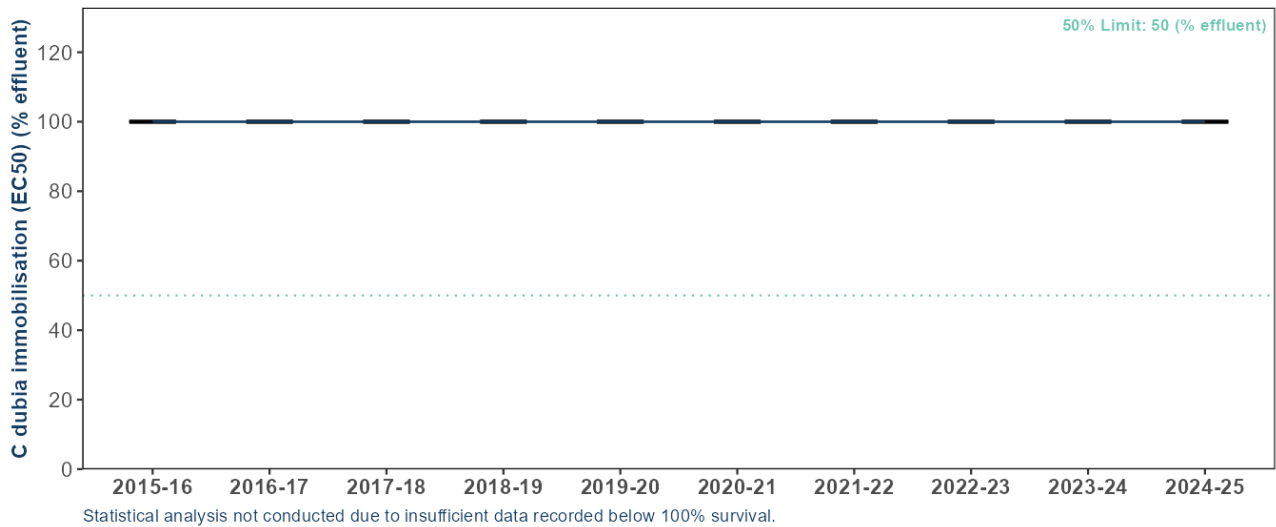
Other chemicals and organics (including pesticides)

QH0005 at Quakers Hill WRRF



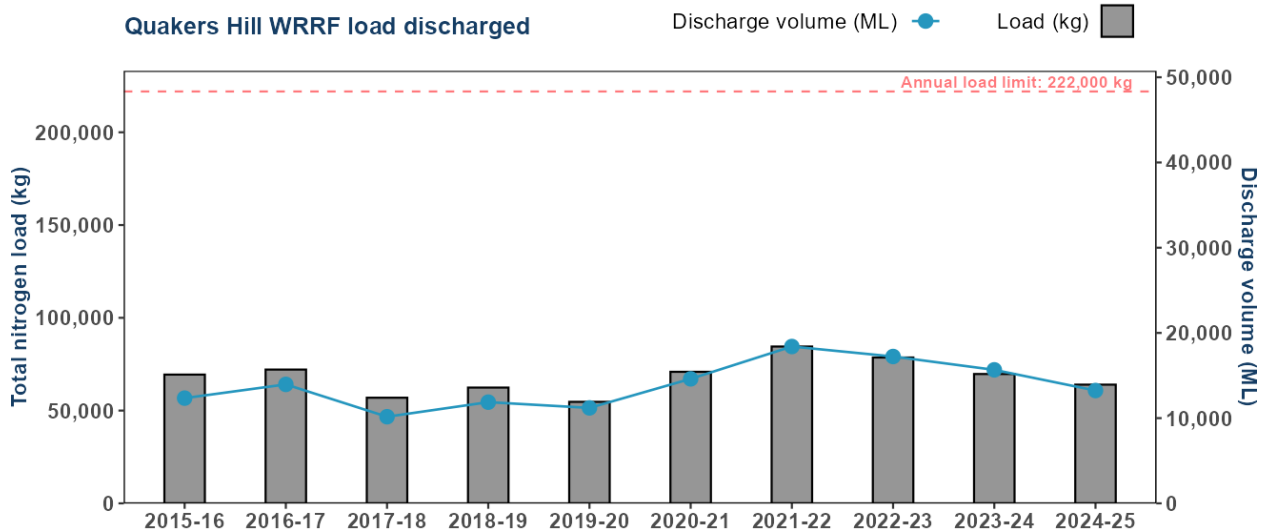
A.9.3. Pressure - Wastewater toxicity

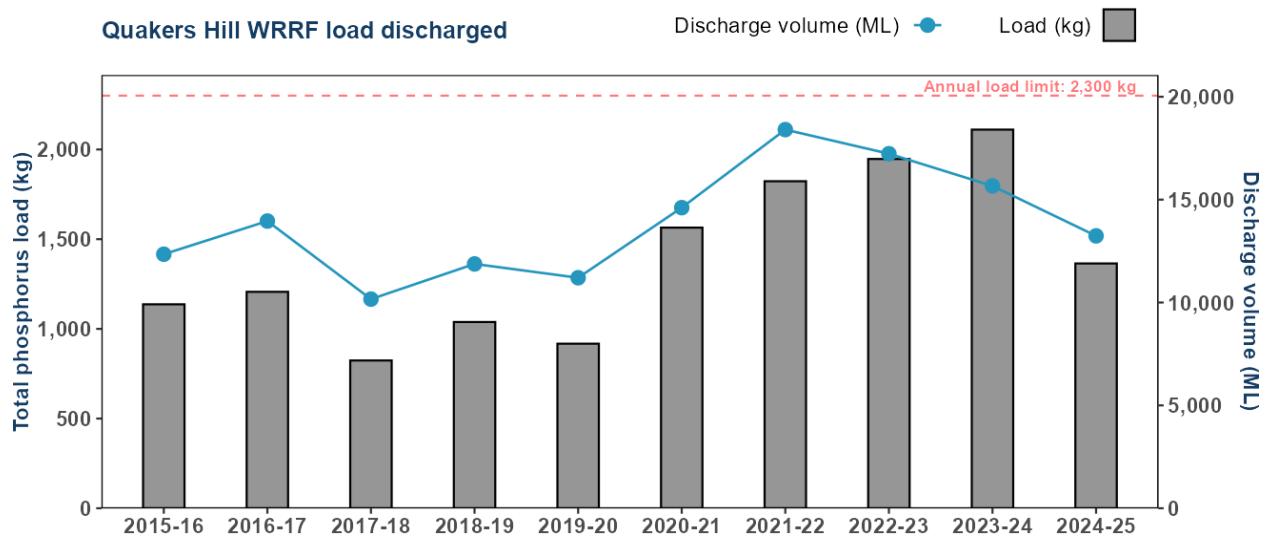
QH0005 at Quakers Hill WRRF



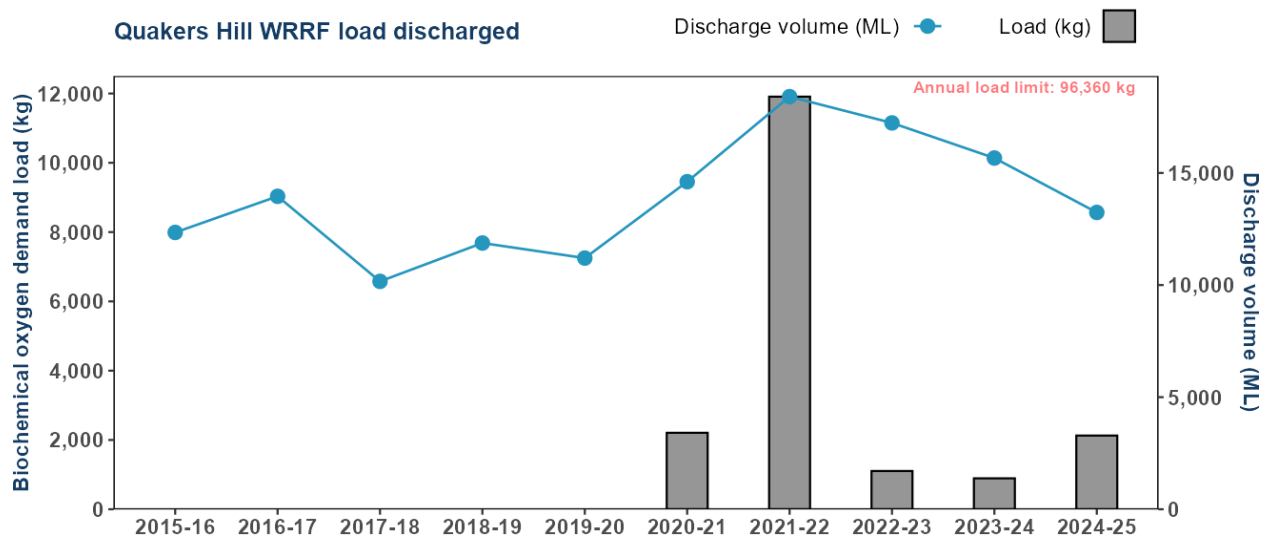
A.9.4. Pressure – Wastewater discharge load

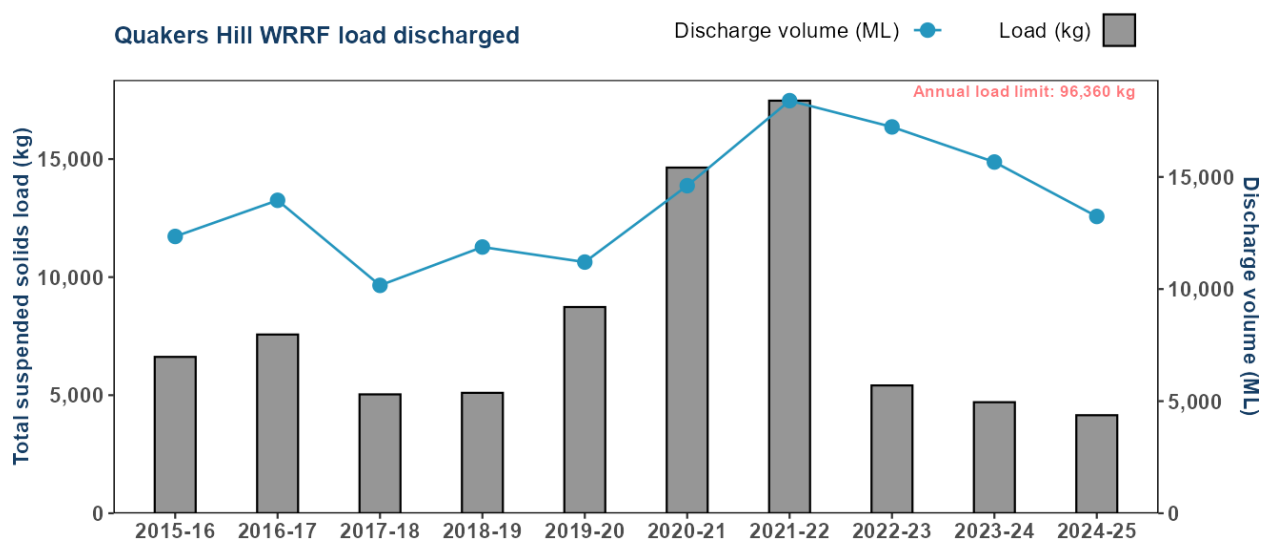
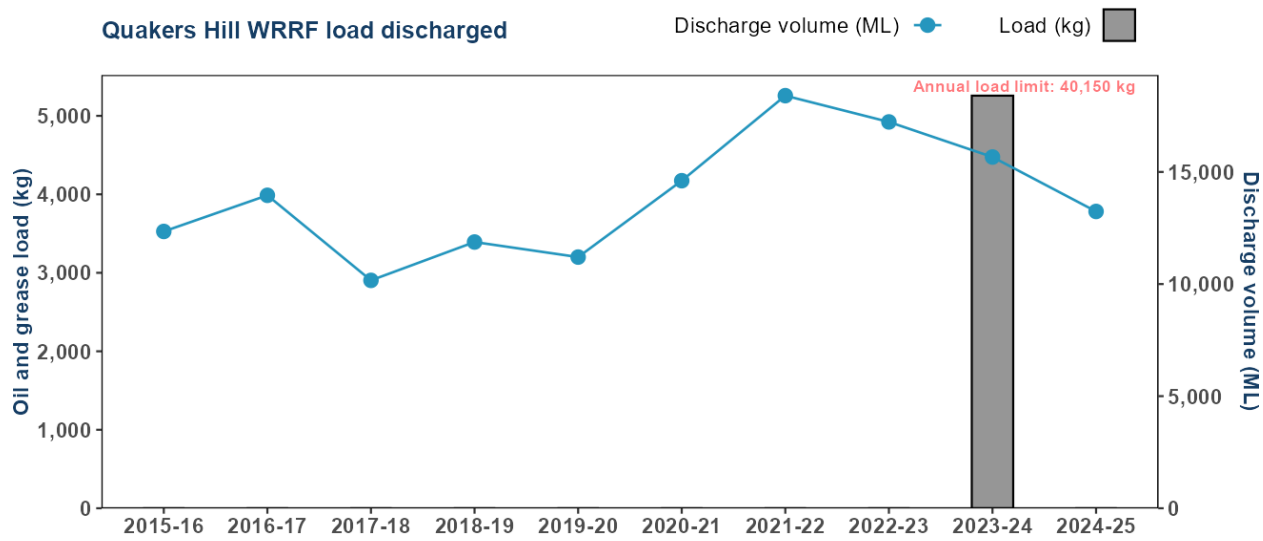
Nutrients



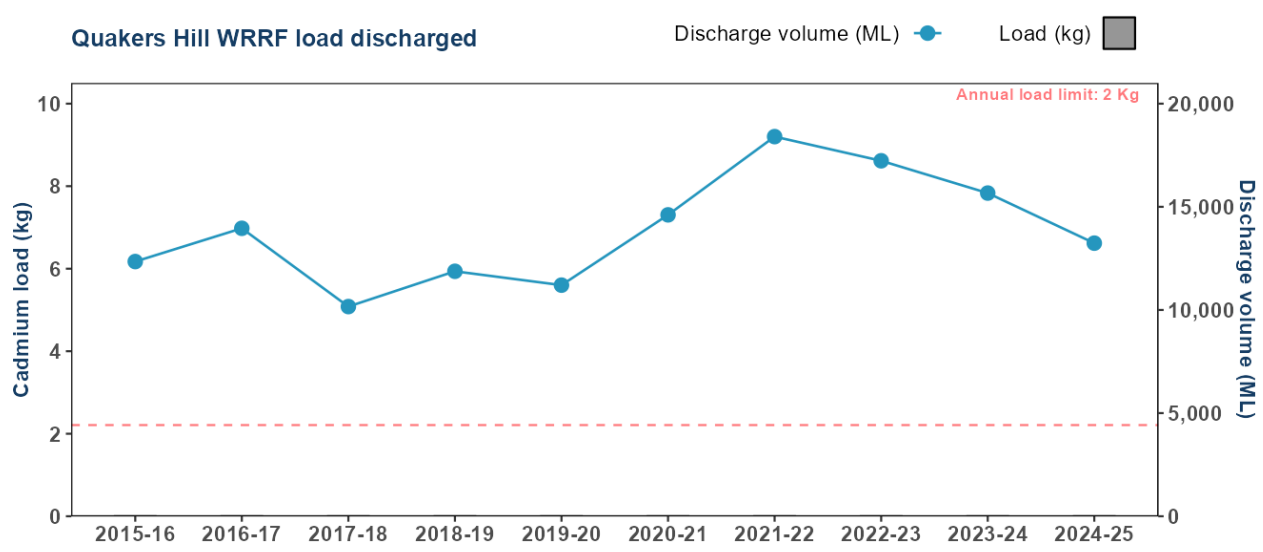


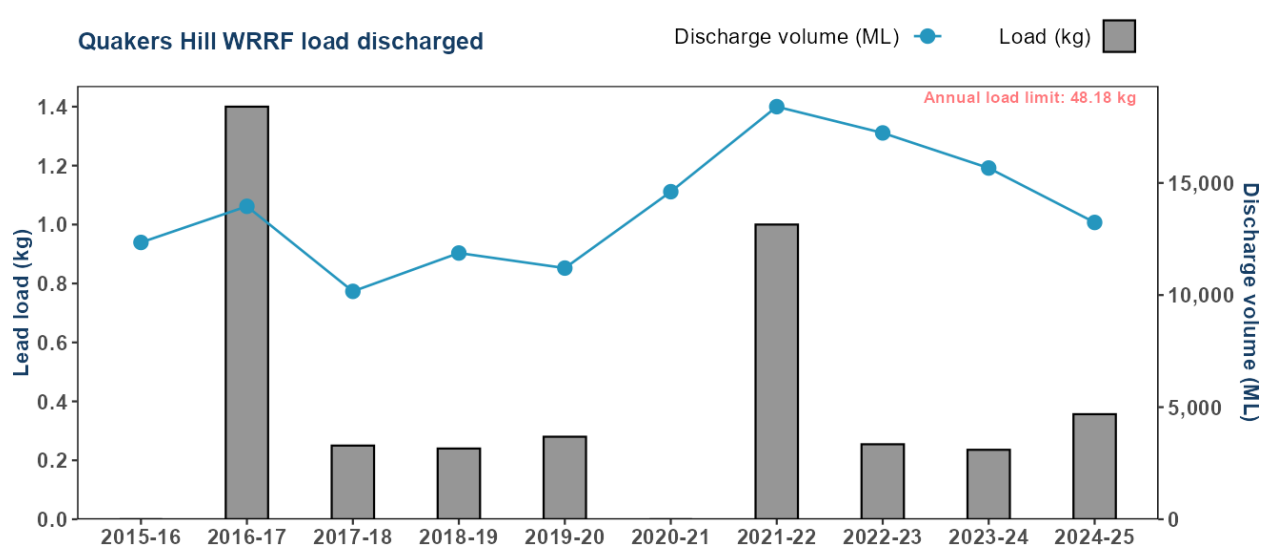
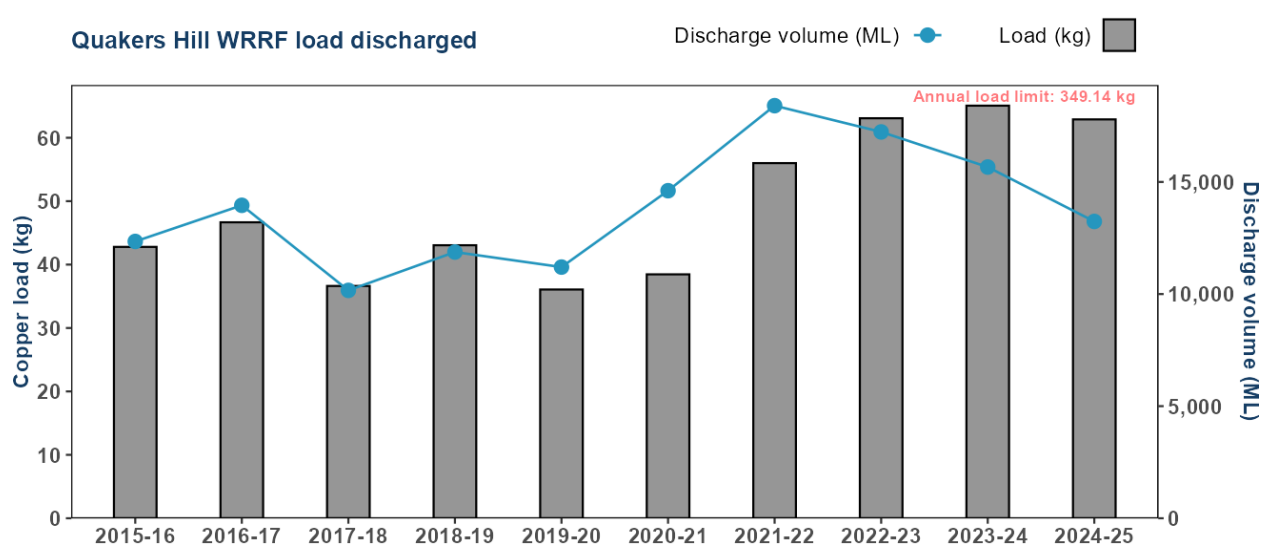
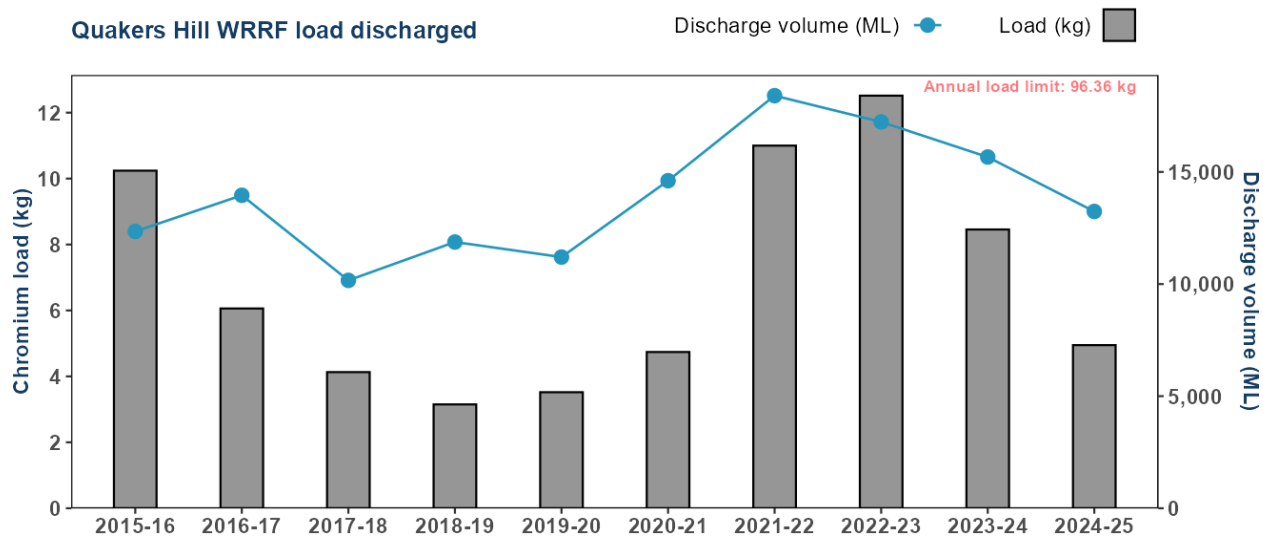
Major conventional analytes

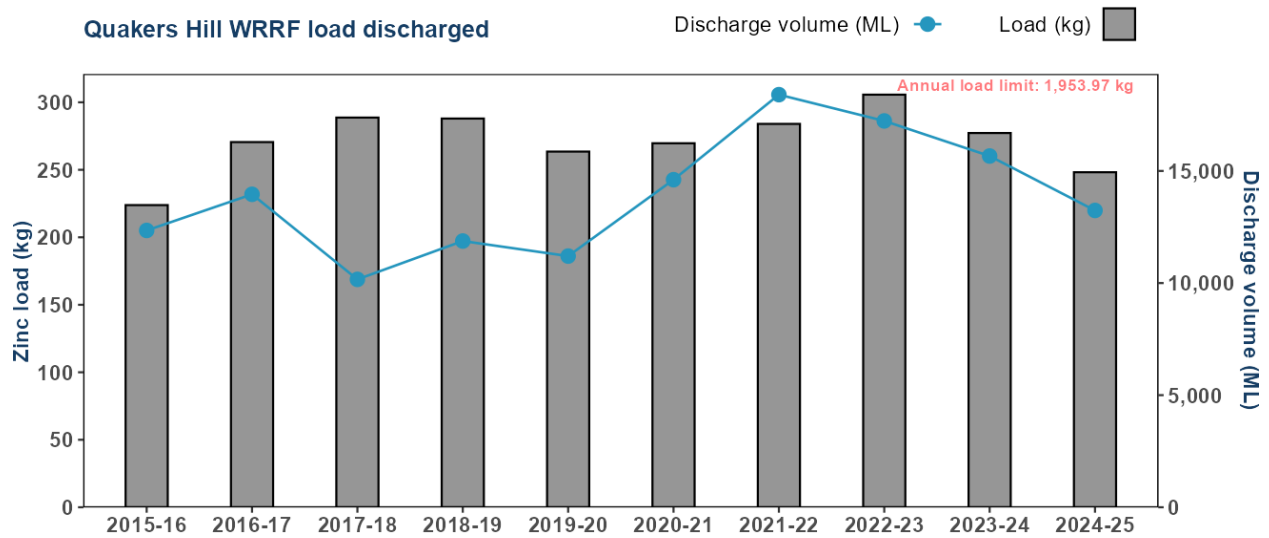
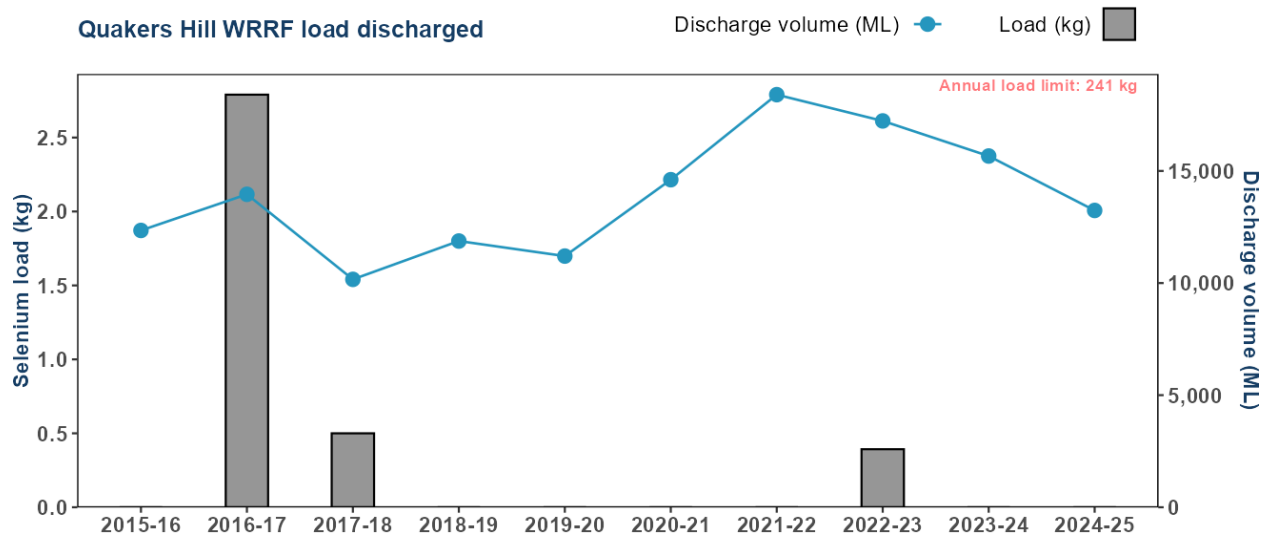
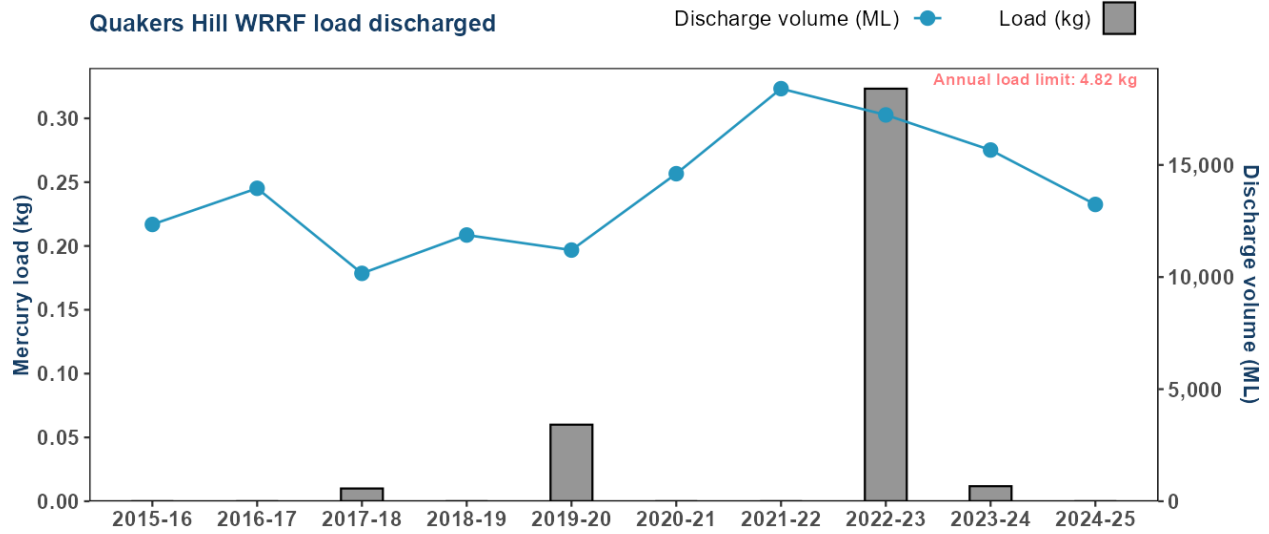




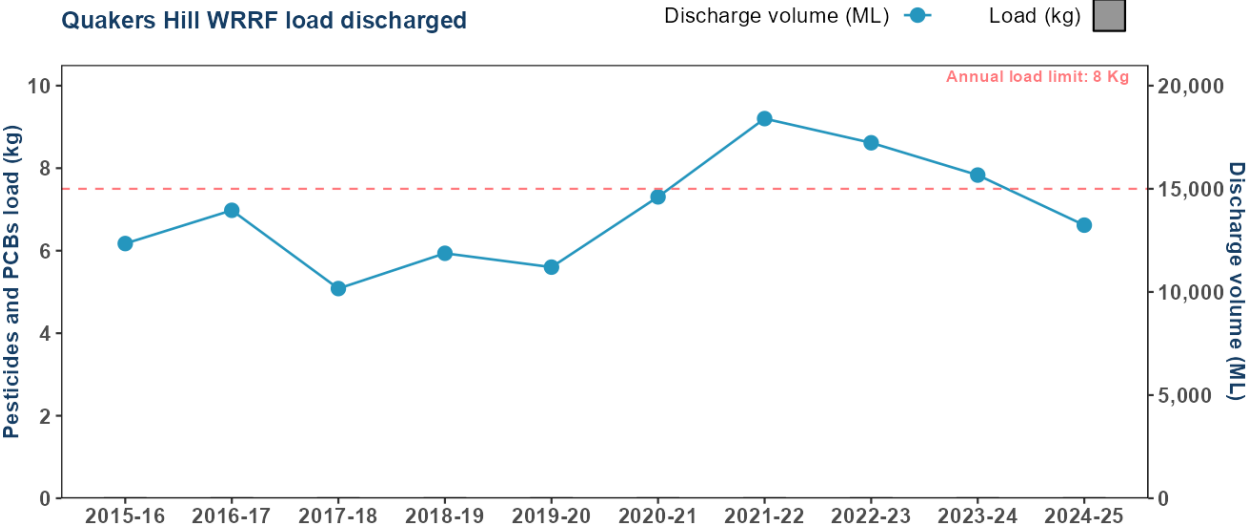
Trace metals







Other chemicals and organics (including pesticides)



A.9.5. Stressor – Statistical analysis outcomes

Table A-98 Upstream vs downstream comparison (2024-25 reporting period) for Breakfast Creek at Quakers Hill WRRF

Breakfast Creek at Quakers Hill WRRF: NS090 vs NS087 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.42	0.17	164	-2.10	0.158
Oxidised nitrogen	20.86	7.04	164	9.01	<0.001
Total nitrogen	3.95	0.50	164	10.89	<0.001
Soluble reactive phosphorus	1.00	0.26	66	0.01	>0.999
Total phosphorus	0.89	0.16	164	-0.62	0.927
Physico-chemical					
Conductivity	0.97	0.15	164	-0.19	0.998
Dissolved oxygen	1.36	0.10	164	4.19	<0.001
Dissolved oxygen saturation	26.01	3.92	164	6.64	<0.001
pH	-0.03	0.06	164	-0.61	0.930
Water temperature	1.27	0.11	164	2.73	0.035
Turbidity	0.20	0.07	164	-4.47	<0.001
Trace Metals					
Filterable aluminium	6.12	1.01	66	10.98	<0.001
Total aluminium	1.15	0.29	66	0.54	0.949
Filterable cobalt	1.32	0.20	66	1.79	0.286
Total cobalt	0.98	0.12	66	-0.17	0.998
Filterable copper	2.21	0.38	66	4.66	<0.001
Total copper	1.33	0.23	66	1.63	0.369
Filterable nickel	1.83	0.18	65	6.08	<0.001
Total nickel	1.43	0.19	66	2.71	0.042
Filterable zinc	1.41	0.25	66	1.94	0.222
Total zinc	1.02	0.17	66	0.15	0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-99 Upstream current period (2024-25) vs previous period comparison (single site) for Breakfast Creek at Quakers Hill WRRF

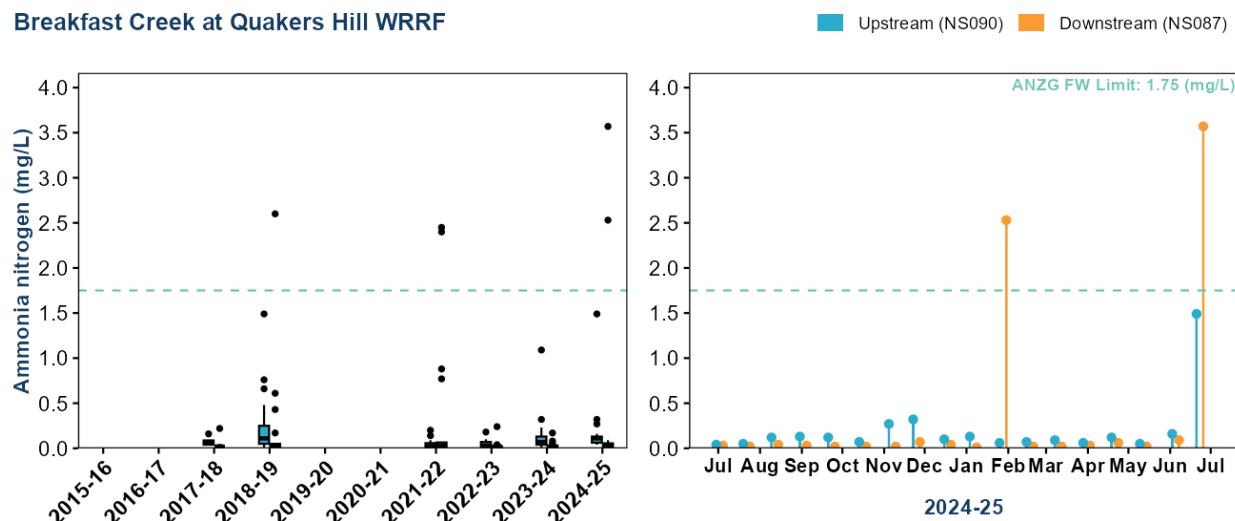
Breakfast Creek at Quakers Hill WRRF: NS090 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	2.12	0.69	164	2.32	0.098
Oxidised nitrogen	0.80	0.21	164	-0.86	0.828
Total nitrogen	1.04	0.10	164	0.44	0.972
Soluble reactive phosphorus	1.05	0.27	66	0.17	0.998
Total phosphorus	1.09	0.16	164	0.61	0.929
Physico-chemical					
Conductivity	0.94	0.12	164	-0.46	0.968
Dissolved oxygen	0.90	0.05	164	-1.86	0.250
Dissolved oxygen saturation	-7.16	3.11	164	-2.30	0.102
pH	-0.08	0.04	164	-1.84	0.256
Water temperature	0.94	0.07	164	-0.85	0.829
Turbidity	0.75	0.21	164	-1.01	0.746
Trace Metals					
Filterable aluminium	1.37	0.23	66	1.88	0.247
Total aluminium	0.56	0.14	66	-2.25	0.120
Filterable cobalt	0.80	0.12	66	-1.43	0.483
Total cobalt	0.79	0.10	66	-1.92	0.230
Filterable copper	0.79	0.14	66	-1.37	0.521
Total copper	0.90	0.16	66	-0.57	0.941
Filterable nickel	0.72	0.07	65	-3.29	0.009
Total nickel	0.79	0.11	66	-1.74	0.314
Filterable zinc	0.92	0.16	66	-0.48	0.963
Total zinc	0.89	0.15	66	-0.68	0.904
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-100 Downstream current period (2024-25) vs previous period comparison (single site) for Breakfast Creek at Quakers Hill WRRF

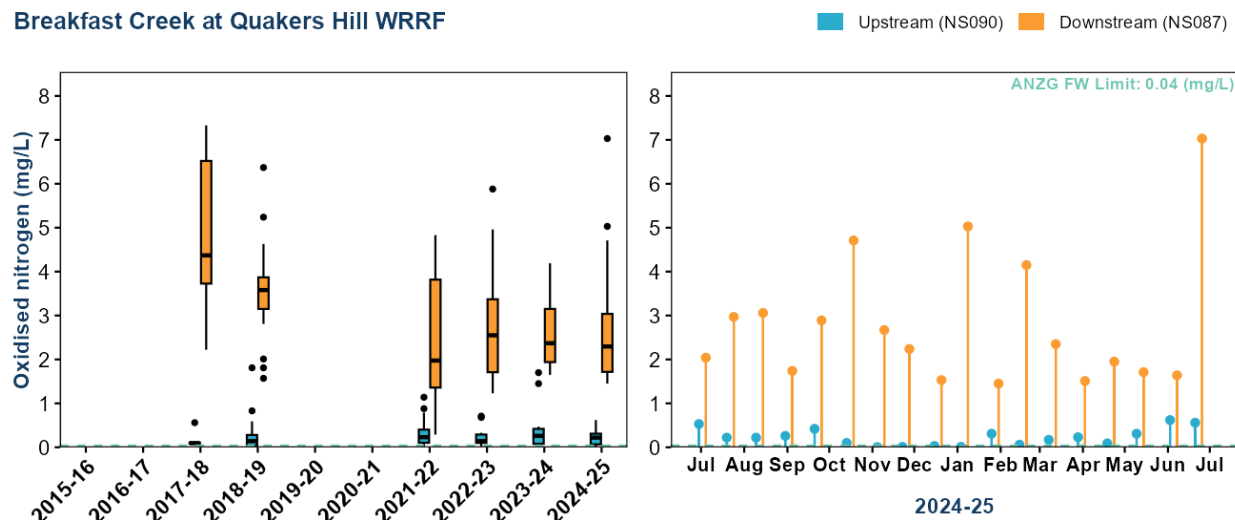
Breakfast Creek at Quakers Hill WRRF: NS087 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.33	0.43	164	0.88	0.814
Oxidised nitrogen	1.00	0.27	164	0.00	>0.999
Total nitrogen	1.03	0.10	164	0.27	0.993
Soluble reactive phosphorus	0.64	0.17	66	-1.71	0.326
Total phosphorus	0.97	0.14	164	-0.23	0.996
Physico-chemical					
Conductivity	1.03	0.13	164	0.26	0.994
Dissolved oxygen	0.96	0.06	164	-0.61	0.928
Dissolved oxygen saturation	-4.75	3.11	164	-1.53	0.424
pH	0.01	0.04	164	0.17	0.998
Water temperature	0.98	0.07	164	-0.27	0.993
Turbidity	0.79	0.22	164	-0.82	0.844
Trace Metals					
Filterable aluminium	1.16	0.19	66	0.91	0.801
Total aluminium	1.09	0.28	66	0.33	0.987
Filterable cobalt	1.06	0.17	66	0.37	0.982
Total cobalt	1.09	0.14	66	0.72	0.890
Filterable copper	0.92	0.16	66	-0.46	0.968
Total copper	0.94	0.17	66	-0.34	0.987
Filterable nickel	1.11	0.11	65	1.03	0.731
Total nickel	1.11	0.15	66	0.76	0.871
Filterable zinc	1.03	0.18	66	0.15	0.999
Total zinc	1.06	0.18	66	0.35	0.985
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.9.6. Stressor – Nutrients

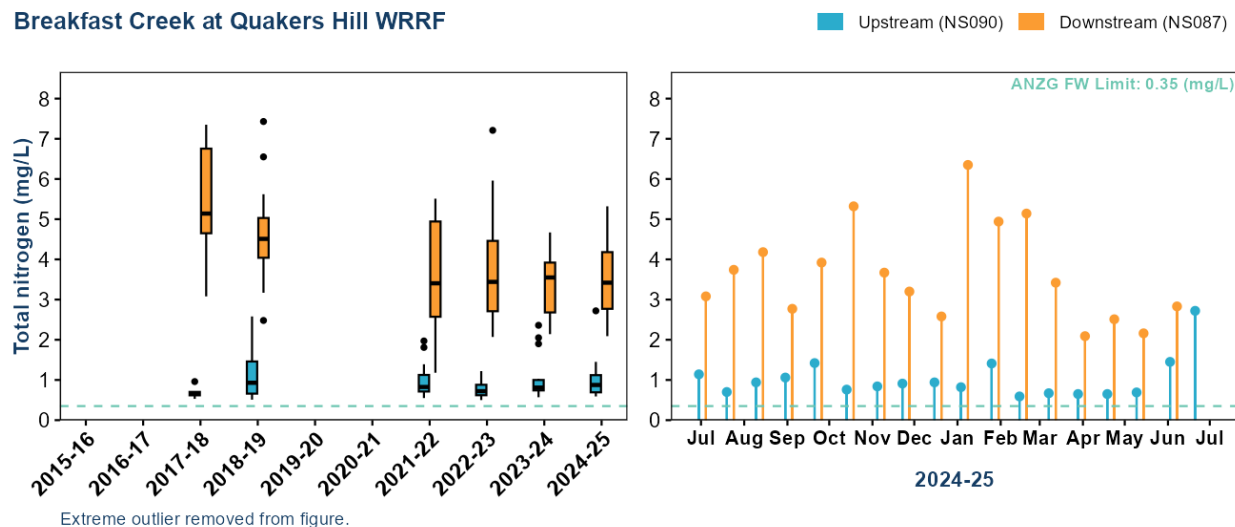
Breakfast Creek at Quakers Hill WRRF



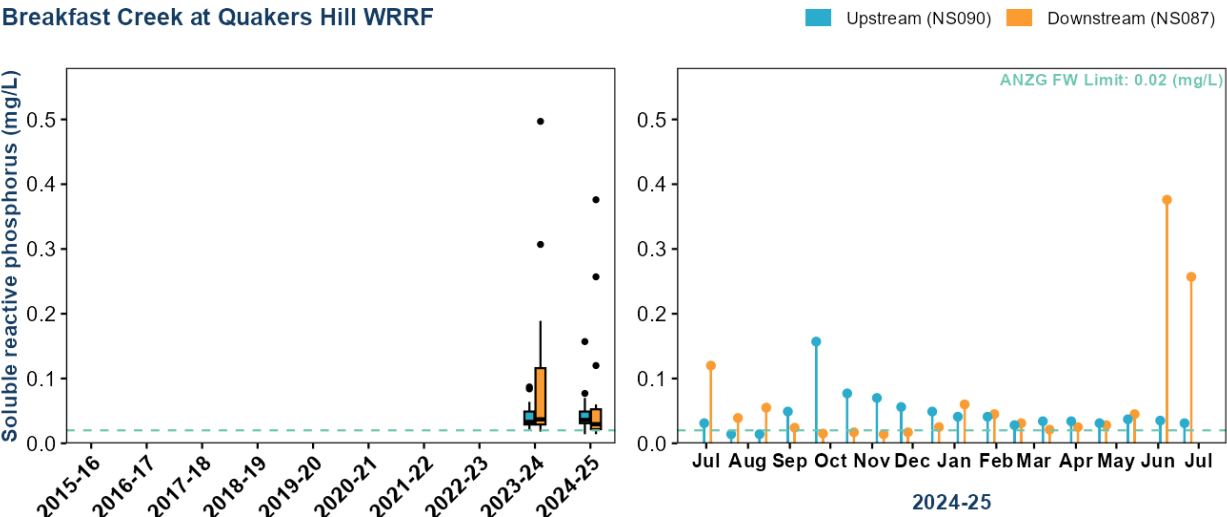
Breakfast Creek at Quakers Hill WRRF



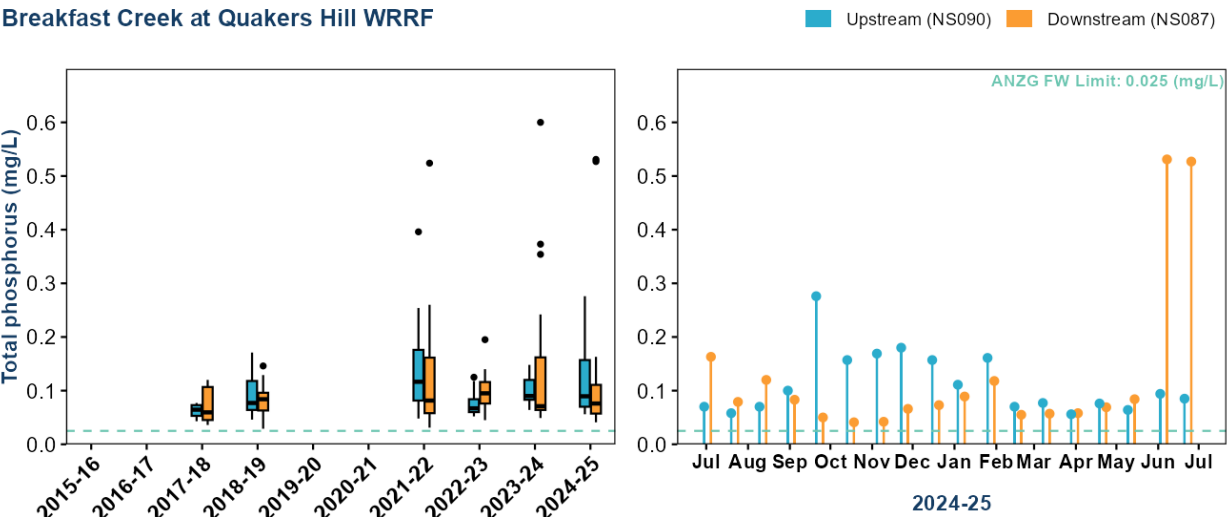
Breakfast Creek at Quakers Hill WRRF



Breakfast Creek at Quakers Hill WRRF

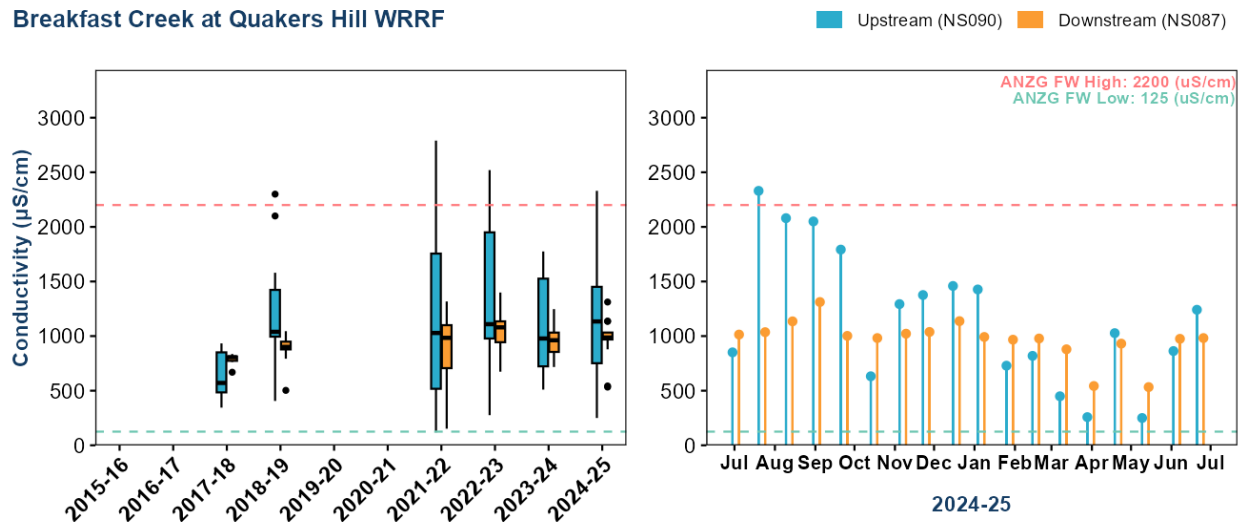


Breakfast Creek at Quakers Hill WRRF

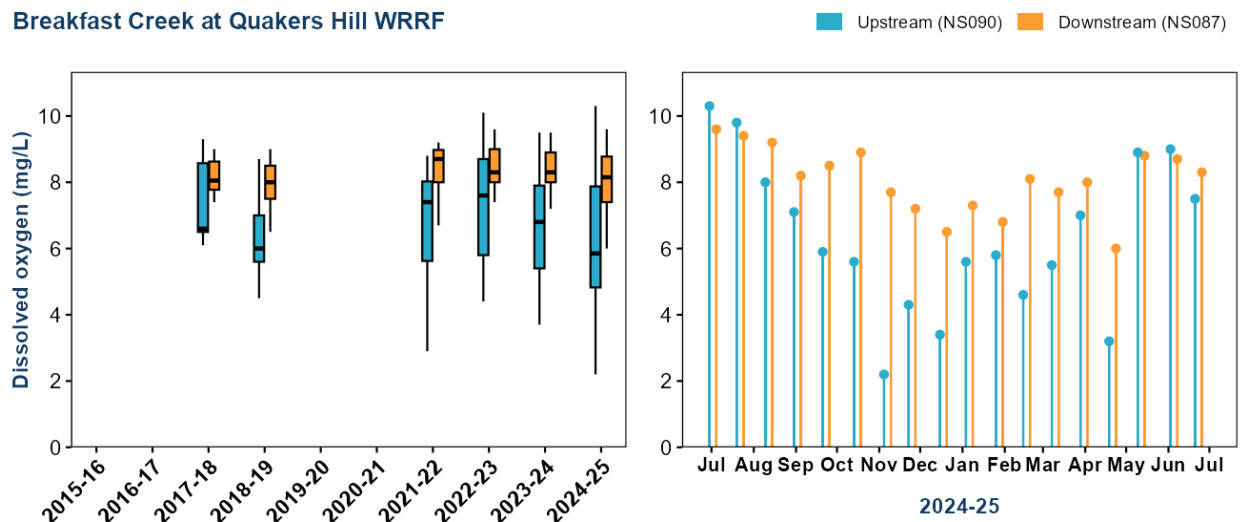


A.9.7. Stressor – Physico-chemical water quality

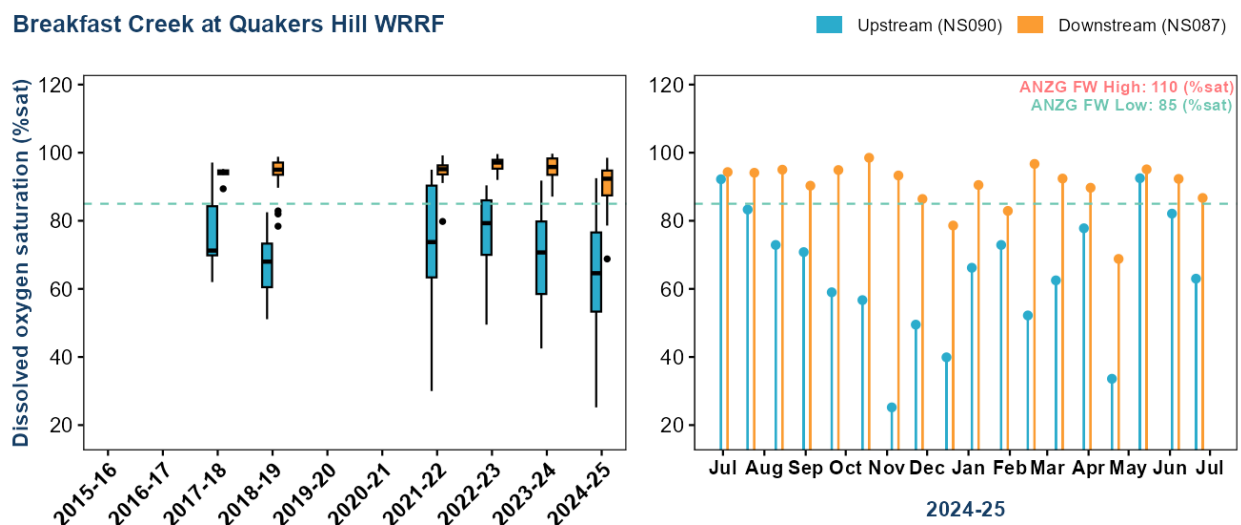
Breakfast Creek at Quakers Hill WRRF



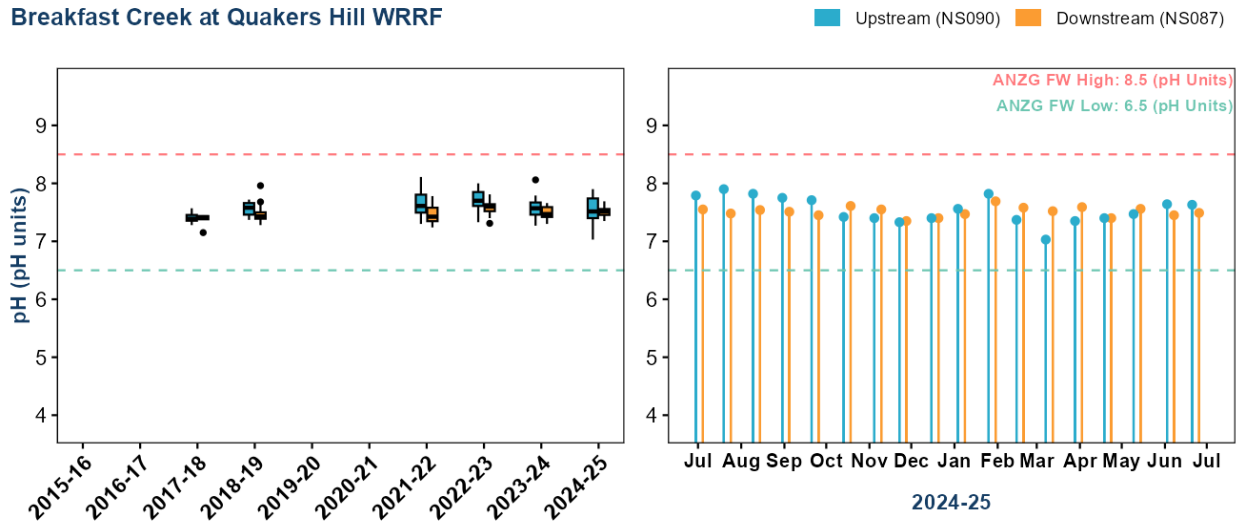
Breakfast Creek at Quakers Hill WRRF



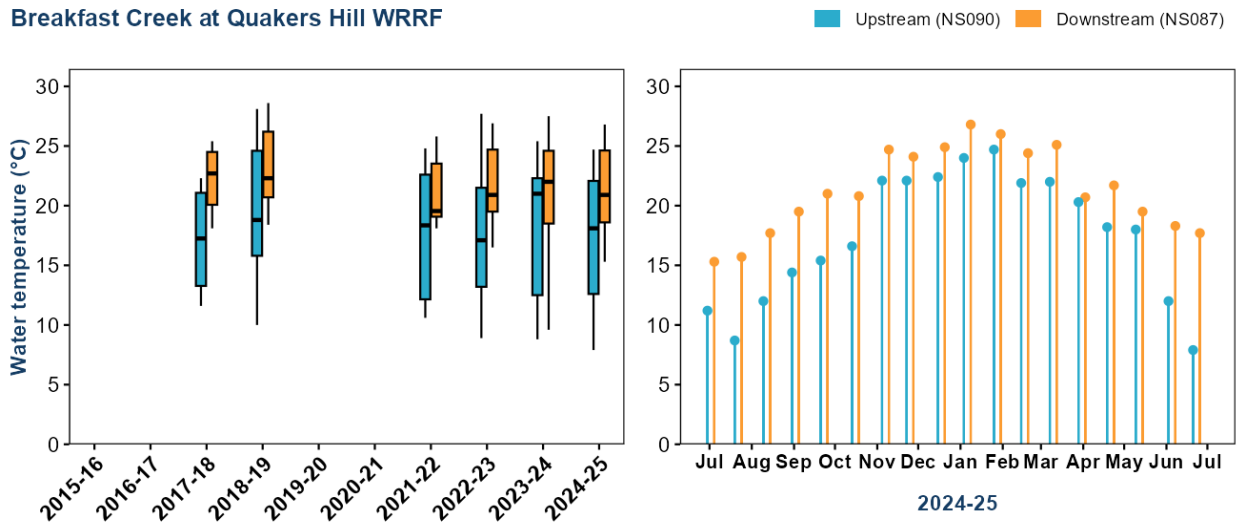
Breakfast Creek at Quakers Hill WRRF



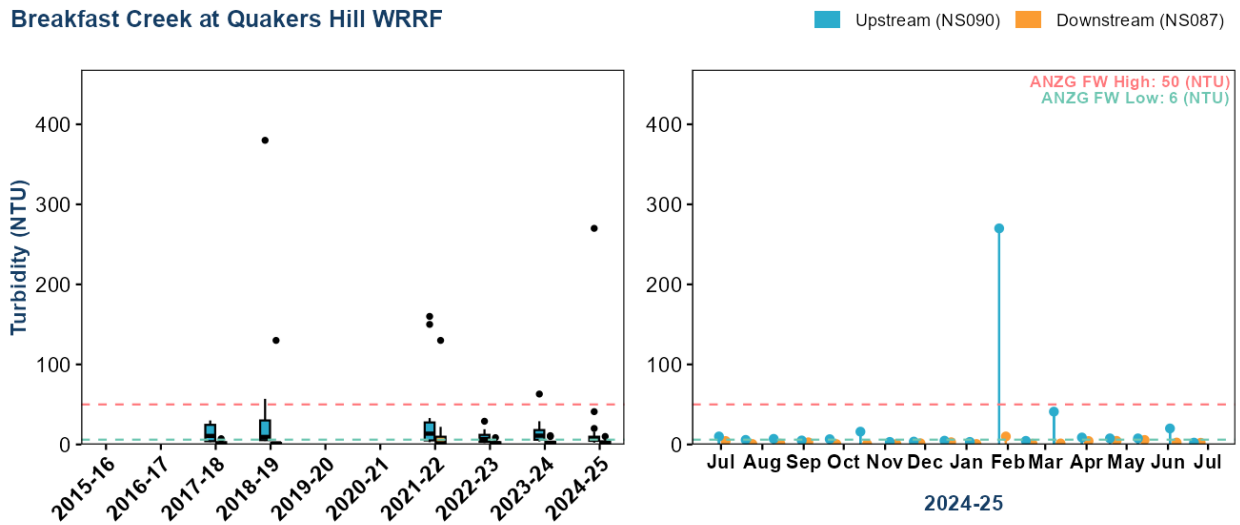
Breakfast Creek at Quakers Hill WRRF



Breakfast Creek at Quakers Hill WRRF

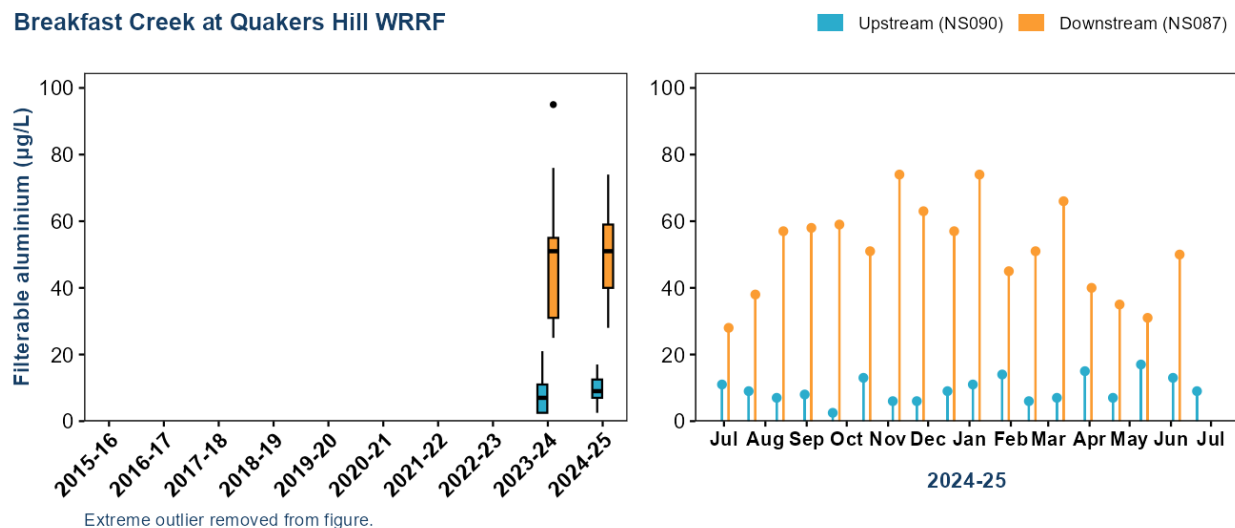


Breakfast Creek at Quakers Hill WRRF

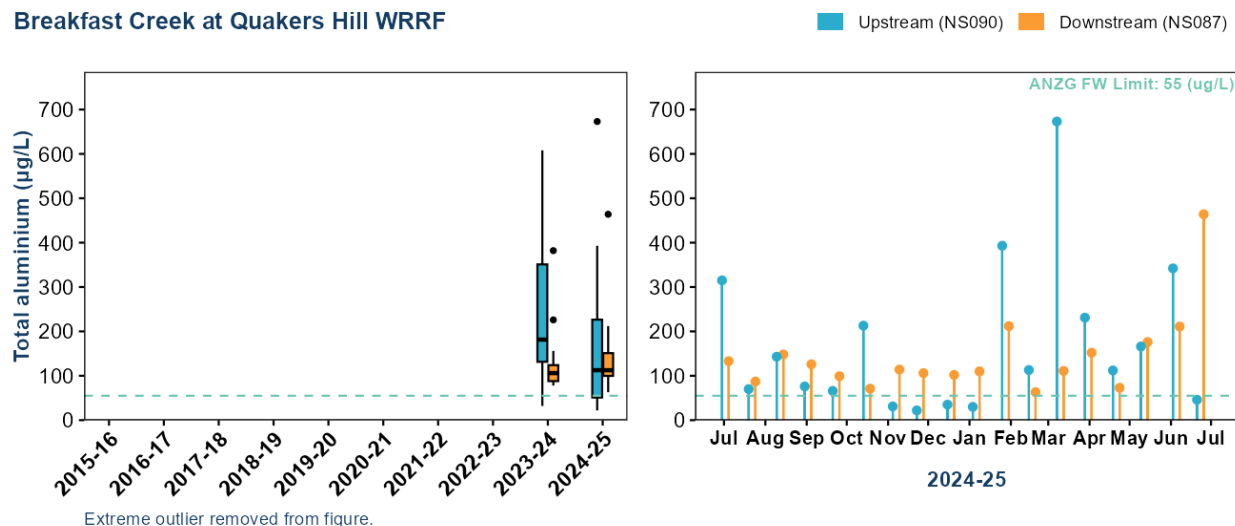


A.9.8. Stressor – Trace metals

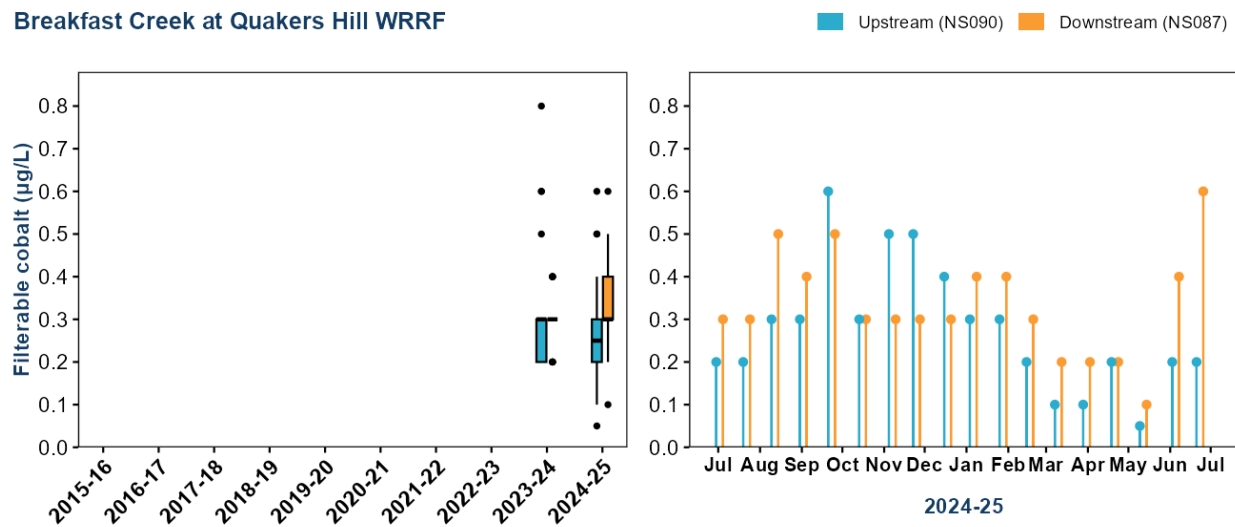
Breakfast Creek at Quakers Hill WRRF



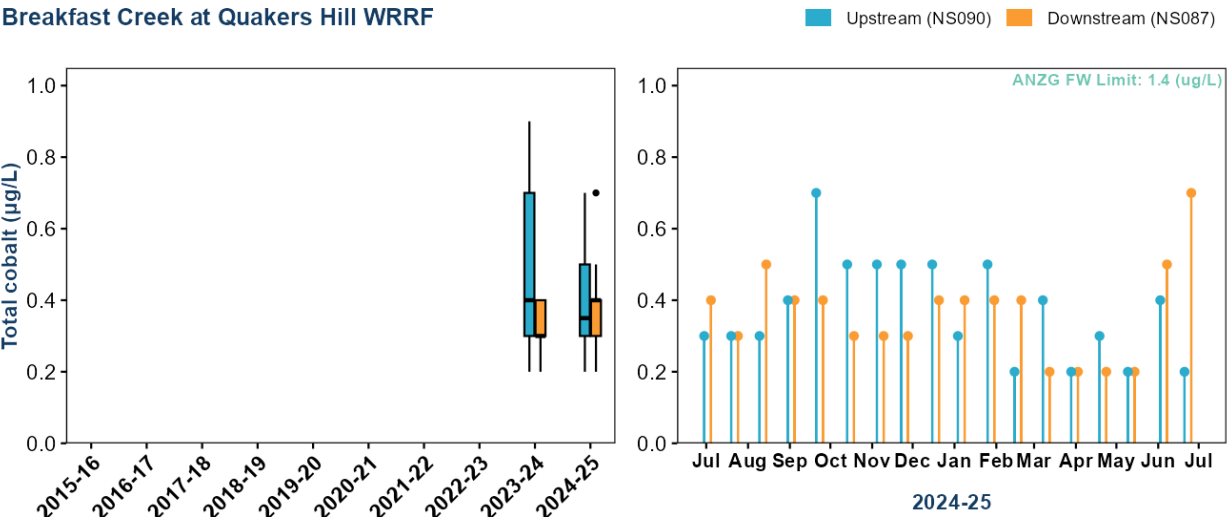
Breakfast Creek at Quakers Hill WRRF



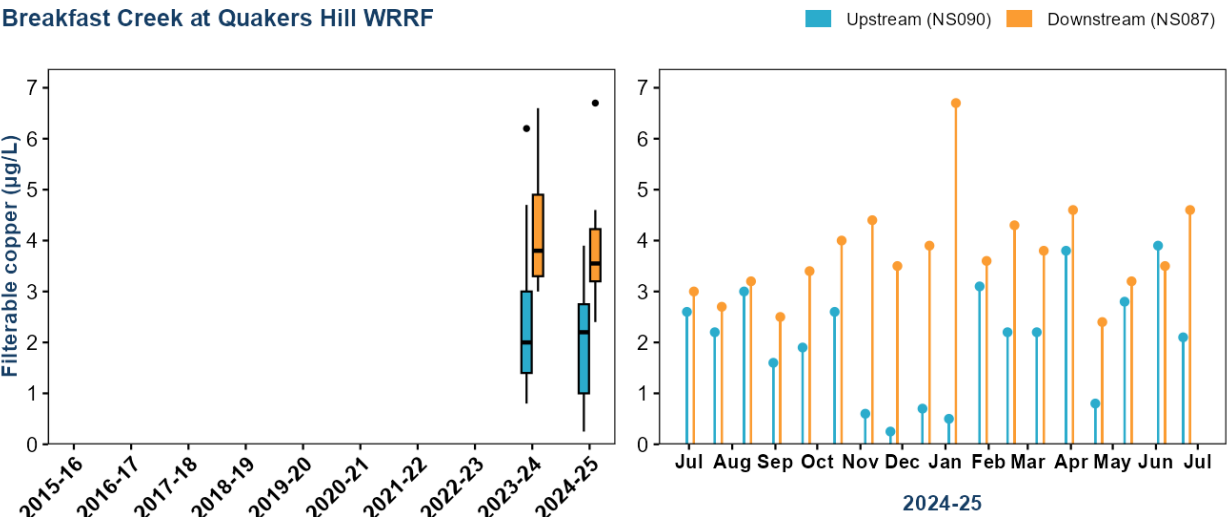
Breakfast Creek at Quakers Hill WRRF



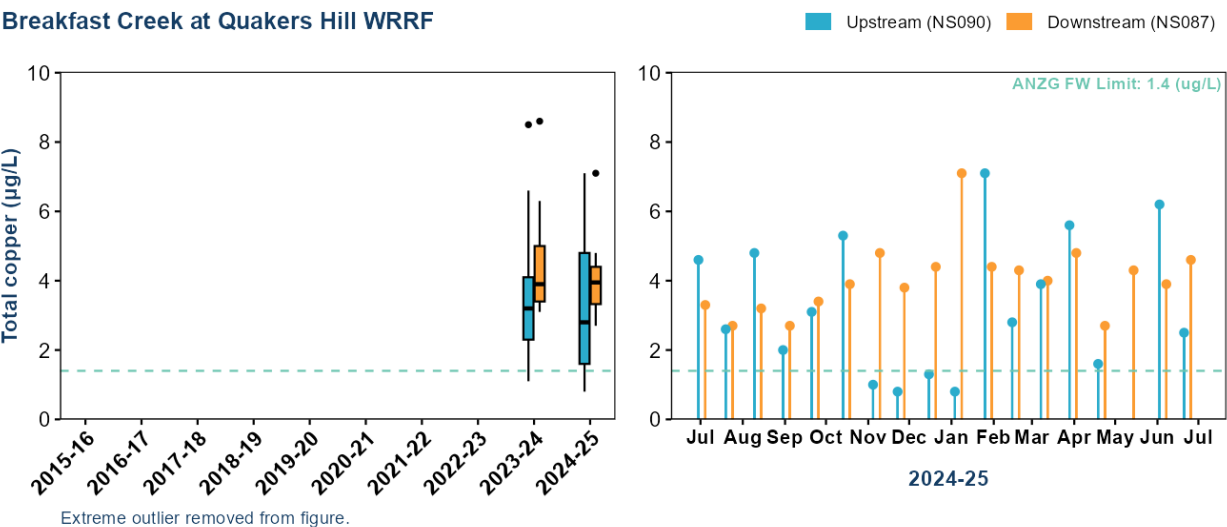
Breakfast Creek at Quakers Hill WRRF



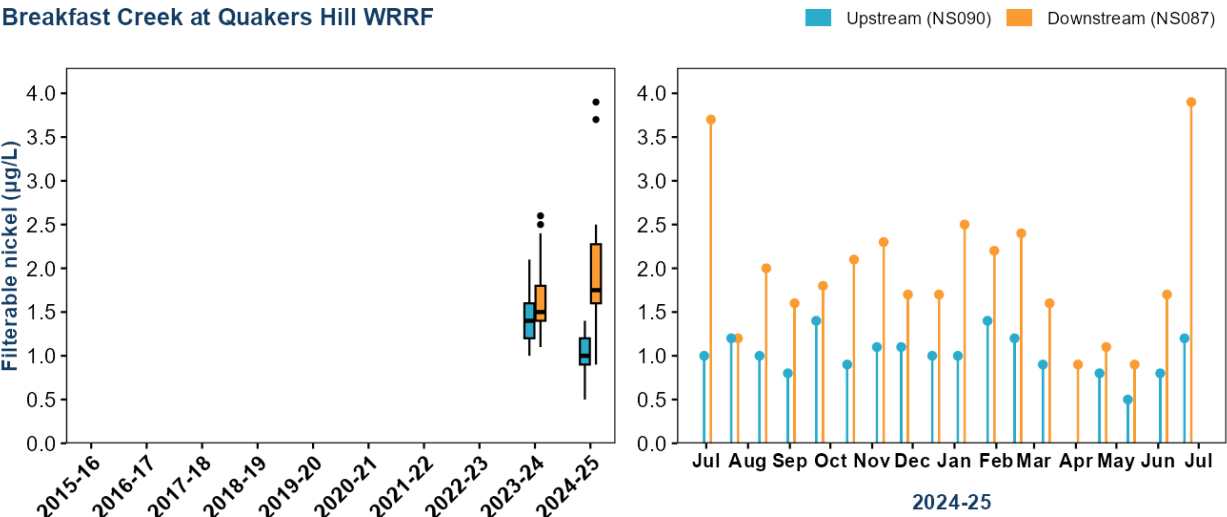
Breakfast Creek at Quakers Hill WRRF



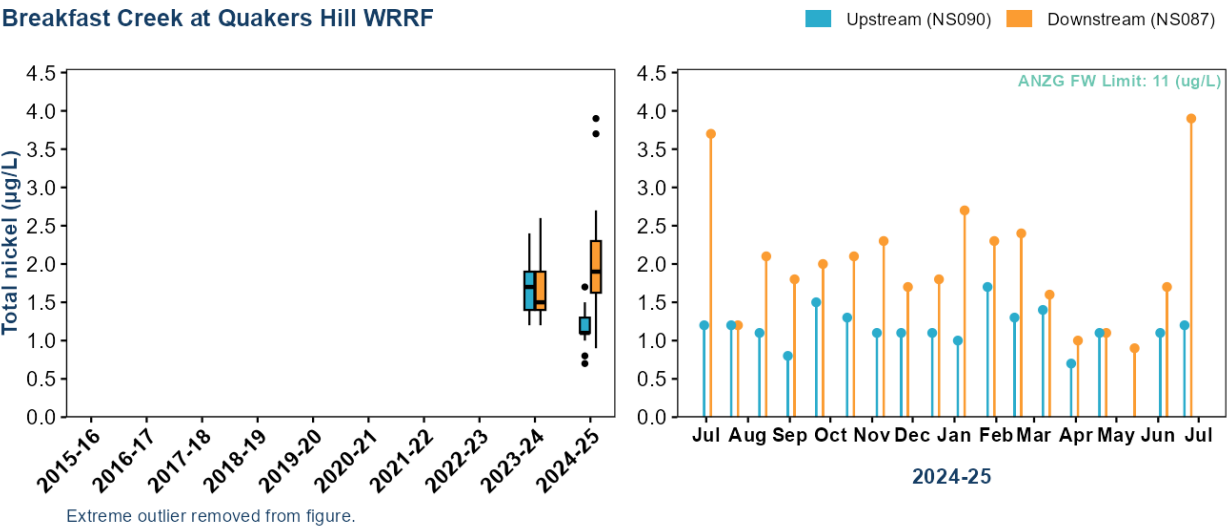
Breakfast Creek at Quakers Hill WRRF



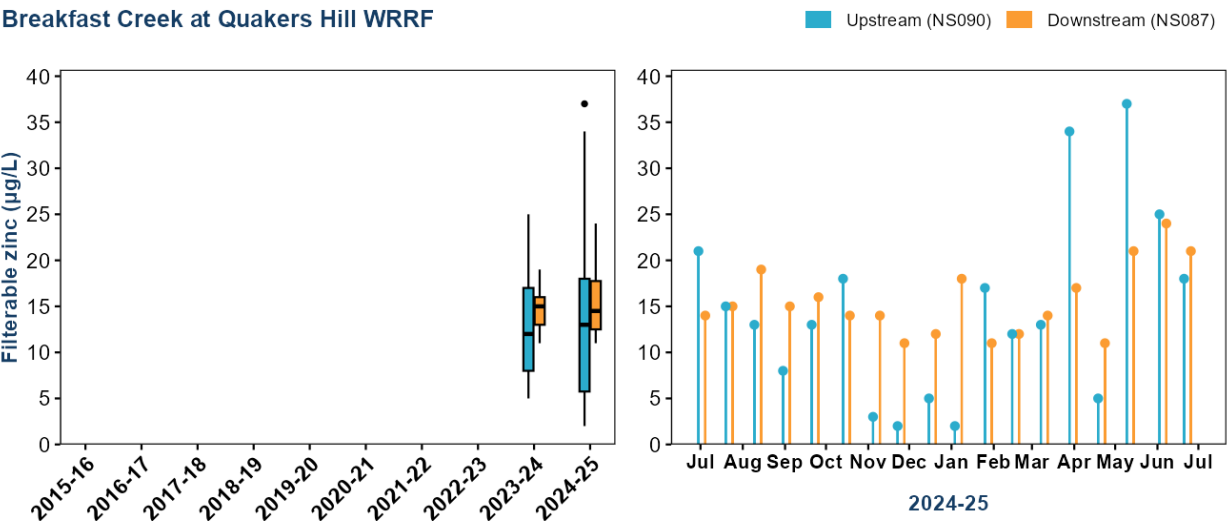
Breakfast Creek at Quakers Hill WRRF



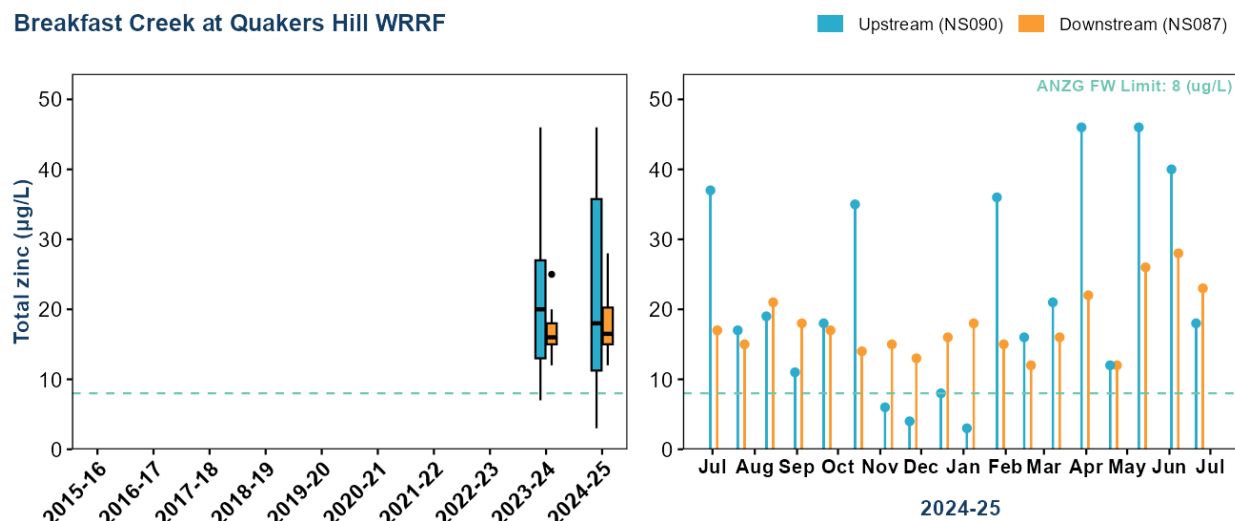
Breakfast Creek at Quakers Hill WRRF



Breakfast Creek at Quakers Hill WRRF



Breakfast Creek at Quakers Hill WRRF



A.9.9. Ecosystem receptor – Statistical analysis outcomes

Table A-101 Upstream vs downstream comparison (2024-25 reporting period) for Breakfast Creek at Quakers Hill WRRF

Breakfast Creek at Quakers Hill WRRF: NS090 vs NS087 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.29	0.11	164	-3.38	0.005
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-102 Upstream current period (2024-25) vs previous period comparison (single site) for Breakfast Creek at Quakers Hill WRRF

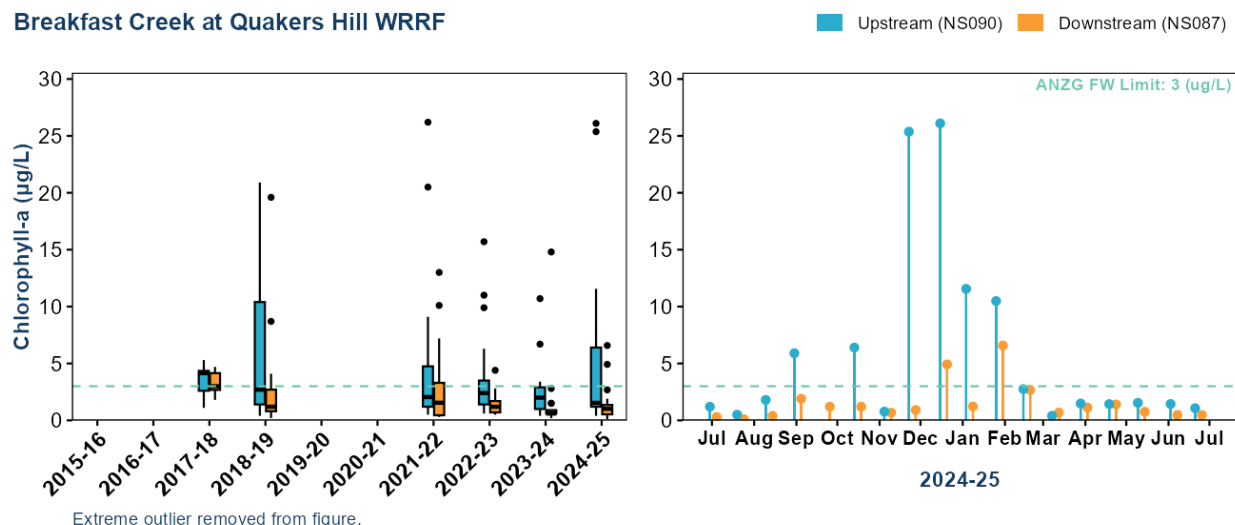
Breakfast Creek at Quakers Hill WRRF: NS090 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.26	0.36	164	0.79	0.858
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-103 Downstream current period (2024-25) vs previous period comparison (single site) for Breakfast Creek at Quakers Hill WRRF

Breakfast Creek at Quakers Hill WRRF: NS087 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.77	0.22	164	-0.91	0.799
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.9.10. Ecosystem receptor – Phytoplankton

Breakfast Creek at Quakers Hill WRRF

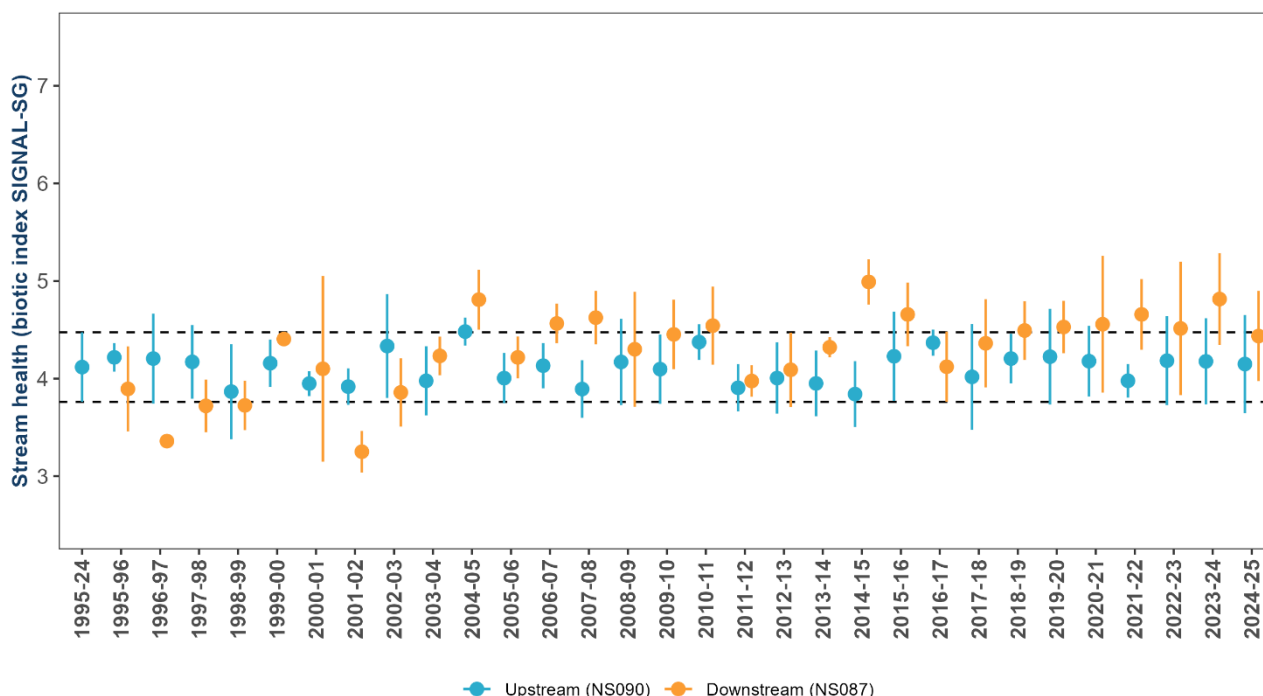


A.9.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Breakfast Creek	River (NS090 vs NS087)	Welch Two Sample t-test	-0.29	-1.03	9.9	0.327

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Breakfast Creek at Quakers Hill WRRF

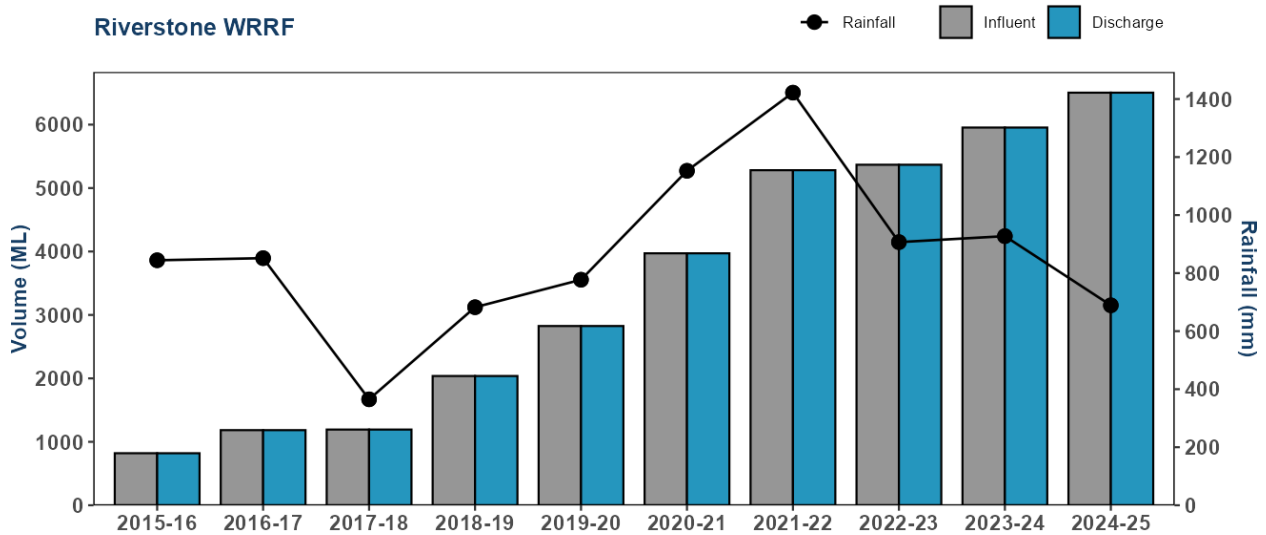


The range of stream health recorded over each period is represented by length of line

A.10. Riverstone WRRF

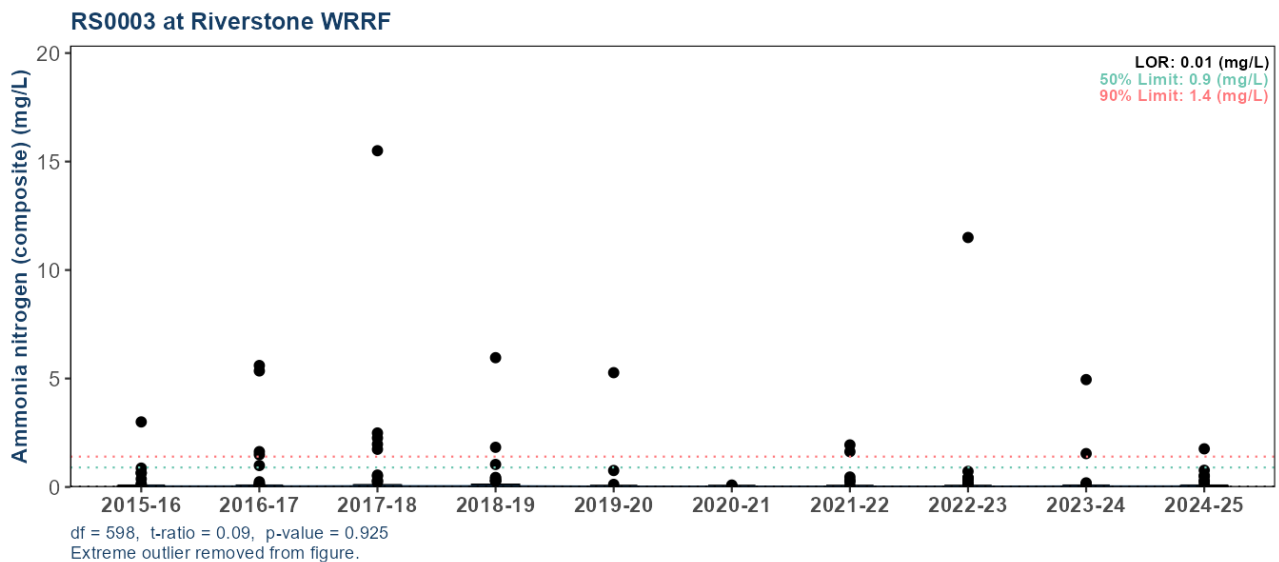
A.10.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall

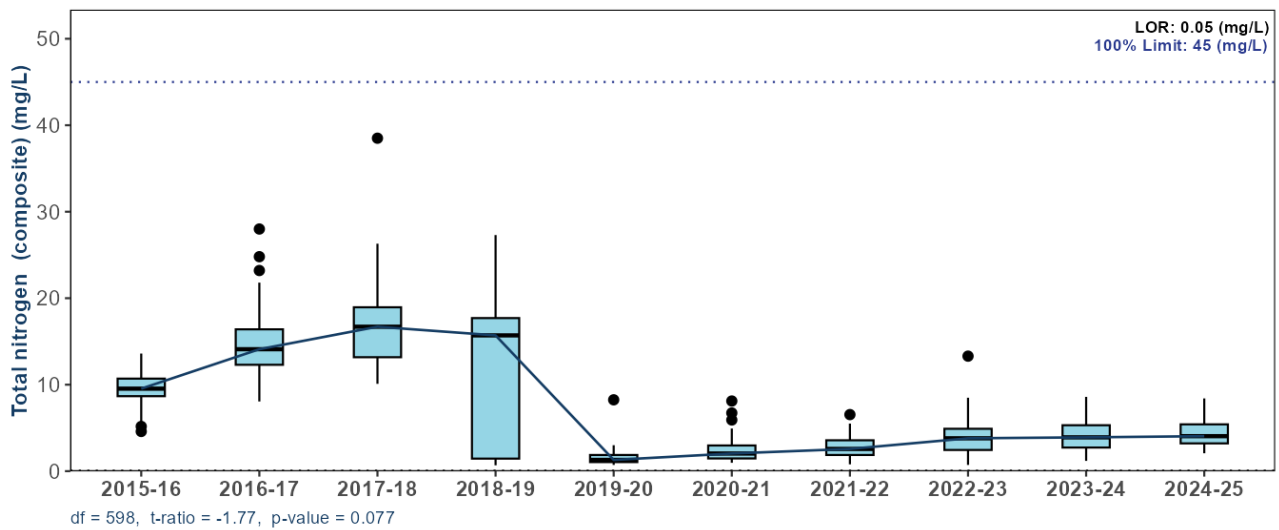


A.10.2. Pressure – Wastewater quality

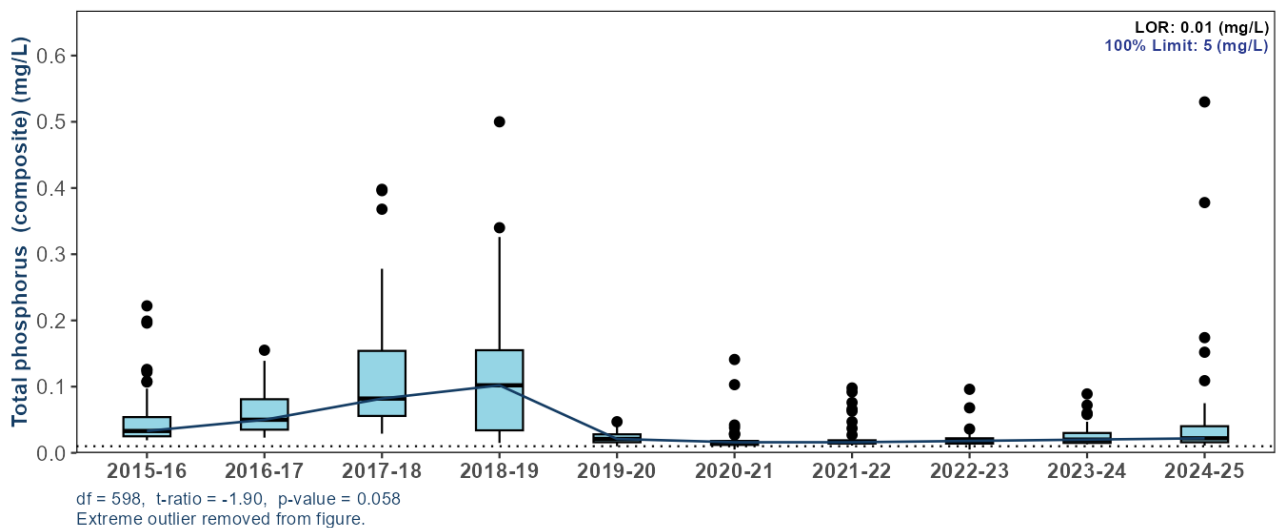
Nutrients



RS0003 at Riverstone WRRF

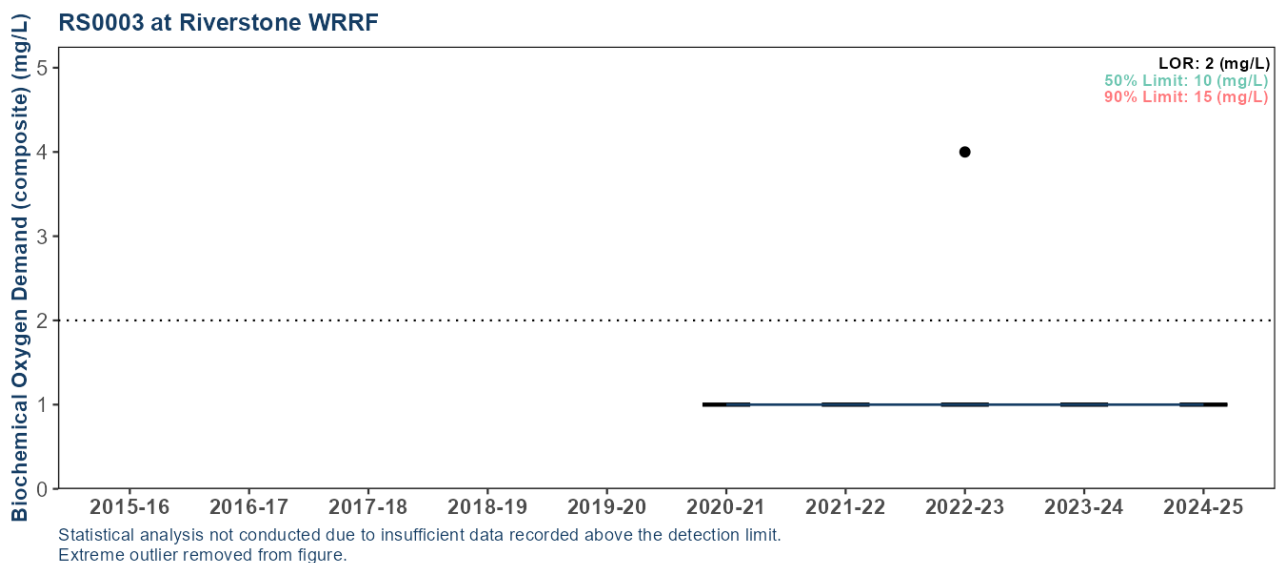


RS0003 at Riverstone WRRF

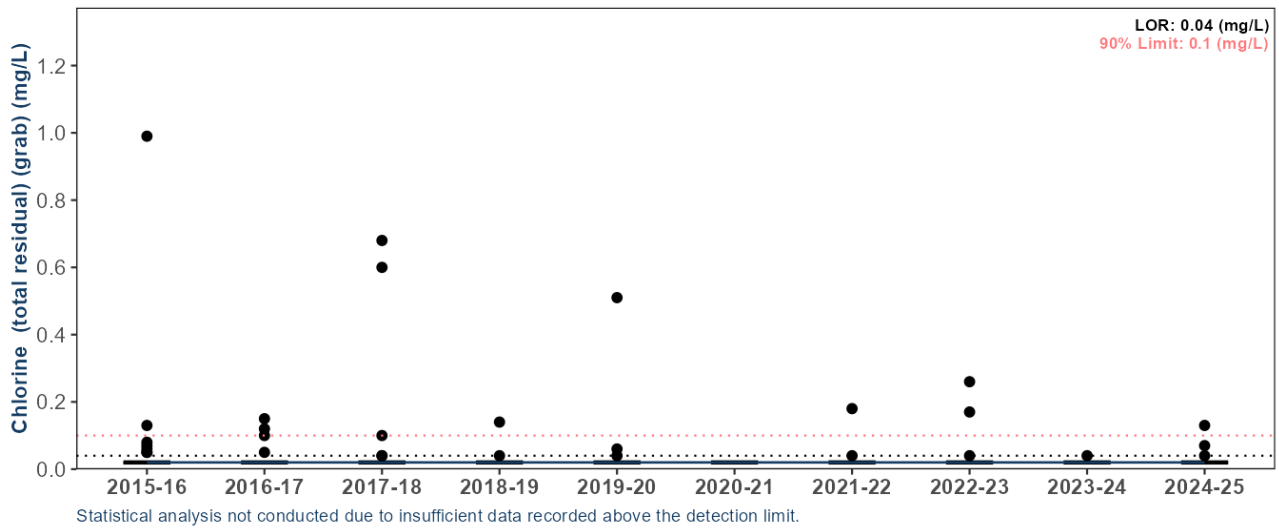


Major conventional analytes

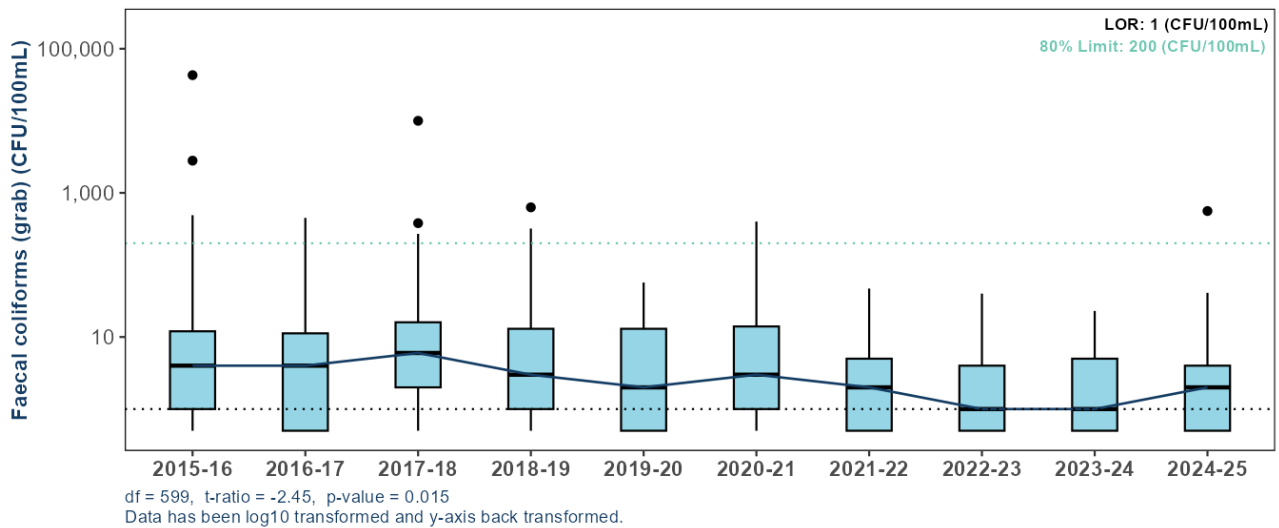
RS0003 at Riverstone WRRF



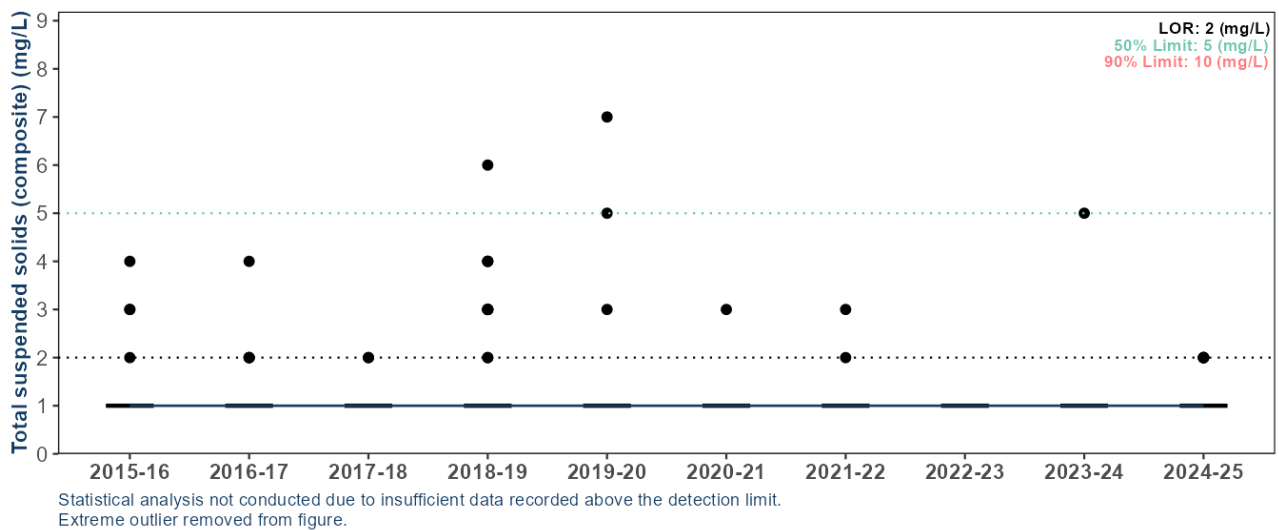
RS0004 at Riverstone WRRF



RS0004 at Riverstone WRRF

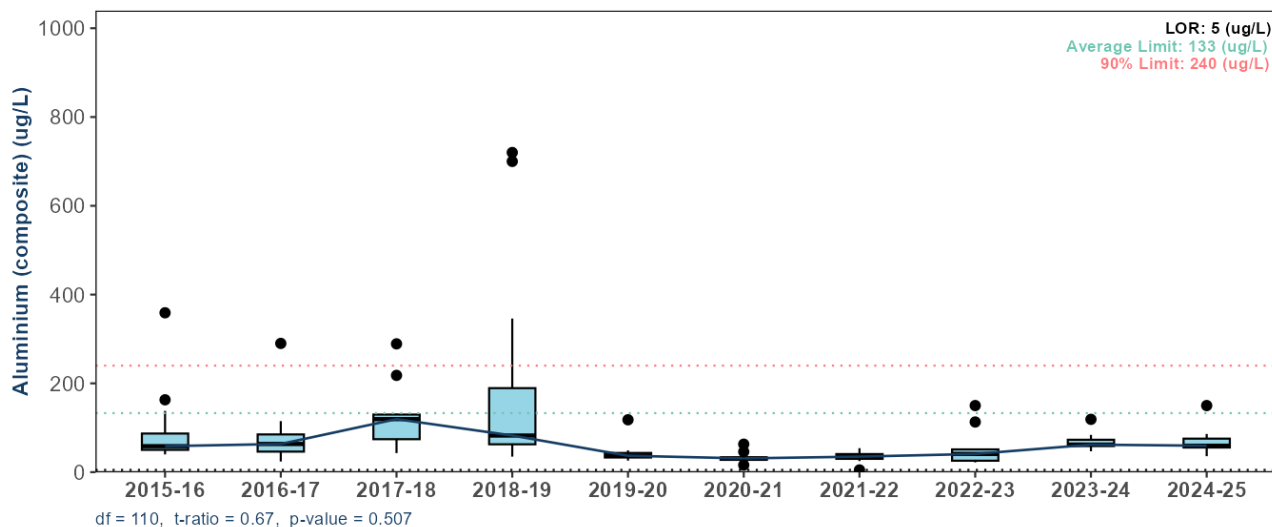


RS0003 at Riverstone WRRF

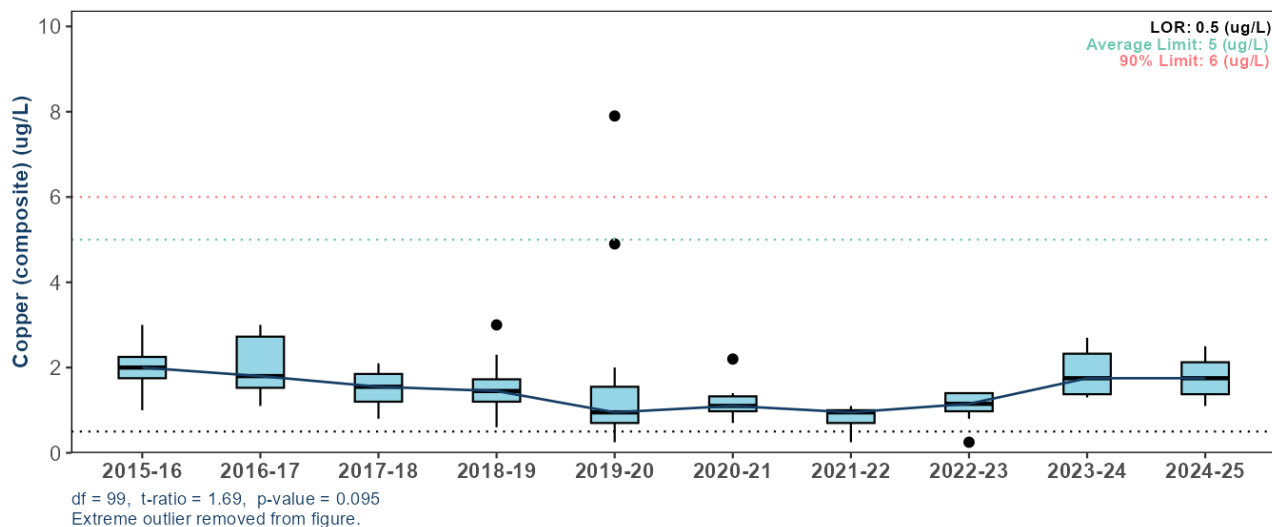


Trace metals

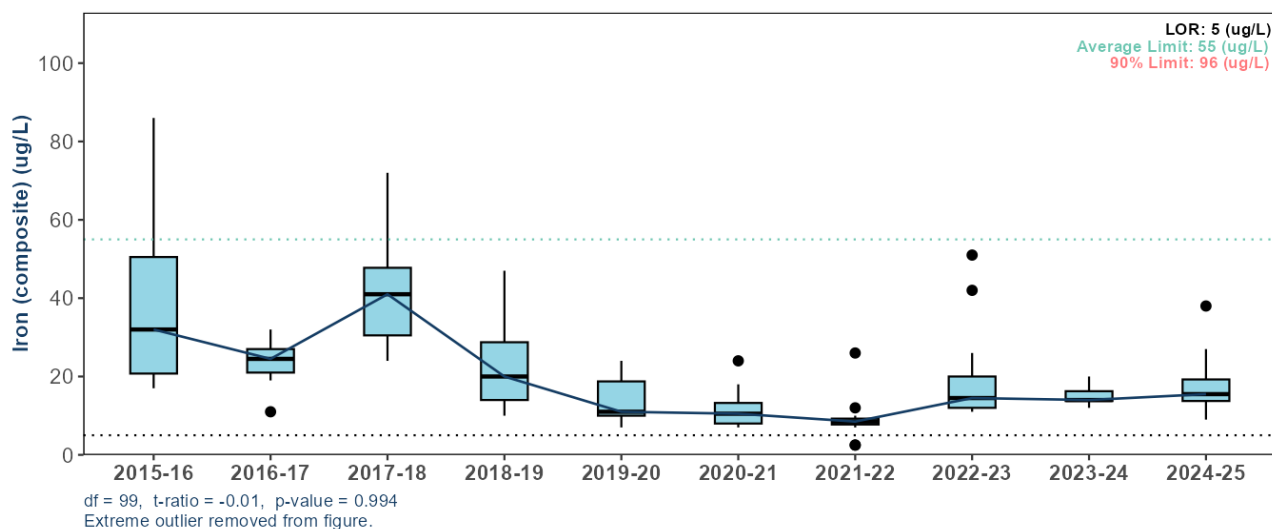
RS0003 at Riverstone WRRF



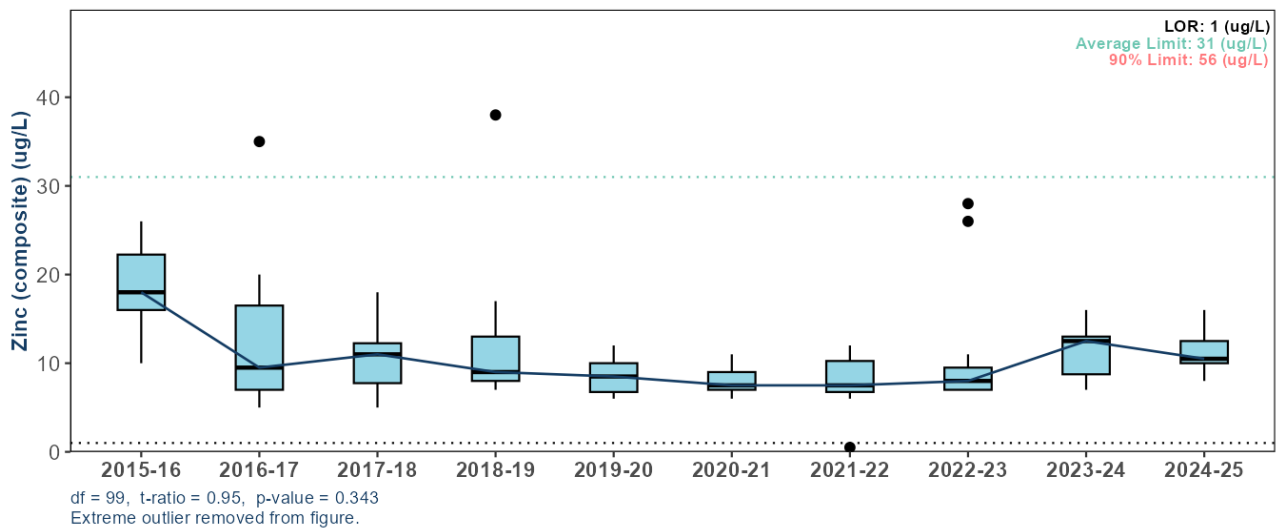
RS0003 at Riverstone WRRF



RS0003 at Riverstone WRRF

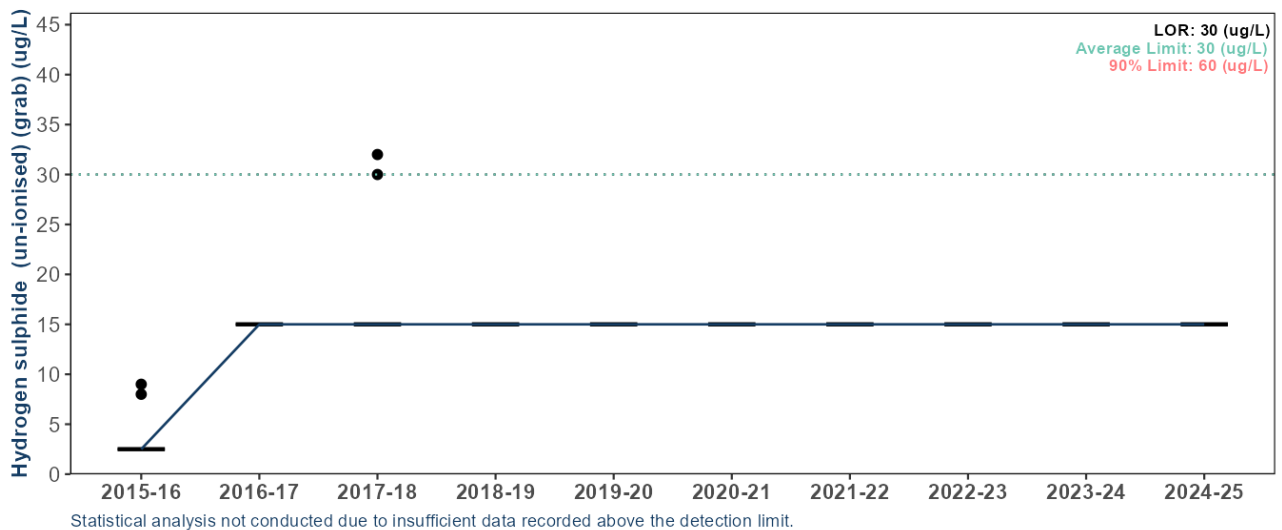


RS0003 at Riverstone WRRF



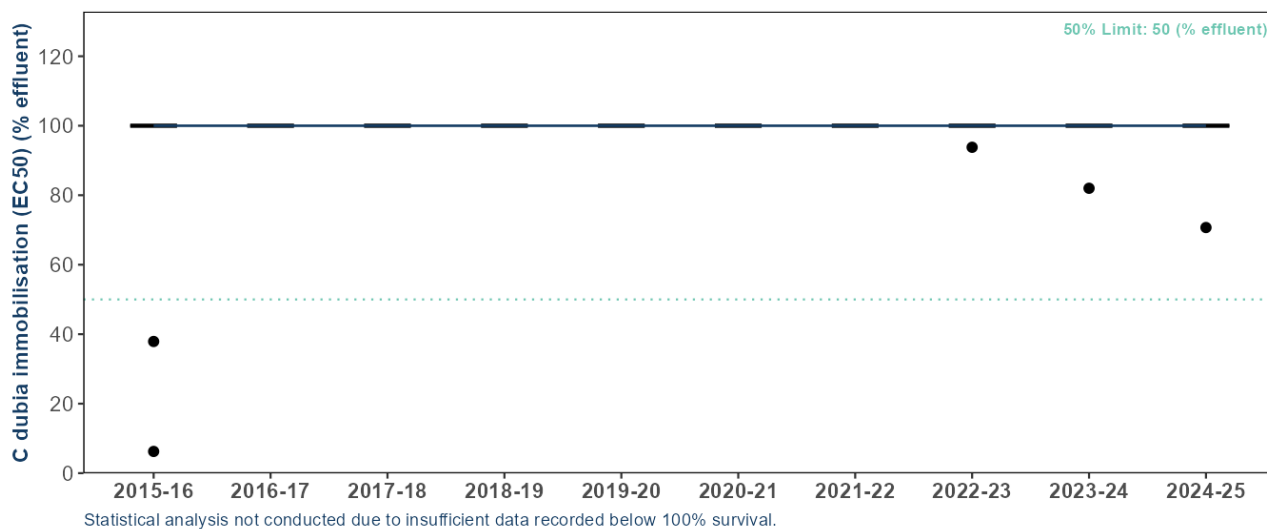
Other chemicals and organics (including pesticides)

RS0004 at Riverstone WRRF



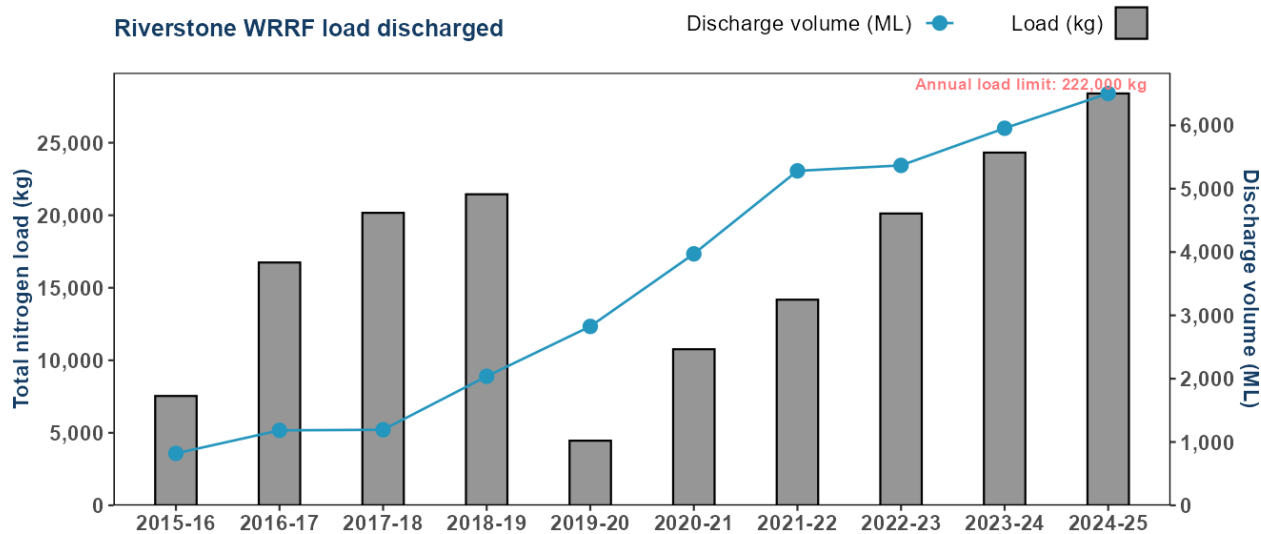
A.10.3. Pressure – Wastewater toxicity

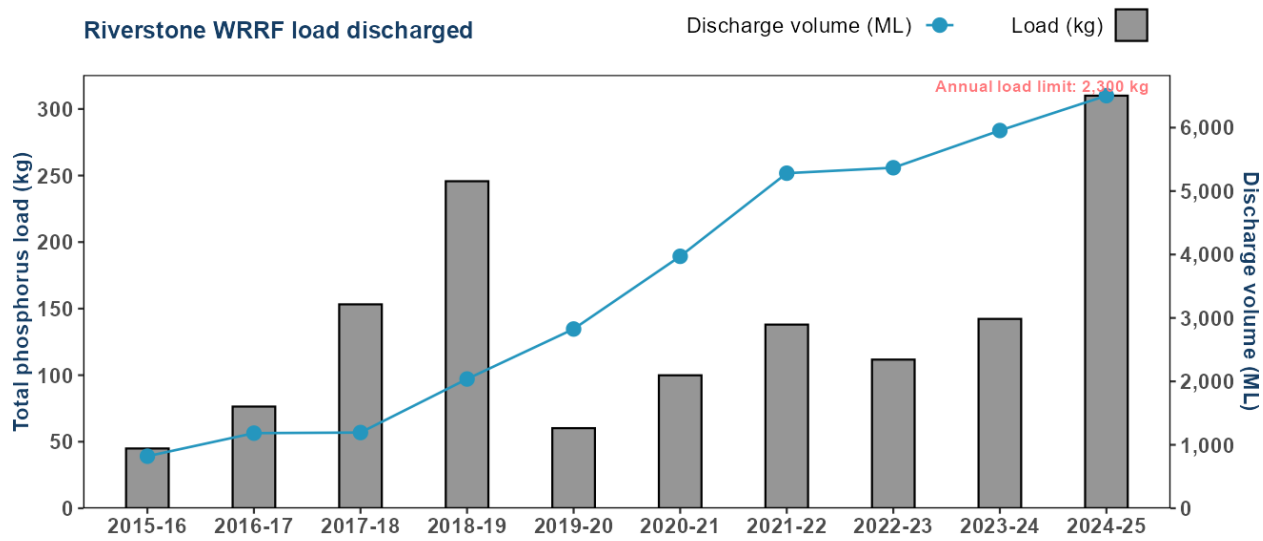
RS0004 at Riverstone WRRF



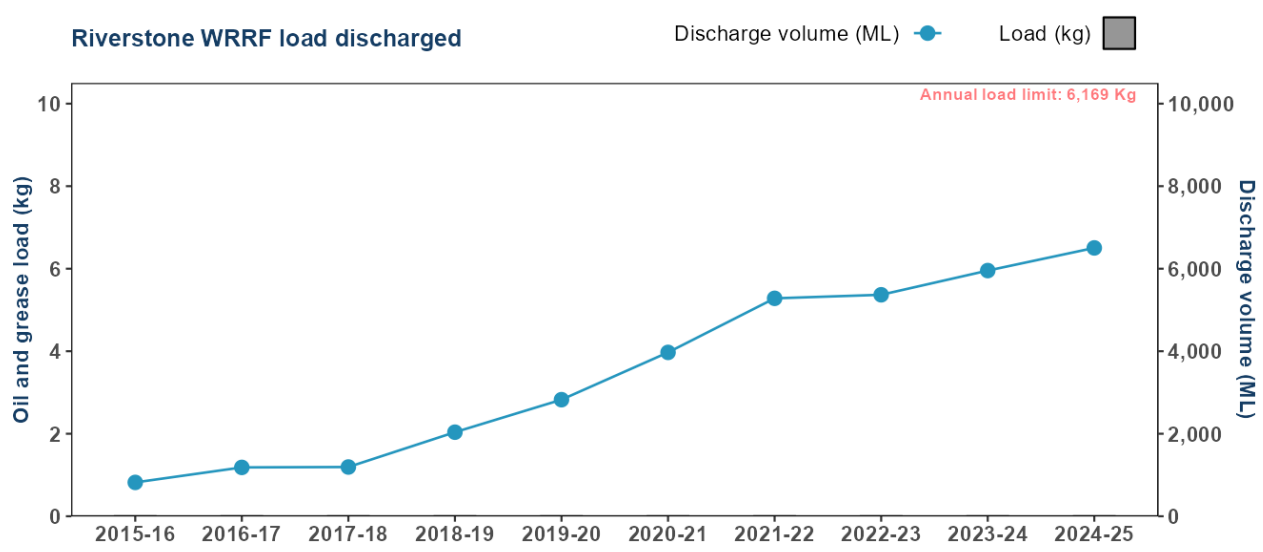
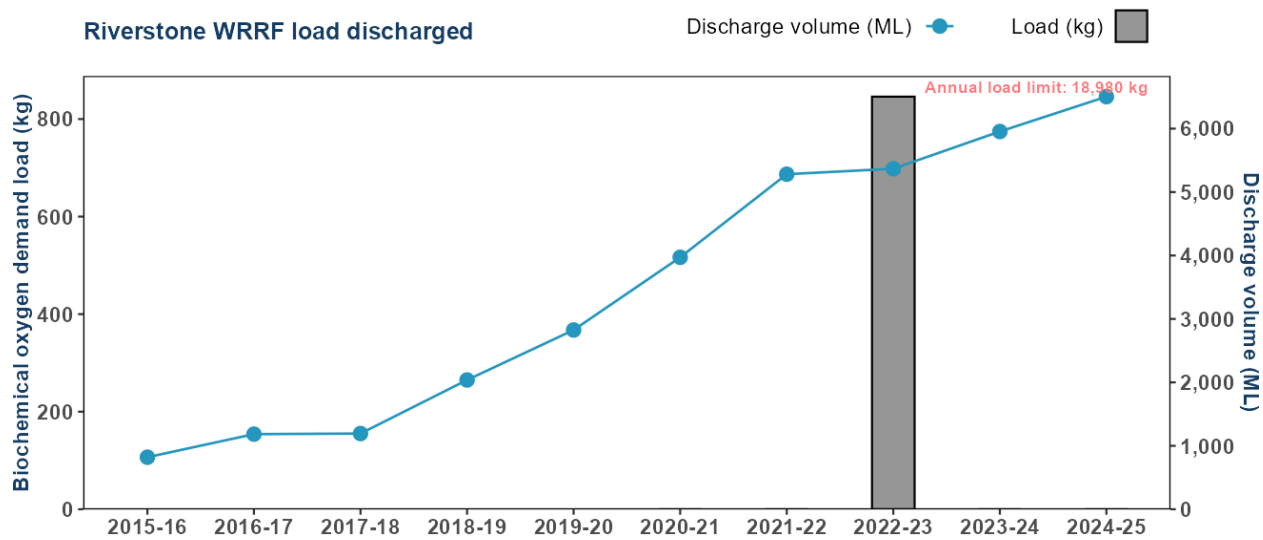
A.10.4. Pressure – Wastewater discharge load

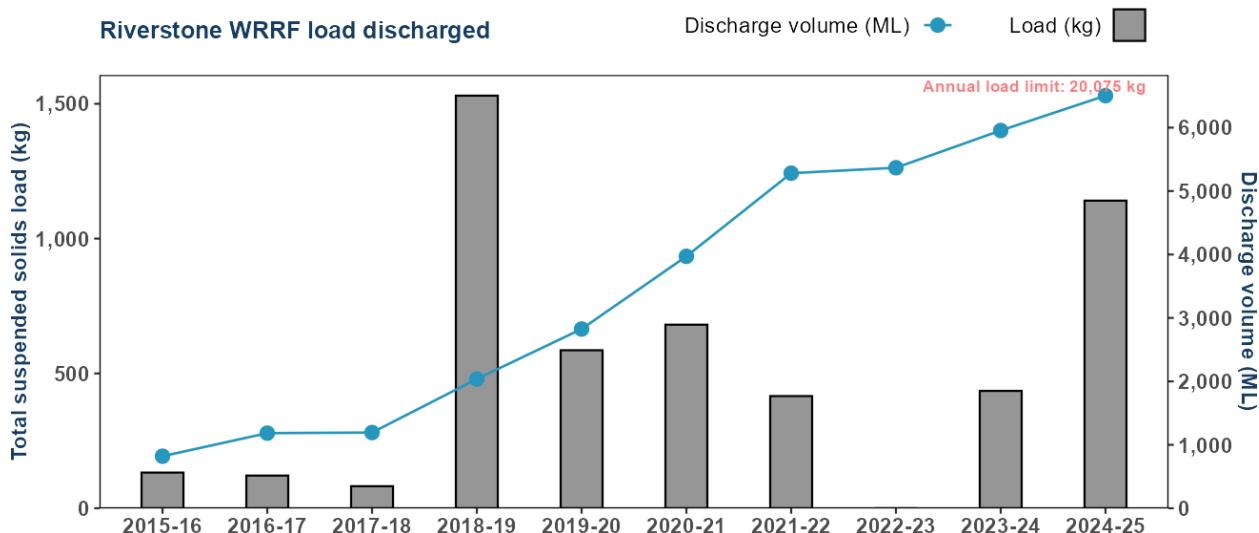
Nutrients





Major conventional analytes





A.10.5. Stressor – Statistical analysis outcomes

Table A-104 Upstream vs downstream comparison (2024-25 reporting period) for Eastern Creek at Riverstone WRRF

Eastern Creek at Riverstone WRRF: NS082 vs NS081 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.82	0.21	187	-0.77	0.869
Oxidised nitrogen	1.36	0.27	187	1.59	0.387
Total nitrogen	1.22	0.14	187	1.66	0.348
Soluble reactive phosphorus	0.86	0.12	64	-1.05	0.723
Total phosphorus	0.81	0.11	187	-1.47	0.457
Physico-chemical					
Conductivity	1.01	0.10	187	0.05	>0.999
Dissolved oxygen	1.00	0.05	185	0.00	>0.999
Dissolved oxygen saturation	1.69	2.18	184	0.78	0.865
pH	0.04	0.07	183	0.51	0.956
Water temperature	1.06	0.09	187	0.67	0.907
Turbidity	0.78	0.16	185	-1.18	0.639
Trace Metals					
Filterable aluminium	2.13	0.29	64	5.48	<0.001
Total aluminium	0.75	0.14	64	-1.57	0.402
Filterable cobalt	0.93	0.10	64	-0.68	0.906
Total cobalt	0.82	0.07	64	-2.29	0.112
Filterable copper	0.95	0.06	64	-0.80	0.855
Total copper	0.84	0.08	64	-1.83	0.271
Filterable nickel	1.13	0.10	64	1.38	0.517
Total nickel	1.04	0.08	64	0.48	0.964
Filterable zinc	1.26	0.16	59	1.86	0.255
Total zinc	0.94	0.12	64	-0.49	0.961

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-105 Upstream current period (2024-25) vs previous period comparison (single site) for Eastern Creek at Riverstone WRRF

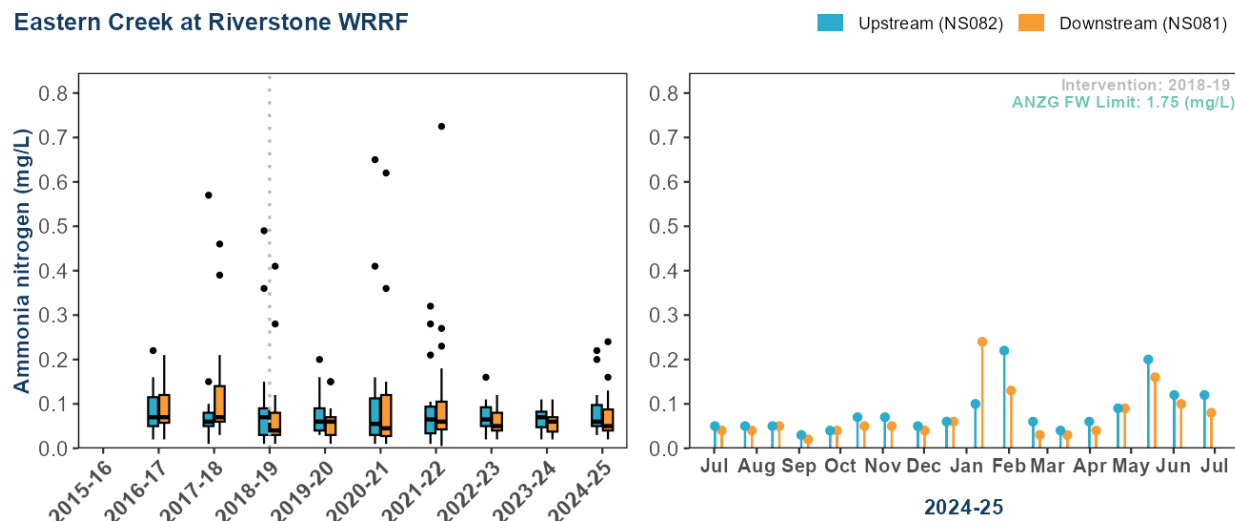
Eastern Creek at Riverstone WRRF: NS082 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.13	0.23	187	0.60	0.931
Oxidised nitrogen	1.14	0.17	187	0.88	0.814
Total nitrogen	1.06	0.10	187	0.59	0.935
Soluble reactive phosphorus	0.62	0.09	64	-3.36	0.007
Total phosphorus	0.91	0.10	187	-0.84	0.834
Physico-chemical					
Conductivity	1.09	0.09	187	1.09	0.698
Dissolved oxygen	1.02	0.04	185	0.54	0.950
Dissolved oxygen saturation	3.11	1.71	184	1.82	0.266
pH	-0.01	0.05	183	-0.22	0.996
Water temperature	1.05	0.07	187	0.76	0.872
Turbidity	0.79	0.13	185	-1.46	0.465
Trace Metals					
Filterable aluminium	1.06	0.15	64	0.43	0.974
Total aluminium	0.73	0.14	64	-1.62	0.372
Filterable cobalt	1.17	0.13	64	1.41	0.499
Total cobalt	0.97	0.09	64	-0.37	0.983
Filterable copper	0.83	0.06	64	-2.76	0.037
Total copper	0.84	0.08	64	-1.81	0.278
Filterable nickel	1.02	0.10	64	0.24	0.995
Total nickel	0.95	0.08	64	-0.66	0.911
Filterable zinc	0.86	0.12	59	-1.14	0.668
Total zinc	0.80	0.10	64	-1.75	0.307
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-106 Downstream current period (2024-25) vs previous period comparison (single site) for Eastern Creek at Riverstone WRRF

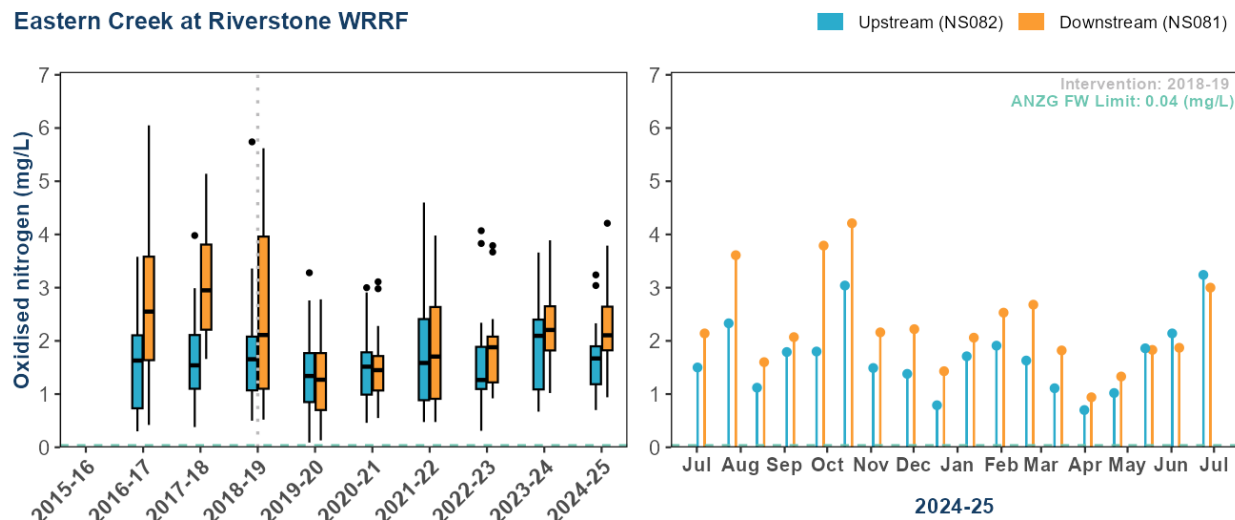
Eastern Creek at Riverstone WRRF: NS081 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.05	0.21	187	0.22	0.996
Oxidised nitrogen	1.40	0.21	187	2.22	0.120
Total nitrogen	1.23	0.11	187	2.27	0.108
Soluble reactive phosphorus	0.68	0.10	64	-2.67	0.046
Total phosphorus	0.89	0.10	187	-1.11	0.687
Physico-chemical					
Conductivity	1.04	0.08	187	0.47	0.965
Dissolved oxygen	1.01	0.04	185	0.17	0.998
Dissolved oxygen saturation	2.87	1.70	184	1.68	0.336
pH	0.00	0.05	183	0.05	>0.999
Water temperature	1.08	0.08	187	1.16	0.652
Turbidity	0.75	0.12	185	-1.77	0.292
Trace Metals					
Filterable aluminium	1.10	0.16	64	0.65	0.915
Total aluminium	0.70	0.13	64	-1.89	0.243
Filterable cobalt	1.04	0.12	64	0.31	0.990
Total cobalt	0.91	0.08	64	-1.08	0.703
Filterable copper	0.82	0.05	64	-3.06	0.017
Total copper	0.82	0.08	64	-2.02	0.193
Filterable nickel	0.98	0.09	64	-0.27	0.993
Total nickel	0.93	0.07	64	-0.87	0.822
Filterable zinc	0.92	0.13	59	-0.59	0.934
Total zinc	0.82	0.11	64	-1.52	0.433
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.10.6. Stressor – Nutrients

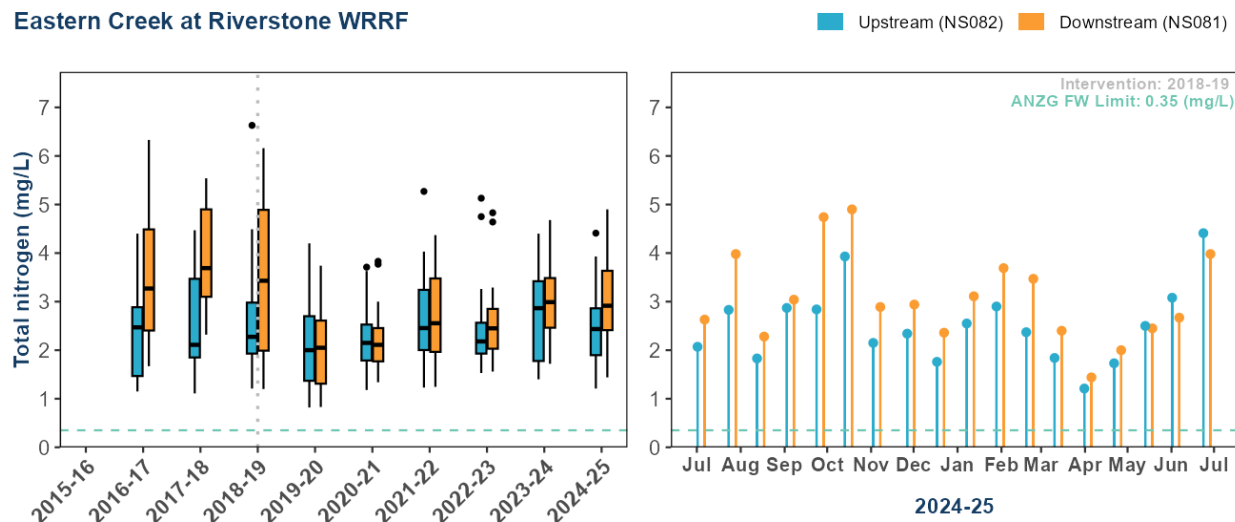
Eastern Creek at Riverstone WRRF



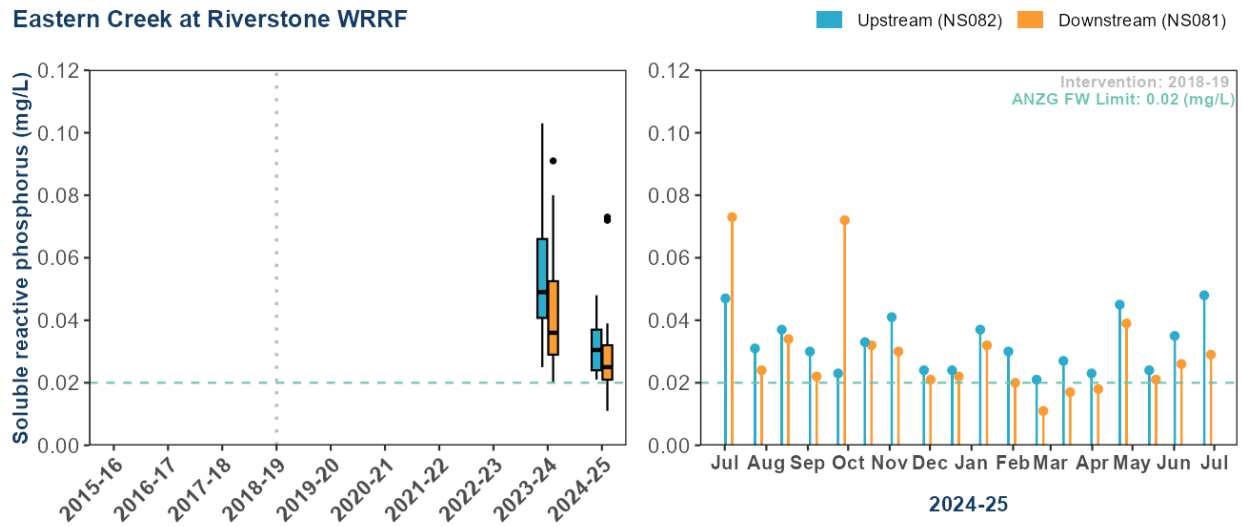
Eastern Creek at Riverstone WRRF



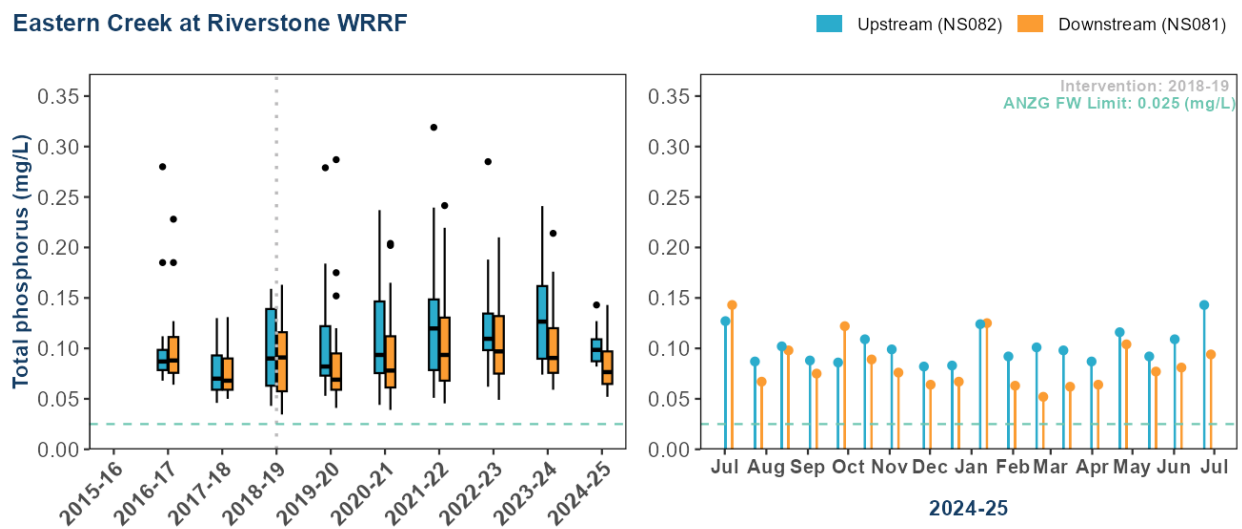
Eastern Creek at Riverstone WRRF



Eastern Creek at Riverstone WRRF

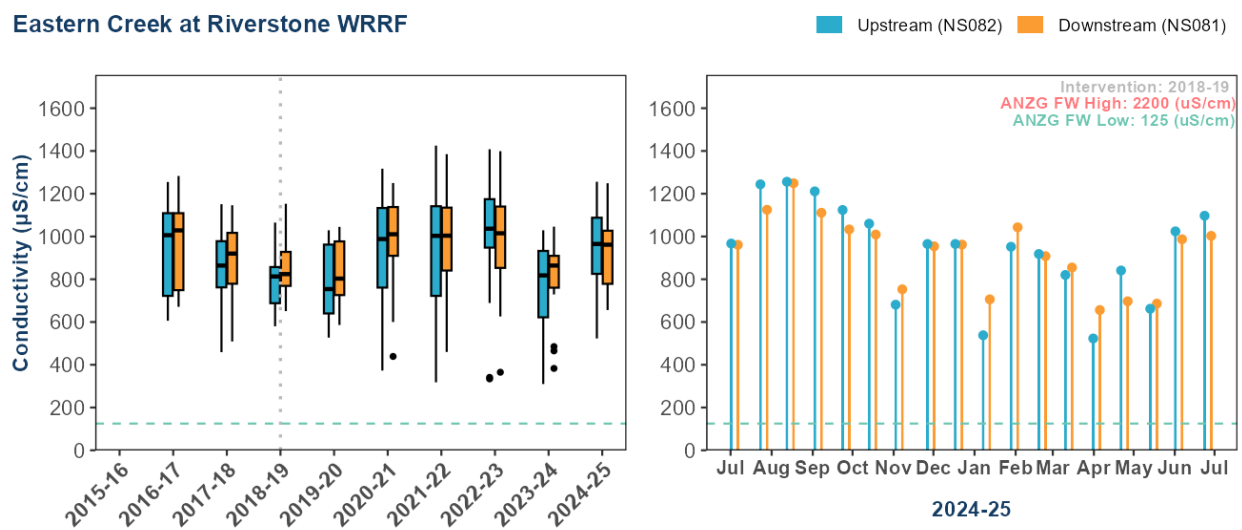


Eastern Creek at Riverstone WRRF

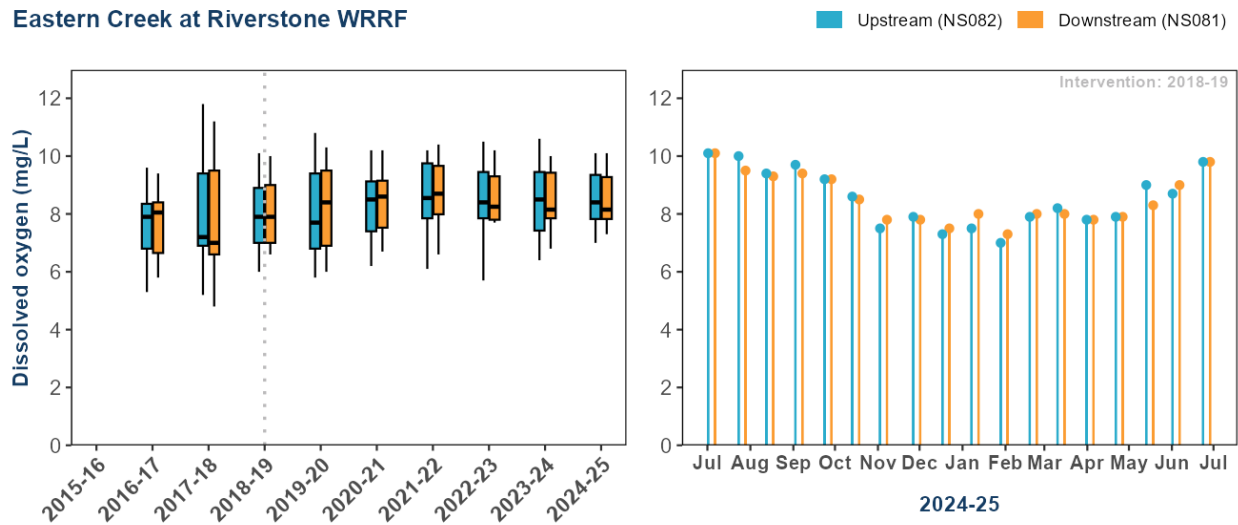


A.10.7. Stressor – Physico-chemical water quality

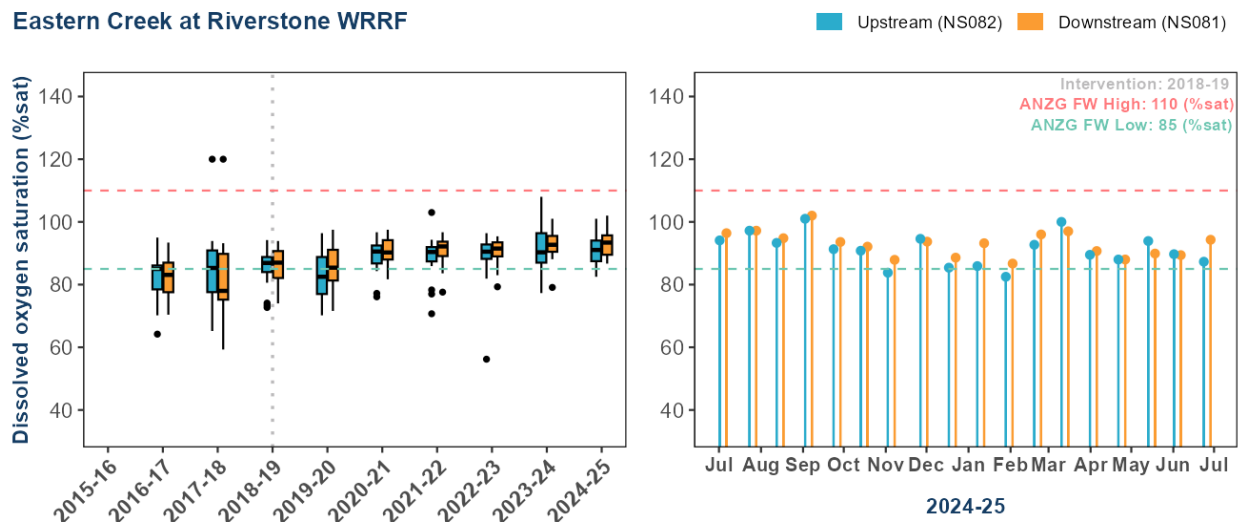
Eastern Creek at Riverstone WRRF



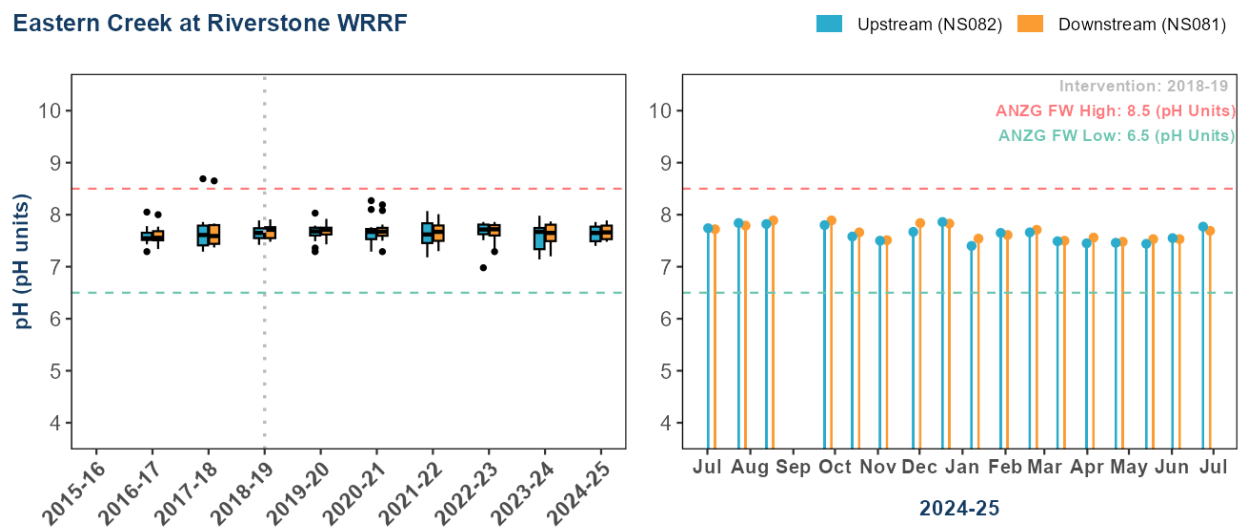
Eastern Creek at Riverstone WRRF



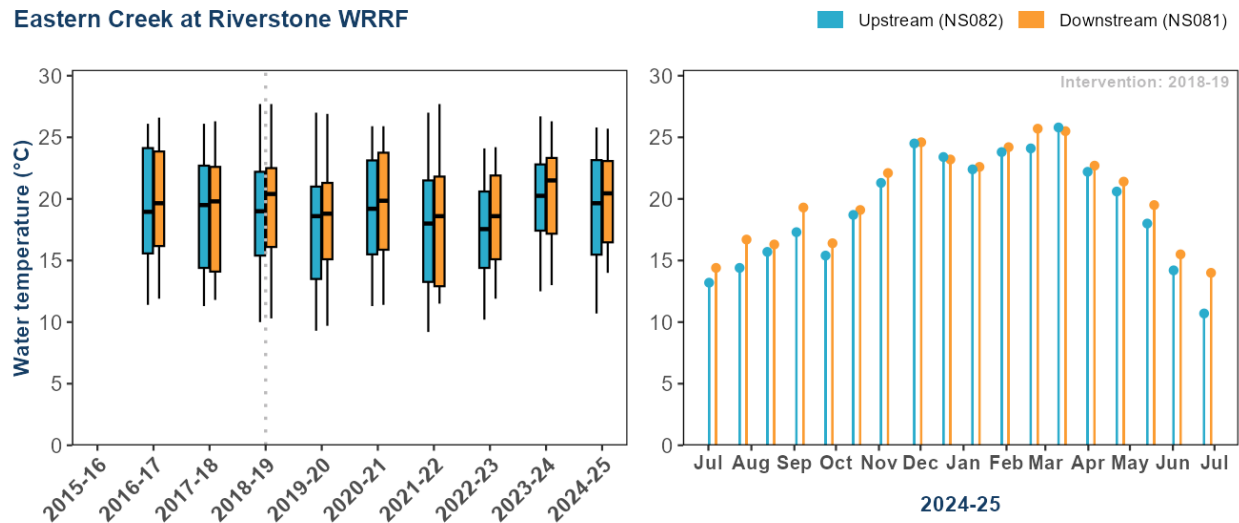
Eastern Creek at Riverstone WRRF



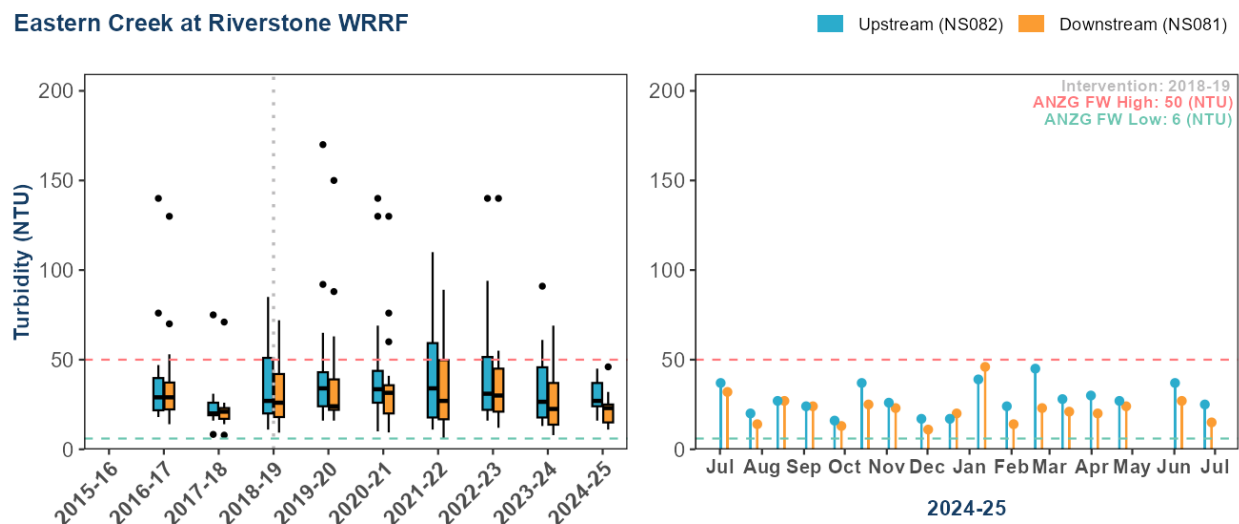
Eastern Creek at Riverstone WRRF



Eastern Creek at Riverstone WRRF

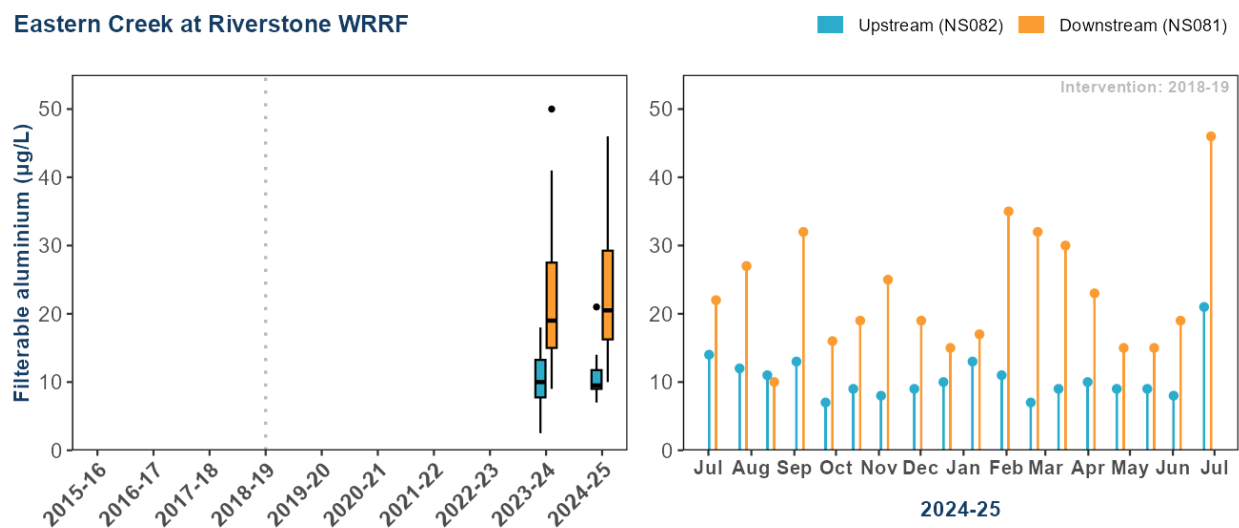


Eastern Creek at Riverstone WRRF

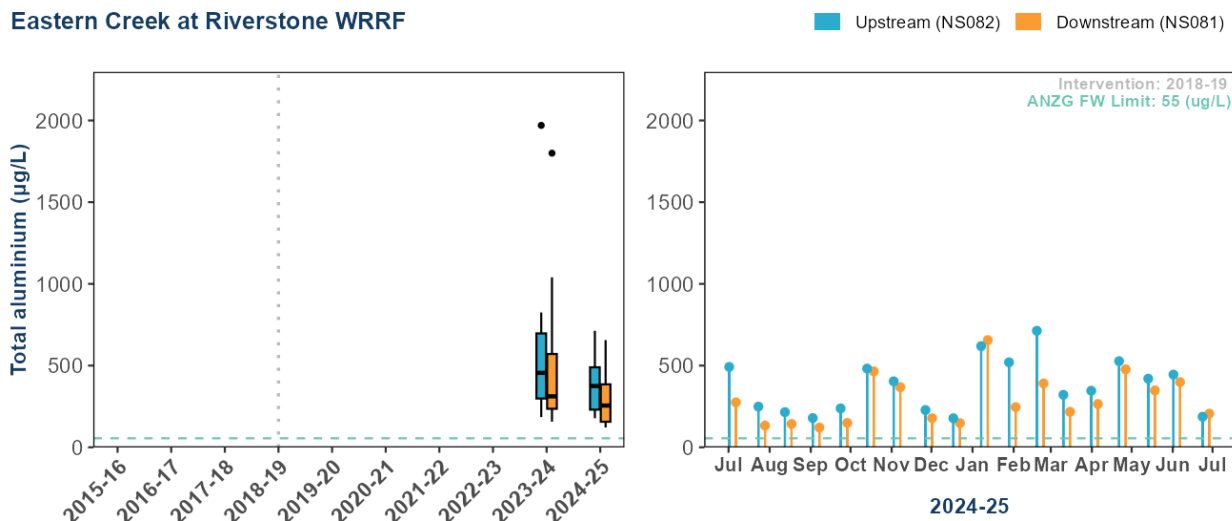


A.10.8. Stressor – Trace metals

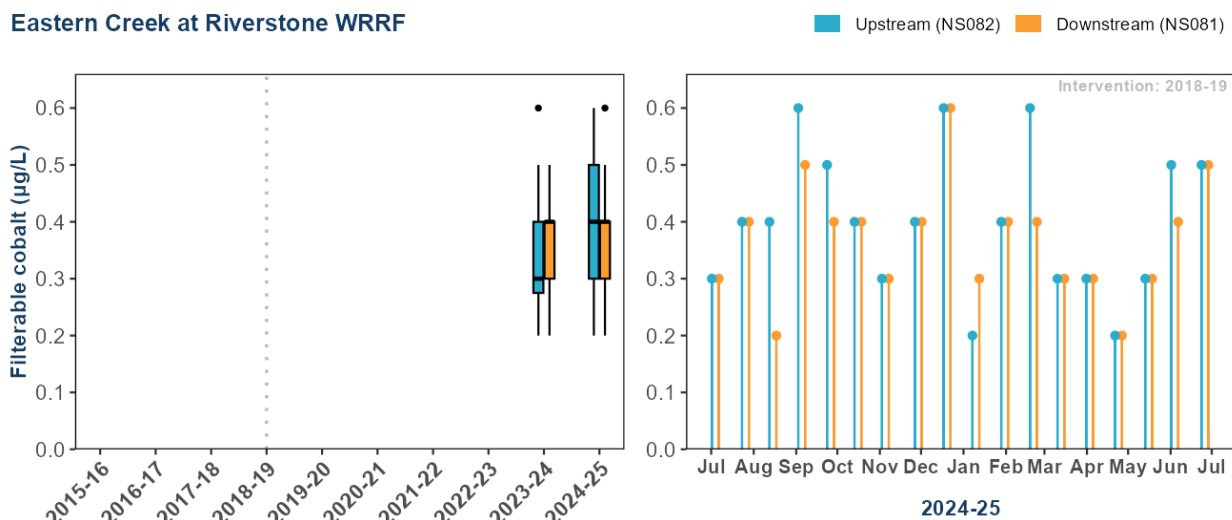
Eastern Creek at Riverstone WRRF



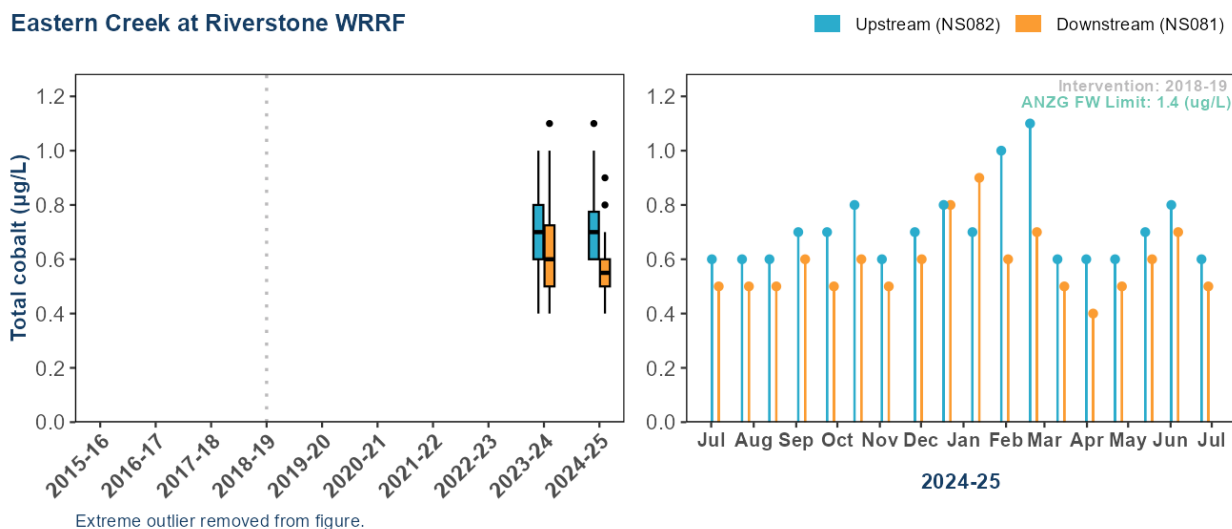
Eastern Creek at Riverstone WRRF



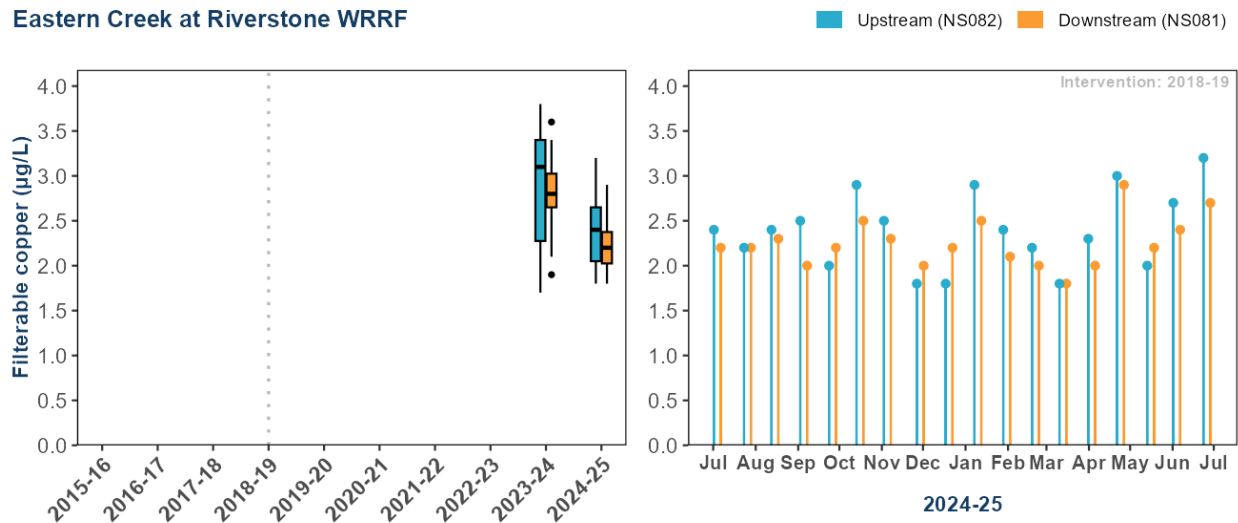
Eastern Creek at Riverstone WRRF



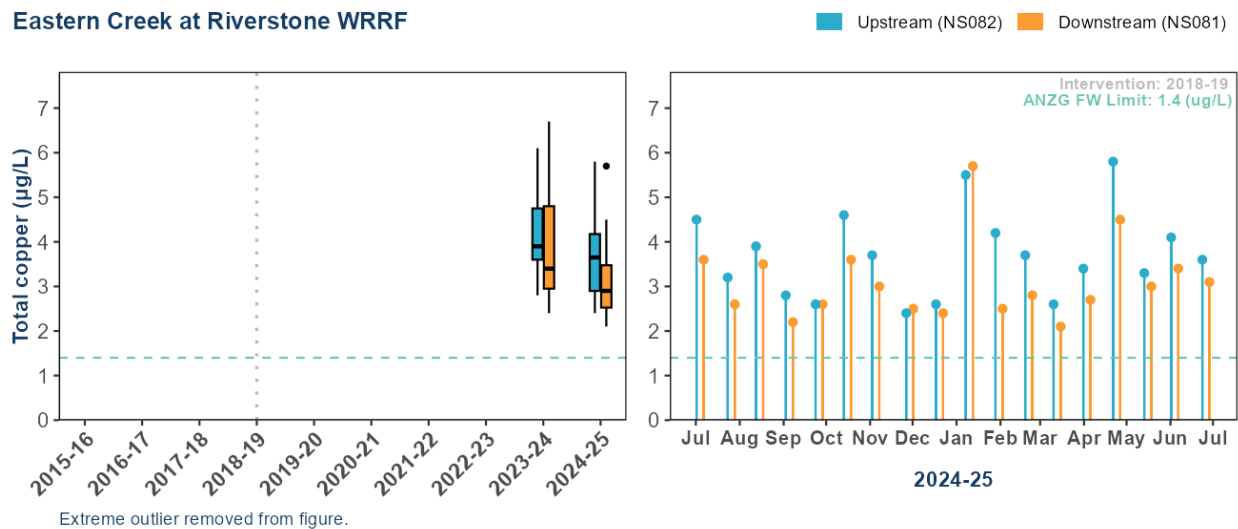
Eastern Creek at Riverstone WRRF



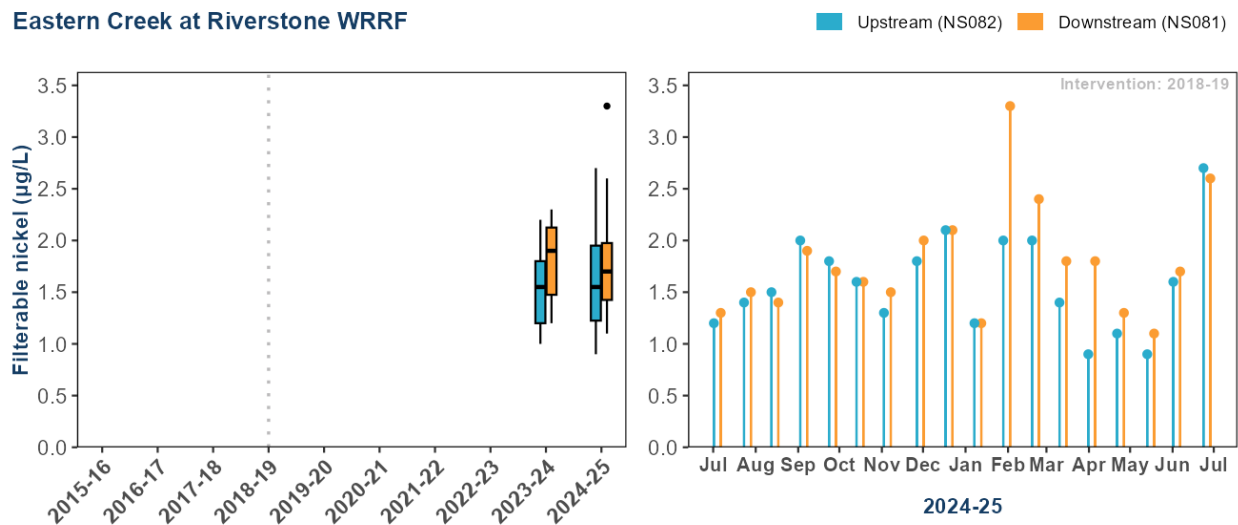
Eastern Creek at Riverstone WRRF



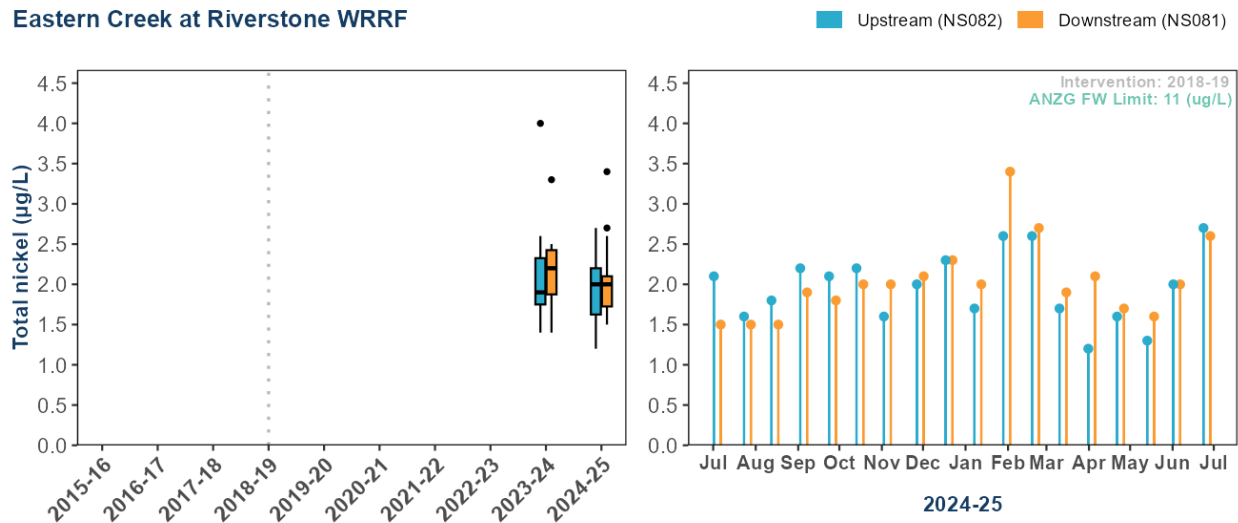
Eastern Creek at Riverstone WRRF



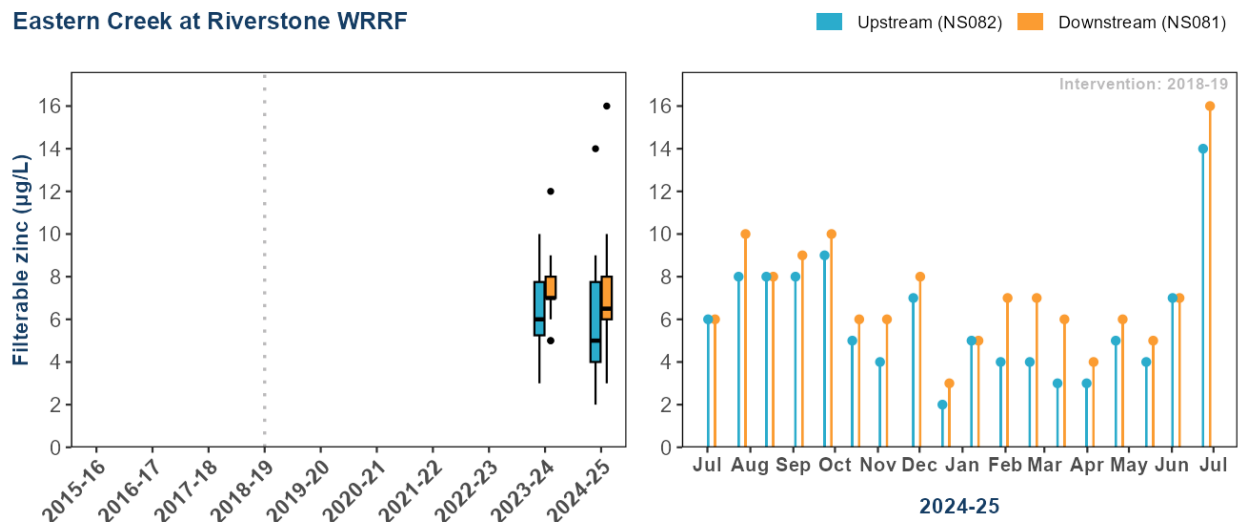
Eastern Creek at Riverstone WRRF



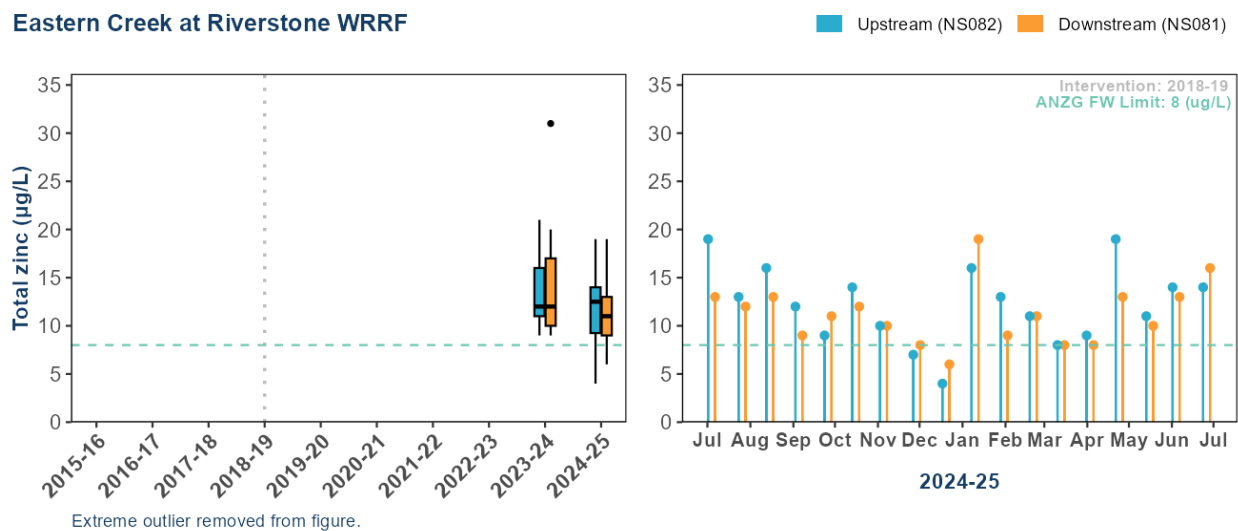
Eastern Creek at Riverstone WRRF



Eastern Creek at Riverstone WRRF



Eastern Creek at Riverstone WRRF



A.10.9. Ecosystem receptor – Statistical analysis outcomes

Table A-107 Upstream vs downstream comparison (2024-25 reporting period) for Eastern Creek at Riverstone WRRF

Eastern Creek at Riverstone WRRF: NS082 vs NS081 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.79	0.24	187	-0.77	0.870
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-108 Upstream current period (2024-25) vs previous period comparison (single site) for Eastern Creek at Riverstone WRRF

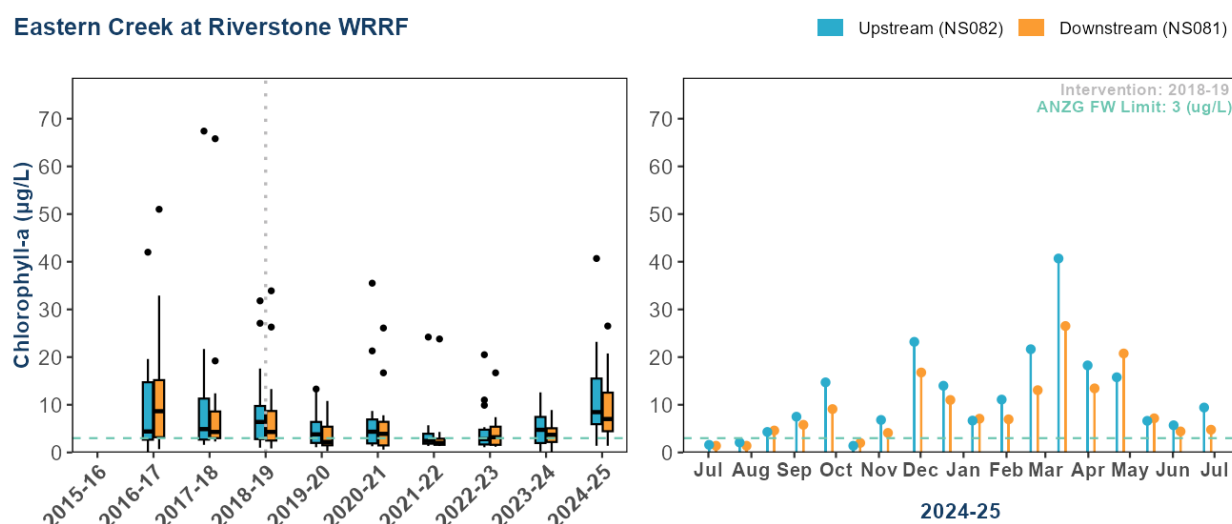
Eastern Creek at Riverstone WRRF: NS082 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	2.36	0.56	187	3.63	0.002
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-109 Downstream current period (2024-25) vs previous period comparison (single site) for Eastern Creek at Riverstone WRRF

Eastern Creek at Riverstone WRRF: NS081 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	2.31	0.55	187	3.56	0.003
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.10.10. Ecosystem receptor – Phytoplankton

Eastern Creek at Riverstone WRRF

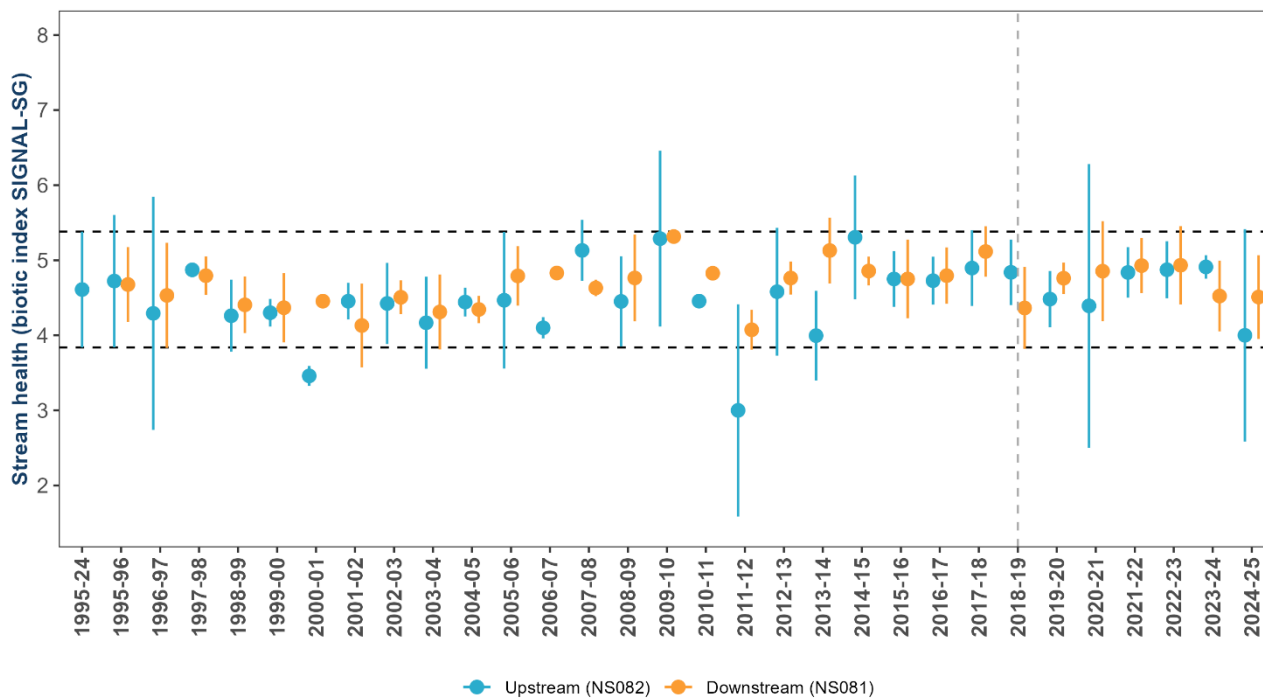


A.10.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Eastern Creek	River (NS082 vs NS081)	Welch Two Sample t-test	-0.51	-0.49	1.2	0.701

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Eastern Creek at Riverstone WRRF

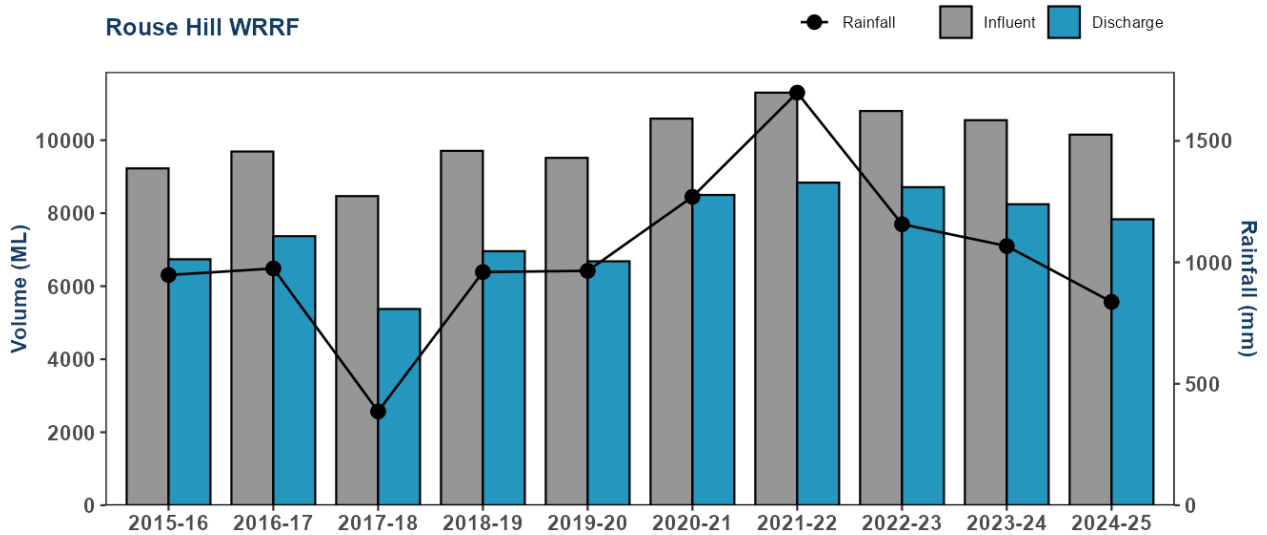


The range of stream health recorded over each period is represented by length of line

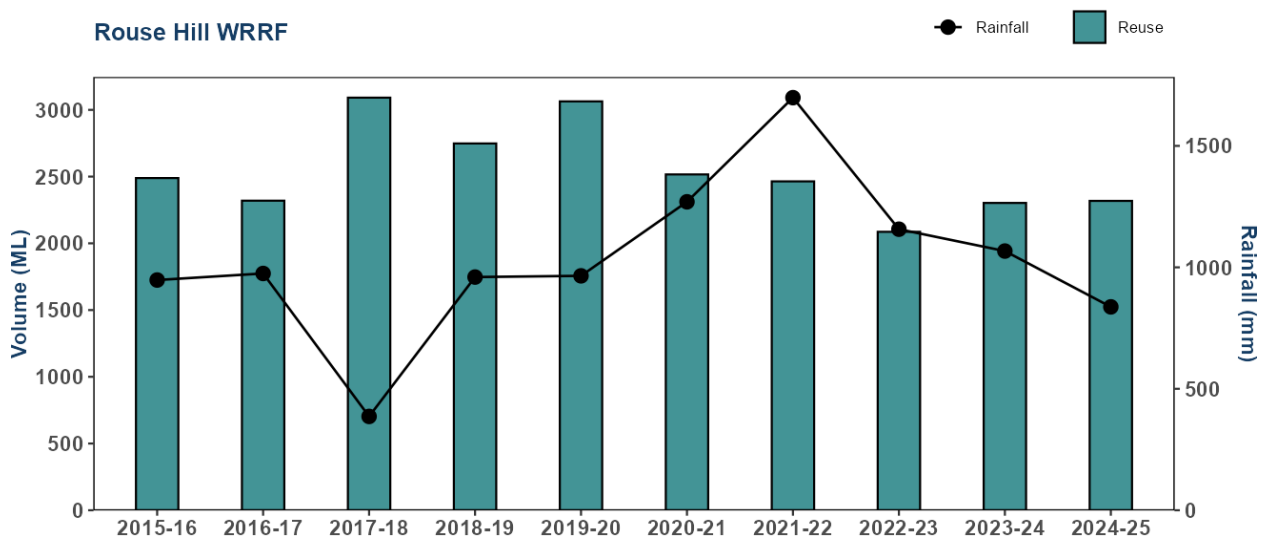
A.11. Rouse Hill WRRF

A.11.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



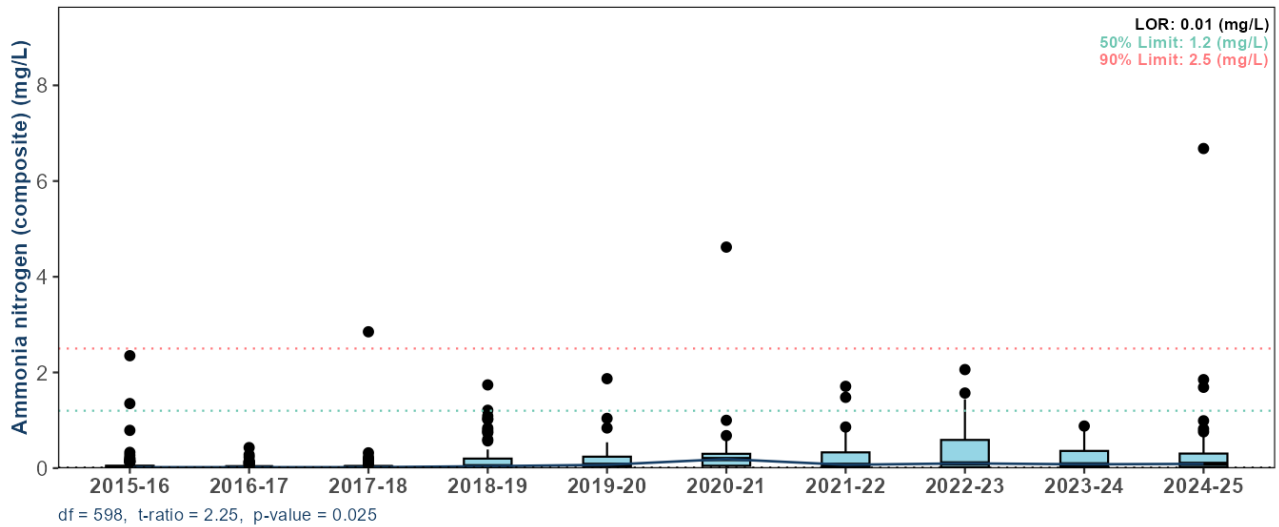
Reuse volume and rainfall



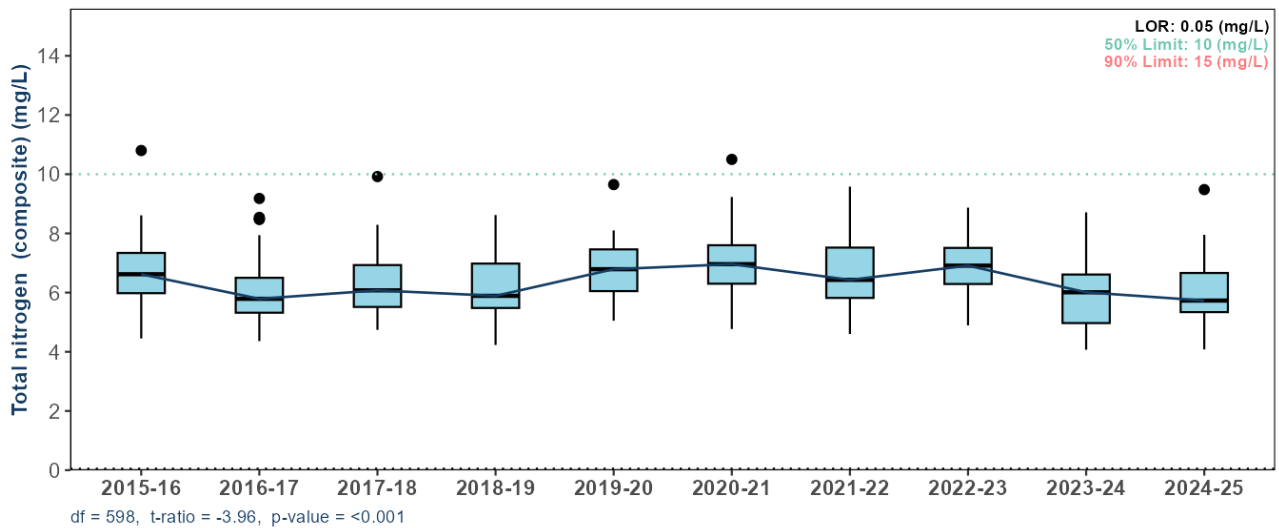
A.11.2. Pressure – Wastewater quality

Nutrients

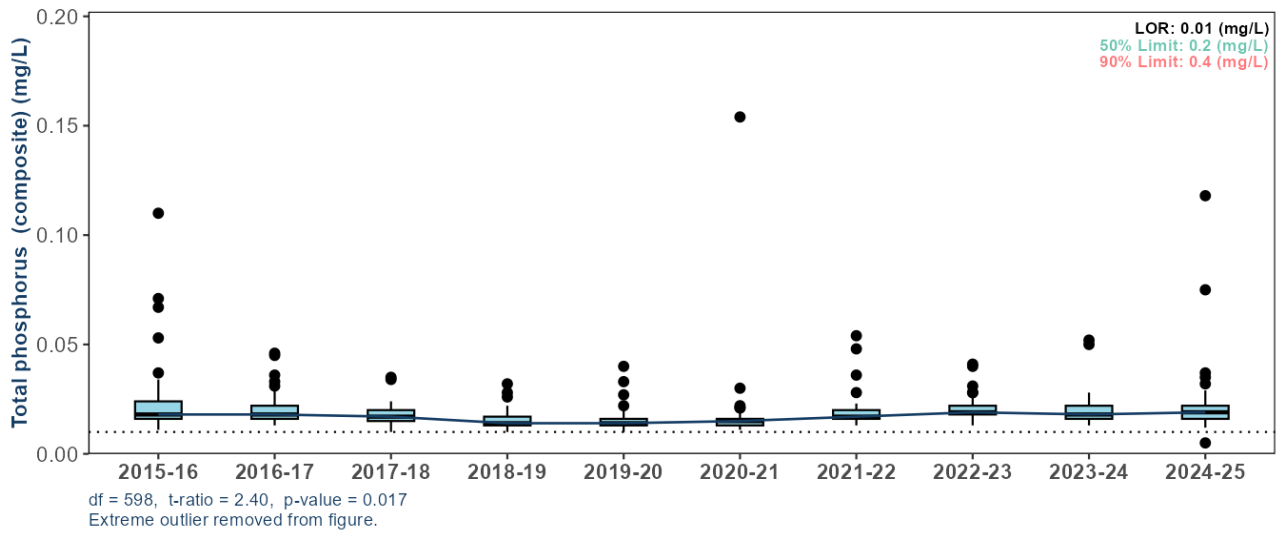
RH0004 at Rouse Hill WRRF



RH0004 at Rouse Hill WRRF

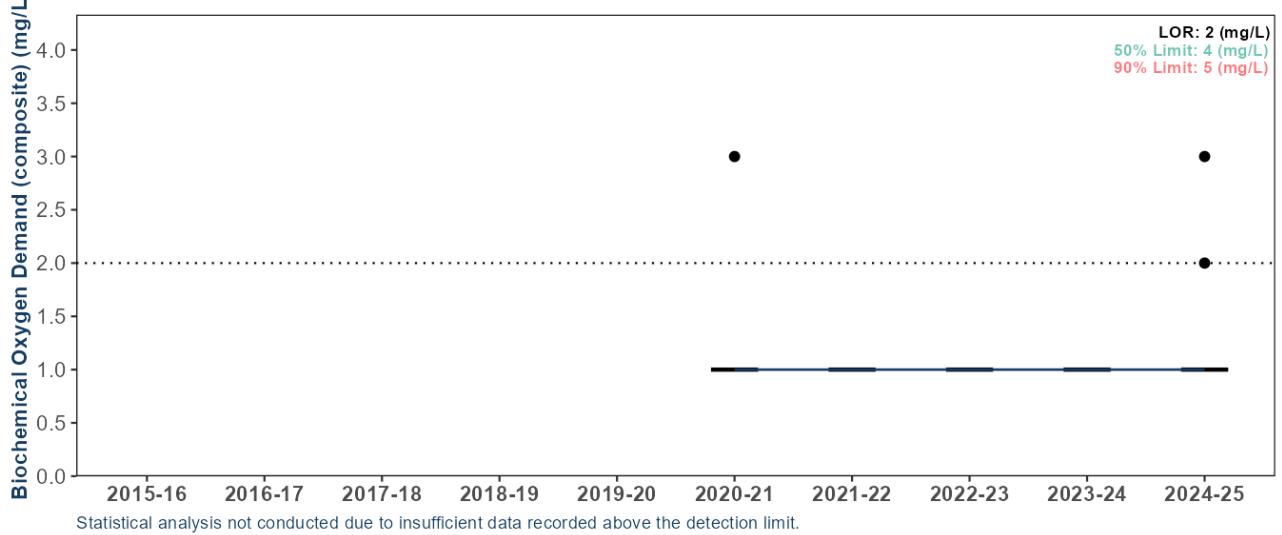


RH0004 at Rouse Hill WRRF

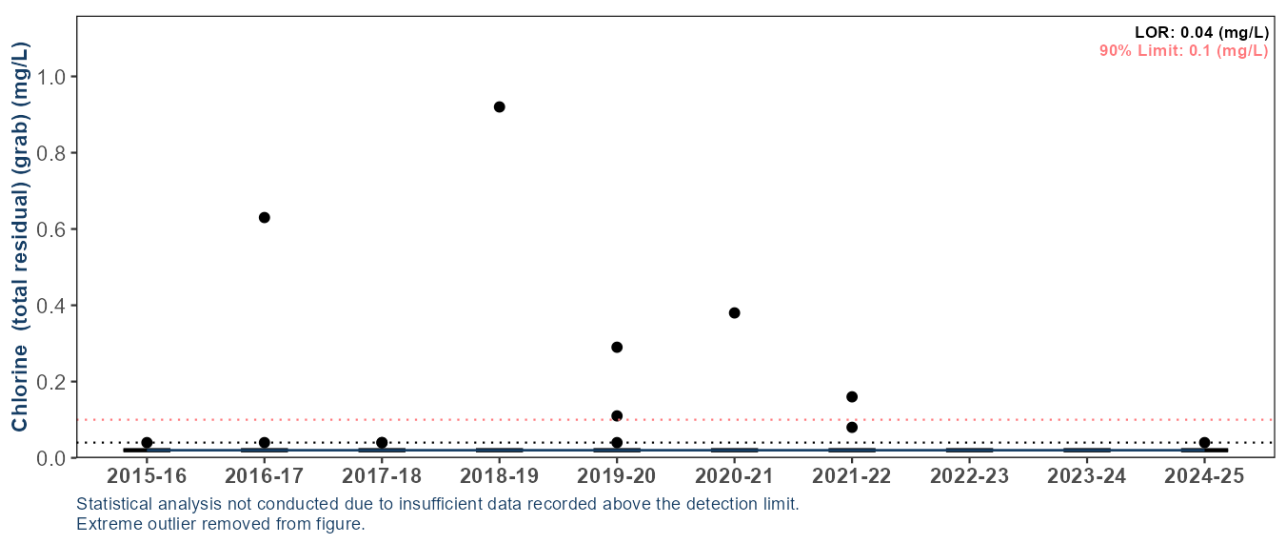


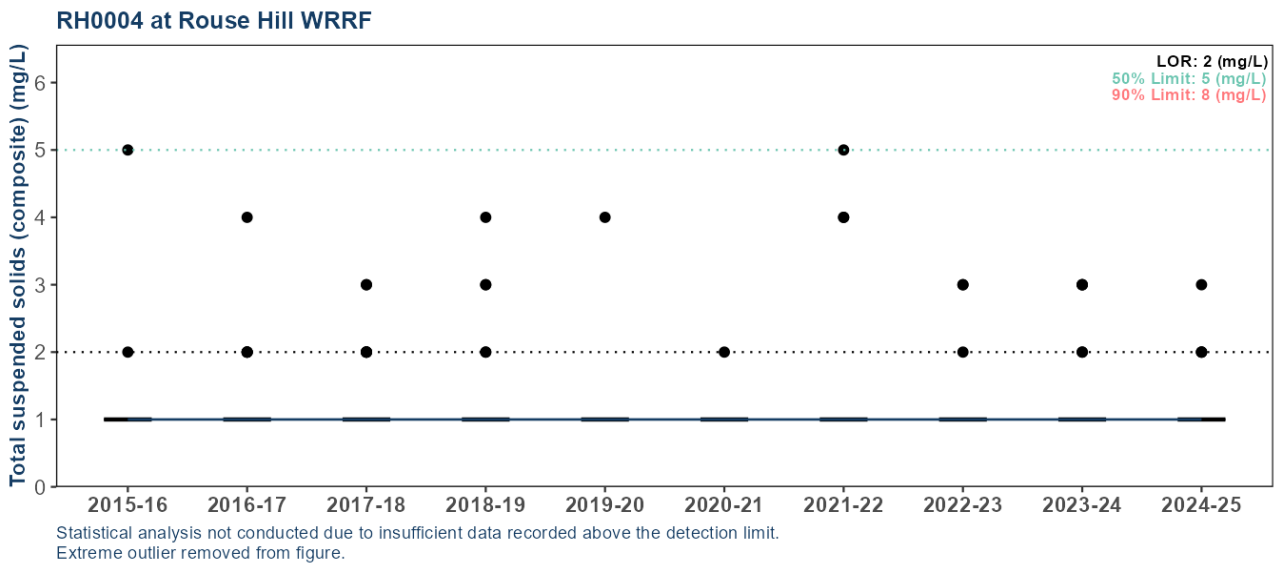
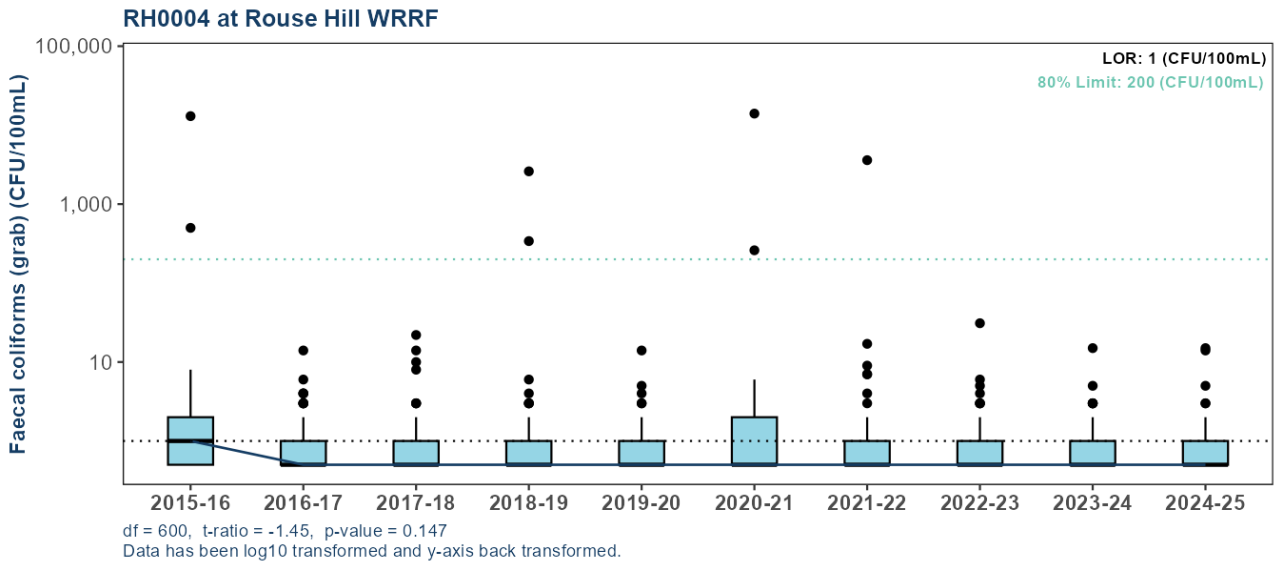
Major conventional analytes

RH0004 at Rouse Hill WRRF

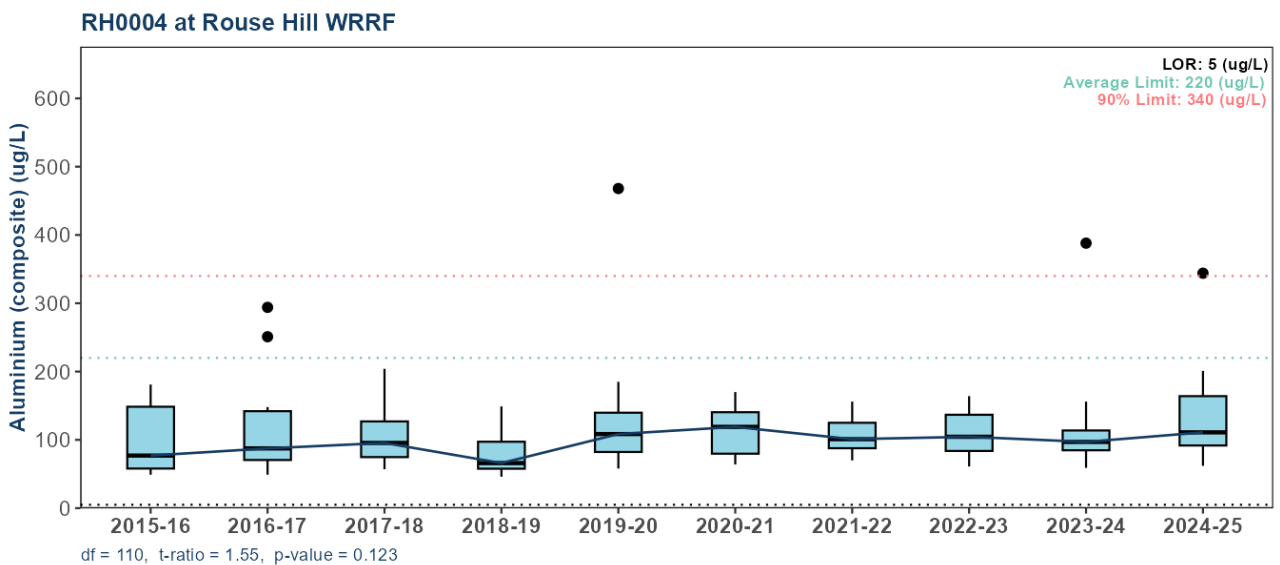


RH0004 at Rouse Hill WRRF

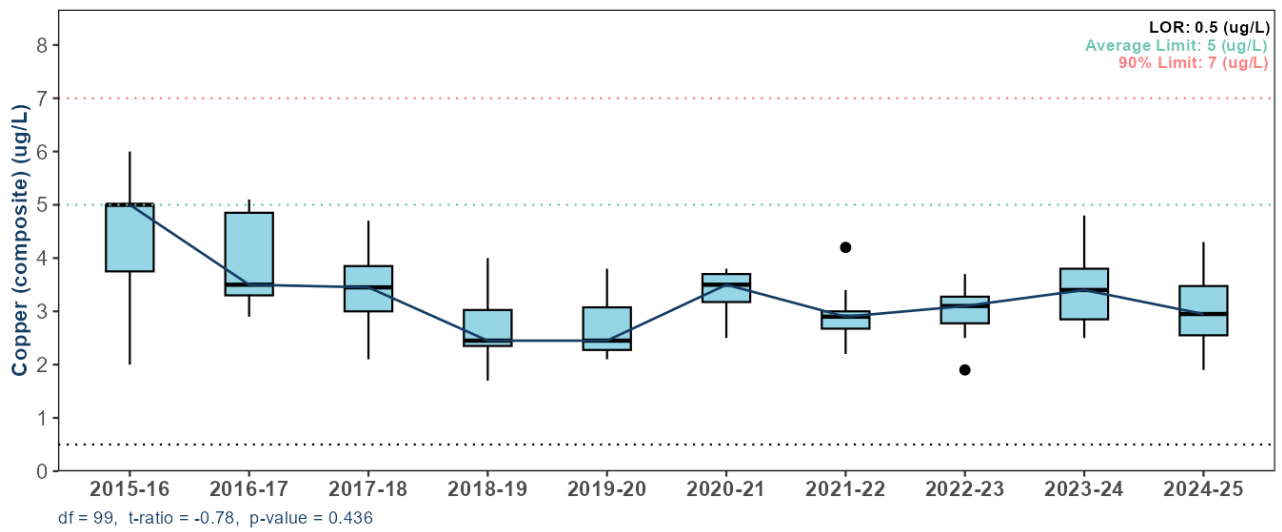




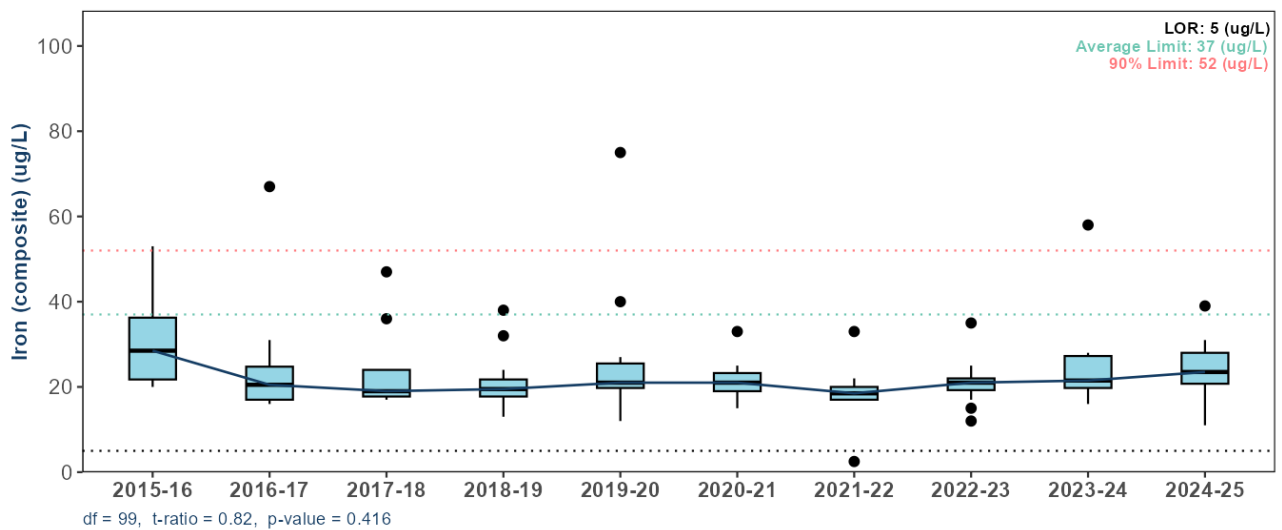
Trace metals



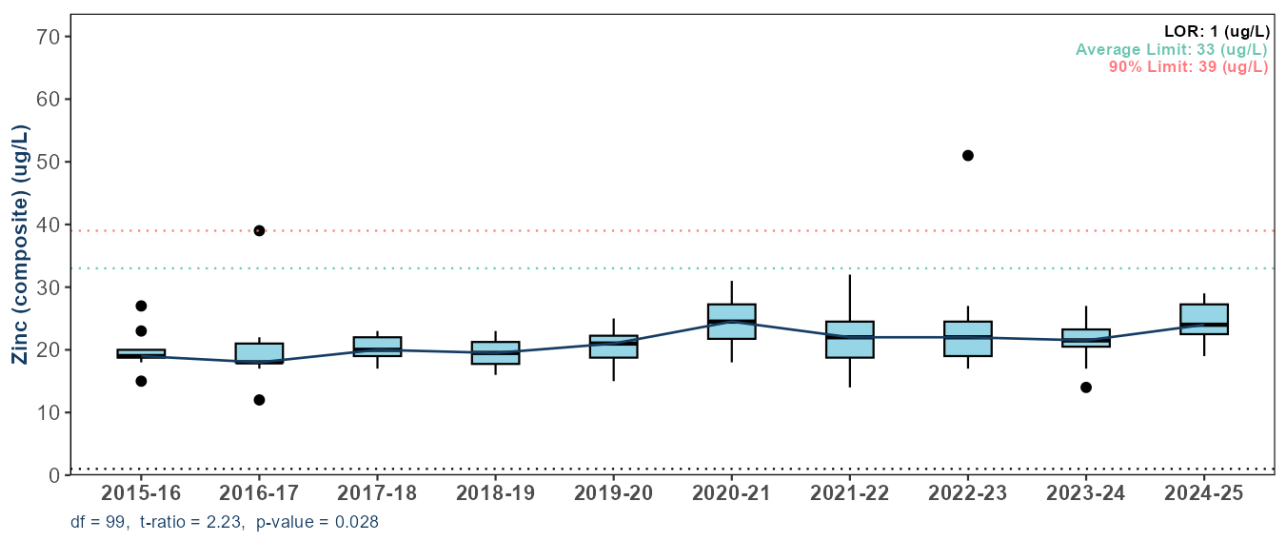
RH0004 at Rouse Hill WRRF



RH0004 at Rouse Hill WRRF

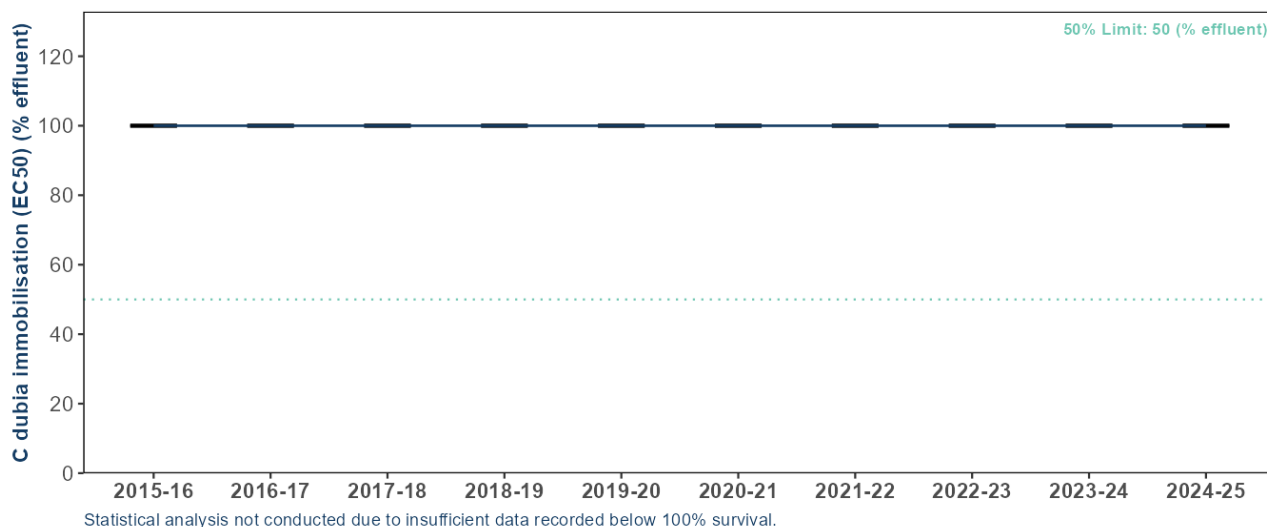


RH0004 at Rouse Hill WRRF



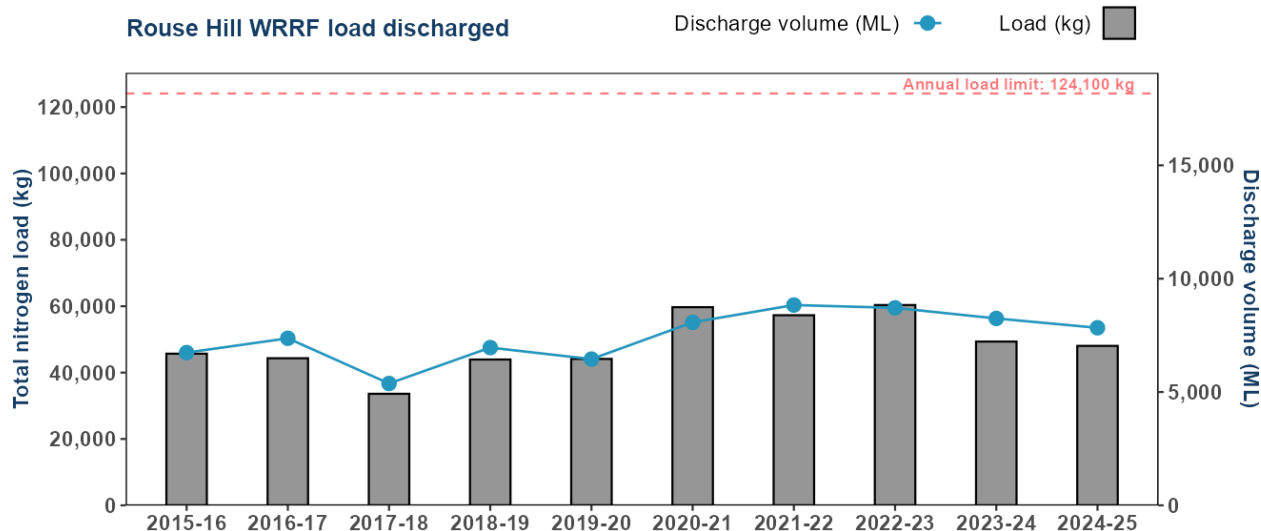
A.11.3. Pressure – Wastewater toxicity

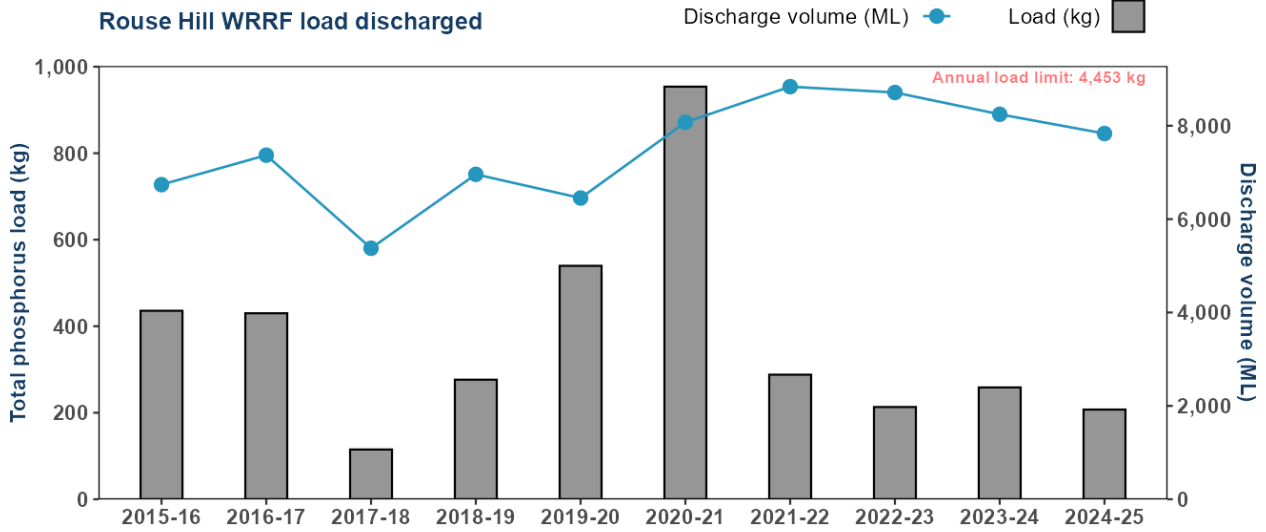
RH0004 at Rouse Hill WRRF



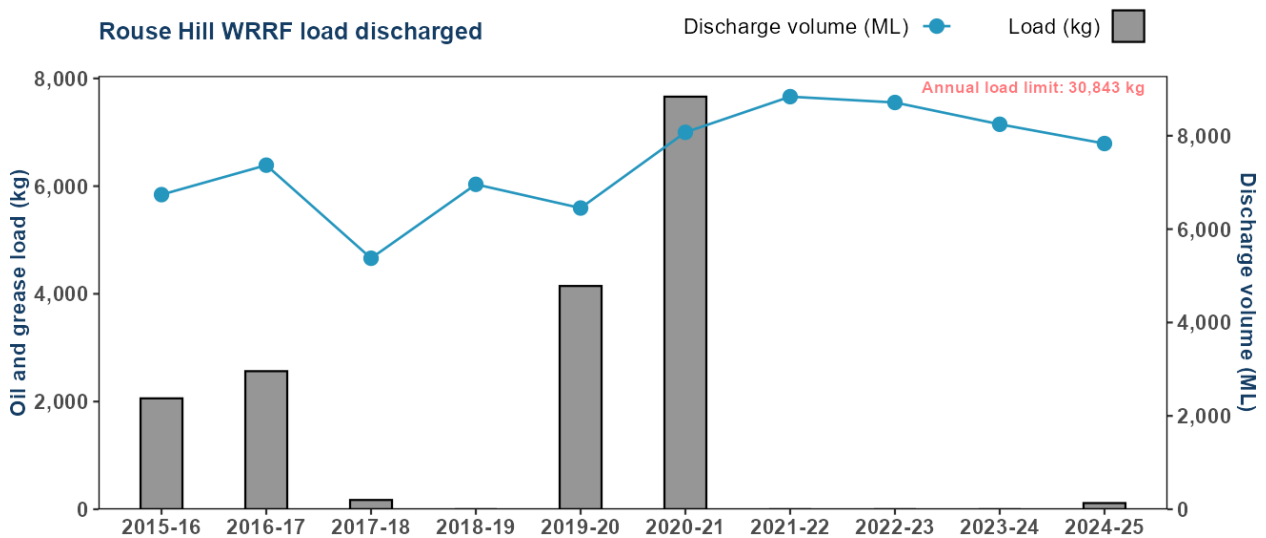
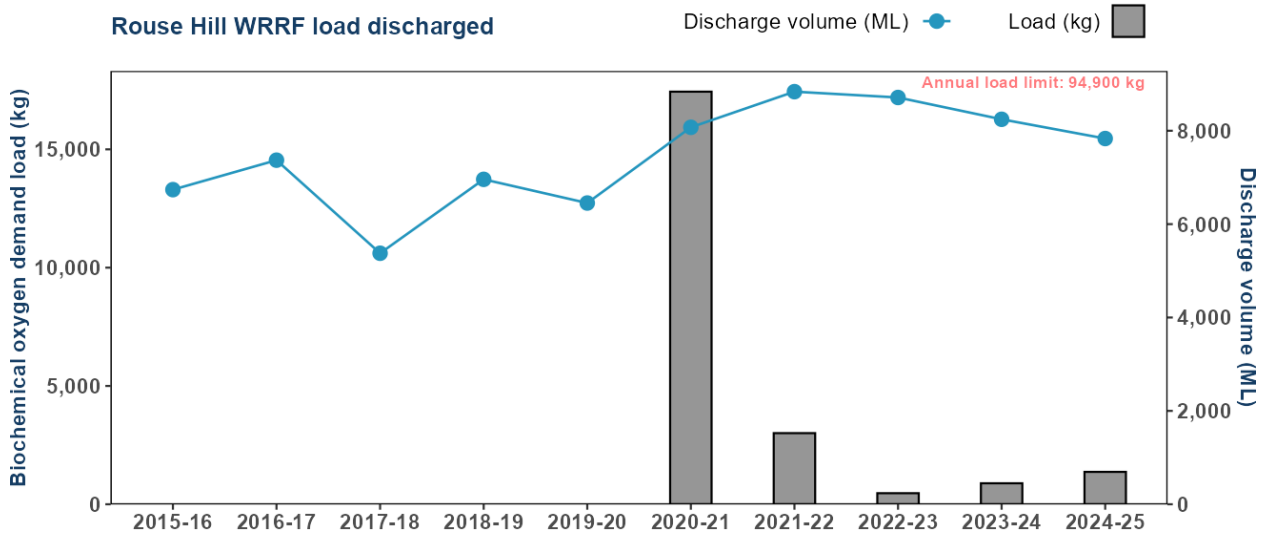
A.11.4. Pressure – Wastewater discharge load

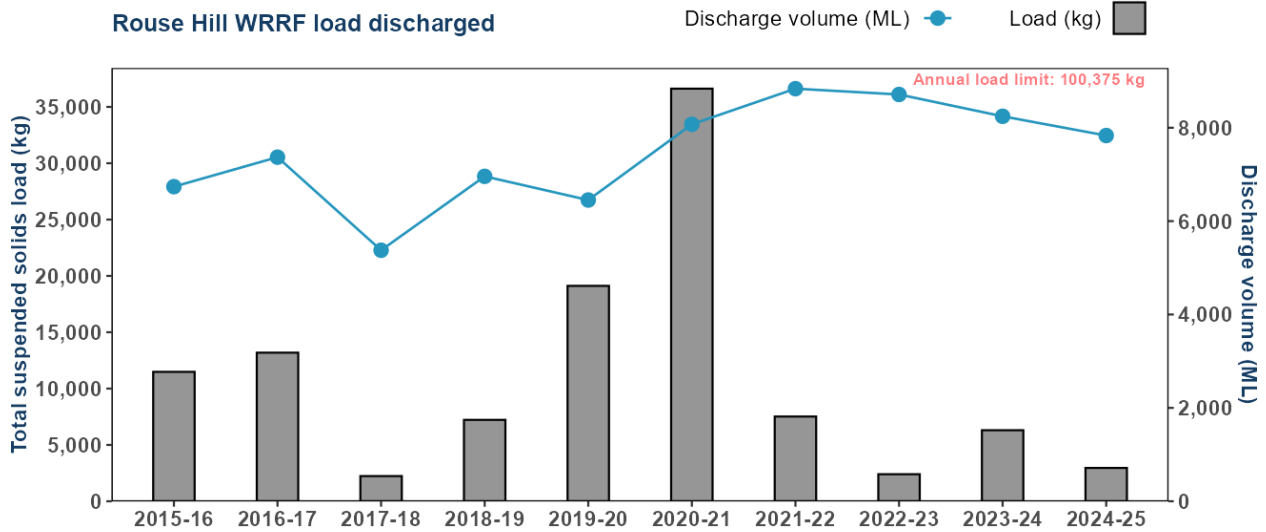
Nutrients





Major conventional analytes





A.11.5. Stressor – Statistical analysis outcomes

Table A-110 Upstream vs downstream comparison (2024-25 reporting period) for Second Ponds Creek at Rouse Hill WRRF

Second Ponds Creek at Rouse Hill WRRF: NC53 vs NC516 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	5.13	1.38	162	6.09	<0.001
Oxidised nitrogen	27.03	8.21	162	10.86	<0.001
Total nitrogen	6.27	0.68	162	16.92	<0.001
Soluble reactive phosphorus	0.29	0.07	65	-5.21	<0.001
Total phosphorus	0.65	0.10	162	-2.77	0.031
Physico-chemical					
Conductivity	0.88	0.08	162	-1.47	0.460
Dissolved oxygen	1.27	0.08	162	3.60	0.002
Dissolved oxygen saturation	23.20	3.27	161	7.09	<0.001
pH	-0.07	0.05	162	-1.46	0.463
Water temperature	1.22	0.10	162	2.44	0.074
Turbidity	0.93	0.27	162	-0.27	0.993
Trace Metals					
Filterable aluminium	7.38	1.40	65	10.54	<0.001
Total aluminium	1.85	0.44	65	2.55	0.062
Filterable cobalt	2.13	0.27	65	5.92	<0.001
Total cobalt	1.75	0.21	65	4.70	<0.001
Filterable copper	1.21	0.14	65	1.72	0.323
Total copper	1.15	0.14	65	1.21	0.621
Filterable nickel	1.45	0.18	65	3.02	0.019
Total nickel	1.32	0.17	65	2.13	0.155
Filterable zinc	4.30	0.58	65	10.78	<0.001
Total zinc	3.69	0.54	65	9.02	<0.001

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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Table A-111 Upstream current period (2024-25) vs previous period comparison (single site) for Second Ponds Creek at Rouse Hill WRRF

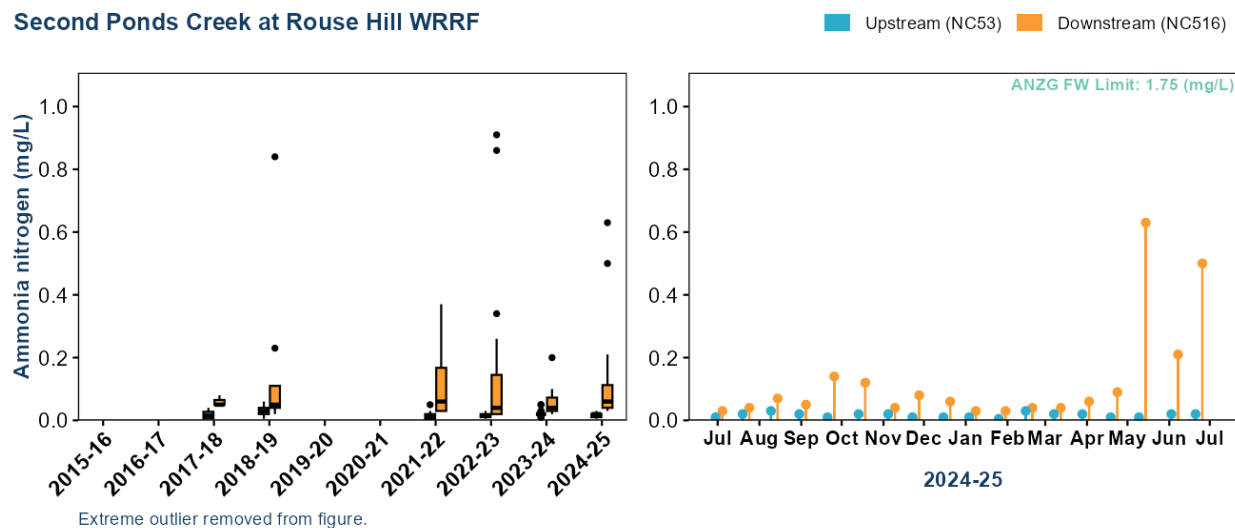
Second Ponds Creek at Rouse Hill WRRF: NC53 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.89	0.19	162	-0.56	0.944
Oxidised nitrogen	1.10	0.26	162	0.38	0.981
Total nitrogen	1.12	0.10	162	1.36	0.526
Soluble reactive phosphorus	1.06	0.26	65	0.26	0.994
Total phosphorus	1.23	0.15	162	1.69	0.331
Physico-chemical					
Conductivity	1.21	0.09	162	2.60	0.050
Dissolved oxygen	0.90	0.05	162	-1.97	0.204
Dissolved oxygen saturation	-6.69	2.60	161	-2.58	0.052
pH	0.03	0.04	162	0.73	0.885
Water temperature	1.02	0.06	162	0.24	0.995
Turbidity	0.76	0.18	162	-1.17	0.647
Trace Metals					
Filterable aluminium	1.06	0.20	65	0.29	0.992
Total aluminium	0.78	0.19	65	-1.04	0.726
Filterable cobalt	1.05	0.14	65	0.37	0.983
Total cobalt	1.15	0.14	65	1.18	0.641
Filterable copper	0.86	0.10	65	-1.38	0.519
Total copper	0.83	0.10	65	-1.54	0.418
Filterable nickel	1.00	0.12	65	0.01	>0.999
Total nickel	1.04	0.14	65	0.30	0.990
Filterable zinc	0.98	0.13	65	-0.13	>0.999
Total zinc	0.89	0.13	65	-0.79	0.859
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-112 Downstream current period (2024-25) vs previous period comparison (single site) for Second Ponds Creek at Rouse Hill WRRF

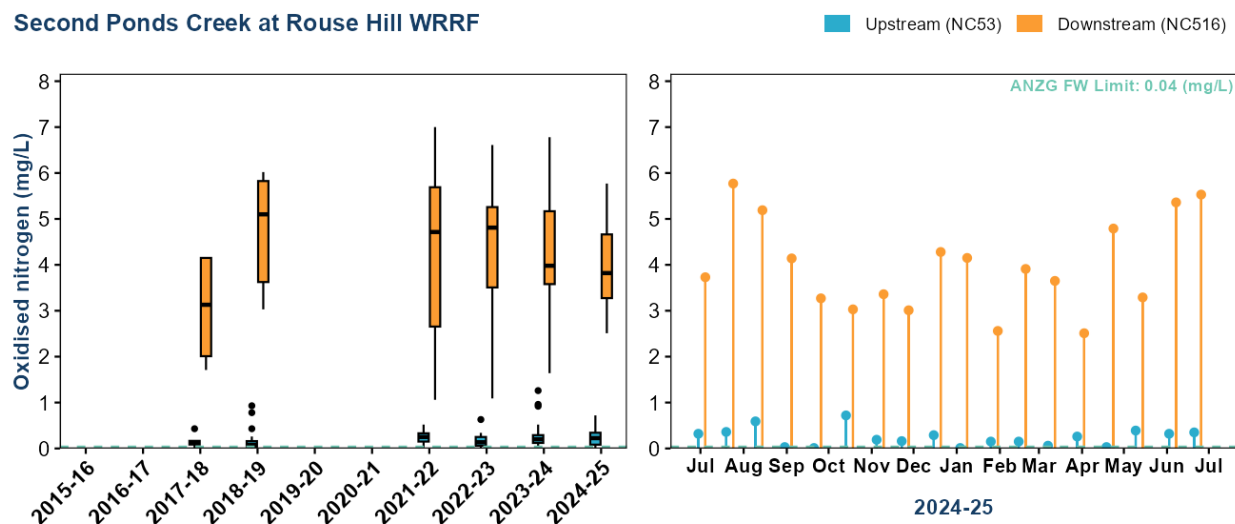
Second Ponds Creek at Rouse Hill WRRF: NC516 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.22	0.26	162	0.92	0.792
Oxidised nitrogen	0.93	0.23	162	-0.28	0.992
Total nitrogen	0.94	0.08	162	-0.68	0.903
Soluble reactive phosphorus	1.17	0.29	65	0.62	0.924
Total phosphorus	1.06	0.13	162	0.50	0.959
Physico-chemical					
Conductivity	1.00	0.07	162	0.03	>0.999
Dissolved oxygen	0.97	0.05	162	-0.58	0.938
Dissolved oxygen saturation	-0.53	2.63	161	-0.20	0.997
pH	0.05	0.04	162	1.21	0.621
Water temperature	1.06	0.07	162	0.94	0.782
Turbidity	1.03	0.24	162	0.13	>0.999
Trace Metals					
Filterable aluminium	0.93	0.18	65	-0.37	0.982
Total aluminium	1.00	0.25	65	-0.01	>0.999
Filterable cobalt	1.06	0.14	65	0.43	0.972
Total cobalt	1.13	0.14	65	0.96	0.774
Filterable copper	0.88	0.10	65	-1.12	0.680
Total copper	0.92	0.11	65	-0.65	0.916
Filterable nickel	0.86	0.11	65	-1.15	0.658
Total nickel	0.90	0.12	65	-0.80	0.856
Filterable zinc	1.06	0.15	65	0.42	0.975
Total zinc	1.09	0.16	65	0.60	0.931
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.11.6. Stressor – Nutrients

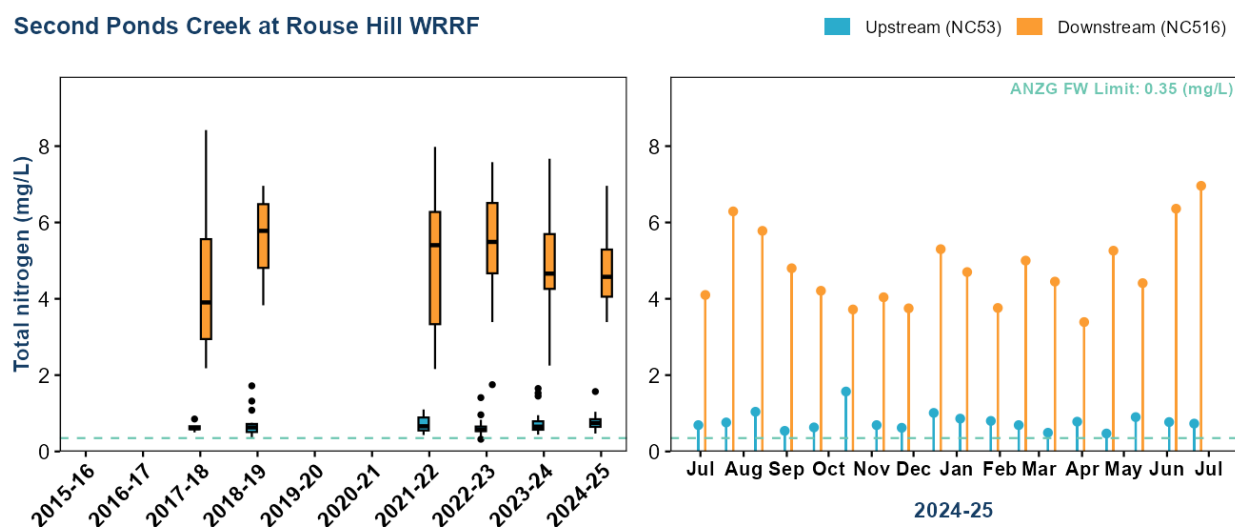
Second Ponds Creek at Rouse Hill WRRF



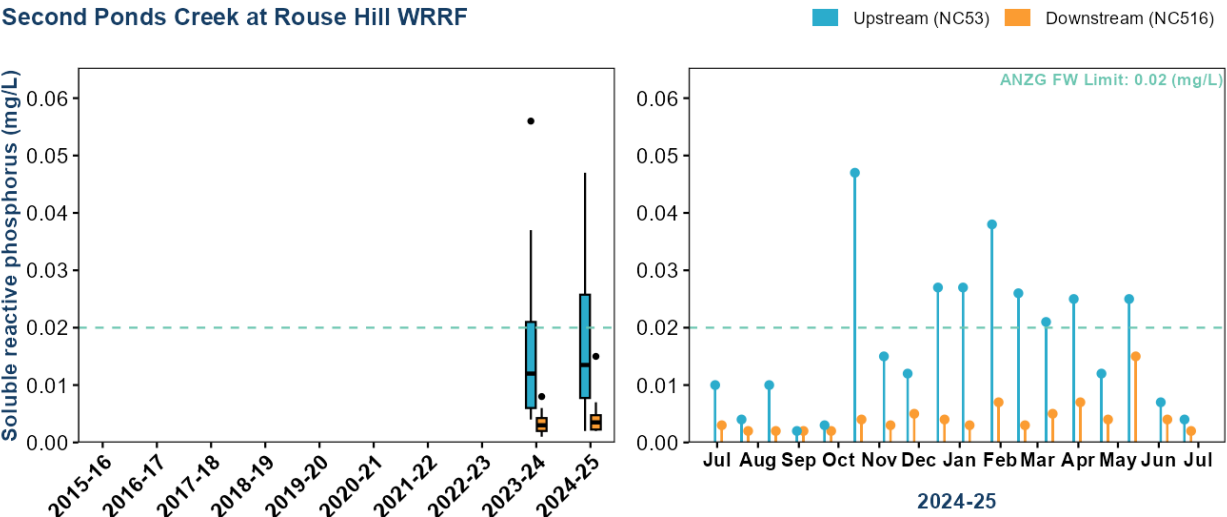
Second Ponds Creek at Rouse Hill WRRF



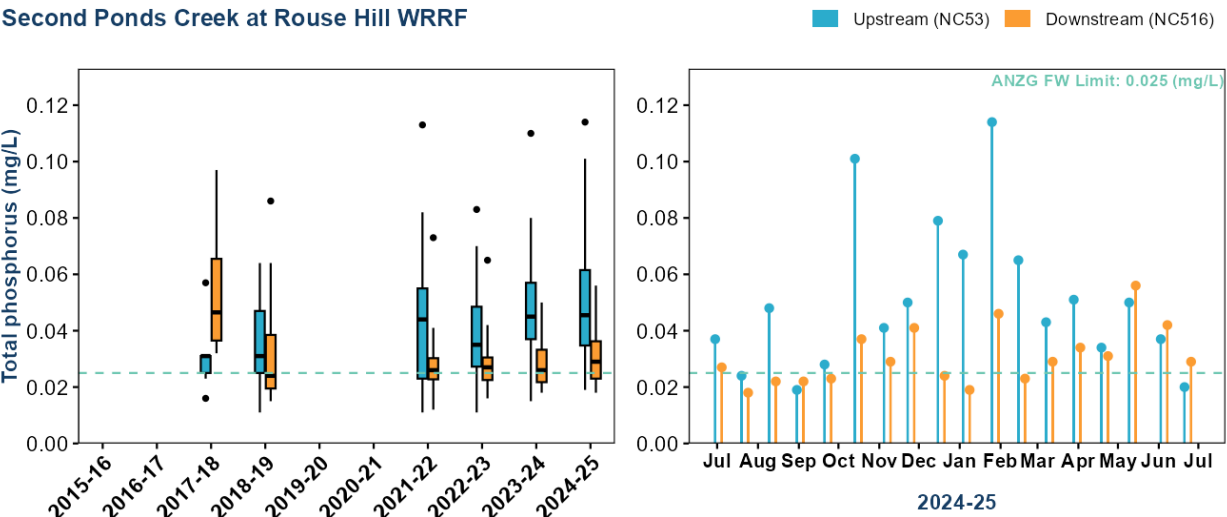
Second Ponds Creek at Rouse Hill WRRF



Second Ponds Creek at Rouse Hill WRRF

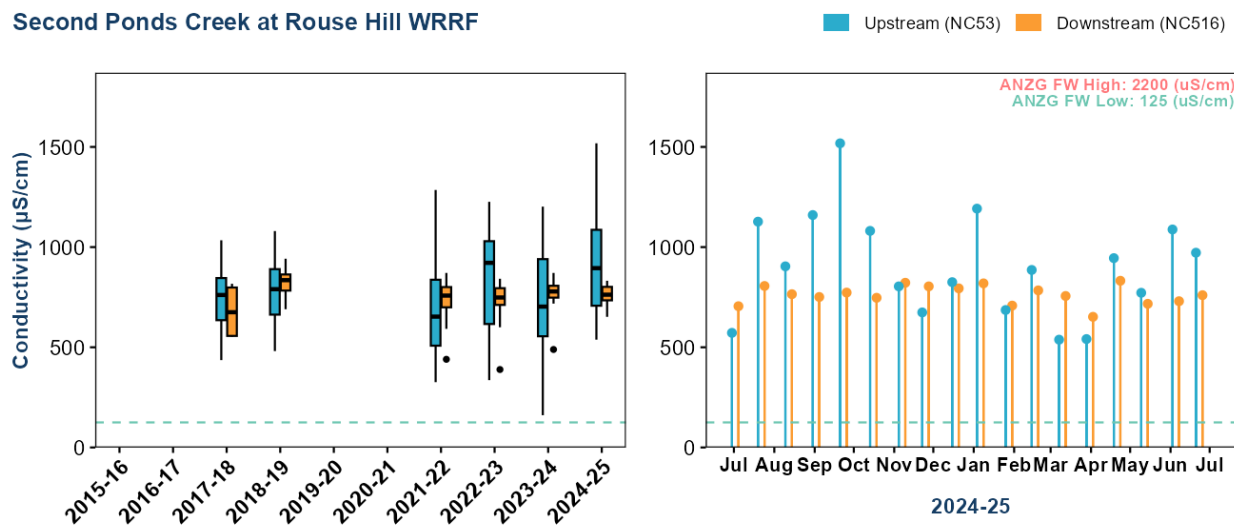


Second Ponds Creek at Rouse Hill WRRF

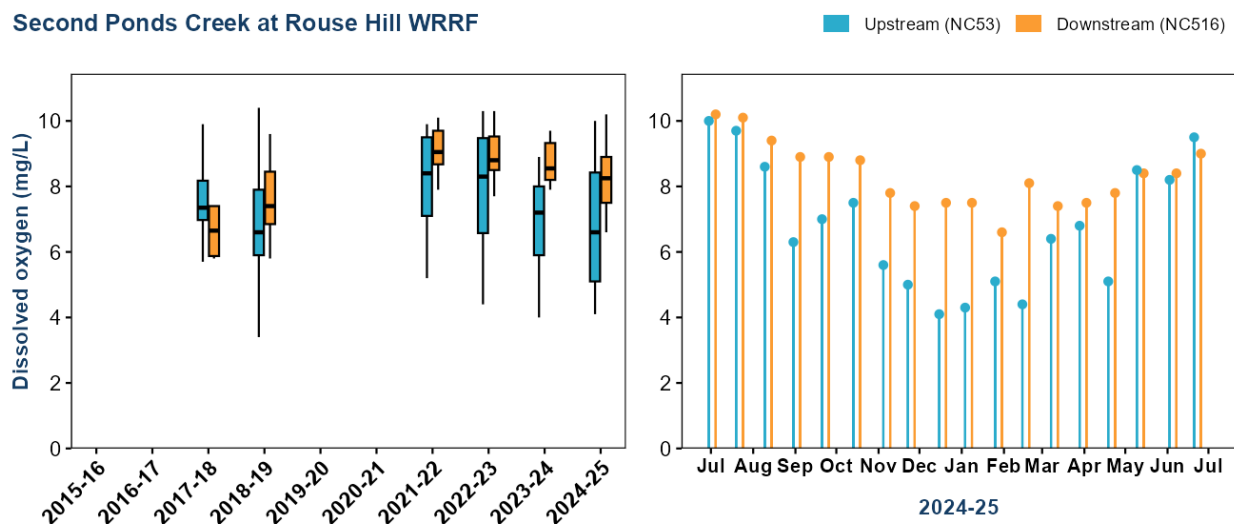


A.11.7. Stressor – Physico-chemical water quality

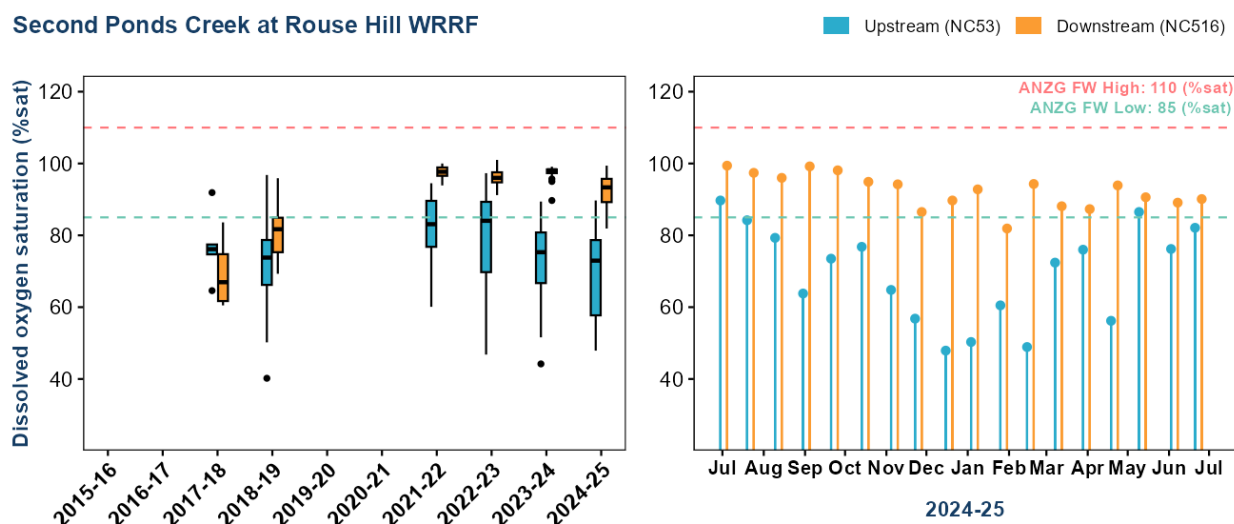
Second Ponds Creek at Rouse Hill WRRF



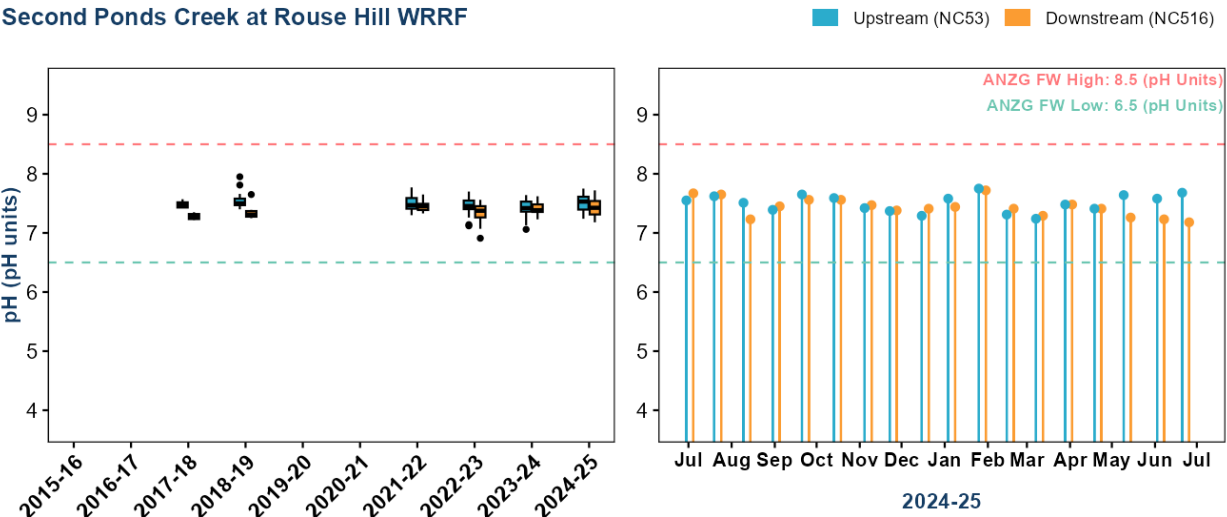
Second Ponds Creek at Rouse Hill WRRF



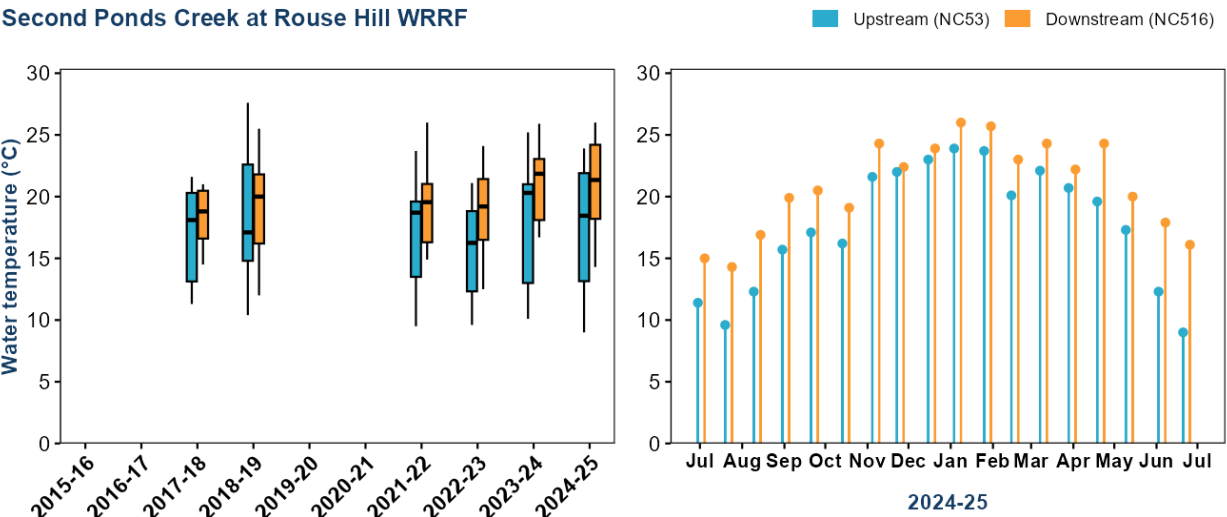
Second Ponds Creek at Rouse Hill WRRF



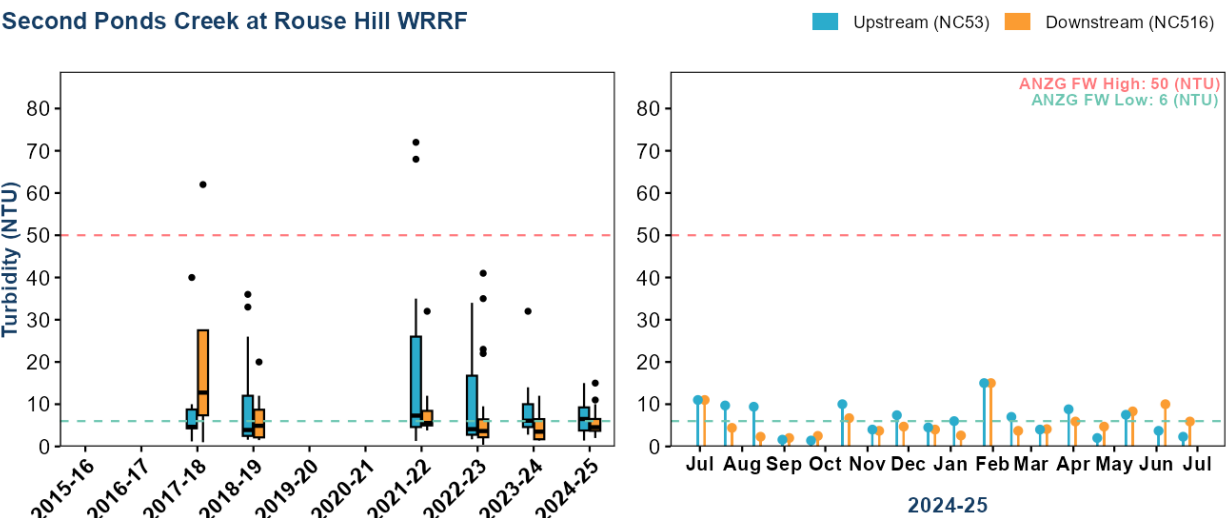
Second Ponds Creek at Rouse Hill WRRF



Second Ponds Creek at Rouse Hill WRRF

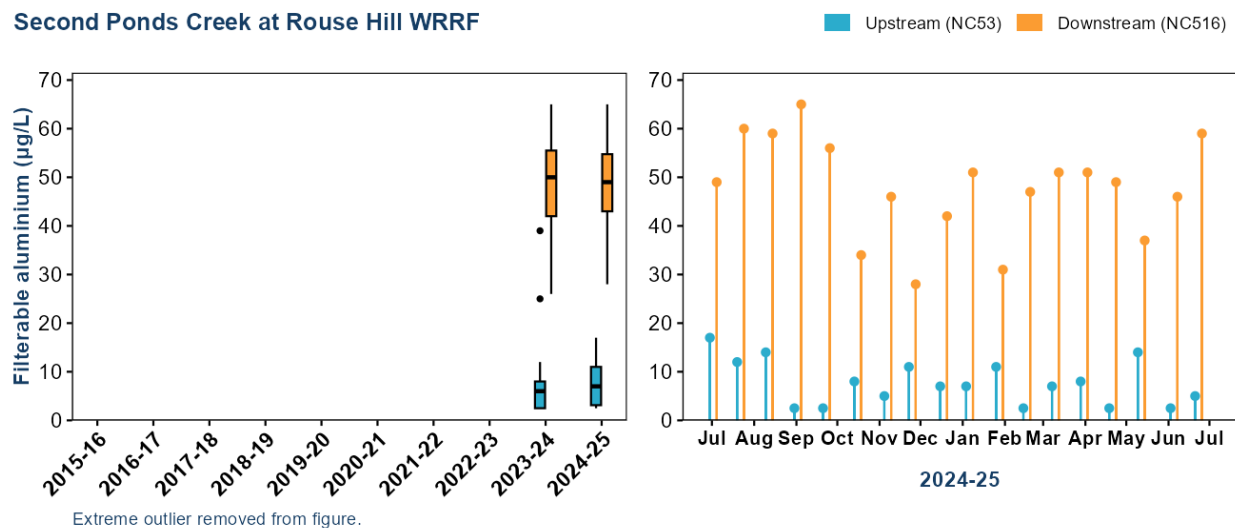


Second Ponds Creek at Rouse Hill WRRF

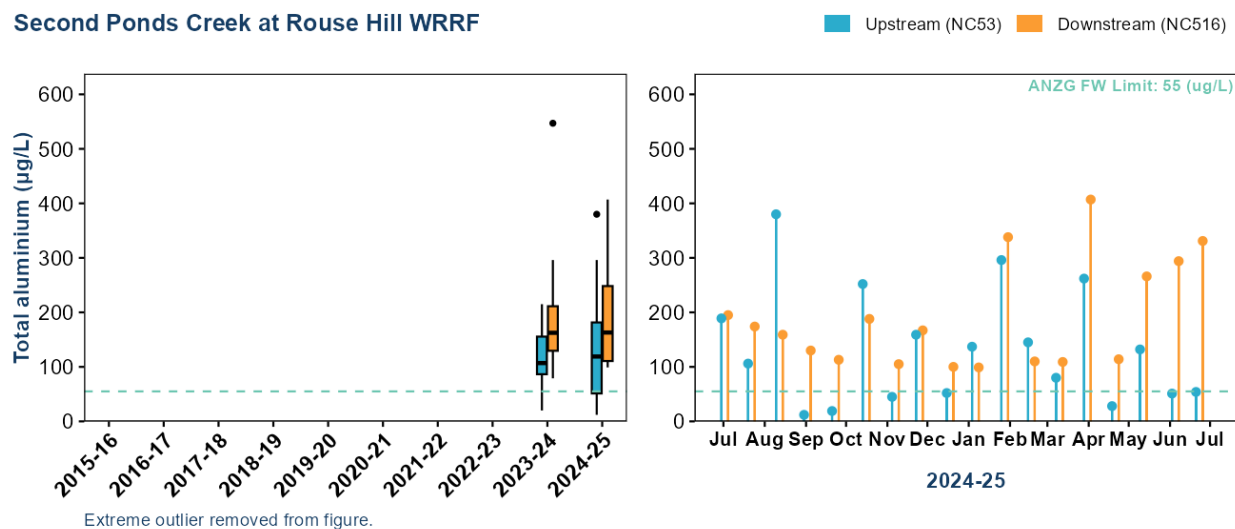


A.11.8. Stressor – Trace metals

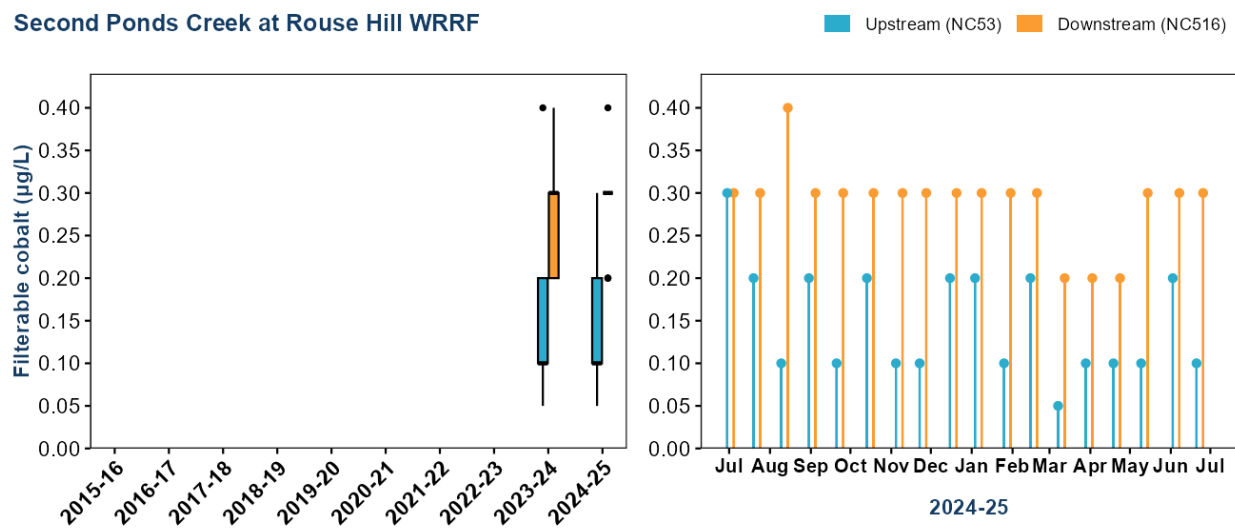
Second Ponds Creek at Rouse Hill WRRF



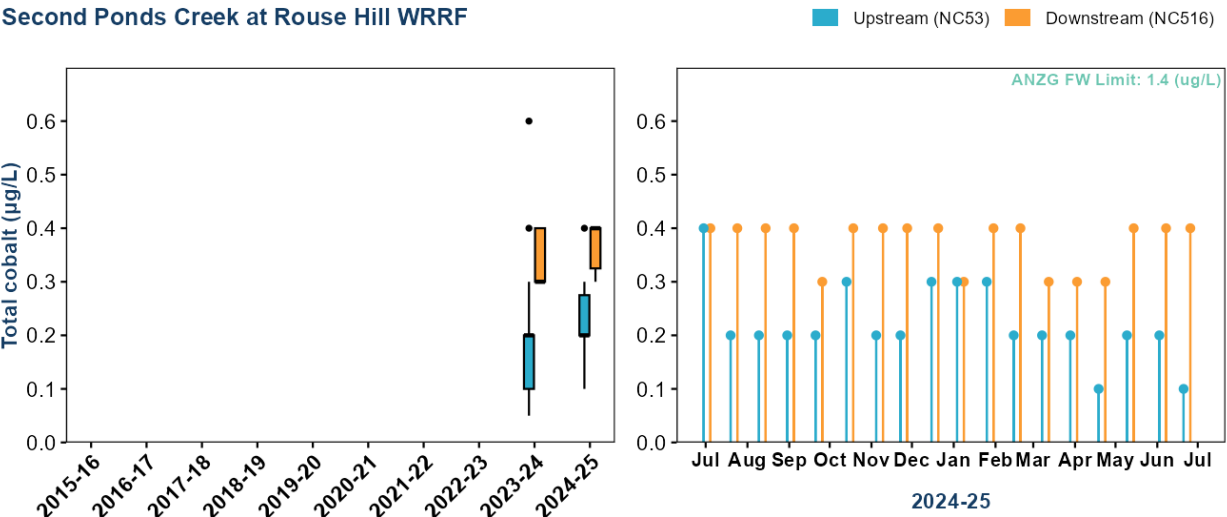
Second Ponds Creek at Rouse Hill WRRF



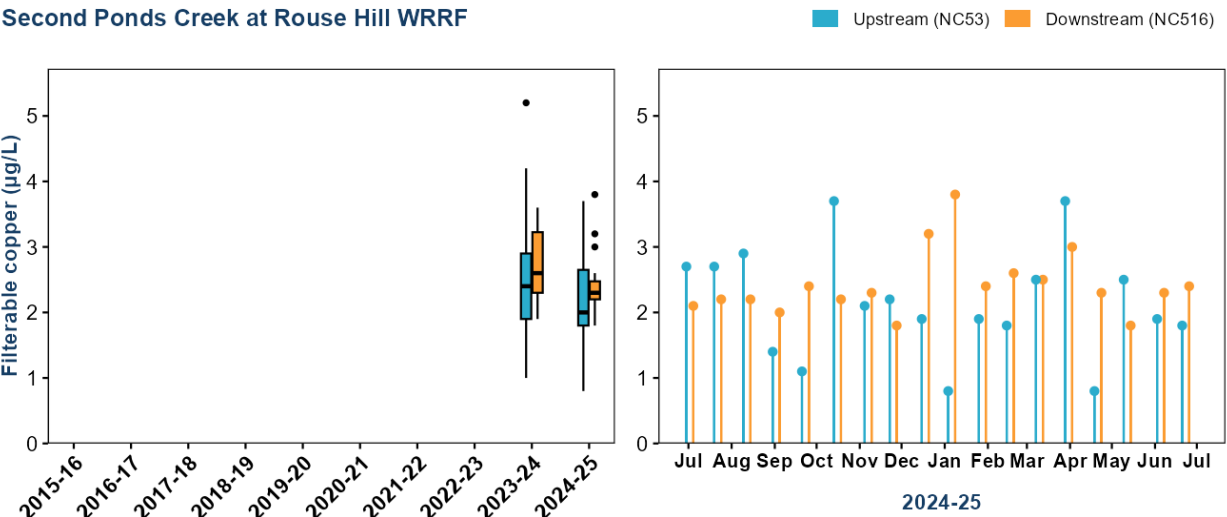
Second Ponds Creek at Rouse Hill WRRF



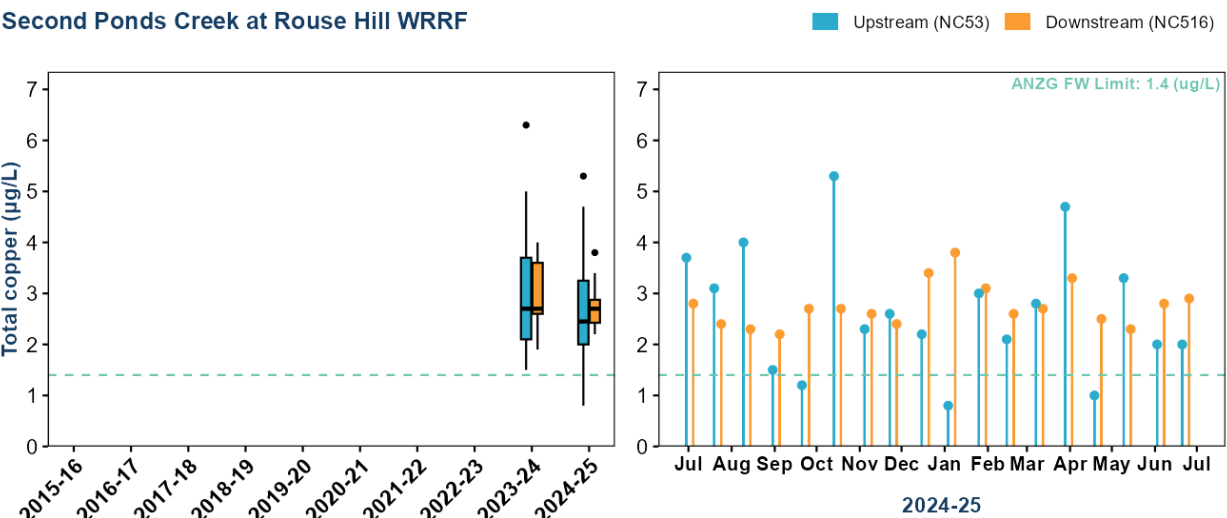
Second Ponds Creek at Rouse Hill WRRF



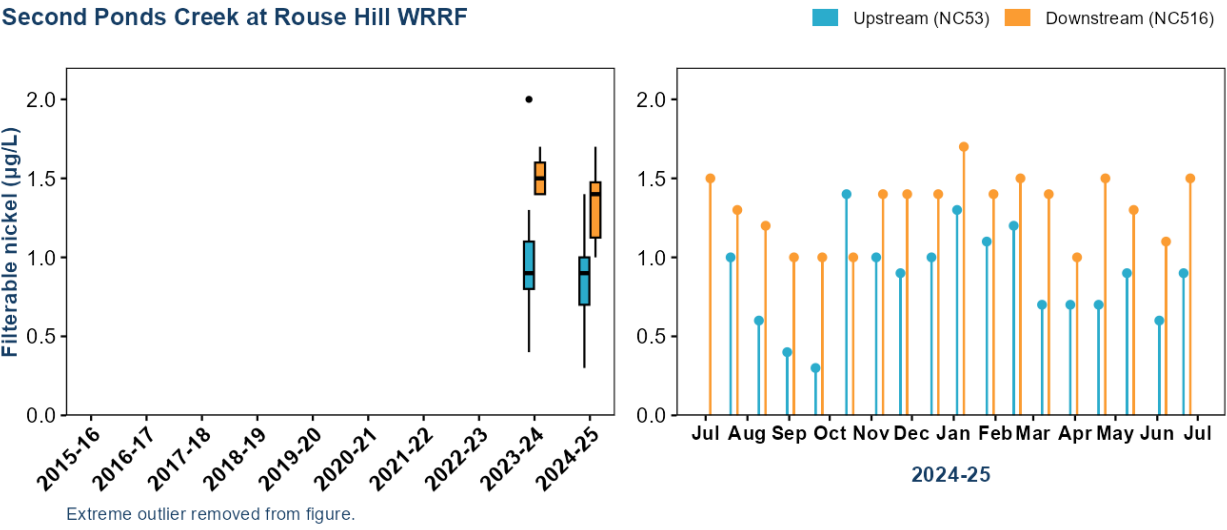
Second Ponds Creek at Rouse Hill WRRF



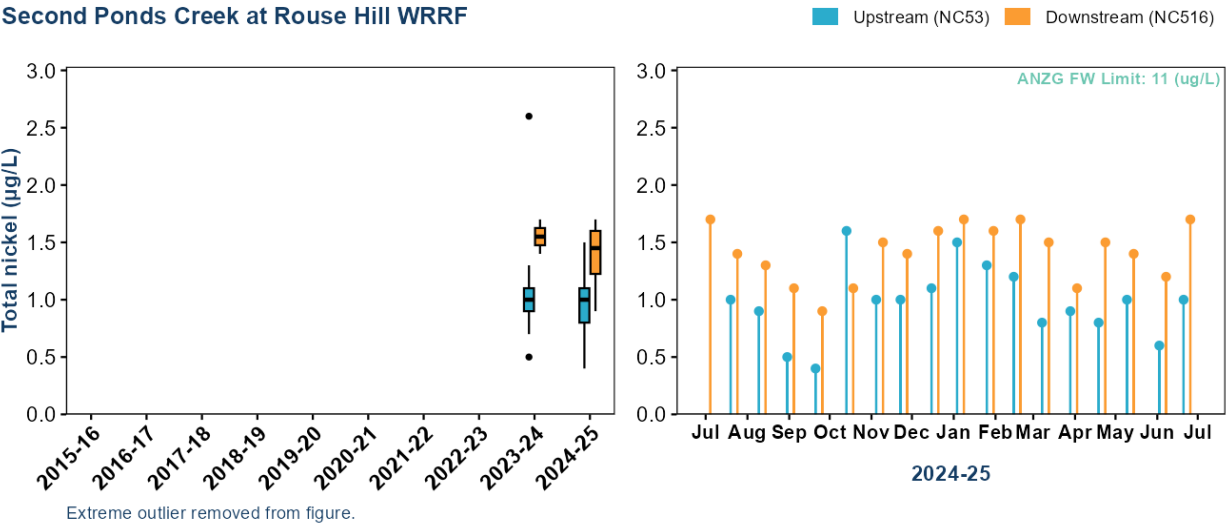
Second Ponds Creek at Rouse Hill WRRF



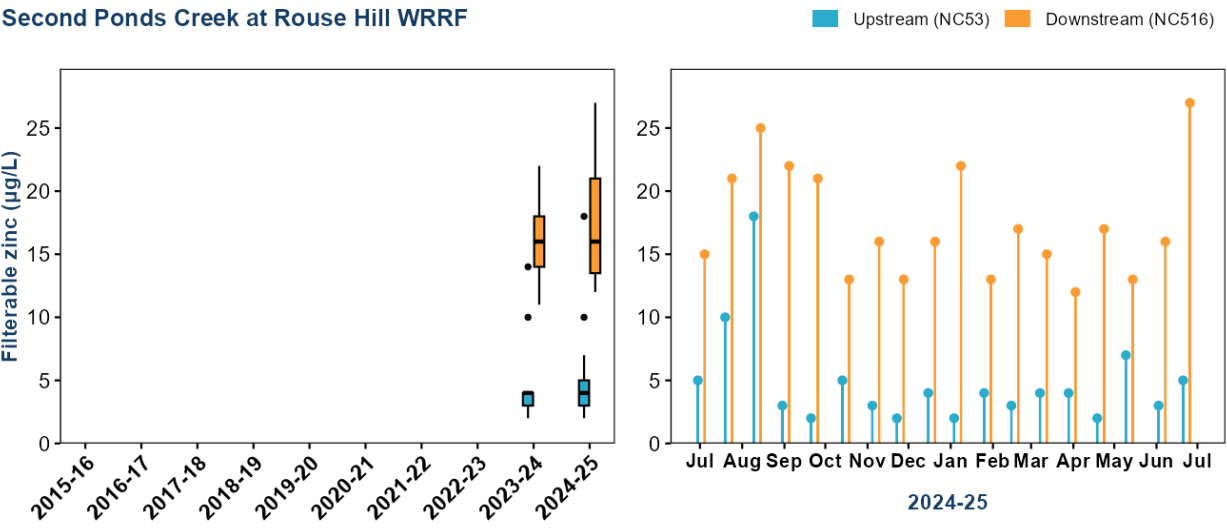
Second Ponds Creek at Rouse Hill WRRF



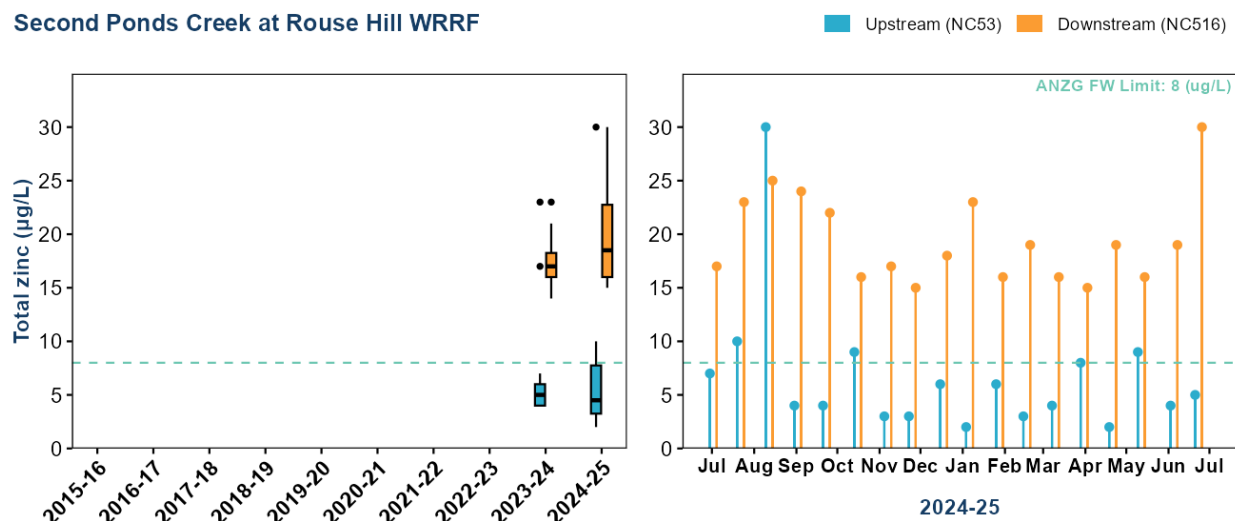
Second Ponds Creek at Rouse Hill WRRF



Second Ponds Creek at Rouse Hill WRRF



Second Ponds Creek at Rouse Hill WRRF



A.11.9. Ecosystem receptor – Statistical analysis outcomes

Table A-113 Upstream vs downstream comparison (2024-25 reporting period) for Second Ponds Creek at Rouse Hill WRRF

Second Ponds Creek at Rouse Hill WRRF: NC53 vs NC516 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.91	0.27	162	-0.32	0.989
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-114 Upstream current period (2024-25) vs previous period comparison (single site) for Second Ponds Creek at Rouse Hill WRRF

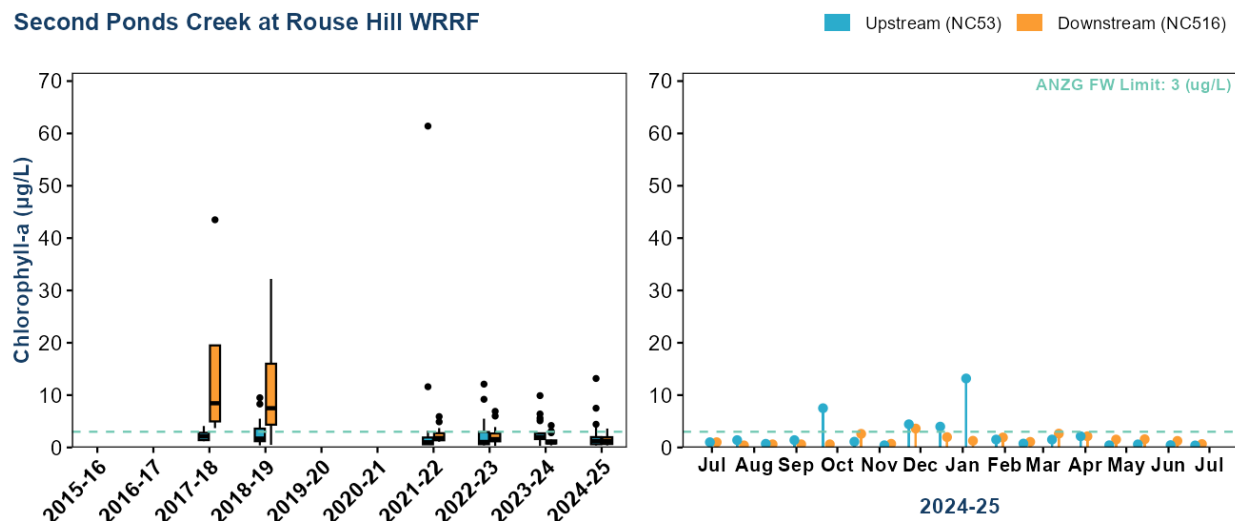
Second Ponds Creek at Rouse Hill WRRF: NC53 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.75	0.18	162	-1.21	0.623
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-115 Downstream current period (2024-25) vs previous period comparison (single site) for Second Ponds Creek at Rouse Hill WRRF

Second Ponds Creek at Rouse Hill WRRF: NC516 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.54	0.13	162	-2.64	0.044
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.11.10. Ecosystem receptor – Phytoplankton

Second Ponds Creek at Rouse Hill WRRF

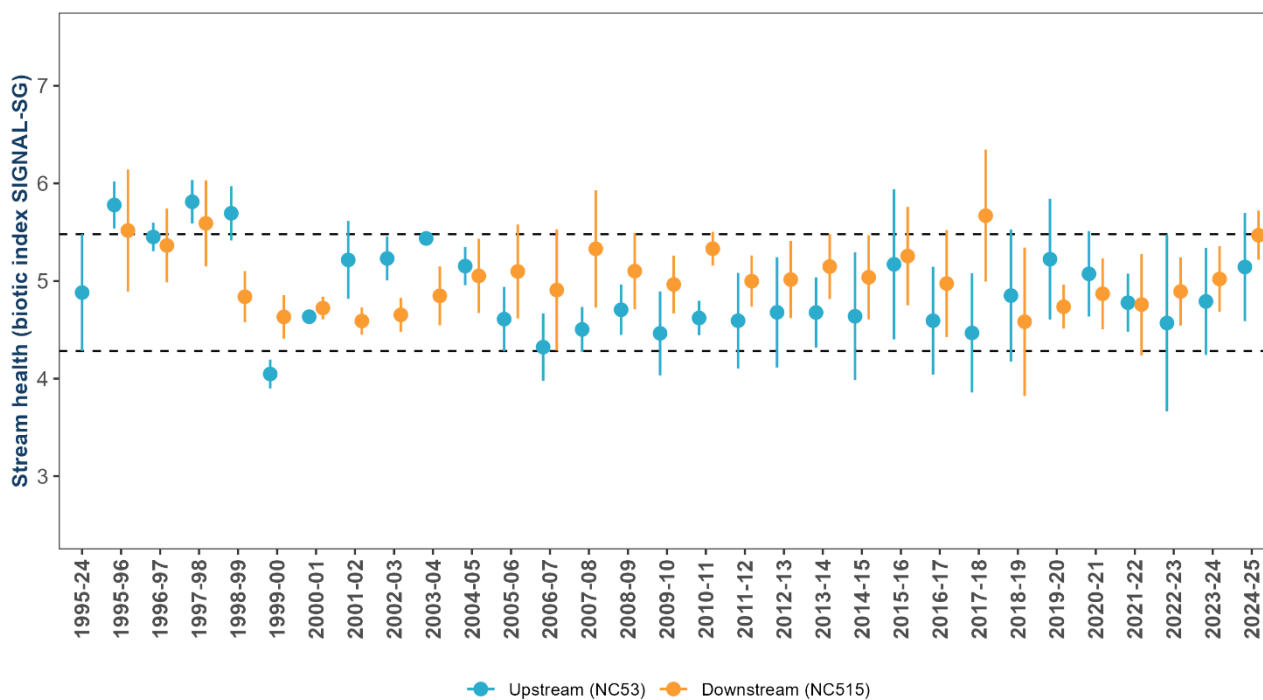


A.11.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Second Ponds Creek	River (NC53 vs NC515)	Welch Two Sample t-test	-0.33	-1.29	7.2	0.237

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Second Ponds Creek at Rouse Hill WRRF

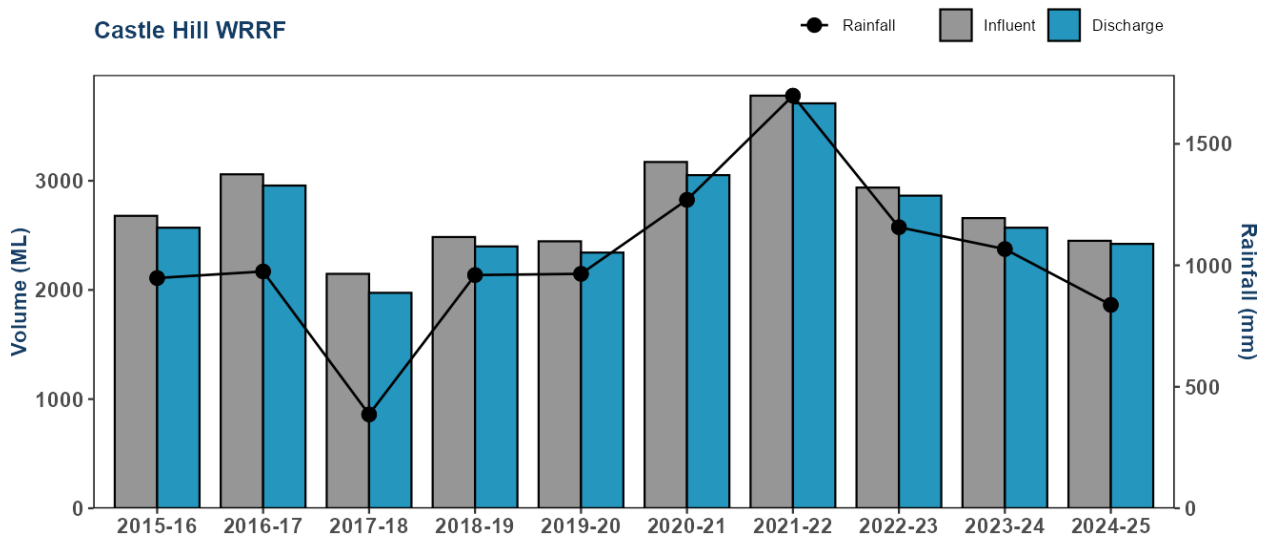


The range of stream health recorded over each period is represented by length of line

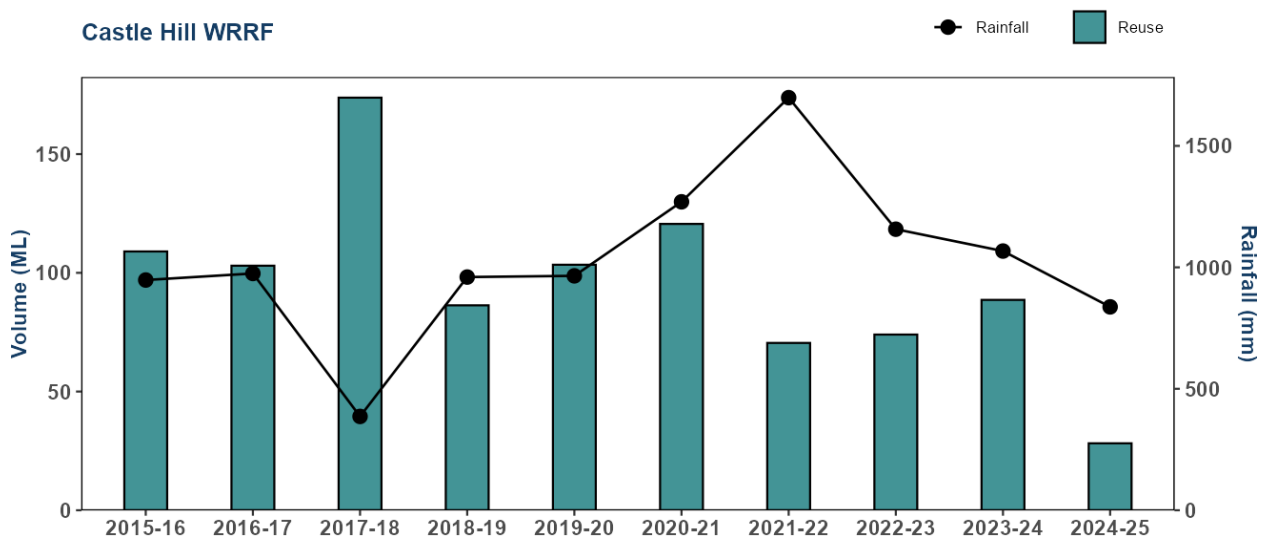
A.12. Castle Hill WRRF

A.12.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall



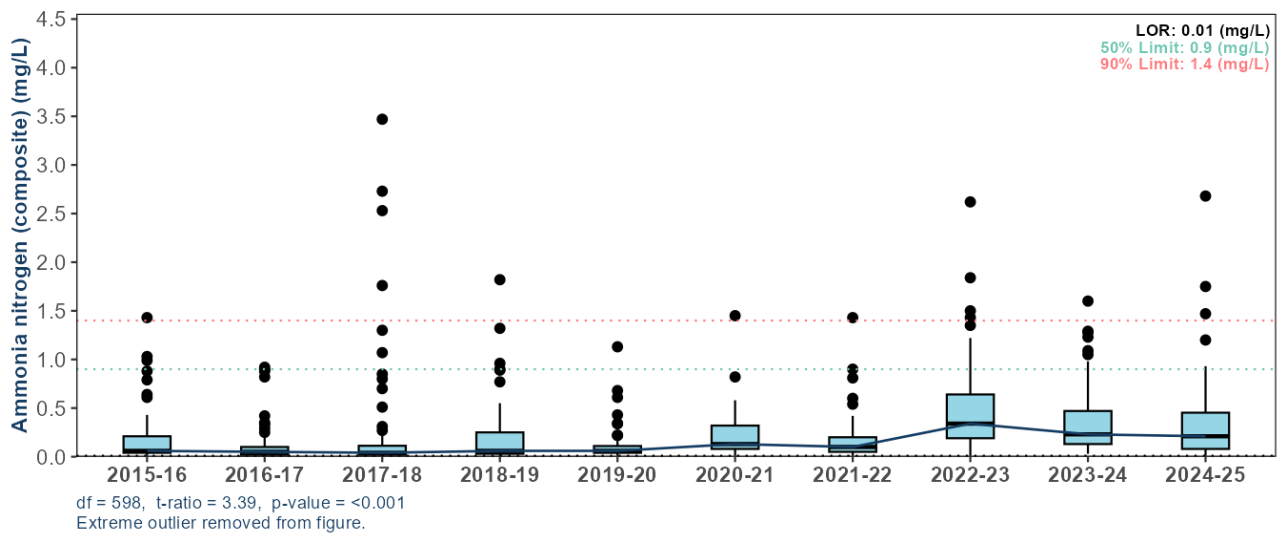
Reuse volume and rainfall



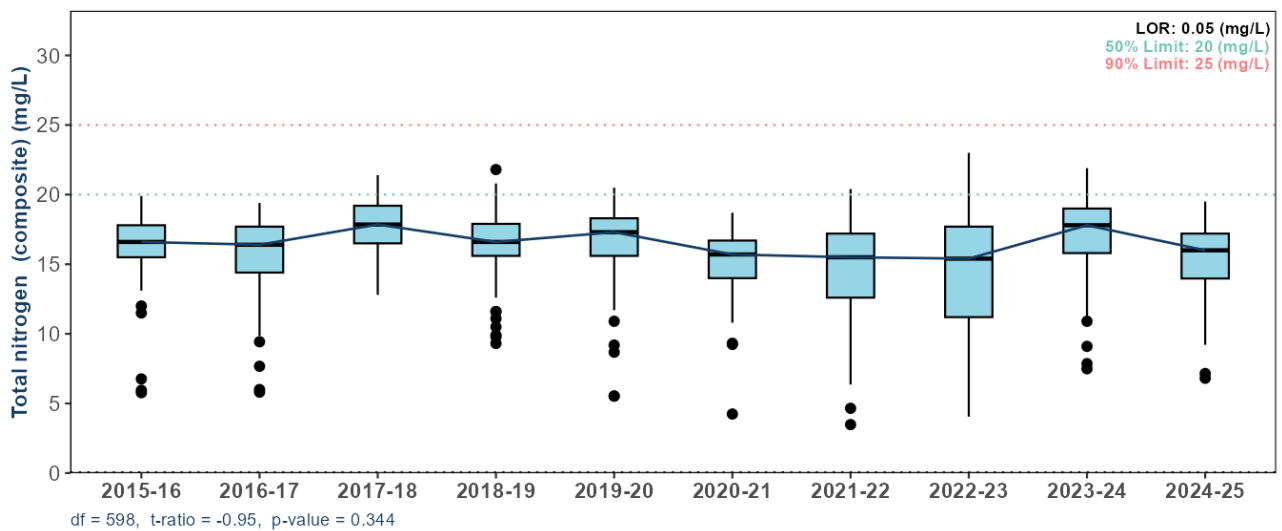
A.12.2. Pressure – Wastewater quality

Nutrients

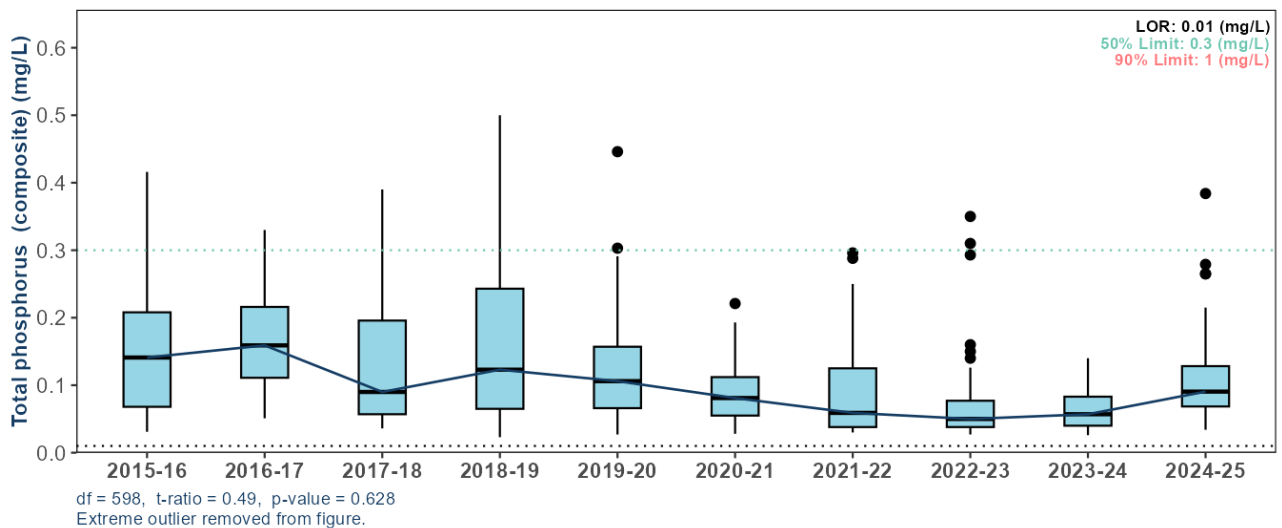
CH0005 at Castle Hill WRRF



CH0005 at Castle Hill WRRF

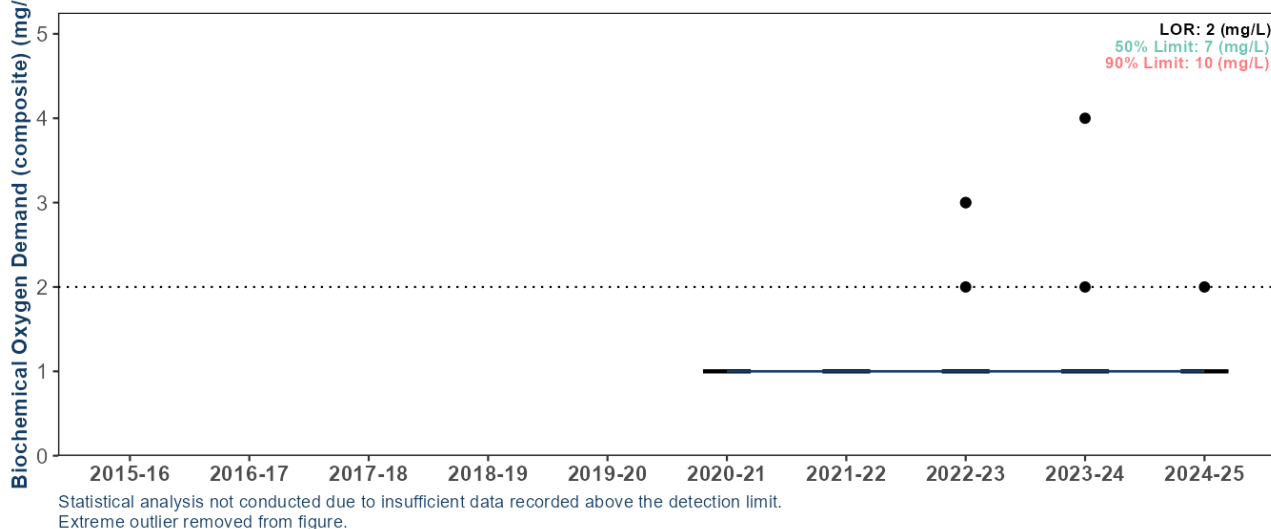


CH0005 at Castle Hill WRRF

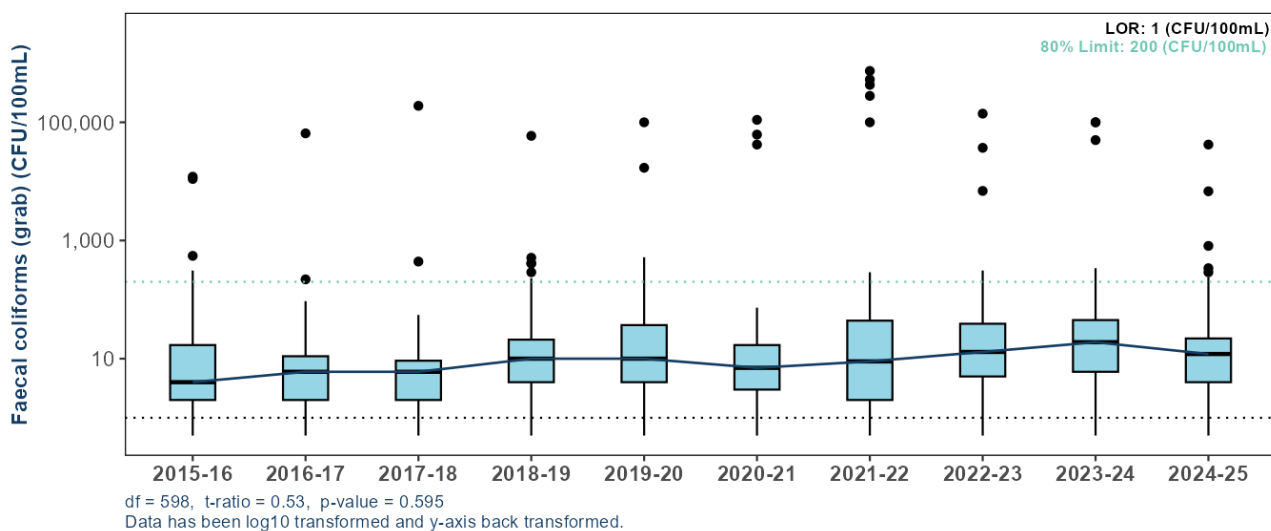


Major conventional analytes

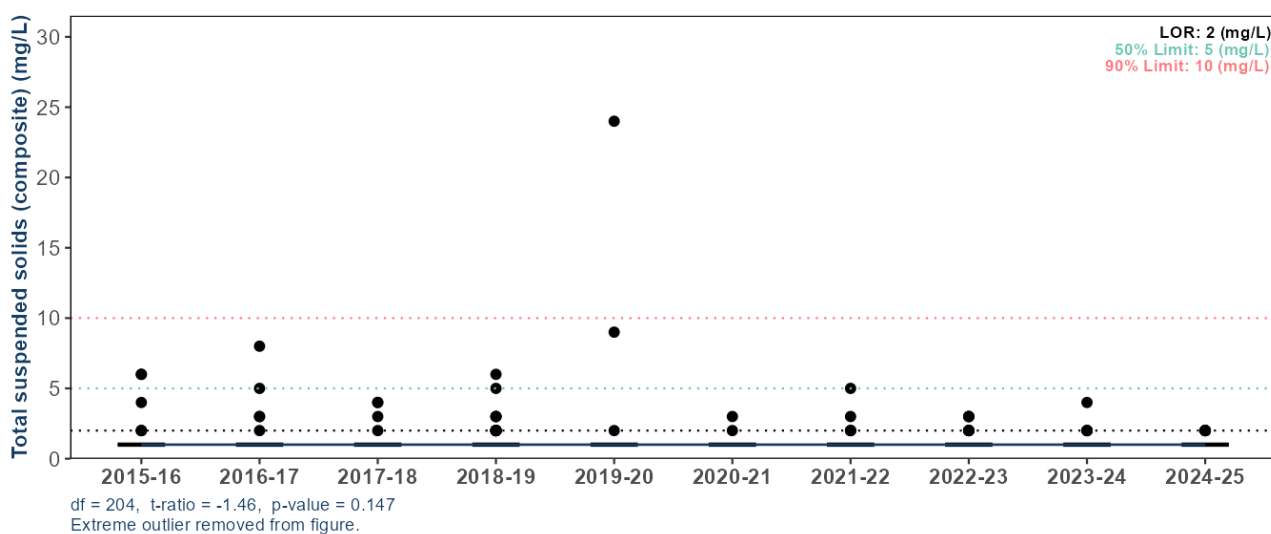
CH0005 at Castle Hill WRRF



CH0006 at Castle Hill WRRF

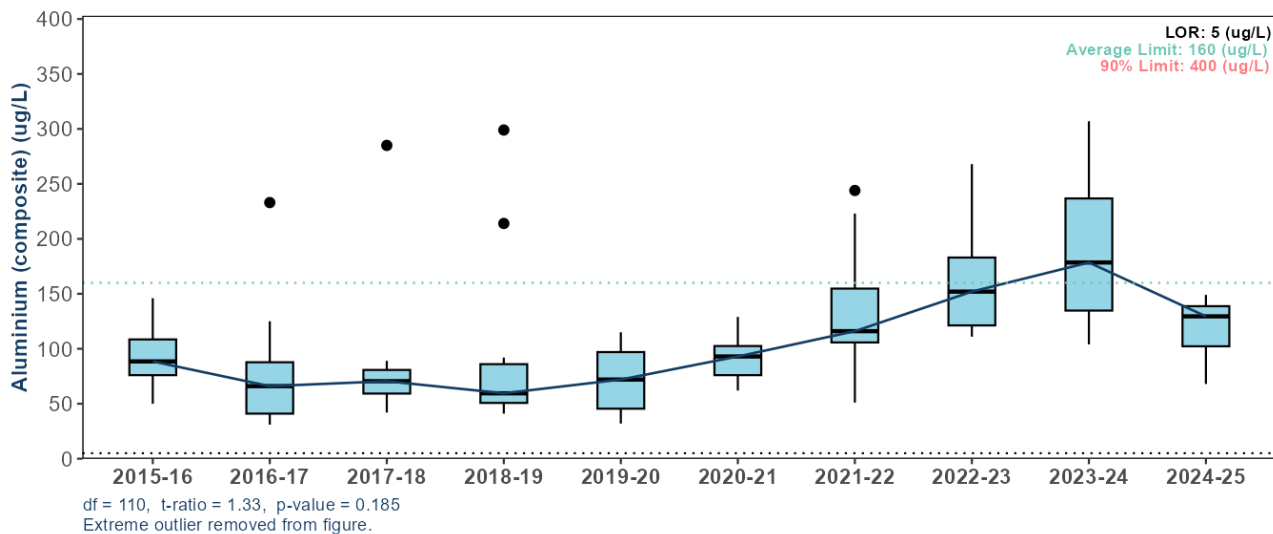


CH0005 at Castle Hill WRRF

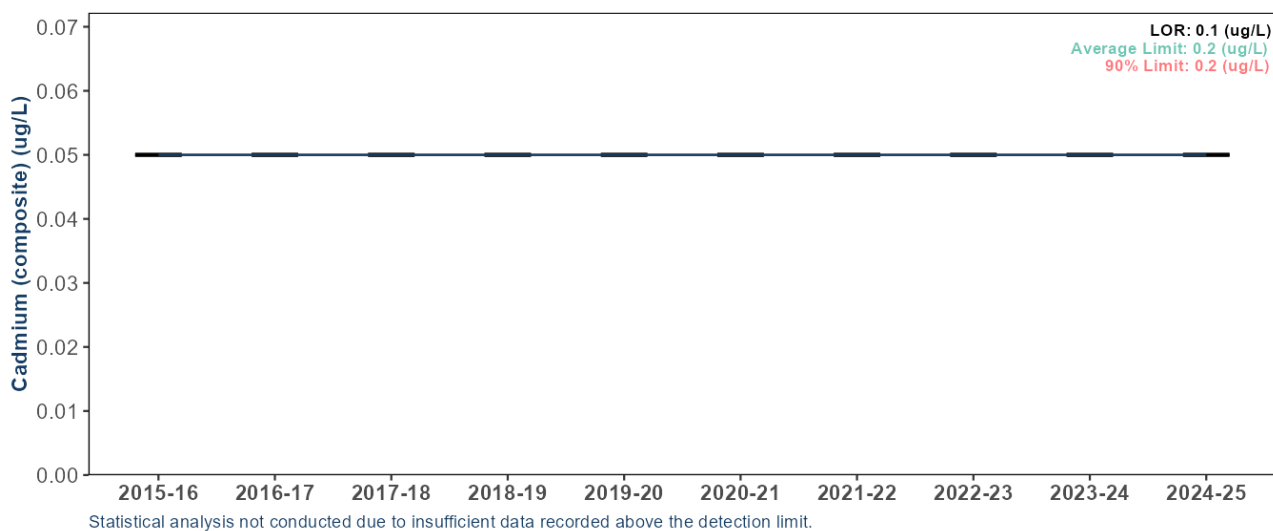


Trace metals

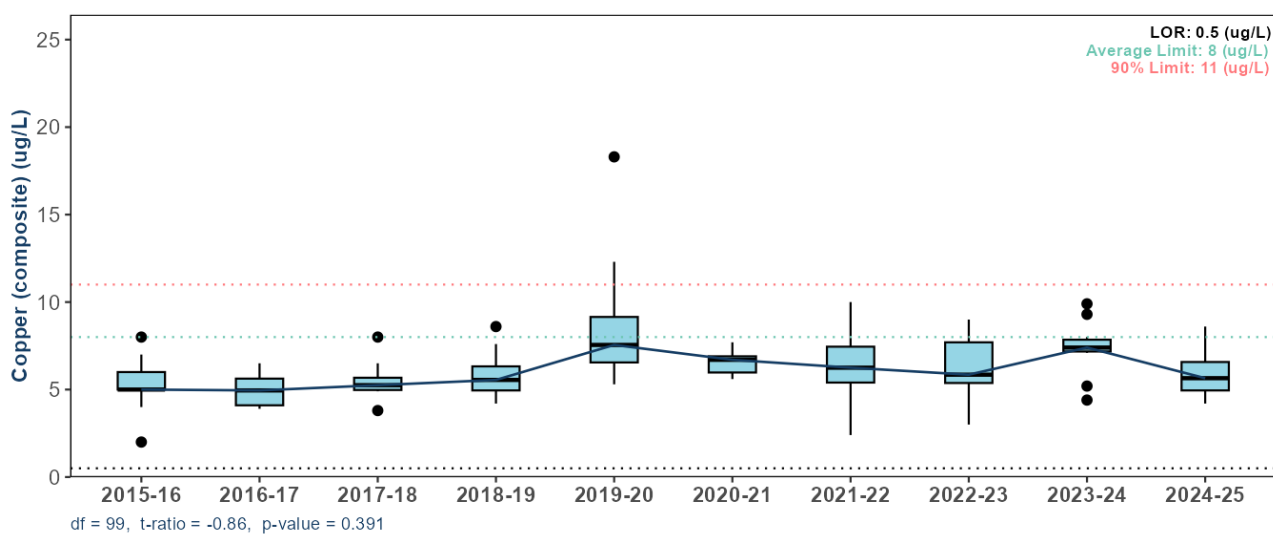
CH0005 at Castle Hill WRRF



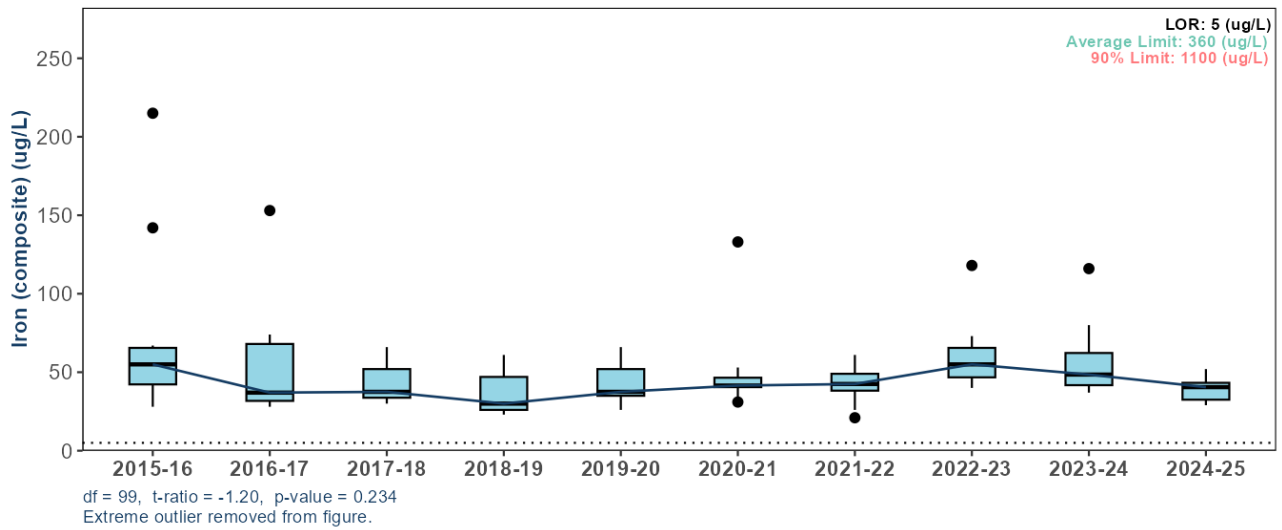
CH0005 at Castle Hill WRRF



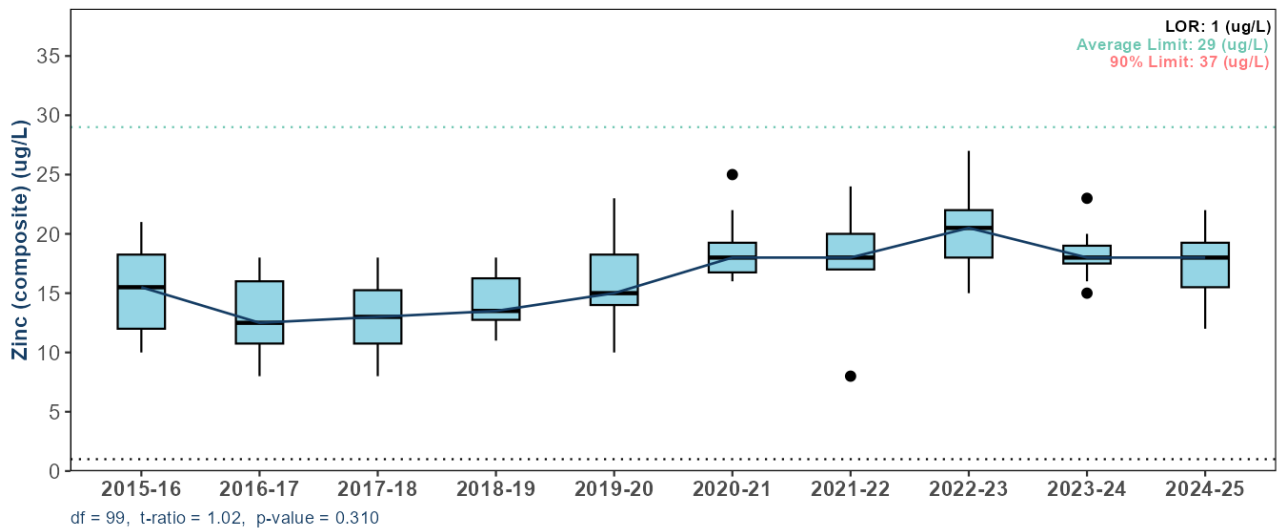
CH0005 at Castle Hill WRRF



CH0005 at Castle Hill WRRF

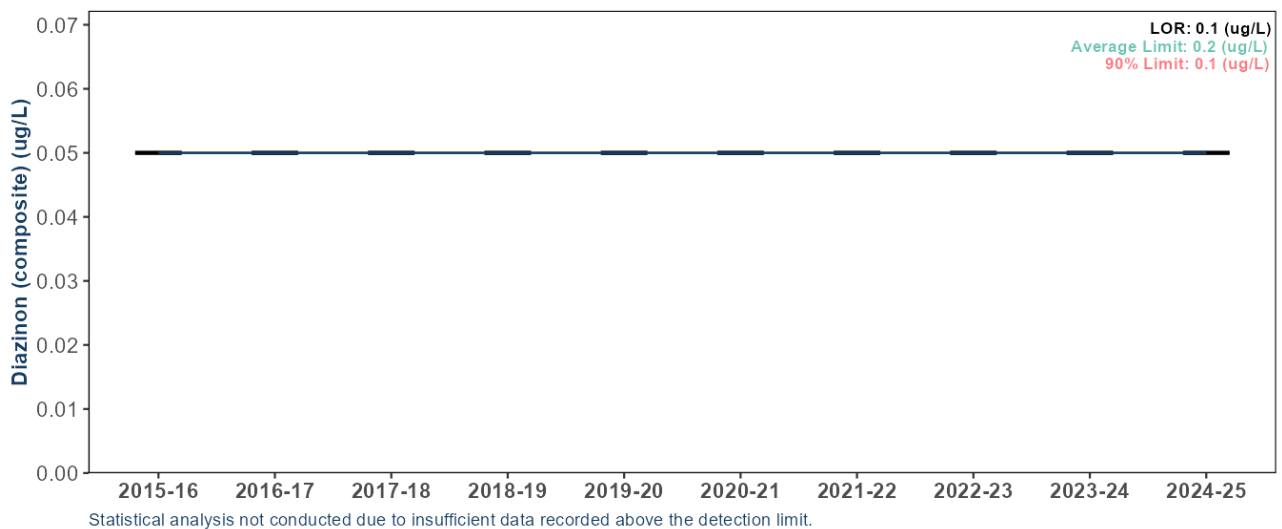


CH0005 at Castle Hill WRRF

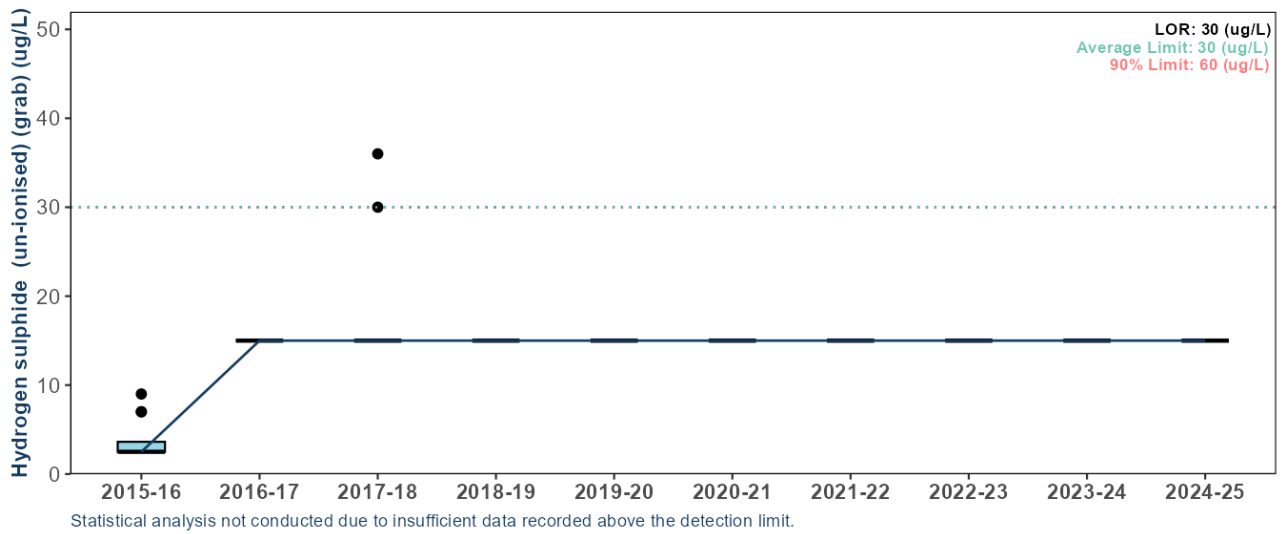


Other chemicals and organics (including pesticides)

CH0005 at Castle Hill WRRF

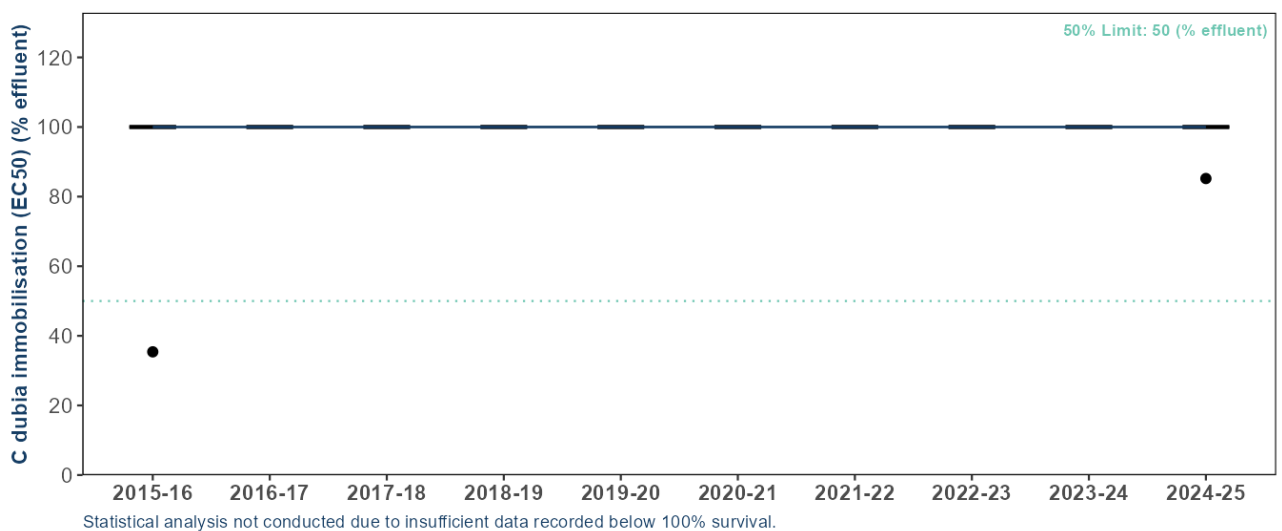


CH0006 at Castle Hill WRRF



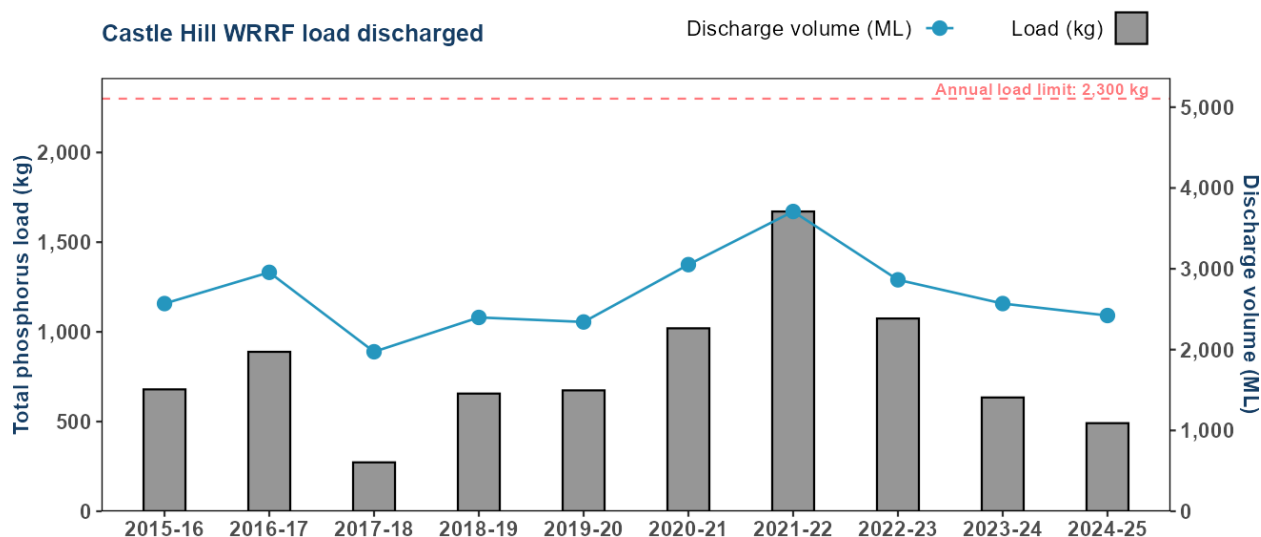
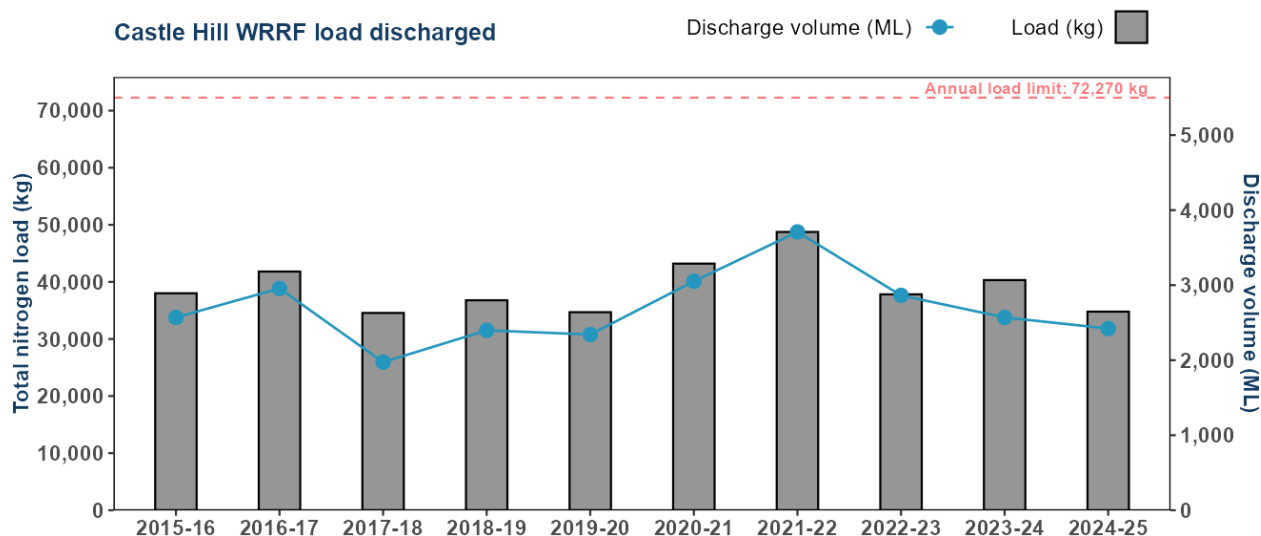
A.12.3. Pressure – Wastewater toxicity

CH0006 at Castle Hill WRRF

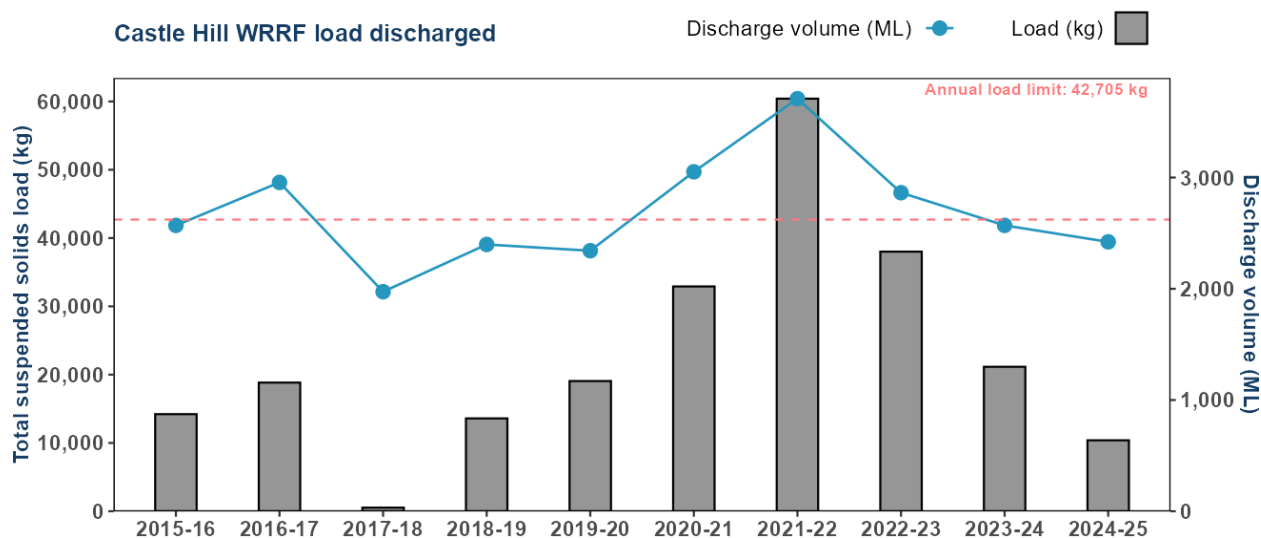
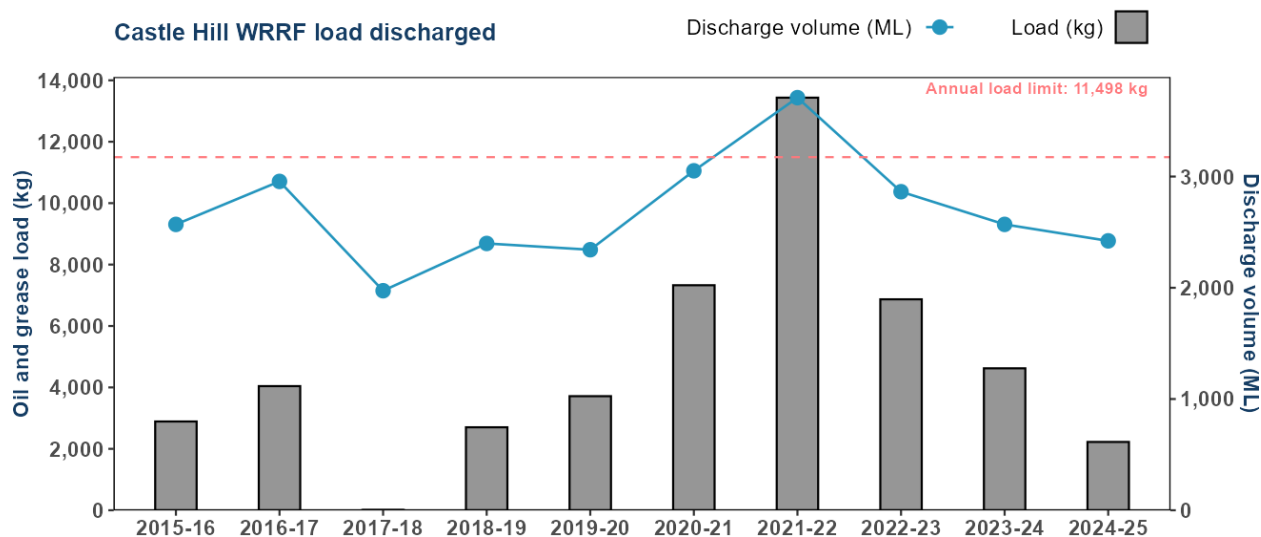
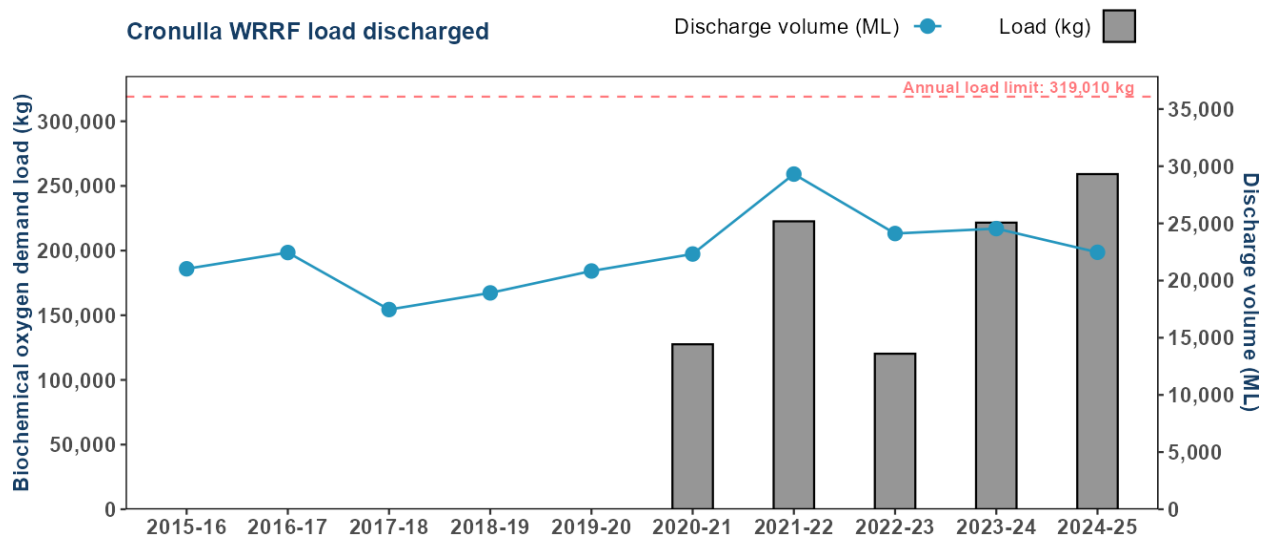


A.12.4. Pressure – Wastewater discharge load

Nutrients



Major conventional analytes



A.12.5. Stressor – Statistical analysis outcomes

Table A-116 Upstream vs downstream comparison (2024-25 reporting period) for Cattai Creek at Castle Hill WRRF

Cattai Creek at Castle Hill WRRF: NC8 vs NC75 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	1.00	0.33	180	0.00	>0.999
Oxidised nitrogen	51.43	19.35	180	10.47	<0.001
Total nitrogen	14.30	3.66	180	10.38	<0.001
Soluble reactive phosphorus	10.12	3.40	66	6.88	<0.001
Total phosphorus	2.29	0.44	180	4.31	<0.001
Physico-chemical					
Conductivity	1.33	0.19	180	1.95	0.210
Dissolved oxygen	1.04	0.05	180	0.90	0.805
Dissolved oxygen saturation	7.65	2.33	180	3.29	0.007
pH	-0.09	0.05	180	-1.61	0.377
Water temperature	1.14	0.09	180	1.61	0.375
Turbidity	0.33	0.12	180	-3.03	0.015
Trace Metals					
Filterable aluminium	5.04	0.99	66	8.23	<0.001
Total aluminium	2.72	0.93	66	2.93	0.023
Filterable cobalt	1.09	0.17	66	0.55	0.948
Total cobalt	1.16	0.19	66	0.93	0.789
Filterable copper	2.10	0.23	66	6.92	<0.001
Total copper	1.62	0.22	66	3.58	0.004
Filterable nickel	1.58	0.17	66	4.28	<0.001
Total nickel	1.55	0.15	66	4.52	<0.001
Filterable zinc	0.83	0.09	65	-1.66	0.351
Total zinc	0.75	0.09	66	-2.40	0.088
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-117 Upstream current period (2024-25) vs previous period comparison (single site) for Cattai Creek at Castle Hill WRRF

Cattai Creek at Castle Hill WRRF: NC8 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.69	0.18	180	-1.45	0.469
Oxidised nitrogen	0.50	0.15	180	-2.36	0.088
Total nitrogen	0.82	0.17	180	-0.98	0.763
Soluble reactive phosphorus	0.82	0.28	66	-0.60	0.932
Total phosphorus	0.85	0.13	180	-1.10	0.692
Physico-chemical					
Conductivity	1.15	0.13	180	1.26	0.589
Dissolved oxygen	0.95	0.03	180	-1.53	0.419
Dissolved oxygen saturation	-2.38	1.83	180	-1.30	0.566
pH	-0.02	0.04	180	-0.41	0.977
Water temperature	1.08	0.07	180	1.22	0.613
Turbidity	0.60	0.17	180	-1.78	0.287
Trace Metals					
Filterable aluminium	0.80	0.16	66	-1.14	0.667
Total aluminium	0.39	0.13	66	-2.73	0.040
Filterable cobalt	0.86	0.13	66	-0.95	0.779
Total cobalt	0.72	0.12	66	-2.00	0.197
Filterable copper	0.91	0.10	66	-0.90	0.806
Total copper	0.88	0.12	66	-0.94	0.785
Filterable nickel	0.93	0.10	66	-0.72	0.890
Total nickel	0.80	0.08	66	-2.30	0.108
Filterable zinc	1.07	0.12	65	0.61	0.930
Total zinc	0.89	0.11	66	-0.96	0.775

not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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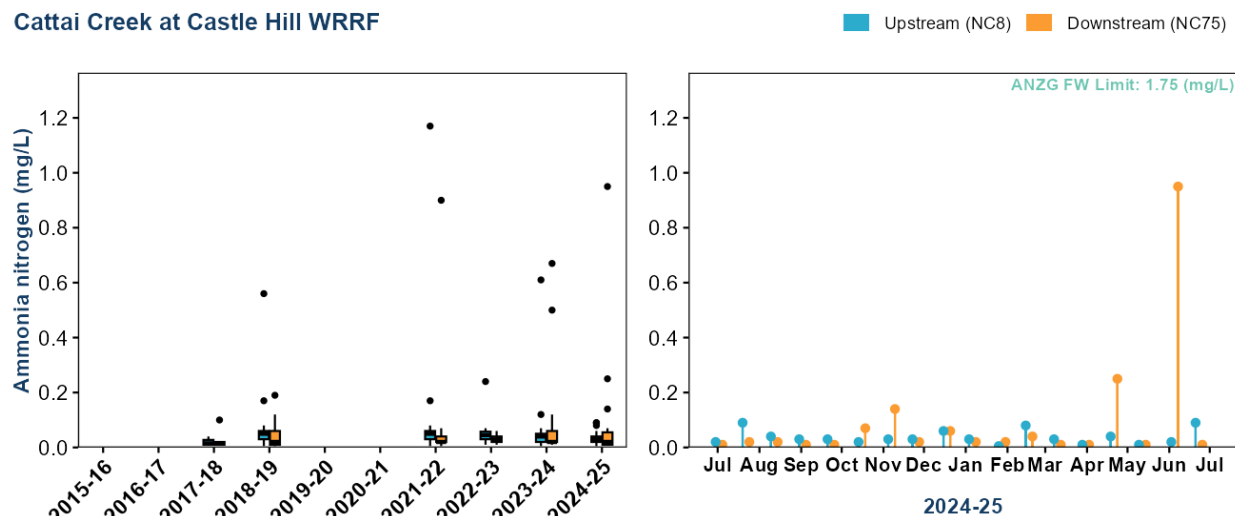
Table A-118 Downstream current period (2024-25) vs previous period comparison (single site) for Cattai Creek at Castle Hill WRRF

Cattai Creek at Castle Hill WRRF: NC75 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.97	0.25	180	-0.13	>0.999
Oxidised nitrogen	1.92	0.57	180	2.19	0.129
Total nitrogen	1.64	0.33	180	2.46	0.071
Soluble reactive phosphorus	2.25	0.77	66	2.38	0.092
Total phosphorus	1.31	0.20	180	1.80	0.279
Physico-chemical					
Conductivity	1.21	0.14	180	1.65	0.351
Dissolved oxygen	0.96	0.03	180	-1.08	0.704
Dissolved oxygen saturation	-0.52	1.83	180	-0.28	0.992
pH	-0.05	0.04	180	-1.23	0.609
Water temperature	1.07	0.07	180	1.12	0.677
Turbidity	0.52	0.15	180	-2.33	0.096
Trace Metals					
Filterable aluminium	0.95	0.19	66	-0.25	0.994
Total aluminium	0.72	0.25	66	-0.97	0.769
Filterable cobalt	0.99	0.15	66	-0.07	>0.999
Total cobalt	0.98	0.16	66	-0.10	>0.999
Filterable copper	0.73	0.08	66	-2.95	0.022
Total copper	0.70	0.10	66	-2.56	0.060
Filterable nickel	0.94	0.10	66	-0.56	0.944
Total nickel	0.90	0.09	66	-1.13	0.671
Filterable zinc	1.01	0.11	65	0.12	>0.999
Total zinc	0.96	0.12	66	-0.36	0.984

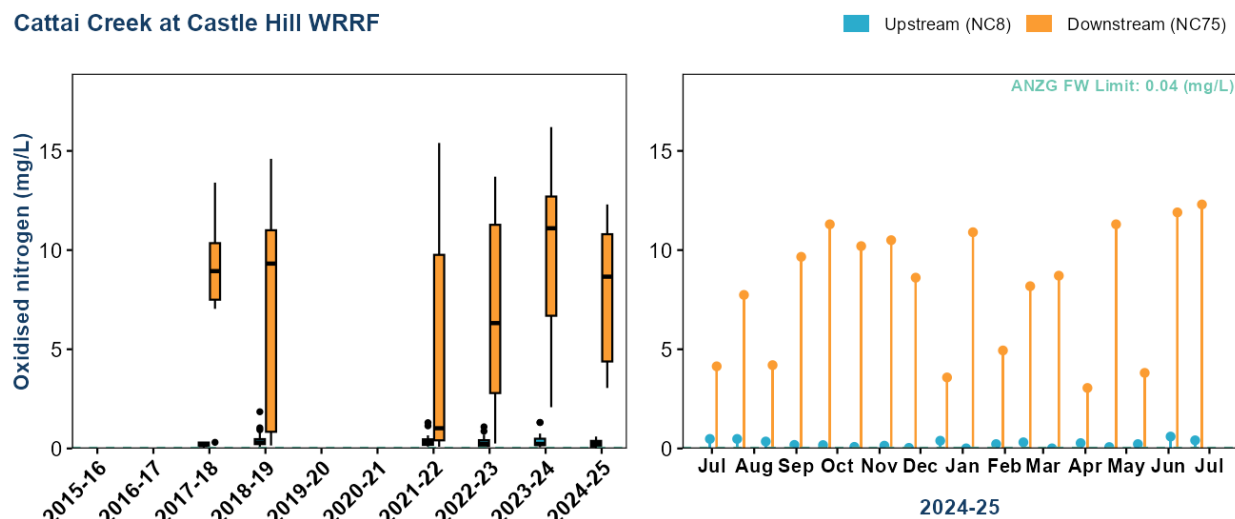
not significant (p>0.05)	p <0.05 and >=0.01	p <0.01 and >=0.001	p <0.001
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A.12.6. Stressor – Nutrients

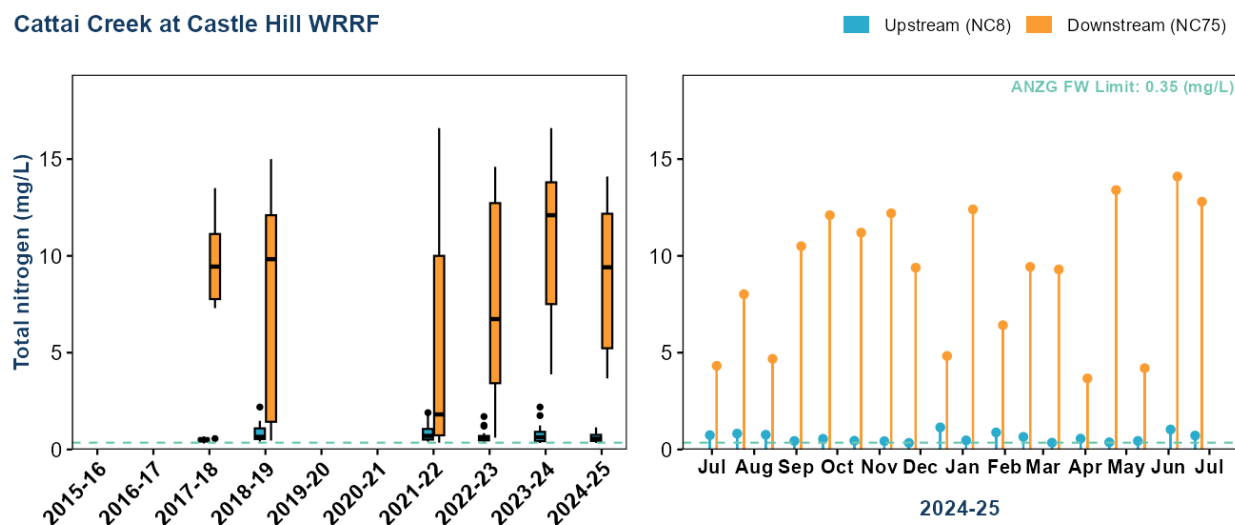
Cattai Creek at Castle Hill WRRF



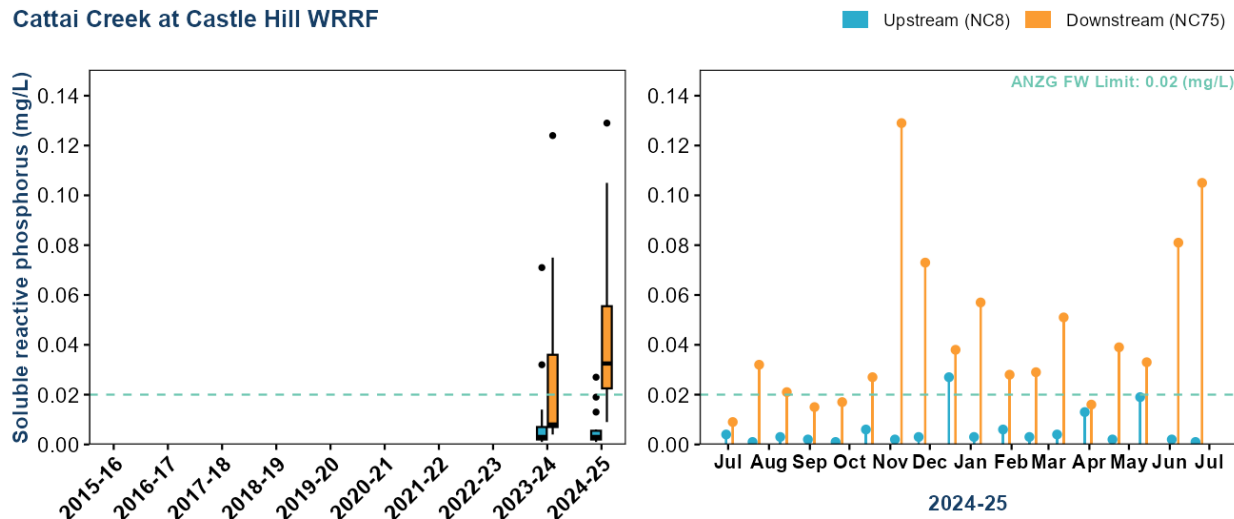
Cattai Creek at Castle Hill WRRF



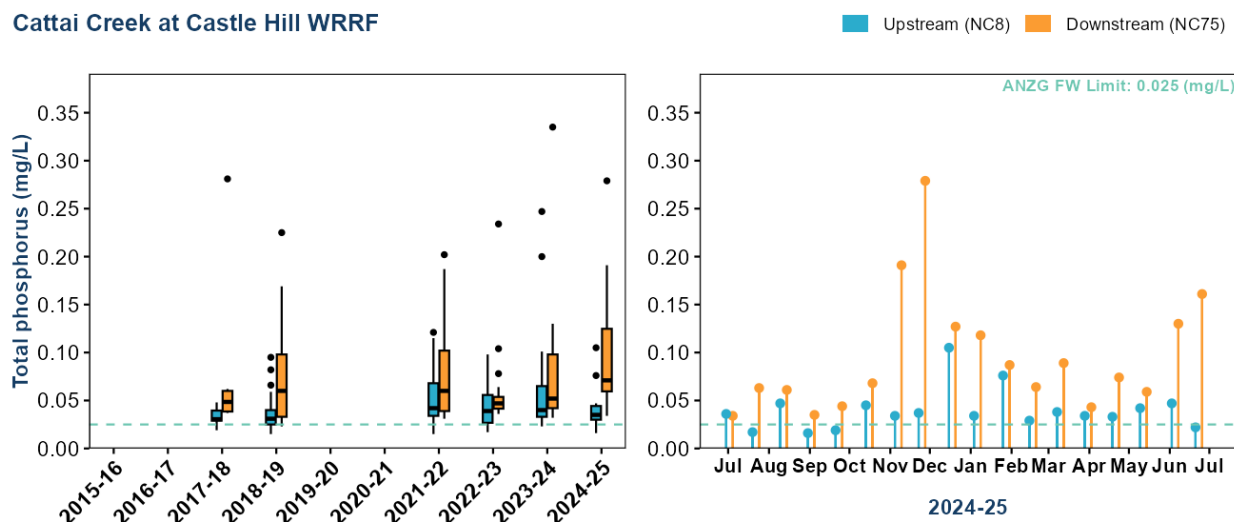
Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF

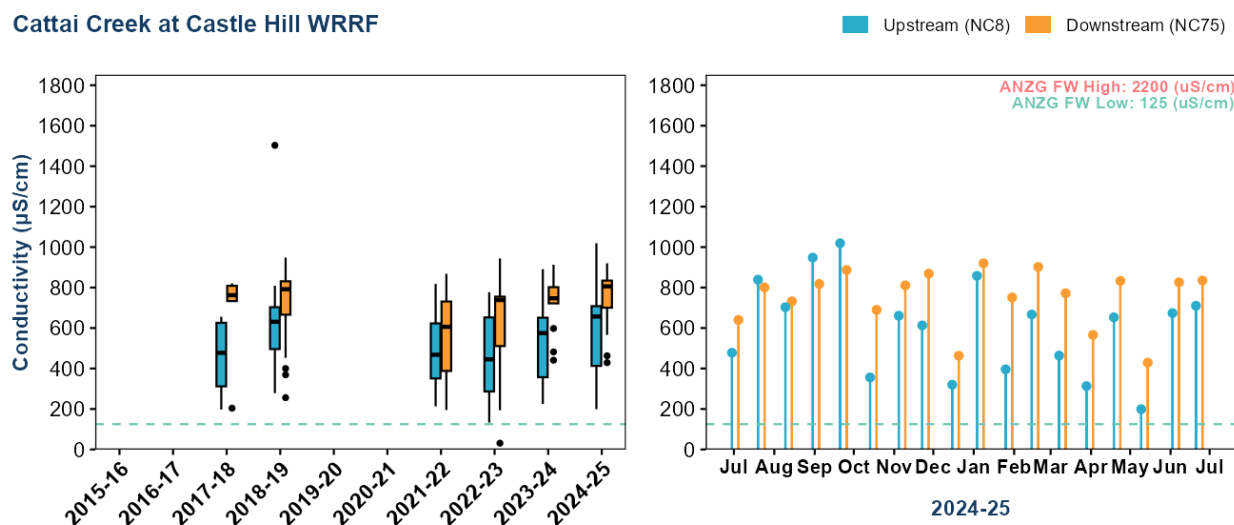


Cattai Creek at Castle Hill WRRF

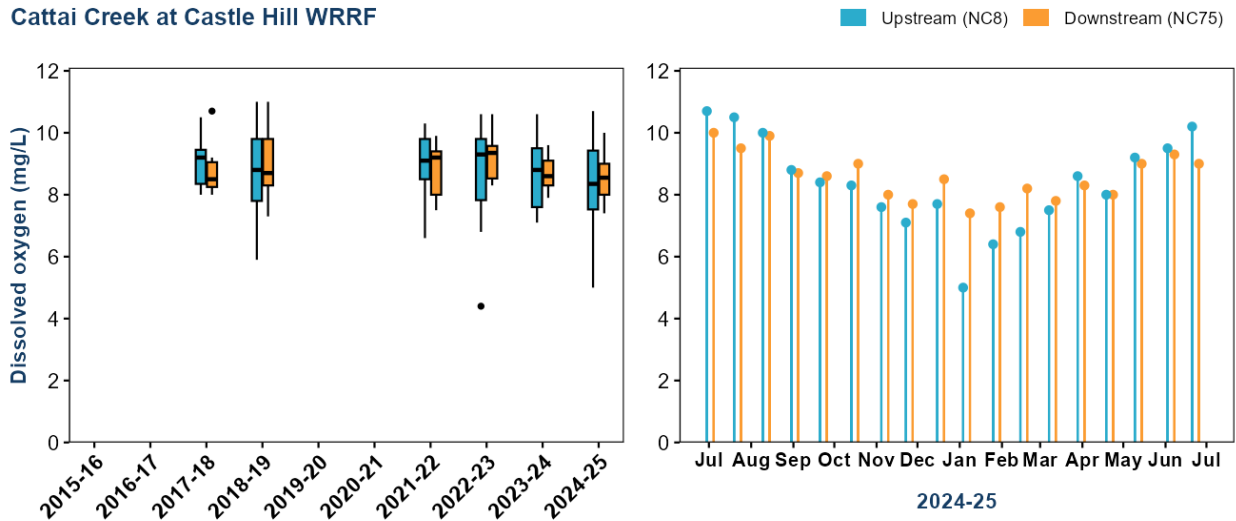


A.12.7. Stressor – Physico-chemical water quality

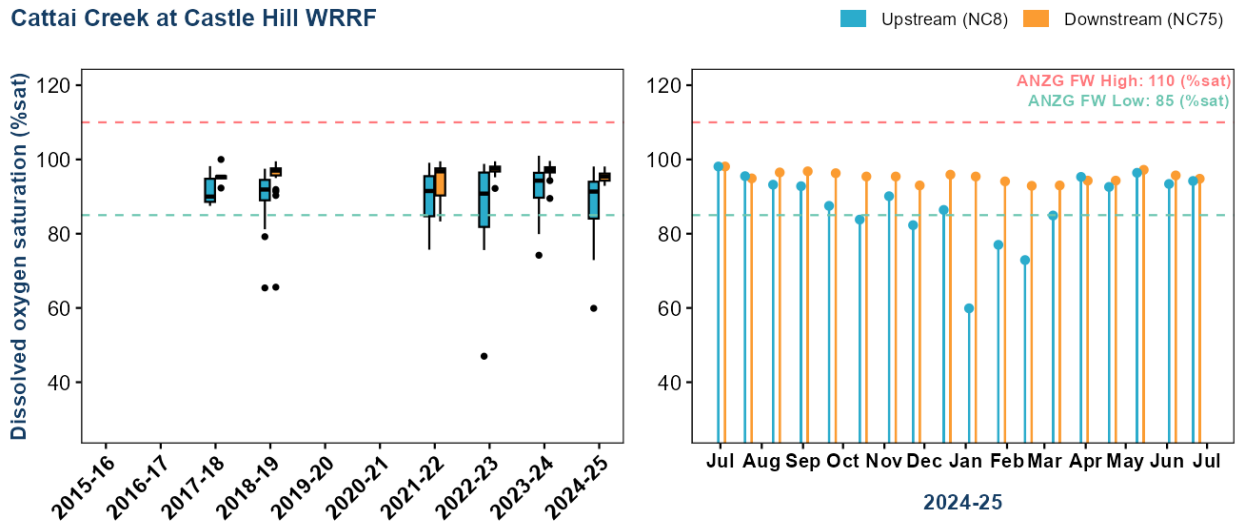
Cattai Creek at Castle Hill WRRF



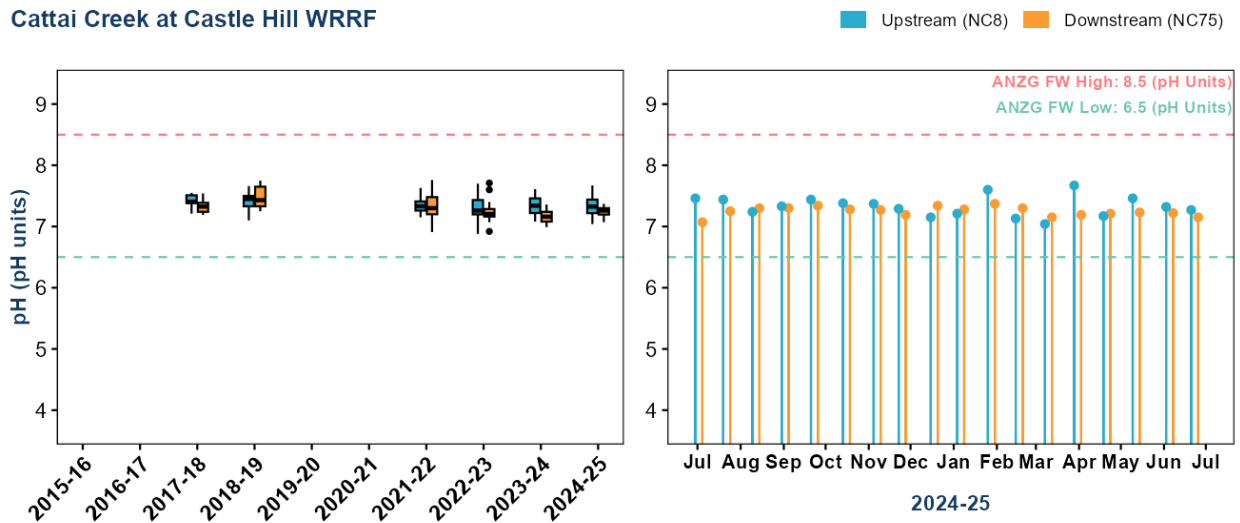
Cattai Creek at Castle Hill WRRF



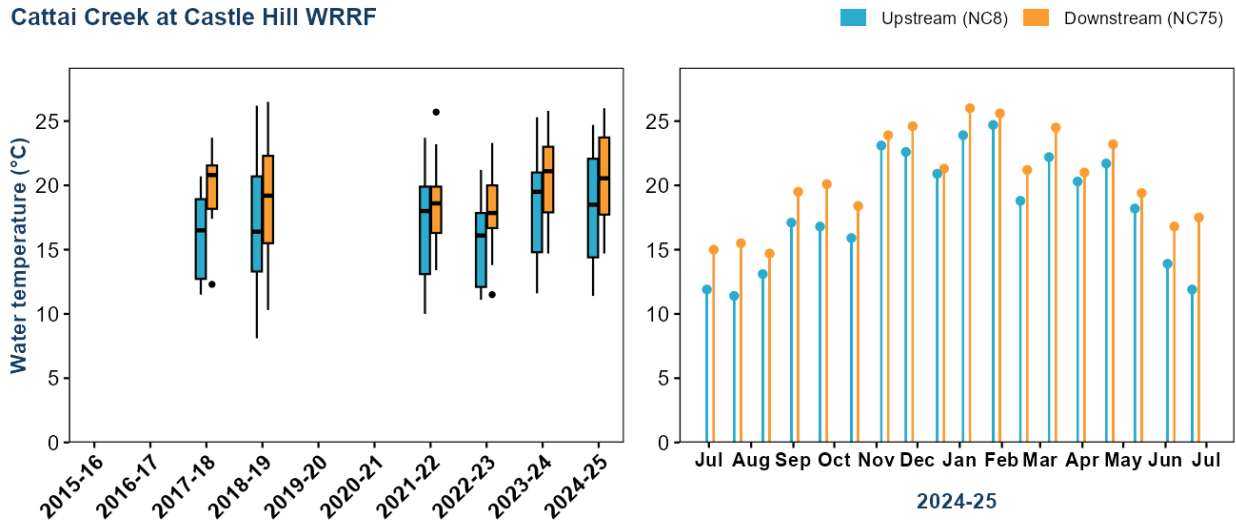
Cattai Creek at Castle Hill WRRF



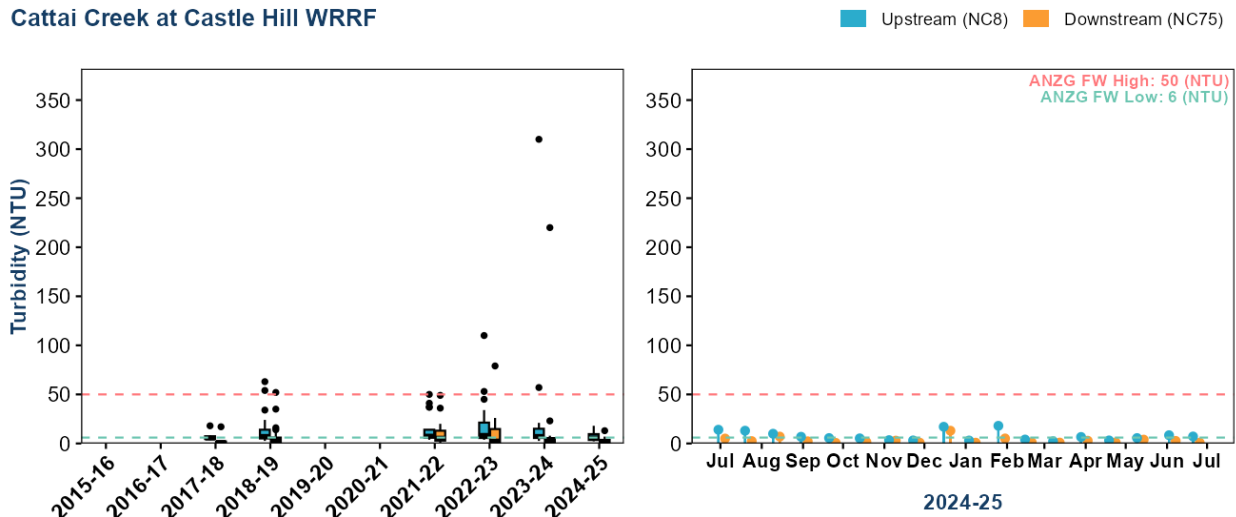
Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF

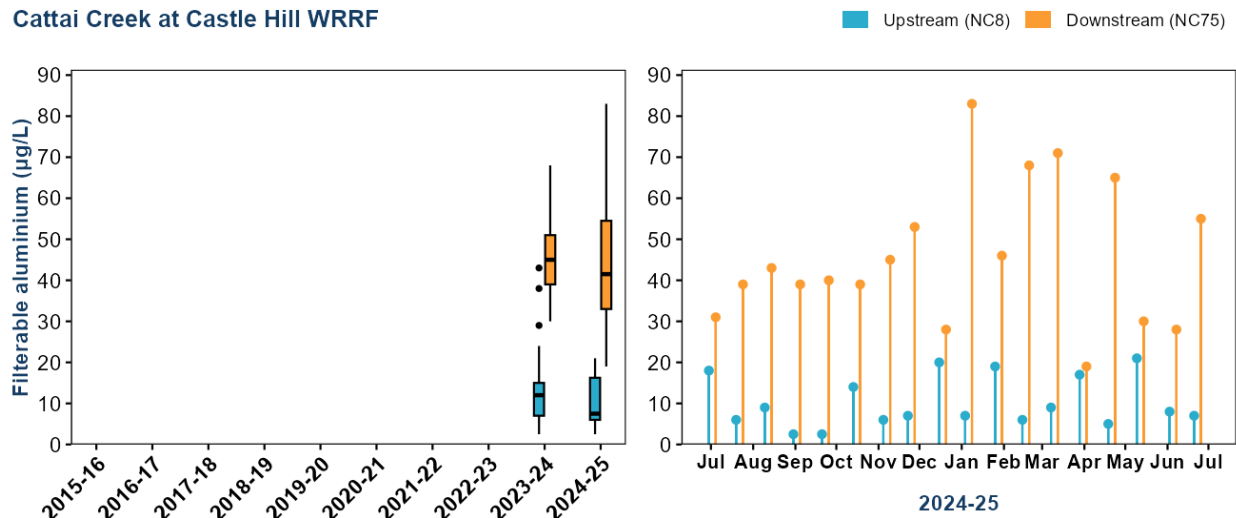


Cattai Creek at Castle Hill WRRF

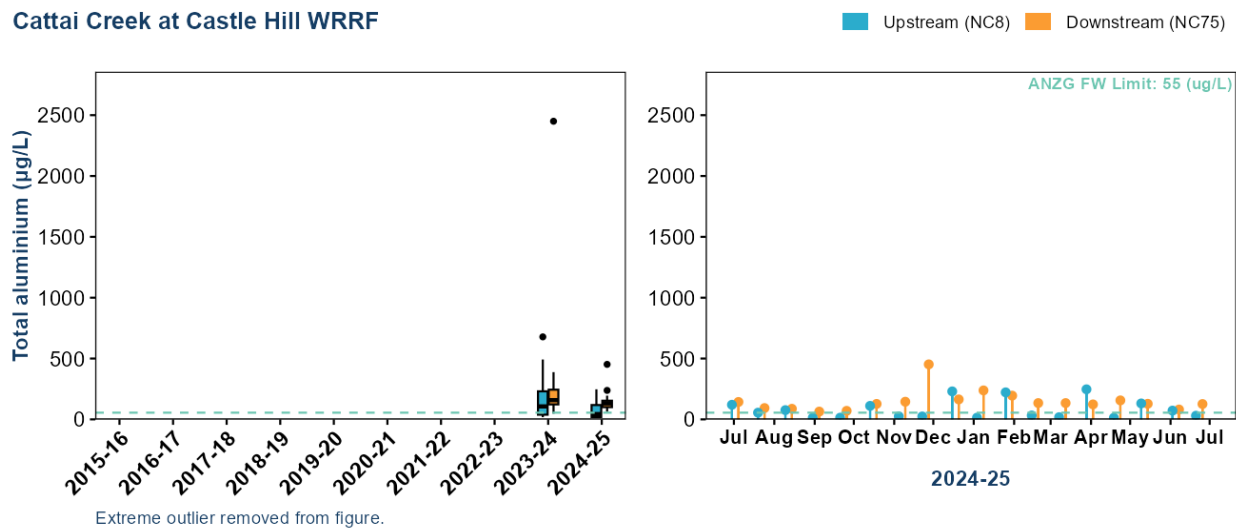


A.12.8. Stressor – Trace metals

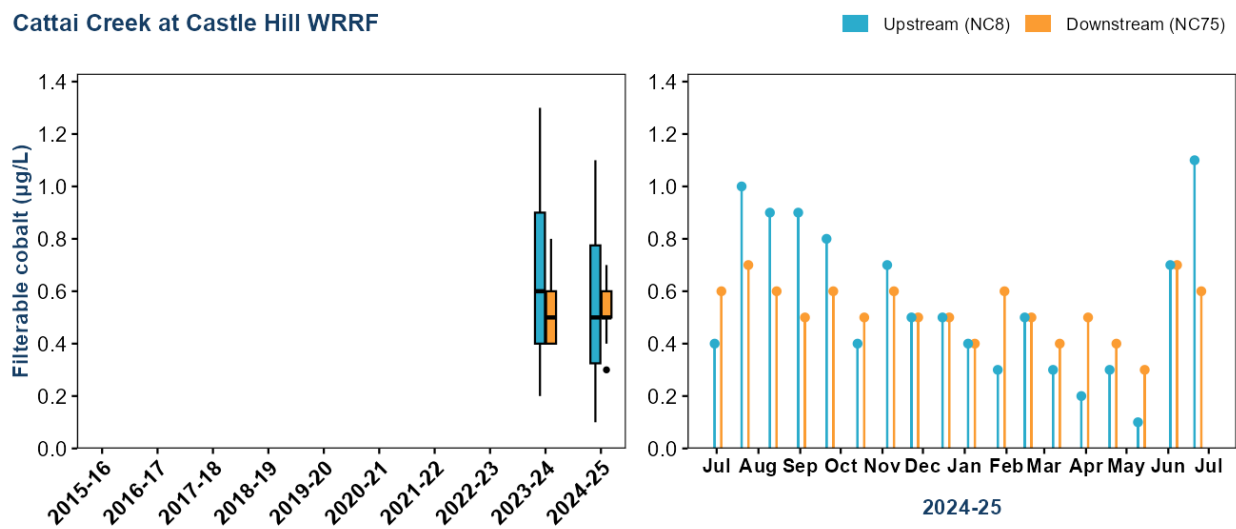
Cattai Creek at Castle Hill WRRF



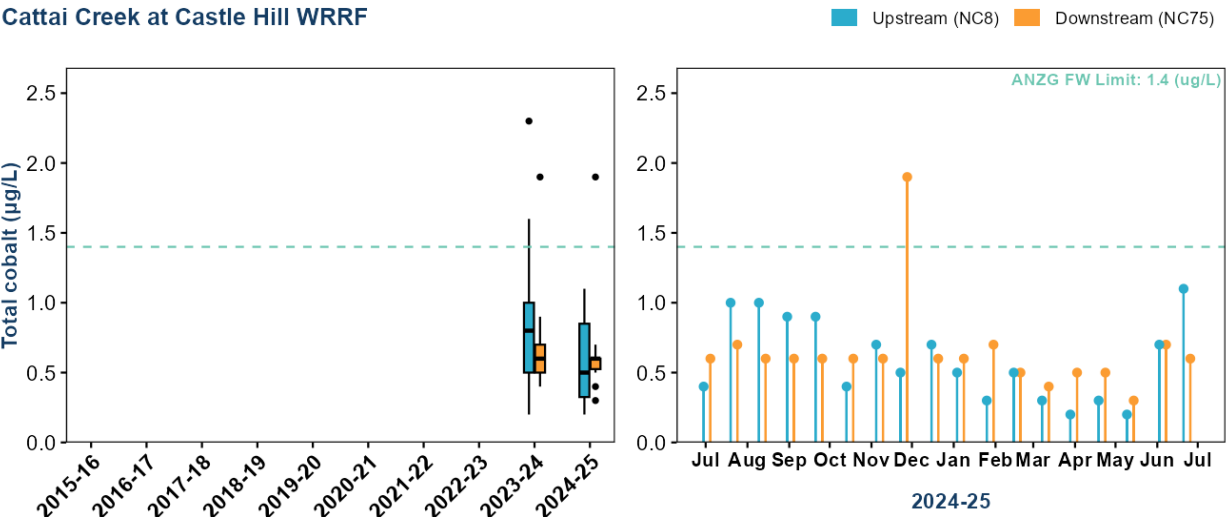
Cattai Creek at Castle Hill WRRF



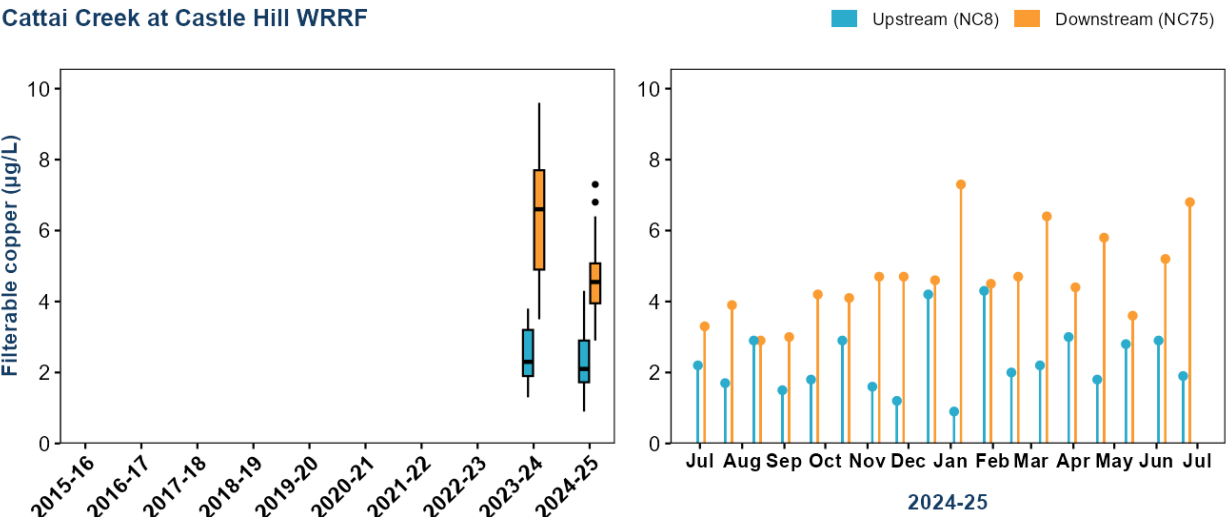
Cattai Creek at Castle Hill WRRF



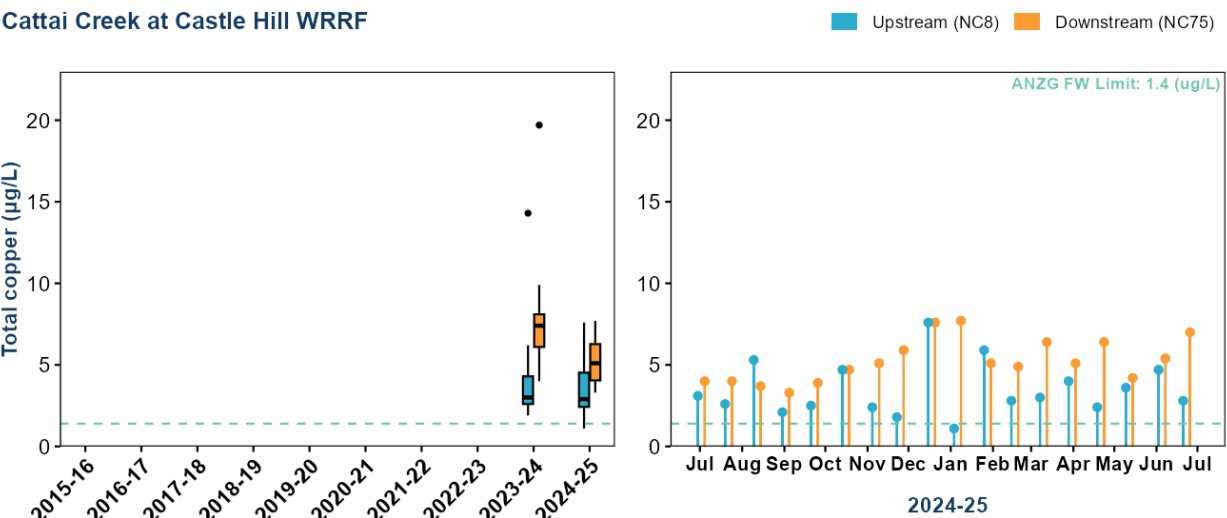
Cattai Creek at Castle Hill WRRF



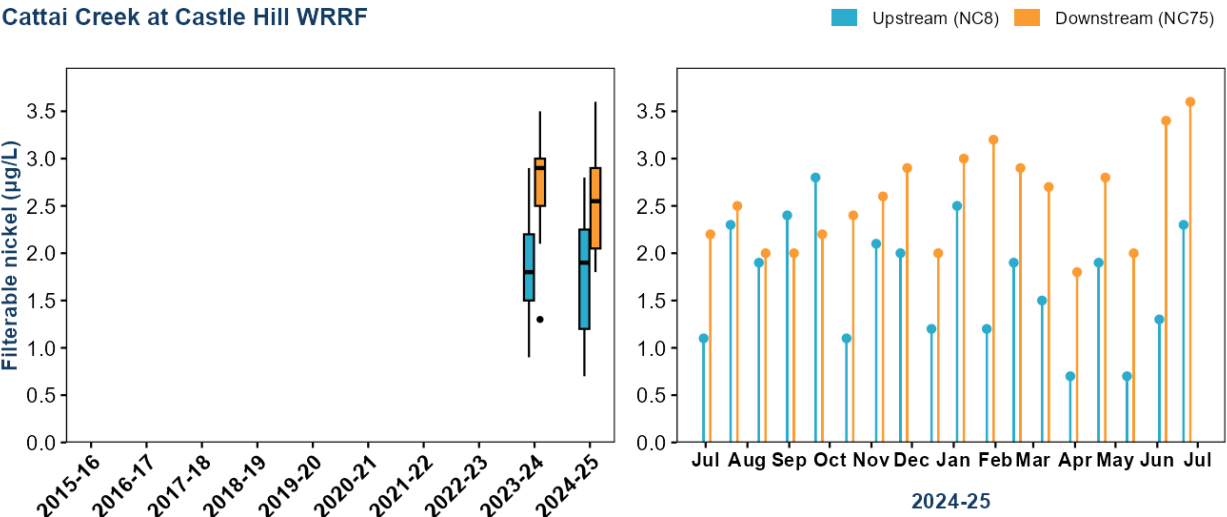
Cattai Creek at Castle Hill WRRF



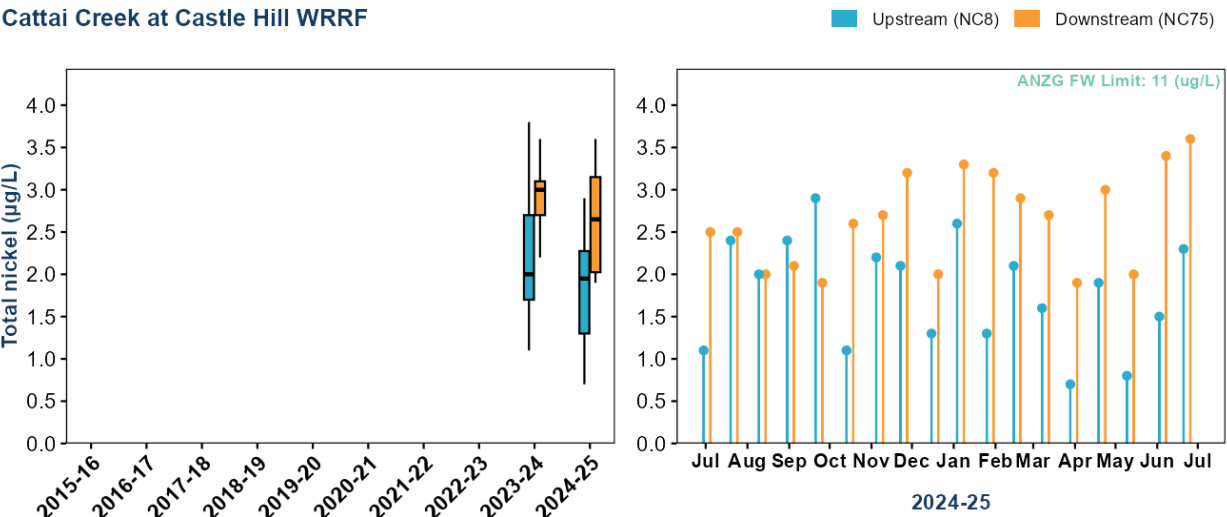
Cattai Creek at Castle Hill WRRF



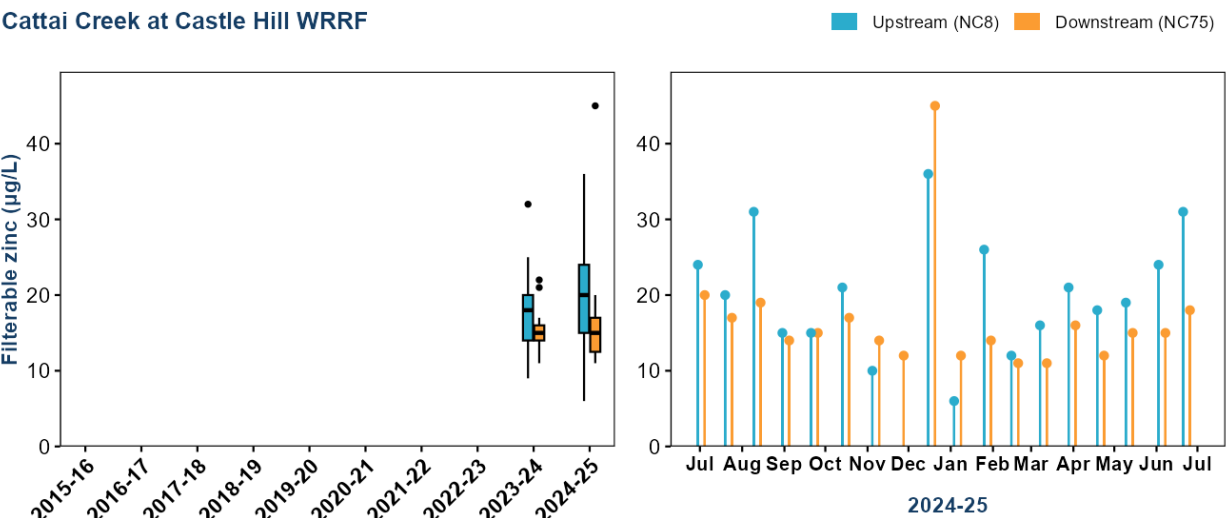
Cattai Creek at Castle Hill WRRF



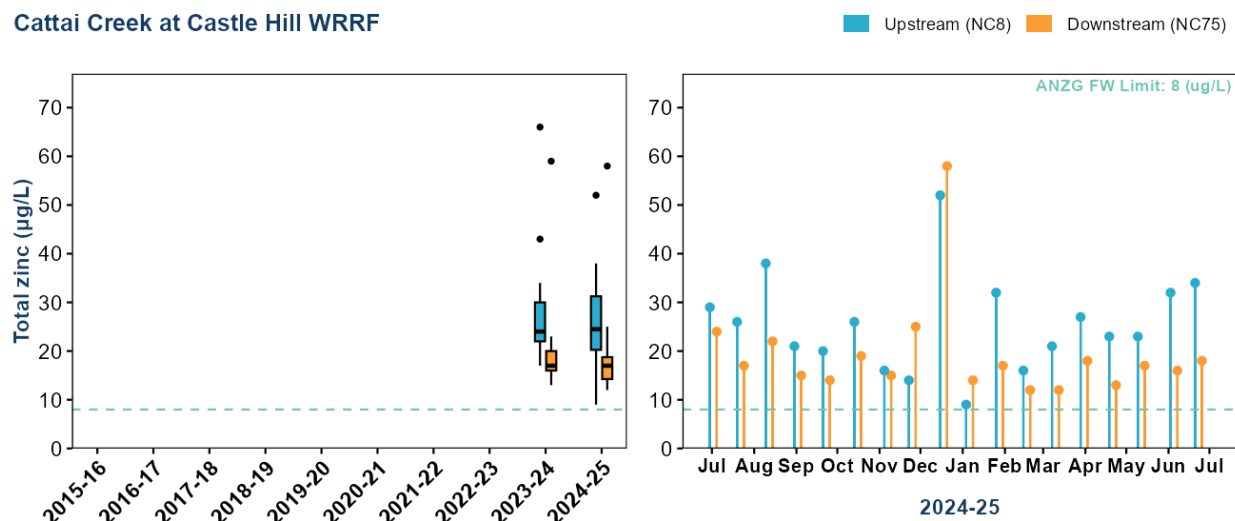
Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF



A.12.9. Ecosystem receptor – Statistical analysis outcomes

Table A-119 Upstream vs downstream comparison (2024-25 reporting period) for Cattai Creek at Castle Hill WRRF

Cattai Creek at Castle Hill WRRF: NC8 vs NC75 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.34	0.44	180	0.88	0.815
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-120 Upstream current period (2024-25) vs previous period comparison (single site) for Cattai Creek at Castle Hill WRRF

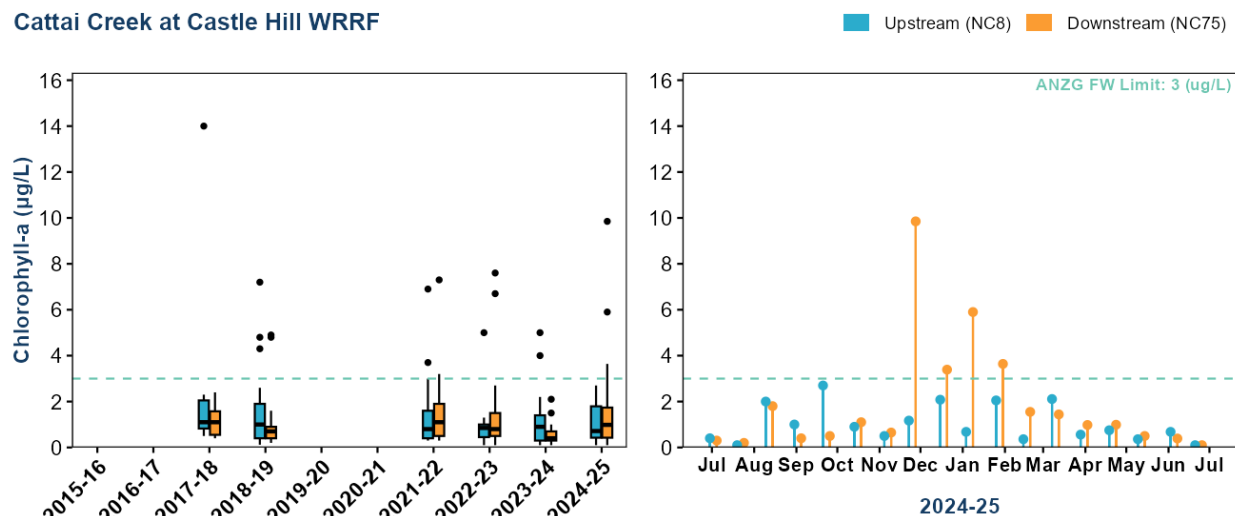
Cattai Creek at Castle Hill WRRF: NC8 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.88	0.23	180	-0.49	0.961
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-121 Downstream current period (2024-25)vs previous period comparison (single site) for Cattai Creek at Castle Hill WRRF

Cattai Creek at Castle Hill WRRF: NC75 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.35	0.35	180	1.17	0.649
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.12.10. Ecosystem receptor – Phytoplankton

Cattai Creek at Castle Hill WRRF

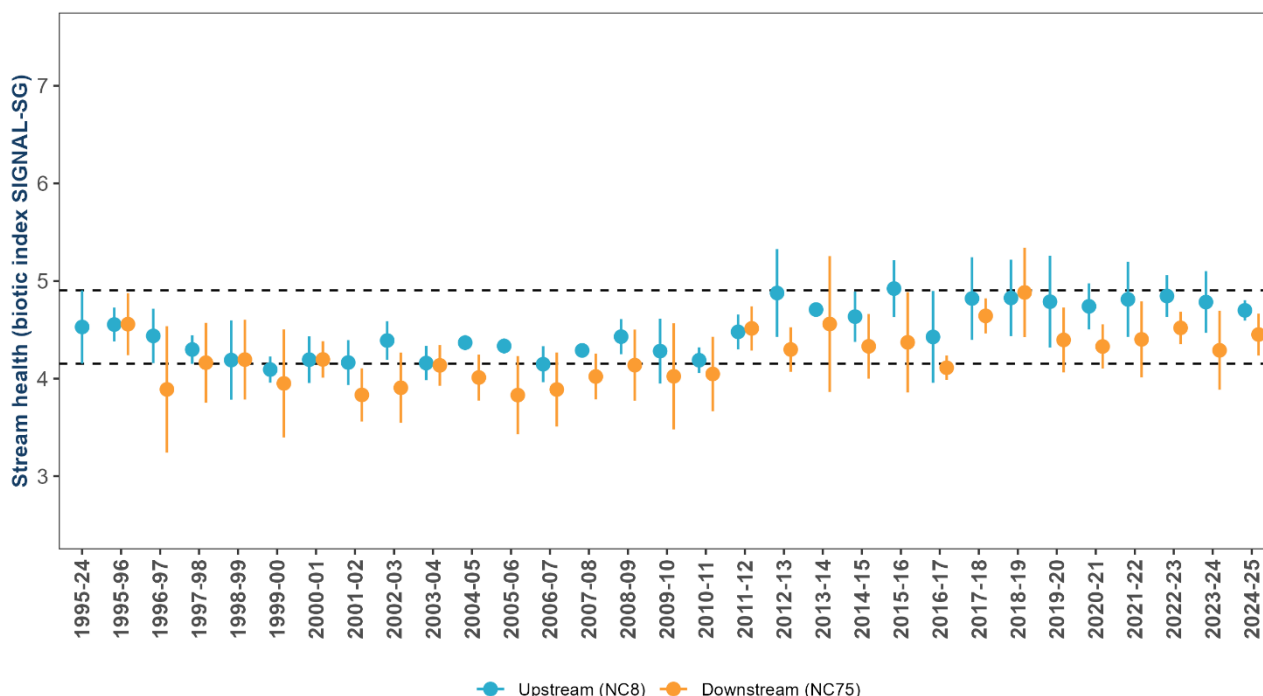


A.12.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Cattai Creek	River (NC8 vs NC75)	Welch Two Sample t-test	0.25	2.49	7.5	0.039

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Cattai Creek at Castle Hill WRRF



The range of stream health recorded over each period is represented by length of line

A.12.12. Gate 3 investigation for Castle Hill WRRF

Ammonia nitrogen concentrations were stable in the receiving waterways despite increasing trends in the discharge from Castle Hill WRRF. All other nitrogen and phosphorus analytes, as well as filterable aluminium, copper and nickel were significantly higher in the receiving waters downstream of the discharge point (NC75). The gate 3 analysis focused on investigating the potential influence of the water quality parameters on the impacted stream health at the Cattai Creek downstream site as indicated by the macroinvertebrate biotic index (SIGNAL-SG) scores.

Stage 1: Multivariate analysis of macroinvertebrate community data

Significant differences in the SIGNAL-SG metric between upstream and downstream sites, combined with potential impact identified during the gate 2 assessment, prompted a gate 3 multivariate assessment of the macroinvertebrate community in receiving waters at Castle Hill WRRF. Riffle and edge were sampled at the upstream and downstream sites for the 2022 to 2025 period.

Visual assessment of the taxonomic assemblage within edge and riffle habitats (Figure A-16 to Figure A-19) provided an initial indication of site separations. The 2D nMDS ordination riffle plot (Figure A-17) shows a substantial overlap between upstream and downstream assemblage, indicating similar macroinvertebrate composition across sites. Upstream samples from 2024-25 clustered near historical points but showed a slight spread, possibly reflecting natural variability. Downstream samples from 2024-25 remained within the historical cluster, indicating continuity rather than a major change. The edge habitat ordination (Figure A-16) showed a greater dispersion overall, with upstream and downstream samples forming loose clusters but with no noticeable overlap. Upstream samples from 2024-25 appeared slightly offset from the main cluster, suggesting potential ecological shifts upstream. Downstream samples from 2024-25 were scattered among historical points, indicating stability. The riffle cluster diagram shows a high similarity amongst most samples, with clustering patterns indicating the upstream and downstream communities are broadly comparable. The first major split separates a subset of upstream samples from the rest, suggesting that upstream samples from 2024-25 may be contributing most to observed differences. The edge habitat cluster diagram also showed high similarity amongst samples, with clustering patterns indicating that upstream and downstream assemblages were comparable over time. Similar to the riffle cluster, upstream data from 2024-25 may be contributing most to observed differences.

Multivariate statistical results are summarised in Table A-122. PERMDISP analysis indicated a significant difference in dispersion between upstream and downstream sites for edge habitat ($p = 0.0119$), suggesting variability within groups differs and interpretation of site differences should consider this heterogeneity. In contrast, the riffle habitat showed no significant difference in dispersion ($p = 0.7497$), meaning any observed site differences are unlikely to be driven by variability within sites.

ANOSIM results confirmed moderate differences in taxonomic assemblage between upstream and downstream sites for both habitats, although the strength of separation varied. For the riffle habitat, the site effect was weak ($R = 0.098$, $p = 0.001$), suggesting broadly similar taxonomic assemblage with only slight compositional differences. For the edge habitat, the site effect was slightly higher ($R = 0.256$, $p < 0.001$), indicating clearer ecological separation in comparison to the riffle habitat.



Temporal interactions (Site $\times$ Period) were also significant for both habitats, but with low R values, indicating minor influence of time on site differences.

Pairwise ANOSIM comparisons revealed that upstream–downstream differences were more pronounced in the edge habitat than in the riffle habitat, particularly in recent years. For the edge habitat, the strongest separation occurred between 2024-25 upstream and downstream samples ($R = 0.696$, $p = 0.002$), indicating a clear divergence in taxonomic assemblage. In contrast, riffle habitat showed consistently low R values across all comparisons, suggesting only minor compositional differences and limited temporal influence. These results reinforce that edge habitat exhibits stronger site-related variation, whereas riffle communities remain broadly similar over time.

PERMANOVA supported these findings, with significant site effects for both habitats (edge: $R = 11.706$, $p < 0.001$; riffle: $R = 5.882$, $p < 0.001$). Year effects were also significant for both habitats (edge: $p < 0.001$; riffle: $p < 0.001$), suggesting that temporal variation contributes to differences in taxonomic assemblage. However, site-year interactions were not significant, indicating that upstream–downstream differences persist across years rather than fluctuating unpredictably. The estimates of components of variation showed that for edge habitat, site (277.25) and year (232.54) explain similar levels of variation, while residual variation remained high (1503.7). For riffle habitat, year explained more variation (360.08) than site (134.64), indicating that temporal factors were more influential for riffle taxonomic assemblages than spatial differences.

Shade plots provide further insight into taxonomic assemblage. For the edge habitat, the plot shows that a few taxa dominate the community, while many occur at low abundance (Figure A-20). 2024-25 upstream and downstream samples display noticeable differences in shading intensity for certain taxa, suggesting shifts in relative abundance that align with the statistical results. For riffle habitat, the shade plot indicate a stable community structure with limited site-based separation (Figure A-21). Most taxa occur at low abundance across samples, and sensitive taxa (SIGNAL 8–9) are present at both sites, suggesting the riffle habitat continues to support taxa indicative of good water quality. Variation in recent years is subtle and likely reflects natural variability rather than major ecological shifts.

Overall, the edge habitat showed clearer upstream–downstream separation, particularly in recent years, while riffle communities remained broadly similar but exhibited stronger temporal variability. These multivariate analysis results suggested alteration of taxonomic assemblage from wastewater discharge in the Cattai Creek from the edge habitat.

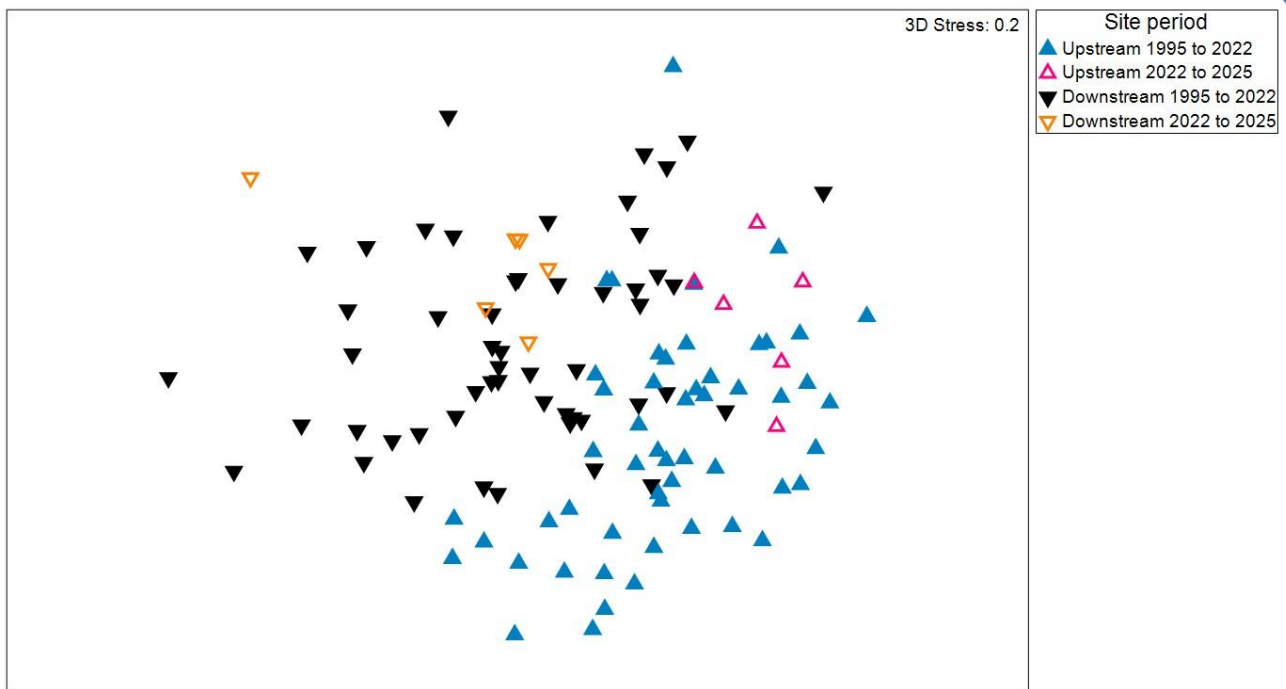


Figure A-16 Dimensions 1 and 2 of 2-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure of upstream and downstream sites in Cattai Creek near Castle Hill WRRF

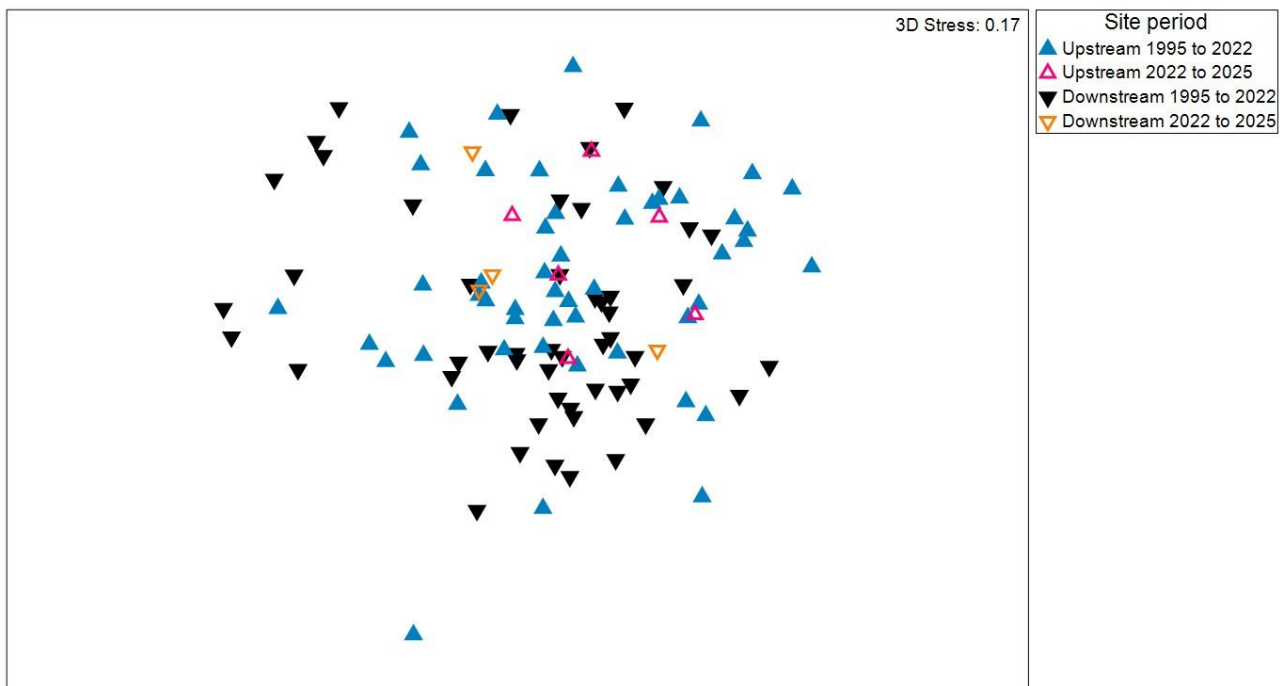


Figure A-17 Dimensions 1 and 2 of 2-dimensional ordination plot of freshwater macroinvertebrate riffle habitat community structure of upstream and downstream sites in Cattai Creek near Castle Hill WRRF

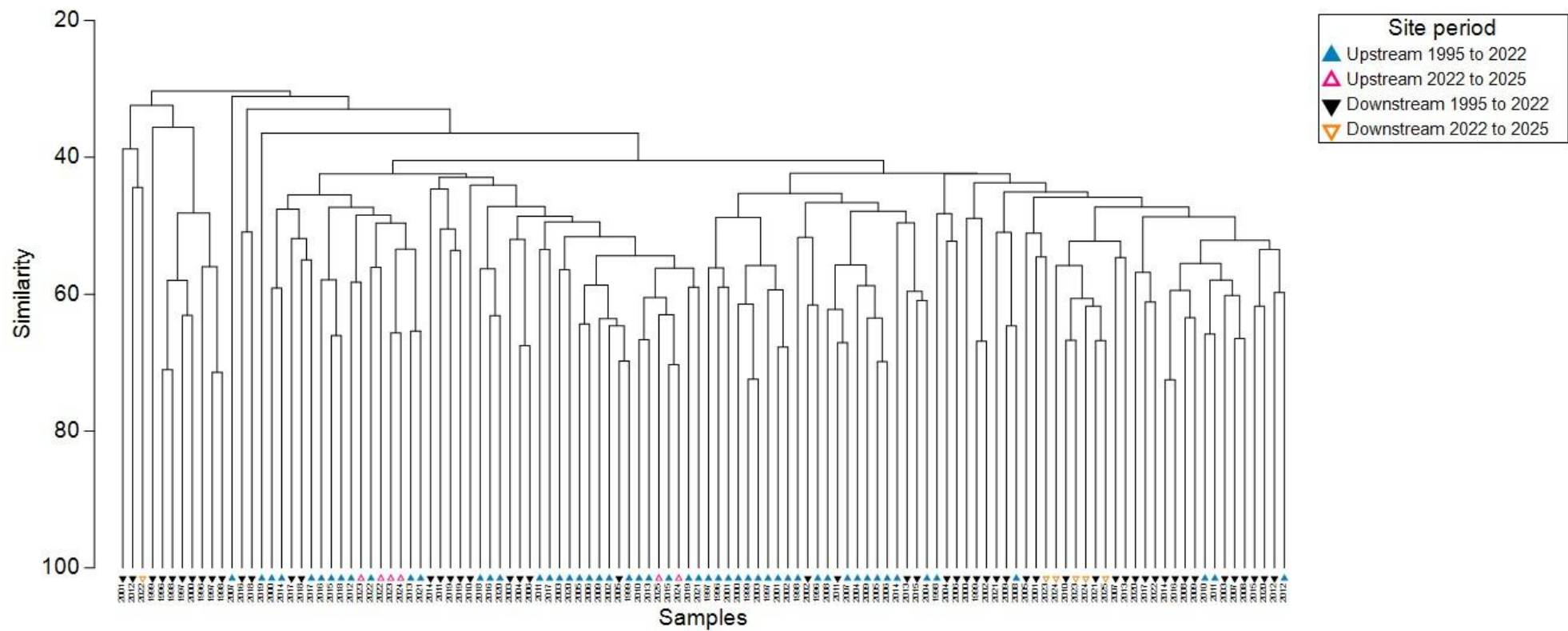


Figure A-18 Cluster diagram of freshwater macroinvertebrate edge habitat community structure in Cattai Creek near Castle Hill WRRF

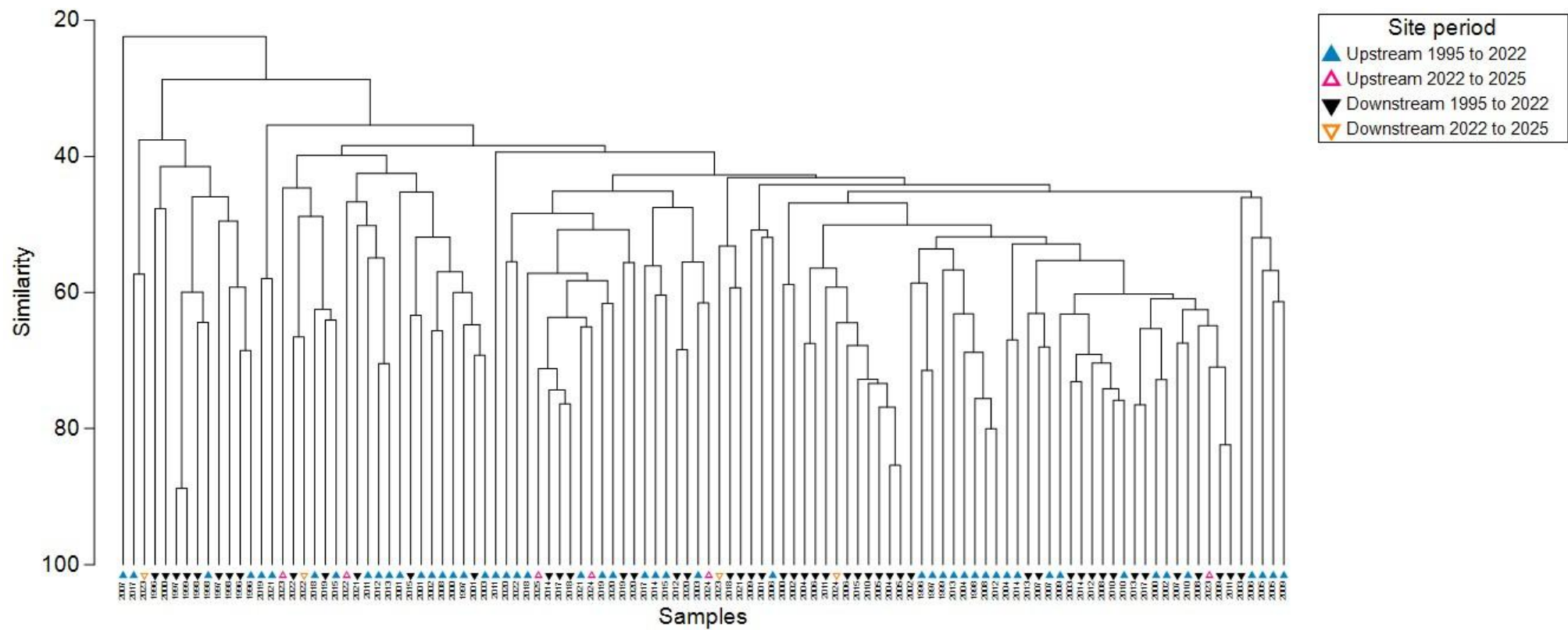


Figure A-19 Cluster diagram of freshwater macroinvertebrate riffle habitat community structure in Cattai Creek near Castle Hill WRRF

Table A-122 Macroinvertebrate multivariate statistical test summary for Cattai Creek near Castle Hill WRRF

Castle Hill		Edge			Riffle		
		df	Sample Statistic (Pseudo-F/R)	p-value	df	Sample Statistic (Pseudo-F/R)	p-value
PERMDISP	Site	1 (116)	7.092	0.0119	1 (108)	0.118	0.7497
ANOSIM	Site	-	0.256	<0.001	-	0.098	<0.001
	SitexPeriod	-	0.219	<0.001	-	0.095	0.001
PERMANOVA	Site	1 (117)	11.706	<0.001	1 (109)	5.882	<0.001
	Year	29 (117)	1.608	<0.001	28 (109)	1.928	<0.001
	SitexYear	29 (117)	0.928	0.8309	27 (109)	0.929	0.7675

Table A-123 ANOSIM pairwise comparisons of 'Site period' test for edge and riffle habitats of Cattai Creek near Castle Hill WRRF

Castle Hill	Edge		Riffle	
	R Statistic	p-value	R Statistic	p-value
Downstream 1995 to 2022, Upstream 1995 to 2022	0.239	<0.001	0.101	<0.001
Downstream 1995 to 2022, Downstream 2022 to 2025	-0.174	0.937	0.029	0.391
Downstream 1995 to 2022, Upstream 2022 to 2025	0.229	0.026	0.08	0.252
Upstream 1995 to 2022, Downstream 2022 to 2025	0.395	<0.001	0.205	0.087
Upstream 1995 to 2022, Upstream 2022 to 2025	0.211	0.032	0.042	0.348
Downstream 2022 to 2025, Upstream 2022 to 2025	0.696	0.002	0.024	0.410

Table A-124 Estimates of components of variation from PERMANOVA tests for Cattai Creek edge and riffle habitats

Castle Hill	Edge	Riffle
S(Site)	277.25	134.64
S(Year)	232.54	360.08
S(SitexYear)	-55.134	-53.619
V(Res)	1503.7	1466

Table A-125 Genera subset whose multivariate pattern matches full genera set of the riffle habitat of Cattai Creek near Castle Hill WRRF

Subset of 34 (correlation of 0.952) genera from edge habitat whose patterns match that of the full set of 120 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, Chironomidae Chironomus, Physidae Physella, Planorbidae Helicorbis, Chironomidae Cricotopus, Chironomidae Cryptochironomus, Chironomidae Dicrotendipes, Dugesidae Cura, Glossiphoniidae Helobdella, Lumbriculidae Lumbriculus, Lymnaeidae Pseudosuccinea, Naididae Branchiura, Naididae Nais, Simuliidae Simulium, Argiolestidae Austroargiolestes, Chironomidae Cladotanytarsus, 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-126 Genera subset whose multivariate pattern matches full genera set of the riffle habitat of Cattai Creek near Castle Hill WRRF

Subset of 28 (correlation of 0.950) genera from riffle habitat whose patterns match that of the full set of 75 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 Vivabдела, Physidae Physella, Tipulidae Limonia, Chironomidae Cricotopus, Chironomidae Cryptochironomus, Chironomidae Dicrotendipes, Dugesidae Cura, Glossiphoniidae Helobdella, Lumbriculidae Lumbriculus, Lymnaeidae Pseudosuccinea, Naididae Nais, Simuliidae Simulium, Chironomidae Eukiefferiella, Chironomidae Polypedilum, Chironomidae Rheocricotopus, Chironomidae Rheotanytarsus, Chironomidae Thienemanniella, Hydropsychidae Cheumatopsyche, Tateidae Potamopyrgus, Elmidae Simsonia, Hydrobiosidae Ulmerochorema, Hydroptilidae Hellyethira, Chironomidae Paramerina, Chironomidae Paratanytarsus, Psephenidae Sclerocyphon, Stratiomyidae Odontomyia

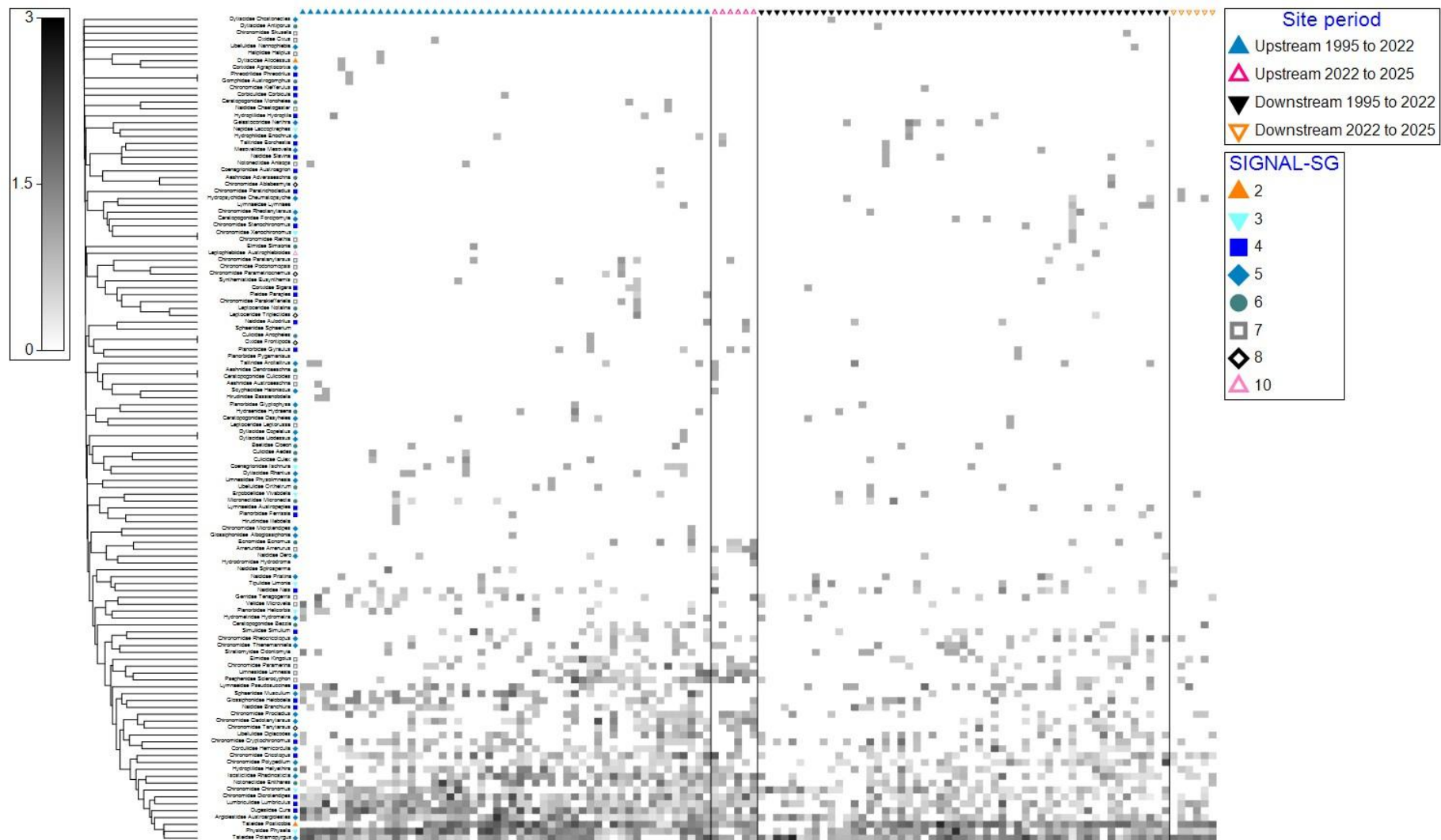


Figure A-20 Shade plot of freshwater macroinvertebrate edge habitat community structure upstream and downstream sites in Cattai Creek near Castle Hill WRRF

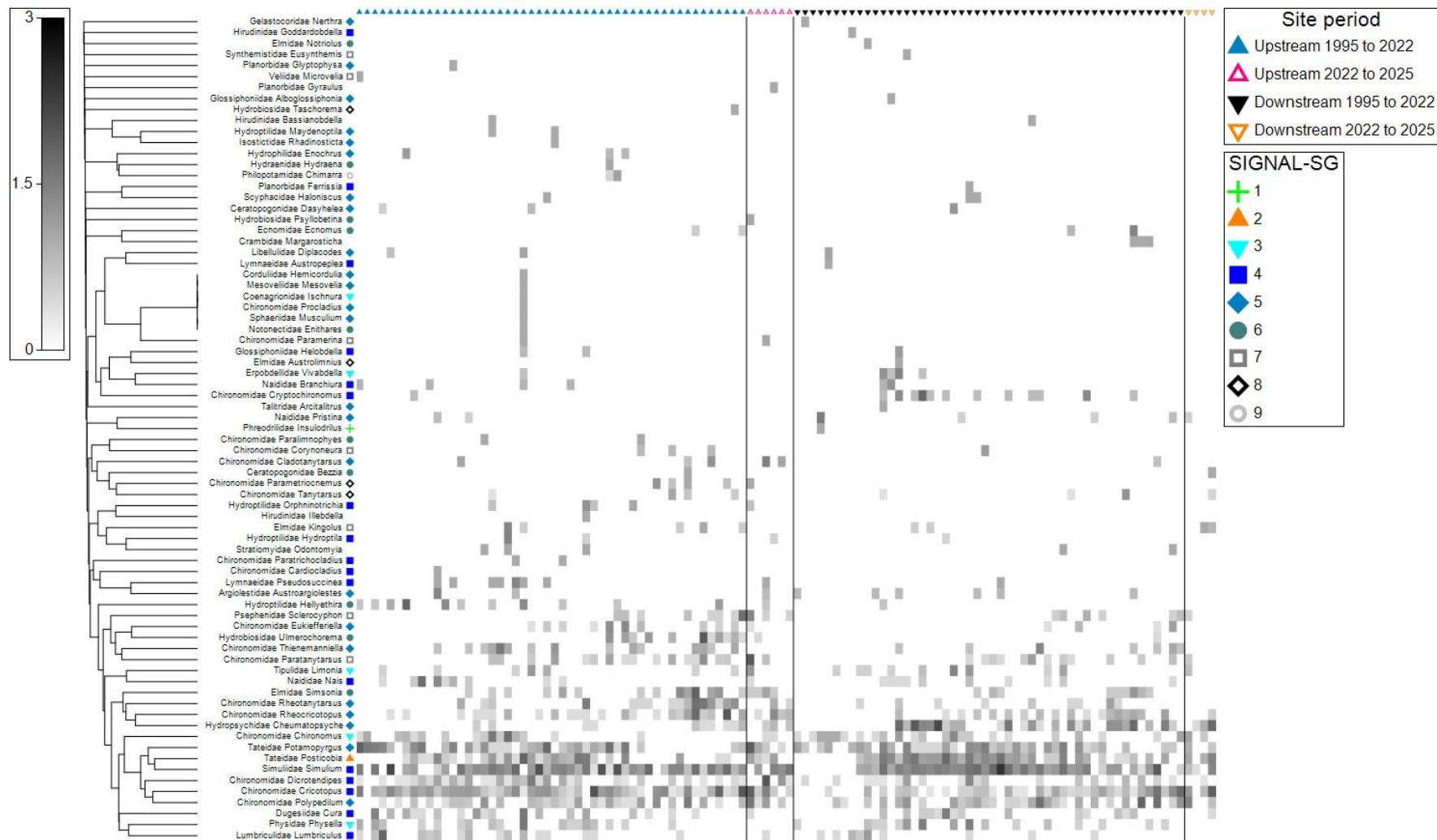


Figure A-21 Shade plot of freshwater macroinvertebrate riffle habitat community structure upstream and downstream sites in Cattai Creek near Castle Hill WRRF

Stage 2: Multivariate regression linking water quality and ecosystem receptors

Boxplots depicting the upstream and downstream comparisons of the modelled parameters indicated a marginally increased total phosphorus concentration downstream (Figure A-22). A visualisation of the long-term trends in the waterway suggests that the marginally increased concentrations of total phosphorus downstream were consistently observed throughout the historic dataset (Figure A-23). This was further supported by the models sequential testing, which suggested that total phosphorus was the best fit predictor of macroinvertebrate SIGNAL-SG score ($AICc = -63.54$). Marginal tests of the model found that the contribution of total phosphorus to the variation in macroinvertebrates as an ecosystem receptor was not significant (Table A-127). Overall, the model explained very little of the variation in macroinvertebrate SIGNAL-SG (17%) score which indicates that there are likely unaccounted for water quality parameters (not monitored or insufficient data) that were not included in the DISTLM.

Cattai Creek at Castle Hill WRRF (2018-25)

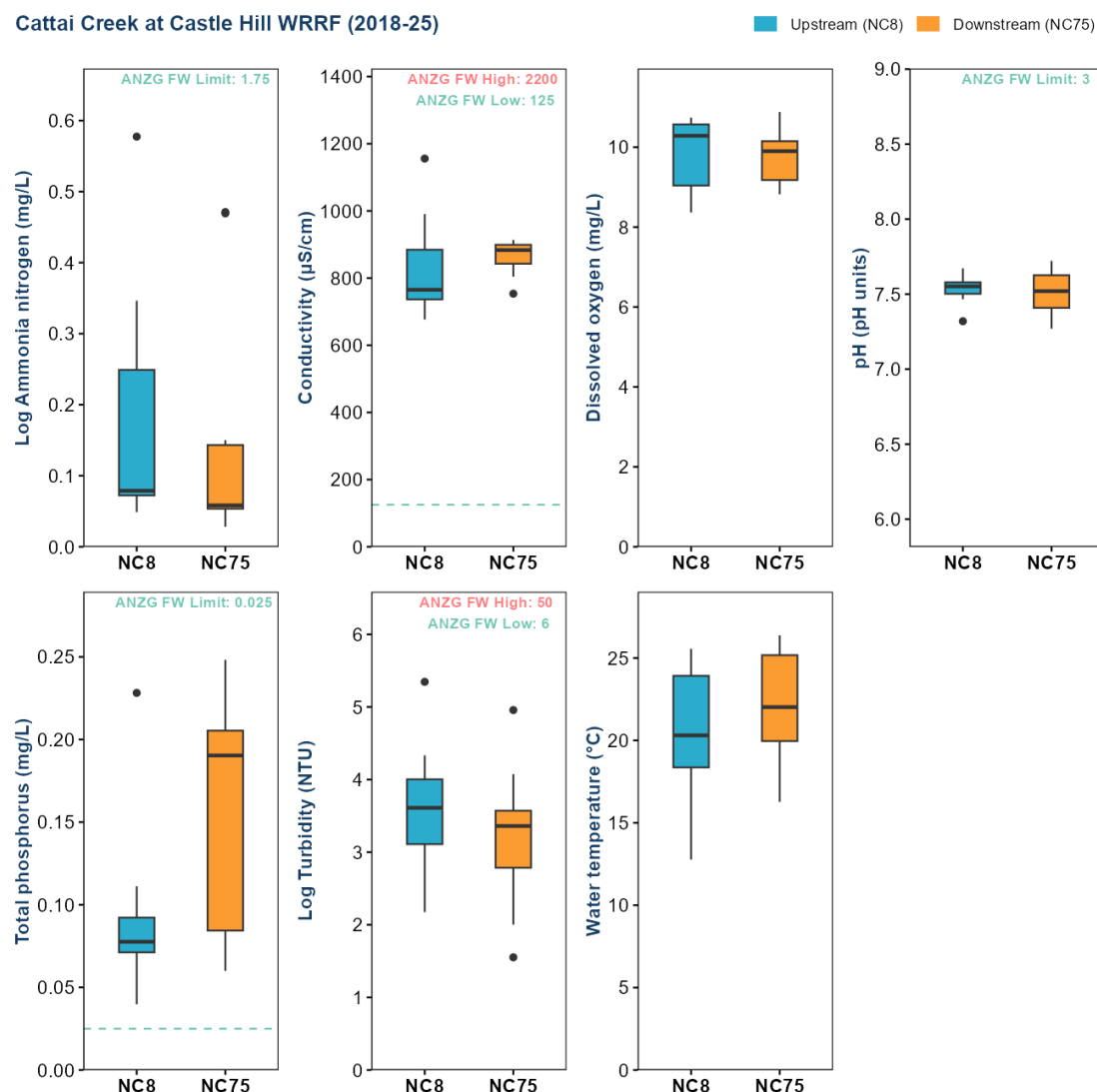


Figure A-22 Boxplots of the modelled parameters from 2018 to 2025) for the sites upstream and downstream of Castle Hill WRRF in the Cattai Creek

Cattai Creek at Castle Hill WRRF

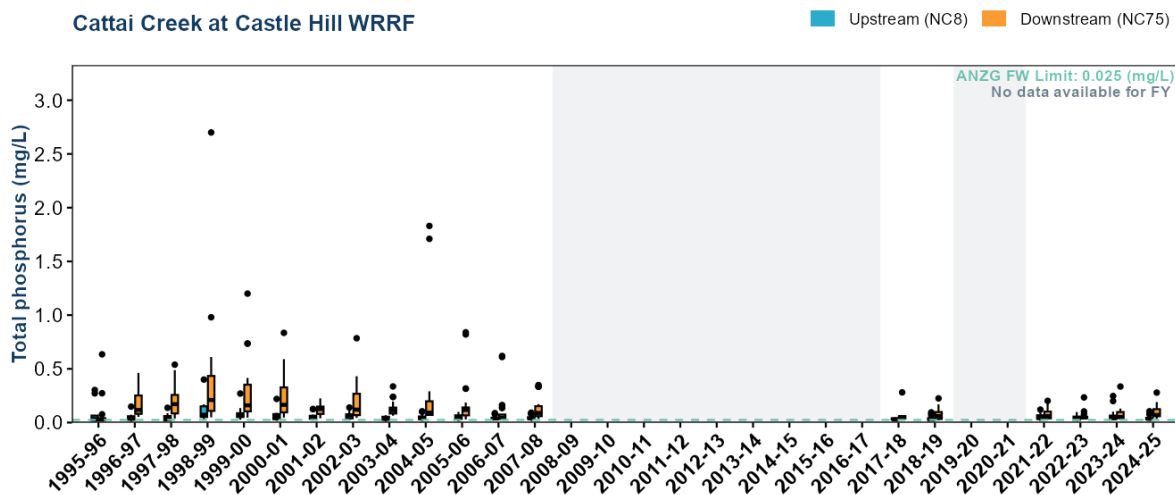


Figure A-23 Boxplots of historic and current data available for total phosphorus concentrations for the sites upstream and downstream of Castle Hill WRRF in Cattai Creek.

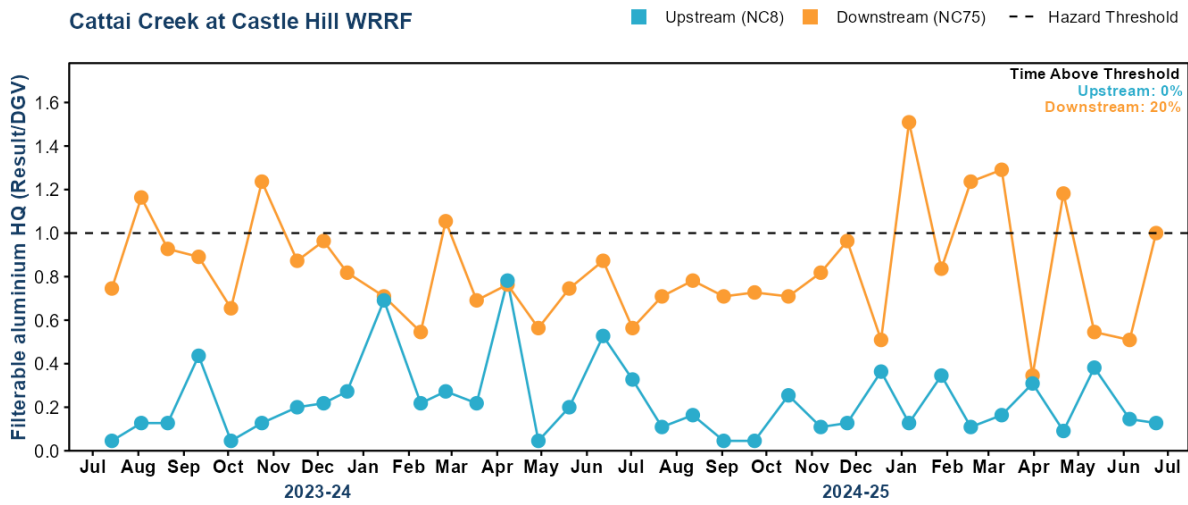
Table A-127 Results from the marginal tests of the DISTLM for Cattai Creek. Parameters are listed in order of their contribution in explaining variation in the SIGNAL-SG score (% Variation). * Represents a log(x+1) transformation; ns = non-significant.

Cattai Creek at Castle Hill WRRF (2018-25)				
Modelled Parameters	SS	Pseudo-F	p	% Variation
Total phosphorus	0.20	4.12	ns	17.04
pH	0.11	1.97	ns	8.96
Dissolved oxygen	0.04	0.65	ns	3.14
Conductivity	0.03	0.49	ns	2.41
Turbidity *	0.02	0.26	ns	1.28
Water temperature	0.00	0.09	ns	0.43
Ammonia nitrogen *	0.00	0.00	ns	0.00

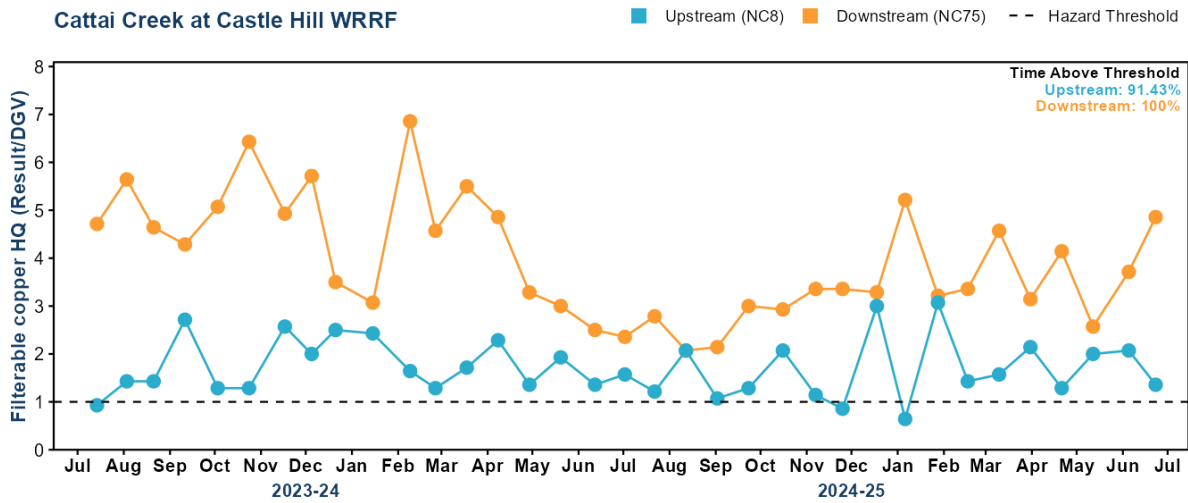
Stage 3: Hazard quotient metric to evaluate the potential risks of filterable metal exposure to organisms

Filterable aluminium, copper and nickel were presented in the gate 2 synthesis to have significantly higher concentrations at the downstream site (NC75). The filterable nickel concentrations were consistently well below the hazard quotient threshold at both the upstream and downstream sites (Figure A-24). Filterable aluminium exceeded the hazard threshold on seven occasions over the last 2 years (Figure A-24). These exceedances could reflect potential processing issues experienced at the Castle Hill WRRF. Filterable copper concentrations exceeded the hazard quotient threshold on most sampling events, both upstream (91% of samples) and downstream (100% of samples) of Castle Hill WRRF (Figure A-24). This pattern was also observed upstream (97% of samples) and downstream (100% of samples) for hazard quotients calculated for filterable zinc (Figure A-24; Table A-128).

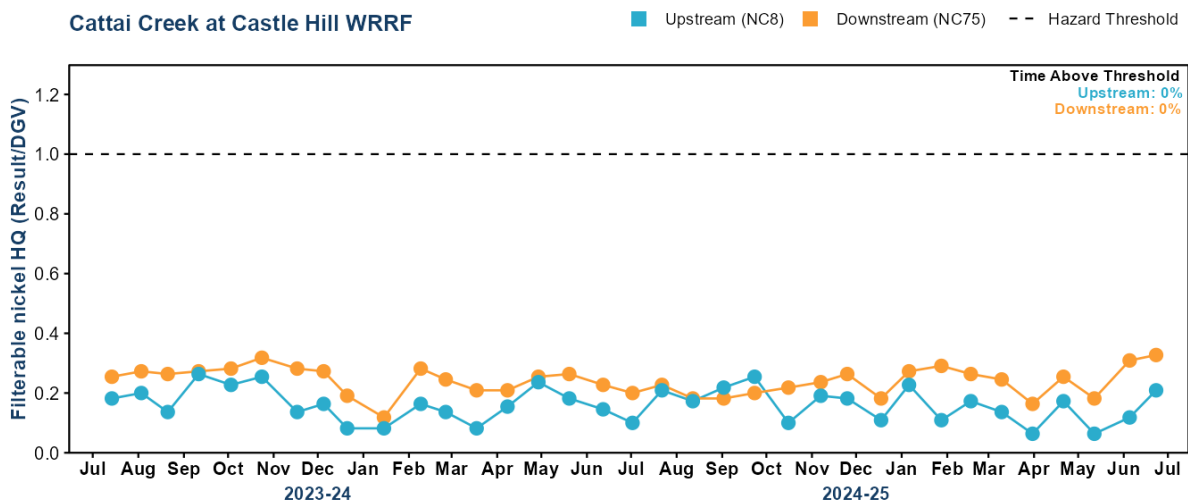
Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF



Cattai Creek at Castle Hill WRRF

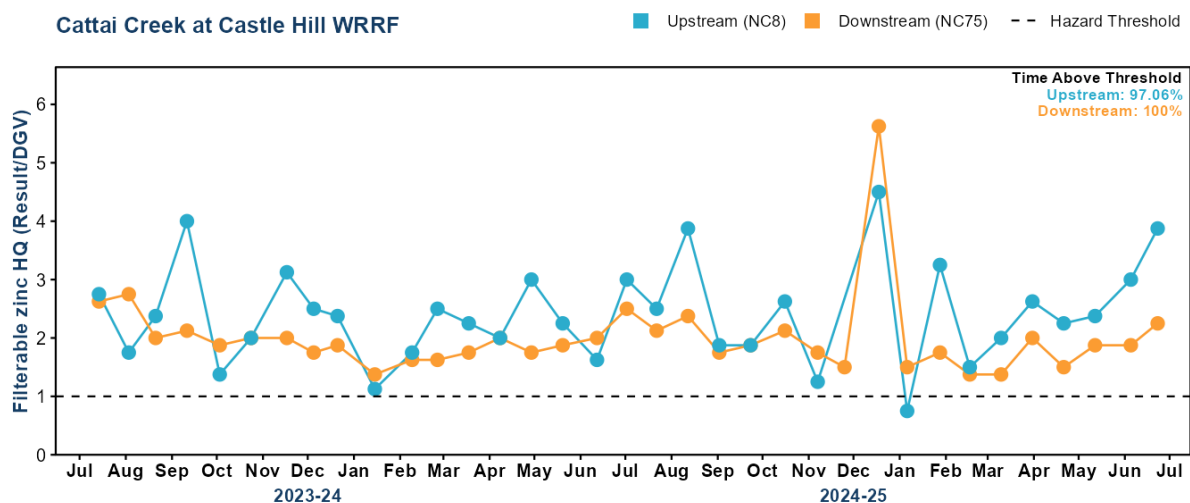


Figure A-24 Hazard quotients for filterable aluminium, copper, nickel, and zinc concentrations between 2023 and 2025 for an unnamed creek situated both downstream and upstream of the discharge from Castle Hill WRRF

Table A-128 Hazard quotients for metal and ammonia nitrogen concentrations between 2023 and 2025 at Cattai Creek upstream and downstream of the discharge from Castle Hill WRRF

Cattai Creek at Castle Hill WRRF: Hazard Quotient (Result/DGV)												
Collection date	Ammonia nitrogen		Filterable aluminium		Filterable cobalt		Filterable copper		Filterable nickel		Filterable zinc	
	NC8 (US)	NC75 (DS)	NC8 (US)	NC75 (DS)	NC8 (US)	NC75 (DS)	NC8 (US)	NC75 (DS)	NC8 (US)	NC75 (DS)	NC8 (US)	NC75 (DS)
2023-07-14	0.03	0.03	0.05	0.75	0.64	0.36	0.93	4.71	0.18	0.25	2.75	2.62
2023-08-03	0.02	0.03	0.13	1.16	0.64	0.36	1.43	5.64	0.20	0.27	1.75	2.75
2023-08-21	0.01	0.01	0.13	0.93	0.43	0.36	1.43	4.64	0.14	0.26	2.38	2.00
2023-09-11	0.35	0.38	0.44	0.89	0.93	0.43	2.71	4.29	0.26	0.27	4.00	2.12
2023-10-03	0.02	0.05	0.05	0.65	0.64	0.50	1.29	5.07	0.23	0.28	1.38	1.88
2023-10-24	0.02	0.01	0.13	1.24	0.43	0.36	1.29	6.43	0.25	0.32	2.00	2.00
2023-11-17	0.00	0.01	0.20	0.87	0.43	0.43	2.57	4.93	0.14	0.28	3.12	2.00
2023-12-05	0.03	0.01	0.22	0.96	0.29	0.36	2.00	5.71	0.16	0.27	2.50	1.75
2023-12-21	0.01	0.01	0.27	0.82	0.14	0.29	2.50	3.50	0.08	0.19	2.38	1.88
2024-01-15	0.07	0.29	0.69	0.71	0.14	0.29	2.43	3.07	0.08	0.12	1.12	1.38
2024-02-09	0.01	0.02	0.22	0.55	0.21	0.36	1.64	6.86	0.16	0.28	1.75	1.62
2024-02-26	0.02	0.01	0.27	1.05	0.29	0.29	1.29	4.57	0.14	0.25	2.50	1.62
2024-03-18	0.01	0.01	0.22	0.69	0.14	0.29	1.71	5.50	0.08	0.21	2.25	1.75
2024-04-08	0.03	0.07	0.78	0.76	0.50	0.50	2.29	4.86	0.15	0.21	2.00	2.00
2024-04-29	0.01	0.01	0.05	0.56	0.71	0.29	1.36	3.29	0.24	0.25	3.00	1.75
2024-05-20	0.03	0.01	0.20	0.75	0.64	0.50	1.93	3.00	0.18	0.26	2.25	1.88
2024-06-12	0.04	0.02	0.53	0.87	0.57	0.57	1.36	2.50	0.15	0.23	1.62	2.00
2024-07-02	0.01	0.01	0.33	0.56	0.29	0.43	1.57	2.36	0.10	0.20	3.00	2.50
2024-07-22	0.05	0.01	0.11	0.71	0.71	0.50	1.21	2.79	0.21	0.23	2.50	2.12
2024-08-12	0.02	0.01	0.16	0.78	0.64	0.43	2.07	2.07	0.17	0.18	3.88	2.38
2024-09-02	0.02	0.01	0.05	0.71	0.64	0.36	1.07	2.14	0.22	0.18	1.88	1.75
2024-09-23	0.02	0.01	0.05	0.73	0.57	0.43	1.29	3.00	0.25	0.20	1.88	1.88
2024-10-16	0.01	0.04	0.25	0.71	0.29	0.36	2.07	2.93	0.10	0.22	2.62	2.12
2024-11-07	0.02	0.08	0.11	0.82	0.50	0.43	1.14	3.36	0.19	0.24	1.25	1.75
2024-11-25	0.02	0.01	0.13	0.96	0.36	0.36	0.86	3.36	0.18	0.26	-	1.50
2024-12-18	0.03	0.03	0.36	0.51	0.36	0.36	3.00	3.29	0.11	0.18	4.50	5.62
2025-01-06	0.02	0.01	0.13	1.51	0.29	0.29	0.64	5.21	0.23	0.27	0.75	1.50
2025-01-28	0.00	0.01	0.35	0.84	0.21	0.43	3.07	3.21	0.11	0.29	3.25	1.75
2025-02-17	0.05	0.02	0.11	1.24	0.36	0.36	1.43	3.36	0.17	0.26	1.50	1.38
2025-03-10	0.02	0.01	0.16	1.29	0.21	0.29	1.57	4.57	0.14	0.25	2.00	1.38
2025-03-31	0.01	0.01	0.31	0.35	0.14	0.36	2.14	3.14	0.06	0.16	2.62	2.00
2025-04-21	0.02	0.14	0.09	1.18	0.21	0.29	1.29	4.14	0.17	0.25	2.25	1.50
2025-05-12	0.01	0.01	0.38	0.55	0.07	0.21	2.00	2.57	0.06	0.18	2.38	1.88
2025-06-05	0.01	0.54	0.15	0.51	0.50	0.50	2.07	3.71	0.12	0.31	3.00	1.88
2025-06-23	0.05	0.01	0.13	1.00	0.79	0.43	1.36	4.86	0.21	0.33	3.88	2.25
% Above Threshold	0.00	0.00	0.00	20.00	0.00	0.00	91.43	100.00	0.00	0.00	97.06	100.00



Stage 4: Synthesis of gate 3 results and recommendation for future investigations

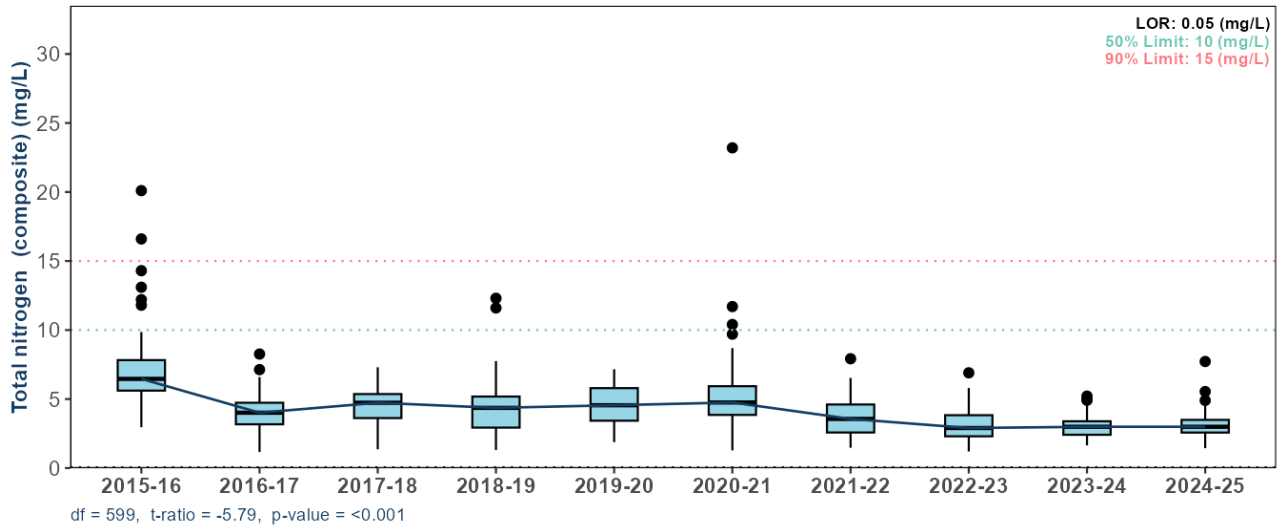
The multivariate analysis provided further evidence of the downstream impact to stream health by showing clear separation in taxonomic assemblages in the edge habitats. Riffle habitats also exhibited strong temporal variability but were overall more stable and supported taxa that are indicative of good water quality.

The sequential testing of the DISTLM highlighted total phosphorus as a possible predictor of the downstream macroinvertebrate biotic index (SIGNAL-SG) score. Elevated total phosphorus levels in the environment are often linked to algal blooms and chlorophyll-a is a reliable indicator of the algal biomass in a water body, with increased concentrations often linked to an increase in algal growth. The absence of a downstream impact to chlorophyll-a in the gate 1 analysis, suggests that total phosphorus is unlikely the driver of poor stream health in the waterway. The non-significant result from the marginal test coupled with the minimal macroinvertebrate SIGNAL-SG score variation explained by the model, supports this statement and emphasises the possibility that unaccounted for parameters (not monitored or insufficient data) are contributing to the downstream ecological receptor impacts.

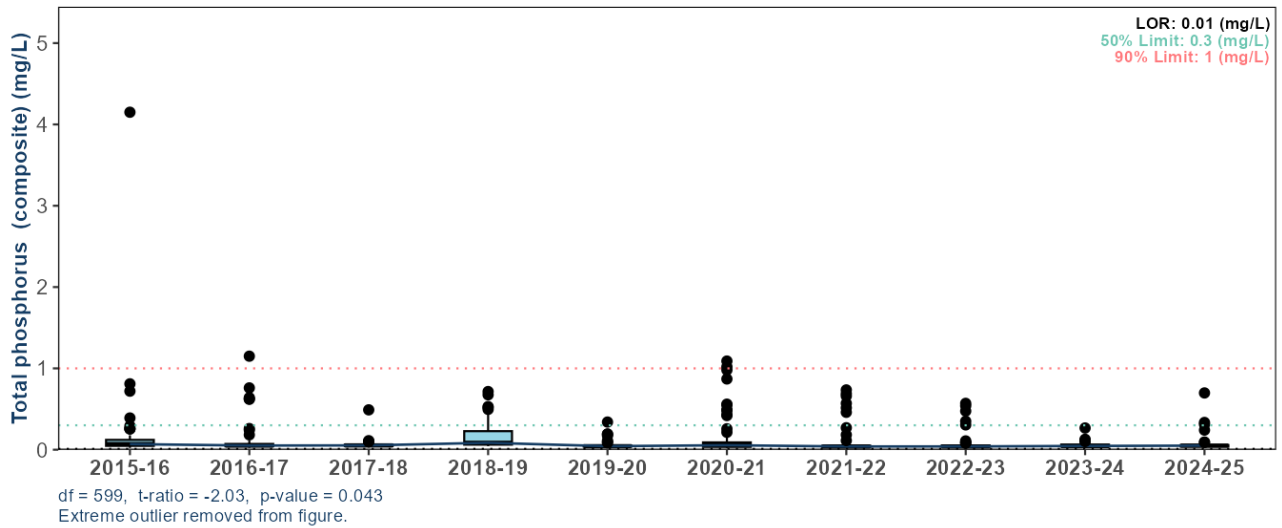
Filterable copper and zinc concentrations in the Cattai Creek downstream of Castle Hill WRRF consistently exceeded the hazard quotient threshold. Liess et al (2017) found linkages between toxic filterable metals and invertebrate communities within Australian streams and waterways. In addition to exceedances downstream, filterable copper and zinc concentrations also consistently exceeded the hazard quotient threshold at the upstream site (NC8). The consistent exposure to elevated filterable trace metals upstream and downstream could be causing a press disturbance that slowly amplifies the ecological impact to macroinvertebrate communities over time. Long-term exposure to trace metals can result in a reduction or removal of metal-sensitive macroinvertebrate taxa and cause a loss of biodiversity in the waterway (Iwasaki et al., 2018). The inferences of these studies partly align with the findings of the multivariate analysis that showed few taxa dominating the edge habitat structure, while most species in the waterway appeared in low abundances.

Continued monitoring of filterable trace metals over future years will provide insights into the potential relationships between consistent exposure to elevated copper and zinc concentrations and the macroinvertebrate biotic index (SIGNAL-SG) scores. In contrast, future multivariate regressions that include filterable trace metals could emphasise that unmonitored water quality parameters are influencing stream health downstream.

WH0005 at West Hornsby WRRF

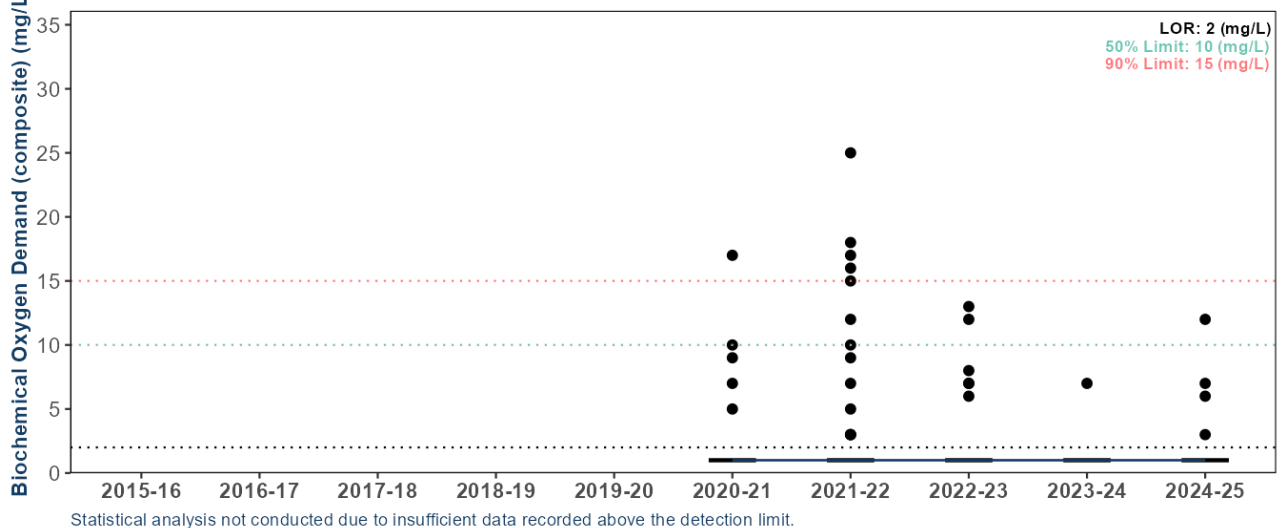


WH0005 at West Hornsby WRRF

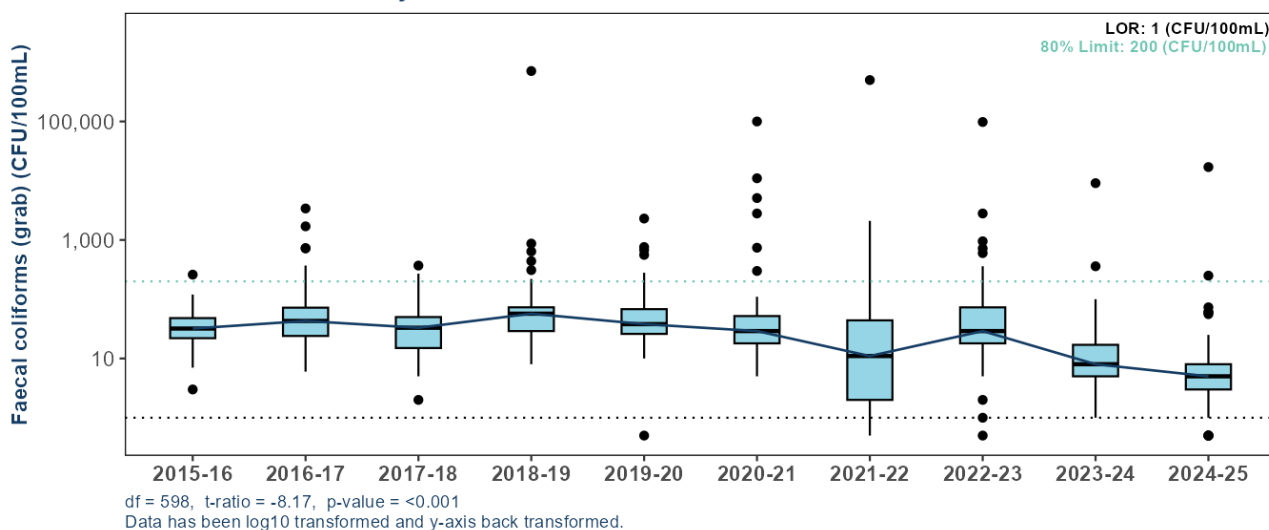


Major conventional analytes

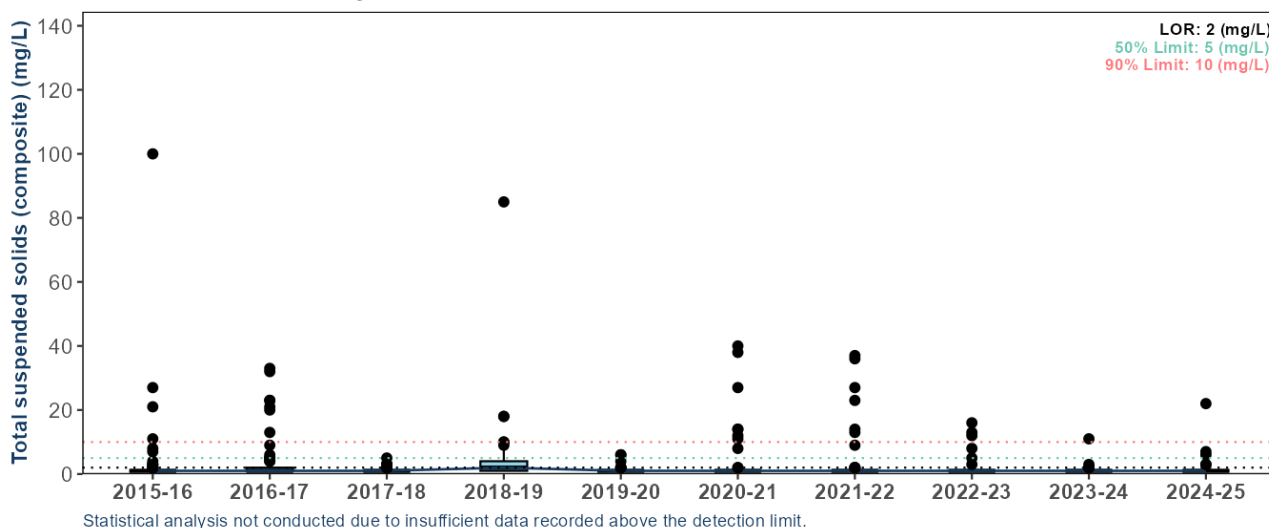
WH0005 at West Hornsby WRRF



WH0005 at West Hornsby WRRF

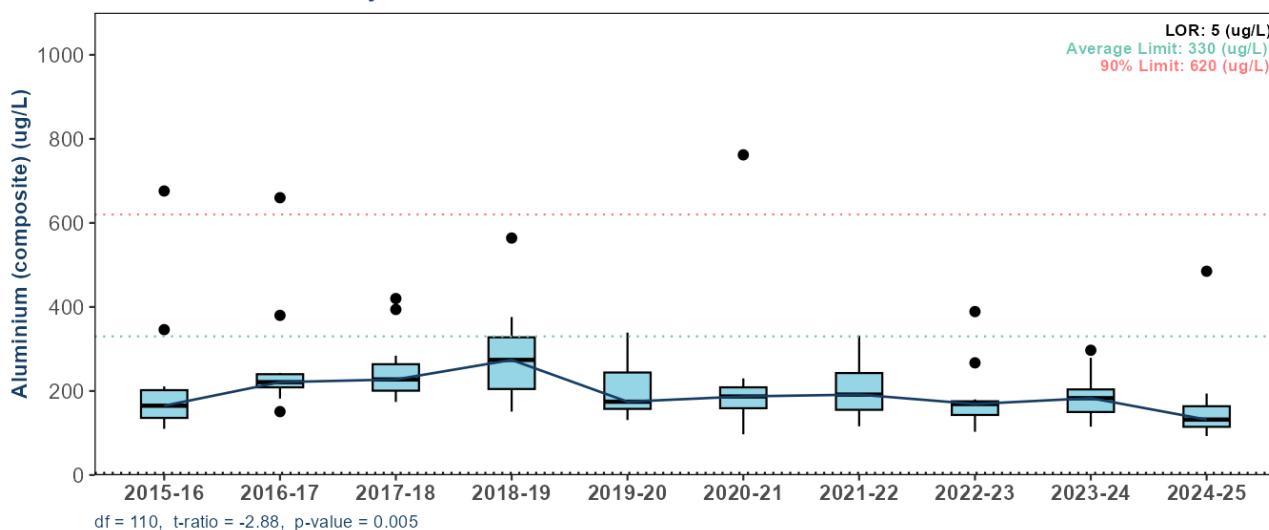


WH0005 at West Hornsby WRRF

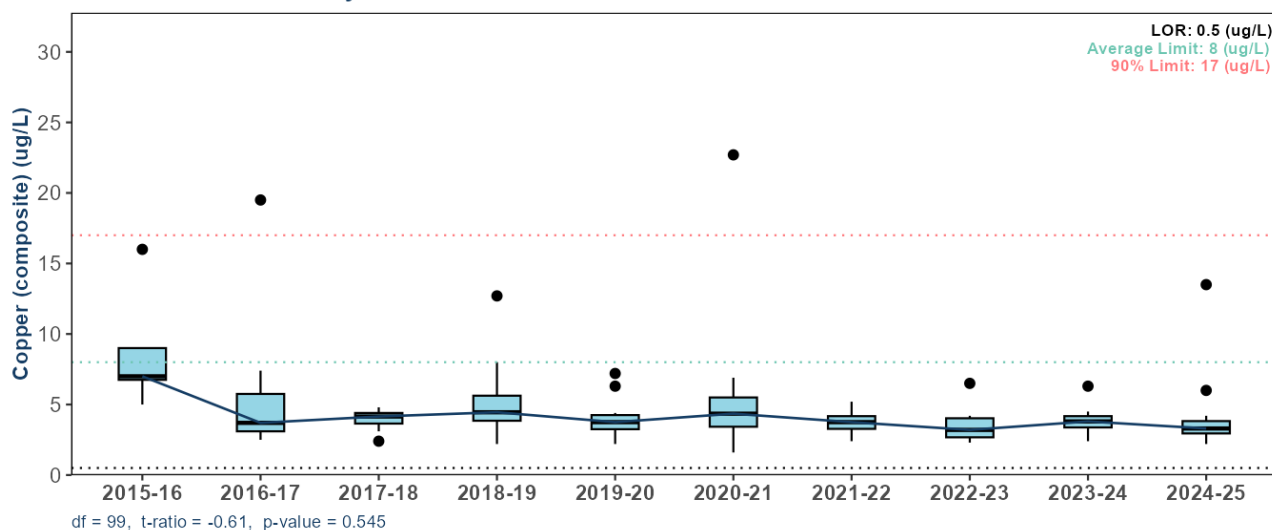


Trace metals

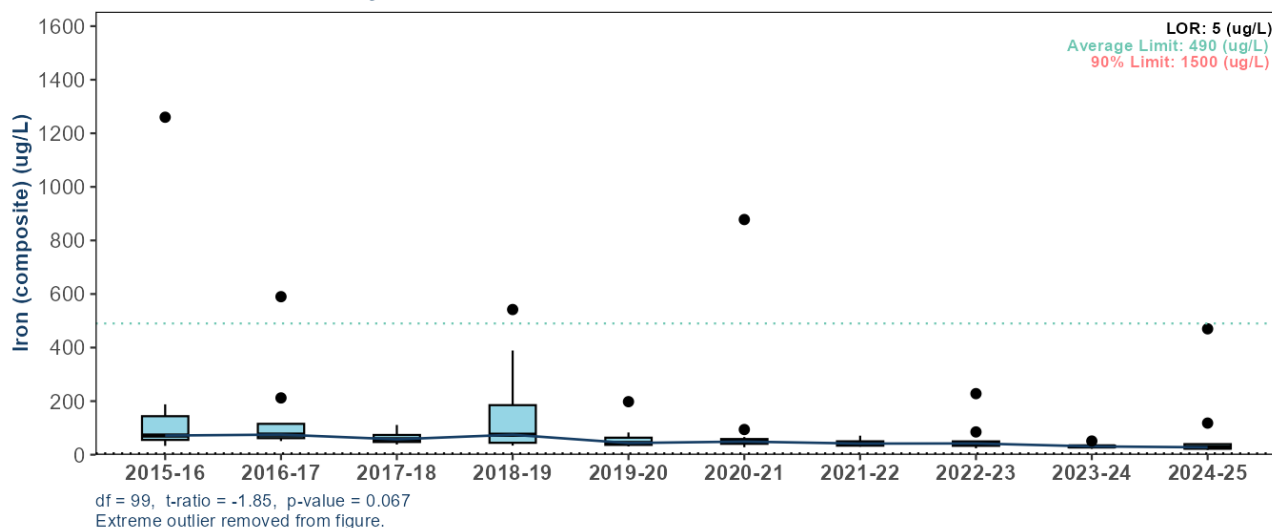
WH0005 at West Hornsby WRRF



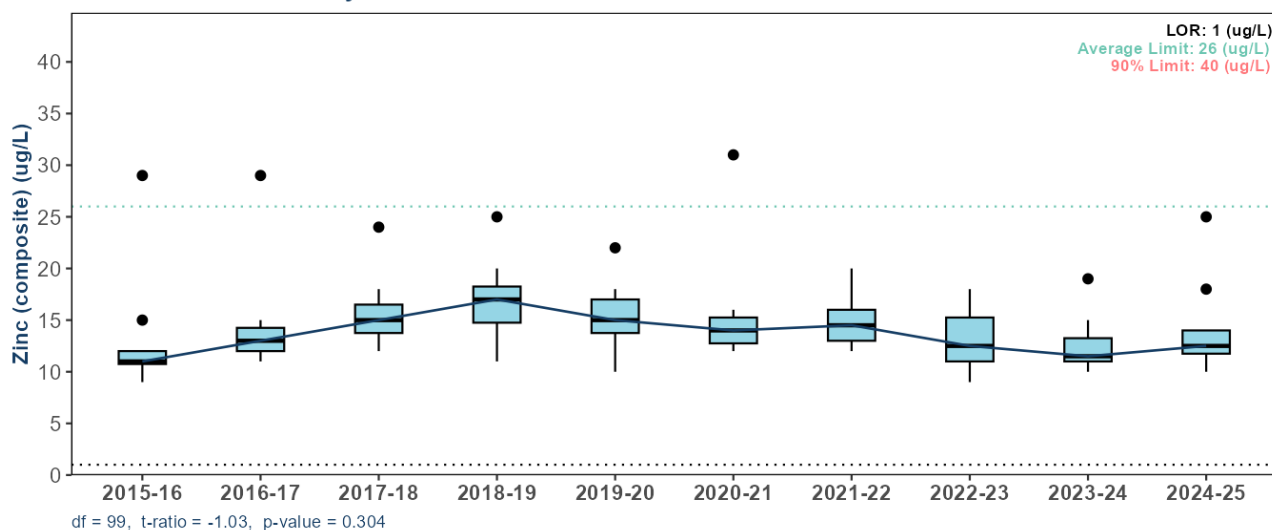
WH0005 at West Hornsby WRRF



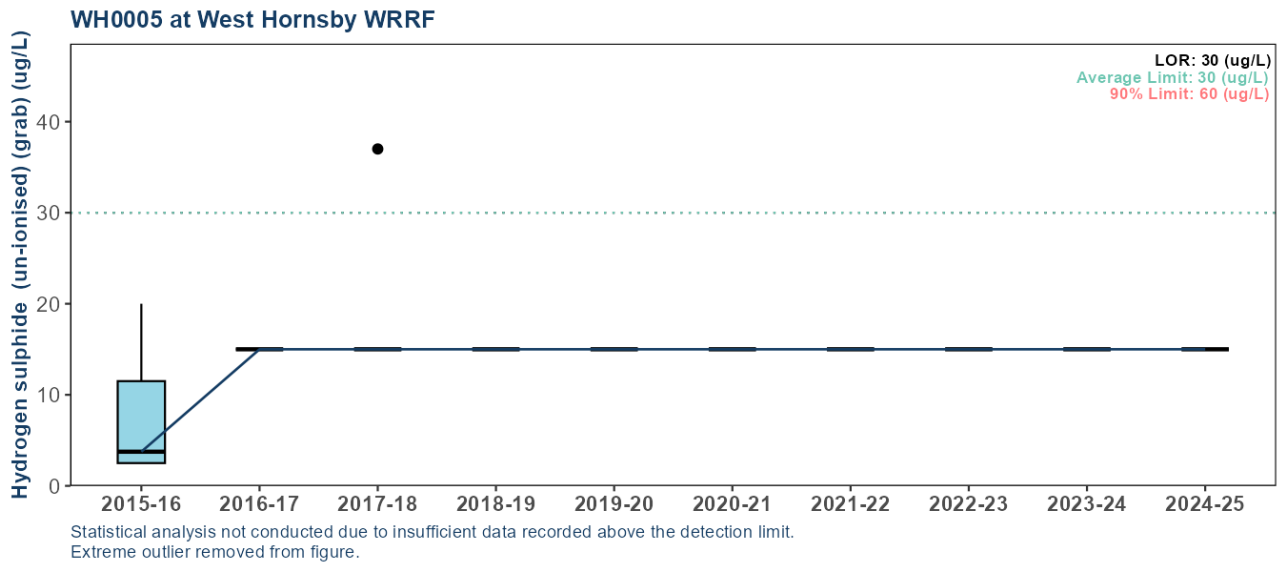
WH0005 at West Hornsby WRRF



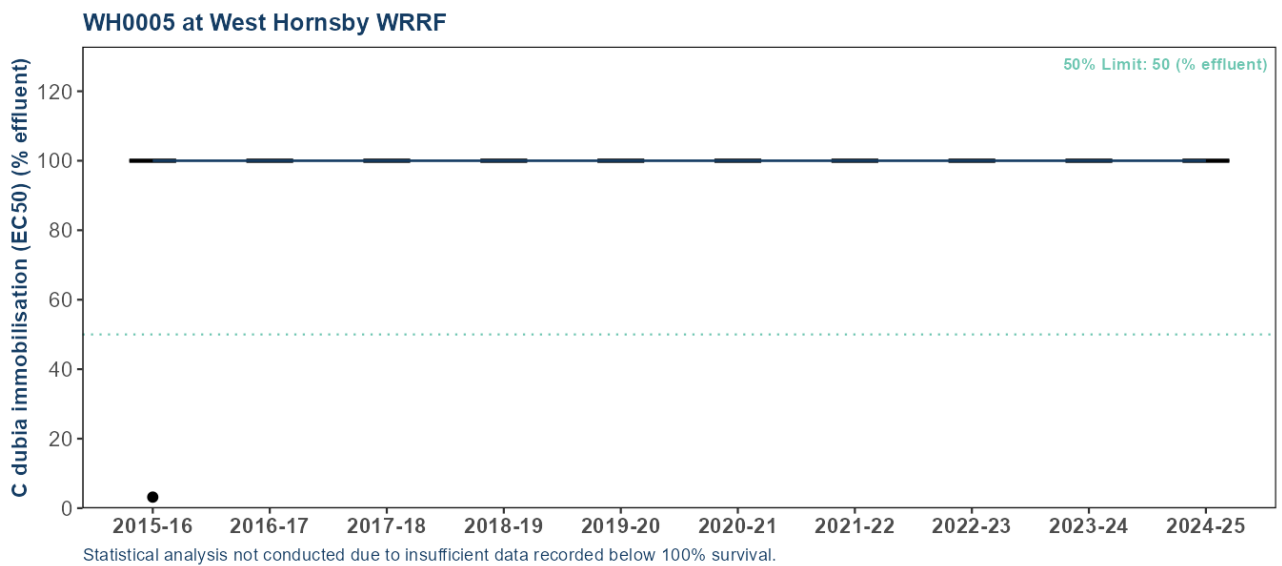
WH0005 at West Hornsby WRRF



Other chemicals and organics (including pesticides)

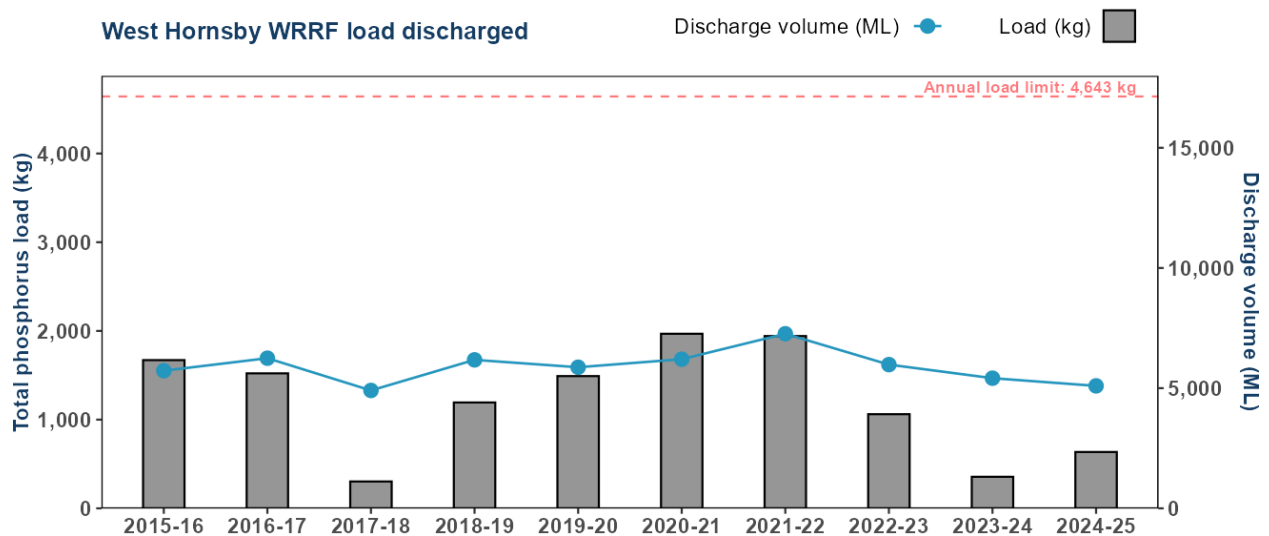
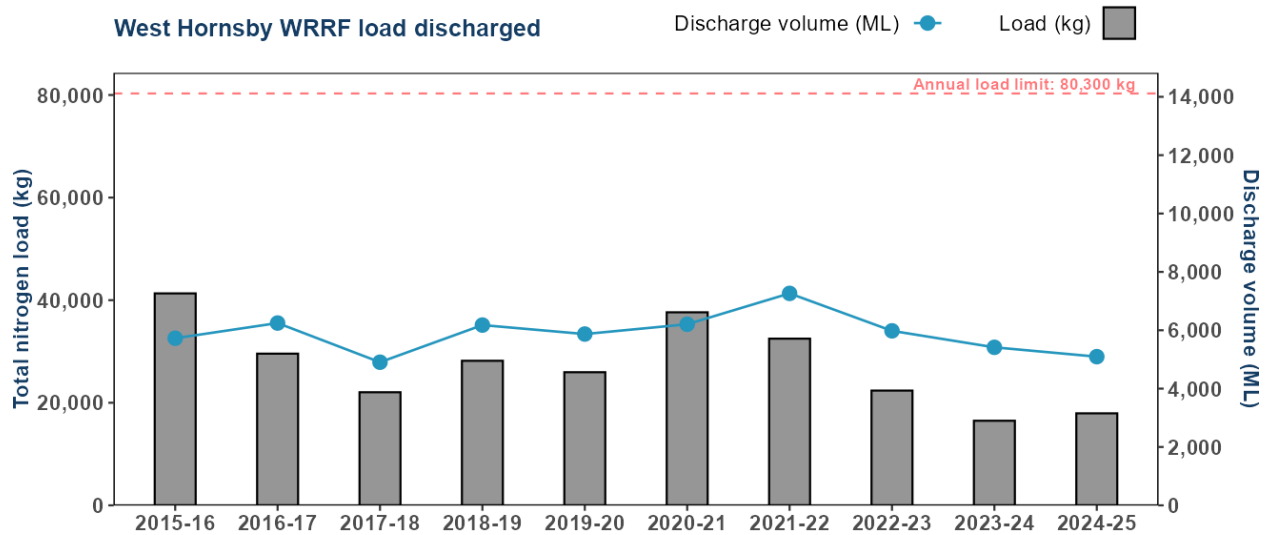


A.13.3. Pressure – Wastewater toxicity

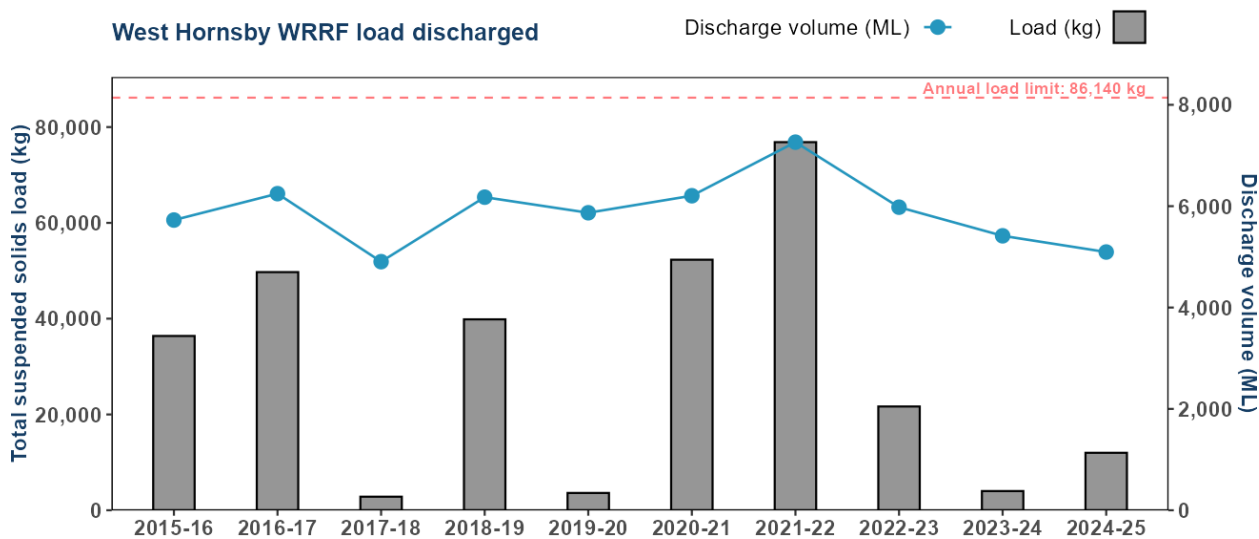
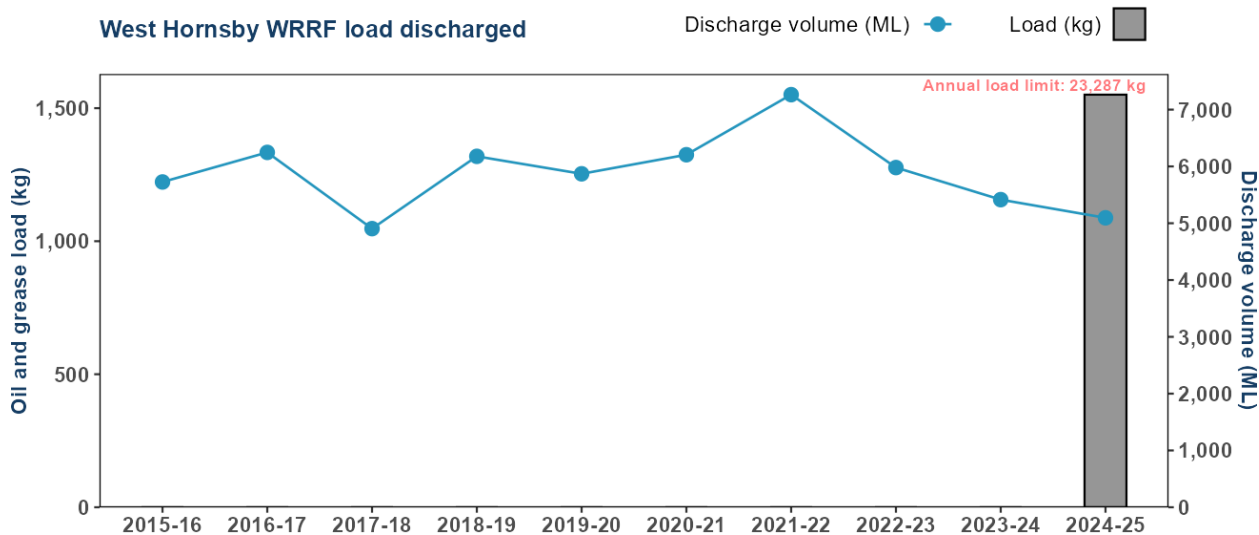
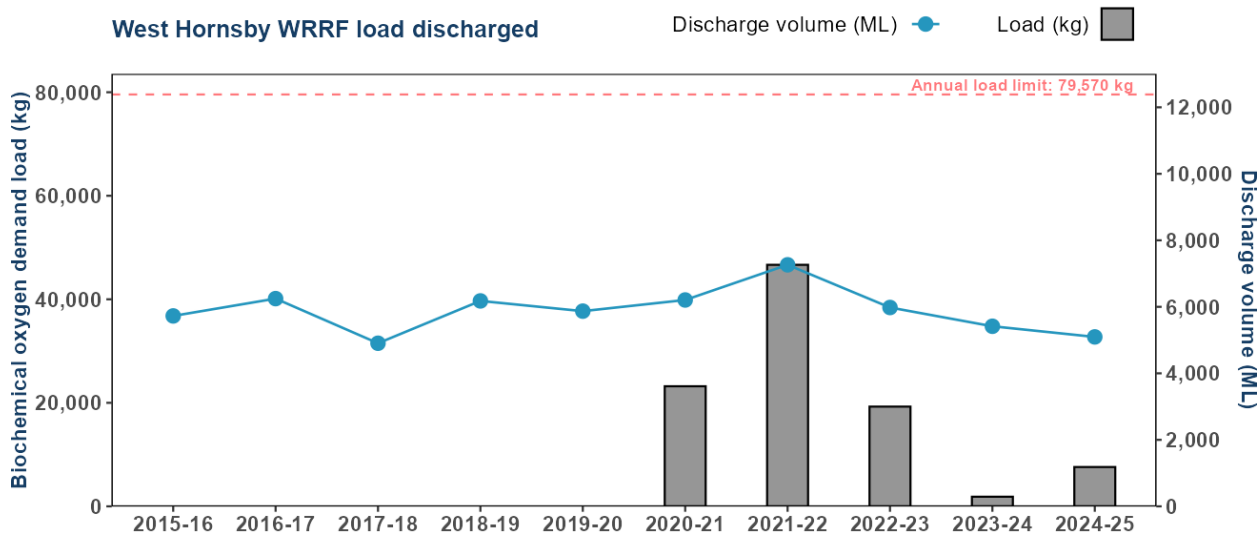


A.13.4. Pressure – Wastewater discharge load

Nutrients



Major conventional analytes



A.13.5. Stressor – Statistical analysis outcomes

Table A-129 Upstream vs downstream comparison (2024-25 reporting period) for Waitara Creek at West Hornsby WRRF

Waitara Creek at West Hornsby WRRF: NB83 vs NB825 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.90	0.36	164	-0.27	0.993
Oxidised nitrogen	5.04	1.81	164	4.50	<0.001
Total nitrogen	3.02	0.55	164	6.09	<0.001
Soluble reactive phosphorus	1.21	0.34	66	0.67	0.908
Total phosphorus	1.08	0.24	164	0.34	0.986
Physico-chemical					
Conductivity	2.38	0.24	164	8.48	<0.001
Dissolved oxygen	1.16	0.10	164	1.79	0.280
Dissolved oxygen saturation	16.79	4.70	163	3.57	0.003
pH	-0.07	0.06	164	-1.08	0.705
Water temperature	1.22	0.09	164	2.79	0.030
Turbidity	0.23	0.08	164	-4.36	<0.001
Trace Metals					
Filterable aluminium	4.16	0.69	66	8.55	<0.001
Total aluminium	2.08	0.55	66	2.78	0.035
Filterable cobalt	1.86	0.29	66	3.97	0.001
Total cobalt	1.41	0.23	66	2.08	0.170
Filterable copper	1.40	0.18	66	2.54	0.063
Total copper	1.10	0.17	66	0.60	0.933
Filterable nickel	2.90	0.30	66	10.15	<0.001
Total nickel	2.52	0.26	66	9.05	<0.001
Filterable zinc	1.99	0.21	66	6.44	<0.001
Total zinc	1.51	0.23	66	2.75	0.037
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-130 Upstream current period (2024-25) vs previous period comparison (single site) for Waitara Creek at West Hornsby WRRF

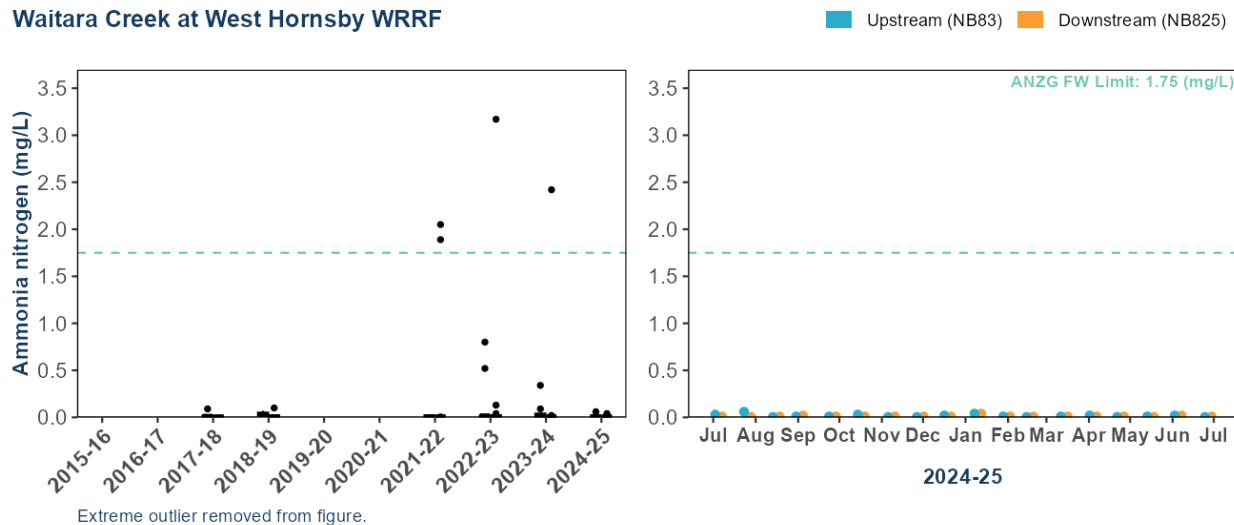
Waitara Creek at West Hornsby WRRF: NB83 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.51	0.16	164	-2.12	0.152
Oxidised nitrogen	0.98	0.28	164	-0.06	>0.999
Total nitrogen	0.88	0.13	164	-0.91	0.797
Soluble reactive phosphorus	0.87	0.25	66	-0.49	0.961
Total phosphorus	0.99	0.17	164	-0.07	>0.999
Physico-chemical					
Conductivity	0.90	0.07	164	-1.33	0.546
Dissolved oxygen	1.01	0.07	164	0.16	0.999
Dissolved oxygen saturation	1.86	3.74	163	0.50	0.960
pH	0.08	0.05	164	1.57	0.397
Water temperature	1.08	0.06	164	1.33	0.545
Turbidity	0.85	0.23	164	-0.60	0.932
Trace Metals					
Filterable aluminium	1.06	0.18	66	0.33	0.987
Total aluminium	1.03	0.27	66	0.10	>0.999
Filterable cobalt	0.73	0.12	66	-1.96	0.215
Total cobalt	0.90	0.15	66	-0.61	0.929
Filterable copper	0.94	0.12	66	-0.50	0.958
Total copper	1.02	0.16	66	0.14	0.999
Filterable nickel	0.65	0.07	66	-4.01	<0.001
Total nickel	0.75	0.08	66	-2.84	0.030
Filterable zinc	1.01	0.11	66	0.14	>0.999
Total zinc	1.16	0.18	66	1.00	0.748
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-131 Downstream current period (2024-25) vs previous period comparison (single site) for Waitara Creek at West Hornsby WRRF

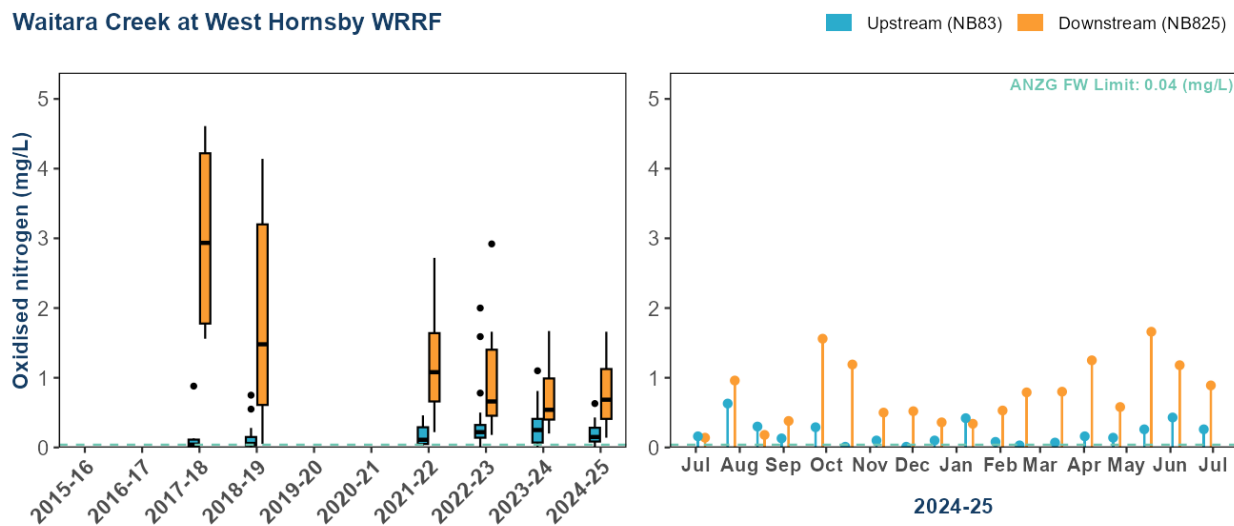
Waitara Creek at West Hornsby WRRF: NB825 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.67	0.21	164	-1.26	0.588
Oxidised nitrogen	0.76	0.22	164	-0.98	0.763
Total nitrogen	0.77	0.11	164	-1.85	0.254
Soluble reactive phosphorus	0.95	0.27	66	-0.19	0.998
Total phosphorus	0.87	0.15	164	-0.82	0.847
Physico-chemical					
Conductivity	0.99	0.08	164	-0.10	>0.999
Dissolved oxygen	0.98	0.06	164	-0.27	0.993
Dissolved oxygen saturation	-0.68	3.74	163	-0.18	0.998
pH	-0.04	0.05	164	-0.68	0.903
Water temperature	1.02	0.06	164	0.41	0.977
Turbidity	0.92	0.25	164	-0.31	0.990
Trace Metals					
Filterable aluminium	0.77	0.13	66	-1.53	0.426
Total aluminium	0.80	0.21	66	-0.85	0.831
Filterable cobalt	1.08	0.17	66	0.47	0.966
Total cobalt	1.08	0.18	66	0.45	0.970
Filterable copper	0.86	0.11	66	-1.14	0.669
Total copper	0.84	0.13	66	-1.13	0.670
Filterable nickel	1.00	0.11	66	0.03	>0.999
Total nickel	1.02	0.11	66	0.22	0.996
Filterable zinc	1.05	0.11	66	0.42	0.976
Total zinc	1.05	0.16	66	0.32	0.988
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.13.6. Stressor – Nutrients

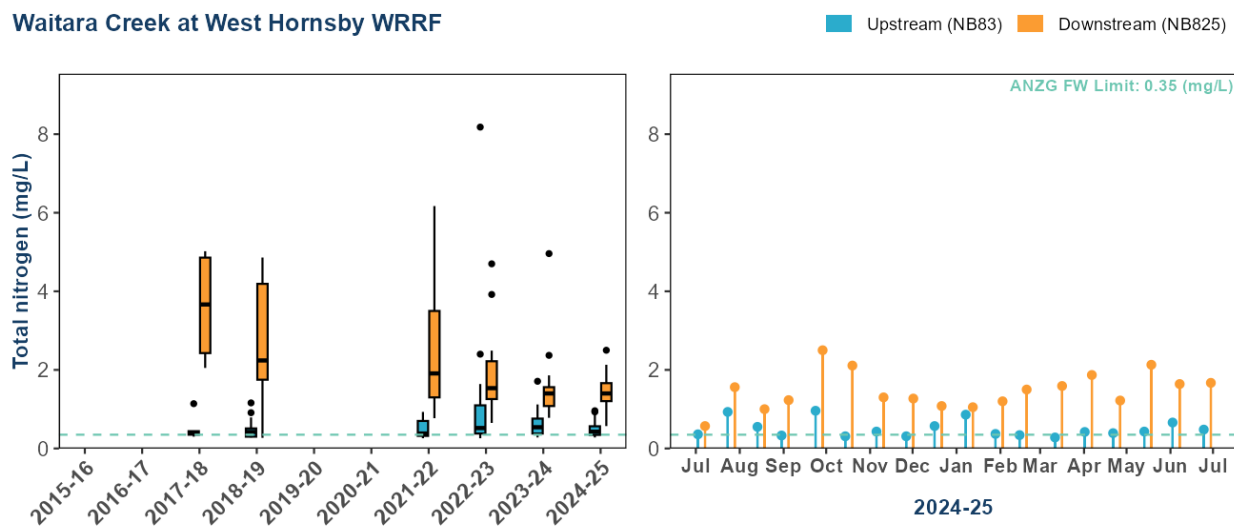
Waitara Creek at West Hornsby WRRF



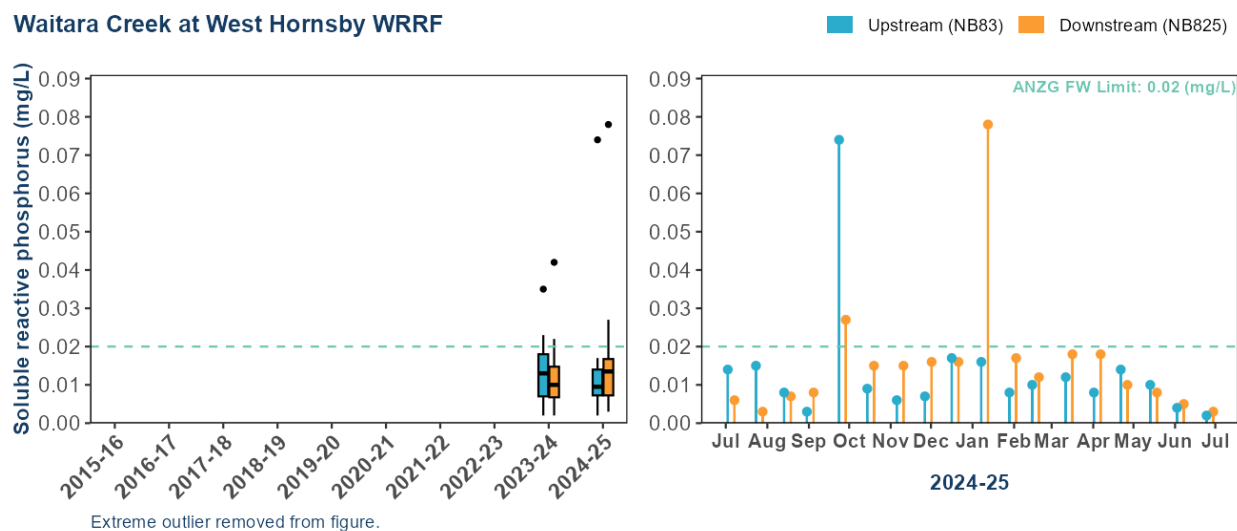
Waitara Creek at West Hornsby WRRF



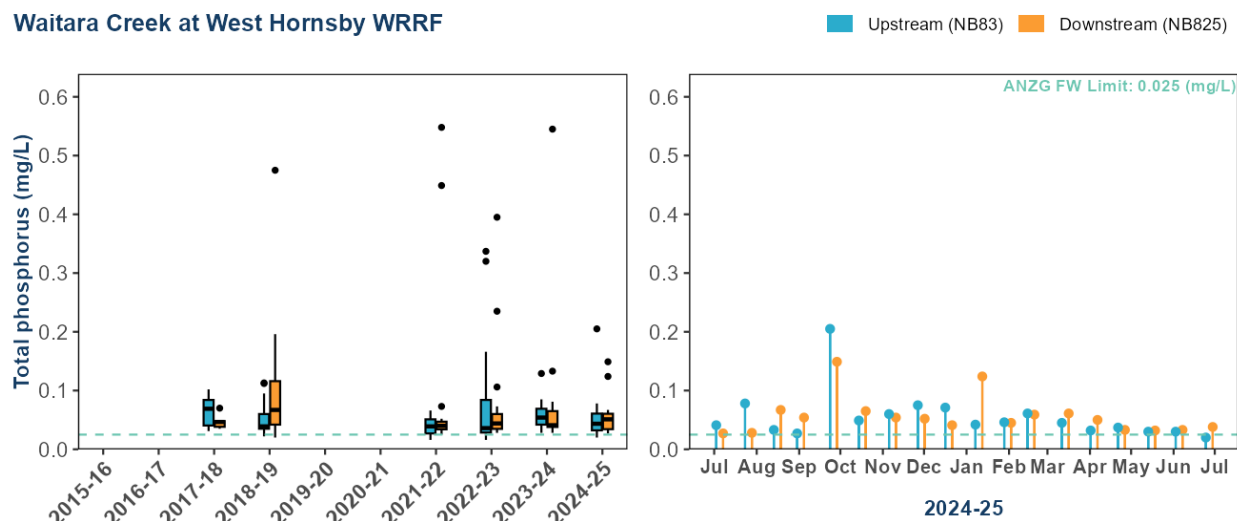
Waitara Creek at West Hornsby WRRF



Waitara Creek at West Hornsby WRRF

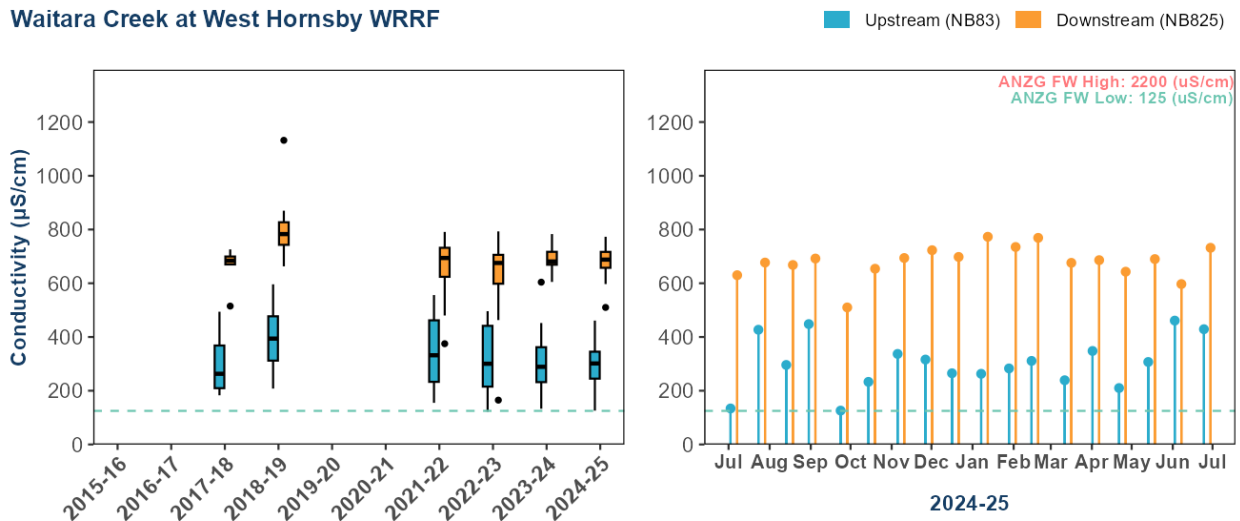


Waitara Creek at West Hornsby WRRF

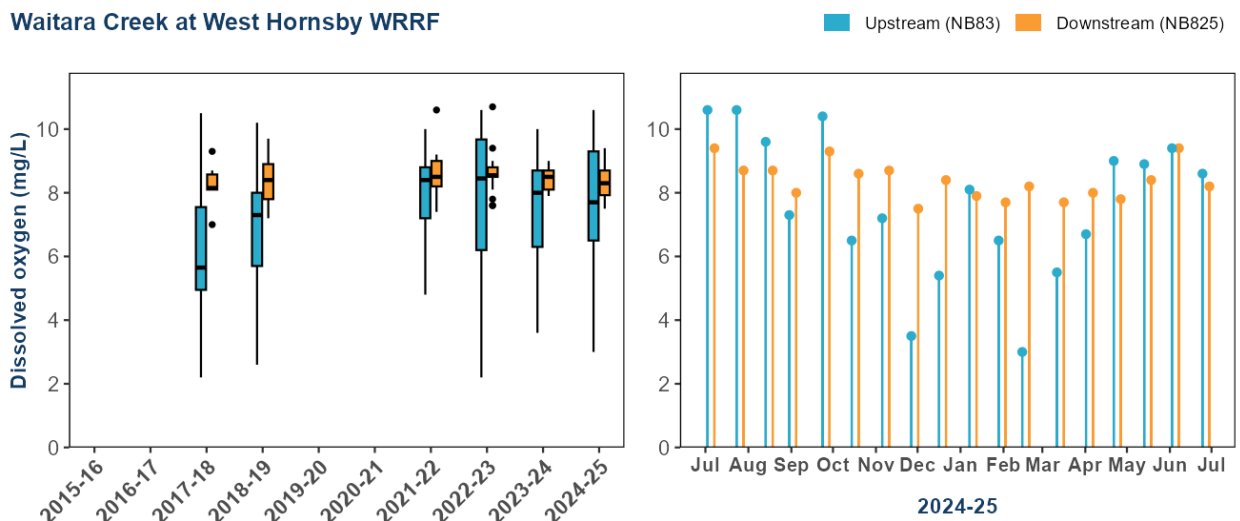


A.13.7. Stressor – Physico-chemical water quality

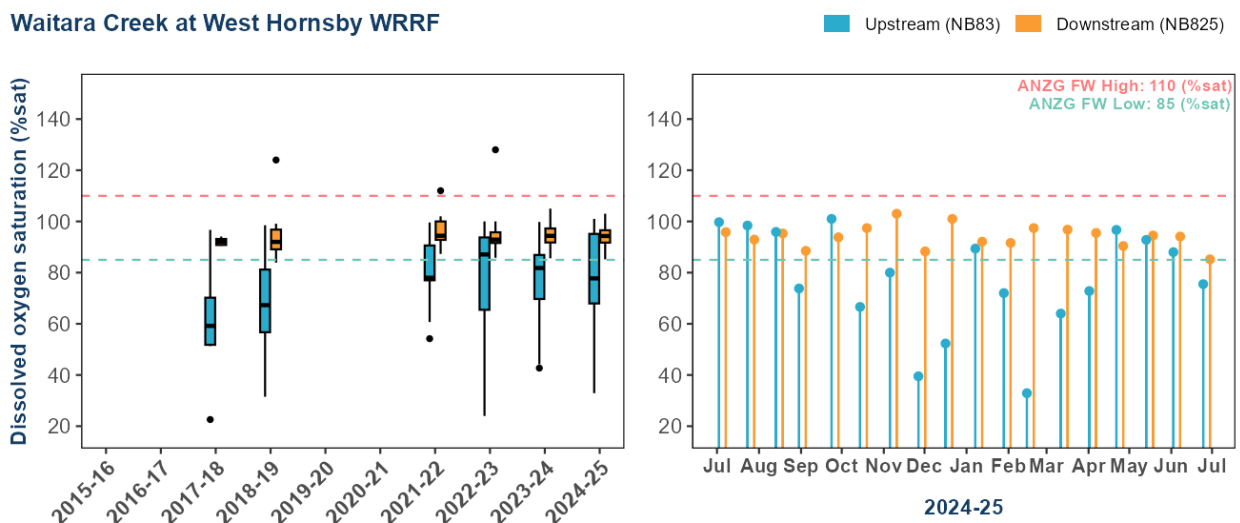
Waitara Creek at West Hornsby WRRF



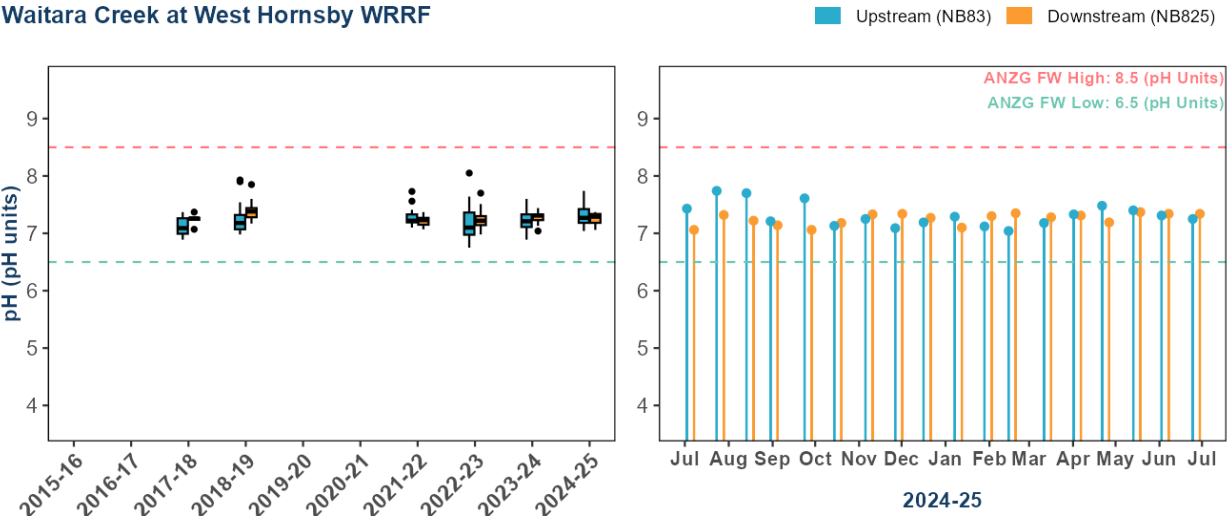
Waitara Creek at West Hornsby WRRF



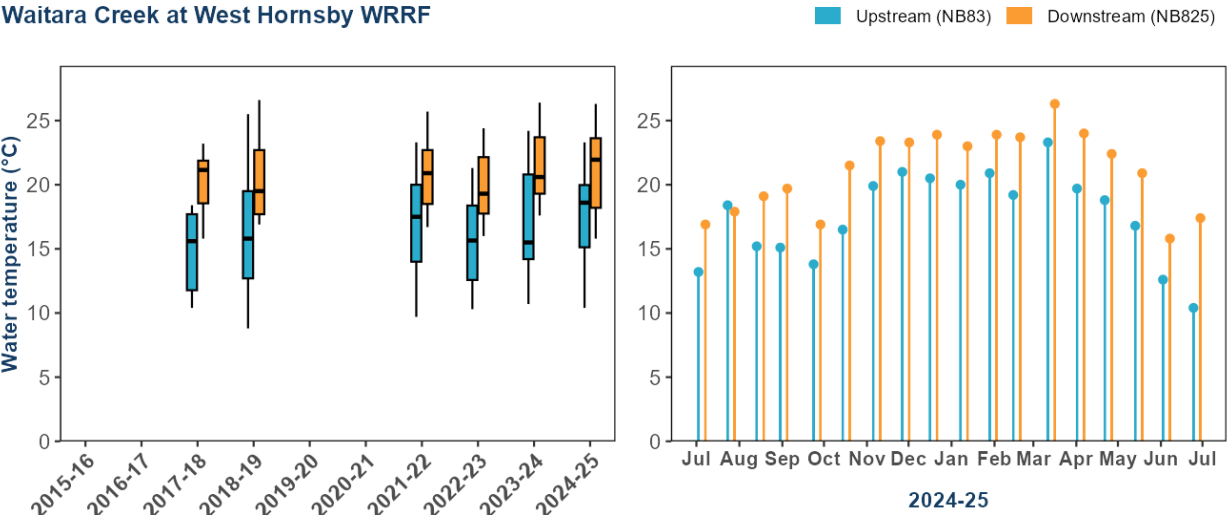
Waitara Creek at West Hornsby WRRF



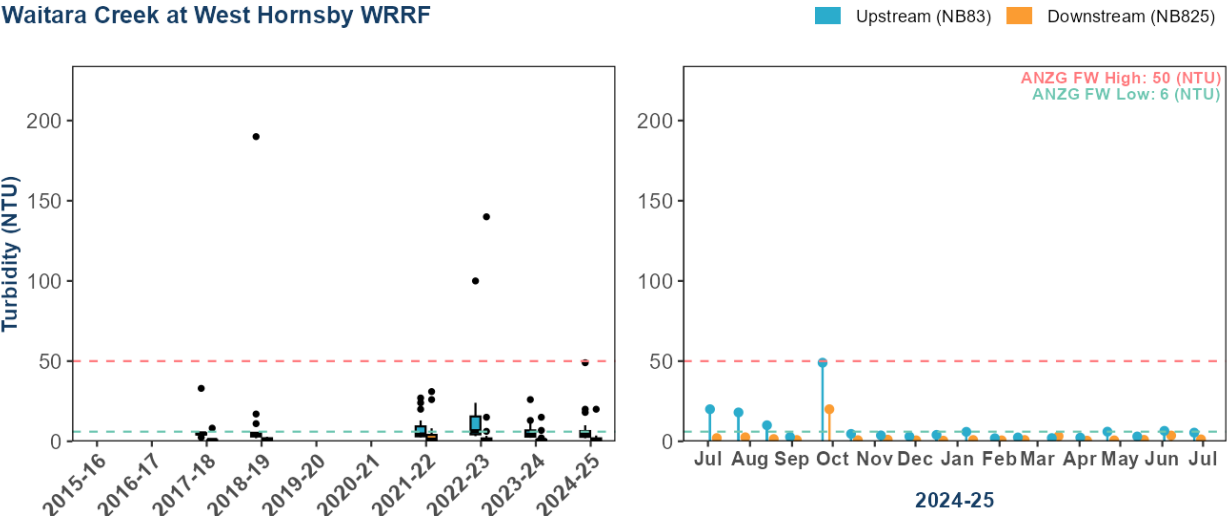
Waitara Creek at West Hornsby WRRF



Waitara Creek at West Hornsby WRRF

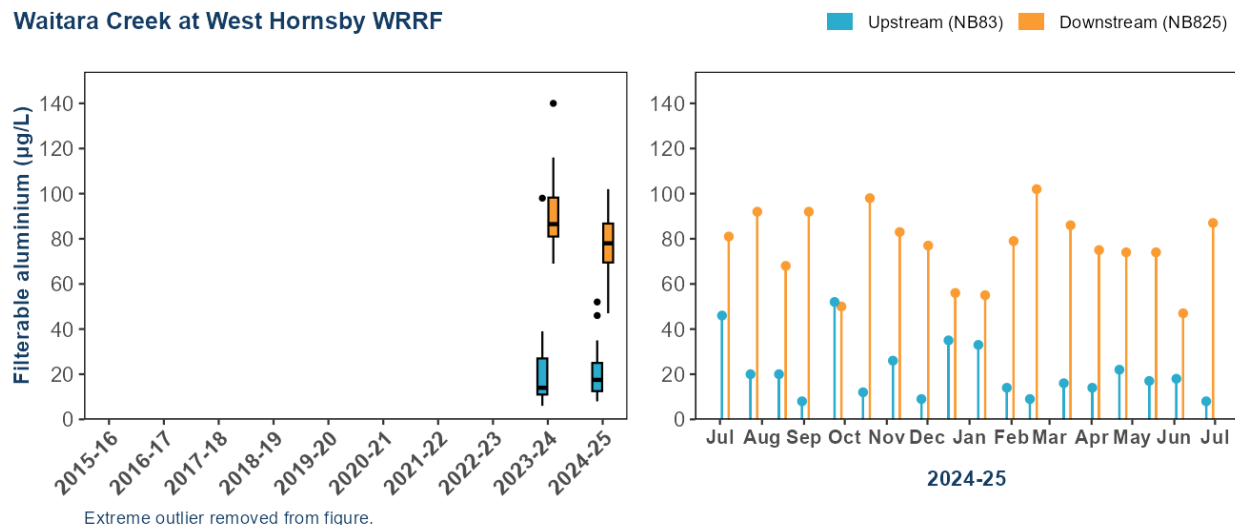


Waitara Creek at West Hornsby WRRF

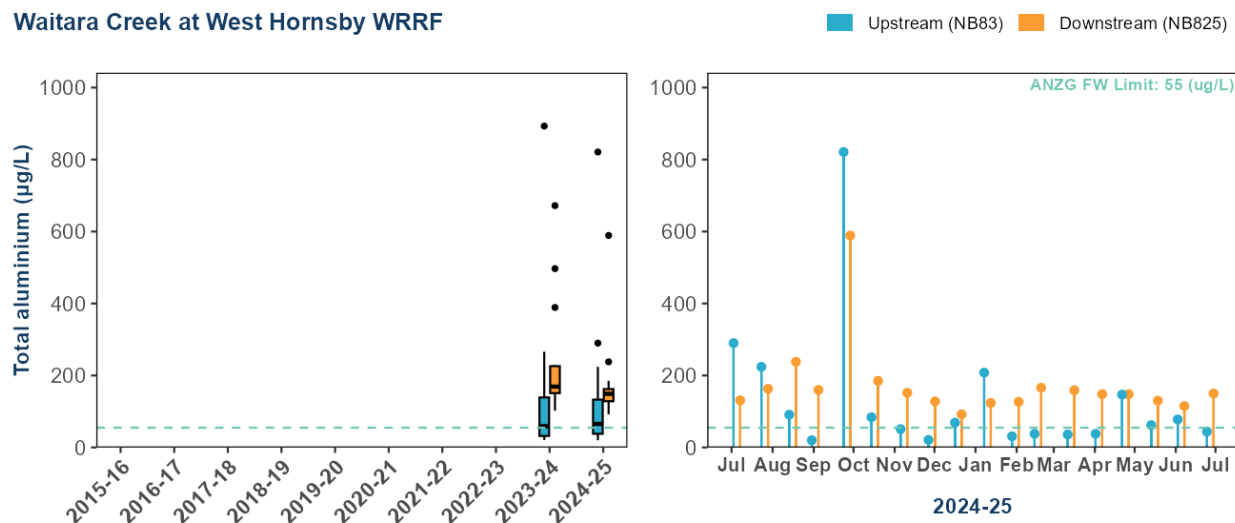


A.13.8. Stressor – Trace metals

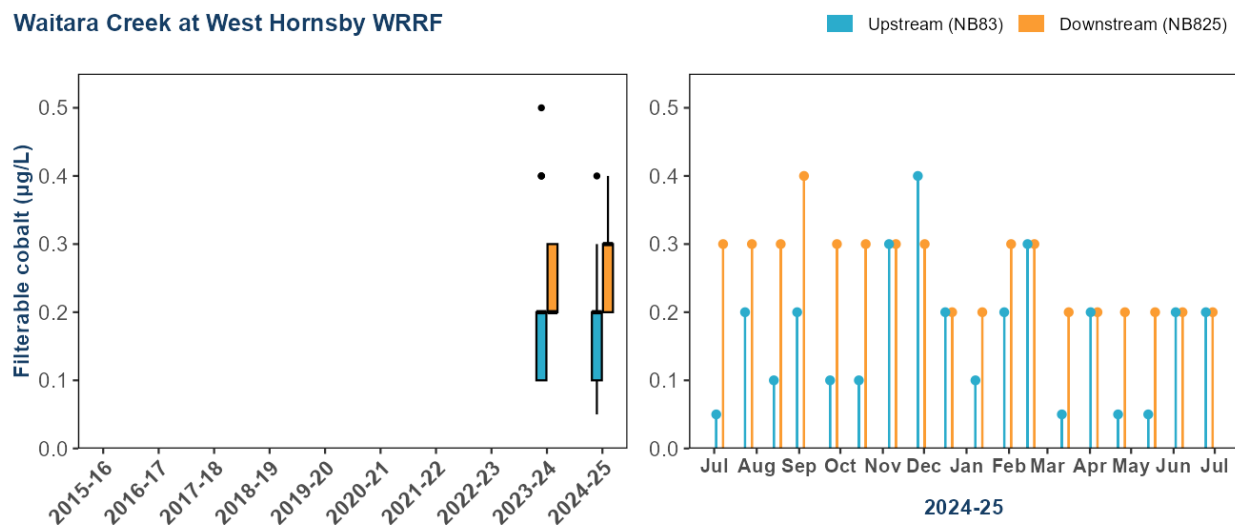
Waitara Creek at West Hornsby WRRF



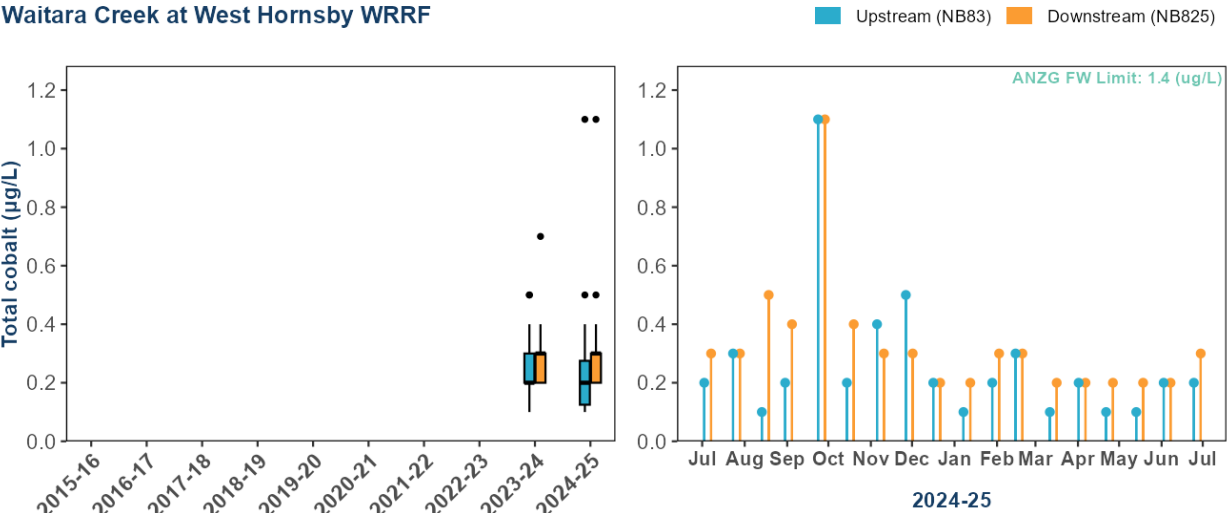
Waitara Creek at West Hornsby WRRF



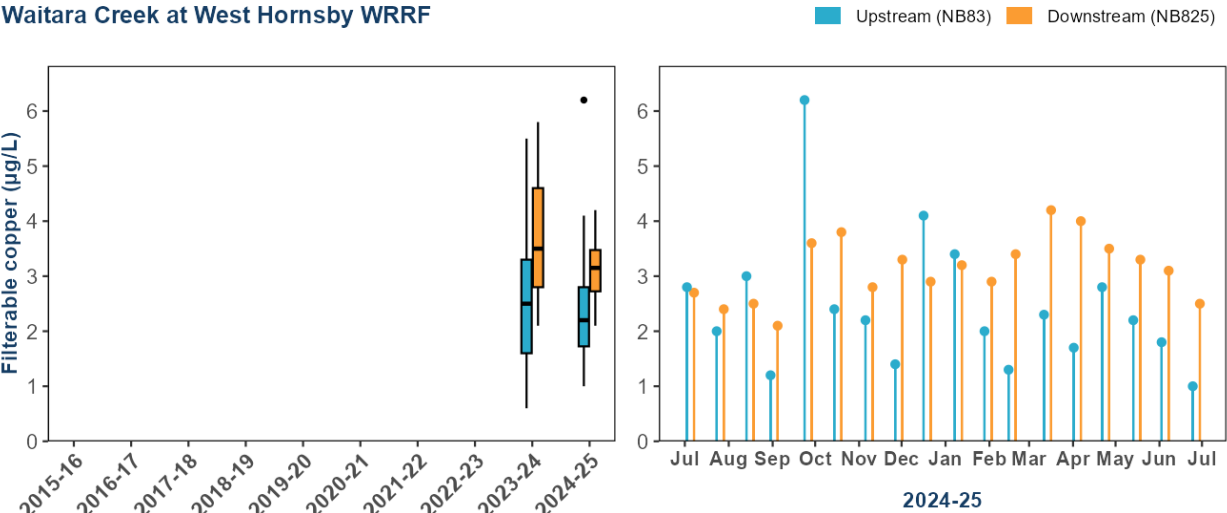
Waitara Creek at West Hornsby WRRF



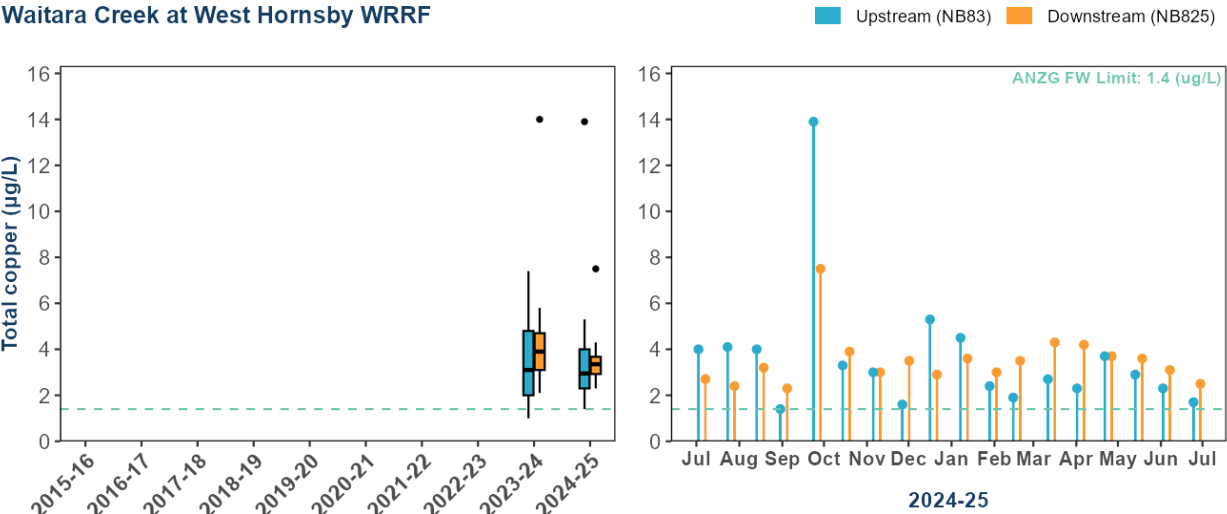
Waitara Creek at West Hornsby WRRF



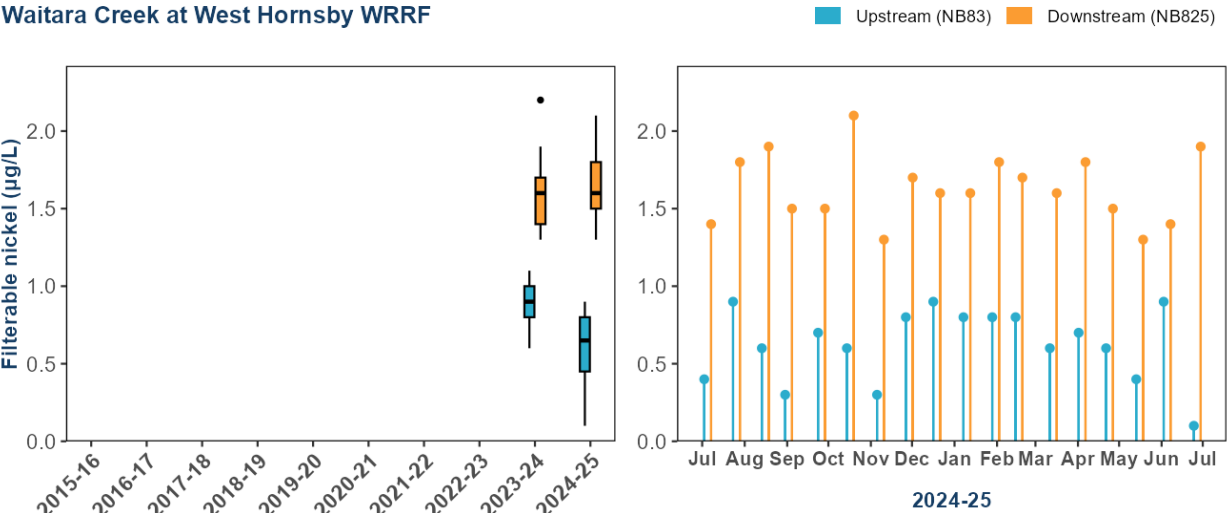
Waitara Creek at West Hornsby WRRF



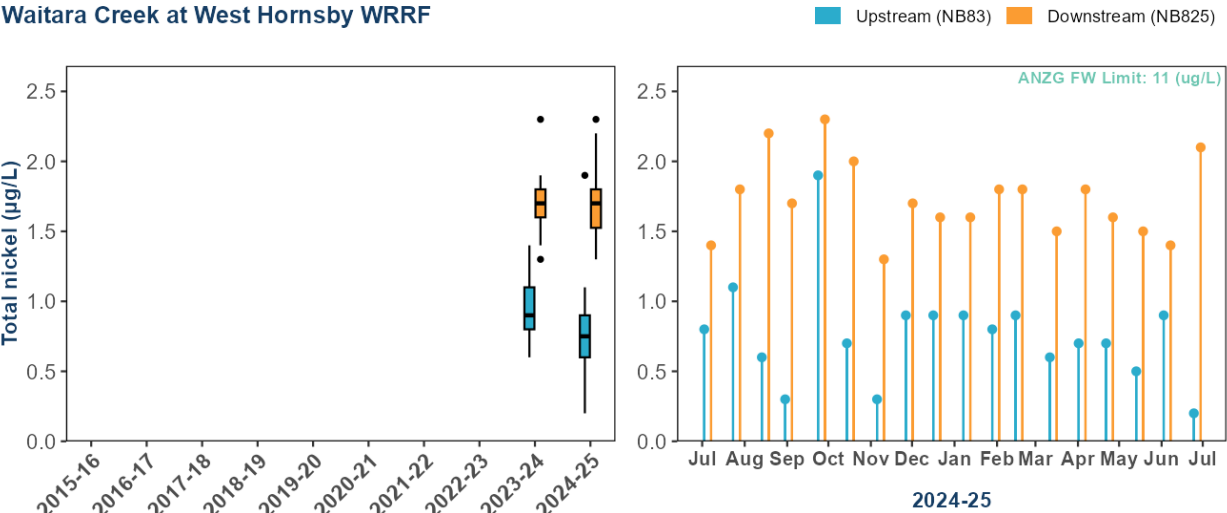
Waitara Creek at West Hornsby WRRF



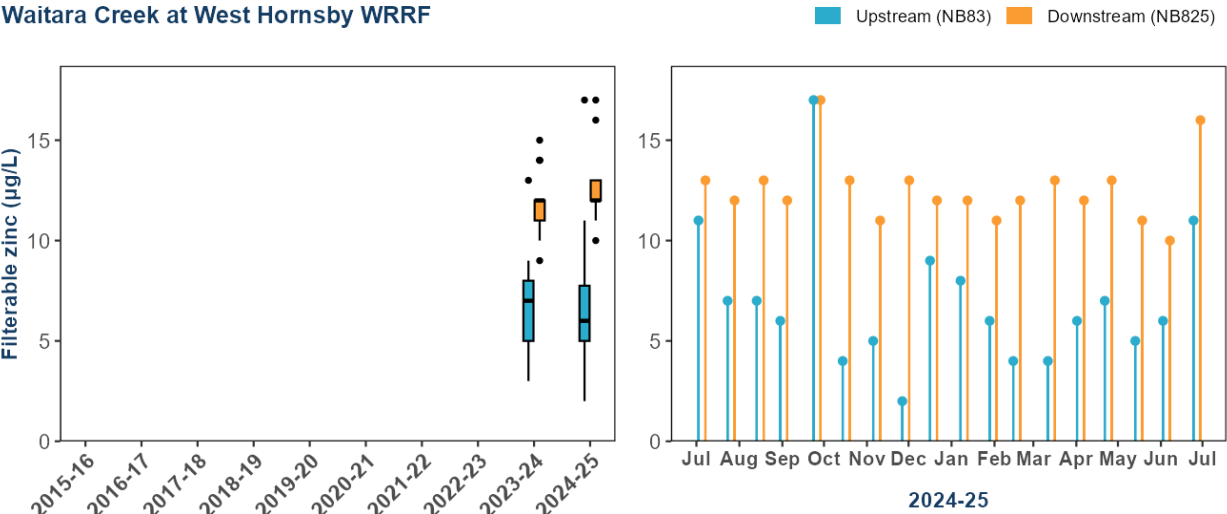
Waitara Creek at West Hornsby WRRF



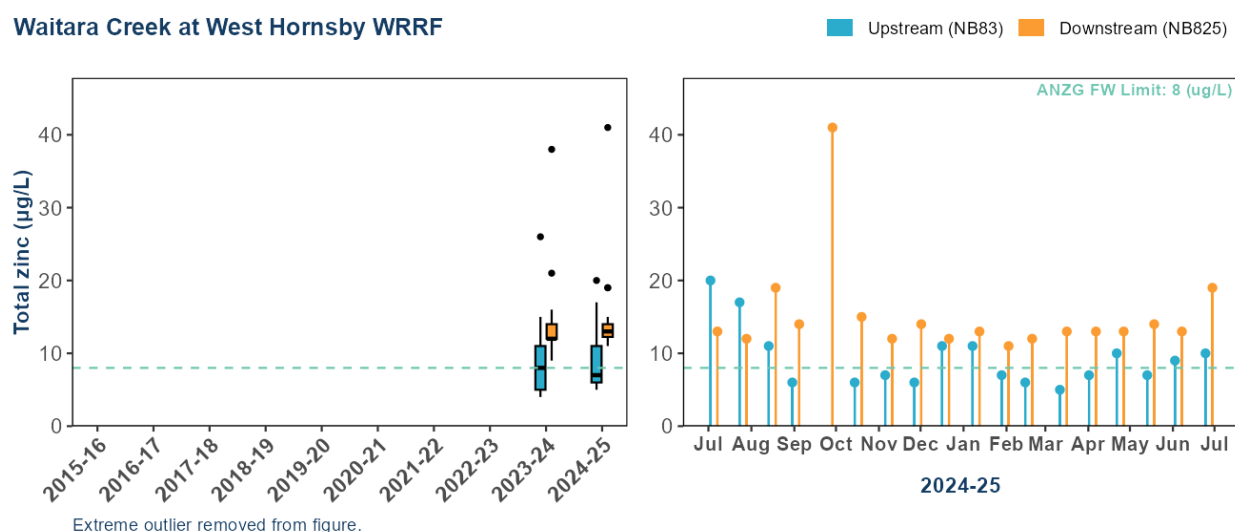
Waitara Creek at West Hornsby WRRF



Waitara Creek at West Hornsby WRRF



Waitara Creek at West Hornsby WRRF



A.13.9. Ecosystem receptor – Statistical analysis outcomes

Table A-132 Upstream vs downstream comparison (2024-25 reporting period) for Waitara Creek at West Hornsby WRRF

Waitara Creek at West Hornsby WRRF: NB83 vs NB825 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.23	0.46	162	0.55	0.946
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-133 Upstream current period (2024-25) vs previous period comparison (single site) for Waitara Creek at West Hornsby WRRF

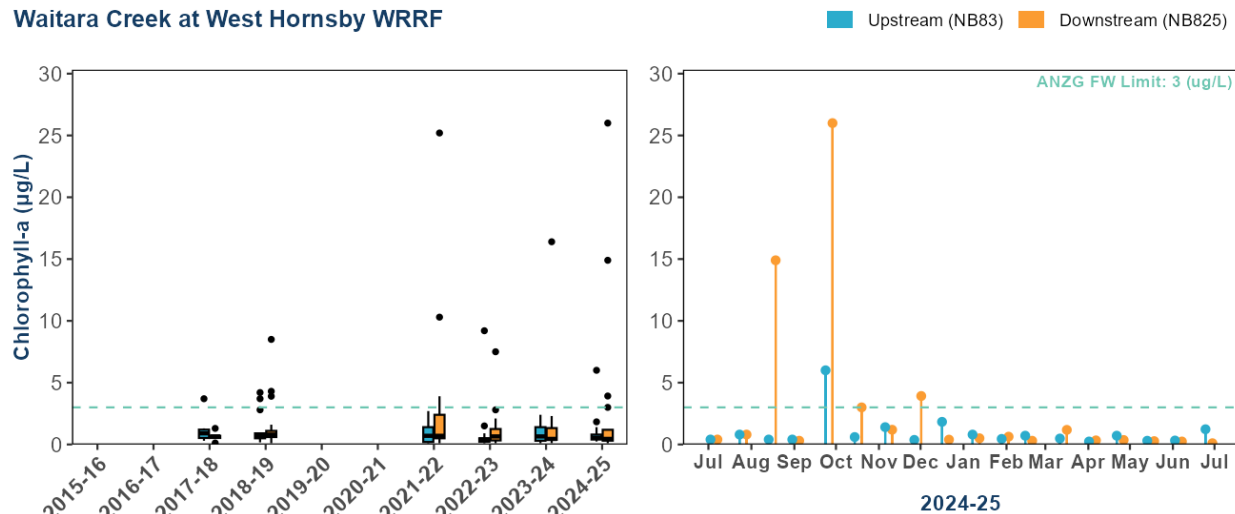
Waitara Creek at West Hornsby WRRF: NB83 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.19	0.35	162	0.60	0.933
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-134 Downstream current period (2024-25) vs previous period comparison (single site) for Waitara Creek at West Hornsby WRRF

Waitara Creek at West Hornsby WRRF: NB825 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.98	0.29	162	-0.08	>0.999
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.13.10. Ecosystem receptor – Phytoplankton

Waitara Creek at West Hornsby WRRF

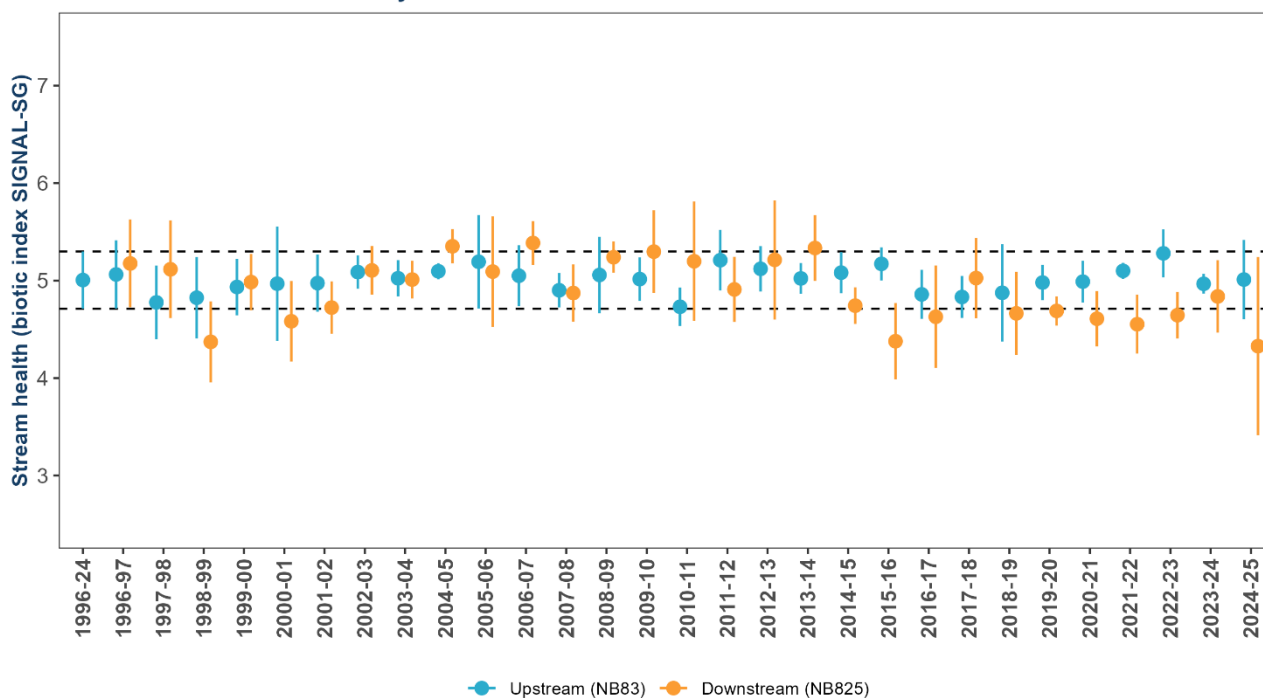


A.13.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Waitara Creek	River (NB83 vs NB825)	Welch Two Sample t-test	0.68	1.67	6.91	0.139

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Waitara Creek at West Hornsby WRRF

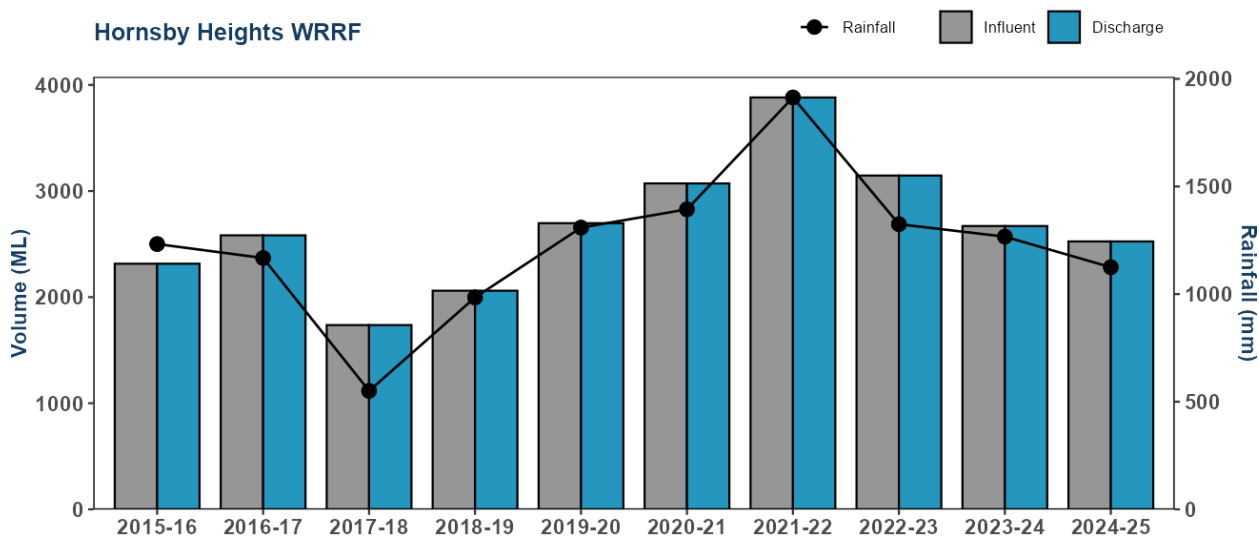


The range of stream health recorded over each period is represented by length of line

A.14. Hornsby Heights WRRF

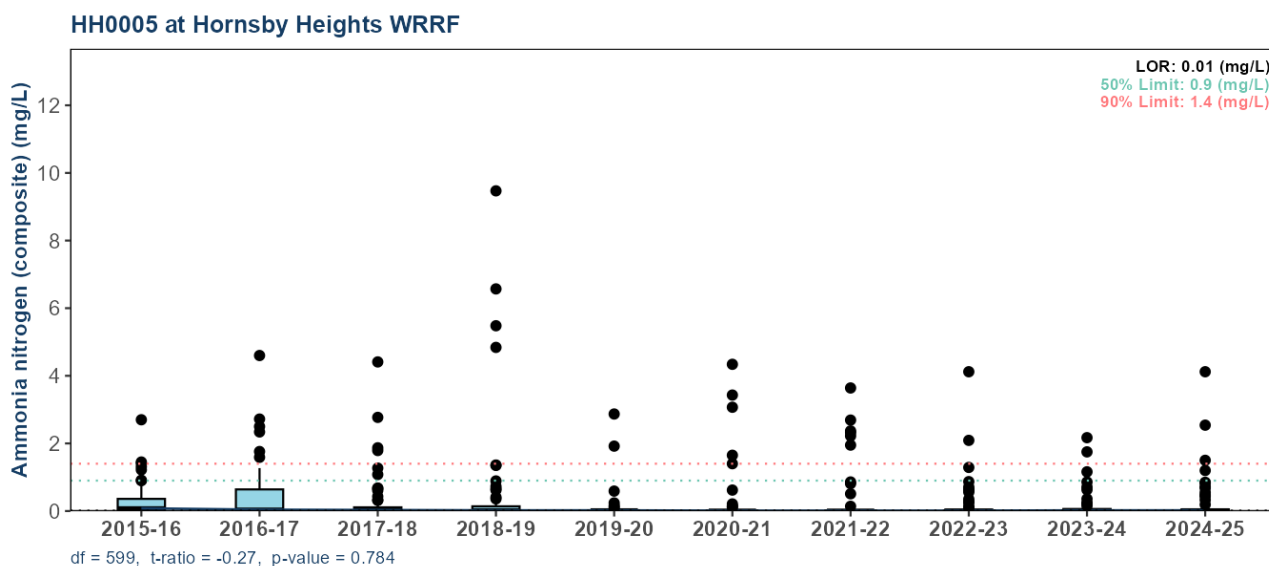
A.14.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall

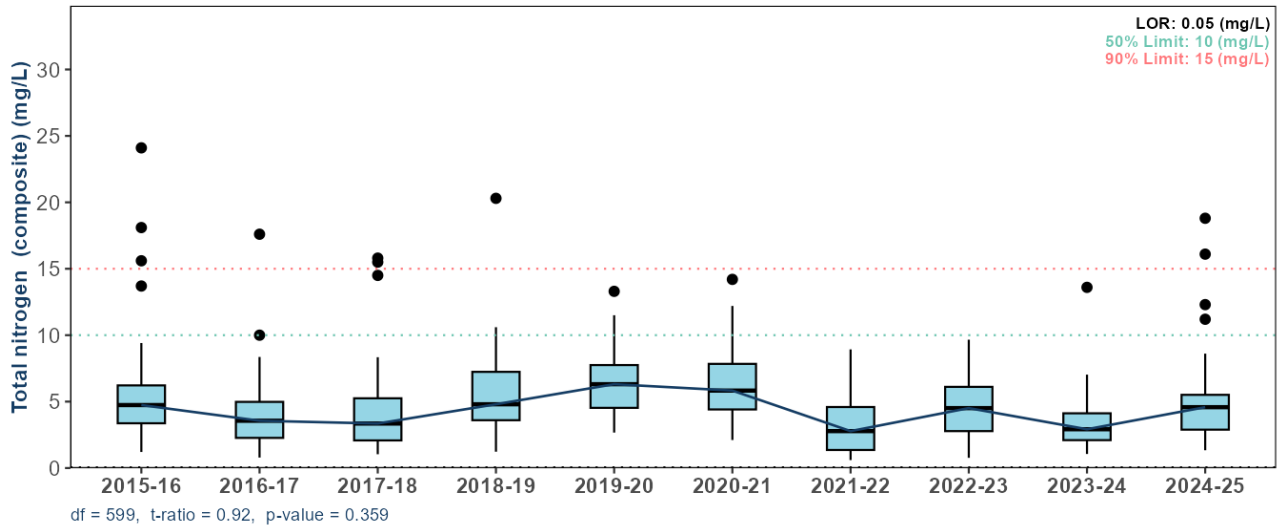


A.14.2. Pressure – Wastewater quality

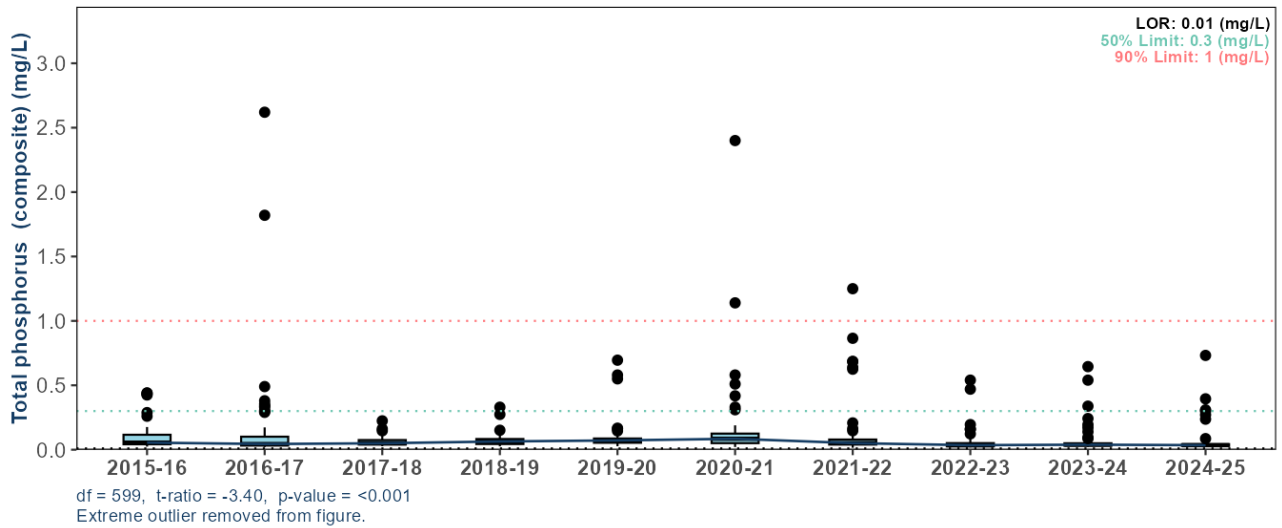
Nutrients



HH0005 at Hornsby Heights WRRF

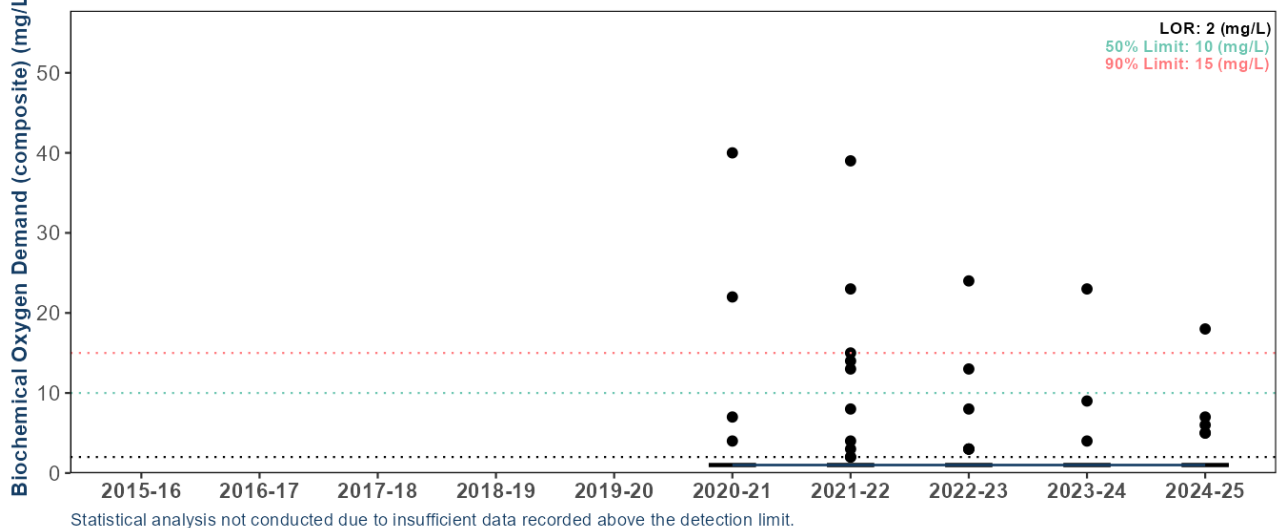


HH0005 at Hornsby Heights WRRF

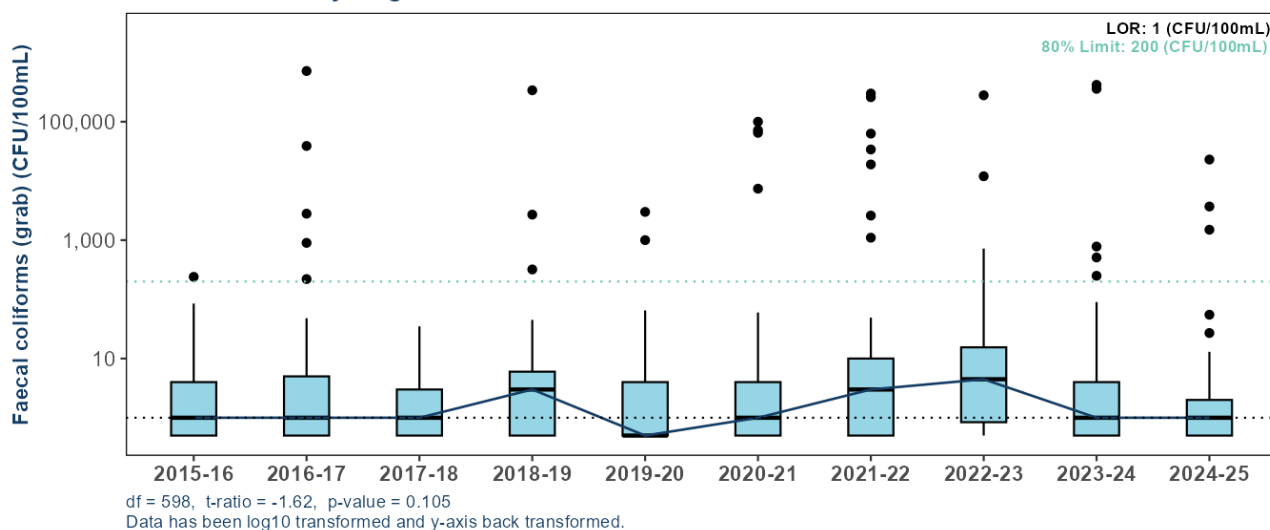


Major conventional analytes

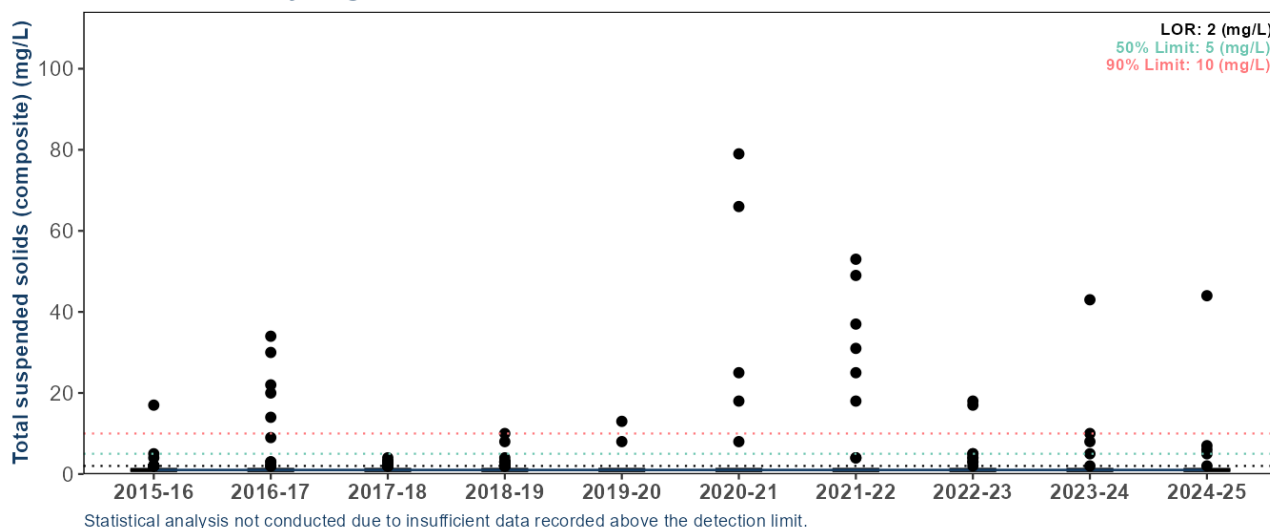
HH0005 at Hornsby Heights WRRF



HH0005 at Hornsby Heights WRRF

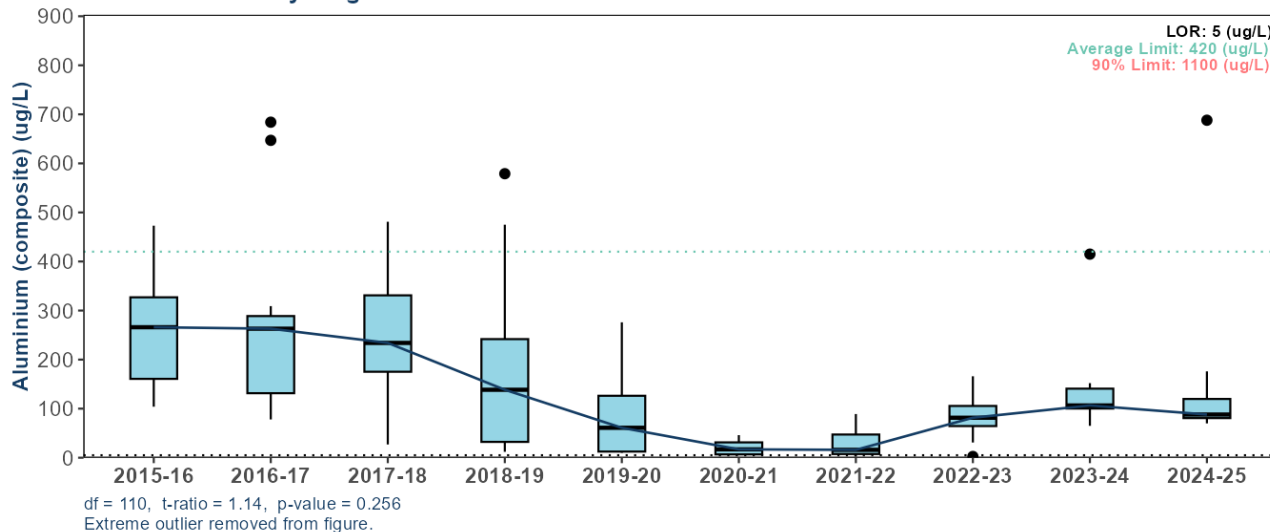


HH0005 at Hornsby Heights WRRF

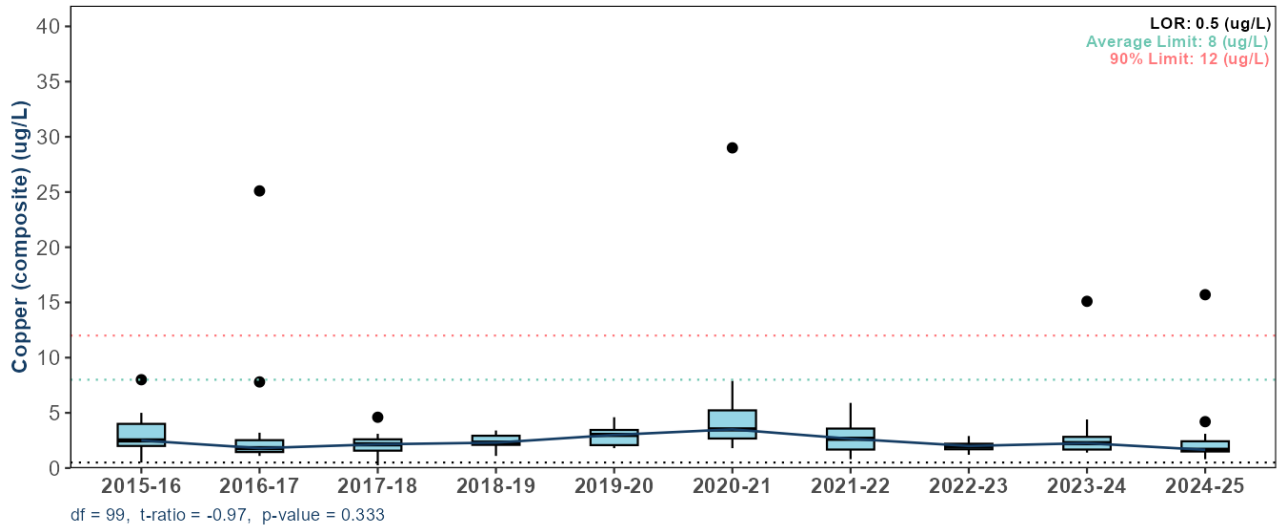


Trace metals

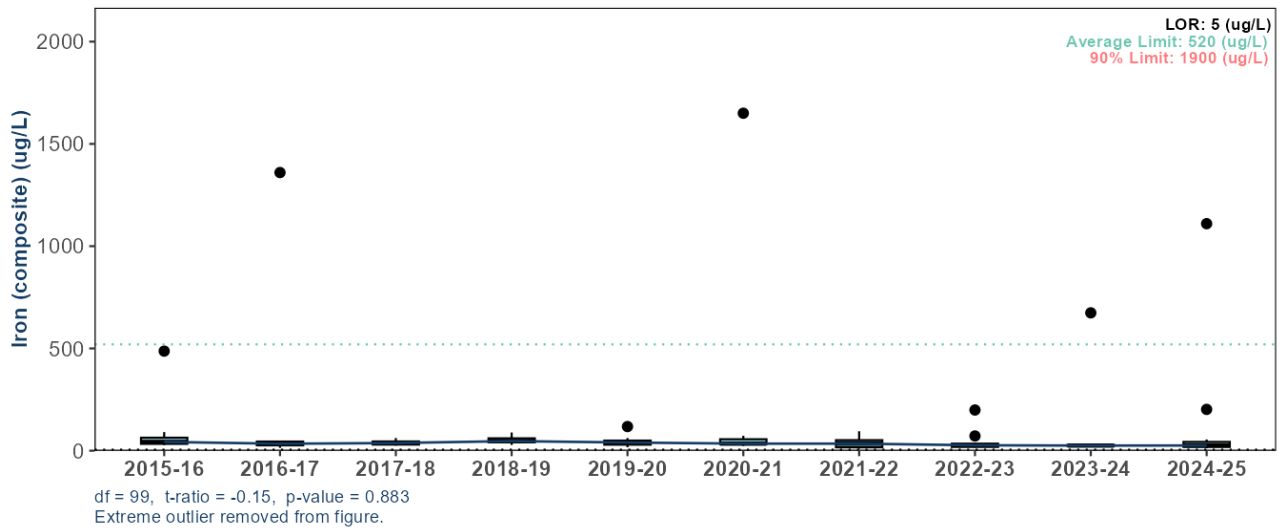
HH0005 at Hornsby Heights WRRF



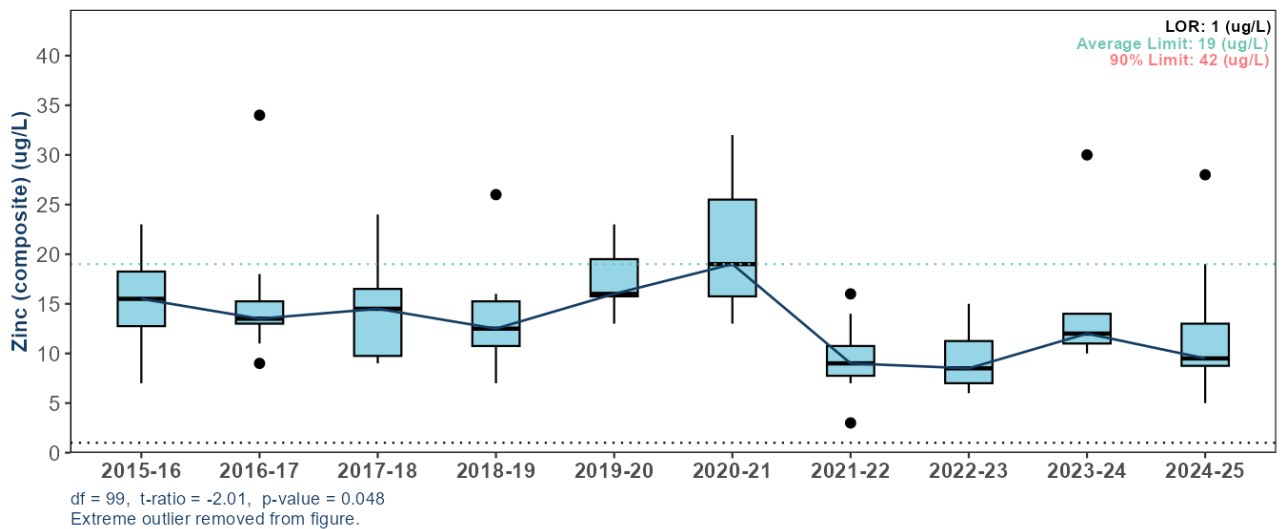
HH0005 at Hornsby Heights WRRF



HH0005 at Hornsby Heights WRRF

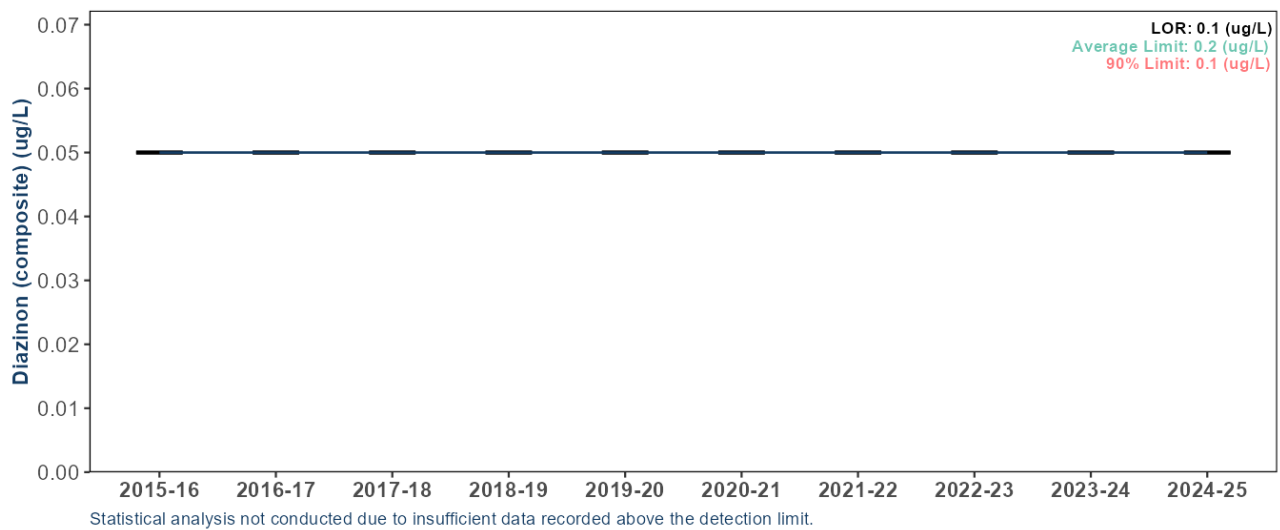


HH0005 at Hornsby Heights WRRF

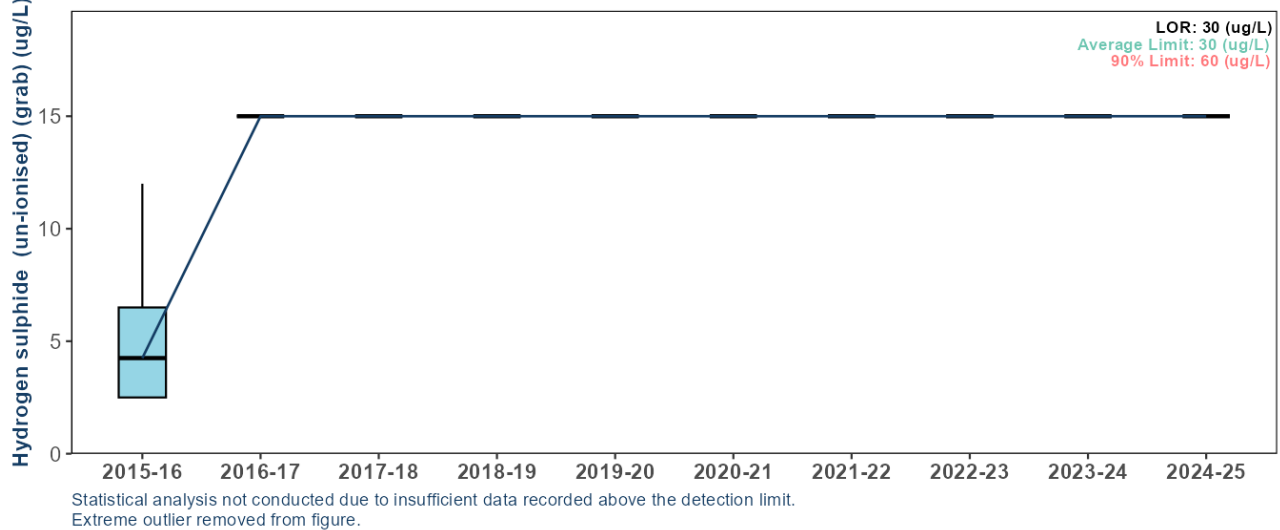


Other chemicals and organics (including pesticides)

HH0005 at Hornsby Heights WRRF

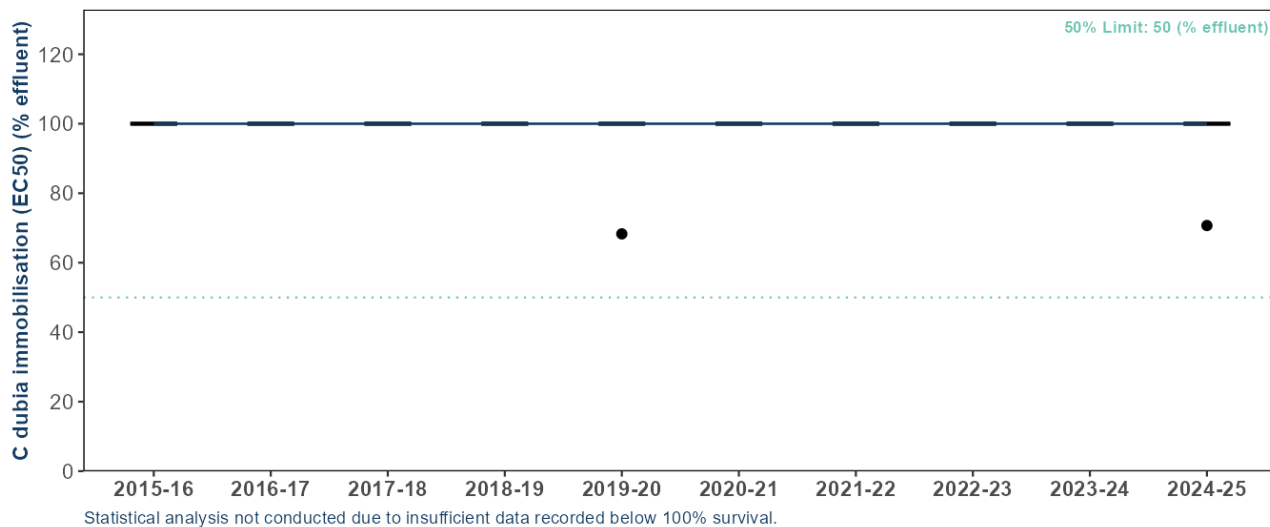


HH0005 at Hornsby Heights WRRF



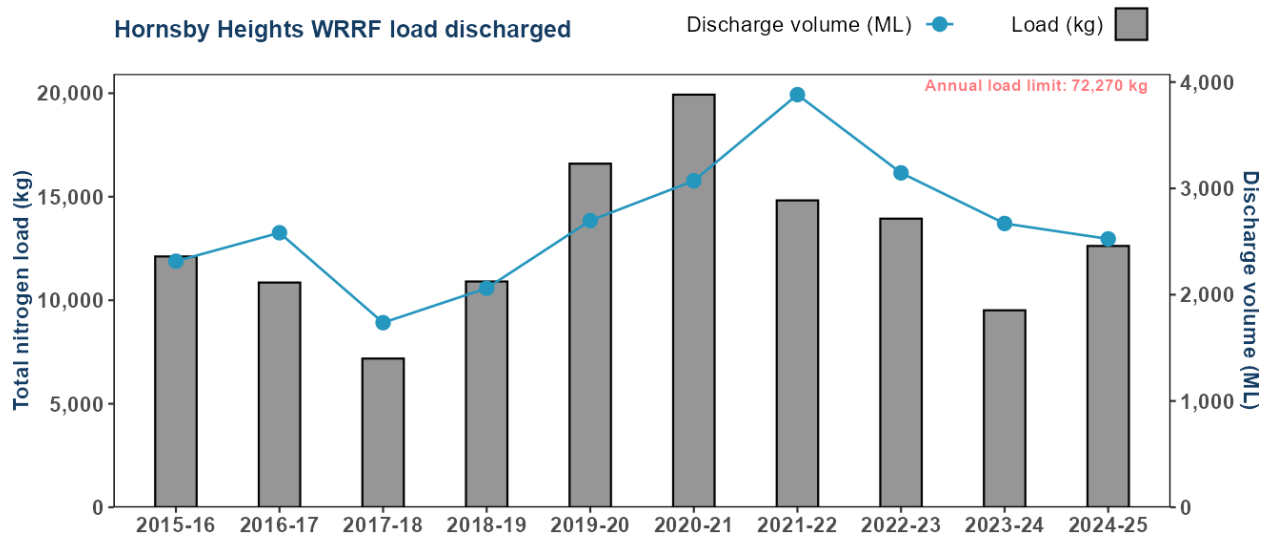
A.14.3. Pressure – Wastewater toxicity

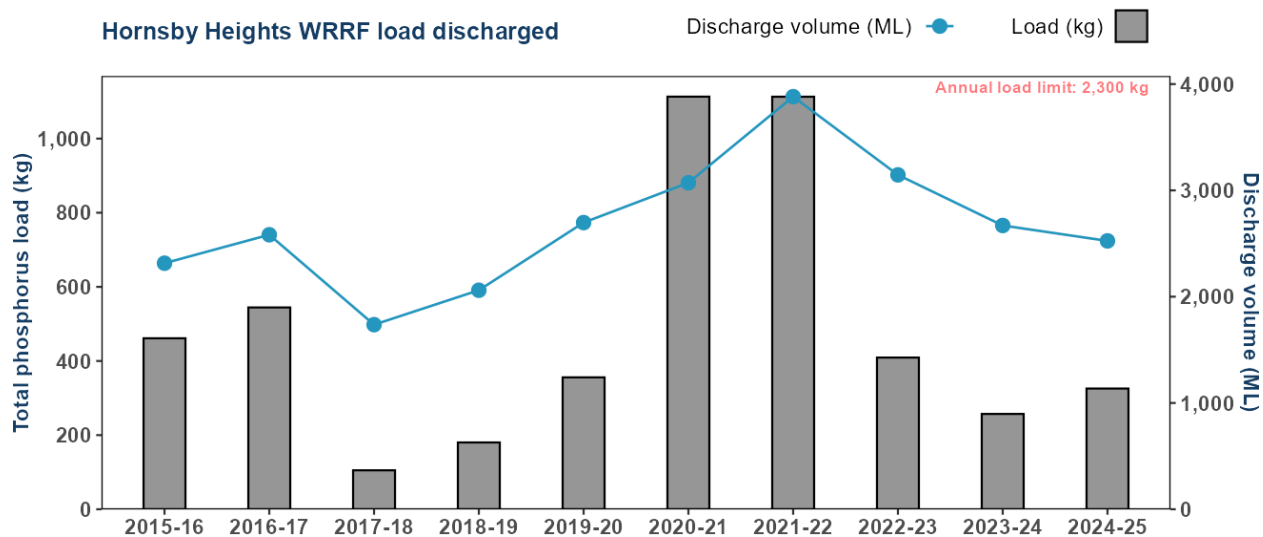
HH0005 at Hornsby Heights WRRF



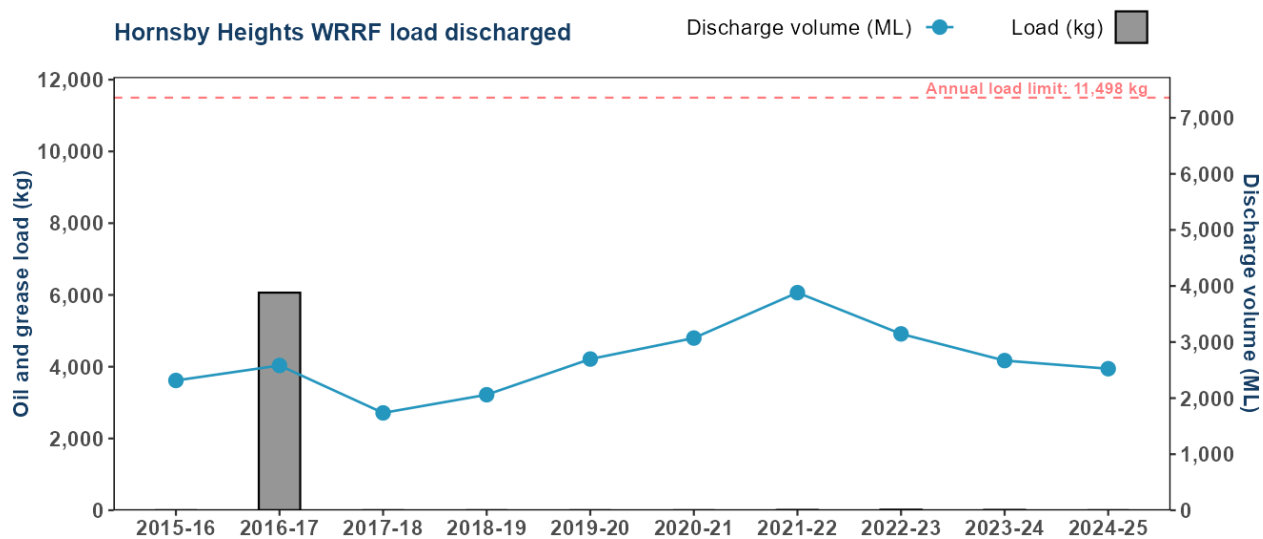
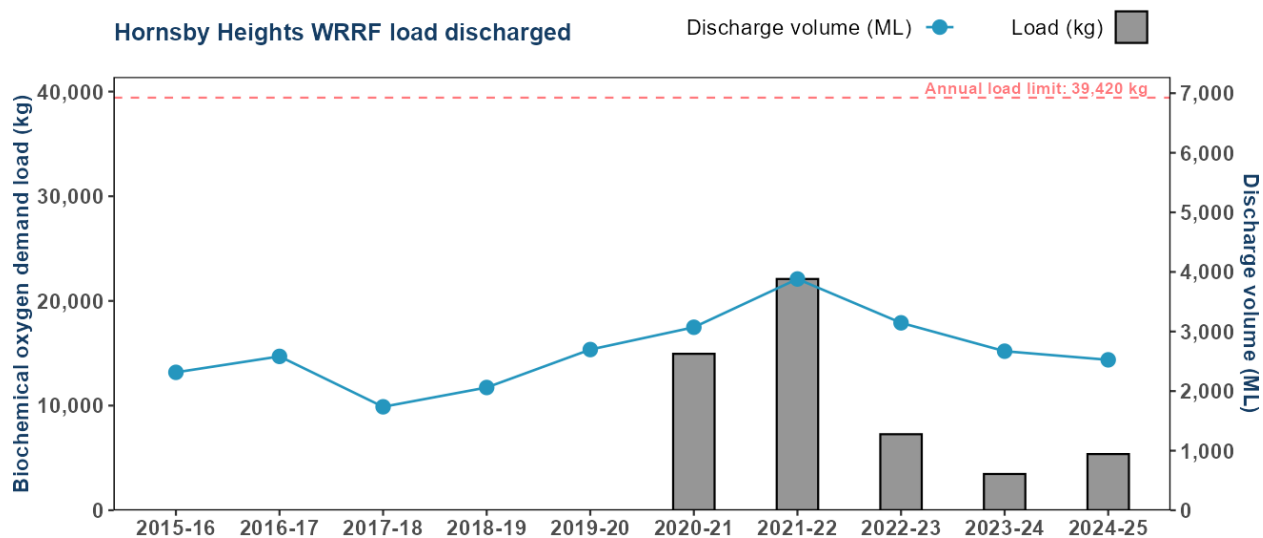
A.14.4. Pressure – Wastewater discharge load

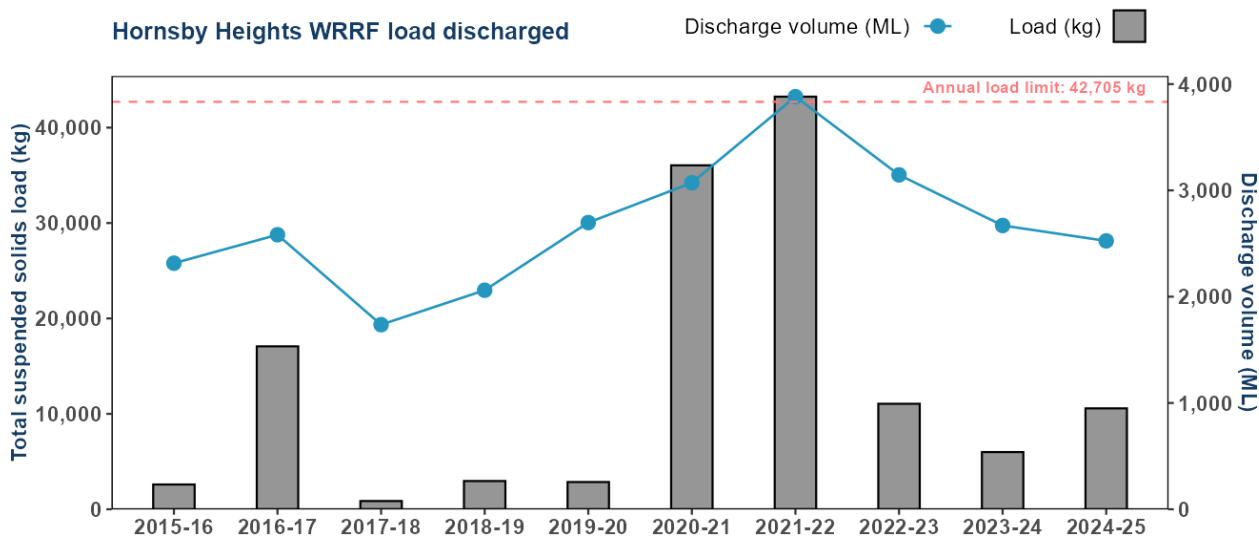
Nutrients





Major conventional analytes





A.14.5. Stressor – Statistical analysis outcomes

Table A-135 Upstream vs downstream comparison (2024-25 reporting period) for Calna Creek at Hornsby Heights WRRF

Calna Creek at Hornsby Heights WRRF: NB43 vs NB42 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	3.61	1.44	161	3.21	0.009
Oxidised nitrogen	32.73	12.21	161	9.35	<0.001
Total nitrogen	9.05	1.88	161	10.62	<0.001
Soluble reactive phosphorus	3.24	1.23	66	3.09	0.015
Total phosphorus	1.63	0.40	161	1.98	0.199
Physico-chemical					
Conductivity	2.41	0.24	161	8.86	<0.001
Dissolved oxygen	1.05	0.05	161	1.16	0.651
Dissolved oxygen saturation	10.27	2.21	161	4.64	<0.001
pH	0.43	0.06	161	6.64	<0.001
Water temperature	1.18	0.09	161	2.33	0.096
Turbidity	0.29	0.09	161	-3.83	0.001
Trace Metals					
Filterable aluminium	4.45	1.03	66	6.44	<0.001
Total aluminium	1.75	0.53	66	1.84	0.264
Filterable cobalt	2.10	0.28	66	5.64	<0.001
Total cobalt	1.58	0.23	66	3.09	0.015
Filterable copper	1.22	0.19	66	1.29	0.572
Total copper	1.07	0.19	66	0.35	0.985
Filterable nickel	2.49	0.28	66	8.00	<0.001
Total nickel	2.35	0.28	66	7.18	<0.001
Filterable zinc	1.30	0.14	66	2.42	0.084
Total zinc	1.15	0.17	66	0.92	0.793

not significant (p>0.05)
p <0.05 and >=0.01
p <0.01 and >=0.001
p <0.001

Table A-136 Upstream current period (2024-25) vs previous period comparison (single site) for Calna Creek at Hornsby Heights WRRF

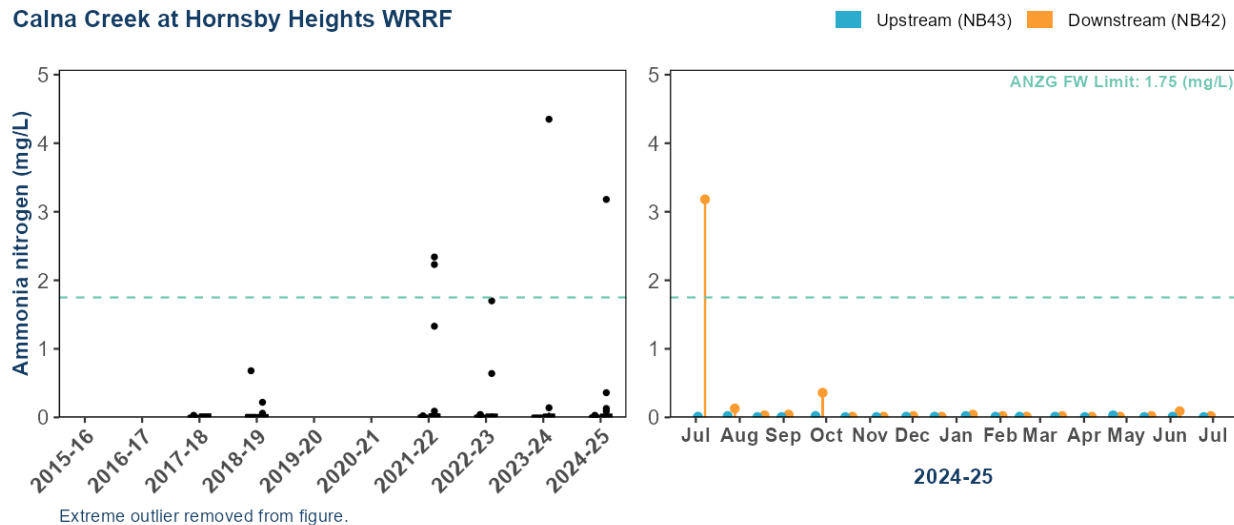
Calna Creek at Hornsby Heights WRRF: NB43 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.66	0.21	161	-1.32	0.554
Oxidised nitrogen	0.94	0.28	161	-0.22	0.996
Total nitrogen	1.02	0.17	161	0.14	>0.999
Soluble reactive phosphorus	1.86	0.72	66	1.60	0.385
Total phosphorus	1.15	0.22	161	0.70	0.896
Physico-chemical					
Conductivity	0.96	0.08	161	-0.52	0.954
Dissolved oxygen	1.03	0.04	161	0.80	0.852
Dissolved oxygen saturation	3.61	1.76	161	2.06	0.172
pH	0.06	0.05	161	1.17	0.645
Water temperature	1.06	0.06	161	1.09	0.699
Turbidity	0.86	0.22	161	-0.60	0.933
Trace Metals					
Filterable aluminium	1.13	0.27	66	0.53	0.952
Total aluminium	0.88	0.27	66	-0.41	0.977
Filterable cobalt	0.74	0.10	66	-2.29	0.110
Total cobalt	0.93	0.14	66	-0.51	0.957
Filterable copper	1.34	0.21	66	1.86	0.256
Total copper	1.39	0.26	66	1.77	0.295
Filterable nickel	0.70	0.08	66	-3.14	0.013
Total nickel	0.69	0.08	66	-3.06	0.016
Filterable zinc	1.29	0.14	66	2.35	0.098
Total zinc	1.35	0.20	66	2.02	0.190
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-137 Downstream current period (2024-25) vs previous period comparison (single site) for Calna Creek at Hornsby Heights WRRF

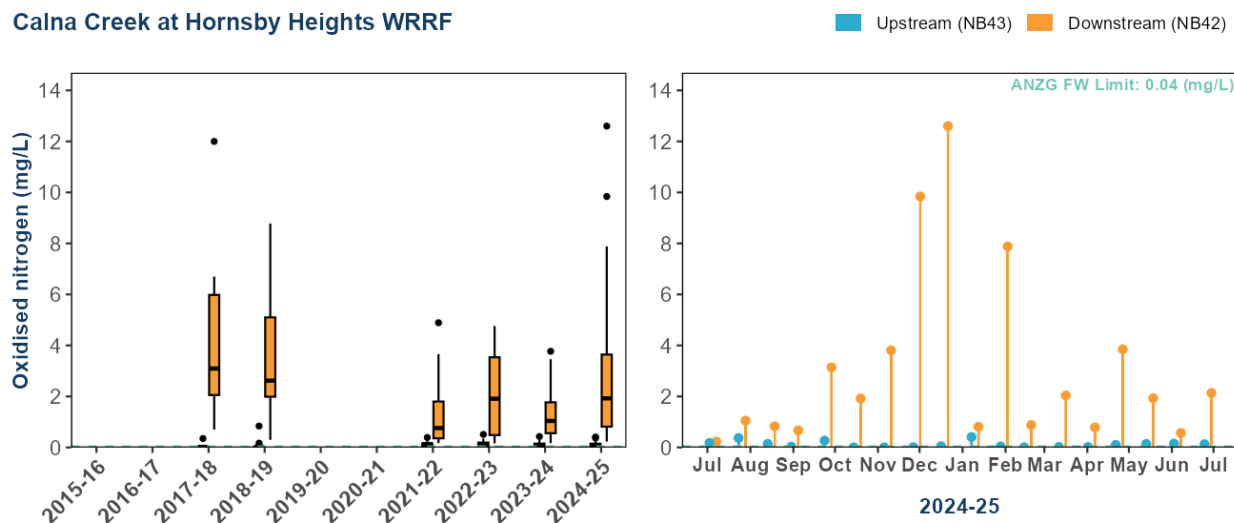
Calna Creek at Hornsby Heights WRRF: NB42 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Nutrient					
Ammonia nitrogen	0.82	0.26	161	-0.64	0.920
Oxidised nitrogen	1.45	0.43	161	1.24	0.603
Total nitrogen	1.23	0.20	161	1.26	0.589
Soluble reactive phosphorus	0.97	0.37	66	-0.08	>0.999
Total phosphorus	0.78	0.15	161	-1.24	0.602
Physico-chemical					
Conductivity	0.97	0.08	161	-0.40	0.978
Dissolved oxygen	1.01	0.04	161	0.34	0.987
Dissolved oxygen saturation	1.21	1.77	161	0.68	0.903
pH	0.00	0.05	161	0.06	>0.999
Water temperature	1.00	0.06	161	0.03	>0.999
Turbidity	1.01	0.26	161	0.03	>0.999
Trace Metals					
Filterable aluminium	0.74	0.17	66	-1.28	0.576
Total aluminium	0.84	0.26	66	-0.57	0.941
Filterable cobalt	0.99	0.13	66	-0.07	>0.999
Total cobalt	1.01	0.15	66	0.06	>0.999
Filterable copper	0.90	0.14	66	-0.67	0.909
Total copper	0.94	0.17	66	-0.31	0.990
Filterable nickel	0.87	0.10	66	-1.22	0.618
Total nickel	0.90	0.11	66	-0.88	0.817
Filterable zinc	0.73	0.08	66	-2.93	0.023
Total zinc	0.80	0.12	66	-1.47	0.462
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.14.6. Stressor – Nutrients

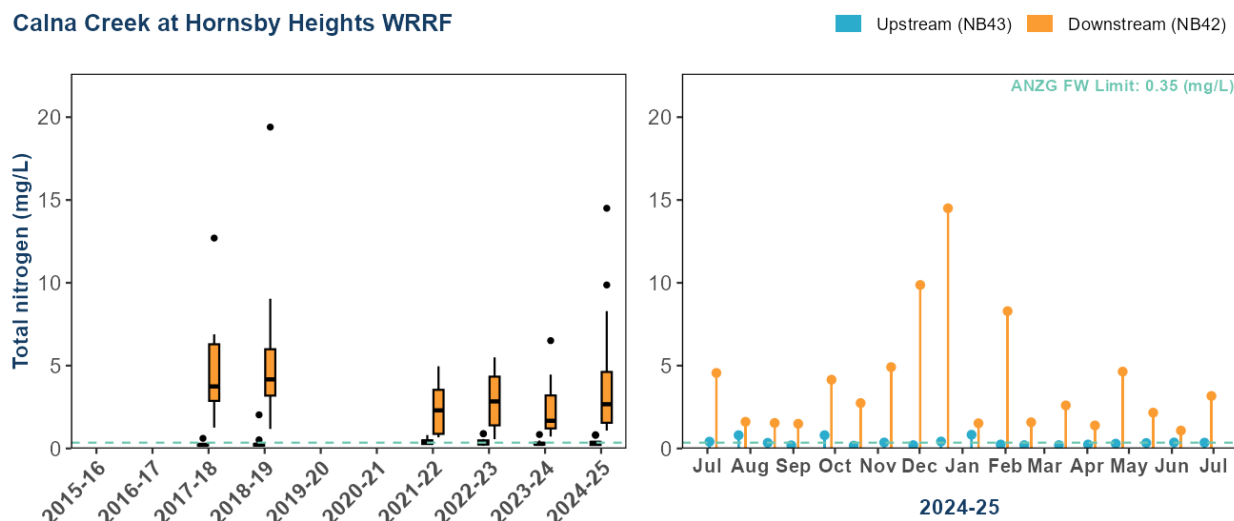
Calna Creek at Hornsby Heights WRRF



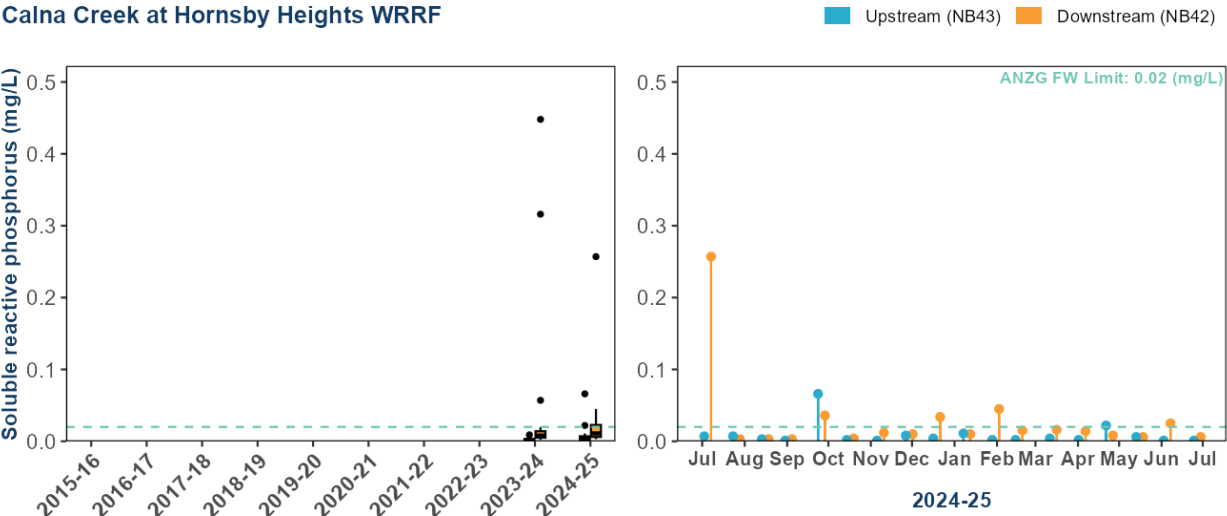
Calna Creek at Hornsby Heights WRRF



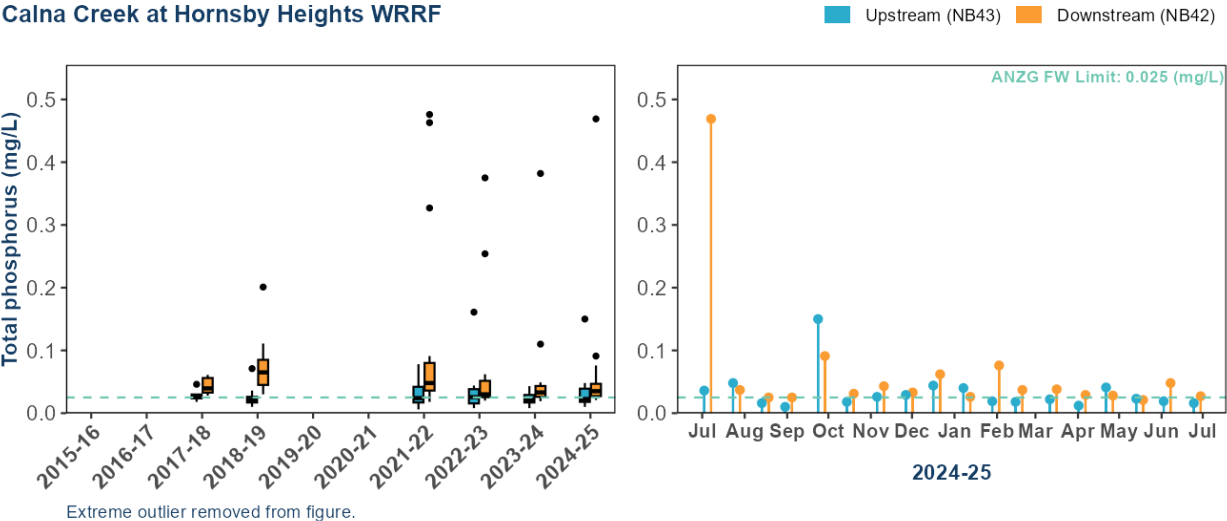
Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF

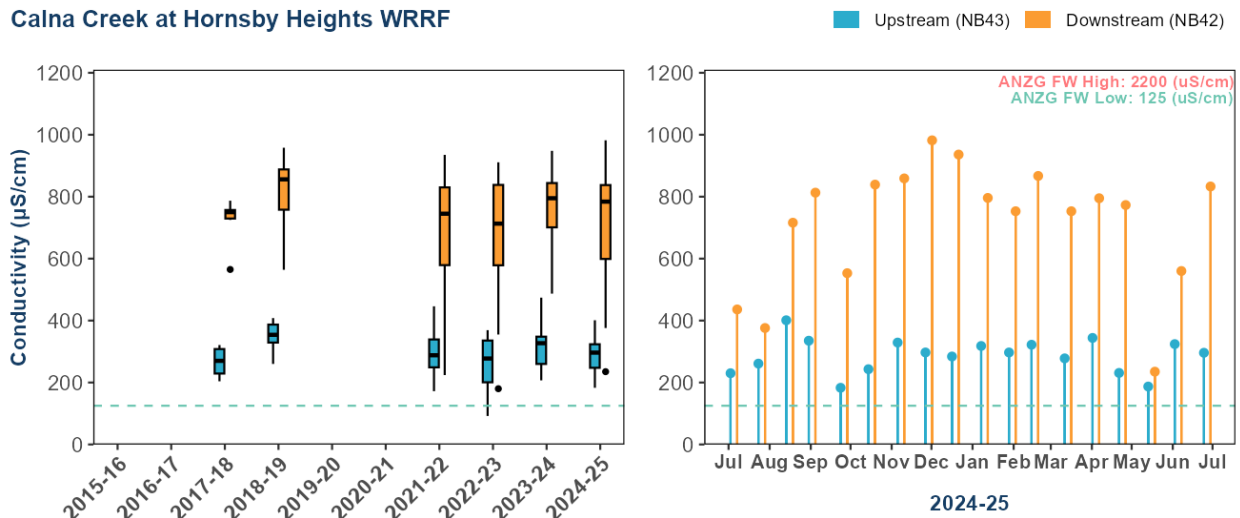


Calna Creek at Hornsby Heights WRRF

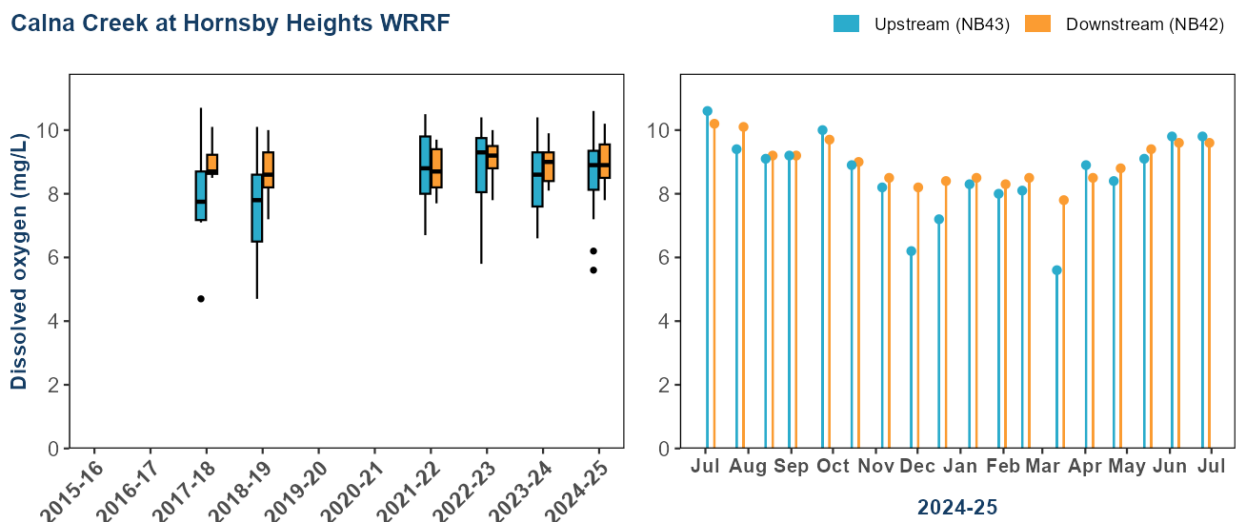


A.14.7. Stressor – Physico-chemical water quality

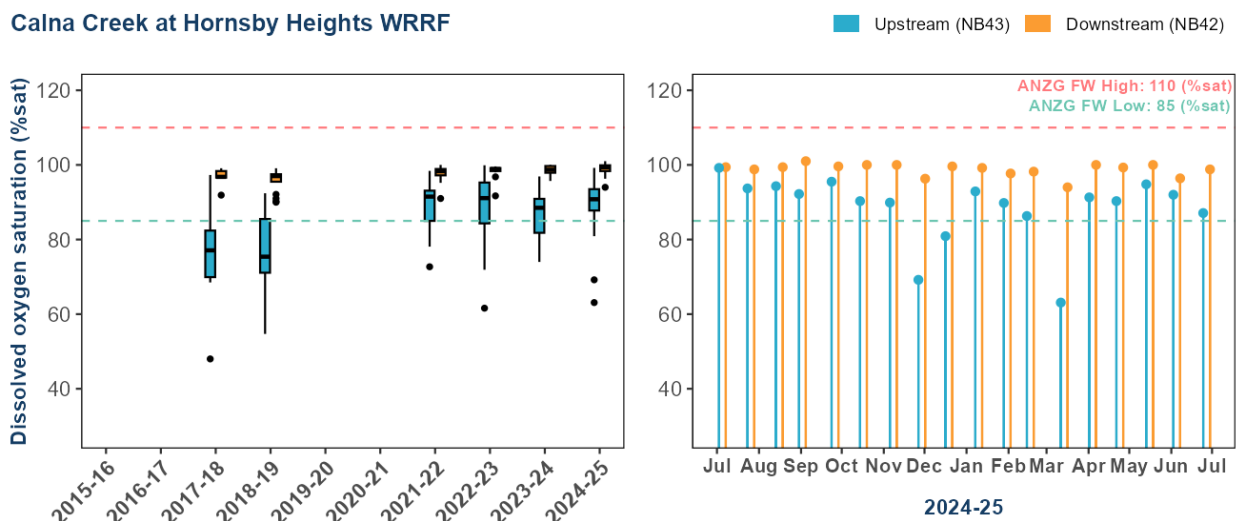
Calna Creek at Hornsby Heights WRRF



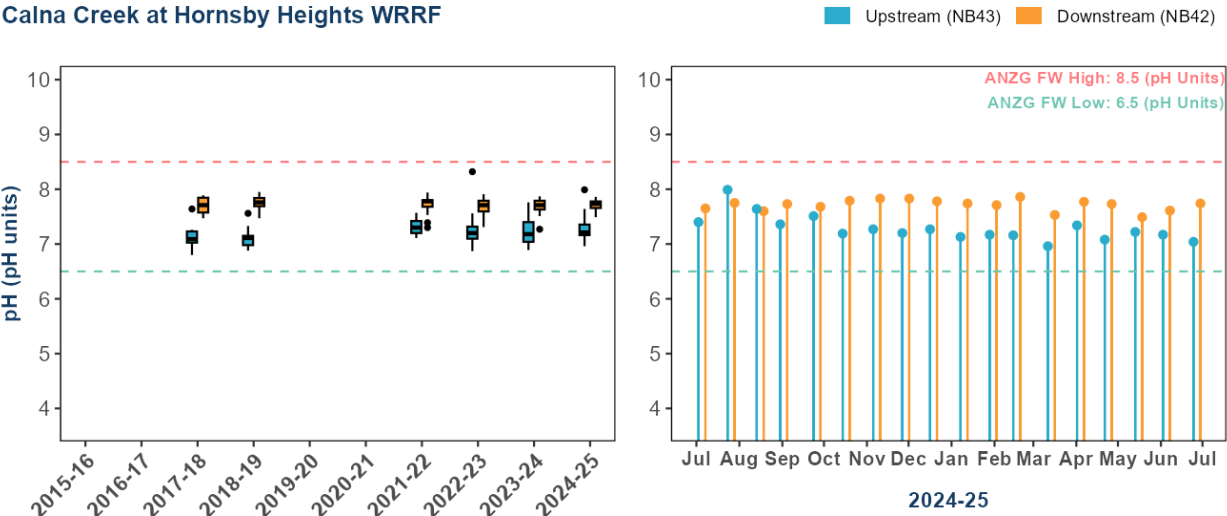
Calna Creek at Hornsby Heights WRRF



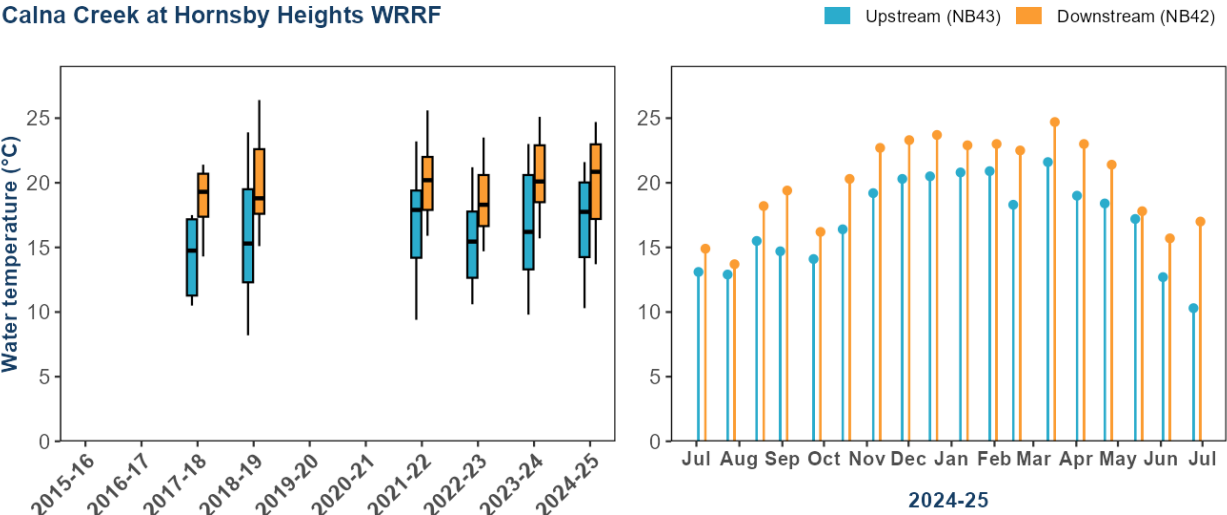
Calna Creek at Hornsby Heights WRRF



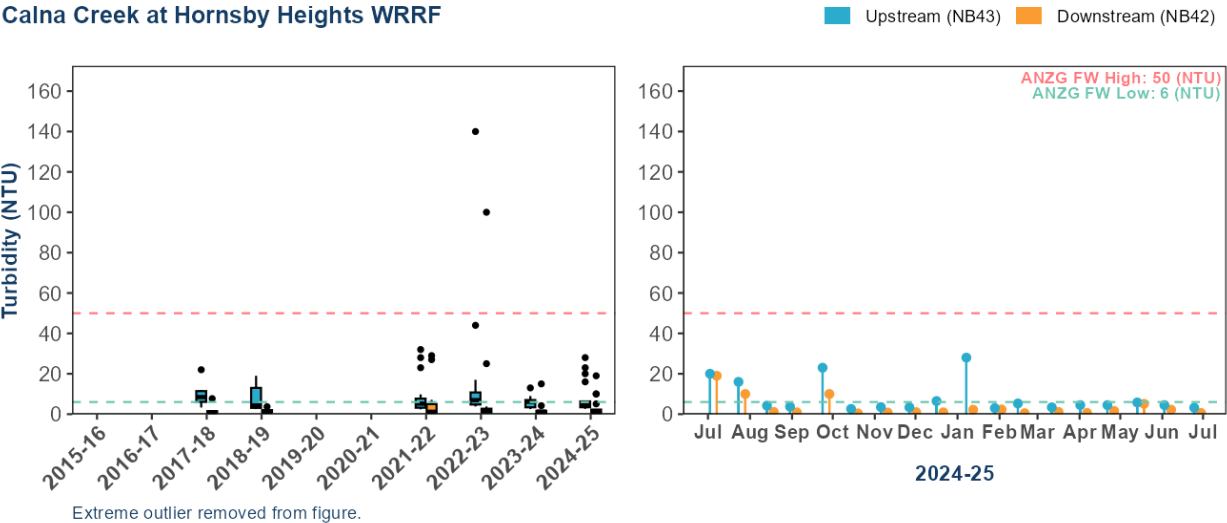
Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF

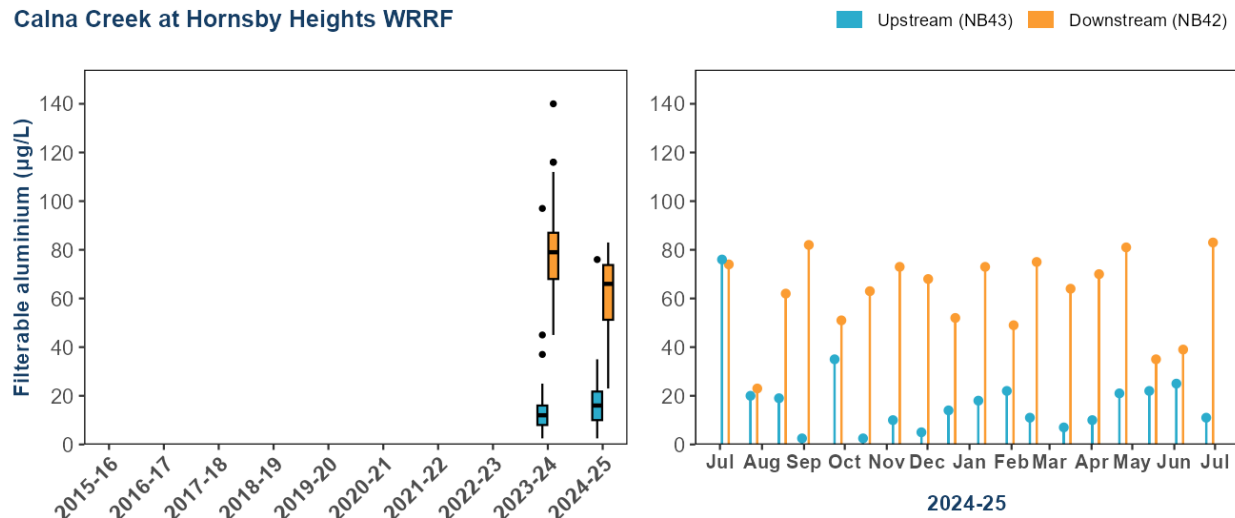


Calna Creek at Hornsby Heights WRRF

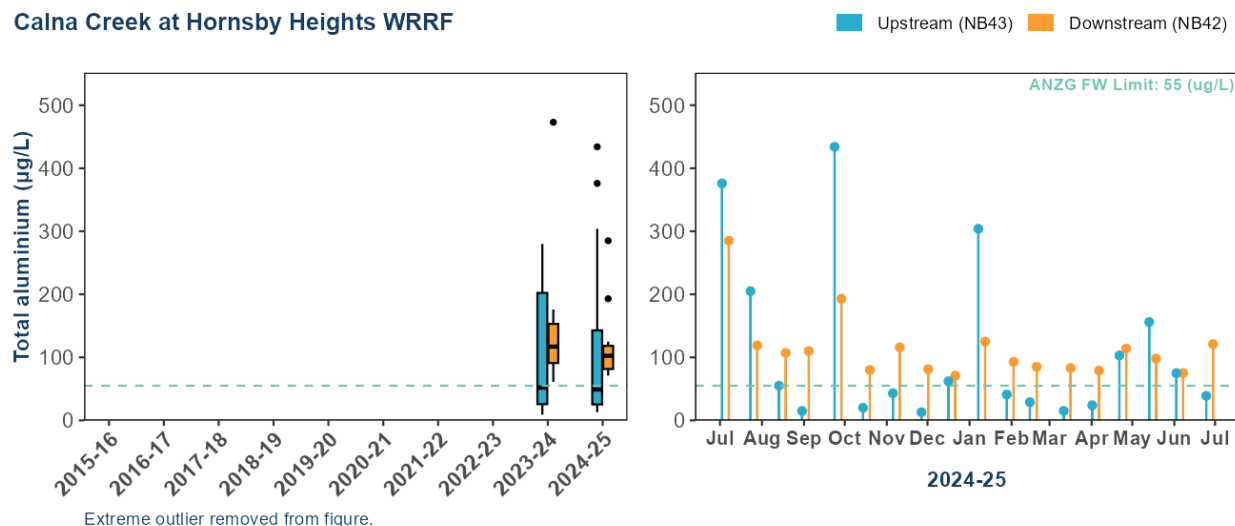


A.14.8. Stressor – Trace metals

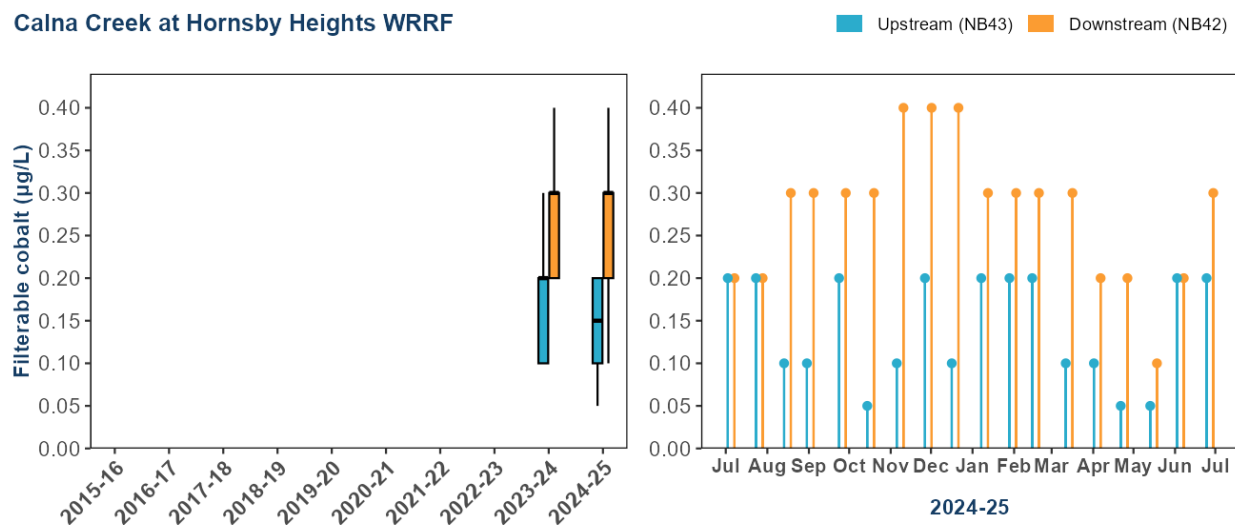
Calna Creek at Hornsby Heights WRRF



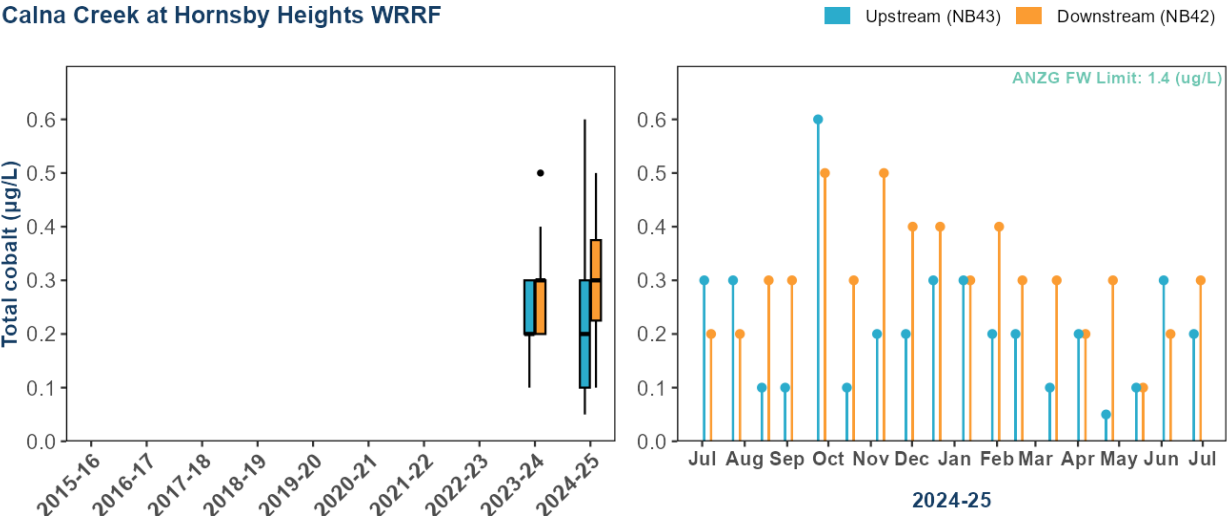
Calna Creek at Hornsby Heights WRRF



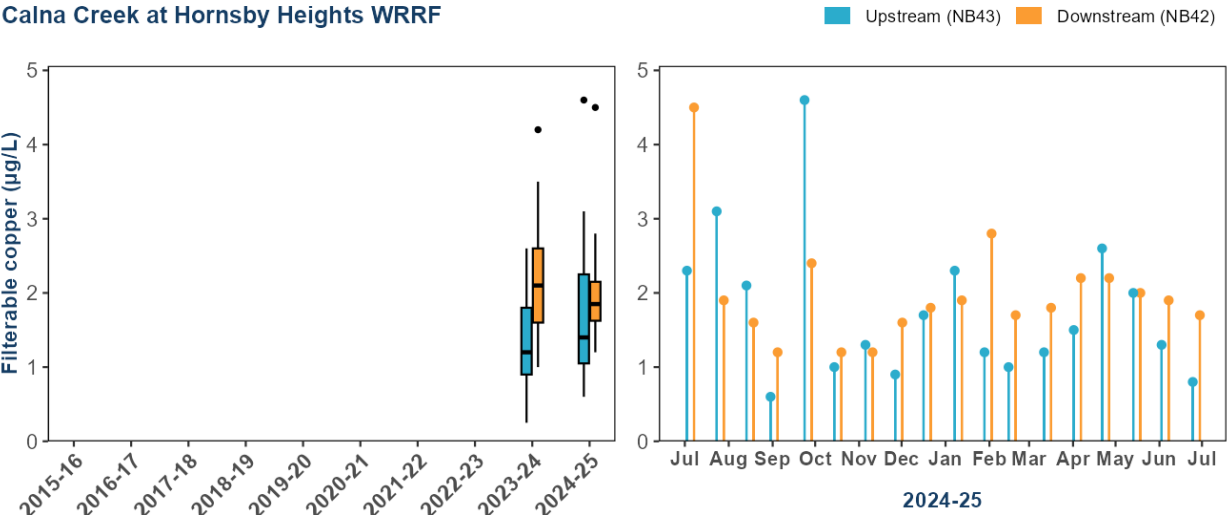
Calna Creek at Hornsby Heights WRRF



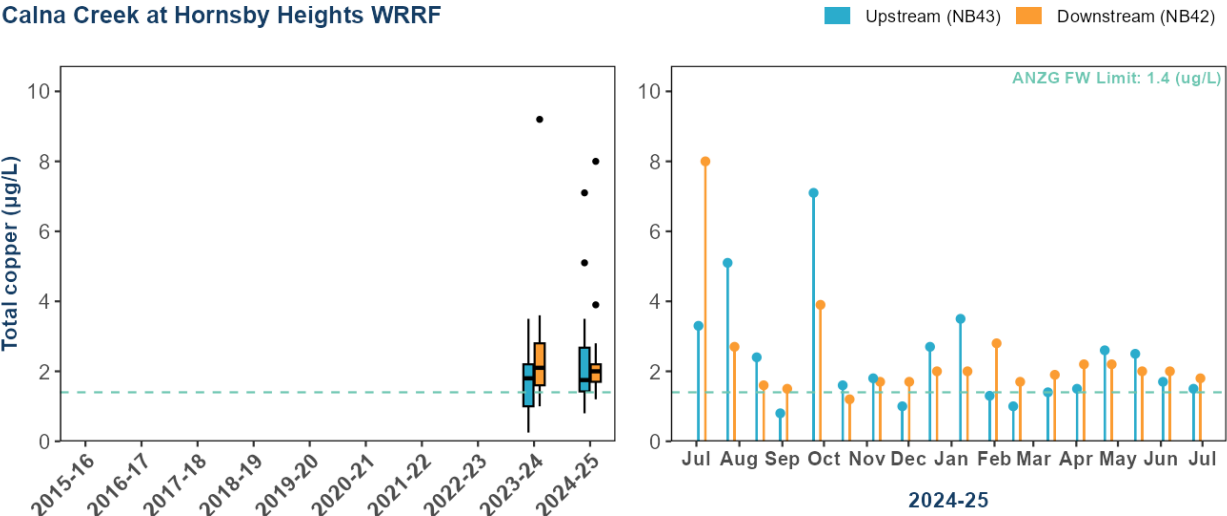
Calna Creek at Hornsby Heights WRRF



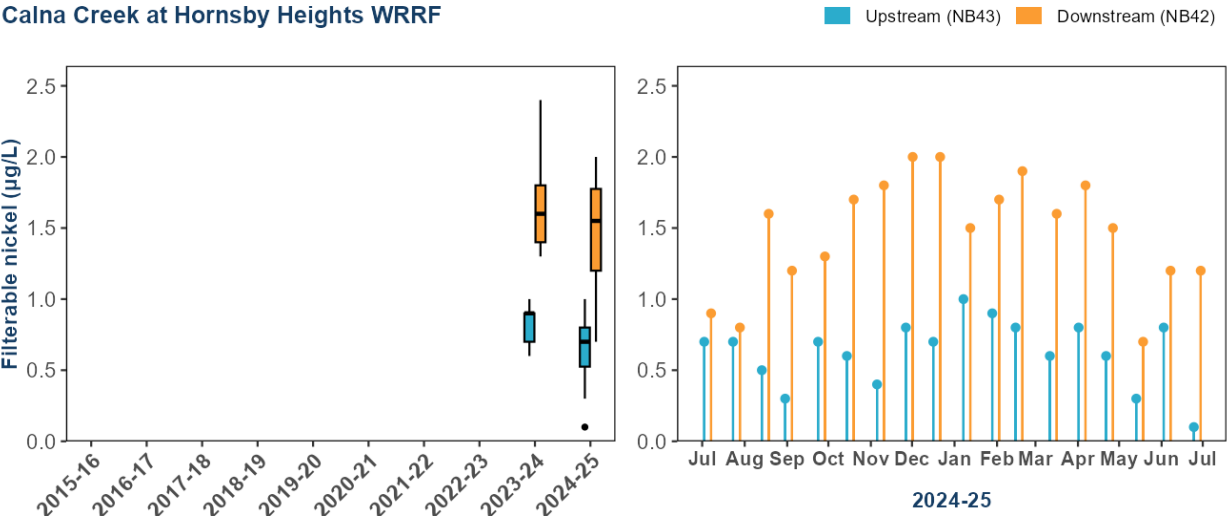
Calna Creek at Hornsby Heights WRRF



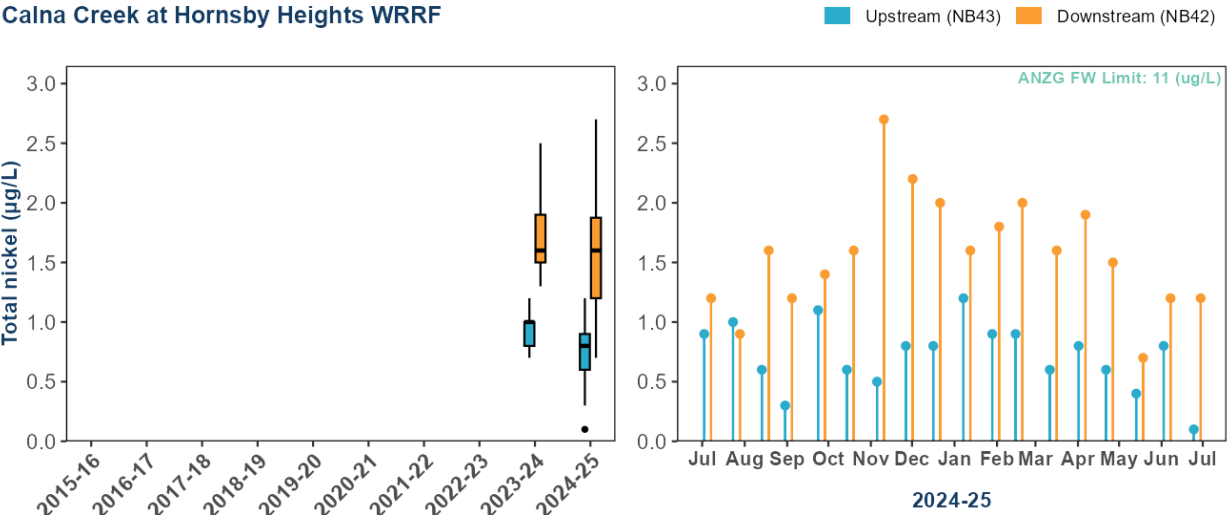
Calna Creek at Hornsby Heights WRRF



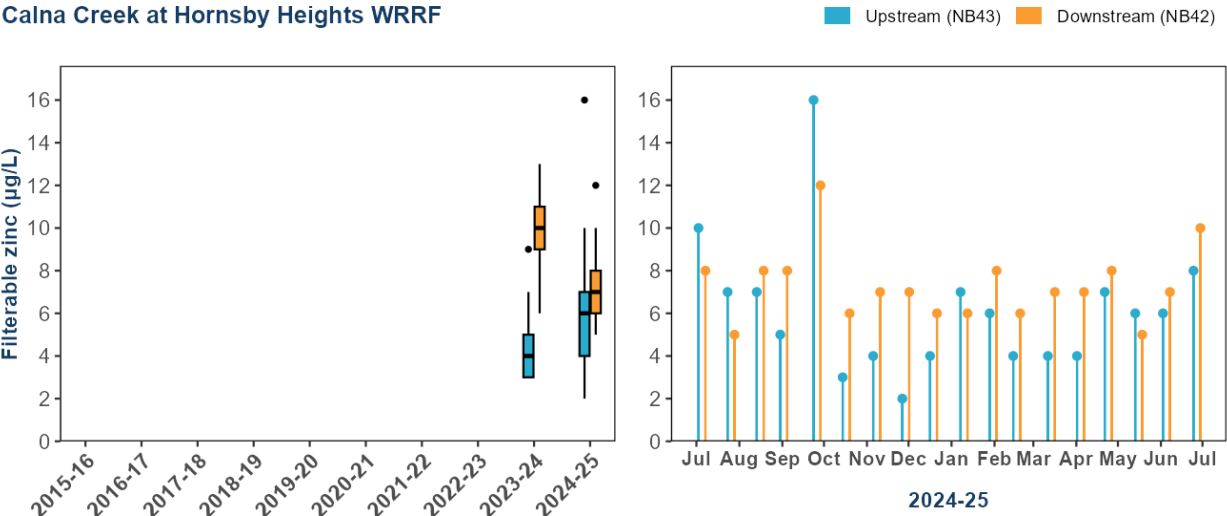
Calna Creek at Hornsby Heights WRRF



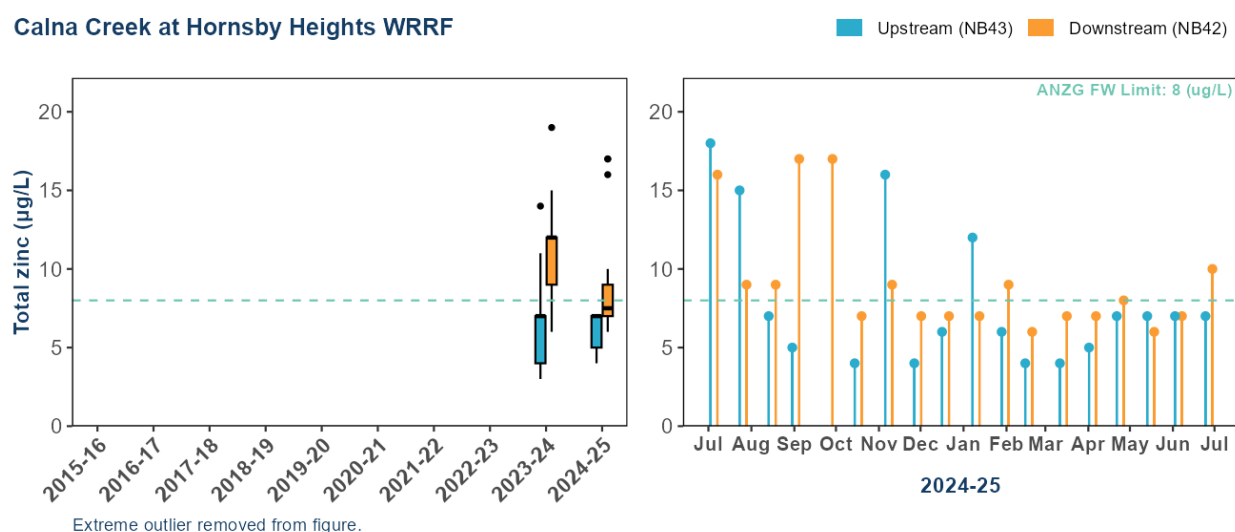
Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF



A.14.9. Ecosystem receptor – Statistical analysis outcomes

Table A-138 Upstream vs downstream comparison (current period) for Calna Creek at Hornsby Heights WRRF

Calna Creek at Hornsby Heights WRRF: NB43 vs NB42 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	0.89	0.31	159	-0.34	0.986
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-139 Upstream current period (2024-25) vs previous period comparison (single site) for Calna Creek at Hornsby Heights WRRF

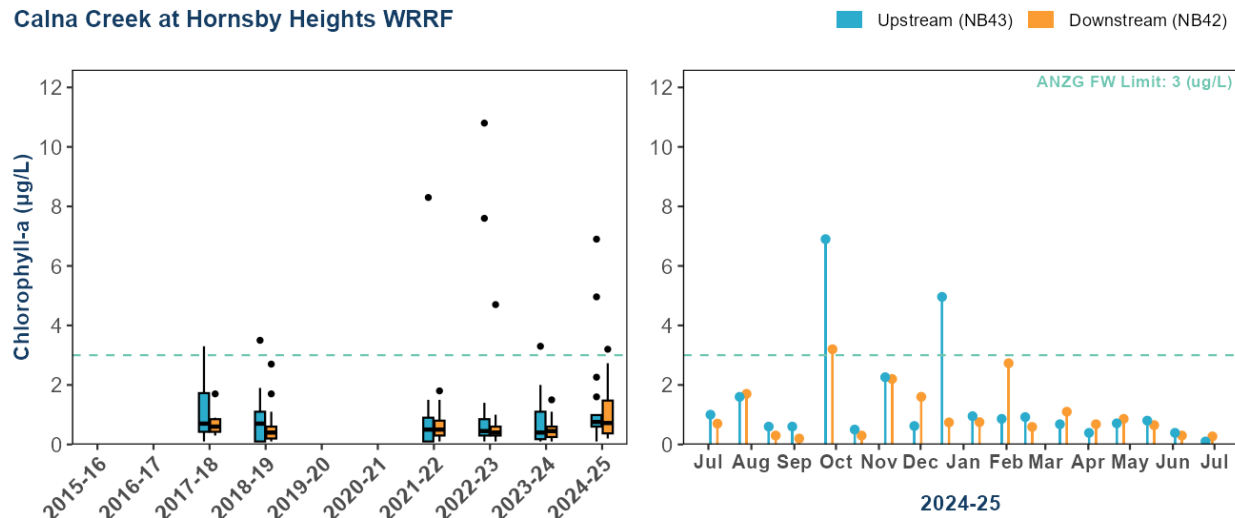
Calna Creek at Hornsby Heights WRRF: NB43 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.87	0.51	159	2.28	0.108
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

Table A-140 Downstream current period (2024-25) vs previous period comparison (single site) for Calna Creek at Hornsby Heights WRRF

Calna Creek at Hornsby Heights WRRF: NB42 (Tributary)					
Analyte	Estimate	SE	df	t-ratio	p-value
Chlorophyll-a					
Chlorophyll-a	1.79	0.49	159	2.11	0.154
not significant (p>0.05) p <0.05 and >=0.01 p <0.01 and >=0.001 p <0.001					

A.14.10. Ecosystem receptor – Phytoplankton

Calna Creek at Hornsby Heights WRRF

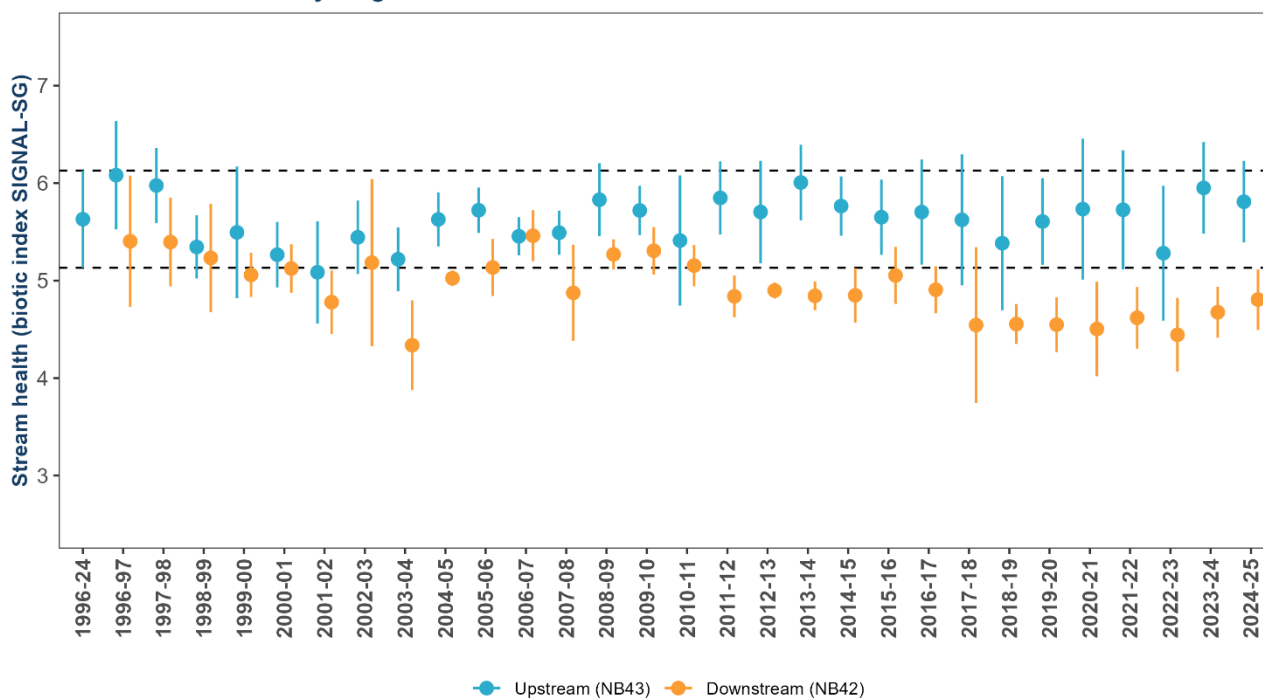


A.14.11. Ecosystem receptor – Macroinvertebrates

Waterway	Paired comparison (upstream vs downstream)	Method	Estimate	Statistic	DF	P value
Calna Creek	River (NB43 vs NB42)	Welch Two Sample t-test	1.00	4.71	9.24	0.001

not significant ($p > 0.05$)	$p < 0.05$ and ≥ 0.01	$p < 0.01$ and ≥ 0.001	$p < 0.001$
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Calna Creek at Hornsby Heights WRRF



The range of stream health recorded over each period is represented by length of line

A.14.12. Gate 3 investigation for Hornsby Heights WRRF

The gate 2 synthesis identified a downstream impact to macroinvertebrates as an indicator of ecosystem health. Most nutrient and physico-chemical water quality parameters were significantly higher at the downstream Calna Creek site (NB42), which differed from the stable conditions found in the Hornsby Heights WRRF discharge. Filterable aluminium, cobalt, and nickel were also significantly higher downstream in Calna Creek compared to the upstream site. The gate 3 analysis focused on investigating the potential influence of these parameters on the impacted stream health at the Calna Creek downstream site as indicated by the macroinvertebrate biotic index (SIGNAL-SG) scores.

Stage 1: Multivariate analysis of macroinvertebrate community data

Both edge and riffle habitats were collected consistently at upstream-downstream sites on the same sampling occasions to allow a multivariate analysis for the monitoring period of 1996 to 2025. 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 slightly interspersed pattern of upstream and downstream samples was observed (Figure A-25). 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-27). The riffle habitat pattern displayed less overlap of upstream-downstream samples in the Calna Creek ordination plot (Figure A-26) and tree diagram (Figure A-28) compared to the edge habitat.

The PERMDISP analysis indicated a significant pattern of dispersion for the edge habitat but not the riffle habitat (Table A-141). This significant outcome for the edge habitat suggests subsequent results of ANOSIM tests are describing both the variability in taxonomic assemblage of samples over time as well as 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 (0.391) (Table A-141) and at a mid-range level for riffle (0.584) (Table A-141). 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-30) and a less distinct pattern within the edge habitat (Figure A-29). These shade plots also show the riffle habitat has a smaller set of taxa (113) compared with the more diverse edge habitat (147) taxa. The BVSTEP routine was used to find a subset of taxa whose multivariate pattern matched that of the full dataset with 41 taxa identified for the riffle habitat and 37 taxa for the edge habitat (Table A-144). These subsets of taxa reflect those taxa which formed the main visual patterns in the respective shade plots.

To further explore taxonomic assemblage, 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 2025 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-141) 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 (0.358) for the edge habitat. Under subsequent upstream-



downstream pairwise comparisons, the test between historical upstream and current downstream returned an R-value at a level ($R = 0.758$) 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 (0.521) was returned for the riffle habitat and the current year upstream and downstream pairwise comparison returned an R-value of 0.969 which was at a level that implied more than natural substratum differences between sites. Pairwise comparisons from the riffle habitat 'Site-period' ANOSIM (Table A-142) suggests that the recent period (2024-25) 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 taxonomic assemblage suggested by SIGNAL-SG results was also evident in multivariate analysis. Both SIGNAL-SG and multivariate results suggest downstream taxonomic assemblage in Calna Creek has been consistently altered by wastewater discharge from the Hornsby Heights WRRF through the 2011 to 2025 monitoring period.

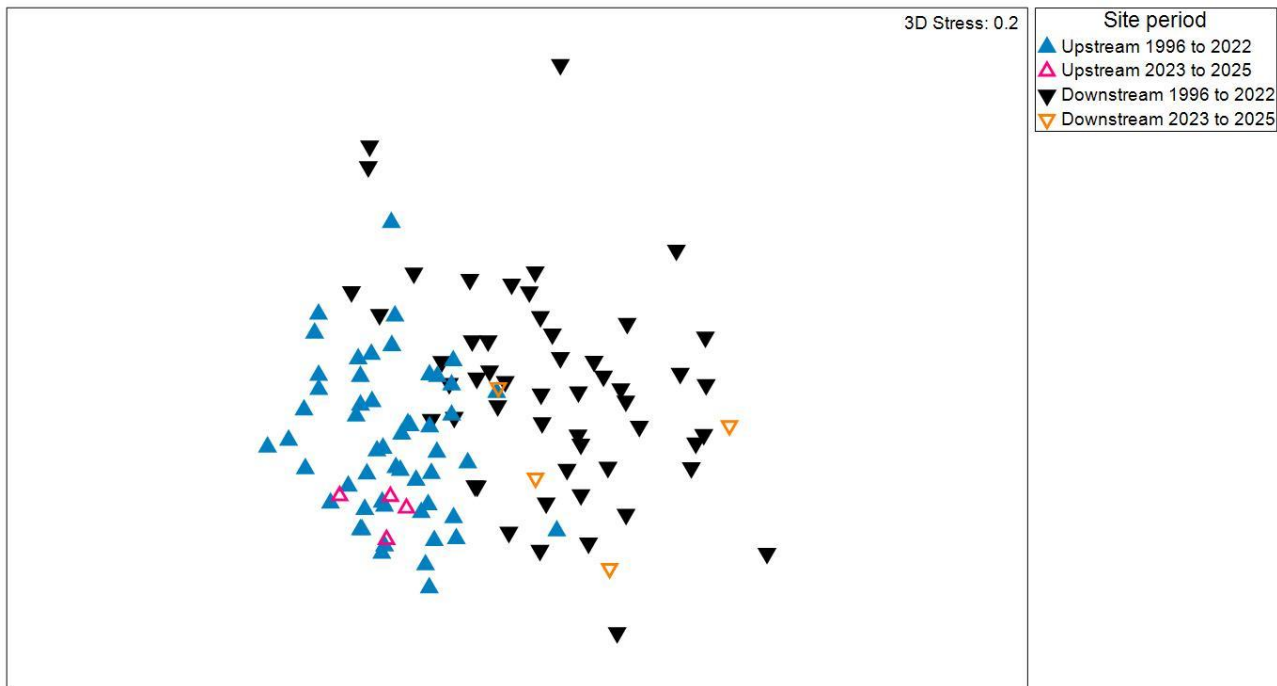


Figure A-25 Dimensions 1 and 2 of 3-dimensional ordination plot of freshwater macroinvertebrate edge habitat community structure upstream and downstream in Calna Creek near Hornsby Heights WRRF

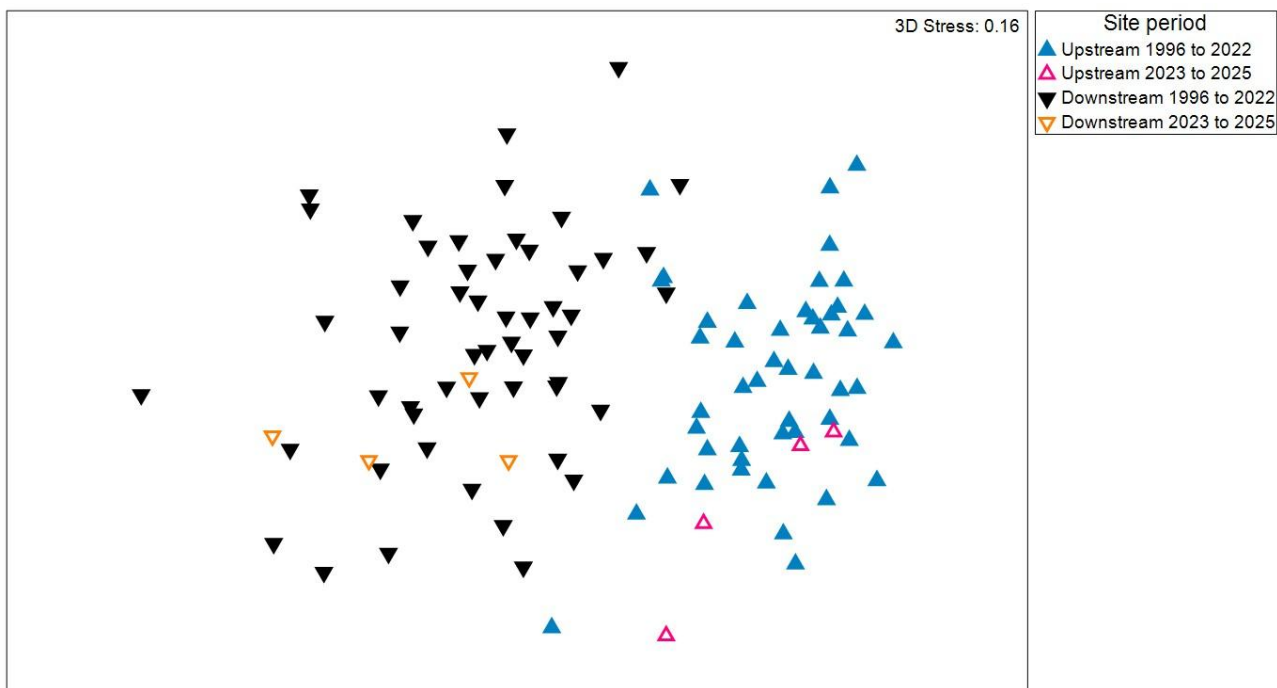


Figure A-26 Dimensions 1 and 3 of 3-dimensional ordination plot of freshwater macroinvertebrate riffle habitat community structure upstream and downstream in Calna Creek near Hornsby Heights WRRF

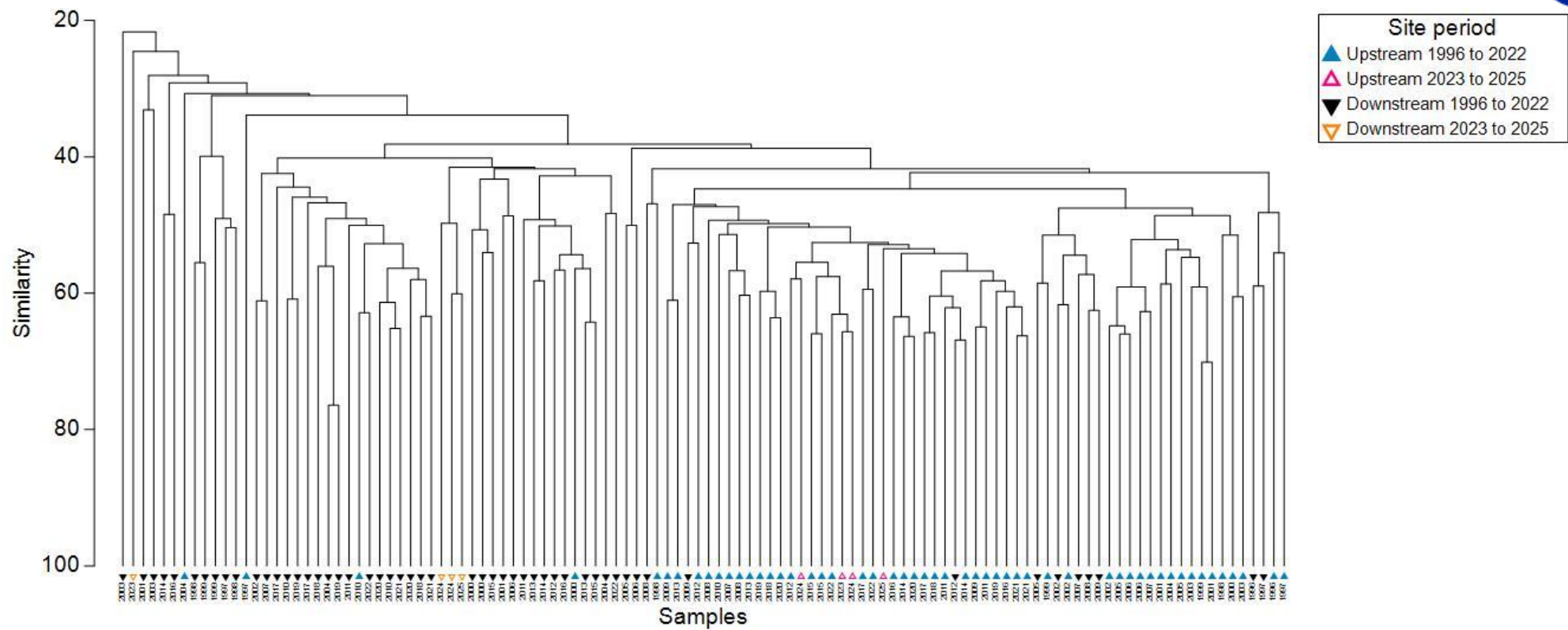


Figure A-27 Tree diagram of freshwater macroinvertebrate edge habitat community structure upstream and downstream in Calna Creek near Hornsby Heights WRRF

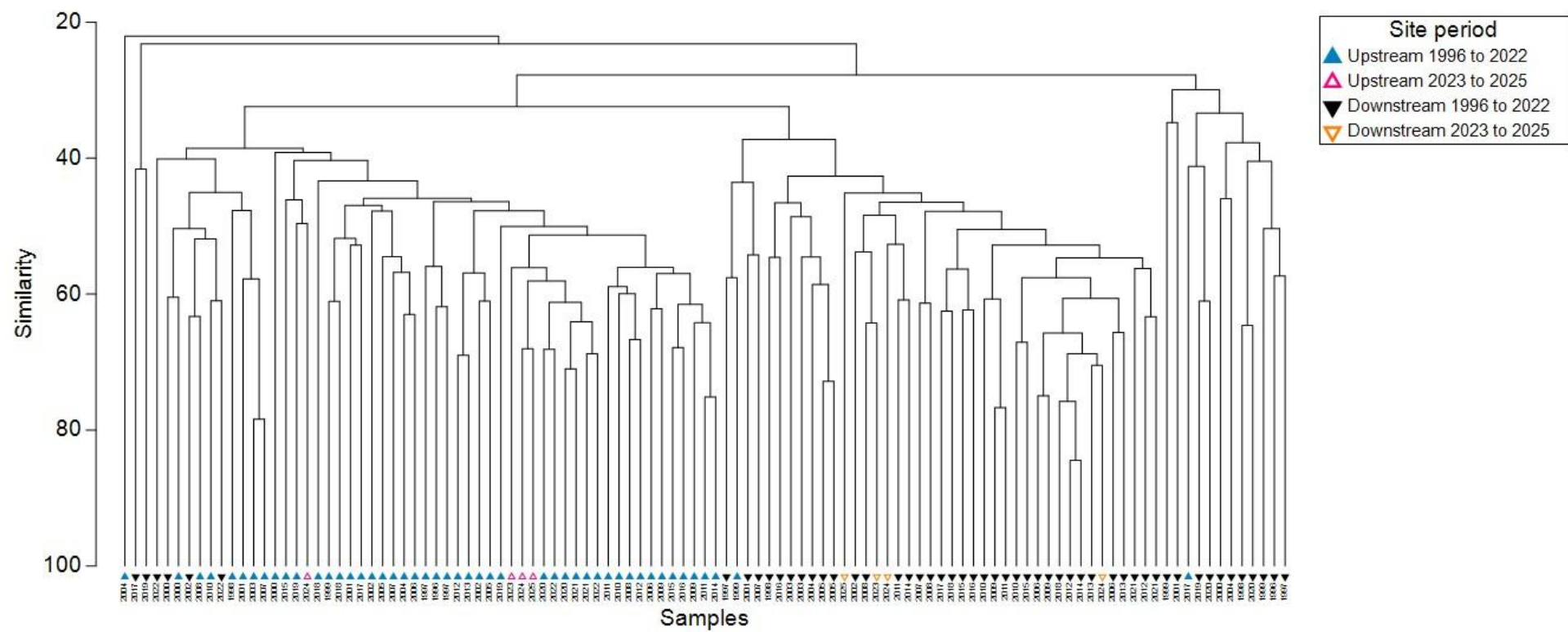


Figure A-28 Tree diagram of freshwater macroinvertebrate riffle habitat community structure upstream and downstream in Calna Creek near Hornsby Heights WRRF

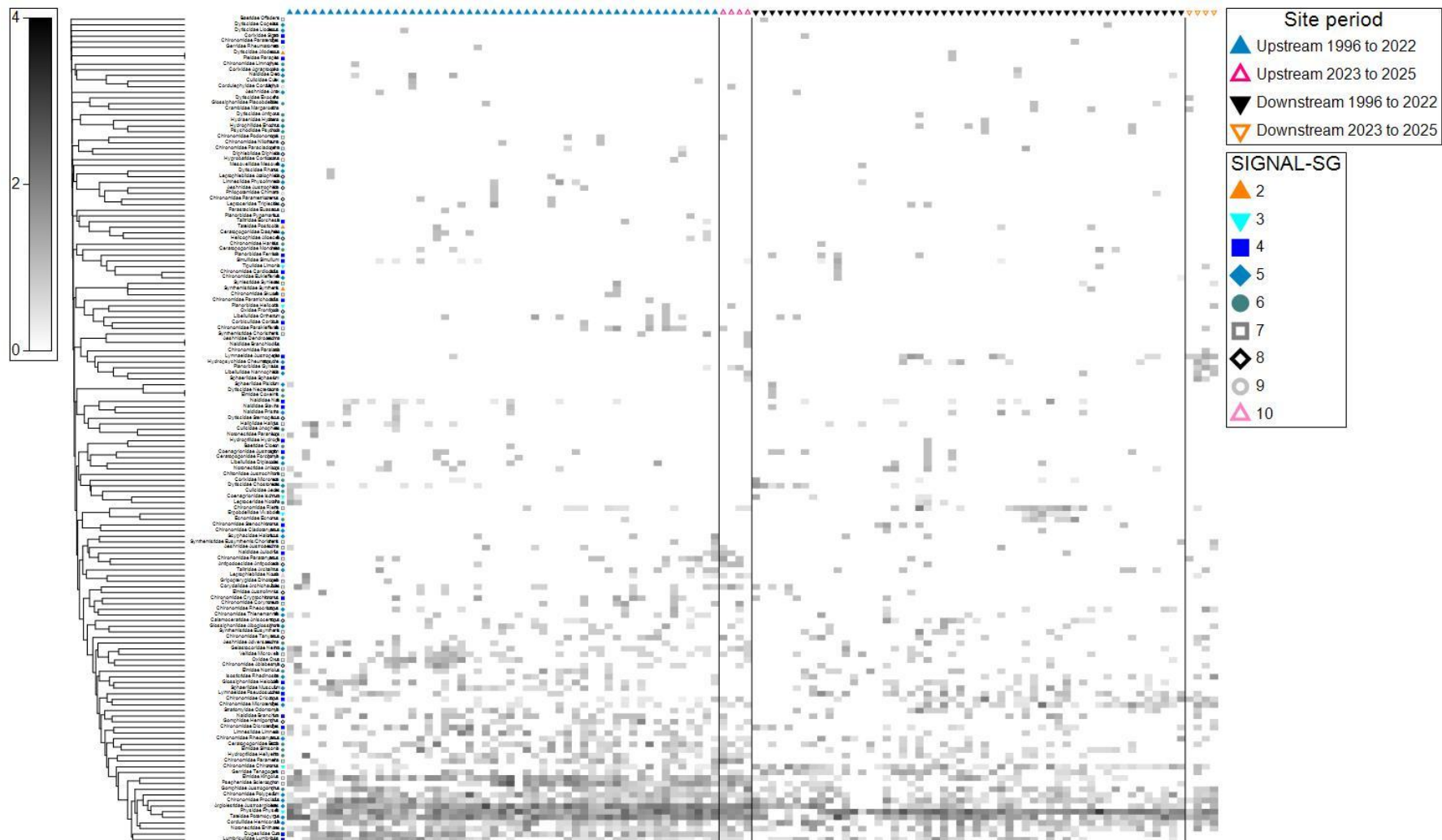


Figure A-29 Shade plot of freshwater macroinvertebrate edge habitat community structure upstream and downstream sites in Calna Creek near Hornsby Heights WRRF

Table A-141 Macroinvertebrate multivariate statistical test summary for Calna Creek near Hornsby Heights WRRF

Hornsby Heights		Edge			Riffle		
		df	Sample Statistic (Pseudo-F/R)	p-value	df	Sample Statistic (Pseudo-F/R)	p-value
PERMDISP	Site	1 (112)	32.047	<0.001	1 (107)	4.161	0.0594
ANOSIM	Site	-	0.391	<0.001	-	0.584	<0.001
	SitexPeriod	-	0.358	<0.001	-	0.521	<0.001
PERMANOVA	Site	1 (113)	15.515	<0.001	1 (108)	29.823	<0.001
	Year	29 (113)	1.543	<0.001	29 (108)	1.616	<0.001
	SitexYear	29 (113)	1.165	0.0139	29 (108)	1.305	0.0006

Table A-142 ANOSIM pairwise comparisons of 'Site period' test for edge and riffle habitats of Calna Creek near Hornsby Heights WRRF

Hornsby Heights	Edge		Riffle	
	R Statistic	p-value	R Statistic	p-value
Downstream 1996 to 2022, Upstream 1996 to 2022	0.386	<0.001	0.567	<0.001
Downstream 1996 to 2022, Downstream 2023 to 2025	0.160	0.155	-0.067	0.640
Downstream 1996 to 2022, Upstream 2023 to 2025	0.179	0.117	0.560	<0.001
Upstream 1996 to 2022, Downstream 2023 to 2025	0.758	<0.001	0.839	<0.001
Upstream 1996 to 2022, Upstream 2023 to 2025	-0.057	0.631	0.181	0.129
Downstream 2023 to 2025, Upstream 2023 to 2025	0.531	0.029	0.969	0.029

Table A-143 Estimates of components of variation from PERMANOVA tests for Calna Creek edge and riffle habitats

Hornsby Heights	Edge	Riffle
S(Site)	380.64	788.09
S(Year)	204.73	239.06
S(SitexYear)	124.54	236.42
V(Res)	1430.4	1386.4

Table A-144 Genera subset whose multivariate pattern matches full genera set of the riffle habitat of Calna Creek near Hornsby Heights WRRF

Calna Creek edge

Subset of 37 (correlation 0.951) genera from edge habitat whose pattern matches that of the full set of 147 genera identified with the same subset found on 38 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, Dugesiiidae Cura, Glossiphoniidae Helobdella, Lumbriculidae Lumbriculus, Lymnaeidae Austropeplea, Lymnaeidae Pseudosuccinea, Naididae Branchiura, Argiolestidae Austroargiolestes, Chironomidae Microtendipes, Chironomidae Polypedilum, Chironomidae Procladius, Chironomidae Rheotanytarsus, Corduliidae Hemicordulia, Gelastocoridae Nerthra, Talitridae Arcitalitrus, Tateidae Potamopyrgus, Ceratopogonidae Bezzia, 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

Calna Creek riffle

Subset of 41 (correlation 0.929) genera from riffle habitat whose pattern matches that of the full set of 113 genera identified with the same subset found on 5 runs from 50 random start runs. Each run was based on three randomly selected genera. Genera were:

Austroaeschna, Chironomidae Parakiefferiella, Chironomidae Paratanytarsus, Corydalidae Archichauliodes, Elmidae Kingolus, Psephenidae Sclerocyphon, Veliidae Microvelia, Calamoceratidae Anisocentropus, Chironomidae Parametriocnemus, Chironomidae Tanytarsus, Elmidae Austrolimnius, Gomphidae Hemigomphus, Philopotamidae Chimarra, Stratiomyidae Odontomyia



Stage 2: Multivariate regression linking water quality and ecosystem receptors

Total nitrogen and oxidised nitrogen were removed from the modelled parameters as they were both found to be highly correlated with conductivity ($r > 0.9$). The modelled parameters were visually displayed in boxplots (Figure A-31) and showed increased concentrations of conductivity and pH downstream (NB42) compared to the upstream site (NB43). Ammonia nitrogen and total phosphorus had more variability in their concentrations downstream (Figure A-31). These patterns were directly reflected in the DISTLM outcomes.

Overall, the model explained a high proportion of the variation in SIGNAL-SG score (81%) and was considered sufficient in explaining the differences in macroinvertebrate stream health. The sequential tests of the model found conductivity and the omitted correlated nitrogen analytes to be the best fit predictor for macroinvertebrate SIGNAL-SG score ($AICc = -52.24$). Marginal testing also found that pH had a moderate influence on the macroinvertebrate SIGNAL-SG scores, while total phosphorus and ammonia nitrogen were found to have minor but significant contributions (Table A-145). In addition, the decrease in turbidity (Figure A-31) was found to have a minor contribution to the variation in macroinvertebrate SIGNAL-SG score between the upstream and downstream sites.

An assessment of the long-term trends of conductivity, turbidity, ammonia nitrogen, and total phosphorus indicates that the patterns observed in the modelled parameters have been consistent over the full historical record (Figure A-32). However, pH records are the exception with the elevated levels downstream being more pronounced since 2017-18 (Figure A-32).

Calna Creek at Hornsby Heights WRRF (2018-25)

Upstream (NB43) Downstream (NB42)

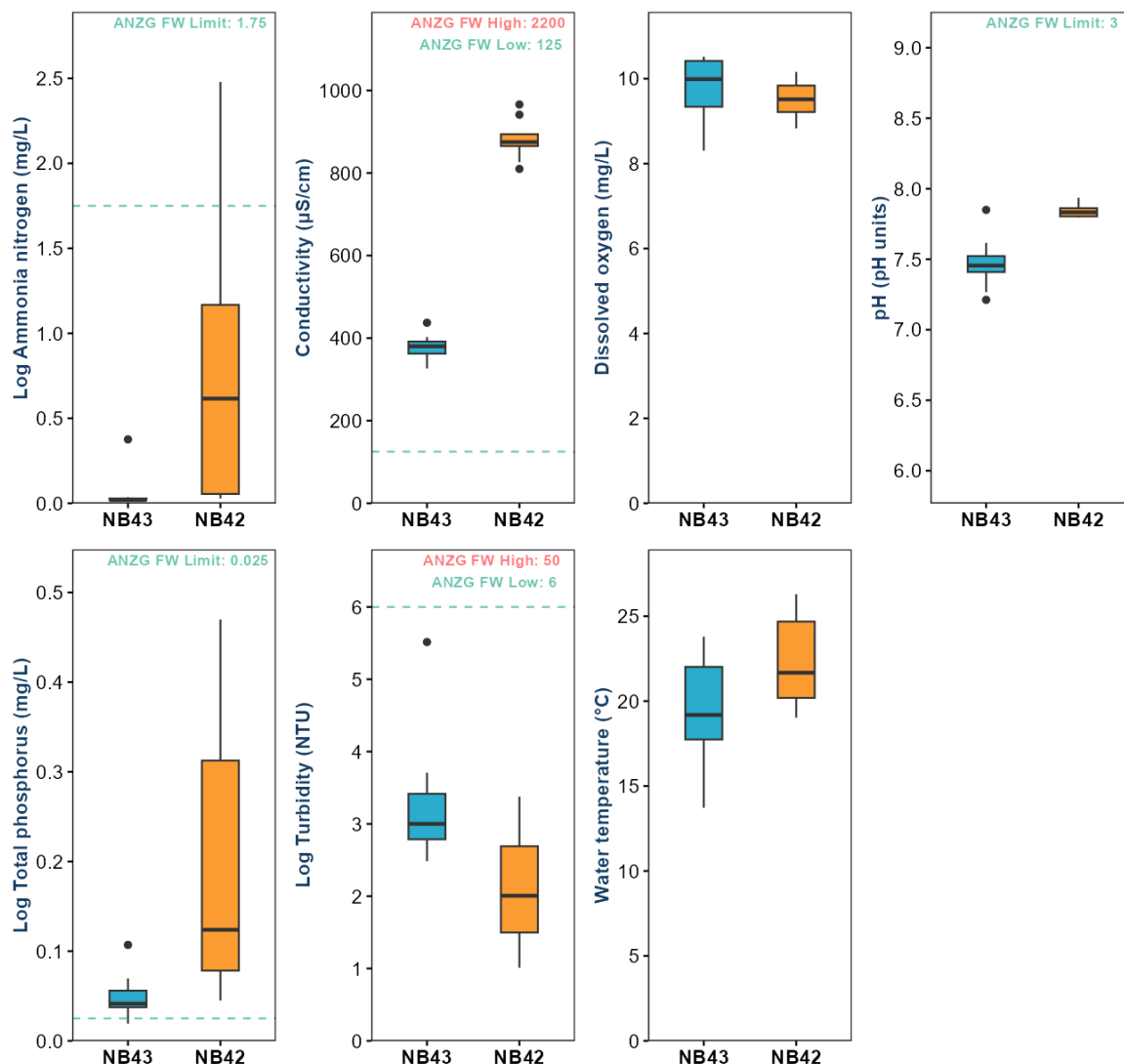
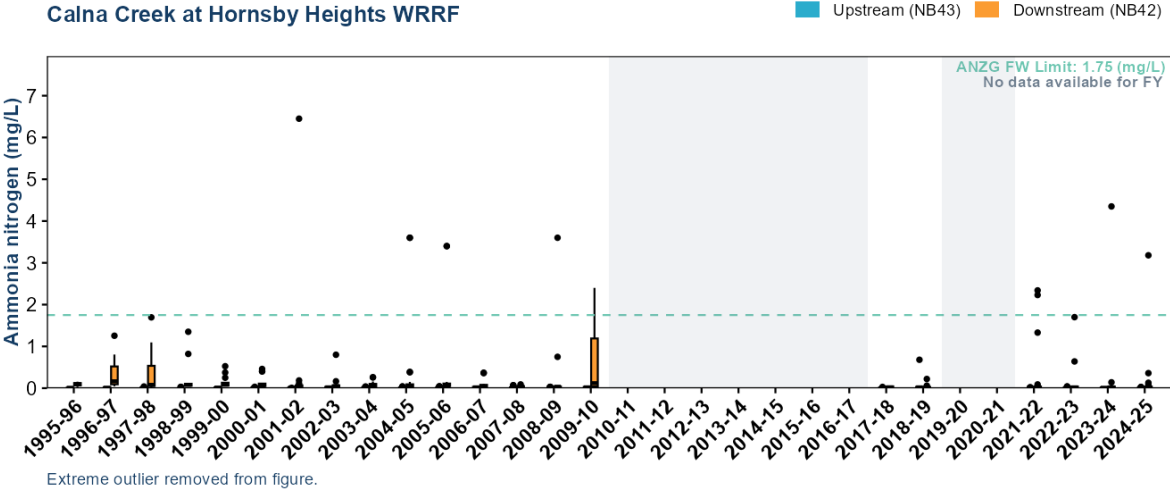


Figure A-31 Boxplots of the modelled parameters from 2018 to 2025 for the sites upstream and downstream of Hornsby Heights WRRF in the Calna Creek

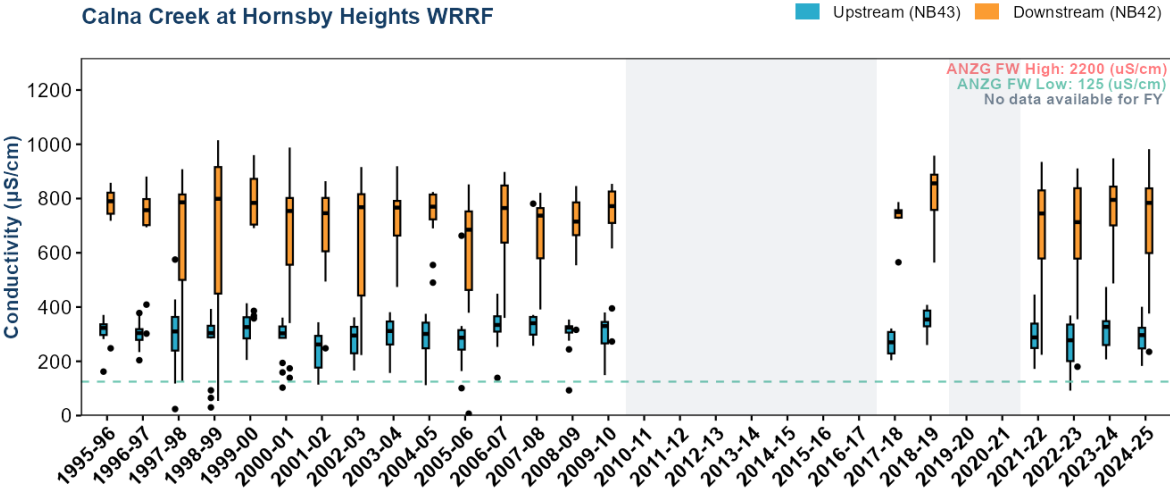
Table A-145 Results from the marginal tests of the DISTLM for Calna Creek. Parameters are listed in order of their contribution in explaining variation in the SIGNAL-SG score (% Variation). * Represents a log(x+1) transformation; ns = non-significant

Calna Creek at Hornsby Heights WRRF (2018-25)				
Modelled Parameters	SS	Pseudo-F	p	% Variation
Conductivity	5.06	78.45	0.00	81.34
pH	3.14	18.40	0.00	50.55
Turbidity *	1.81	7.42	0.01	29.18
Ammonia nitrogen *	1.71	6.83	0.01	27.51
Total phosphorus *	1.59	6.20	0.02	25.63
Water temperature	0.88	2.96	ns	14.14
Dissolved oxygen	0.28	0.85	ns	4.52

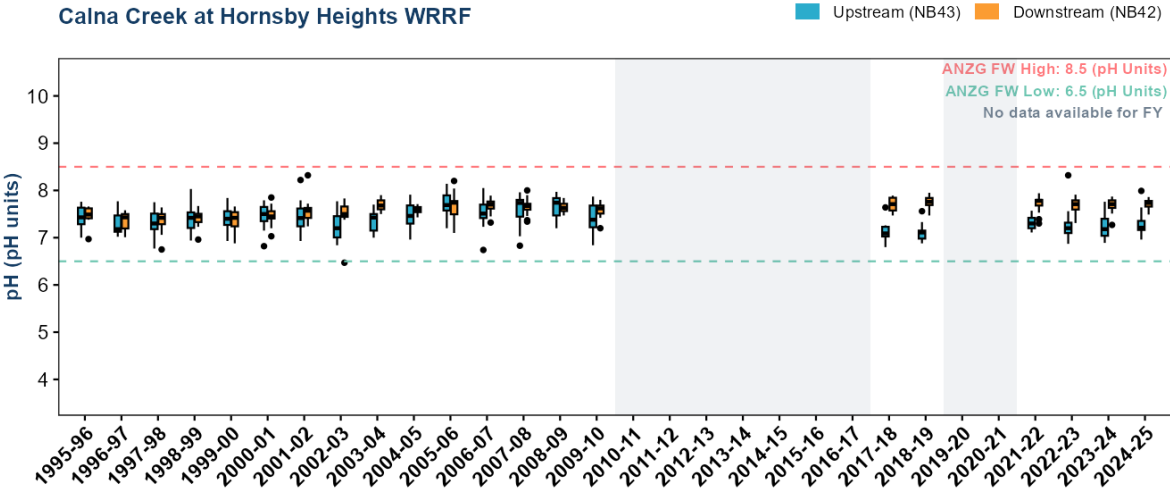
Calna Creek at Hornsby Heights WRRF



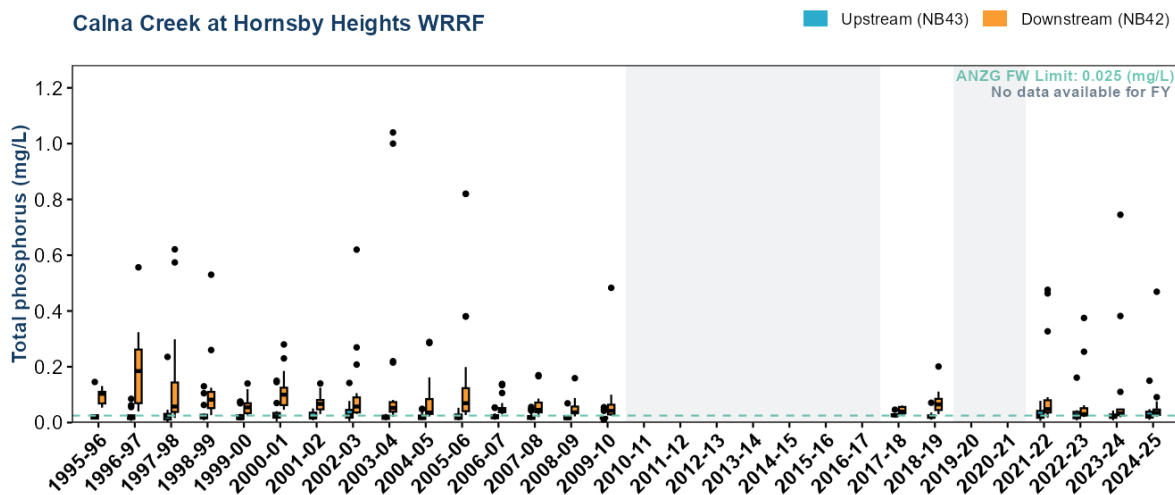
Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF

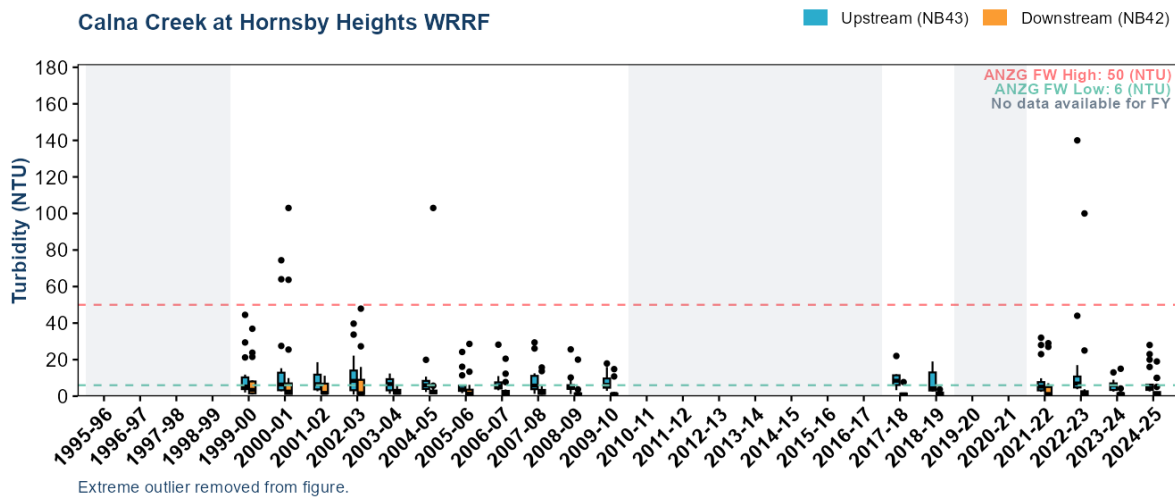
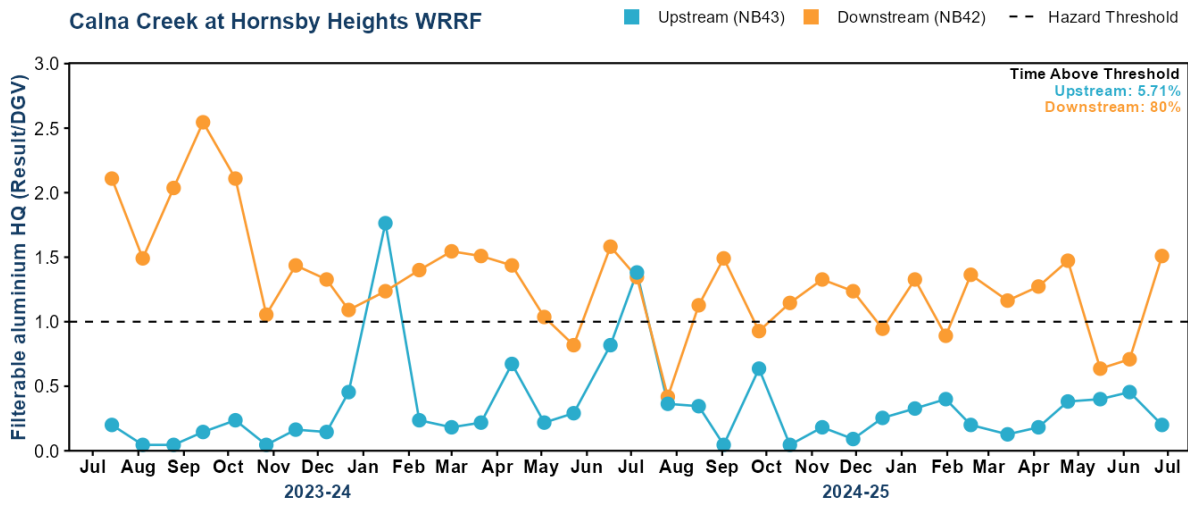


Figure A-32 Boxplots of historic and current data available for ammonia nitrogen, conductivity, pH, total phosphorus, and turbidity concentrations for the sites upstream and downstream of Hornsby Heights WRRF in Calna Creek

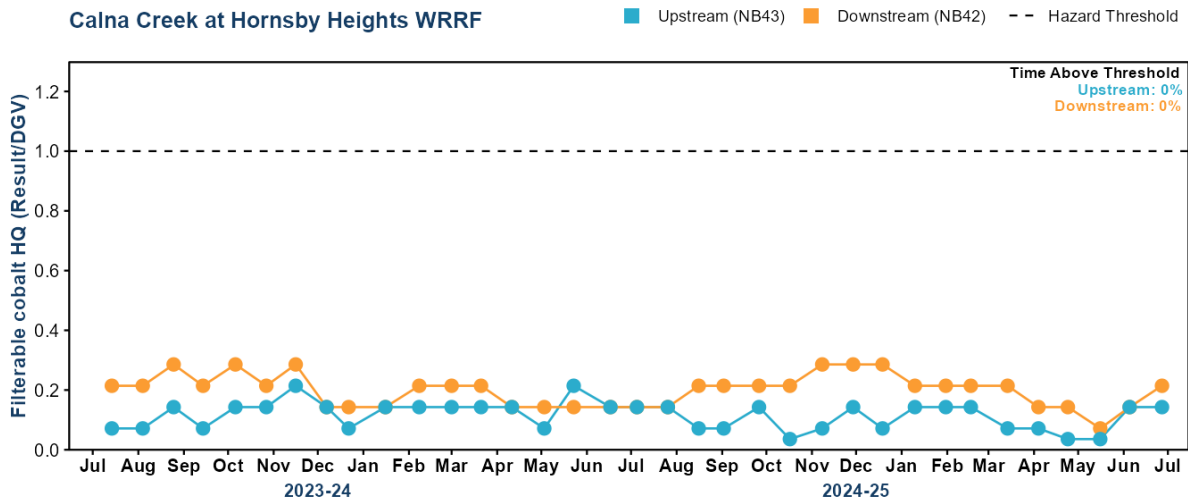
Stage 3: Hazard quotient metric to evaluate the potential risks of filterable metal exposure to organisms

Filterable cobalt and nickel hazard quotients were below the hazard quotient threshold on every sampling event in the previous two-year period at sites both upstream and downstream of the discharge from Hornsby Heights WRRF (Figure A-33). Filterable aluminium exceeded the hazard threshold more frequently downstream (80% of samples) compared to the upstream site (6% of samples; Figure A-33). Filterable copper and zinc also observed similar patterns with the downstream site exceeding hazard quotient thresholds more frequently than the upstream site (Figure A-33). Ammonia nitrogen hazard quotients exceeded the hazard quotient threshold on two occasions at the downstream site in January and July 2024, indicating a possible process issue at the Hornsby Heights WRRF (Table A-146).

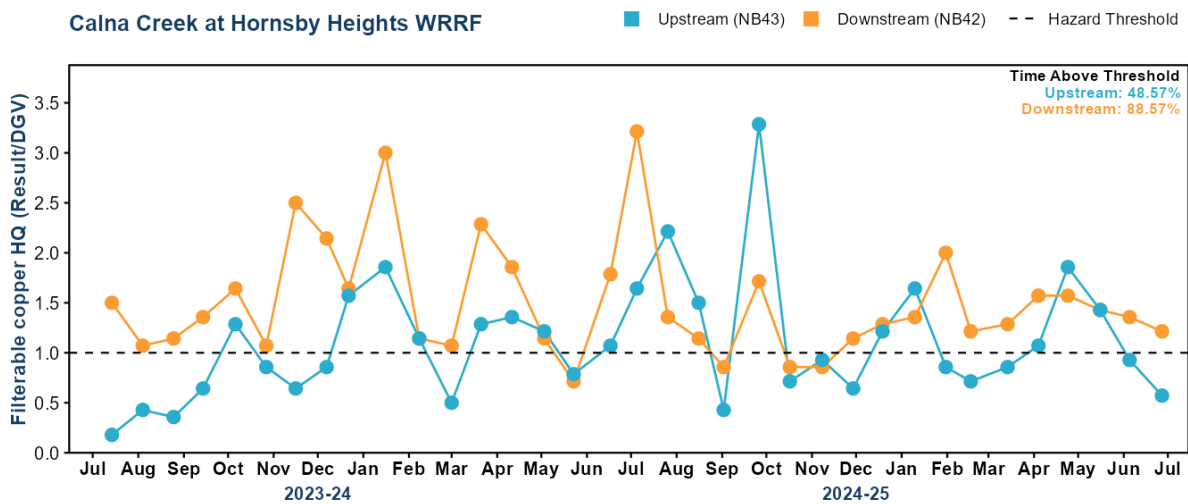
Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF



Calna Creek at Hornsby Heights WRRF



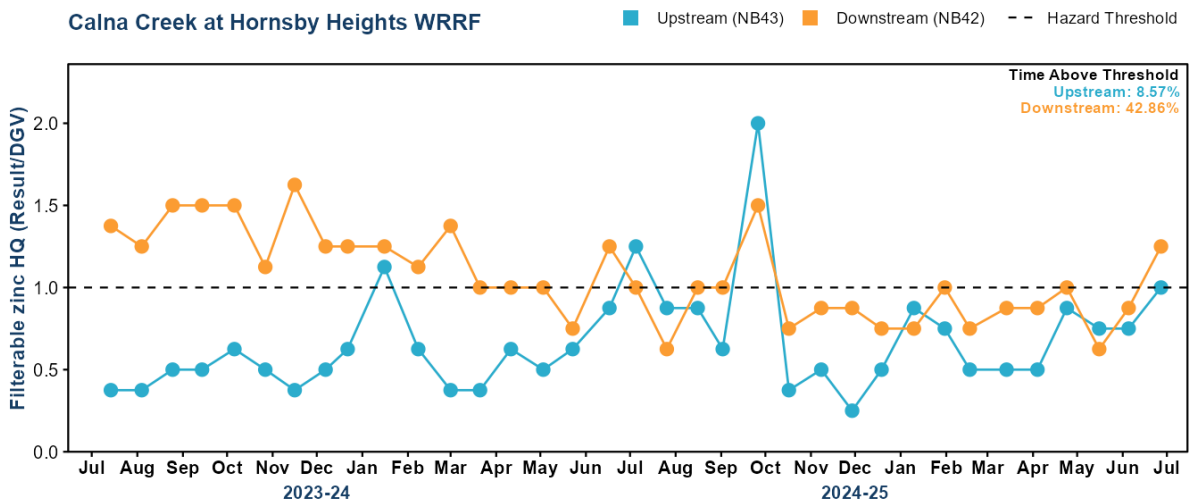
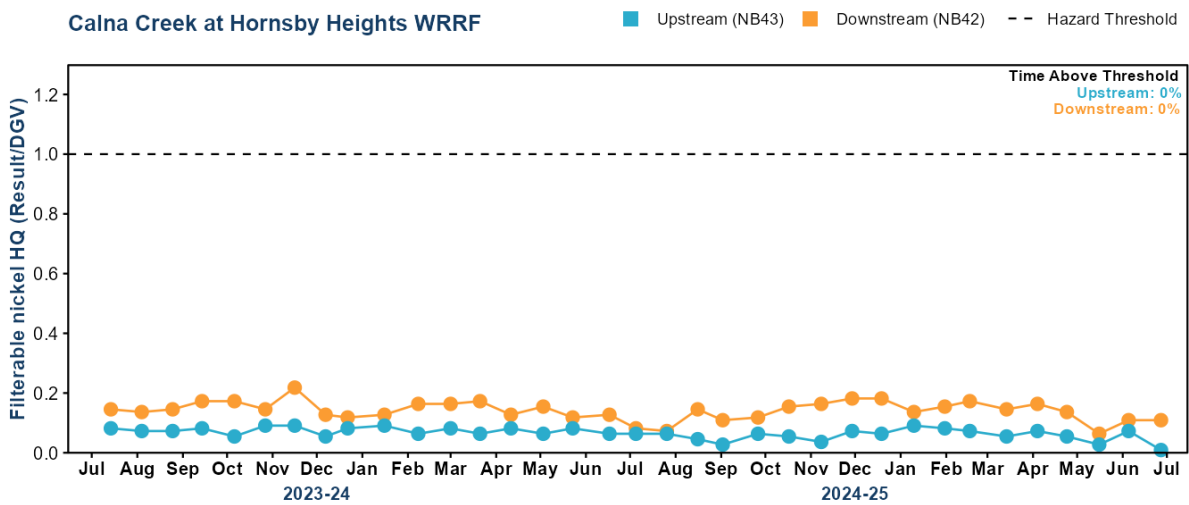


Figure A-33 Hazard quotients for filterable aluminium, cobalt, copper, nickel, and zinc concentrations between 2023 and 2025 at Calna Creek bot upstream and downstream of the discharge from Hornsby Heights WRRF

Table A-146 Hazard Quotients for metal and ammonia nitrogen concentrations between 2023 and 2025 at Calna Creek upstream and downstream of the discharge from Hornsby Heights WRRF

Calna Creek at Hornsby Heights WRRF: Hazard Quotient (Result/DGV)												
Collection date	Ammonia nitrogen		Filterable aluminium		Filterable cobalt		Filterable copper		Filterable nickel		Filterable zinc	
	NB43 (US)	NB42 (DS)	NB43 (US)	NB42 (DS)	NB43 (US)	NB42 (DS)	NB43 (US)	NB42 (DS)	NB43 (US)	NB42 (DS)	NB43 (US)	NB42 (DS)
2023-07-14	0.01	0.01	0.20	2.11	0.07	0.21	0.18	1.50	0.08	0.15	0.38	1.38
2023-08-04	0.01	0.04	0.05	1.49	0.07	0.21	0.43	1.07	0.07	0.14	0.38	1.25
2023-08-25	0.00	0.01	0.05	2.04	0.14	0.29	0.36	1.14	0.07	0.15	0.50	1.50
2023-09-14	0.01	0.01	0.15	2.55	0.07	0.21	0.64	1.36	0.08	0.17	0.50	1.50
2023-10-06	0.00	0.01	0.24	2.11	0.14	0.29	1.29	1.64	0.05	0.17	0.62	1.50
2023-10-27	0.00	0.03	0.05	1.05	0.14	0.21	0.86	1.07	0.09	0.15	0.50	1.12
2023-11-16	0.01	0.01	0.16	1.44	0.21	0.29	0.64	2.50	0.09	0.22	0.38	1.62
2023-12-07	0.01	0.01	0.15	1.33	0.14	0.14	0.86	2.14	0.05	0.13	0.50	1.25
2023-12-22	0.01	0.01	0.45	1.09	0.07	0.14	1.57	1.64	0.08	0.12	0.62	1.25
2024-01-16	0.01	2.49	1.76	1.24	0.14	0.14	1.86	3.00	0.09	0.13	1.12	1.25
2024-02-08	0.01	0.01	0.24	1.40	0.14	0.21	1.14	1.14	0.06	0.16	0.62	1.12
2024-03-01	0.01	0.01	0.18	1.55	0.14	0.21	0.50	1.07	0.08	0.16	0.38	1.38
2024-03-21	0.01	0.01	0.22	1.51	0.14	0.21	1.29	2.29	0.06	0.17	0.38	1.00
2024-04-11	0.01	0.02	0.67	1.44	0.14	0.14	1.36	1.86	0.08	0.13	0.62	1.00
2024-05-03	0.01	0.02	0.22	1.04	0.07	0.14	1.21	1.14	0.06	0.15	0.50	1.00
2024-05-23	0.01	0.08	0.29	0.82	0.21	0.14	0.79	0.71	0.08	0.12	0.62	0.75
2024-06-17	0.01	0.02	0.82	1.58	0.14	0.14	1.07	1.79	0.06	0.13	0.88	1.25
2024-07-05	0.01	1.82	1.38	1.35	0.14	0.14	1.64	3.21	0.06	0.08	1.25	1.00
2024-07-26	0.01	0.07	0.36	0.42	0.14	0.14	2.21	1.36	0.06	0.07	0.88	0.62
2024-08-16	0.00	0.02	0.35	1.13	0.07	0.21	1.50	1.14	0.05	0.15	0.88	1.00
2024-09-02	0.00	0.02	0.05	1.49	0.07	0.21	0.43	0.86	0.03	0.11	0.62	1.00
2024-09-26	0.01	0.21	0.64	0.93	0.14	0.21	3.29	1.71	0.06	0.12	2.00	1.50
2024-10-17	0.00	0.01	0.05	1.15	0.04	0.21	0.71	0.86	0.05	0.15	0.38	0.75
2024-11-08	0.00	0.01	0.18	1.33	0.07	0.29	0.93	0.86	0.04	0.16	0.50	0.88
2024-11-29	0.01	0.01	0.09	1.24	0.14	0.29	0.64	1.14	0.07	0.18	0.25	0.88
2024-12-19	0.01	0.01	0.25	0.95	0.07	0.29	1.21	1.29	0.06	0.18	0.50	0.75
2025-01-10	0.01	0.02	0.33	1.33	0.14	0.21	1.64	1.36	0.09	0.14	0.88	0.75
2025-01-31	0.01	0.01	0.40	0.89	0.14	0.21	0.86	2.00	0.08	0.15	0.75	1.00
2025-02-17	0.01	0.01	0.20	1.36	0.14	0.21	0.71	1.21	0.07	0.17	0.50	0.75
2025-03-14	0.01	0.01	0.13	1.16	0.07	0.21	0.86	1.29	0.05	0.15	0.50	0.88
2025-04-04	0.00	0.01	0.18	1.27	0.07	0.14	1.07	1.57	0.07	0.16	0.50	0.88
2025-04-24	0.02	0.01	0.38	1.47	0.04	0.14	1.86	1.57	0.05	0.14	0.88	1.00
2025-05-16	0.00	0.01	0.40	0.64	0.04	0.07	1.43	1.43	0.03	0.06	0.75	0.62
2025-06-05	0.01	0.05	0.45	0.71	0.14	0.14	0.93	1.36	0.07	0.11	0.75	0.88
2025-06-27	0.00	0.01	0.20	1.51	0.14	0.21	0.57	1.21	0.01	0.11	1.00	1.25
% Above Threshold	0.00	5.71	5.71	80.00	0.00	0.00	48.57	88.57	0.00	0.00	8.57	42.86



Stage 4: Synthesis of gate 3 results and recommendation for future investigations

The multivariate analysis of macroinvertebrate community data supported the findings of the gate 2 synthesis, indicating that taxonomic assemblages within Calna Creek have been consistently altered by wastewater discharge from Hornsby Heights WRRF between 2011 and 2025. Outcomes from the DISTLM identified conductivity as a best fit predictor for this variation in macroinvertebrate biotic index (SIGNAL-SG) score. Concentrations of pH were also found to moderately contribute to the variation experienced in the waterway.

Deviations in conductivity between sites are not likely attributed to natural geological or topographical causes, as Calna Creek is not located in an area of high salinity potential (Department of Infrastructure, Planning and Natural Resources, 2002). Calna Creek is near the tidal range of the Hawkesbury estuary and experiences minor tidal influence that is localised to the confluence with Berowra Creek, particularly during extreme high tides (MHL, 2025). The macroinvertebrate taxa assessment suggested that while the upstream site supports greater diversity and abundance, both sites supported similar salt-tolerant taxa such as *Chironomidea* and *Potamopyrgus* (Rossaro & Marziali, 2004; Hoy et al., 2012). In addition, the long-term neutral to mildly alkaline pH concentrations in Calna Creek would indicate that macroinvertebrates that prefer mildly acidic water may already be absent from the waterway. Therefore, conductivity and pH are unlikely candidates to explain the adverse ecological effects observed in the macroinvertebrate indicator, and instead the highly correlated nitrogen parameters could be influencing the variation.

Total and oxidised nitrogen were both highly correlated with conductivity, which was found to be the primary contributor to variation in macroinvertebrate biotic index (SIGNAL-SG) score. In addition, ammonia nitrogen was also found to be a minimal but significant predictor of this variation. Ammonia has been reported as a toxicant of concern in wastewater treatment plant effluents (Adams et al., 2008). Several studies have also indicated that ammonia is a primary component of toxicity immediately downstream from wastewater discharge points (Davis, 1997; Environment Canada, 2007). Nitrogen parameters have been found to contribute to direct toxicity of aquatic organisms. Besley et al (2023) stated that elevated ammonia concentrations in influent to WRRFs can pose a considerable risk to downstream ecosystem health. The current data available and supporting literature indicates that elevated nitrogen parameters, in particular ammonia nitrogen, could be influencing the stream health as indicated by macroinvertebrate biotic index (SIGNAL-SG) scores.

Total phosphorus was also identified as a minimal but significant contributor to SIGNAL-SG score variation. An increase in total phosphorus concentration is often associated with algal blooms, in which chlorophyll-a is a reliable indicator. The absence of a downstream impact to chlorophyll-a noted in the gate 2 synthesis implies that total phosphorus is an unlikely influencing poor stream health in the waterway.

A literature review of metal contamination sources in domestic wastewater from households in Australia indicated that the major inputs were from lead, zinc, and copper. Inputs of zinc mainly originated from the bathroom, and the major sources of copper were linked to the plumbing and water supply (Tjadraatmadja and Diaper, 2006). Road-derived metals have also been identified as a primary source for trace metals in stormwater that can result in the contamination of receiving waters (Birch, 2024). These sources of metal contamination were further supported by Davis and Birch (2009) that showed the contaminants lead, copper and zinc were predominantly derived from



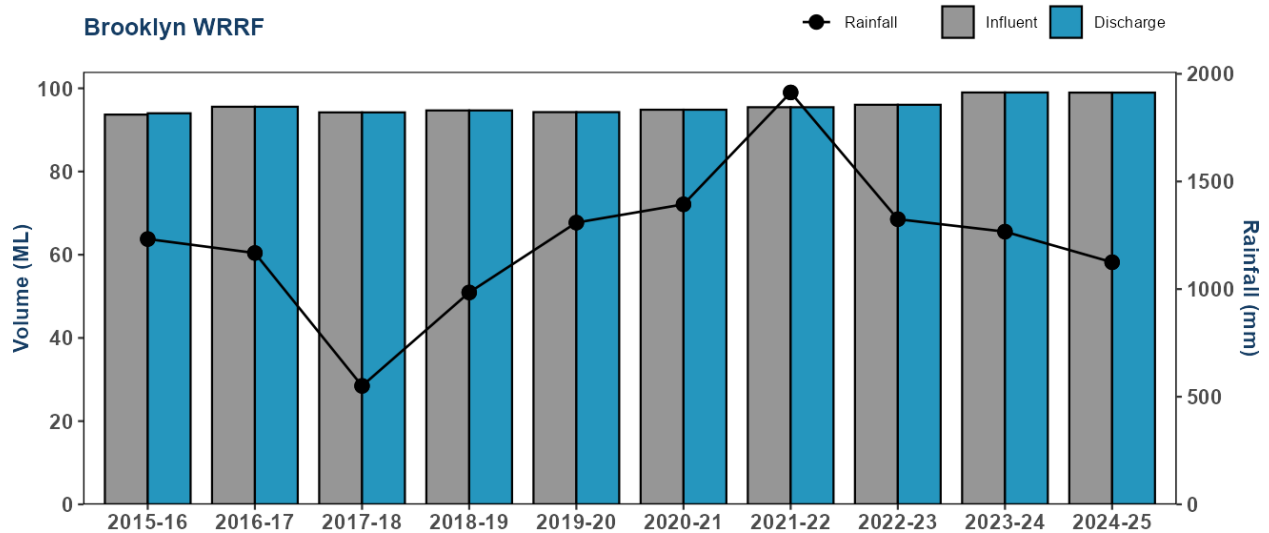
diffuse sources (residential properties and roads). Previous studies have also reported a relationship between increased trace metal contamination and both the reduction in macroinvertebrate biodiversity and changes to community structure (Iwasaki et al., 2018; Liess et al., 2017). The identification of filterable aluminium, copper, and zinc exceeding the hazard quotient threshold, combined with the supporting literature indicates that elevated filterable trace metals downstream could be impacting stream health.

The gate 3 analysis identified elevated nitrogen parameters and filterable trace metals as possibly influencing the adverse ecological impacts identified downstream. Ongoing monitoring of filterable trace metals upstream and downstream of the Hornsby Heights WRRF will enable sufficient data for inclusion in future multivariate regression investigations. Temporary installation of an instream ammonia sonde will allow for a more comprehensive understanding of the ammonia nitrogen patterns present in the waterway. It is further recommended to investigate potential impacts from trade waste discharge in the catchment.

A.15. Brooklyn WRRF

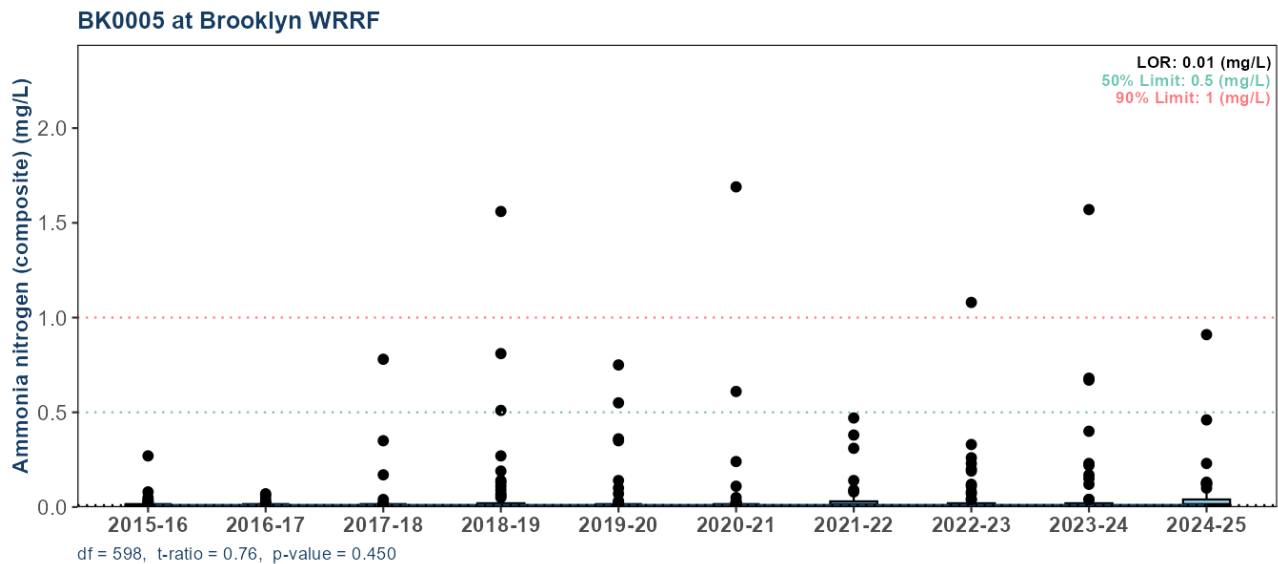
A.15.1. Pressure – Wastewater quantity

Inflow/discharge volume and rainfall

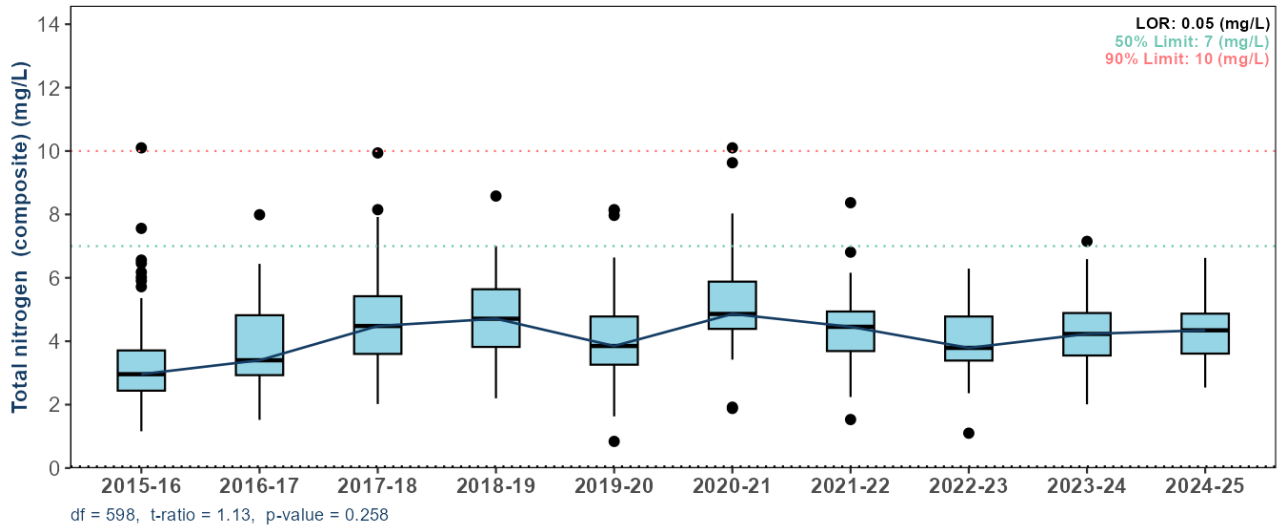


A.15.2. Pressure – Wastewater quality

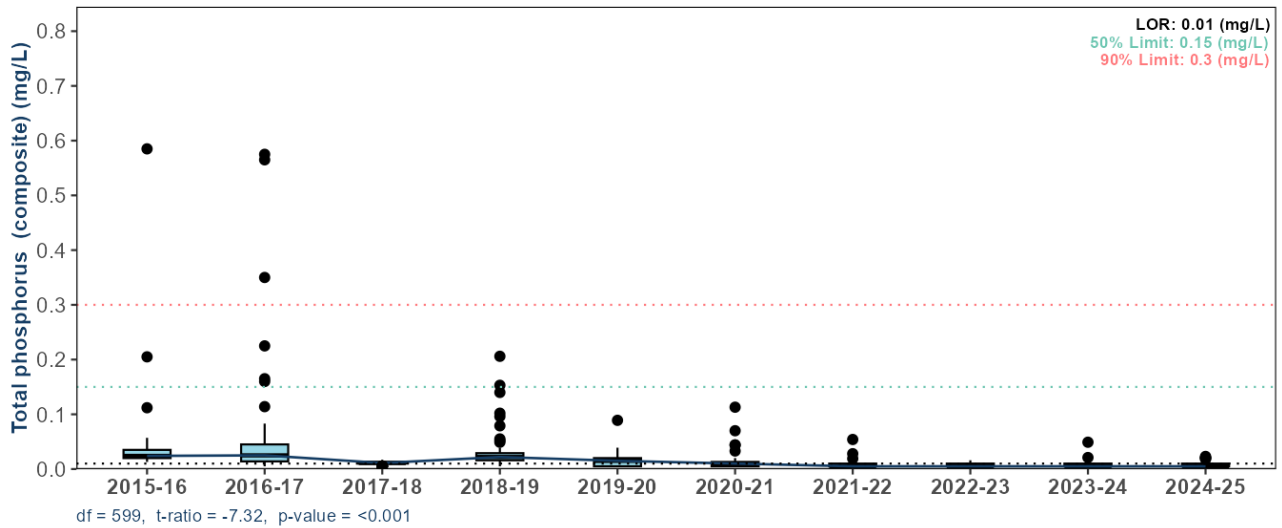
Nutrients



BK0005 at Brooklyn WRRF

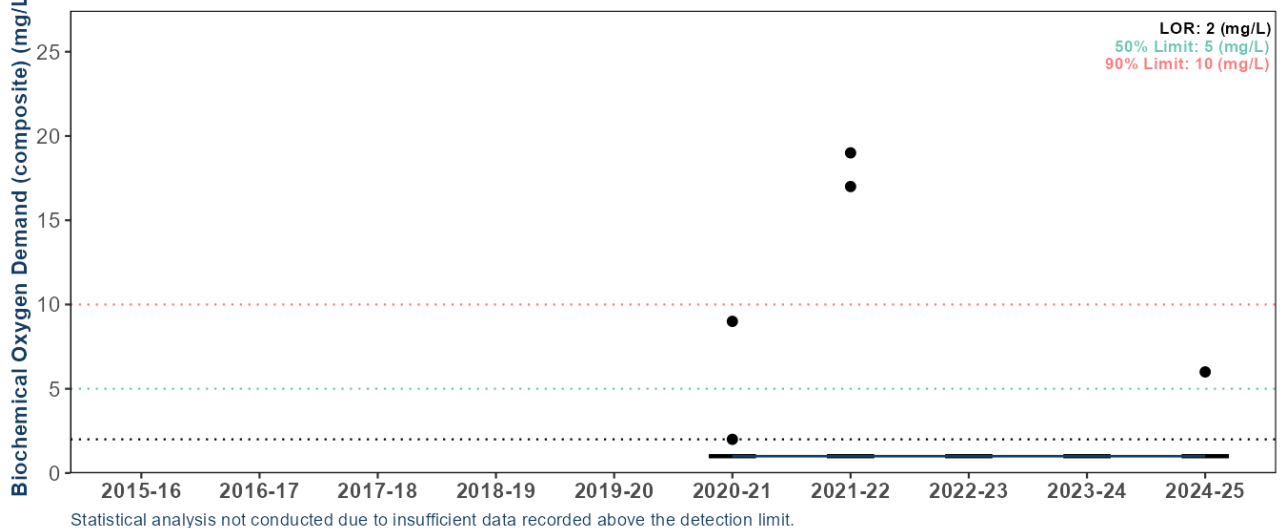


BK0005 at Brooklyn WRRF

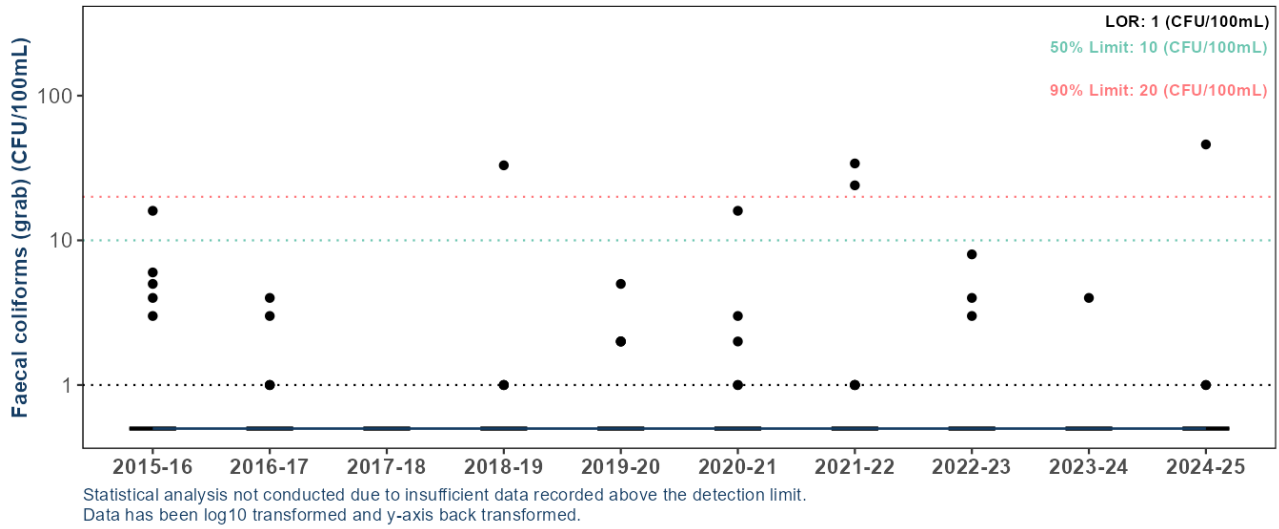


Major conventional analytes

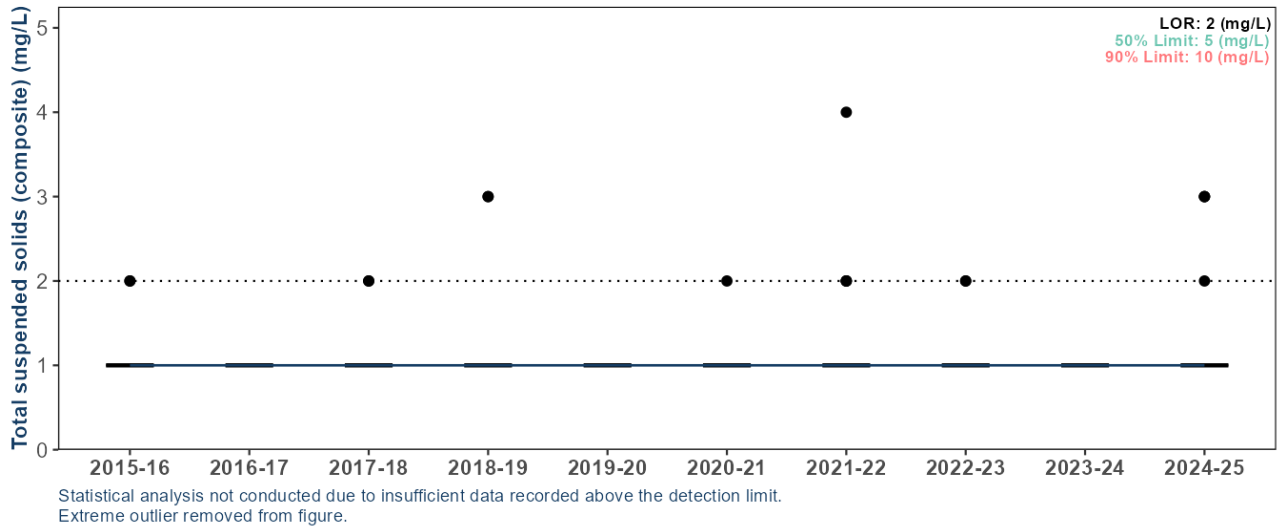
BK0005 at Brooklyn WRRF



BK0005 at Brooklyn WRRF

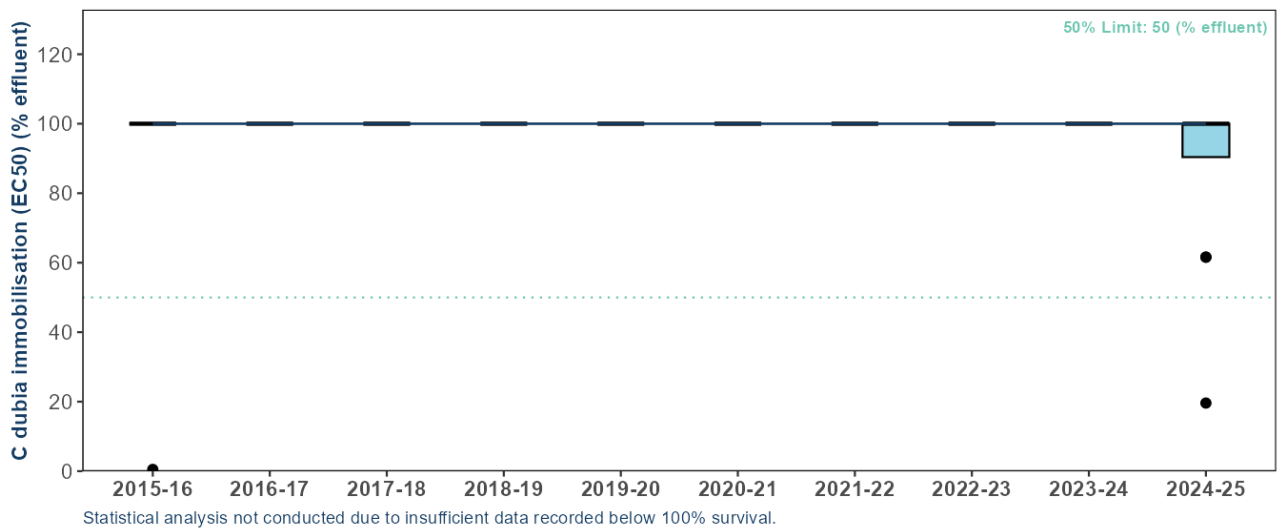


BK0005 at Brooklyn WRRF



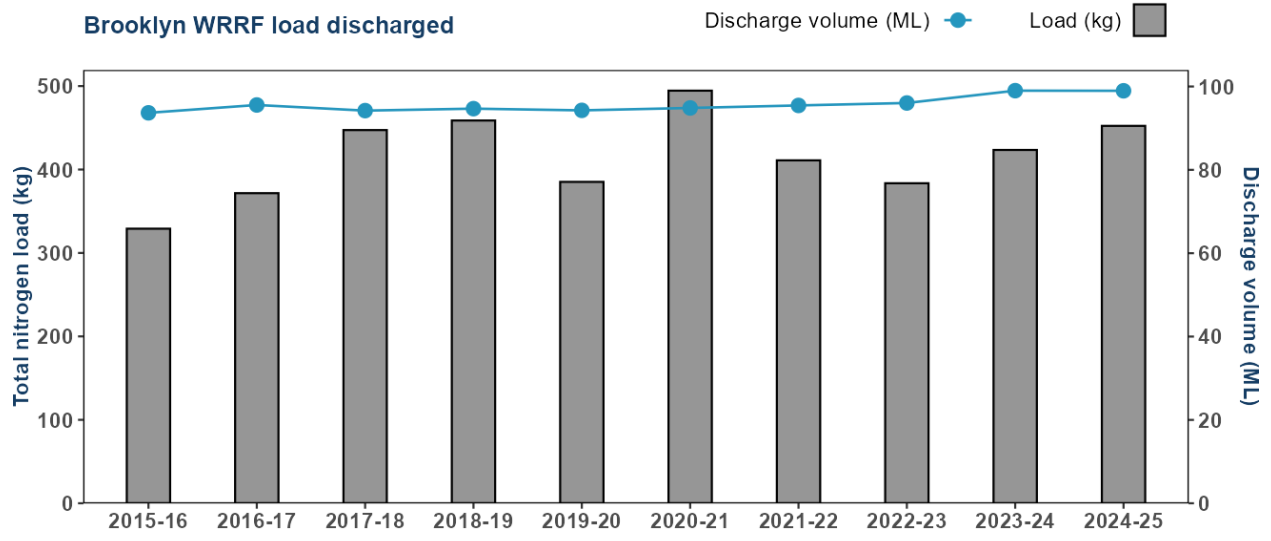
A.15.3. Pressure – Wastewater toxicity

BK0005 at Brooklyn WRRF

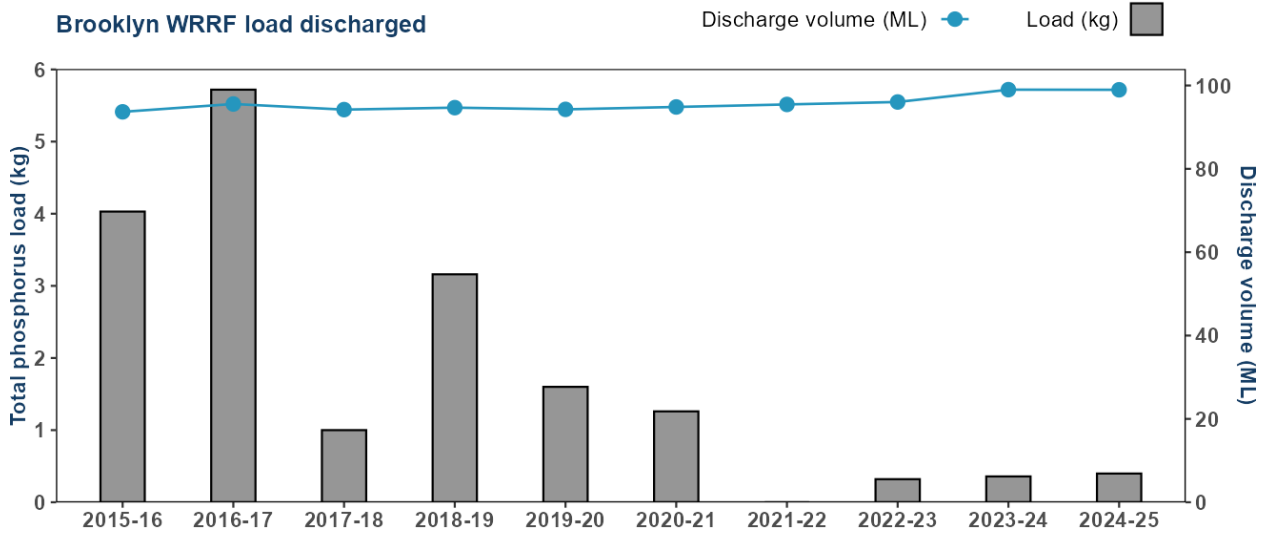


A.15.4. Pressure – Wastewater discharge load

Nutrients

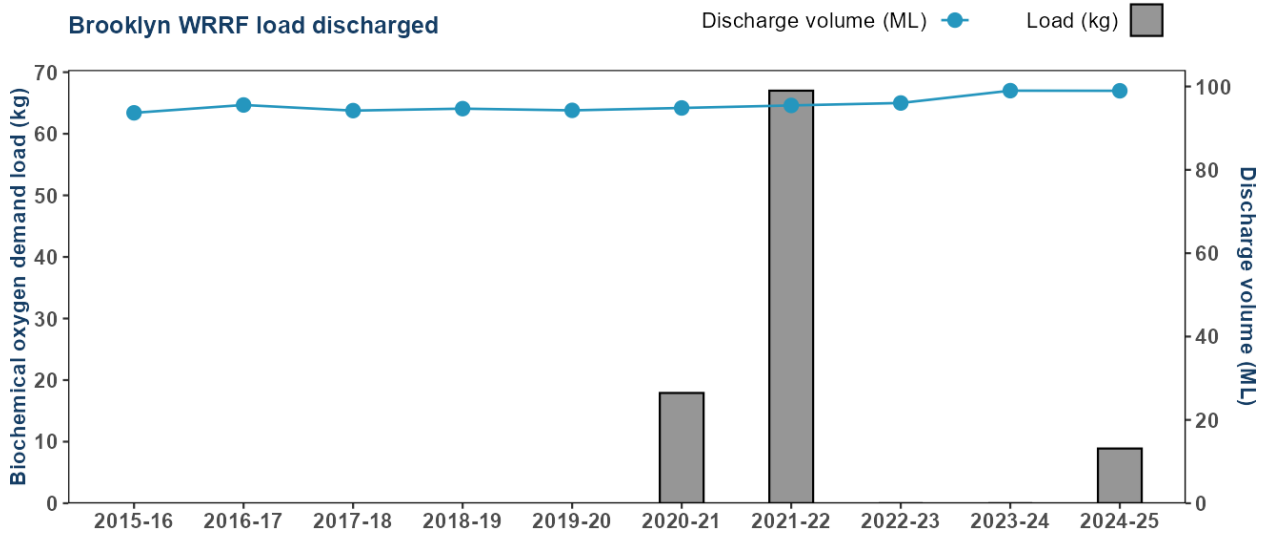


Brooklyn WRRF load discharged

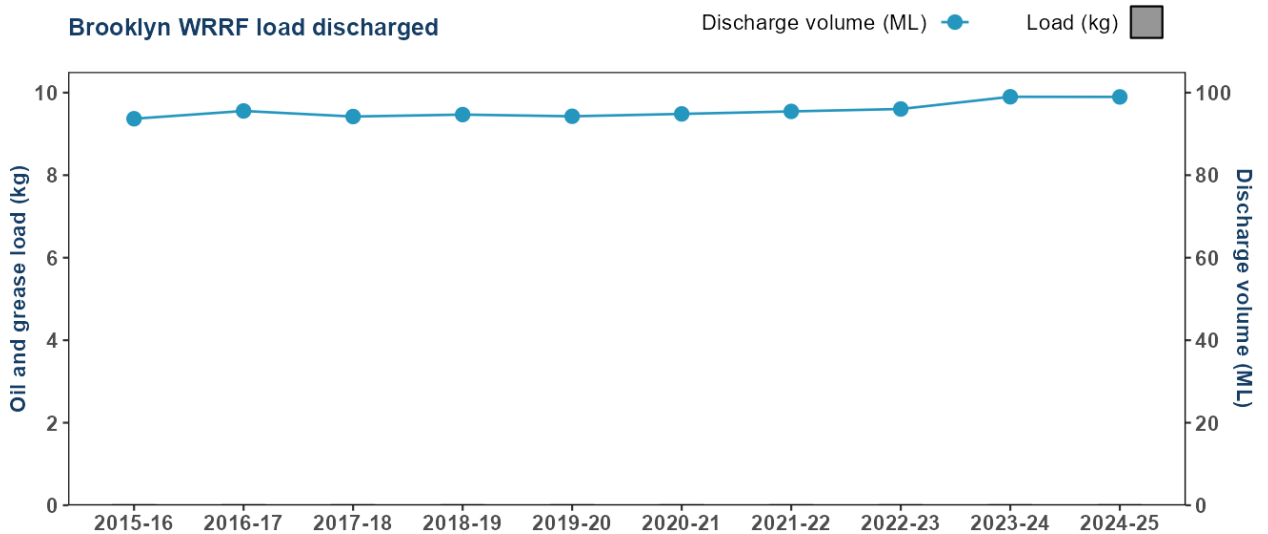


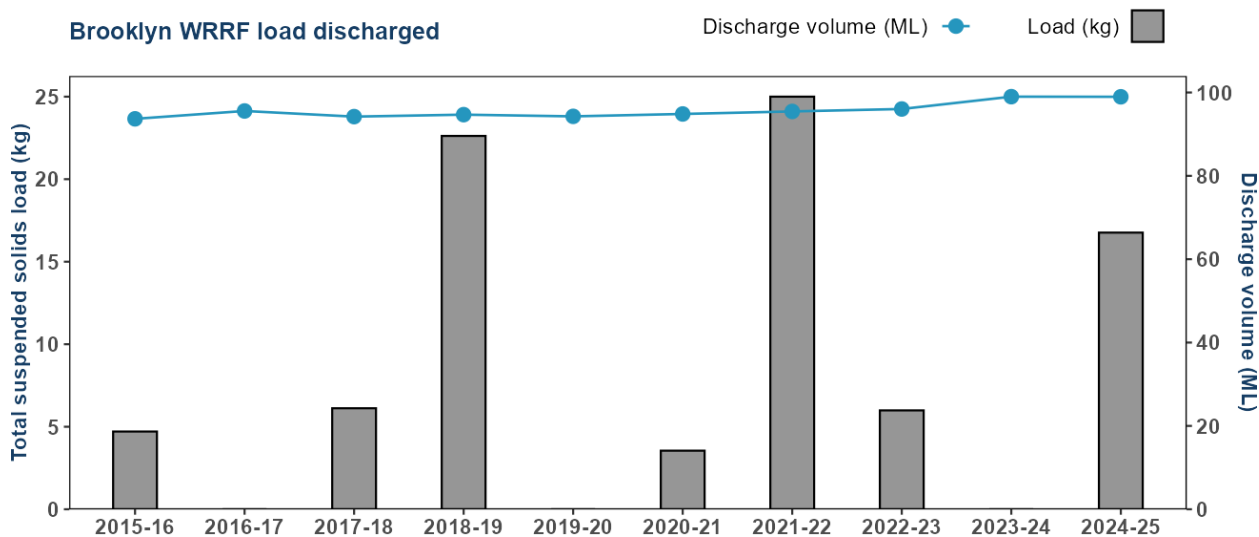
Major conventional analytes

Brooklyn WRRF load discharged



Brooklyn WRRF load discharged





A.15.5. Stressor – Nutrients

Water quality monitoring near the Brooklyn outfall is not recommended for regular monitoring in the SWAM program given treatment level (tertiary), volume discharged, receiving environment, mixing and dilution, but this decision should be regularly reviewed.

A.15.6. Stressor – Physico-chemical water quality

Water quality monitoring near the Brooklyn outfall is not recommended for regular monitoring in the SWAM program given treatment level (tertiary), volume discharged, receiving environment, mixing and dilution, but this decision should be regularly reviewed.

A.15.7. Stressor – Trace metals

Water quality monitoring near the Brooklyn outfall is not recommended for regular monitoring in the SWAM program given treatment level (tertiary), volume discharged, receiving environment, mixing and dilution, but this decision should be regularly reviewed.

A.15.8. Ecosystem receptor – Phytoplankton

Water quality monitoring near the Brooklyn outfall is not recommended for regular monitoring in the SWAM program given treatment level (tertiary), volume discharged, receiving environment, mixing and dilution, but this decision should be regularly reviewed.

A.15.9. Ecosystem receptor – Macroinvertebrates

Brooklyn WRRF lies in the Hawkesbury estuary, where freshwater macroinvertebrate monitoring is not suitable due to tidal conditions, depth and fast flows (refer to van Dam et al. 2023 for further information).

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

A.16.1. EPL concentration limits for the Hawkesbury-Nepean River WRRFs (2024-25)

WRRF	Sampling Points	Nitrogen (Ammonia)		Total Nitrogen			Total Phosphorus			Biochemical Oxygen Demand		Chlorine (Total Residual)	Faecal Coliform			pH	Total Suspended Solids		Ceriodaphnia dubia
		(mg/L)		(mg/L)			(mg/L)			(mg/L)		(mg/L)	(cfu/100mL)			(pH units)	(mg/L)		(%effluent)
		50 th %ile	90 th %ile	50 th %ile	90 th %ile	100 th %ile	50 th %ile	90 th %ile	100 th %ile	50 th %ile	90 th %ile	90 th %ile	50 th %ile	80 th %ile	90 th %ile	50 th %ile	50 th %ile	90 th %ile	50 th %ile
Picton	PI0001 (G)	0.5	1	4.5	7		0.1	0.3		2	5			200			5	10	
	PI0011 (G)	2	5	10	15		8	9		10	15			2000	10000	6.5 to 9.5	120	480	
	PI0013 (G)	0.5	1	6	10		0.2	0.4		7	10			200		6.5 to 9.5	7	15	
West Camden	WC0005: WC0015 (C,G)	0.9 ^a	1.4 ^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	WM0004 (C), (G)	0.9	1.4 ^c	3 ^c	7 ^c		0.1 ^c	0.3 ^c		10	15	0.1		200			5	10 ^c	50
North Richmond	NR0004 (C), NR0005 (G)	1.2 ^d	2.5 ^d	10	15		2	5		10	15			200			5	10	50
Richmond	RM0016 (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)	1.2 ^f	2.5 ^f	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

WRRF	Sampling Points	Aluminium		Cadmium		Chromium		Copper		Iron		Nickel		Zinc		Diazinon		Un-ionised H ₂ S		Nonylphenol ethoxylates	
		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)		(µg/L)	
		90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average	90 th %-ile	Average
Picton	PI0001 (G)																				
	PI0011 (G)																				
	PI0013 (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 (G)																				
	RM0017 (C), (G)																				
St Marys	SM0005 (C), (G)	200	120					50	25 ^a	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

a Values shown are West Camden WRRF's ammonia nitrogen limits effective from 1 June 2025. Prior to this date the temporary ammonia nitrogen 50th and 90th percentile limits effective from 1 April 2022 were 1.0 and 3.5, respectively.

b Values shown are Penrith WRRF's temporary ammonia nitrogen limits effective from 10 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's latest limits set following facility upgrades:

- Ammonia nitrogen effective 1st October 2024, prior to this date 90th limit was 5.0 mg/L.
- Total nitrogen effective 15 November 2024, prior to this date 50th and 90th limits were 10 and 15 mg/L commencing 1st October 2024, superseding 6 and 12 mg/L.
- Total phosphorus effective 15 November 2024, prior to this date 50th and 90th limits were 2.0 and 3.0 mg/L commencing 1st October 2024, superseding 50th limit of 1.5 mg/L.
- Total suspended solids effective 1st October 2024, prior to this date 90th limit was 15 mg/L.

d Values shown are North Richmond WRRF's temporary ammonia nitrogen limits effective from 28 June 2024. Prior to this date the ammonia nitrogen 50th and 90th percentile limits were 0.9 and 1.4, respectively.

e Value represents 50th percentile limit replacing the average limit.

f Values shown are Rouse Hill WRRF's temporary ammonia nitrogen limits effective from 1 January 2025. Prior to this date the ammonia nitrogen 50th and 90th percentile limits were 0.9 and 1.4, respectively.

A.16.2. EPL load limits for the Hawkesbury-Nepean River WRRFs (2024-25)

Load limits (kg)	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						

