Te Tauawa-a-Maka – Nottingham Stream Wet Weather Monitoring 2025

Prepared for

Christchurch City Council

2026

PATTLE DELAMORE PARTNERS LTD
Level 2, 134 Oxford Terrace
Christchurch Central, Christchurch 8011
PO Box 389, Christchurch 8140, New Zealand

Tel +64 3 **345 7100**
Web www.pdp.co.nz

solutions *for your environment*

Quality Control Sheet

TITLE	Te Tauawa-a-Maka - Nottingham Stream Wet Weather Monitoring 2025
CLIENT	Christchurch City Council
ISSUE DATE	30 March 2026
JOB REFERENCE	C0429880002

Revision History

REV	Date	Status/Purpose	Prepared By	Reviewed by	Approved
1.0	13/2/26	Draft for client review	Liv Hore Emma Yelavich	Tom Stephens	Jarred Arthur
2.0	30/03/26	Final	Liv Hore Emma Yelavich	Jarred Arthur	Jarred Arthur

DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE

Liv Hore & Emma Yelavich

Reviewed by

SIGNATURE

Tom Stephens

Approved by

Jarred Arthur

Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Christchurch City Council and [others (not directly contracted by PDP for the work), including Christchurch City Council Laboratory. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Christchurch City Council for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

© 2026 Pattle Delamore Partners Limited

Executive Summary

Christchurch City Council ('Council') monitors waterways across Christchurch and Banks Peninsula to meet the requirements of the Comprehensive Stormwater Network Discharge Consent (CSNDC) and its Environmental Monitoring Programme (EMP). Where water quality results have an exceedance of Attribute Target Levels (ATLs), Council is required to investigate whether stormwater discharges are contributing to these exceedances.

Pattle Delamore Partners (PDP) undertook wet weather event monitoring in the Te Tauawa-a-Maka - Nottingham Stream catchment throughout 2025. This was to assess compliance, determine whether ATL exceedances are linked to stormwater inputs, and help identify priority locations for treatment within the catchment.

Five wet-weather storm events were sampled. Sampling followed EMP storm criteria, including a minimum three-day antecedent dry period, at least 3 mm of rainfall, and collection within 1–2 hours of the target rainfall being reached. A total of eight locations were sampled including two ISCO autosampler (ISCO) sites (flow paced sampling), and six grab sites. All sites were sampled for contaminants of concern (zinc, copper, lead, conductivity, pH, turbidity and Total Suspended Solids (TSS)).

Compliance Results

Measured 95th percentile or median values were compared to EMP ATLs and metals guidelines derived from dry weather sampling at Candys Road (NS1). The following exceedances were recorded:

- Median TSS – NS5, HALS and NS1 exceeded ATL.
- Median Conductivity – NS5, HALS and NS1 exceeded ATL (Candys Road (NS1) dry weather also exceeded ATL).
- Median turbidity – All sites exceeded ATL (Candys Road (NS1) dry weather also exceeded ATL);
- 95th percentile dissolved copper – All sites exceeded ATL.
- 95th percentile dissolved zinc – All sites exceeded ATL (Candys Road (NS1) dry weather also exceeded ATL).

TSS, turbidity and conductivity levels were most elevated at the further downstream sites. Dissolved zinc decreased in a downstream direction, whilst dissolved copper was elevated at sites NS3 and NS2. The largest rainfall event occurred on 13 November 2025 and recorded the most elevated TSS and turbidity values and the lowest dissolved zinc concentrations and conductivity measurements.

Inter-event Variation and Contaminant Source Findings

To determine whether elevated concentrations observed in Te Tauawa-a-Maka – Nottingham Stream are driven by stormwater discharges, PDP evaluated:

- spatial relationships between upstream stormwater-generating surfaces and contaminant concentrations; and,
- event-scale behaviour of contaminants in relation to rainfall characteristics and stormwater runoff processes.

Surface imperviousness variation was too little across the sites to show strong relationships with contaminant concentrations. This indicates ATL exceedances are unlikely to reflect a simple surface-runoff response and are better interpreted using broader event-based patterns driven by characteristics such as antecedent dry period, event depth, wet hours, and peak intensity, rather than imperviousness alone.

Dissolved metals (particularly zinc and copper) and conductivity respond to build-up and wash-off processes and show dilution during larger or more intense events, while particulate indicators (TSS and turbidity, and total metals with peak rainfall intensity (PRI)) consistently reflect first-flush, erosion, and storm-energy effects. Collectively, these patterns provide strong quality assurance that the wet-weather data are representative of stormwater-generating conditions. They also support the interpretation of exceedances using event-based mechanisms rather than simple imperviousness-driven runoff responses.

Insights and Recommendations

Dry and wet weather monitoring indicated generally acceptable water quality within Te Tauawa-a-Maka - Nottingham Stream, with limited but consistent exceedances of dissolved copper and zinc that are most likely linked to stormwater input. Dry weather zinc enrichment at the most downstream site (NS1 at Candys Road) cannot be conclusively attributed to a local source and is likely influenced by cumulative upstream discharges. Wet weather results show widespread exceedances of dissolved metals across the network, with build-up and wash-off behaviour linked to antecedent dry periods, consistent with stormwater-derived mobilisation from impervious surfaces. In contrast, TSS and turbidity increase cumulatively downstream, suggesting contributions from sediment sourcing and instream processes rather than direct stormwater inputs alone.

Overall, the data provides a representative basis for an assessment. It indicates that targeted stormwater management focused on dissolved copper and zinc, particularly improved first-flush and source-control treatment on high-risk impervious surfaces, offers the greatest opportunity to improve stormwater from this sub catchment in accordance with the Huritini-Halswell stormwater Management Plan, and work towards contaminant load reductions as per Table 2 of the CSNDC.

Table of Contents

SECTION		PAGE
Executive Summary		**ii**
1.0	**Introduction**	**1**
1.1	**Background**	**1**
1.2	**Scope**	**1**
1.3	**Objectives**	**2**
2.0	**Methodology**	**2**
2.1	**Site Selection**	**2**
2.2	**Monitoring Parameters and Attribute Target Levels**	**5**
2.3	**Wet Weather Sampling**	**6**
2.4	**Statistical Analysis**	**7**
2.5	**Baseline (Dry Weather) Sampling**	**8**
3.0	**ATL Exceedance & Compliance**	**8**
3.1	**Dry Weather**	**8**
3.2	**Wet Weather**	**12**
4.0	**Contaminant & Stormwater Association**	**24**
4.1	**Imperviousness and Concentration**	**24**
4.2	**Stormwater Concentrations across rainfall events**	**30**
5.0	**Insights & Recommendations**	**40**
5.1	**Dry weather water quality**	**40**
5.2	**Wet weather water quality**	**40**
5.3	**Recommendations for stormwater management**	**41**
6.0	**References**	**42**

Table of Figures

Figure 1: Sample Point Locations 4

Figure 2: Wet weather event TSS data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples). 14

Figure 3: Wet weather event turbidity data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples). 15

Figure 4: Wet weather event dissolved zinc data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples). 18

Figure 5: Wet weather event dissolved copper data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples). 19

Figure 6: Wet weather event conductivity data, red line indicates Attribute Target (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples) 21

Figure 7: Sample Point Locations with associated exceedances 23

Figure 8: TSS (mg/L) against percent cumulative imperviousness. 25

Figure 9 Dissolved copper (mg/L) against percent cumulative imperviousness.. 26

Figure 10 Dissolved lead (mg/L) against percent cumulative imperviousness. 27

Figure 11 Dissolved zinc (mg/L) against percent cumulative imperviousness. 28

Figure 12 Conductivity (µS/cm) against percent cumulative imperviousness. 29

Figure 13 All sampled contaminant parameters wet weather data against antecedent dry period (time since last rainfall event). 32

Figure 14 All sampled contaminant parameters grab sample wet weather data against wet hours (time raining when sample was taken). 35

Figure 15 All sampled contaminant parameters wet weather data against the total rainfall event depth (mm). 37

Figure 16 All sampled contaminant parameters wet weather data against the peak rainfall intensity (mm).. 39

Table of Tables

Table 1: Candy's Road Dry Weather Sampling Results – January 2025 – October 2025 10

Table 2: Summary statistics for dry weather at Nottingham at Candys Rd 11

Table 3: Summary of Exceedance by Site 22

Appendices

Appendix A: Halswell Catchment Site Locations, Monitoring Parameters and Metadata

Appendix B: Site Specific Guidelines

Appendix C: Wet Weather Sample Results

Appendix D: Dissolved Lead Concentration Plot

1.0 Introduction

1.1 Background

The Christchurch City Council ('Council') undertake monitoring of Christchurch and Banks Peninsula waterways principally due to the requirements of the Comprehensive Stormwater Network Discharge Consent (CSNDC; CRC252424) and the associated Environmental Monitoring Programme (EMP) (CCC, 2025).

Where exceedances of Attribute Target Levels (ATLs) are recorded through surface water quality monitoring under the EMP, Council are required to undertake an investigation to determine if the water quality results are due to the effects of stormwater discharges, authorised by this consent (Condition 59b.):

If the monitoring results identify that the TSS, copper, lead and zinc Attribute Target Levels in surface water, as set out in Schedules 7 and 8, and Escherichia coli, copper, lead and zinc in groundwater, as set out in Schedule 9, are not being met, the Consent Holder shall:

a. Engage with the Canterbury Regional Council about conducting an investigation into whether this is due to the effects of stormwater discharges authorised under this resource consent, with site investigations prioritised for areas with high levels of contaminants, or with sensitive or high value receiving environments;

b. Carry out an investigation if required under Condition 59(a) and compile the results of such an investigation into a report to be submitted to the Canterbury Regional Council and Papatipu Runanga (via Mahaanui Kurataiao Ltd).

1.2 Scope

PDP was contracted to collect water quality samples in accordance with the Council EMP for Te Tauawa-a-Maka – Nottingham Stream, across eight instream locations and five repeated wet weather events, to demonstrate if exceedance in ATL's under CSNDC Schedules 7-9 are evident. For those ATLs in exceedance, PDP has also undertaken a limited investigation of a link to stormwater discharges.

1.3 Objectives

The objectives for this investigation of Te Tauawa-a-Maka – Nottingham Stream are (in order):

1. Assess water quality samples for compliance with ATLs (Schedules 7-9).
2. Assess whether ATL exceedances (if applicable) are the result of stormwater inputs into the catchment discharged in accordance with the CSNDC and associated EMP.
3. Recommend locations to prioritise for stormwater management interventions (e.g., device or practice-based treatment, regulatory compliance with network users) in the catchment.

2.0 Methodology

2.1 Site Selection

Te Tauawa-a-Maka - Nottingham Stream is a spring-fed plains stream that converges with Knights Stream, another tributary, to form the Huritini-Halswell River (LAWA, 2026). Wet weather water quality monitoring in the Te Tauawa-a-Maka - Nottingham Stream catchment was carried out at eight in-channel sites listed in Appendix A and shown in Figure 1. Table A1 and Figure 1 also delineate the percentage land use types in the individual sample point catchments potentially contributing to stormwater run-off.

Upstream catchment areas were estimated for each sample point by utilising the open-source Council major stormwater catchment and stormwater subcatchment geospatial data together with the piped stormwater network plans (all sourced from the Council 3-Waters Asset Network map (CCC, 2026)). Three subcatchments were found to overlay Te Tauawa-a-Maka - Nottingham Stream, Lower Nottingham, Mid Nottingham and Upper Nottingham[1]. The Nottingham subcatchments were amalgamated by PDP geospatial specialists to provide an estimated total catchment area for Te Tauawa-a-Maka - Nottingham Stream.

Expert judgement utilising 3-waters Asset Network datasets (sourced via Council geospatial viewer) and LiDAR-drainage surfaces (flow-enforced raster) was used to estimate specific extents of the three subcatchments draining to each of the eight sampled locations within Te Tauawa-a-Maka - Nottingham Stream

[1] Inspection of Council's major and minor catchment dataset revealed neighbouring (western) catchments drained via surface treatment features (wet and dry ponds) to locations downstream of the furthest downstream sites sampled (i.e., assumed to not impact sampled water quality). The Council's 3 Waters Asset Network geospatial overlay indicated neighbouring minor stormwater catchments likely drained into the Halswell River (accessed on 29 January 2026).

("sampling point catchment areas"). A Council surface raster[2] was overlaid on the sampling point catchment areas to generate absolute area and corresponding percentage thereof by each of eight land cover classes (bare earth/sand/gravel/clay/rock, buildings, grass, impervious other, roads, rough low vegetation, trees and water). Corresponding net surface area in "imperviousness" were estimated as sum of areas in "buildings" plus "impervious other" plus "roads". Outputs were used to explore association between catchment imperviousness and contaminant concentrations to inform the secondary objective (exceedance sourcing assessment). Cumulative estimated surface composition per sampling point catchment area (encompasses delineated catchment area plus upstream catchment) are reported in Table A1.
Non- cumulative areas - areas pertaining only to the delineated catchment area for each sampling point are also included in Table A1 to provide an indication of the relative catchment sizes and proportion of stormwater generating areas in each sampling point catchment.

The monitoring location and method undertaken at each sample site (grab sampling or automatic flow paced sampling) was determined following a catchment assessment on advisement by Council. Sites were selected to give a spread of cumulative water quality within the stream, including spread of upstream catchment surfaces allowing for patterns to be examined for relationships with differing stormwater conditions (e.g., differing pervious and impervious relative cover).

Conditions of grab sampling and automatic sampling methodology is discussed in further detail in Section 2.3.

[2] Lynker 8 class layer provided by Stormwater and Waterways Engineer, Peter Christensen at CCC on 29 January 2026.

0 250 500
METRES
SCALE : 1:15,000 (A3)

THIS DRAWING REMAINS THE PROPERTY OF PATTLE DELAMORE PARTNERS LTD AND MAY NOT BE REPRODUCED OR ALTERED WITHOUT WRITTEN PERMISSION. NO LIABILITY SHALL BE ACCEPTED FOR UNAUTHORISED USE OF THE DRAWING.

NO.	REVISION	DATE	BY
B	FINAL	MAR 26	DK
A	ISSUED FOR REVIEW	JAN 26	DK

SOURCE:
1. AERIAL IMAGERY : CHRISTCHURCH 0.075M URBAN AERIAL PHOTOS (2025) SOURCED FROM NZ IMAGERY (ENVIRONMENT CANTERBURY).
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.

NOTES:
1. 95TH PERCENTILE AND MEDIAN VALUES COMPARED TO ATLS. GREEN HIGHLIGHTED VALUES ARE BELOW GUIDELINES; ORANGE HIGHLIGHTED VALUES EXCEED GUIDELINES.
2. BOLD VALUES ALSO EXCEED THE CANDYS ROAD DRY WEATHER 25TH PERCENTILE SITE SPECIFIC GUIDELINE VALUE.

Christchurch City Council

FIGURE

FIGURE 1: NOTTINGHAM STREAM CATCHMENT

PROJECT

NOTTINGHAM STREAM WET WEATHER MONITORING 2025

© 2022 Pattle Delamore Partners Limited

2.2 Monitoring Parameters and Attribute Target Levels

All samples were analysed for the suite of parameters provided in Appendix A ; Table A2. Analytes measured for this investigation were based on monitoring parameters required under the CSNDC EMP. Total metals were included to help understand the bioavailable fraction of metal contaminants in the stream. Associated EMP ATLs for each analyte are listed in Table A2.

Copper, zinc and lead, alongside other metal effects, are modified by hardness or other toxicity modifying factors (TMFs) such as pH and dissolved organic carbon. Where possible, collected chemistry data should be used to derive site-specific guideline values to account for local conditions. Warne et al. (2018) and Gadd et al. (2023) provide guidelines to correct DGVs for toxicity modifying factors.

Under the updated EMPs dated January 2025 (Version 10) and November 2025 (Version 11), site-specific guideline values for 95% species protection for dissolved lead, zinc and copper shall be calculated for each sample. However, the wet weather monitoring programme was developed and agreed upon in December 2024 under the previous EMP (Version 9, dated September 2022) which utilised 5-year catchment rolling medians, recalculated each year. The agreed wet weather sampling programme excluded toxicity modifying factors and dissolved metals have been compared to the Huritini/Halswell River catchment median values listed in the most recent EMP[3]. It is noted that the applicable ATLs listed in the EMP have not changed between Version 9 and Version 11, with the exception of rounding variation (a reduction in the number of significant figures between Version 9 and Version 10).

The 2025 dry weather sampling values have been used to calculate site-specific guidelines for Candys Road, and the 25th percentile value of these guidelines has been compared to monitoring results to provide a guideline value for a conservative comparison in lieu of Te Tauawa-a-Maka - Nottingham Stream wet weather site specific metals guidelines. The Candys Road guideline values are not considered conservative compared to the EMP ATLs which are based on 5- years of catchment wide data. Derived site-specific freshwater guideline values for Candys Road are provided in Appendix B .

Adjustment for toxicity modifying factors

2.3 Wet Weather Sampling

Five wet weather (stormwater) events were sampled throughout 2025. The sampling adhered to the storm criteria prerequisites set out by the EMP (section 5.3.2):

- Dry period prior to sampling is a minimum of 3 days;
- Rainfall depth is a minimum of 3 mm total before sampling begins; and,
- Sampling should occur within 1-2 hours of the desired rainfall being achieved.

Event rainfall conditions including wet hours (period prior to sampling but since commencement of rainfall), total rainfall event depth, peak intensity and antecedent dry period (ADP – in days) were determined using NIWA rainfall data provided for Site 326617, Upper Cashmere Catchment at Worsley Road. Wet weather event metadata is presented in Appendix A ; Table A3.

Surface water quality sampling was completed in general accordance with the methodology outlined in New Zealand National Environmental Monitoring Standards (NEMS, 2019).

2.3.1 Grab Samples

Grab samples were collected during rainfall at four of the five stormwater events in 2025. Rainfall occurred outside of daylight hours on the 4 June 2025. Health and safety policies prevent manual sampling from streams in the dark, as such, grab samples were not able to be collected alongside the auto-sampling for one event.

Sample collection and laboratory analyses were consistent with past sampling undertaken by Council (primarily for stormwater consenting requirements).

All grab samples were collected either from the bank using a telescopic sampler (i.e., 'Mighty Gripper'), or by wading instream and collecting the sample. Samples were collected at depth of 0.2 m. As preference, samples were collected from the upstream extent of the assessment reach at each monitoring site. This was to maintain consistency and to minimise effects of any instream disturbance potentially caused by the autosampler functions.

Immediately after collection, samples were stored in a large, insulated container (i.e., a 'chilly bin'). Pre-frozen ice packs or ice-slush were used to keep the samples chilled for transport. Care was taken to ensure that sample exposure to UV light was minimised as far as practicable during this process.

An International Accreditation New Zealand (IANZ) laboratory (Council Laboratory) was used for the analysis of all water samples. Samples were received by the laboratory within 24-hours of collection, allowing for the minimum two-hour processing period.

2.3.2 ISCO Autosamplers

Automatic samplers (autosamplers) are battery or solar operated instruments that collect water samples into a series of up to 24 individual bottles at time or flow-based intervals. Automatic samples were collected using ISCO autosamplers (ISCOs) on all five of the monitored stormwater events in 2025 at two locations (HALS and NS3).

PDP staff manually programmed and started the ISCO when the rainfall event had reached 3 mm depth (or as near as practicable). ISCOs were installed with an in-situ flow instrument, which enabled the ISCO to be 'triggered' to collect a water sample each time a predetermined flow volume was measured.

The trigger flow volume was calculated for each site and individual event based on predicted rainfall volumes[4] and estimated rainfall/discharge relationships determined for each location (refer to Appendix A ; Table A4). The estimated combined event and baseflow volume was used as the flow volume required to pass by the ISCO between aliquots. For each 600 – 800 mL aliquot was collected into a discrete ISCO bottle, resulting in flow-proportional samples.

Sample collection ended when all bottles were filled or the storm event ceased. Once sampling had ceased, PDP staff returned to site, capped the full ISCO bottles, numbered lids with corresponding ISCO base numbers, and samples were delivered chilled to Council Laboratory for testing.

In-situ level data was used to determine the hydrograph and provide the testing laboratory with instructions for compositing the discrete samples in the Chain of Custody (CoC).

Discrete ISCO bottles were acid washed by the laboratory and returned to PDP for subsequent monitoring.

2.4 Statistical Analysis

Event mean concentrations (EMC) were calculated from flow-proportional ISCO data. Results below laboratory detection limits were substituted with half the Limit of Detection (LOD) (LOD/2). As sampling was flow-weighted, EMCs were calculated as the mean of sample concentrations per each rainfall event.

Percentile and median values were calculated and reported for each sampling point across this monitoring programme as EMP ATLs are applicable to median and 95th percentile values as opposed to discrete sampling results. (Note the distinction that median and 95th% were estimated per site, for four grab samples [6 sites] and five flow-proportionate EMC's [2 sites] – this creates some temporal incongruity with 95th% particularly sensitive to differing number of samples to estimate from).

[4] Mean value of five numerical rainfall forecast models – GFS 22km, ECMWF 9km, ICON 13km, METEOBLUE, ACCESS-G3 12km.

2.5 Baseline (Dry Weather) Sampling

Monthly dry weather sampling is undertaken at Candys Road by Council. The January 2025 – October 2025 dry weather sampling results were used to calculate hardness or DOC modified dissolved metals guideline values for both comparisons to dry weather sampling results and to provide a conservative guideline utilising the 25th percentile of dry weather TMF modified guidelines for application against wet weather values where TMFs were not sampled.

Dry weather values were also used to provide a baseline against wet weather compliance sampling to aid in understanding the source of any elevated contaminants.

No rain was recorded during January 2025 – October 2025 dry weather sampling events; however, it is noted that a minor volume of rainfall was detected in the 24-hours before the following monitoring rounds (site data provided by Council):

- April 2025 (1.8 mm);
- June 2025 (0.8 mm); and,
- August 2025 (0.2 mm).

3.0 ATL Exceedance & Compliance

3.1 Dry Weather

Dry weather monthly and statistical results for Candys Road, spanning January 2025 to October 2025 are presented in Table 1 and Table 2.

Results have been compared to EMP ATL values as well as derived site/sample specific guidelines for dissolved copper, lead and zinc.

All pH values were circumneutral (median of 7.4) and within the EMP ATL guideline of 6.5 - 8.5. Conductivity was elevated in all dry weather samples, with the annual median value of 242.5 µS/cm above the EMP ATL of 116 µS/cm.

All dissolved copper and lead concentrations were very low and compliant with all site-specific guideline values and catchment specific Version 11 EMP ATLs. Dissolved zinc was elevated above the site-specific guideline value for 95% species protection in the April and August dry weather samples. The 95th percentile for dissolved zinc also exceeded the Version 11 EMP catchment specific median guideline value.

All Total Suspended Solids (TSS) concentrations were relatively low in all 2025 dry weather sampling, with the median value compliant with the EMP Attribute Target Level of 25 mg/L. The dry weather median turbidity of 2.05 FNU was non-compliant with the EMP ATL (1.3 NTU).

The highest TSS concentration of 11 mg/L was recorded at the April sampling round, the corresponding turbidity was 4 FNU, which is also elevated in comparison to other monitoring events and sits just above the 75^{th} percentile value. The April monitoring event was preceded by 1.8mm of rainfall in the 24 hours before sampling, however it was dry on the sampling day.

The highest turbidity value was recorded in the August monitoring round, where 0.2 mm of rainfall fell in the preceding 24-hours. The TSS on this date was also slightly elevated in comparison to other winter months.

In June, sampling was preceded by 0.8 mm of rainfall, constituting “wetter” conditions that what preceded the August sampling round. However, June dissolved zinc, TSS and turbidity are all lower than August values. It is also noted that the EMP states the predicted minimum rainfall to generate run-off in urban catchments sufficient to allow monitoring to be 3 mm. Although elevated contaminants appear to correspond with antecedent conditions, the lack of distinct correlation between preceding rainfall volume and increased contaminants in dry weather, coupled with the low volume compared to expected rainfall required to generate run-off, suggests that increased dissolved zinc, TSS and turbidity in the baseline samples may be attributed to uncontrolled point source contributions occurring in dry weather.

Table 1: Candy's Road Dry Weather Sampling Results – January 2025 – October 2025

Date	14/01/2025	27/02/2025	27/03/2025	29/04/2025	27/05/2025	26/06/2025	24/07/2025	21/08/2025	23/09/2025	21/10/2025
Dissolved Copper	0.00017	0.00024	0.0002	0.00037	0.00019	0.00025	0.00018	0.00028	0.0002	0.00027
Dissolved Lead	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
Dissolved Zinc	0.0091	0.0063	0.0098	0.025	0.011	0.015	0.010	0.025	0.010	0.011
Conductivity (µS/cm)	212	217	221	222	248	258	259	263	249	237
pH (pH Units)	7.5	7.6	7.5	7.3	7.3	7.5	7.4	7.4	7.4	7.4
TSS	1.1	0.5	1.5	11	0.5	4.5	5.6	6.4	4.8	2.4
Turbidity (FNU)	0.87	1.5	1.2	4	1.3	2.5	3.3	6.7	3.3	1.6

Notes:

1. *Values in mg/L unless otherwise stated.*
2. Single sample metals values compared to site-specific guideline values (Appendix B:). Green highlighted values are below site specific guidelines; Orange highlighted values exceed site-specific guidelines.

Table 2: Summary statistics for dry weather at Nottingham at Candys Rd

Percentile	Min	25th	Med	75th	95th	Max	Number	EMP Attribute Target Level
Conductivity (µS/cm)	212	221.25	242.5	255.75	261.2	263	10	116
Dissolved Copper	0.00017	0.00019	0.00022	0.00027	0.00033	0.00037	10	≤0.0014 – also compared to site/sample-specific values in Table 4.
Dissolved Lead	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	10	≤0.0109 – also compared to site/sample-specific values in Table 4.
Dissolved Zinc	0.00630	0.00985	0.01050	0.01400	0.02500	0.02500	10	≤0.0174 – also compared to site/sample-specific values in Table 4.
pH (pH units)	7.3	7.4	7.4	7.5	7.6	7.6	10	6.5 - 8.5
TSS	0.5	1.2	3.45	5.4	8.9	11	10	≤25
Turbidity (FNU)[3]	0.87	1.4	2.05	3.3	5.5	6.7	10	≤1.3 (NTU)

Notes:

1. *All values in mg/L unless otherwise stated.*
2. *Median or 95th percentile values compared to EMP Attribute Target Levels, Green highlighted values are compliant with EMP ATLs, Orange highlighted values exceed EMP ATLs.*
3. *Dry weather samples are in FNU units, EMP ATL is in NTU. NTU and FNU are both nephelometric turbidity units but are derived from different analytical methods and light sources; therefore, they are not directly interchangeable, particularly at higher turbidity or in waters with variable particle characteristics such as stormwater runoff. However, these methods are considered sufficiently comparable for the purposes of this investigation.*

3.2 Wet Weather

A statistical summary of data from the five monitoring events, by site, compared to EMP ATLs and the derived Candys Road dry weather guidelines is provided in Table 7. The EMP states dissolved metals ATLs are to be compared to 95th percentile values and ATLs for all other parameters analysed in this report are to be compared to sample medians.

Sites are presented upstream to downstream, top to bottom. Percentiles were calculated using EMCs for composite (ISCO) samples and discrete grab samples. Given the small number of events sampled, there is limited confidence in the 95% percentile values to reliably reflect extreme event concentrations, particularly with regard to grab sampling, which constitutes four samples only.

Table 3 and Figure 7 provides a summary of exceedances by site. Full results are provided in Appendix C. Further discussion surrounding potential sources of contamination is undertaken in Section 4.0 and includes consideration of upstream land-use characteristics within the stormwater catchments of each sample location.

3.2.1 pH

pH values were circumneutral across all sites and events with values ranging from 6.8 – 7.4. The highest pH results were measured at HALS ISCO sampling point. Wet weather median pH values were compliant with EMP ATLs of 6.5 – 8.5 pH units. No longitudinal pattern for changes to pH with distance downstream was evident across events.

Candys Road (NS1) wet weather sampling median pH (7) was slightly lower than the dry weather median of 7.4 at the same site. Urban stormwater runoff pH is influenced by the acidity of rainfall (often < pH 6.0), and this acidic input can lower the pH of receiving streams during wet-weather events (Kingett Mitchell Ltd, 2005). Baseflow conditions are dominantly groundwater-derived with an absence of nearby geothermal inputs indicating more alkaline conditions in dry weather is expected. The difference wet and dry weather pH is minor with regard to toxicity effects given the variation in wet weather values and the broad median ATL range.

3.2.2 Total Suspended Solids and Turbidity

A longitudinal increase in median TSS values is evident in a downstream direction (refer to Figure 2). This is pattern is reflected in the following downstream median TSS concentrations which exceed the EMP ATL of 25 mg/L:

- NS5 (grab, 52 mg/L TSS);
- HALS (ISCO, 38.3 mg/L TSS); and,
- NS1 (grab, 52.5 mg/L TSS).

The most elevated TSS concentrations were recorded during the highest intensity event sampled 13/11/2025 (Appendix B). Median TSS was below the EMP ATL at all other sites.

Turbidity results mirror TSS concentration patterns with the furthest downstream sites recording the highest results (Figure 3). Median turbidity was in exceedance of the EMP ATL (1.3 NTU) at all sites, with values discrete and EMC turbidity values ranging from 5.9 – 27 NTU. Note, the Candys Road (NS1) dry weather result of 2.05 FNU[5] is also above the EMP ATL, however this value is substantially lower than the wet weather value of 27 NTU.

5 Dry weather samples are in FNU units, EMP ATL is in NTU. NTU and FNU are both nephelometric turbidity units but are derived from different analytical methods and not are directly interchangeable. However, these methods are considered sufficiently comparable for the purposes of this investigation.

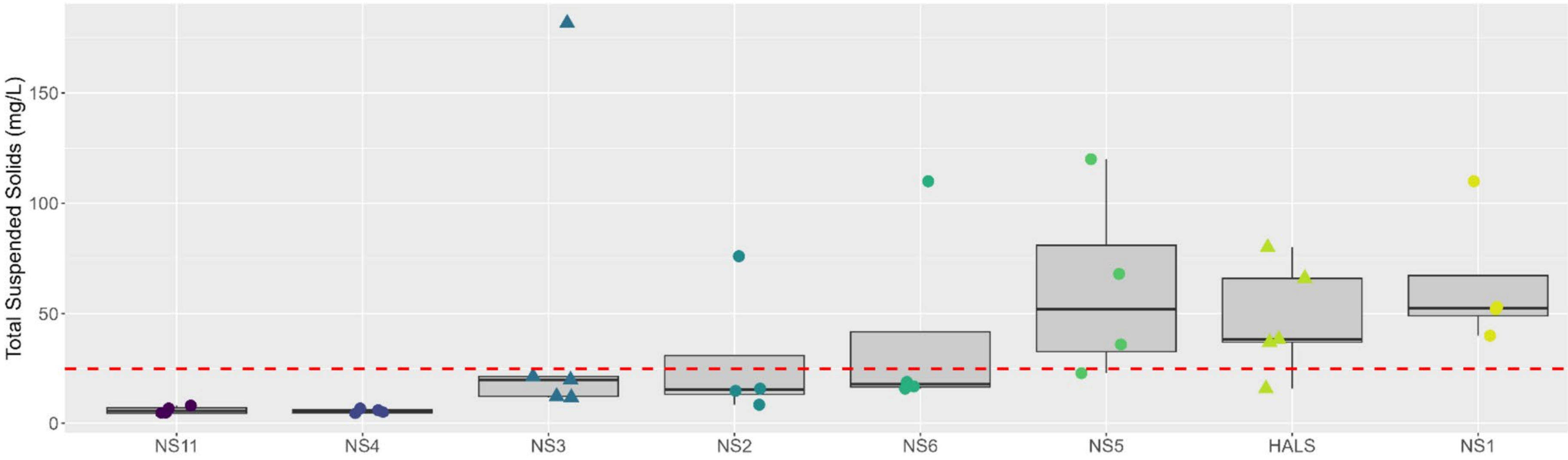

Figure 2: Wet weather event TSS data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples).

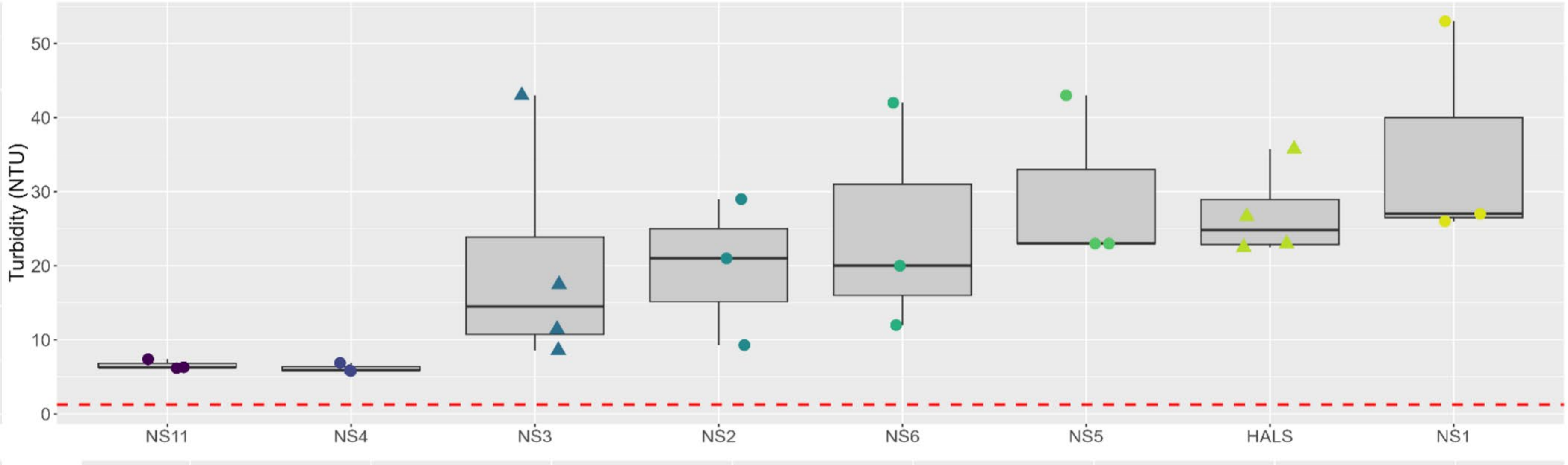

Figure 3: Wet weather event turbidity data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples).

3.2.3 Metals

The EMP stipulates the 95th percentile for dissolved metals is to be compared to ATLs. All dissolved lead concentrations were low and 95th percentiles were below EMP ATLs and the dry weather Candys Road guideline at all sites. There is no discernible pattern in dissolved lead concentrations between sites or sampling method (grab versus ISCO collection, as shown in Appendix D).

Dissolved copper and dissolved zinc 95th percentile concentrations were in exceedance of the EMP ATLs at all sites. All dissolved zinc and NS3 dissolved copper 95th percentile concentrations were also above the Candys Road dry weather guideline value.

There was an observable decrease in dissolved zinc concentration in a downstream direction (Figure 4). A similar pattern with an increased dissolved copper concentration was observed at upstream and midstream sites NS3 and NS2 (Figure 5).

The dissolved fraction of copper and zinc measured in Te Tauawa-a-Maka – Nottingham Stream was determined by calculating a partitioning ratio of the dissolved portion to the total concentration for each discrete sample or EMC (as provided in Appendix C). A ratio near 1 indicates metals are mostly dissolved (bioavailable), a ratio near zero denotes primarily particulate metals. (Note dissolved metal concentrations are the principal vector for toxicity with national guidance intended for use against dissolved concentrations).

Upstream sites NS11, NS4, NS3, and NS2 had higher copper ratios (>0.5), indicating bioavailable (dissolved) copper dominated the upper reaches of the stream under stormwater flows. Further downstream, (NS6, NS5, HALS and NS1) samples primarily consisted of particulate copper (<0.5), with the exception of the ISCO HALS sample on 04/06/2025 where the ratio is greater than 1 (the total portion was below laboratory detection limit), this value is considered to be an outlier and more weight should be applied to the other monitoring events. The increase in the particulate copper fraction at the downstream sites is matched by a corresponding increase in TSS (Section 3.2.2).

The bioavailable (dissolved) fraction of zinc dominated the majority of wet weather samples across sites (25 out of 34 discrete and ISCO samples with partitioning ratios > 0.5). However, it is noted that at the 13/11/2025 event, zinc was primarily comprised of the particulate fraction at all sites. The 13/11/2025 rainfall event had the highest peak rainfall intensity and rainfall depth (24.2 mm). Samples collected 13/11/2025 typically had the lowest dissolved zinc concentrations and highest TSS in the downstream sites (Appendix C), which correlates to the particulate dominated zinc in the high stormwater flow event.

Dry weather Candys Road 95th percentile dissolved zinc concentration of 0.025 is above the EMP ATL, indicating some level of existing background contamination in Te Tauawa-a-Maka – Nottingham Stream. However, the Candys Road (NS1) wet weather 95th percentile was 3.5 times higher than the dry weather result, indicating a predominantly wet weather enrichment, and potential for dry weather zinc to be a consequence of delayed dissolution from wet weather inputs (or naturally enriched baseflow).

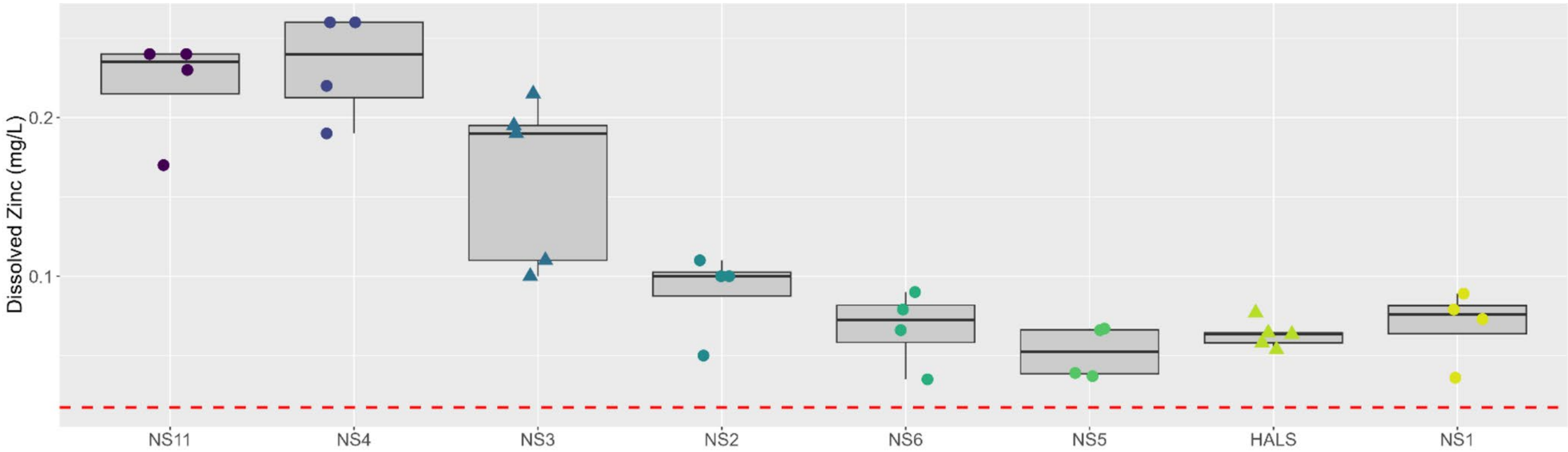

Figure 4: Wet weather event dissolved zinc data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples).

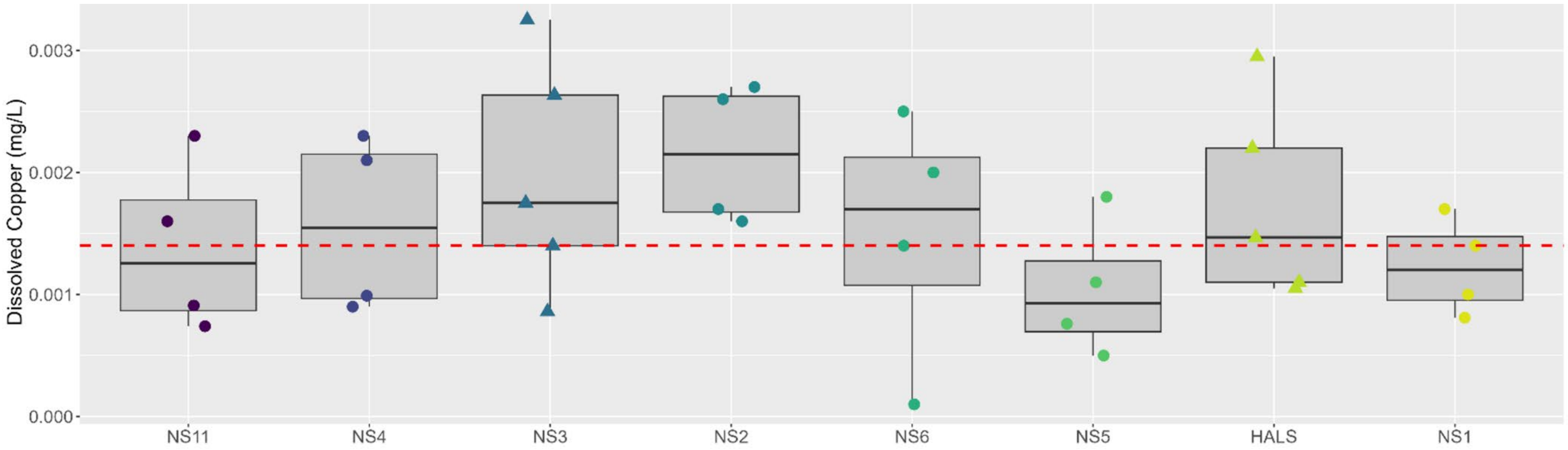

Figure 5: Wet weather event dissolved copper data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples).

3.2.4 Conductivity

Median conductivity values were below the EMP ATL of 116 µS/cm in the upstream locations and increasingly elevated downstream (Figure 6). The three most downstream sites exceeded the EMP ATL for conductivity, with the highest median measured at NS5:

- NS5 (grab sample, 194 µS/cm);
- HALS (ISCO, 131.7 µS/cm); and,
- NS1 (grab sample, 161 µS/cm).

The lowest conductivity measurements were recorded at the highest intensity event (13/11/2025) across most sites, likely due to dilution.

Candys Road (NS1) dry weather median conductivity of 242.5 µS/cm was well above the EMP ATL (Table 6), and greater than any recorded wet weather conductivity result. This indicates that conductivity exceedances were likely related to background conditions in the stream, rather than a direct result of stormwater network input (with stormwater inputs reducing conductivity on background).

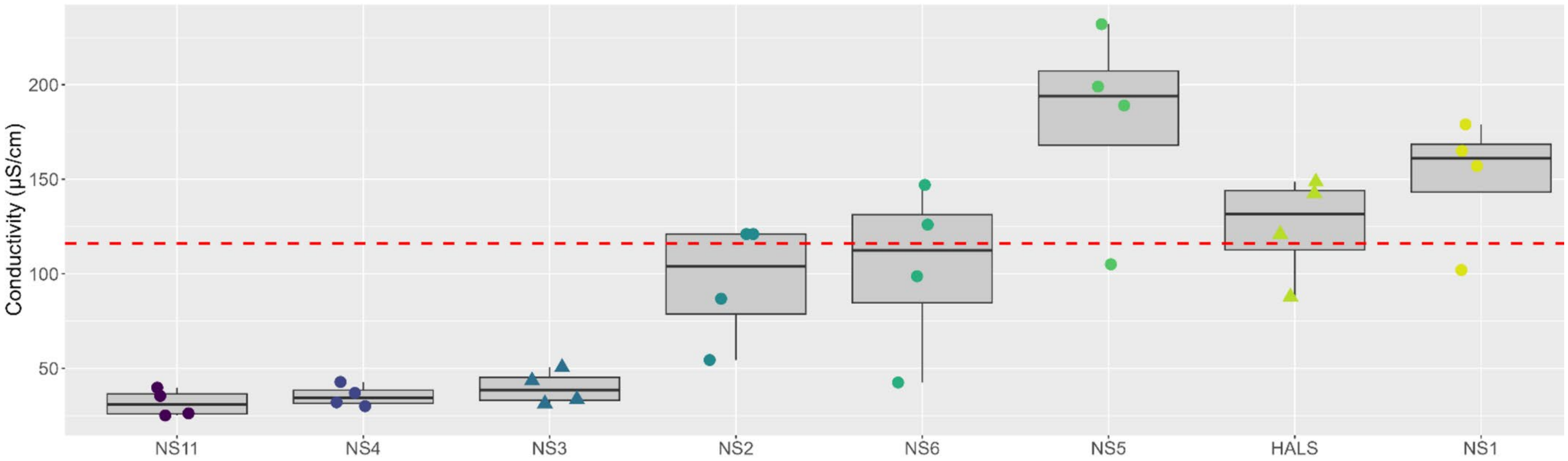

Figure 6: Wet weather event conductivity data, red line indicates Attribute Target (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples)

Table 3: Summary of Exceedance by Site

Site	Exceedances of 95th Percentile Values Against ATL			Exceedances of Median Values Against ATL			
	Dissolved Copper (mg/L)	Dissolved Lead (mg/L)	Dissolved Zinc (mg/L)	Conductivity (µS/cm)	pH (pH units)	TSS (mg/L)	Turbidity (NTU)
NS11	0.00220	0.00018	**0.24**	30.8	7.05	5.9	6.3
NS4	0.00227	0.000209	**0.26**	34.5	7.1	5.7	5.9
NS3 (ISCO)	**0.003127**	0.00025	**0.211**	38.6	7.08	20	14.48
NS2	0.00269	0.00025	**0.1085**	103.9	6.9	15.5	21
NS6	0.00243	0.00026	**0.08835**	112.4	6.9	18	20
NS5	0.001695	0.00019	**0.06685**	194	7	52	23
HALS (ISCO)	0.0028	0.000205	**0.074467**	131.7	7.4	38.3	24.8
NS1	0.00166	0.00022	**0.0875**	161	7	52.5	27

Notes:

1. *95th percentile and median values compared to ATLs. Green highlighted values are below guidelines; Orange highlighted values exceed guidelines.*
2. ***Bold** values also exceed the Candys Road dry weather 25th percentile site specific guideline value.*

NS11

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✓	✓	✓	✗

NS4

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✓	✓	✓	✗

NS3

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✓	✓	✓	✗

NS2

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✓	✓	✓	✗

NS6

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✓	✓	✓	✗

NS5

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✗	✓	✗	✗

HALS

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✗	✓	✗	✗

NS1

95th Percentile ATL			Median ATL			
Dissolved Copper	Dissolved Lead	Dissolved Zinc	Conductivity	pH	TSS	Turbidity
✗	✓	✗	✗	✓	✗	✗

0 250 500
METRES
SCALE : 1:15,000 (A3)

THIS DRAWING REMAINS THE PROPERTY OF PATTLE DELAMORE PARTNERS LTD AND MAY NOT BE REPRODUCED OR ALTERED WITHOUT WRITTEN PERMISSION. NO LIABILITY SHALL BE ACCEPTED FOR UNAUTHORISED USE OF THE DRAWING.

NO.	REVISION	DATE	BY
B	FINAL	MAR 26	DK
A	ISSUED FOR REVIEW	JAN 26	DHK

SOURCE:
1. AERIAL IMAGERY : CHRISTCHURCH 0.075M URBAN AERIAL PHOTOS (2025) SOURCED FROM NZ IMAGERY (ENVIRONMENT CANTERBURY).
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET DERIVED FROM LINZ DATA.

NOTES:
1. 95TH PERCENTILE AND MEDIAN VALUES COMPARED TO ATLS. GREEN HIGHLIGHTED VALUES ARE BELOW GUIDELINES; ORANGE HIGHLIGHTED VALUES EXCEED GUIDELINES.

Christchurch City Council

FIGURE
FIGURE 7: NOTTINGHAM STREAM CATCHMENT SUMMARY OF ATL EXCEEDANCE BY SITE

PROJECT
NOTTINGHAM STREAM WET WEATHER MONITORING 2025

4.0 Contaminant & Stormwater Association

The purpose of this assessment was to determine whether elevated concentrations observed in Te Tauawa-a-Maka – Nottingham Stream are driven by stormwater discharges. This was evaluated by examining:

- Spatial relationships between upstream stormwater-generating surfaces and contaminant concentrations, and,
- Event-scale behaviour of contaminants in relation to rainfall characteristics consistent with stormwater runoff processes.

This is discussed further in the following sections. Full results are provided in Appendix C.

4.1 Imperviousness and Concentration

Across the sample sites there was little variation in percentage imperviousness (47.4-51.2%), with minimal strong or consistent relationship observed between contaminant concentrations and percent imperviousness. This narrow range in impervious cover limits the ability to detect clear patterns. Some parameters (dissolved lead and conductivity) were marginally higher at the more impervious sites, other contaminants (TSS, copper and zinc) showed site-specific variability rather than systemic increases with imperviousness.

The marked variation in concentrations, including for sites observed to exceed ATL, within such a limited range of imperviousness does not preclude a stormwater source for exceedance, but instead offers insights that any exceedance is unlikely to be related to a simple stormwater surface-based response (e.g., patterns are likely more complex than simply responses to changes in imperviousness). From this, PDP advises greater reliance on any assessment for objective 2 (demonstrating if exceedance is stormwater related) on broader event-based patterns.

4.1.1 TSS and Turbidity

There was no consistent increase in TSS with imperviousness, highest TSS concentrations were recorded at NS1 (52.5 mg/L) and NS5 (52 mg/L) which are both sites with higher imperviousness (48.7% & 51.2%). Overall, there was no consistent increase in TSS with imperviousness (Figure 8).

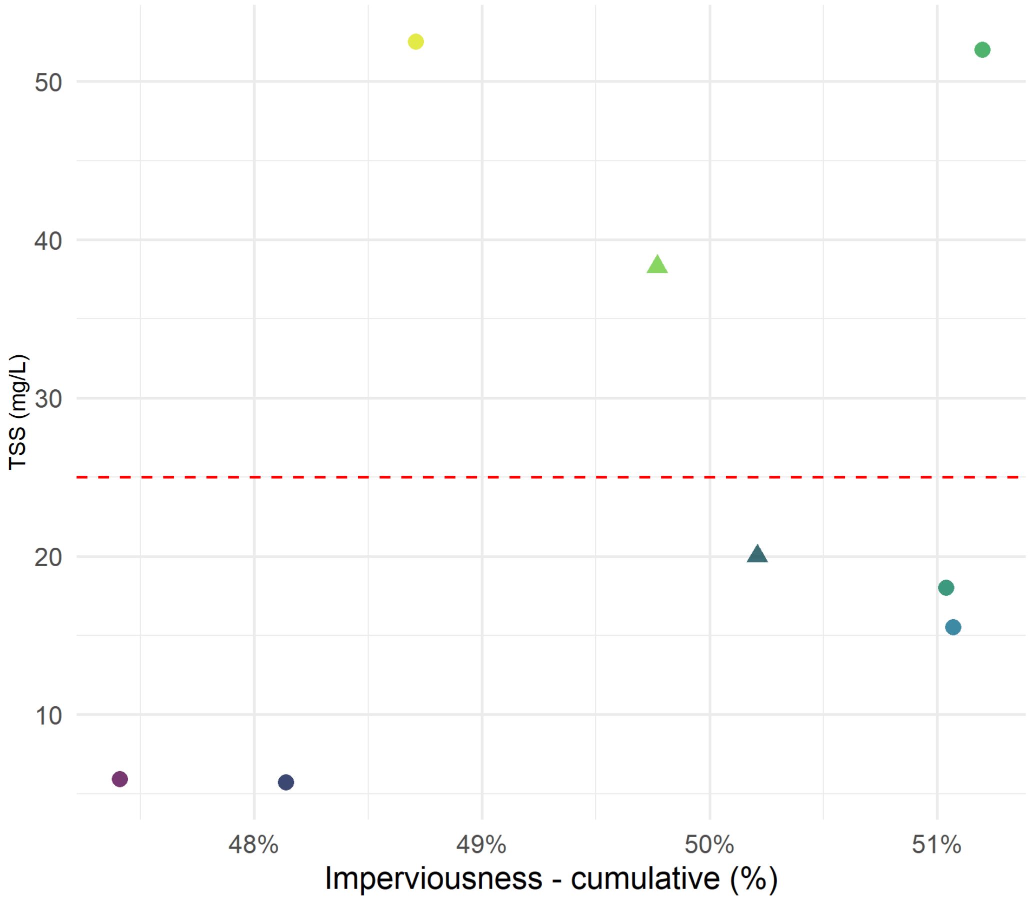

Figure 8: TSS (mg/L) against percent cumulative imperviousness. Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

4.1.2 Metals

There is no clear pattern between imperviousness (%) and dissolved copper, with the highest concentration (0.00019 mg/L) being recorded at 51.07 % imperviousness, and the lowest concentration (0.000085 mg/L) being recorded at 51.2 % imperviousness (Figure 9). Dissolved lead and imperviousness (%) show a weak positive pattern with the highest concentration of dissolved lead (0.0021 mg/L) being observed at 51% imperviousness (Figure 10). Dissolved zinc concentrations were highest at NS4 (0.24 mg/L) and NS3 (0.19 mg/L), with the imperviousness at NS4 being low (48.1 %) and relatively high at NS3 (50.2 %). Overall, suggesting minimal pattern between imperviousness (%) and dissolved zinc (Figure 11).

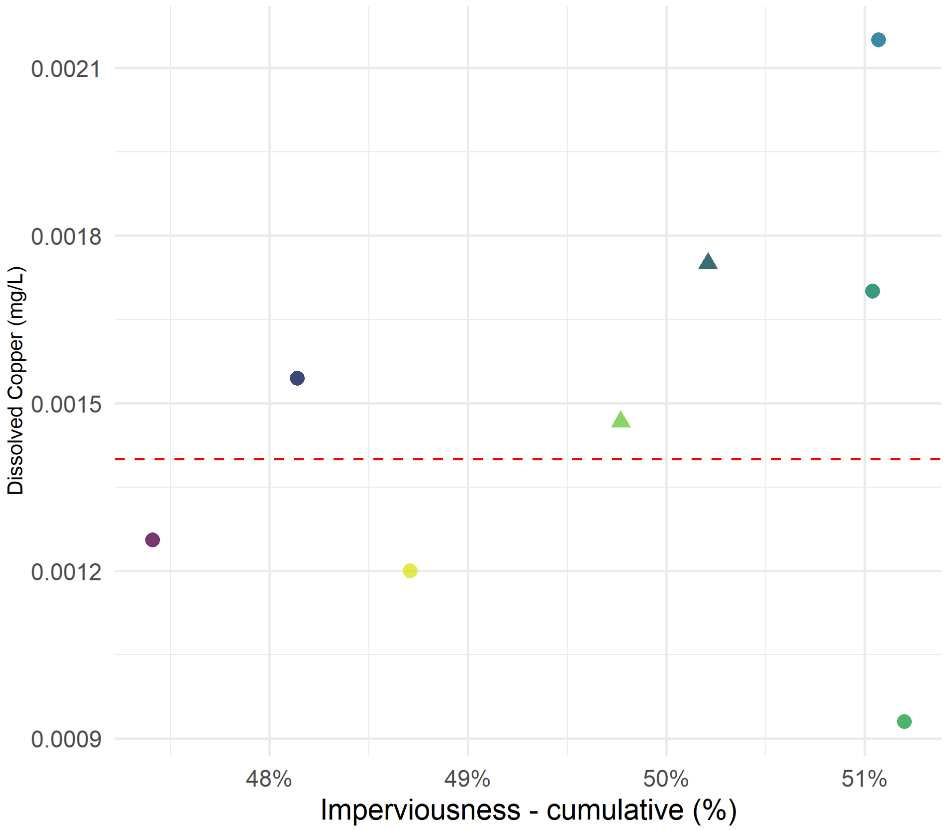

Figure 9 Dissolved copper (mg/L) against percent cumulative imperviousness. Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

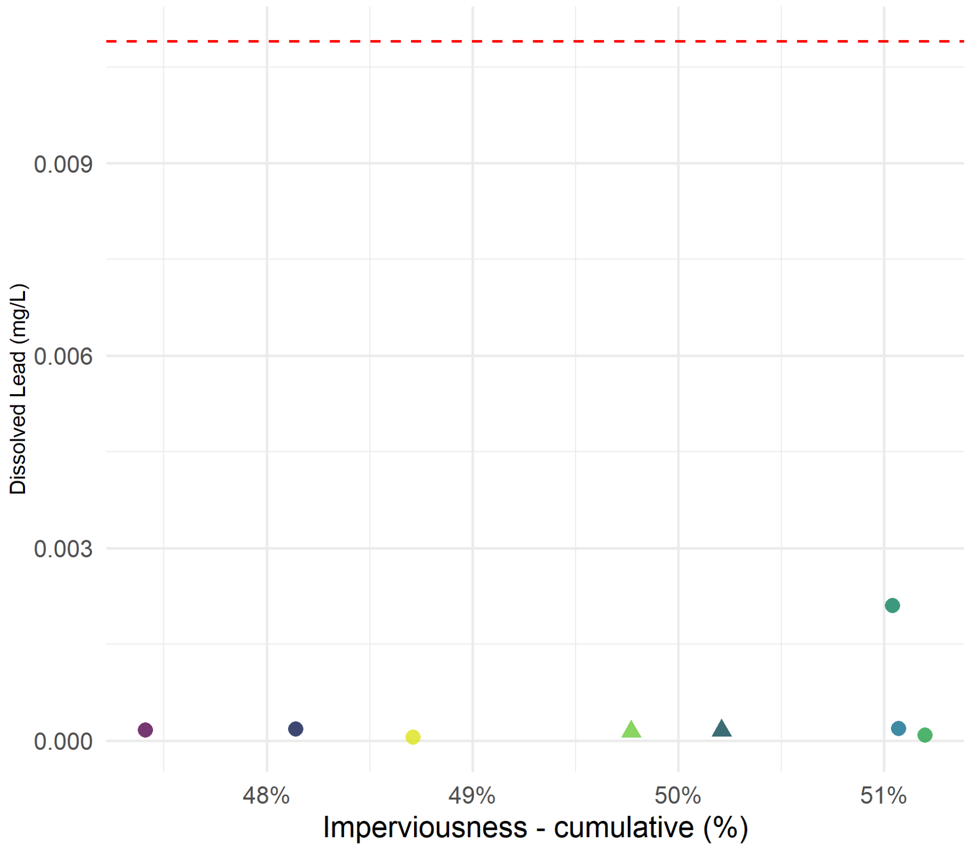

Figure 10 Dissolved lead (mg/L) against percent cumulative imperviousness. Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

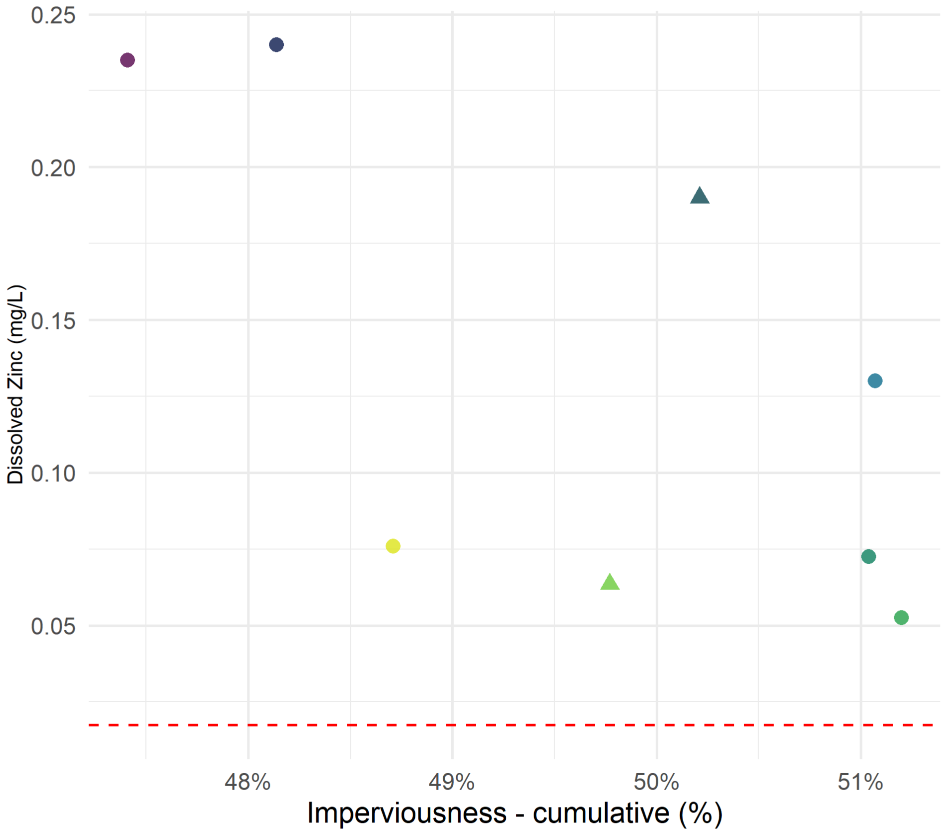

Figure 11 Dissolved zinc (mg/L) against percent cumulative imperviousness. Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

4.1.3 Conductivity and pH

There was no apparent relationship between pH and imperviousness with stable values recorded across the range of imperviousness. Conductivity showed a variable pattern of higher conductivity at more impervious sites (Figure 12), consistent with urban runoff effects, but the gradient is small.

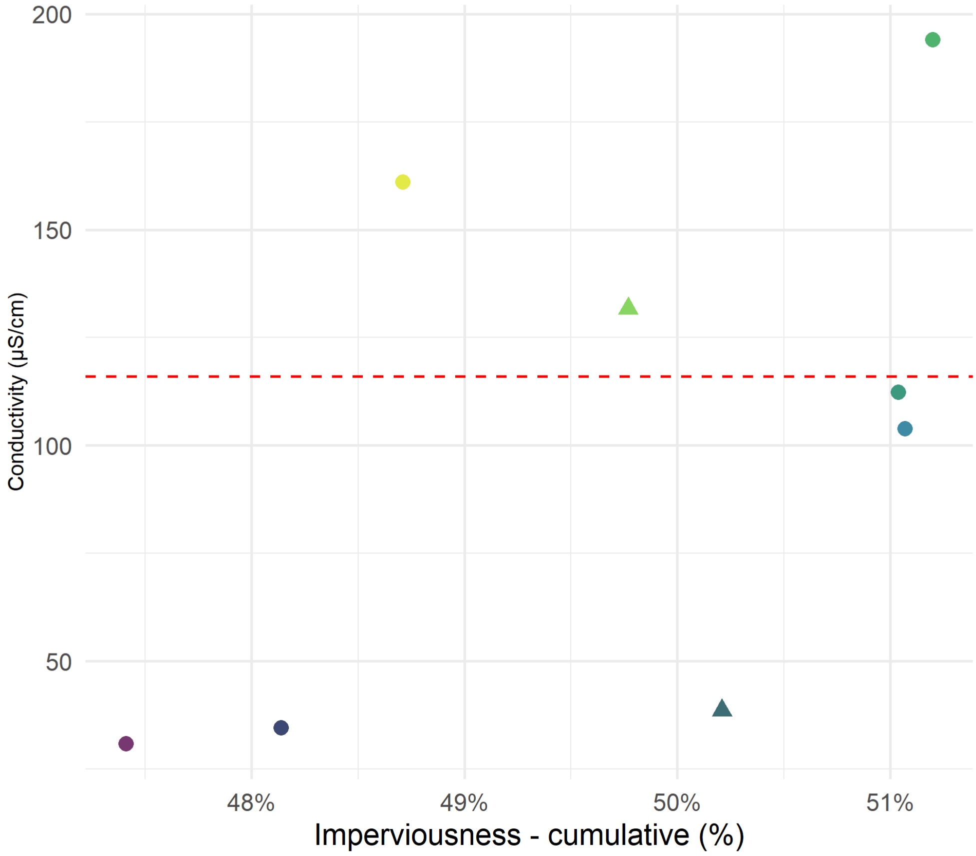

Figure 12 Conductivity (µS/cm) against percent cumulative imperviousness. Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

4.2 Stormwater Concentrations across rainfall events

4.2.1 Antecedent Dry Period

Contaminant concentrations were assessed against antecedent dry period (ADP) to determine if patterns were consistent with wash-off from impervious urban surfaces (e.g., increasing concentration for increasing ADP). Patterns in contaminant concentrations against ADP, across all sample sites are presented in Figure 13, these relationships also provide insight into inter-event variability.

- Conductivity typically increased with longer ADP at several sites (NS11, NS4, NS3, NS2, NS6, HALS), ranging from 25.1-199 µS/cm following short dry periods (2-4 days) and reaching a maximum concentration of 232 µS/cm after extended dry periods (6-19 days). The pattern likely reflects a greater dominance of channel flow by baseflow contributions (more conductive as per Chapter 3) but might also include a response to build-up of solutes on impervious surfaces and wash-off raising subsequent wet-weather conductivity (on an event basis).
- pH exhibited little variation with ADP and remained circumneutral across rainfall events. No clear ADP-related pattern was observed.
- TSS and turbidity did not show consistent positive relationships with ADP. In several events, higher concentrations occurred following shorter dry periods, with TSS reaching up to 110-120 mg/L at NS1, NS5 and NS6. The maximum recorded value was 181.67 NTU at NS3. Both indicators showed inter-event variability that did not align with ADP but is likely more closely related to rainfall intensity and duration (see later – indicating a predominant erosional source via pervious surfaces but where stormwater might remain a contributor indirectly via enhanced channel peak flow and instream erosion). Concentrations were more frequently elevated at mid- and downstream sites compared to upstream, these sites (NS1; NS5; NS6) varied in imperviousness (%) from 48.71-51.2 %. These sites with high imperviousness points to stormwater-driven channel erosion occurring within the stream.
- Copper (total) showed some evidence of higher concentrations following longer dry periods at certain sites (maximum of 0.0244 mg/L at HALS), although the relationship was variable. When comparing to longitudinal imperviousness, there was also no consistent longitudinal pattern evident.
- Copper (dissolved) displayed a clearer positive relationship with ADP at several sites, with higher concentrations observed following longer dry conditions (0.0005-0.00325 mg/L), indicating inter-event variability. Dissolved copper concentrations were also more frequently elevated at mid- to upstream sites compared to downstream.

- Lead (total) concentrations were generally low and showed limited variation with ADP, aside from isolated higher values (up to 0.086 mg/L). Dissolved lead concentrations were also low (<0.0005 mg/L) and showed no clear relationship with ADP. Some variability between sites was observed, when considering imperviousness (%) the sites exhibiting higher imperviousness (%) had higher concentrations of lead (total). This indicates some potentially historic (legacy load) or ongoing unusual stormwater contribution occurring in Te Tauawa-a-Maka – Nottingham Stream.
- Zinc (total) was variable, with some higher concentrations at longer ADPs, particularly at more urban-influenced sites (maximum of 0.3 mg/L at NS4).
- Zinc (dissolved) showed one of the clearest positive relationships with ADP, concentrations increased following longer dry periods (increasing from 0.039-0.26 mg/L), showing strong inter-event variability. Dissolved zinc concentrations were more frequently elevated at mid- to upstream sites compared to downstream, possibly indicating localised urban stormwater input.

The evident positive relationships for ADP ~ copper and zinc indicate a likely stormwater association driving increased concentration following prolonged contaminant build-up and wash-off. This pattern is reassuring for qualifying the event data (assuring representativity) and widely reported in the literature (Camponelli et al., 2010; Haselbach et al., 2014; Hwang et al., 2016).

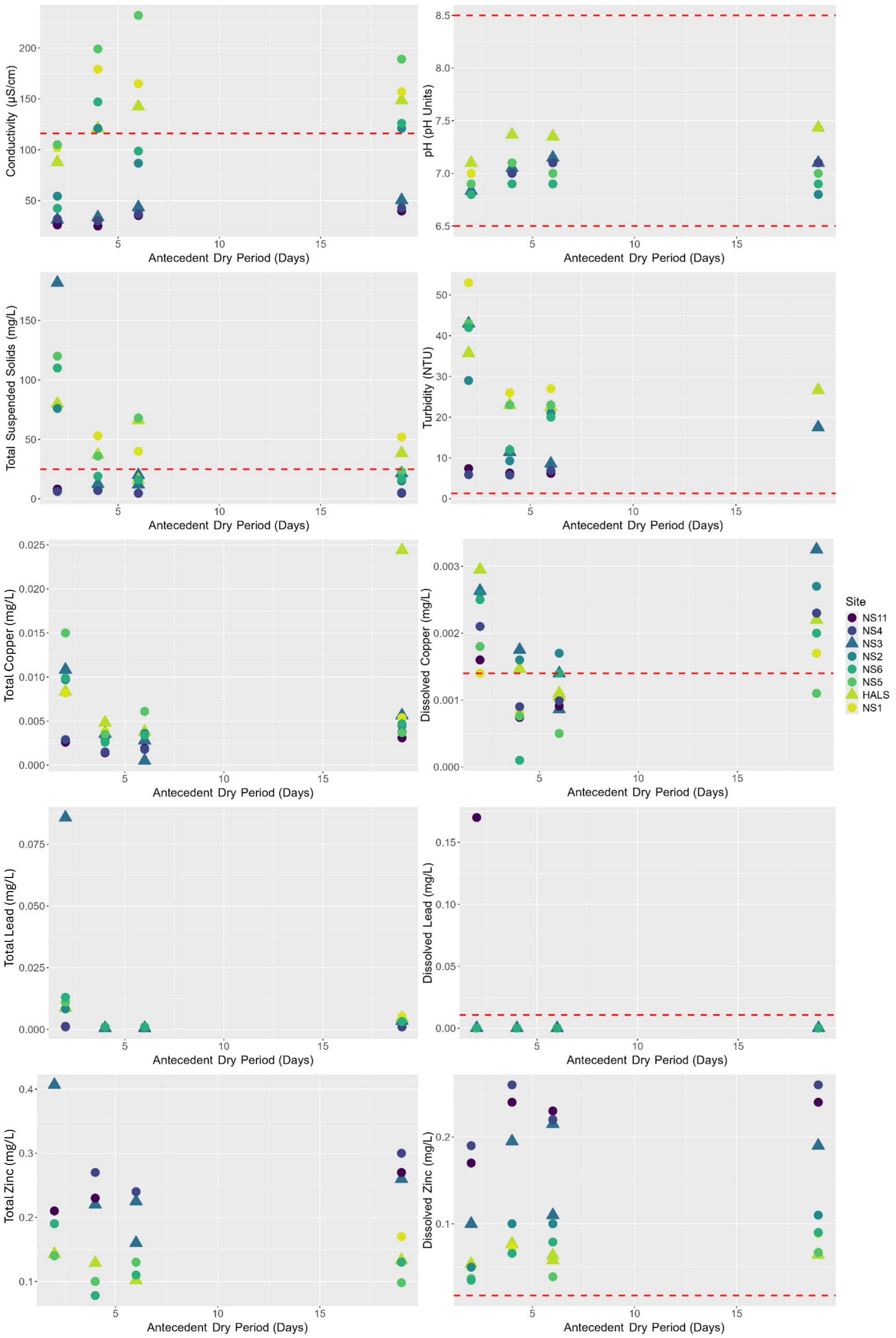

Figure 13 All sampled contaminant parameters wet weather data against antecedent dry period (time since last rainfall event). Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

4.2.2 Wet Hours

Wet hours (WH) record how far into an event rainfall-runoff might have been generated, with contrast between lesser/greater WH events offering potential insights to "first-flush" responses in stormwater contaminant (or for rural and pervious locations, potential for channel erosion and mass wastage responses to increasing saturation and/or greater peak flow).

Patterns in contaminant concentrations against WH are presented in Figure 14.

- Conductivity increases from 18-19 WH, with the highest concentration recorded at 19 WH at NS5 (232 µS/cm). Following 19 WH, per associated sample site, conductivity became more variable across 20-23 WH. Some sites improved (NS5 & NS1), at 20 WH, then conductivity increased at 23 WH. Conductivity at Sites NS2 and NS6 consistently increased as WH increased. Whereas, at sites NS4 and NS11, conductivity increased up until 20 WH, then improved following 23 WH. Site-specific relationships to WH are therefore common.
- pH exhibited little variation with WH and remained circumneutral across rainfall events. No clear WH-related pattern was observed.
- Overall patterns, show both turbidity and TSS decreased as WH increased, for example, TSS at NS5 was recorded as 120 mg/L at 18 WH then decreased to 36 mg/L at 23 WH. This likely implies there is a strong first flush with TSS and turbidity responding to particulate wash-off, strongest earlier in rainfall conditions.
- Copper (total) exhibit slightly higher values at lower WH but this pattern is variable. For example, WH 18 values range from 0.0026- 0.015 mg/L, whereas WH 23 values range from 0.0014-0.0038 mg/L. This shows a moderate first flush effect, but the variability suggests local source influence is also important.
- Copper (dissolved) was variable across WH, highest values were recorded during 18 (max: 0.0026 mg/L) and 20 WH (max: 0.0027 mg/L), while the lowest values were recorded during 19 (max: 0.0017) and 23 WH (max: 0.0016).
- There was no strong lead (total and dissolved) WH pattern, but occasional higher early values were recorded.
- Zinc (total) also showed no discernible patterns across WH, this is likely due to continued inputs during rainfall maintaining instream levels.
- Zinc (dissolved) showed increases in concentration during the lower WH (18-20 WH) (max: 0.26 mg/L), then plateaued as WH reached 23 (max: 0.26 mg/L).

Results were also examined by grouping sites into relatively higher (≥50%) and lower (≤49%) imperviousness. This showed no consistent difference in WH concentration between the groups. Across both impervious group types, contaminant concentrations were primarily influenced by individual rainfall events, with overlap in concentrations at comparable WH values. For some parameters (e.g. TSS), higher concentrations tended to occur at lower WH across all sites, consistent with a first-flush response, but this response was not more pronounced at the higher impervious sites. Overall, stratification by imperviousness did not show a clear modification of WH-concentration relationships, indicating that WH duration does alone does not explain spatial variability in contaminant concentrations.

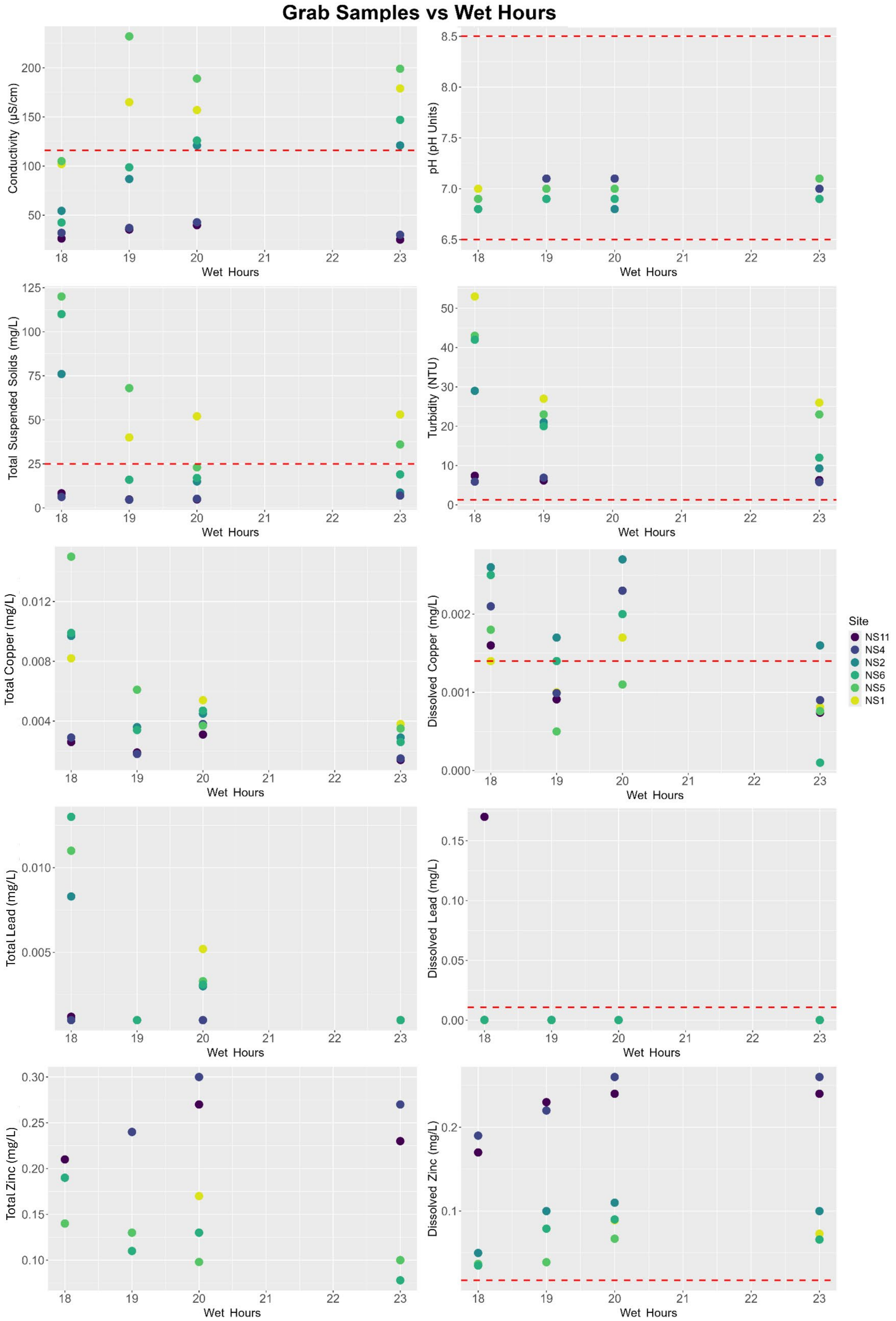

Figure 14 All sampled contaminant parameters grab sample wet weather data against wet hours (time raining when sample was taken). Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1).

4.2.3 Total Rainfall Event Depth

Total rainfall event depth (TRED) is a measure of the intensity of each rainfall event, this separates between wash-off and dilution effects. For example, concentration decreases with larger events (dilution), when concentration increases with larger events (more wash-off). Additionally, events of greater depth would be expected to generate greater erosion of pervious surfaces and instream channels (with potential for such responses to mask a stormwater origin). It is expected that dissolved contaminants often decrease with higher TRED, whereas particulates often increase with higher TRED. Patterns in parameter concentration versus TRED are included in Figure 15.

- Conductivity decreases as TRED increases. When TRED was highest (24.2 mm), conductivity was lowest at each matching site. Whereas, at lower TRED (12.6-14.4 mm), several sites show higher conductivity (NS5 = 232 µS/cm at 12.6 mm).
- There was no clear pH vs TRED pattern.
- TSS and turbidity patterns were similar, where both parameters increased as TRED increased. When TRED =24.2 TSS was very high at some sites (NS5 = 120 mg/L; NS6 = 110 mg/L). Whereas, as TRED decreased (12.6-14.4 mm) TSS was still elevated at some sites but had lower peaks than 24.2 mm. At TRED 24.2 mm turbidity reached 53 NTU (NS1), whereas at lower TRED turbidity was more moderate (<30 NTU).
- Copper (total) tended to be higher at higher TRED (TRED 24.2 mm; NS5 = 0.015, NS6 = 0.0099) but overall was variable. Whereas, copper (dissolved) slightly decreased as TRED increased, with higher intensity events often showing similar or lower dissolved copper compared to moderate intensity events.
- No clear lead (total and dissolved) patterns evident across varying rainfall intensity.
- Zinc (total) slightly increased as TRED increased, for example TRED 24.2 showed elevated zinc at multiple sites (NS11 = 0.21, NS6 = 0.19). However, zinc (dissolved) slightly decreased as TRED increased, with some dilution effect visible at very high rainfall intensity.

The patterns in TRED offer further quality assurance that data captured over the wet weather events was representative of conditions more generally under stormwater-generating conditions. The patterns offer further confirmation that TSS and turbidity share similar sources, with those being predominantly in pervious surfaces – stormwater contributions to channel flow might indirectly be a source of elevation in TSS and turbidity downstream (e.g., cumulative effect).

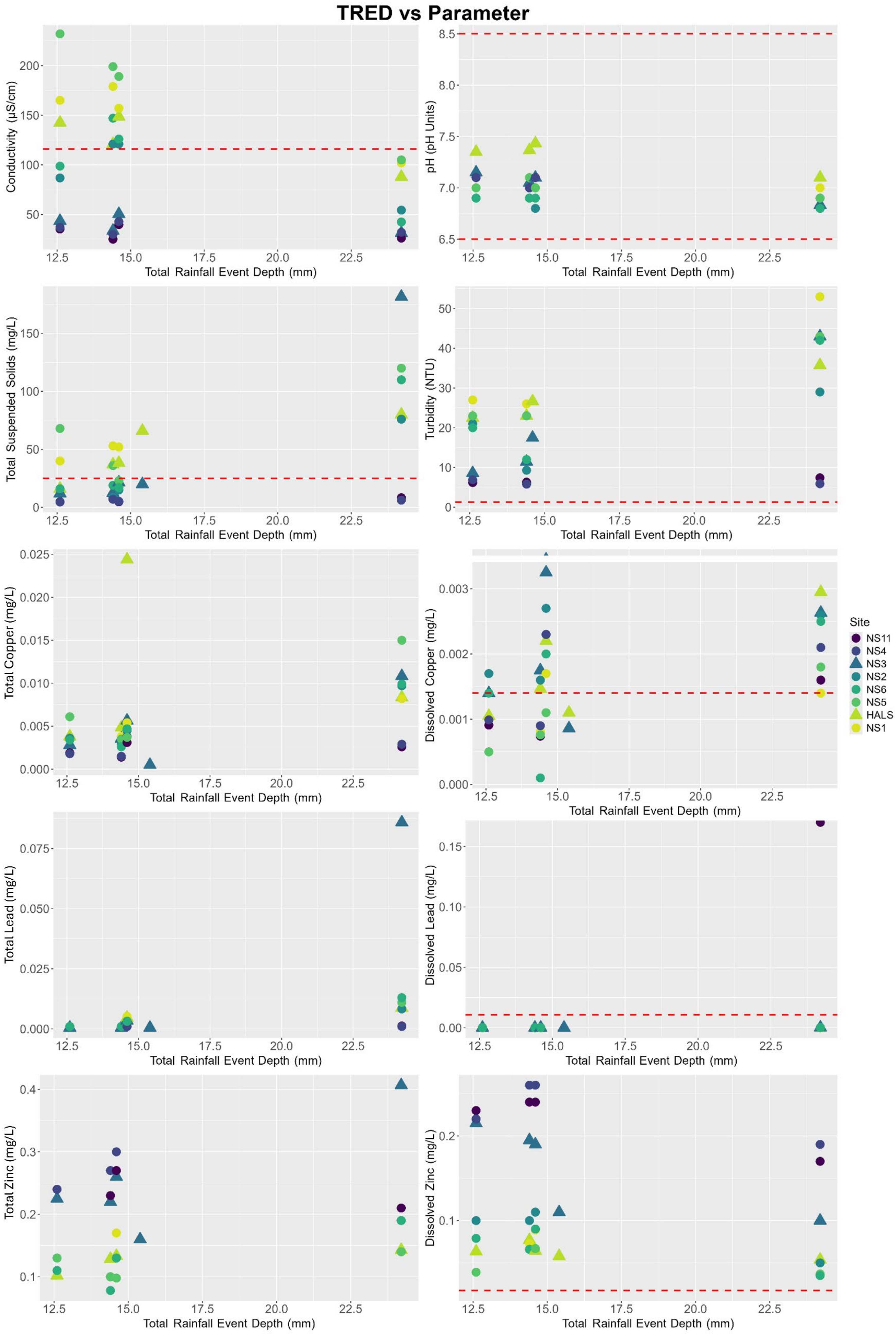

Figure 15 All sampled contaminant parameters wet weather data against the total rainfall event depth (mm). Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

4.2.4 Peak rainfall intensity (PRI) plots

PRI reports on rainfall events being able overwhelm stormwater device treatment (i.e., causing bypass or non-treated flow in network) and where pervious surfaces predominate, of erosional responses. Any association between PRI in more dominantly impervious sites, offers a useful indication that added detention or retention will improve stormwater quality. Patterns in contaminant parameters and PRI are included in Figure 16.

- As PRI increases conductivity decreased, with the highest values occurring at lower PRI (max = 232 at 1.6 mm), and higher PRI (4.6 mm) showing lower conductivity (26-54 µS/cm across multiple sites). It is likely that high intensity rainfall introduces a large volume of low-ion rainwater, causing dilution.
- There is no discernible relationship occurring between pH and PRI.
- Both turbidity and TSS increase as PRI increases, this is because PRI is a key driver of instream sediment loads, with higher peak intensity rainfall resulting in increased suspended fine particles.
- Copper (total) tended to be higher at higher PRI with PRI 4.6 mm indicating several elevated values (0.015; 0.0108). Whereas, copper (dissolved) shows a slight decrease or no clear increase at high PRI, with PRI 4.6 mm values not being consistently higher than lower PRI values.
- Lead (dissolved) was low across all PRI levels, and lead (total) was slightly higher as PRI increased, but this was variable.
- Zinc (total) had several higher values occur during highest intensity rainfall, whereas zinc (dissolved) showed a mixed pattern but was not strongly elevated at PRI 4.6 mm.

Higher PRI was associated with elevated TSS, turbidity, and particulate-bound metals, indicating that storm energy plays a key role in sediment and particle-associated contaminant mobilisation. This response was observed at all sites and was not disproportionately greater at the most impervious locations, indicating that higher imperviousness did not amplify contaminant concentrations under higher PRI conditions. In contrast, dissolved parameters such as conductivity, and some dissolved metals shower dilution effects during the most intense rainfall events. These patterns support earlier findings that water quality samples were representative of broader wet weather conditions (e.g., quality assurance of the investigation serving confirmation that exceedances are as a result of stormwater influence).

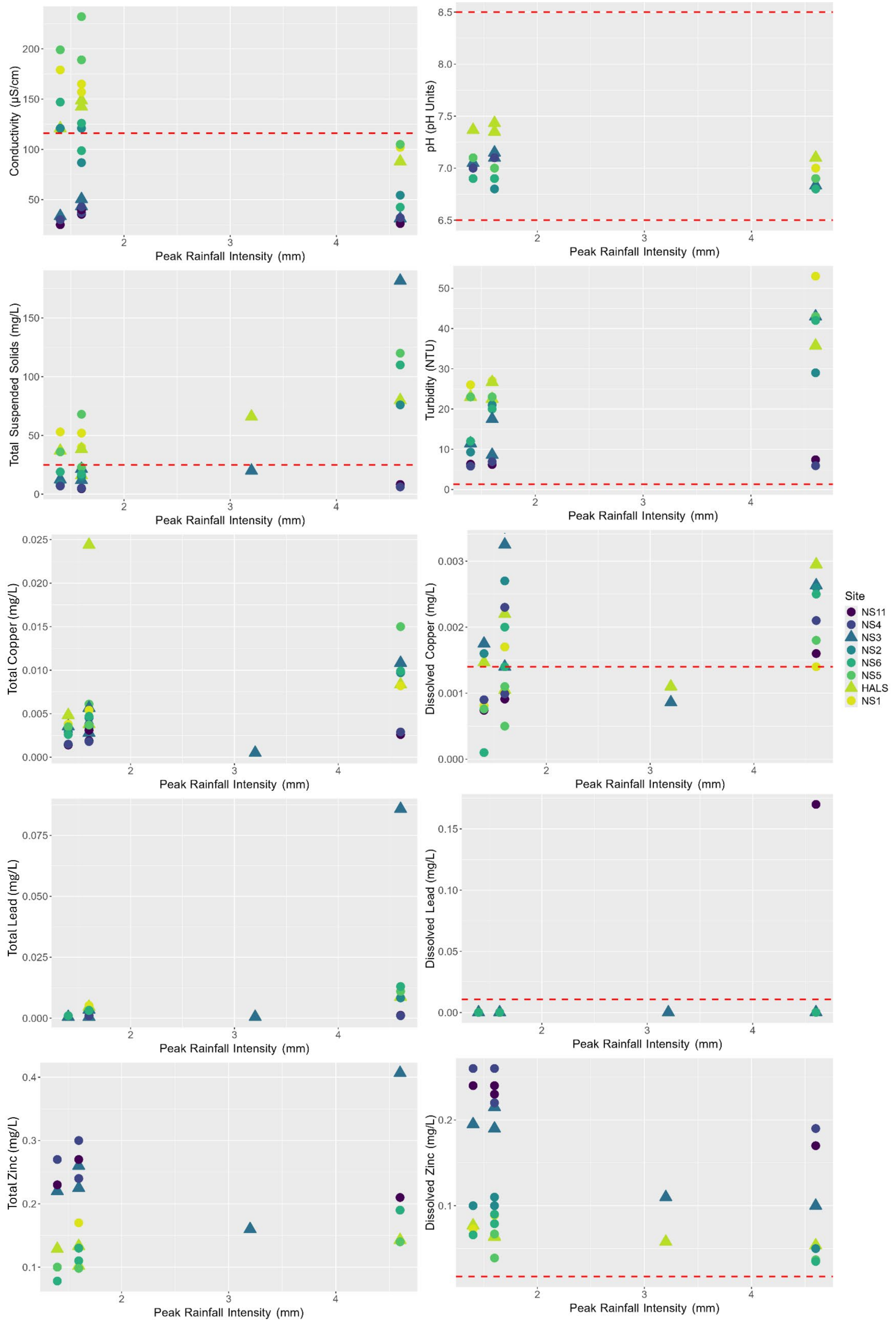

Figure 16 All sampled contaminant parameters wet weather data against the peak rainfall intensity (mm). Red line indicates Attribute Target Level; colour indicates site with legend in order from upstream (NS11) to downstream (NS1); shape indicates sample type (circle = grab; triangle = ISCO).

5.0 Insights & Recommendations

5.1 Dry weather water quality

Dry weather results for Candys Road (NS1) showed some degree of zinc contamination and increased turbidity at the baseline flow level, particularly during winter months. The 95th percentile dissolved zinc ATL exceedances occurred in April and August 2025 samples. However, zinc contamination in-channel was heightened above 95th percentile ATL limits under wet weather conditions in all samples. The cumulative surface catchment imperviousness at Candy's Road was estimated to be 48.7% (Table 1), which is slightly lower than at midstream sites and comparable to upstream locations. There was no evident pattern between imperviousness and recorded dissolved zinc concentrations.

As there is only one dry weather sampling location, it is difficult to definitively ascertain if the dry weather zinc enrichment is related to a.) stormwater inputs with potential later dissolution under drier conditions; or b.) another source within the NS1 catchment area. However, it is noted that non-cumulative imperviousness (i.e., the impervious surfaces pertaining only to the direct catchment area, not all upstream contributions) at the most downstream location (NS1) is the lowest at 18.11%. This indicates the majority of any stormwater run-off impacts at this location are likely to be occurring as a result of cumulative effects of upstream discharges.

5.2 Wet weather water quality

Patterns in repeated wet weather sampling across eight sites indicate that this investigation has captured a representative estimate of instream water quality suitable for assessing EMP compliance with ATLs. The primary contaminants of interest, exhibiting exceedance in median or 95th percentile values, are TSS and conductivity at the most downstream locations (NS5, HALS and NS1), and turbidity, dissolved copper, and dissolved zinc at all sites.

Dissolved zinc concentrations showed a general decrease in a downstream direction (Figure 4), while dissolved copper concentrations were elevated at upstream and midstream sites (NS3 and NS2; Figure 5). The most impervious cumulative catchments were NS5 (51.3%), NS2 (51.2%), NS6 (51.1%) and NS3 (50.2%). At these sites, turbidity and dissolved copper and zinc were in exceedance; however, comparable exceedances also occurred at less impervious sites, indicating that exceedance is not unique to the most impervious locations.

The event-pattern assessment indicates that first-flush behaviour is most evident for particulate indicators (TSS and turbidity), which generally decrease with increasing wet hours; however, this response was not more pronounced at higher-imperviousness sites. In contrast, dissolved copper and dissolved zinc show clearer build-up and wash-off behaviour, with concentrations increasing with antecedent dry period, consistent with stormwater-associated accumulation and mobilisation processes.

For TSS and turbidity, results show a cumulative downstream increase in concentration, with median TSS exceedances confined to downstream sites, rather than a distinct step-change immediately downstream of the most impervious areas. This suggests that particulate elevations are likely only indirectly linked to stormwater contributions and are influenced by cumulative sediment sourcing and/or instream mobilisation, with non-stormwater sources also plausible contributors.

For TSS and turbidity, results showed a cumulative downstream increase in concentration, with median TSS exceedances confined to downstream sites rather than a distinct step-change immediately downstream of the most impervious areas. This suggests that particulate elevations are likely only indirectly linked to stormwater contributions and are influenced by cumulative sediment sourcing and/or instream mobilisation, with non-stormwater sources also plausible contributors.

5.3 Recommendations for stormwater management

Interventions for ensuring greater compliance with EMP-associated ATLs, limited to stormwater, should be focussed primarily on addressing elevations in dissolved copper and zinc.

Enhanced treatment (via source control and stormwater devices) of build-up and wash-off contaminants (zinc and copper) are the priority given the predominance of dissolved forms at stream sites with greater upstream imperviousness and patterns in ADP. Treatment targeting particulate metal removal will be of lesser benefit to addressing EMP compliance. Both dissolved zinc and copper also exhibit patterns of increasing concentrations with ADP, demonstrating potential for increased treatment on contributing impervious surfaces (e.g., roads and non-inert rooves). This could be achieved by either increasing device design volumes or prioritising designs to enhance first-flush treatment (e.g., ensuring bypass of later rather than earlier stormwater runoff).

PDP understands that Council is in the process of investigating the feasibility of a stormwater treatment device to be installed at 46 Nicholls Road, located in the vicinity of the NS3 monitoring site (design details are not currently known). Monitoring results indicate that the highest dissolved copper and zinc concentrations occur at NS3 and within sites further upstream. Targeting treatment to first-flush phenomenon, and the aforementioned priority build-up and wash-off contaminants, could help reduce dissolved metal contaminant loads discharged to Nottingham Stream. The proposed location of the Nicholls Road treatment device may also help mitigate cumulative water quality effects on downstream catchments.

Further investigations identifying higher-risk impervious surfaces (e.g., high vehicle frequency roading and non-painted/inert roofing) could help prioritise where to focus any investment in enhanced first-flush treatment for dissolved copper and zinc (i.e., utilising Council surface libraries and geospatial datasets).

For future EMP assessments, and more broadly across the Council networks, PDP also recommend creating a primary flow layer (combined overland flow path and piped network dataset indicating direction and connection of surface areas with receiving environment). The assessment here has adopted a simplified approach to delineating upstream drainage areas to overlay with the Council surface layer raster meaning there is some uncertainty in above findings.

Overall, the quality of sampled data is reasonable for the scope and purpose of the assessment undertaken. The patterns contained within the data offer clear evidence of limited exceedances, with exceedances in dissolved copper and zinc likely linked to stormwater-derived inputs.

6.0 References

ANZG (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Default Guideline Values (ANZG DGVs) (ANZG, 2018).

Camponelli, K. M., Lev, S. M., Snodgrass, J. W., & Landa, E. R. (2010). Chemical fractionation of Cu and Zn in stormwater, roadway dust and stormwater pond sediments. *Environmental Pollution*, *158*(6), 2143–2149. https://doi.org/10.1016/j.envpol.2010.02.024

CCC (2022). Environmental Monitoring Programme for the Comprehensive Stormwater Network Discharge Consent. Christchurch City Council (CCC). September 2022. Version 9.

CCC (2025a). Environmental Monitoring Programme for the Comprehensive Stormwater Network Discharge Consent. Christchurch City Council (CCC). January 2025. Version 10.

CCC (2025b). Environmental Monitoring Programme for the Comprehensive Stormwater Network Discharge Consent. Christchurch City Council (CCC). November 2025. Version 11.

CCC (2026). Christchurch City Council (CCC) 3-Waters Network Asset Map. Accessed https://gis.ccc.govt.nz/portal/apps/webappviewer/index.html?id=c4ff85ba75724391ae89fbf5f773e00d Accessed February 2026.

Gadd, J., Hickey, C., van Dam, R., Milne, J., and Wood, D. (2023). Implementing bioavailability-based toxicity guideline values for copper and zinc in Aotearoa New Zealand. Interim technical guidance for scientists and practitioners on freshwater applications. National Institute of Water and Atmospheric Research Ltd (NIWA). September 2023.

Haselbach, L., Poor, C., & Tilson, J. (2014). Dissolved zinc and copper retention from stormwater runoff in ordinary portland cement pervious concrete. *Construction and Building Materials*, *53*, 652–657. https://doi.org/10.1016/j.conbuildmat.2013.12.013

Hwang, H. M., Fiala, M. J., Park, D., & Wade, T. L. (2016). Review of pollutants in urban road dust and stormwater runoff: Part 1. Heavy metals released from vehicles. *International Journal of Urban Sciences*, *20*, 334–360. https://doi.org/10.1080/12265934.2016.1193041

LAWA (2026). Land Air Water Aotearoa (LAWA). https://www.lawa.org.nz/explore-data/canterbury-region/river-quality/halswell-river/nottingham-stream-at-candys-rd . Accessed February 2026.

Kingett Mitchell Ltd (2005). Assessment of Urban Stormwater Quality in the Greater Wellington Region. Prepared for Greater Wellington Regional Council. October 2005.

NEMS (2019). National Environmental Monitoring Standards (NEMS) Water Quality. (2019).

Warne, MstJ, Batley, GE, van Dam, RA, Chapman, JC, Fox, DR, Hickey, CW & Stauber, JL. (2018). Revised method for deriving Australian and New Zealand water quality guideline values for toxicants. Prepared for the revision of the Australian and New Zealand guidelines for fresh and marine water quality. October 2018.

Appendix A: Halswell Catchment Site Locations, Monitoring Parameters and Metadata

Appendix A: Halswell Catchment Site Locations, Monitoring Parameters and Metadata

Table A1: Locations in Halswell catchment for wet weather sampling, sites are listed in order from upstream to downstream, left to right.

Sample Type		**Grab**	**Grab**	**ISCO**	**Grab**	**Grab**	**Grab**	**ISCO**	**Grab**
Sample Name		**NS11**	**NS4**	**NS3**	**NS2**	**NS6**	**NS5**	**HALS**	**NS1**
Location		**Ridder Reserve**	**Patterson Terrace**	**Nicholls Road**	**Halswell Junction Road**	**Halswell Junction Road**	**O'Halloran Road**	**570 Halswell Road**	**Candys Road**
Easting		**1564195.201**	**1564330.757**	**1564651.93**	**1565310.021**	**1565260.293**	**1565093.411**	**1564890.725**	**1564532.876**
Northing		**5175171.386**	**5174944.737**	**5174605.227**	**5174071.241**	**5174016.995**	**5173506.781**	**5173245.034**	**5173071.312**
Cumulative Catchment (includes delineated sample point catchment plus upstream area)									
Estimated Cumulative Total Upstream Drainage Area (Ha)		69.0	75.4	101.7	119.2	120.4	145.1	155.5	160.9
Pervious Surfaces in Ha (% of total area in parentheses)	Bare Earth/ Sand/Gravel/Clay/Rock	2.2 (3.2%)	2.2 (3.0%)	2.4 (2.4%)	2.5 (2.1%)	2.5 (2.1%)	2.6 (1.8%)	2.7 (1.7%)	2.8 (1.7%)
	Grass	21.6 (31.3%)	23.3 (30.9%)	30.5 (30.0%)	34.7 (29.1%)	34.9 (29.0%)	42.0 (28.9%)	48.0 (30.8%)	51.1 (31.7%)
	Rough Low Vegetation	0.4 (0.6%)	0.4 (0.6%)	0.4 (0.4%)	0.4 (0.4%)	0.5 (0.4%)	0.5 (0.3%)	0.5 (0.3%)	0.6 (0.4%)
	Trees	9.7 (14.0%)	10.9 (14.4%)	15.0 (14.8%)	18.4 (15.4%)	18.8 (15.6%)	23.4 (16.1%)	24.7 (15.9%)	25.8 (16.1%)
Water		2.3 (3.4%)	2.3 (3.1%)	2.3 (2.3%)	2.3 (2.0%)	2.3 (1.9%)	2.3 (1.6 %)	2.3 (1.5%)	2.4 (1.5%)
Impervious Surfaces in Ha (% of total area in parentheses)	Buildings	16.1 (23.3%)	17.7 (23.4%)	24.3 (23.9%)	28.6 (24.0%)	28.8 (23.9%)	35.2 (24.3%)	36.7 (23.6%)	37.2 (23.1%)
	Impervious Other	16.4 (23.8%)	18.4 (24.4%)	26.5 (26.1%)	32.1 (27.0%)	32.5 (27.0%)	38.9 (26.8%)	40.4 (26.0%)	41.0 (25.5%)
	Roads	0.2 (0.3%)	0.2 (0.3%)	0.2 (0.2%)	0.2 (0.2%)	0.2 (0.2%)	0.2 (0.2%)	0.2 (0.1%)	0.2 (0.1%)
Total Impervious Surfaces in Catchment (%)		**47.4%**	**48.1%**	**50.2%**	**51.2%**	**51.1%**	**51.3%**	**49.7%**	**48.7%**
Non-Cumulative Catchment (includes delineated sample point catchment only)									
Estimated Total Upstream Drainage Area (Ha)		69.0	6.5	26.3	17.5	1.1	24.8	10.4	5.4
Pervious Surfaces in Ha (% of total area in parentheses)	Bare Earth/ Sand/Gravel/Clay/Rock	2.2 (3.2%)	0.0 (0.2%)	0.1 (0.5%)	0.1 (0.7%)	0.0 (0.8%)	0.1 (0.4%)	0.0 (0.4%)	0.1 (2.2%)
	Grass	21.6 (31.3%)	1.7 (25.9%)	7.2 (27.5%)	4.1 (23.7%)	0.2 (18.4%)	7.1 (28.8%)	6.0 (57.5%)	3.1 (57.1%)
	Rough Low Vegetation	0.4 (0.6%)	0.0 (0.0%)	0.0 (0.0%)	0.01(0.0%)	0.0 (0.4%)	0.0 (0.1%)	0.0 (0.2%)	0.1 (1.8%)
	Trees	9.7 (14.1%)	1.2 (18.0%)	4.1 (15.8%)	3.4 (19.4%)	0.4 (32.4%)	4.6 (18.7%)	1.3 (12.0%)	1.1 (20.5%)
Water		2.3 (3.4%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.1%)	0.0 (0.0%)	0.0 (0.2%)
	Buildings	16.1 (23.3%)	1.6 (24.6%)	6.4(25.3%)	4.2 (24.1%)	0.2 (17.4%)	6.5 (26.1%)	1.5 (14.6%)	0.4 (7.6%)
	Impervious Other	16.4 (23.8%)	2.0 (31.3%)	8.1 (30.8%)	5.6 (32.0%)	0.4 (30.5%)	6.4 (25.8%)	1.6 (15.2%)	0.6 (10.5%)

DRAFT

Table A1: Locations in Halswell catchment for wet weather sampling, sites are listed in order from upstream to downstream, left to right.									
Sample Type		**Grab**	**Grab**	**ISCO**	**Grab**	**Grab**	**Grab**	**ISCO**	**Grab**
Sample Name		**NS11**	**NS4**	**NS3**	**NS2**	**NS6**	**NS5**	**HALS**	**NS1**
Location		**Ridder Reserve**	**Patterson Terrace**	**Nicholls Road**	**Halswell Junction Road**	**Halswell Junction Road**	**O'Halloran Road**	**570 Halswell Road**	**Candys Road**
Easting		**1564195.201**	**1564330.757**	**1564651.93**	**1565310.021**	**1565260.293**	**1565093.411**	**1564890.725**	**1564532.876**
Northing		**5175171.386**	**5174944.737**	**5174605.227**	**5174071.241**	**5174016.995**	**5173506.781**	**5173245.034**	**5173071.312**
Impervious Surfaces in Ha (% of total area in parentheses)	Roads	0.2 (0.3%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)	0.0 (0.0%)
Total Impervious Surfaces in Catchment (%)		**47.4%**	**55.9%**	**56.1%**	**56.1%**	**47.9%**	**51.9%**	**29.8%**	**18.11%**

Notes:

1. *Cumulative absolute area includes upstream drainage and drainage within delineated stormwater catchment area.*
2. *2. The cumulative area downstream of NS1 (i.e. the total Nottingham Stream catchment) is estimated at 172.844 ha.*

DRAFT

Table A2: Monitoring Parameters

Analyte	Units	CSNDC EMP Attribute Target Levels for Huritini/Halswell Catchment		Candys Road 95% Species Protection[2]
		Guideline Level	Conditions[1]	
Conductivity	µS/cm	116	Median	-
Dissolved Copper[3]	mg/L	≤0.0014	95th percentile	≤0.0028
Dissolved Lead[3]	mg/L	≤0.0109	95th percentile	≤0.0114
Dissolved Zinc[3]	mg/L	≤0.0174	95th percentile	≤0.0179
Total Copper	mg/L	-	-	-
Total Lead	mg/L	-	-	-
Total Zinc	mg/L	-	-	-
pH	pH units	6.5 - 8.5	Median	-
TSS	mg/L	≤25	Median	-
Turbidity	NTU	≤1.3	Median	-

Notes:

1. *Statistical value the ATL shall be applied to.*
2. *Based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018). Metals guidelines are 25th percentile of derived 95% species protection bioavailable guideline values calculated for Candys Road dry weather sampling (January 2025 – October 2025).*
2. *Based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018). Metals guidelines are derived 95% species protection bioavailable guideline values calculated using the 5-year median for the Huritini/Halswell River Catchment as outlined in the EMP Version 11.*

DRAFT

Table A3: Wet Weather Event Metadata					
Date of Sample	4/06/2025	28/06/2025	3/07/2025	30/07/2025	13/11/2025
Start of Rainfall Event	1600 4/6/2025	0300 27/6/2025	0400 3/07/2025	0800 30/07/2025	0200 13/11/2025
Finish of Rainfall Event	0600 5/6/2025	2400 27/6/2025	1100 4/07/2025	1100 31/07/2025	1900 13/11/2025
Wet Hours	13	19	23	20	18
Total Rainfall event depth (mm)	15.4	12.6	14.4	14.6	24.2
Peak Rainfall intensity (mm/hr)	3.2	1.6	1.4	1.6	4.6
Antecedent Dry Period (days)	6	6	4	19	2[1]

Notes:

1. *There was a small rainfall event within 3 days, 11th November 2025 (3.4mm between 3am and 7am), this was not sampled as it wasn't forecast to rain, a large event was due 13th November 2025, this was sampled at Council's request.*

DRAFT

Table A4: Flow between aliquots for each event		
Event	**Discharge volume between aliquots (m^3)**	
	NS3[1]	**HALS[2]**
4 June 2025	135.03	217.77
27 June 2025	155.73	258.62
3 July 2025	283.01	938.78
30 July 2025	240.73	816.02
13 November 2025	331.02	703.18

Notes:

1. *Based on predicted event volume only, no baseflow. Rainfall/discharge relationship of y= 528.52x + 16.634 (where x = predicted event rainfall).*
2. *Based on combined event and baseflow volume. Rainfall/discharge relationship of y = 1043.4x – 1135.8 (where x = predicted event rainfall).*

DRAFT

Appendix B: Site Specific Guidelines

Table B1: Site-Specific Derived Guideline Values 95% Species Protection			
	Dissolved Lead Guideline	**Dissolved Copper Guideline**	**Dissolved Zinc Guideline**
14/01/2025	0.0100	0.0028	0.0164
27/02/2025	0.0116	0.0028	0.0182
27/03/2025	0.0113	0.0038	0.0178
29/04/2025	0.0113	0.0041	0.0178
27/05/2025	0.0133	0.0023	0.0200
26/06/2025	0.0135	0.0049	0.0202
24/07/2025	0.0135	0.0023	0.0202
21/08/2025	0.0141	0.0052	0.0207
23/09/2025	0.0130	0.0030	0.0196
21/10/2025	0.0137	0.0036	0.0204
25th Percentile	**0.0114**	**0.0028**	**0.0179**
Median	**0.0132**	**0.0033**	**0.0198**
75th Percentile	**0.0135**	**0.0040**	**0.0202**

Notes:

1. *Based on Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018). Calculations from Warne et al., 2018 and Gadd et al., 2023.*
2. *All values in mg/L.*

DRAFT

Appendix C: Wet Weather Sample Results

Table C1: Wet Weather Event Data

		TSS	Total Copper	Dissolved Copper	Copper Partitioning Ratio	Total Lead	Dissolved Lead	Total Zinc	Dissolved Zinc	Zinc Partitioning Ratio	pH	Conductivity	Turbidity
Sample Type	**Site**	**mg/L**	**mg/L**	**mg/L**		**mg/L**	**mg/L**	**mg/L**	**mg/L**		**pH Units**	**µS/cm**	**NTU**
4 June 2025													
ISCO	NS3	20	0.0005	0.00086	1.72	0.0005	0.00013	0.16	0.11	0.69	-[2]	-[2]	-[2]
ISCO	HALS	66	0.0005	0.0011	2.20	0.0005	0.0001	0.16	0.058	0.36	-[2]	-[2]	-[2]
27 June 2025/28 June 2025													
Grab Sample	NS11	4.8	0.0019	0.00091	0.48	<0.0010	0.00018	0.24	0.23	0.96	7.1	35.4	6.2
Grab Sample	NS4	4.6	0.0018	0.00099	0.55	<0.0010	0.00021	0.24	0.22	0.92	7.1	37	6.9
ISCO	NS3	12	0.0028	0.0014	0.50	0.0005	0.000115	0.225	0.215	0.96	7.15	43.5	8.6
Grab Sample	NS2	16	0.0036	0.0017	0.47	<0.0010	<0.00010	0.13	0.1	0.77	6.9	86.8	21
Grab Sample	NS6	16	0.0034	0.0014	0.41	<0.0010	0.00026	0.11	0.079	0.72	6.9	98.7	20
Grab Sample	NS5	68	0.0061	0.0005	0.08	<0.0010	<0.00010	0.13	0.039	0.30	7	232	23
ISCO	HALS	16	0.0038	0.00105	0.28	0.0005	0.00014	0.102	0.0635	0.62	7.35	142.5	22.5
Grab Sample	NS1	40	0.0036	0.001	0.28	<0.0010	<0.00010	0.11	0.079	0.72	7	165	27
3 July 2025													
Grab Sample	NS11	7	0.0014	0.00074	0.53	<0.0010	0.00012	0.23	0.24	1.04	7	25.1	6.3
Grab Sample	NS4	7	0.0015	0.0009	0.60	<0.0010	0.00013	0.27	0.26	0.96	7	30	5.8
ISCO	NS3	12.5	0.00355	0.00175	0.49	0.0005	0.00016	0.22	0.195	0.89	7.05	33.65	11.45
Grab Sample	NS2	8.7	0.0029	0.0016	0.55	<0.0010	0.00018	0.1	0.1	1.00	6.9	121	9.3
Grab Sample	NS6	19	0.0026	<0.00010	0.02	<0.0010	0.00013	0.078	0.066	0.85	6.9	147	12
Grab Sample	NS5	36	0.0035	0.00076	0.22	<0.0010	<0.00010	0.1	0.066	0.66	7.1	199	23
ISCO	HALS	37	0.00483	0.00147	0.30	0.0005	0.00021	0.1287	0.077	0.60	7.3667	120.9	23
Grab Sample	NS1	53	0.0038	0.00081	0.21	<0.0010	0.00023	0.1	0.073	0.73	7.1	179	26

Table C1: Wet Weather Event Data

Sample Type	Site	TSS mg/L	Total Copper mg/L	Dissolved Copper mg/L	Copper Partitioning Ratio	Total Lead mg/L	Dissolved Lead mg/L	Total Zinc mg/L	Dissolved Zinc mg/L	Zinc Partitioning Ratio	pH pH Units	Conductivity µS/cm	Turbidity NTU
30 July 2025													
Grab Sample	NS11	4.8	0.0031	0.0023	0.74	<0.0010	0.00018	0.27	0.24	0.89	7.1	39.8	-
Grab Sample	NS4	5.2	0.0038	0.0023	0.61	<0.0010	0.00015	0.3	0.26	0.87	7.1	42.8	-
ISCO	NS3	21.5	0.0057	0.0033	0.58	0.00345	0.00017	0.26	0.19	0.73	7.1	50.5	17.5
Grab Sample	NS2	15	0.0045	0.0027	0.60	0.003	0.0002	0.13	0.11	0.85	6.8	121	-
Grab Sample	NS6	17	0.0047	0.002	0.43	0.0031	0.00017	0.13	0.09	0.69	6.9	126	-
Grab Sample	NS5	23	0.0037	0.0011	0.30	0.0033	0.00012	0.098	0.067	0.68	7	189	-
ISCO	HALS	38.3	0.0244	0.0022	0.09	0.00463	0.00012	0.13	0.06	0.48	7.4	148.7	26.7
Grab Sample	NS1	52	0.0054	0.0017	0.31	0.0052	<0.00010	0.17	0.089	0.52	7	157	-
13 November 2025													
Grab Sample	NS11	8.3	0.0026	0.0016	0.62	0.0012	0.00015	0.21	0.17	0.81	6.8	26.2	7.4
Grab Sample	NS4	6.2	0.0029	0.0021	0.72	<0.0010	0.0002	0.19	0.19	1.00	6.9	32	5.9
ISCO	NS3	181.7	0.01083	0.00263	0.24	0.0859	0.00027	0.41	0.1	0.25	6.8	31.3	43
Grab Sample	NS2	76	0.0097	0.0026	0.27	0.0083	0.00026	0.14	0.05	0.36	6.8	54.4	29
Grab Sample	NS6	110	0.0099	0.0025	0.25	0.013	0.00025	0.19	0.035	0.18	6.8	42.5	42
Grab Sample	NS5	120	0.015	0.0018	0.12	0.011	0.0002	0.14	0.037	0.26	6.9	105	43
ISCO	HALS	80	0.00835	0.00295	0.35	0.0087	0.00017	0.14	0.054	0.38	7.1	87.9	35.8
Grab Sample	NS1	110	0.0082	0.0014	0.17	0.011	0.0001	0.14	0.036	0.26	7	102	53

Notes:

1. *Event Mean Concentration recorded for ISCO data.*
2. *The field meter was not available at short notice, these parameters were measured at the laboratory for subsequent events.*

Table C1: Wet Weather Event Data

		TSS	Total Copper	Dissolved Copper	Copper Partitioning Ratio	Total Lead	Dissolved Lead	Total Zinc	Dissolved Zinc	Zinc Partitioning Ratio	pH	Conductivity	Turbidity
Sample Type	Site	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L		pH Units	µS/cm	NTU
4 June 2025													
ISCO	NS3	20	0.0005	0.00086	1.72	0.0005	0.00013	0.16	0.11	0.69	-[2]	-[2]	-[2]
ISCO	HALS	66	0.0005	0.0011	2.20	0.0005	0.0001	0.16	0.058	0.36	-[2]	-[2]	-[2]
27 June 2025/28 June 2025													
Grab Sample	NS11	4.8	0.0019	0.00091	0.48	<0.0010	0.00018	0.24	0.23	0.96	7.1	35.4	6.2
Grab Sample	NS4	4.6	0.0018	0.00099	0.55	<0.0010	0.00021	0.24	0.22	0.92	7.1	37	6.9
ISCO	NS3	12	0.0028	0.0014	0.50	0.0005	0.000115	0.225	0.215	0.96	7.15	43.5	8.6
Grab Sample	NS2	16	0.0036	0.0017	0.47	<0.0010	<0.00010	0.13	0.1	0.77	6.9	86.8	21
Grab Sample	NS6	16	0.0034	0.0014	0.41	<0.0010	0.00026	0.11	0.079	0.72	6.9	98.7	20
Grab Sample	NS5	68	0.0061	0.0005	0.08	<0.0010	<0.00010	0.13	0.039	0.30	7	232	23
ISCO	HALS	16	0.0038	0.00105	0.28	0.0005	0.00014	0.102	0.0635	0.62	7.35	142.5	22.5
Grab Sample	NS1	40	0.0036	0.001	0.28	<0.0010	<0.00010	0.11	0.079	0.72	7	165	27
3 July 2025													
Grab Sample	NS11	7	0.0014	0.00074	0.53	<0.0010	0.00012	0.23	0.24	1.04	7	25.1	6.3
Grab Sample	NS4	7	0.0015	0.0009	0.60	<0.0010	0.00013	0.27	0.26	0.96	7	30	5.8
ISCO	NS3	12.5	0.00355	0.00175	0.49	0.0005	0.00016	0.22	0.195	0.89	7.05	33.65	11.45
Grab Sample	NS2	8.7	0.0029	0.0016	0.55	<0.0010	0.00018	0.1	0.1	1.00	6.9	121	9.3
Grab Sample	NS6	19	0.0026	<0.00010	0.02	<0.0010	0.00013	0.078	0.066	0.85	6.9	147	12
Grab Sample	NS5	36	0.0035	0.00076	0.22	<0.0010	<0.00010	0.1	0.066	0.66	7.1	199	23
ISCO	HALS	37	0.00483	0.00147	0.30	0.0005	0.00021	0.1287	0.077	0.60	7.3667	120.9	23
Grab Sample	NS1	53	0.0038	0.00081	0.21	<0.0010	0.00023	0.1	0.073	0.73	7.1	179	26

Table C1: Wet Weather Event Data													
		TSS	Total Copper	Dissolved Copper	Copper Partitioning Ratio	Total Lead	Dissolved Lead	Total Zinc	Dissolved Zinc	Zinc Partitioning Ratio	pH	Conductivity	Turbidity
Sample Type	Site	mg/L	mg/L	mg/L		mg/L	mg/L	mg/L	mg/L		pH Units	µS/cm	NTU
30 July 2025													
Grab Sample	NS11	4.8	0.0031	0.0023	0.74	<0.0010	0.00018	0.27	0.24	0.89	7.1	39.8	-
Grab Sample	NS4	5.2	0.0038	0.0023	0.61	<0.0010	0.00015	0.3	0.26	0.87	7.1	42.8	-
ISCO	NS3	21.5	0.0057	0.0033	0.58	0.00345	0.00017	0.26	0.19	0.73	7.1	50.5	17.5
Grab Sample	NS2	15	0.0045	0.0027	0.60	0.003	0.0002	0.13	0.11	0.85	6.8	121	-
Grab Sample	NS6	17	0.0047	0.002	0.43	0.0031	0.00017	0.13	0.09	0.69	6.9	126	-
Grab Sample	NS5	23	0.0037	0.0011	0.30	0.0033	0.00012	0.098	0.067	0.68	7	189	-
ISCO	HALS	38.3	0.0244	0.0022	0.09	0.00463	0.00012	0.13	0.06	0.48	7.4	148.7	26.7
Grab Sample	NS1	52	0.0054	0.0017	0.31	0.0052	<0.00010	0.17	0.089	0.52	7	157	-
13 November 2025													
Grab Sample	NS11	8.3	0.0026	0.0016	0.62	0.0012	0.00015	0.21	0.17	0.81	6.8	26.2	7.4
Grab Sample	NS4	6.2	0.0029	0.0021	0.72	<0.0010	0.0002	0.19	0.19	1.00	6.9	32	5.9
ISCO	NS3	181.7	0.01083	0.00263	0.24	0.0859	0.00027	0.41	0.1	0.25	6.8	31.3	43
Grab Sample	NS2	76	0.0097	0.0026	0.27	0.0083	0.00026	0.14	0.05	0.36	6.8	54.4	29
Grab Sample	NS6	110	0.0099	0.0025	0.25	0.013	0.00025	0.19	0.035	0.18	6.8	42.5	42
Grab Sample	NS5	120	0.015	0.0018	0.12	0.011	0.0002	0.14	0.037	0.26	6.9	105	43
ISCO	HALS	80	0.00835	0.00295	0.35	0.0087	0.00017	0.14	0.054	0.38	7.1	87.9	35.8
Grab Sample	NS1	110	0.0082	0.0014	0.17	0.011	0.0001	0.14	0.036	0.26	7	102	53

Notes:

1. *Event Mean Concentration recorded for ISCO data.*
2. *The field meter was not available at short notice, these parameters were measured at the laboratory for subsequent events.*

Table C2: Summary statistics for wet weather samples									
Percentile	**Min**	**25th**	**Med**	**75th**	**95th**	**Max**	**Count**	**EMP ATLs**	**Candys Road 95% Species Protection**
Nottingham Stream 11 (NS11)									
Conductivity (µS/cm)	25.1	25.925	30.8	36.5	39.14	39.8	4	**116**	-
Dissolved Copper	0.00074	0.00087	0.00126	0.00178	0.00220	0.0023	4	**≤0.0014**	**≤0.0028**
Total Copper	0.0014	0.00178	0.00225	0.00273	0.00303	0.0031	4	-	-
Dissolved Lead	0.00012	0.000143	0.000165	0.00018	0.00018	0.00018	4	**≤0.0109**	**≤0.0114**
Total Lead	*0.00005*	*0.00005*	*0.00005*	0.000338	0.001028	0.0012	4	-	-
Dissolved Zinc	0.17	0.215	0.235	0.24	**0.24**	0.24	4	**≤0.0174**	**≤0.0179**
Total Zinc	0.21	0.225	0.235	0.2475	0.2655	0.27	4	-	-
pH (pH units)	6.8	6.95	7.05	7.1	7.1	7.1	4	**6.5 - 8.5**	-
TSS	4.8	4.8	5.9	7.3	8.1	8.3	4	**≤25**	-
Turbidity (NTU)	6.2	6.3	6.3	6.9	7.3	7.4	3	**≤1.3**	-
Nottingham Stream 4 (NS4)									
Conductivity (µS/cm)	30	31.5	34.5	38.45	41.93	42.8	4	**116**	-
Dissolved Copper	0.0009	0.00097	0.00155	0.00215	0.00227	0.0023	4	**≤0.0014**	**≤0.0028**
Total Copper	0.0015	0.00173	0.00235	0.00313	0.00367	0.0038	4	-	-
Dissolved Lead	0.00013	0.00015	0.00018	0.00020	0.000209	0.00021	4	**≤0.0109**	**≤0.0114**

Table C2: Summary statistics for wet weather samples									
Percentile	**Min**	**25th**	**Med**	**75th**	**95th**	**Max**	**Count**	**EMP ATLs**	**Candys Road 95% Species Protection**
Total Lead	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	*0.0005*	4	**-**	**-**
Dissolved Zinc	0.19	0.2125	0.24	0.26	**0.26**	0.26	4	**≤0.0174**	**≤0.0179**
Total Zinc	0.19	0.2275	0.255	0.2775	0.2955	0.3	4	**-**	**-**
pH (pH units)	6.9	7.0	7.1	7.1	7.1	7.1	4	**6.5 - 8.5**	**-**
TSS	4.6	5.1	5.7	6.4	6.9	7	4	**≤25**	**-**
Turbidity (NTU)	5.8	5.9	5.9	6.4	6.8	6.9	3	**≤1.3**	**-**
Nicholls Road (NS3) - ISCO									
Conductivity (µS/cm)	31.33333	32	38.6	47	49.45	50.5	5	**116**	**-**
Dissolved Copper	0.00086	0.00135	0.00175	0.00268	**0.003127**	0.00325	5	**≤0.0014**	**≤0.0028**
Total Copper	0.0005	0.00298	0.00355	0.00578	0.009797	0.010833	5	**-**	**-**
Dissolved Lead	0.000115	0.00014	0.000155	0.00019	0.00025	0.00027	5	**≤0.0109**	**≤0.0114**
Total Lead	0.0005	0.0005	0.0005	0.00358	0.069383	0.085867	5	**-**	**-**
Dissolved Zinc	0.1	0.1025	0.19	0.2275	**0.211**	0.215	5	**≤0.0174**	**≤0.0179**
Total Zinc	0.16	0.1925	0.225	0.255	0.377333	0.406667	5	**-**	**-**
pH (pH units)	6.83	6.9	7.08	7.1	7.14	7.15	5	**6.5 - 8.5**	**-**
TSS	12	13.75	20	24.5	149.6333	181.6667	5	**≤25**	**-**
Turbidity (NTU)	8.6	9.9	14.48	21	39.175	43	5	**≤1.3**	**-**

Table C2: Summary statistics for wet weather samples									
Percentile	**Min**	**25th**	**Med**	**75th**	**95th**	**Max**	**Count**	**EMP ATLs**	**Candys Road 95% Species Protection**
Nottingham Stream 2 (NS2)									
Conductivity (µS/cm)	54.4	78.7	103.9	121	121	121	4	**116**	**-**
Dissolved Copper	0.0016	0.00168	0.00215	0.00263	0.00269	0.0027	4	**≤0.0014**	**≤0.0028**
Total Copper	0.0029	0.00343	0.00405	0.0058	0.00892	0.0097	4	**-**	**-**
Dissolved Lead	*0.00005*	0.000195	0.00019	0.00032	0.00025	0.00026	4	**≤0.0109**	**≤0.0114**
Total Lead	0.0005	0.0005	0.00175	0.004325	0.007505	0.0083	4	**-**	**-**
Dissolved Zinc	0.05	0.0875	0.1	0.1025	**0.1085**	0.11	4	**≤0.0174**	**≤0.0179**
Total Zinc	0.1	0.1225	0.13	0.1325	0.1385	0.14	4	**-**	**-**
pH (pH units)	6.8	6.8	6.9	6.9	6.9	6.9	4	**6.5 - 8.5**	**-**
TSS	8.7	13.4	15.5	31	67	76	4	**≤25**	**-**
Turbidity (NTU)	9.3	15.2	21	25	28.2	29	3	**≤1.3**	**-**
Nottingham Stream 6 (NS6)									
Conductivity (µS/cm)	42.5	84.7	112.4	131.3	143.9	147	4	**116**	**-**
Dissolved Copper	*0.00005*	0.0017	0.0017	0.00225	0.00243	0.0025	4	**≤0.0014**	**≤0.0028**
Total Copper	*0.0026*	0.0032	0.00405	0.006	0.00912	0.0099	4	**-**	**-**
Dissolved Lead	0.00013	0.00016	0.00021	0.00025	0.00026	0.00026	4	**≤0.0109**	**≤0.0114**

Table C2: Summary statistics for wet weather samples									
Percentile	**Min**	**25th**	**Med**	**75th**	**95th**	**Max**	**Count**	**EMP ATLs**	**Candys Road 95% Species Protection**
Total Lead	0.0031	0.005575	0.00805	0.010525	0.012505	0.013	4	-	-
Dissolved Zinc	0.035	0.05825	0.0725	0.08175	**0.08835**	0.09	4	**≤0.0174**	**≤0.0179**
Total Zinc	0.078	0.102	0.12	0.145	0.181	0.19	4	-	-
pH (pH units)	6.8	6.9	6.9	6.9	6.9	6.9	4	**6.5 - 8.5**	-
TSS	16	16.8	18	41.8	96.4	110	4	**≤25**	-
Turbidity (NTU)	12	16	20	31	39.8	42	3	**≤1.3**	-
Nottingham Stream 5 (NS5)									
Conductivity (µS/cm)	105	168	194	207.25	227.05	232	4	**116**	-
Dissolved Copper	0.0005	0.000695	0.00093	0.001275	0.001695	0.0018	4	**≤0.0014**	**≤0.0028**
Total Copper	0.0035	0.00365	0.0049	0.00833	0.01367	0.015	4	-	-
Dissolved Lead	*0.00005*	*0.00005*	0.000085	0.0005	0.00019	0.0002	4	**≤0.0109**	**≤0.0114**
Total Lead	*0.0005*	*0.0005*	0.0019	0.005225	0.009845	0.011	4	-	-
Dissolved Zinc	0.037	0.0385	0.0525	0.06625	**0.06685**	0.067	4	**≤0.0174**	**≤0.0179**
Total Zinc	0.098	0.0995	0.115	0.1325	0.1385	0.14	4	-	-
pH (pH units)	6.9	6.975	7	7.025	7.085	7.1	4	**6.5 - 8.5**	-
TSS	23	32.8	52	81	112.2	120	4	**≤25**	-

Table C2: Summary statistics for wet weather samples									
Percentile	**Min**	**25th**	**Med**	**75th**	**95th**	**Max**	**Count**	**EMP ATLs**	**Candys Road 95% Species Protection**
Turbidity (NTU)	23	23	23	33	41	43	3	**≤1.3**	**-**
Halswell Road (HALS) - ISCO									
Conductivity (µS/cm)	87.9	95.0	131.7	158.3	147.7	148.7	5	**116**	**-**
Dissolved Copper	0.00105	0.0014	0.001467	0.0026	0.0028	0.00295	5	**≤0.0014**	**≤0.0028**
Total Copper	0.0005	0.0048	0.004833	0.008	0.02119	0.0244	5	**-**	**-**
Dissolved Lead	0.0001	0.00012	0.00014	0.0002	0.000205	0.000213	5	**≤0.0109**	**≤0.0114**
Total Lead	0.0005	0.0005	0.0005	0.0045	0.007907	0.008725	5	**-**	**-**
Dissolved Zinc	0.05375	0.054	0.0635	0.075	**0.074467**	0.077	5	**≤0.0174**	**≤0.0179**
Total Zinc	0.102	0.11	0.133333	0.15	0.15655	0.16	5	**-**	**-**
pH (pH units)	7.1	7.25	7.4	7.4	7.4	7.4	5	**6.5 - 8.5**	**-**
TSS	16	29	38.3	66	77.2	80	5	**≤25**	**-**
Turbidity (NTU)	22.5	20.5	24.8	31.5	34.3875	35.75	5	**≤1.3**	**-**
Nottingham Stream 1 (NS1)									
Conductivity (µS/cm)	143.25	135	161	168.5	176.9	179	4	**116**	**-**
Dissolved Copper	0.00081	0.00095	0.0012	0.1475	0.00166	0.0017	4	**≤0.0014**	**≤0.0028**
Total Copper	0.0036	0.00375	0.0046	0.0061	0.00778	0.0082	4	**-**	**-**

Table C2: Summary statistics for wet weather samples									
Percentile	**Min**	**25th**	**Med**	**75th**	**95th**	**Max**	**Count**	**EMP ATLs**	**Candys Road 95% Species Protection**
Dissolved Lead	*0.00005*	*0.00005*	*0.00005*	0.00020	0.00022	0.00023	4	**≤0.0109**	**≤0.0114**
Total Lead	0.0052	0.00665	0.0081	0.00955	0.01071	0.011	4	-	-
Dissolved Zinc	0.036	0.06375	0.076	0.0815	**0.0875**	0.089	4	**≤0.0174**	**≤0.0179**
Total Zinc	0.1	0.1075	0.125	0.1475	0.1655	0.17	4	-	-
pH (pH units)	7	7	7	7.03	7.09	7.1	4	**6.5 - 8.5**	-
TSS	40	49	52.5	67.3	101.5	110	4	**≤25**	-
Turbidity (NTU)	26	26.5	27	40	50.4	53	3	**≤1.3**	-

Notes:

1. *Units are mg/L unless otherwise stated in brackets.*
2. *Italics indicates that sample concentrations were below laboratory detection for this indicator.*
3. *Median or 95th percentile values compared to EMP Attribute Target Levels, Green highlighted values are compliant with EMP ATLs, Orange highlighted values exceed EMP ATLs. **Bold** results are also above the 25th percentile of 2025 dry weather site-specific guideline values for metals (refer to Appendix A:).*

Appendix D: Dissolved Lead Concentration Plot

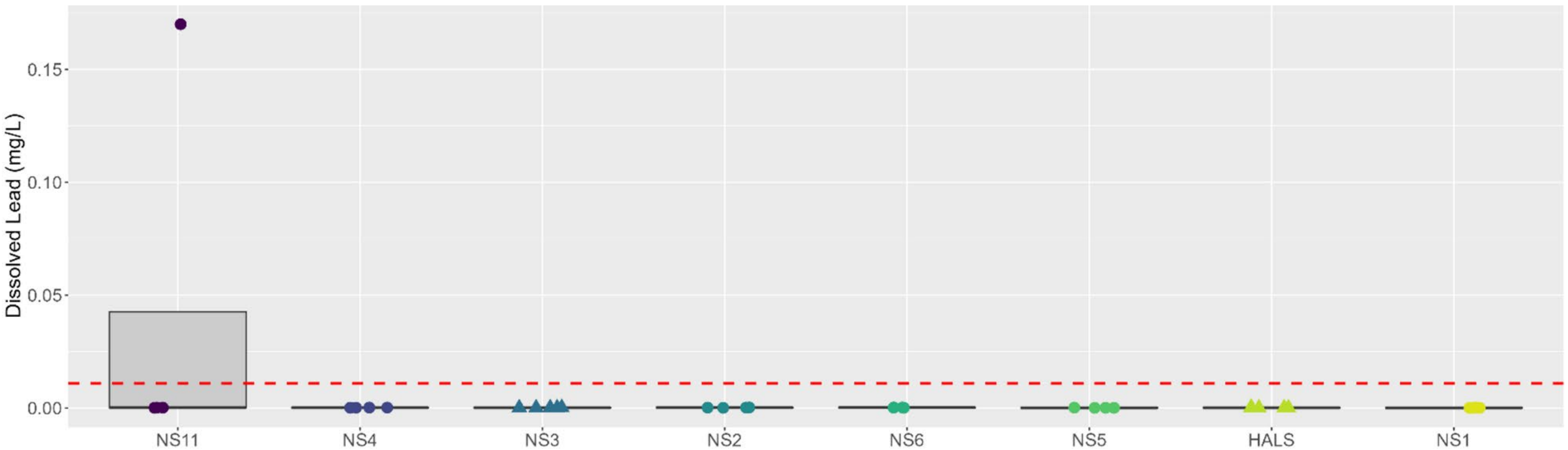

Figure D1: Wet weather event dissolved lead data, red line indicates Attribute Target Level (presented upstream to downstream, left to right, triangles represent ISCO samples and circles represent grab samples