Appendix I:

River Water Quality Monitoring Report

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GISBORNE DISTRICT COUNCIL

WASTEWATER OVERFLOW ASSESSMENT RIVER MONITORING REPORT

For Gisborne District Council
Lifelines

June 2020

REPORT INFORMATION AND QUALITY CONTROL

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EXECUTIVE SUMMARY

Controlled wastewater overflow events occur in Gisborne due to excessive ingress of stormwater into the wastewater network during heavy rainfall. Where this occurs to the point where the capacity of Gisborne District Council's (GDC) wastewater network will be exceeded, overflow valves are opened to discharge the overflows, primarily to the Taruheru, Waimata and Turanganui Rivers and several other smaller watercourses. This controlled discharge is undertaken to avoid the more significant public health risks associated with uncontrolled wastewater overflows including back-flow on to private property (in toilets and gully traps) and discharges from manholes. GDC records indicate that wet weather overflows occurred on average 2.5 times per year from 2006 to 2019, during heavy rainfall.

Wastewater overflows, although they are of relatively short duration, can give rise to a range of adverse effects. These include the direct discharge of wastewater to water, which is culturally offensive to iwi and unacceptable to the community, an increase in pathogenic microbiological contaminants that can cause a risk to public health, and a contribution to nutrient and other contaminant loads.

The Council has committed to a programme of work, as part of its DrainWise programme, to improve the wastewater and stormwater systems and reduce the frequency of overflows. This includes identifying illegal stormwater connections and sources of high stormwater inflows, particularly on private property, and requiring these to be rectified.

In accordance with the Tairāwhiti Resource Management Plan, GDC is required to obtain a resource consent for wet weather overflows from its wastewater network. To inform GDC's wastewater overflow resource consent application and associated assessment of environmental effects (AEE), GDC implemented a water quality monitoring programme in early 2017 to assess the effect of the controlled wastewater overflows in Gisborne on the water quality in freshwater and estuarine receiving environments and the interface with coastal waters.

The water quality assessment addressed both the background water quality, from GDC's state of the environment monitoring programme from 2015 to 2019, and from data collected from significant monitoring of seven wastewater overflow events and a large 'rain-only' event (where there were no overflows). Overflow/rainfall event monitoring included three in-network sites, to assess the composition of stormwater-diluted wastewater, and some 12 river/estuarine sites across the Taruheru, Waimata and Turanganui Rivers, the Waikanae Stream and the Kopuawhakapata Stream. In the initial overflow/rain event monitoring programme, a wide range of parameters were monitored to provide a broad assessment of the effects of wastewater overflows. These included microbial indicators, nutrients, metals and some other parameters.

Background water quality

Analysis of state of the environment (routine) water quality sampling for Gisborne's main urban rivers was undertaken. This analysis excluded any periods where wastewater overflows occurred to provide an indication of river water quality without the influence of overflows. This assessment has indicated the following:

- The highest concentrations of enterococci, nutrients, and sediment were typically measured at the most upstream sites. This indicates that, in general, the primary source of these is from the upper catchment. The obvious exception to this is the Waimata River, where there was typically an increase between the most upstream site (Goodwins) and the nearest downstream site (Grant). This indicates that the predominant source of most contaminants is between these two sites. It is not possible to identify whether this is a result of the rural or urban land use in this area without further information or studies.
- The median enterococci concentration at all sites except Tuckers on the Taruheru River and Hirini on the Kopuawhakapata Stream were within (less than) the Urban FMU (annual median) guideline of 280 CFU/100mL. The 95th percentile of data at all sites, however, exceeded (greater than) the Urban FMU 95th percentile guideline of 500 CFU/100 mL. As background water quality was assessed for data that excluded overflow events, this is likely due to high levels of microbial contaminants being discharged from (non-wastewater overflow) catchment sources during rain events – particularly those in the upper catchment.
- Median levels of enterococci in the Kopuawhakapata Stream in particular indicate chronic microbial contamination that is not related to wastewater overflow events.
- Total nitrogen, total phosphorus, and total suspended solids all exceeded their relevant guideline levels at all sites, indicating elevated background levels of these contaminants in the rivers.

- Ammonia (toxicity) was low at all sites and the median concentration was well below the guideline value.
- Metal concentrations were below the analytical level of detection in most samples; however they were, at times, up to an order of magnitude higher than their respective guideline values. Again, these high levels are likely to be associated with heavy rain events, and most likely urban stormwater derived..
- The Kopuawhakapata Stream had the highest metal concentrations, which exceeded the toxicity guideline for 95% protection of species for copper and zinc on 26% and 67% of sampling occasions, respectively.

The effects of wastewater overflows on water quality

Wastewater overflow discharges add to the contaminant loads that are already carried in the rivers during heavy rainfall event. The assessment of the impacts of wastewater overflows on water quality are complicated by a range of factors, including:

1) Rainfall events causing overflows differed in magnitude and hence background contaminant concentrations were different;
2) Each overflow event involved overflows from a different combination of locations (often on different rivers) and different overflow volumes; and
3) Different timing of sampling across events, meaning that it is not possible to determine what part of the overflow 'peak' was sampled.

These complex interactions mean that unpicking the monitoring data and drawing definitive conclusions is difficult. Accordingly, the following conclusions on the impact of wastewater overflows of river water quality are indicative.

- Contaminant levels (faecal bacteria, nutrients, sediment, and metals) increase during rainfall events, even when there are no wastewater overflows. This is due to catchment-derived contaminants. Thus, a primary effect of overflows on water quality is the potential for further increase in contaminant levels over and above the levels that would have occurred during rainfall events without overflows.
- The greatest effect that overflows have on the receiving environment water quality is increasing the levels of faecal bacteria. This is expected as in-network measurements show enterococci concentrations in wastewater overflows to be in the range of less than 1,000,000 to 2,500,000 CFU/100mL following initial dilution by stormwater. The overflows are then further diluted by stormwater runoff and river flow when discharged.
- The maximum measured enterococci concentration in the Taruheru River was higher during overflow events than during rainfall with no overflows. The maximum instream concentration of approximately 60,000 CFU/100ml was measured in the Taruheru River (Overflow Event 2 - 13/04/17) compared to a 'rain-only' maximum level of approximately 40,000 CFU/100mL.
- The maximum measured enterococci concentration in the Waimata River was approximately 40,000 CFU/100mL (Overflow Event 6 - 04/06/18). However, for all other overflow events, including those where overflows occurred to the Waimata River, measured enterococci concentrations were similar to those recorded for the 'rain only' event (approximately 10,000 CFU/100mL).
- The highest measured enterococci concentration in the Turanganui River (@ the Cut) was approximately 40,000 CFU/100mL (Overflow Event 1 - 04/04/17). However, for all other overflow events, including those where overflows occurred to the Waimata River, measured enterococci concentrations were similar to those recorded for the 'rain only' event (approximately 10,000 CFU/100mL).
- The Kopuawhakapata Stream had elevated levels of enterococci (30–40,000 CFU/100mL) for several events including with and without overflows.
- Nitrogen concentrations in the Gisborne urban rivers was more highly elevated than phosphorus during wastewater overflows. Maximum ammonia concentrations were all below the guideline value during overflow events and, therefore, posed little risk of toxicity to aquatic organisms. Overall, the effect of overflows on the levels of nutrients appears to be generally low as the maximum concentrations measured during overflow events are in a similar range to those measured during rainfall with no overflows, infrequent and of short duration.
- Maximum total suspended solid concentrations were frequently lower during overflow events than during rainfall events with no overflows. This is most likely to the nature of the storm event that was sampled and wider catchment characteristics than any relationship with the overflow discharge (e.g., greater dilution).

- Metal concentrations (dissolved copper and dissolved zinc) were generally low in the rivers. During wastewater overflows, the stormwater component, rather than the wastewater component, is likely to be the dominant source of metals.
- Maximum fluoride concentrations generally increased from upstream to downstream, suggesting that wastewater overflows were likely to be the dominant source in the lower catchment. However, elevated fluoride concentrations were also measured at locations not affiliated with wastewater overflows and the sources are not clear.
- Contaminants in the river typically revert to pre-event concentrations within 24–48 hours of an overflow. This period is no longer than would be expected following heavy rainfall with no overflows; that is, the wastewater overflows don't appear to prolong degraded water quality following heavy rainfall any more than due to the rainfall itself. However, as above, contaminant concentrations (particularly microbial) are higher during an overflow event.

Routine and overflow event monitoring has shown that there are a number of contaminants that are primarily sourced from non-urban areas higher up in the catchment; that is, there are elevated levels of contaminants that are not derived from wastewater network discharges. Notable examples include enterococci in the Taruheru River and total nitrogen, ammonia, and total suspended solids in all catchments. During a rainfall event with or without overflows, these contaminants are generally highest in the upper-catchment sites and become more diluted as they move downstream and are mixed with further stormwater and, when they occur, overflows. Water quality in the mid to lower catchment is affected by urban-sourced contaminants, such as those from stormwater runoff and, during an overflow event, from wastewater overflows.

The Taruheru River has the highest recorded levels of microbial contamination. In general, water quality in the Taruheru River appears to be the most heavily affected river during rainfall with and without overflow events. This is likely due to a combination of factors including land use within the catchment, the number of potential overflow locations along the river, and the volume of water that is discharged at each location during an overflow event.

Water quality in the Waimata and Waikanae catchments appear to be largely dominated by catchment-derived contaminants. This is especially so for suspended sediment in the Waimata catchment. On the occasion that an overflow does occur on the river, water quality is degraded below this point. However, in general, contaminants are higher in the upper catchment and become more diluted downstream.

The Waikanae Stream, which has not received overflows in any of the events, showed elevated contaminant concentrations in some rain events including enterococci (up to 60,000 CFU/100ml), ammonia, metals (particularly copper) and fluoride. This suggests other catchment sources of most contaminants, including microbial contaminants.

The Kopuawhakapata Stream has been noted as showing signs of chronic contamination. Elevated levels of ammonia and faecal bacteria point toward wastewater contamination. One potential cause of this is illegal cross-connections that may warrant further investigation to determine the number of these connections, if any, and the frequency at which they discharge.

Potential impacts of future changes

Wastewater overflows are now controlled through two primary (Seymour Rd/Turenne St [Waimata River] and Wainui Road [Turanganui River]) and two secondary (Oak St and Palmerston Rd/Peel St [both Taruheru River]) overflow points. Limiting overflows to these more downstream sites will help maximise dilution and flushing from the river and tidal flushing and should reduce the potential impact that overflows will have on water quality in the urban river reaches – particularly in the Taruheru River which only has secondary overflows and hence will receive fewer overflow events. As the DrainWise programme is implemented, and the frequency and volume of overflows is progressively reduced, the wastewater contribution to degraded water quality during rain events will similarly reduce. However, the background water quality, as evidenced by the routine monitoring, will remain unchanged unless there are changes in the wider catchments or other measures put in place.

The Tairāwhiti Resource Management Plan sets out objectives for the improvement of water quality in the Gisborne region. The plan includes for specific parameters, the current state of the environment statistics, and limits/future targets for each parameter.

For enterococci, the limits set for the catchments relevant to this study (Gisborne Urban Freshwater Management Unit) aim to keep the median recorded concentration at <280 CFU/100mL, and the 95th percentile value to <500 CFU/100mL.

Given the infrequent overflows and short duration of the effects of an overflow event, as discussed in this report, it is only likely to be the 95th percentile value that overflow events will influence. DrainWise seeks to significantly reduce overflow frequency, the number of overflow locations and overflow volumes. This will assist in improving overall water quality and achieving this 'improvement' target sought by the TRMP. However, the 95th percentile value objective of <500 CFU/100mL is currently not met for 'background water quality' (excluding the effects of overflows) at any site assessed in this report and hence substantial improvement in catchment water quality will be required for this to be achieved.

1 INTRODUCTION

1.1 Background

Controlled wastewater overflow events occur in Gisborne due to excessive ingress of stormwater into the wastewater network during heavy rainfall. Where this occurs to the point where the capacity of Gisborne District Council's (GDC) wastewater network will be exceeded, overflow valves are opened to discharge the overflows, primarily to the Taruheru, Waimata and Turanganui Rivers. An ephemeral open drain next to Seymour Street is also used. It is possible that several other smaller watercourses could be impacted (if tertiary overflow points have to be opened), although this is highly unlikely. This controlled discharge is undertaken to avoid the more significant public health risks associated with uncontrolled wastewater overflows including back-flow on to private property (in toilets and gully traps) and discharges from manholes.

GDC records[1] indicate that wet weather overflows occurred on average 2.5 times per year from 2006 to 2019, during sustained heavy rainfall.

Wastewater overflows, although they are of relatively short duration, can give rise to a range of adverse effects. These include the direct discharge of wastewater to water, which is culturally offensive to iwi and unacceptable to the community, an increase in pathogenic microbiological contaminants that can cause a risk to public health, and a minor contribution to nutrient and other contaminant loads that are derived from other catchment sources.

The Council has committed to a programme of work, the DrainWise programme, to upgrade the wastewater and stormwater systems and reduce the frequency of overflows. This includes identifying illegal stormwater connections and sources of high stormwater inflows, particularly on private property, and requiring these to be rectified.

1.2 Water Quality Monitoring Programme

In accordance with the Tairāwhiti Resource Management Plan (TRMP), GDC is required to obtain a resource consent for overflows from its wastewater network. To inform GDC's wastewater overflow resource consent application and associated assessment of environmental effects (AEE), GDC implemented a water quality monitoring programme in early 2017 to assess the effect of wet weather wastewater overflows in Gisborne on the water quality in freshwater and estuarine receiving environments and the interface with coastal waters. Additional studies were commissioned on the dispersion of overflow events in Tūranganui-a-Kiwa /Poverty Bay, health risks associated with pathogens and emerging organic contaminants and the potential effects of overflows on freshwater and marine ecosystems.

4Sight Consulting Ltd (4Sight) was engaged by GDC to assist with the preparation of the resource consent application and the water quality monitoring programme. This programme built on GDC's existing overflow response monitoring regime but with additional sites and sampling parameters and more frequent post-event monitoring. The monitoring programme was designed to collect data to support the consent acquisition as follows:

1) Within the wastewater network to characterise the nature of stormwater-diluted wastewater overflows;
2) From the key rivers affected by wastewater overflows;
3) Upstream and downstream in major rivers to differentiate contributions from up-catchment sources;
4) At several points along the Taruheru and Waimata Rivers to assess changes/difference along the water body;
5) Sampling for key indicator parameters – microbial, nutrients and metals (and other standard parameters);
6) Before (where an overflow event was anticipated), during and following valve closure to assess antecedent conditions and dissipation of effects; and
7) Assess a 'stormwater only' event, to differentiate the water quality impacts of heavy rainfall, with and without the addition of overflows.

[1] Wastewater discharge volumes and river monitoring (vA2462687)

The monitoring programme aimed to capture water quality information from events that occurred, expecting only one or two events over the winter period. However, as evidenced across most of New Zealand, the period from early April to the end of May 2017 was extremely wet resulting in significant flooding in many places. Four separate overflow events occurred in Gisborne over this period. This has resulted in significant and detailed information on the receiving environment quality following overflow events. Following the collection of this detailed information, which characterised the effects on water quality in the rivers, the monitoring programme was reduced to a monitoring regime of only microbial contaminants, being the primary indicator of the health risk effects of overflows. As discussed below, a further three overflows were monitored in 2017 and 2018.

1.3 Purpose of Report

The purpose of this report is to:

- Categorise the monitoring data collected by GDC by parameter type and organise it in such a way that the data can be readily interrogated; and
- Provide an analysis of the data to indicate the state of water quality before an overflow event, during an overflow event, and after the overflow event has ceased, to assess the impact of the overflow on the water quality of the receiving environments both in terms of intensity and duration.

2 OVERFLOW LOCATIONS AND MONITORING METHODS

2.1 Overflow Locations

The GDC wastewater network includes controlled overflow points that are dedicated network relief valves, which are opened if necessary to discharge a mixture of wastewater and stormwater in preference to discharges from uncontrolled points (manholes, gully traps etc) on private property. Opening of the overflow points is governed by a standard operating procedure, which determines if and when an overflow relief valve is opened and in turn, closed.

That is, discharges associated with each wet weather overflow event are controlled, and as such, they are supported by robust information on the location and duration of the overflow. Overflow valves are only opened where necessary such that each overflow event can be a different combination of overflow points, affecting different water bodies, on each occasion.

GDC has made significant advances in reducing the quantity of wastewater discharged and the number of locations at which overflow discharges occur. Management processes continue to be refined and overflows are now controlled through two primary (Seymour Rd/Turenne St [Waimata River] and Wainui Road [Turanganui River]) and two secondary (Oak St and Palmerston Rd/Peel St [both Taruheru River]) overflow points. Up to six 'tertiary' overflow points may also be used if necessary. However, the monitoring below was undertaken prior to this regime being implemented.

In respect of the period over which this report covers, overflow points occurred in the following rivers (but not all rivers for all events):

- Turanganui River;
- Waimata River;
- Taruheru River;
- Lower reach of the Mangapapa Stream (a tributary of the Taruheru River); and
- Lower reach of the Kopuawhakapata Stream.

2.2 Monitored Overflow Events

Prolonged heavy rain caused overflows to occur for four separate periods in early 2017 as follows:

Overflow 1: 4 April 2017 to 5 April 2017 (8 overflow points)

Overflow 2: 13 April 2017 to 14 April 2017 (5 overflow point)

Overflow 3: 12 May 2017 to 13 May 2017 (3 overflow points)

Overflow 4: 28 May 2017 (2 overflow points)

A further three overflow events happened from late 2017 to July 2018. For these events, the monitoring programme was reduced to only monitor faecal bacteria.

Overflow 5: 3 September 2017 (1 overflow point)

Overflow 6: 4 June 2018 (2 overflow points)

Overflow 7: 11 June 2018 (6 overflow points)

A heavy 'rainfall only' event was also sampled from 12 to 18 March 2018, to assess river and estuarine water quality during heavy rain, but in the absence of any overflows.

The overflow points and durations for each event are shown in Table 1 and the overflow locations for each event are mapped in Appendix A. As can be seen from the table, the maximum duration of an overflow was 48 hours during the 11 June 2018 event with the maximum discharge volume (wastewater and stormwater) being 37,000m^3 for the same event. For the other overflow events, overflow durations ranged from 11–26 hours in length and volumes ranged from 7,000 to 27,000m^3. Additionally, Overflow 5 only occurred at one point, Wainui Road.

2.3 Monitoring Programme

As indicated above, an initial monitoring programme was established to capture detailed information on the quality of the receiving environments that are likely to be affected by the wastewater overflows.

2.3.1 Monitoring Locations

Monitoring was conducted at 15 sites within the Gisborne city region (Table 2). These 15 monitoring sites were separated into 12 river sites or 'in-stream' sites, and three network sites ('in-pipe' sites). Figure 1 shows the location of the 15 sampling sites monitored, the results of which are discussed further in this report.

Each stream (where possible) was sampled well upstream out of the potential effects of the overflow and tidal influence, as well as at various locations down the length of the stream and down to the coast to characterise the quality of the river prior to it entering the urban area potentially affected by overflows. In addition to the main streams potentially affected by overflows discussed above, two sites were located on the Waikanae Stream. These Waikanae Stream sites were monitored to assess the effects of overflows to the stream (should any occur), and to provide an indication of the effects of urban stormwater discharge on the stream in the absence of an overflow event. As there were no overflows to the Waikanae Stream during the monitoring period, the results for this stream indicate contaminants such as metals, nutrients and bacteria to these streams from other sources within the catchment.

The three network sites were monitored with samples being collected from within the wastewater pipe itself (during heavy rain) to characterise the quality of stormwater-diluted wastewater prior to discharge. This information was then used for the hydrodynamic modelling of the discharge within the bay.

All data collected for the overflow events monitored between April 2017 and July 2018 were provided to 4Sight for review. In addition to event related monitoring, GDC operates a state of the environment monitoring programme. Relevant monitoring data from this programme was also provided for analysis. The data were summarised, and graphs produced for key indicator water quality parameters. Where possible, water quality results were analysed against relevant guidelines to determine the relative risk of the overflows to human health and the receiving environment. The implications of these levels, in terms of human health risk and impacts on ecology, are addressed in the other reports that have been commissioned.

Table 1: Overflow events – overflow points, times, durations, and estimated volumes *(data provided by GDC).*

Overflow Point	Open	Close	Duration (hours)	Estimated Volume (m^3)	Volume Per River (m^3)	Event Volume (m^3)
Event 1 (4/04/2017)						
Oak Street pump station	4/04/2017 18:54	5/04/2017 8:55	14.02	1,917	Taruheru 15,298	27,253
Oak Street sluice valve	4/04/2017 17:30	5/04/2017 10:40	17.17	6,427		
Peel Street/Palmerston Road	4/04/2017 16:17	5/04/2017 10:20	18.05	6,953		
Owen Road/Seymour Road	4/04/2017 16:11	5/04/2017 9:58	17.78	1,152	Waimata 10,792	
Russell Street	4/04/2017 16:20	5/04/2017 10:50	18.50	1,865		
Wainui Road	4/04/2017 16:11	5/04/2017 9:45	17.57	7,083		
Wainui Road	5/04/2017 12:17	5/04/2017 14:00	1.72	692		
Parau Street (slide gate)	4/04/2017 21:45	5/04/2017 10:00	12.25	794	Kopuawhakapata 1,164	
Portside	4/04/2017 21:00	5/04/2017 8:25	11.42	370		
Event 2 (13/04/2017)						
Oak Street sluice valve	13/04/2017 19:05	14/04/2017 6:11	11.10	4,156	Taruheru 4,156	10,501
Derby Street	13/04/2017 19:36	13/04/2017 21:01	1.42	0		
Russell Street	13/04/2017 19:18	14/04/2017 6:25	11.12	1,121	Waimata 5,959	
Wainui Road	13/04/2017 18:45	14/04/2017 6:45	12.00	4,838		
Portside	13/04/2017 18:30	14/04/2017 6:25	11.92	386	Kopuawhakapata 386	
Event 3 (12/05/2017)						
Peel Street/Palmerston Road	12/05/2017 19:32	13/05/2017 6:45	11.22	4,321	Taruheru 4,321	9,915
Russell Street	12/05/2017 20:00	13/05/2017 6:50	10.83	1,092	Waimata 5,594	
Wainui Road	12/05/2017 19:25	13/05/2017 6:35	11.17	4,502		
Event 4 (28/05/2017)						
Russell Street	29/05/2017 0:40	29/05/2017 14:42	14.03	1,415	Waimata 7,127	7,127
Wainui Road	29/05/2017 0:35	29/05/2017 14:45	14.17	5,712		
Event 5 (3/09/2017)						
Wainui Road	3/09/2017 7:50	4/09/2017 5:59	22.15	8,931	Waimata 8,931	8,931
Event 6 (4/06/2018)						
Wainui Road	4/06/2018 10:00	5/06/2018 12:10	26.17	1,415	Waimata 7,127	7,127
Seymour/Turenne	4/06/2018 10:10	5/06/2018 12:20	26.17	5,712		
Event 7 (11/06/2018)						
Peel Street/Palmerston Road	11/06/2018 21:00	13/06/2018 8:40	35.67	12,059	Taruheru 15,054	36,956
Oak Street sluice valve	12/06/2018 10:00	12/06/2018 18:00	8.00	2,995		
Wainui Road	11/06/2018 8:30	13/06/2018 8:30	48.00	10,195	Waimata 21,902	
Seymour/Turenne	11/06/2018 8:40	13/06/2018 8:50	48.17	*No data*		
Fitzherbert Street	11/06/2018 9:00	11/06/2018 21:00	12.00	7,733		
Russell Street	11/06/2018 10:00	12/06/2018 13:30	27.50	2,419		

Table 2: Site names, site numbers, site locations and site coordinates for each sampling site monitored

Stream Name	Monitoring Site Location	Monitoring Site Name	Monitoring Site Number	Site Coordinates
Stream Sampling Sites				
Taruheru River	Tuckers Road Bridge	Tuckers	7	E 2032530 N 5712096
	Lytton Road Bridge	Lytton	5	E 2035244 N 5710509
	Wi Pere Pipe	Wi Pere	8	E 2036997 N 5709556
	Peel Street Bridge	Peel	6	E 2037523 N 5708357
Waimata River	Goodwins Road Bridge	Goodwins	13	E 2041156 N 5711034
	Grant Road	Grant	14	E 2038530 N 5708362
	William Petty Bridge	William Petty	15	E 2037786 N 5708128
Waikanae Stream	Airport Culvert	Airport Culvert	11	E 2033800 N 5709013
	Grey Street Bridge	Grey	12	E 2036828 N 5708060
Turanganui River	Gladstone Road Bridge	Gladstone	9	E 2037580 N 5707995
	The Cut	The Cut	10	E 2036914 N 5707555
Kopuawhakapata Stream	Hirini Street	Hirini	4	E 2037830 N 5707761
Network Sites				
Wastewater interceptor manhole	Harris Street	Harris Street	1	E 2037995 N 5707878
	Munro Street	Munro Street	2	E 2034914 N 5708893
	Ormond Street	Ormond Street	3	E 2037750 N 5708486

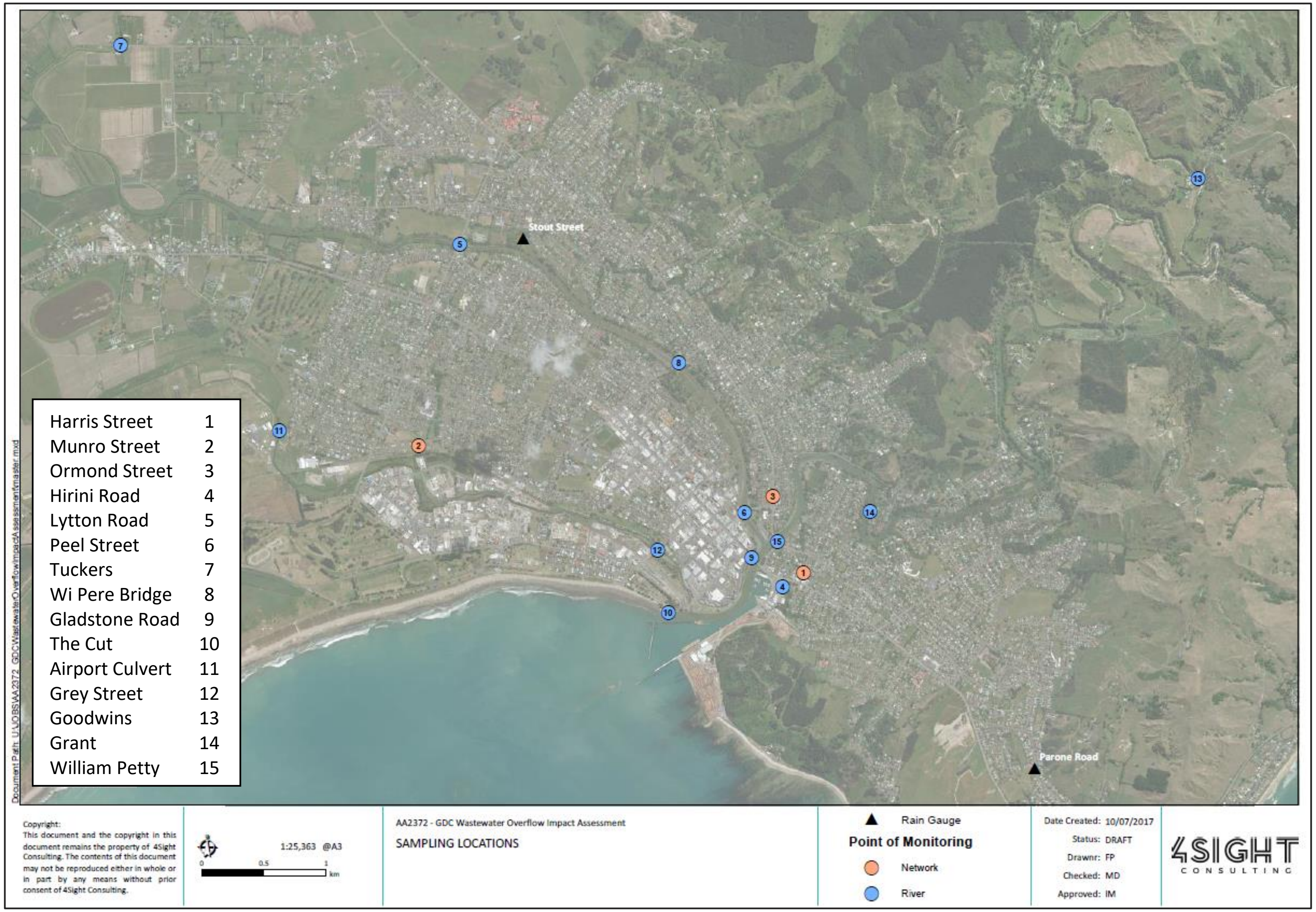

Figure 1: Rain gauge, river and network sampling locations

2.3.2 Sample Collection

Water samples were collected at each sampling location and in-stream field measurements of physical parameters were recorded onsite for pH, salinity, temperature, and dissolved oxygen on each overflow event sampling occasion.

Laboratory analysis of the water samples was undertaken for a large suite of parameters including various forms of nitrogen and phosphorus, total suspended solids, and three faecal bacteria indicators: total faecal coliforms, *Escherichia coli* (*E. coli*), and enterococci. The initial sampling regime also included a range of metals, inorganic compounds, organic compounds and physicochemical parameters.

Water quality samples were collected by GDC field monitoring staff and sent to Watercare Services Limited for analysis.

2.3.3 Monitoring Frequency

Water quality sampling was undertaken at all in-stream sampling locations prior to an overflow event occurring (when significant rainfall was predicted), at various intervals during the overflow event, and at intervals following the end of the overflow event. This provides information on antecedent conditions, changes through an event and the time taken for contaminant concentration to revert to background levels following valve closure.

The initial monitoring regime was as follows:

Sample 1: Before opening

Sample 2: 12 hours after opening (where possible)

Sample 3: 24 hours after opening

Sample 4: 48 hours after Step 3 or just after closing (depending on the event)

Sample 5: 5 days after closing.

Due to logistical and health and safety reasons, not all monitoring could be undertaken for all events, particularly where the 12-hour monitoring was scheduled for the middle of the night. However, sampling was undertaken where it was feasible to undertake it safely.

Following the first overflow event, additional, more frequent (3 hourly for 12 hours) monitoring was undertaken for monitoring sites in the Taruheru River. The purpose of this more frequent monitoring was to assess any potential influence of tidal cycles on the concentration and distribution of contaminants and the time taken for concentrations to return to background levels.

2.3.4 Parameters Monitored

As previously indicated, an extended suite of parameters was initially monitored to gain a robust and broad understanding of the potential effects on the receiving environment with the intention of refining and developing a more focussed monitoring programme for subsequent overflow events, should they occur, that focuses on the parameters of most relevance.

As monitoring covered seven separate events, and a significant number of parameters were monitored, a large quantity of monitoring data was received for the programme. While all information has been considered, due to the significant body of information that was received this assessment has focussed on key parameters. The parameters that were analysed in greater detail are listed below in Table 3.

Table 3: List of parameters analysed in detail

Nutrients	Bacteria	Heavy metals	Inorganic compounds	Physiochemical parameters
▪ Total Phosphorus ▪ Total Nitrogen ▪ Ammonia	▪ Enterococci	▪ Copper (dissolved) ▪ Zinc (dissolved)	▪ Fluoride	▪ Total Suspended Solids (TSS)

2.3.5 Quality Assurance

All sample collection was completed by GDC, with laboratory testing of samples being completed by Watercare Laboratories. Sample collection and monitoring were subject to these organisations' quality control and quality assurance protocols and processes.

2.3.6 Guideline Values

There is a range of typical water quality parameters that are usually used as indicators of 'ecological health' or as an indicator of contact recreational risk of a water body. The parameters used to measure instream health during this study are summarised in Table 4.

Table 4: Water quality parameters monitored, parameter relevance, and relevant guideline values

Water quality parameter	Relevance	Guideline value	Unit
Ecological health			
Turbidity*	Amenity, deposition/accumulation	5.6[1]	NTU
Total Nitrogen	Can cause nuisance plant growth	0.281[1]	g/m^3
Total Phosphorus	Can cause nuisance plant growth	0.023[1]	g/m^3
Ammonia (toxicity)	Can cause nuisance plant growth/toxic to aquatic life	Annual median ≤1.3[6] Annual maximum ≤2.4[6]	g/m^3
Fluoride	Toxic to aquatic life	0.12[2]	g/m^3
Copper	Toxic to aquatic life	0.0014[3] 0.0025[4]	g/m^3
Zinc	Toxic to aquatic life	0.008[3] 0.031[4]	g/m^3
Contact Recreation/Public Health			
Enterococci	Human health risk	Annual median <280[6] Annual 95th %ile <500[6]	CFU/100 mL

** No guideline for TSS has been established. Refer to the New Zealand specific guideline for turbidity. The correlation between TSS and turbidity is strongly positively correlated.*
[1] ANZG (2018) guideline value for New Zealand Warm Dry Low-elevation rivers (80th %ile of data)
[2] Canadian environmental quality guidelines for the protection of aquatic life (1999)
[3] ANZG (2018) toxicant guideline value for the 95% protection of species in freshwater
[4] ANZG (2018) toxicant guideline value for the 80% protection of species in freshwater
[5] Microbiological Water Quality Guidelines for Marine and Freshwater Areas Recreational Water Quality Guidelines (2002)
[6] Limit outlined in the Tairāwhiti Resource Management Plan for the Gisborne Urban Freshwater Management Unit

Bacteria in water are a measure of the suitability for contact recreation (e.g. swimming and wading) and the potential risk to human health. The Ministry of Health and the Ministry for the Environment published guidelines in 2002[2] that are widely used in New Zealand to interpret the results from bacterial measurements and are widely referred to as the recreational water quality guidelines.

The recreational water quality guidelines recommend measuring enterococci in saline waters as an indicator of potential pathogens and *E. coli* in freshwater. The guidelines also generally recommend against the use of enterococci as an indicator in freshwaters, as it can multiply from natural sources such as leaf decay. However, given the estuarine nature of many of the sampling locations, enterococci (marine trigger values) have been assessed in this report (see Table 5).

Furthermore, the Tairāwhiti Resource Management Plan only provides guideline values for enterococci in the Gisborne Urban Freshwater Management Unit.

Table 5: Trigger levels for enterococci and *E. coli* from the recreational water quality guidelines

Highly likely to be uncontaminated (green) (<260 *E. coli*/100 mL)	Highly likely to be uncontaminated (green) (<140 enterococci/100 mL)
Potentially contaminated (amber) (260–550 *E. coli*/100 mL)	Potentially contaminated (amber) (140–280 enterococci /100 mL)
Highly likely to be contaminated (red) (>550 *E. coli*/100 mL)	Highly likely to be contaminated (red) (>280 enterococci /100 mL)

2.4 Rainfall

Heavy rainfall is the primary driver for wet weather overflow events. It is also one of the key climatic factors that will influence background concentrations of contaminants, such as indicator bacteria, in waterways as it 'washes' contaminants off the land and into waterways, increasing concentrations of contaminants in streams.

GDC operates several rainfall sites in Gisborne. Two sites were selected to provide rainfall information to this assessment (based on proximity to the wastewater network overflows):

- Paraone Road – to the south of the city (Kaiti); and
- Stout Street – in the northeast of the city area, adjacent to the Taruheru River.

The location of these sites is shown in Figure 1 above. Rainfall records from these two sites were averaged to provide indicative rainfall for the overflow events across the city.

2.5 Data Analysis

Due to the wide range of concentrations that were measured during this monitoring period, some concentrations were reported by the laboratory as being above or below the analytical detection limit. The analytical level of detection is the lowest and highest concentration that the laboratory reports for each method. These limits are dependent on a number of factors, including the type and quality of the sample, the parameter being measured, and the methodology used by the laboratory.

For the purpose of statistical analysis, a typical approach was used whereby measurements that were reported as below the analytical level of detection were assumed to be half of the detection limit (e.g., <0.02 g/m^3 = 0.01 g/m^3).

[2] MfE/MoH. 2002. *Microbiological Water Quality Guidelines for Marine and Freshwater Areas Recreational Water Quality Guidelines*. Ministry for the Environment and Ministry of Health, Wellington.

Results that were above the analytical level of detection were assumed to be 1.2 times the reported upper limit (e.g., >24,000 CFU/100 mL = 28,800 CFU/100 mL).

3 BACKGROUND WATER QUALITY

This section presents an overview of background water quality in each of the four water bodies: Taruheru River, Waimata River, Waikanae Stream, and Kopuawhakapata Stream. Throughout the text, these will be referred to generally as water bodies or rivers, regardless of whether they are rivers, streams, or creeks.

Results have been analysed from routine sampling conducted from 2015 to 2019 only. Any samples collected specifically around a wastewater overflow or other 'pollution' event has been excluded (i.e., results labelled as 'pollution' in the supplied datasets). The purpose of this is to provide a context for the wastewater overflow analysis in the following sections and to highlight that there are, at times, elevated levels of contaminants (faecal bacteria, nutrients, sediment, and heavy metals) that are unrelated to wastewater overflows. As stated, this is a broad overview of the existing water quality data and the analysis does not delve into a detailed analysis of the rivers' response to rainfall events or as a result of catchment land use.

3.1 Enterococci

Enterococci is the primary faecal bacteria used to indicate the suitability of the water for recreational use in saline environments. Enterococci is used, rather than *E. coli,* as the lower reaches of the Gisborne urban rivers are tidally influenced (i.e., river estuaries). The TRMP Gisborne Urban Freshwater Management Unit (Urban FMU) defines an annual median of <280 CFU/100 mL and an annual 95th percentile of <500 CFU/100 mL as numerical limits for these rivers.

Over the analysed period of routine monitoring, enterococci concentrations spanned a broad range, covering five orders of magnitude (Figure 2; Table 6). The concentrations are typically highest during and following rainfall events, however, that correlation hasn't been formally analysed here.

The median enterococci concentration at all sites except Tuckers on the Taruheru River and Hirini on the Kopuawhakapata Stream were within the Urban FMU guideline. No sites, however, were within (less than) the 95th percentile guideline of 500 CFU/100 mL. This shows that, in general, the Taruheru, Waimata, and Waikanae rivers have relatively low enterococci concentrations, but on occasion, they exceed the guideline value. Both the frequency and magnitude of rainfall events that result in elevated levels of enterococci are the reason for exceeding the annual 95th percentile.

Hirini had the highest minimum and 25th percentile for data collected from 2015 to 2019. Only one measurement was less than 280 CFU/100 mL. This indicates persistently elevated enterococci concentrations at this location.

The Taruheru River shows a clear trend of higher concentrations of enterococci in the upper catchment (Tuckers, a location not affected by wastewater overflows) and lower concentrations in the lower urban catchment (Peel). This suggests that in the absence of wastewater overflows the upper catchment is the primary source of enterococci, with greater dilution by stormwater during rainfall events downstream.

This pattern is not as noticeable with the other rivers as they have fewer monitoring locations. The Gladstone site is downstream of the confluence of the Waimata and Taruheru Rivers and is, therefore, influenced by both rivers. Similarly, with Waikanae Stream, 'The Cut' site is located at the edge of the harbour so will be influenced by all upstream contributions and, in addition, is likely to have increased dilution from tidal flushing compared to the more upstream site at Grey. The lower reaches of each river are tidally influenced and incoming tides may 'push' contaminants back upstream, even into a river that it did not originate from – although whether this occurs in practice will be determined by river hydrology and tidal levels.

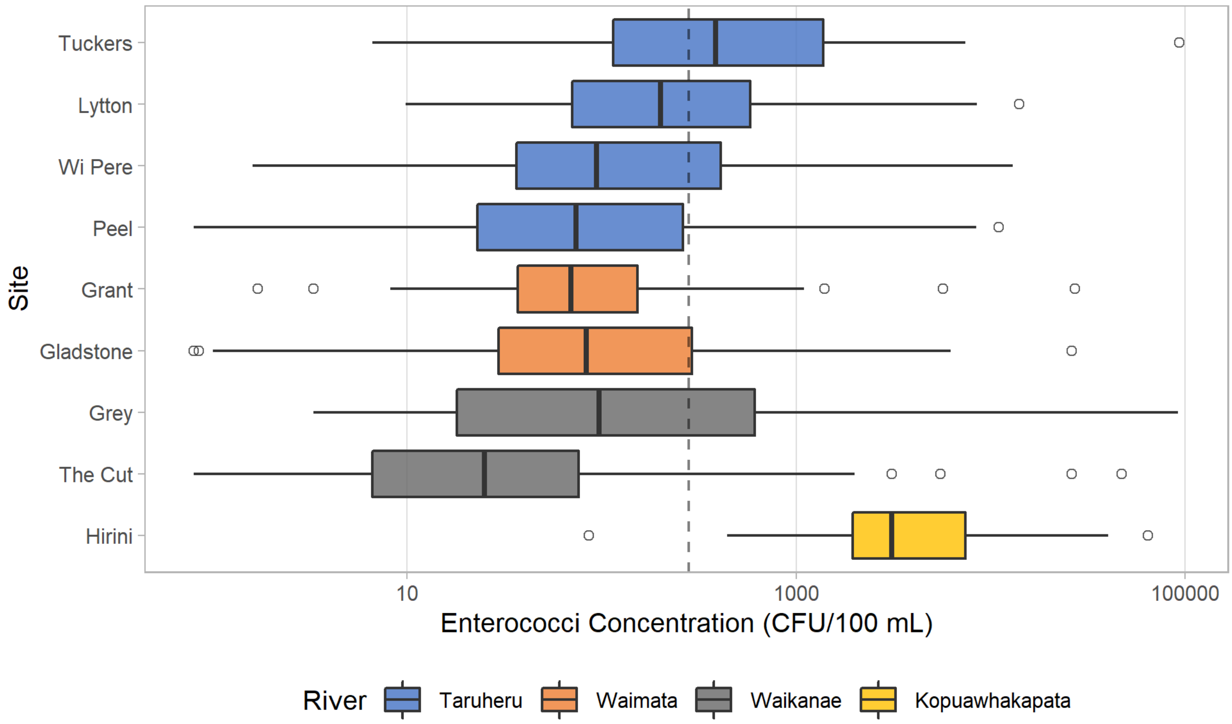

Figure 2: Summary of enterococci concentrations (routine sampling) from 2015 to 2019

(note the log scale on the x-axis). The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black line, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the Gisborne Urban Freshwater Management Unit median guideline of 280 CFU/100 mL.

Table 6: Summary statistics of enterococci concentrations (CFU/100 mL)

(measured for routine sampling from 2015 to 2019)

River	Site	5th %ile	Median	95th %ile	No. Samples
Taruheru	Tuckers	33	360	5,970	55
Taruheru	Lytton	30	200	4,780	87
Taruheru	Wi Pere	10	94	3,440	63
Taruheru	Peel	5	74	2,670	62
Waimata	Goodwins	*Insufficient data*			
Waimata	Grant	5	69	1,030	66
Waimata	William Pettie	*Insufficient data*			
Waimata	Gladstone	4	83	2,645	112
Waikanae	Airport Culvert	*Insufficient data*			
Waikanae	Grey	5	97	6,500	64
Waikanae	The Cut	2	25	2,990	63
Kopuawhakapata	Hirini	639	3,050	32,700	72

* Insufficient data where there are less than 10 samples. Possibly not collected for routine sampling.

3.2 Nutrients

Excess nutrients (nitrogen and phosphorus) can lead to nuisance algal growth. This section focuses on total nitrogen and total phosphorus concentrations to assess ecosystem health. At high concentration, nitrate and ammonia can be toxic to aquatic species. Only ammonia has been assessed in this regard because aquatic animals are more sensitive to ammonia and, therefore, it is the more likely component to approach toxic levels, if at all. A high-level inspection of nitrate data indicated that nitrate toxicity is not likely to be an issue.

3.2.1 Total Nitrogen

In general, total nitrogen concentrations are highest in the upper catchment and lowest in the lower catchment (Figure 3; and

Table 7). This again indicates that the predominant source of total nitrogen is from the upper catchment. This pattern is most clearly seen in the Taruheru River, which also has the highest overall concentrations. At times, nitrogen concentrations were highly elevated, most notably at the upper Taruheru sites (Tuckers and Lytton). These highly elevated concentrations are likely associated with rainfall events.

There is no total nitrogen guideline in TRMP. As a point of reference, the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers has been used (0.281 g/m³).

All sites exceeded the 80th percentile guideline value by 2–16 times. This indicates elevated background nitrogen concentrations in the rivers, which generally decrease with distance down the river.

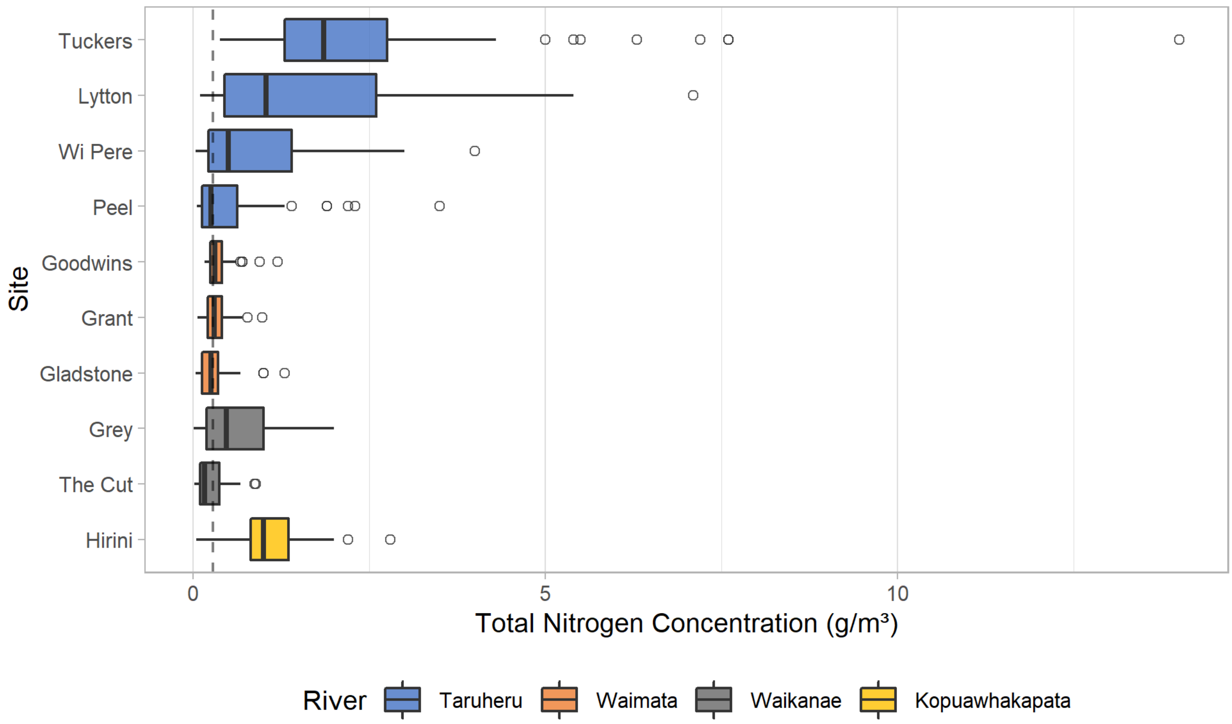

Figure 3: Summary of total nitrogen concentrations (routine sampling) from 2015 to 2019

The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black line, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers of 0.281 g/m³.

Table 7: Summary statistics of total nitrogen concentrations (g/m^3)
(measured for routine sampling from 2015 to 2019)

River	Site	20th %ile	Median	80th %ile	No. Samples
Taruheru	Tuckers	1.20	1.85	4.37	80
Taruheru	Lytton	0.36	1.04	4.03	80
Taruheru	Wi Pere	0.19	0.50	2.06	55
Taruheru	Peel	0.12	0.25	1.36	55
Waimata	Goodwins	0.23	0.31	0.58	55
Waimata	Grant	0.19	0.30	0.57	55
Waimata	William Pettie	*Insufficient data*			
Waimata	Gladstone	0.13	0.25	0.63	55
Waikanae	Airport Culvert	*Insufficient data*			
Waikanae	Grey	0.15	0.47	1.44	57
Waikanae	The Cut	0.10	0.16	0.61	55
Kopuawhakapata	Hirini	0.76	1.00	1.80	64

3.2.2 Total Phosphorus

Total phosphorus concentrations show a similar pattern to that of total nitrogen, with the highest concentrations being measured in the upper catchment and lowest in the lower catchment (Figure 4; Table 8). Once again, indicating the predominant source of phosphorus to be the upper catchment.

There is no total phosphorus guideline in TRMP. As a point of reference, the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers has been used (0.023 g/m^3).

All sites exceeded the 80th percentile guideline value by 2–22 times, indicating elevated background phosphorus concentrations in the rivers. One exceptionally high concentration (2.4 g/m^3) was measured at Tuckers, which is about 100 times greater than the guideline value.

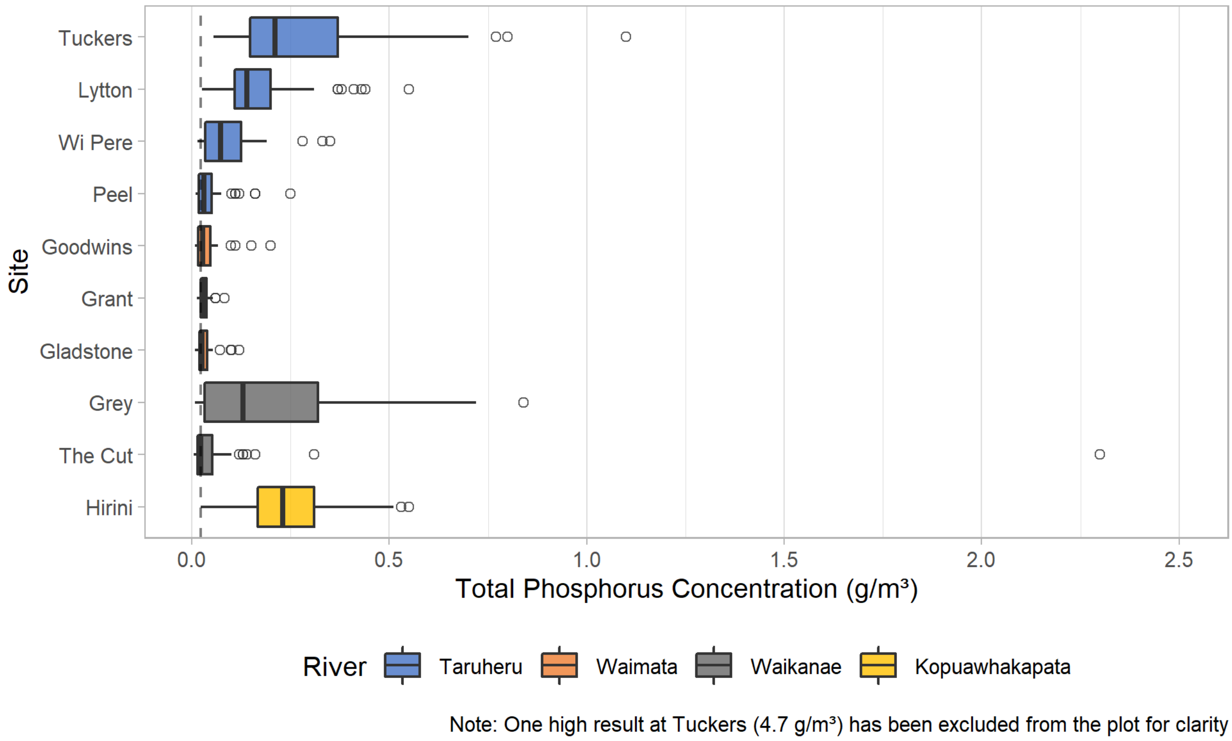

Figure 4: Summary of total phosphorus concentrations (routine sampling) from 2015 to 2019

The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black line, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers of 0.023 g/m³.

Table 8: Summary statistics of total phosphorus concentrations (g/m³)

(measured for routine sampling from 2015 to 2019)

River	Site	20th %ile	Median	80th %ile	No. Samples
Taruheru	Tuckers	0.14	0.21	0.50	80
Taruheru	Lytton	0.09	0.14	0.30	80
Taruheru	Wi Pere	0.03	0.07	0.16	55
Taruheru	Peel	0.02	0.03	0.11	55
Waimata	Goodwins	0.02	0.03	0.07	55
Waimata	Grant	0.02	0.03	0.05	55
Waimata	William Pettie	*Insufficient data*			
Waimata	Gladstone	0.02	0.03	0.05	56
Waikanae	Airport Culvert	*Insufficient data*			
Waikanae	Grey	0.03	0.13	0.50	57
Waikanae	The Cut	0.01	0.02	0.13	56
Kopuawhakapata	Hirini	0.16	0.23	0.42	64

3.2.3 Ammonia (Toxicity)

Ammoniacal nitrogen (herein, ammonia) contributes to the overall total nitrogen load and, at high concentrations, can be toxic to aquatic species. The toxicity of ammonia is primarily a factor of pH, but also water temperature. The reason for this is that total ammoniacal nitrogen (as these data have been measured) comprises NH_3 (ammonia) and NH_4^+ (ammonium). The ratio of NH_3 to NH_4^+ in solution is dependent on pH and temperature and the toxicity is primarily due to NH_3. A common approach for analysing ammonia data is to standardise the concentrations to pH 8.0, which is the approach that was used for this analysis.

The TRMP has interim ammonia objectives for the Gisborne Urban Freshwater Management Unit which includes an annual median concentration of ≤1.3 g/m^3 and an annual maximum concentration of ≤2.20 g/m^3.[3] These values are consistent with Band C of the National Policy Statement for Freshwater Management, 2014 (NPS:FM) (i.e., national bottom line), which was derived for ammonia concentrations normalised to pH 8.0.

With regard to toxicity, ammonia concentrations at all sites were generally low (Figure 5; Table 9). Only one ammonia result exceeded the median guideline value, which was measured at Tuckers, with a concentration of 2.4 g/m^3. In the Taruheru River, ammonia concentrations were highest (and spanned the widest range) in the upper catchment and lowest in the lower catchment, although none of the concentrations (other than one measurement at Tuckers) exceeded the median guideline value. This is consistent with other nutrient measurements. This indicates that the primary source of ammonia is from the upper catchment and its concentration decreases due to dilution and mixing as it flows downstream. A similar pattern was observed at the two locations on the Waikanae Stream.

The Waimata River showed a different pattern, whereby, ammonia concentrations slightly increased after the most upstream site (Goodwins) and then were similar to slightly greater downstream at Gladstone. This shows a greater contribution of ammonia downstream from Goodwins than upstream, presumably due to the rural area downstream of Goodwins or the urban catchment although the cause of the increase downstream in this river was not investigated.

[3] The Tairāwhiti Resource Management Plan states these numeric objectives in mg/L, which is equivalent to g/m^3

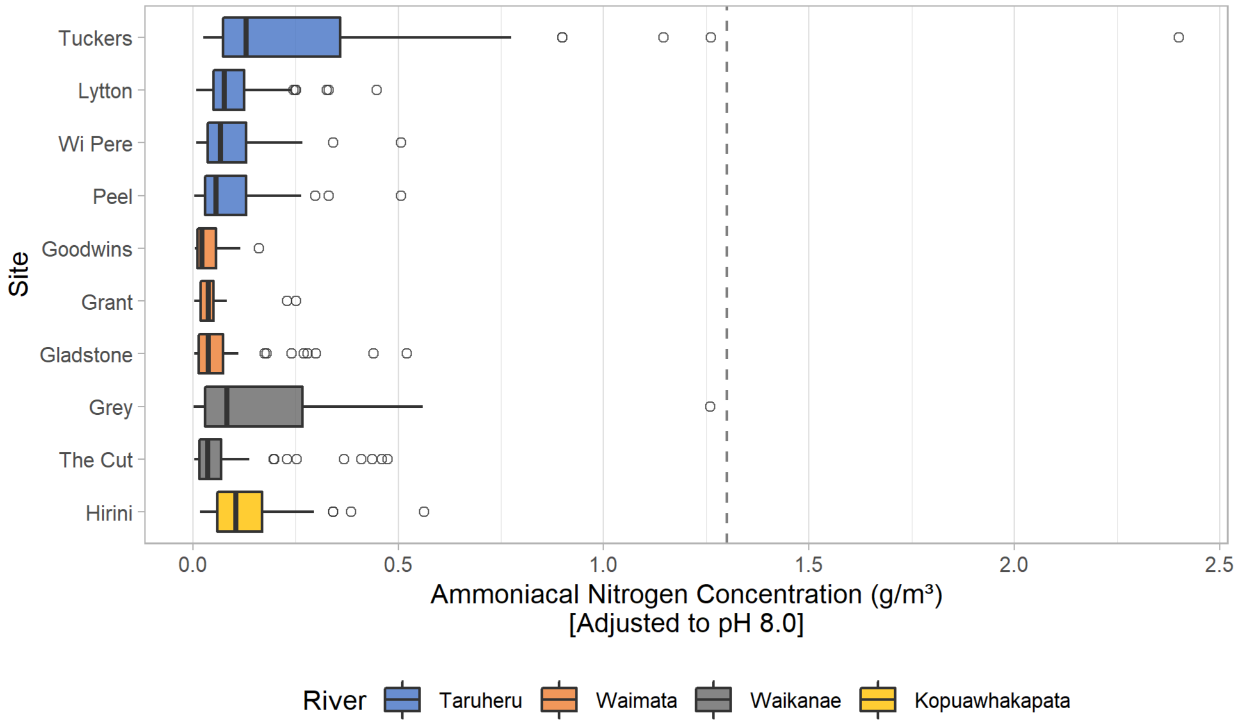

Figure 5: Summary of ammoniacal nitrogen concentrations (routine sampling) from 2015 to 2019

The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black line, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the Gisborne Urban Freshwater Management Unit median guideline of 1.3 g/m3.

Table 9: Summary statistics of ammoniacal nitrogen concentrations (g/m^3)

(adjusted to pH 8.0 measured for routine sampling from 2015 to 2019)

River	Site	20th %ile	Median	80th %ile	No. Samples
Taruheru	Tuckers	0.06	0.13	0.70	74
Taruheru	Lytton	0.04	0.08	0.21	74
Taruheru	Wi Pere	0.03	0.07	0.20	53
Taruheru	Peel	0.03	0.06	0.21	53
Waimata	Goodwins	0.01	0.02	0.10	53
Waimata	Grant	0.02	0.04	0.07	53
Waimata	William Pettie	*Insufficient data*			
Waimata	Gladstone	0.01	0.04	0.22	54
Waikanae	Airport Culvert	*Insufficient data*			
Waikanae	Grey	0.03	0.08	0.37	54
Waikanae	The Cut	0.01	0.04	0.25	54
Kopuawhakapata	Hirini	0.05	0.11	0.27	61

3.3 Total Suspended Solids

There is no total suspended solids (TSS) guideline in TRMP. As a point of reference, the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers has been used (4.6 g/m^3).

The majority of results were between 10 and 50 g/m^3 (Figure 6; Table 10). Occasionally higher concentrations were measured that were presumably associated with rainfall events. No sites' median concentrations were within (less than) the ANZG (2018) 80th percentile guideline value.

In general, TSS concentrations in the Taruheru River were higher in the upper catchment (Tuckers) and lower in the lower catchment (Peel). This indicates that the primary source of sediment is from the upper catchment. A similar pattern was seen in the Waikanae Stream.

Interestingly, the Waimata River generally had lower TSS concentrations at its uppermost site (Goodwins) despite being in a rural location with steep pasture. Goodwins had the lowest median TSS concentration of all sites of 4 g/m^3. The other two sites, Grant and Gladstone, are located in the urban area. This suggests that a large proportion of sediment in the Waimata River is introduced between the Goodwins and Grant sites.

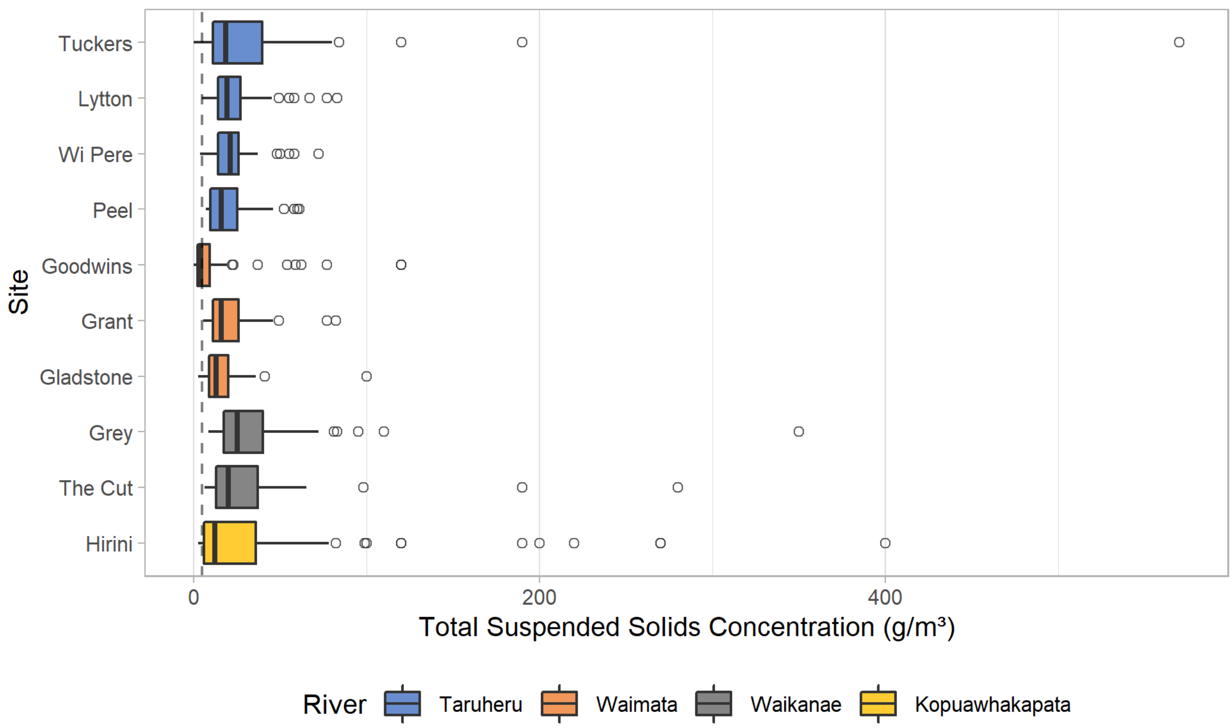

Figure 6: Summary of total suspended solids concentrations (routine sampling) from 2015 to 2019

The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black line, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers of 4.6 g/m^3.

Table 10: Summary statistics of total suspended solids concentrations (g/m^3)
(measured for routine sampling from 2015 to 2019)

River	Site	20th %ile	Median	80th %ile	No. Samples
Taruheru	Tuckers	9.5	18.5	58.5	82
Taruheru	Lytton	14.0	19	40.0	81
Taruheru	Wi Pere	13.0	21	36.4	57
Taruheru	Peel	9.2	16	40.4	57
Waimata	Goodwins	2.0	4	43.8	57
Waimata	Grant	11.0	16	38.0	57
Waimata	William Pettie	*Insufficient data*			
Waimata	Gladstone	8.0	13	29.2	57
Waikanae	Airport Culvert	*Insufficient data*			
Waikanae	Grey	15.0	25	61.4	64
Waikanae	The Cut	11.0	20	54.0	57
Kopuawhakapata	Hirini	5.5	12	120.0	69

* Insufficient data where there are less than 10 samples. Possibly not collected for routine sampling.

3.4 Metals

Metals occur naturally in the environment at low concentrations. Elevated concentrations of metals can cause toxicity-related issues for aquatic plants and animals.

3.4.1 Copper (Dissolved)

There is no copper (dissolved) guideline in TRMP. As a point of reference, the ANZG (2018) toxicant guideline value for the 95% protection of species in freshwater has been used (0.0014 g/m^3). This value is marginally higher than the equivalent guideline for estuarine water (0.0013 g/m^3).

In all rivers except the Kopuawhakapata, metal concentrations were typically below the analytical level of detection (i.e., very low). The median concentration at all sites was below the guideline value (Figure 7). The guideline value was developed for chronic metal concentrations and so, in this case, the risk from copper toxicity is very low.

More than 25% of results from the Kopuawhakapata Stream were above the guideline value. Further investigation of potential sources may be warranted as the typical background copper concentrations in this stream are significantly higher than those measured in all other water bodies.

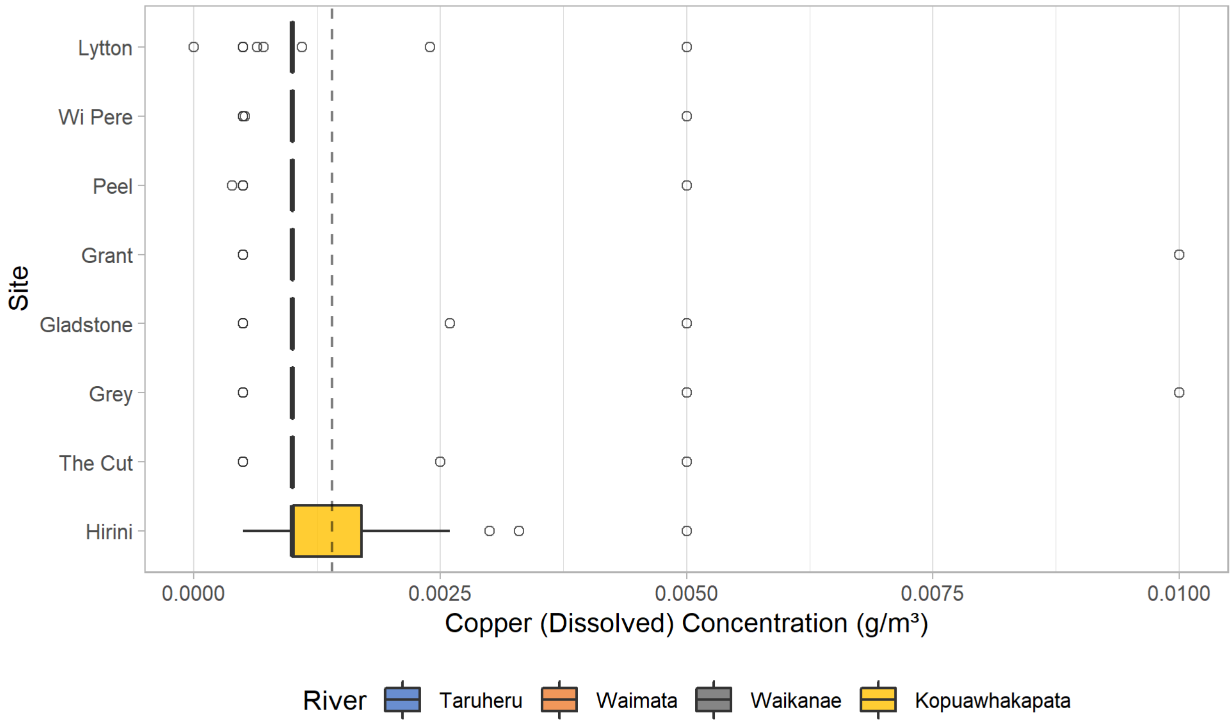

Figure 7: Summary of copper (dissolved) concentrations (routine sampling) from 2015 to 2019

The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black lines, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the ANZG (2018) toxicant guideline value for the 95% protection of species in freshwater of 0.0014 g/m³.

3.4.2 Zinc (Dissolved)

There is no zinc (dissolved) guideline in TRMP. As a point of reference, the ANZG (2018) toxicant guideline value for the 95% protection of species in freshwater has been used (0.008 g/m^3). This value is lower than the equivalent guideline for estuarine water (0.0015 g/m^3).

Most of the results from all rivers, excluding the Kopuawhakapata, were below the analytical level of detection (Figure 8). The lower level of detection varied between <0.02 and <0.001 g/m^3, depending on the method used. The higher detection limits (e.g., <0.01 and <0.02 g/m^3) are higher than the toxicity guideline value for 95% protection of species in freshwater. In general, the risk of toxicity as a result of zinc is low in all rivers except for the Kopuawhakapata.

The median zinc concentration at Hirini on the Kopuawhakapata Stream (0.013 g/m^3) is about 1.6 times greater than the guideline value for 95% protection of species in freshwater. Although this represents some elevation in zinc concentration, it is still below the next level of protection, that is, the 90% protection of species in freshwater, which has a guideline value of 0.015 g/m^3.

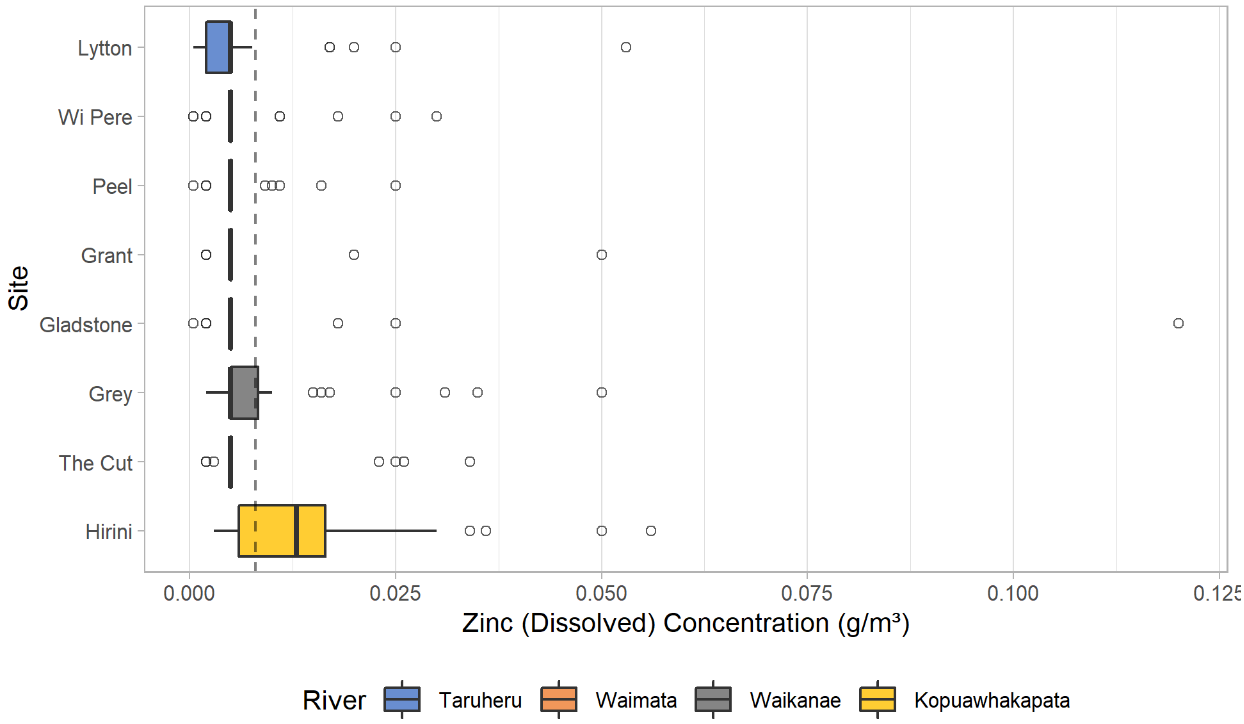

Figure 8: Summary of zinc (dissolved) concentrations (routine sampling) from 2015 to 2019

The boxes show the lower- and upper quartiles of the data (the interquartile range) and the solid black lines, the median. Open circles show results that are more than 1.5 times the interquartile range. The vertical dashed line denotes the ANZG (2018) toxicant guideline value for the 95% protection of species in freshwater of 0.008 g/m³.

3.5 Fluoride

There were no data available because fluoride is not measured for routine sampling.

3.6 Summary

Analysis of state of the environment (routine) water quality sampling for Gisborne's main urban rivers has indicated the following:

- The highest concentrations of enterococci, nutrients, and sediment were typically measured at the most upstream sites. This indicates that, in general, the primary source of these is from the upper catchment. The obvious exception to this is the Waimata River, where there was typically an increase between the most upstream site (Goodwins) and the nearest downstream site (Grant). This indicates that the predominant source of most contaminants is between these two sites. It is not possible to identify whether this is a result of the rural or urban land use in this area without further information or studies.
- The median enterococci concentration at all sites except Tuckers on the Taruheru River and Hirini on the Kopuawhakapata Stream were within (less than) the Urban FMU (annual median) guideline of 280 CFU/100mL. No sites, however, were within (less than) the Urban FMU 95th percentile guideline of 500 CFU/100 mL. As background water quality was assessed for data that excluded overflow events, this is likely due to high levels of microbial contaminants being discharged from (non-wastewater overflow) catchment sources – particularly those in the upper catchment – during rain events.
- Median levels of enterococci in the Kopuawhakapata Stream in particular indicate chronic microbial contamination that is not related to wet weather wastewater overflow events.
- Total nitrogen, total phosphorus, and total suspended solids all exceeded their relevant guideline levels at all sites, indicating elevated background levels of these contaminants in the rivers.
- Ammonia (toxicity) was low at all sites and the median concentration was well below the guideline value.

- Metal concentrations were below the analytical level of detection in most samples; however they were, at times, up to an order of magnitude higher than their respective guideline values. Again, these high levels are likely to be associated with heavy rain events, and most likely urban stormwater derived.
- The Kopuawhakapata Stream had the highest metal concentrations, which exceeded the toxicity guideline for 95% protection of species for copper and zinc on 26% and 67% of sampling occasions, respectively.

4 OVERFLOW EVENT SAMPLING

The results of the overflow event monitoring between March 2017 and July 2018 are summarised in this section. As previously indicated, there is a large body of data and hence the analysis has focussed largely on microbiological water quality parameters, specifically that of enterococci. This is because it shows the greatest responses to wastewater overflows and aids the identification of patterns and changes to water quality during a wastewater overflow. Selected nutrients, suspended sediment, and metals have also been analysed to understand the potential impact of the overflows on the water quality of the receiving environment.

Results are presented for each overflow event and parameter of interest. To provide context for the event-monitoring results, they are compared to results from routine monitoring and a rainfall event that had no overflows, (12-18 March 2018). There are generally insufficient samples for each of the event-based sampling occasions (about 5–8 samples per event) to enable a statistical analysis similar to that undertaken for the state of the environment sampling. Accordingly, only the **maximum** concentration measured during each event (at each location) is presented, except where an assessment of the duration of elevated water quality is undertaken or of in-pipe enterococci concentrations.

Plots showing all collected data are presented in Appendix B.

4.1 Rainfall During Events

Figure 9 shows the 3-day average rainfall for each overflow and 'rainfall only' event to provide an indication of the level of rainfall that triggered the overflow event (and the rain-only event for comparison). The 3-day average was used as overflow valves appear to be generally opened in response to prolonged rainfall overwhelming the wastewater network. However, it is understood that the wastewater network response to rainfall intensity is substantially more complex and overflows can occur as a result of very high intensity short duration rainfall within a period of prolonged rainfall.

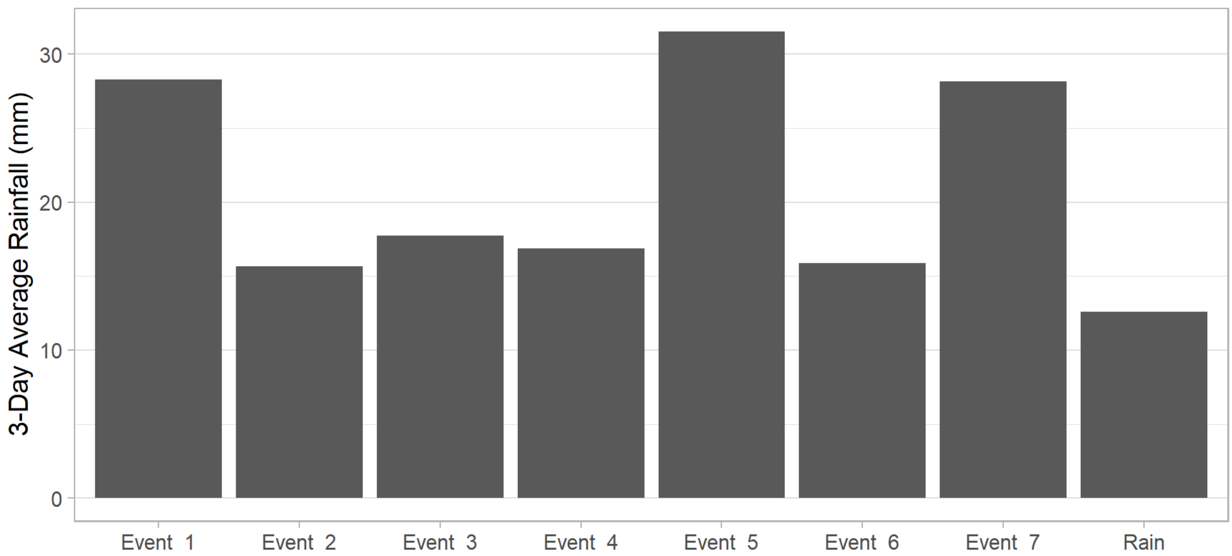

Figure 9: 3-Day average rainfall during overflow events and a rainfall-only event
(e.g., Event 1 = average rainfall during 3–5 April 2017).

4.2 Enterococci

4.2.1 In-Network Concentrations

As expected, the enterococci concentrations in samples collected directly from the network were high (Figure 10). Enterococci concentrations were consistently higher in the Munro St interceptor than in the other two interceptors. However, it is noted that the Munro Street interceptor is located to the west of the city, some distance away from the overflow locations – hence it is possible that at this location the interceptor is not full of stormwater and hence wastewater is only partially diluted.

Both the Harris Street and Ormond Road interceptors are located in areas of high stormwater inflow and within the area where overflows typically occur. It is therefore likely that these two sites are more representative of the concentration of enterococci in overflows after substantial dilution by stormwater, during and immediately after heavy rain.

The results indicate that enterococci concentrations in discharged overflows (a combination of wastewater and stormwater) are generally less than 1,000,000 CFU/100mL but can be up to 2,500,000 CFU/100mL, which is about 4,000 to 7,000 times greater than the recreational water quality guidelines.

While overflows are likely to occur at the maximum inflow of stormwater (and therefore dilution), and hence can be expected to be at the lower range of the in-pipe measurements, the conservative concentration of 2,500,000 CFU/100mL was subsequently utilised in hydrodynamic modelling.

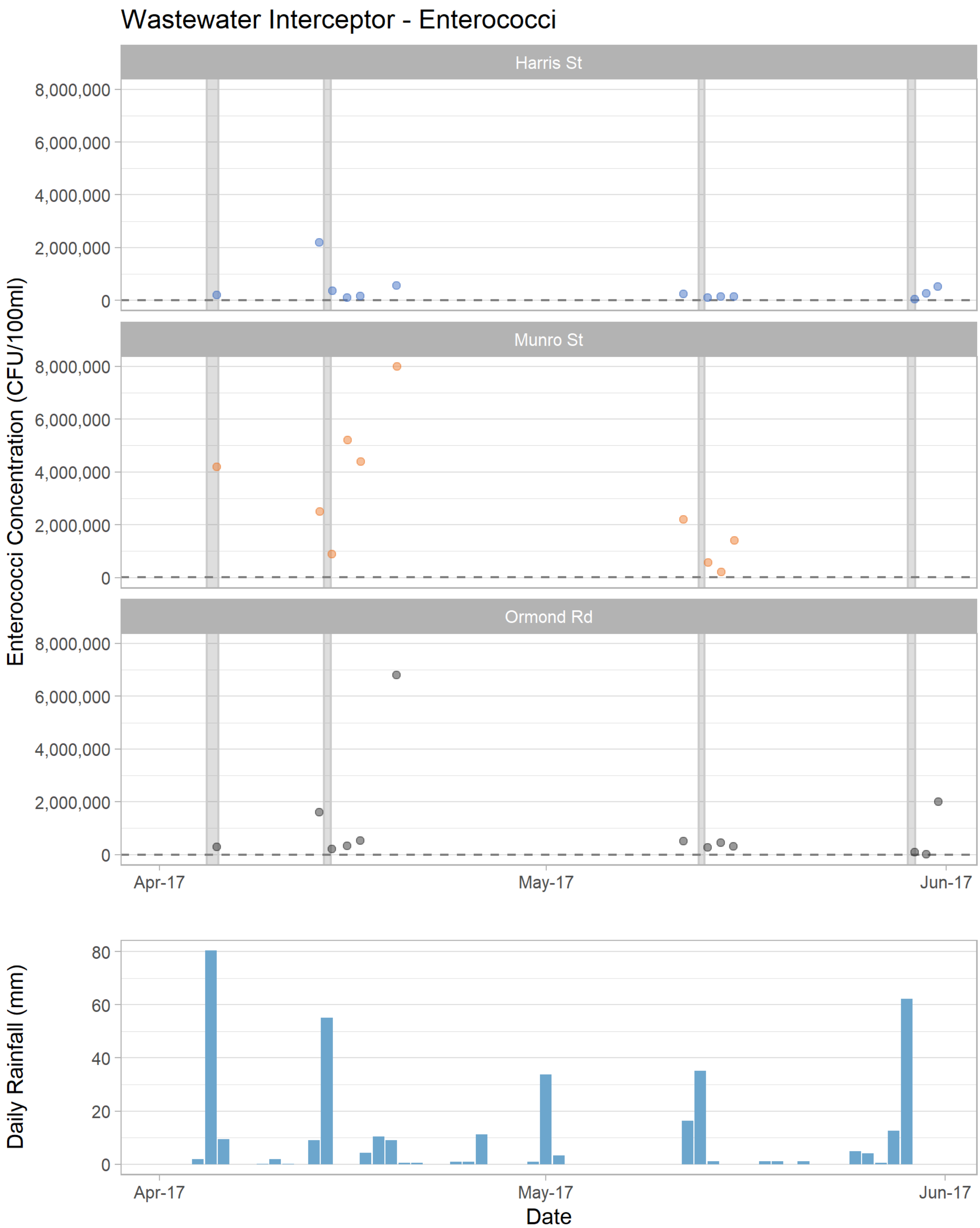

Figure 10: Enterococci concentrations measured in the network and the total daily rainfall during this period.

The dashed, horizontal line shows the recreational water quality guideline for reference (280 CFU/100 mL). The grey, vertical bars show the periods when wastewater overflow valves were opened.

4.2.2 Effect of Overflows on Microbial Water Quality

The effect of wastewater overflows on the water quality of Gisborne urban rivers is complex because it is a factor of multiple variables including total contaminant load, the time over which the overflow valves are open, the state of the tide and wind, the amount of rainfall, and the number of overflow values open on any one river at any one time.

The true maximum enterococci concentration during an overflow event is likely to occur over a short period of time and there is a high chance that periodic sampling did not capture this maximum. This makes the data more difficult to interpret quantitatively. Instead, a more qualitative approach is used to capture high-level patterns and observations. This approach to sampling, however, still provides good insight into changes in water quality in the Gisborne urban rivers during overflow events.

The highest enterococci concentrations recorded over the monitoring programme were measured in the lower Taruheru River, most notably during Events 1 and 2 (Figure 11) when there were overflow discharges to the river (see Table 1). The maximum concentrations were about twice as high during these overflow events than the maximum recorded during routine (background) sampling.

There is no clear relationship between the estimated volume of wastewater discharged into the Taruheru River and the highest measured enterococci concentrations. Enterococci concentrations were higher in the Taruheru River during Event 2 than they were during Event 1, despite Event 2 having around 1/3 of the volume of wastewater discharged relative to Event 1 and from one less overflow source (Table 1). This may be due to the timing of sampling following the overflow discharge. Additionally, there was a greater volume of rain during Event 1 (~28 mm/day) than during Event 2 (~15 mm/day), which may have resulted in greater dilution within the river.

Events 1 and 2 on the Taruheru River showed expected responses to overflow discharges to the lower river, whereby maximum concentrations generally increased downstream as wastewater overflows were discharged to the river. This effect was much smaller, if it occurred at all, during subsequent overflow events. This is likely due to no overflows occurring on the Taruheru River in Events 4–6. This response differs to that seen in the routine sampling and the rain only event, which showed highest enterococci concentrations in the upstream sites – as a result of wastewater inputs to the urban section of the river.

During Events 3 and 7, similar or larger volumes of wastewater overflows were discharged into the Taruheru River to Events 1 and 2, but a much smaller change in water quality was measured in the river. Enterococci concentrations were relatively low during Events 3 and 7 such that higher maximum enterococci concentrations were measured during a rainfall event with no overflows and during routine monitoring than during these overflow events. This may be due to the location of the predominant overflows for these events (being Peel Street/Palmerston Road) low in the catchment.

The Waimata River generally only had small elevations in enterococci concentrations during overflow events. Concentrations typically increased from upstream to downstream, indicating the contribution from wastewater overflows through the urban section of the river. Gladstone is downstream of the confluence of the Waimata and Taruheru Rivers and is, therefore, influenced by overflows from all upstream sites. There was one unusually high maximum concentration at Gladstone during Event 6. The cause of this is not clear from the data but it appears to be a 'one-off'. It is noted that the primary overflow location for this event was Wainui Road, which is in close proximity to the Gladstone Road sampling point – although it is noted that the maximum recorded enterococci concentration downstream at the Cut for this same event was substantially lower..

The Waikanae Stream was not subject to overflows and while maximum levels were elevated (typically 5,000 to 20,000 CFU/100mL), they were similar to (and in some cases less) than those observed in routine monitoring. While the Cut is located at the mouth of the Waikanae Stream, it is also influenced by overflows from all upstream sites and hence isn't reflective of water quality within the Waikanae Stream.

Hirini on the Kopuawhakapata Stream had consistently high enterococci concentrations even though it only received wastewater overflows during Events 1 and 2. This may indicate the presence of illegal cross-connections of private wastewater pipes to the stormwater network, or other microbial sources, which would provide a constant source of contamination into the receiving environment.

4.2.3 Duration of Overflow Effects

Figure 11 focuses on a single overflow event (Overflow 3) in the Taruheru River to understand theduration of effects of the overflow on receiving environment water quality. It is important to note that the dotted lines joining each data point provide a visual link between points rather than indicating the enterococci concentration in between water quality measurements (i.e. the concentration of enterococci in between data points is unknown).

As can be seen by the results, enterococci concentrations in the river increased substantially after the overflow valve was opened but returned to pre-event levels within 48 hours after the closure of the overflow. Enterococci concentrations peaked during the overflow event when the valve was open, with concentrations then dropping off progressively once the overflow valves had been closed, decreasing to approximately half the peak concentration within the first 24 hours, and returning to pre-overflow concentrations approximately 48 (or slightly longer) of the overflow valve being closed. This general pattern is observed for all contaminants measured in this study.

The dilution/dispersion of contaminants in the stream combined with the effects of tidal flushing at the stream mouth and in the lower half of the Taruheru River allows for the dissipation of contaminants in a comparable time frame to that which would occur after a normal heavy rainfall event that does not include wastewater overflows.

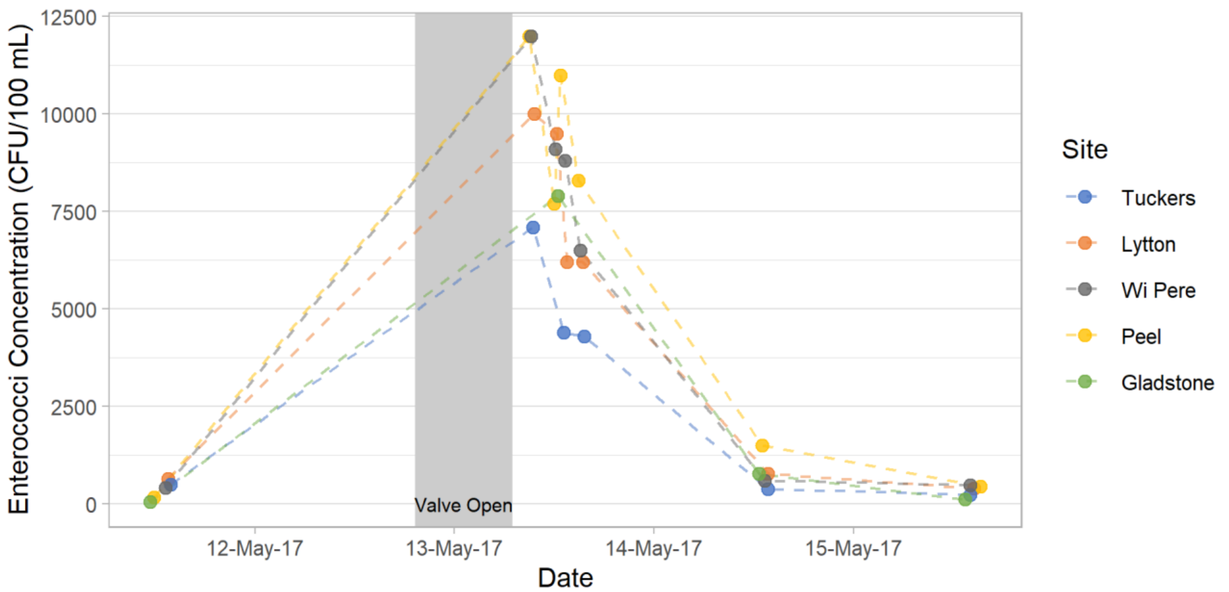

Figure 11: Enterococci concentrations - Taruheru River, 11 – 15 May 2017

(before, during, and after a wastewater overflow event)

ENTEROCOCCI

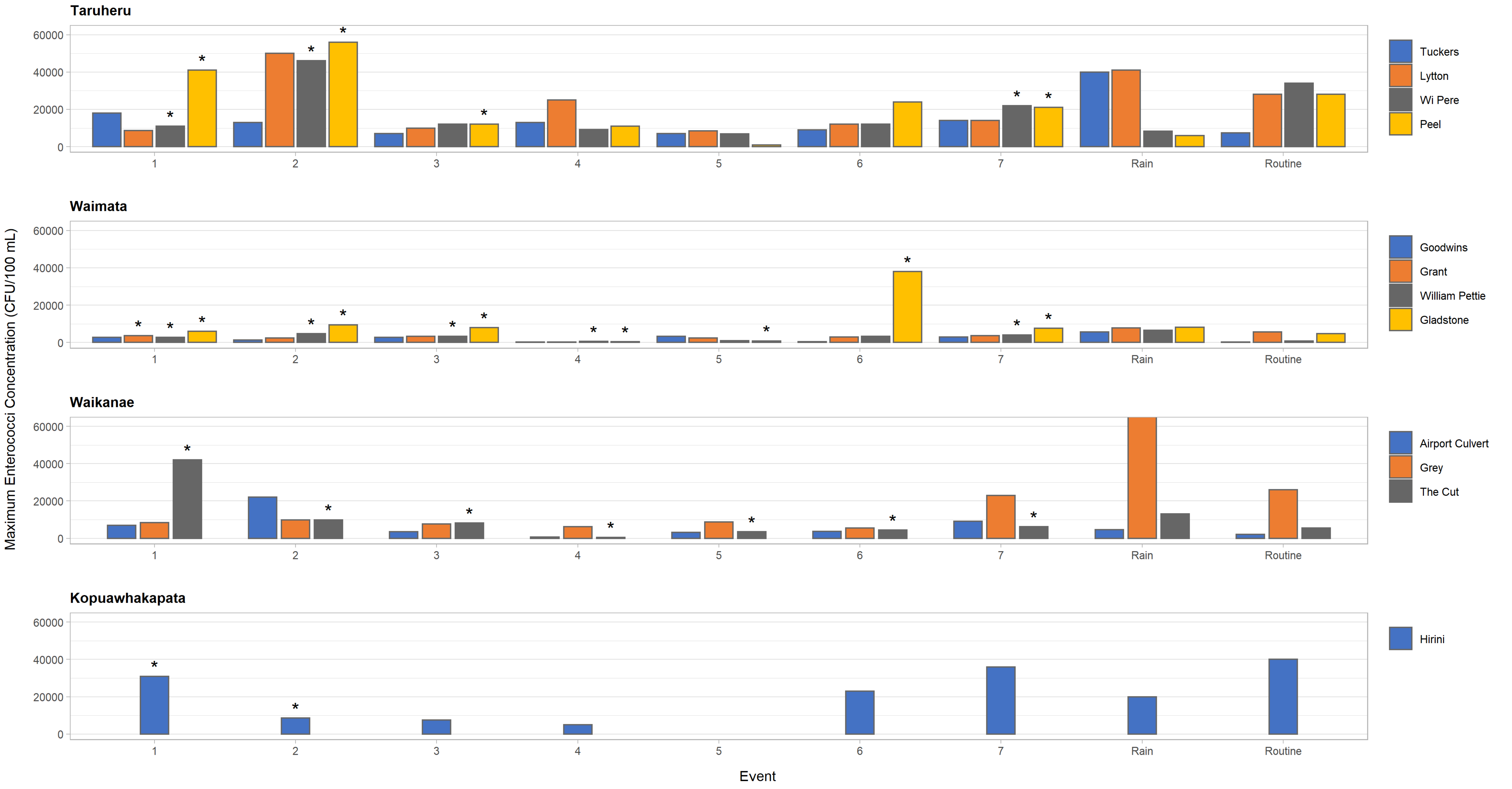

Figure 12: Maximum enterococci concentrations during wastewater overflow events (1–7), a rain-only event and routine sampling

A star indicates that a wastewater overflow was nearby or upstream of the monitoring location. Note there were no measurements in the Kopuawhakapata Stream during Event 5.

4.3 Nutrients

Nutrients (nitrogen and phosphorus) are essential for plant growth, however, excess nutrients can cause nuisance algal growth. This can lead to reduced light and oxygen levels in the water and overall decreased habitat quality.

4.3.1 Total Nitrogen

In the Taruheru and Waikanae Rivers, nitrogen concentrations tended to be higher overall in the upper catchment (Tuckers and Lytton) than in the lower catchment even during overflow events (Figure 13). This indicates that the dominant source of nitrogen is from the upper catchment. During the overflow events sampled, nitrogen concentrations in the lower sections of the rivers were higher than during routine monitoring in that nitrogen concentration remained relatively similar along the entire stretch of the river (rather than the clear decline from upstream to downstream as seen in the routine sampling).

In contrast, the Waimata River typically had higher nitrogen concentrations downstream (William Pettie and Gladstone) than upstream during some overflow events, most notably during Events 2 and 3. This may be a result of the contribution of wastewater overflows, as total nitrogen measured 'in-pipe' at the Harris St and Ormond Rd manholes during heavy rain were between 10 and 30 g/m^3 (i.e., at least one order of magnitude higher than typical ambient concentrations in the river). Gladstone is downstream of the confluence of the Waimata and Taruheru Rivers and is, therefore, influenced by overflows from all upstream sites.

Overall, wastewater overflows are likely to increase the nitrogen levels in Gisborne urban rivers, as the concentration in the overflow discharge is higher than that in river flows from the upstream catchment. The overflows, therefore, add to the typical background source of nitrogen from up-catchment, reducing the dilution effect that would otherwise occur through the urban area. However, as previously discussed, background total nitrogen levels are substantially above the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers (0.281 g/m^3). The short period over which nitrogen is elevated due to wastewater overflows is unlikely to add substantially to existing effects, and will reduce substantially following the implementation of DrainWise.

4.3.2 Total Phosphorus

In the Taruheru River and Kopuawhakapata Stream, wastewater overflows do not appear to elevate total phosphorus levels substantially above that in typical rainfall events (Figure 14). In regard to the Taruheru River, total phosphorus concentrations measured during overflow events were slightly elevated, but generally within the same range that had been measured during routine monitoring. The Kopuawhakapata Stream had slightly elevated phosphorus concentrations during Event 1 where there were overflows on the stream; however, Event 2, which also had an overflow into the stream exhibited maximum concentrations similar to those from routine monitoring and rain only events without overflows.

The Waimata River demonstrated an increase in total phosphorous (above that observed in routine sampling) in Events 1 and 2, and to a lesser extent Event 3. This may be a result of the contribution of wastewater overflows, as total phosphorous concentrations measured 'in-pipe' at the Harris St and Ormond Rd manholes during heavy rain were between 1 and 2 g/m^3 , which is approximately two times upstream concentrations (measured at Tuckers).

The Waikanae Stream, which was not subject to overflows, returned concentrations that were within the range measured in routine sampling.

Overall, wastewater overflows are likely to slightly increase total catchment loads of phosphorus. However, as for total nitrogen, background total phosphorous concentrations are substantially above the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers (0.023 g/m^3). The short period over which phosphorus is elevated due to wastewater overflows is unlikely to add substantially to existing effects, and will reduce substantially following the implementation of the DrainWise programme. It is also noted that total phosphorus concentrations measured during overflow events are generally consistent with those from the rain-only event, suggesting that stormwater runoff may also contribute to phosphorous loads.

4.3.3 Ammonia (toxicity)

Total ammoniacal nitrogen (ammonia; NH_4-N) is potentially toxic to aquatic life depending on the availability of two chemical species: NH_3 and NH_4^+, of which their relative abundances are determined by pH and temperature (NIWA, 2014). Ammonia can be an indicator of human wastewater and was therefore measured in this monitoring programme. All ammonia concentrations were adjusted to pH 8.0 for comparison with the toxicity guidelines.

Maximum ammonia concentrations in river water at all locations during all overflow events were substantially below the Gisborne Urban Freshwater Management Unit median guideline (1.3 g/m^3) (Figure 15). In contrast, the maximum ammonia concentration measured during routine monitoring exceeded the guideline on one monitoring occasion. The maximum ammonia concentration measured at Airport Culvert during the rain event with no overflow (1.32 g/m^3) slightly exceeded the guideline value.

The relatively low concentrations measured during overflow events indicate that ammonia toxicity is not a concern in the monitored rivers. The contribution of ammonia from wastewater overflows appears to be low and very unlikely to cause toxicity-related issues for aquatic organisms.

TOTAL NITROGEN

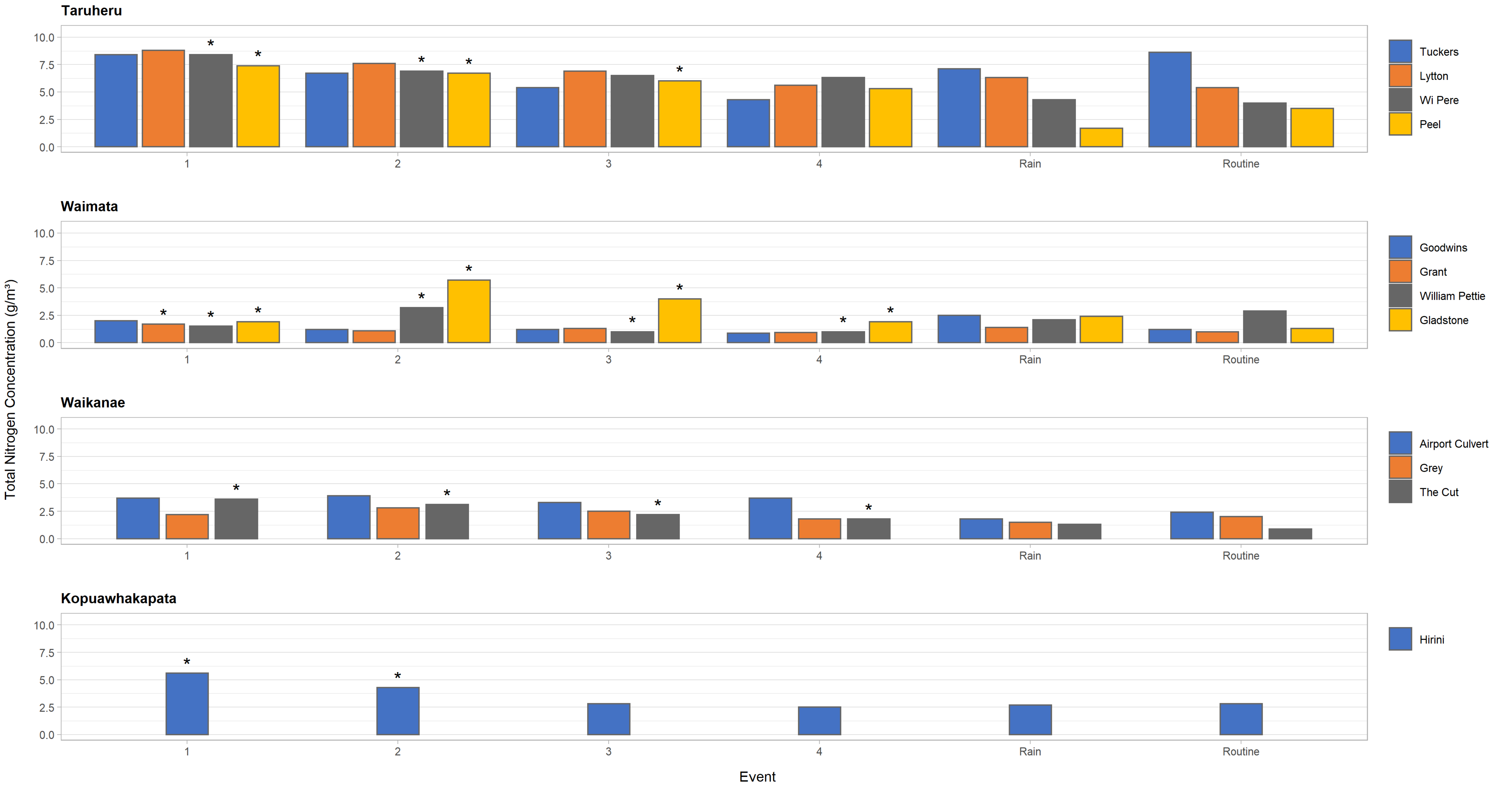

Figure 13: Maximum total nitrogen concentrations during wastewater overflow events (1–4), a rainfall only event and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location)

TOTAL PHOSPHORUS

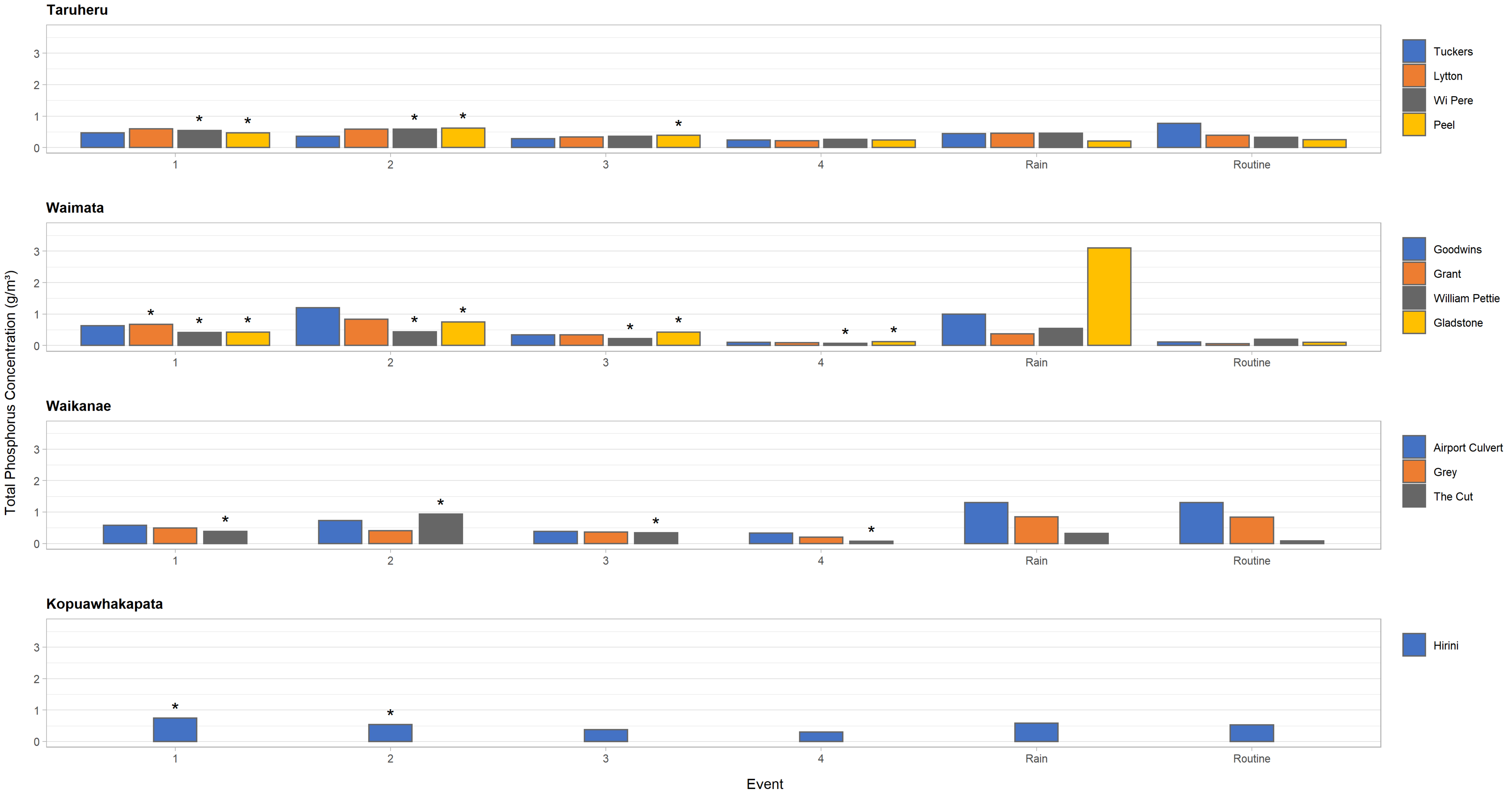

Figure 14: Maximum total phosphorus concentrations during wastewater overflow events (1–4), a rainfall only event, and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location)

AMMONIA (TOXICITY)

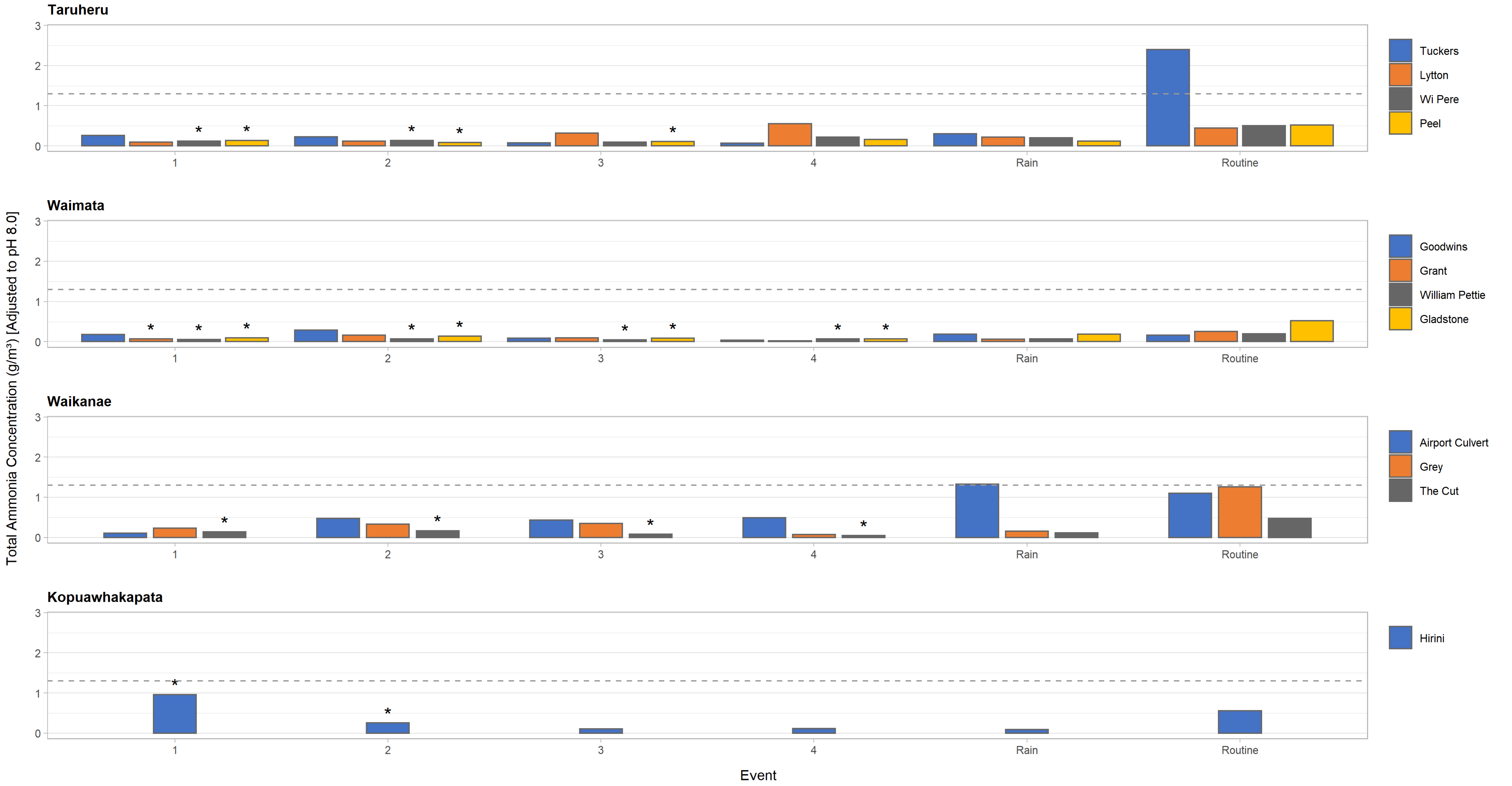

Figure 15: Maximum ammonia concentrations (adjusted to pH 8.0) during wastewater overflow events (1–4), a rainfall only event, and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location. The horizontal dashed line denotes the Gisborne Urban Freshwater Management Unit median guideline of 1.3 g/m³)

4.4 Total Suspended Solids

Maximum TSS concentrations were relatively low on most rivers, with the exception of the Waimata and overflow Event 5 on the Taruheru River.

The maximum TSS concentration on the Waimata River was substantially higher during wastewater overflow events than during routine monitoring (Figure 16). For the reasons discussed below, this is likely to be due to the size of the rainfall events that caused overflows rather than the overflows themselves. Importantly, the Waimata River concentrations clearly show the influence of sediment sources in the upper catchment, with the highest levels observed in the upper most site, which is well upstream of the Gisborne urban area and declining levels from there. Additionally, the TSS concentration measured 'in-pipe' at Harris St and Ormond Rd during a heavy rain event ranged from 50 to 100 g/m^3, which is substantially less than upstream river concentrations measured at Goodwins during Events 1, 2, 3 and 5 and similar to that for Event 4. Hence, it is unlikely that the wastewater component of the overflows contributes appreciably to the overall suspended solids loads and concentration in the Waimata River.

No substantial changes were measured in any of the other rivers during overflow events, indicating that wastewater overflows generally have a low effect on the receiving environment water quality with regard to suspended sediment.

4.5 Metals

Urban contaminants such as heavy metals, particularly copper and zinc are generally present in urban stormwater. Potential sources include stormwater runoff from roads where metals can accumulate from the combustion of fuels in motor vehicles, tyres, and from brake pads. Other sources can be from urban household roofs. Copper and zinc are both toxic to aquatic life above certain concentrations.

Water samples were analysed for both dissolved and total forms of copper and zinc. Typically, the majority of metals in the total metal fraction are bound to sediment and thus relatively unavailable to interact with the environment. For this reason, dissolved metal concentrations have been assessed in the following section as they are essentially the bioavailable metals.

It is noted that wastewater overflows contain a significant amount of stormwater, and of course occur during periods of heavy rain when stormwater discharges are also at a maximum.

4.5.1 Copper (Dissolved)

The majority of measurements taken during the overflow monitoring programme were below the analytical level of detection, indicating typically low concentrations of copper. However, maximum copper concentrations measured in the Taruheru River were typically higher during overflow and rainfall events than during routine monitoring (Figure 17). However, dissolved copper is unlikely to be sourced from wastewater. Rather it is more likely to be discharged to streams via stormwater. This is supported by the lack of a relationship between the location of a wastewater overflow and the concentration measure nearby or downstream; i.e. there is generally no step-wise increase in copper concentration nearby or downstream of an opened overflow valve. The guideline value was exceeded during some rainfall (non-overflow) and routine events indicating occasional significant contributions from the catchment during rain events.

With the exception of Event 1, maximum copper concentrations were generally at or below the 80% protection guideline value. Correspondingly, Event 1 had the highest amount of rainfall of the four overflow events (Figure 9). These are chronic guideline values and hence the overall risk to aquatic species from episodic rain (and even less frequent overflow) events is highly likely to be low considering the short period they are elevated (<24–48 hours).

Due to their low frequency, short duration and limited contribution, elevated copper concentrations from wastewater overflows are likely to have a very small to negligible effect on in-stream chronic or long-term copper concentrations. The predominant influence is likely to be from urban stormwater runoff.

4.5.2 Zinc (Dissolved)

Similar to that of dissolved copper, many samples for zinc taken during the overflow monitoring programme were below the analytical level of detection. Maximum concentrations measured during overflow events in the Taruheru

River were within the range of concentrations measured during routine monitoring (Figure 18). This suggests a relatively low contribution to zinc concentrations from overflows and, similarly to copper, the primary source is likely to be from the stormwater rather than the wastewater component. Overall, zinc concentrations tended to be slightly higher in Waikanae Stream than in the other rivers.

With the exception of Event 1, which had the most rainfall, maximum zinc concentrations were generally at or below the 80% protection guideline value. These are chronic guideline values and, therefore, the overall risk to aquatic species episodic rain (and even less frequent overflow) events is highly likely to be low considering the short period they are elevated (<24–48 hours).

Due to their low frequency and short period, elevated copper concentrations from wastewater overflows are likely to have a very small to negligible effect on long-term median zinc concentrations.

4.6 Fluoride

Fluoride was monitored as a potential indicator of the presence of wastewater as it is added to water at a concentration of between 0.7–1.0 mg/L[4] and is less likely to be present in stormwater. Maximum fluoride concentrations in the Taruheru and Waimata Rivers and Waikanae Stream all show a similar, general pattern of increasing maximum concentrations the further downstream measurements are taken (Figure 19). This suggests that that the wastewater overflows are a source of fluoride and concentrations of fluoride increase as more wastewater is added to the waterway.

However, elevated fluoride concentrations were also measured at locations that were not associated with overflow events (for example the Waikanae River). This may indicate other catchment sources, or the potential presence of illegal connections of private wastewater pipes to the stormwater network, which would provide a constant source of fluoride into the receiving environment.

All maximum concentrations exceed the Canadian water quality guideline for the protection of aquatic life[5]. However, it is also noted that the upstream sites in the Taruheru River (Tuckers) and the Waimata River (Goodwins), which are well outside the urban area, also showed appreciable concentrations of fluoride. Due to the relatively short nature of these overflow events, there are unlikely to be long-lasting effects on aquatic organisms from these temporarily elevated levels.

[4] https://www.gdc.govt.nz/fluoridation-of-gisborne-drinking-water/

[5] There are no New Zealand specific water quality for ecosystem health guidelines for fluoride. The Canadian water quality guidelines are referenced in a number of places throughout the ANZECC (2000) guidelines as a substitute in the absence of regionally or locally derived guidelines.

TOTAL SUSPENDED SOLIDS

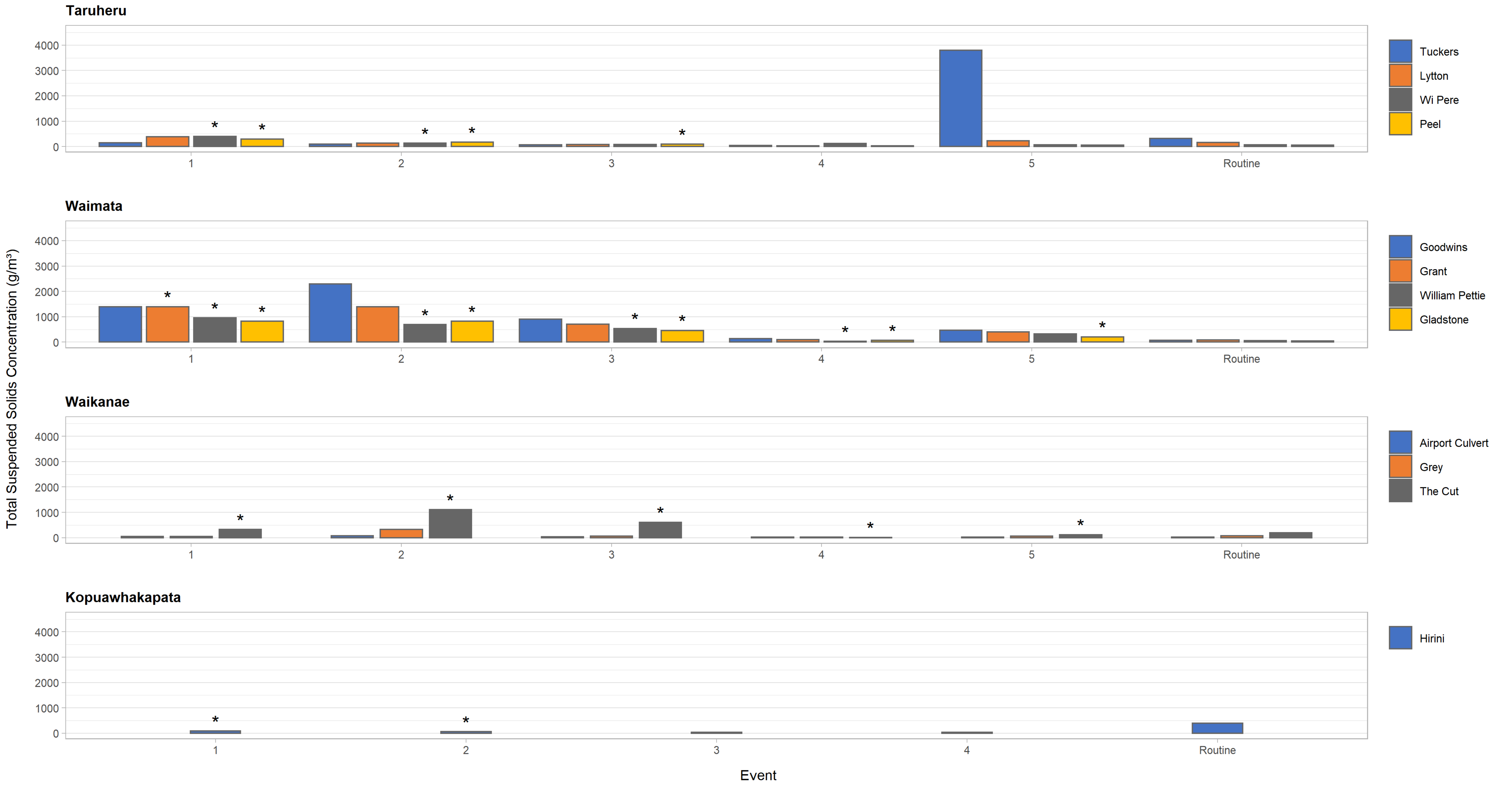

Figure 16: Maximum total suspended solids concentrations during wastewater overflow events (1–4), a rainfall only event, and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location)

COPPER (DISSOLVED)

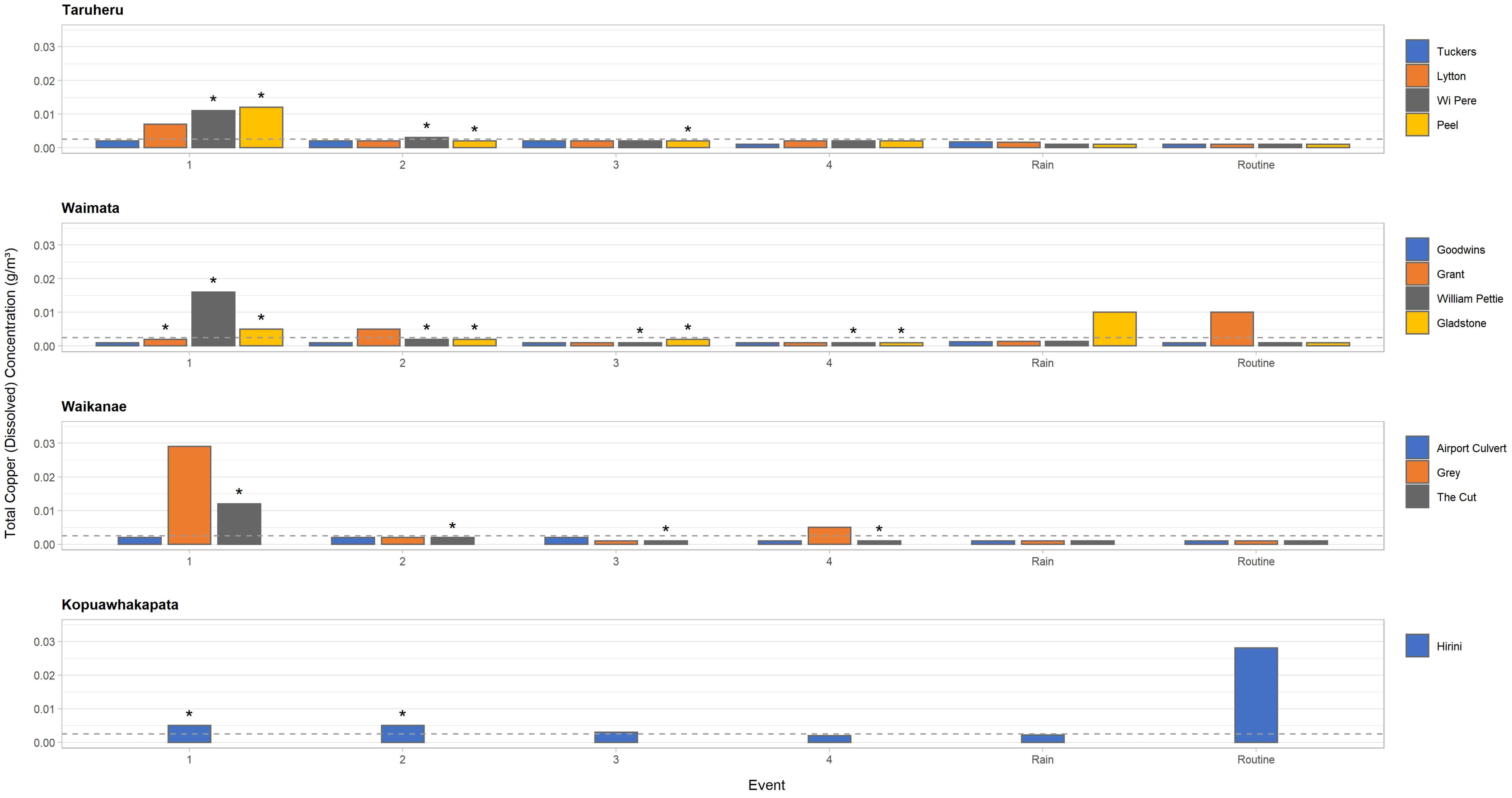

Figure 17 Maximum total copper (dissolved) concentrations during wastewater overflow events (1–4), a rainfall only event, and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location. The dashed horizontal line shows the ANZG (2018) toxicant guideline value for the 80% protection of freshwater species (0.0025 g/m³))

ZINC (DISSOLVED)

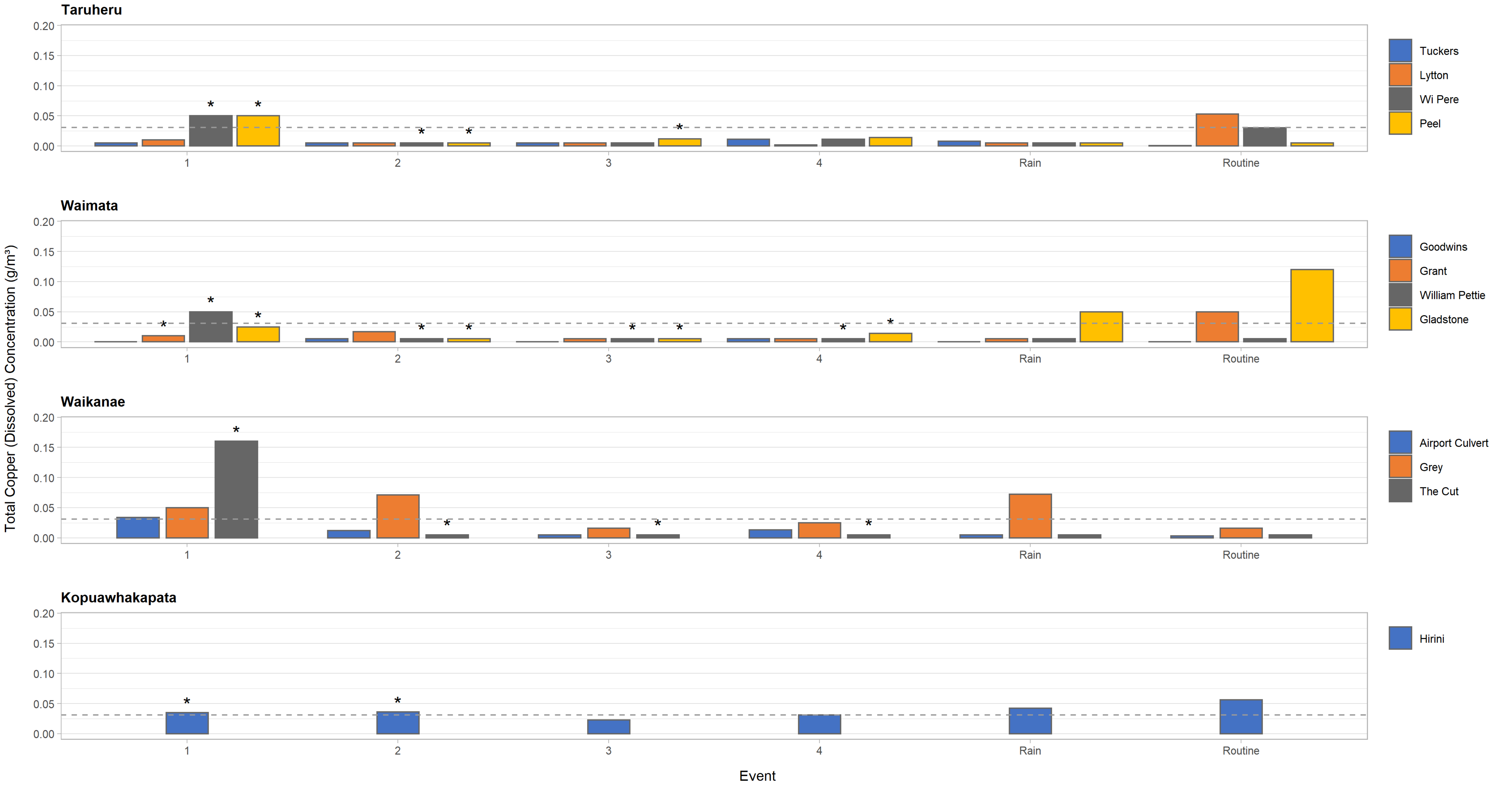

Figure 18: Maximum total zinc (dissolved) concentrations during wastewater overflow events (1–4), a rainfall only event, and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location. The dashed horizontal line shows the ANZG (2018) toxicant guideline value for the 80% protection of freshwater species (0.031 g/m³))

FLUORIDE

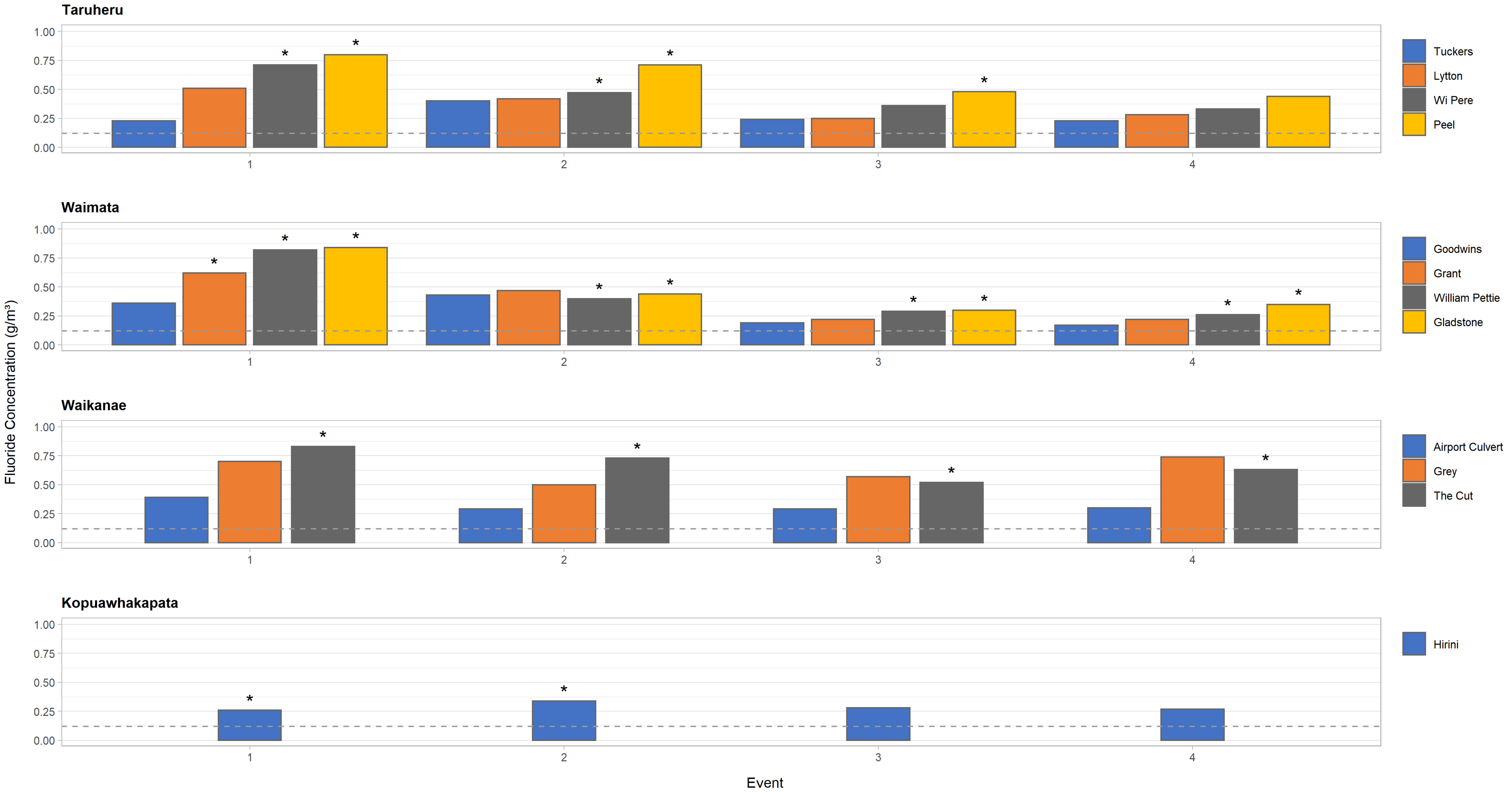

Figure 19: Maximum fluoride concentrations during wastewater overflow events (1–4), a rainfall only event, and routine sampling

(A star indicates that a wastewater overflow was nearby or upstream of the monitoring location. The dashed, horizontal line shows the Canadian environmental quality guideline for the protection of aquatic life of 0.12 g/m³)

4.7 Summary

There were generally insufficient samples for each of the event-based sampling occasions (about 5–8 samples per event) to enable a statistical analysis similar to that undertaken for the state of the environment sampling. Accordingly, only the **maximum** concentration measured during each event (at each location) was analysed, except where an assessment of the duration of elevated water quality is undertaken.

Analysis of maximum concentrations measured during wastewater overflow events and the overflows' effects on the water quality of Gisborne's main urban rivers suggests the following:

Enterococci

- As expected, the enterococci concentrations in samples collected directly from the wastewater network were high. Enterococci concentrations in discharged overflows that combine wastewater and stormwater generally range from less than 1,000,000 to 2,000,000 CFU/100mL (and up to 2,500,000 CFU/mL), which is about 4,000 to 7,000 times greater than the recreational water quality guidelines. This is rapidly dispersed and diluted, with a maximum instream concentration of approximately 60,000 CFU/100mL being measured (in the Taruheru River) – which also includes any background contribution from upstream sources.
- The relationship between the volume of wastewater discharged and the concentration of enterococci in the rivers is complex. A larger discharge volume doesn't necessarily result in a proportionate increase in enterococci in the rivers. This is most likely due to the levels of dilution (both in-pipe and within the rivers), the timing of sampling, location of the overflows relative to the sampling location, and climatic factors including rainfall, wind and tide.
- During Events 1 and 2, maximum enterococci concentrations increased from upstream to downstream in the Taruheru River – consistent with the location of overflow discharges. This clear trend demonstrates that wastewater overflows can contribute significantly to enterococci concentrations in the rivers.
- The highest enterococci concentrations over this period were measured in the lower Taruheru River. Most notably during Events 1 and 2 (in which overflow valves that discharge to the Taruheru River were opened). The maximum concentrations were about twice as high during these overflow events than the maximums measured during routine sampling indicating that wastewater overflows can increase microbial concentrations beyond the range that would normally occur.
- As for the assessment of routine sampling, the Kopuawhakapata Stream showed evidence of chronic microbial (and other contaminant) input.
- Concentrations in the river typically revert to pre-event concentrations within approximately 48 hours of an overflow. This period is no longer than would be expected following heavy rainfall with no overflows; that is, the wastewater overflows don't appear to prolong degraded water quality following heavy rainfall any more than due to the rainfall itself.

Nutrients

- In general, nutrient concentrations were highest in the upper catchment of the Taruheru, indicating that the catchment is the dominant source. However, overflows in the lower catchment appear to sustain the elevated levels down the river, rather than the declining downstream trend observed in the routine monitoring (absent of overflows) – particularly for nitrogen and to a lesser extent phosphorus in the Taruheru River.
- Wastewater overflows are likely to increase the nitrogen and phosphorus levels in Gisborne urban rivers, as the concentration in the overflow discharge is higher than that in river flows from the upstream catchment. The overflows therefore add to the typical background source of nitrogen from up-catchment, reducing the stormwater dilution effect that would otherwise occur through the urban area.
- However, background total nitrogen levels are substantially above the ANZG (2018) 80th percentile guideline value for Warm Dry Low-elevation rivers (0.281 g/m^3). The short period over which nitrogen and phosphorus is elevated due to wastewater overflows is unlikely to add substantially to existing effects, and will reduce substantially following the implementation of the DrainWise programme.

Ammonia (Toxicity)

- Maximum ammonia concentrations in river water at all locations during all overflow events were substantially below the Gisborne Urban Freshwater Management Unit median guideline (1.3 g/m^3).

- The low concentrations measured during overflow events indicate that ammonia toxicity is not a concern in the monitored rivers. The contribution of ammonia from wastewater overflows is appears to be low and very unlikely to cause toxicity-related effects on aquatic organisms.

Total Suspended Solids

- In general, wastewater overflows are unlikely to have more than a minor (if noticeable) contribution to river TSS concentrations during overflow events. Wet weather wastewater TSS concentrations, measured 'in-pipe', are at a similar level to, or below, river TSS concentrations particularly in the Waimata River.
- TSS concentrations were notably elevated on the Waimata River during the sampled during the rainfall/overflow events. However, these were highest in the upper catchment, indicating the catchment to be the dominant source during heavy rain. There was no evidence of any significant input from wastewater overflows and urban stormwater. This is not surprising given the large size of the catchment compared to the urban area, and the known dominant source of TSS from agricultural runoff.

Metals

- Results for copper (dissolved) and zinc (dissolved) were often below the analytical level of detection, indicating the generally low concentrations of dissolved metals in river waters.
- Metal concentrations were below (less than) the guideline value for the 80% protection of species most of the time. These are chronic guideline values and hence the overall risk to aquatic species from episodic rain (and even less frequent overflow) events is likely to be low considering the short period they are elevated (<24–48 hours). Given the primary source of metals is likely to be from stormwater component, rather than wastewater, wastewater overflows are likely to have a very small to negligible effect on in-stream chronic or long-term copper concentrations.

Fluoride

- Maximum fluoride concentrations generally increased from upstream to downstream, indicating that wastewater overflows were likely to be the dominant source in the lower catchments. This is likely to be associated with the presence of fluoride in Gisborne's water supply. However, elevated fluoride concentrations were also measured at locations not associated with wastewater overflows and the wider sources of fluoride are not clear.

5 DISCUSSION

This section presents a synthesis of the findings from the monitoring. It primarily focusses on patterns and changes seen in the Taruheru River in particular as it appears to have the most notable effects from overflows of the studied rivers; however, conclusions are drawn from all the data analysed in this report.

5.1 Changes in river water quality before, during, and after an overflow event

The 'background' state of the river is assessed and described through the ongoing routine monitoring carried out by Council. Routine monitoring results will be dominated by dry weather sampling; however, they will also capture the effects of some rainfall events. To aid in assessing the added impacts of overflows, those events where overflows have occurred were removed from the analysis of background water quality.

Routine monitoring (background) shows that the median concentration of faecal bacteria (enterococci) are typically at or slightly below the TRMP numeric objective, however, the 95th percentile of the data, exceeds the equiovalent TRMP numeric objective. Routine monitoring also showed that levels of total nutrients and suspended sediment are elevated, and that levels of metals are generally low in most rivers. The main exception to this is in the Kopuawhakapata Stream, which shows signs of chronic contamination.

Contaminant levels (faecal bacteria, nutrients, sediment, and metals) increase during rainfall events, even when there are no wastewater overflows. This is due to catchment-derived contaminants. One such event was monitored during 12–16 March 2018 and is used as a point of reference.

In this context, the effect of overflows on water quality is the potential for further increase in contaminant levels over and above the levels measured during rainfall events without overflows.

The greatest effect that overflows have on the receiving environment water quality is increasing the levels of faecal bacteria. This effect is most notable in the Taruheru River and less so in the other catchments. One reason for this is likely that the Taruheru River catchment is substantially smaller than that of the Waimata River and accordingly river flows and hence available dilution are less. The effect of wastewater overflows on enterococci concentrations is expected as in-network measurements show enterococci concentrations to be typically less than 1,000,000 to 2,000,000 (CFU/100mL) following initial dilution by stormwater – which is substantially higher than background levels in the rivers. The overflows are then diluted by stormwater runoff and river flow when discharged. This results in maximum faecal bacteria concentration in the rivers that are more than twice as high during overflow events than during rainfall with no overflows.

Wastewater overflows are likely to increase the nitrogen levels in Gisborne urban rivers, as the concentration in the overflow discharge is higher than that in river flows from the upstream catchment. The overflows, therefore, add to the typical background source of nitrogen from up-catchment, reducing the stormwater dilution effect that would otherwise occur through the urban area. This response was less pronounced for phosphorous. However, both nitrogen and phosphorus levels are above guideline values – both with and without the influence of overflows.

Maximum ammonia concentrations were all below the guideline value during overflow events and, therefore, posed little risk of toxicity to aquatic organisms. Overall, the effect of overflows on the levels of nutrients appears to be generally low as the maximum concentrations measured during overflow events are in a similar range to those measured during rainfall with no overflows.

Maximum total suspended solid concentrations were frequently lower during overflow events than during rainfall events with no overflows. This is most likely to the nature of the storm event and wider catchment characteristics (sediment sources in upper catchment areas) and erosion during heavy rainfall events is likely to be the most dominant source. During a heavy rain event, TSS levels in discharged wastewater overflows can be less than background levels in the river.

Metal concentrations (dissolved copper and dissolved zinc) were generally low in the rivers. During wastewater overflows, the stormwater component, rather than the wastewater component, is likely to be the dominant source of metals.

Maximum fluoride concentrations generally increased from upstream to downstream, suggesting that wastewater overflows were likely to a source in the lower catchment. However, elevated fluoride concentrations were also measured at locations not associated with wastewater overflows and the range of catchment sources are not clear.

Contaminants in the river in the monitored events reverted to pre-event concentrations within approximately 48 hours of an overflow. This period is no longer than would be expected following heavy rainfall with no overflows; that is, the wastewater overflows don't appear to prolong degraded water quality following heavy rainfall any more than due to the rainfall itself, but do result in much higher indicator pathogen levels (with little effect on nutrients, metals, and fluoride levels).

5.2 Changes in water quality along the water body during an overflow event

Routine and overflow event monitoring has shown that there are a number of contaminants that are primarily sourced from the upper catchment; that is, there are elevated levels of contaminants that are not derived from wastewater network discharges. Notable examples include enterococci in the Taruheru River and total nitrogen, ammonia, and total suspended solids in all catchments. During a rainfall event, with or without overflows, these contaminants are generally highest in the upper-catchment sites and become more diluted as they move downstream and are mixed with further stormwater and, when they occur, overflows.

Water quality in the mid to lower catchment is affected by urban contaminants such as those carried in stormwater and, during an overflow event, from wastewater overflows. During overflow events, water quality is generally poorer downstream of the overflows, however, this is complicated by the tidal nature of the lower reaches of the river. On an incoming tide, contaminants may be 'pushed up', sometimes into a different river than the contaminants came from. The hydrodynamics of estuaries and tidal rivers are complex and further investigation of potential contaminant transport scenarios due to tides may be warranted.

5.3 Differences between catchments

In respect of faecal bacteria, the Taruheru River has the highest recorded levels of contamination. This has been measured during routine monitoring and during rainfall with and without overflows. This is likely due to a combination of factors including the river flow (noting that the Taruheru catchment is substantially smaller than that of the Waimata), land use within the catchment, the number of potential overflow locations along the river, and the volume of water that is discharged at each location during an overflow event.

Water quality in the Waimata and Waikanae catchments appear to be largely dominated by catchment-derived contaminants. This is especially so for suspended sediment in the Waimata catchment. On the occasion that an overflow does occur on the river, water quality is reduced below this point. However, in general, contaminants are higher in the upper catchment and become more diluted as they move downstream.

The Waikanae Stream, which did not receive overflows in any of the events, showed elevated contaminant concentrations in some rain events including enterococci (up to 60,000 CFU/100ml, ammonia, metals (particularly copper) and fluoride. This suggests other catchment sources of most contaminants.

The Kopuawhakapata Stream has been noted throughout this report as showing signs of chronic contamination. Elevated levels of ammonia and faecal bacteria point toward wastewater contamination. One potential cause of this is illegal cross-connections that may warrant further investigation to determine the number of these connections, if any, and the frequency at which they discharge.

5.4 Future changes and impacts

Between April 2017 and June 2018 there were seven overflow events during which there were up to eight locations where overflow valves were opened during each event. The Council has committed to a programme of work, as part of its DrainWise Wastewater Discharge Reduction Programme, to upgrade the wastewater and stormwater systems and reduce the frequency and volume of overflows. This includes identifying illegal stormwater connections and putting in place drainage solutions for areas where surface water is entering the sewers from flooding. As a result, there should be a reduction in both the frequency of overflow events and the number of locations from which overflows occur and, therefore, a reduction in the total contaminant loading into the environment.

Wastewater overflows are now controlled through two primary (Seymour Rd/Turenne St [Waimata River] and Wainui Road [Turanganui River]) and two secondary (Oak St and Palmerston Rd/Peel St [both Taruheru River]) overflow points. Limiting overflows to these sites, and only having secondary overflows on the Taruheru River, should reduce the extent of adverse effects – in particular on the Taruheru River. The primary use of overflows on the Waimata will help maximise dilution and flushing from the river/tidal and should reduce the potential impact that overflows will have on water quality in the urban river reaches.

As the DrainWise programme is implemented, and the frequency and volume of overflows is progressively reduced, then the wastewater contribution to degraded water quality during rain events will similarly reduce. However, the background water quality, as evidenced by the routine monitoring, will remain unchanged unless there are changes in the wider catchments or other measures put in place.

The TRMP sets out objectives for the improvement of water quality in the Gisborne region. The plan includes for specific parameters, the current state of the environment statistics, and limits/future targets for each parameter. For enterococci, the limits set for the catchments relevant to this study (Gisborne Urban Freshwater Management Unit) aim to keep the median recorded concentration at <280 CFU/100mL, and the 95th percentile value to <500 CFU/100mL.

Given the short duration of the effects of an overflow event, as discussed in this report, it is only likely to be the 95th percentile value that overflow events will influence. The DrainWise Programme seeks to significantly reduce overflow frequency, the number of overflow locations and overflow volumes. This will assist in improving overall water quality and achieving this ‘improvement’ target, in accordance with the TRMP.

6 MONITORING RECOMMENDATIONS

A summary of recommendations for future monitoring and further data analysis is outlined below:

- Continue monitoring in-stream microbiological contaminants during overflow events to allow public health management.
- On-going monitoring of heavy metals, nutrients, ammonia, TSS, and fluoride in-stream and in-pipe during overflow events are not required. These have been sufficiently characterised and assessed through this initial monitoring programme and the wastewater contribution to effects associated with the contaminants is low.
- Consider undertaking more detailed monitoring along the Kopuawhakapata Stream to understand background levels and try and isolate potential wastewater sources.

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Appendix A:

Monitored Event Overflow Locations

Overflow Event 1: 04/04/2017

Date: 11/06/2020

Scale @A4 1:15,000

Overflow Event 2: 13/04/2017 Date: 11/06/2020

Scale @A4 1:15,000

Overflow Event 3: 12/05/2017 Date: 11/06/2020

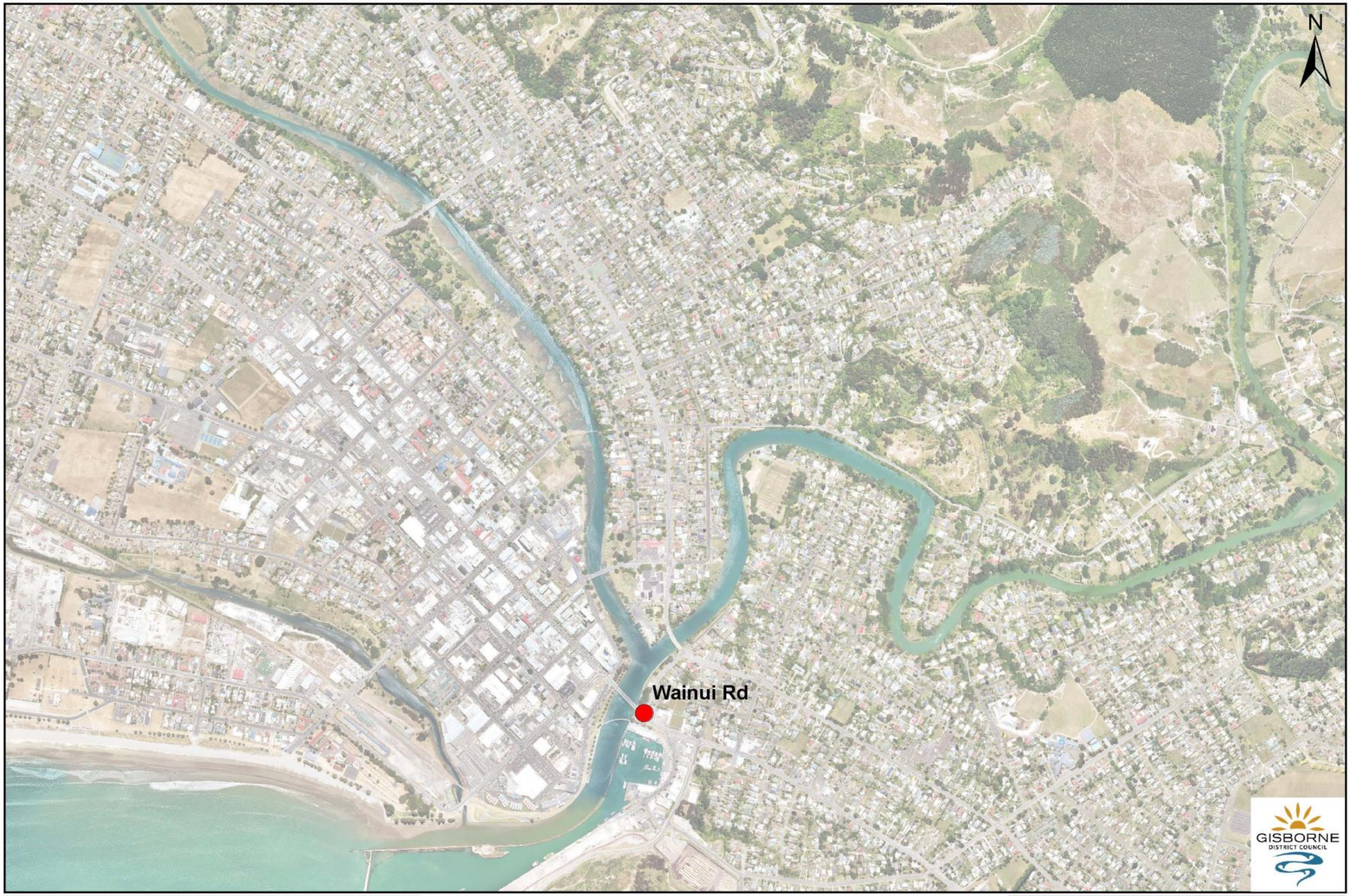
Contains Crown Copyright Data - Sourced from Land Information NZ. Aerial Imagery - AAM NZ Ltd. Gisborne District Council

Scale @A4 1:15,000

Overflow Event 4: 28/05/2017

Date: 11/06/2020

Scale @A4 1:15,000



Overflow Event 5: 03/09/2017

Date: 11/06/2020

Scale @A4 1:15,000

Overflow Event 6: 04/06/2018

Date: 11/06/2020

Scale @A4 1:15,000

Overflow Event 7: 11/06/2018

Date: 11/06/2020

Scale @A4 1:15,000

Appendix B:

Data Plots

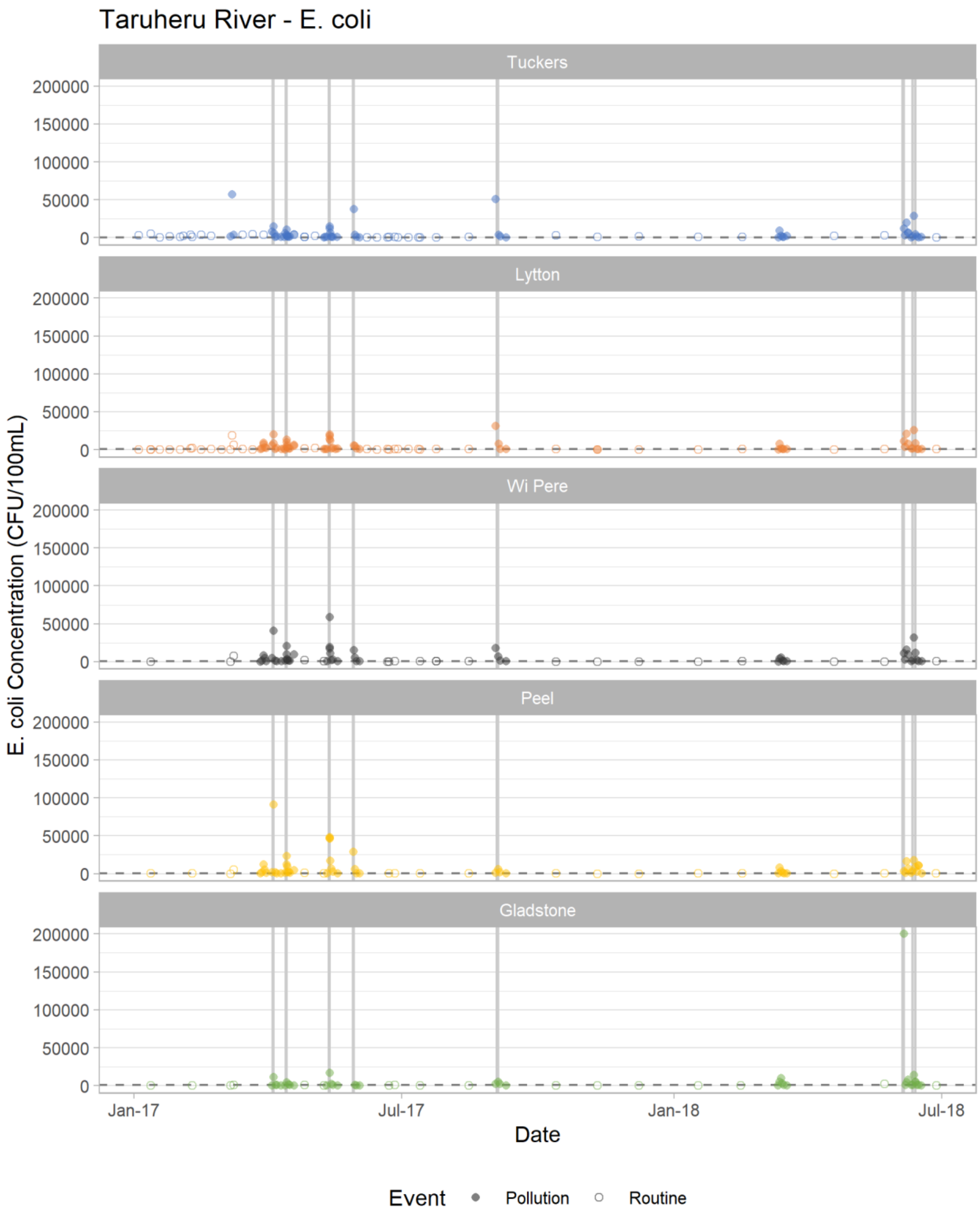


Figure C1: *E. coli* concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 550 CFU/100mL

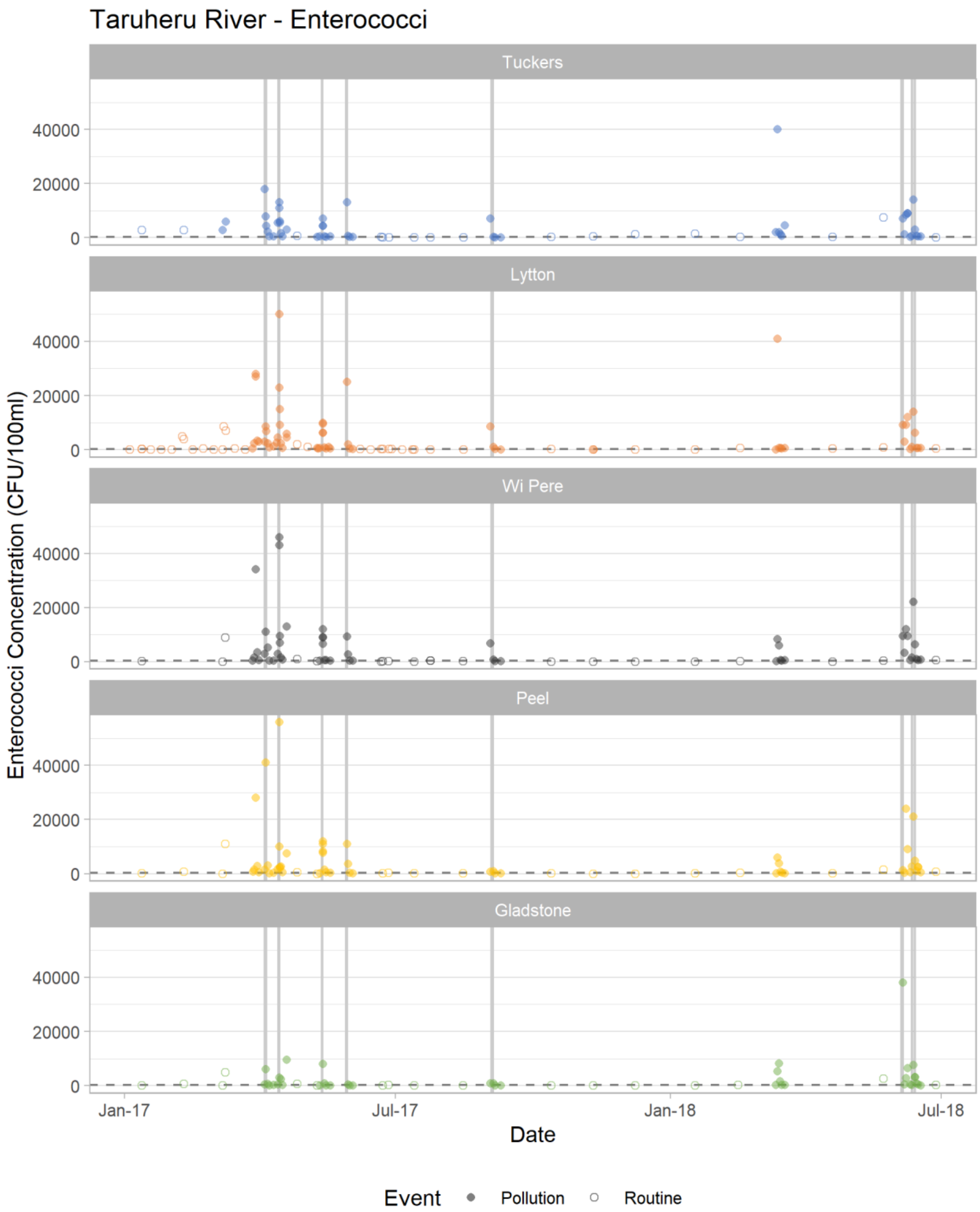


Figure C2: Enterococci concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 280 CFU/100mL

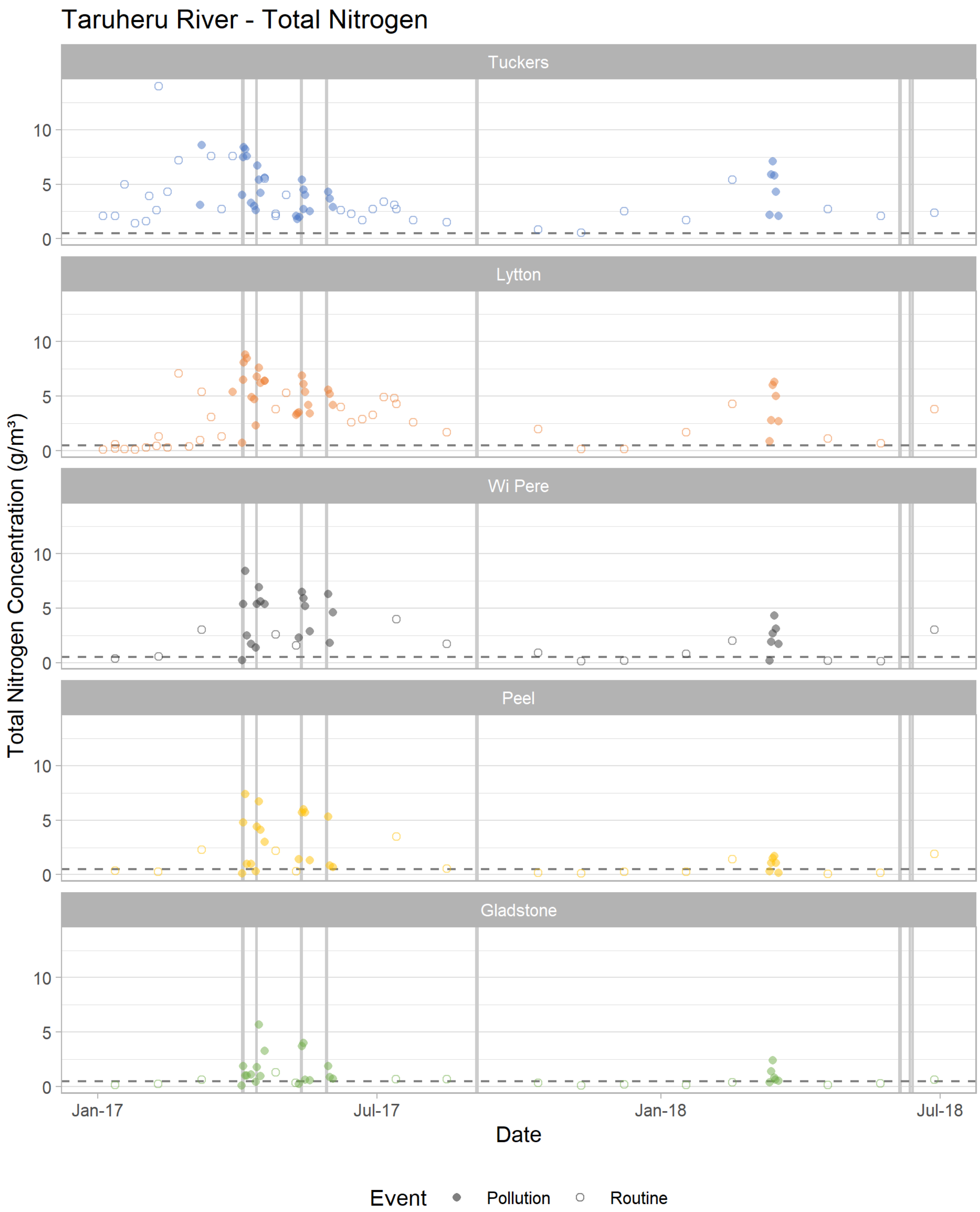


Figure C3: Total nitrogen concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.5 g/m^3

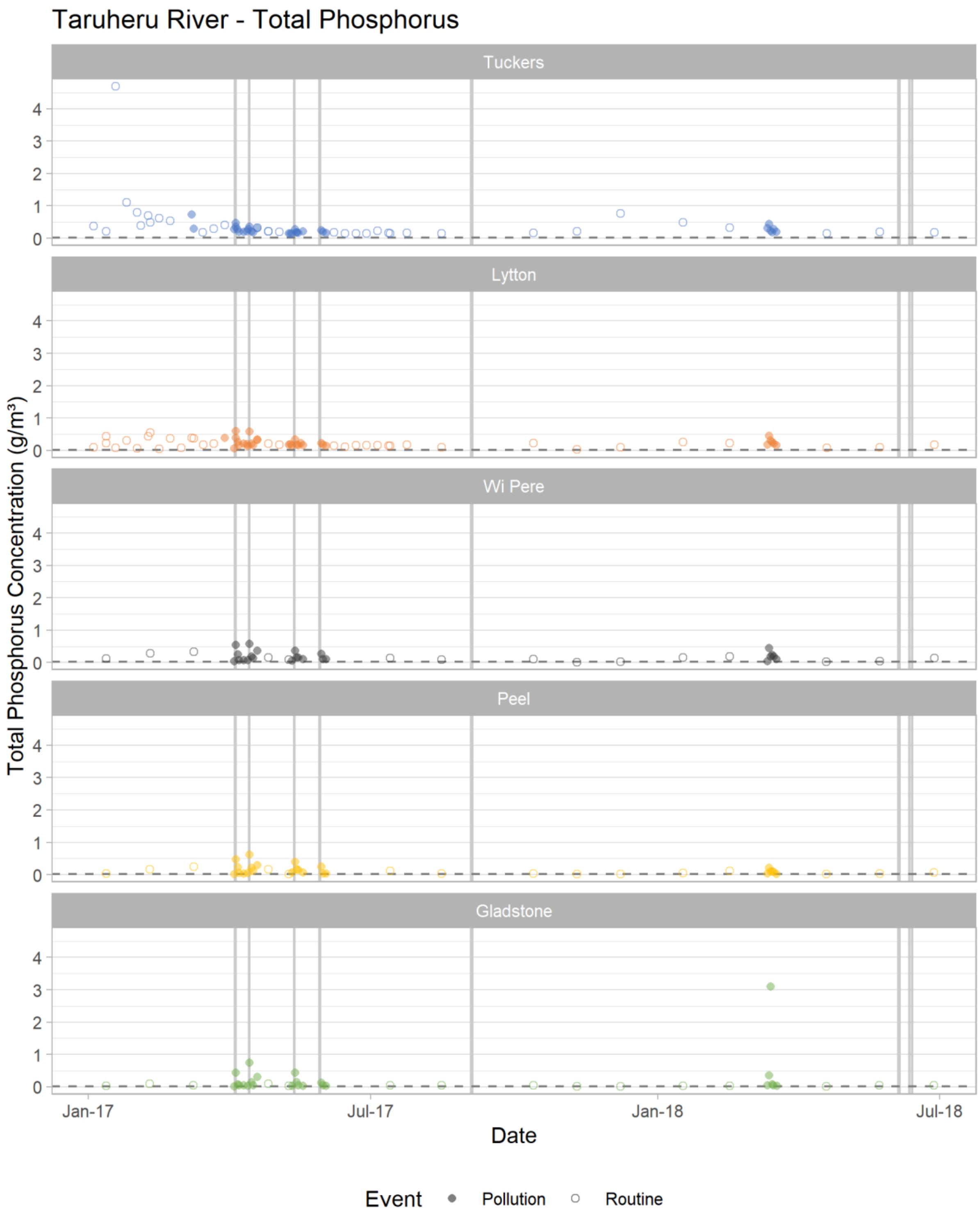


Figure C4: Total phosphorus concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.02 g/m^3

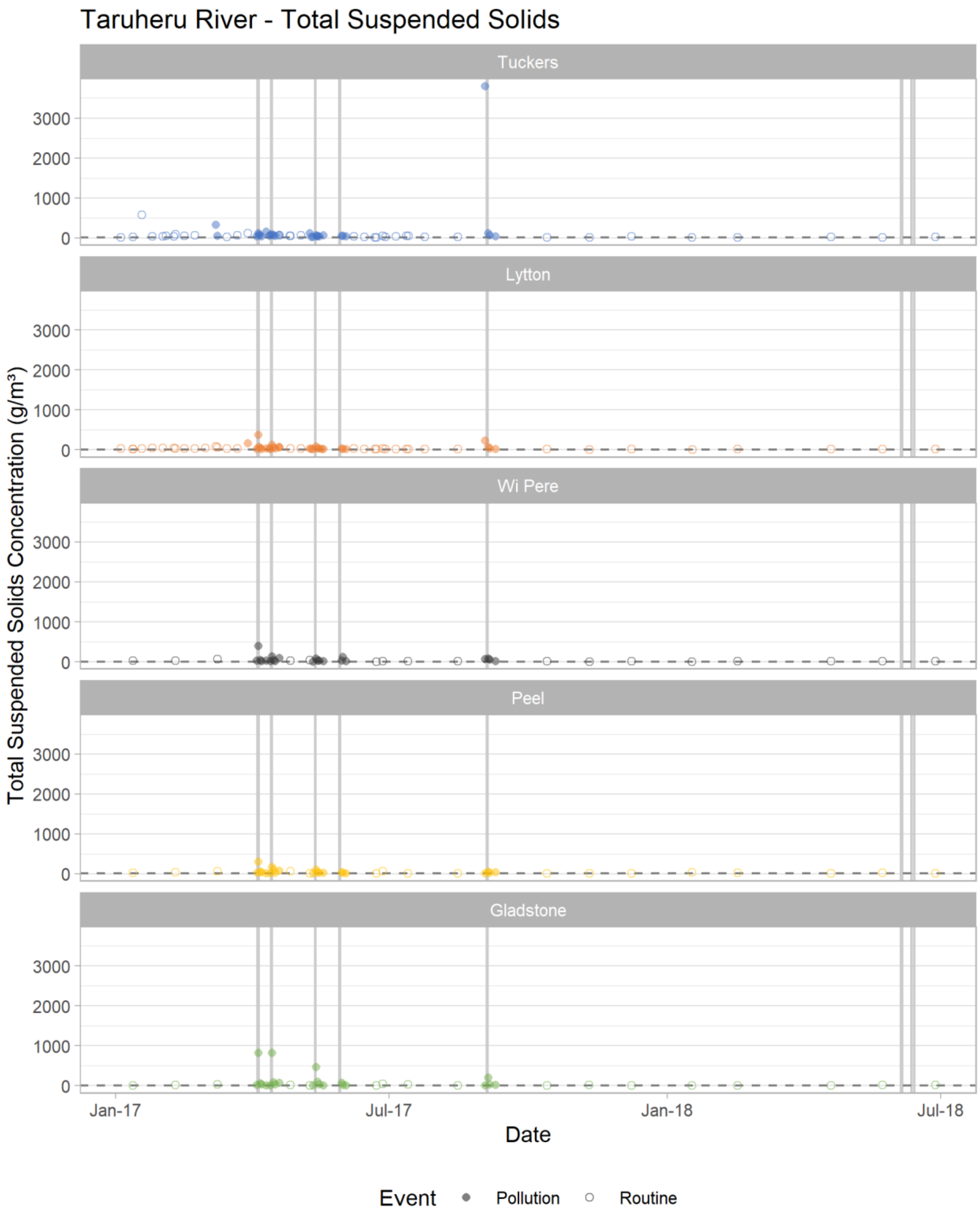


Figure C5: Total suspended solids concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for turbidity for NZ lowland rivers. There is no guideline specifically for TSS but the correlation between TSS and turbidity is strongly positive

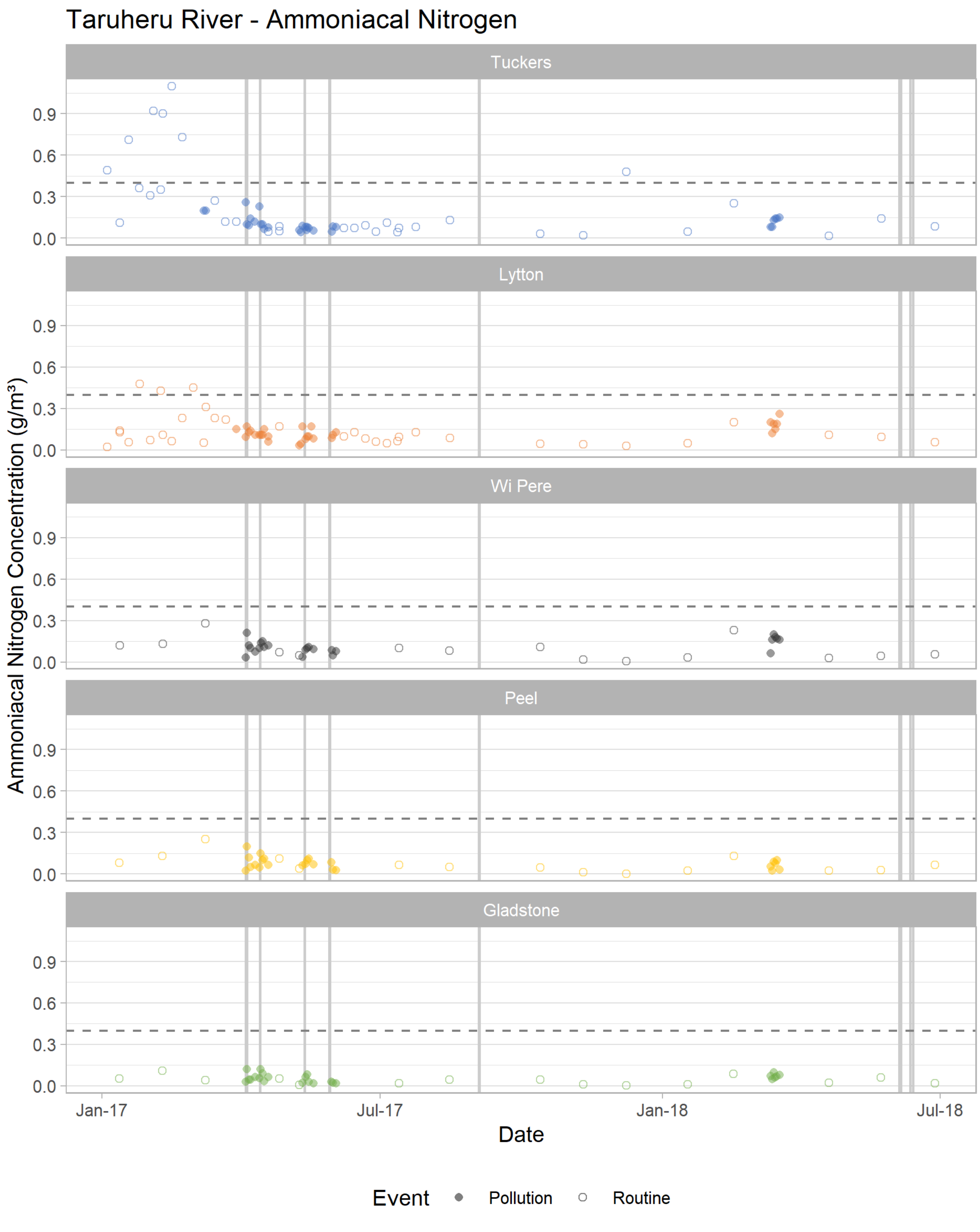


Figure C6: Ammoniacal nitrogen concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.4 g/m^3

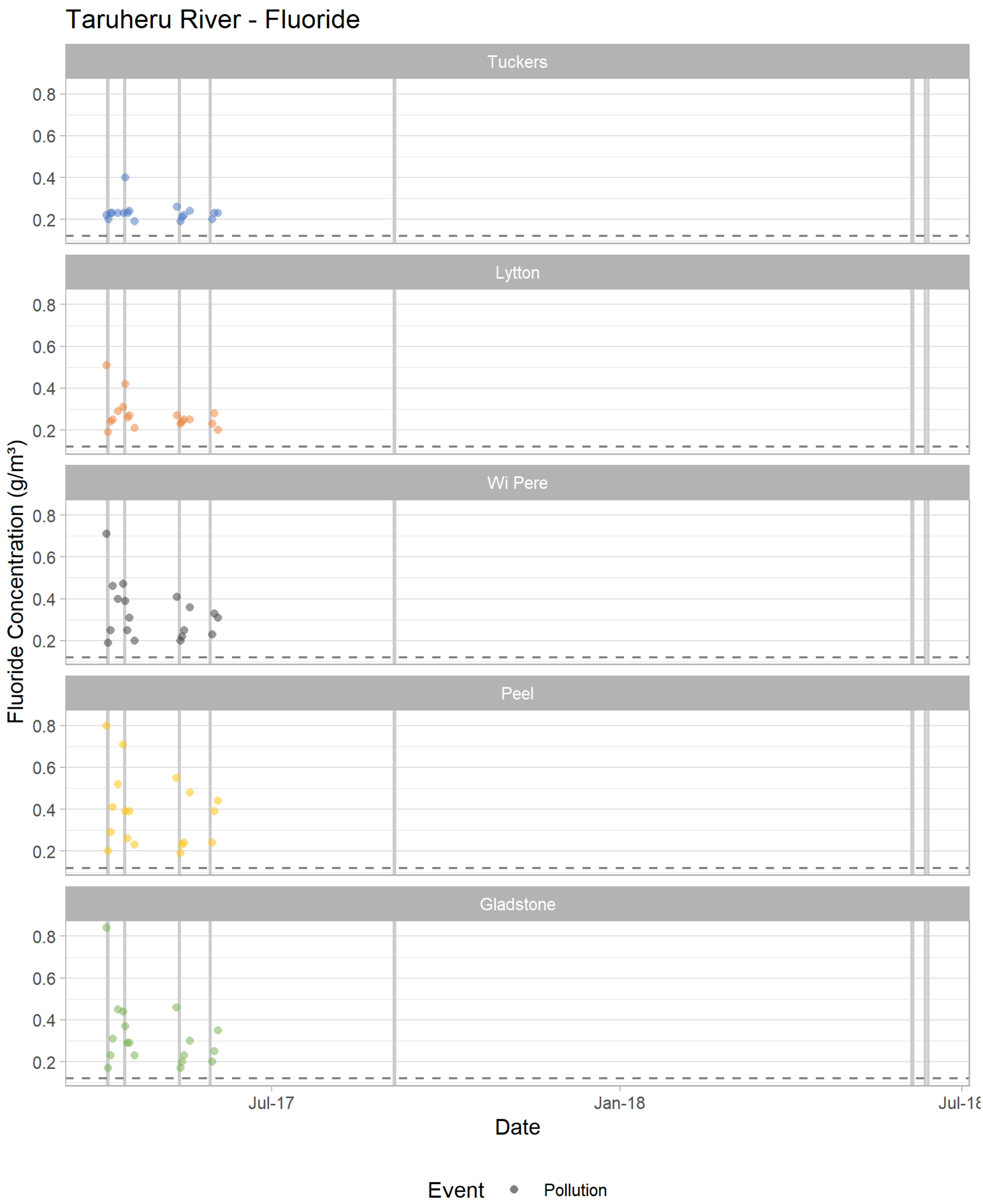


Figure C7: Fluoride concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the Canadian environmental quality (1999) guideline value of 0.12 g/m^3

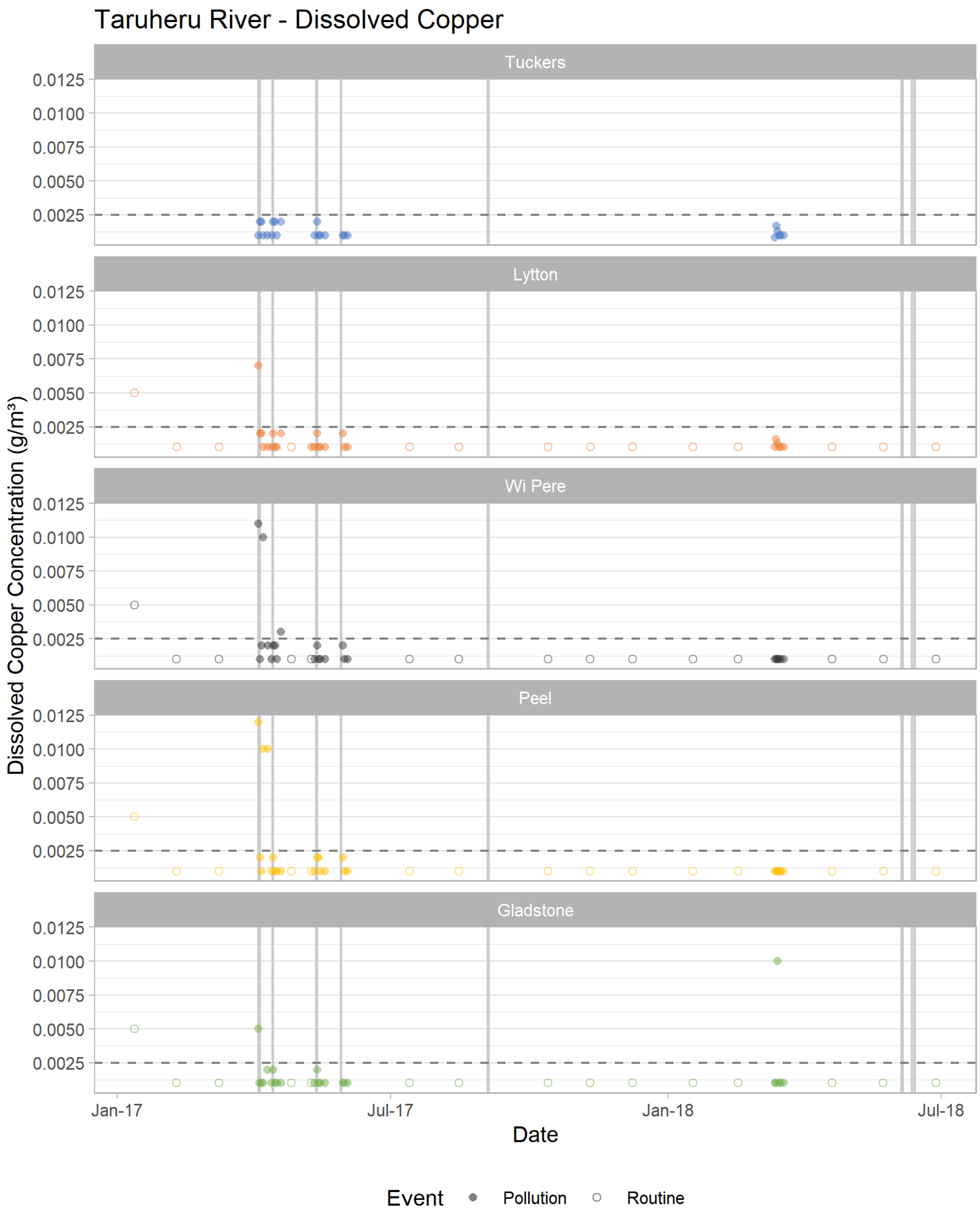


Figure C8: Dissolved copper concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.0025 g/m^3

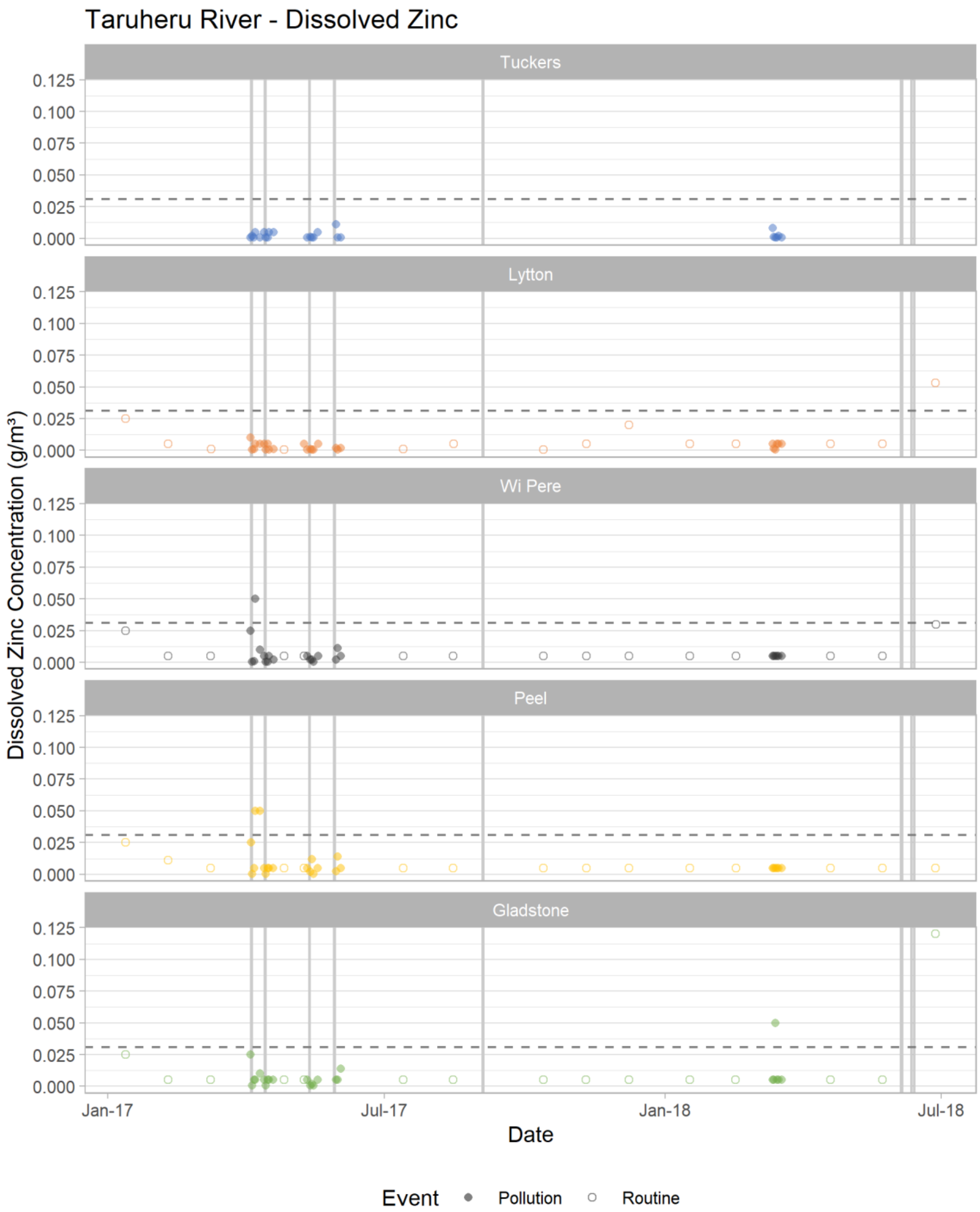


Figure C9: Dissolved zinc concentrations, Taruheru River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.031 g/m^3

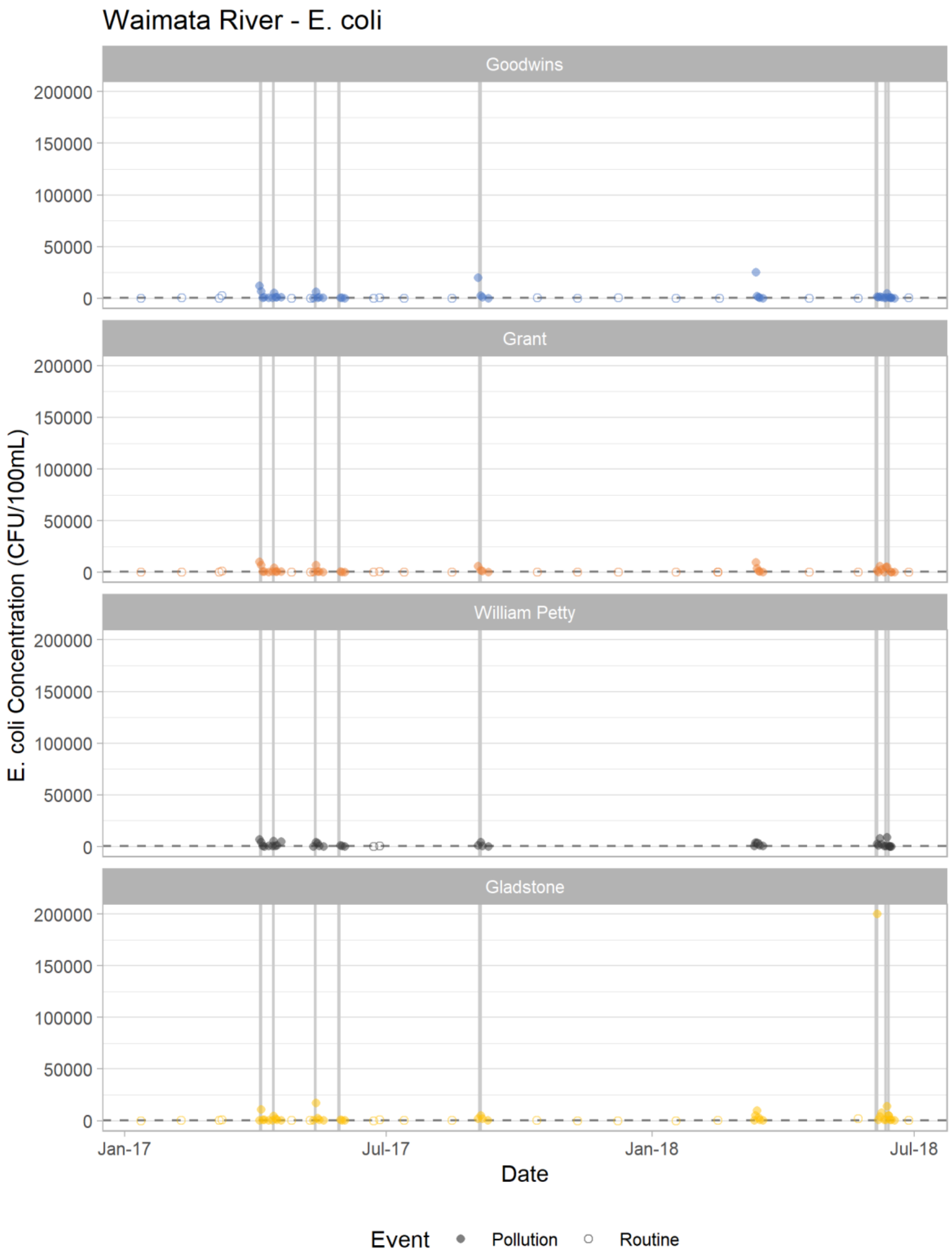


Figure C10: *E. coli* concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 550 CFU/100mL

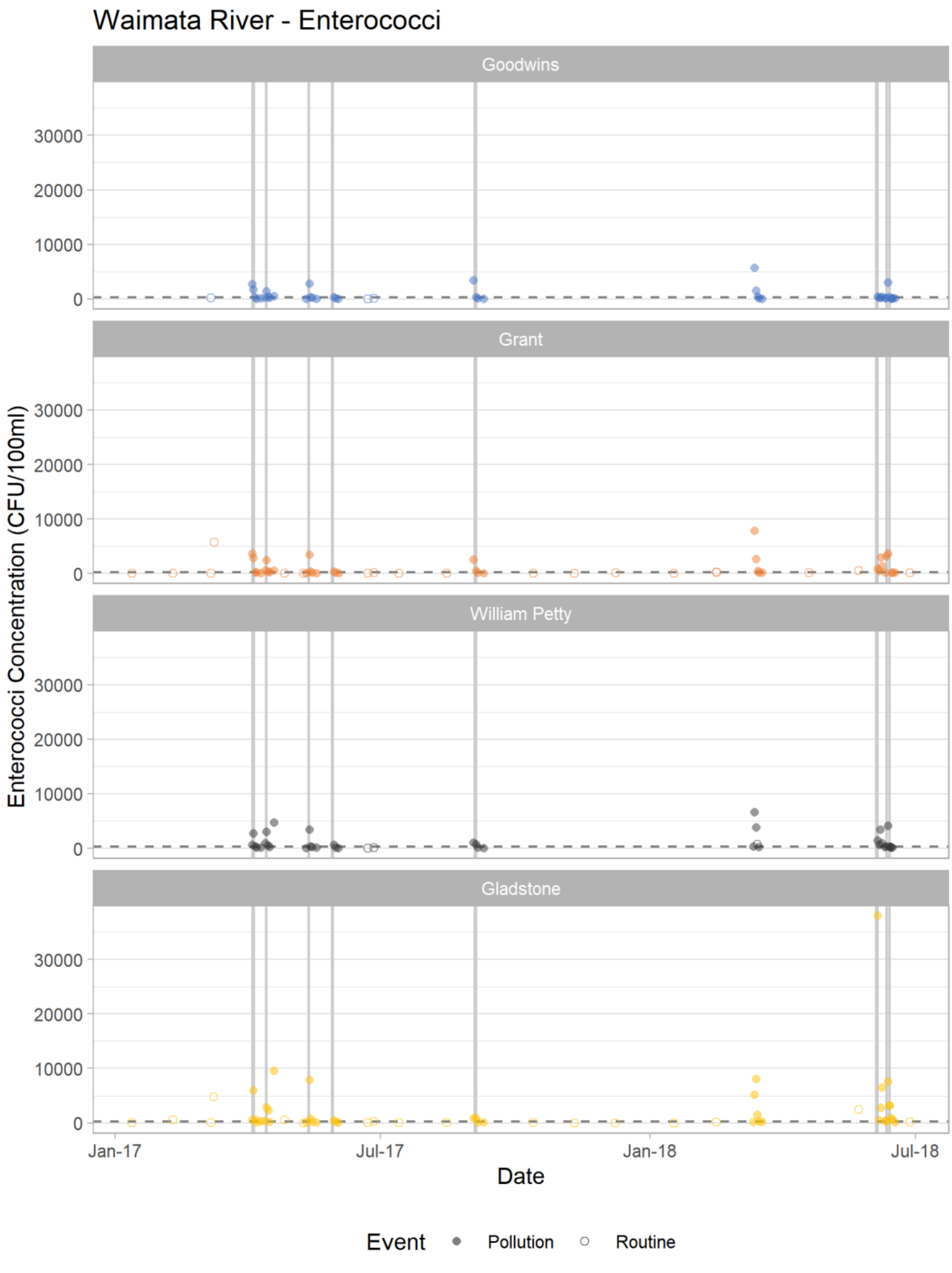


Figure C11: Enterococci concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 280 CFU/100mL

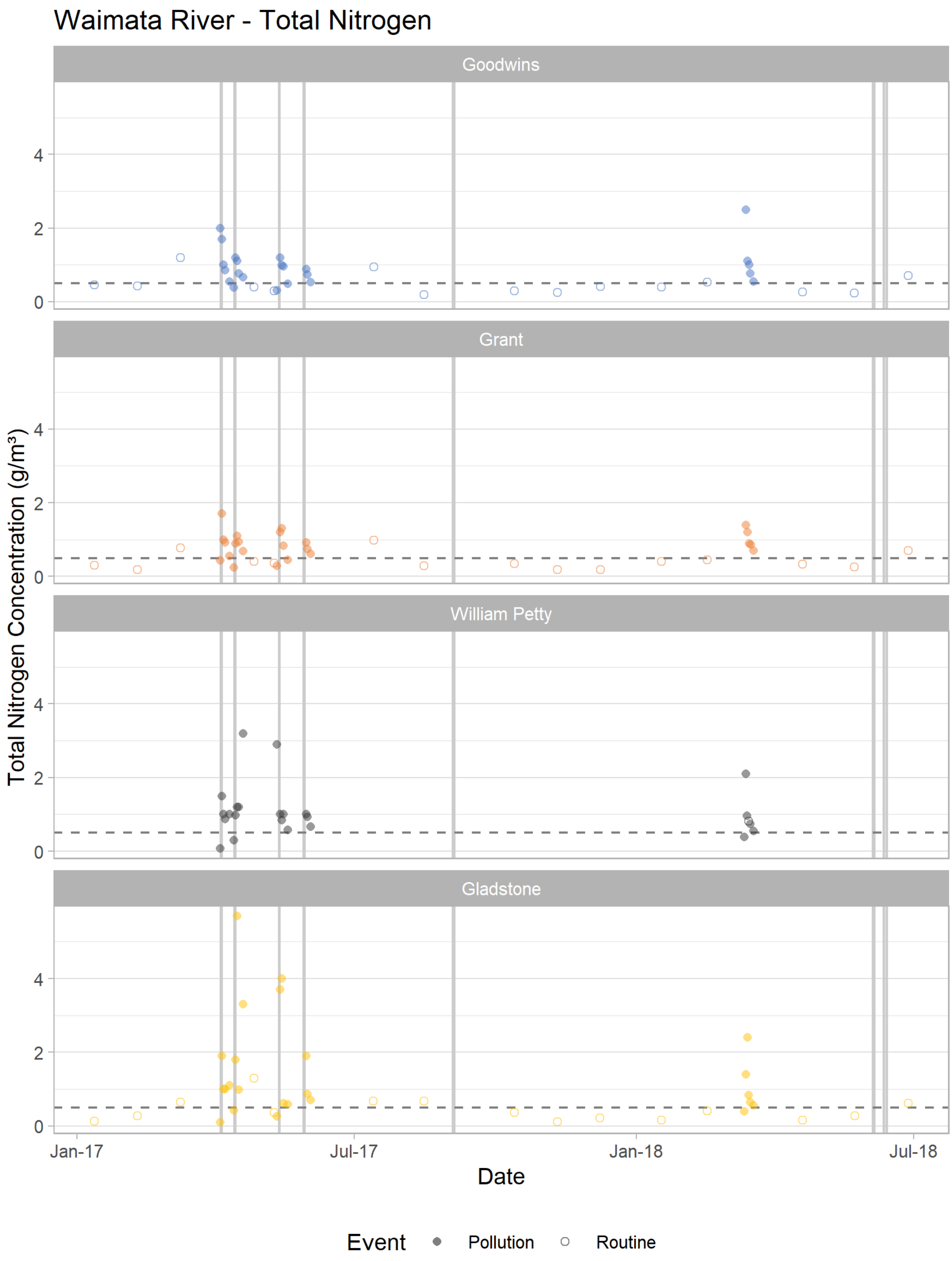


Figure C12: Total nitrogen concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.5 g/m^3

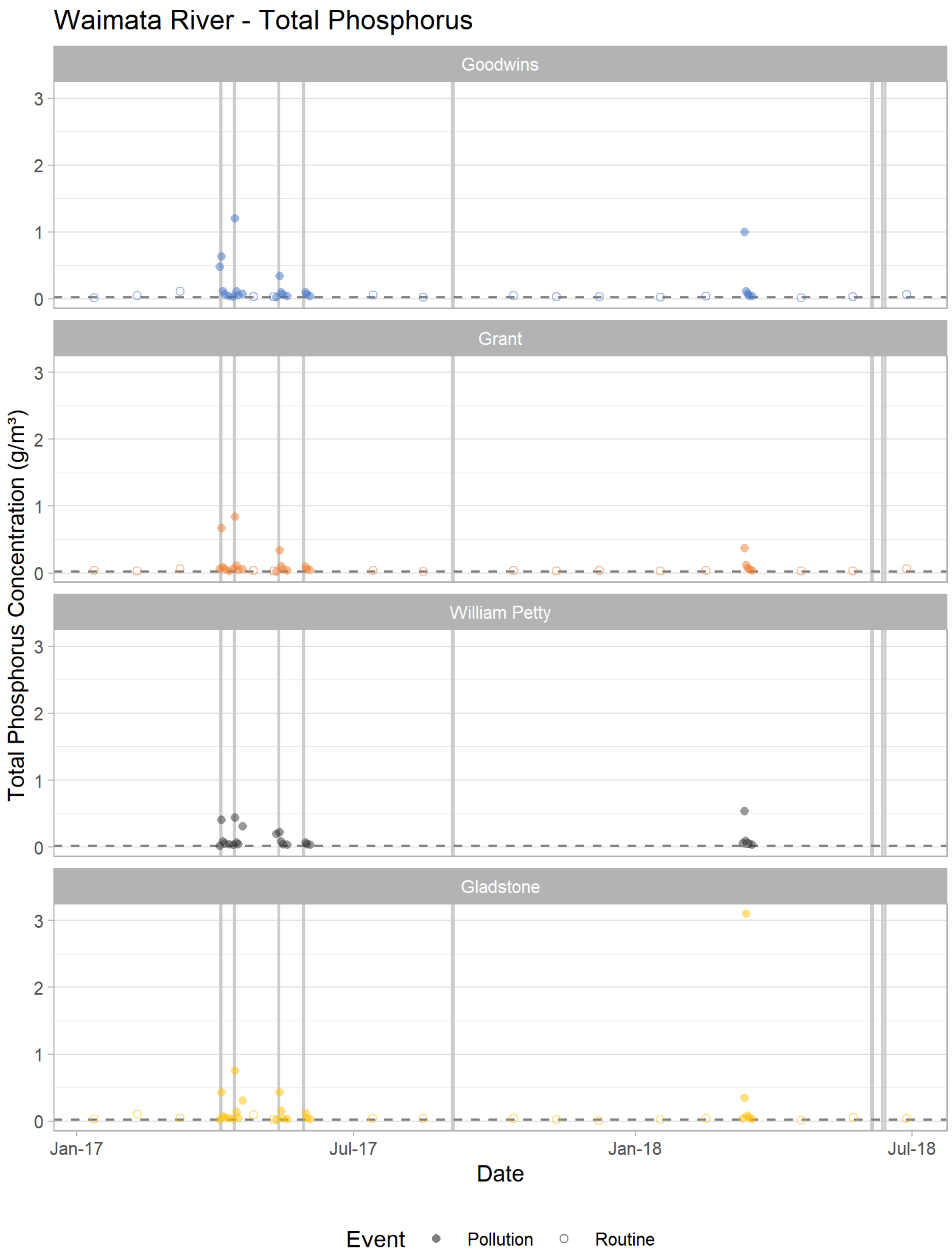


Figure C13: Total phosphorus concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.02 g/m^3

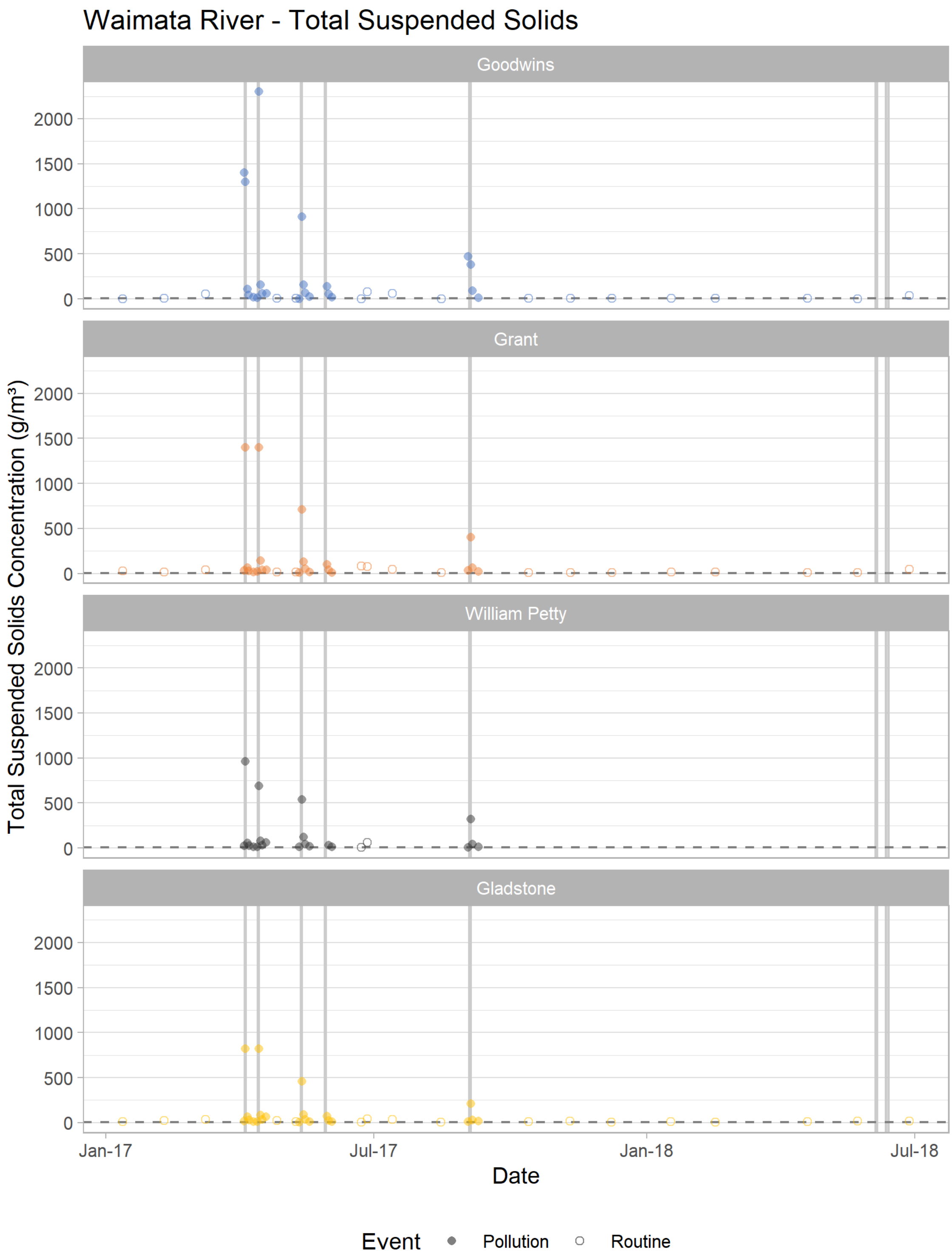


Figure C14: Total suspended solids concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for turbidity for NZ lowland rivers. There is no guideline specifically for TSS but the correlation between TSS and turbidity is strongly positive

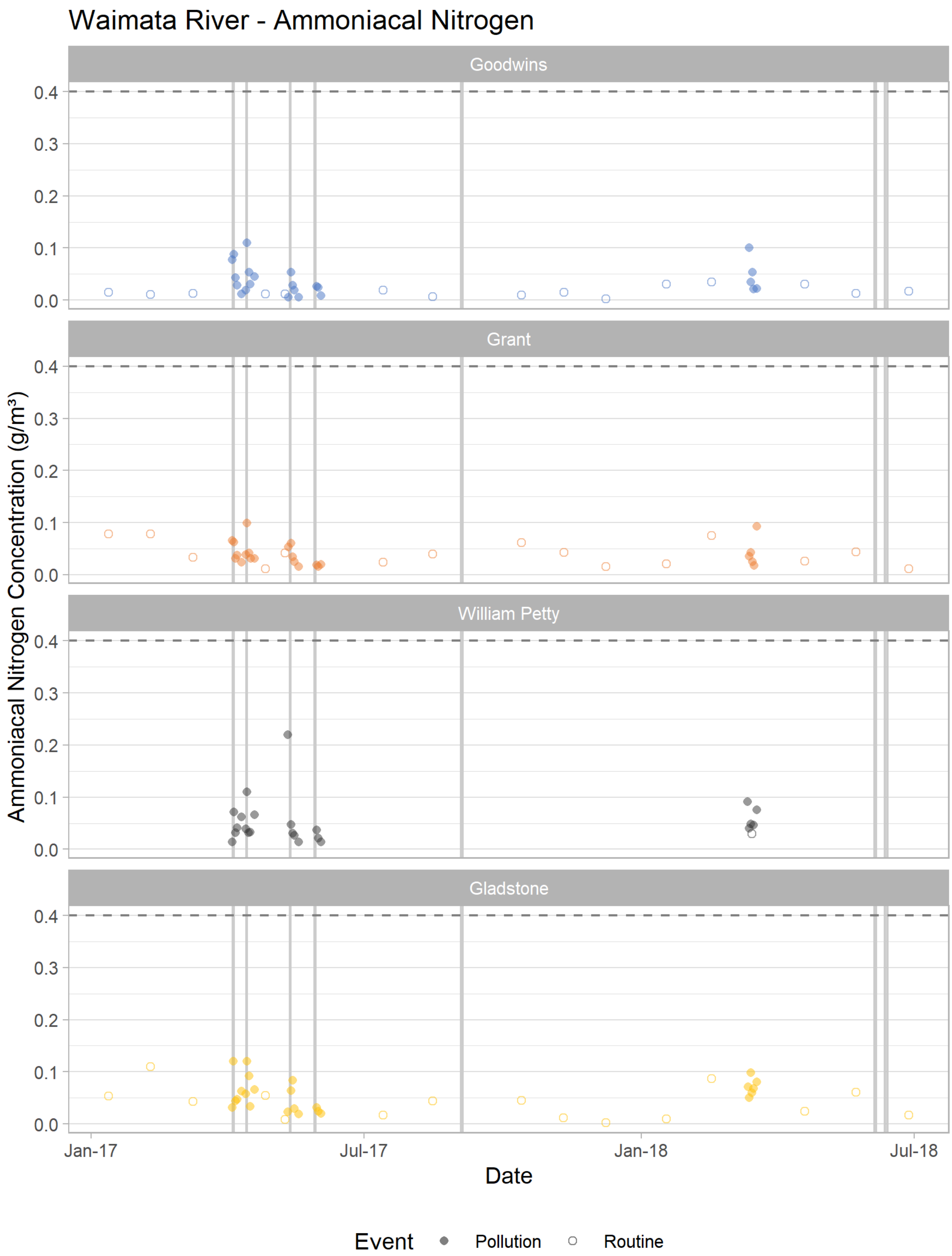


Figure C15: Total ammoniacal nitrogen concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.4 g/m^3

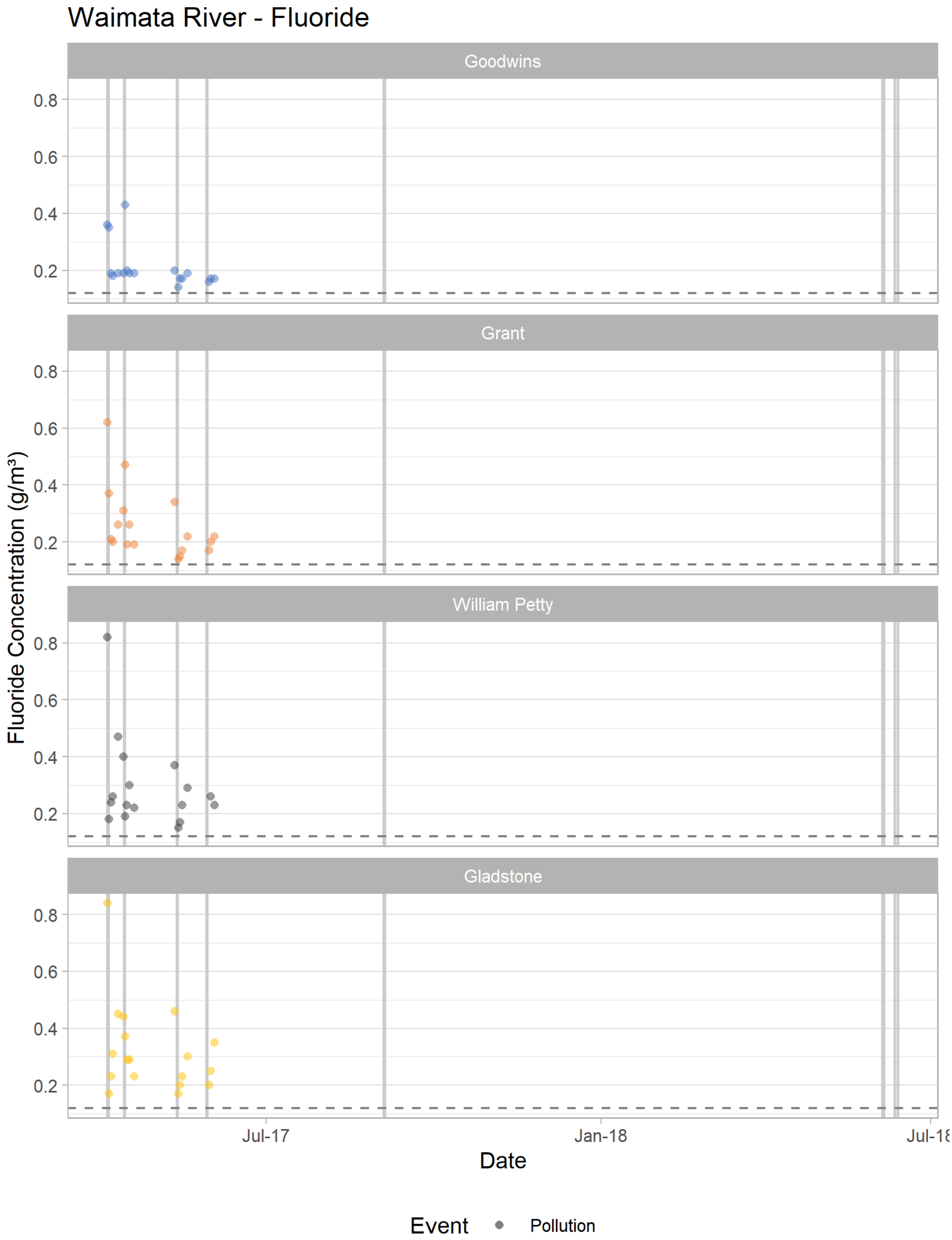


Figure C16: Fluoride concentrations, Waimata River (all events). The horizontal dashed line shows the Canadian environmental quality (1999) guideline value of 0.12 g/m^3

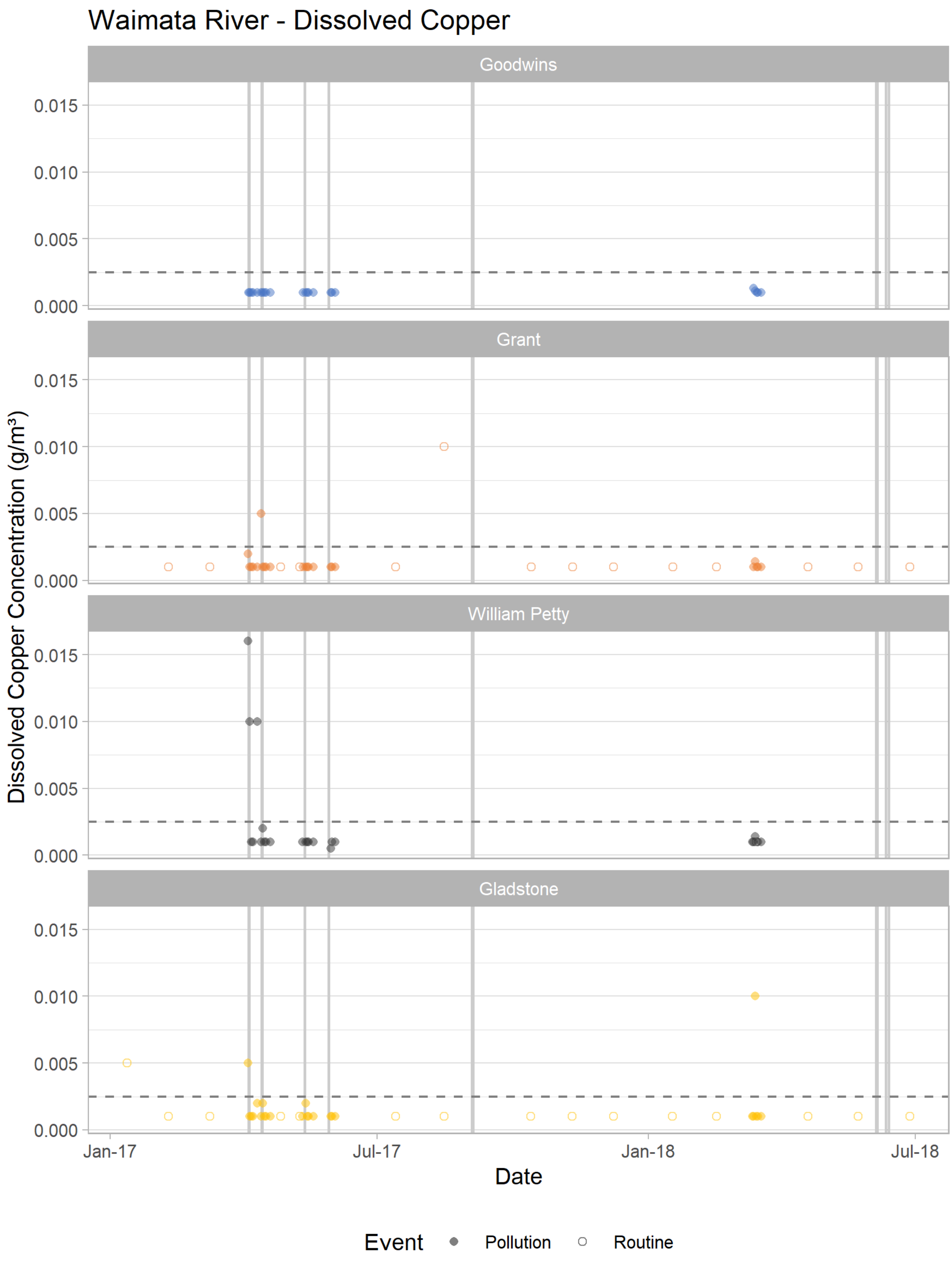


Figure C17: Dissolved copper concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.0025 g/m^3

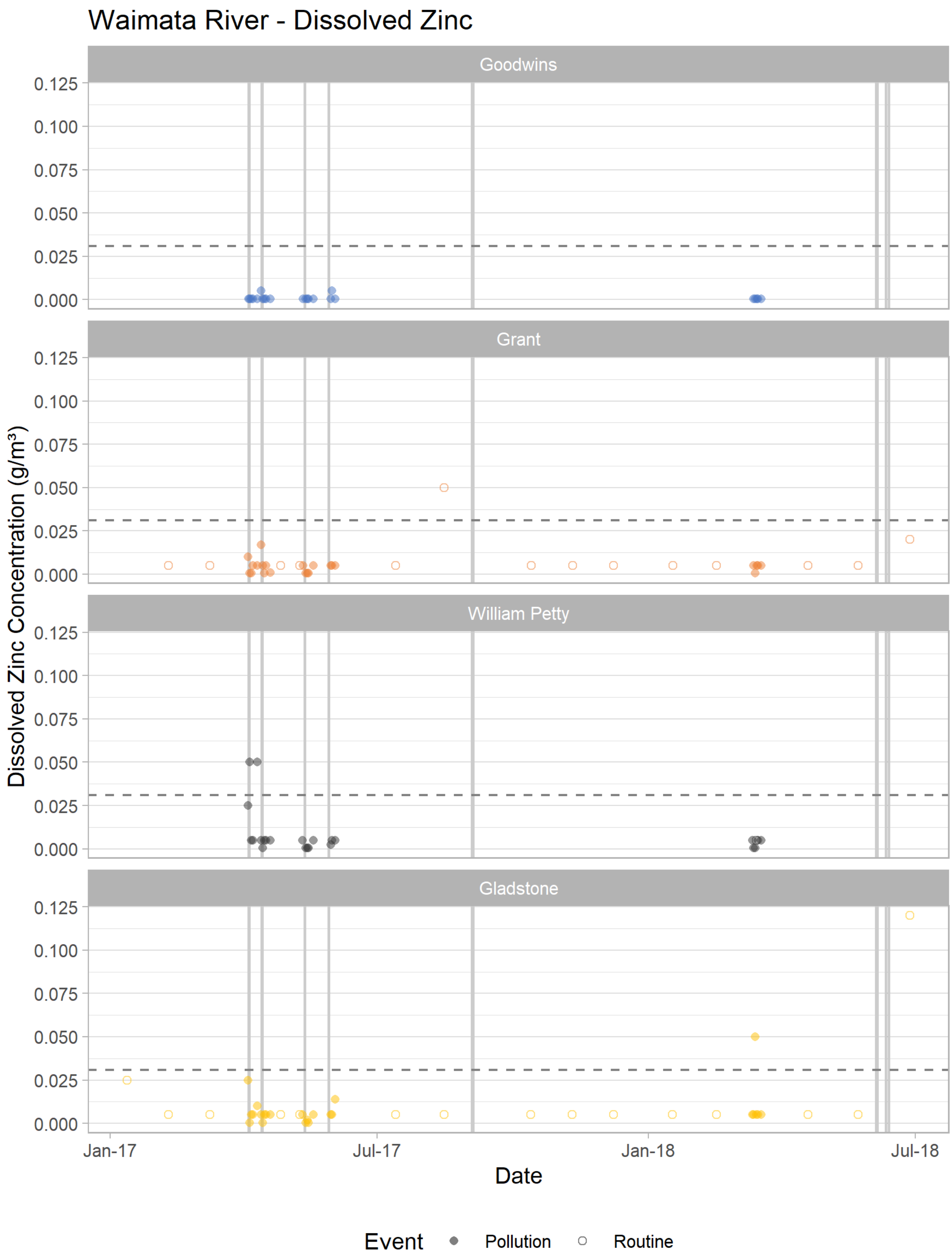


Figure C18: Dissolved zinc concentrations, Waimata River (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.031 g/m^3

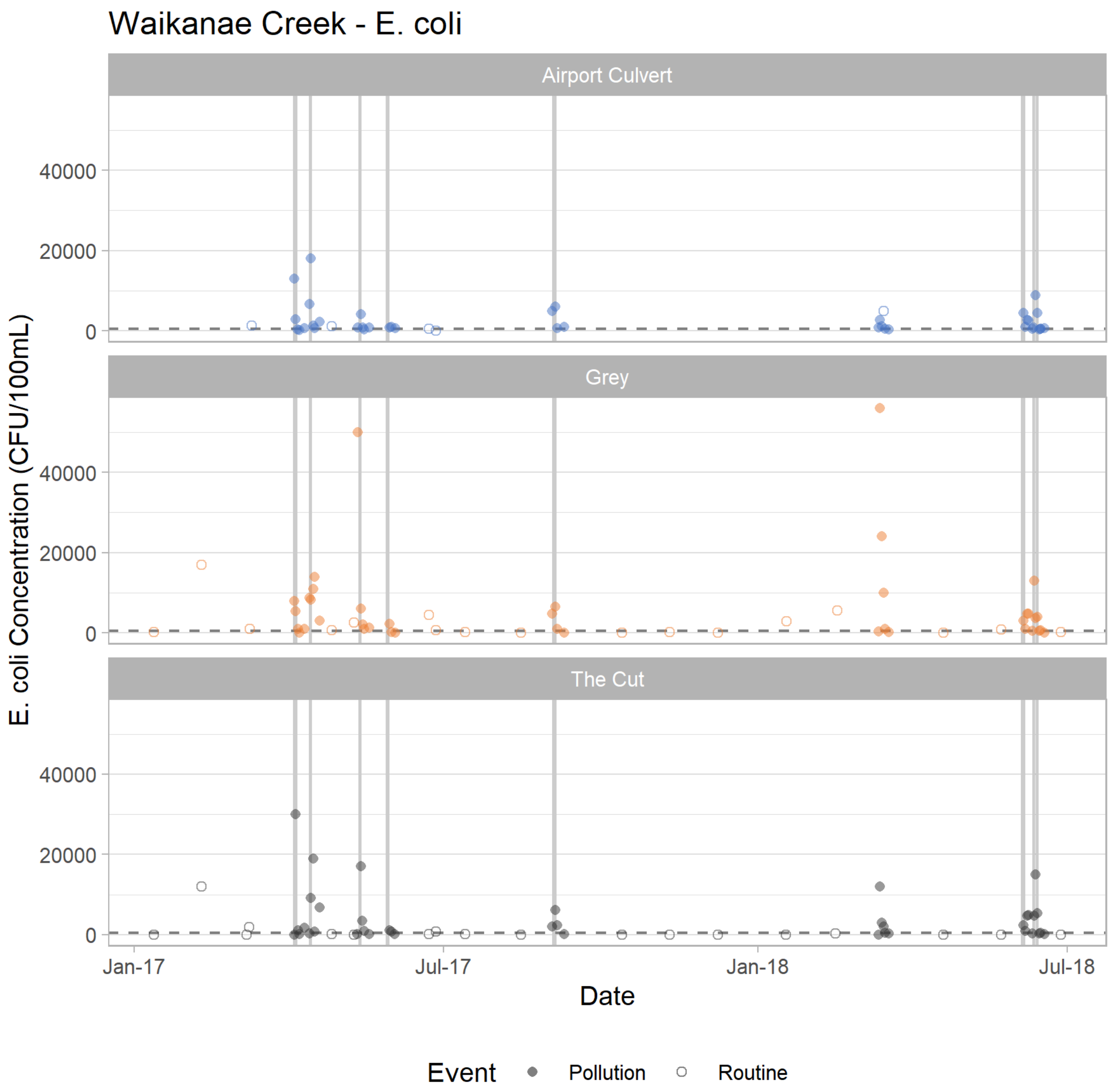


Figure C19: *E. coli* concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 550 CFU/100mL

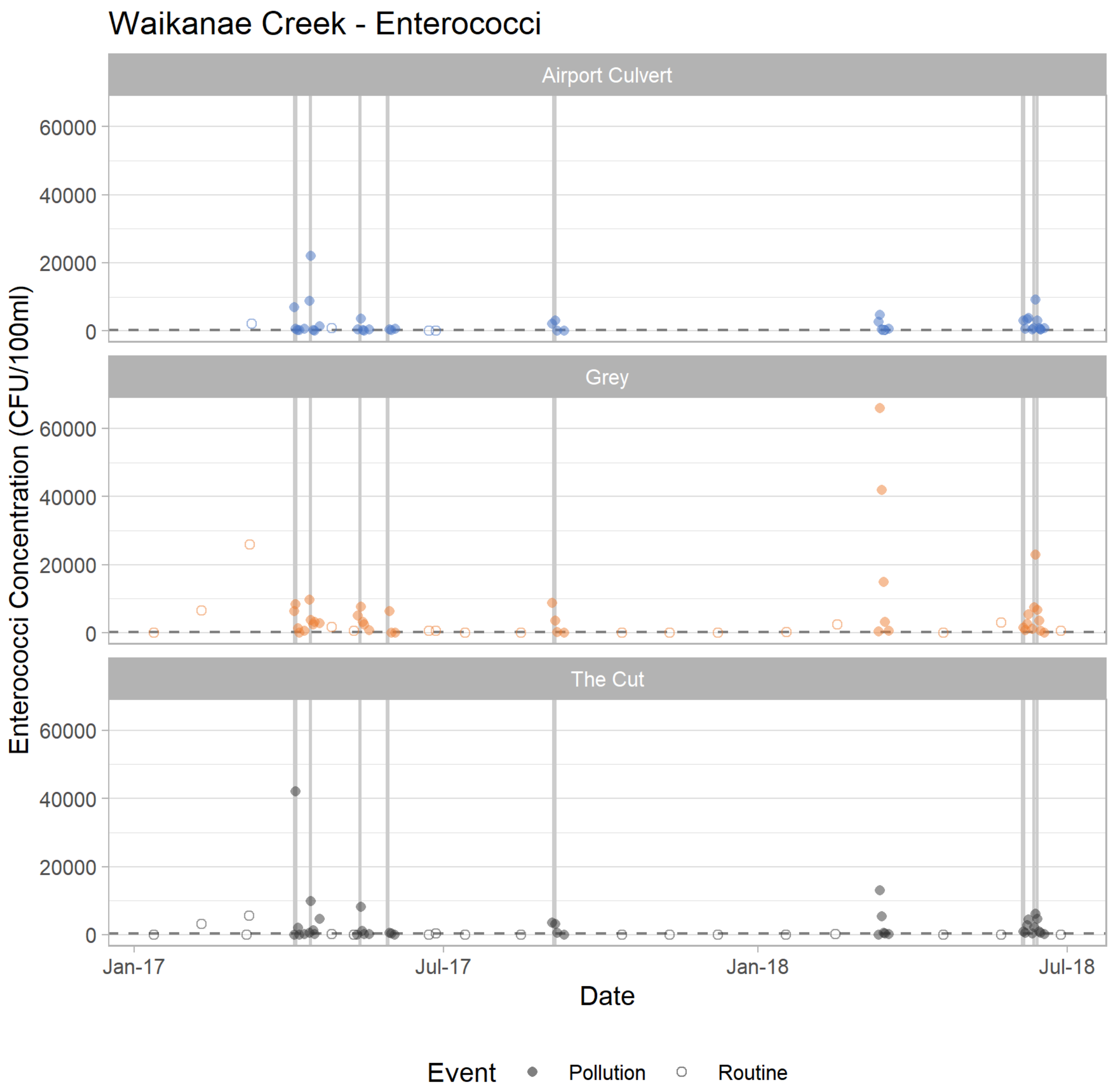


Figure C20: Enterococci concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 280 CFU/100mL

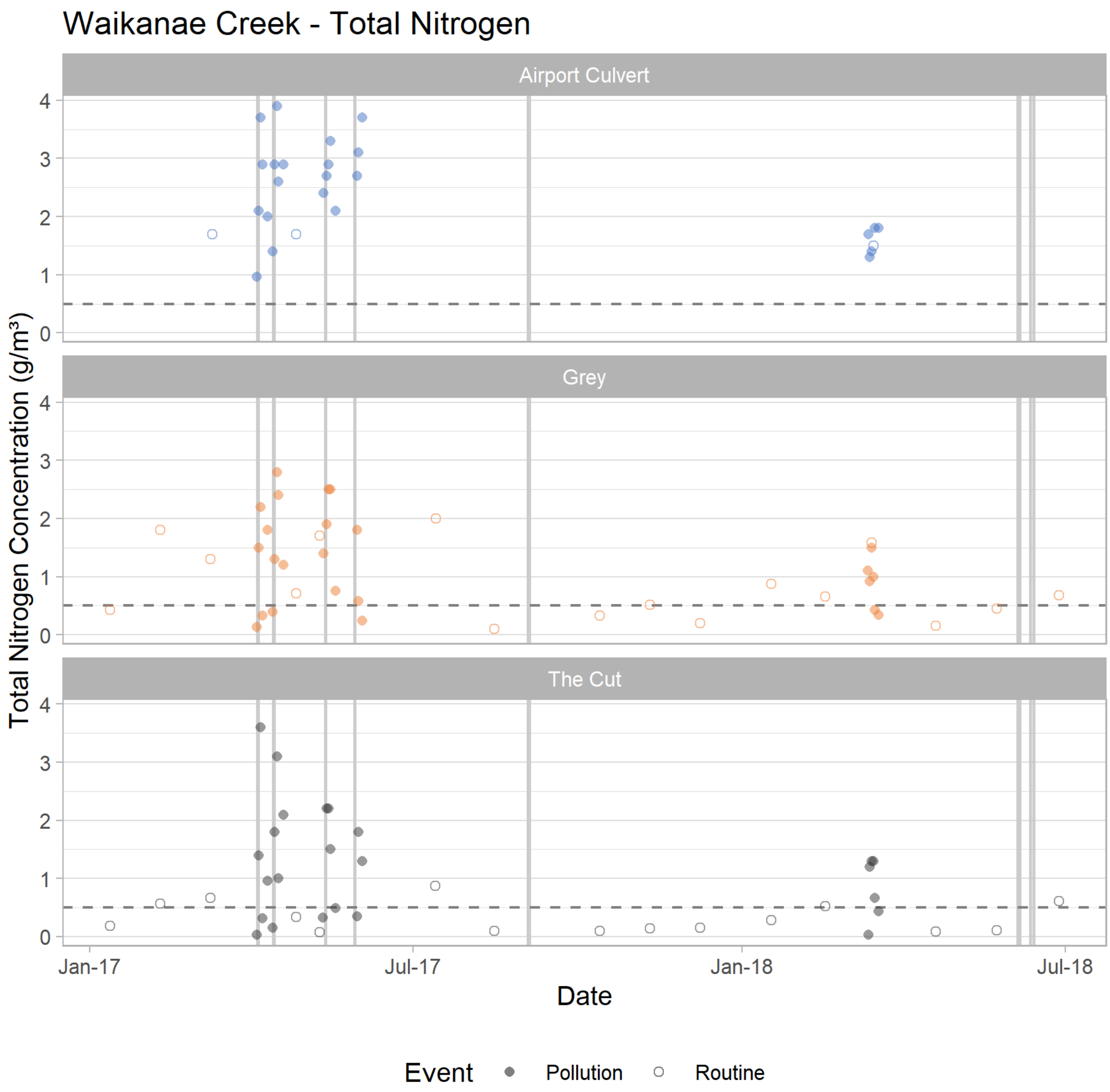


Figure C21: Total nitrogen concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.5 g/m^3

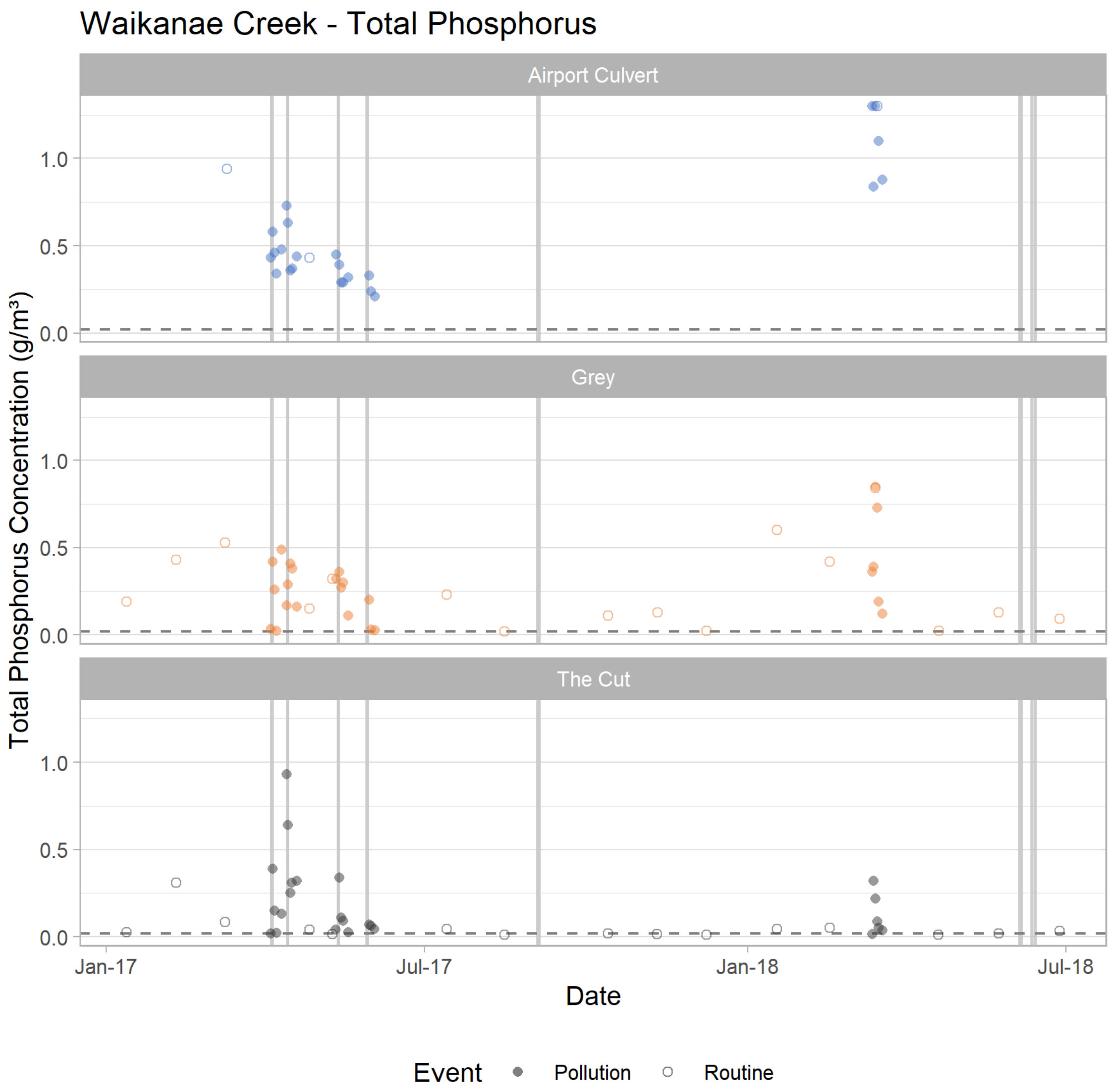


Figure C22: Total phosphorus concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.02 g/m^3

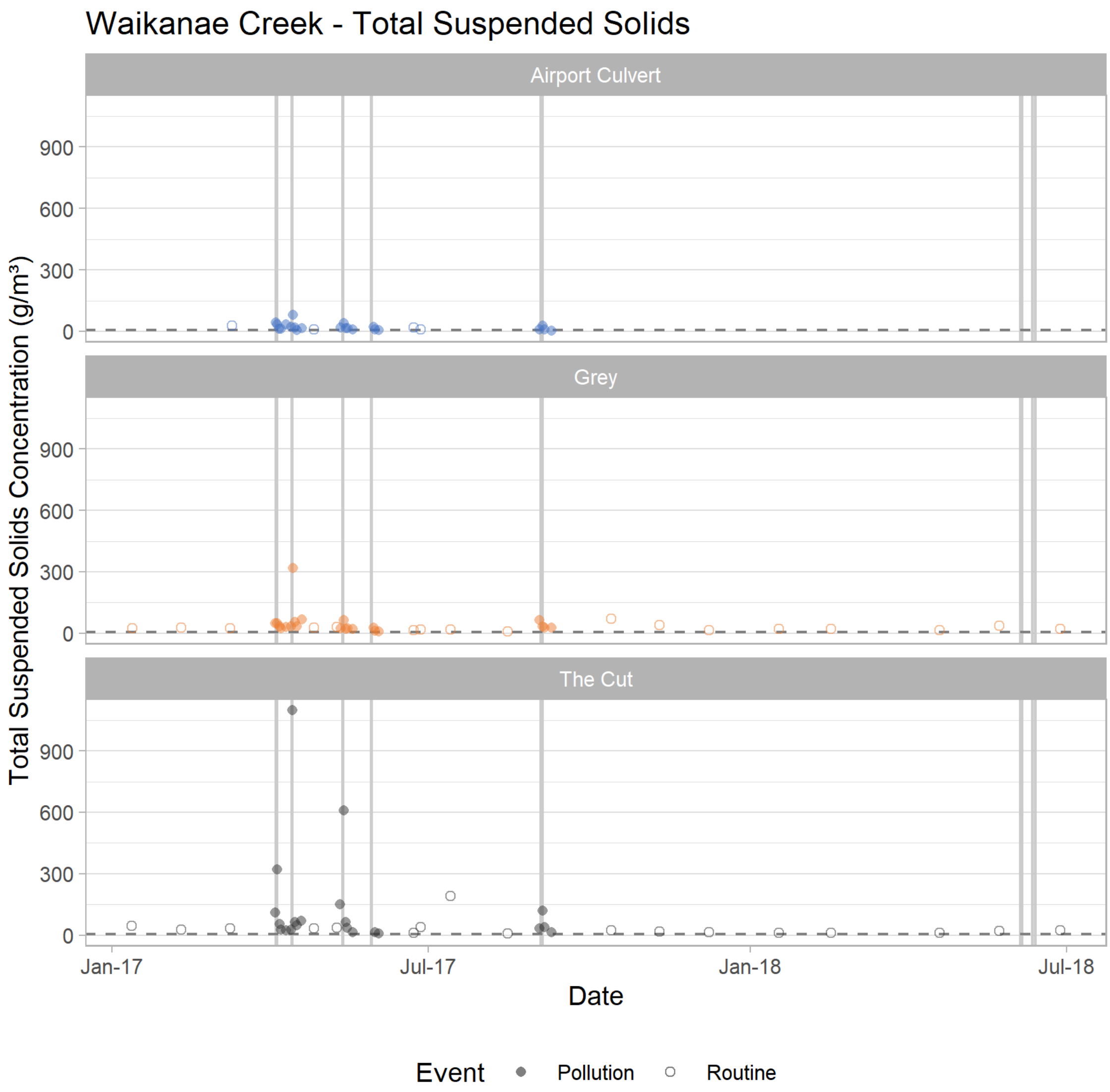


Figure C23: Total suspended solids concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for turbidity for NZ lowland rivers. There is no guideline specifically for TSS but the correlation between TSS and turbidity is strongly positive

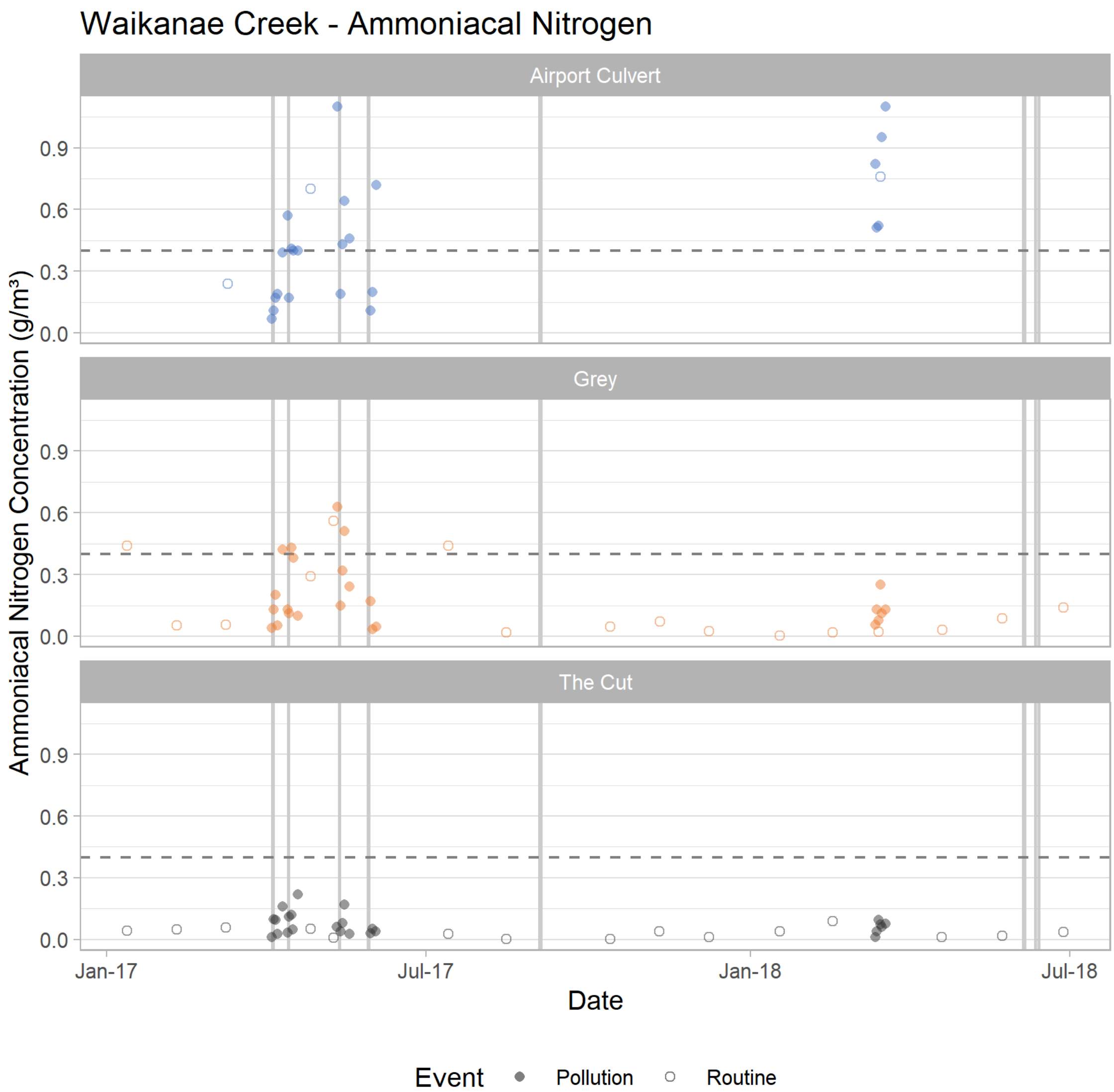


Figure C24: Ammonical nitrogen concentrations, Waikanae Stream (all events)

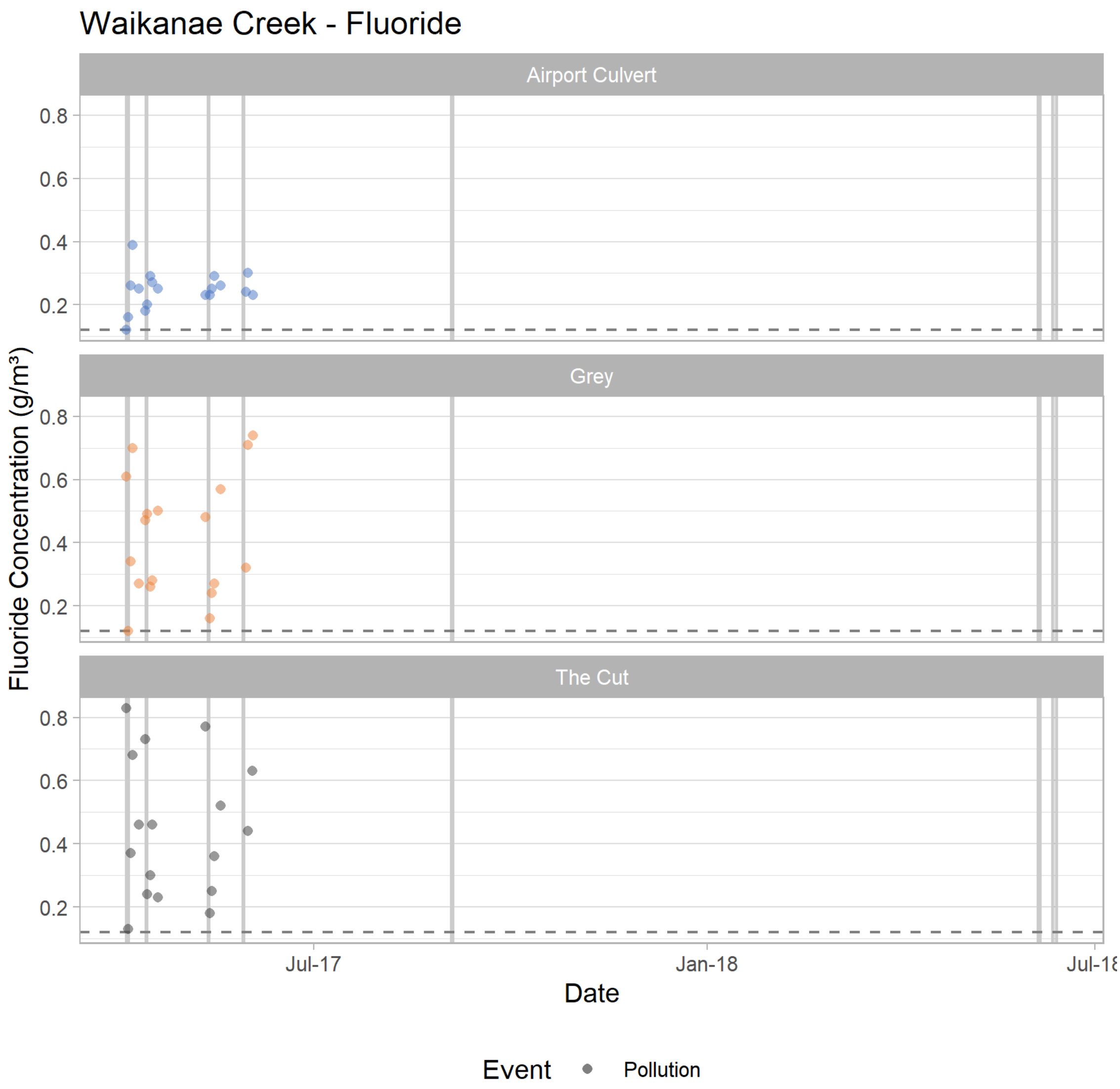


Figure C25: Fluoride concentrations, Waikanae Stream (all events). The horizontal dashed line shows the Canadian environmental quality (1999) guideline value of 0.12 g/m^3

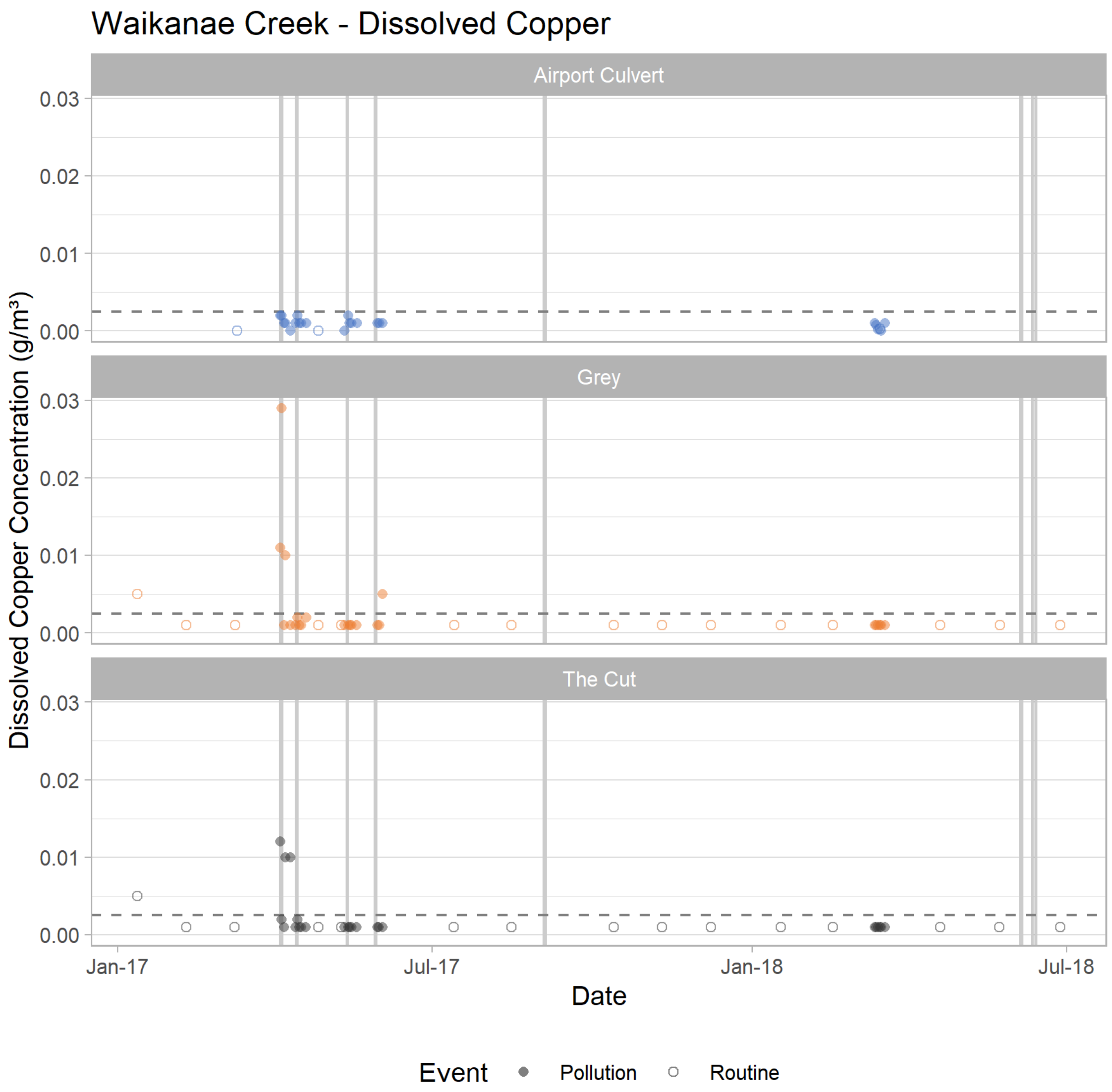


Figure C26: Dissolved copper concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.0025 g/m^3

Figure C27: Dissolved zinc concentrations, Waikanae Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.031 g/m^3

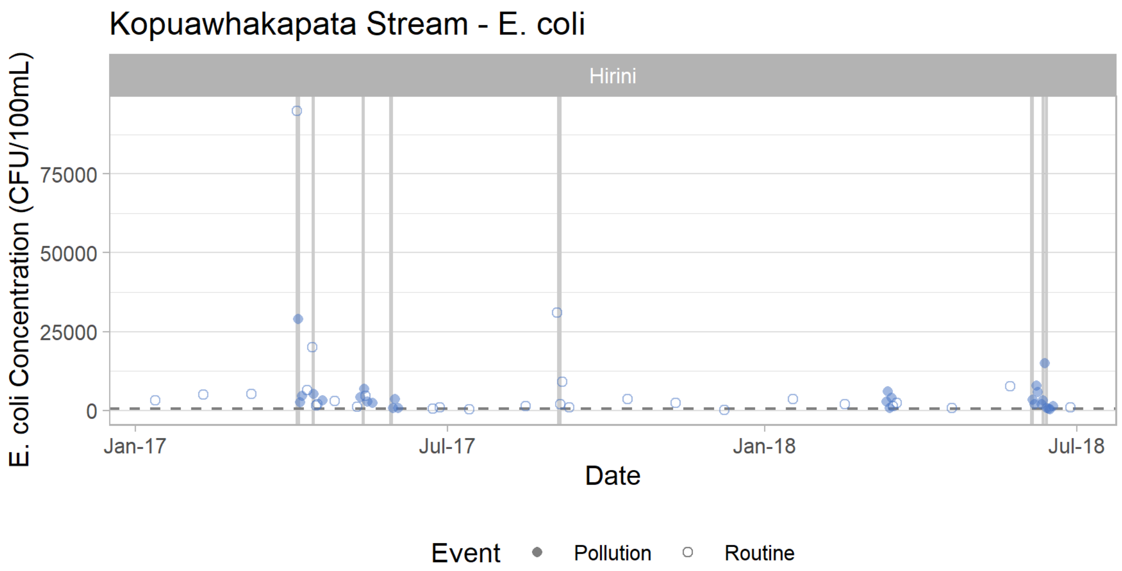


Figure C28: *E. coli* concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 550 CFU/100mL

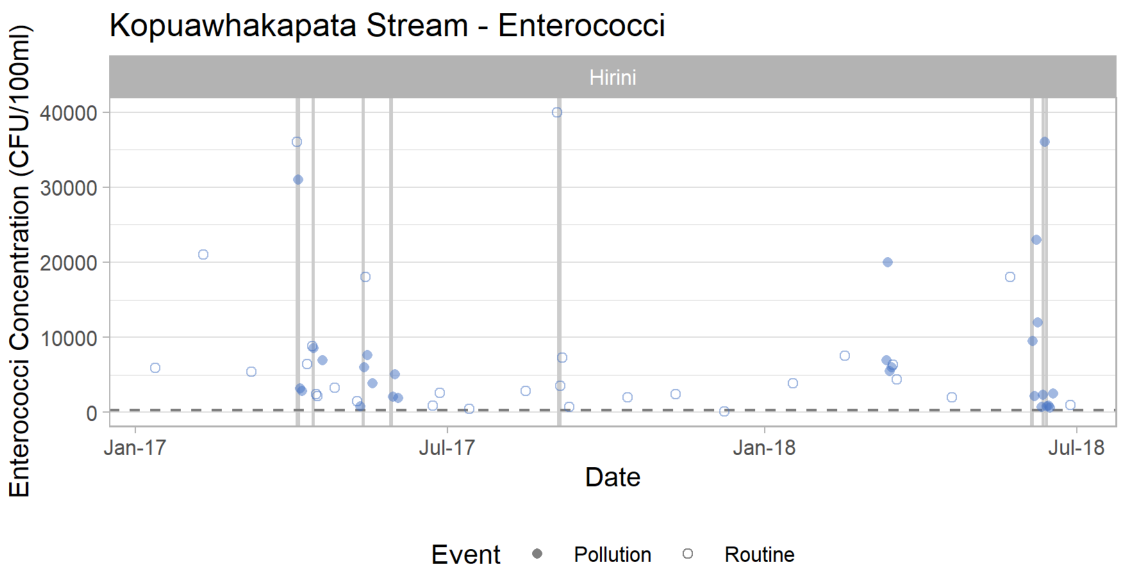


Figure C29: Enterococci concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 280 CFU/100mL

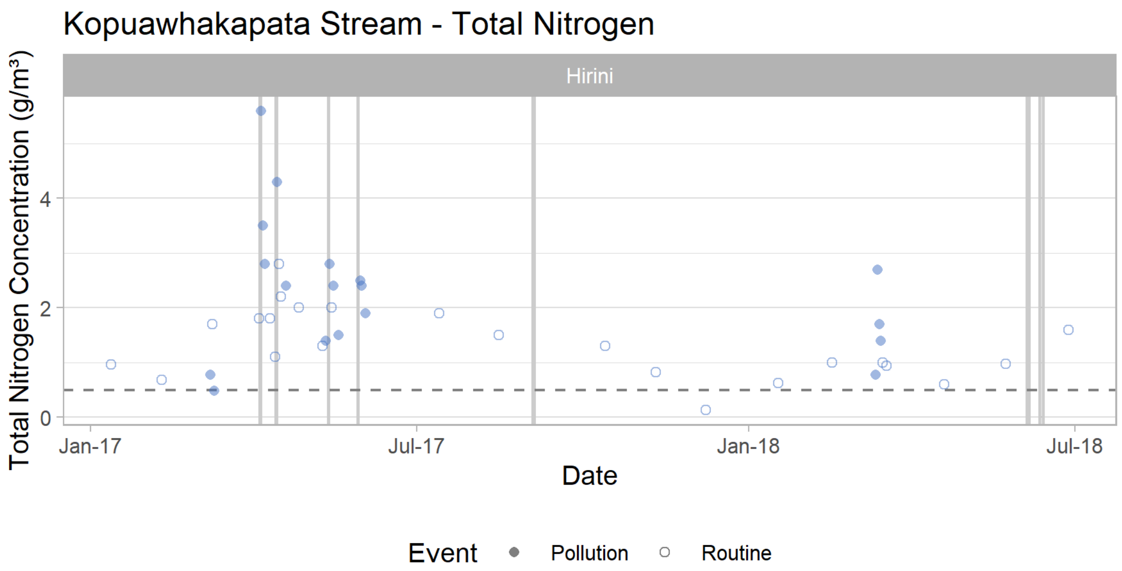


Figure C30: Total nitrogen concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.5 g/m^3

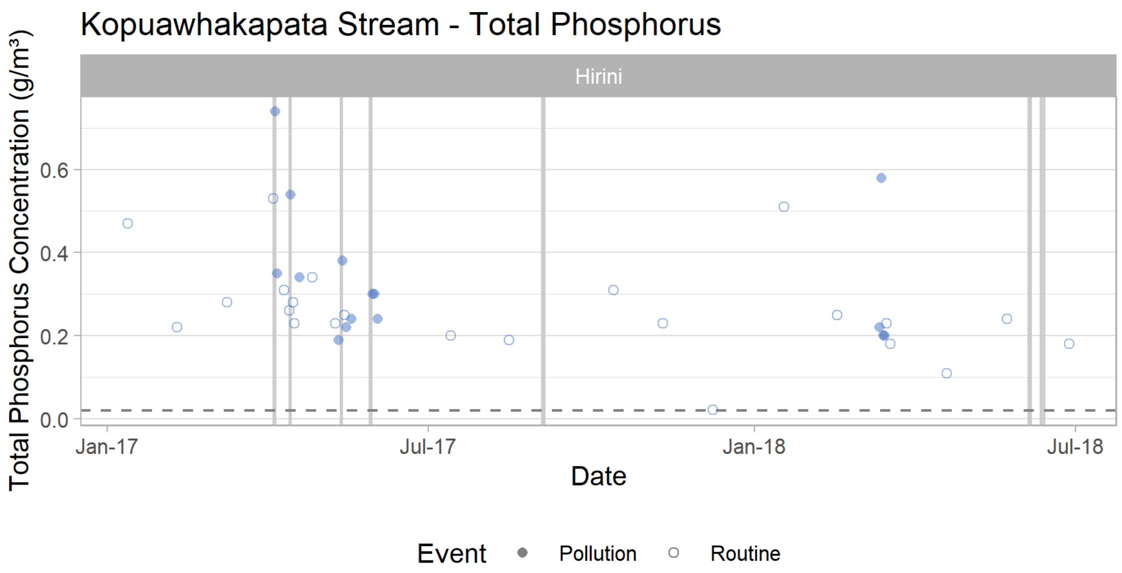


Figure C31: Total phosphorus concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.02 g/m^3

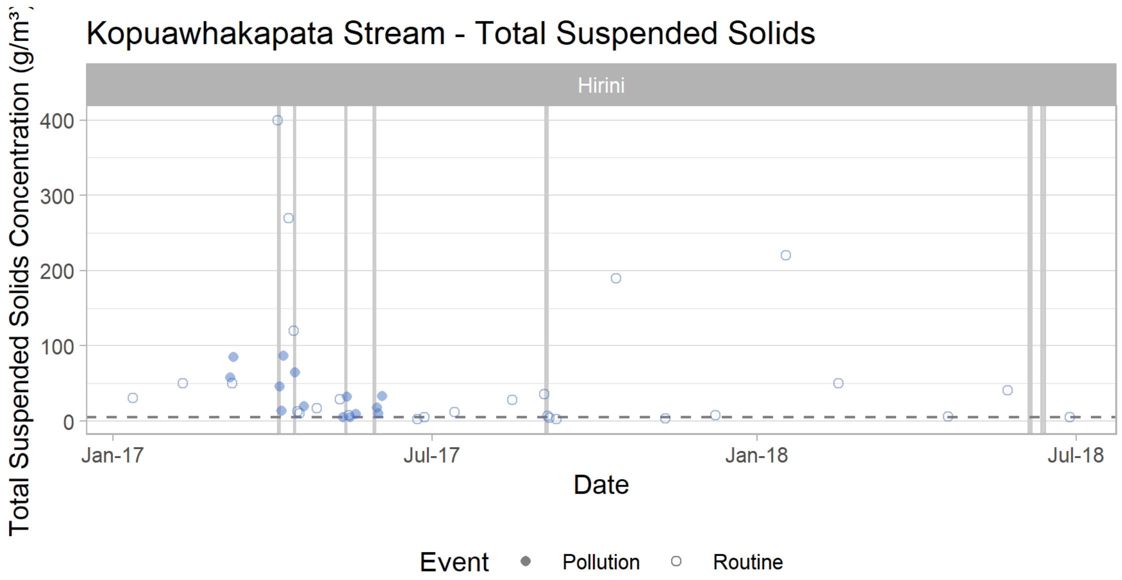


Figure C32: Total suspended solids concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for turbidity for NZ lowland rivers. There is no guideline specifically for TSS but the correlation between TSS and turbidity is strongly positive

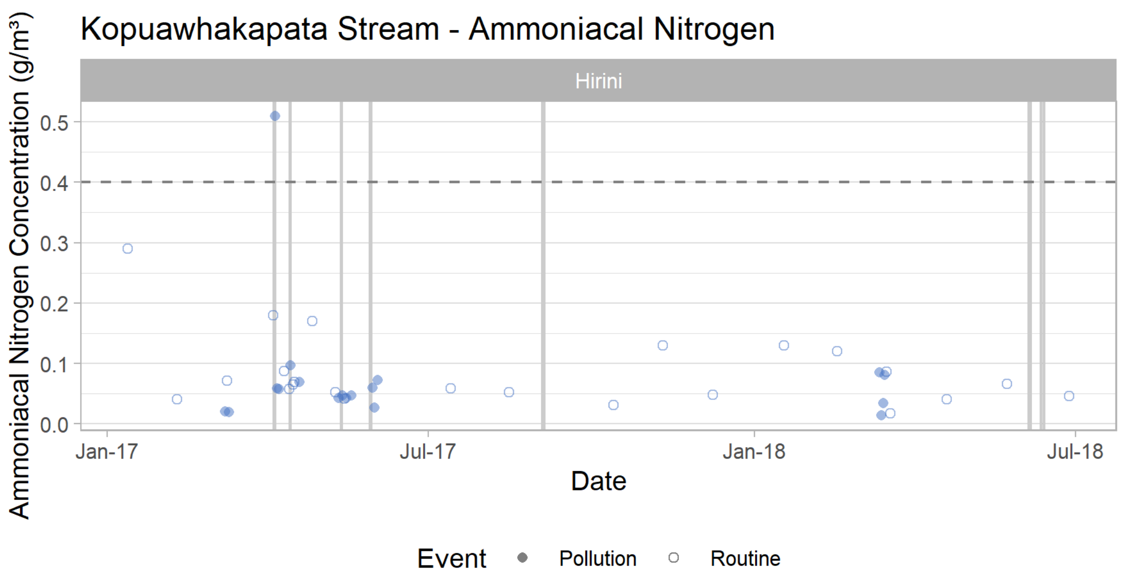


Figure C33: Ammonical nitrogen concentrations, Kopuawhakapata Stream (all events)

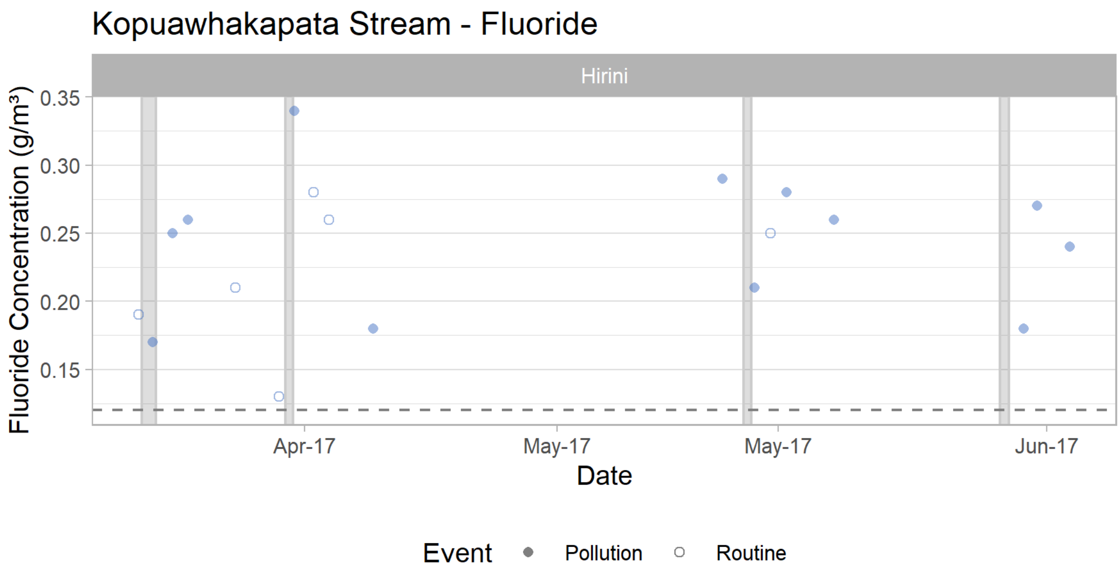


Figure C34: Fluoride concentrations, Kopuawhakapata Stream (all events). The horizontal dashed line shows the Canadian environmental quality (1999) guideline value of 0.12 g/m3

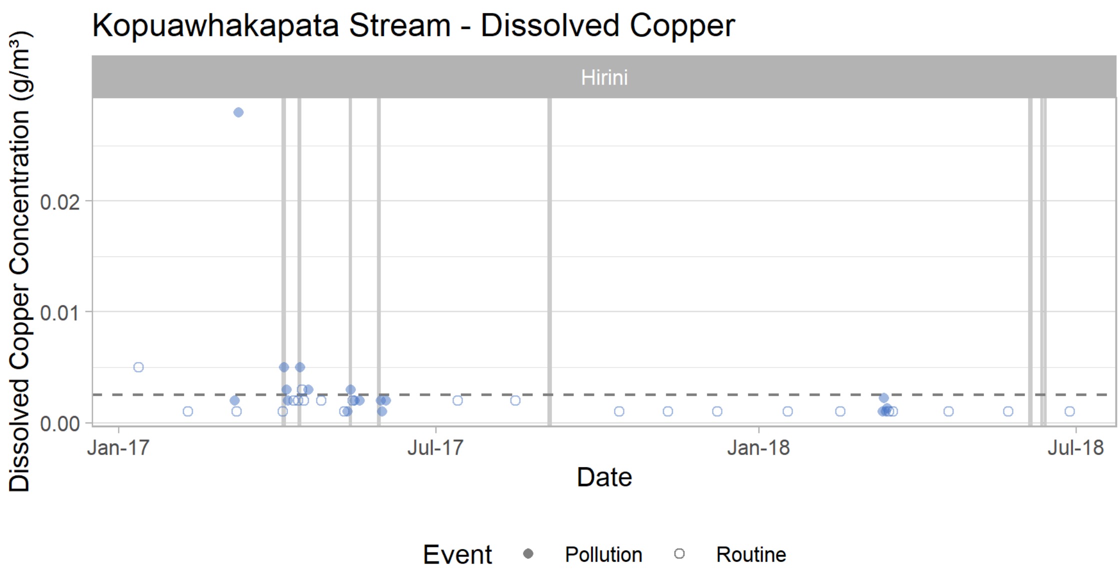


Figure C35: Dissolved copper concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.0025 g/m3

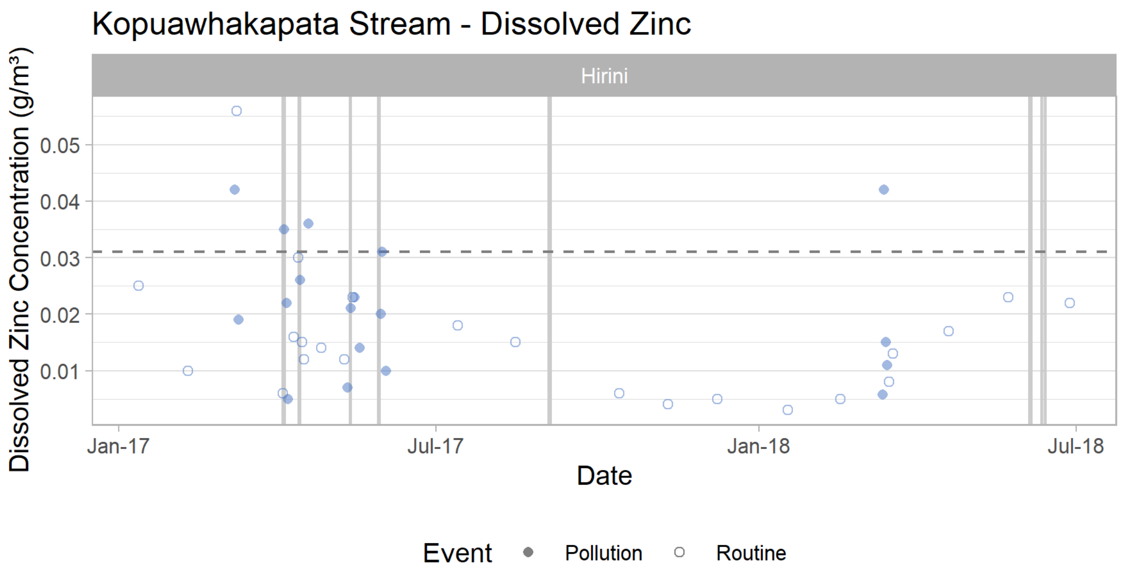


Figure C36: Dissolved zinc concentrations, Kopuawhakapata Stream (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.031 g/m3

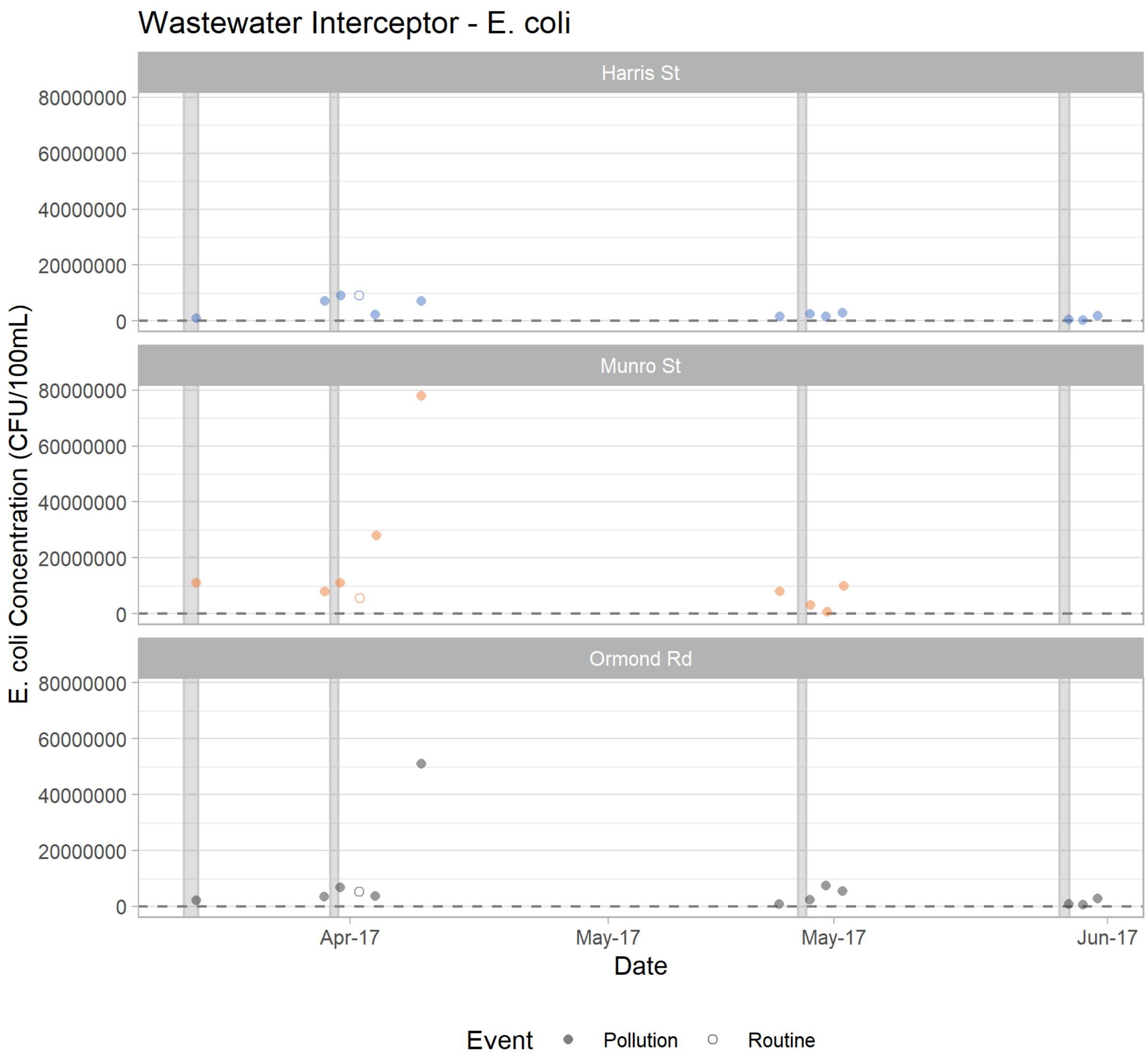


Figure C37: E. coli concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 550 CFU/100mL

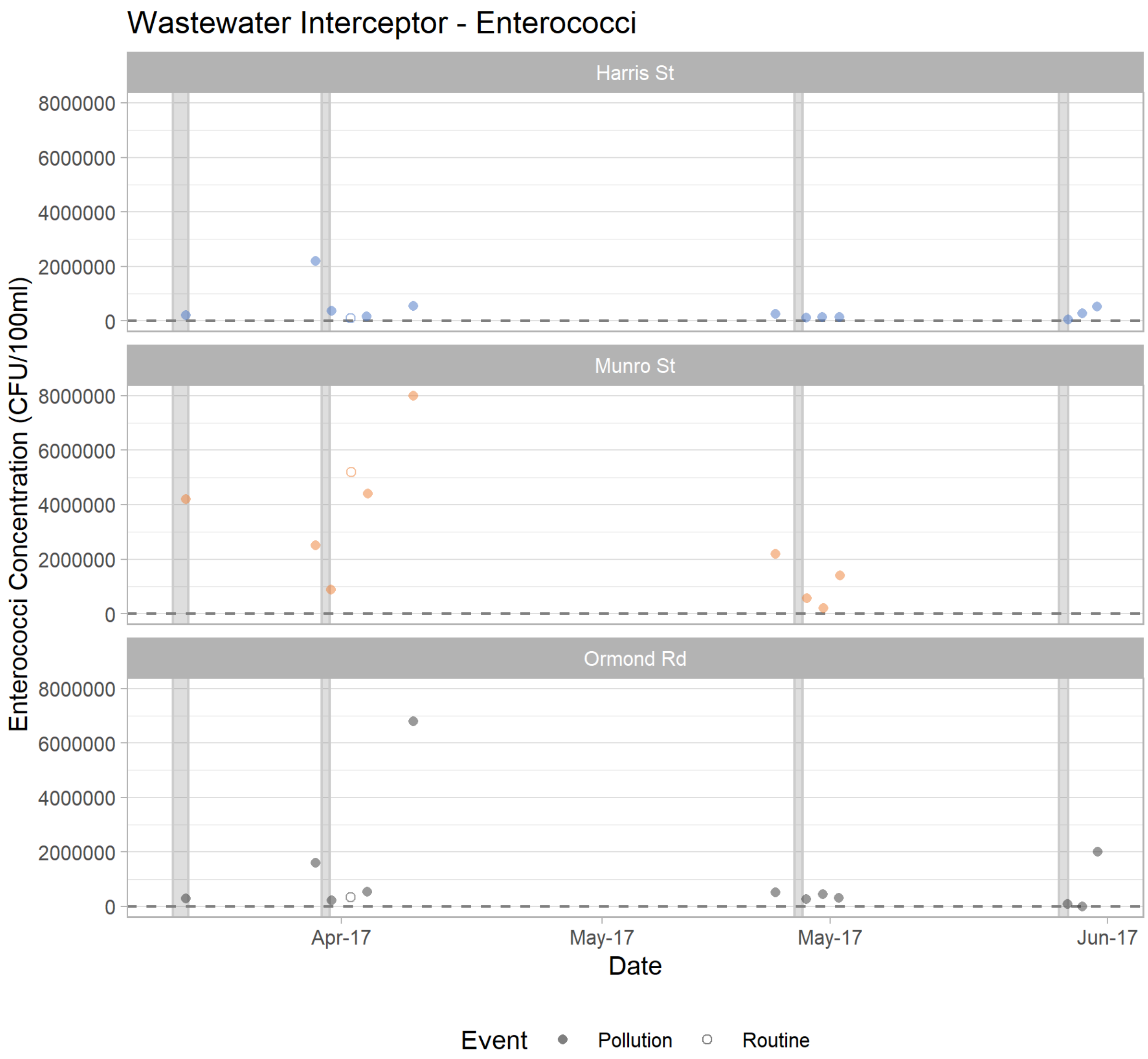


Figure C38: Enterococci concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the recreational water quality guideline value of 280 CFU/100mL

Figure C39: Total nitrogen concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.5 g/m^3

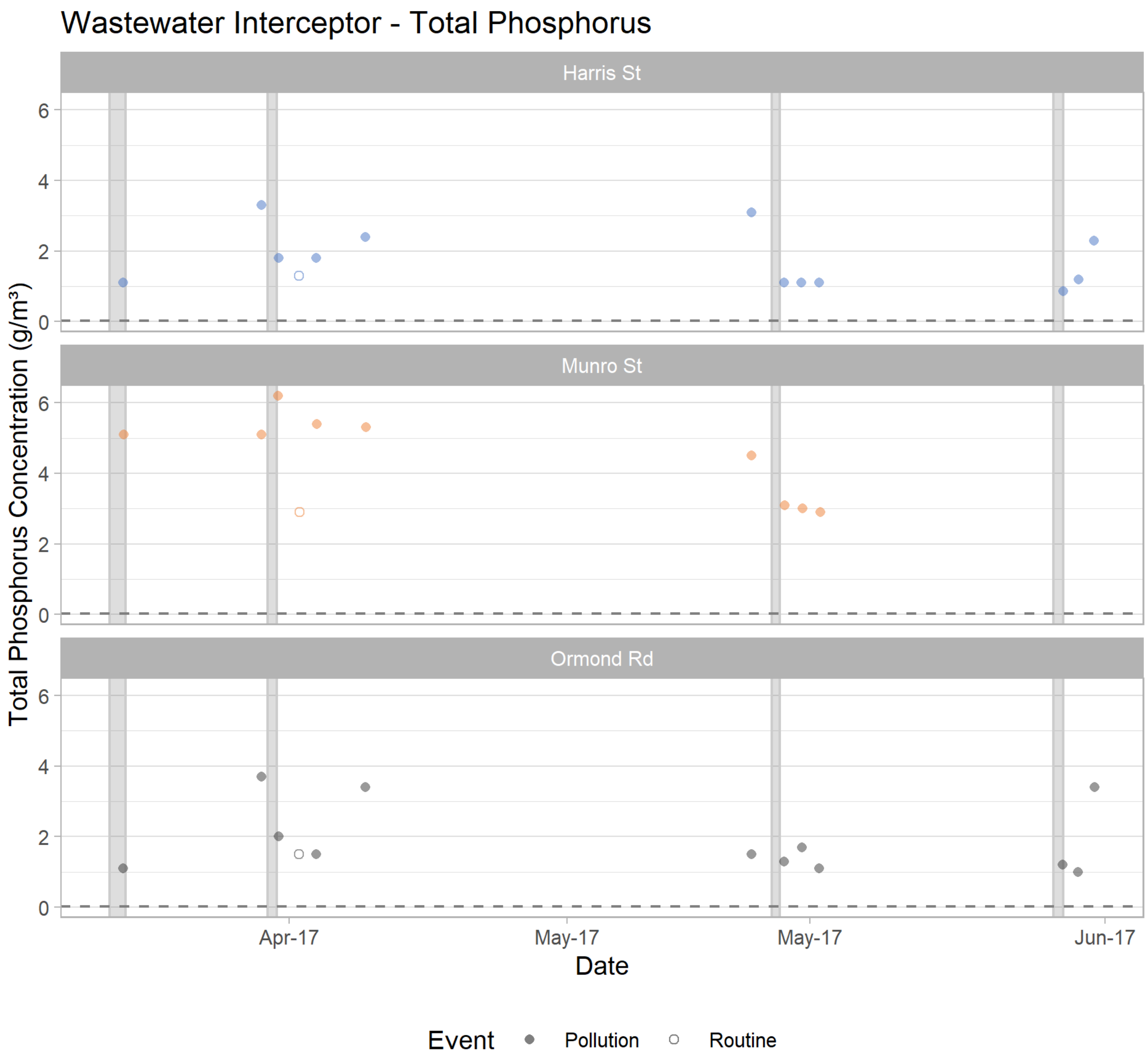


Figure C40: Total phosphorus concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.02 g/m3

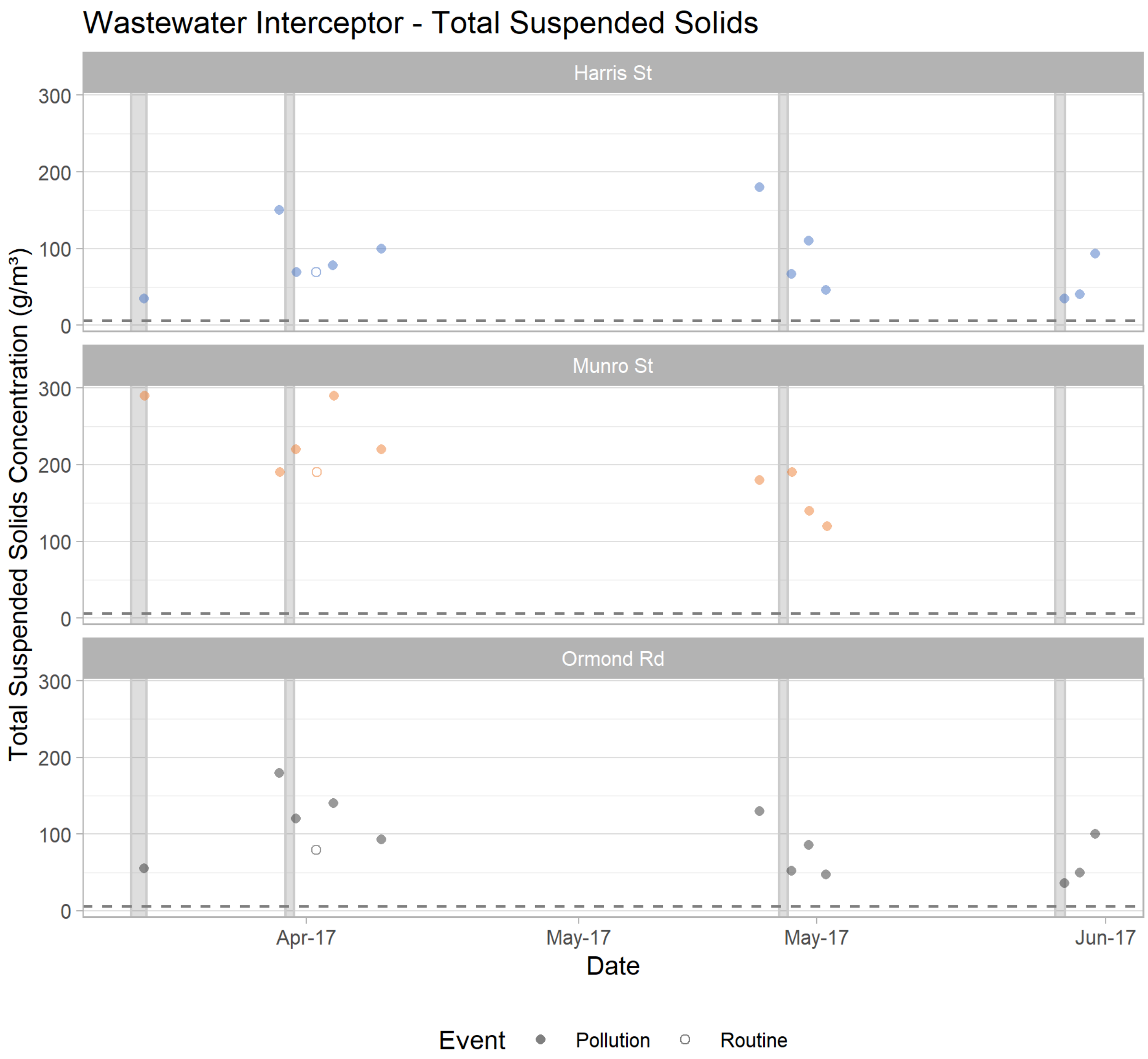


Figure C41: Total suspended solids concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for turbidity for NZ lowland rivers. There is no guideline specifically for TSS but the correlation between TSS and turbidity is strongly positive

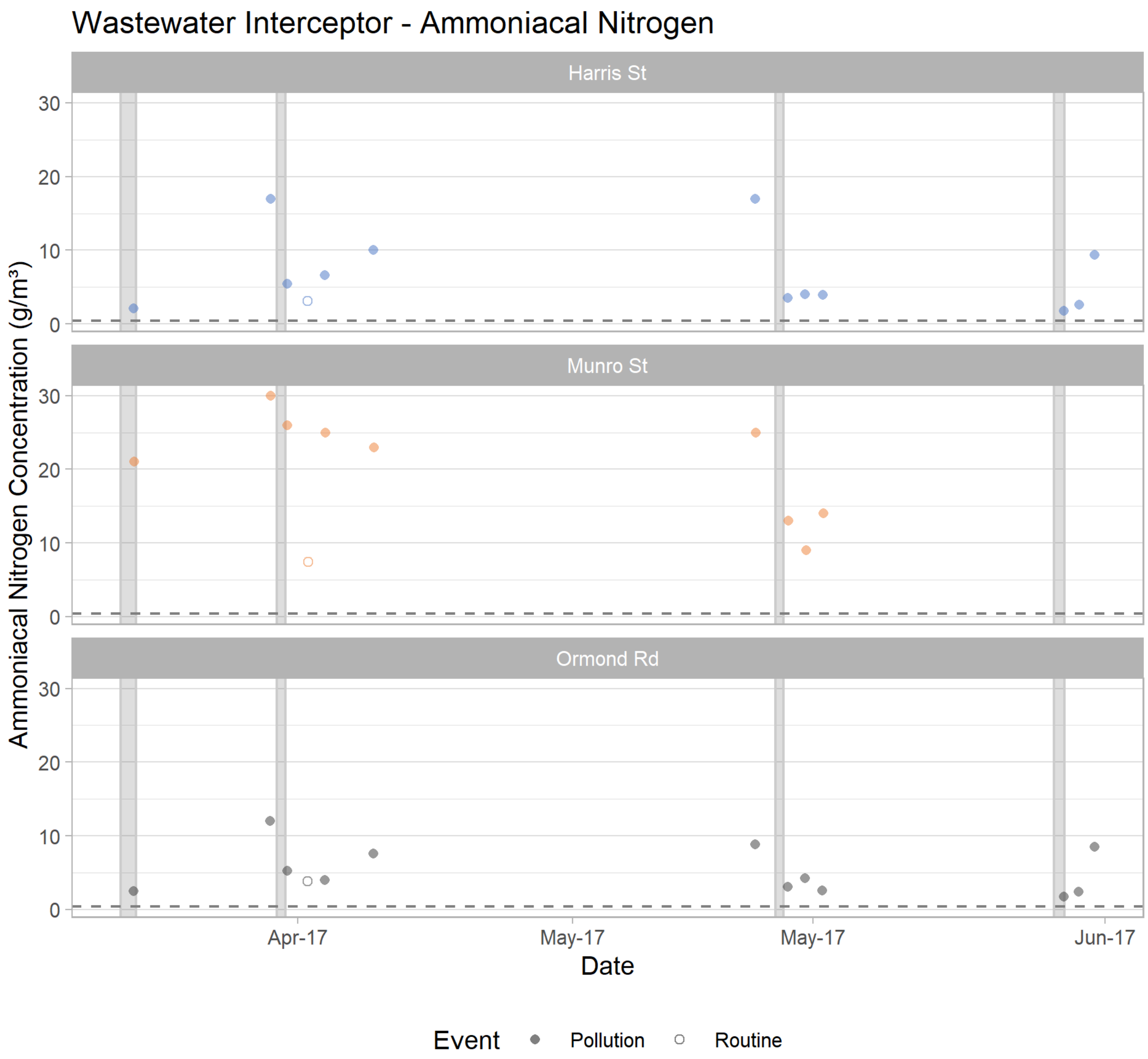


Figure C42: Total ammoniacal nitrogen concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the NPSFM attribute state B guideline value of 0.4 g/m3

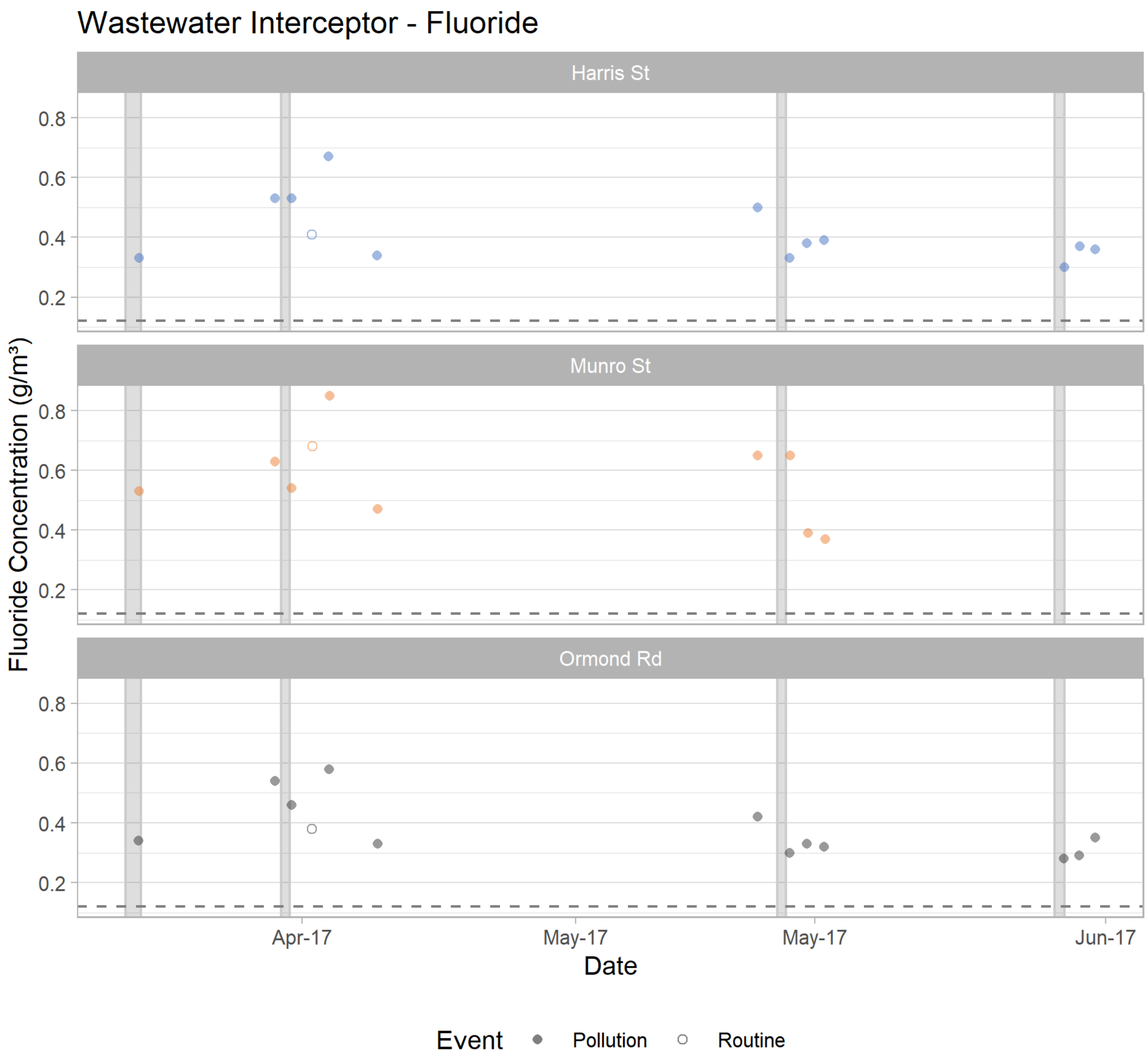


Figure C43: Fluoride concentrations, in-network (all events). The horizontal dashed line shows the Canadian environmental quality (1999) guideline value of 0.12 g/m3

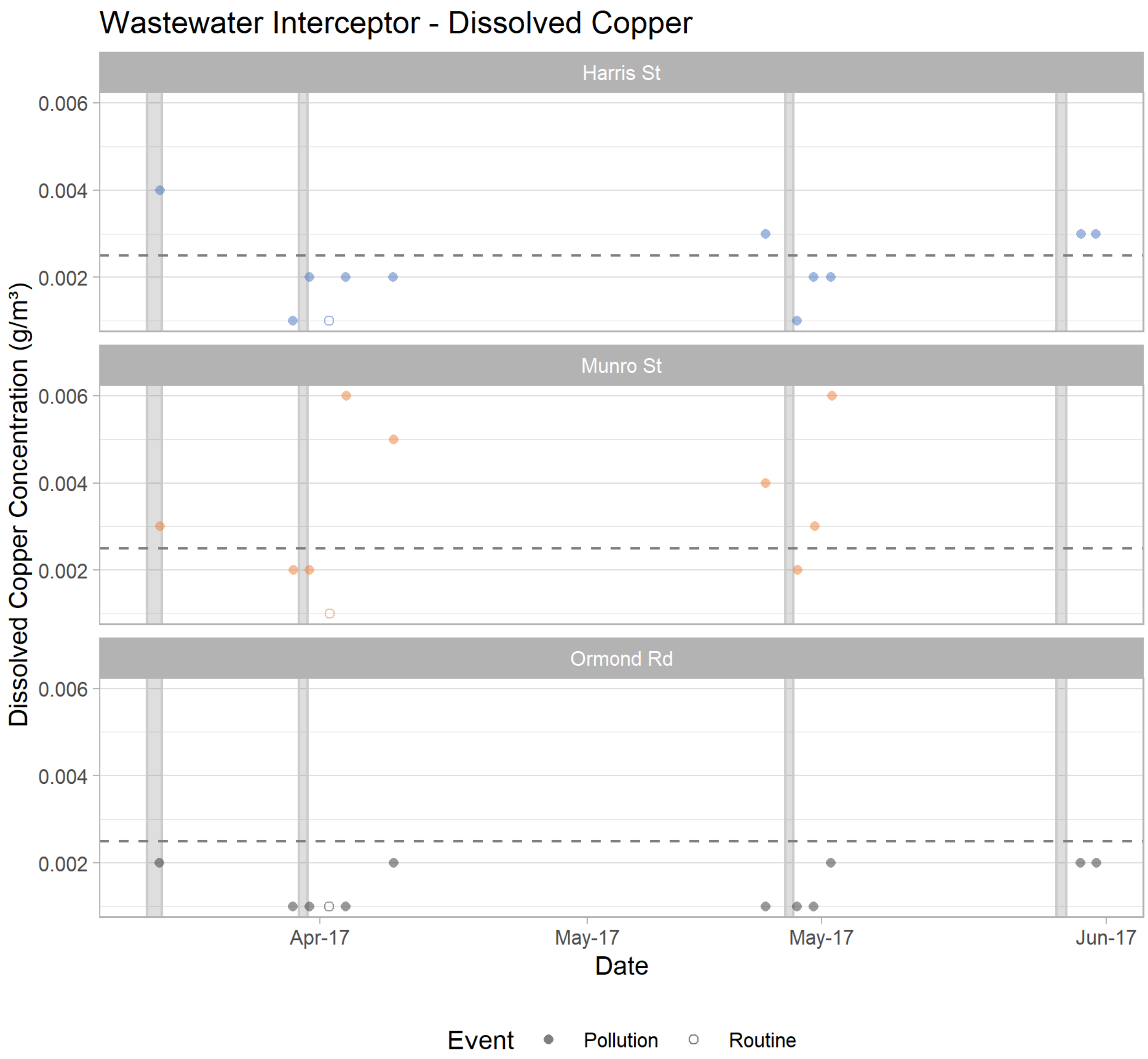


Figure C44: Dissolved copper concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.0025 g/m3

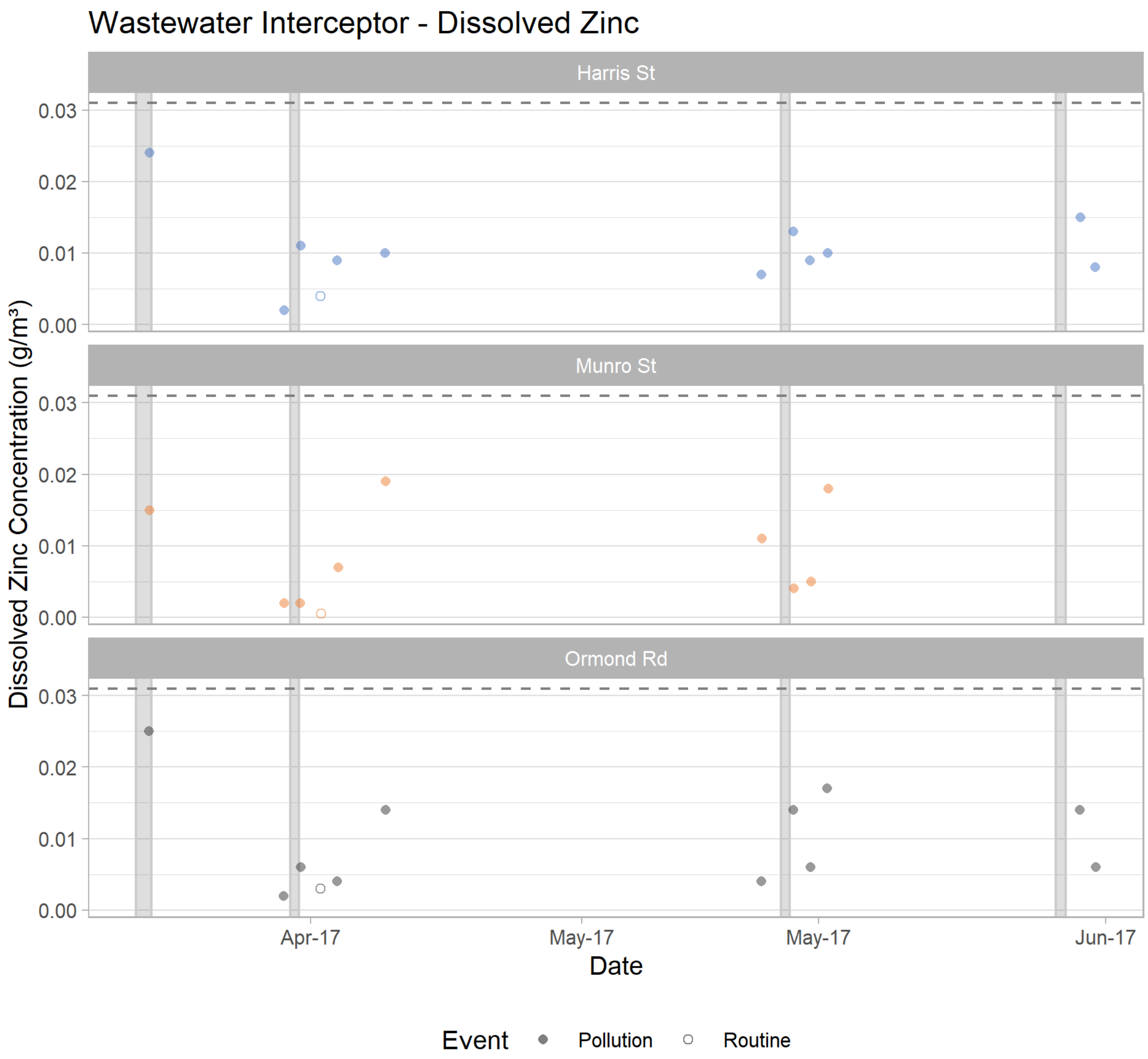


Figure C45: Dissolved zinc concentrations, in-network (all events). Overflow events are shown by the vertical grey lines. The horizontal dashed line shows the ANZECC (2000) guideline value for the protection of 80% freshwater species of 0.031 g/m^3

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