Before the Southland Regional Council

APP – 20191339

Under	the Resource Management Act 1991 (**RMA**)
In the matter of	An application for replacement water and discharge permits for cooling and processing purposes at the Mataura Processing Plant
Applicant	Alliance Group Limited (**Alliance**)

Statement of evidence of Chris Dada for Alliance Group Limited

16 November 2020

Counsel:

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Qualifications and experience

1 My full name is Christopher Ayokunle Dada.

2 I worked previously at the University of Waikato and Streamlined Environmental Limited. I currently work at QMRA Data Experts as an environmental health microbiologist. I specialise in researching and advising on the fate, transport, detection, and control of pathogens in environmental media. In my current role I provide specialist expertise in microbiology, quantitative microbial risk assessment (QMRA), predictive modelling and big data analysis to a range of commercial projects.

3 I hold the following relevant qualifications:

   a) Bachelor of Science (First Class) in Microbiology from the University of Ado-Ekiti (2004);

   b) Master of Science (Hons) in Water Science, Policy and Management from Oxford University (2007), and;

   c) PhD in Water Microbiology from the National University of Malaysia (UKM) (2014);

   d) Postgraduate Certificate in Data Analytics from Massey University, New Zealand (2019).

4 My PhD research focused on the molecular characterization of faecal indicator bacteria and pathogens in aquatic environments. I have also been involved in environmental effects assessment projects in New Zealand. This involved using a variety of models to assess/predict the effect of past/future management decisions on water quality. I have published in several international journals on public health aspects of faecal pollution in water.

5 While at Streamlined Environmental Limited, I was engaged by Aquatic Environmental Sciences Limited (Dr Mark James) on behalf of Alliance to undertake a Quantitative Microbial Risk Assessment ("QMRA") for the discharge of treated meat processing factory wastewater into the Mataura River. This involved:

   a) Assessing the effect of the Alliance Mataura discharge on the Mataura River water quality, involving:

      i. A microbiological quality assessment of the receiving environment;

ii. A mass-balance based assessment of the impact of wastewater discharge on *E. coli* loadings in Mataura River during normal and peak daily discharge scenarios;

iii. An assessment of the impact of scheduled Alliance Plant discharges on Mataura River *E. coli* concentrations;

b) An evaluation of the risk to swimmers in the Mataura River, at the Bridge, ~300m downstream of the Alliance Mataura discharge, using a QMRA approach).

6 The result of the QMRA is reported in a document I authored entitled “Quantitative Microbial Risk Assessment for the discharge of treated meat processing factory wastewater into the Mataura River”, dated May 2019. A copy of that QMRA is included as Appendix 3 to the AEE.

7 I have not visited the Alliance Mataura processing plant however, have been involved in assessments of data.

8 In preparing this evidence I have reviewed the section 42A report prepared for Environment Southland. I have also read the review report by Dr Marion Poore and have provided specific comments in a section of this evidence.

9 Although these proceedings are not before the Environment Court, I have read the Environment Court’s Code of Conduct for Expert Witnesses and I agree to comply with it as if these proceedings were before the Court. My qualifications as an expert are set out above. I confirm that the issues addressed in this brief of evidence are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

Scope of evidence

10 The purpose of my evidence is to describe the existing state of the discharge and the receiving environment, and summarise the results of the QMRA, and in particular to assist the Commissioners in understanding the extent to which the discharge of treated wastewater into the Mataura River from the Alliance Mataura Plant poses a risk to human health.

11 My evidence addresses the following matters:

a) A description of the microbial characteristics of the discharge;

b) A description of the microbial characteristics of the receiving environment;

c) An assessment of the actual and potential effects of the existing and future discharge on the aquatic environment.

Executive summary

12 Results from analysis of monitoring data and mass balance modelling show that *E. coli* concentrations increase significantly following discharge of the Alliance Mataura treated wastewater.

13 Results from analysis of monitoring data also shows that increases in *E. coli* concentrations as a result of the Alliance Mataura treated wastewater discharge did not necessarily relate to the abundance of zoonotic pathogens.

14 QMRA was used to evaluate the current risk to swimmers (both adults and children) in the Mataura River (at the Bridge). This approach incorporated dose response functions of a range (minimum and maximum) of specific zoonotic pathogens[1]; zoonotic pathogen concentrations in treated wastewater; discharge volumes of the treated wastewater; how much water a child will ingest over a period of time during a particular recreational activity; the amount, frequency, and length of time of exposure, as well as the doses for an exposure.

15 Based on the QMRA results, individual illness risk (IIR) levels attributable to the current discharge were below the acceptable "no observable effects" threshold of 1%.

16 Alliance Plant has committed to a phased upgrade of the Alliance Mataura treatment system. Five years after the consent is granted, a new disinfection system will be operational and this will reduce the discharge *E.coli* annual median and 95th percentile to 1,000 CFU/100ml and 10,000 CFU/100 ml, respectively. Additional biological treatment will be installed at Year 15 to further improve effluent quality already been treated by the existing disinfection system, such that a 95th percentile concentration of 1,000 CFU/100ml is achieved. The projected future concentrations are significantly lower than the current 95th percentile concentration (1,400,000). Hence, future conditions[2] will be a significant improvement over the existing condition.

17 Despite the lack of correlation between high *E.coli* concentrations and pathogens monitored in the discharge, Alliance's proposed programme to reduce *E.coli* concentrations in the discharge is supported.

18 I recommend further year-round bacteria and protozoan sampling to address potential for increased concentrations to be recorded in spring months not currently covered in the Alliance Plant monitoring. If, based on the year-round pathogen concentrations, the individual illness risk profiles are greater than the acceptable "no observable adverse effects level", I recommend that the proposed upgrade be

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[1] *Campylobacter, E. coli O157:H7, Salmonella, Cryptosporidium* and *Giardia spp.*

[2] i.e. from five years after the consent is granted

brought forward and completed within 12 months of such increased individual illness risk profiles being determined.

19 I recommend the addition of an upstream site to the existing compliance monitoring program (i.e. weekly upstream and downstream *E.coli* monitoring), such that there is a basis for easy upstream-downstream comparison of *E.coli* concentrations following the proposed upgrade.

20 The push for health risk assessment based on viruses and/or assessment of virus loads in the meatworks discharge is not technically justifiable.

Microbial characteristics of the discharge

21 I have reviewed the Alliance Mataura treated wastewater discharge compliance monitoring and zoonotic pathogen[3] data. This includes an analysis of *E. coli* concentrations of the discharge water as well as an analysis of zoonotic pathogens in the discharged wastewaters that could present a human health risk.

22 The current discharge consent does not contain a compliance limit for *E. coli*. It is important to note that the *E.coli* concentrations of the discharged Alliance Plant wastewater have varied significantly over the years (historical *E.coli* concentrations of fortnight samples collected from 2004-2017). Of interest, is the observation of a decreasing trend in *E. coli* concentrations noticeable from 2013-2017 (see bar charts of yearly 95th percentile in **Figure 1**). For instance, in the most recent years, 2015, 2016 and 2017, the 95th percentile *E. coli* levels reduced significantly from 972,000 CFU/100mL to 240,000 CFU/100mL, the lowest ever in the 14-year historical compliance data (**Figure 1**). These indicate continued improvements over the past three years but cannot be explained by any targeted work by Alliance in this area. On the other hand, however, the 14-year 95th percentile (2004-2017) and the most recent 5-year 95th percentile (2012-2017) were approximately 1,400,000 CFU/100mL (**Figure 1**).

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[3] i.e. microorganisms that originate from animals and cause disease in humans.

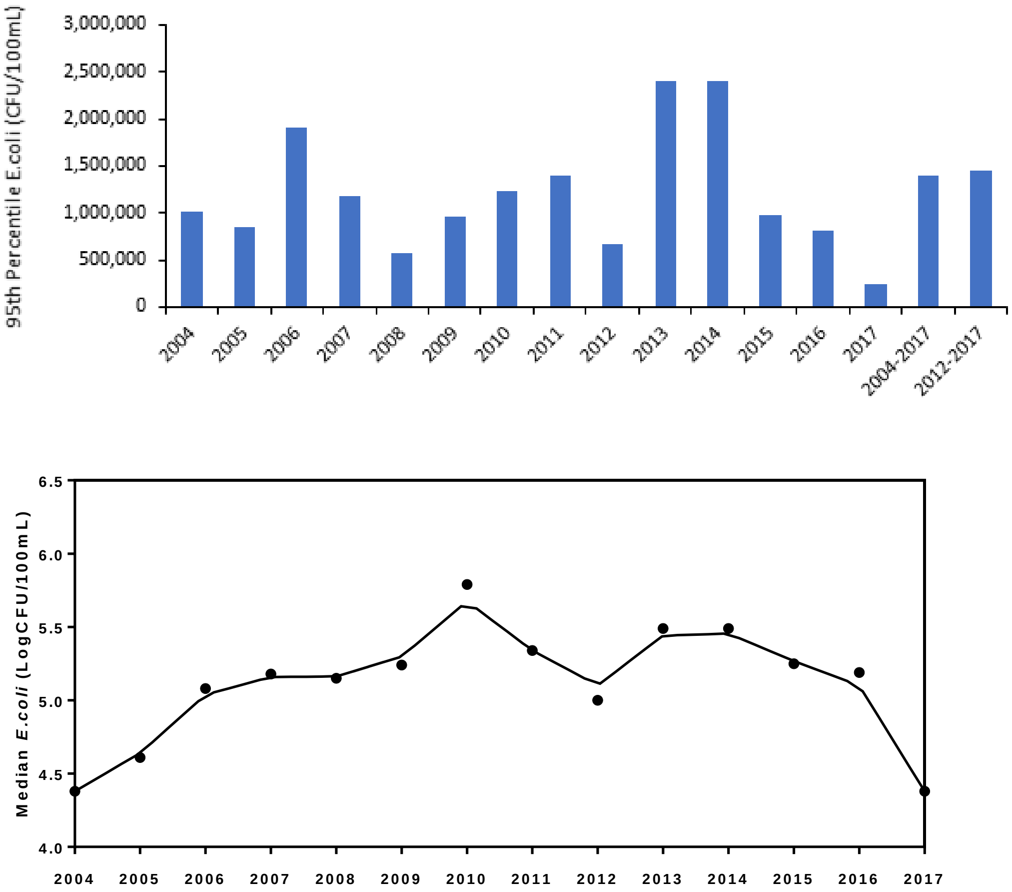

Figure 1 (a) Yearly 95th Percentile *E.coli* concentrations and (b) Lowess-fitted trend analysis of historical *E. coli* data, Alliance Mataura treated wastewater discharge.

23 Pathogen assessment for the Alliance Mataura treated wastewater discharge was informed by available literature which affirmed that two key groups of pathogens are of most concern in animal wastewater; bacteria and protozoans (Sobsey et al., 2006; USEPA, 2010).

a) Bacteria:

i. Results from the Autumn 2018 pathogen monitoring (ESR laboratories) indicate that a very high level of *E. coli*, up to 10^6 CFU/100mL, was being discharged into the Mataura River from the Alliance Mataura Plant but that the levels of the representative pathogens were very much lower and more variable (Table 1). For example, the discharge contained a low level of *Salmonella* species (120 cells per 100mL, Table 1) and *Campylobacter jejuni* (22 cells per 100mL, Table 1). *E. coli* 0157: H7, the pathogenic variant of *E. coli*[4]

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[4] rising number of cases of *E. coli* 0157: H7infection in New Zealand is rising, but the transmission routes remain obscure.

was also rarely detected despite the high *E. coli* concentrations in the treated wastewater. These data indicate that high *E. coli* concentrations did not result in high levels of pathogens in the treated wastewater (Table 1).

    ii. Additional summer pathogen monitoring was conducted in the summer of 2019. Similar to the Autumn 2018 results, a very high concentration of *E. coli* (up to 10^6 CFU/100mL) was recorded in the Alliance Mataura Plant discharge, but the concentrations of the representative bacteria pathogens were very much lower (Table 1). Variability in pathogen concentrations has also been reported in previous studies (e.g. Sobsey et al 2006).

b) Protozoans:

    i. Among the notifiable gastrointestinal diseases which can be contracted through contaminated water, Cryptosporidiosis and *Giardia*sis are the top two[5] reported disease caused by protozoans. Cryptosporidiosis and *Giardia*sis are caused by infection with protozoan parasites of the genus *Cryptosporidium* and *Giardia* respectively*.* An analysis of the treated wastewater discharge pathogen data indicates that protozoan pathogens were very low following treatment. In the first sampling that occurred in Autumn 2018, no protozoan oocysts were detected in the discharge (see Table 2).

    ii. In contrast, over the summer of 2018/19, *Cryptosporidium* and *Giardia* were detected at levels up to 310 oocysts per litre (Table 2). This variability is not unexpected because pathogens in meat works wastewater will depend on the variable resident population of pathogens in the animals before slaughter (Sobsey et al 2006).

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[5] http://www.ehinz.ac.nz/assets/Factsheets/Released-2016/EHI47-WaterBorneDiseasesNotificationsUntreatedDrinkingWater2005-2014-released201608.pdf

Table 1. Bacteria pathogen monitoring data, Alliance Mataura Plant discharge, Autumn 2018 and Summer 2019.

Season	Date	*E. coli* (CFU/100ml)	*Salmonella* (CFU/100ml)	*Campylobacter* (CFU/100ml)	*E. coli* 0157: H7 (CFU/100ml)
Autumn 2018	7-May	2,400,000	240	4	0.3
	9-May	520,000	0.6	43	0.3
	Average	1,460,000	120	24	0
Summer 2019	18-Dec	300,000	21	<3	<3
	19-Jan	4,500,000	4	9	<3
	19-Feb	90,000	<3	4	*
	Average	1,630,000	9	5	2

* E. coli O157 was detected in this sample, however quantification was not possible due to the presence of inhibitory substances in the matrix.

Table 2. Protozoa pathogen monitoring data, Alliance Mataura Plant discharge, Autumn 2018 and Summer 2019.

Season	Date	*Giardia* oocysts /1000ml)	*Cryptosporidium* (oocysts /1000ml)
Autumn 2018	7-May	<1	<1
	9-May	N.D.	N.D.
Summer 2019	18-Dec	32	310
	19-Jan	150	250
	19-Feb	2	1

N.D. = not detected.

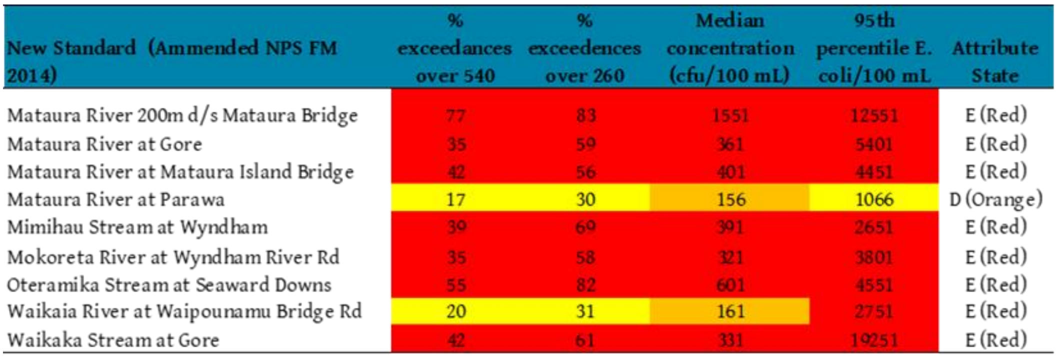
Microbial characteristic of the receiving environment

24 I examined monitoring microbiological data (historical and more recent sampling) in relation to existing guidelines. The NPS-FM (2020) defines River Attribute States for *E. coli*. In relation to this guideline, I reviewed the historical microbiological water quality collected for sites in the Mataura River and associated tributaries. Based on the analysis, I observed that:

A) The proportion of samples exceeding the NPS-FM (2020) 540 CFU/100mL bathing water standards increased between the upstream and downstream sites. For instance, at the site immediately downstream of the discharge (200m d/s Mataura Bridge), exceedance increased from 35%

(Mataura River @Gore) and 42% (Waikaka Stream @ Gore) to 77% (Table 3). This suggests that the discharge is increasing the levels of *E. coli* in the receiving water.

Table 3. Attribute State[6] of Mataura River based on historical *E. coli* data.



New Standard (Ammended NPS FM 2014)	% exceedances over 540	% exceedences over 260	Median concentration (cfu/100 mL)	95th percentile E. coli/100 mL	Attribute State
Mataura River 200m d/s Mataura Bridge	77	83	1551	12551	E (Red)
Mataura River at Gore	35	59	361	5401	E (Red)
Mataura River at Mataura Island Bridge	42	56	401	4451	E (Red)
Mataura River at Parawa	17	30	156	1066	D (Orange)
Mimihau Stream at Wyndham	39	69	391	2651	E (Red)
Mokoreta River at Wyndham River Rd	35	58	321	3801	E (Red)
Oteramika Stream at Seaward Downs	55	82	601	4551	E (Red)
Waikaia River at Waipounamu Bridge Rd	20	31	161	2751	E (Red)
Waikaka Stream at Gore	42	61	331	19251	E (Red)

b) Attribute State classification based on the historical *E. coli* data for the Mataura River and tributaries (2011-2015) indicates that the river is classified as E (Red) for most monitored sites. This occurs regardless of whether the monitoring site is upstream or downstream of the Alliance discharge. This poor baseline microbiological state of Mataura River is not surprising. The 190km long Mataura River flows through several towns whose industries and sewage treatment plants input wastewater to the river. In addition to the Alliance Mataura treated wastewater discharge and discharges from the Gore and Mataura township wastewater treatment systems, the river also supports a rapidly growing dairy industry (Cressey et al 2013) and many other large commercial interests including milk processing plants and a fibre board factory. These discharges may also contribute to the poor microbiological quality of the river. Thus, a catchment wide approach would be needed to improve the quality of the river.

c) In relation to the NPS-FM guideline, I have also reviewed the data generated from an intensive longitudinal sampling exercise, conducted between 2017 and 2018, for several sites upstream and downstream of the discharge (Figure 2). An analysis of these data showed that *E. coli* concentrations increase significantly following discharge of the Alliance Plant wastewater (Figure 3). Also, *E. coli* concentrations reduce gradually downstream, i.e. with increasing distance away from the discharge point (Figure 3). The longitudinal *E. coli* survey also suggests that the point of full mixing is somewhere at a distance between the PDP2 (80m

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[6] The amended 2017 NPS was used for the Attribute State Classification. I note that the amended NPS FM table is often inconclusive in determining Attribute States for some sites. This is a New Zealand wide phenomenon and is not peculiar to Mataura River.

downstream of discharge) and PDP3 site (150m downstream), as concentrations are reasonably stable beyond these sites.

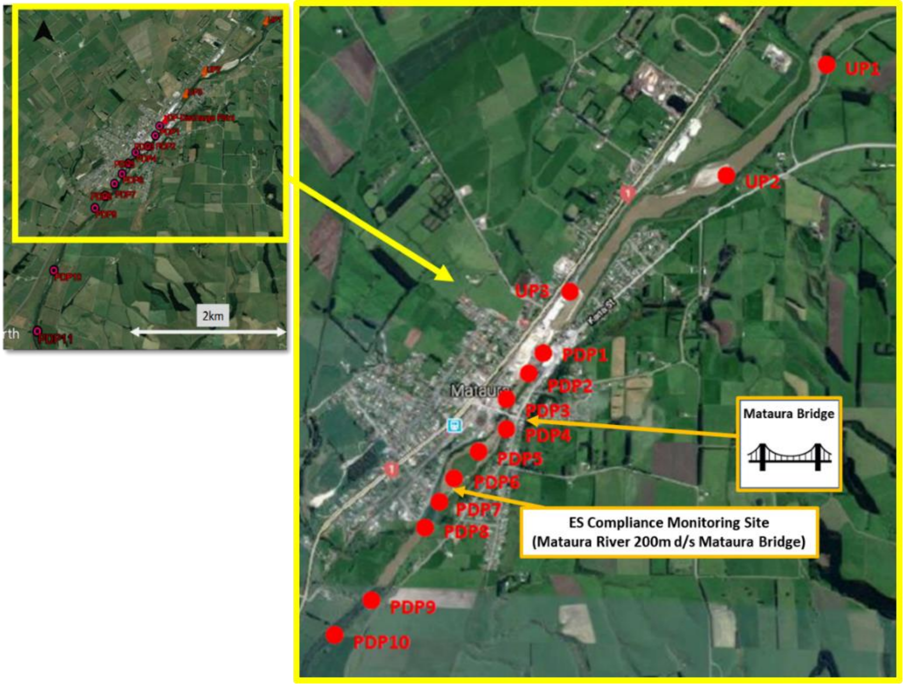

Figure 2. Sampling sites for the intensive monitoring conducted in 2017/2018 summer. Upstream sites are UP1, UP2 and UP3. Post-discharge sites PDP 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 are 50,80,150,370,450,720,850,900, 1670, 2650 and 3340 m, respectively, away from the discharge. Additional summer pathogen monitoring was conducted for samples collected at Mataura Bridge, ~300m downstream of the discharge. The ES compliance monitoring site 'Mataura River 200m d/s Mataura Bridge' is approx. 800m from the outfall, i.e. between PD6 and PD7.

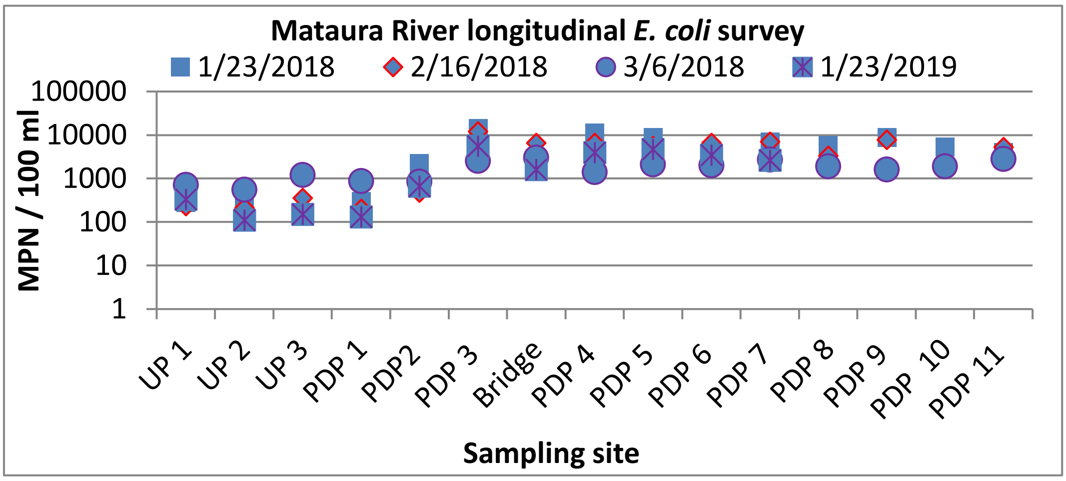

Figure 3. Plots of observed *E. coli* data from longitudinal study, Mataura River, Summer 2017/2018. Upstream sampling sites are designated UP while downstream sites are designated PDP (in m, estimated using the Google Map distance tool). Sampling sites PDP 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 are 50,80,150,370,450,720,850,900, 1670, 2650 and 3340 m, respectively, away from the discharge. Bridge is ~330m downstream of the discharge. The bridge samples were taken on different dates (12/19/2018, 01/21/2019 and 02/18/2019).

Effects of the current discharge

25 In order to assess the effects of the discharge of Alliance Mataura treated wastewater discharge on the Mataura River, I used two approaches. The first approach involved the use of mass balance dilution modelling to predict the impact of the discharge on Mataura River *E. coli* levels while the second approach was a QMRA. I now discuss the results.

Mass balance[7] modelling

26 I combined current treated wastewater concentrations of *E. coli* in Alliance Plant wastewater with Mataura River *E. coli* data to predict how the discharged wastewater will affect the faecal bacteria load in the Mataura river. Modelling results show:

a) Increases in the proportion of samples at the downstream site (Mataura River 200m d/s Mataura Bridge), exceeding the NPS-FM (2020) bathing water standards following the discharge. For instance, percentage exceedances doubled after the discharge. This suggests that the Alliance Plant discharge is having an adverse effect on the levels of *E. coli* in the receiving water downstream of the discharge.

b) During baseline conditions (i.e. Mataura River at Gore), the *E. coli* concentrations correspond to the Attribute State designated as E (Red, the poorest attribute state). With the Alliance Plant discharge, the estimated *E. coli* concentrations in the downstream Mataura River site following dilution still correspond to the NPS-FM Attribute State designated as E (Red).

Quantitative microbial risk assessment (QMRA)

27 I have also examined the effect of the Alliance Plant discharge using a QMRA approach that incorporates:

a) dose response functions of a range of specific zoonotic pathogens[8] and the zoonotic pathogen concentrations in treated effluent;

b) discharge volumes of the treated wastewater;

c) how much water a child will ingest over a period of time during a particular recreational activity;

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[7] Mass balance modelling approach assumes: 1) conservation of mass; 2) complete mixing, and; 3) that water quality measurements and projections are accurate and representative.

[8] *Campylobacter, E. coli O157:H7, Salmonella, Cryptosporidium* and *Giardia spp.*

d) the amount, frequency, length of time of exposure, as well as the doses for an exposure.

28 The reasons I have used a QMRA approach are two-fold:

a) In line with available literature (USEPA, 2010, Savichtcheva & Okabe, 2006, Wu et al 2011), current monitoring data collated at Mataura River has highlighted the inadequacies of the *E.coli* approach to assess risk, given the lack of observed correlations of *E. coli* levels with zoonotic pathogen concentrations;

b) Multiple stressors contribute to the faecal loading in the Mataura River, hence, a better approach to safeguarding public health is to assess attributable risks to health as a result of the discharge from the Alliance Mataura plant using a quantitative approach. Attributable risk is the increment in risk associated with the Alliance Plant discharge, without encompassing risks associated with upstream catchment runoff or overflows.

29 Eight scenarios were applied in the QMRA covering conditions of normal and peak Alliance Plant discharge rate, during summer and during the rest of the year[9], as well as during conditions of no treatment and when the wastewater was treated before discharge.

30 Considering that the wastewater flow rate is a small fraction of the Mataura River flow, it is expected that 50 percent of the time, during normal discharge conditions (i.e. when a maximum of 6,776 m^3/day of treated wastewater is released into the Mataura River), the wastewater discharge will be diluted by at least 2,904 times in summer and at least 4,363 times at other times of the year (Table 4). During a worst-case discharge scenario (i.e. when a maximum of 14,400 m^3/day of treated wastewater is released into the Mataura River[10]), the wastewater discharge will be diluted by at least 1,367 times in summer and at least 2,054 times at other times of the year (Table 4).

31 Results of the QMRA indicate that risks were marginally higher during summer due to low flow and accordingly lower dilutions within the Mataura River, compared to other times in the year. This is because a conservative principle that assumes no microbial inactivation in the Mataura River following discharge was applied in this QMRA, which would be expected to be higher in summer.

32 The results of QMRA analysis (Table 5) show:

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[9] Simply called SummerSite and WinterSite in the microbial assessment reports

[10] It should be noted that Alliance is now proposing a maximum discharge rate of 8,000 m^3/day. 14,400 m^3/day represents the previously consented discharge volume.

a) No treatment, normal WW discharge scenario –recreational health risks for children[11] who engage in downstream recreational activities are above the 1% threshold for all zoonotic pathogens.

b) No treatment, peak WW discharge scenario – children recreational health risks are above the 1% threshold for all zoonotic pathogens.

c) Treatment applied, normal WW discharge scenario – children recreational health risks are below the 1% threshold for all zoonotic pathogens.

d) Treatment applied, peak WW discharge scenario – children recreational health risks are below the 1% threshold for all zoonotic pathogens.

33 I conclude, based on the results of the QMRA, that the current wastewater treatment applied at Alliance Plant is sufficient to reduce attributable swimming health risks[12] associated with the discharge at the study site (Mataura Bridge) to levels below 'the NZ threshold for tolerable risk', even at maximum discharge of 14,400 m^3/d which has been replaced by a maximum proposed discharge rate of 8,000 m^3/s.

Table 4. Effective (a) summer and (b) annual dilution plots of wastewater contaminant in Mataura River at the Bridge site during normal and worst-case scenarios of discharge at the plant (i.e. max discharge of 6776 and 14,400 m^3/d[13], respectively).

Statistics	Effective dilution, normal discharge, Annual	Effective dilution, normal discharge, Summer	Effective dilution, peak discharge, Annual	Effective dilution, peak discharge, Summer
Minimum	141	135	67	64
50th Perc	4,363	2,904	2,054	1,367
60th Perc	5,609	3,771	2,640	1,775
70th Perc	7,391	5,025	3,479	2,365
80th Perc	10,601	7,148	4,989	3,364
90th Perc	18,376	12,509	8,648	5,887
95th Perc	29,513	20,436	13,888	9,617
99th Perc	67,265	46,987	31,653	22,110
Max	192,027	155,576	90,360	73,208

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[11] A precautionary approach in this QMRA is to report the children's illness risk as opposed to the generally lower adults' risk. This is consistent with previous NZ QMRAs.

[12] That is, Individual Illness Risk (IIR) calculated as the total number of infection cases divided by the total number of exposures, expressed as a percentage.

[13] It should be noted that Alliance is now proposing a maximum discharge rate of 8,000 m^3/day. 14,400 m^3/day represents the previously consented discharge volume.

Table 5. Child Individual's Illness Risk (%) per 100 swimmers who are exposed to Mataura River water that potentially contains zoonotic pathogens following Alliance Plant wastewater discharge.

	Giardia	*Crypto*	*E. coli 015:h7*	*Campy*	*Salm.*
Statistics	**IIR (%)**	**IIR (%)**	**IIR (%)**	**IIR (%)**	**IIR (%)**
SummerSite1C_NormalDischarge_notreatment_ill	1.41	16.63	2.73	4.48	12.66
WinterSite1C_NormalDischarge_notreatment_ill	0.93	11.05	1.92	3.08	8.56
SummerSite1C_Worstcase_notreatment_ill	2.33	21.56	4.03	5.81	16.67
WinterSite1C_Worstcase_notreatment_ill	1.46	15.05	2.90	4.09	11.63
SummerSite1C_NormalDischarge_withtreatment_ill	0.02	0.33	0.0001	0.11	0.03
WinterSite1C_NormalDischarge_withtreatment_ill	0.01	0.20	0.0001	0.07	0.02
SummerSite1C_Worstcase_withtreatment_ill	0.03	0.54	0.0001	0.18	0.05
WinterSite1C_Worstcase_withtreatment_ill	0.02	0.28	0.0001	0.09	0.03

34 Results from this QMRA agree with a recent ESR study (Cressey et al 2017) which adopted a combination of faecal source tracking, genotypic analysis and QMRA to assess recreational human health risk of the Mataura River, Southland. The ESR QMRA applied three scenarios, viz:

a) Scenario 1 - measured *Campylobacter* concentrations in the river (May 2017);

b) Scenario 2 - simulated concentrations based on dilution of Gore WWTP and Alliance Mataura effluent *Campylobacter* in the river (May 2017), and;

c) Scenario 3 - based on regression of *Campylobacter* concentrations against flow rate.

35 Results from the ESR-led investigation (Cressey et al 2017) affirmed that:

> *"…Effluent discharged from the Gore WWTP and the meat processing plant contribute a relatively small proportion of the overall Campylobacter risk. This is consistent with other work that indicated that Campylobacter contamination in this region of the Mataura River was predominantly of wild fowl origin…".* (Source: Cressey et al 2017).

Effects of future discharges

36 Mr Khan reported results of pilot plant initial trials in a previous evidence. The pilot trials indicated that it is possible to reduce Alliance Mataura discharge *E.coli*

through a double pH adjustment and UV disinfection treatment to very low levels prior to final discharge.

37 Alliance Plant has provided information on the *E.coli* concentrations expected following the phased upgrades to the existing treatment system. These are presented below:

a) Year 0 – Year 5, that is the current situation will continue at the plant, with no compliance limit set for *E.coli.*

b) Year 5 – 15, a new disinfection system will be operational 5 years after the consent is granted and this will reduce the Alliance Mataura discharge *E.coli* levels to:

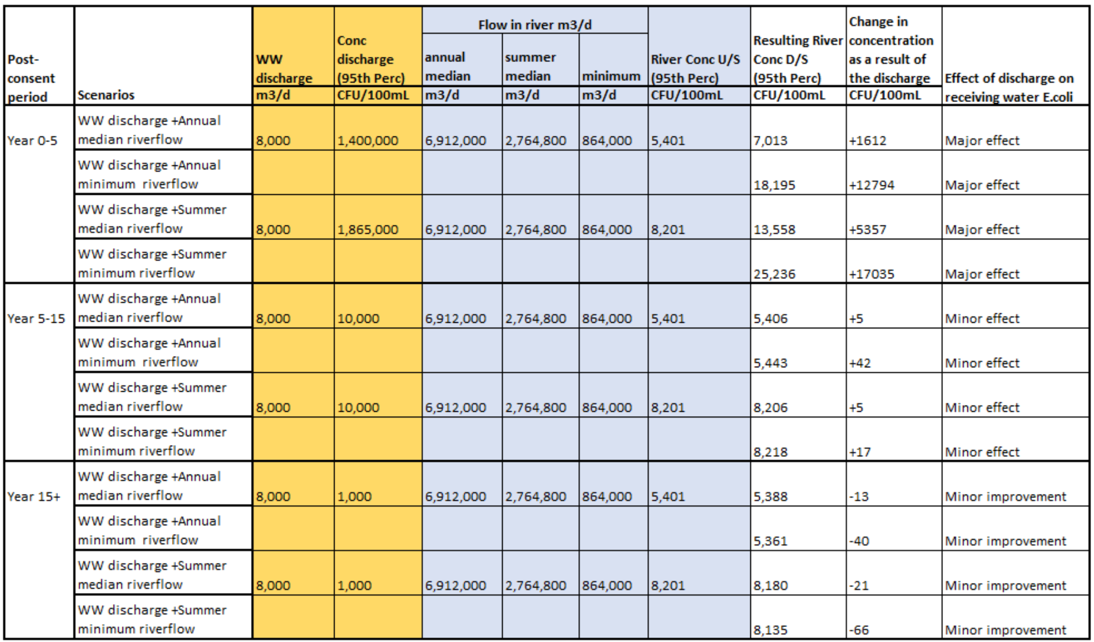
   i. annual median 1,000 CFU/100ml, and

   ii. 95th percentile of 10,000 CFU/100 ml

c) Year 15+, an additional biological treatment will be installed at Year 15 to further improve effluent quality already been treated by the existing disinfection system installed at Year 5, such that a 95th percentile concentration of 1,000 CFU/100ml is achieved.

38 Mass balance modelling results show that the projected future concentrations of the Alliance Mataura discharge will cause very little attributable increases in *E.coli* concentrations in the Mataura River (Table 6). For instance, in Years 5-15 after the consent is granted, a maximum *E.coli* increase of 42 CFU/100mL will be caused as a result of the Alliance Mataura discharge. Beyond year 15 after the consent approval, the combination of disinfectant and biological treatment of the Alliance Mataura discharge will produce an improvement in the receiving water *E.coli* levels.

Table 6 Effect of the Alliance Mataura discharges on *E.coli* levels in the Mataura River



Post-consent period	Scenarios	WW discharge m3/d	Conc discharge (95th Perc) CFU/100mL	Flow in river m3/d			River Conc U/S (95th Perc) CFU/100mL	Resulting River Conc D/S (95th Perc) CFU/100mL	Change in concentration as a result of the discharge CFU/100mL	Effect of discharge on receiving water E.coli
				annual median m3/d	summer median m3/d	minimum m3/d				
Year 0-5	WW discharge +Annual median riverflow	8,000	1,400,000	6,912,000	2,764,800	864,000	5,401	7,013	+1612	Major effect
	WW discharge +Annual minimum riverflow							18,195	+12794	Major effect
	WW discharge +Summer median riverflow	8,000	1,865,000	6,912,000	2,764,800	864,000	8,201	13,558	+5357	Major effect
	WW discharge +Summer minimum riverflow							25,236	+17035	Major effect
Year 5-15	WW discharge +Annual median riverflow	8,000	10,000	6,912,000	2,764,800	864,000	5,401	5,406	+5	Minor effect
	WW discharge +Annual minimum riverflow							5,443	+42	Minor effect
	WW discharge +Summer median riverflow	8,000	10,000	6,912,000	2,764,800	864,000	8,201	8,206	+5	Minor effect
	WW discharge +Summer minimum riverflow							8,218	+17	Minor effect
Year 15+	WW discharge +Annual median riverflow	8,000	1,000	6,912,000	2,764,800	864,000	5,401	5,388	-13	Minor improvement
	WW discharge +Annual minimum riverflow							5,361	-40	Minor improvement
	WW discharge +Summer median riverflow	8,000	1,000	6,912,000	2,764,800	864,000	8,201	8,180	-21	Minor improvement
	WW discharge +Summer minimum riverflow							8,135	-66	Minor improvement

Annual median, summer median and minimum Mataura River flows correspond to 80 m^3, 32 m^3/s and 10 m^3 respectively (i.e. 6912000, 2764800 and 86400 m3/d)

Response to Dr Marion Poore's Review

39 I share Dr Poore's position that our collective goal should be to "prevent illness in communities by explicitly addressing the risk factors for disease and by promoting actions that achieve health and wellbeing".

40 I also agree with the reviewer's position in Section 15, with respect to the inadequacies associated with the use of *E.coli* in that "they poorly correlate with pathogens in water" and that "high *E.coli* levels do not always correlate with high pathogens". Several studies have also documented the limitations with the *E.coli* indicator.

> *"…E. coli and enterococci are not well correlated with pathogenic Cryptosporidium and Giardia spp. (Lemarchand and Lebaron 2003; Harwood et al. 2005), Salmonella spp. (Lemarchand and Lebaron 2003), Campylobacter spp. and human enteroviruses (Lemarchand and Lebaron 2003; Hellein et al. 2011)[14]….".* (Source: Rodrigues & Cunha, 2017 , Page 7).

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[14] Harwood VJ, Levine AD, Scott TM, Chivukula V et al (2005) Validity of the indicator organism paradigm for pathogen reduction in reclaimed water and public health protection. Appl Environ Microbiol 71(6):3163–3170.
Lemarchand K, Lebaron P (2003) Occurrence of Salmonella spp. and Cryptosporidium spp. in a French coastal watershed: relationship with fecal indicators. FEMS Microbiol Lett 218(1):203–209.
Hellein KN, Battie C, Tauchman E, Lund D et al (2011) Culture-based indicators of fecal contamination and molecular microbial indicators rarely correlate with Campylobacter spp. in recreational waters. J Water Health 9(4):695–707

41 As I previously stated in this evidence, the discharge is having an impact in relation to the levels of *E.coli* in the receiving water. However, based on the actual pathogen data used for the QMRA, health risks are below the “no observable adverse effects level” of 1%. Despite the lack of correlation between high *E.coli* concentrations and pathogens monitored in the discharge I agree that efforts aimed at reducing *E.coli* concentrations in the discharge be expedited. Hence, I agree the upgrades should be done as soon as practicably possible.

42 The reviewer, however, submitted some generalizations to buttress points raised in the review document, which need to be addressed. For instance, Dr Poore appears to relate the “detection” of pathogens rather than the “levels” of pathogens to occurrence of risks (for instance, section 18 and 30 of the review report). This approach is incorrect as it exaggerates health risks. Pathogen exposure leading to illness is not a simple question of whether exposure has occurred, as argued by the reviewer. It is not the presence (or detection) of pathogens *per se* that stakeholders need to be concerned about but the levels of the pathogens after dilution in the receiving environment. This would need to be considered in relation to the infectious dose[15] of the pathogen (i.e. the amount of a pathogen that is required to establish an infection within a susceptible host). This is a key health risk determinant in several dose response functions that have been established for zoonotic pathogens.

43 There are also some incorrect assertions in the reviewer’s comment on Section 25 (review report) in response to my position that no substantial risks have been established for transmission of viruses through animal wastewater discharge. According to the reviewer, “…*the assumption that “there is no substantial risk established for transmission of animal viruses is questionable*”. The reviewer also pushed for a health risk assessment based on viruses and/or assessment of virus loads in the meatworks discharge (Section 34 and 35 of review report). This position is not technically justifiable.

44 In my opinion it is important to note that viruses are specific in terms of the host that they cause diseases in (i.e. they are host-adapted). Hence, transmission of faecally-associated viruses of animal origin to humans is considered rare (Rosen, 2000; Sobsey et al., 2006)[16].

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45 McDaniel et al. (2014)[17] published an extensive literature review article on the epidemiology of bovine zoonoses[18]. Among all the listed bovine viruses that are capable of causing infections via ingestion in humans, none relates to New Zealand in terms of their geographic distribution (Table 7). Also, none of the listed viruses are notifiable in New Zealand (Table 7).

46 A U.S. Environmental Protection Agency study (USEPA 2010) provides a "state-of-the-science" review for QMRA for estimating risk of illness resulting from exposure to animal-derived faecal material (cattle, swine, and poultry). According to the model QMRA document:

> *"…*<u>The reference pathogens in livestock …are primarily bacterial and protozoan</u>*. Among human viruses of potential concern, only hepatitis E is associated with livestock operations (Banks et al., 2004; Legrand-Abravanel et al., 2009; Rutjes et al., 2009; Sinclair et al., 2009; Takahashi et al., 2009)* [19]*. Although the presence of Hepatitis E antibodies in pigs is notable (Meng et al., 1999; Smith, 2001)*[20]*, including Hepatitis E in QMRA is limited by the lack of dose response relationships available to estimate risks to humans. In this regard, experiments with monkeys indicate that oral inoculation with hepatitis E is inefficient in producing disease."* (Source: USEPA 2010, page 19).

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[17] McDaniel, C. J., Cardwell, D. M., Moeller, R. B., Jr, & Gray, G. C. (2014). Humans and cattle: a review of bovine zoonoses. Vector borne and zoonotic diseases,14(1), 1–19. https://doi.org/10.1089/vbz.2012.1164

[18] A bovine zoonosis is any disease or infection that is naturally transmissible from cattle to humans.

[19] Banks, M., Bendall, R., Grierson, S., Heath, G., Michell, J., and Dalton, H. (2004) Human and porcine hepatitis E virus strains, United Kingdom. Emerging Infectious Diseases 10(5): 953-955.
Legrand-Abravanel, F., Mansuy, J.-M., Dubois, M., Kamar, N., Peron, J.-M., Rostang, L., and Izopet, J. (2009) Hepatitis E virus genotype 3 diversity, France. Emerging Infectious Diseases 15(1): 110-114.
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Smith, J.L. (2001) A review of hepatitis E virus. J ournal of Food Protection 64(4): 572-586.

Table 7 Recognized bovine zoonotic pathogens (viruses)

Pathogen	***Potential transmission routes***	***Disease***	***System potentially affected***						***Geographic distribution***	***Notifiable in New Zealand?***
			Cardiovascular	***Pulmonary***	***Gastrointestinal***	***Cutaneous***	***Ocular***	***Neurological***		
Crimean-Congo hemorrhagic fever virus	Cutaneous, Ingestion, Vector-borne, Inhalation	Crimean-Congo hemorrhagic fever	•	•	•	•	•	•	Africa, Middle East, Asia, and most of Europe	No
Kyasanur Forest disease virus	Vector-borne, Ingestion	Tick-borne hemorrhagic fever	•		•			•	Asia	No
Rift Valley fever virus	Vector-borne, Cutaneous, Inhalation	Rift Valley fever			•			•	Africa, Saudi Arabia, Yemen, possibly others	No
Vesicular stomatitis virus	Vector-borne, Cutaneous, Inhalation	Vesicular stomatitis		•		•	•		Central and South America	No
Wesselsbron virus	Vector-borne, Inhalation	Wesselsbron fever	•	•		•	•	•	Central and South America	No

47 I note that the reviewer quoted a recent paper (Villabruna et al., 2019)[21] to support an argument that animal viruses may jump species barrier and infect humans. However, the published article appears to suggest otherwise. The article started with an initial hypothesis that norovirus may not be host restricted and might be able to jump the species barrier but concluded with a presentation of results from binding assays of interactions between virus attachment factors. The figure below, which was extracted from the same article cited by the reviewer (Figure 4 in Villabruna et al. 2019) indicates that no serological binding is noticeable between cattle and human viruses considered in the study[22].

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[21] Villabruna, N., Koopmans, M., & de Graaf, M. (2019). Animals as Reservoir for Human Norovirus. *Viruses*, *11*(5), 478.

[22] Although the focus of the Villabruna et al (2019) study was on noroviruses, results from the binding assays show that serological binding is noticeable between human viruses and those from some other animals (e.g. bat and human viruses).The emergence of the SARS-CoV-2, a coronavirus thought to have originated from bats, which took the world stage in 2020, infecting millions of people globally, is thus not surprising.

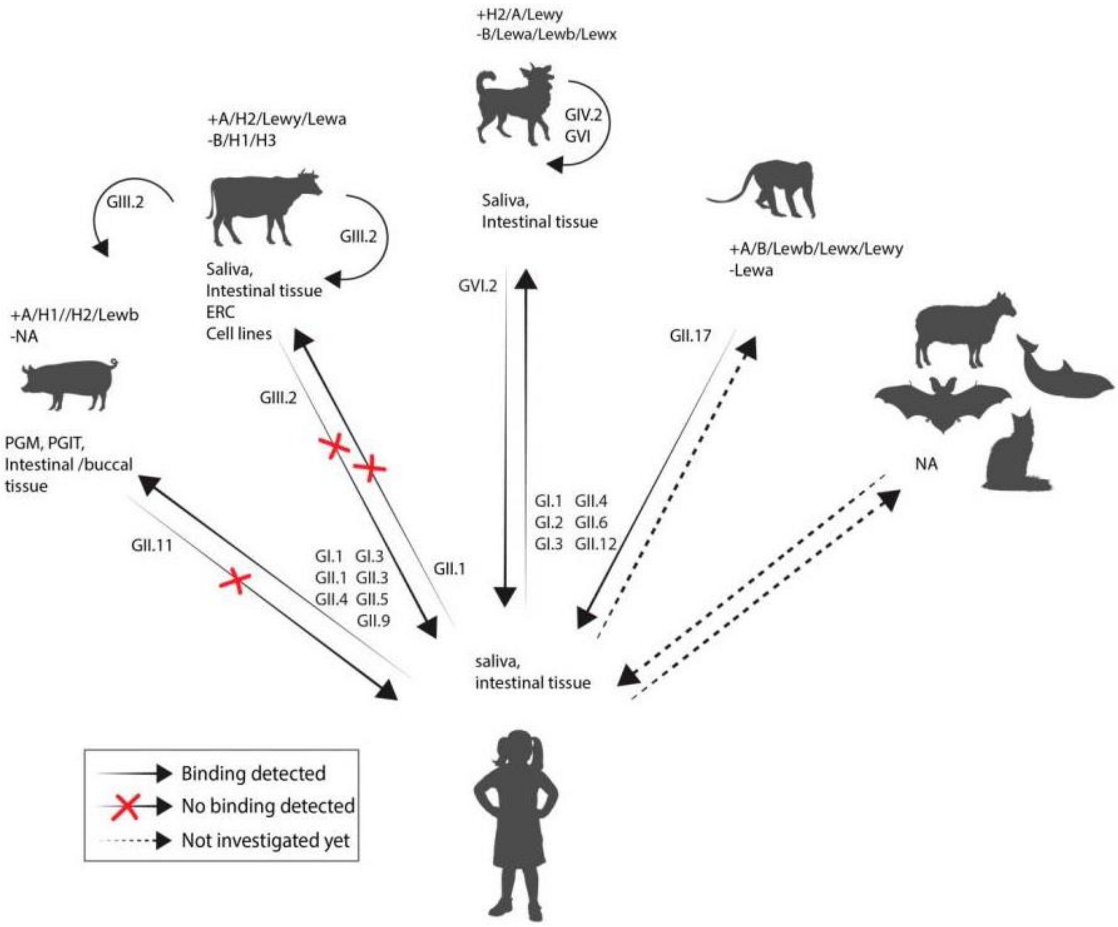

Figure 4 Summary results of binding studies with animal and human norovirus virus-like-particles (Source: Figure 4 in Villabruna et al 2019).

48 The Villabruna et al (2019) study cited by the reviewer further argued that *"…evidence for transmission of animal norovirus to humans is sparse and… if these transmissions occur, they are likely to be rare events".*

49 For the reasons stated above, in QMRAs that address health risk assessment associated with meatworks or livestock discharge, it is recommended that the focus is on bacterial and parasitic protozoan pathogens only. This approach was also replicated in the Mataura meatworks discharge QMRA report and is consistent with the USEPA model QMRA study (USEPA 2010). According to the USEPA QMRA document:

> *"…In this QMRA, we use the bacterial and parasitic protozoan reference pathogens to characterize the risk associated with animal-impacted waters -since the viruses are primarily species-specific, we do not need them to estimate the risk of human GI illness from animal-based water contamination-…"* (Source: USEPA 2020, page 17)

50 Based on the above published work and analysis, I do not recommend that virus loads be routinely monitored in the Mataura Plant discharge as the reviewer suggests in Section 35 (of the review report).

51 The reviewer argues about the need to handle conclusions from the QMRA with caution on the basis that it is somewhat novel and complex (Section 32). This is an erroneous view. It is important to note that the QMRA approach is not new and neither does it involve complex science. The *MfE/MoH* (2003) Microbiological Water Quality Guidelines for Marine and Recreational Areas specifically refer to it as a robust approach to risk assessment.

> *"Some early work leading to the setting of water quality microbiological standards and guidelines was based on a risk calculation approach. ….With the advent of powerful computer technology these issues can now be addressed relatively easily, using 'Monte Carlo' mathematical modelling. This is known as the Quantitative [Microbial] Risk Assessment (QRA) approach. Historical data is used to assign statistical distributions to the ingestion/inhalation rates, duration of exposure, and the concentration of pathogens in the water. Then a random sample is taken from each distribution to calculate the dose, which is then turned into infection or illness probabilities, or into cases, using a dose-response curve. This sampling is done many times over to simulate a large population being exposed to beach water that may, on some occasions, be contaminated." (Source: Page 114, MfE/MoH 2003)*

52 A recent study also emphasized the importance of quantitative approaches to risk assessment in relation to discharges.

> *"…Predictions from a Quantitative Microbial Risk Assessment (QMRA) offer an ideal means of analysing these risks and projecting these risks into the future. Indeed, the use of QMRA to determine risk to human health is recommended by the New Zealand recreational water quality guidelines (MfE/MoH, 2003, at page 3): When treated wastewater discharges are close by, compliance with a faecal indicator threshold "…is not a guarantee of safety" and (ibid., at page 4): "the relationship between indicator bacteria and key pathogens (such as viruses and protozoa) must be established for that treatment". These statements have resulted in the use of QMRA methods to assess the risk of infection and illness faced by individuals who may be exposed to pathogens in the receiving waters or through consumption of shellfish harvested locally, e.g., Napier (McBride 2011), Hokitika (Stott & McBride 2011), New Plymouth and Motueka (McBride 2012 & 2015)."* (Source: Page 6, McBride 2017 - Bell Island QMRA).

53 The reviewer apparently assumes that the Mataura QMRA study has suggested the absence of risks due to the discharge. This position incorrectly projects the results of the Mataura QMRA report. There is always going to be some level of risk associated with discharges to the receiving water environment. The fundamental question is whether the level of risk is above the nationally recognized or acceptable threshold (i.e. 1%). In the case of the Mataura discharge, based on the available pathogen data, the level of incremental risk associated with the discharge is below the acceptable threshold or "no observable adverse effects level".

54 Similar results were also reported in a recent ESR study (Cressey et al., 2017) which adopted a combination of faecal source tracking, genotypic analysis and QMRA to assess human health risk associated with the Alliance Plant discharge in the Mataura River, Southland. Results from the ESR-led QMRA affirmed that:

> *"Effluent discharged from the Gore WWTP and the meat processing plant contribute a relatively small proportion of the overall Campylobacter risk. This is consistent with other work that indicated that Campylobacter contamination in this region of the Mataura River was predominantly of wild fowl origin". (*Source: Cressey et al 2017)

55 However, Dr Poore raises an important point on the non-representative nature of the sampling period and the potential for increased concentrations to be recorded in spring months not covered in the Alliance Plant monitoring. As the reviewer pointed out, there are observed increased peaks in cryptosporidiosis notifications during the spring season. There are, however, uncertainties about whether these increased notifications of cryptosporidiosis in springtime are due to exposure to pathogens during swimming or a result of contact with farm animals and faecal matter. To resolve uncertainties on this issue, I recommend that the operators of the plant conduct an intensive year-round monthly monitoring of pathogens in the treated discharge. This will provide a more robust indication of the range of pathogen concentrations in the treated wastewater and a better picture of the risks associated with the discharge. If, based on the year-round pathogen concentrations, the individual illness risk profiles are greater than the acceptable "no observable adverse effects level", I recommend that the proposed upgrade be brought forward and completed within 12 months of that information becoming available.

56 I recommend the addition of an upstream site to the existing compliance monitoring program (i.e. weekly upstream and downstream *E.coli* monitoring), such that there is a basis for easy upstream-downstream comparison of *E.coli* concentrations following the proposed upgrade.

57 The reviewer’s comments on emerging organic compounds (EOCs) and microplastics in relation to the discharge is outside the scope of the Mataura River quantitative microbial risk assessment.

Conclusion

58 While the current Alliance Plant discharge increases the concentrations of *E. coli* in the Mataura River downstream of the discharge, these increases in *E. coli* concentrations are not associated with an abundance of zoonotic pathogens or individual illness risks beyond the acceptable “no observable effects” threshold of 1% (based on the limited monitoring conducted). Under the proposed treatment to significantly reduce *E.coli* during future conditions, the most probable outcome will be that the already acceptable health risk is further reduced. I support the call for the treatment system upgrades to be done as soon as practicably possible.

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