TECHNICAL MEMORANDUM

QMRA DATA EXPERTS

DATE: 1 April 2021

FROM: Christopher A. Dada, PhD
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TO: Garrett Hall, BECA
Stephen Howard, WaterCare
John Oldman, DHI

RE: Health risks assessment of Raglan WWTP treatment and discharge options

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Introduction

Waikato District Council (WDC) has an existing consent to discharge treated wastewater via a pipeline to the channel that connects Raglan Harbour to the Tasman Sea. This consent is, however, due for renewal. Watercare Services Ltd (Watercare, which has a management contract for WDC's water and wastewater services) is considering a series of options for future treatment and discharge of wastewater. Current treatment at the Raglan WWTP consists of a pond and ultraviolet (UV) disinfection system. Future options being considered include a combination of "pond + tertiary membrane + UV" or a combination of "membrane bioreactor + UV" treatment under varying discharge scenarios (i.e. tidally staged discharge from the existing discharge location or a new outfall, or continuous discharge from Wainui Stream (Table 1).

To support the "preferable treatment and discharge option" decision-making process, Watercare commissioned QMRA Data Experts (QDE) to conduct an initial Quantitative Microbiological Risk Assessment (QMRA) to address health risks related to treated wastewater discharge into the Raglan Harbour, for each of the considered discharge options and treatment scenarios.

Purpose

This memo presents an assessment of comparative illness risks associated with the options for future treatment and discharge of wastewater at Raglan WWTP (Table 1). Specifically, it presents a high-level summary of results of a QMRA that addresses enteric illness risks related to contact recreation (swimming), raw shellfish consumption, and acute febrile respiratory illness[1] risks associated with potential inhalation of diluted wastewater in the receiving environment.

[1] worsening episode of either cough or shortness of breath, presenting with fever.

Table 1 Options for future treatment and discharge of wastewater at Raglan WWTP

Option	Treatment	Discharge, Location	Flow scenarios
Existing	Pond + UV	Tidally staged, existing outfall	Existing flows only
M1	Tertiary membrane +UV	Tidally staged, new outfall	2025 and 2055 flows
M2	MBR + UV	Tidally staged, new outfall	2025 and 2055 flows
F1	MBR + UV	Continuous, Wainui Stream	2025 and 2055 flows
L1 – public and/outfall	Tertiary membrane +UV	New outfall	2025 and 2055 flows
L3 – private land/outfall	Tertiary membrane +UV	New outfall	2025 and 2055 flows
L4 – public land/outfall	MBR + UV	New outfall	2025 and 2055 flows

QMRA Methodology

Quantitative Microbial Risk Assessment (QMRA) is a framework that applies information and data incorporated into mathematical models to assess the potential public health risks from pathogens after treated wastewater is discharged into receiving water environments. Four steps were involved in this QMRA: hazard analysis and pathogen selection; exposure assessment; dose-response analysis; and risk characterization.

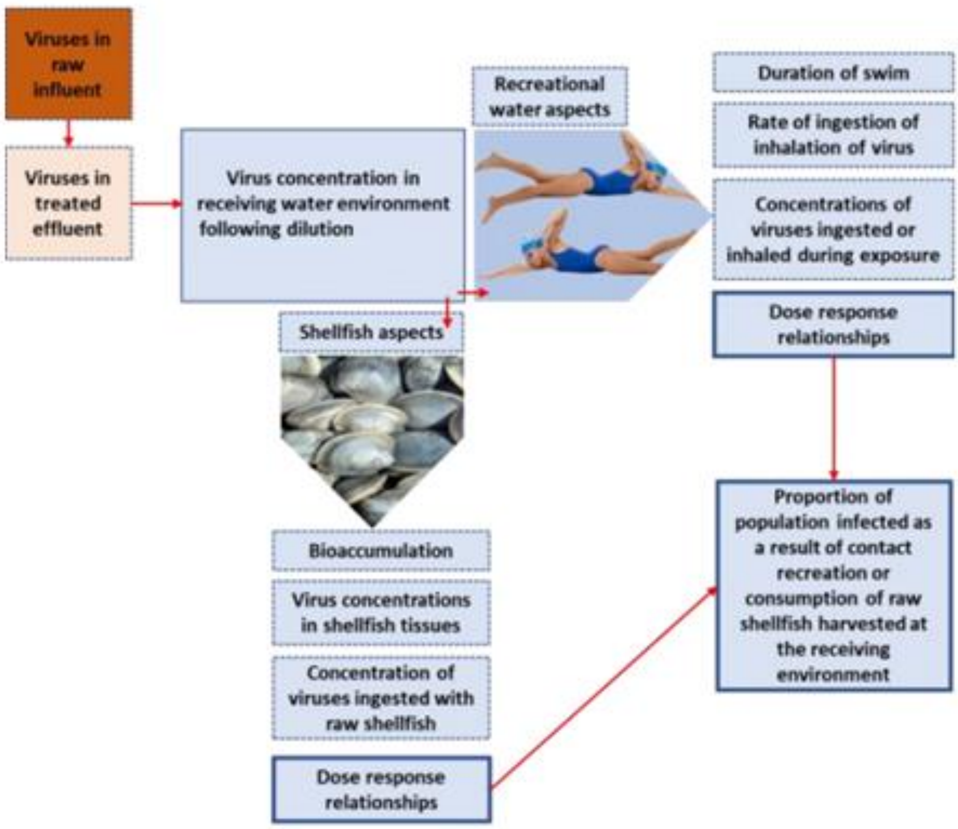


Figure 1 Stages in the QMRA.

a) Hazard analysis and pathogen selection

In this QMRA, and consistent with several previous NZ QMRAs (Dada 2018a, b ,2019a, b, c, 2020, McBride 2011, 2012, 2016a,b., Hudson 2019), norovirus and enteroviruses were used as reference QMRA pathogens for primary contact recreation. For secondary contact recreation, which includes activities such as shoreline walking, jogging, paddling, wading, boating and rowing, in which there may be some direct contact, but the chance of swallowing water is unlikely, only adenovirus (Type 4) was used as a reference pathogen for assessing risks associated with inhalation of potentially polluted water (e.g., from wind or wave-induced spray) containing aerosolised pathogens.

Typical concentrations of these viruses in untreated wastewater are presented in Appendix A and are in line with values that have been documented in several previous New Zealand QMRAs (e.g., Dada 2018a, b ,2019a, b, c, 2020, McBride 2011, 2012, 2016a,b).

Treatment options being considered to reduce risks associated with the Raglan WWTP discharge will achieve varying levels of virus log reductions. Based on a review of literature and actual data from the Te Kauwhata Aquamat plant, BECA provided QDE a summary of projected log reductions achievable at the plant, viz;

- Pond + UV treatment in the existing WWTP reduces adenovirus, enterovirus and norovirus concentrations in the wastewater by 0.3-2.8 log, 1.1-5.3 log and 1.4 - 7.2 log, respectively.
- A proposed MBR+UV future treatment option will reduce adenovirus, enterovirus and norovirus concentrations in the wastewater by 2.3 - 6.3 log, 3.0 – 9.5 log and 1.6 – 10.5 log, respectively.
- A proposed Pond + Tertiary membrane + UV treatment option will reduce adenovirus, enterovirus and norovirus concentrations in the wastewater by 0.9 – 6.1 log, 1.7 – 7.7 log and 2.0 – 9.3 log, respectively (see **Appendix A** for detailed percentile statistics of achievable log reductions).

b) Exposure Assessment

Watercare, QDE and DHI identified a total of 16 sites that may be used for recreation and 13 sites where shellfish collection may take place (Figure 1). For the various discharge options and wastewater flow scenarios, DHI carried out ocean modelling to predict how contaminants in the wastewater discharge plume would behave in the receiving water, with regards to dilution. Details of this modelling are provided in DHI (2020) and 95th percentile dilution statistics for all exposure sites are presented in **Appendix B**. The DHI model was based on a conservative tracer, i.e., it excluded solar radiation based-UV inactivation that would take place in the receiving environment. To estimate concentration of viral pathogens for each of the exposure sites, the reciprocal dilution factors[2] from the hydrodynamic modelling were multiplied by hockey-stick fitted concentrations[3] of viruses in the sewage discharging from

[2] Sampled from the entire 1-year range using a "riskcumul" function. This is a cumulative distribution which uses the parameters (minimum, maximum, range of values i.e., spread between the 10th and 99.9th percentile, and the cumulative probabilities of each value in range i.e. spread between 0.1 and 0.999). This is consistent with previous New Zealand QMRAs.

[3] Minimum, median and maximum raw wastewater virus concentrations documented for New Zealand WWTPs were bounded in such a way that the resulting virus concentrations were strongly right skewed with a hinge at the 95%ile. In line with published literature (McBride et al 2013,2016a, 2016b, Dada & Gyawali 2021), the hockey stick distribution captures "low probability events" (such as periods of infectious outbreaks in the community or WWTP system

the outfall diffuser. The RiskGeneral function was used to generate the random draws from the virus concentrations. The final virus concentrations in the water at each of the exposure sites on a random day were then subjected to varying log removals, depending on the treatment scenario considered, before they were incorporated into the QMRA (see **Appendix A** for projected log removals). This method is consistent with the methods that have been used in several previous NZ QMRAs and international literature (Dada 2018a, b ,2019a, b, c, 2020, McBride 2011, 2012, 2016a,b, Hudson 2019). To estimate doses, the final virus concentrations in the water were multiplied by the volume of water ingested at an exposure site or the quantity of shellfish ingested at a sitting. In the case of shellfish, bioaccumulation factors were applied, consistent with published literature (Campos & Lees, 2014, Dada 2018a, b ,2019a, b, c, 2020, McBride 2011, 2012, 2016a,b). Parameter estimates used in this QMRA are detailed in **Appendix C**.

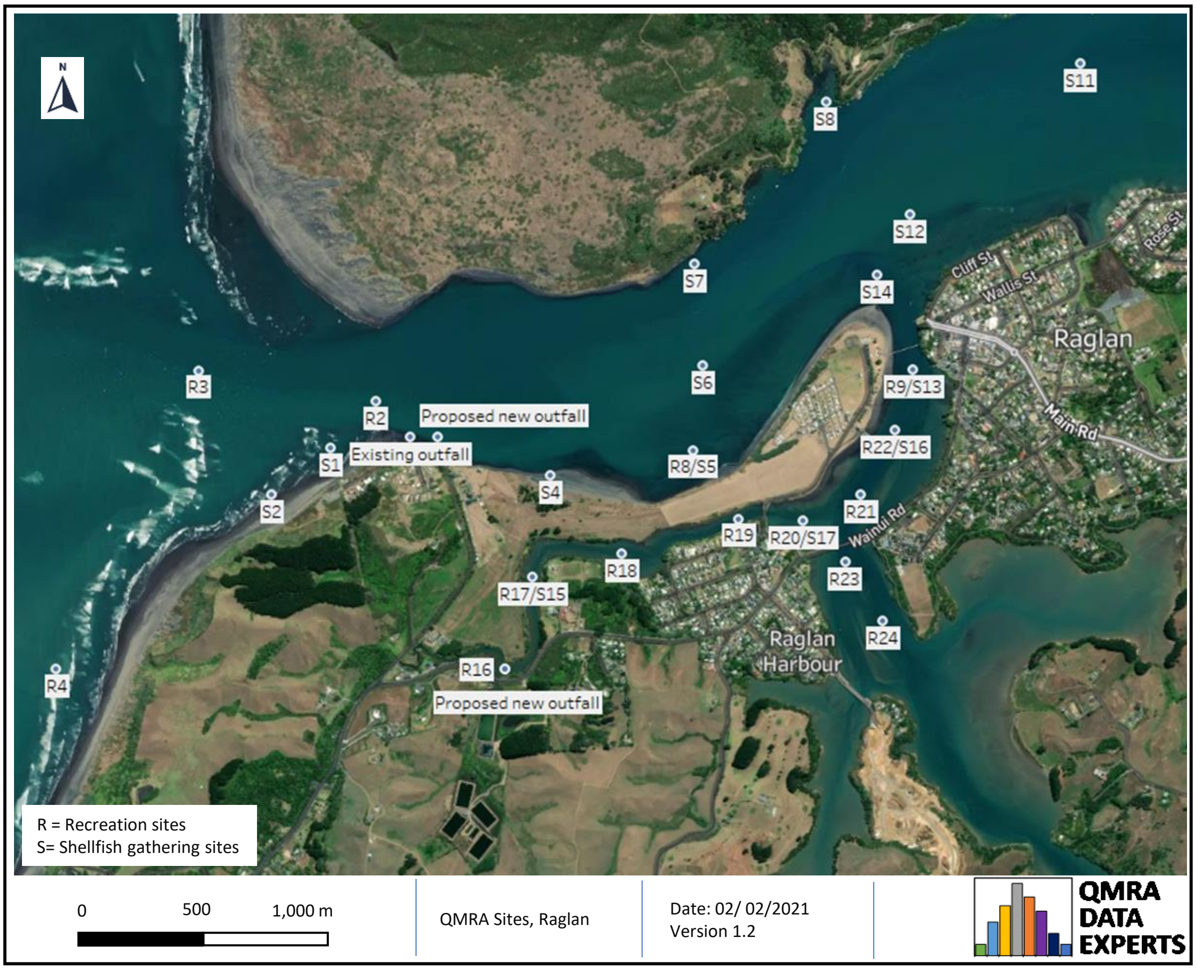


Figure 2: Selected QMRA sites.

R16 : Wainui Stream (Recreational), R17/S15 : Marae (Shellfish), R18 : Airstrip (Recreational), R19 : Airstrip Bridge (Recreational), R2 : Inshore Kite surf, R20 : Wainui/Opotoru (Recreational), R21 : Domain Boat Ramp (Recreational), R22 : Domain South (Recreation/Shellfish), R23 : Raglan Area School (Recreational), R24 : Upper Opotoru (Recreational), R3 : Entrance kite surf, R4 : Northern swimming, R6 : Bar surf, R8/S5 : Western Swimming & Shellfish (In Harbour), R9/S13 : Domain North (Recreation/Shellfish), S1 : Eastern end of tuatua, S11 : Inner Harbour (Shellfish C), S12 : Inner Harbour (Shellfish D), S14 : Inner Harbour (Shellfish), S2 : Mid point of tuatua, S4 : Western Cockle/Pipi (In Harbour), S6 : Western Shellfish (In Harbour A), S7 : Western Shellfish (In Harbour B), S8 : Mid Harbour Shellfish

malfunction) coupled with elevated virus concentrations, which may be rare but can be substantial. In this way, the QMRA aligns with the Resource Management Act which defines an "effect" to include considerations for instances of rare (i.e., low probability of occurrence) but high potential impact.

c) Dose-response analysis

Dose-response models are established mathematical functions which estimate the risk of a response (for example, infection or illness) given a known dose of a pathogen. Dose-infection curves for the viral pathogens used in this QMRA have been established in literature from clinical test results from volunteers challenged with laboratory-prepared aliquots of viral suspensions at varying serial dilutions of known mean doses of viruses (Abramowitz and Stegun, 1964; Haas et al.1999; Haas 2002; Teunis et al., 2008). Dose-response equations applied in this QMRA are presented in **Appendix C.**

d) Risk characterisation

Information from the previous steps was incorporated into Monte Carlo simulations to determine the likelihood of illness from exposure to pathogens. The Monte Carlo simulation is a randomization method that applies multiple random sampling from distributions assigned to key input variables, in a way that incorporates the uncertainty profiles of each key input variable into the uncertainty profile of the output.

Typically, in a Monte Carlo model run, 100 individuals who do not have prior knowledge of existing contamination in the water are 'exposed' to potentially infectious water on a given day and this exposure is repeated 1,000 times. Therefore, the total number of exposures is 100,000. The result of the analysis is a full range of possible risks, including average and worst-case scenarios, associated with exposure to pathogens during the identified recreational activities. Monte Carlo simulations were undertaken using @Risk software (Palisade, NY). The predicted risk is reported as the Individual Illness Risk (IIR), calculated as the total number of illness cases divided by the total number of exposures, and is expressed as a percentage. The IIR is then compared with thresholds defined in the New Zealand "*Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas*" (MfE/MoH 2003). Depending on the risk being examined, the applicable NZ thresholds differ.

In the case of enteric illness risks as a result of ingestion of polluted water, risks were classified as high (IIR >10% GI illness), moderate (IIR: 5-10%), low (IIR: 1-5%), or if <1%, below the 'no observable adverse effects level' (NOAEL). In the case of acute febrile respiratory illness risks due to inhalation of aerosolized pathogens, near or at the impacted sites, comparatively lower **thresholds** apply, i.e. high (IIR >3.9%), moderate (IIR: 1.9-3.9%); low (IIR: 0.3 - <1.9%) AFRI illness); or if <0.3%, below the 'no observable adverse effects level' (NOAEL). These thresholds are widely applied when assessing the effect of wastewater discharge on recreational human health risk (Dada 2018a; 2018b; McBride 2016a,b, 2017; Stewart et al.2017).

Results

The Individual's Illness Risk (IIR) results of the QMRA analysis for individuals exposed to a range of reference pathogens under the various proposed treatment and discharge scenarios are detailed in Appendices A to H. A high-level summary of the results is presented in Table 2.

Table 2: Summary of QMRA results

<table>
<tr><th>Treatment and discharge option</th><th>Year</th><th>Primary contact recreation e.g., swimming</th><th>Consumption of raw shellfish harvested at exposure site</th><th>Secondary contact recreation (e.g. shoreline walking, jogging, boating)</th></tr>
<tr><td rowspan="2">L1
(Tertiary membrane +UV, discharge to public land/outfall)</td><td>2025</td><td rowspan="13">16 out of 16 sites safe for swimming</td><td rowspan="11">14 out of 14 sites safe for collection of shellfish, IIR below NOAEL</td><td rowspan="6">16 out of 16 sites safe for secondary contact recreation</td></tr>
<tr><td>2052</td></tr>
<tr><td rowspan="2">L3
(Tertiary membrane +UV, discharge to private land/outfall)</td><td>2025</td></tr>
<tr><td>2052</td></tr>
<tr><td rowspan="2">L4
(MBR + UV, discharge to public land/outfall)</td><td>2025</td></tr>
<tr><td>2052</td></tr>
<tr><td>Existing
(Pond + UV, discharge to existing outfall)</td><td>2025</td><td>15 out of 16 sites safe for secondary contact recreation, low risks at outfall, see Appendix D</td></tr>
<tr><td rowspan="2">M1
(Tertiary membrane +UV, discharge to new outfall)</td><td>2025</td><td rowspan="4">16 out of 16 sites safe for secondary contact recreation</td></tr>
<tr><td>2052</td></tr>
<tr><td rowspan="2">M2
(MBR + UV discharge to new outfall)</td><td>2025</td></tr>
<tr><td>2052</td></tr>
<tr><td rowspan="2">F1
(MBR + UV discharge to Wainui Stream)</td><td>2025</td><td rowspan="2">13 out of 14 sites safe for shellfish collection. low risks at 1 site (R17/S15 near Wainui discharge), IIR > NOAEL, see Appendix D</td><td>14 out of 16 sites safe for secondary contact recreation, low risks at 2 sites (outfall at Wainui Stream and R17/S15)</td></tr>
<tr><td>2052</td><td>13 out of 16 sites safe for secondary contact recreation, low risks at 3 sites (outfall at Wainui Stream, R17/S15 and R18)</td></tr>
</table>

Illness risks associated with the proposed treatment and discharge options.

- Estimated IIR profiles generally varied with sites but were well below the NOAEL for most of the exposure sites across all tested treatment and discharge scenarios. Exceptions to this generalization were observed at the outfall or sites close to the outfall during the existing treatment scenario or during F1 scenarios (MBR + UV discharge to Wainui Stream, see Figures 3, 4, 5 and 6).
- Based on 2025 flows, five (M1, L1, L3, M2, L4) out of the proposed treatment and discharge options presented far lower individual illness risks than the existing treatment approach currently employed at Raglan WWTP. With expected higher flows in 2055, these proposed treatment and discharge options still presented lower risks than the existing treatment (see Table 2 and Figure 3). With the notable exception of F1 (MBR + UV discharge to Wainui Stream), any of the proposed upgrades are thus a major improvement upon the existing treatment system at Raglan WWTP.
- Based on QMRA results, predicted illness risks at the outfall and the other exposure sites were observed to be in this order (highest to lowest); F1 (MBR + UV discharge to Wainui Stream) > existing treatment (Pond + UV, discharge to existing outfall) >> M1 (Tertiary membrane +UV, discharge to new outfall) > L1 (Tertiary membrane +UV, discharge to public land/outfall) > L3 (Tertiary membrane +UV, discharge to private land/outfall) > M2 (MBR + UV discharge to new outfall) > L4 (MBR + UV, discharge to public land/outfall, see Figure 3).
- Based on the dilutions achieved in the receiving environment and the virus log reductions achievable at the Raglan WWTP, this QMRA results indicate that M2 (MBR + UV discharge to new outfall) and L4 (MBR + UV, discharge to public land/outfall) are the best among the seven treatment and discharge options considered to mitigate risks associated with the treated wastewater discharge. Based on 2055 flows, if either of these two treatment and discharge scenarios are implemented, it is predicted that:
    - enteric illness risks associated with swimming near the outfall or at other exposure sites would be at least 700 times below the threshold defined as the "no observable adverse effects level" (Figure 3).
    - acute febrile respiratory illness risks associated with secondary contact recreation will be at least 20 times below the NOAEL (Figure 3).
    - enteric illness risks associated with consumption of raw shellfish harvested near the outfall or at other exposure sites will be at least 70 times below the NOAEL (Figure 3).
- Careful consideration will need to be given to other aspects (including logistics, financial considerations, and socio-cultural dimensions), which are outside the scope of this study, to ultimately determine the preferred treatment option. However, regardless of the methods ultimately selected from M1, L1, L3, M2 and L4, any of the proposed upgrades will still be a major improvement upon the existing Raglan WWTP treatment.

Acknowledgment

We acknowledge the peer review provided by Dr Jim Cooke.

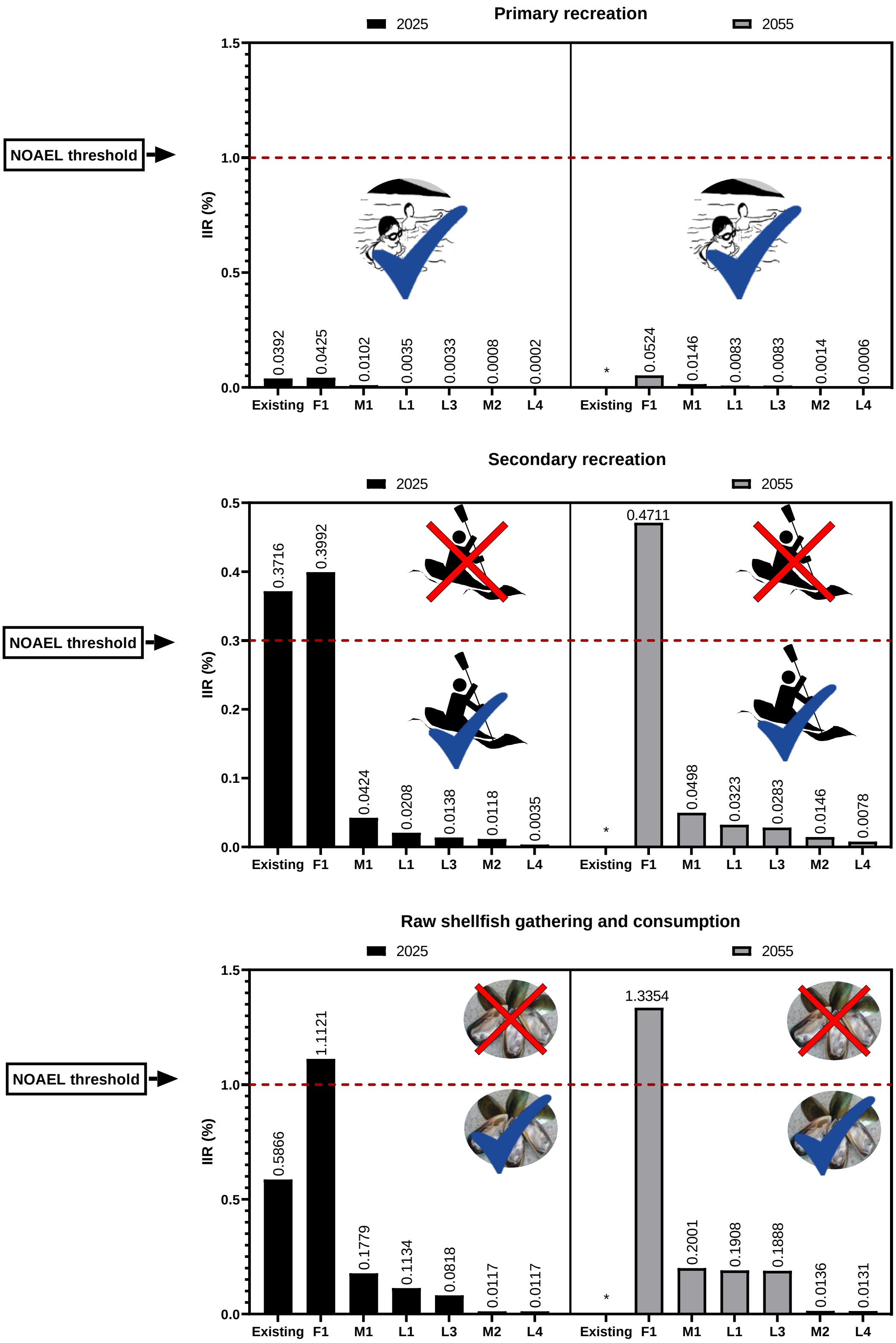


Figure 3. Comparison of risk profiles (at the outfall) to inform preferred treatment and discharge scenario. L1 (Tertiary membrane +UV, discharge to public land/outfall), L3 (Tertiary membrane +UV, discharge to private land/outfall), L4 (MBR + UV, discharge to public land/outfall), Existing (Pond + UV, discharge to existing outfall), M1 (Tertiary membrane +UV, discharge to new outfall), M2 (MBR + UV discharge to new outfall), F1 (MBR + UV discharge to Wainui Stream). * Existing 2055 flow was not modelled.

Figure 4. Spatial distribution of child gastrointestinal illness risk (based on enterovirus) associated with contact recreation at the various exposure sites. Individual illness risk profiles are presented as numbers below the sites. Sample scenarios reflected in plot: Existing (Pond + UV, discharge to existing outfall), M2 (MBR + UV discharge to new outfall), F1 (MBR + UV discharge to Wainui Stream).

Figure 5. Spatial distribution of child acute febrile respiratory illness risk (based on adenovirus) associated with non-contact recreation at the various exposure sites. Individual illness risk profiles are presented as numbers below the sites. Sample scenarios reflected in plot: Existing (Pond + UV, discharge to existing outfall), M2 (MBR + UV discharge to new outfall), F1 (MBR + UV discharge to Wainui Stream).

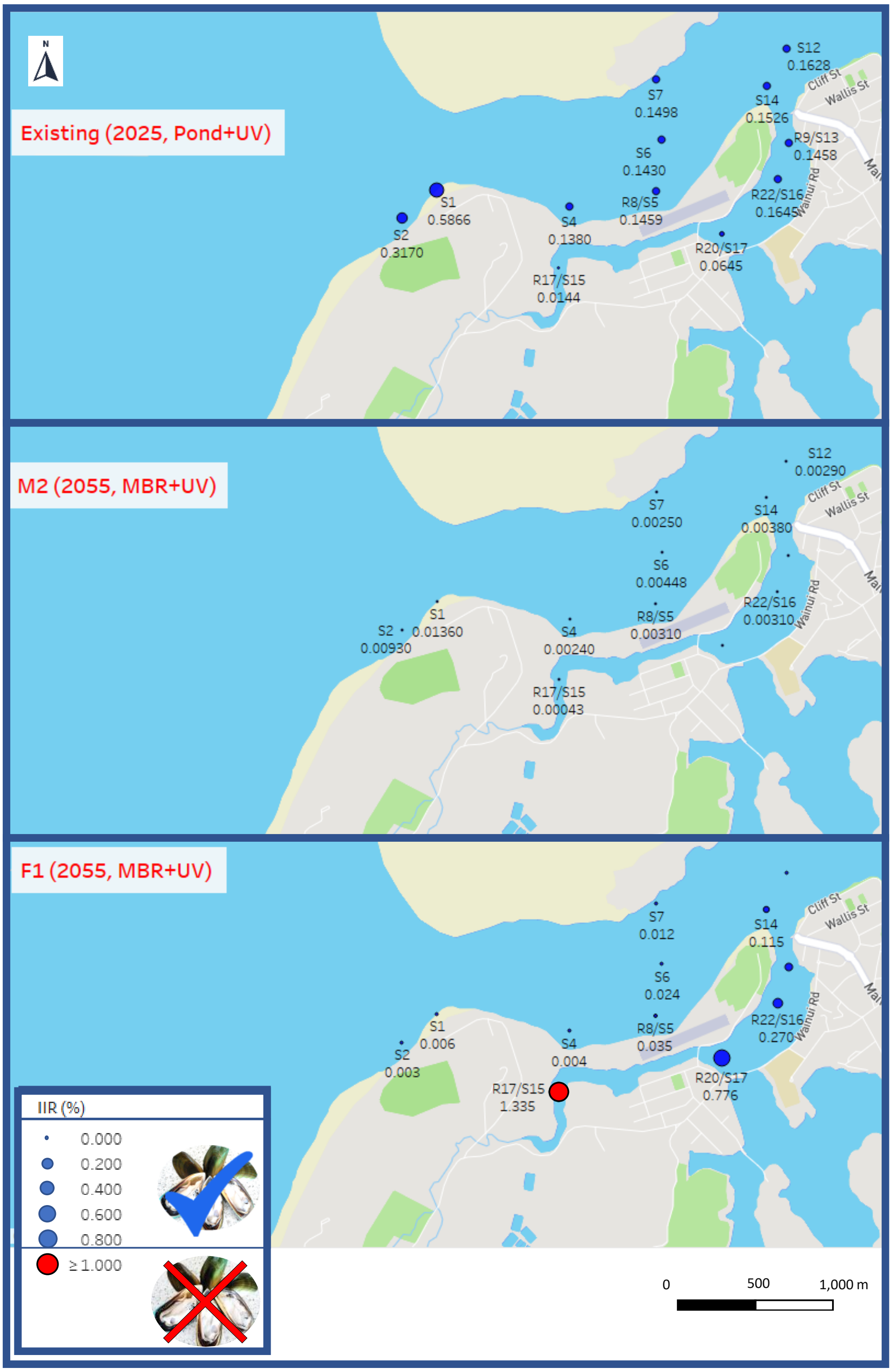
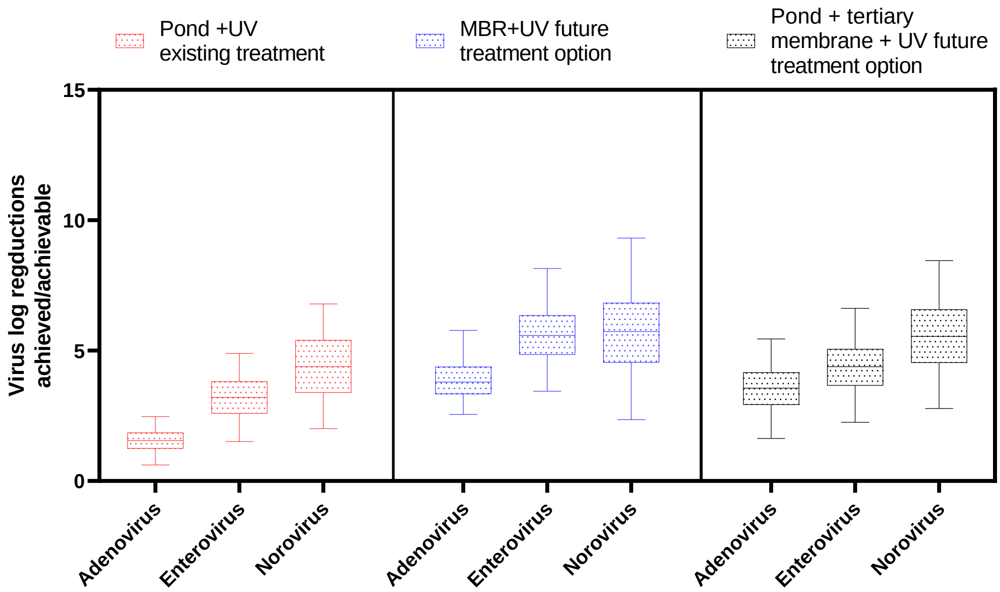


Figure 6. Spatial distribution of gastroenteric illness risk (based on enterovirus) associated with consumption of raw shellfish harvested at the various exposure sites. Individual illness risk profiles are presented as numbers below the sites. Sample scenarios reflected in plot: Existing (Pond + UV, discharge to existing outfall), M2 (MBR + UV discharge to new outfall), F1 (MBR + UV discharge to Wainui Stream).

List of Appendices

Appendix A Box plots and percentile statistics of log reductions achieved during the existing treatment and the proposed treatment options

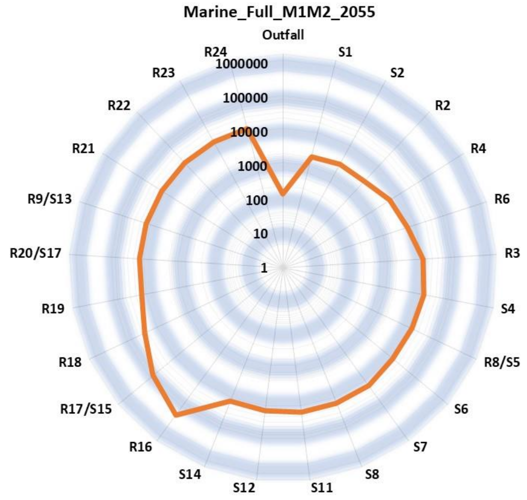
(a) Box plots

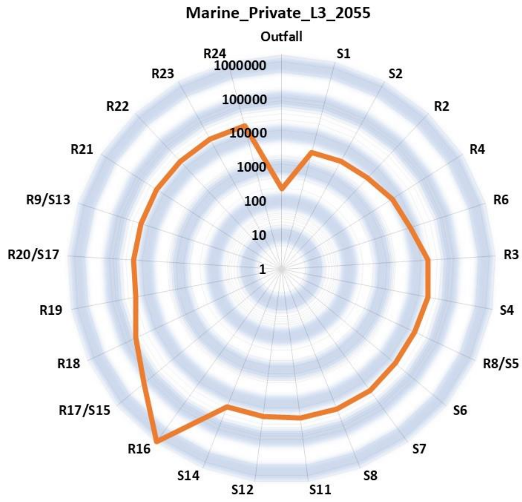


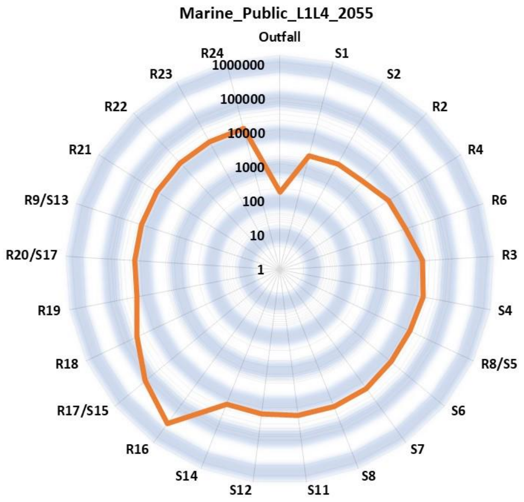
(b) Summary Statistics

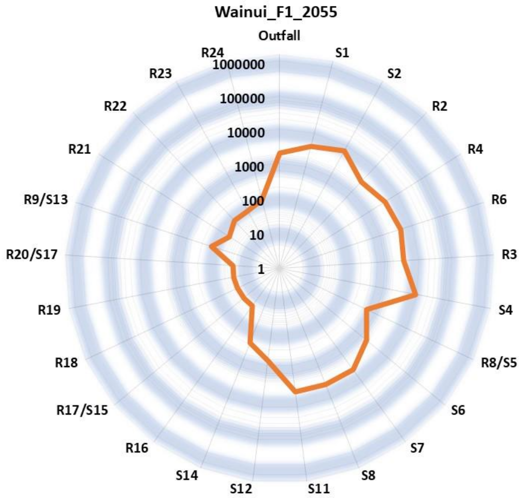
Treatment scenario	Pond +UV existing discharge scenario			MBR+UV future treatment option			Pond + tertiary membrane + UV future treatment option		
Pathogen	Adenovirus	Enterovirus	Norovirus	Adenovirus	Enterovirus	Norovirus	Adenovirus	Enterovirus	Norovirus
Minimum	0.3	1.1	1.4	2.3	3.0	1.6	0.9	1.7	2.0
Maximum	2.8	5.3	7.2	6.3	9.5	10.5	6.1	7.7	9.3
Percentiles									
1%	0.6	1.5	2.0	2.6	3.4	2.4	1.6	2.3	2.8
2.5%	0.7	1.7	2.2	2.7	3.7	2.8	1.8	2.5	3.0
5%	0.8	1.9	2.4	2.8	3.9	3.2	2.1	2.8	3.4
10%	1.0	2.1	2.7	3.0	4.2	3.7	2.4	3.1	3.8
20%	1.2	2.5	3.2	3.2	4.7	4.3	2.8	3.5	4.3
25%	1.2	2.6	3.4	3.3	4.8	4.5	2.9	3.7	4.5
50%	1.5	3.2	4.4	3.8	5.6	5.7	3.6	4.4	5.6
75%	1.9	3.8	5.4	4.4	6.4	6.8	4.2	5.1	6.6
80%	1.9	4.0	5.6	4.5	6.6	7.1	4.3	5.2	6.8
90%	2.1	4.3	6.1	4.9	7.1	7.8	4.7	5.6	7.4
95%	2.3	4.5	6.4	5.2	7.5	8.3	5.0	6.0	7.8
97.5%	2.4	4.7	6.6	5.4	7.8	8.8	5.2	6.3	8.1
99%	2.5	4.9	6.8	5.8	8.1	9.3	5.4	6.6	8.5

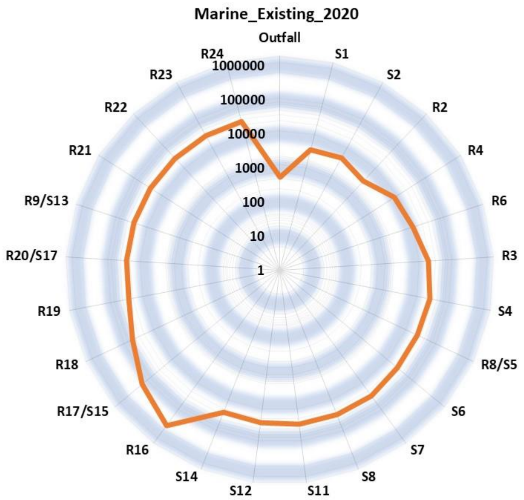
Appendix B 99.9th Percentile dilutions at exposure sites during scenarios considered.







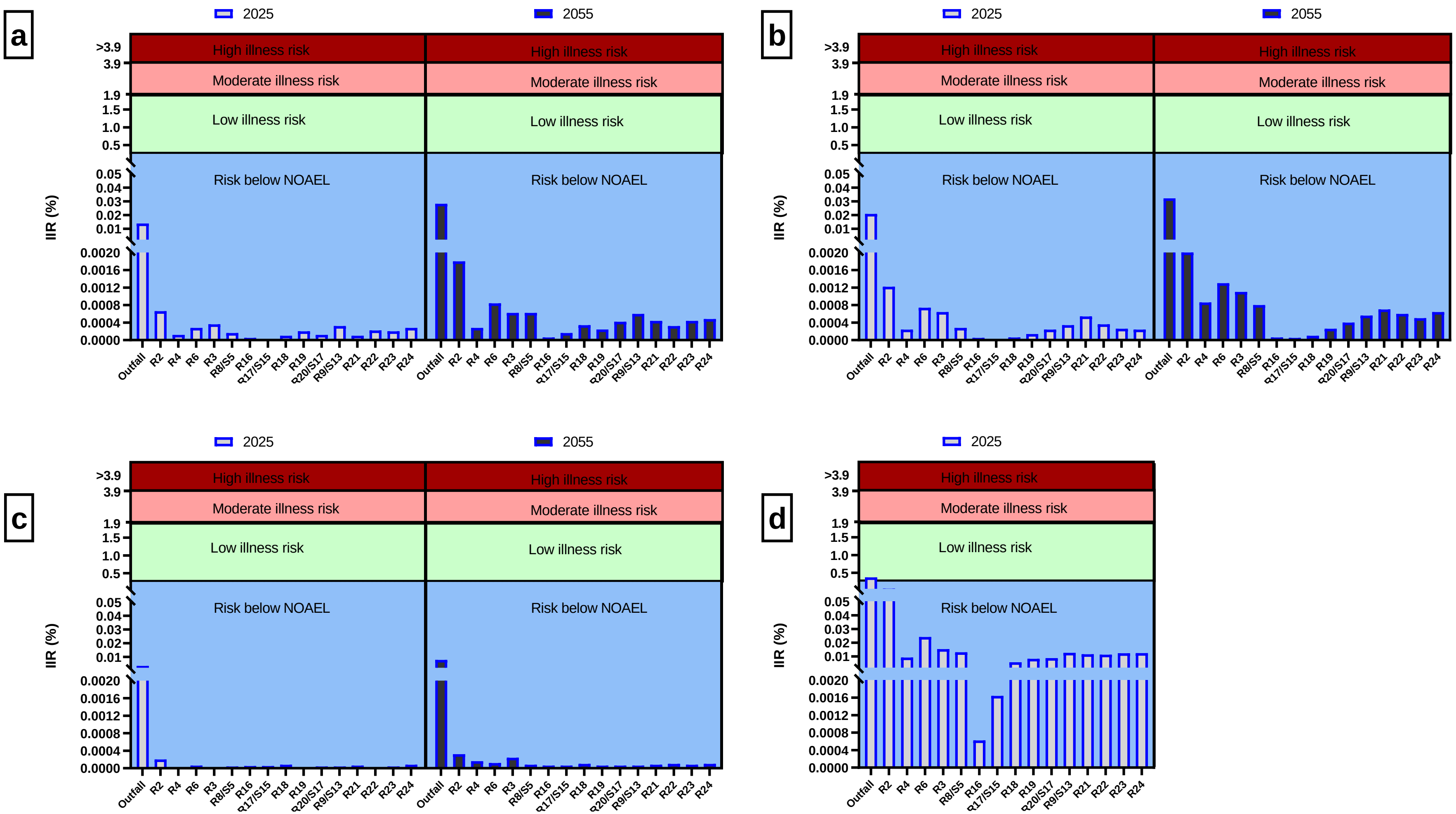




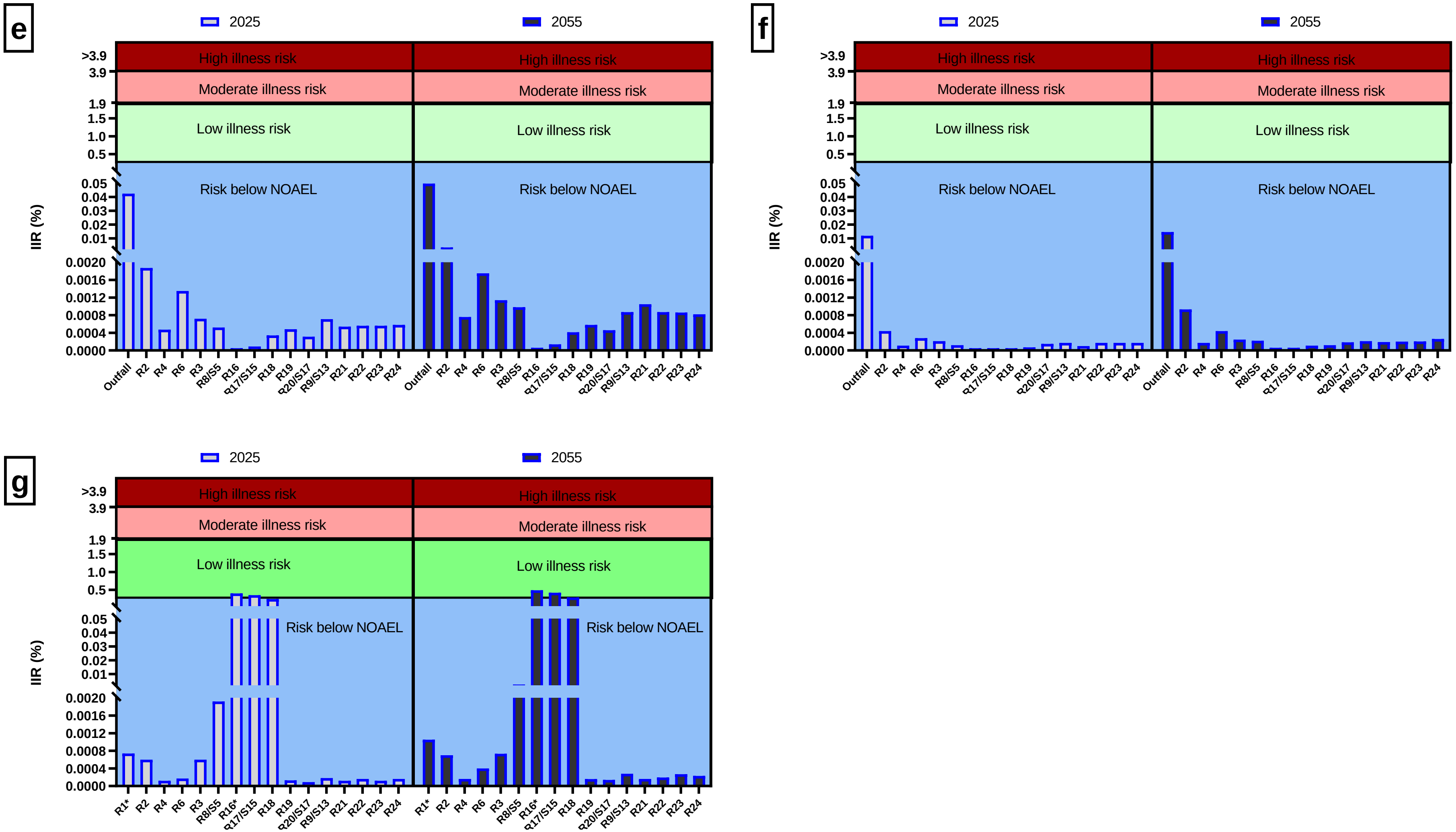
Appendix C. Distributions and inputs for the QMRA.

Parameter	QMRA Statistics applied	Comments
Influent concentration, Adenovirus (per litre)	Minimum = 2,000 Median = 5,000 Maximum = 30,000,000	Hockey stick distribution, as previously described (McBride 2007, 2011; 2012; 2016 a,b). Norovirus harmonization factor of 18.5 was included, in line with McBride 2011 and 2017)
Influent concentration, Norovirus (per litre)	Minimum = 100 Median = 10,000 Maximum = 10,000,000	
Influent concentration, Enterovirus (per litre)	Minimum = 500 Median = 4,000 Maximum = 50,000,000	
Duration of exposure to secondary contact recreation (includes activities such as shoreline walking, jogging, paddling, wading, boating and rowing, in which there may be some direct contact but the chance of swallowing water is unlikely)	Minimum = 0.1 Median = 0.25 Maximum = 2	Consistent with the child rate reported in previous QMRAs (Dada 2018a, b ,2019a, b, c, 2020, McBride 2011, 2012, 2016a,b).
Swimmers water ingestion rate, mL per hour	Minimum = 20 Median =50 Maximum = 100	PERT distribution for a child rate. Typically, adult rate is half the child rate (Dufour et al, 2006)
Water inhalation rate, mL per hour	Minimum = 10 Median =25 Maximum = 50	PERT distribution for an adult, assumed as half of child rate (McBride 2007, 2011; 2012; 2016 a,b)
Dose response parameters	Adenovirus Type 4 (simple binomial model, r = 0.4142). Only 3-10% of adenoviruses cause respiratory illnesses. Prob(illness/infection)=0.5	Dada 2018a; 2018b; McBride 2007, 2011; 2012; 2016; Stewart et al. 2017, Soller et al. 2010 a,b, Kundu et al. 2013
	Norovirus (beta-binomial model, α = 0.04, β =0.055) Prob(illness/infection)=0.6	Dada 2018a; 2018b; McBride 2007, 2011; 2012; 2016; Stewart et al.2017, Soller et al. 2010 a,b
	Enterovirus (beta-binomial model, α = 1.3, β =75) Prob(illness/infection)=1	Dada 2018a; 2018b; McBride 2007, 2011; 2012; 2016; Stewart et al. 2017, Soller et al. 2010a,b

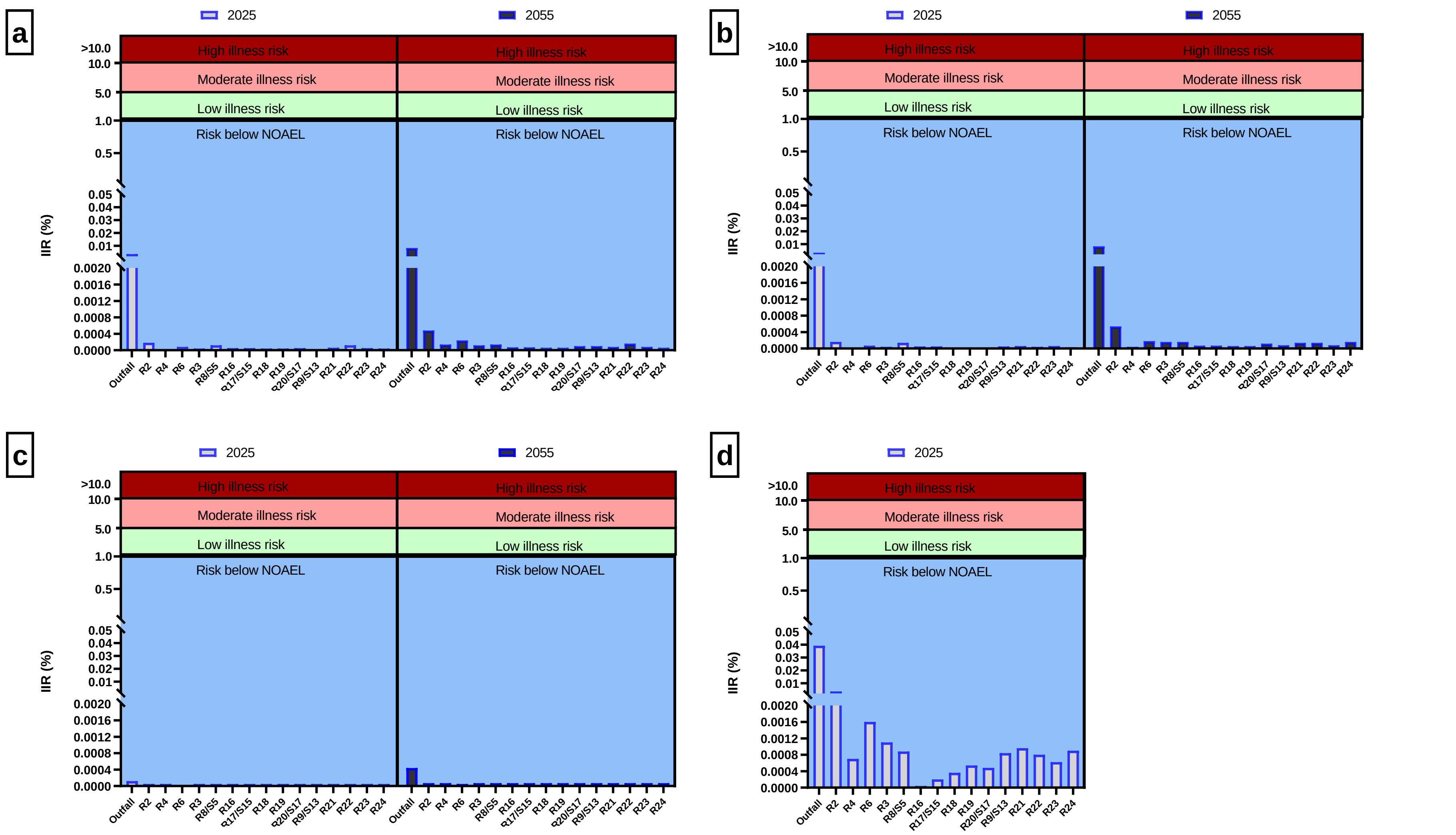
Appendix D. Child acute febrile respiratory illness risk (based on adenovirus) associated with non-contact recreation at the various exposure sites. Scenarios: (a) L1 (Tertiary membrane +UV, discharge to public land/outfall), (b) L3 (Tertiary membrane +UV, discharge to private land/outfall), (c) L4 (MBR + UV, discharge to public land/outfall), (d) existing (Pond + UV, discharge to existing outfall)



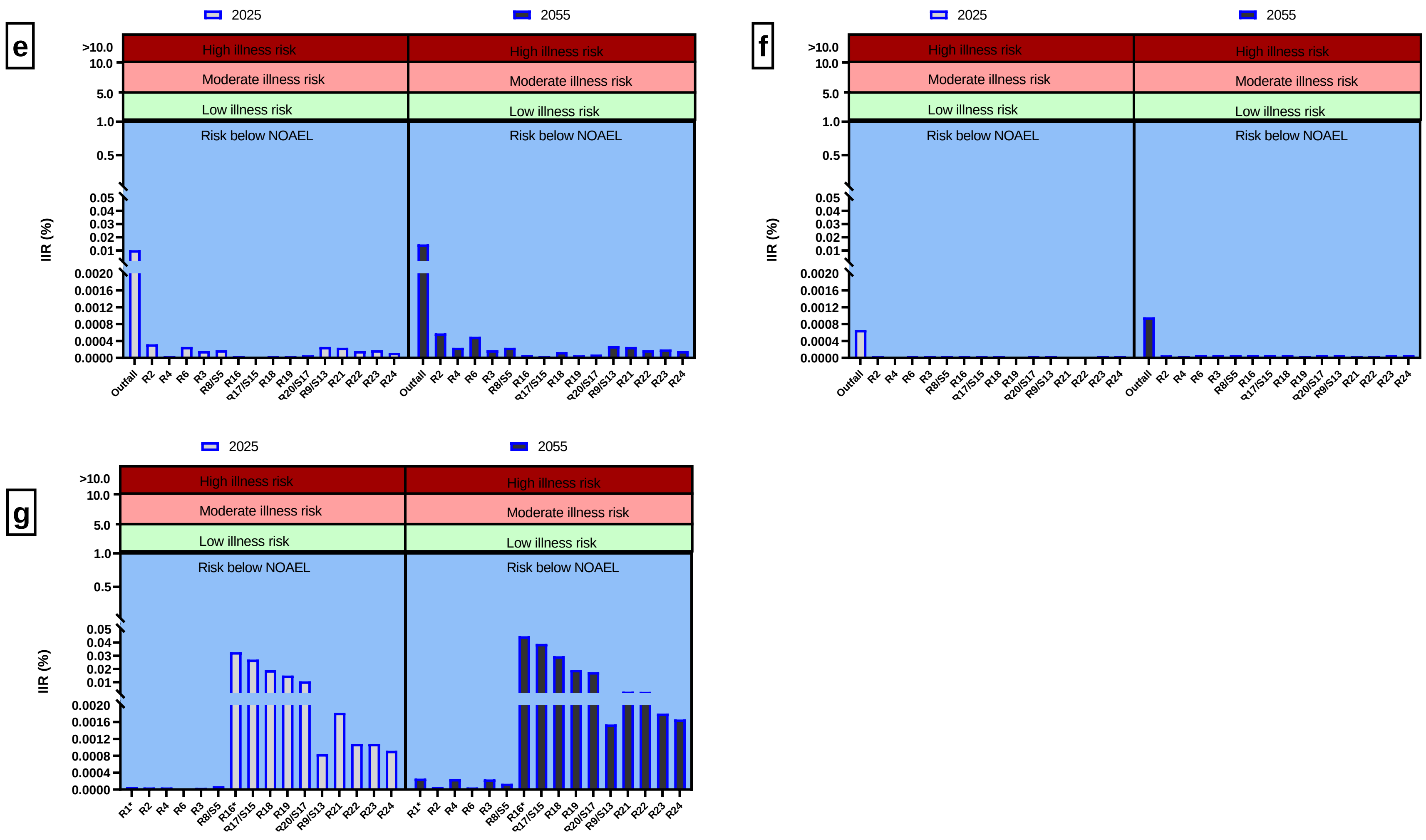
Appendix D (cont'd). Child acute febrile respiratory illness risk (based on adenovirus) associated with non-contact recreation at the various exposure sites. Scenarios: (e) M1 (Tertiary membrane +UV, discharge to new outfall) (f) M2 (MBR + UV discharge to new outfall) (g) F1 (MBR + UV discharge to Wainui Stream)



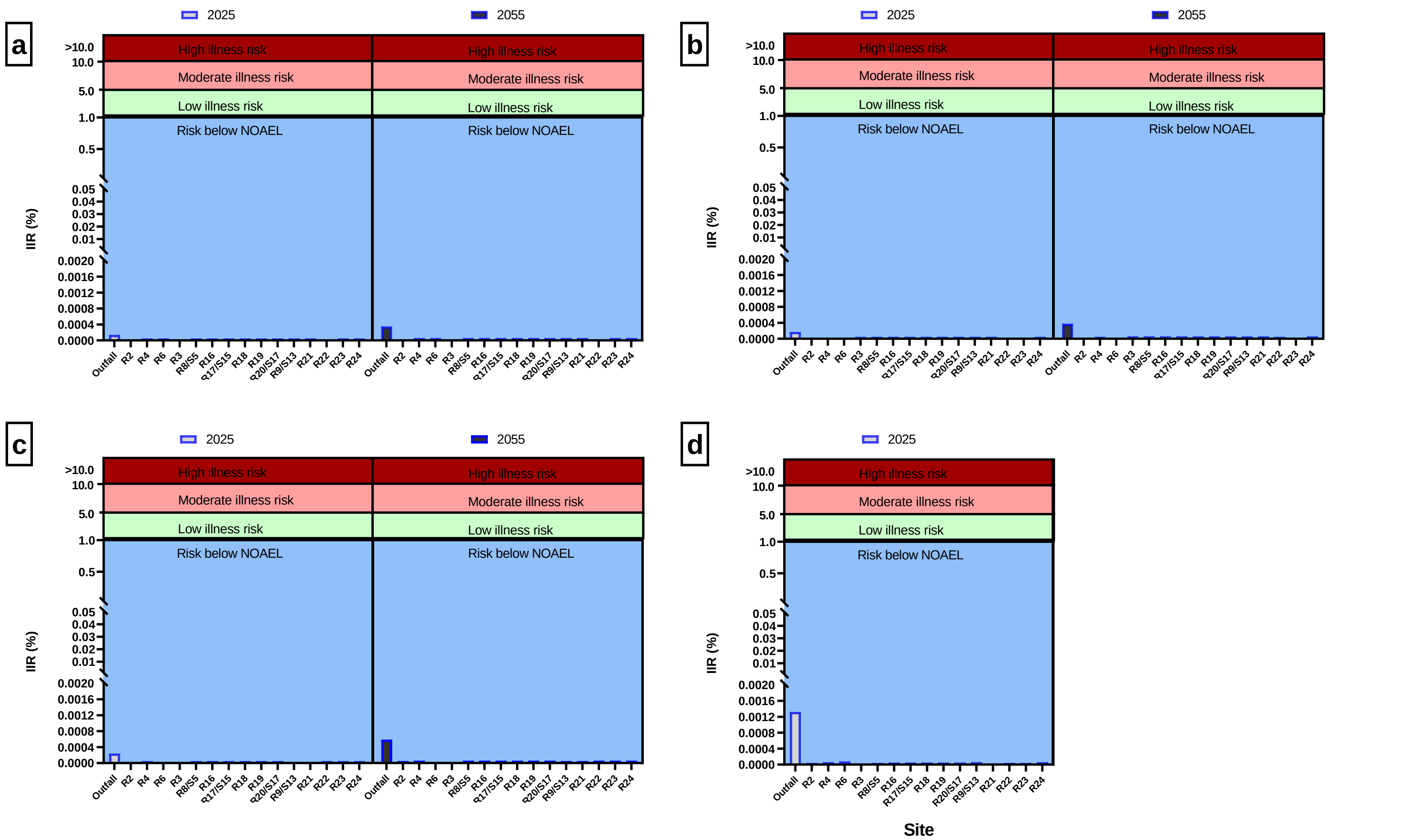
Appendix E: Child gastrointestinal illness risk (based on enterovirus) associated with contact recreation at the various exposure sites. Scenarios: (a) L1 (Tertiary membrane +UV, discharge to public land/outfall), (b) L3 (Tertiary membrane +UV, discharge to private land/outfall), (c) L4 (MBR + UV, discharge to public land/outfall), (d) existing (Pond + UV, discharge to existing outfall)



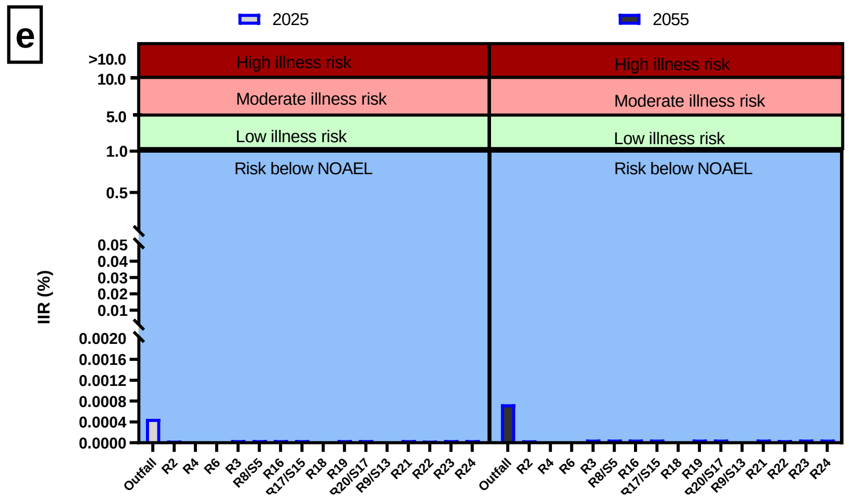
Appendix E(cont'd): Child gastrointestinal illness risk (based on enterovirus) associated with contact recreation at the various exposure sites. Scenarios: (e) M1 (Tertiary membrane +UV, discharge to new outfall) (f) M2 (MBR + UV discharge to new outfall) (g) F1 (MBR + UV discharge to Wainui Stream)

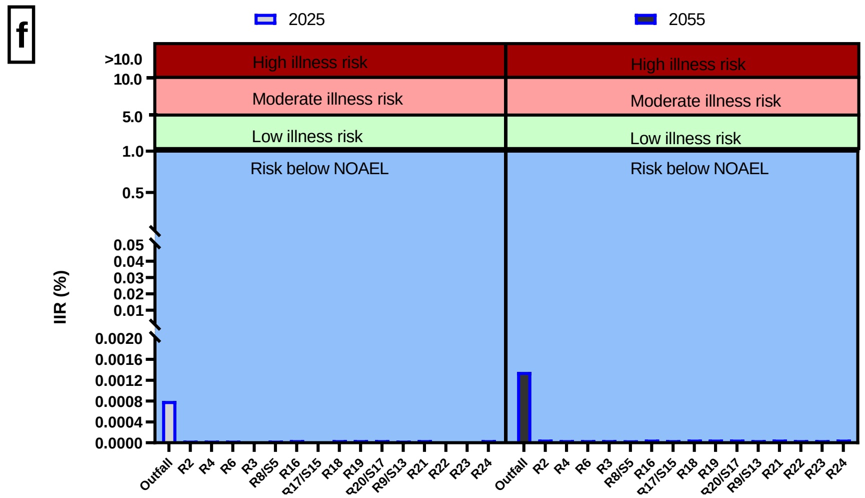


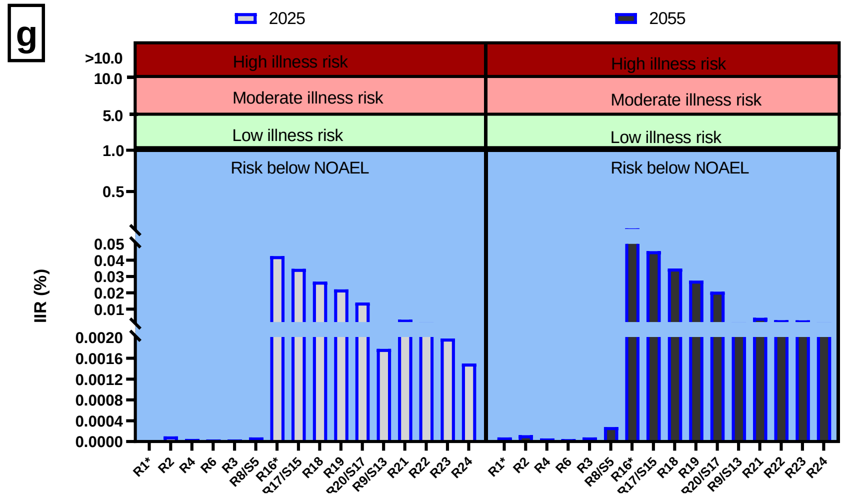
Appendix F: Child gastrointestinal illness risk (based on norovirus) associated with contact recreation at the various exposure sites. Scenarios: (a) L1 (Tertiary membrane +UV, discharge to public land/outfall), (b) L3 (Tertiary membrane +UV, discharge to private land/outfall), (c) L4 (MBR + UV, discharge to public land/outfall), (d) existing (Pond + UV, discharge to existing outfall)



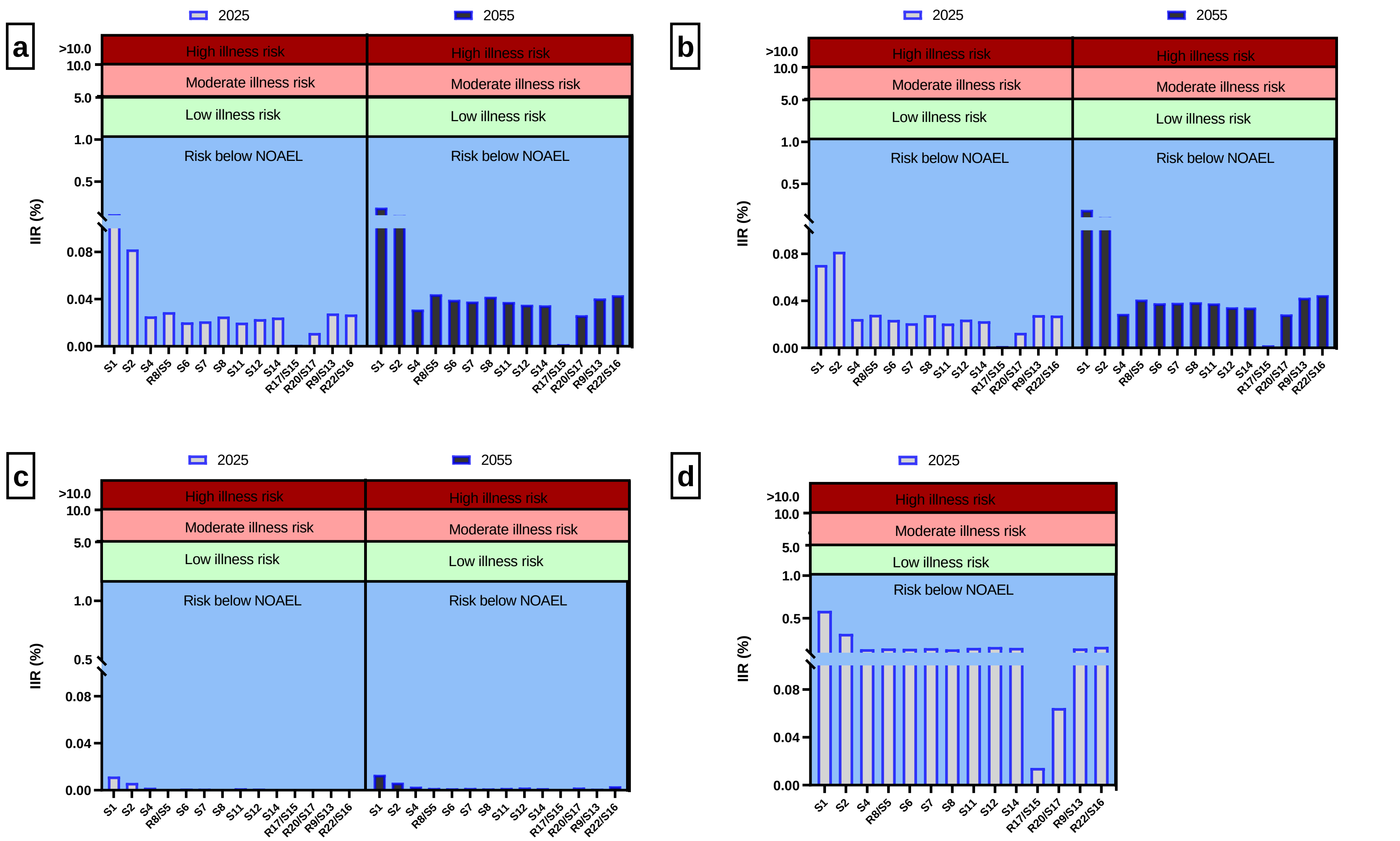
Appendix F(cont'd): Child gastrointestinal illness risk (based on norovirus) associated with contact recreation at the various exposure sites. Scenarios: (e) M1 (Tertiary membrane +UV, discharge to new outfall) (f) M2 (MBR + UV discharge to new outfall) (g) F1 (MBR + UV discharge to Wainui Stream)



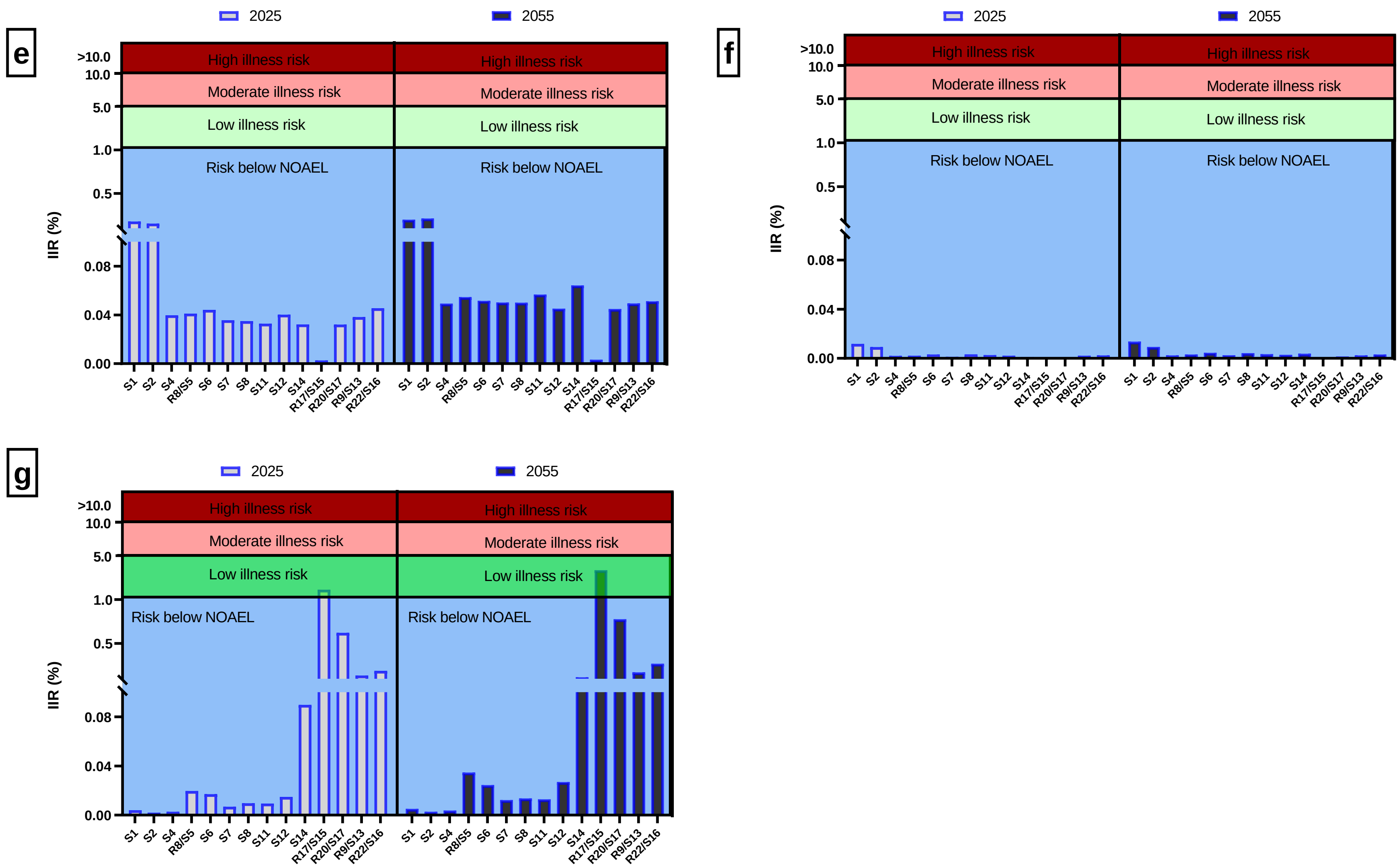




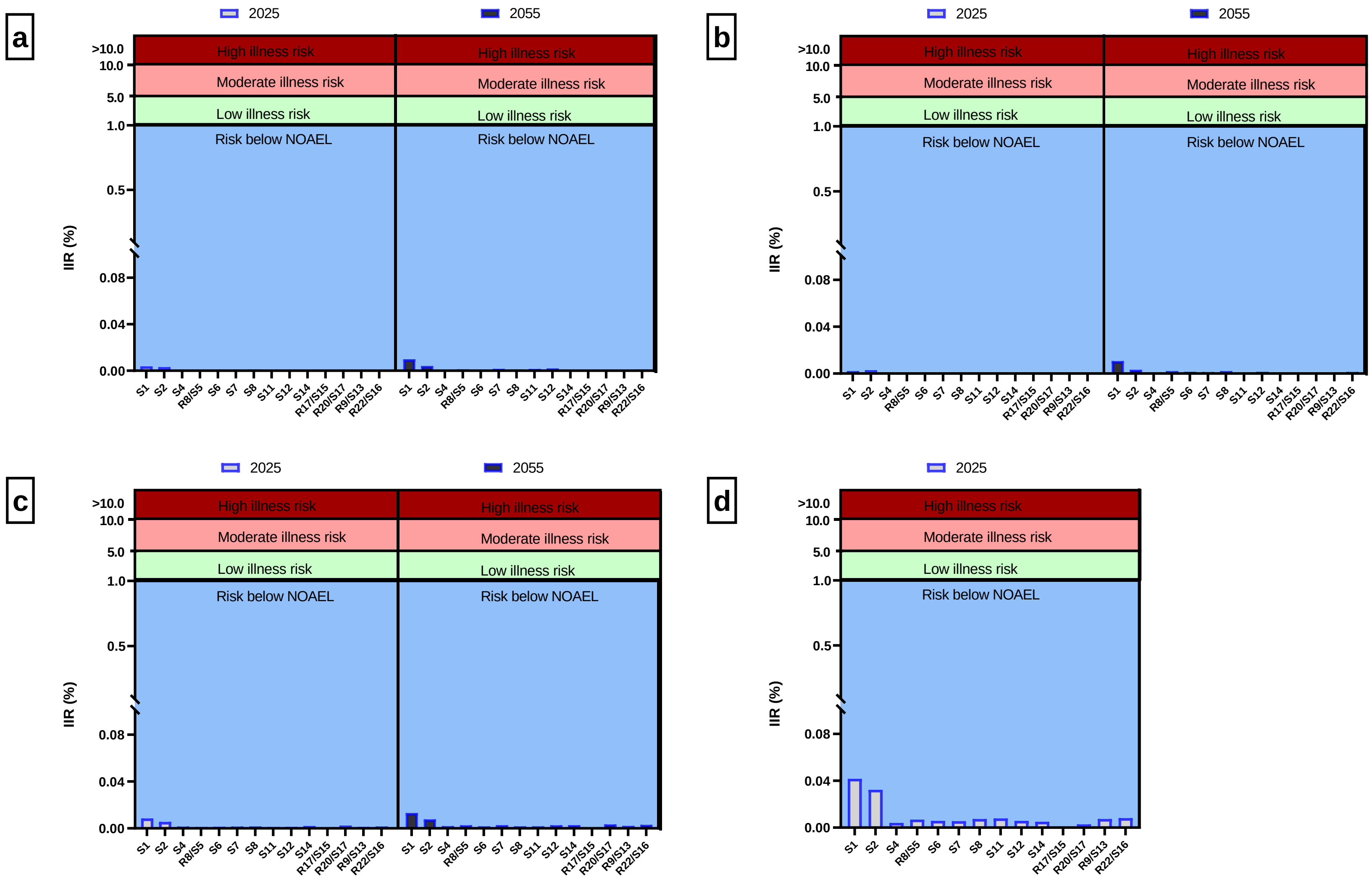
Appendix G: Gastroenteric illness risk (based on enterovirus) associated with consumption of raw shellfish harvested at the various exposure sites. Scenarios: (a) L1 (Tertiary membrane +UV, discharge to public land/outfall), (b) L3 (Tertiary membrane +UV, discharge to private land/outfall), (c) L4 (MBR + UV, discharge to public land/outfall), (d) existing (Pond + UV, discharge to existing outfall)



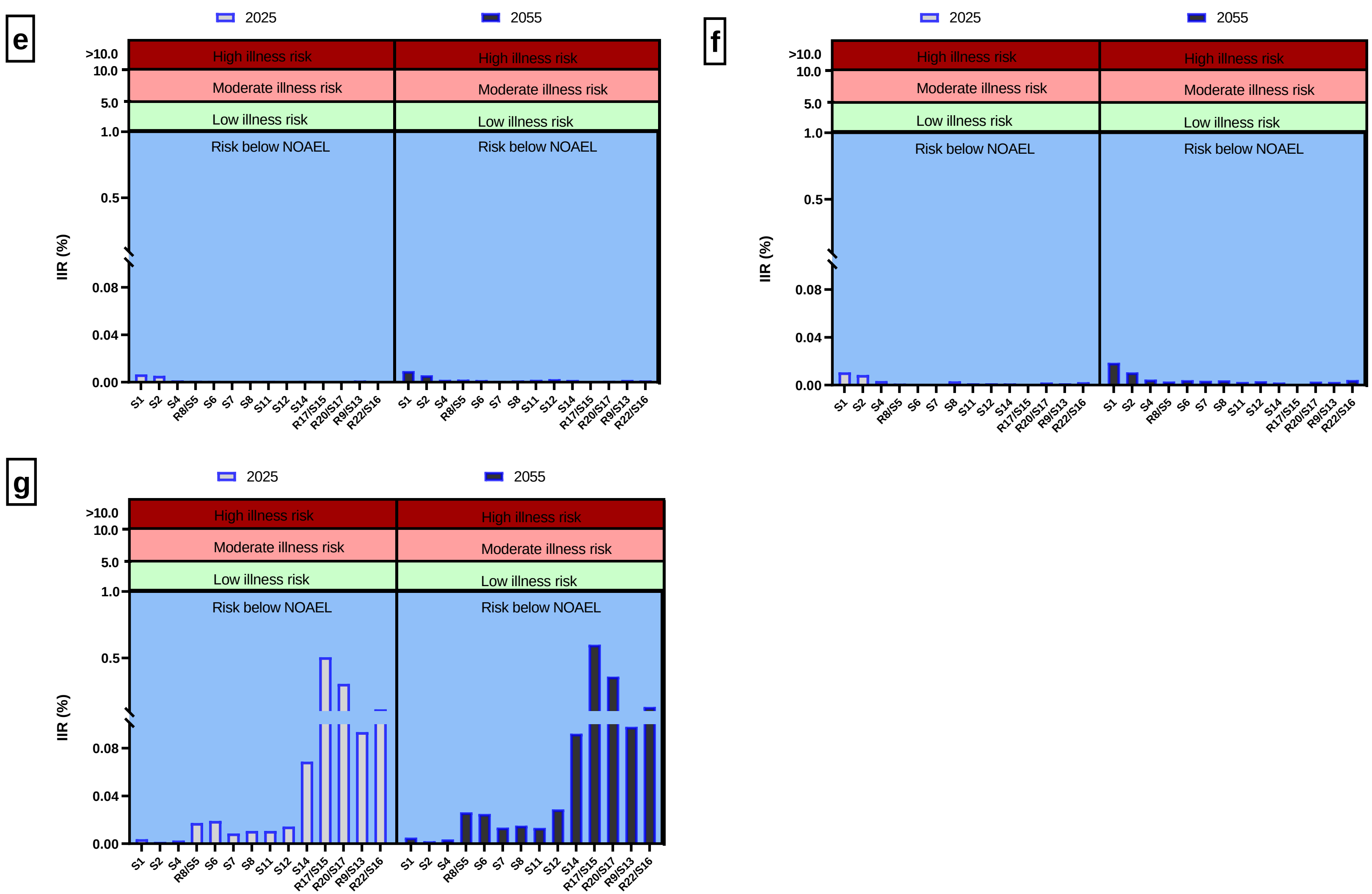
Appendix G (cont'd): Gastroenteric illness risk (based on enterovirus) associated with consumption of raw shellfish harvested at the various exposure sites. Scenarios: (e) M1 (Tertiary membrane +UV, discharge to new outfall) (f) M2 (MBR + UV discharge to new outfall) (g) F1 (MBR + UV discharge to Wainui Stream)



Appendix H: Gastroenteric illness risk (based on norovirus) associated with consumption of raw shellfish harvested at the various exposure sites. Scenarios: (a) L1 (Tertiary membrane +UV, discharge to public land/outfall), (b) L3 (Tertiary membrane +UV, discharge to private land/outfall), (c) L4 (MBR + UV, discharge to public land/outfall), (d) existing (Pond + UV, discharge to existing outfall)



Appendix H (cont'd): Gastroenteric illness risk (based on norovirus) associated with consumption of raw shellfish harvested at the various exposure sites. Scenarios: (e) M1 (Tertiary membrane +UV, discharge to new outfall) (f) M2 (MBR + UV discharge to new outfall) (g) F1 (MBR + UV discharge to Wainui Stream)



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