Appendix MC1

Figure 3: water-way loadings of E.coli and flow

Panel Questions:

Question 1: Does Figure 5 waterway loadings of E.coli (CFU x 108/ha/pasture year for major sources of faecal matter in the Waikato region, New Zealand. Source: McDowell and Wilcock 2008 p37) take into account flow?

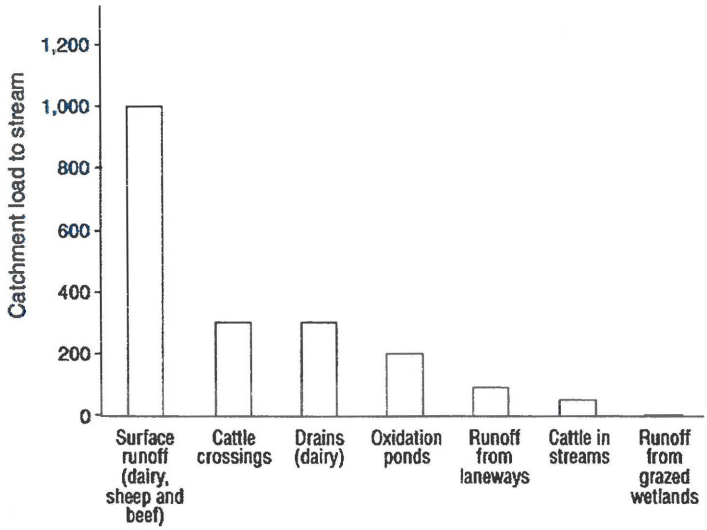

Figure 1: Waterway loadings of *E.coli* (CFU x 10^8/ha./pasture/year for major sources of faecal matter in the Waikato Region, New Zealand. Source: McDowell and Wilcock 2008[1])

Response:

After reviewing the McDowell and Wilcock (2008) (and the Environment Waikato Report -Wilcock 2006 where the authors extracted the figure), my answer to the question is yes.
The studies took flow into account and categorically applied it to estimate loads. Loads for surface flow from drains and loads due to cattle crossing were derived using annual average flows.

For the surface overland flow load estimate plotted in the figure, the authors did not explicitly mention which specific flow metric was applied e.g. annual average or high flow event.

The reports explicitly refer to 'base flow' and 'storm flow' when considering specific source contributions in relation to E.coli loadings. For instance;

- *"Faecal contamination of streams can be very high during floods owing to mobilisation of contaminated sediments and wash-in from contributing pasture areas of catchments. Concentrations of E. coli of 41,000 cfu (treated in this paper as analogous to most probable number)/100 ml were measured in a single flood*

[1] McDowell, R.W and Wilcock, R.J. (2008) Water quality and the effects of different pastoral animals. New Zealand Veterinary Journal 56(6): 289-296
https://www.researchgate.net/publication/23556427_Water_Quality_and_the_Effects_of_Different_Pastoral_Animals

event in an agricultural stream, compared with a pre-flood level of about 100 cfu/100 ml (Nagels et al. 2002). Baseflow concentrations are important when considering the health risk from pathogens to downstream water users, including bathers and other recreational users, and drinking water for livestock. Storm-flow loads are particularly important to water users well downstream, including aquaculture (e.g. Davies-Colley et al. 2007)".

Source page 290, McDowell and Wilcock (2008).

- *"A recent analysis of E. coli loadings to waterways in the Waikato region, an intensively farmed area in the North Island of New Zealand, showed that surface runoff was the major source of faecal pollution from agriculture, but that inputs from dairy herds crossing streams and from drains were almost equally important"*

  Source page 290, McDowell and Wilcock (2008).

- *"It is important to make a conceptual distinction between characteristic faecal concentrations, (e.g., as expressed by median E. coli concentrations), particularly in baseflow conditions, and faecal yield (or the load) that affects downstream water use such as shellfish aquaculture. Characteristic faecal concentrations of pastoral streams can often be 'modest' because pasture and wetland plants, and stream and drain sediments, act as a sink for faecal matter in relatively low flow conditions. However, in large flood events, concentrations and loads of faecal indicator bacteria are often very high because of washoff from land, and flushing of wetland and stream sediment stores. Hence the yield is heavily weighted towards flood events. Moreover, control of faecal yields in order to protect downstream waters by reducing yields may emphasise a different set of BMPs than control of stream faecal characteristic concentrations".*

  Source: Page 2, **Environment Waikato Technical Report (Wilcock 2006[2]).**

Other studies have also cited markedly different E.coli concentrations during conditions of base and storm flow in determining the relative risk profile of E.coli loads in relation to receiving environments and pathogenic risk. For instance;

- *"Rainstorms can flush large amounts of faecal pollution from land sources into water bodies, threatening, particularly, contact recreation and bivalve shellfish harvest"* **(Source: Page 1519, David Colley et al 2008[3]).**
- *"Loads of E. coli in storm events increased with water yield .The sum of export in the storm events amounted to 95% of the total annual E. coli export from the Toenepi Catchment"* **(Source: Page 1522, David Colley et al 2008).**

[2] Wilcok B. (2006) Assessing the Relative Importance of Faecal Pollution Sources in Rural Catchments. Environment Waikato Technical Report 2006/41 (NIWA Client Report: HAM2006-104.https://www.waikatoregion.govt.nz/assets/PageFiles/5375/tr06-41.pdf

[3] Davies-Colley, R. Lydiard, E and Nagels, J (2008) Stormflow-dominated loads of faecal pollution from an intensively dairy-farmed catchment

Question 2: Are low flow conditions considered in relation to the relative risk of different flow pathways on pathogenic risk for primary contact recreation?

Yes, all flow conditions are considered

The NPS FM E.coli attribute states are to be applied across all flow metrics (across the flow distribution), rather than just at specific flows such as baseflow. Attribute state must be determined by satisfying all numeric attribute states (footnote 2, page 40, NPS-FM 2017). According to the NPS FM (2017), "the predicted average infection risk is the overall average infection to swimmers based on a random exposure on a random day, ignoring any possibility of not swimming during high flows or when a surveillance advisory is in place (page 40, NPS-FM 2017)". The policy document further posited that "E.coli attribute state should be determined by using samples ...collected on a regular basis regardless of weather and flow conditions (page 40, NPS-FM 2017)". The NPS-FM policy document however acknowledges that actual risk will generally be less if a person does not swim during high flows.

While the NPS FM attribute states are to be applied regardless of flow ie across the flow distribution curve, flow metrics such as medium or high flow are an inherent part of the NPS FM, as is demonstrated by the combination of the four statistics, which include median, and 95th percentile attribute states. Given that samples can be collected anytime (regardless of the flow and weather conditions), the NPS-FM median E.coli concentrations would generally align with the conditions of the river at or below baseline flow (i.e. 50% of the time), while the 95th percentile concentrations would tend to be associated with conditions during high flow events.