Before Independent Hearings Commissioners
At Wellington

Under	the Resource Management Act 1991
In the matter of	Applications for resource consents, and a Notice of Requirement for a Designation, by Wellington Water Limited ('**WWL**') on behalf of Upper Hutt City Council, for the construction, operation and maintenance of the structural flood mitigation works identified as the Pinehaven Stream Improvements Project

Joint Witness Statement – Hydrology and Flood Modelling

Dated 30 July 2020

Experts participating:

1 Peter Kinley engaged by the Applicant, Wellington Water Ltd (WWL)

2 Michael Law (Beca Ltd) engaged by Greater Wellington Regional Council (GWRC)

3 Robert Hall engaged by Save Our Hills (SOH)

4 Graeme Horrell engaged by Save Our Hills (SOH)

No facilitator was present

1 Introduction

1.1 All experts confirm that they have read and are familiar with Code of Conduct for Expert Witnesses in the current Environment Court Practice Note (2014) and agree to comply with it.

1.2 The experts meeting was conducted 2pm to 4pm on Tuesday, 28 July 2020. Mr Law, Mr Hall and Mr Horrell met at Beca's Christchurch office, while Mr Kinley joined the meeting online. Subsequent discussions to refine and agree the contents of this documents have been made online.

1.3 The primary purpose of expert conferencing is to assist the Commissioners and to reduce hearing time.

1.4 The experts discussions were informed by the following information, much of which is in the document library on the application website[1]. Note that not all of the experts had sighted all of the documents listed. The experts relied on the documents in coming to their opinion, though noting that :

a Evidence of Mr Hall, Mr Kinley, and Mr Law

b Supporting information provided by Mr Hall

c MIKE Flood model files (sighted by Mr Kinley and Mr Law only)

d Flood Hazard Assessment (FHA) prepared by Jacobs, dated 15 June 2020

[1] https://haveyoursay.gw.govt.nz/Pinehaven-Streamworks/widgets/268043/documents

e Correspondence between Applicant, GWRC and experts relating to flood modelling and the FHA, as listed under 'Formal Correspondence with applicant' on the application website. Not sighted by Mr Horrell.

f Submissions on the application, as provided on the application website. Not sighted by Mr Horrell.

g Technical Review of the flood modelling by Michael Law (Beca Ltd). Not sighted by Mr Horrell.

h Report to the Hearing Committee 'S42a report' of Josephine Burrows (GWRC)

Information predating the application

i Reference Guide for Design Storm Hydrology (WWL 2019), referred to as the WWL Hydrology Guidelines

j GWRC Flood Management Plan 2016

k MfE Climate Change Projections for New Zealand 2018

2 Issues which the witnesses discussed

2.1 The issues discussed by the witnesses were focused around the hydrology rather than the hydraulic model, but included the following:

a Opportunity and value of expert conferencing, including the Process timeline. The meeting had been arranged at a few hours' notice, with Mr Hall's evidence and supporting information only made available to Mr Law and Mr Kinley on the morning of the meeting. This limited the experts' ability to be fully conversant with the information prior to the meeting. Given the two hours available for the meeting, the focus was on a limited number of hydrological factors.

b The history of flow and water level recording in the Pinehaven catchment.

Five years of flow data (2008-2013) is available for the Pinehaven Stream, and this includes one large flood event; 23 July 2009. Flow gaugings were not carried out at the peak of the flood event of 23 July 2009, and so the stage-discharge rating for the water level recorder site was extrapolated at that time to account for the range of recorded water levels observed during that period, but without flow gauging results to validate the calculated flows at high water levels.

The staff gauge remains at the former recorder site, and so local residents have referred to this in observing the 8 December 2019 storm event and flood.

Rainfall data is available for the Tasman Vaccine site on the hills above Pinehaven, and for Wyndum Park (Pinehaven Reservoir) in the catchment. The Tasman Vaccine site has a longer record of data, including the 23 July 2009 storm.

Mr Law noted that the peak two-hour rainfall during the 23 July 20019 event was 32 mm according to information on the GWRC website, whereas Mr Hall had reported the depth to be 66.5 mm in his draft document titled ***Pinehaven Stream Flood 8 December 2019 at Chatsworth Road Gauge Site and Its Implications for Flood Frequency Estimates in The Catchment***. After the meeting, Mr Horrell confirmed that he two-hour rainfall depth was 31.5 mm. This has implications for the rainfall return period (ARI) assigned to the event. Based on 66.5 mm of rain, Mr Hall had assigned a return period of 50-80 years, whereas Mr Law has assigned return period of 2-5 years based on 32 mm of rain.

Subsequent to the meeting, Mr Horrell noted the rainfall at the Wallaceville raingauge (the only other raingauge available for MWH modelling of the 23 July 2009 flood event) had a two-hour rainfall total of 28.2 mm, approximating to a 3 year ARI, and that that the Pinehaven raingauge was not operating at this time.

Mr Horrell describes the 23 July 2009 event as a large flood (20-30 year ARI), and so the to calibrate the model, the modeller needed to minimise initial (5 mm) and continuing losses(2mm) to generate the flood, when knowing this was a mainly forested catchment where losses would be large. Mr Horrell noted that this is evidence that modelling one single flood can produce erroneous results and is therefore not fit for purpose. He believes that had the 8 December 2019 flood (slightly smaller flood peak than the 2009 event) been used in calibration then results would be more reliable for design purposes. Mr Horrell believes multiple floods should have been used in the calibration, with additional floods for verification.

In response to Mr Horrell's comments, Mr Law notes that MWH did not consider the 23 July 2009 event to be a large flood. They calibrated their rainfall-runoff model against this event assuming that the peak flow was 8.8 m^3/s and the ARI was less than 5 years (See sections 6.2 and 8 of MWHS 2009 supplement to their 2008 hydrology report).

This is where Mr Hall and Mr Horrell disagree with the MWH flood frequency analysis.

c Model hydrology

i Whether hydrological regime changes as a result of potential future development was relevant to this Application and Hearing. The experts discussed whether this had been dealt with as part of UHCC Plan Change 42 and agreed that it was not directly relevant to this application, though Mr Hall and Mr Horrell are of the opinion that there were errors in the post-development hydrology discussed in 2015-2016. Mr Kinley and Mr Law expect that post-development hydrology would be re-calculated using current practice if there is an application for development, and would be robustly reviewed at that time.

ii The experts agreed the importance, and implications, of appropriate hydrological inputs being applied to the hydraulic modelling. They discussed the longevity of the hydrological inputs being used, and the need to update the hydrology in line with current practice. The experts disagreed about whether the hydrology should be updated prior to this application being decided, and this is summarised in paragraph 3.2a.

iii Mr Hall and Mr Horrell believe that the flows used in the model are too high and so the proposed stream works are over-designed, meaning that the community will pay for works that are not required for the design level of service for flood impunity. Therefore, they believe the hydrology should be re-calculated, the flood model recalibrated and re-run, and the stream works design amended accordingly. Only then will the Council and community be able to make an informed decision on the Application.

Mr Kinley believes that the hydrology is fit for the purpose of demonstrating the beneficial effects of the project on flooding and demonstrates that the proposed works will provide betterment for the community.

Mr Law acknowledges that the hydrology should be updated, but believes that the history of flooding in the middle and lower reaches of the catchment indicate that the hydrology is fit for use (his previous reviews of the flood modelling confirmed his view that the design 100-year ARI model results were comparable to the observed flood extents for the 1976 flood) and that the stream works were beneficial.

iv Catchment runoff response and rainfall losses. MWH's use of Initial and Constant Losses in their 2008 hydrological modelling was discussed. While an accepted method, Mr Hall and Mr Horrell considered the 5 mm Initial Loss and 2 mm/h Ongoing Losses to be low, especially compared to the results of infiltration tests in the Pinehaven catchment (reported in Mr Ross's evidence). Mr Law asked whether the reported infiltration rates of 600 mm/h would generate any runoff.

Mr Hall and Mr Horrell have not seen Mr Ross's evidence.

Mr Hall commented on the high infiltration of the catchment, noting that the infiltration tests were carried out under his instruction for the purpose of determining the soil type for the SCS Curve Numbers rather than relying on published maps. Mr Law commented that the WWL Hydrology Guidelines recommended a SCS Curve Number (CN) of 63 be used for modelling the Pinehaven catchment. Mr Hall responded that he had looked at upper and lower band estimates in the A-B soil types for forested catchments. Mr Law believes that the CN of 63 is in line with hydrologic soil group B. Using a CN based on soil group A would increase rainfall losses and thereby reduce flows.

v Flood frequency curve used for the modelling, and Mr Hall's recent work proposing a revised flood frequency curve. Mr Hall explained how he had derived at an updated flood frequency curve for the Pinehaven catchment using a range of methods that are explained briefly in his supporting information, and include downscaling from the larger adjacent Mangaroa catchment. Mr Law and Mr Kinley noted that they had only received the information a few hours prior and had not had time to review it properly. The updated flood frequency curve shows flows approximately 6 m^3/s lower than the MWH 'lumped catchment' flows for all ARIs. Mr Hall's flows do not include climate change.

Mr Law noted that the flows (without an allowance for climate change) extracted from NIWA's online flood frequency tool were higher than Mr Hall's estimate but lower than MWH's.

Mr Law noted that the flows in the hydraulic model at Sunbrae Drive (just upstream of the old recorder site) were 3-4 m^3/s (30-40%) higher than Mr Halls flows for the 25-year and 100-year ARI design events, and included an allowance for climate change.

However, these may not be directly comparable given that the modelled flows are input as individual sub-catchment inputs from the hydrological model that are then routed through the hydraulic model, as opposed to the lumped catchment approach of Mr Hall's updated flood frequency curve.

vi Magnitude of observed flood events of 23 July 2009 and 8 December 2019. As noted in 2.1b, there is some uncertainty about the return periods of the 2009 and 2019 flood events. Though the rainfall data suggests 2-5 years ARI for 2009 and about 30 years ARI for 2019. The experts discussed whether these rainfall events generated flows of the same ARIs. Mr Hall assumed that they did, but Mr Law noted that neither event was preceded by antecedent rainfall, and so rainfall losses would have been higher than for a design 'nested storm' rainfall event with similar two-hour rainfall bursts.

Subsequent to the meeting, Mr Hall noted that there had been significant rainfall in the three weeks leading up to the weeks leading up to the 23 July 2009 event, but Mr Law noted that it is rainfall in the hours immediately prior to the peak rainfall that sets the antecedent moisture conditions in most rainfall-runoff modelling methods used for design event hydrology.

Mr Hall and Mr Horrell disagree with this last statement by Mr Law, they say that it is their experience that it is imperative that any modelling exercise takes proper account of the condition of the catchment prior to the onset of a rainstorm if realistic runoff and peak flows are to be obtained from a model. It is Mr Horrell's experience that the most reliable way to do this is to ensure that the stream flow occurring immediately prior to any event that is to be modelled is the best indicator of the catchment hydrological condition and needs to be accounted for. They note that the whole purpose of the calibration and verification exercises are there to demonstrate the extent to which reliance can be had in the model's outputs.

2.2 During the meeting, we did not discuss the hydraulic flood model and its representation of the proposed stream works at any length because Mr Hall and Mr Horrell advised that their concerns related to the hydrological modelling, only noting that catchment was difficult to model (especially in the upper reaches) due to numerous obstructions in the channel and across the valley bottom.

2.3 Mr Horrell recommends that multiple floods are calibrated in the rainfall runoff model with additional floods for testing/verifying the model, before being input into the hydraulic model. Mr Law concurs that this is good practice, though notes that it is often difficult to achieve due to the absence of recorded water level and flow data, especially in small urban catchments, such as Pinehaven.

2.4 Mr Horrell notes that evidence of the risk with using just one flood is shown in the SKM report where the Pinehaven recorder site where the water level was recorded for the 23 July 2009 event, as the hydraulic model produces flood depth in the channel 25% in error from what was actually measured. Mr Law and Mr Kinley have not had the opportunity to verify that statement.

2.5 Mr Law and Mr Kinley had discussed the flood modelling during their meeting of 21 July 2020, reported in their Joint Witness Statement of 23 July 2020.

3 Summary of areas of agreement and disagreement

3.1 Issues which the witnesses do agree upon

a Expert conferencing is a valuable part of the Hearing process and it would have been beneficial for it to have occurred much earlier in the process. It is imperative that all parties recognise this and facilitate expert conferencing as early in the process as possible. The proximity of this expert conferencing session to the Hearing dates (and the very limited time between receipt of information and the expert conferencing) has limited the value of the expert conferencing.

b The hydrological model is a key input to the hydraulic flood model, and so should be appropriate. The experts agree that, at some point in time the hydrological modelling for the Pinehaven catchment should be updated in line with current practice, but disagree whether or not that is required before this Application is decided (see paragraph 3.2a below). Mr Law is of the opinion that the hydrological modelling should be updated in line with Wellington Water's *Reference Guide for Design Storm Hydrology* (WWL 2019). Mr Hall and Mr Horrell favour a catchment-specific (based on recorded and validated Pinehaven flows), rather than a regional-based approach. As noted below, the experts disagree as to when that hydrology should be updated.

c All experts agree that the issues relating to the hydrological modelling may have been resolved more easily if a better hydrological record was available. Ten to twelve years of flow record would have provided the hydrological baseline to develop a more robust flood frequency curve for Pinehaven Stream, and could have resolved issues where the experts still disagree.

d Increased runoff from potential new development in the catchment is not of relevance to this application, as this will be managed through the hydraulic neutrality provisions of UHCC Plan Change 42. This require that post-development peak flows do not exceed existing peak flows. Mr Hall commented that that changes in sediment load, baseflow and debris potential as a result of development would have to be managed in the catchment.

3.2 **Issues which the witnesses do not agree upon**

a The experts disagree on whether the hydrology is fit for use for this application. The key issue is the flood frequency curve. Mr Hall and Mr Horrell believe that the flood frequency curve derived by MWH in 2009 over-estimates flows, and Mr Hall has developed an updated flood frequency curve.

Mr Law and Mr Kinley have not had time to review fully Mr Hall's work. While they acknowledge that there may be some value in Mr Hall's approach, they consider the current hydrology is fit for use.

b Mr Hall and Mr Horrell disagree with Mr Law regarding the size of the 23 July 2009 flood peak used to calibrate the rainfall/runoff model which inputs into the hydraulic model. Mr Hall and Mr Horrell asses the flow peak to be 12 m^3/s, in contrast Mr Law noted that MWH had assigned a flow of 8.8 m^3/s to that event. This is a significant difference and these stream upgrades are designed from this single event.

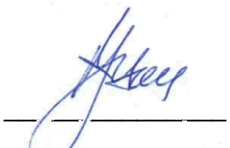
c Delay the consenting process

i Mr Hall and Mr Horrell recommend that the Hearing and Application should be put on hold until the hydrology issue has been resolved, the model re-run and the design of the proposed stream works revised in response to updated model results. That way, Council can make an informed decision on expenditure.

ii Mr Kinley and Mr Law believe that the hydrology used in the model is fit for use for this application, and so the Hearing should not be delayed.

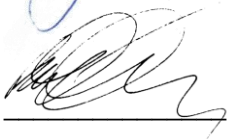
Date: 30 July 2020

Signed



Robert Hall

Graeme Horrell



Peter Kinley

Michael Law