BEFORE THE PALMERSTON NORTH CITY COUNCIL
HEARING COMMISSIONERS

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	proposed Private Plan Change for Whiskey Creek Residential Area to the Palmerston North District Plan

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STATEMENT OF EVIDENCE OF TIMOTHY PRESTON FOR THE PALMERSTON NORTH CITY COUNCIL S42A REPORT (STORMWATER)

Dated 11th May 2022

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1. INTRODUCTION

Qualification and Role

1.1. My full name is Timothy James Preston. I am a Civil Engineer. I have been requested by the Palmerston North City Council (**Council**) to provide expert assessment for the Council's section 42A report on Proposed Private Plan Change: Whiskey Creek residential area.

1.2. I hold a Bachelor of Engineering (Civil), First Class Honours, 1990. I am a member of Engineering New Zealand. I have been involved in numerous stormwater Engineering assessments to address strategic service level objectives and support growth development. I lead GHD nationally in stormwater modelling and locally lead a team of four stormwater modellers in our Christchurch office. This team led development of Christchurch's Citywide stormwater modelling after the 2014 floods and we continue to operate and maintain the Avon and Sumner models for Council. As part of this Avon model work, I have frequently explored site-specific model results in order to rationalise or find fault with model results. This has been motivated by model calibration work (comparing the model results to real world flooding observations) and model functional checks (comparing the model to preconceived engineering expectations of infrastructure performance) and results quality assurance inspections, in particular relating to areas where the computational processes are unstable and failing to produce rational results.

1.3. Whilst this is not an Environment Court hearing, I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014. I have complied with it in preparing this evidence and I agree to comply with it in presenting evidence at this hearing. The evidence I give is within my area of expertise except where I state that my evidence is given in reliance on another person's evidence. I have considered all material facts that are known to me that might alter or detract from the opinions that I express in this evidence.

2. SCOPE OF EVIDENCE

2.1. This evidence is on the stormwater quantity (flood risk) aspects associated with the proposed private plan change.

2.2. I have read and used the following stormwater related information that has been as supplied by the applicant in preparing this evidence:

a. DHI 2019 "Flygers Line Hydraulic Modelling Memo"

b. Mitch Hydro 2021 "Stormwater Management Plan for Flygers Investment Group Limited"

2.3. In preparation of this evidence I have also reviewed the following.

a. DHI 2007 report "Mangaone Stream and Taonui Basin, Floodplain Hazard Assessment, Hydraulic Modelling and Mapping"

b. DHI 2017 report "Taonui Basin Model Runs, Renewed application of 2006 MIKE FLOOD model"

c. Horizons 200 year flood depth results data "200yr_d_update20210302.tif" as supplied 29/3/2022

d. Veni Demado (PNCC) email to Kevin Judd 12/11/2019 with comments on the DHI Flood Modelling report

e. Digital information on the DHI modelling extents, map of inflows and inflow timeseries data received in email from Phil Wallace (DHI) to me on 20/4/2022 and 26/4/2022.

2.4. I understand that Horizons have agreed with the applicant that an increase in flood levels of not more than 50mm in the presently rural areas, and in particular areas southwest from the plan change request and outside of the Palmerston North City Boundary is considered less than minor.[1]

2.5. I note that PNCC commented, via email[2], positively about the mitigation option recommended in the DHI 2019 report, but cautioned that Council would "not allow any increase in discharge to the downstream network at Benmore Avenue" and that they would rely on "...Horizons to ensure the stopbank upgrade works along Benmore Ave will ensure the proposed

[1] John Bell, per teleconf 1pm 23/3/2022 with John Bell, Sara Carswell, Cliff Thomas, Veni Demado, Marz Asgar, Reiko Baugham, Tim Preston

[2] Veni Demado, Activity Manager Stormwater, sent to Kevin Judd (Resonant) on 12/11/2019

increase in flood levels (+50mm) under this development is acceptable and has no adverse impact to the residential line along Benmore Ave".

3. SUMMARY OF EVIDENCE

3.1. I consider that the key stormwater question related to the request is whether urban development similar to what is outlined in the request can be achieved while avoiding more than minor increases in the regional flood risks elsewhere.

3.2. I note significant limitations and weaknesses in the applicant's evidence (DHI 2019) assessing that the increase in regional flood risks from the proposed development concept is less than minor.

3.3. In my opinion, based on the applicants evidence and my experience, residential subdivision at the proposed location is more likely than not practicable albeit that may require significant optioneering changes to the proposed concept and should require significantly improved modelling, and reporting of the modelling to support peer review.

3.4. In my opinion, the Mitch Hydro 2021 evidence is sound with the exception of having used nested storm methodology. A revised assessment consistent with recommendations of Grove et al 2020 is likely to result in larger storage volume and more sophisticated outlet design.

3.5. Accordingly, I have no objections on the basis of stormwater quantity, to the requested plan change.

4. EVIDENCE EVALUATION

Geographic references

4.1. In various reports and even within the same report, key geographic features are referred to with different names. For clarity, I use the following consistent names and have listed commonly used alternative names in brackets.

a. Flygers Line Spillway (Mangaone Spillway)

b. Benmore Ave Stopbanks (Whiskey Creek stopbanks, Flygers Line stopbank)

Key planning requirements

4.2. Horizons One Plan

4.2.1. Horizons One Plan, Part-1 Regional Policy Statement, Chapter-9, Section 9-4 Policies, Policy 9-2, is relevant to this application. It defines two classes of location, either within or outside of floodways, in clauses 9-2a and 9-2b. In this case the Taonui Basin floodway is relevant Figure J-2.

4.2.2. Policy 9-5 is also relevant in requiring Regional and Territorial Authorities take "a precautionary approach when assessing the effects of climate change ... on flood mitigation activities" when managing new development. Horizons One Plan, Part-1 Regional Policy Statement, Chapter-9, Section 9-7 Explanations goes on to explain that the 200 yr current flood has been chosen by Horizons as an approximation for the 100yr future flood risk taking into account climate change.

4.2.3. Both clauses focus on the 0.5% AEP (1 in 200 year) flood hazard and with differing emphases provide for flood hazard avoidance or mitigation. The document gives no indication of the standard of mitigation expected. The simplest interpretation is strictly no worsening of predicted flood hazards to any existing locations in any circumstances, however this is usually prohibitive and in planning hearings a less than minor affect is the usual standard sought, with commissioners varying in opinions on what constitutes less than minor effects in various circumstances.

4.2.4. This proposal is marginal to the floodway and, while it isn’t practicable to determine coverage from Figure J-2, we understand that the proposed plan change provides for development within the floodway.

4.3. District Plan

4.3.1. Within the Palmerston North District Plan, a key relevant clause is in section 7 Subdivision, subsection 7.3 Objectives and Policies, policy 2.9, which states the subdivision shall ensure that a stormwater drainage system “..caters for a 1% annual exceedance probability [AEP] rainfall event (100 year flood) using a system appropriate for intended land use”

and “ensures that stormwater disposal from the subdivision would not increase the risk of inundation in urban areas”.

4.3.2. In common NZ historic practice this 1% AEP requirement would be taken as the minimum applicable to the design of flood defences such as stopbanks and floodways where failure would mean flooding of houses above normal residential build floor levels, plus some freeboard to account for reasonable uncertainties. 1% AEP is also a common historic standard used to identify existing areas at risk of flooding. Protection from flooding in residential garages, undeveloped private land, commercial property and public land such as roadways is generally less and quite variable.

4.3.3. Interpretations of “would not increase risk” are typically not treated conservatively with analyses using some estimate of uncertainty as cause to excuse findings that the subdivision would cause small increases in the risks of urban inundation. Uncertainty is usually a matter of subjective opinion with analytical determinations difficult and uncommon.

4.3.4. Another key clause in the District Plan is R10.6.1.5(i)i. which stipulates minimum floor levels at reasonable freeboard above 200 year ARI for the Whakarongo Residential Area.

4.3.5. The District Plan document makes no recognition of increased future risks associated with climate change, however this is covered in their Engineering Standards for Land Development.

4.4. PNCC Engineering Standards for Land Development

4.4.1. Within the Palmerston North Engineering Standards for Land Development, key relevant clauses are 6.1.1, 6.2.2 and 6.9.2. 6.1.1 states that ”The implications of future development on adjoining land should be on the basis of replicating the pre-development hydrological regime. All stormwater systems shall provide for the management of stormwater runoff to ensure upstream flood levels are not increased by any downstream development and downstream impacts (changes in flow peaks and patterns, flood water levels, contamination levels, erosion or silting effects etc.) are determined to be less than minor.” Again, the definition of less than minor is a subject of differing opinions and debate.

4.4.2. This clause requires what is often referred to as “hydraulic neutrality”. Clause 6.2.2 goes on to require analysis of effects up to the 50 yr ARI

storm size and clause 6.9.2 specifies the consideration of future climate change rainfall.

4.4.3. In summary the planning requirements specify a reasonably typical suite of controls on subdivision development but the key point of standard of mitigation and what constitutes a “less than minor impact” is subject to interpretation by and opinion of the Regional Council and City Council. In my evidence I will give my opinion on this point.

Details sought from the DHI work

4.5. This section highlights information sought from DHI, identifies gaps in DHI study or lack of information in the reporting of it. This section is intended to identify what further assessment, clarifications or considerations need to be made in order to provide reasonable recommendations on what better but practicable assessments should be carried out in support of an anticipated application for subdivision.

a. How is it reasonable that the Flygers Spillway flow rate of 114m^3/s does not vary from 50, 100, 200yr ARI design events (DHI 2007, table 4-1)?

b. Does DHI 2007, section 6.2.2 “An area of the model that requires improvement is the Mangaone stream and its tributaries upstream of the Flygers Line spillway” indicate that there is low confidence in the design flows at Flygers Line Spillway? If so has there been any subsequent improvement to improve this confidence?

c. What data and colour legends are shown on figures 5, 6, 7?

d. Where is the 2m wide opening described under option 6 but not evident on Figure 7? Is there only one opening despite there being two channels?

e. What is the full specification for understanding of the model LiDAR accuracy (LiDAR from 2005), as the quoted 0.5m vertical accuracy is surely not the local point noise level to 95% confidence.

f. Were the road inlets connected to the 900mm culvert running parallel to Benmore Ave modelled?[3]

g. What Benmore Ave stopbank levels (and extents) were used in the modelling? The DHI 2019 report section 5 infers that some modelling was done with infinitely high stopbanks and other modelling may have been done with recent survey levels. Do the figures in Appendix D indicate that the baseline flooding overtops the Benmore Ave stopbanks and that the Option 6 result marginally worsens this overtopping?

h. What downstream boundary condition was used and what evidence and analysis supports the authors reduction in the downstream model extent[4] "...no artificial backwater effects were created by the boundaries at the area of interest"

i. Has the baseline flood level in the detailed model been validated as being consistent with the baseline flood level from the regional model?

Assumptions on the DHI work

4.6. A meeting was held between Greg Whyte (DHI), Paul Mitchell (Mitch Hydro), Paul Thomas (the applicant's planner), Veni Demado (PNCC) and Marz Asgar (Stantec planner on behalf of PNCC) on 21/3/2022 to discuss the items above and general questions on the assessments. This was followed by an email to DHI requesting further information to inform this evidence, however the information was not provided.

4.7. In the absence of the requested information I have made the following assumptions to support subsequent inferences.

a. Confidence in the 200 year design inflows across Flygers Line Spillway are low. As listed in Table 4-1, the 50, 100, 200 year ARI inflows are all identical at 114m^3/s. Real world systems rarely have such simplicity and such simplicity in results suggests an overly simplified analysis. DHI

[3] Refer DHI 2019 Section 5, final bullet – implies that these road inlets and local pipes were not modelled. These pipes will likely form a permeable flow path across the Benmore Ave stopbank, rendering it imperfect in reality. Excluding them from the model seems likely to be a significant departure from reality.

[4] DHI 2019 Section 4 "..no artificial backwater effects were created by the boundaries at the area of interest"

quote Horizons as the origin for this flow estimate but provide no reference to written source, nor comment on the apparent irregularity in the 114m^3/s flow rate. My understanding is that this 114m^3/s flow is the only inflow into the DHI 2019 modelling used for this study.

b. The LiDAR used to generate the new base model in practicable terms of local relative levels within the model domain has much better accuracy than is implied.

c. Local drainage and road inlets connected to the 900mm culvert running parallel to Benmore Ave are not modelled.

d. Recent survey levels were used for modelling the Benmore Ave stopbanks. Baseline flooding overtops the Benmore Ave stopbanks and the Option 6 result marginally worsens this overtopping.

e. The downstream boundary condition sets a constant tailwater level somewhat below the peak flood levels predicted at that location by the regional model.

f. Flood levels in the detailed model have not been validated and might be inconsistent with the baseline flood level from the regional model.

Interpretation of the DHI work

4.8. Overall the single event and simplified modelling approach is reasonable for this early planning phase, however the choice of the single event with unquantified uncertainties, assumed missing model elements and the omission of the local drainage network connecting into the Benmore Avenue culvert all limit the evidential value of this assessment.

4.9. More importantly though construction of the Benmore Ave stopbank upgrades since the time of this modelling is likely to significantly and positively change the findings (unless the modelling actually anticipated this upgrade rather than using the then current survey levels).

4.10. If I assume a high degree of trust in the modelling and memo, with my assumptions where detail is absent, the results would indicate an outcome that I would accept as tolerably ‘less than minor impact’, with provisos that for subdivision approval optioneering and modelling must be substantially improved with expectations that I outline later in my evidence.

4.11. When modelled, the local drainage system in Benmore Avenue is likely to undermine the effectiveness of the Benmore Avenue stopbanks, increase model baseline flood risks and are likely to increase the modelled sensitivity to the proposed development (especially in long duration flood events).

4.12. The other various assumed simplifications and imperfections in the modelling are at least common to both base case and developed models and so the change analysis may be generally valid.

4.13. A single flood event has been modelled. The modelled flood event is unlikely to show the worst case in terms of downstream affects. If other baseline flood conditions were assessed some may show results with worse downstream affects (ie: more than 50mm change in flood depth).

4.14. There is no supporting detail to the inflow rates modelled (ie peak flow rates in Table 4-1 and timeseries flow rates used in modelling and supplied to me digitally. In addition the key inflow of 114m3/s has an obvious cause for suspicion. It is therefore uncertain whether the modelled condition is a good representation of a current 200-year flood level condition. It could reasonably represent a lesser or greater event than 200 years.

4.15. The findings, especially the Appendix figures, illustrate that the proposed earthworks are drawing floodwaters to the south (toward the urban area). This is being somewhat mitigated by the various features in option 6 but not fully mitigated. While option 6 is preliminary and is expected to be improved further following the plan change, as it has been modelled I would agree with some submitter comments that residents on Benmore Ave would be right to be concerned if option 6 was built.

4.16. A fundamentally different earthworks scheme that does not primarily channelise increased flow to the south (and preferably one which does instead channelise increased flow to the west) would be advantageous to flood risks around Benmore Ave. However, further assessment would be required to evaluate environmental waterway impacts and the impact on the adjacent rural land and downstream effects.

4.17. In summary my view of the DHI 2019 report evidence is that it provides modest evidential value because of the numerous features which are unreported, and the lack of assurance that their new baseline model

matches the Taonui Basin baseline model, the inference that the recent Benmore Ave stopbank upgrades have not been included and the statement that local drainage systems are not included.

4.18. Based partly on trust in the unreported elements of the DHI modelling but more based on a common-sense assessment of the regional flooding character and the location of the proposed plan change (marginal to the flood plain) I would expect that a reasonable subdivision plan could more likely than not be developed, supported by appropriate modelling and thorough reporting. For this reason I do not oppose the plan change.

4.19. I am concerned at the applicant's risk, having to date demonstrated little progress in addressing the regional flood risk, that they may be disappointed by what is eventually required. Improved modelling now could substantially mitigate that risk prior to proceeding with the plan change process.

4.20. If this plan change is accepted, and then when the anticipated application for subdivision is being evaluated, PNCC should consider the spatial extent and level change predicted by modelling of the proposed development across a spectrum of flood conditions. Efforts to thoroughly consider 'all options' and find the best practicable mitigation should be required in proportion to the extent to which the predicted change in flood levels are negative. This means that if neutral results are demonstrated that demonstration of options and best practicable mitigation is not required, however if results are near the worst tolerable limits then exhaustive efforts to demonstrate that the best practicable mitigation will be expected. If results are beyond the worst tolerable limits then the subdivision would be rejected.

4.21. Suggested tolerable for increase in flood level if best practicable has been fully demonstrated are recommended as follows;

Regional flood event	Suggested tolerable increase in flood level if best practicable has been demonstrated
10 yr current	10mm
50 yr current	20mm
200 yr current	50mm

200 yr with future climate change[5]	100mm

Floor level controls

4.22. Effective floor level control provisions are not found in the District Plan although useful precedent floor level controls for a specific subdivision are provided in R10.6.1.5(i)i. Floor level controls are found in Horizons One Plan but these only apply within designated floodways. These presently cover a part of the proposal plan change area, but leave part of it uncontrolled. It is also possible that proposed earthworks might be accepted as a cause to reduce the floodway extent and further reduce or eliminate floor level controls with respect to flood levels.

4.23. Accordingly I recommend in section 6, that the District Plan floor level control rule be extended across the Whiskey Creek plan change area, so as to ensure suitable floor levels are achieved above floodplain levels.

Mitch Hydro - Regional Timing

4.24. In Mitch Hydro 2021, section 7, the author asserts that the risk of a regional flood via Flygers Line Spillway, coinciding in time with a peak flood flow from the proposed development site, is low. I consider this analysis reasonable and agree with it.

Mitch Hydro Local Runoff Mitigation

4.25. In Mitch Hydro 2021, section 6.1, the author presents analysis of a conceptual flood detention design that demonstrates successful mitigation of peak outflows to below pre-development levels across a range of ARI from 2 to 200 years.

4.26. I find this analysis generally comprehensive and I have only one concern which is the question of design rainfall shape (hyetograph), which is not reported. Based on figures 9-15 it seems reasonable to assume that a nested design storm shape has been adopted. This has been shown to produce unconservative results (refer Groves et al 2020[6]). The

[5] Future climate changed event being as defined in PNCC ESLD clause 6.9.2

[6] “Does Your Detention Meet Your Intention?” by Groves, Hellberg, Schicker and Bird (Stormwater 2020 conference)

assessment should be revised to use one of the Groves recommended storm shapes. This may increase the required basin size and outlet complexity. A maximum design rainfall duration of 24 hours should be complied with and the outcome for a rainfall duration of 48 hours demonstrated.

4.27. Sensitivity of the final design to the most conservative rectangular storm shape should also be demonstrated but reductions in peak flow for a rectangular storm based assessment should not be a requirement.

4.28. We acknowledge that the PNCC ESLD clause 6.2.2 recommends the use of nested storm analyses. It is a subject for others as to whether the ESLD thus provides legal basis for the nested storm analysis to be upheld. My evidence is that this ESLD nested storm recommendation is not good practice and that good practice such as defined by Groves et al, should be applied to all subdivision development.

4.29. While I consider the Mitch Hydro (section 6.1) Local Runoff Mitigation analysis presented to be unconservative, I would expect that a reasonable development scenario can be shown to be effective and for this reason I find no reason to oppose the plan change request.

Planning next steps

4.30. During consideration of the resource consent for subdivision (assuming the plan change is approved) the applicant should be expected to provide credible evidence that alternative development concepts encouraging flood flows to the west (rather than south) and improving (reducing) flood risks to Benmore Ave urban area are not feasible. Based on this I recommend in section 6 “Recommendations” of my evidence district plan rules to ensure these concerns are appropriately addressed.

4.31. The base model for this analysis should be validated to ensure that it matches results from the Taonui regional model.

4.32. Local drainage and road inlets connected into the 900mm diameter Benmore Ave culvert should be modelled. A reasonable provision for rainfall on this local drainage should be included, with intensity matching one tenth of the regional ARI and a rain duration of 48 hours. This would be applied as constant local rainfall throughout the model simulation period.

4.33. Design input flows should be validated, with respect to both current rainfall statistics and climate change forecasts and their uncertainty estimated.

4.34. Opportunities to improve the model of the Mangaone stream and its tributaries upstream of the Flygers Line spillway should be scoped and realised.

4.35. The regional model should be updated to take advantage of modern and more accurate LiDAR input data

4.36. The Benmore Avenue stopbank system should be modelled reflecting current top levels.

4.37. Regional flood conditions associated with a range of ARIs (such as 10/50/200/200+ future climate change) should be considered. Modelling may not necessarily be required for all scenarios if it can reasonably otherwise be shown without modelling that some scenarios will be less demanding and will not determine compliance.

4.38. Regional flood conditions associated with a range of event durations (such as current model (circa 6hr), three times shorter (circa 2hr) and a steady state model (continuous flooding) should be considered. Modelling may not necessarily be required for all scenarios if it can reasonably otherwise be shown without modelling that some scenarios will be less demanding and will not determine compliance.

4.39. The modelling work should be comprehensively reported including presentation of change in flood levels at 20mm increments and supply of digital results and differencing data to support peer review.

4.40. The principals and recommendations contained in “Does Your Detention Meet Your Intention?” by Groves, Hellberg, Schicker and Bird (Stormwater 2020 conference) should be followed in local runoff mitigation meaning that the nested storm method should be replaced with one of Groves recommended storm shapes, up to a 24 hour rainfall duration, future climate changed rainfall. Sensitivity should be demonstrated to a rectangular storm shape and to an overdesign (48 hour) rainfall event.

4.41. The design analyses should be peer reviewed by a practitioner with demonstrated experience in similar modelling, estimation of uncertainties and understanding of the above paper by Groves et al.

Stormwater quality

4.42. I note that I do not have expertise in stormwater quality and accordingly I have not critically reviewed the Mitch Hydro 2021 section 6.2. That noted I do not anticipate any reasons why suitable stormwater quality could not be achieved from the proposed development, nor any rationale as to why stormwater quality should be a significant impediment to approval of the requested plan change.

5. CONCLUSIONS

5.1. In respect of regional flood plain risks, from the limited evidence provided by the applicant, together with my understanding of the circumstances and general experience I consider the proposed area will more likely than not be able to be subdivided will due regard to avoidance and mitigation of regional flood risks and, on this subject, I would not oppose the plan change request. I do note however that there is little evidence that the applicants currently proposed development concept will prove to be close to acceptable and that until improved modelling and reporting is completed, the applicant carries a significant risk in that material changes may be required in the development concept.

5.2. In respect of local stormwater discharge mitigation, while I consider the analysis presented to be unconservative, I would expect that a reasonable development scenario can be shown to be effective and, on this subject, I would not oppose the plan change request.

5.3. While I do not have expertise in stormwater quality I do not anticipate any reasons why suitable stormwater quality could not be achieved from the proposed development, nor any rationale as to why stormwater quality concerns should be a reason to oppose the plan change request.

5.4. From an overall stormwater perspective, I do not oppose the plan change request.

6. RECOMMENDATIONS

I have drafted recommendations (below) in relation to possible District Plan rule modifications to give effect to my recommendations. From interactions with Richard Peterson between 9-11th May I understand that my wording does not

suit due to several planning considerations. Richard and I have collaborated on his improved version of proposed changes. Per his final email 11/5/22 1:08pm (showing an extract of text which I understand will be included in his S42A report) and my reply 2:47pm I believe his version generally reflects my intentions but I am not confident that I understand the planning context sufficiently to be entirely sure that his version suitably reflects the intent of my recommendations, yet. Accordingly I have left my original recommendations in my evidence.

My recommendation is that the District Plan rules should be modified as follows (new text is formatted in italics).

6.1. 7.5.2.2 (a)(xiii) should have the following inserted; "…proposed Water Sensitive Design measures will ensure hydraulic neutrality is achieved ~~and ensure~~ *ensuring* that there is no increase in stormwater effects on *(ie: peak outflows to)* surrounding areas *for the rain event conditions evaluated.*

6.2. 7.5.2.2 (f) should be modified as follows; Heading becomes; **Water Sensitive Design in the Kikiwhenua *and Whiskey Creek* Residential Areas**. Insert new first bullet; "the SMP shall meet general requirements in the Engineering Standards for Land Development, including section 6.2.2, and demonstrate reductions in park flow (hydraulic neutrality in accordance rule 7.5.2.2 (a)(xiii)), and the following supplementary requirements";

- Results for 100 and 200 year ARI (and including climate change) should also be demonstrated but these do not need to achieve hydraulic neutrality (ie: full peak flow mitigation).
- Contrary to the Engineering Standards for Land Development, the assessment should use a triangular design rainfall with a peak at either 50% or 70% of the rainfall duration. Design rainfall durations of 1,2,6,12, 24 hours should be complied with and the outcomes for a rainfall duration of 48 hours demonstrated.
- Sensitivity of the final design to the rectangular design rainfall (most conservative) should also be demonstrated for 24 and 48hr rainfall durations and 50 year ARI including climate change but hydraulic neutrality (ie: full peak flow mitigation) for the rectangular storm based assessment should not be a requirement.

6.3. 7.5.2.2 (g) should be added as follows: "**Regional Flood Considerations in the Whiskey Creek Area**".

- During consideration of the resource consent for subdivision evidence that alternative development concepts encouraging flood flows to the west (rather than south) and improving (reducing) flood risks to Benmore Ave urban area are not feasible should be provided.

- The base model for the regional flood analysis should be validated to ensure that it matches results from the Taonui regional model.
- Local drainage and road inlets connected into the 900mm diameter Benmore Ave culvert should be modelled. A reasonable provision for rainfall on this local drainage should be included, with intensity matching one tenth of the regional ARI and a rain duration of 24 hours. This would be applied as constant local rainfall throughout the model simulation period.
- Design input flows should be validated, with respect to both current rainfall statistics and climate change forecasts and at least qualitative discussion of their confidence and uncertainty provided.
- Opportunities to improve the model of the Mangaone stream and its tributaries upstream of the Flygers Line spillway should be scoped and realised (refer DHI 2007 modelling report, section 6.2).
- The regional model should be updated to take advantage of modern and more accurate LiDAR input data
- The Benmore Avenue stopbank system should be modelled reflecting the current top levels.
- Regional flood conditions associated with a range of ARIs (such as 10/50/200/200+ future climate change) should be considered. Modelling may be waived for some scenarios if it can reasonably otherwise be shown without modelling that some scenarios will be less demanding and will not drive compliance.
- Regional flood conditions associated with a range of event durations (such as current model (circa 6hr), three times shorter (circa 2hr) and a steady state model (continuous flooding) should be considered.
- The modelling work should be comprehensively reported including presentation of change in flood levels at 20mm increments and supply of digital results and differencing data to support thorough peer review.
- The maximum tolerable local changes in flood levels, if best practicable outcomes have been fully demonstrated, and if the extent of changes in flood levels are modest will be as follows;

Regional flood event (for any assessed rain duration)	Suggested tolerable increase in flood level if best practicable has been demonstrated
10 yr current	10mm
50 yr current	20mm
200 yr current	50mm
200 yr with future climate change[7]	100mm

- The extent of changes in flood levels shall mean that the geographic area affected with quarter of the above tabulated increase in flood level is contained within an area with 1km diameter.
- Modelling requirements for some ARIs scenarios may be waived if it can reasonably otherwise be shown without modelling that some scenarios will be less demanding and will not drive compliance.
- Modelling requirements for some rainfall duration scenarios may be waived if it can reasonably otherwise be shown without modelling that some scenarios will be less demanding and will not drive compliance.

[7] Future climate changed event being as defined in PNCC ESLD clause 6.9.2

- Modelling requirements may be reduced if the proposed concept results in reductions in flood levels

6.4. 10.6.1.5 (i) should be extended as follows: Occupied structures are to have a finished floor or ground level, which includes reasonable freeboard, above the 0.5% AEP (1 in 200 years) flood level, *without climate change* for the Whakarongo *and Whiskey Creek* Residential Areas.

6.5. 10.6.1.5 (ii) bullets under should be clarified as follows:

- • A 0.5% AEP (1 in 200 years) flood *without climate change* for the Whakarongo Residential Area.
- • A 1% AEP (1 in every 100 years) *without climate change* for all other Greenfield Residential Areas.

6.6. 10.6.1.5 (***NOTES TO PLAN USERS****)* bullet 4 should be extended as follows; … referred to Horizons Regional Council for further clarification on 'reasonable freeboard' and safe areas for safe evacuation'. *Such reasonable freeboard shall not be less than 0.3m in any circumstances.*

Dated at Christchurch this 11th day of May 2022

[signed]

……

Timothy Preston