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Ōhoka Residential Subdivision Expert Panel Chair

9 October 2026

Attention: Kate Barry-Piceno

Dear Kate

Ōhoka FTAA – Stormwater Review

Introduction

Purpose of the document

1. The purpose of this document is to summarise my review of the proposed stormwater management for the proposed Ōhoka residential development. This review includes consideration of the updated information provided by the applicant dated September 2026. This does not include a review of flooding and flood modelling which is being undertaken by others.

Documents reviewed

2. I have referred to the following documents as part of my review:
 - Stormwater Management Report – PDP, Fast Track Application - Stormwater Management for 531 and 535 Mill Road, Ohoka, Revision 5, Dated 10/09/2026, *Appendix 31 (UPDATED) - Stormwater Management Report - PDP.pdf*
 - Civil Engineering Plans – Inovo, Mill Road Ohoka Waimakariri Canterbury Subdivision Development, For Fast Track Consent Application, Project #16013, Date June 2026 - *RC255196 FTAA - 2606 - 1253 CIVIL ENGINEERING PLANS CARTER GROUP WAIMAKARIRI LIMITED 531 MILL ROAD OHOKA.PDF*
 - Proposed District Council Consent Conditions - *RC255196 FTAA - 2606 - 1253 PROPOSED DISTRICT COUNCIL CONSENT CONDITIONS CARTER GROUP WAIMAKARIRI LIMITED 531 MILL ROAD OHOKA.pdf*
 - Scheme Plans – Inovo, Mill Road Ohoka Waimakariri Canterbury, Issued for Fast Track Consent Application, Project #16013, Dated September 2026 - *Appendix 26 (UPDATED)- Scheme Plans – Inovo.pdf*
 - Flood Assessment – PDP, Flood Effects - 531 and 535 Mill Road, Ohoka, Revision E, Dated 09/09/2026 - *Appendix 22 (UPDATED) - Flood Effects Report - PDP.pdf*
 - Groundwater Assessment (Hydrology Assessment) – PDP, Fast Track Application - 531 and 535 Mill Road, Ohoka – Hydrology Assessment, Revision 5, Dated 02/06/2026 - *RC255196 FTAA - 2606 - 1253 HYDROLOGY ASSESSMENT CARTER GROUP WAIMAKARIRI LIMITED 531 MILL ROAD OHOKA.PDF*

Key areas discussed in this memo

3. Key areas discussed in this memo are:
 - a. Design standards
 - b. High groundwater



- c. Stormwater treatment and attenuation approach and site layout
- d. Design of stormwater management areas
- e. Unattenuated catchments
- f. Off-site flood risk
- g. Footprint provided for stormwater management areas
- h. Proprietary treatment devices including raingardens
- i. Stormwater Management Plan
- j. Proposed conditions and review of detailed design at engineering acceptance stage.

Qualifications

- 4. I hold a Bachelor of Engineering with Honours (Civil) from the University of Canterbury and am a Chartered Professional Engineer (Civil, Environmental).
- 5. I am a Chartered Member of Engineering New Zealand, a member of Water New Zealand and a past chair of the Water NZ Stormwater Group, and a member of the Engineering NZ Rivers Group.
- 6. I have 25 years’ experience, with the last 15 years specialising in stormwater and flood risk management.
- 7. My experience in stormwater and flood risk management is from a wide range of projects and includes stormwater management planning, and the design of stormwater conveyance, treatment and attenuation systems, and waterway and river works. I have also independently peer reviewed stormwater designs for residential and commercial developments, roads and motorways.
- 8. I am familiar with the Ōhoka area and the Kaiapoi area including the existing conditions for stormwater and groundwater. I was seconded to Waimakariri District Council (WDC) for a period of 6 months in 2014, to lead the WDC flood team following the 2014 floods. Ōhoka was one of the areas of focus for the flood team’s work.
- 9. I am familiar with plan change and resource consent processes from my work as an employee at councils (Hastings District Council and Christchurch City Council) and my work at Beca as a consultant working both for councils and for applicants. I am also generally familiar with the Fast Track Approvals Act (FTAA) having provided stormwater review for a council for another FTAA project in Canterbury.

Code of Conduct

- 10. I confirm that I have read and agree to comply with the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023. This technical review has been prepared in accordance with that Code. In particular, unless I state otherwise, the opinions I express are within my area of expertise, and I have not omitted to consider material facts that might alter or detract from the opinions that I express.

Discussions with the Applicant

- 11. I attended an online meeting on 14 August 2026 with the applicant’s engineers and planners, Waimakariri District Council representatives and Waimakariri District Council’s flooding reviewer.

Key Issues

Design standards

- 12. The applicant’s design standards (as set out in the applicant’s Stormwater Management Report) meet WDC’s current Code of Practice (as updated 2025) for primary and secondary conveyance systems but are different to WDC’s requirements for attenuation, as shown in Table 1.

Table 1: Comparison of design standards

Component	Applicant’s design	WDC CoP (2025)
Primary conveyance system	10-year ARI event	10-year ARI event
Secondary conveyance system	100-year ARI event	100-year ARI event
Peak flow attenuation	Post-development peak flow from the site does not exceed the pre-development peak flow rate in a <u>10-year and 100-year ARI event for the 1-, 6-, 12- and 24-hour durations.</u>	Post-development peak flow from the site does not exceed the pre-development peak flow rate in a <u>5-, 10-, 50-, and 100-year ARI event of all durations from 10-minutes to 72-hours.</u>

13. This difference in the peak flow attenuation standard means that compared to a development designed to WDC’s requirements, the applicant’s stormwater system:
- a. Could result in larger peak flows being discharged from the site in the 5-year and 50-year ARI events, depending on the detailed design of the attenuation outlet controls.
 - b. Could result in a larger peak flows being discharged from the site in any return period events exceeding 24-hour duration.
14. The applicant’s Stormwater Management Report notes that the critical duration for the discharge from the site is the 6-hour duration. This is also understood to be the critical duration for flooding in the wider Ōhoka area including immediately downstream of the site. However further downstream, including in Silverstream and Kaiapoi, the critical duration of flooding is likely to be much longer than this. The applicant’s design approach is focused on the attenuation of peak flows at the site boundary and area immediately downstream, but does not consider the effects on the catchment further downstream where it could increase the flood risk.
15. The WDC Code of Practice also requires that development must not increase the depth or duration of off-site flooding.
16. The applicant has carried out flood modelling of the wider catchment in TUFLOW which includes the proposed development landform and land use. However, this modelling does not include the proposed site stormwater system including the stormwater management areas. This means that TUFLOW flood model does not test the effects of the development’s stormwater system on the timing and potential coincidence of downstream flows and therefore the effects on off-site flood risk.
17. Refer to items 68 to 71 below for further discussion of assessment of off-site flood risk.

High groundwater

18. As noted by the applicant, the site is an area of very high groundwater. The area has a history of high groundwater events where groundwater rises to be close to ground surface level (referred to as groundwater resurgence), often for extended periods of time.
19. The high groundwater adds complexity to the stormwater design, including the stormwater management areas and waterways. High groundwater limits the depths of stormwater management devices and increases surface water levels, reducing capacity for stormwater runoff.
20. The applicant has carried out an assessment of groundwater levels at the site and established “maximum groundwater levels” across the site. I have not reviewed the groundwater assessment.
21. These maximum groundwater levels have been used as a key input into the design of the stormwater management areas, with the permanent water levels in the first flush basin and wetland set at the maximum groundwater level. (See also further comments in items 38 to 46 below.)
22. The depth to maximum groundwater level range for each catchment is noted in the Stormwater Management Report Table 7 and the depths vary from 0.11 m and 0.91 m, with most being less than 0.5m.

- 23. The maximum groundwater level or depth to maximum groundwater level at each stormwater management area does not appear to be reported in the Stormwater Management Report or in the Groundwater Assessment (Hydrology Assessment). As noted above, the depth to maximum groundwater is provided as a range for each catchment.
- 24. The high groundwater levels assumed by the applicant within the stormwater management areas can also be reasonably expected to occur in the receiving waterways. High tailwater levels in the receiving waterways would mean that there is limited driving head (or water level difference) through the stormwater system.
- 25. It is not clear what assumptions have been made about the water levels in the receiving waterways (i.e. tailwater levels) in developing the stormwater design. Refer to items 54 to 59 below for comments on the tailwater assessment provided for the stormwater management areas.
- 26. There is limited information on the proposed levels of the stormwater system from the individual lots through the conveyance paths and the stormwater management areas to the receiving waterways. It is therefore difficult to assess whether there is sufficient driving head or hydraulic gradient through the system for the system to operate as intended.
- 27. If the design has not allowed for suitably conservative tailwater levels in the receiving waterways and considered the hydraulic gradient or water levels through the system, this could lead to higher water levels through the stormwater system including in the stormwater management areas, into roads and onto lots, as well as into road pavements. This could mean that the stormwater system does not comply with the required levels of service and freeboard requirements.
- 28. The hydraulic gradient or water levels through the proposed stormwater system, from the lots to the receiving waterways, should be assessed using hydraulic modelling.
- 29. High groundwater levels will also affect the performance of proprietary treatment devices and raingardens. Refer to items 88 to 90.

Stormwater treatment and attenuation approach and site layout

- 30. The Stormwater Management Report sets out the proposed stormwater treatment and attenuation approach for each catchment. This varies between catchments.
- 31. With regard to water quality treatment, some catchments are treated by first flush basins followed by wetlands in stormwater management areas, some have treatment swales, and some have proprietary treatment systems or raingardens.
- 32. With regard to attenuation storage, catchments with first flush basins and wetlands have attenuation storage provided as part of these, some catchments have basins (wet ponds) in stormwater management areas, and some catchments (catchments 6 and 11) have no attenuation proposed but are proposed to be offset by attenuation in neighbouring catchments.
- 33. The retirement village catchment is proposed to have a separate private system for treatment and attenuation (i.e. proprietary systems or stormwater management area), which is not described or sized as part of the information provided. To understand the scale of treatment and attenuation required and so that sufficient space is provided for it, initial sizing of this retirement village system should be undertaken along with the other catchments.
- 34. It is not clear from the information provided why these different approaches for treatment and attenuation for different catchments have been adopted or how the proposed layout has been arrived at.
- 35. In terms of treatment efficacy, the treatment swales alone would provide a lower standard of treatment than first flush basins followed by wetlands. Proprietary devices including proprietary raingardens, if suitably designed and maintained, should be able to provide a similar standard treatment to first flush basins followed by wetlands.
- 36. The proposed swales could create safety and operational issues, particularly if they are partially full for extended periods due to high groundwater.
- 37. Proprietary treatment devices including proprietary raingardens are also sensitive to high groundwater and tend to have higher ongoing operation, maintenance and renewal requirements than stormwater management areas. Refer to items 85 to 90 for further comments on proprietary treatment devices.

Design of stormwater management areas

Arrangement

38. In the stormwater management areas, the applicant proposes two different arrangements for different catchments, either:
- a. First flush ponds (wet ponds) and wetlands to provide first flush treatment and attenuation storage to manage peak flows, or
 - b. Attenuation basins (wet ponds) to provide attenuation storage to manage peak flows, with first flush treatment provided upstream the stormwater management area in swales or proprietary devices.
39. It is understood that, for both arrangements, the permanent water level in the stormwater management devices is set at the assessed maximum groundwater level and the maximum design water level is set at the natural ground level. The live storage for the first flush and/or the attenuation storage is between the permanent water level and maximum design water level.
40. The Stormwater Management Report includes tables with calculated first flush volumes, stormwater management device areas, and device storage volumes. It does not include information on the depths or levels of the devices or operating water levels.
41. A typical plan and cross-section of the proposed first flush basin and wetland arrangement is shown in the drawings included in Appendix D: Typical SMA Details of the Stormwater Management Report. (Ohoka Wetland Concept Design drawing Pond SMA 9C, Drawing No. C045180001-GN-003 Rev A.) An excerpt from this drawing is included in Figure 1 below for ease of reference.

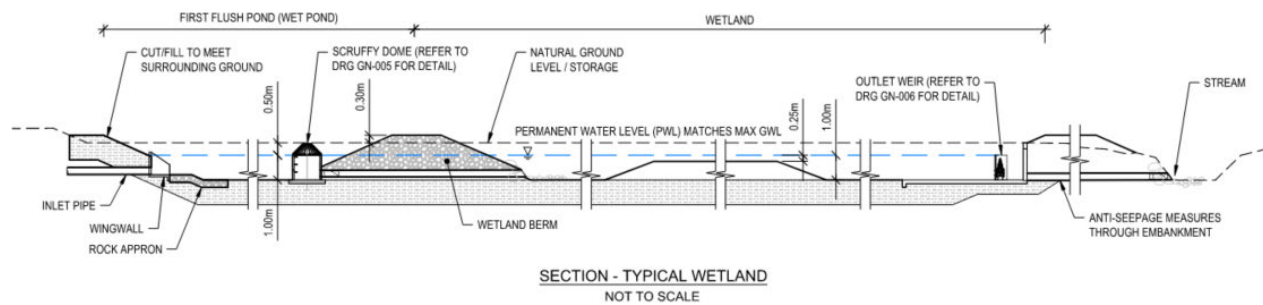


Figure 1: Typical cross-section

42. The Stormwater Management Report states the first flush basins are designed to capture the runoff from 25 mm of rainfall and slowly release it over four days to the wetland, with two days' hydraulic residence time in the wetland (as per Christchurch City Council's Waterways, Wetlands and Drainage Guide).
- Relative timing and effects on storage volume**
43. The attenuation storage would need to fill and drain down much more rapidly to limit the peak flows discharged in larger events. The Stormwater Management Report notes that the attenuation volume would be discharged in less than 24 hours. My alternative calculations (refer item 49) suggest that it could be in the order of a few hours.
44. If the first flush volume takes a number of days to drain down, then that storage volume is occupied during that time and is not available to provide the faster response attenuation storage. If this is not accounted for the design, this would lead to the attenuation function not performing as intended.
45. Understanding this difference in timing for the storage and release of the first flush treatment volume and attenuation volume is important for design of the stormwater management areas in terms of their arrangement, outlet control structures and total storage volumes.
46. The water level in the first flush basin will sit above the permanent water level for a period of time following any rainfall event, and for four days following a rainfall of 25 mm or larger. This means the first flush basin will be partially full much of the time. This reduces the storage volume available for peak flow

attenuation if the event is larger than a first flush event or if there is a subsequent rainfall event. This does not appear to have been allowed for in the design.

- 47. If the storage is already full or partially full when the design storm arrives, the system would not perform as intended. It would reduce the live storage available in the stormwater management devices, increasing the peak water levels in the stormwater management devices (and the upstream stormwater system) and increasing the discharge from the devices. The increased peak flow discharged could be higher than the pre-development peak flow.

Attenuation storage and HEC-HMS modelling

- 48. The Stormwater Management Report refers to calculations to establish the first flush basin and wetland sizing and HEC-HMS modelling to establish the attenuation storage sizing.
- 49. I have carried out simplified alternative calculations of the attenuation volumes required assuming a 6-hour pre-development critical duration (without considering the details of the outlets, tailwater water levels and levels and depths of the devices), which gave larger attenuation volumes than those proposed in the applicant's design.
- 50. HEC-HMS is a hydrological modelling software, rather than a hydraulic modelling software, meaning its focus is on hydrology (converting rainfall into runoff and routing this). It has limited ability to assess hydraulics, particularly in tailwater-controlled systems such as that which appears to be present at this site.
- 51. There is very little information provided on the HEC-HMS modelling and the key inputs and assumptions used, including how the limitations of HEC-HMS have been overcome to correctly assess system performance.
- 52. This makes it difficult to review the attenuation storage design, including sizing and layout, and therefore the footprint of the stormwater management areas.

Tailwater effects

- 53. The Stormwater Management Report notes that the HEC-HMS model used for the stormwater attenuation sizing does not account for tailwater effects. In other words, it assumes free outfall conditions.
- 54. The Stormwater Management Report includes an assessment of when the stormwater management areas might be affected by tailwater levels in the receiving waterways. The HEC-HMS model and TUFLOW flood model have both been run for a 6-hour duration (presumably 100-year ARI) event and a table provided comparing the timing of the peak flow out of the stormwater devices from the HEC-HMS model and the times when the water levels in the receiving waterways from the TUFLOW flood model are higher than the permanent water levels in the stormwater devices. Water levels in the devices and the waterways are not provided.
- 55. For several devices, this assessment identifies that water levels in the receiving waterways are above the permanent water levels in the stormwater devices for some time during the event, and for four devices the water level in the receiving waterway is above the permanent water level at the HEC-HMS time of peak flow out of the stormwater devices.
- 56. This simplified assessment highlights the dynamic interaction between the stormwater management devices and the waterways, and the shortcomings of trying to analyse them separately.
- 57. The tailwater levels in the receiving waterways are a very important assumption as the stormwater management area design relies on the balance of inflow, outflow and storage. If the tailwater level in the waterway is higher than designed, then:
 - a. The outflow will be reduced and so the storage will fill up more quickly than designed, meaning that designed flow attenuation will not be achieved; and
 - b. The higher than designed water levels in the stormwater management areas may increase the water levels in upstream system, including in the primary system, the secondary flow paths, and on roads and on lots, and reduce freeboard.

- c. Ponding of stormwater adjacent to the carriageway can also pose a risk of carriageway pavement damage from a saturated sub-base if adequate freeboard is not provided.
- 58. The applicant notes in the Stormwater Management Report that the current tailwater assessment is conservative and appropriate for the current stage of design. I do not agree with this.
- 59. The applicant also notes that the stormwater management devices will be incorporated into the TUFLOW model to assess tailwater effects at a later design stage.
- 60. The performance of the stormwater system, including the primary and secondary conveyance systems and the stormwater management devices (with levels, volumes, inlets and outlets), needs to be tested in a hydraulic model which includes appropriate tailwater level assumptions in the receiving waterways and the wider catchment.
- 61. I agree that this should be carried out by developing the TUFLOW flood model, but do not agree that this should be left to a later date.
- 62. This modelling is fundamental to testing the performance of the proposed stormwater management system and its effects on off-site flooding, and to confirming the stormwater management area footprint required and therefore the development layout. It should be carried out and reviewed before a decision is made on the consent.

Unattenuated catchments

- 63. The applicant is proposing that, due to the constraints of the site, some catchments will not be attenuated and instead other catchments discharging to the same receiving waterway will be over-attenuated, such the combined discharge at the receiving waterway does not exceed pre-development.
- 64. The applicant is proposing this approach in two areas: catchments 6 (residential housing) and 10 (polo field); and catchments 8 and 11 (both residential housing).
- 65. In theory, this is a reasonable approach (and is accepted industry practice), provided the design considers the combined discharge (including timing of peaks) from all the contributing sub-catchments to a point of discharge.
- 66. This would need to be assessed using hydraulic modelling of the contributing sub-catchments and the proposed development stormwater system (including the primary and secondary conveyance and stormwater management devices) and considering tailwater levels in the receiving waterway. This has not been carried out.
- 67. I have carried out simplified alternative calculations of the attenuation volumes required for catchment 6 (excluding the retirement village) and catchment 10, and for catchments 8 and 11, assuming a 6-hour pre-development critical duration and without considering the details of the outlets, tailwater water levels and levels and depths of the devices. My alternative calculations indicated:
 - a. For catchment 6 (excluding the retirement village) and catchment 10 together, a significantly larger attenuation volume than the applicant’s design. If the retirement village was allowed for this would further increase attenuation volume.
 - b. For catchments 8 and 11 together, a larger attenuation volume than the applicant’s design.

Off-site flood risk

- 68. The applicant’s design focuses on attenuation of peak flows at the point of discharge from the site, for the 1-, 6-, 12- and 24-hour durations. It does not appear to consider the timing of these flows and the effects of these discharges downstream of the site.
- 69. There is existing flood risk downstream of the site, both immediately downstream in the Ōhoka area and further downstream in Silverstream and Kaiapoi. WDC’s flood modelling shows the area immediately downstream to have a critical duration of 6 hours. The post-development site runoff has a much shorter critical duration (approximately 10 minutes), however once buffered through the attenuation storage in the stormwater management system the discharge from the stormwater basins will have a longer duration, closer to the 6-hour critical duration downstream. Therefore, the discharge from the site may exacerbate the downstream flood risk.

70. There are two generally accepted approaches to mitigating this risk of downstream flooding:
- a. Model the proposed development and site stormwater system with the wider catchment to understand its effect on downstream flooding. This tests the performance of the stormwater system and the effect of the stormwater system on the timing of the flows discharged and how these flows combine with the wider catchment flows downstream. This is the preferred approach as it is more robust site-specific assessment.
 - b. Reduce the peak post-development discharge to 80% of the pre-development peak flow, rather than 100% of the pre-development peak flow. This reduces the risk that if peak flows coincide downstream, they will exceed the pre-development peak. This approach is more common where the development is small, there is no known existing downstream flood risk, and there is not an existing model of the wider catchment flood risk.
71. The applicant has not taken either of these approaches.
72. For this site, where there is existing wider catchment flood modelling available and there are known downstream flood risks, the first option in item 70 above (option a), modelling of the proposed development system in a wider catchment model, should be carried out to understand the effects of the development on off-site flood risk.
73. Without this having been completed, the effects of the development on off-site flood risk have not been adequately assessed.

Footprint provided for stormwater management areas

74. As noted above, there are issues with the applicant’s attenuation design standards and design approach which may mean the devices in the stormwater management areas are likely to be undersized.
75. This means that the land areas allowed for these systems are likely insufficient to allow the required WDC levels of service to be achieved and the stormwater management areas may need to increase in footprint.
76. In Appendix H of both the previous and current revision of the Stormwater Management Report there are “available storage” and “required storage” volumes tabulated for each catchment/stormwater management area. These are summarised in Table 2.

Table 2: Comparison of total storage volumes across all catchments between versions to Stormwater Management Report

Previous version dated June 2026 (revision 4)			Current version dated September 2026 (revision 5)		
Available Storage (m³)	Required Storage (m³)	Spare Storage (m³)	Available Storage (m³)	Required Storage (m³)	Spare Storage (m³)
30,452	17,527	12,925	35,874	34,436	1,478
		42% of available storage			4% of available storage

77. Between the previous and current revision of the Stormwater Management Report the total required storage volume reported has increased significantly (almost doubling from a total of 17,527m³ to 34,436m³). However the available storage only increased slightly (from 30,452m³ to 35,914m³) and correspondingly the proposed total area for the stormwater management areas shown on the scheme plans has also increased slightly. (It is difficult to quantify the change in total area of stormwater management areas due to differences in the two revisions of the scheme plans.)
78. This means that, based on the latest revision of the Stormwater Management Report, at this early stage of design there is only limited spare capacity available within the stormwater management areas for refinement of the design.
79. It is not clear from the information provided in the Stormwater Management Report what allowance has been made for safety in design, and operation and maintenance access to the stormwater management areas.

- 80. Safety in design considerations include maximum batter slopes (to allow for safe exit on foot from the basin or wetland, and also excavator access for maintenance) and provision of safety benches where there is deep water (to limit the height and depth of water someone could fall into). These are particularly important for wet ponds and wetlands which have permanent water depth.
- 81. Operation and maintenance allowance includes providing space for regular access for inspections and sufficient space and access into the devices for maintenance activities (such as mowing or weeding, clearing inlets and outlets, and removal of debris and sediment). This includes access onto the stormwater management areas lot for utility vehicles and excavators, access around the perimeter of the devices for utility vehicles and excavators, and access ramps into the base of devices for excavators. This could also increase the footprint required for the stormwater management areas.
- 82. If additional space is needed for the stormwater management areas this would also affect the wider development layout.
- 83. I understand that once consent is granted for the development, the site layout is confirmed.
- 84. The space required for stormwater management areas needs to be resolved before a decision is made on the application. This means confirming the stormwater management device sizing and the form and layout of the stormwater management areas including safety in design and operation and maintenance allowance. This will require further design and hydraulic modelling.

Proprietary treatment devices including raingardens

- 85. The applicant is proposing to use:
 - a. Proprietary flow-through stormwater treatment devices for high contaminant load areas, with the Stormwater Management report referring to gross pollutant traps (LittaTrap or TetraTrap) and filtration devices (Stormwater360 Stormfilter).
 - b. Proprietary raingardens for areas which cannot be treated by stormwater management areas or swales.
- 86. The catchments where proprietary devices including raingardens are proposed are described in the Stormwater Management Report, but not the number of devices. It is not explicitly stated in the Stormwater Management Report but it is assumed that the applicant intends that the proprietary devices will be maintained WDC. This will create ongoing operation and maintenance requirements, renewal requirements, and associated costs for WDC.
- 87. While supplier information is included in the Appendices of the Stormwater Management Report, no typical details of the proposed arrangement and levels of these proprietary devices including raingardens within the stormwater system have been provided.
- 88. The proprietary devices including raingardens proposed generally need quite high headloss (or water level difference) through them to provide treatment. It is not clear whether there will be sufficient driving head through the system for these to operate as intended given the high groundwater.
- 89. The applicant notes that proprietary devices are available that operate under low head conditions to mitigate the presence of high groundwater. However, in some areas where these devices are proposed, the headloss through the proprietary devices proposed is likely to be greater than the reported depths to maximum groundwater level.
- 90. Should these proprietary devices be found not to be practicable in these locations, there may not be other suitable alternatives to provide adequate treatment within the space available.

Stormwater Management Plan

- 91. The applicant is currently proposing that the stormwater design will be developed further and tested in the TUFLOW model at a later design stage. It is not clear when this is proposed, presumably at detailed design by development stage.
- 92. Due to the scale of the development, the complexity and dynamic nature of the stormwater management system, and the risks of worsening existing off-site flooding if the design is not appropriate, a Stormwater Management Plan should be required now before a decision is made on the consent.

- 93. The Stormwater Management Plan should develop the stormwater design for the whole development (all catchments) to a preliminary design level and test its performance and effects on downstream flood risk in a hydraulic model. This includes the design of the primary and secondary system, and all stormwater treatment and attenuation devices, including consideration of the volumes, areas, depths and levels and inlet and outlet structures at the stormwater management devices, and water levels through the stormwater system from the lots to the receiving waterways. This should also include the footprint required for the stormwater management areas. The hydraulic model should include the development and proposed stormwater system, as well as the upstream and downstream catchments and drainage features and tailwater levels, and should test a range of events and durations.
- 94. The Stormwater Management Plan should be reviewed by WDC or an independent peer reviewer and accepted by WDC, before a decision is made on the consent.
- 95. Detailed design will follow for each stage as development progresses, with engineering acceptance reviews.

Proposed conditions and review of detailed design at engineering acceptance stage

- 96. The proposed conditions provided by the applicant are not explicit about the design standards required for stormwater management.
- 97. If consent is granted, I recommend that the conditions are modified to be explicit about the design standards for key aspects of the stormwater design, in addition to referencing the current WDC Code of Practice. Key aspects include:
 - a. Primary and secondary conveyance.
 - b. First flush treatment.
 - c. Attenuation and downstream flood effects.
 - d. Management of flows from upstream and sizing of waterways and culverts through the site.
- 98. The proposed conditions provided by the applicant include an “ ‘Acceptance’ Advice Note ” which appears to place very tight timeframes on WDC review and engineering acceptance of the detailed design for each stage and on independent review if WDC and the applicant do not agree. It appears to allow only five working days for WDC to advise if the information provided by the applicant is sufficient to satisfy the consent conditions and give details of any further information required, and only 10 working days for an independent review. In my opinion these timeframes are insufficient for WDC or an independent consultant to carry out a meaningful review of the design.
- 99. The timeframes for the review will depend on the information provided including its quality and complexity. Because of the potential consequences, it is important that adequate time is allowed for proper review.
- 100. I recommend that the conditions are modified to allow for the design to be peer reviewed prior to engineering acceptance, but remove reference to timeframes for this. This is consistent with industry practice around NZ for new subdivisions, particularly for large and/or complex stormwater systems.

Information Gaps / Clarification Required

- 101. As noted above, there are some issues with the design approach and a number of gaps in the information/level of design provided, and further analysis (modelling) is required to test the performance of the stormwater design and its effects, and confirm the stormwater management area which needs to be set aside within the site.
- 102. This information is needed to review the stormwater design and assess the off-site flood effects of the development, and should therefore be provided before decision is made on the application.
- 103. Further information is needed on the design of the primary and secondary systems, and all stormwater management devices through to the receiving waterways. This includes: the assumption regarding maximum groundwater levels and tailwater levels in the receiving waterways; the volumes, areas, depths and levels, operating water levels and inlet and outlet structures at the stormwater management devices; and flows and water levels through the primary and secondary stormwater back to the lots.

104. To test the performance of the design and the off-site effects of the development, hydraulic modelling needs to be carried out including: the development and proposed stormwater system; the upstream and downstream catchments and drainage features; and appropriate boundary conditions including tailwater levels. This modelling needs to test a range of events up to 100-years and durations up to 72-hours. The model needs to extend to include downstream areas of known flooding which could be affected by the development including Ōhoka, Silverstream and Kaiapoi.

Areas of Agreement

105. At a high level, the proposed approach to stormwater management should be generally suitable. This includes:

- a. primary conveyance in pipes and swales.
- b. secondary conveyance along roads.
- c. first flush treatment of runoff from up to 25 mm of rainfall depth or 5 mm/hour rainfall intensity, provided in first flush basins and wetlands (where feasible) or proprietary treatment devices.
- d. attenuation storage so that post development peak flows discharged from the site do not exceed pre-development.
- e. passing flows from upstream catchments through the site in the waterways and culverts, keeping these separate from the stormwater management system for the site runoff up to the design event.

However, there are issues with and gaps in the information provided that mean the applicant has not demonstrated that the proposed stormwater system and stormwater management area footprints are sufficient to meet the required levels of service and mitigate the off-site effects of the development.

106. Groundwater is a key consideration for the site stormwater design, including at the stormwater management areas.

107. Further modelling of the proposed stormwater system is required.

Recommendations / Conditions

108. As noted above, I recommend that further work (Stormwater Management Plan including further modelling) is carried out prior to a decision being made on the application to confirm the performance of the stormwater system, the off-site effects, and the stormwater management area footprints and therefore the development layout.

109. If consent is granted, I recommend that consent conditions are included to address the following items.

110. The primary conveyance system is designed for the 10-year ARI event.

111. The secondary conveyance system is designed for the 100-year ARI event along the roads. Secondary flow along roads must not exceed 100mm depth at the crown of the road, and allow for vehicle and pedestrian access along the road reserve.

112. First flush treatment is provided.

113. First flush treatment is provided in first flush basins and wetlands in stormwater management areas where practicable, or otherwise by approved proprietary treatment devices.

114. First flush treatment is sized as follows:

- a. For volumetric devices, for the runoff from up to 25 mm rainfall depth
- b. For flow-through devices, for the runoff from up to 5 mm/hour rainfall intensity

115. Attenuation storage is provided so that:

- a. The post-development peak flow from the site does not exceed the pre-development peak flow rate in a 5-, 10-, 50-, and 100-year ARI event of all durations from 10-minutes to 72-hours.

- b. There is no increase in the depth or duration of downstream flood for all events up to the 100-year ARI event.
 - c. Pre- vs post-development peak flows are documented at each receiving waterway or drainage path immediately downstream of the development.
116. Freeboard throughout the stormwater system is provided in accordance with WDC's Code of Practice.
117. The stormwater system design considers the effects of seasonal high groundwater levels within the site and seasonal high groundwater and flood levels in the receiving waterways.
118. The stormwater management areas are designed to consider safety including maximum batter slopes and safety benches where there is permanent water storage.
119. The stormwater management areas are designed to allow for operation and maintenance including requirements for maximum batter slopes, provision for maintenance access including into the lot, around the perimeter of the devices, and ramps into the base of the devices.
120. Hydraulic modelling is required for pre-development and post-development (including the proposed development and proposed stormwater system) to demonstrate the stormwater system performance and the effects on downstream flooding. The model needs to include the upstream and downstream catchments and drainage features, as well as the development site, stormwater system and stormwater devices, and be run for a range of events and durations. The model results need to be assessed to consider:
- a. Peak flow in each receiving waterway downstream of the development; and
 - b. Off-site flood effects downstream of the development including Ōhoka and further downstream including Silverstream and Kaiapoi (where the critical duration is expected to be longer than at the site).
121. At each stage of development, the stormwater system detailed design report, calculations, drawings and modelling are provided to WDC for review, and reviewed prior to engineering acceptance.

Overall Position / Conclusions

122. It should be feasible to manage stormwater within the site to mitigate the effects of the development on the receiving environment, however from the information provided the current design does not appear to achieve this.
- a. There are shortcomings with the design standards and design as described in the Stormwater Management Report which mean this would not be achieved with the current design.
 - b. If these issues were addressed, the stormwater management areas are likely to increase in size, which would affect the development layout.
 - c. To adequately assess the performance and effects of the proposed stormwater system, hydraulic modelling is required. This needs to include the full site stormwater system, as well as flows into the site and downstream floodplain and the effects on downstream flooding.
 - d. Further development of the design and testing of its effects is required. A Stormwater Management Plan should be provided, developing the stormwater design for the whole development to a preliminary design level and test its performance and effects on downstream flood risk in a hydraulic model. This should be provided by the applicant and independently peer reviewed before a decision is made on the application.
 - e. The effectiveness of the stormwater management system will also depend on the detailed design for each stage. Detailed design submissions therefore also need further review and engineering acceptance.

Yours sincerely



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on behalf of

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