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Flood Assessment

Milldale Fast Track Application

Milldale Stages 10 - 13

Fulton Hogan Land Development Limited ("FHLD")

25/02/2025

Final

DOCUMENT CONTROL

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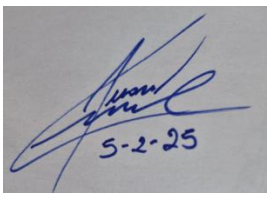
Reviewer	Juan Alvarez De Lugo – Associate Engineer 
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APPENDICES

1. INTRODUCTION

This report has been prepared in support of the application by Fulton Hogan Land Development (FHLD) for a resource consent to the Environmental Protection Authority (EPA) under the Fast-Track Approvals Act 2024 (FTAA).

Resource consent is required for bulk earthworks, subdivision, streamworks, water permits and discharge consents for the development of 606 residential lots, 27 residential super lots, jointly owned access lots (JOALS) and roads to vest, reserves to vest, and all associated works, landscaping and infrastructure.

This report covers the flood assessment for proposed Stages 10-13 of the Milldale development.

2. STATEMENT OF QUALIFICATIONS AND EXPERIENCE

Pranil Wadan

I am a Technical Director and the General Manager of Water Infrastructure & Planning at Wood and Partners Consultants Limited ("Woods"). Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since 2012.

I hold a Bachelor of Engineering degree from the University of Auckland, which I completed in 2007. I am a Chartered Professional Engineer (CPEng) and a member of Engineering New Zealand (CMEngNZ) and Water New Zealand. In addition, I also hold the following qualifications and affiliations:

- International Professional Engineer (IntPe(NZ))
- Certified Independent Hearing Commissioner
- Certificate in Company Direction & Governance

I have over 16 years of experience in stormwater design, hydrodynamic modelling, flood risk assessments, water infrastructure and stormwater management for land development.

I have been the principal author and lead stormwater engineer for a wide range of stormwater management plans and flood modelling reports to support Woods' land development, urban design and planning teams. I have been involved in and prepared numerous catchment scale flood models, detailed stormwater pipe models and integrated catchment management plans for private clients as well as for district and regional councils.

I confirm that, in my capacity as approver of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023

Juan Alvarez De Lugo

I am an Associate Water Engineer within the Water Infrastructure & Planning team at Wood and Partners Consultants Limited ("Woods"). Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since May 2019.

I hold a Bachelor of Engineering degree from the University of Auckland. I am a Chartered Professional Engineer (CPEng), member of Engineering New Zealand (CMEngNZ) and Water New Zealand. In addition, I also hold the following qualifications and affiliations:

- International Professional Engineer (IntPe(NZ))
- Water New Zealand Modellling group committee member

I have over 12 years of experience in stormwater modelling (hydrology and hydraulic), stormwater model reviews, technical report writing and review, and flood risk assessments for land development.

I have been the lead stormwater engineer responsible for employing different software packages to create/review stormwater models and analyse flood hazards for complex land development and infrastructure projects in the public and private sector. Recent projects include:

- Supporting the infrastructure development in multiple neighbourhoods for Kainga-Ora
- Stormwater models conversion for Auckland Council aimed to aid with stormwater catchment planning and decision making processes
- Creating and reviewing stormwater models and reports to support resource consent applications for multiple Milldale development stages

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Shakti Singh

I am a Water Engineer at Wood and Partners Consultants Ltd ("Woods"). Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since April 2023.

I hold the qualifications of Bachelor of Civil Engineering Technology (BEngTech) from Unitec Institute of Technology, which I completed in 2019. I am an Engineering NZ member and Rivers Group member.

I have 5 years of professional experience within the water engineering field. My key areas of expertise includes stormwater management, flood management and modelling, hydrological and hydraulic assessments, and design of urban drainage infrastructure.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Ricky Kiddle

I am a Graduate Water Engineer at Wood and Partners Consultants Ltd ("Woods"). Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since February 2024.

I hold the qualifications of Bachelor of Engineering with Honours from Canterbury University, which I completed in 2023. I am an Engineering NZ emerging professional member.

I have 1.5 years of professional experience in the water engineering field. My experience includes stormwater management, flood management, and stormwater modelling.

I confirm that, in my capacity as author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

3. BACKGROUND

The Wainui East Stormwater Management Plan (V4) (Woods, September 2016) is the adopted Stormwater Management Plan (SMP) for the proposed development area. The flood assessment work undertaken as part of the proposed Stages 10-13 of the Milldale development is consistent with the SMP.

This report is to be read in conjunction with the Wainui East Model Build Report (Woods, July 2016), which is included as an Appendix in the Wainui East SMP (refer to Appendix A), which was reviewed and accepted by Auckland Council's technical specialists at the time.

Since the adoption of the Wainui East SMP, the flood model has undergone various updates and high-level reviews with Healthy Waters, the most recent being in May 2022.

The high-level review undertaken in May 2022 resulted in updates to the following:

- Tailwater level boundary conditions
- Wainui Road bridge losses
- Overflow representation; and
- Stream bed roughness.

It is noted that all queries and updates raised by Healthy Waters were undertaken as agreed and a copy of the full query list and correspondence can be found in Appendix B.

4. FLOOD MANAGEMENT

The adopted Wainui East SMP breaks the catchment into five stormwater management zones (Zones A-E as shown in Figure 1), these zones detail both the stormwater and flood management approach to be incorporated based on various factoring including location and discharge environment.

The Stormwater Management Zones for Stages 10-13 are as follows:

- Stage 10 – 11 – Zone C – Recommended flood management approach is pass flows forward; and
- Stage 12 – 13 – Zone D – Recommended flood management approach is pass flows forward, option to attenuate (if required).

The recommended flood management approach as per the adopted SMP for both Zones C & D is to pass flows forward. To enable pass flows forward, upgrades to existing culverts are required to facilitate upstream flows.

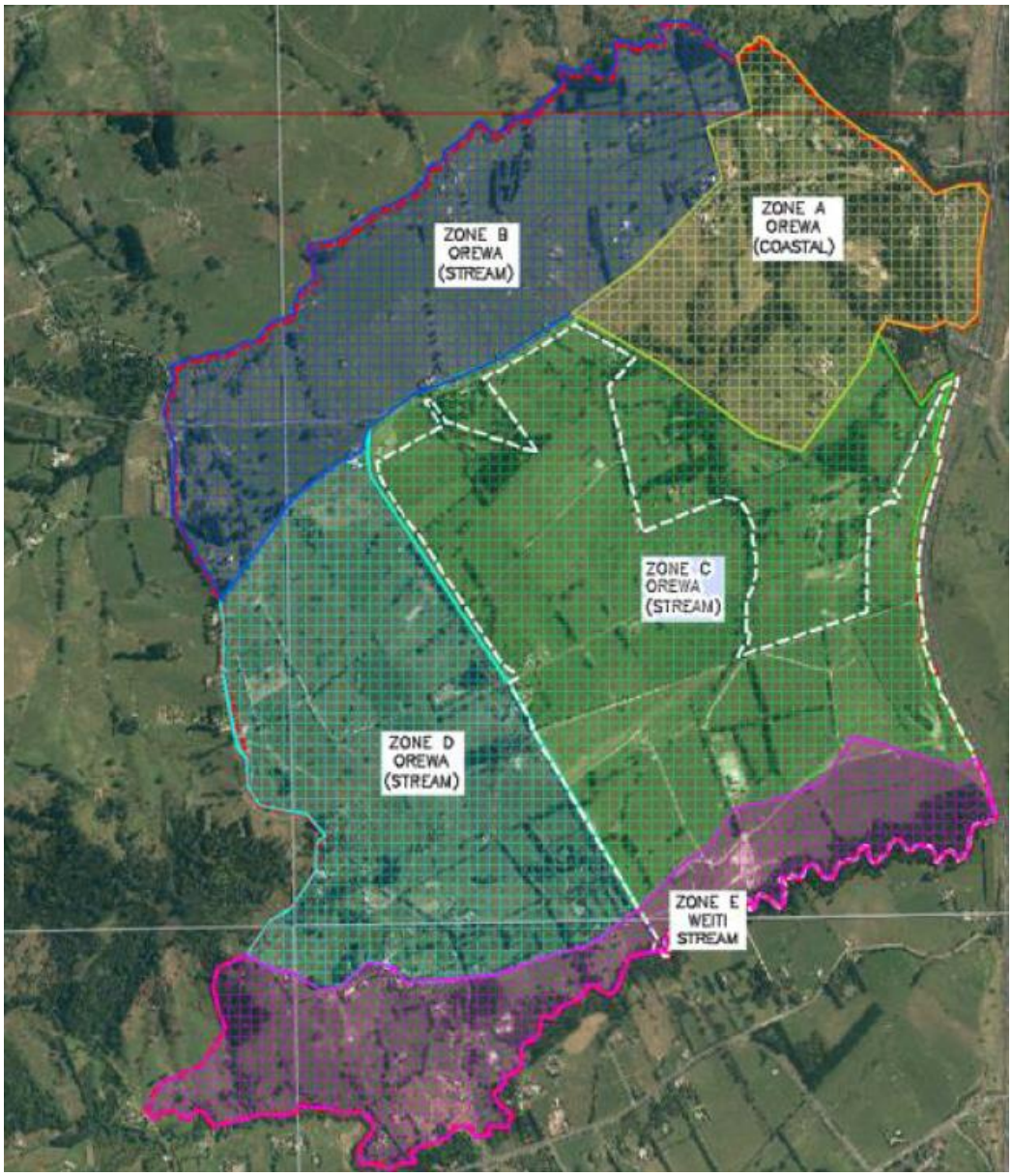

Figure 1: Stormwater Management Zones

Previous modelling and flood assessments showed that there is no overtopping risk at the Wainui Road Bridge and this was agreed with Healthy Waters as part of the modelling query list generated during the high-level review in 2022 (Further details in Section 9.1). The most recent assessment was undertaken to highlight potential effects (if any) that result from the increased flows along Waterloo Creek generated from upstream developed area under maximum probable development (MPD) and confirmed that the pass flows forward strategy is appropriate.

An effects assessment has been undertaken for 147 Argent Lane as this landholding is not owned by the applicant. 147 Argent Lane is located downstream of proposed Stages 12 & 13. This effects assessment is detailed in Section 8 of this report.

The flood modelling scenarios undertaken for the Stages 10-13 of the Milldale development flood assessment are summarised as follows:

- Pre-Development – Existing Development (ED) - land use as per existing / grassed state; and
- Post-Development – Maximum Probable Development (MPD) - MPD land use for contributing catchment related to and including the Milldale development extent. The post-development model scenarios simulated were as follow:
    a. 10-year and 100-year ARI storm event with allowance for 2.1 °C temperature increase by 2090 as per the adopted SMP and operative Stormwater Code of Practice, Version 3, Jan 2022 (SWCoP)
    b. Blockage scenario for 100-year ARI storm event with allowance for 2.1°C temperature increase by 2090 as per the operative Stormwater Code of Practice (V3 - Jan 2022); and
    c. For the purpose of ensuring resilience, an additional 100-year ARI storm event with allowance for 3.8 °C temperature increase by 2110 as per the draft/non-operative Stormwater Code of Practice (V4 – June 2021).

5. SITE DESCRIPTION

The site subject to this application is located within the Milldale development and referred to as the Milldale Stages 10 – 13 subdivision areas (the Site). The Site consists of land covered by Lot 9006 DP 602895; Lot 9007 DP 602895; Lot 3 DP 151229; Lot 1 DP 147739; Lot 1 DP 488814; Lot 2 DP 488814; Lot 3 DP 488814; and Lot 2 DP 147739. Stages 10 – 13 are located within the northern and western extents of the Milldale development and comprise the remaining undeveloped greenfield stages of Milldale.

Overall, the Site covers a total area of approximately 71 ha. The Site is bordered by Wainui Road to the north, Lysnar Road to the north-east, and undeveloped land to the west. Previously consented Milldale stages (Stages 5-8) and the Milldale Town Centre are located to the south of the Site.

A full description of the Site and surroundings is provided in the application Assessment of Environmental Effects (AEE).

5.1. Location & Stages Boundaries

The total land area associated with the Milldale Stages 10-13 is approximately 71 ha. Each individual stages' areas are as follow:

- Stage 10: 12.4 ha
- Stage 11: 13.1 ha
- Stage 12: 19.1 ha; and
- Stage 13: 25.9 ha.

The third-party land at 147 Argent Lane is approximately 12.3 ha. Figure 2 shows the boundaries of the Milldale Stages 10-13 and 147 Argent Lane (third-party land).

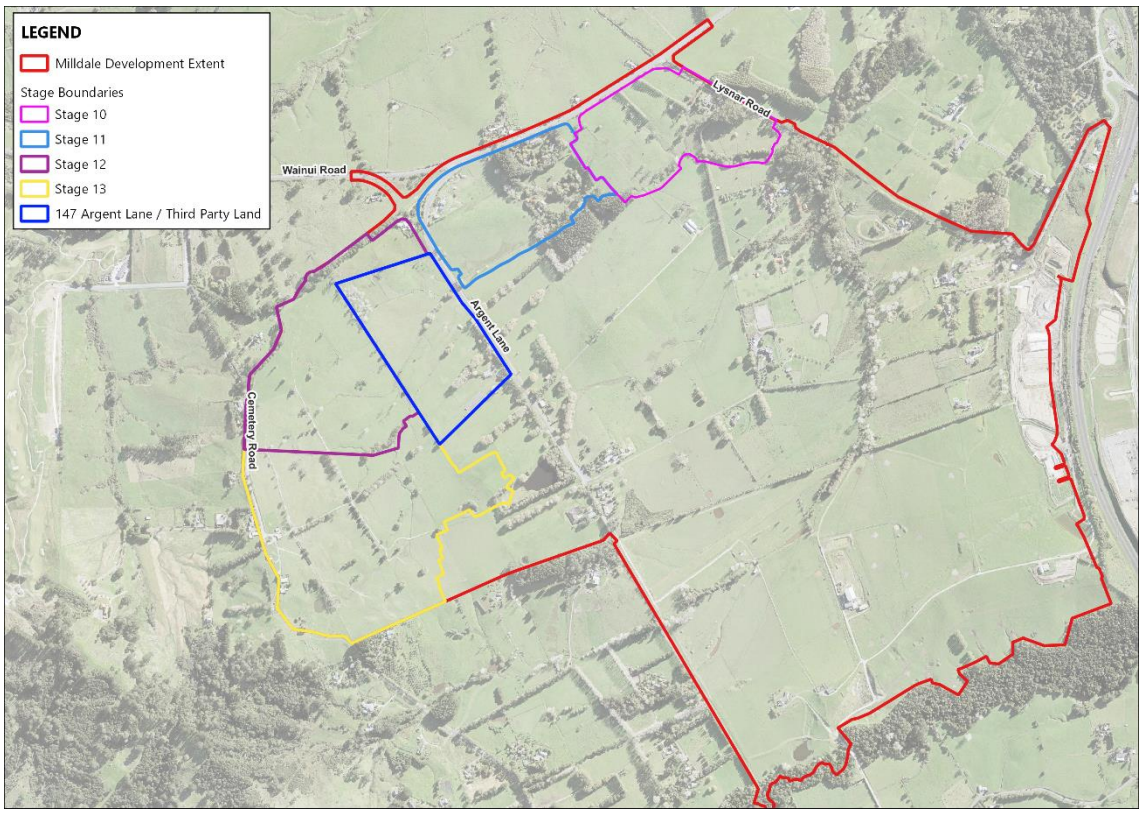

Figure 2. Milldale Stages 10-13 boundaries and 147 Argent Lane (third-party land)

5.2. Topography and Watercourses

The Milldale development site is located within a natural basin defined by Cemetery Road and Wainui Road as the ridgelines that form the northern and western catchment boundaries. The gradient of the Site steepens towards these ridgelines and features small gullies.

A permanent watercourse, identified as Stream 21 flows adjacent to Stage 10 and Stage 11 development boundaries and ultimately discharges to the north, towards Orewa River. The Waterloo Creek is another water body which transverses the Milldale development while flowing north-east towards the Orewa River and ultimately discharges to the Hauraki Golf. A smaller watercourse, referred to as "Endsley" stream traverses the Milldale development at the eastern end. All watercourses, including those proposed within Stages 10-13 can be seen in Figure 3.

Woods originally used raw ground classified point cloud data from the Auckland Council LiDAR Dataset 2013 to represent the surface for flood modelling.

Topography for areas within consent/under consent development stages is modelled with a combination of LiDAR 2016, topo and either design surface or as-built surface, depending on the development progress of previous stages and availability of data.

Surface for the post development model scenarios has been updated to include the proposed design contours for Stages 10-13 and the wider Milldale development consented to date.

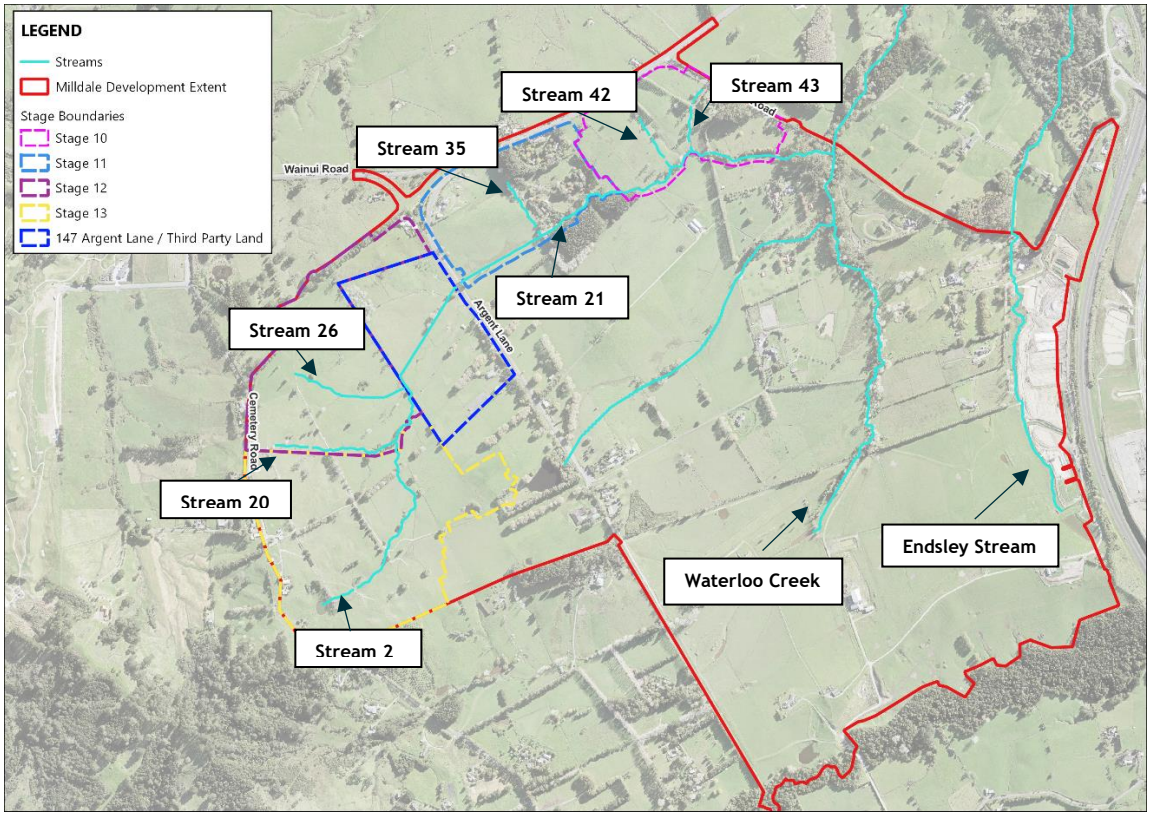

Figure 3: Watercourses within the Milldale development

5.3. Pre-development Scenario Landuse and Stormwater Infrastructure

The pre-development scenario assumed ground cover to be predominantly pasture with several isolated bush areas, tree shelter belts and rural residential/lifestyle blocks. Furthermore, the pre-development scenario considered the main gully system to be generally covered by trees and/or bush, with several farm dwellings and limited stormwater structures located across the Milldale development extent.

The landuse and stormwater infrastructure assumed and included when developing the pre-development scenario for the Milldale development Stages 10-13 is consistent with the pre-development scenario in the Wainui East SMP (Woods, Sept 2016). It is noted that the structure across Argent Lane and adjacent to Rillside Crescent is shown as having a 1600 mm diameter in Auckland Council Geomaps, however the field survey confirmed a 1500 mm diameter. Figure 4 shows the stormwater structures within the Milldale development extent included in the pre-development scenario.

Figure 4: Stormwater infrastructure included in pre-development scenarios

6. FLOOD MODELLING

The flood modelling builds on the flood model originally developed in consultation with Auckland Council's technical specialists when preparing the Wainui East Model Build Report (Woods, July 2016). The purpose of the flood modelling is to assess any flood effects upstream, downstream and within Stages 10-13 whilst also providing an updated flood extent.

Since the adoption of the Wainui East SMP (Woods, Sept 2016), the flood model has undergone various updates and high-level reviews with Healthy Waters, the most recent being in May 2022 and a copy of the full query list and correspondence can be found in Appendix B.

The high-level review undertaken in May 2022 resulted in updates to the following:

- Tailwater level boundary conditions
- Wainui Road bridge losses
- Overflow representation; and
- Stream bed roughness

It is noted that all queries and updates raised by Healthy Waters were undertaken as agreed.

A summary of the base parameters for all flood model scenarios and the parameters updates undertaken in the post- development model scenarios are covered in the sections below. Further details on the flood model parameters can be found in the Wainui East Model Build Report (Woods, July 2016).

The post-development flood model scenarios also include topography and landform updates within the proposed development Stages 10-13 and previous Milldale development consented stages with design and as-built data, including proposed or already constructed stormwater structures.

6.1. Flood Model Base Parameters

Table 1 summarises base parameters used for all modelled scenarios and they are consistent with the Wainui East Flood Model Build Report (Woods, July 2016). The sub-catchments in the post-development scenarios assume maximum probable development and maintained a weighted impervious coverage of 65%.

Table 1 – Pervious and impervious base parameters

	Pervious	Impervious
Curve Number	74	98
Initial Abstraction	5	1*
Slope calculation method	Equal-area method	
Time of concentration	Calculated as per TP108 method, minimum of 10 minutes	

*Ia of 1mm was used as XPStorm modelling software does not allow a value of 0.

6.2. Flood Model Parameters Updates

6.2.1. Subcatchment Delineation

The sub-catchment delineation has been updated and adjusted to reflect the landform changes undertaken as part of Stages 10-13 Milldale development and previously consented stages. The sections below show a subcatchments delineation comparison between the pre-development scenario and the post-development scenarios.

Figure 5 shows a schematic of the pre-development model scenario subcatchments which has been slightly modified from the delineation outlined in the Wainui East Flood Model Build Report (Woods, July 2016).

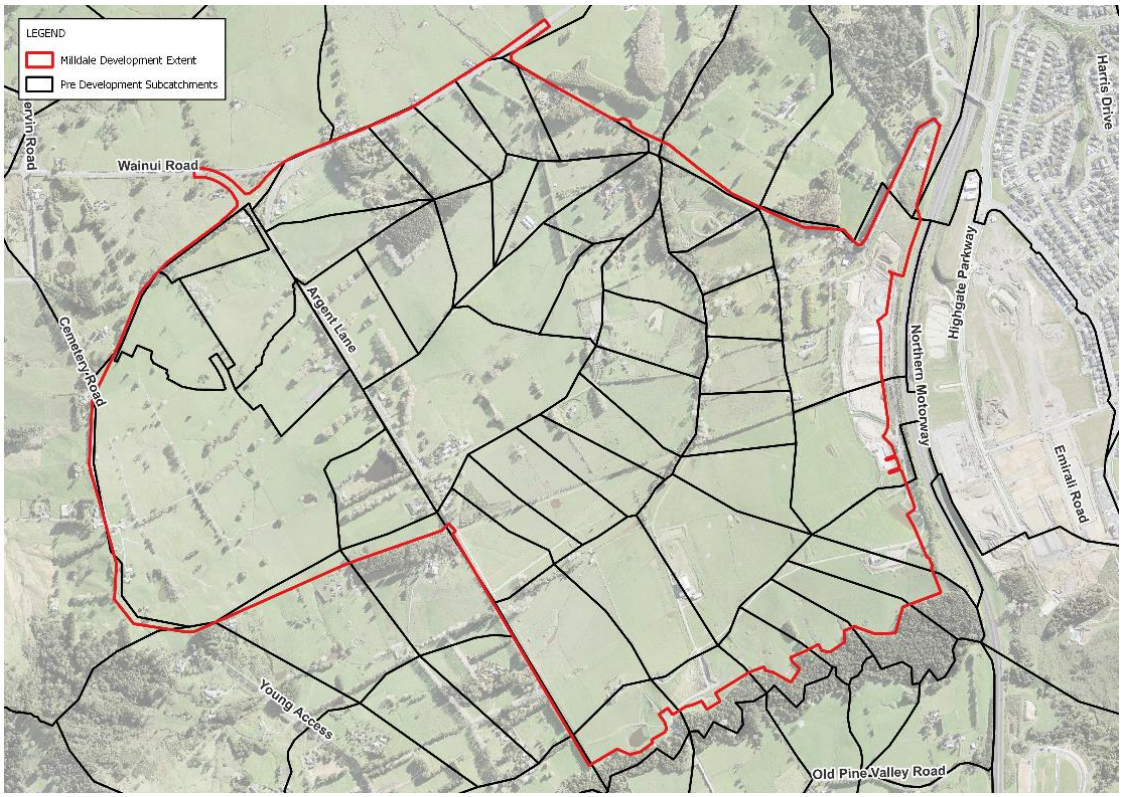

Figure 5. Pre-development scenarios subcatchments delineation

The post-development model scenario subcatchments delineation was based on the post development surface contours from Milldale Stages 10-13 and previous Milldale stages consented to date it is shown in Figure 6.

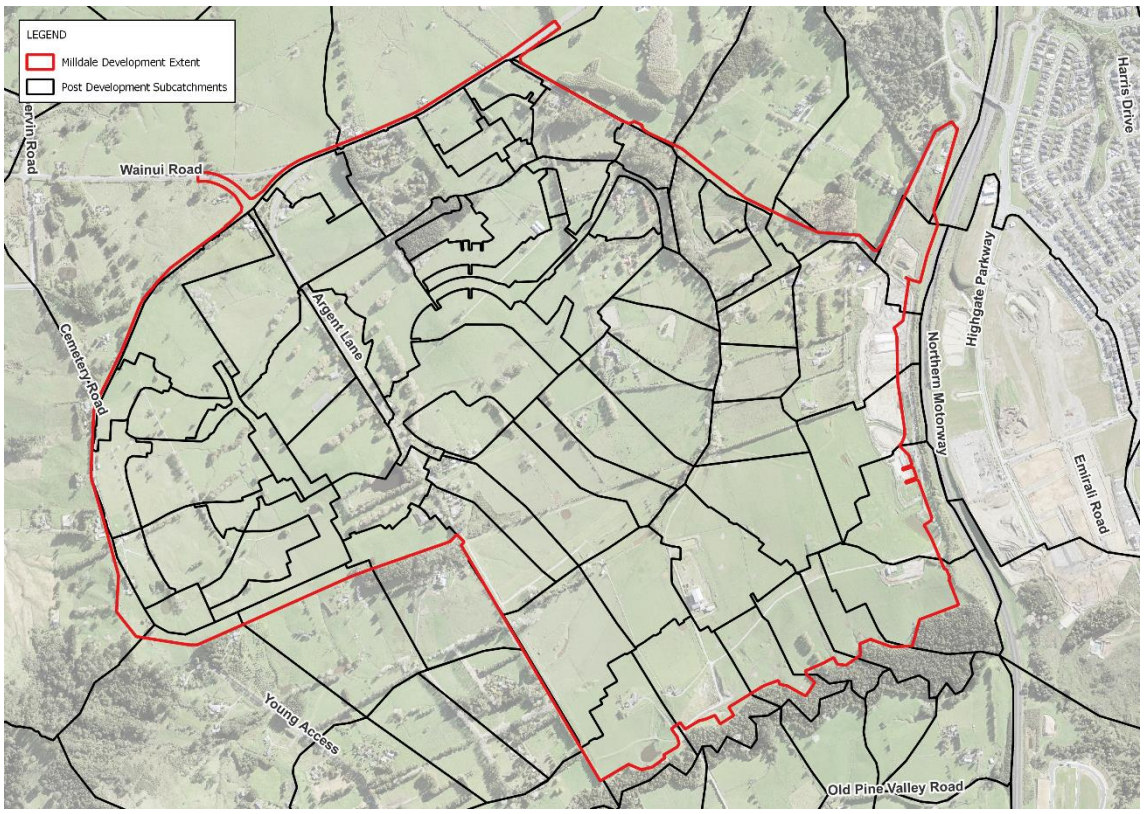

Figure 6. Post-development subcatchments delineation for Stages 10-13 Milldale development and previously Milldale consented stages

6.2.2. Rainfall Depths

The rainfall depths used in the flood model scenarios are as per the adopted Wainui East SMP (Woods, Sept 2016) with allowance for 2.1°C temperature increase by 2090 and in accordance with the operative Stormwater Code of Practice (V3, Jan 2022).

It is noted that the draft/non-operative Stormwater Code of Practice (V4, March 2024) has been published for industry feedback, and whilst this version is not operative, considerations has been made with respect to the future temperature increase of 3.8°C by 2110 and sea level rise.

The rainfall depths applied in the flood model are summarised in Table 2 as follows:

Table 2: Flood Model Rainfall depths with climate change allowances

Storm Event	Rainfall Depth (mm)	
	2.1 °C	3.8 °C
10-year	164.1	190.0
100-year	262.8	298.6

6.2.3. Boundary Conditions

The boundary conditions applied in the stormwater model for the Orewa River and Weiti Creek are shown in Table 3. It is noted that the boundary conditions applied in the Wainui East SMP (Woods, Sept 2016) were lower as the allowance for sea level rise was only +0.50 m. The updated boundary conditions are reflective of the high-level review queries raised by Healthy Waters in May 2022 and are based on the Mean High-Water Springs (MHWS) 10 percentile levels and allow for +1 m of sea level rise, as per Auckland Unitary Plan (AUP(OP)).

Table 3: Boundary conditions based on MHWS 10%ile allowing for +1m sea level rise

	Boundary Condition (May 2022)
Orewa River	2.44m RL
Weiti Creek	2.51 m RL

6.2.4. Model Surface Grid

The post-development model scenarios use 1m and 3m resolution grids in the 2-D domain. The 1m grid allows for better definition and accuracy in model results, particularly within watercourses and Argent Lane, and the 3m grid has been used for the remaining area of the model extent. It is noted that 3m grid have been retained around areas where watercourses have been represented in the 1-D domain.

Figure 7 shows the grid extents in the 2-D domain grids and watercourses represented in the 1-D domain.

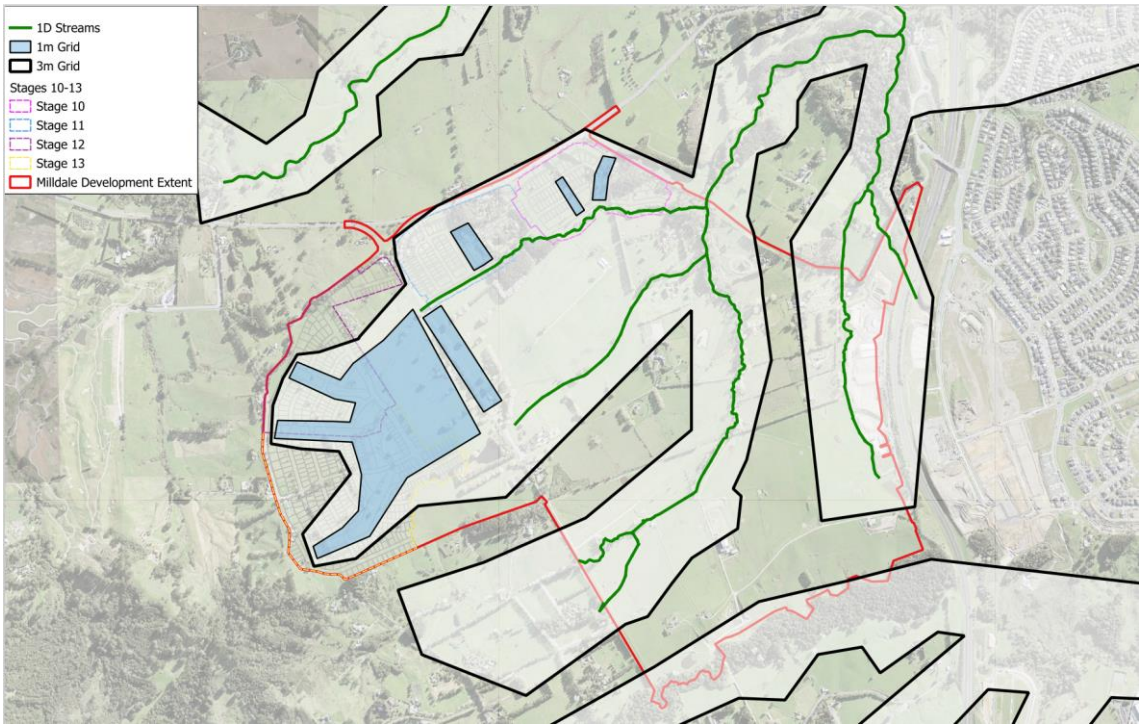

Figure 7: Post-development model scenarios grid extents in the 2D domain and watercourses represented in the 1-D domain

7. FLOOD MODEL RESULTS

Flood modelling has been undertaken to assess if any flood effects result from the proposed development of Milldale Stages 10-13 to the upstream or downstream areas. The flood modelling has been undertaken in line with recommended flood management strategy i.e. pass flow forward, as per the Wainui East SMP (Woods, Sept 2016).

Water levels and flood depth results were extracted from the simulated model scenarios and used to assess flood effects (if any) for the 10-year and 100-year ARI events with allowance for 2.1°C climate change (as per the operative Stormwater Code of Practice, V3-Jan 2022)

The flood assessment also covers an analysis of the minimum freeboard requirements and blockage for culvert structures in accordance with the Stormwater Code of Practice (V3, Jan 2022). The culverts' freeboard requirements are covered in more detail in Section 7.4 and the culverts blockage scenario in Section 7.4.1.

An additional resilience scenario has been included in the flood assessment assuming future climate change allowance for 3.8°C temperature increase by 2110 as stated in the draft / non operative Stormwater Code of Practice (V4, March 2024) and it is discussed in Section 9. The Wainui Road bridge structure has also been included in the flood assessment as part additional scenario and it is covered in more detail in Section 9.1. It is noted that previous modelling and flood assessments showed that there is no overtopping risk at the Wainui Road Bridge and this was agreed with Healthy Waters as part of the modelling query list generated during the high-level review in 2022.

7.1. Modelled Scenarios

There were a total of five modelled scenario and they are summarised in Table 4.

Table 4 -Modelled scenarios summary

#	Model Scenario	Rainfall Event	Land Use	Landform	Stormwater Network	Purpose
1	Pre-Development (ED)	100-Year ARI + 2.1°C future climate change	Existing development for full model extent	Topographical Survey LiDAR 2016 LiDAR 2013	No primary network within the development Includes existing 600mm and 1500 mm diameter culvert under Argent Lane.	To provide a baseline reference model which is used to compare the effects from proposed development
2	Post-Development (MPD)	10-Year ARI + 2.1°C future climate change	Maximum Probable development (MPD) for Milldale development area and all other areas discharging to Orewa stream. Existing development for the remaining model extent	Design Surface Topographical Survey LiDAR 2016 LiDAR 2013	No primary network within the development Includes proposed culverts/structures for development stages 10-13 and proposed U-culverts along Stream 21 watercourse. Includes stormwater conveyance structures from previous Milldale development stages	To assess the culvert performance as per the Stormwater Code of Practice, Version 3, Jan 2022.
3		100-Year ARI + 2.1°C future climate change				To assess flood effects (if any) resulting from Stages 10-13 Milldale development
Additional Scenarios						

4	Post-Development (MPD) assuming culverts blockage	100-Year ARI + 2.1°C future climate change	Maximum Probable development (MPD) for Milldale development area and all other areas discharging to Orewa stream. Existing development for the remaining model extent	Design Surface Topographical Survey LiDAR 2016 LiDAR 2013	No primary network within the development. Includes proposed culverts/structures proposed for development stages 10-13 and allows for blockage as per SWCOP, Ver 3, Jan 2022. Includes proposed U-culverts along Stream 21 watercourse and allows for 25% blockage. Includes stormwater convevance	To assess the proposed infrastructure performance with allowance for blockage and overtopping risk/hazard that may be posed to the surrounding areas (if any).
5	Post-Development (MPD)	100-Year ARI + 3.8°C future climate change			No primary network within the primary development Includes proposed culverts/structures proposed for development stages 10-13 and proposed U-culverts along Stream 21 watercourse. Includes stormwater conveyance structures from previous Milldale development stages	To assess the resiliency of the proposed infrastructure with allowance for future 3.8° temperature increase by 2110.

7.2. Pre-Development Model Results

The pre-development scenario flood depth results for the 100-year ARI events (including 2.1 °C climate change) is shown in Figure 8. It is noted that the flood depth model results are filtered by 50 mm (consistent with the Wainui East SMP, Woods, 2016).

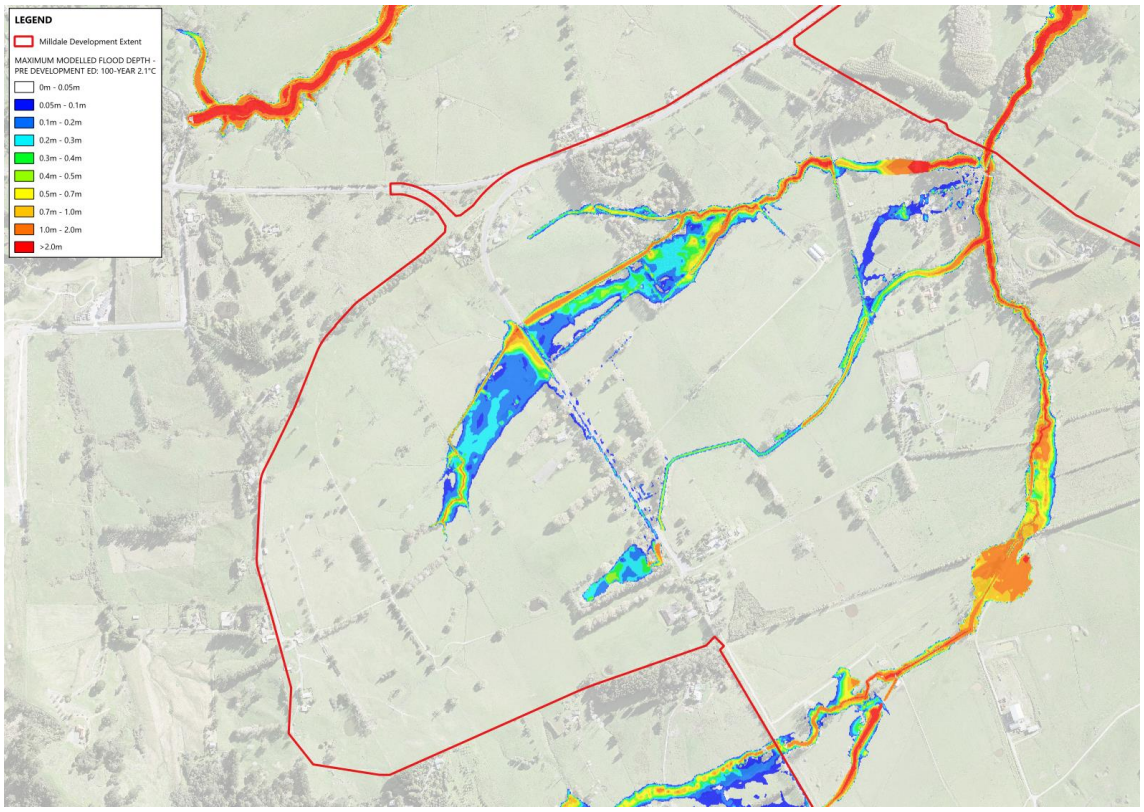

Figure 8: Pre-development scenario model flood depth results (100-year ARI event including 2.1 °C climate change)

7.3. Post-Development Model Results

The post-development scenario flood depth results for the 10-year and 100-year ARI events (including 2.1 °C climate change) are shown in Figure 9 and Figure 10. It is noted that the flood depth model results are filtered by 50 mm (consistent with the Wainui East SMP, Woods, 2016).

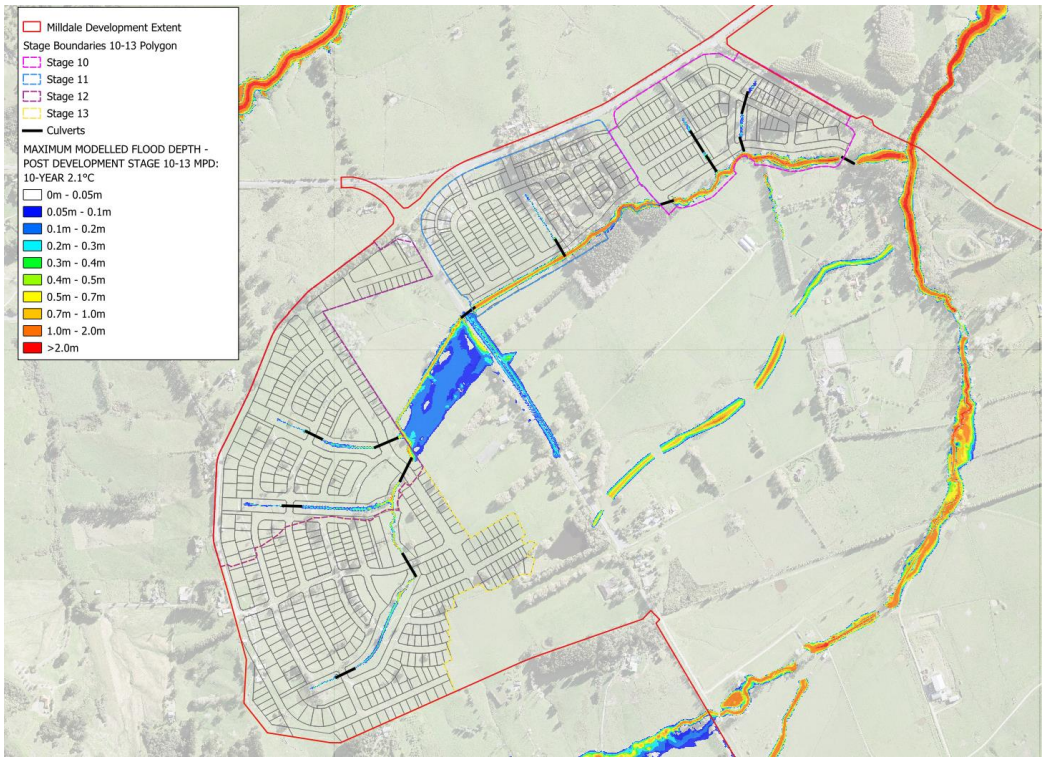

Figure 9: Post-development scenario model flood depth results (10-year ARI event including 2.1 °C climate change)

Figure 10: Post-development scenario model flood depth results (100-year ARI event including 2.1 °C climate change)

7.4. Culvert Assessments

The Milldale development Stages 10-13 include a total of 14 culvert structures as shown in Figure 11. It is noted that all three culvert structures along Stream 21 have an inverted-U shape and retain the natural stream cross section. The inverted-U shape culverts cross section can be found in Appendix C.

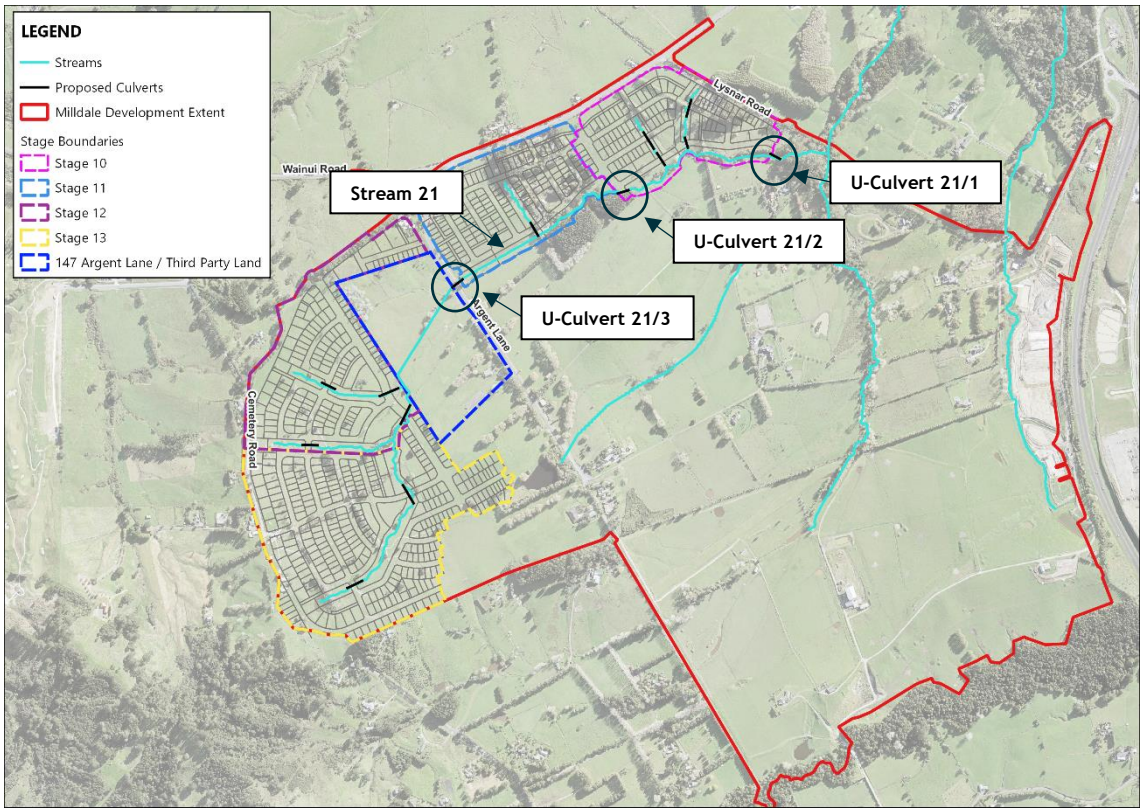

Figure 11: Culvert structures included in Milldale Stages 10-13

The post-development model results also show that all culvert structures comply with the freeboard requirements stated in the operative Stormwater Code of Practice (V3, Jan 2022) for both 10 and 100-year ARI storm events (inclusive of 2.1°C future climate change) as:

- *The maximum water level in the culvert does not exceed the soffit level of the pipe during a 10- year ARI storm event (inclusive of 2.1°C future climate change).*
- *The maximum headwater level has a freeboard of 500mm to the top of the edge of seal and maximum headwater depth less than 3m during a 100-year ARI storm event (inclusive of 2.1°C future climate change).*

Figure 12 and Figure 13 show the culvert locations and notations within the development.

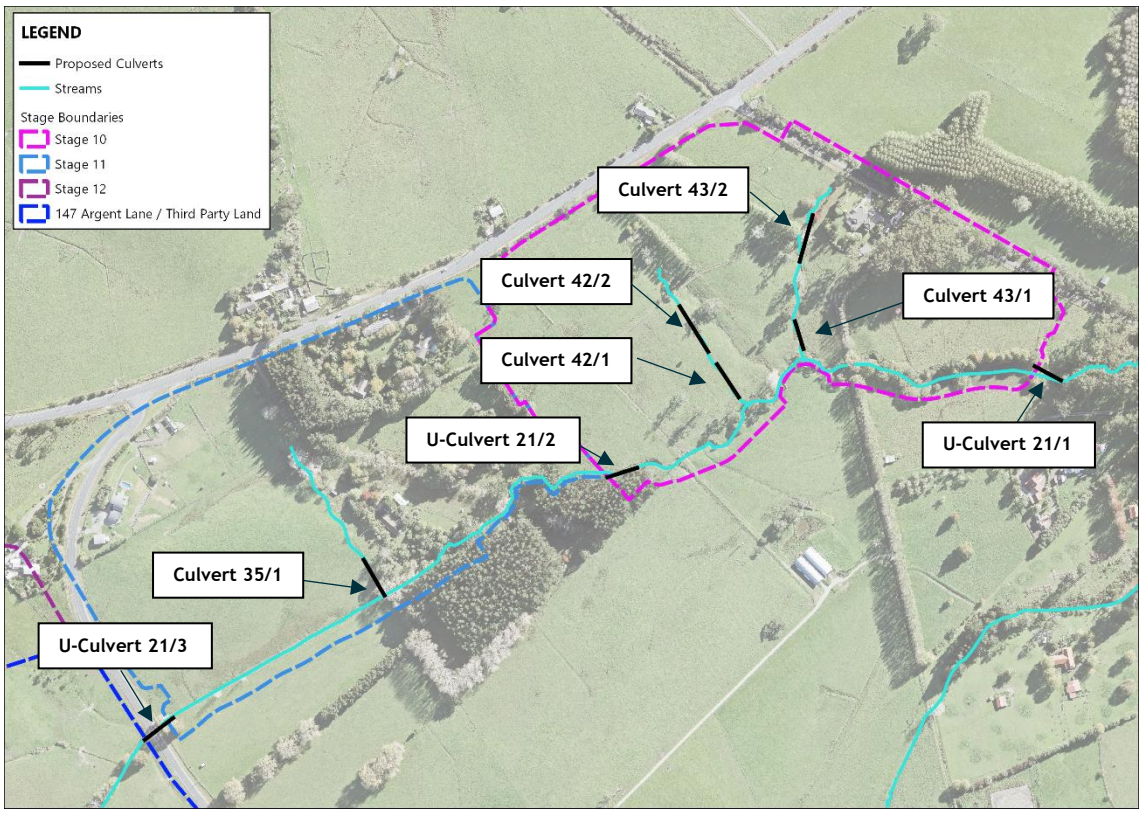

Figure 12. Proposed culverts within Stages 10 & 11

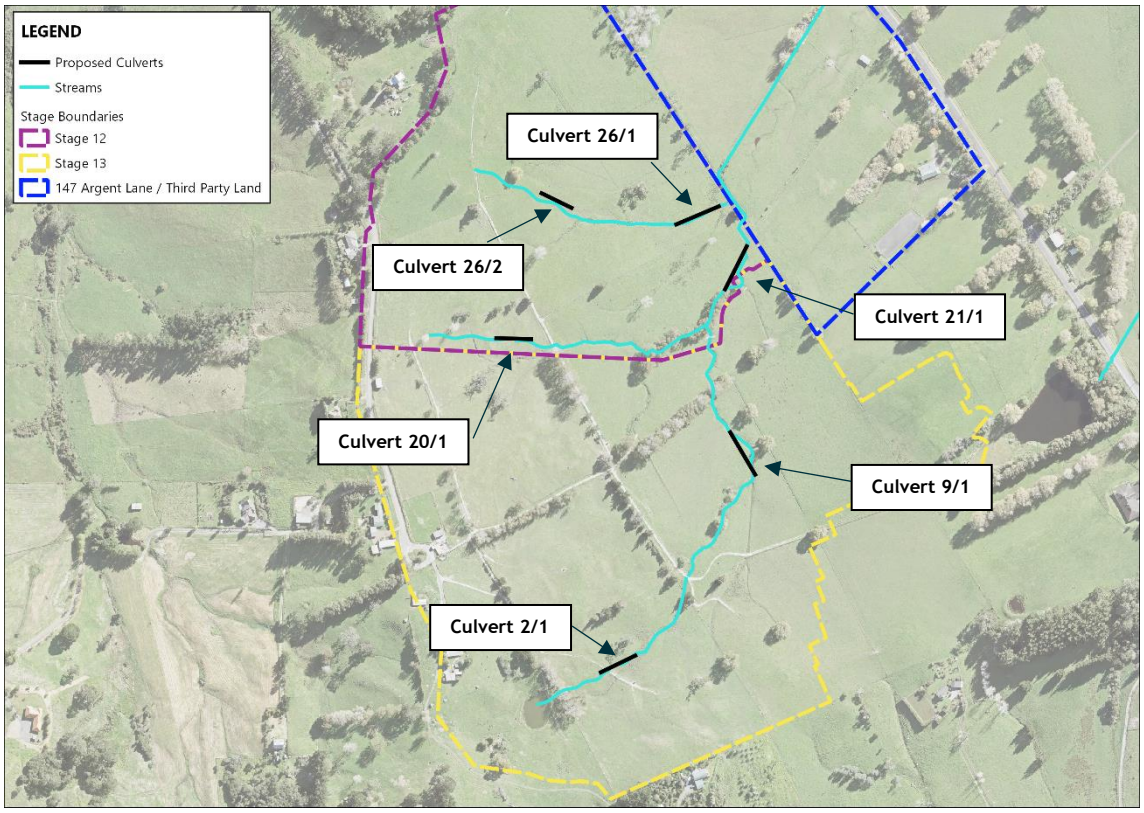

Figure 13. Proposed culverts within Stages 12 & 13

Table 5 and Table 6 provide a summary showing that all proposed culverts within Milldale Stages 10-13 are compliant with the freeboard requirements stated in the operative Stormwater Code of Practice (V3, Jan 2022) for both 10- and 100-year ARI storm events (inclusive of 2.1°C future climate change). It is noted that the final engineering design for all proposed structures within Milldale Stages 10-13 development will be completed during the detailed design phase.

Table 5 - 10-year ARI (2.1°C climate change) SWCOP v3 culvert compliance summary

STAGE 10				
Culvert #	**Diameter (mm)**	**Soffit level (m RL)**	**Headwater level (m RL)**	**Compliance Status**
UCulvert 21/1	U-Culvert	10.9	9.5	Complies
43/1	1050	16.6	16.3	Complies
43/2	825	24.7	24.1	Complies
42/1	1050	16.6	16.5	Complies
42/2	825	21.7	21.4	Complies
UCulvert 21/2	U-Culvert	19.3	17.2	Complies
STAGE 11				
Culvert #	**Diameter**	**Soffit level (m RL)**	**Headwater level**	**Compliance Status**
35/1	900	22	21.9	Complies
UCulvert 21/3	U-Culvert	26.7	25.1	Complies
STAGE 12				
Culvert #	Diameter	Soffit level (m RL)	Headwater level	Compliance Status
26/1	1200	33.3	32.4	Complies
26/2	825	46.1	46	Complies
21/1	2100	32.3	32	Complies

20/1	1050	52.6	51.9	Complies
STAGE 13				
Culvert #	Diameter	Soffit level (m RL)	Headwater level	Compliance Status
9/1	1800	39.1	38.6	Complies
2/1	900	57.4	57.3	Complies

Table 6 - 100-year ARI (2.1°C) SWCOP compliance summary

STAGE 10						
Culvert #	**Diameter (mm)**	**Headwater level (m RL)**	**Headwater depth (m)**	**Top of embankment (m RL)**	**Freeboard (m)**	**Compliance Status**
U Culvert 21/1	U-Culvert	10.1	3.2	12.6	2.5	Complies
43/1	1050	16.6	0.8	18.6	2.0	Complies
43/2	825	24.7	1.0	25.9	1.2	Complies
42/1	1050	17.1	1.5	18.0	0.9	Complies
42/2	825	21.7	0.9	23.5	1.8	Complies
UCulvert 21/2	U-Culvert	17.7	1.4	21.0	3.4	Complies
STAGE 11						
Culvert #	**Diameter**	**Headwater level (m RL)**	**Headwater depth (m)**	**Top of embankment (m RL)**	**Freeboard (m)**	**Compliance Status**
35/1	900	22.3	1.0	24.3	1.9	Complies

UCulvert 21/3	U-Culvert	25.4	2.2	27.4	2.0	Complies
STAGE 12						
Culvert #	**Diameter (mm)**	**Headwater level (m RL)**	**Headwater depth (m)**	**Top of embankment (m RL)**	**Freeboard (m)**	**Compliance Status**
26/1	1200	33.2	0.7	35.2	2.0	Complies
26/2	825	46.4	1.0	47.5	1.1	Complies
21/1	2100	33.0	2.5	34.8	1.8	Complies
20/1	1050	52.5	0.9	53.6	1.1	Complies
STAGE 13						
Culvert #	**Diameter (mm)**	**Headwater level (m RL)**	**Headwater depth (m)**	**Top of embankment (m RL)**	**Freeboard (m)**	**Compliance Status**
9/1	1800	39.3	2.0	41.8	2.5	Complies
2/1	900	57.9	1.0	58.8	0.9	Complies

7.4.1. Culvert Blockage Assessment

Culverts proposed as part of Milldale Stages 10-13 are required to be assessed assuming blockage as per the Stormwater Code of Practice (V3, Jan 2022). The culverts blockage assessment criteria is as follow:

- For culverts less than DN1500 diameter, there should be a blockage allowance of 100%
- For culverts greater than or equal to DN1500, there should be a blockage allowance of 50%.

The post-development culvert blockage model scenario flood depth results for 100-year ARI (with allowance for 2.1°C future climate change) is shown in Figure 14. It is noted that the flood depth model results are filtered by 50 mm (consistent with the Wainui East SMP, Woods, 2016).

The post-development culvert blockage model scenario assumed all the proposed culverts within Milldale stages 10-13 to be fully or partially blocked and the three inverted U-shape culvert structures along Stream 21 watercourse have been assumed to be blocked by 25%.

The culvert blockage assessment aims to demonstrate resilience for proposed infrastructure in an event of blockage. This is not considered to be suitable for assessing flood effects (if any) on areas upstream, downstream and within the Site.

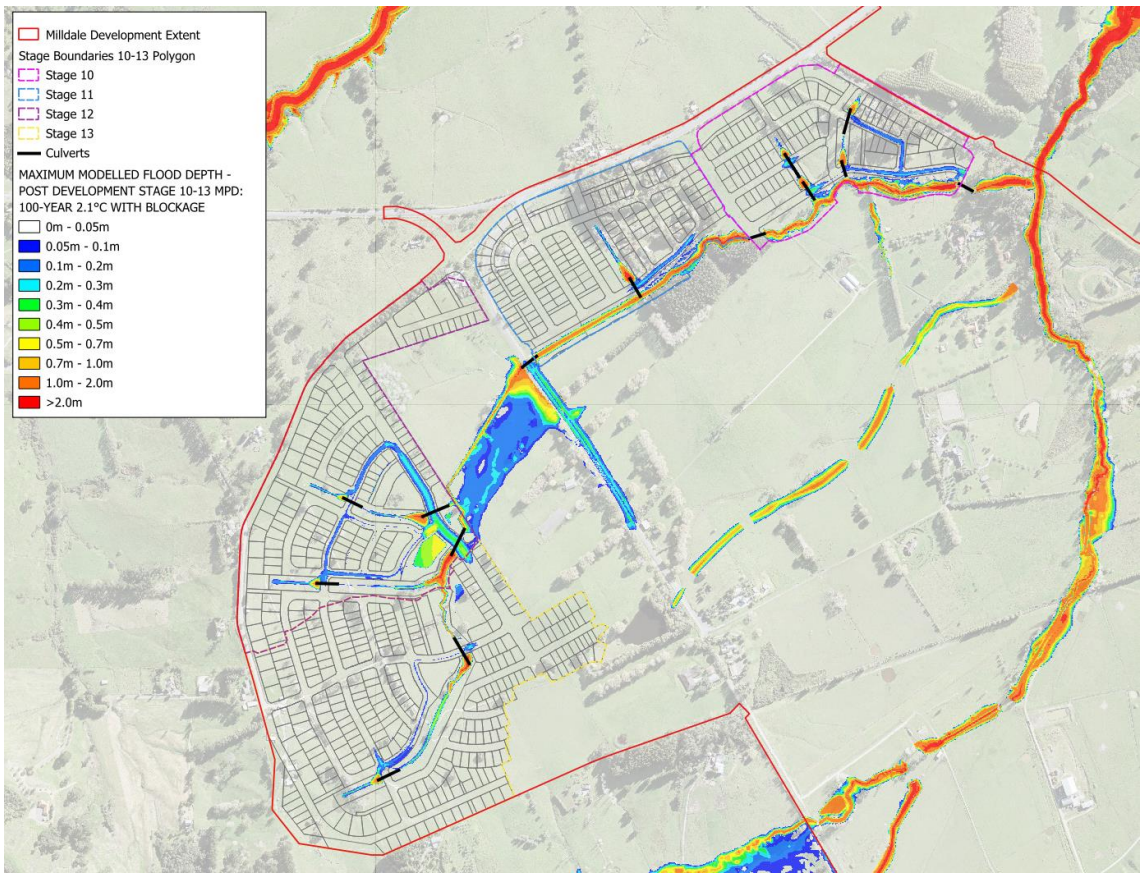

Figure 14: Maximum flood depth assuming culverts blockage for the 100-year ARI storm event including 2.1°C climate change maximum flood depth

The culvert blockage assessment shows that:

- There is road overtopping where the culverts are assumed to be fully blocked; and
    - In most instances, the flows overtopping the culvert immediately returns to the stream; and
    - Instances where flows overtop and do not immediately return to the stream, they are fully contained within the roads and do not enter lots.
- There is no flooding entering the proposed lots boundaries within the proposed Milldale Stages 10-13 development during a 100-year ARI storm event including 2.1°C climate change scenario where proposed culverts are assumed to be blocked as per SWCOP (V3, Jan 2022).

8. FLOOD EFFECTS ASSESSMENT

The flood effects assessment consists of a maximum flood depth results comparison between the pre-development and post-development scenarios.

Results comparing the maximum flood depth of post-development and pre-development model scenario for the 100-year ARI event (including 2.1 °C climate change) are shown in Figure 15.

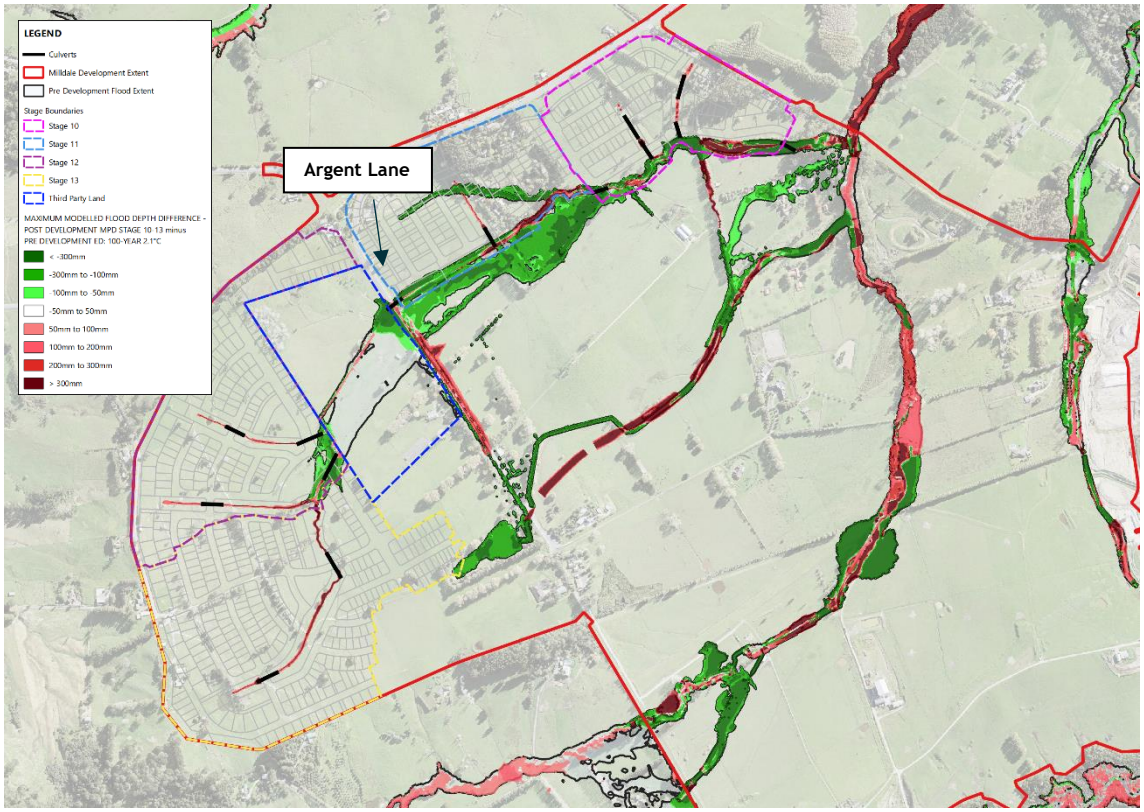

Figure 15: Afflux comparing post-development 100-year ARI event (inclusive of 2.1 °C climate change) minus pre-development 100-year ARI event (inclusive of 2.1 °C climate change) maximum flood depth model results

The flood effects assessment shows that:

- Flood depth increases are limited to the stream corridors and are contained within the pre-development flooding extent
- A detailed flood path assessment has been undertaken to demonstrate that flows can be adequately conveyed along Argent Lane corridors, and this is covered in more detailed in Section 8.1
- The post-development flood extent has reduced when compared against the pre-development flood extent resulting from the stormwater structures upgrades and the pass flow forward approach; and
- Overall, there are no upstream or downstream flood effects caused by the proposed Milldale Stages 10-13 development for the 100-year ARI events with allowance for 2.1°C climate change.

8.1. Argent Lane Overland Flow Path Assessment

An overland flow path assessment memorandum has been prepared by Woods, dated March 2024, which supported an Engineering Plan Approval application for the construction of roads in Stages 6D, 6G, and Local Centre of the Milldale development. Furthermore, this memorandum was used to determine whether vehicular and pedestrian safety requirements in accordance with the Auckland Transport – Transport Design Manual (AT TDM) are met. The extent of the overland flow path assessment is approximately 14.3 ha and it can be seen in Figure 16.

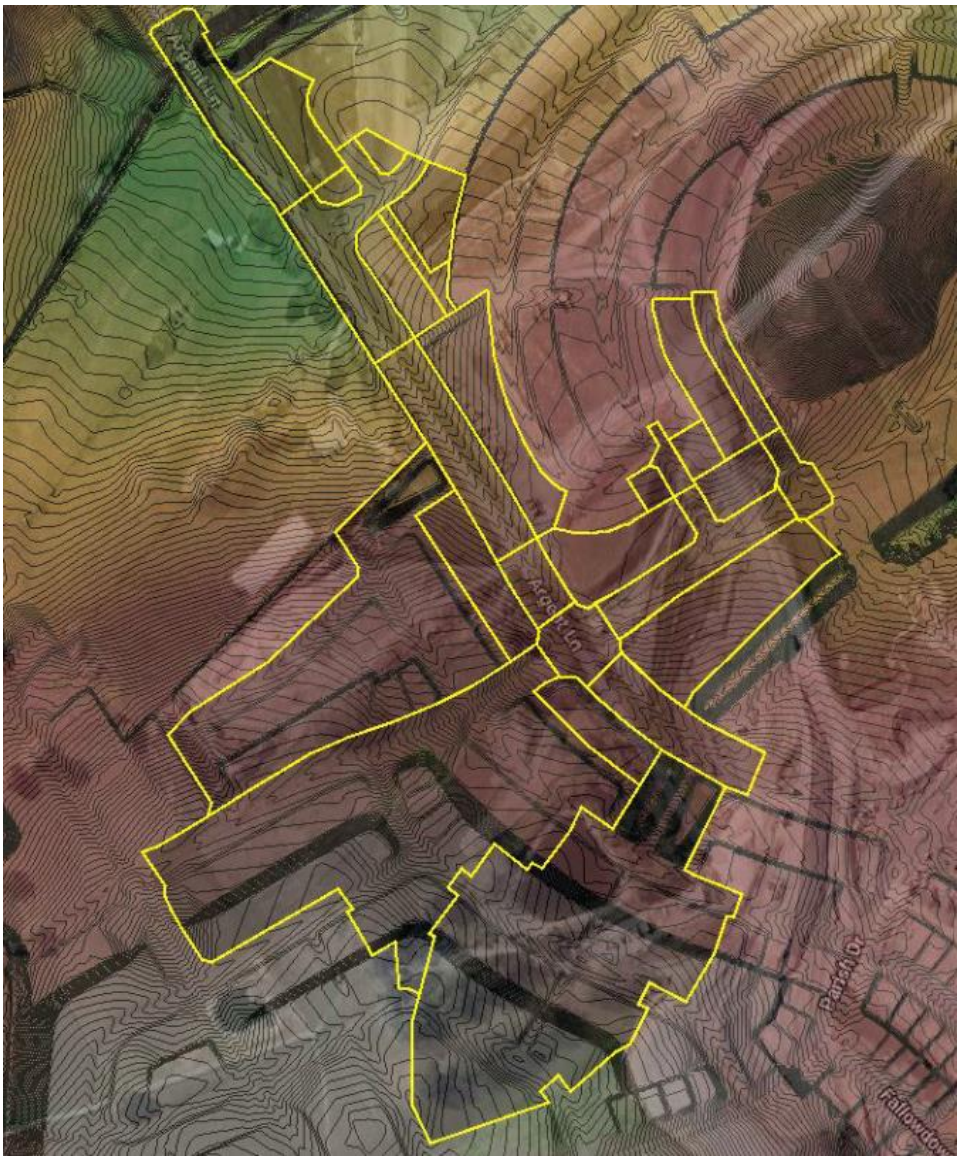

Figure 16: Argent Lane overland flow path assessment extent

The overland flow path assessment memorandum concluded that flows for the 100-year ARI storm event assuming maximum probable development with allowance for 3.8°C future climate change can be adequately conveyed along Argent Lane corridors. Furthermore, the design meets the pedestrian and vehicle safety requirements as per the AT TDM Version 1, while not exceeding any safety thresholds. The proposed road network design is considered appropriate, and the full overland flow path assessment can be found in Appendix D. Overland flows generated from Milldale Stages 10-13 are not contributing to runoff generated within, along or towards Argent Lane.

9. 100-YEAR 3.8°C ARI STORM EVENT CLIMATE CHANGE SCENARIO

The flood modelling undertaken for Milldale Stages 10-13 is in accordance with the currently operative version of Stormwater Code of Practice (V3, Jan 2022) which states that the secondary overland flow paths should be assessed with allowance for 2.1°C future climate change.

The Auckland Design Manual (ADM) website currently states that Version 4 of the Stormwater Code of Practice has been published for industry feedback. Subject to the feedback received, Auckland Council is aiming for Version 4 of this chapter of the Stormwater Code of Practice to become operative in 2025. Until then, the operative version is Version 3.

Given the timing of the application and long-term nature of the Mildalle development, an additional flood model scenario has been created for the 100-year ARI storm event allowing for MPD and future climate change allowance for 3.8°C temperature increase by 2110 as stated in the Stormwater Code of Practice (V4, March 2024).

The flood model maximum depth results from the 100-year ARI storm event allowing for MPD and future climate change allowance for 3.8°C are shown in Figure 17 and demonstrate that:

- Runoff generated from the proposed Milldale Stage 10-13 subcatchments is contained within the watercourses; and
- The stormwater infrastructure included in the proposed Milldale Stages 10-13 development have sufficient capacity to convey the upstream flows during a 100-year ARI storm event assuming maximum probable development with allowance for 3.8 °C climate change.

The model results from the 100-year ARI storm event allowing for MPD and future climate change allowance for 3.8°C aims to demonstrate future resilience of proposed infrastructure, and it is not used to assess flood effects (if any). A map showing the model maximum modelled flood depth results for the 100-year ARI storm event allowing for MPD and future climate change allowance for 3.8°C temperature increase can be found in Appendix E.

Figure 17: 100-year ARI storm event including 3.8°C climate change maximum flood depth

9.1. Wainui Road Bridge Assessment

Previous modelling and flood assessments showed that there is no overtopping risk at the Wainui Road Bridge and this was agreed with Healthy Waters as part of the modelling query list generated during the high-level review in 2022. The most recent Wainui Road Bridge assessment was undertaken to highlight potential effects (if any) that result from the increased flows along Waterloo Creek generated from proposed Milldale Stages 10-13 development under maximum probable development (MPD) and confirmed that the pass flows forward strategy is appropriate.

The Wainui Road bridge has been represented in the flood model using the parameters stated in Table 7. The Wainui Road bridge is located downstream of the Milldale Stages 10-13 development as shown in Figure 18. Figure 19 shows the cross-section view of the Wainui Bridge.

Table 7: Wainui Road bridge data summary

DATA	Value
High Chord Elevation	5.44 m
Low Chord Elevation	4.79 m
Reach Length	14.25
Max WSEL	10 m
Skew Angle	18.1 degrees
Manning's n	0.06
Entrance Loss Coefficient	0.5
Exit Loss Coefficient	1
Weir Representation	Broad-crested

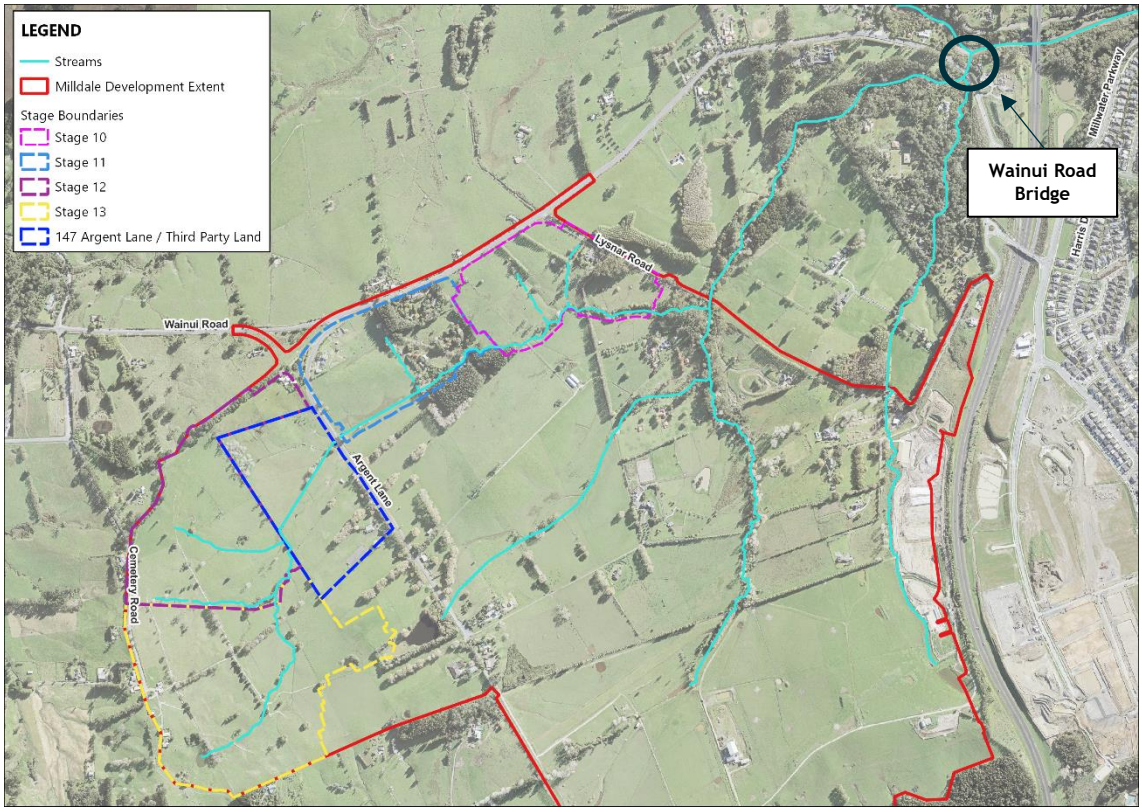

Figure 18. Wainui Road Bridge location downstream of development

Figure 19: Wainui Bridge cross-section view

It is noted that flood effects listed in the Wainui East SMP (Woods, Sept 2016) are considered outdated and no longer relevant. Since the adoption of the SMP, the flood model has undergone various updates and high-level reviews with Healthy Waters with the most recent being in May 2022 (Appendix B).

Furthermore, the latest post-development flood model results show that:

- Water levels do not exceed the low chord elevation for the post-development scenario in the 10-year ARI plus 2.1° climate change event
- The 100-year ARI plus climate change event water levels do not overtop the Wainui Bridge as the maximum water level is not more than the bridge's high chord elevation of 5.44 m. The water level for the 100-year ARI storm event including 2.1°C climate change scenario is 4.74 m RL and the water level including 3.8°C climate change scenario is 5.27 m RL; and
- The model results show that the water level does not overtop the Wainui Road Bridge in any of the modelled scenarios.

Overall, the flood modelling undertaken for the proposed Milldale Stages 10-13 development confirmed that there is not an overtopping risk at the Wainui Road Bridge, and it does not act as a bottleneck for the upstream catchment while not showing flood effects downstream.

10. AUCKLAND UNITARY PLAN (OP) ASSESSMENT

Per Table E36.4.1 the development proposes Activity A33 (Construction of other land drainage works, stormwater management devices or flood mitigation works in a 1% AEP floodplain), which is a restricted discretionary (RD) activity. Based on the flood modelling undertaken for the proposed Milldale Stages 10-13 development, under the MPD scenario, the magnitude of flow approaching exceeds the 2 m^3/s threshold for the floodplain classification. For relevant matters of discretion, the following is noted:

- The construction of conveyance structures within the floodplain will not increase flood risk either upstream or downstream of the culverts with the modelling showing that flows will be contained within the watercourse and not create a hazard at the adjoining land parcels
- The proposed culverts are designed to adequately convey flows up to the 10-year ARI event (including 2.1 °C climate change) where the maximum headwater level does not exceed the soffit level of the pipe; and
- The proposed culverts are designed to adequately convey flows up to the 100-year ARI event including 2.1 °C climate change with adequate freeboard and thus it is inferred that small events will also be adequately managed without creating a nuisance in the surrounding environment.

With respect to activities in overland flow paths, the development proposes Activity A42 in Table E36.4.1 (Any buildings or other structures located within or over an overland flow path) which is considered a restricted discretionary activity. As far as relevant matters for discretion are concerned, while the culverts are located along an OLFP (existing situation), the proposed culvert upgrades are not expected to create negative effects in that flows are contained within the watercourses and do not overtop the banks to create a hazard in the area.

11. CONCLUSION

The flood assessment report for Milldale Stages 10-13 (referred to as the Site) supports the resource consent application by Fulton Hogan Land Development (FHLD) to the Environmental Protection Authority (EPA) under the Fast-Track Approvals Act 2024. The flood assessment has been performed in consistency with the recommended flood management strategy to pass flow forward of the adopted Wainui East Stormwater Management Plan (SMP), Version 4, September 2016. The recommended flood management strategy for the Site also ensures there are no flood effects upstream or downstream of the Site while the downstream stormwater infrastructure, both proposed and already constructed, have sufficient capacity to convey upstream flows for MPD development conditions.

The flood assessment involved stormwater modelling and five model scenarios were developed, including pre-development and post-development scenarios. The flood modelling undertaken in this flood assessment builds on the Wainui East flood models originally developed while creating the Wainui East Model Build Report (Woods, July 2016). Since the adoption of the Wainui East SMP, the flood model has undergone various updates and high-level reviews with Healthy Waters, the most recent being in May 2022.

The flood model scenarios have been simulated for the 10 and 100-year ARI storm events including climate change including 2.1°C temperature increase by 2090 as well as a resilience assessment for the 100-year ARI storm event including 3.8°C temperature increase by 2110. An additional model scenario has been developed which allows for blockage of the proposed culverts within the Site extent as per the currently operative Stormwater Code of Practice, Version 3, Jan 2022 (SWCoP).

The flood assessment findings are as follow:

- Flood Effects Assessment

  Flood depths comparison between the pre-development and post-development scenario for the 100-year ARI event including 2.1 °C climate change shows that any flood depth increases are limited to the stream corridor and does not increase pre-development flood extents, this is consistent with the adopted SMP. There are no upstream or downstream flood effects resulting from developing the Site.

- Culverts Freeboard Assessment

  The post-development model results also show that all proposed culvert structures within the Site comply with the freeboard requirements stated in the operative Stormwater Code of Practice (V3, Jan 2022) for both 10 and 100-year ARI storm events including 2.1°C climate change.

- Resilience Assessment

  An additional flood model scenario has been created for the 100-year ARI storm event allowing for MPD and future climate change allowance for 3.8°C temperature increase by 2110 as stated in the draft/ non-operate version 4 of the Stormwater Code of Practice (V4, March 2024). The resilience assessment demonstrated that Runoff generated from the proposed Milldale Stage 10-13 subcatchments is contained within the watercourses and the proposed stormwater infrastructure within the Site have sufficient capacity to convey the upstream flows during a 100-year ARI storm event assuming maximum probable development with allowance for 3.8 °C climate change.

- Blockage Assessment

  The culvert blockage assessment shows that there is road overtopping where the proposed culverts within the Site are assumed to be fully blocked, and in most instances, the runoff overtopping the culverts immediately returns to the stream. Instances where flows overtop and do not immediately return to the stream, then flows are fully contained within the roads and do not enter the proposed lots.

- Wainui Bridge Assessment

  Previous modelling and flood assessments showed that there is no overtopping risk at the Wainui Road Bridge and this was agreed with Healthy Waters as part of the modelling query list generated during the high-level review in 2022. There is not an overtopping risk at the Wainui Road Bridge, and it does not act as a bottleneck for the upstream catchment

while not showing flood effects downstream either, confirming the pass flow forward strategy is appropriate.

- Auckland Unitary Plan Assessment

  Per Table E36.4.1 the proposed Milldale Stages 10-13 development proposes Activity A33 and Activity A42 which are considered a restricted discretionary activity. As far as relevant matters for discretion are concerned, the proposed culverts are designed to adequately convey flows up to the 10-year and 100-year ARI events (including 2.1 °C climate change) while not creating any negative effects in that flows are contained within the watercourses and do not overtop the banks to create a hazard in the area.