APPENDIX E | PDP Report - Effects on Flooding

Effects on flooding – 535 Mill Road, Ohoka – Stormwater Management

Prepared for

Rolleston Industrial Developments Ltd

2022

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Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by LINZ, Waimakariri District Council and Innovo not directly contracted by PDP for the work. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Rolleston Industrial Developments for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Executive Summary

Pattle Delamore Partners Ltd have completed an assessment of the effect on flood levels and flood hazard to support a plan change request at 535 Mill Road, Ohoka. The site is approximately 156 ha and zoned as rural and located in Waimakariri District Council.

PDP constructed a 2D hydraulic model of the proposed development site using Tuflow. The inflows for the model were obtained from Waimakariri District Council, from their district wide model for the 200YR Average Recurrence Interval (ARI) event.

The purpose of the PDP model was to investigate flood effects that the proposed development could have on flood hazard and flood level as a result of floodplain displacement.

PDP found that:

- The proposed development is consistent with the Environment Canterbury Regional Policy Statement. Floor levels will be located above the 200YR event, no development will take place in areas designated 'high hazard' and there will be no increased risk to life as a result of the development;

- The effects on flood flow vary throughout the subdivision. The model predicts that flow over the south-eastern boundary of the subdivision (Whites Road) is increased by 300 L/s (36.1 m^3/s to 36.4 m^3/s). Flow over the north-eastern boundary of the subdivision (Mill Rd) decreases slightly by approximately 40 L/s. Peak flow over Mill Rd is around 8.7 m^3/s;

- The predicted increase in flood level for habitable dwellings is no greater than 45 mm for average flood depth and no more than 39 mm for peak flood elevations. This demonstrates that there is a feasible solution for the development of this land which will ensure the effects of development are less than minor; and,

- No change to the high hazard classification with the exception of some locations along the realigned streams.

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1.0 Introduction

Rolleston Industrial Developments Limited (RID) are proposing a new residential development at Ohoka, Canterbury. The proposed development is located between Bradleys Road and Whites Road directly south of Mill Road, comprising a total area of approximately 156 Ha (Figure A1, Appendix A) and will consist of predominantly residential land. RID has engaged Pattle Delamore Partners Limited (PDP) to provide an assessment of the effects on flooding for the proposed development and identify flood mitigation options, if required. The proposed development is located upon land currently zoned rural by Waimakariri District Council (WDC). RID are applying for a plan change to zone this land a mixture of residential, rural-residential and commercial use.

This report summarises the flood modelling undertaken by PDP to assess the impact of the proposed development on the 0.5% Annual Exceedance Probability (AEP) flood event. Flows inputs to our model have been sourced from the Waimakariri District Localised Flood Model (WDC model).

The site has four established water courses flowing west to east through it, the Ohoka Stream, Ohoka South Branch and two unnamed water courses. Culverts constraining flow upgrade and downgrade of the proposed development area were identified, and surveyed, during a site visit in March 2022 by PDP.

This modelling is for the purposes of supporting the rezoning application. It is expected that further modelling will be required to support the necessary resource and building consent applications. Modelling to incorporate additional detail of the subdivision surface, including roads, section levels, swales and landscaping will be carried out at these latter stages.

All vertical elevations reported are in terms of the New Zealand Vertical Datum 2016 (NZVD2016).

2.0 Rules and Plans

2.1 Canterbury Regional Policy Statement 2013

The Canterbury Regional Policy Statement[1] 2013 (CRP) in ‘*Chapter 11 – Natural Hazards*’ outlines policy for the development of new subdivisions upon land in high hazard areas and areas subject to inundation.

[1] https://www.ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-regional-policy-statement/

Policy 11.3.1 states that:

> *To avoid new subdivision, use and development (except as provided for in Policy 11.3.4) of land in high hazard areas, unless the subdivision, use or development:*
>
> 1. *is not likely to result in loss of life or serious injuries in the event of a natural hazard occurrence;*
> 2. *is not likely to suffer significant damage or loss in the event of a natural hazard occurrence;*
> 3. *is not likely to require new or upgraded hazard mitigation works to mitigate or avoid the natural hazard;*
> 4. *is not likely to exacerbate the effects of the natural hazard;*
> 5. *Outside of greater Christchurch, is proposed to be located in an area zoned or identified in a district plan for urban residential, industrial or commercial use, at the date of notification of the CRPS, in which case the effects of the natural hazard must be mitigated; or*
> 6. *Within greater Christchurch, is proposed to be located in an area zoned in a district plan for urban residential, industrial or commercial use, or identified as a "Greenfield Priority Area" on Map A of Chapter 6, both at the date the Land Use Recovery Plan was notified in the Gazette, in which the effect of the natural hazard must be avoided or appropriately mitigated; or*
> 7. *Within greater Christchurch, relates to the maintenance and/or upgrading of existing critical or significance infrastructure.*

High hazard areas are classified by the RPS as:

> *flood hazard areas subject to inundation events where the water depth (metres) x velocity (metres per second) is greater than or equal to 1, or where depths are greater than 1 metre, in a 0.2% AEP flood event;*

The development will be located outside of areas of high hazard.

Policy 11.3.2 states:

> *In areas not subject to Policy 11.3.1 that are subject to inundation by a 0.5% AEP flood event; any new subdivision, use and development (excluding critical infrastructure) shall be avoided unless there is no increased risk to life, and the subdivision, use or development:*

1. is of a type that is not likely to suffer material damage in an inundation event; or

2. is ancillary or incidental to the main development; or

3. meets all of the following criteria:

a. new buildings have an appropriate floor level above the 0.5% AEP design flood level; and

b. hazardous substances will not be inundated during a 0.5% AEP flood event provided that a higher standard of management of inundation hazard events may be adopted where local catchment conditions warrant (as determined by a cost/benefit assessment).

Floor levels will meet the RPS requirements, and we also note that WDC have their own floor level requirement (0.5% AEP + 500 mm). A hydraulic model has been constructed to assess the effects of floodplain displacement as a result of increasing the land elevation to meet minimum floor level requirements.

3.0 Hydraulic Model

3.1 Model Software

The hydraulic model was constructed using Tuflow. Tuflow is a computational software which contains a 1D and 2D engine to numerically model free surface flows. The 2D depth averaged, momentum and continuity equations for free-surface flows are solved using a 2nd order semi-implicit solver. The 1D component of Tuflow is based on a numerical solution of the 1D St Venant fluid flow equations. Tuflow is widely used throughout New Zealand and is considered a suitable tool for assessing the effects on flooding of the proposed development.

3.2 Model Inputs

3.2.1 Boundary conditions

Boundary conditions define how water enters and exits the model. The boundaries must be set suitably far from the study area (proposed development area) to ensure boundary effects do not influence the conclusions drawn from the model. For this model, upstream boundary flows were introduced into the model at six different locations. Four located directly north-west of the site where well-defined flow paths exist. The two remaining flows were located south-east of the Ashworths Road and Mill Road intersection.
Figure A2, Appendix A shows the locations of the six upstream boundary flows represented by the red lines on the figure.

Flow was removed from the model at the downstream boundary, which was set at Jacksons Road between Tram Road and Hicklands Road (Figure A2, Appendix A).

The upstream boundary flows were represented by 0.5% AEP flow hydrographs provided by WDC[2]. They were obtained directly from the WDC model and are presented in Figure 1 below.

The downstream boundary at Jacksons Road was assumed to be a normal depth boundary. A normal depth boundary is representative of uniform flow conditions with an energy slope set to the grade of the fall of the land. The sensitivity of the model to this assumption was tested.

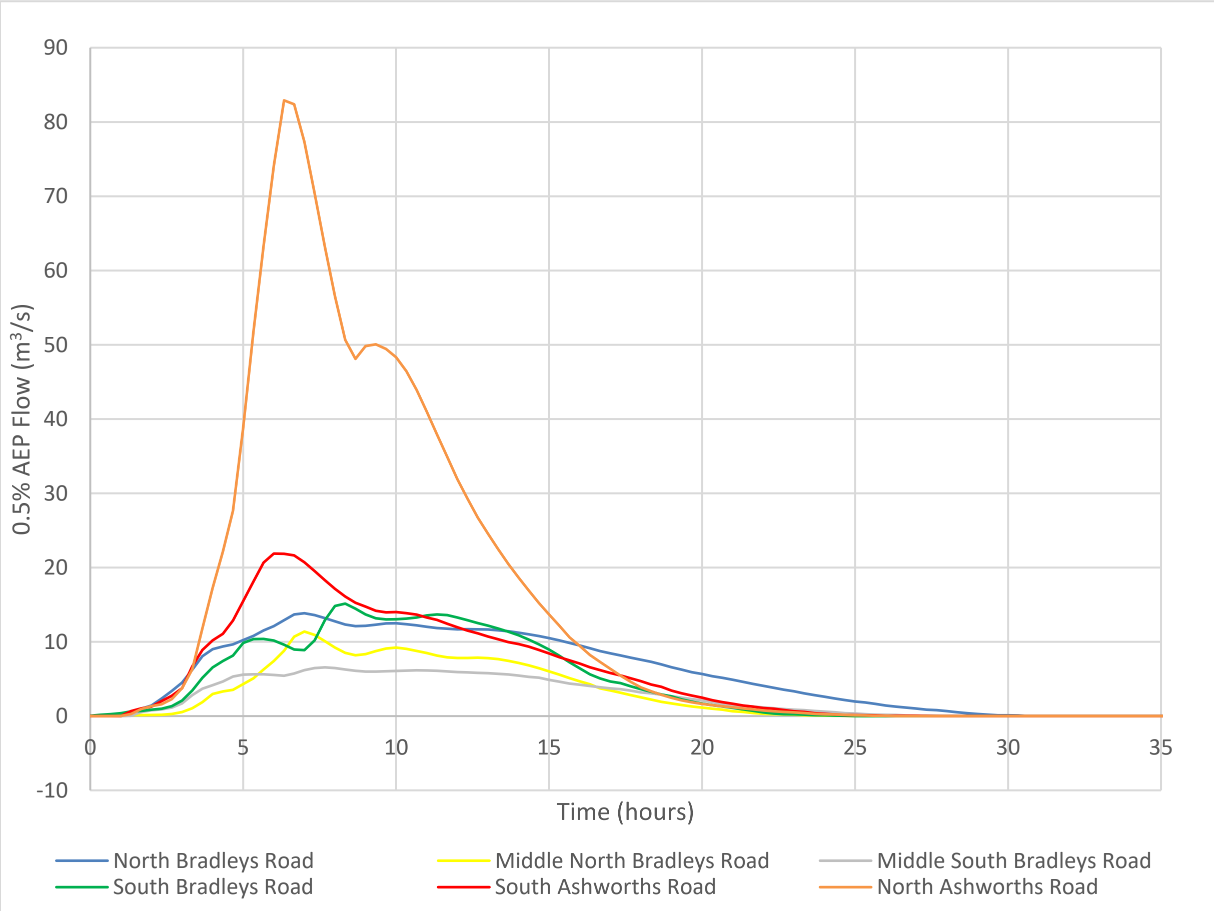


Figure 1: 0.5% AEP flows input into the model

[2] Email from Chris Bacon (WDC) to Ben Throssell (PDP) on 18/Feb/2022

3.2.2 Model Roughness

Roughness represents the friction losses incurred by the water body as it traverses over the topography. The model roughness is determined by utilising multiple sources to define land cover. These include:

- LINZ Road Parcels;
- LINZ Building footprints;
- LRIS Land Cover Version 5.0; and,
- Aerial imagery and google street view.

Appendix A, Figure A2 shows the defined land cover types for the pre- and post-development hydraulic models. Table 1 shows the Manning's roughness value associated with each land cover type. The Manning's roughness values are selected based on values typical for the respective land cover.

Table 1: Model roughness

Land Cover	Manning's n	Typical Range[2][3]
Building	1.000[1]	-
Roads	0.020	0.020 - 0.030
Urban Parkland/Open space	0.035	0.030 - 0.050
River	0.030	0.025 - 0.060
Medium Dense Bush	0.07	0.045 – 0.160
Dense Bush	0.11	0.045 – 0.160

Notes:

[1] This high manning's rough value allows for floodplain storage within the building footprint but prevents any significant conveyance.

[2] Sources: Cardno. (2021). Flood Hazard Modelling Standard. Wellington: Greater Wellington Regional Council.

[3] Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors)

Australian Rainfall and Runoff: A Guide to Flood Estimation, © Commonwealth of Australia (Geoscience Australia), 2019

3.2.3 Topographic Data

The existing topographic area was derived from the Canterbury – Rangiora LiDAR 1m DEM (2014) available from Land Information New Zealand. While LIDAR provides excellent coverage of the land surfaces, the quality of the surface captured starts to drop in the presence of thick vegetation or water. Stream bed elevations of water courses directly upstream and downstream of culverts was therefore modified using culvert survey measurements.

The post development scenario and associated topographic modifications are described in further detail in Section 3.2.5.

3.2.4 Structures

Five existing culverts were identified upgrade and downgrade of the site. Key culvert parameters determined from the survey undertaken by PDP are provided in Table 2. The culverts were modelled in the 1D domain. Culverts included within the model are shown in Appendix A, Figure A2.

Table 2: Culvert parameters applied in model

Culvert Description	Type	Culvert Width (m)	Culvert Height (m)	Depth from road to culvert (m)	Downstream Bed Elevation (m RL)	Upstream Bed Elevation (m RL)
Bradleys Road (North)	Box	4.0	1.5	0.3	27.1	27.1
Bradleys Road (South)	Box	1.5	1.5	0.3	24.11	23.81
Whites Road (North)	Archway	3.7	1.5	0.5	19.01	19.01
Whites Road (Middle)	Box	4.0	1.5	0.3	19.81	19.81
Whites Road (South)	Box	1.5	0.9	0.45	21.51	21.51

3.2.5 Post-Development Scenario

The modelled post-development scenario is based upon the indicative development plan[3] and Outline Development Plan (ODP)[4]. Figure A3, Appendix A shows the post development scenario.

Proposed areas of relatively medium to high development have been modelled as a platform above the flood level. Therefore, these areas of development are "blocked out" of the model (i.e. no water can flow over or into the proposed development area). For this density, the entire lot parcel was blocked out of the model which is a conservative assumption. No allowance was made for conveyance or storage that may be available in roadside swales or stormwater detention facilities. This assumption is considered conservative.

Proposed areas of relatively low development density (average of 3300 m^2 lots) have been modelled to include an assumed 400 m^2 building platform within each lot. These building platforms have been "blocked out".

[3] Provided by INOVO Projects dated 5 April 2022.
[4] Provided by RID dated 2021.

There are four existing drainage channels flowing west to east through the site which been enhanced to slightly improve conveyance capacity along the existing water courses. These proposed channels vary in cross sectional profile, but are typically less than 750 mm deep. It is noted that the final design of these watercourses will likely evolve but the purpose of this assessment is to demonstrate that there is a feasible solution.

4.0 Model Validation and Sensitivity

To confirm the PDP model was producing sensible hydraulic predictions, the peak water levels for the PDP model (pre-development) were compared to the peak water levels predicted by the equivalent WDC district wide model[5] (WDC model). Figure B1, Appendix A shows the WDC model and predicted flood extent by the PDP model. It is worth noting the main differences between the PDP and WDC models include:

- the PDP model employs a 2 m grid resolution compared to the 5 to 8 m triangular mesh employed in the WDC model;
- a number of culverts are included in the WDC model, but it is not clear from the WDC model report if the culverts along Bradley's and White's Road were incorporated; and,
- the definition of roads and buildings is likely similar for both models. The spatial extent of vegetation in the WDC model was derived from the LCDB v4.1 database. PDP have used the recently updated LCDB database (v5.0). PDP also manually delineated a number of hedgerows and shelter belts that were orientated perpendicular to the predominant flow direction and not included in the LCDB V5.0 database.

The PDP model produces reasonably similar results to the WDC model and given the purpose of this assessment is to determine flood differences, the model is considered suitable for its stated purpose.

It is noted that the WDC model may provide conservative flow estimates. Section 3.5 of the WDC model report comments on the validation. The report notes that for the Fox Creek Okuku gauge, the predicted flow (by the model) for the 100YR event is double the flow obtained using a flood frequency analysis. Given the flow estimates for the PDP model have been derived from the WDC model, by extension, the PDP model may also be conservatively high with regards to flow estimates.

[5] https://openmaps.waimakariri.govt.nz/HazardsReports/DistrictFloodMappingDHI.pdf

4.1 Model Sensitivity

At this stage, only the model sensitivity to the downstream boundary has been tested. If this model is used for prediction of absolute water levels, for example, setting minimum floor levels, then further sensitivity testing will be required. The sensitivity to the downstream boundary was assessed by decreasing the normal depth boundary by an order of magnitude (1 in 200 to 1 in 2000). This assessment showed that the downstream boundary effect, at a distance of 100 m upstream, is a difference in flood elevation of 3 mm. Therefore, the model is not considered sensitive to this downstream boundary.

5.0 Model Results

Figures B2 and B3 of Appendix A, respectively show the pre and post-development flood depths from the PDP model. For the pre-development event, much of the site is flooded although typically, depths of greater than 1 m are constrained to the channels and drains the flow through the site.

For the post developed event, flood depths are displaced by the developed area and constrained to the enhanced drains. Similar to the pre-developed event, depths greater than 1 m are constrained to these drains and channels.

5.1 Effects on Flood Levels

To assess the effects of floodplain displacement due to the proposed development, the difference between the pre-development and post-development water levels were taken (Figure B4, Appendix A). The difference between the two water levels indicates where the flood level may improve/worsen as a result of the development.

Excluding differences within the proposed development boundary, changes in flood elevation are generally less than 50 mm with some small, localised increases between 50 and 100 mm. Any effects on water level have largely dissipated at the downstream boundary (Jacksons Road). Generally, Figure B4 shows that the model predicts:

- Increased water levels at the Mill Rd and Bradleys Road intersection;
- Decreased water levels elsewhere along Mill Rd;
- Decreased water levels along Ohoka Stream; and,
- Increased water levels to the south-east of Whites Road.

Further work, swales, maintaining secondary flow paths, could be implemented to better balance the discharge of flow and minimise the differences further.

Table 3 details all building footprints located outside of the proposed rezoning extent, (as identified by the LINZ building footprint layer) that have a predicted increase in the maximum flood elevation of 10 mm or greater. Explaining Table 3 in more detail:

- Building ID, unique building ID associated with the LINZ layer;
- Area, the area occupied by the building footprint;
- Comment, the assumed use of the building based on manual inspection of aerials and google street view;
- Average Depth (pre/post), the average depth over the building footprint;
- Flood elevation difference, the difference in flood elevation, that is, the maximum post developed flood elevation recorded within the building footprint less the greater of either,
  - the maximum pre-developed flood elevation recorded within the building footprint or,
  - the maximum terrain elevation within the building footprint;

  For a building footprint, if the maximum terrain elevation is greater than the flood elevation, this indicates that the entire parcel is not inundated and as the building platform is often built relative to the highest ground elevation, may indicate a floor level that exceeds the flood elevation; and,
- Italicised and greyed rows, either these footprints have been identified as a garage or shed (i.e., unlikely to be a habitable dwelling).

Table 3 shows that in total, there are seven habitable dwellings (houses) which may experience an increase in flood elevation of 10 mm or more. The greatest increase in average flood depth increase is 45 mm. Of these seven habitable dwellings, four encompass a maximum terrain elevation that exceeds the maximum recorded flood elevation for the post developed event indicating that potentially the ground level exceeds the flood level.

This demonstrates that there is a feasible solution for the development of this land which will ensure the effects of development are less than minor.

Table 3: Building footprints with a predicted increase in flood elevation of 10 mm or greater

Building ID	Area (m^2)	Comment	Average Depth (Pre, mm)	Average Depth (Post, mm)	Average flood depth difference (mm)	Flood elevation difference (mm)
2282892	*112*	*Shed*	*82*	*142*	*60*	*0*
2228804	176	House	0	45	45	0
2221977	360	House	4	47	44	0
2254741	*208*	*Garage*	*32*	*72*	*40*	*0*
1926799	*94*	*Garage*	*42*	*77*	*34*	*0*
1931645	132	House	146	179	33	28
1928682	176	House	125	154	29	39
2285541	*75*	*Shed*	*0*	*25*	*25*	*0*
1932598	213	House	20	40	21	0
1925021	*12*	*Shed*	*97*	*115*	*19*	*13*
2223796	80	House	36	53	17	0
1922109	*61*	*Garage*	*31*	*44*	*13*	*1*
1924882	136	House	79	91	13	15
1934033	*12*	*Shed*	*50*	*63*	*13*	*0*
1934132	*17*	*Shed*	*43*	*54*	*11*	*14*
1933669	*51*	*Garage*	*64*	*73*	*9*	*17*

5.2 Effects on Flood Flows

The pre and post-development model results have been assessed at the downstream end of the proposed development (Whites Road). The exact locations that flows were extracted from the model are presented in Figure A4, Appendix A.

Figure **2** shows the pre and post development flow over Mill Road (north-eastern boundary of the subdivision). A small decrease (approximately 40 L/s or 0.5%) is predicted as a results of the development and the peak flow is around 8.7 m^3/s.

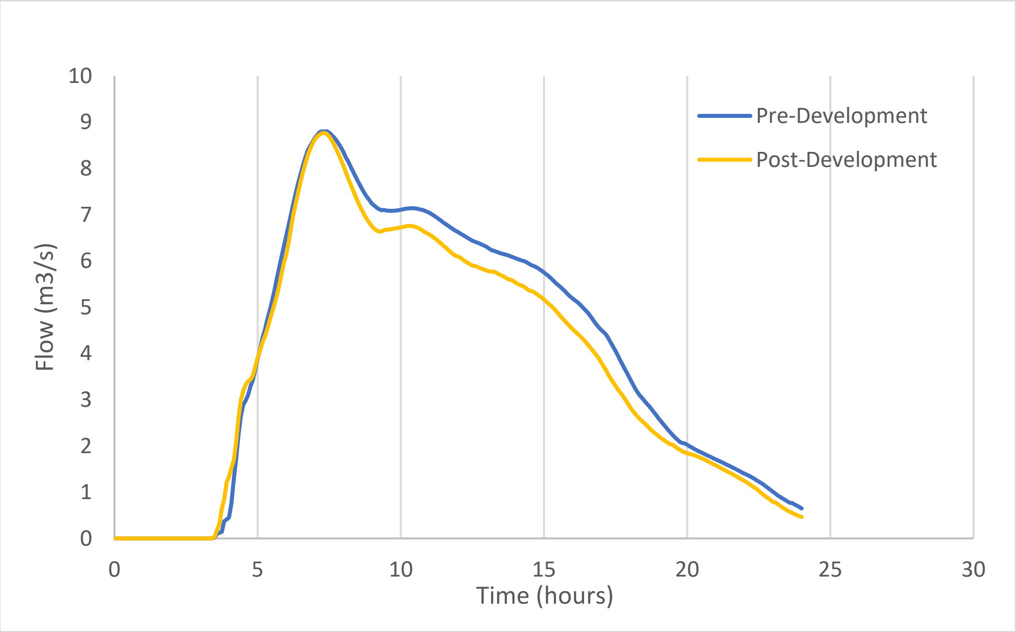


Figure 2: Pre and post flows over Mill Road

Figure 3 shows the pre and post developed flows for Whites Road (south-eastern boundary of the subdivision) both via the three culverts beneath Whites Road and over the top of Whites Road.

For the flow over Whites Rd, the pre-developed peak flow is 16.5 m^3/s whilst the post-developed peak flow is 15.7 m^3/s, a reduction of 800 L/s (5.1%). For the flow via the culverts, the pre-developed flow is 19.6 m^3/s and the post-developed flow is 20.7 m^3/s, an increase of 1100 L/s (5.6%). Therefore, the balance, pre and post development, accounting for both culverts and flow over Whites Road, is an additional 300 L/s as a result of the proposed subdivision.

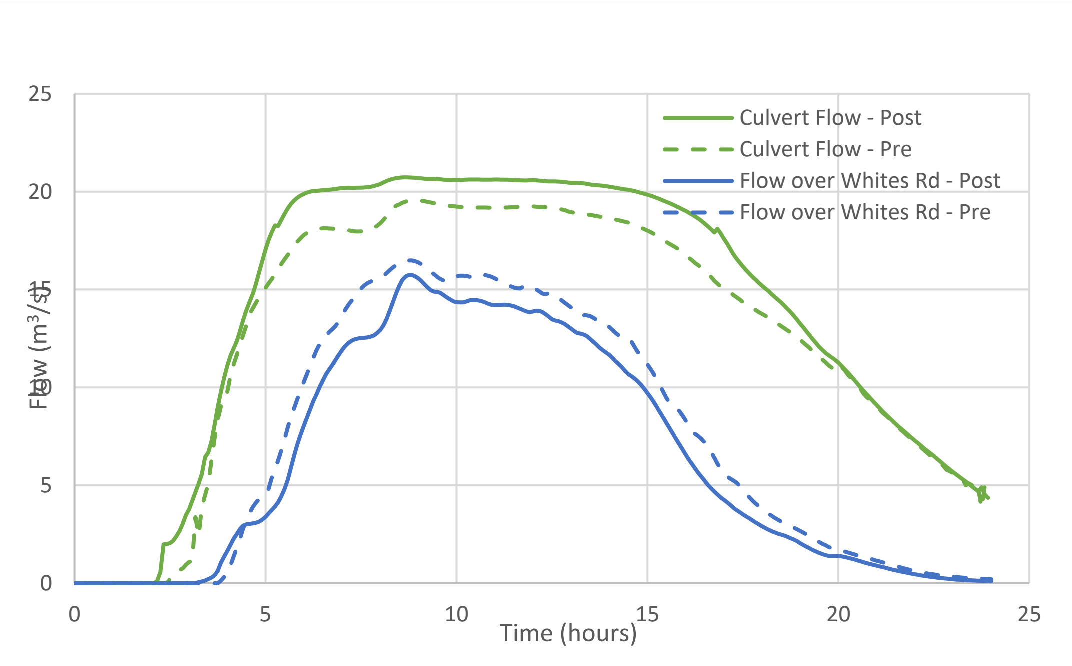


Figure 3: Pre and post flows over Whites Road

Figure **4** shows the pre and post development flows at locations along Whites Road (delineations marking where these flows were extracted are presented in Figure A4, Appendix A).

The pre developed flow for the flow "North at Breakout" is approximately 1.1 m^3/s higher than the post developed flow (6.6 m^3/s and 5.5 m^3/s). "North at Breakout" is located between Mill Road and Wilson Drive.

For the other flow locations:

- downstream of north drain, predicted increase in peak flow of 300 L/s (2.2%), 13.6 m^3/s to 13.9 m^3/s;
- mid-north drain, predicted increase in peak flow of 100 L/s, 0 L/s to 100 L/s;
- mid-south drain, predicted increase in peak flow of 500 l/s (5.0%), (10.1 m^3/s to 10.6 m^3/s); and,
- south drain, predicted increase of 300 L/s (3.8%), 7.9 m^3/s to 8.2 m^3/s;

Figure **4** essentially shows some increase and decreases to the flow discharged from the subdivision site at various locations along Whites Road. This indicates that further work can be done to better balance the discharge of flow overall which will help to mitigate effects.

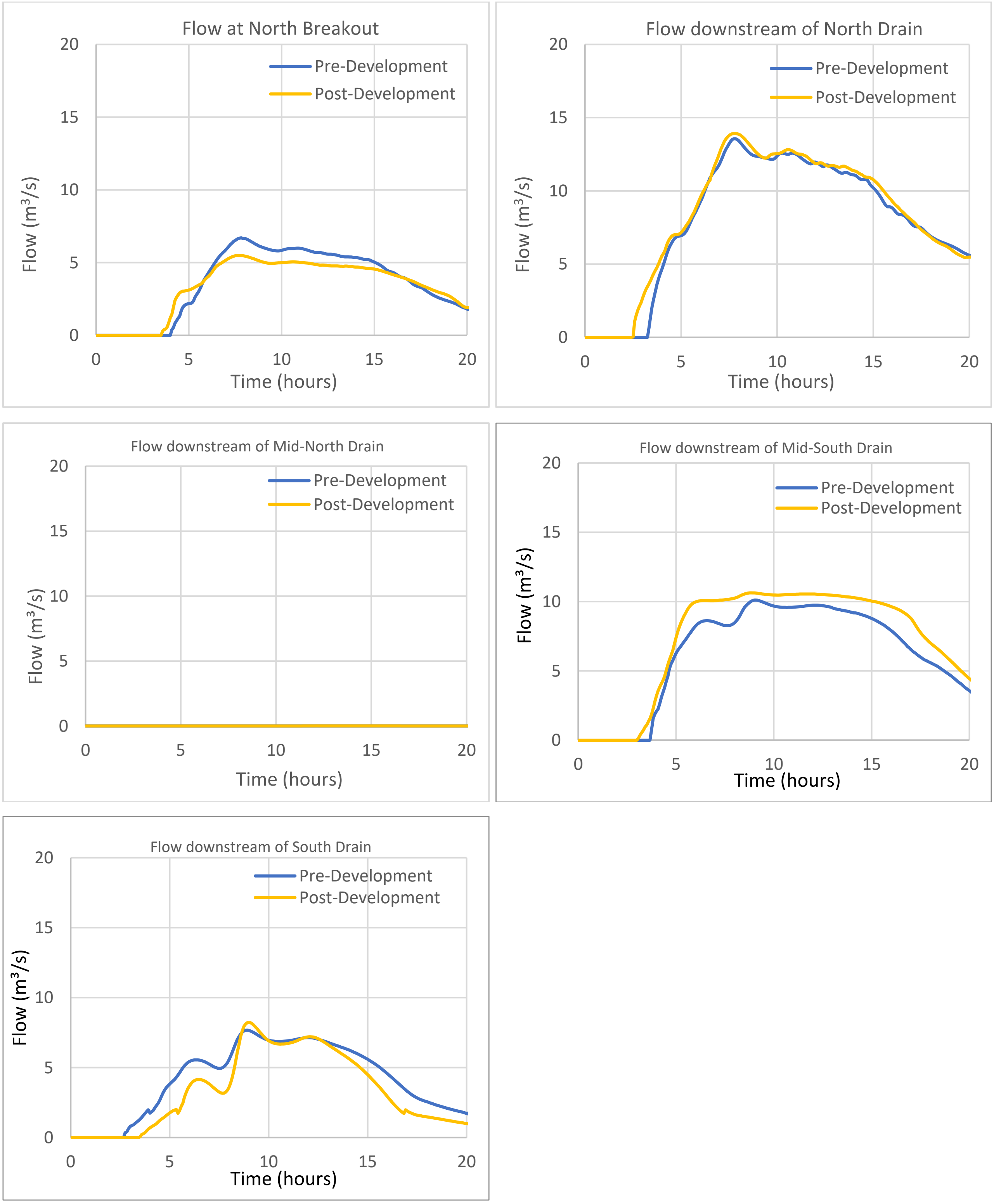


Figure 4: Pre and post flows at various sections over Whites Road

5.3 Effects on Flood Hazard

Policy 11.3.2 for the RPS requires that "any new subdivision, use and development (excluding critical infrastructure) shall be avoided unless there is no increased risk to life". High hazard areas can be used to identify and quantify the risk to life.

ECan defines high flood hazard as depths greater than 1 m or where the product of depth and velocity is greater than one. Figure B5, Appendix A shows the new high flood hazard classification as a result of the proposed development. Any significant changes in the flood hazard classification are limited to the proposed realignment channels. There is no change from low to high flood hazard for any habitable dwellings and therefore, we consider that there is no increased risk to life.

6.0 Conclusion

PDP have constructed a hydraulic flood model for determining the effects of a proposed 156 ha residential development on flood depth, flows and hazard. The purpose of this assessment is to inform a plan change application to rezone the land to a mixture of residential, rural-residential and commercial use. Key conclusions are:

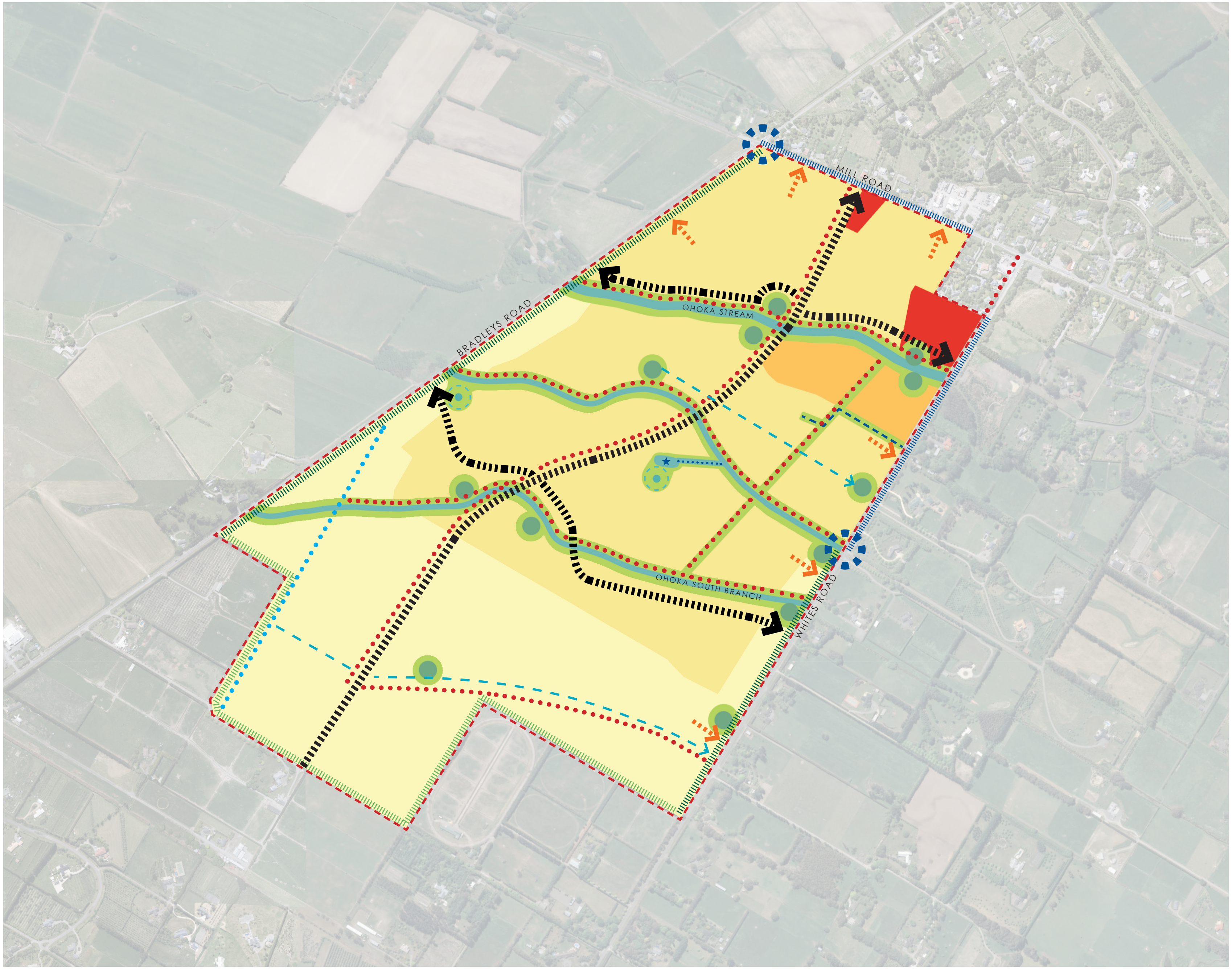
- The proposed development is consistent with the ECan RPS. Floor levels will be located above the 0.5% AEP event, no development will take place in areas designated 'high hazard' and there will be no increased risk to life as a result of the development;
- The effects on flood flow vary throughout the subdivision. The model predicts that flow over the south-eastern boundary of the subdivision (Whites Road) is increased by 300 L/s (36.1 m^3/s to 36.4 m^3/s). Flow over the north-eastern boundary of the subdivision (Mill Rd) decreases slightly by approximately 40 L/s. Peak flow over Mill Rd is around 8.7 m^3/s; and,
- The predicted increase in flood level for habitable dwellings is no greater than 45 mm for average flood depth and no more than 39 mm for peak flood elevations. This demonstrates that there is a feasible solution for the development of this land which will ensure the effects of development are less than minor.

Appendix A: Figures

OUTLINE DEVELOPMENT PLAN - MILL ROAD

LEGEND

- Outline Development Plan Area
- Residential 3
- Residential 4a
- Residential 8
- Business 4 Zone
- Indicative Road
- Indicative Local Road Connection
- Threshold / Gateway
- Indicative Pedestrian Network
- Indicative Stormwater Management Areas (size and location to be confirmed)
- Existing / Naturalised Waterways
- Existing Springs and Associated Setback
- Stormwater Conveyance Flow Path
- Groundwater Seep
- Existing Pond (size and location to be confirmed)
- Southern Spring Channel
- Green Network
- Landscape Treatment A
- Landscape Treatment B
- Extent of Road Frontage Upgrade
- Overhead 66kV Power Lines



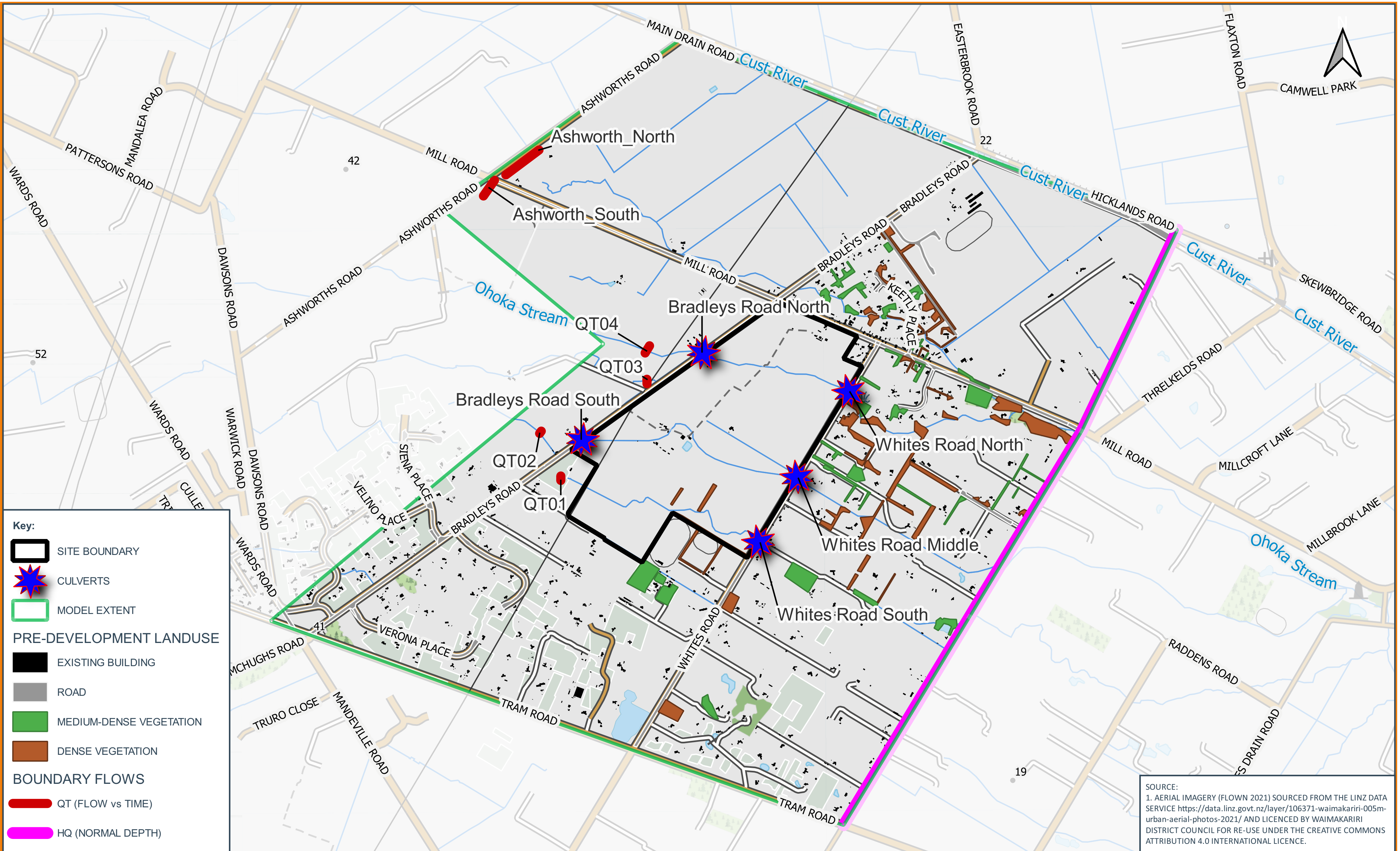


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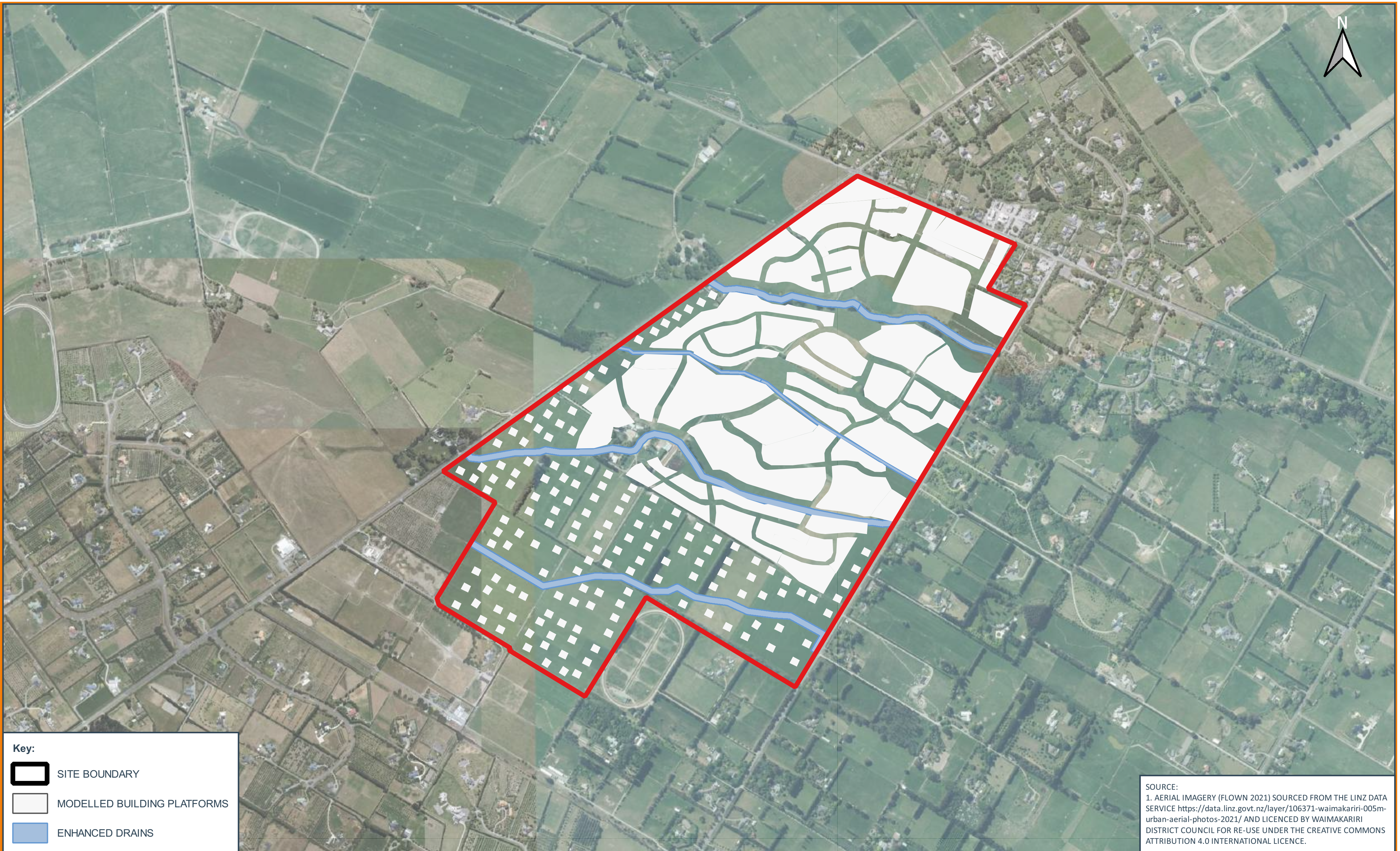
FIGURE
Figure A2: Model Extent, Materials & Boundary Flows

PROJECT
C04518300 Flooding Impacts Assessment



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ROLLESTON INDUSTRIAL DEVELOPMENTS LIMITED

FIGURE

Figure A3: Post Development Modified Topography

PROJECT

C04518300 Flooding Impacts Assessment

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SOURCE:
1. AERIAL IMAGERY (FLOWN 2021) SOURCED FROM THE LINZ DATA SERVICE https://data.linz.govt.nz/layer/106371-waimakariri-005m-urban-aerial-photos-2021/ AND LICENCED BY WAIMAKARIRI DISTRICT COUNCIL FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

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FIGURE
Figure A4: Location of Flow Output Lines from Model

PROJECT
C04518300 Flooding Impacts Assessment

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FIGURE

Figure B1: WDC Model Validation

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C04518300 Flooding Impacts Assessment

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FIGURE
Figure B2: Pre-Development Maximum Flooding Depth for 0.5% AEP event

PROJECT
C04518300 Flooding Impacts Assessment

006_Design\Tuflow\1_GIS\Project\C04518300Q002_May2022_R001_Flood_Effects_V2.qgz

0 100 200 m

METRES

SCALE : 1:10,000 (A4)

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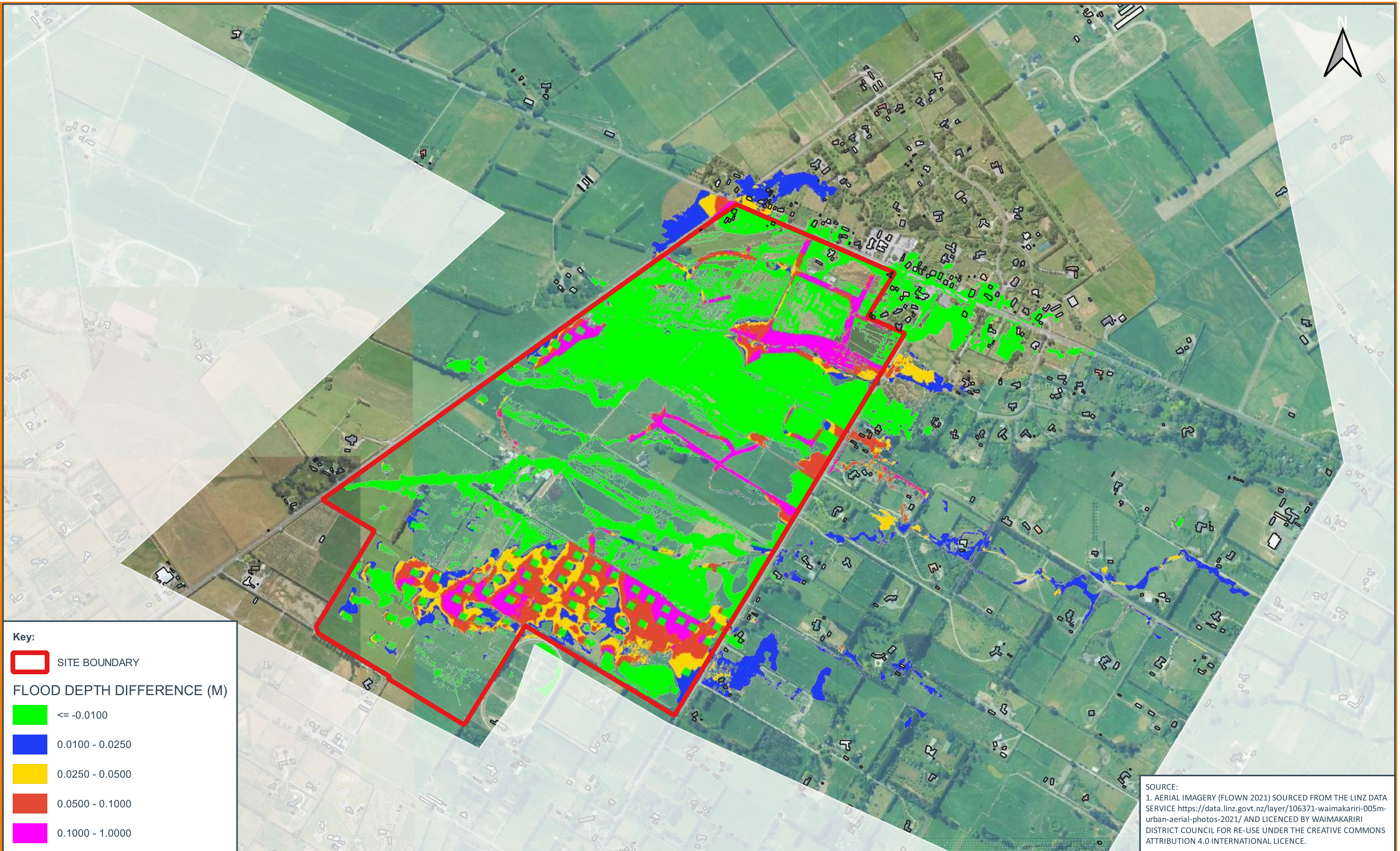
FIGURE

Figure B3: Post-Development Maximum Flooding Depth for 0.5% AEP Event

PROJECT

C04518300 Flooding Impacts Assessment

…_Design\Tuflow\1_GIS\Project\C04518300Q002_May2022_R001_Flood_Effects_FINAL.qgz



pdp

0 150 300 m

METRES

SCALE : 1:15,000 (A4)

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FIGURE

Figure B4: Flood depth difference for pre and post 0.5% AEP event, differences of less than 10 mm are not shown

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pdp

0 450 900 m

METRES

SCALE : 1:14,999.999985 (A4)

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FIGURE

Figure B5: Flood hazard difference, showing new hazard areas only

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