Annexure A: Professional Curriculum Vitae

PATTLE DELAMORE PARTNERS LTD

Neeraj Pratap

ENVIRONMENTAL ENGINEER

Neeraj has developed his specialist skills in hydraulic and hydrologic modelling since joining PDP's Christchurch Water Infrastructure group at the beginning of 2018. Neeraj has been involved in a broad range of stormwater and flood assessments for a range of clients.

Qualifications

Bachelor of Engineering (Hons) (Civil), University of Canterbury, 2017

Diploma in Global Humanitarian Engineering, University of Canterbury, 2019

Affiliations

Member of Engineering New Zealand

Career Summary

2018 – Present (Feb 2024)
Environmental Engineer, Pattle Delamore Partners Ltd, Christchurch

EXPERTISE

- Hydraulic and Hydrological analysis;
- 1D/2D hydraulic modelling;
- Flood hazard assessments;
- Stormwater Design.

CAREER SUMMARY

Neeraj has experience working across a range of projects involving assessment of effects on the environment and design of water related infrastructure. Neeraj's understanding hydraulic and hydrologic processes enables him to develop hydraulic models to realistically represent physical systems.

Neeraj is confident in using industry recognised software to create, assess and present solutions to clients.

Key software skill sets include: TUFLOW, HEC-HMS, HEC-RAS, and GIS Software.

Neeraj has worked on assessment of environmental effects for various water-related projects to provide options and solutions around identified effects on the environment.

PROJECT EXPERIENCE

Staig and Smith, Stormwater management for Proposed sub-division – Kaikoura
Engineer

Neeraj undertook a stormwater assessment as part of a proposed residential subdivision in Kaikoura. Neeraj developed a stormwater model to estimate the attenuation requirements for the development. The site included complex stormwater catchments and outlets. A resource consent for the stormwater discharge has been granted by Environment Canterbury. The building consent application is currently being processed by Kaikoura District Council.

Hop Field Developments, Stormwater/Flood management for proposed sub-division – Tasman District
Engineer

Neeraj has been involved in developing onsite stormwater management options and developing a 2D hydraulic model to assess the impact of a proposed residential development on flooding. The project is currently ongoing. The assessments to date will form part of the consent application

Awatoto Industrial Action Group, Stormwater Modelling
Hydraulic Modeller

The Awatoto Industrial Action Group have been assessing options to understand the capacity of the Awatoto drain following Cyclone Gabrielle. PDP has been engaged to develop a 2D hydraulic model of the catchment and assess potential drain upgrades and flood mitigation options for primary storm events. Neeraj developed the model including key stormwater infrastructure such as pump stations and network connections within the drain.

Southland District Council, Riverton Stormwater Modelling
Hydraulic Modeller

Neeraj developed a detailed 1D/2D hydraulic model for the Riverton township. The purpose of the modelling was to understand the existing Riverton stormwater level of service and identify key areas for stormwater upgrades. Mitigation scenarios were modelled to provide SDC with potential stormwater upgrade options.

JPR Holdings Limited, Stormwater Flood Assessment
Hydraulic Modeller

A detailed 1D/2D model was developed on TUFLOW to hydraulically assess the effect on floodwaters on a proposed residential sub-disvion from a breakout of the Waiteti Stream which neighbours the site. The model was calibrated to a 2018 flood event and used to determine the extent of ground filling and mitigating the increases in post-development flood levels. A detailed modelling and options assessment report was produced for review by the client.

Avon Loop Developments Limited, Flood displacement and hazard advice
Hydraulic Modeller

Neeraj undertook a flood displacement and flood hazard assement as part of a proposed new retirement village located within a flood management area. A 2D model was develop in Tuflow utilsing a combination of LiDAR, surveyed data, and information from an existing model developed by Chirstchurch City Council. The model results were used as part of the site development to ensure that adverse flood effects were avoided and provide an assessment of effects for resource consenting.

Environment Canterbury, Resource Consent Processing
Consent Planner

Sub-contracted to process resouce consents including section 88 completeness checks and s42A reports auditing assessment of environmental effects and planning. Consensts processed include water takes and discharges.

Otago Regional Council, Resource Consent Technical Assessments
Engineer

Technical review of consent applications subbitted to Otago Regional Council. The technical assessments were in relation to the effects on the environment for resouce consent applications, includign onsite wastewater discharge applications

Otago Regional Council, Woolshed Creek Lower Floodway and Western Channel Works Technical Review
Engineer

Technical review of channel sizing for the Lower Floodway channel. The review included capacity and erosion calculation checks assuming a 100-year flow. The calculation checks included cross-section analysis and checking the conveyance capacity of the proposed channel using mannings equation.

Environment Canterbury/ Hekeao Hinds Water Enhancement Trust, Flood Study
Hydraulic Modeller

As part of a managed aquifer recharge along the Hekeao/Hinds River, Neeraj modelled effects on floodwaters arising from a proposed near river rechage basin. The model was used to assess the impacts of the proposed NRR facility on adjacent flood levels. The modelled flood levels were also used to inform the facility embankment design.

Spring Grove Land Limited, Stream capacity assessment
Engineer

Neeraj undertook a stream capacity assessment to assess the impacts of a proposed dewatering discharge. The rational method approach was considered the most appropriate for the scale of the site and the proposed discharge. The assessment was used to inform construction phase consenting.

All Good Properties, Conceptual Design of a Stormwater Wetland
Engineer

Neeraj was involved in the conceptual design of a stormwater treatment and attenuation wetland. Neeraj created a hydrological model to estimate stormwater treatment and 1% AEP volumes. A conceptual wetland design was then prepared for the client for consenting.

JPR Holdings Limited, Stormwater Design
Engineer

Developed a HEC-HMS model to assess the quantity of stormwater runoff from a proposed residential sub-division. The model was used to develop options in attenuating peak stormwater discharges to match post and pre-development flows. Completed a design for a preliminary attentuntaion basin for review by the client.

Annexure B: Stormwater Report for 308 Cones Road

308 Cones Road, Loburn – Stormwater Report for Subdivision

Prepared for

Andy Carr

December 2022

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Quality Control Sheet

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Approved by

Scott Wilson

Limitations:

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Andy Carr and and others (not directly contracted by PDP for the work), including Town Planning Group NZ LTd. 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 Andy Carr 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.

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1.0 Introduction

1.1 Scope

Pattle Delamore Partners Limited (PDP) has been engaged by Andy Carr (the client) to undertake a comprehensive stormwater assessment of the property located at 308 Cones Road, Loburn (i.e., the site) shown in Figure A1, Appendix A. The purpose of this report is to provide stormwater management and an assessment of the natural hazards to aid in the subdivision of the site.

The site has a total land development area of 40,850 m^2 comprising Lot 3 DP 386430. It is proposed to subdivide the site into seven lots, with Lot 1 being reserved for the existing dwelling that fronts Cones Road; see Figure 1 below.

The objective of the assessment was to determine the following:

- Provide an assessment for the management of on-site stormwater, and
- Assess the existing flood hazard to inform building platform locations.

The assessment was undertaken in response to a request for information (RFI) from Waimakariri District Council (WDC):

- *The application notes that the storm water disposal is intended to discharge into ground, however, Council mapping indicates the site is likely to be underlain by low-permeability soils in which case the disposal of storm water into ground may not be practical. If adequate soakage capacity is not achievable, then on-site storm water attenuation systems may be required. Evidence from soakage testing to confirm the ability to achieve rapid infiltration of storm water into ground is required, across the site. Please confirm that the subsoil strata is consistent across the site and that it has sufficient permeability to allow discharge of roof storm water into ground. The lidar data and ground contour/flood hazard mapping data indicates there are two shallow alluvial depressions that drain down to the southeast that are located around the mid-part of the site. Please confirm that a new building platform can be established within each of the proposed lots without diverting surface storm water onto adjacent property. As the ROW driveway will be constructed along the south boundary of the site, it may intercept and divert surface storm water to the southeast corner of the site. If this occurs, then consideration will need to be given to ensure any discharge of storm water does not lead to erosion or nuisance flooding on adjacent property. Please advise how the access Lot 1001 is to be formed to avoid adverse effects to property that is located immediately south and west of the site.*

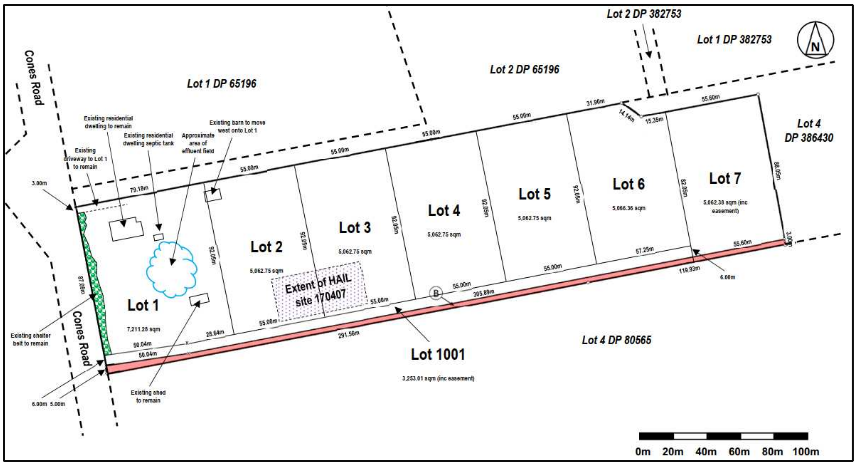

Figure 1 – 308 Cones Road Proposed Subdivision Layout.

1.2 Site Location and Description

The site details and description are summarised below in Table 1, while a site location map and an aerial photograph showing the current site layout (Figure A1) is attached in Appendix A.

Table 1: Site Identification	
Address	308 Cones Road, Loburn
Legal Description	LOT 3 DP 386430 BLK II RANGIORA SD
Site Owner	Sarah Jean Pallett
Grid Reference	NZTM BW24: 6608-0999
Land Area	40,850 m^2
Zoning	Rural
Land Use	Dwelling and several sheds/buildings located in the north-western corner of the site bounded by Cones Road to the west and an unnamed gravelled road to the north, while the remainder of the site comprises open paddocks.
Site Description	Open paddocks with gentle gradients.
Surrounding Land Use	The site is surrounded by rural residential properties and agricultural land. An unnamed road runs along the northern boundary of the site.
Maximum site impervious area	20%

2.0 Existing Site Features

The site has been covered in the 2014 Canterbury – Rangiora LiDAR survey. The LiDAR has been used to estimate the upstream catchments and overland flow paths (OLFPs) through the site. Figure A2, Appendix A shows the catchments and OLFPs for the site. The LiDAR indicates two OLFPs through the site. The western OLFP flows across proposed Lots 3 to 6 and the eastern flows through proposed Lots 6 and 7.

While LiDAR provides a good level of accuracy in open areas where geography is relatively consistent, the 1 metre grid size does not effectively capture land features within this extent, and it is likely these OLFPs are not 100% accurate. A site visit was undertaken on 8 November 2022 to inspect the site geography and geology. During the site visit, a drain was observed that was not picked up or did not exist when the 2014 LiDAR was flown. This drain intercepts the modelled OLFPs along the southwestern boundary of the site and conveys the flows through the existing drain to the neighbouring property. A 300 mm culvert is located at northern site boundary at the beginning of the observed drain. An image of the drain is shown in Figure 2 below, while the location of the drain and culvert are shown on Figure A2 in Appendix A.

It is most likely that the flows from the upgradient hill catchments are captured and conveyed onto site via the 300 mm culvert. The flows are then conveyed off the site through the observed drain flowing to the east. The western OLFP is expected to be from the internal site catchment.

The stormwater flows downstream of the site are conveyed via farm drains and channels before eventually merging into Saltwater Creek, north of the Ashley River.

Figure 2: Drain along south eastern site boundary

3.0 Design Parameters

The design parameters used for this assessment are based on the following documents:

- Waimakariri District Council (WDC), Engineering Code of Practice (ECOP) (2019) – Part Five, Stormwater & Land Drainage;
- Christchurch City Council (CCC), Waterways Wetlands and Drainage Guide (WWDG): Part B
  - Chapter 21 – Rainfall and Runoff (updated June 2020)
  - Chapter 22 – Hydraulics (2003)

Figure 3 shows an excerpt from the WDC ECOP. The site is in the upper catchment of Saltwater Creek and flows under various roads and railways. A 1% Annual Exceedance Probability (AEP) or 100-year Average Return Interval (ARI) was therefore, selected as the design event for attenuation. This provides a conservative assessment.

Table 5.1 Design Storm AEP for System or Infrastructure

System or Infrastructure	AEP
Primary reticulation system – general	20%
Primary reticulation – Rangiora and Kaiapoi CBD	10%
Secondary flowpaths	2%
Culvert (Refer also NZTA Bridge Manual Clause 2.3 for heading up and maximum levels below road surface).	10%
Bridge (Refer also NZTA Bridge Manual Appendix A3 for minimum clearance above water level).	1%

Figure 3: Design Storm AEP for systems or infrastructure (Waimakariri District Council, 2019)

Section 21.4.1.2 of the CCC WWDG, recommends a climate change scenario of RCP 8.5 be used for design of permanent infrastructure and flood hazard mapping as a conservative approach.

The general design principal section 5.4.5 of the WDC ECOP is that any development must not increase upstream or downstream flood levels, unless any increase is negligible and can be shown to have no detrimental effects.

4.0 Stormwater Management

4.1 Discharge to Land

During the site visit, several test pits were excavated to assess the site geology and suitability for stormwater to be discharged to land via rapid infiltration soak pits. The test pits showed that the underlying geology was consistently clayey silts below silty topsoil over the site. No soil layers suitable for rapid infiltration were encountered in any of the test pits, excavated to depths between 3.0 m to 3.9 m below ground level.

Discharge to land was assessed as unviable for the site without further investigations to locate suitable soils for rapid infiltration. Attenuation of stormwater flows and discharge to existing drain on site has therefore, been assessed.

4.2 Discharge to Existing Drain

Discharging to the existing drain (as shown in Figure A2, Appendix A) will require any additional flows in excess of pre-development to be attenuated. Attenuating flows to the pre-development and maintaining the existing flow paths, will ensure that flood levels downstream of the proposed sub-division will not increase.

4.2.1 Peak Flows

The peak flow is important as it determines the extent of flooding expected through the site, and downstream. The WWDG equation 21-1 describes the rational method as a simple empirical procedure for determining runoff from small catchments. Table 2 shows the rational method flow rate estimation for the site. The two areas shown are:

- The full upstream catchment, including the site up to the discharge point at the south eastern site boundary (as shown on Figure A2, Appendix A); and
- Only the site catchment.

The runoff coefficients used were taken from the WDC Engineering Code of Practice. They were area weighted for the changes in catchment slopes.

Table 2: Rational Method for Site Catchments

Parameter	Full Catchment[1]	Site
Area (ha)	15.4	4.1
Runoff Coeffecient[2]	0.32	0.3
Time of Concentration[3] (min)	39.5 min	18.5 min
Rainfall Intensity[4] (mm/hr)	56.3	83.5
Peak Flow (m^3/s)	0.77	0.29

Notes:

1. *Includes the site*
2. *Based on Table 5.2 from the WDC Engineering Code of Practice*
3. *Using Bransby-Williams Equation*
4. *Linearly interpolated (for the corresponding time of concentration) from HIRDS v4, using a 100-year ARI and RCP 8.5 climate scenario for the period 2081-2100*

While the rational method generally provides a reasonable estimation of peak flow, it does not produce a catchment hydrograph to undertake volumetric analysis. A HEC-HMS model was used to estimate the hydrographs for the site and estimate the required volume of run-off for storage. The HEC-HMS model was used for the site only and not the full catchment because the development changes are only occurring in the site boundaries.

4.2.2 Required Attenuation

HEC-HMS generates a hydrograph based on an input rainfall hyetograph. For this assessment, a CCC triangular hyetograph with a peak twice the average intensity occurring at 0.7 duration (as per section 21.4.1 of the WWDG). Hydrographs for the durations from 20 minutes to 24 hours were modelled.

The rainfall-runoff was modelled using the SCS curve number method described in Auckland Regional Councils Guidelines for Stormwater Runoff Modelling in the Auckland Region (TP108) (1999). The HEC-HMS model was developed to assess the required attenuation for the site. A pre and post development scenario for the site catchment. It was assumed that 20% of each proposed lot was developed with an impermeable surface. Lot 1 has no proposed changes to the existing dwelling and was therefore, modelled as existing.

The SCS curve number method uses rainfall-runoff curves based on hydrological soil groups. The site was classified as hydrological group C based on having moderately high runoff potential and a clayey silt texture from the site visit. The predevelopment curve number of 74 is in line with the values presented in TP-108 for group C pasture, lightly grazed, good grass cover soils. The post-development curve number is area weighted assuming a curve number of 98 for impervious areas.

Table 3: HEC-HMS Flows

Parameter	Pre-Development	Post-Development
Area (ha)	4.1	4.1
Curve Number	74	78
Initial abstraction (mm)[1]	5	4.15
Peak flow generated (m^3/s)	0.29	0.34
Required attenuation (m^3)	39 (plus additional 5 m^3 for Lot 7)	

Notes:
1. *Area weighted*

The peak flow in the pre-development scenario using the curve number of 74 is similar to the rational method estimation using the WDC Engineering code of practice runoff coefficients. This provides confidence in the HEC-HMS model assumptions for the local soils. The attenuation volume of 39 m^3 assumes that the detention outlet can discharge pre-development flows during the storm duration and any excess stormwater is stored and released after the rainfall event. This ensures that the pre-development flows are not exceeded and existing downstream flood levels are not exceeded. The volume for Lot 7 has been calculated separately.

4.3 Attenuation

The HEC-HMS model estimates that 39 m^3 of storage is required to attenuate flows from Lots 2 to 6 to pre-development levels and 5 m^3 to attenuate flows from Lot 7. A potential solution for stormwater attenuation for the full site is presented below. This solution is presented to give an example of how storage can be achieved on site at a conceptual level. Individual site management for every lot has not been considered.

4.3.1 Proposed Detention Swale

A suitable location for detention is where the overland flow paths for each of the lots can be intercepted. It is proposed to locate a detention swale with a sequence of check dams north of the access road, as shown by the “detention dam” in Figure A3 (Appendix A). The road and easement area located at the south of the site has been kept clear to provide access to any future developments to the land south of the proposed development.

A detention swale with 1V:4H side slopes, a top width of 4 m and a depth of 0.5 m will be required for a length of approximately 175 m to accommodate the required detention volume. The average fall of the land along the southern boundary is 1.5%. Maintaining this grade will require a maximum distance between check dams of 33 m. Given the location of the proposed detention swale, the width of the check dams can be extended to provide vehicle crossings to the lots, as shown in Figure 4.

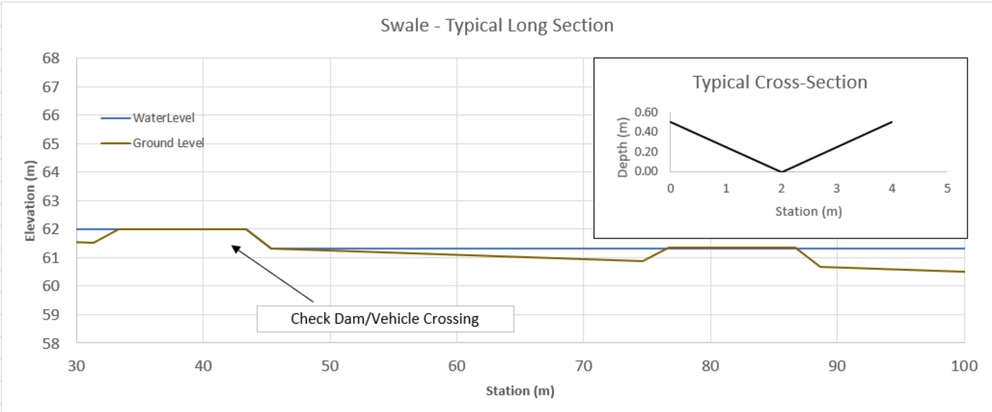

Figure 4: Typical swale cross-section

The LiDAR indicates that the general fall of the site is from the northwest to southeast. The site flow is expected to sheet flow towards the southern boundary rather than concentrating in the western OLFP shown in Figure A2. A drain is proposed along the boundary between the Lots 2 and 3 and the access road, upstream of the detention swale to intercept flow (as shown in Figure A3 as 'South Drain'). The access road will be contoured for stormwater flows to enter the drain/detention swale. A controlled outlet will be required to limit the flows to pre development flows that can discharge from the swale to the existing drain prior to Lot 7. Road access will need to be maintained for Lot 7 and a pipe will be required to direct the flow from the end of the detention swale to the existing drain. To reduce the impact of the detention swale on Lot 7, it is proposed that attenuation for Lot 7 is managed within the Lot. The estimated 5 m^3 of stormwater to be attenuated can be managed via a standalone detention pond. This can be located adjacent to the existing drain and flows discharged via a controlled outlet.

4.4 Flood Hazard

The Waimakariri District Natural Hazards Interactive Viewer provides a flood hazard mapping from modelling undertaken within the district. Figure 5 shows that there is one location within the site categorised as low flood hazard. This area is along the western existing overland flow path. Contouring the proposed Lots to favour flows being directed to the proposed 'South Drain' (as shown in Figure A3) would ensure flows do not concentrate along this flow path.

The existing drain, shown as the 'Existing Drain' on Figure A3, should be maintained and formalised to convey overland flow through the site from the upgradient catchment. As previously discussed, the existing drain likely acts as the current overland flow path for the eastern portion of the site, rather than the modelled LiDAR OFLPs. The 'Modified Existing Drain' shown on Figure A3 shows the drain relocated along the boundary of Lot 5 and 6. This will allow greater flexibility in where the building footprint can be located, while maintaining capacity to convey the overland flow path. It is recommended that the site be contoured towards the proposed drain to reduce existing preferential flow paths. Table 4 presents the dimensions of a trapezoidal channel suitable to convey the overland flows. The estimated 100-year flow used in Table 4 is from the calculated rational method presented in Section 4.2.1.

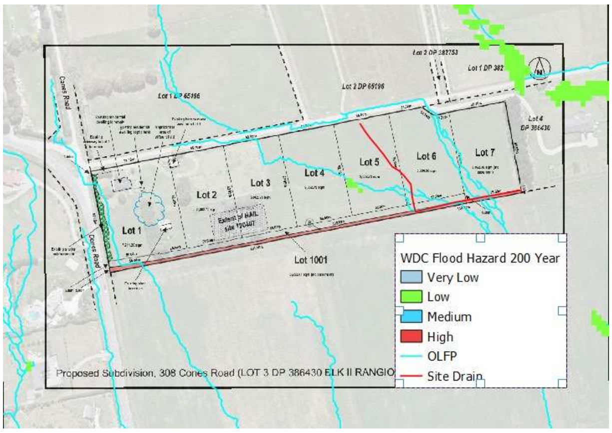

Figure 5: Waimakariri District Natural Hazards Interactive Viewer Flood Hazards

Table 4: Overland Flow Channels

Parameter	Formalised Existing Drain	Proposed South Drain
Top Width (m)	3.9	2.7
Base Width (m)	0.3	0.3
Side slopes 1V:xH	4	4
Depth (m)	0.45	0.3
Mannings n[1]	0.035	0.035
Slope (%)	1.8%	1.6%
Flow Capacity (m^3/s)[2]	0.86	0.30
Estimated 100 year flow (m^3/s)	0.77	0.29

Notes:

1. *From WWDG Table 22-I*
2. *Using Mannings equation (WWDG equation 22-2)*

All flows within the site up to the 100-year ARI event will be captured within the site and conveyed to a detention area prior to being discharged via a controlled outlet to the existing drain at the south eastern boundary.

Figure A3, Appendix A shows the proposed stormwater features at the site. It is recommended that any structures are located outside of these areas to reduce the risk of inundation.

5.0 Conclusion

This stormwater assessment has been prepared in response to the RFI question from WDC regarding stormwater management. The site currently has an existing drain along the southern eastern boundary which conveys stormwater flows from the site and a upgradient catchment.

A site investigation concluded that a discharge to land will not be viable without further investigations to locate suitable soils for rapid infiltration. Therefore, a discharge to the existing drain is proposed with additional flows from the sub-division being attenuated before being discharged via a controlled outlet.

A HEC-HMS model was developed to assess the volume of detention required. For a 100-year ARI, with a RCP 8.5 Climate scenario, 39 m^3 of storage is required for Lots 2 to 6 and 5 m^3 for Lot 7 to ensure pre-development flows are not exceeded. Lot 1 is not included in the calculation as there is already an existing dwelling and no further development planned. A potential solution for attenuating flows for Lots 2 to 6 is a detention swale constructed with a sequence of check dams to detain the water before being discharged via a controlled outlet to the existing drain on the south eastern corner of the site. For Lots 2 and 3 west of the detention swale, a drain will be formed on the southern boundary of these sites to intercept the runoff and convey stormwater flows to the detention swale. Lot 7 is proposed to be attenuated via a detention pond prior to discharging to the existing drain through a controlled outlet. It is recommended that structures are not located along any of the proposed stormwater infrastructure to reduce the risk of inundation.

6.0 References

Auckland Regional Council. (1999). *Guidelines for stormwater runoff modelling in the Auckland Region.* Auckland: Auckland Regional Council.

Chirstchurch City Council. (2003). *Waterways Wetlands and Drainage Guide: Part B.* Christchurch: Chirstchurch City Council.

Waimakariri District Council. (2019). *Engineering Code of Practice.* Rangiora: Waimakariri District Council.

Appendix A: Figures

Figure A1: Site location
Figure A2: Site Catchments
Figure A3: Proposed overland flow paths

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.
2. CADASTRAL/TOPOGRAPHICAL INFORMATION AND INSET SOURCED FROM THE LINZ DATA SERVICE https://data.linz.govt.nz/ AND LICENSED FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 4.0 INTERNATIONAL LICENCE.

Key:

Site

pdp

75 150 m

METRES

SCALE : 1:5,000 (A4)

NO.	REVISION	DATE	BY
A	Final	DEC 22	NP

CLIENT

Andy Carr

FIGURE

Figure A1 - Site Location

PROJECT 308 Cones Road - Stormwater Assessment

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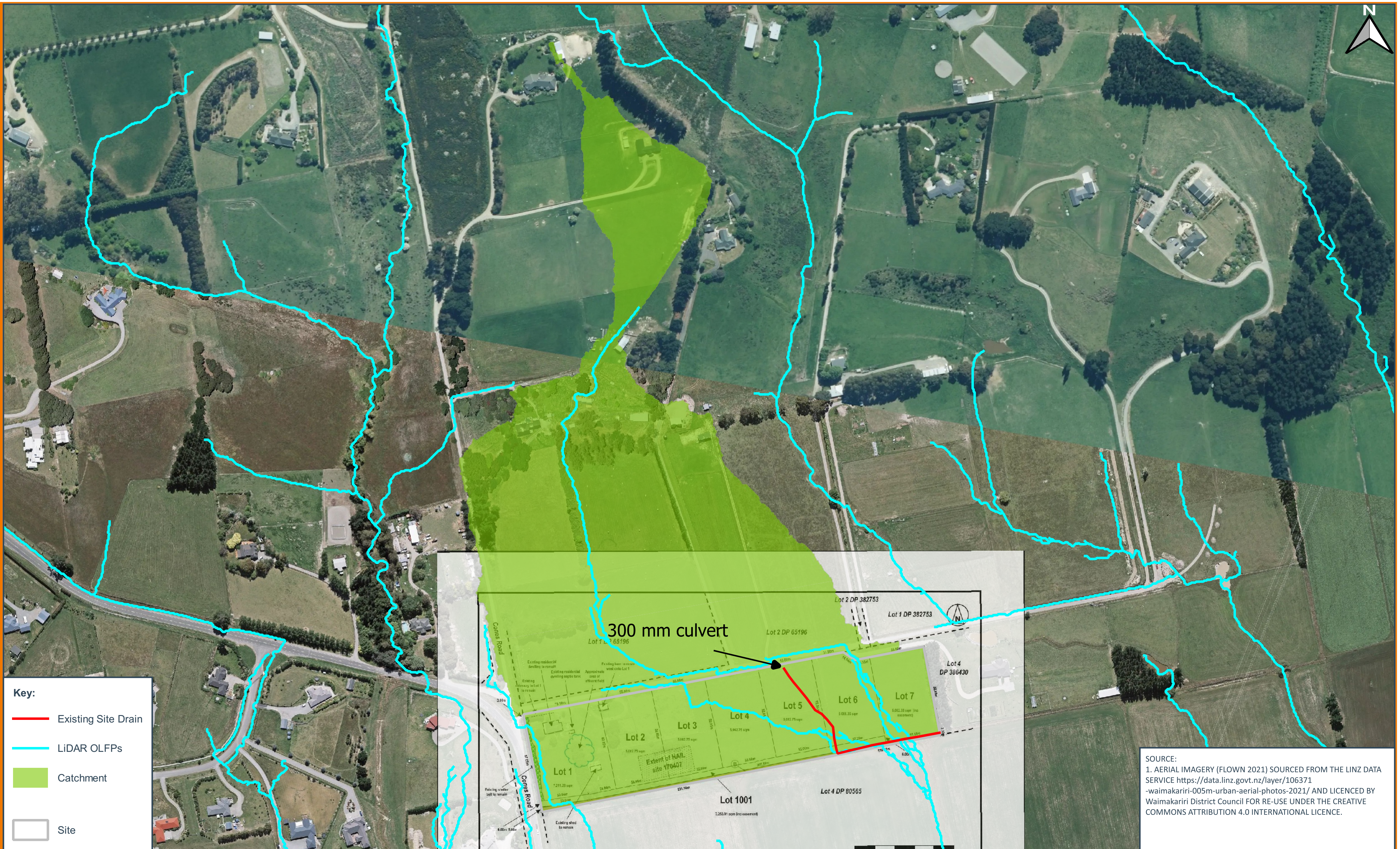

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pdp

75 150 m

METRES

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CLIENT

Andy Carr

FIGURE

Figure A2 - Stormwater Catchment

PROJECT

308 Cones Road - Stormwater Assessment

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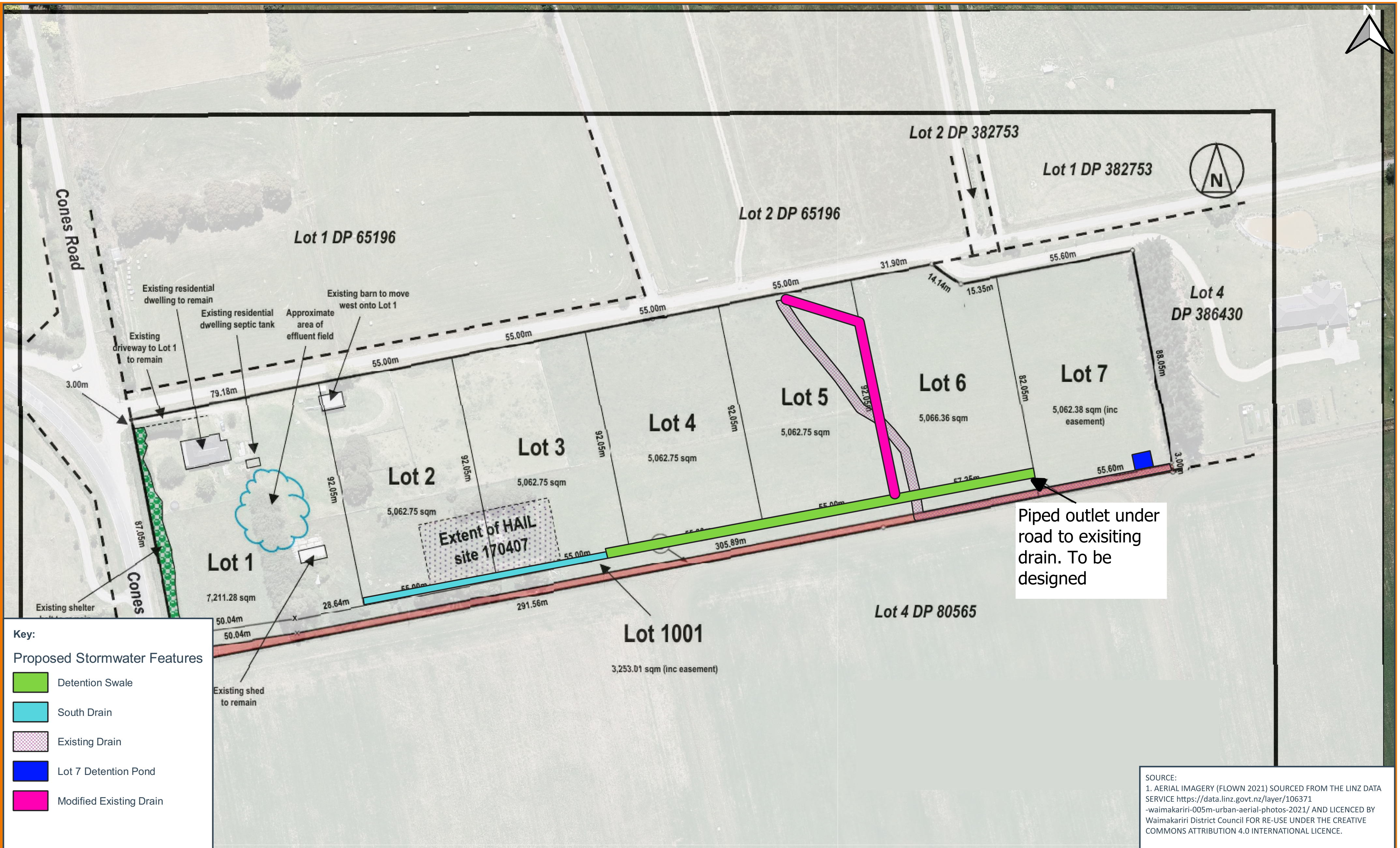

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pdp

25 50 m

METRES

SCALE : 1:2,000 (A4)

NO.	REVISION	DATE	BY
A	Final	DEC 22	NP

CLIENT

Andy Carr

FIGURE

Figure A3 - Proposed Stormwater Features

PROJECT

308 Cones Road - Stormwater Assessment

Annexure C: Stormwater Report for 90 Dixons Road

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29 September 2023

Andy Carr
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Dear Andy

STORMWATER ASSESSMENT FOR NEIGHBOURING LAND – 308 CONES ROAD, LOBURN

1.0 Introduction

A stormwater assessment has previously been undertaken by Pattle Delamore Partners Limited (PDP) for 308 Cones Road ('Site' in Figure 1) as part of a previous subdivision application for the site. Both the site and an area of land to the immediate south of the site ('Additional Area' in Figure 1) are proposed to be zoned in the Waimakariri Proposed District Plan as Large Lot Residential Zone Overlay. This means that any Outline Development Plan for one parcel of land needs to be cognisant of the other. PDP has therefore been engaged to undertake a high-level desktop assessment to evaluate the ability of the Additional Area to manage its own stormwater if it is developed in the future. No site inspection was undertaken as part of this assessment.

This letter outlines the existing stormwater flow paths and high-level storage requirement estimates for the Additional Area (hereon referred to as the 'assessment area').

Figure 1: Site and Additional Area Location

2.0 Overland Flow Paths

Figure 2 shows the overland flow paths (OLFP) generated using LiDAR flown in 2020 (obtained from Land Information New Zealand). Currently, a drain (shown as the red line on Figure 2) on the eastern end of the southern boundary of the site intercepts the OLFP entering the central portion of the assessment area and conveys the flow to the southeast corner of 308 Cones Road. This flow continues east within the drain before eventually flowing through the assessment area via the eastern most OLFP. This appears to be a well-formed drainage flow path.

In general, overland flow paths across the assessment area travel in a south to south-easterly direction. The flows are collected along grassed berm adjacent to Dixons Road and flow to a drain east of the assessment area. The land is currently undeveloped farmland and contains a Transpower high voltage power pylon in the eastern most paddock. There are three major OLFPs through the site.

- One conveying upgradient flows adjacent to the eastern boundary;
- One conveying upgradient flows through the south-eastern corner of the assessment area; and
- OLFPs through the centre of the assessment area. The upgradient portion of these OLFPs are intercepted as discussed above. During very large storm events, the capacity of the upgradient drain is exceeded, flows are expected to utilise these OLFPs.

For this assessment it has been assumed that the existing OLFPs that pass through the assessment area will be retained/maintained as part of any future development of this land area. As part of any proposed development, engineered modifications and/or diversion to the OLFP may be undertaken. The stormwater design for the site will be required to ensure that the post-development flows do not result in adverse flood effects outside of the area.

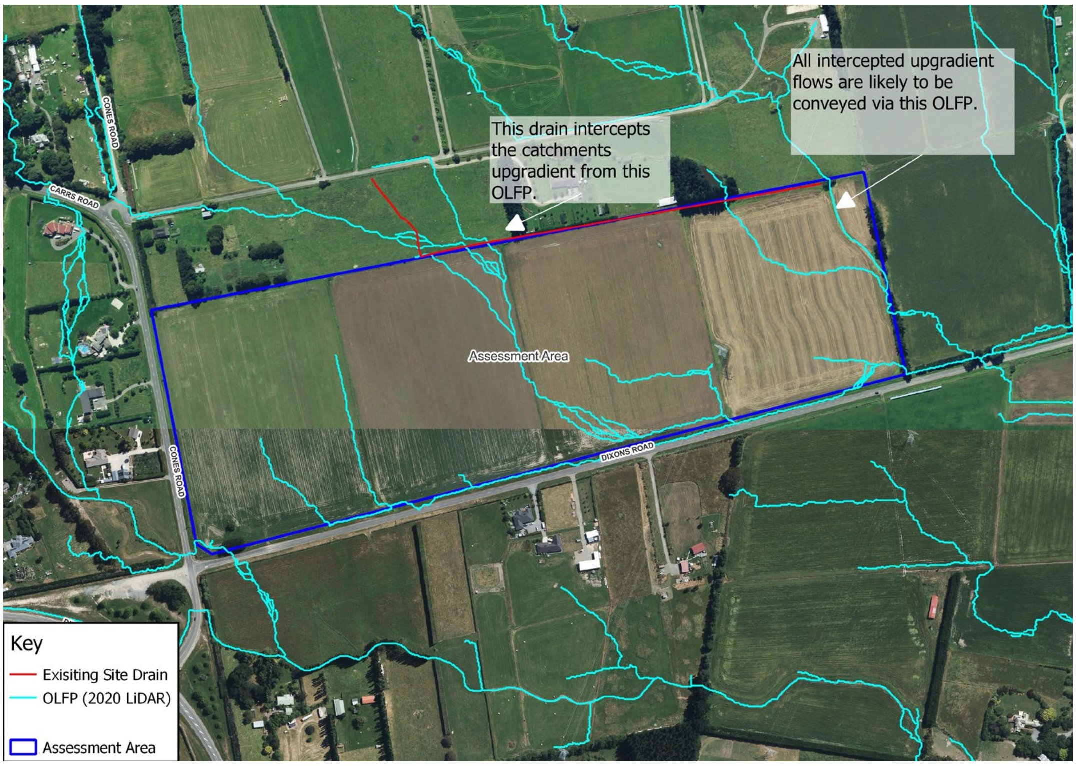

Figure 2: Overland Flow Paths generated using the 2020 LiDAR.

3.0 Proposed Development

Development often results in an increase in impermeable area. This, in turn, increases the potential stormwater flows during rainfall events as water that previously would have infiltrated now forms runoff. This increase in stormwater flows needs to be managed to ensure that there are less than minor effects on flooding on adjacent properties. This is often managed by attenuating flows or disposal of additional flows on site.

A high-level hydrologic model has been developed in HEC-HMS. The purpose of this model is to estimate the additional stormwater flows and potential storage requirements resulting from the development of the assessment area. A 100-year average recurrence interval (ARI) rainfall event has been assessed.

The maximum impermeable area for the assessment area post development has been assumed to be 20%. This is the same assumption that was used for the 308 Cones Road assessment. The parameters for the hydrologic model were also based on the previous 308 Cones Road assessment for consistency and without any other site-specific information. These parameters are summarised in Table 1. The SCS curve number methodology was used to model the runoff in the pre and post-development scenarios. A curve number (CN) is used to estimate the portion of runoff generated over a particular area. A higher CN value greater impermeability (CN of 98 represents impervious).

Table 1: Hydrologic Model Parameters

Parameter	Pre Development	Post Development[3]
Area (ha)[1]	20.6	20.6
Curve Number[2]	74.0	78.8
Initial Abstraction (mm)	5.0	4.0
Storm Event	100-year ARI, RCP 8.5, 2 hour duration	

Notes:

1. *Total area of the 'Assessment Area', upgradient areas have been excluded from this assessment.*
2. *Pre-development curve number based on the 308 Cones Road investigations. Post-development curve number is an area weighted average.*
3. *Based on a development impervious area of 20%*

Within the model, all flows greater than 80% of the pre-development flow is stored to conservatively estimate the storage requirement for the assessment area post-development. The modelled storage requirement under these assumptions is 900 m^3.

Figure 3 illustrates the modelled storage mechanism. To estimate the storage requirements, the model has assumed all flows will enter a single attenuation basin and be discharged via a controlled outlet. Given the topography of the land, multiple basins along the southern and eastern boundary may be required. This will be dependent on the proposed development layout. The location and outlet structures for basins will require engineering design during the design stages of any development. Field observations at 308 Cones identified rapid stormwater discharge to ground via soak pits was not feasible due to the underlying soils. The same assumption has been made for the assessment area, however, given the lower elevations of the assessment area, it is recommended that soakage testing be undertaken to confirm this assumption. Disposal of stormwater to land will reduce the stormwater attenuation footprint on the site.

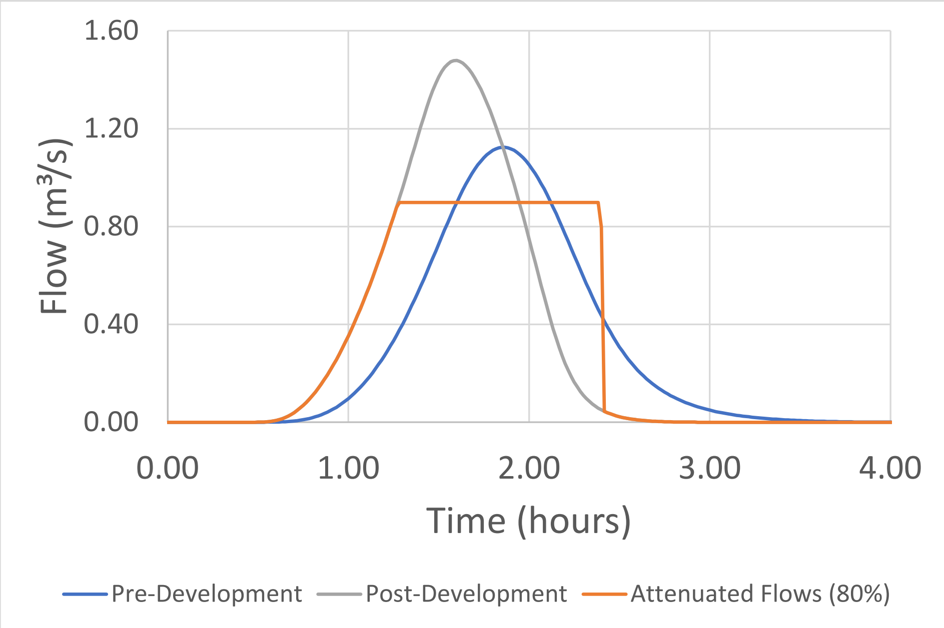

Figure 3: Pre-development and post-development hydrographs for the assessment area

4.0 Topographical Depressions

Figure 4 shows the existing topographical depressions for the area based on 2020 LiDAR. The depressions are areas where water will enter and pond until it reaches its 'full level'. Without engineered outlets (i.e. culverts), ponded areas will infiltrate slowly to land, which is likely the current situation. Minor depressions have been filtered out and are not shown in Figure 4.

It is noted that the depressions located within the assessment area are located within existing flow paths. The storage within these depressions has not been accounted for in the hydrologic model described in Section 3.0 as the model assesses change of land use, not topography. Therefore, the capacity of the depression areas to accommodate the additional development flows has not been assessed.

Given the low-elevation nature of these depression areas, attenuation solutions may benefit to be located in and around existing depressions. It is recommended that the attenuation solution selected utilise the depressions and any additional storage capacity these depressions have (i.e., able to accommodate an additional 900 m^3) to reduce the stormwater attenuation footprint and earthworks in the area. This would need a topographical survey of the area and more detailed hydraulic modelling to be undertaken which is beyond the scope of this assessment. Alternatively, there appears to be sufficient area to accommodate dedicated stormwater storage if the modification of the existing depressions are found to be unfeasible.

Figure 4: Existing Depressions

5.0 Conclusions and Recommendations

This stormwater assessment has been undertaken to assess the current stormwater features and a high-level estimation of stormwater storage requirements for the land area located to the south of 308 Cones Road. The assessment was undertaken using LiDAR flown in 2020 and assumed a post-development impervious area percentage of 20%, which is consistent with the 308 Cones Road assessment.

There are two large OLFPs along the southeastern and western boundaries of the assessment area which convey flows from upgradient catchments. The upgradient component of the OLFP through the centre of the assessment area will be intercepted by the existing drain within 308 Cones Road and likely conveyed to the eastern assessment area OLFP. For this assessment it has been assumed that the existing OLFPs that pass through the assessment area will be retained/maintained as part of any future development of this land area. As part of any proposed development, engineered modifications and/or diversion to the OLFP may be undertaken.

A high-level HEC-HMS model estimates that the storage requirements over the entire assessment area will be approximately 900 m³ in a 100-year ARI storm event. Given the topography and extent of the assessment area, multiple attenuation basins may be required.

There are several existing topographic depressions within the assessment area. These depressions typically are located within the OLFPs and may be incorporated into the design of any attenuation basin. The capacity for these depressions to accommodate the additional flows has not been taken into account in the HEC-HMS modelling. It is recommended that the existing storage capacity of the depressions be assessed to determine whether they have the capacity to take the additional storage requirement. This will help reduce any basin footprints and earthworks within the area. However, there also appears to be sufficient area to accommodate dedicated stormwater storage if the existing depressions cannot be utilised. Discharge to land options were not assessed in this assessment however it is recommended that soakage testing be undertaken in the future to check the feasibility of this option.

This initial high-level assessment indicates that with proper development layout and engineering design, stormwater can be appropriately managed within the assessment area.

6.0 Limitations

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Andy Carr. 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 Andy Carr 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.

Yours faithfully

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