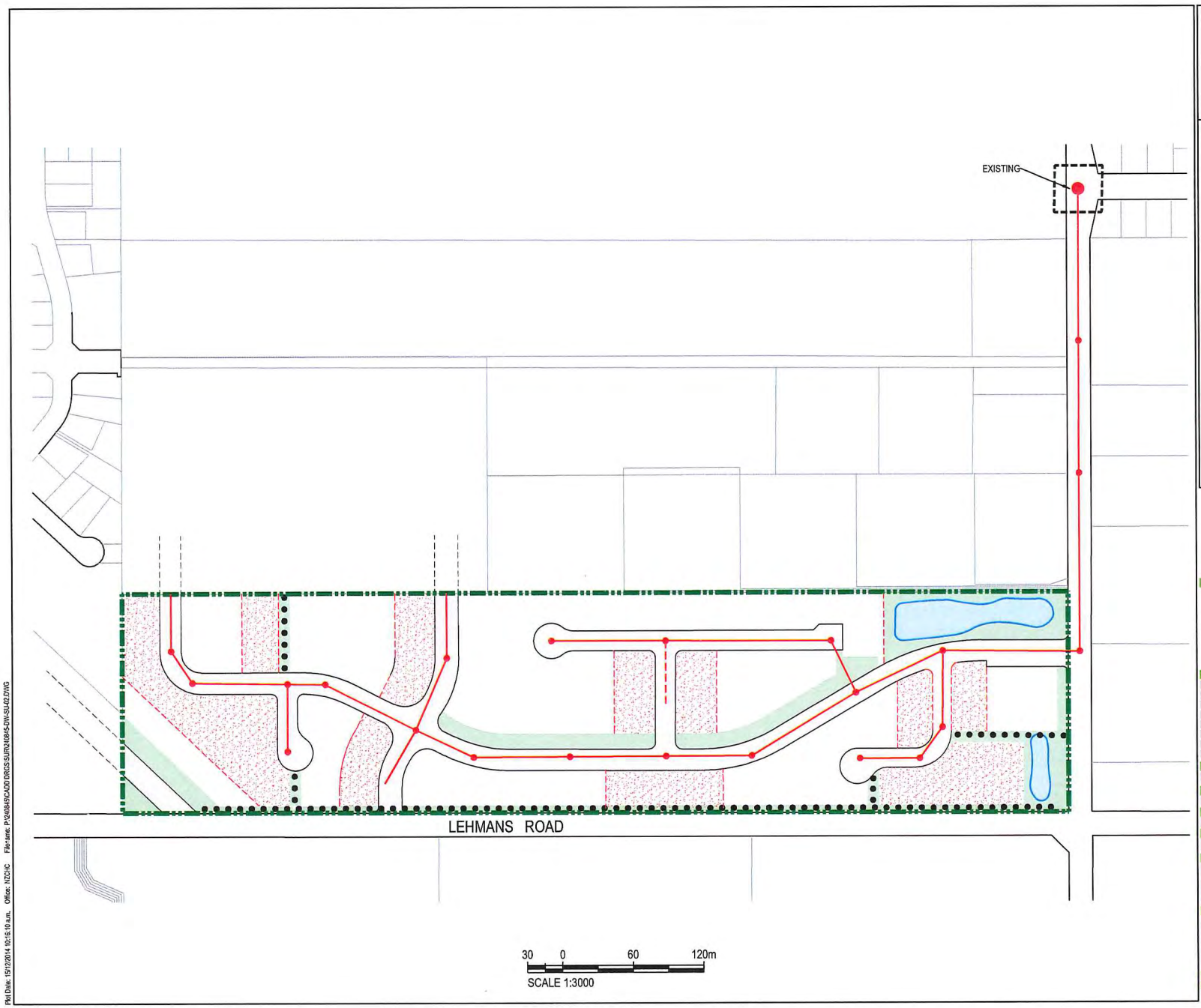


N

AREA OF DEVELOPMENT

APPROXIMATE LAYOUT OF NEW LOCAL ROADS

PROPOSED ROAD

OFF-STREET PEDESTRIAN / CYCLE FACILITIES

PROPOSED STORMWATER & RECREATION RESERVES

PROPOSED STORMWATER MANAGEMENT AREA

PROPOSED COMPREHENSIVE RESIDENTIAL DEVELOPMENT

PROPOSED WASTEWATER DRAINAGE SYSTEM

PROPOSED CONNECTION

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CLIENT

**WESTPARK RANGIORA LTD**

| REV | DATE | REVISION DETAILS | APPROVED |
|---|---|---|---|
| A | 09/05/14 | ISSUE | M HANRAHAN |
| B | 30/07/14 | COMPREHENSIVE RESIDENTIAL ADDED | M HANRAHAN |
| C | 15/12/14 | REALIGNMENT - SOUTHERN END ONLY | J TRIST |

| SCALE | SIZE |
|---|---|
| 1:3000 | A3 |

PRELIMINARY
NOT FOR CONSTRUCTION

DRAWN: R DAWSON
DESIGNED: M HANRAHAN
CHECKED: J TRIST

APPROVED
DATE 09/05/14
M HANRAHAN
M HANRAHAN

PROJECT
WESTPARK
LEHMANS ROAD

TITLE
INDICATIVE
WASTEWATER RETICULATION PLAN

DRAWING NUMBER

| PROJECT No. | WBS | TYPE | DISC | NUMBER | REV |
|---|---|---|---|---|---|
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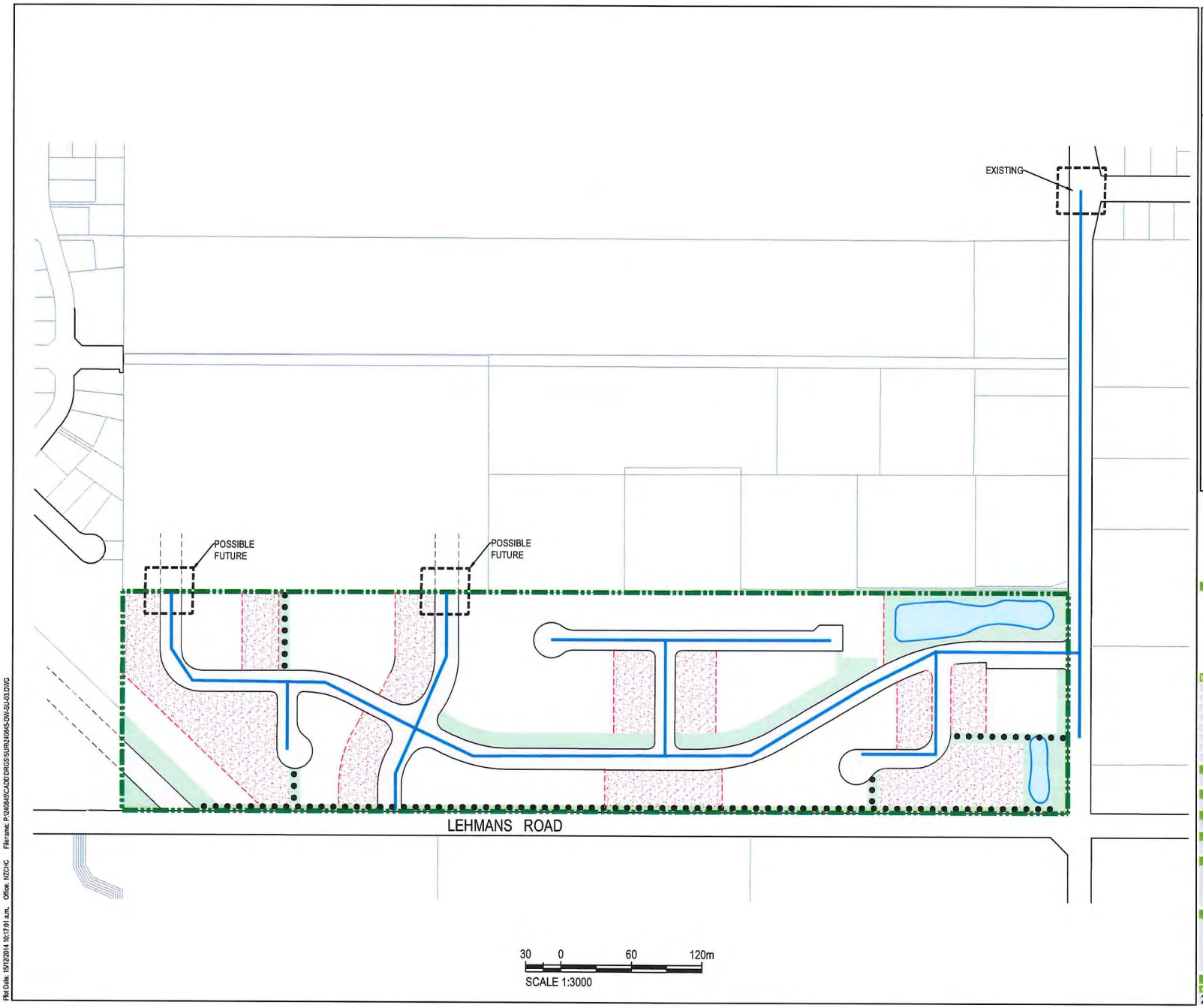


AREA OF DEVELOPMENT

APPROXIMATE LAYOUT OF NEW LOCAL ROADS

PROPOSED ROAD

OFF-STREET PEDESTRIAN / CYCLE FACILITIES

PROPOSED STORMWATER & RECREATION RESERVES

PROPOSED STORMWATER MANAGEMENT AREA

PROPOSED COMPREHENSIVE RESIDENTIAL DEVELOPMENT

PROPOSED WATERMAIN

PROPOSED CONNECTION

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| REV | DATE | REVISION DETAILS | APPROVED |
|---|---|---|---|
| A | 09/05/14 | ISSUE | M HANRAHAN |
| B | 30/07/14 | COMPREHENSIVE RESIDENTIAL ADDED | M HANRAHAN |
| C | 15/12/14 | REALIGNMENT - SOUTHERN END ONLY | J TRIST |

| SCALE | SIZE |
|---|---|
| 1:3000 | A3 |

PRELIMINARY
NOT FOR CONSTRUCTION

DRAWN: R DAWSON
DESIGNED: M HANRAHAN
CHECKED: J TRIST

APPROVED
DATE 09/05/14
M HANRAHAN
M HANRAHAN

PROJECT
WESTPARK
LEHMANS ROAD

TITLE
INDICATIVE
WATER RETICULATION PLAN

DRAWING NUMBER

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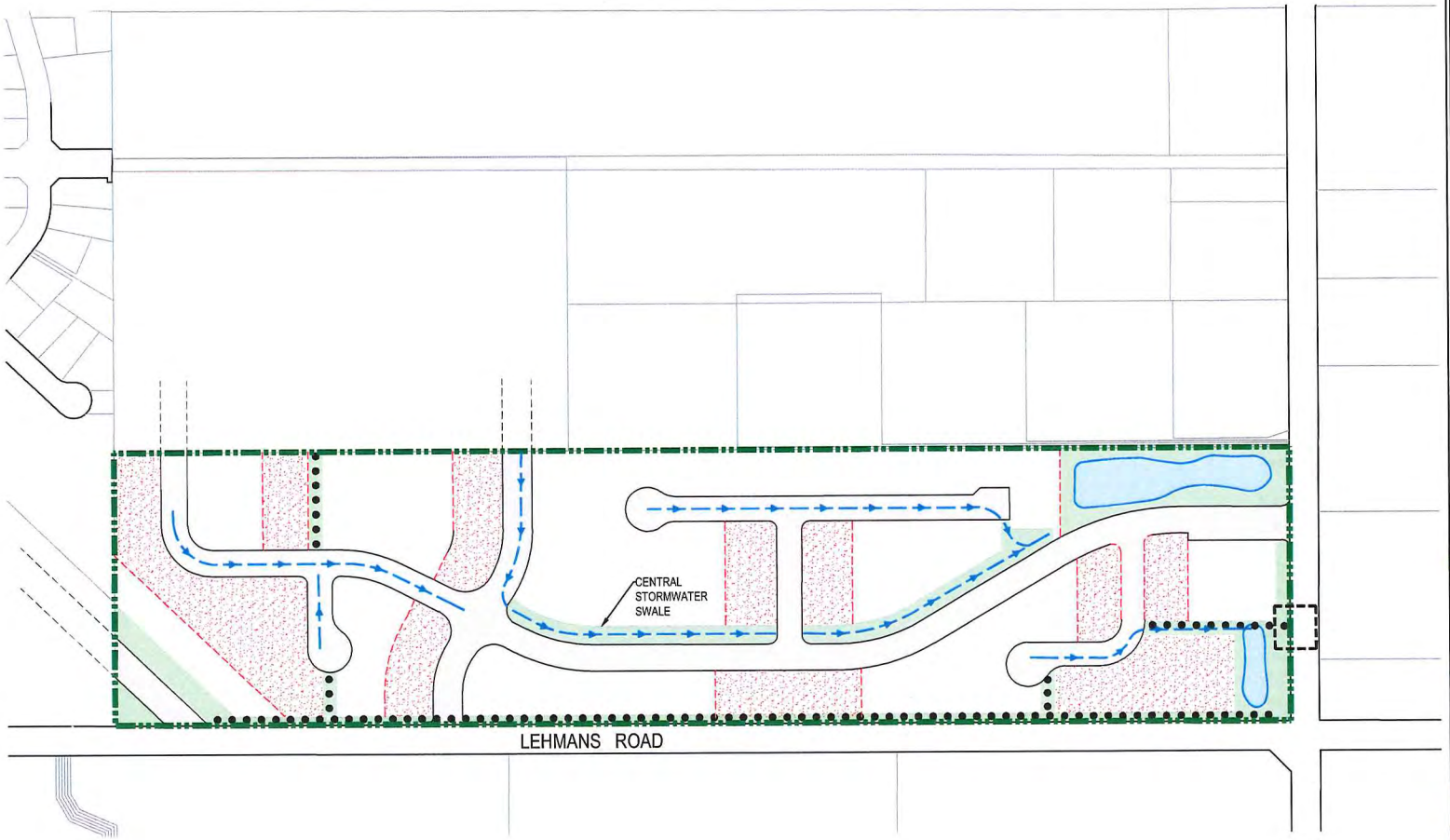


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SCALE 1:3000

AREA OF DEVELOPMENT

APPROXIMATE LAYOUT OF NEW LOCAL ROADS

PROPOSED ROAD

OFF-STREET PEDESTRIAN / CYCLE FACILITIES

PROPOSED STORMWATER & RECREATION RESERVES

PROPOSED STORMWATER MANAGEMENT AREA

PROPOSED COMPREHENSIVE RESIDENTIAL DEVELOPMENT

STORMWATER DRAINAGE PATH

PROPOSED EXTERNAL ROAD CONNECTION

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WESTPARK RANGIORA LTD

| REV | DATE | REVISION DETAILS | APPROVED |
|---|---|---|---|
| A | 09/05/14 | ISSUE | M HANRAHAN |
| B | 30/07/14 | COMPREHENSIVE RESIDENTIAL ADDED | M HANRAHAN |
| C | 15/12/14 | REALIGNMENT - SOUTHERN END ONLY | J TRIST |

| SCALE | SIZE |
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| 1:3000 | A3 |

PRELIMINARY
NOT FOR CONSTRUCTION

DRAWN: R DAWSON
DESIGNED: M HANRAHAN
CHECKED: J TRIST

APPROVED
DATE 09/05/14
M HANRAHAN
M HANRAHAN

PROJECT
WESTPARK
LEHMANS ROAD

TITLE
INDICATIVE
STORMWATER MANAGEMENT SYSTEM

DRAWING NUMBER

| PROJECT No. | | WBS | | TYPE | | DISC | | NUMBER | | REV |
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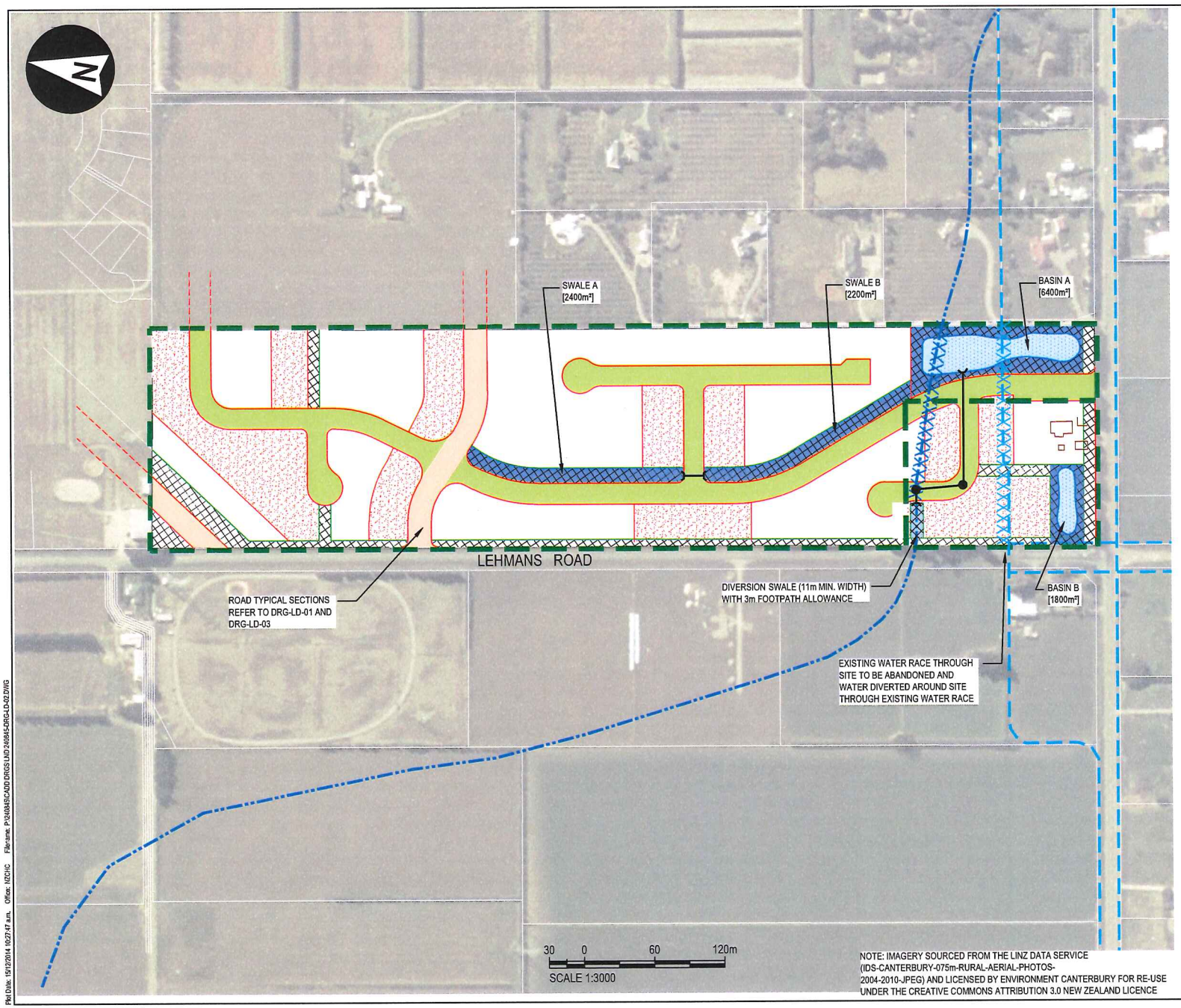
# Appendix C
# Indicative Stormwater Management Plan




NOTE: IMAGERY SOURCED FROM THE LINZ DATA SERVICE (IDS-CANTERBURY-075m-RURAL-AERIAL-PHOTOS-2004-2010-JPEG) AND LICENSED BY ENVIRONMENT CANTERBURY FOR RE-USE UNDER THE CREATIVE COMMONS ATTRIBUTION 3.0 NEW ZEALAND LICENCE

## LEGEND

- EXISTING ROAD RESERVE
- LOCAL ROAD
- URBAN COLLECTOR ROAD
- LOCAL PURPOSE RESERVE
- MEDIUM DENSITY HOUSING
- STORMWATER CATCHMENTS WITHIN DEVELOPMENT AREA
- STORMWATER MANAGEMENT AREA
- STORMWATER BASIN
- EXISTING WATER RACE
- EXISTING DRAINAGE PATH
- EXISTING DRAINAGE PATH (TO BE ABANDONED)
- EXISTING WATER RACE (TO BE ABANDONED)
- DRAINAGE CORRIDOR
- STORMWATER PIPE
- STORMWATER MANHOLE

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**WESTPARK RANGIORA LTD**

| REV | DATE | REVISION DETAILS | APPROVED |
|---|---|---|---|
| A | 30/05/14 | FOR INFORMATION | M HANRAHAN |
| B | 01/08/14 | UPDATE FOR COMPREHENSIVE RESIDENTIAL | M HANRAHAN |
| C | 15/12/14 | REALIGNMENT - SOUTHERN END ONLY | J TRIST |

| SCALE | SIZE | |
|---|---|---|
| AS SHOWN | A3 | INFORMATION NOT FOR CONSTRUCTION |

DRAWN: W. SUTERS
DESIGNED: M. HANRAHAN
CHECKED: J. TRIST
APPROVED: M HANRAHAN DATE 03/05/14
M. HANRAHAN

PROJECT: WESTPARK LEHMANS ROAD

TITLE: PROPOSED STORMWATER MANAGEMENT PLAN

DRAWING NUMBER

| PROJECT No. | WBS | TYPE | DISC | NUMBER | REV |
|---|---|---|---|---|---|
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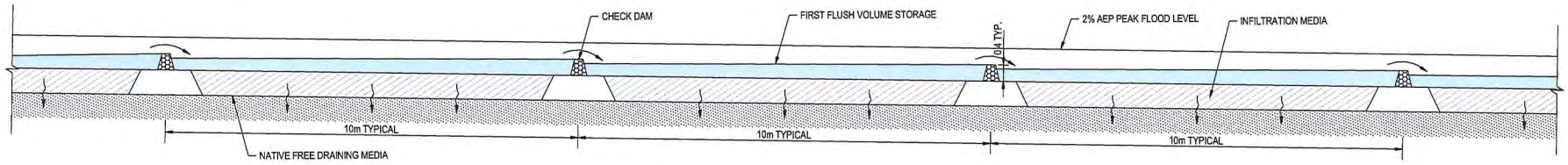
# Appendix D
# Swale Details




TYPICAL LONG SECTION SWALE A & B (REFER DRG-LD-02)
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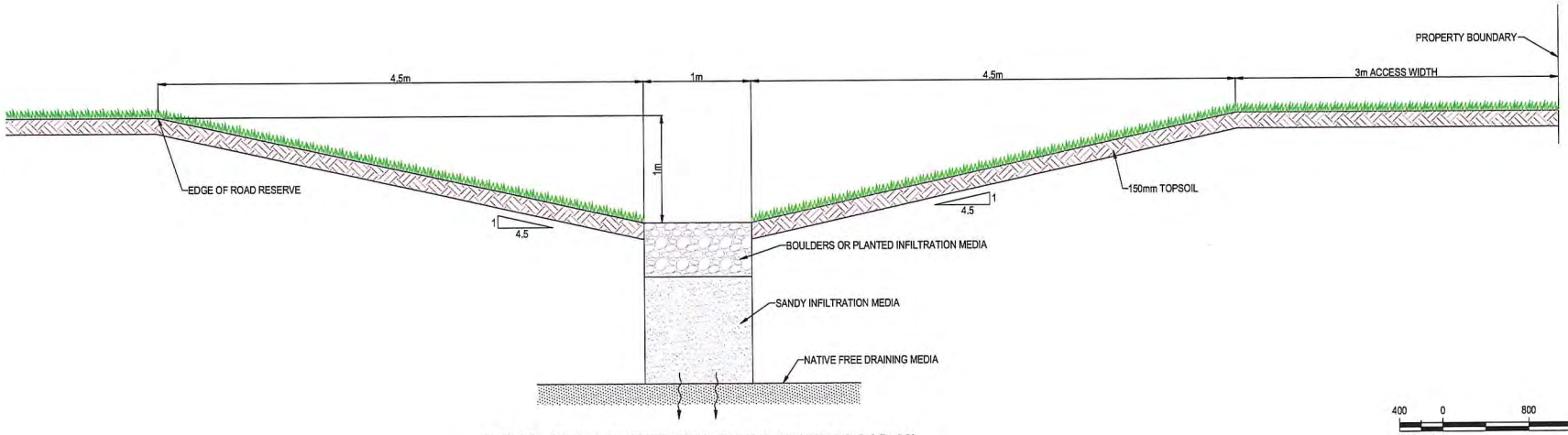


TYPICAL CROSS SECTION SWALE A & B (REFER DRG-LD-02)
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SCALE 1:40

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SCALE 1:100

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CLIENT
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| REV | DATE | REVISION DETAILS | APPROVED |
|---|---|---|---|
| A | 16/06/14 | FOR INFORMATION | M.HANRAHAN |

| SCALE | SIZE |
|---|---|
| AS SHOWN | A3 |
| DRAWN | D.NICHOLSON |
| DESIGNED | E.PAYNE |
| CHECKED | J.TRIST |

PRELIMINARY
NOT FOR CONSTRUCTION
APPROVED
DATE 16/06/14
M.HANRAHAN
M.HANRAHAN

PROJECT: WESTPARK LEHMANS ROAD
TITLE: INFILTRATION SWALE TYPICAL SECTIONS
DRAWING No.: 240845 - 00 - DRG - LD - 03 - A

# Appendix E
# ECan Discharge Consent

3 December 2014

Westpark Rangiora Limited
c/- Mr P D McGowan
74 Mabers Road
RD 2
**Kaiapoi 7692**

Environment Canterbury
Regional Council
Kaunihera Taiao ki Waitaha

Customer Services
P. 03 353 9007 or 0800 324 636

PO Box 345
Christchurch 8140

P. 03 365 3828
F. 03 365 3194
E. ecinfo@ecan.govt.nz

www.ecan.govt.nz

Dear Sir/Madam

**NOTICE OF RESOURCE CONSENT DECISION(S)**

**RECORD NO: CRC152112**
**NAME: Westpark Rangiora Limited**

The decision of Environment Canterbury is to grant your application(s) on the terms and conditions specified in the attached resource consent document(s). Your resource consent(s) commences from the date of this letter advising you of the decision. The reasons for the decision are:

1. Any adverse effects on the environment as a result of the proposed activity will be minor.

For some activities a report is prepared, with officer recommendations, to provide information to the decision makers. If you require a copy of the report please contact our Customer Services section.

If you do not agree with the consent authority decision, you may object to the whole or any part. Notice of any objection must be in writing and lodged with Environment Canterbury within 15 working days of receipt of this decision.

Alternatively you may appeal to the Environment Court, PO Box 2069, Christchurch. The notice of appeal must be lodged with the Court within 15 working days of receipt of this decision, with a copy forwarded to Environment Canterbury within the same timeframe. If you appeal this decision, the commencement date will then be the date on which the decision on the appeal is determined. If you are in any doubt about the correct procedures, you should seek legal advice.

Our Ref: CRC152112
Your Customer No: EC331336,EC351708
Contact: Customer Services

You can find online information about your consent document at http://ecan.govt.nz/publications/General/YourConsentDocumentBooklet09.pdf and also information regarding the monitoring of your consent at http://ecan.govt.nz/publications/General/monitoring-your-consent-booklet.pdf. These booklets contain important information about your consent and answers some commonly asked questions about what will happen next in the life of your resource consent. There is an Annual Compliance Monitoring Charge associated with every consent. For details of this, please refer to page 10 of the "Monitoring Your Consent' booklet.

Charges, set in accordance with section 36 of the Resource Management Act 1991, shall be paid to the Regional Council for the carrying out of its functions in relation to the administration, monitoring and supervision of resource consents and for the carrying out of its functions under section 35 of the Act.

Thank you for helping us make Canterbury a great place to live.

**For all queries please contact our Customer Services Section by telephoning (03) 353 9007, 0800 ECINFO (0800 324 636), or email ecinfo@ecan.govt.nz quoting your CRC number above.**

Yours sincerely

**CONSENTS PLANNING SECTION**

**CC Address:**

Aurecon New Zealand Limited, Christchurch
PO Box 1061
**Christchurch 8140**

# RESOURCE CONSENT CRC152112

***Pursuant to Section 104 of the Resource Management Act 1991***

**The Canterbury Regional Council (known as Environment Canterbury)**

| | |
|---|---|
| GRANTS TO: | Westpark Rangiora Limited |
| A DISCHARGE PERMIT: | To discharge stormwater into land. |
| COMMENCEMENT DATE: | 03 Dec 2014 |
| EXPIRY DATE: | 03 Dec 2049 |
| LOCATION: | 100 Oxford Road & 198 Lehmans Road, Rangiora |

***SUBJECT TO THE FOLLOWING CONDITIONS:***

**Limits**

1 The discharge shall be only stormwater generated from:

a. Roofs, roads and hardstand areas (impervious areas); and

b. Exposed soils during the site construction activities

associated with the residential subdivision development of Part RS 175 located at 100 Oxford Road and 198 Lehmans Road, Rangiora, shown on attached Plan CRC152112A which forms part of this consent.

**Construction Discharges**

2 Stormwater generated during works associated with the construction of the residential subdivision and general earthworks shall be directed within the site to temporary sediment ponds, as described in the consent application.

3 At least 48 hours prior to the commencement of works authorised by this consent, the consent holder shall inform the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager of the start date of works.

4 Prior to the commencement of works the consent holder shall submit an Erosion and Sediment Control Plan (ESCP) to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, for their approval. The ESCP shall be consistent with Canterbury Regional Council's "Erosion and Sediment Control Guidelines for the Canterbury Region", Report No. CRC06/23. Measures shall include, but not be limited to:

a. Ensuring that sediment is not discharging directly off-site;

b. Staging the construction activities; and

c. Taking all practicable measures to prevent tracking of mud or earth to the surrounding road network.

5 The ESCP shall be submitted to Canterbury Regional Council, Attention: Compliance and Enforcement Manager, at least 10 working days prior to construction commencing.

6 The consent holder shall ensure that all relevant personnel working on the site are made aware of and have access to the contents of this consent document and the ESCP.

7 All ESCP measures are to remain in place until the site has been stabilised.

8 All exposed surfaces, shall be stabilised to prevent erosion once earthworks are complete or if the exposed area is not to be further worked on for a period of 14 days or more.

9 The erosion and sediment control measures shall be inspected and maintained in accordance with the ESCP.

10 The ESCP may be amended at any time. Any amendments shall be:

a. Only for the purposes of improving the efficiency of the erosion and sediment control measures and/or quality of the discharge;

b. Consistent with the conditions of this resource consent, and

c. Submitted in writing to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, prior to any amendments being implemented.

**Post-Construction/Operational Discharges**

11 Stormwater that arises from the residential subdivision development in accordance with Condition (1)(a) up to and including a two percent annual exceedance probability storm event shall be only discharged to land within the land parcel, at or about map reference NZ Topo50 BW24 649-050, via the following stormwater systems.

a. Stormwater from roofs shall be discharged directly to ground via individual lot soakage pits. The soakage pits shall be designed for a ten percent annual exceedance probability 1 hour storm event. Flows in excess of this storm event will be discharged as overland flow to the stormwater system.

b. Stormwater from Catchment 1 outlined in Plan CRC152112B shall be collected by catchpits and/or sumps, directed into the treatment swale and first flush basins before discharging into detention basin A.

c. Stormwater from Catchment 2 outlined in Plan CRC152112B shall be directed into the road stormwater network and conveyed via pipe and to first flush basins to discharge into infiltration basin B.

12 The treatment swale shall be:

a. Designed and constructed in accordance with the Waimakariri District Council's Engineering Code of Practice: Part 5, the NZ Transport Agency's Stormwater Treatment Standard for State Highway Infrastructure or the Christchurch City Council's Waterways, Wetlands and Drainage Guide. Where there is any conflict with the conditions of this consent, the requirement of the conditions shall apply;

b. Uniformly vegetated with grass with at least 90% coverage of the ground surface of at least 50 millimetres in height but no greater than 150 millimetres in height.

13 The first flush basins, in accordance with Condition (11), shall be designed and constructed to:

a. Capture stormwater from at least the first 17.5 millimetres of rainfall on the contributing catchment;

b. Have an infiltration rate not exceeding:

i. 112 millimetres per hour and not less than 18mm per hour as determined using a double ring infiltrometer test; or

ii. 75 millimetres per hour and not less than 12 mm per hour as determined using a flooded basin test.

c. Be lined with a layer of sandy loam topsoil at least 150 millimetres thick on the base and sides sufficient to maintain vegetation or ground cover plants.

14 The infiltration basins, in accordance with Condition (11), shall be designed and constructed to:

a. Provide a minimum stormwater detention volume equal to the 20% AEP 18 hour storm event;

b. Provide for rapid soakage to land of stormwater that exceeds the first flush event up to and including the 2% AEP storm event;

c. Provide for a secondary overflow path to the existing drainage path immediately downstream of the site or the Oxford Roadside drain when capacity is exceeded in the 2% AEP storm event;

d. Be lined with a layer of sandy loam topsoil at least 150 millimetres thick on the base and sides sufficient to maintain vegetation or ground cover plants

e. Have outlets and secondary overflow paths that provide for appropriate protection to minimise erosion and scour.

15 Within 20 working days of the construction and installation of the stormwater system, a certificate signed by a Chartered Professional Engineer (CPEng) with stormwater system construction experience shall be submitted to the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, to certify that the system is constructed and installed in accordance with the submitted concept design plans and in accordance with Conditions (11) to (15) of this consent. This CPEng shall also sign a statement confirming that they are competent to certify the engineering work.

**Inspections, Maintenance and Monitoring**

16 The completed operational stormwater system shall be inspected following completion of bulk earthworks. Any accumulated sediment or debris shall be removed as soon as practicable but within 10 working days.

17 Within six months of the commencement of this consent, the consent holder shall prepare and implement a routine maintenance programme for the discharges authorised by this consent. At a minimum, the programme shall detail:

a. The first flush basins to be inspected at least twice a year and any accumulated sediment to be removed when the sediment occupies more than 10 percent of the capacity, within 20 working days of the inspection.

b. For the swales, first flush basins and dry detention basins to be inspected at least once every year and:

i. Any visible debris or litter to be removed

ii. Any accumulated sediment to be removed within 20 working days of the inspection;

iii. Any scour or erosion in the sides or invert to be repaired and replanted within ten working days of the inspection;

iv. Vegetation or grass to be maintained in a healthy and uniform state with the exception of seasonal browning off in the summer and autumn, and shall be replanted where erosion or die-off has resulted in bare or patchy soil cover.

c. Any material removed in accordance with this condition shall be disposed of at a facility authorised to receive such material.

18 A record shall be kept of all inspections, maintenance, and monitoring undertaken in accordance with Conditions (16) to (17). These records shall be made available to the Canterbury Regional Council on request.

**Spills**

19 In the event of a spill of fuel or any other contaminant, the fuel or other contaminant shall be prevented from entering the stormwater system or discharging off site. When such a spill occurs, the consent holder shall:

a. Immediately notify the Canterbury Regional Council Pollution Hotline; and

b. Provide the Canterbury Regional Council, Attention: RMA Compliance and Enforcement Manager, within 24 hours, details as to the time, date and duration of the spill and the procedures undertaken to clean up the spill.

**Administration**

20 The lapsing date for the purposes of Section 125 of the RMA Act 1991 shall be 31 December 2019.

21 The Canterbury Regional Council may, on any of the last five days of May or September each year, serve notice of its intention to review the conditions of this consent pursuant to section 128 of the Resource Management Act 1991 for the purposes of:

a. Dealing with any adverse effect on the environment which may arise from the exercise of this consent and which it is appropriate to deal with at a later stage; or

b. Managing the discharge of water that may have a more than minor effect on flooding or drainage on downstream land owners; or

c. Requiring the adoption of the best practicable option to remove or reduce any adverse effects on the environment; or

d. Requiring the consent holder to carry out monitoring and reporting instead of, or in addition to, that required by the consent; or

e. Complying with the requirements of a relevant rule in an operative regional plan; or

f. Taking into account any Act of Parliament, Regulation, National Policy Statement, Regional Policy Statement or relevant regional plan which relates to limiting, recording or mitigating activities authorised by this consent.

**Issued at Christchurch on 3 December 2014**

Canterbury Regional Council

Environment Canterbury Regional Council
Kaunihera Taiao ki Waitaha

**Consent No: CRC152112**

# Exercising of resource consent

## It is important that you notify Environment Canterbury when you first start using your consent.

---

**GRANTED TO:** Westpark Rangiora Limited
**A DISCHARGE PERMIT:** To discharge stormwater into land.
**LOCATION:** 100 Oxford Road & 198 Lehmans Road, Rangiora

---

Even if the consent is replacing a previous consent for the same activity, you need to complete and return this page.

Providing this information will:

- Validate your consent through to its expiry date
- Minimise compliance monitoring charges
- Help provide an accurate picture of the state of the environment.

If consent CRC152112 is not used before 31 Dec 2019 this consent will lapse and no longer be valid.

**Declaration:**

I have started using this resource consent.

**Action taken:** (e.g. pasture irrigated, discharge from septic tank/boiler/spray booth etc).

_____

**Approximate start date** (***Note: this may be different to the date the consent was granted):***: _____

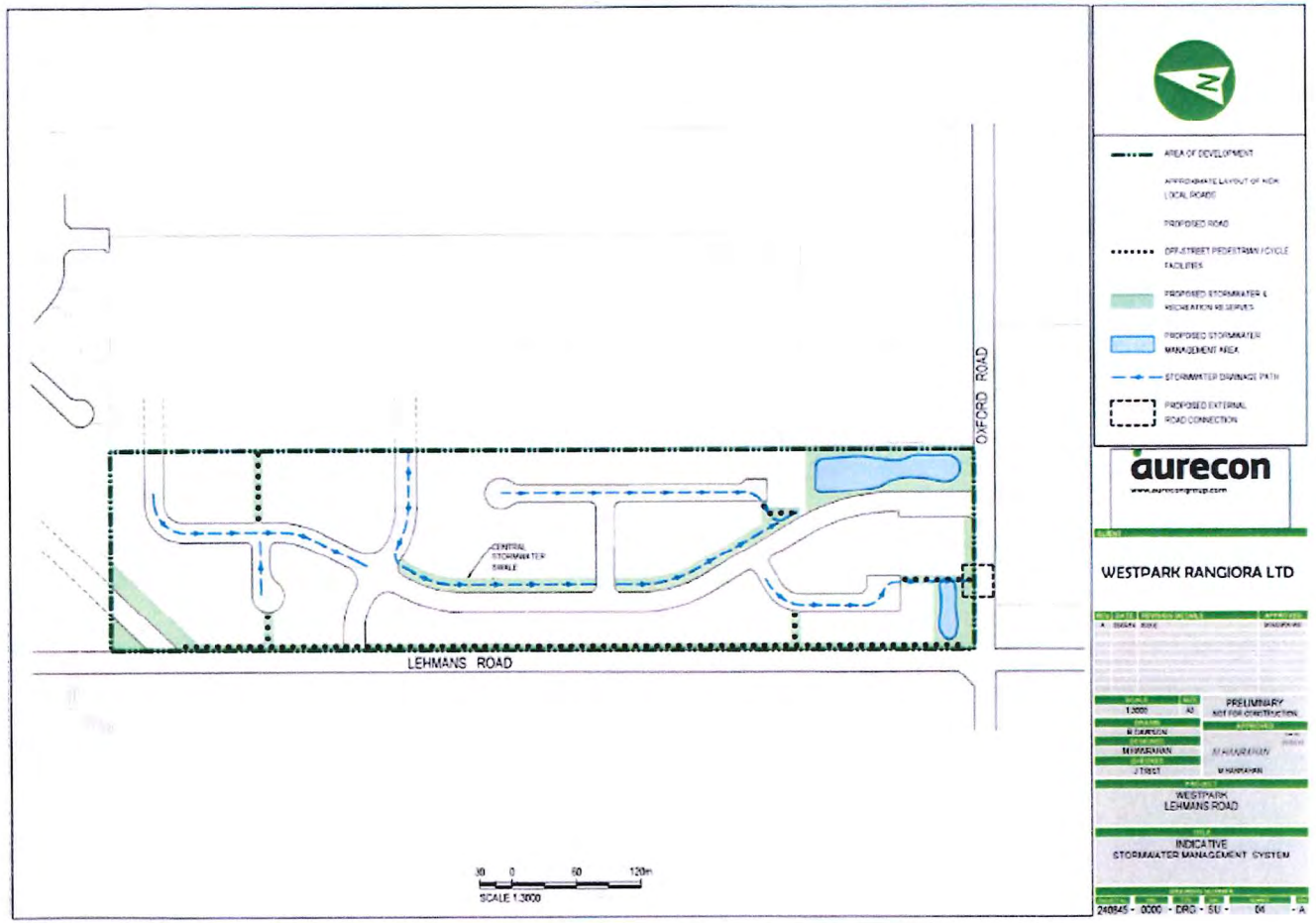
**Signed:** _____ **Date:** _____

**Full name of person signing** (please print): _____

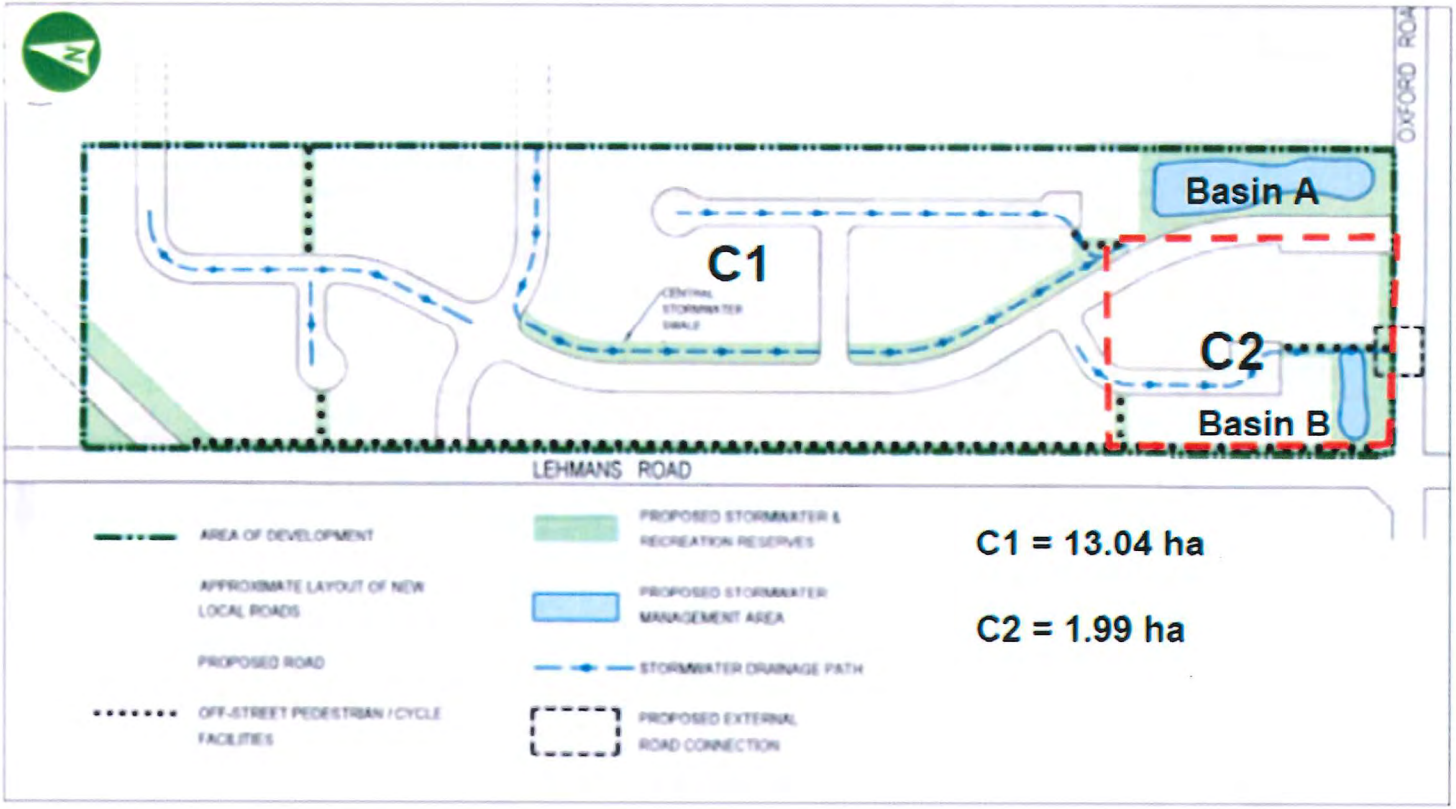
**Please return to:**

**Environmental Protection - Administration**
**Environment Canterbury**
**PO Box 345**
**Christchurch 8140**

## CRC152112A: Site location plan: Westpark Rangiora Limited



**CRC152112B: Stormwater treatment system: Westpark Rangiora Limited**



# Appendix F
# Ashley River Breakout Flood Modelling

aurecon

# Westpark Development

## Ashley River Breakout Flood Modelling

## Westpark Rangiora Ltd

**21 November 2014**
**Revision:** 0
**Reference:** 240845

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# Document control record

Document prepared by:

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Casebrook Christchurch 8051
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**W** aurecongroup.com

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|---|---|---|---|---|---|---|
| **Report title** | | Ashley River Breakout Flood Modelling | | | | |
| **Document ID** | | 137057956 | **Project number** | | 240845 | |
| **File path** | | P:\240845\Flood Modelling\Report\Westpark_Development_Flood Modelling_Report.docx | | | | |
| **Client** | | Westpark Rangiora Ltd | **Client contact** | | c/- Paul McGowan | |
| **Rev** | **Date** | **Revision details/status** | **Prepared by** | **Author** | **Verifier** | **Approver** |
| 0 | 21 November 2014 | Preliminary issue for discussion | MS | MS | PC | BT |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **Current revision** | | **0** | | | | |

| Approval | | | |
|---|---|---|---|
| Author signature | | Approver signature | |
| Name | Mark Stone | Name | Brent Toms |
| Title | **Senior Civil Engineer** | Title | **Technical Director** |

# Contents



## Appendices



## Figures

# 1 Introduction

Both Waimakariri District Council (WDC) and Environment Canterbury (ECan) have undertaken flood modelling investigations that cover the proposed Westpark Development site (from here on referred to as the "site").

The ECan study investigated the depth and extent of flooding across the Ashley River floodplain resulting from Ashley River breakout flood events of various Annual Exceedance Probability (AEP). The results of this study are documented in the *Waimakariri District Flood Hazard Management Strategy – Ashley River Floodplain Investigation (ECan, June 2008)* report. This event is referred to in this report as the "Ashley River Breakout Flood Event".

The WDC study investigated the depth and extent of flooding within the WDC region for local rainfall events for a range of AEP events. This study was undertaken using a rain-on-grid 2D hydraulic model. The results of this study are documented in the *Waimakariri District Localised Flood Hazard Assessment (WDC, 2014)* report. This event is referred to in this report as the "Local Flood Event".

The Westpark Development site is potentially affected from an Ashley River flood breakout to the west of Rangiora.

The ECan flood modelling indicates that floodwater will break out from the Ashley River in the 0.5% AEP (1 in 200 year average recurrence interval) event upstream of the site and then be conveyed through the site after overtopping Lehmans Road. This flood modelling indicates that the site could be inundated to depths up to 0.25m during the 0.5% AEP Ashley River breakout event. This is classified as Low Hazard based on the *NSW Floodplain Development Manual (NSW Government, April, 2005)* flood hazard categories. It is also noted that this flooding is not defined as a high hazard area in accordance with the *ECan Regional Policy Statement.*

The WDC flood modelling indicates that floodwater from the 0.5% AEP local rainfall event may overtop Lehmans Road and be conveyed through the site. The depth of this flooding is typically less than 0.2m except at the existing drainage path that passes through the site.

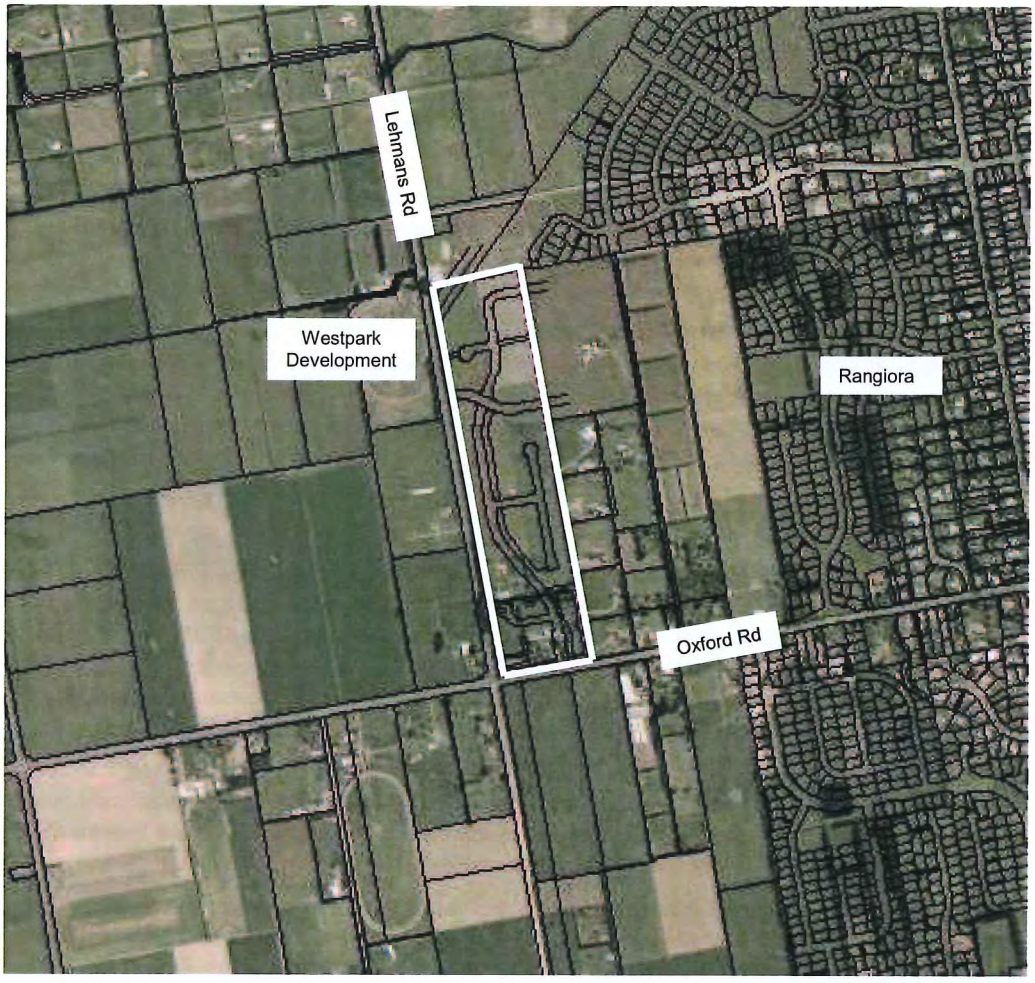
Development of the site will result in construction of sections sloping towards the roadways. The floor levels of the subsequent buildings will be further elevated above the roadways and 0.5% AEP peak flood level from the Ashley River breakout event.

WDC have requested that flood modelling is undertaken to assess the potential impacts of the 0.5% AEP Ashley River flood breakout event on the proposed development and to identify potential impacts of the development on surrounding properties.

This flood modelling was not completed prior to issue of the Infrastructure report for the ODP submission. The outcomes from this flood modelling are discussed in this report. It is intended that the findings from this flood modelling investigation are discussed with WDC to allow agreed results to be presented at the hearing.

A site plan is included in Figure 1.

**Figure 1 Site Plan**



# 2 Key Findings

**Ashley River Breakout Flood Event**

Construction of raised building platforms within the Westpark Development will reduce peak flood levels immediately downstream of the site but increase peak flood levels to the north and south of the site, including at the existing Rangiora vet clinic site.

These predicted flood impacts could be mitigated with the following measures:

- Raised landscape bund beside the proposed Bypass Road to the west of the Arlington Park Development.
- Construction of an earth bund around the Rangiora vet clinic site.
- Construction of a new box culvert beneath Oxford Road to convey floodwater beneath Oxford Road from the proposed swale along the western boundary of the Westpark Development to the existing swale in the eastern berm of Lehmans Road. The final size of this culvert needs to be determined during detailed design of flood mitigation measures following the hearing.
- Potential upgrade of the existing box culvert beneath Lehmans Road. This will convey any increased floodwater on western side of Lehmans Road beneath Lehmans Road to the proposed swale and then beneath Oxford Road via the new box culvert.

It is expected that a solution to reduce flood levels in the vicinity of the Rangiora vet clinic site (in addition to the proposed bund around the site) can be found using additional culvert capacity if required.

It is considered that an increase in flood levels of up to 50mm typically is acceptable in rural areas as a result of the 0.5% AEP Ashley River breakout flood event given the infrequency of this event.

**Local Flood Event**

It is noted that the post-development 0.5% AEP local flood event results in the same peak flood level, maximum depth and inundation extent around the site as the existing scenario. This occurs because no floodwater is predicted to enter the site during the 0.5% AEP local flood event, except through the existing drainage path from Lehmans Road.

**Proposed Building Platforms**

The 0.5% AEP Ashley River breakout flood event flood model predicts peak flood depths in local roadways through the Westpark Development typically not exceeding 150mm.

It is also expected that the proposed kerb and channel and swale (to the stormwater management area) will be overwhelmed by a 0.5% AEP local rainfall event.

Therefore it is recommended that all FFLs are raised at least 350mm above the proposed top of kerb level within the development to ensure that the proposed freeboard during the 0.5% AEP Ashley River breakout event can be achieved. FFLs will be set during detailed design to ensure that the proposed freeboard requirements are achieved.

It is recommended that the final site grading layout be added to both flood models (local and Ashley River breakout) and the models rerun to ensure that the 350mm freeboard requirement is achieved.

# 3 Scope

The scope of this Ashley River breakout flood modelling study included:

- Obtain the WDC local flood model and ECan Ashley River breakout flood model.
- Determine the potential impacts of the 0.5% AEP Ashley River breakout event on the proposed development and surrounding areas. This task was undertaken using the existing ECan MIKE 21 hydraulic model with modifications made as required. Existing, post-development and preliminary post-development mitigation scenarios were modelled for this study.
- Determine the potential impacts of the 0.5% AEP local flood event on the proposed development and surrounding areas. This task was undertaken using a 2D sub-model covering the Westpark Development and surrounding areas. The sub-model was to be developed from the original WDC localised 2D flood model. Existing and post-development scenarios were modelled for this study.
- Prepare report and figures to summarise the study findings.

This report presents the findings from the Ashley River breakout and local event flood modelling for the Westpark Development. The following maps are included in Appendix A to illustrate the results from this study.

- Map1 – Ashley River Breakout 0.5% AEP Flood Event – Existing Scenario Peak Flood Depth (Drawing DRG-LND-001).
- Map 2 – Ashley River Breakout 0.5% AEP Flood Event – Post Development Scenario Peak Flood Depth (Drawing DRG-LND-002).
- Map 3 – Ashley River Breakout 0.5% AEP Flood Event – Post Development Scenario Peak Flood Level Difference (No Mitigation) (Drawing DRG-LND-003).
- Map 4 – Ashley River Breakout 0.5% AEP Flood Event – Post Development Mitigation Scenario Peak Flood Depth (Drawing DRG-LND-004).
- Map 5 – Ashley River Breakout 0.5% AEP Flood Event – Post Development Mitigation Scenario Peak Flood Level Difference (Drawing DRG-LND-005).
- Map 6 – Ashley River Breakout 0.5% AEP Flood Event – Post Development Mitigation Scenario Peak Flood Level Difference (Zoomed Extent) (Drawing DRG-LND-006).
- Map 7 – Local 0.5% AEP Flood Event – Existing Scenario Peak Flood Depth (Drawing DRG-LND-007).
- Map 8 – Local 0.5% AEP Flood Event – Post Development Scenario Peak Flood Depth (Drawing DRG-LND-008).
- Map 9 – Local 0.5% AEP Flood Event – Peak Flood Level Difference (Drawing DRG-LND-009).
- Map 10 – Existing Scenario Roughness Map for Sub-model (Drawing DRG-LND-010).
- Map 11 – Post Development Scenario Roughness Map for Sub-model (Drawing DRG-LND-011).

# 4 Design Objectives

It has been proposed that minimum finished floor levels (FFLs) shall be set 350mm above the 0.5% AEP Ashley River breakout flood event. This is consistent with the requirements adopted for other nearby subdivisions.

It is also a requirement that the Westpark Development does not worsen flooding of adjacent areas both upstream and downstream of the site.

# 5 ECan Ashley River Breakout Flood Model

ECan developed a 2D MIKE 21 model of the Ashley River floodplain to investigate the depth and extent of flooding during Ashley River breakout flood events. The results of this study are documented in the *Waimakariri District Flood Hazard Management Strategy – Ashley River Floodplain Investigation (ECan, June 2008)* report. The Ashley River breakout MIKE 21 model was provided to Aurecon for this study. This model comprises a 10m grid size and no hydraulic structures.

The ECan hydraulic model was used in this study to test the potential impacts of the 0.5% AEP Ashley River breakout flood event on the proposed Westpark Development and surrounding areas, with model modifications made as required.

## 5.1 Modelling Methodology

### 5.1.1 Model Development

The existing ECan MIKE 21 model has been used in this study to test the potential impacts of the 0.5% AEP Ashley River breakout flood event on the proposed Westpark Development and surrounding areas. This model comprises a 10m grid size.

Modifications made to the existing ECan flood model include:

- The model topography was updated to the east of Lehmans Road using the recent WDC LiDAR data.
- The existing culverts at Lehmans Road and Oxford Road were included in the model. Mitigation measures were included in the post-development mitigation scenario model.
- Roughness maps were updated to include the current extent of existing urban development (existing scenario roughness map) and proposed Westpark Development (post-development scenario roughness map).

These modifications are discussed separately in the following sections.

### 5.1.2 Ground Data

The ECan flood model topography was developed from LiDAR survey flown in July 2005. This LiDAR survey does not include changes in ground elevation resulting from recent subdivisions along the western fringe of Rangiora i.e. Arlington Park and therefore may not accurately represent the actual flow paths through Rangiora during a 0.5% AEP Ashley River breakout flood event.

Whilst the July 2005 LiDAR survey will be adequate for modelling the vast majority of the Ashley River floodplain in this study, it was decided that the topography has changed significantly to the east of Lehmans Road and therefore the model topography would be updated in this location to represent the ground topography as accurately as possible with a 10m grid size. The recent WDC LiDAR survey (flown between March and June 2014) has been included into the model topography to the east of Lehmans Road.

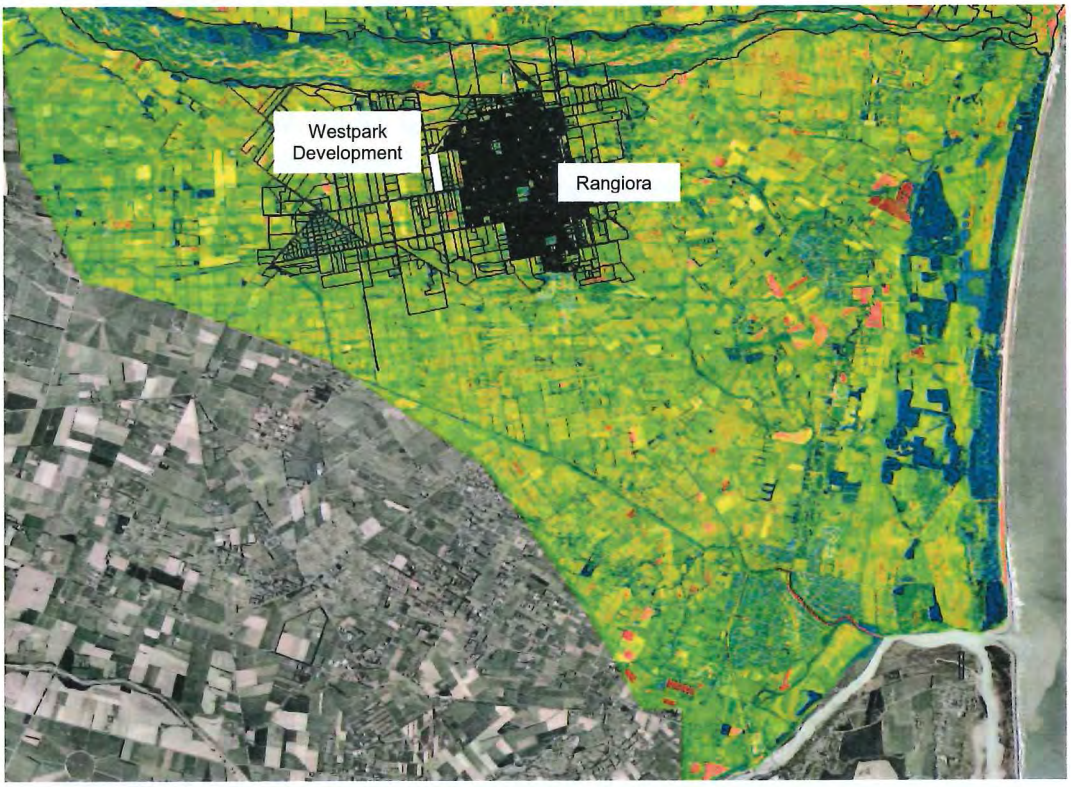
### 5.1.3 Surface Roughness

The existing scenario roughness map has been updated to include recent urban developed along the western fringe of Rangiora that had not been developed at the time the ECan flood model was developed.

A post-development scenario roughness map has been developed to include the proposed Westpark Development.

The existing scenario roughness map is presented in Figure 2.

**Figure 2 Ashley River Breakout Existing Scenario Roughness Map**




### 5.1.4 Structures

The existing ECan flood model does not include any hydraulic structures. The existing culverts at Lehmans Road (1150 x 950mm box culvert) and Oxford Road (600mm diameter pipe) have been included in the hydraulic model. These culverts have been included in MIKE 11 and coupled to the MIKE 21 model using MIKE FLOOD.

A proposed 525mm diameter stormwater pipe from Lehmans Road to the proposed Westpark Development stormwater management area has been included in the post-development model scenario. This proposed stormwater pipe is discussed further in the *Westpark – Plan Change – Lehmans Road Rangiora – Infrastructure Assessment, Aurecon, August 2014.*

An additional box culvert has been included in the post-development mitigation scenario to convey floodwater across Oxford Road from the proposed swale along the western boundary of the Westpark Development to the existing swale in the eastern berm of Oxford Road. This culvert has currently been

modelled as a 1050 x 950mm box culvert but the final size needs to be determined during detailed design of flood mitigation measures following the hearing.

#### 5.1.5 Boundary Conditions

The 0.5% AEP flows included in the ECan flood model have been adopted for this study. These flows were provided to ECan by NIWA and are discussed further in the *Waimakariri District Flood Hazard Management Strategy – Ashley River Floodplain Investigation (ECan, June 2008)* report.

# 6 WDC Local Flood Model

WDC developed a 2D MIKE 21 hydraulic model of the Waimakariri District to investigate the depth and extent of flooding during local rainfall events for a range of AEP events. This study was undertaken using a rain-on-grid 2D hydraulic model. The results of this study are documented in the *Waimakariri District Localised Flood Hazard Assessment (WDC, 2014)* report. This model comprises a 10m grid size and no hydraulic structures.

WDC provided a copy of the localised event flood model to Aurecon for use in this study. This model comprises a large catchment area, 10m grid size and rain-on-grid modelling and these parameters result in large model run times of up to six weeks.

The WDC flood modelling indicates that floodwater from the 0.5% AEP local rainfall event may overtop Lehmans Road and be conveyed through the site. It is noted that the 10m grid size does not accurately represent the raised Lehmans Road embankment and therefore it is expected that the extent of flooding within the site from a 0.5% AEP local flood event will be less than identified by the WDC flood model.

Whilst it has been shown that the 0.5% AEP Ashley River breakout flood event will be critical for the design of building platform elevations and would result in greater flood impacts requiring mitigation, the 0.5% AEP local event has also been modelled to provide an indication of the likely flood depth, extent and impacts from this event as a result of the proposed Westpark Development construction.

## 6.1 Modelling Methodology

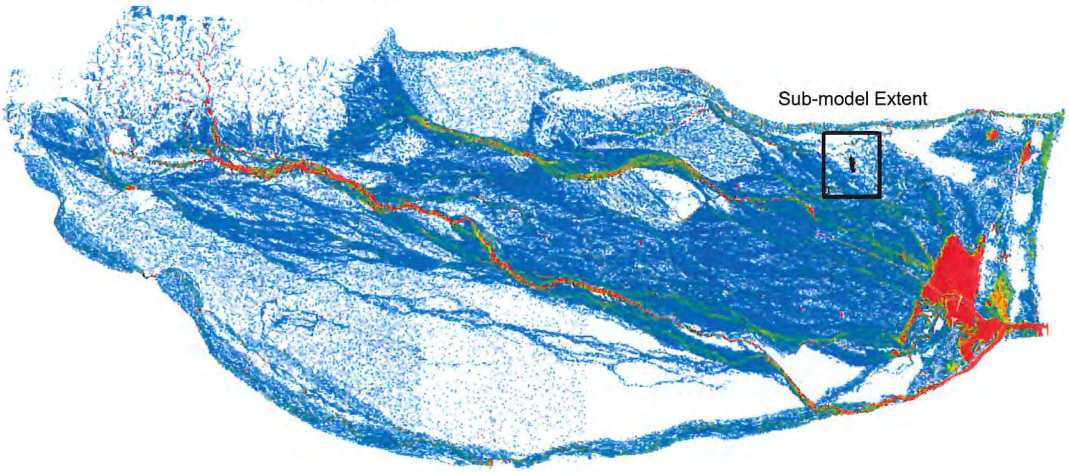
#### 6.1.1 Sub-Model Development

To ensure that a finer grid size can be adopted that better represents the Westpark Development site topography, allow more recent LiDAR survey to be included in the flood model topography and reduce the model run times, a 2D sub-model has been developed for this study that covers a smaller model extent. This model will be used to identify the potential flood impacts from a 0.5% AEP local flood event on the proposed Westpark Development and surrounding areas.

The sub-model has been developed using a 2D MIKE 21 hydraulic model. The sub-model extent stretches between the Ashley River (north), South Belt (south), Merton Road (west) and White Street in Rangiora (east). The extent of the sub-model topography is presented on the attached figures. A 2m grid size has been adopted to better represent the topography whilst achieving reasonable model run times.

Figure 3 presents the extent of the WDC flood model 0.5% AEP peak flood depth. The extent of the Westpark sub-model is represented by the black outline.

**Figure 3 Sub-model Extent within WDC Flood Model**




The sub-model uses transfer boundaries (flows, depth and velocity) obtained from the WDC flood model for the 0.5% AEP event. This methodology ensures that the flood flows entering the sub-model from west of Lehmans Road are the same as those within the larger WDC local flood model.

Existing culverts surrounding the Westpark Development site have been included in the sub-model.

It is also noted that the sub-model does not utilise a rain-on-grid methodology and is therefore based on concentrated flood flows that approach the Westpark Development from the west of the site.

### 6.1.2 Ground Data

The WDC flood model was developed from a combination of pre-earthquake District LiDAR (WDC, 2005), post-earthquake LiDAR (CERA, 2011) and Rural Aerials DTM (WDC, 2012).

The sub-model topography has been developed from the recent WDC LiDAR survey (flown between March and June 2014). This recent LiDAR survey includes the full urban development extent within Rangiora and will allow overland flow paths along roadways to be better represented in the model.

### 6.1.3 Surface Roughness

A surface roughness map has been adopted as per the WDC local flood model. The same roughness parameters used in the WDC local flood model have been adopted. These parameters were derived from the *LCDB3 (Land Cover Database Version 3)* land use classification from *MfE (Ministry for the Environment)* and verified for this study from a site walkover and aerial photographs.

Roughness maps (with corresponding roughness parameters) for the existing (Map 10) and post-development (Map 11) scenario are included in Appendix A.

### 6.1.4 Structures

The existing WDC local flood model does not include any existing hydraulic structures. The existing culverts at Lehmans Road (1,150 x 950mm box culvert) and Oxford Road (600mm diameter pipe) have been included in the sub-model for this study. These culverts have been included in MIKE 11 and coupled to the MIKE 21 model using MIKE FLOOD.

A proposed 525mm diameter stormwater pipe from Lehmans Road to the proposed Westpark Development stormwater management area has been included in the post-development model scenario.

### 6.1.5 Boundary Conditions

As discussed in Section 6.1.1, the sub-model uses transfer boundaries obtained from the WDC local flood model for the 0.5% AEP event. These flux boundaries are located along the western extent of the sub-model boundary.

Downstream water level boundaries have been applied to the eastern and southern boundaries of the sub-model extent.

The WDC local flood model used a rain-on-grid approach to generate model flows. The sub-model developed for this study uses transfer boundaries from the larger WDC local flood model and therefore precipitation on the model grid (rain-on-grid) has not been applied for the sub-model. This could however be included if required.

# 7 Discussion

## 7.1 Ashley River Breakout Flood Model Results

### 7.1.1 Original ECan Ashley River Breakout Flood Model Results

The original ECan flood modelling indicates that floodwater will breakout from the Ashley River in the 0.5% AEP event upstream of the site and then be conveyed through the site after overtopping Lehmans Road. This flood modelling indicates that the site could be inundated to depths less than 0.25m during the 0.2% AEP Ashley River breakout event.

The 0.5% AEP peak flood depth from the ECan flood modelling is presented in Figure 4 and Figure 5.

**Figure 4 ECan Ashley River Breakout Flood Model Results – 0.5% AEP Peak Flood Depth (Full Model Extent)**

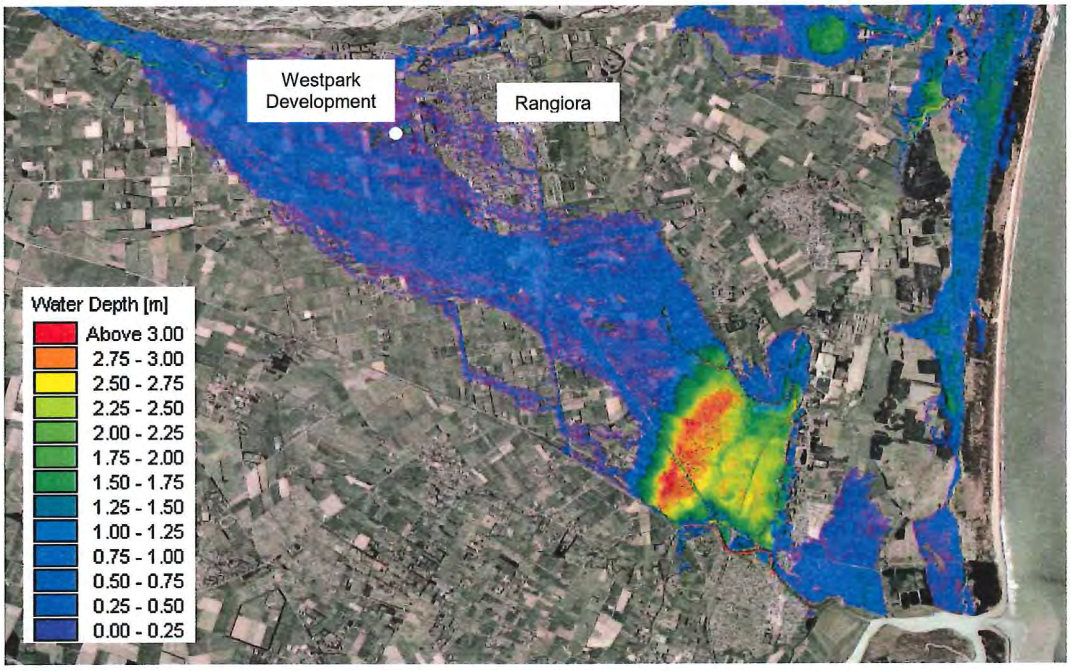
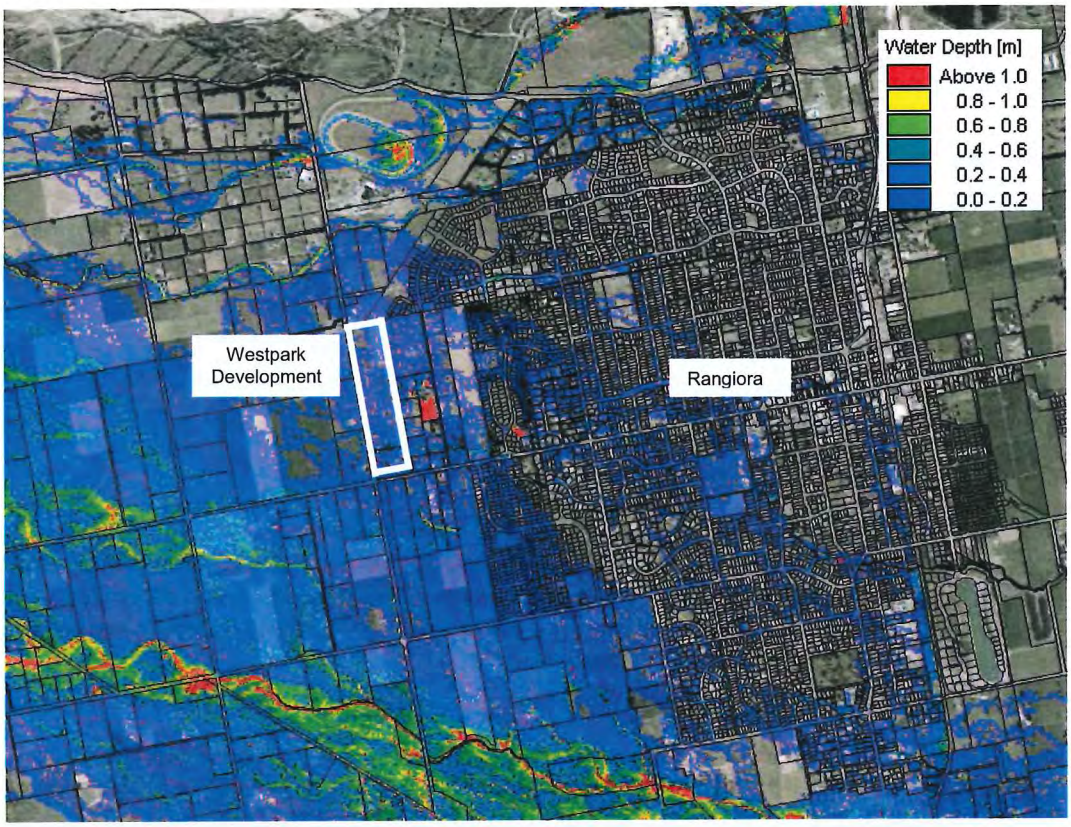


Figure 5 ECan Ashley River Breakout Flood Model Results – 0.5% AEP Peak Flood Depth (Zoomed In Extent)




### 7.1.2 Revised Ashley River Breakout Flood Model Results

**Existing Scenario Results**

The peak flood depth and inundation extent from the 0.5% AEP Ashley River breakout event (existing scenario) are presented on Map 1 (refer Appendix A). The flood model predicts floodwater entering the existing Westpark site in two main flow paths after overtopping Lehmans Road. Floodwater will also pass through the site via the existing box culvert beneath Lehmans Road and existing drainage path.

The flood inundation extent in the revised Ashley River breakout flood model differ from the original ECan model however the maximum depth of flooding is similar. This occurs due to the more recent LiDAR survey that has been included in the revised model topography to better represent site elevations and elevations along the Lehmans Road embankment.

**Post-Development Scenario Results**

The post-development 0.5% AEP Ashley River breakout scenario was modelled in the revised Ashley River breakout flood model. This model is similar to the existing scenario model with the exception that the proposed building platforms within the Westpark Development were raised to prevent floodwater being conveyed in these areas. Whilst it is only proposed to raise building FFLs above the 0.5% AEP flood event; this modelling methodology was adopted due to the location of buildings within individual lots being unknown, fences may provide a barrier to floodwaters, and to ensure that the predicted flood impacts are conservative.

The peak flood depth and inundation extent from the 0.5% AEP Ashley River breakout event (post-development scenario) is presented on Map 2 (refer Appendix A).

The 0.5% AEP post-development scenario peak flood level variation is presented on Map 3 (refer Appendix A). The following outcomes have been identified from this model simulation.

- The raised Westpark Development building platforms will provide a barrier to floodwater in the 0.5% AEP event. This will result in floodwaters during the Ashley River breakout flood event being diverted around the site (to the north and south) and some floodwater may pass through the development after entering local roads from Lehmans Road.
- Peak flood depths immediately downstream of the raised building platforms at the site will be reduced to less than the existing scenario. The inundation extent downstream of the site will be reduced and the peak flood depths reduced by typically up to 50mm.
- Floodwater is concentrated to the north of the site and this results in an increase in peak flood levels to the north of the site and along the corresponding drainage path through Rangiora. Peak flood levels are typically increased by up to 50mm but up to 100mm in some localised areas.
- Floodwater is concentrated to the south of the site and this results in an increase in flood levels to the south and south-west of the site (in the location of the existing Rangiora vet clinic). Peak flood levels are typically increased by up to 50mm but up to 100mm in some localised areas.

A preliminary post-development mitigation scenario model was developed to attempt to reduce the extent of potential negative flood impacts that could occur as a result of the development. This is discussed further in the section below.

**Post-Development Mitigation Scenario Results**

A preliminary post-development mitigation scenario has been developed and modelled in the revised Ashley River breakout flood model. This model is similar to the post-development scenario but with the following potential mitigation measures included. These potential mitigation measures are presented on Maps 4 to 6 (refer Appendix A).

- Raised earth landscape bund beside the proposed Bypass Road to the west of the Arlington Park Development. It is understood that this bund is proposed to be constructed during future development at this site but does not currently exist. This bund would allow floodwater to be captured and conveyed within the proposed swale along the western boundary of the site.
- A new box culvert beneath Oxford Road to convey floodwater across Oxford Road from the proposed swale along to western boundary of the Westpark Development to the existing swale in the eastern berm of Lehmans Road. This culvert has currently been modelled as a 1050 x 950mm box culvert but the final size needs to be determined during detailed design of flood mitigation measures.
- Potential upgrade of the existing box culvert beneath Lehmans Road if it is necessary to convey additional floodwater from the area to the west of Lehmans Road.

The peak flood depth and inundation extent from the 0.5% AEP Ashley River breakout event (post-development mitigation scenario) is presented on Map 4 (refer Appendix A). It can be seen from Map 4 that the floodwater that was previously concentrated around the north of the site has been diverted along the raised bund and in a southerly direction; both in the proposed swale (along western boundary of the site) and along roadways through the proposed development.

The 0.5% AEP post-development mitigation scenario peak flood level variation is presented on Map 5 and Map 6 (refer Appendix A). The following outcomes have been identified from this model simulation.

- The peak flood depths immediately downstream of the raised building platforms at the site will be reduced to less than the existing scenario. The inundation extent downstream of the site will be reduced and the peak flood depths reduced by typically up to 50mm. There are no increases in peak flood level to the north of the site and in the corresponding flow path through Rangiora.

- Floodwater is concentrated to the south of the site and this results in an increase in flood levels to the south and south-west of the site (including in the location of the existing Rangiora vet clinic). Peak flood levels are typically increased by up to 50mm but up to 100mm in some localised areas. The model is predicting an increase in peak flood levels of approximately 60mm in the vicinity of the Rangiora vet clinic site.

It is noted that the existing scenario model predicts that peak flood depths at the Rangiora vet clinic site are up to approximately 350mm. It is understood that an earth bund will be constructed around the Rangiora vet clinic site that has a height of approximately 500mm. This earth bund has not been included in the post-development mitigation scenario model due to the location and height of the bund being currently unknown. A 60mm increase in peak flood depth during the 0.5% AEP event will result in peak flood depths up to 410mm. These flood depths are lower than the height of the proposed earth bund and therefore it has been assumed that the Rangiora vet clinic site would be protected from flooding from the Ashley River breakout event. The proposed earth bund can be included in the post-development mitigation flood model simulation when this has been constructed and as-built survey or design details available.

Other localised increases in peak flood level upstream of the proposed Westpark Development embankment are within rural land.

The predicted increases in peak flood level to the south of Oxford Road are typically up to 50mm and on rural sites without any existing residential developments. It is expected that the increase in flood flows in this area will be diverted to the South Brook in the Lehmans Road drain upgrades being investigate by WDC. This will prevent flood levels being increased on existing rural land where future development may occur.

### 7.1.3 Proposed Building Platform

As discussed in Section 4, it has been proposed that minimum finished floor levels (FFLs) shall be set 350mm above the 0.5% AEP Ashley River breakout flood event within the site. Whilst the vertical grade of internal roads within the proposed development have not yet been designed; the post-development mitigation scenario flood model predicts peak flood depths in roadways through the development typically not exceeding 150mm.

Therefore it is recommended that all FFLs are raised at least 350mm above the proposed top of kerb level within the development to ensure that the required freeboard during the 0.5% AEP Ashley River breakout event can be achieved. FFLs will be set during detailed design to ensure that the proposed freeboard requirements are achieved.

It is recommended that the final site grading layout be included in both flood models (local and Ashley River breakout) to enable minimum floor levels to be set to ensure that the 350mm freeboard requirement is achieved.

## 7.2 Local Event Flood Model Results

### 7.2.1 Original WDC Flood Model Results

The WDC 0.5% AEP local flood model identifies shallow flooding within the site. This flooding is typically less than 0.25m deep with the exception of the existing drainage path passing through the south of the site where concentrated flow reaches greater depths. These flood depths are similar to that identified at the site from the ECan flood model.

The model results indicate that the primary flow paths from the 0.5% AEP local flood event pass to the south of the site flowing in a south-east direction (after overtopping Merton Road, Oxford Road and Johns Road) and to the north of the site (between Belmont Avenue and the Rangiora Racecourse after overtopping Lehmans Road). Floodwater entering the site originates from both of these primary

flow paths but is generally of a shallow depth. The majority of the inundation extent within the site has a very shallow depth and is expected to be occurring in the model as a result of rainfall directly over the site.

### 7.2.2 Sub-model Results

**Comparison of Existing Scenario Sub-Model Results with WDC Local Flood Model Results**

The peak flood depth and inundation extent from the 0.5% AEP local flood event (existing scenario) determined from the Westpark sub-model are presented on Map 7 (refer Appendix A).

Both the WDC local flood model and Westpark Development sub-models predict the two primary flow paths to the north and south of the site.

It is noted that the sub-model developed for the Westpark Development does not predict floodwater entering the site from either of these primary drainage paths. Floodwater flows through the existing drainage path to the south of the site (after passing through the culvert beneath Lehmans Road).

Reasons identified for floodwater not entering the site in the Westpark sub-model include:

- Better representation of upstream flow paths by the smaller 2m model grid size.
- Better representation of the Lehmans Road elevations and other topography by the recent WDC LiDAR survey that has been used to develop the sub-model topography.

It is also noted that large areas of shallow (typically less than 50mm) flooding within the WDC local flood model occur due to the rain-on-grid methodology adopted. Given that the sub-model developed for this study uses inflow conditions obtained from the larger WDC flood model (but no sub-model rain-on-grid inputs) these shallow flows originating from rainfall over the area are not represented in the sub-model results.

**Post Development Scenario Results**

A post-development 0.5% AEP local flood event scenario was modelled in the Westpark Development sub-model. This model is similar to the existing scenario model with the exception that the proposed building platforms within the Westpark Development were raised to prevent floodwater being conveyed in these areas. This is consistent with the methodology adopted for the Ashley River breakout flood event modelling. The post-development scenario model also includes the basins in the proposed stormwater management area and the proposed 525mm diameter stormwater pipe from Lehmans Road to the stormwater management area.

It is noted that the post-development 0.5% AEP local flood event results in the same peak flood level, maximum depth and inundation extent around the site as the existing scenario. This occurs because no floodwater is predicted to enter the site during the 0.5% AEP existing scenario local flood event, except through the existing drainage path from Lehmans Road. There is a localised increase in peak flood depth at the location of the proposed stormwater management areas which have been included in the post-development model topography.

It can be seen from Map 9 (refer Appendix A) that a small increase in peak flood level of up to 50mm is predicted on Oxford Road downstream of the proposed stormwater management area. It is expected that this minor increase in flood level can be mitigated by reducing the flow that enters the existing drainage path from Lehmans Road.

The 0.5% AEP local flood event peak flood depth for the post-development scenario is presented on Map 8 (refer Appendix A).

The 0.5% AEP post-development scenario peak flood level variation for the local flood event is presented on Map 9 (refer Appendix A).

### 7.2.3 Proposed Building Platform

As discussed in Section 4, it is recommended that minimum finished floor levels (FFLs) shall be set 350mm above the 0.5% AEP Ashley River breakout flood event within the site.

Floodwater is not expected to enter the Westpark site from concentrated floodwater upstream of Lehmans Road during the 0.5% AEP local event. A 0.5% AEP local rainfall event is expected to overwhelm the capacity of the proposed kerb and channel and swale draining to the stormwater management area.

Therefore it is recommended that all FFLs are raised at least 350mm above the proposed top of kerb level within the development. This is consistent with the recommended building platform for the Ashley River breakout flood event. FFLs will be set during detailed design to ensure that the proposed freeboard requirements are achieved.

A higher building platform level may be adopted adjacent the existing drainage path that will be retained through the site. It is recommended that the final site grading layout be included in both flood models (local and Ashley River breakout) to enable minimum floor levels to be set to ensure that the 350mm freeboard requirement is achieved.

The proposed floor level control to address Ashley River breakout flooding will provide adequate protection against the 0.5% AEP local event.

# 8 Conclusion

Flood models have been developed to assess the potential impacts of the 0.5% AEP Ashley River breakout flood event and 0.5% AEP local flood event on the proposed Westpark Development and surrounding areas. This modelling has also identified preliminary building platform elevations.

**Ashley River Breakout Flood Event**

The existing scenario Ashley River breakout flood model indicates that floodwater will enter the site during the 0.5% AEP Ashley River breakout flood event.

The post-development scenario Ashley River breakout flood model indicates that the raised building platform will reduce peak flood levels immediately downstream of the site but increase peak flood levels to the north and south of the site, including at the existing Rangiora vet clinic site. A post-development mitigation scenario has been developed to mitigate these predicted flood impacts.

The preliminary post-development mitigation scenario model indicates that these negative flood impacts can be mitigated by the following infrastructure:

- Raised landscape bund beside the proposed Bypass Road to the west of the Arlington Park Development.
- Construction of the earth bund around the Rangiora vet clinic site.
- Construction of a new box culvert beneath Oxford Road to convey floodwater across Oxford Road from the proposed swale along to western boundary of the Westpark Development to the existing swale in the eastern berm of Lehmans Road. The final size of this culvert needs to be determined during detailed design of flood mitigation measures following the hearing.
- Potential upgrade of the existing box culvert beneath Lehmans Road. This will convey any increased floodwater on western side of Lehmans Road beneath Lehmans Road to the proposed swale and then beneath Oxford Road via the new box culvert.

It is noted that whilst Map 5 still shows some flood impacts (flood levels increased by approximately 60mm) near the existing Rangiora vet clinic it is expected that a solution to reduce flood levels in this