



APPIN ROAD UPGRADE, MT GILEAD

2113521 December 2017

Concept Design Report – Hydrology and
Drainage

Document No: 2113521-DR-REP-002-RevB

APPIN ROAD UPGRADE, MT GILEAD

CONCEPT DESIGN REPORT – HYDROLOGY AND DRAINAGE LENDLEASE COMMUNITIES

WSP
LEVEL 27, 680 GEORGE STREET
SYDNEY NSW 2000
GPO BOX 5394
SYDNEY NSW 2001

TEL: +61 2 9272 5100
FAX: +61 2 9272 5101
WSP.COM

This document may contain confidential and legally privileged information, neither of which are intended to be waived, and must be used only for its intended purpose. Any unauthorised copying, dissemination or use in any form or by any means other than by the addressee, is strictly prohibited. If you have received this document in error or by any means other than as authorised addressee, please notify us immediately and we will arrange for its return to us.

CONFIDENTIAL
OUR REF: 2113521-DR-REP-002-REVB_HYDROLOGYDRAINAGE
15 DECEMBER 2017

DOC CONTROL

Document description

Project	Appin Road Upgrade, Mt Gilead	
Document Title:	Appin Road Upgrade, Mt Gilead Concept Design Report – Hydrology and Drainage	Document No/Ref: 2113521-DR-REP-002-RevA Lendlease Communities
General Description	Report describes the main project objectives and design process adopted to produce the Hydrology and Drainage Design for the project, Appin Road Upgrade, Mt Gilead project	
Document File	2113521-DR-REP-002-RevB_Hydrology drainage.docx	
Design Lot(s)	DR-01	

Document development

		Originator(s)	Reviewed by	Approved by
Revision	Phase			
A	Draft Concept Design (80%)	Manisha Dhungel Daniel Suwito	Eric Lam	Nuno Muralha

		Originator(s)	Reviewed by	Approved by
Revision	Phase			
B	Concept Design (80%)	Manisha Dhungel Vincent Wong	Ian Wilcock	Nuno Muralha

		Originator(s)	Reviewed by	Approved by
Revision	Phase			

		Originator(s)	Reviewed by	Approved by
Revision	Phase			

Issue Summary

Revision	Date	Issue description	Distribution
A	27 Oct 2017	Concept Design Report – Hydrology and Drainage	LLC and stakeholders
B	15 Dec 2017	Concept Design Report – Hydrology and Drainage	LLC and stakeholders

TABLE OF CONTENTS

ABBREVIATIONS.....	IV
1 INTRODUCTION	1
1.1 Project description.....	1
1.2 Scope of this report	2
1.3 Design lot.....	2
1.4 Deliverables.....	3
1.5 Design submissions.....	3
2 DESIGN CRITERIA AND TECHNICAL REQUIREMENTS	4
2.1 Hydrology and drainage	4
2.2 Reference documents	5
2.3 Design inputs.....	5
3 DESIGN DEVELOPMENT	6
3.1 Changes from previous design stage	6
3.2 Cross discipline review	6
3.3 Design verification and review	6
3.4 Design non-conformances	6
3.5 Design alternatives for consideration.....	6
3.6 Further design development	7
3.6.1 General issues	7
3.6.2 Water quality.....	7
3.6.3 Area 1 (CH0 to CH1880).....	7
3.6.4 Area 2 (CH1880 to CH3520)	7
3.6.5 Area 3 (CH3520 to CH4250).....	8
3.6.6 Area 4 (CH4900 to CH5800)	8
4 DESIGN DESCRIPTION.....	9
4.1 Design assumptions	9
4.2 Concept drainage design strategy	9
4.2.1 Longitudinal drainage.....	9
4.2.2 Transverse drainage.....	10
4.2.3 Water quality management systems	10
4.2.4 On-site detention basins.....	10

4.3	Hydrologic & hydraulic assessment	11
4.3.1	DRAINS modelling.....	11
4.3.2	Catchment areas.....	12
4.4	Existing drainage situation	14
4.4.1	Area 1 (CH0 to CH1880).....	15
4.4.2	Area 2 (CH1880 to CH3520).....	16
4.4.3	Area 3 (CH3520 to CH4250).....	19
4.4.4	Area 4 (CH4900 to CH5800)	20
4.5	Impact Assessment.....	22
4.6	Water quality assessment	26
4.6.1	Construction phase	26
4.6.2	Operational phase.....	27
4.7	Erosion and sedimentation	31
4.7.1	Key factors.....	31
4.7.2	Construction basin assessment.....	32
5	DESIGN INTEGRATION	34
5.1	Key interfaces	34
6	ENVIRONMENTAL CONSIDERATIONS.....	35
6.1	Environmental criteria	35
6.1.1	Environmental constraints	35
6.1.2	Clearing limits.....	37
7	CONSTRUCTION AND MAINTENANCE CONSIDERATIONS.....	38
7.1	Key constructability issues	38
7.2	Maintenance access strategy	38
7.2.1	Maintenance activities	38
7.2.2	Access provisions for maintenance	38
8	SAFETY IN DESIGN	40
8.1	Road safety audit	40
9	DURABILITY	41
9.1	Design life requirements	41

10	VALUE ENGINEERING.....	42
11	FUTURE WORKS	43
11.1	Design philosophy.....	43
11.2	Provision for future widening.....	43
12	ISSUES OUTSTANDING OR TO BE ADDRESSED DURING NEXT PHASE	44

LIST OF APPENDICES

Appendix A Design Drawings (Not used)
Appendix B Concept Design Drawing List
Appendix C Safety In Design Register
Appendix D Design Non-Conformances
Appendix E Issues register
Appendix F Constructability register
Appendix G Value Engineering register
Appendix H Cross-Discipline review
Appendix I Independent Verification
Appendix J Stakeholders Review Comments
Appendix K Catchment Plans
Appendix L Request-For-Information (RFI) to Campbelltown City Council

ABBREVIATIONS

12d	12d design software package
1-D	One-dimensional
2-D	Two-dimensional
3-D	Three-dimensional
ADT	Average Daily Traffic
AHD	Australian Height Datum
AHIP	Aboriginal Heritage Impact Permit
ARI	Average Recurrence Interval
AS	Australian Standards
ASD	Intersection Approach Sight Distance
AUSTROADS	The Association of Australian and New Zealand Road Transport and Traffic Authorities
AGRD	AUSTROADS Guide to Road Design
CDR	Cross Discipline Review
CEMP	Construction Environmental Management Plan
CH	Chainage
EEC	Endangered Ecological Communities
EP&A Act	Environmental Planning and Assessment Act 1979 (NSW). Provides the legislative framework for land use planning and development assessment in NSW
EP&A Regulation	Environmental Planning and Assessment Regulation 2000
EPA	Environment Protection Authority
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth). Provides for the protection of the environment, especially matters of national environmental significance, and provides a national assessment and approvals process.
GDA	Geodetic Datum of Australia
GIS	Geographic Information System
GPS	Global Positioning System
ITS	Intelligent Transport Systems
IV	Independent Verification
km/h	Kilometres per hour
LALC	Local Aboriginal Land Council
LEP	Local Environmental Plan. A type of planning instrument made under Part 3 of the EP&A Act.
LGA	Local Government Area
LLC	Lendlease Communities
LLE	Lendlease Engineering
LoS	Level of Service. A qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers.
MGA	Map Grid of Australia
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
NB	Northbound
NSW	New South Wales
Other Roads	Roads in the site other than the Main Carriageway
PV	Project Verifier

REF	Review of Environmental Factors
RL	Reduced Level
RMS or Roads and Maritime	Roads and Maritime Services
RSA	Road Safety Audit
SB	Southbound
SISD	Safe Intersection Sight Distance
SSD	Sight Stopping Distance
SWTC	Scope of Work and Technical Criteria
TEC	Threatened ecological communities
TS	Threatened Species
TSC Act	Threatened Species Conservation Act 1995
VMS	Variable Message Sign
WHS	Work Health and Safety
WRSB	Wire Rope Safety Barrier
WSUD	Water-Sensitive Urban Design

1 INTRODUCTION

1.1 PROJECT DESCRIPTION

Two land owners (Mount Gilead Pty Ltd and the Dzwonnik Family) prepared a joint rezoning application for the development of land in Mount Gilead which has been on the NSW Government Metropolitan Development Program (MDP) for over 10 years. The planning proposal achieved Gateway approval in 2012 and gazettal of the LEP amendment is expected to be imminent.

The proposal is to enable 210 hectares of rural land at Mount Gilead to be developed as residential subdivision. The MDP yield is planned to be for 1,700 lots.

As a result of the increase in road traffic, the proposed new land subdivision to be constructed by Lendlease Communities (LLC) will generate certain road and intersection upgrades along Appin Road, Mt Gilead. These works will be agreed under a Regional Voluntary Planning Agreement (RVPA) with Department of Planning & Environment (DP&E) who would act as the stakeholder on behalf of Roads and Maritime Services (RMS).

Lendlease Communities and project stakeholders are collaboratively seeking to complete the necessary site investigations and Review of Environmental Factors (REF) to inform the concept and detailed design of the Appin Road Upgrade, Mt Gilead project.

The Appin Road is a major arterial road linking the townships of Campbelltown and Appin. The project includes upgrading Appin Road at Mt Gilead north of Appin to the intersection of St John's with Appin Road, Bradbury; a total length of approximately 3.7 kilometres. This includes upgrading the existing intersections, Kellerman Drive/ Fitzgibbon Lane, Copperfield Drive/ Kellerman Drive and St. Johns Road with Appin Road.

The key features of the Appin Road Upgrade, Mt Gilead project include:

- Duplicating the existing carriageway from two (2) to four (4) lanes, between St Johns Road to about 2.5km south of Copperfield Drive, Rosemeadow;
- The road widening will be achieved by using the existing two-way carriageway for future southbound traffic only and building a two (2) lane northbound carriageway in the existing road corridor reservation;
- Upgrading and future proofing the existing St John's Road intersection with Appin Road (existing traffic signals) to achieve the target levels of service;
- Upgrading and future proofing the existing intersections of Fitzgibbon Lane and Kellerman Drive (existing traffic signals) and Copperfield Drive and Kellerman Drive (existing roundabout) to signalised intersections to achieve the target levels of service;
- Construction of two new signalised intersections (north and south accesses) for access to the proposed Mt Gilead residential subdivision;
- Road works as required to tie the new pavement in with the existing Appin Road;
- New line marking and signposting for the new four lane carriageway;
- Provision of new drainage lines and channels where widening impacts overland flows;
- Adjustments to existing drainage pit and pipe network where directly impacted by the new upgrade works; and
- New utilities (to supply the residential subdivision) and adjustments to existing utilities, where required.

1.2 SCOPE OF THIS REPORT

This report documents the hydrology and hydraulics assessment undertaken for the Appin Road Upgrade, Mt Gilead and evaluates the impacts of the proposed upgrade on the surrounding areas upstream and downstream of the alignment and on the existing drainage infrastructure. The scope of the assessment is summarised below:

- Document assumptions and inclusions in the drainage design;
- Provide a description of the drainage design including areas where value, safety and quality are incorporated into the design;
- Describe criteria and technical inputs to the drainage design such as for drainage and pavements;
- Demonstrate compliance with the adopted design criteria;
- Identify and discuss any remaining design issues, and further opportunities in design;
- Highlight any interdisciplinary interface that has taken place in order to develop the design; and
- Demonstrate how constructability has been considered within the design.

This report complements the design drawings listed in Appendix B and provides background to the development of the Concept Design. However, it is not intended to repeat or describe in detail all the information provided on those drawings. Where necessary, information from those drawings is used to help explain certain aspects of the longitudinal drainage design.

1.3 DESIGN LOT

The design for this project has been split into seven design reports. A summary of all the design lots that are included in the current report has been provided in Table 1-1.

Table 1-2 indicates those design lots that present an interface with the Hydrology and Drainage design report.

Table 1-1 Design Lots included in the Hydrology and Drainage Design Report

REPORT	DESIGN LOT	DESCRIPTION
Hydrology and Drainage Concept Design Report	DR-01	Longitudinal / Cross Drainage

Table 1-2 Interface Design Lots

REPORT	DESIGN LOT	DESCRIPTION
Road Design Report	RG-01	Road geometry and detail
	RF-01	Road furniture
	RL-01	Street lighting
	CS-01	Construction staging
	PA-01	Property adjustments / works
	ST-01	Structures
	TS-01	Traffic control signals

REPORT	DESIGN LOT	DESCRIPTION
Pavement Concept Design Report	PT-01	Pavement design
Utilities Concept Design Report	UT-01	Utilities
Landscape and Urban Concept Design Report	LS-01	Landscaping and urban design
Geotechnical Factual Report	GT-01 and GT-02	Geotechnical - factual report
Geotechnical Interpretative and Contamination Report	GT-02	Geotechnical - Interpretative report

1.4 DELIVERABLES

The scope of this design package is outlined below:

- Drainage plan drawings – design Lot DR-01; and
- Drainage design report (this report).

1.5 DESIGN SUBMISSIONS

This is the Road Design report for the 80% Concept Design stage. The purpose of this submission is to achieve a Hydrology and Drainage Design that is comprehensive and technically accurate in the design of all elements included. It is intended that this design will be developed to the Detailed Design stage following receipt of comments on this design lot.

2 DESIGN CRITERIA AND TECHNICAL REQUIREMENTS

2.1 HYDROLOGY AND DRAINAGE

Design standards for this project and to the hydrology and drainage assessment include:

- Austroads Guides and relevant RMS supplements; and
- Campbelltown City Council guidelines and standards.

The proposed design objectives for managing hydrological and hydraulic impacts are:

- Preserving existing elements such as natural channels, wetlands and riparian vegetation;
- Managing stormwater quality and quantity as close to its source as possible, including the installation of devices that treat stormwater and retain runoff so that changes to the system are kept to the minimum amount practical; and
- Minimising downstream erosion and sedimentation risk.

Project specific performance requirements relating to drainage and water quality are detailed in Table 2-1 and it lists the key drainage design criteria.

Table 2-1 Minimum ARI requirements

ITEM NO.	ITEM	MINIMUM ARI
1	Channels and open drains	5 years
2	Piped system (including pits)	10 years
3	Culverts where surcharge is allowable	50 years
4	Structures where surcharge is undesirable	100 years
5	No flow spread onto the traffic lane*	10 years
6	Gross pollutant traps	1 year
7	Pavement drainage wearing surface	10 years
8	Major storm event check for no property damage	100 years
9	Cycleway	1 year
10	Temporary drainage	2 year

* Where no shoulder provided, refer Austroads Part 5A, Table 5.1: Allowable spread widths and gutter flows

2.2 REFERENCE DOCUMENTS

This assessment has been prepared in accordance with the following documents:

- Austroads, 2013, Guide to Road Design – Part 5: Drainage Design, Sydney;
 - o Including Roads and Maritime (RMS) supplement to Austroads Guide to Road Design Part 5A: Drainage – Road Surface, Networks, Basins and Subsurface (2013) – (Date of approval 07/04/2017)
- Campbelltown City Council (2009). *Campbelltown (Sustainable City) Development Control Plan 2009 - Engineering Design for Development Volume 2*;
- The OEH’s Publication, “Managing Urban Stormwater – Soils and Construction” (BlueBook Vol.1);
- Greater Metropolitan Regional Environmental Plan No 2—Georges River Catchment;
- The CSIRO’s “Urban Stormwater - Best Practice Environmental Management Guidelines”;
- Pilgrim, D H (ed.), first published 1987, reprinted 1998, and updated 2001 Australian Rainfall and Runoff, Engineers Australia, Canberra;
- Australian Runoff Quality (1987);
- NSW Road and Traffic Authority, Road Design Guide, NSW Road and Traffic Authority, Sydney; and
- Campbelltown City Council’s MUSIC modelling parameter (supplied by Council on 27th September 2017).

2.3 DESIGN INPUTS

The following data were used in this study:

- Reference design – J. Wyndham Prince, March 2015;
- Drainage plans extract from Campbelltown City Council, including details of Oswald Reserve Detention Basin (Date approved 08/11/1984, Works as Executed sign-off on 03/04/1990);
- RMS drainage plans, Woodland Road and Fitzgibbon Lane, St Helens Park – Works as Executed, 16/09/2003;
- Aerial photography of the project area;
- Preliminary ground survey and LiDAR data obtained 1 July 2017;
 - o Additional topographical survey data obtained 22 September 2017;
- Utilities and services survey obtained 22 September 2017;
- Campbelltown City Council MUSIC modelling guidelines, Parameters to be used in MUSIC modelling, obtained 26 September 2017;
- Proposed discharge points into future subdivision from Cardno, Gilead Subdivision / draft 80% Concept Design review, obtained 22 November 2017;
- Site visit – 15 August 2017; and
- Hydrology and hydraulics assessment memo (2113521-DR-MEM-001_RevA), including operational quality, methodology draft.

3 DESIGN DEVELOPMENT

3.1 CHANGES FROM PREVIOUS DESIGN STAGE

Drainage design was not undertaken for the Strategic Concept Design.

Drainage design has been developed for the 80% Concept Design and the key drainage items are as follows:

- Longitudinal drainage has been designed. Proposed pipes have been sized for the future six-lane arrangement scenario and pits have been spaced to control flow widths for the four-lane scenario;
- Three new discharge points have been introduced in Area 1 as discussed with Lend Lease and Cardno. Proposed road drainage would tie into the sub-division drainage works as per the discussion;
- DRAINS models have been created for impact assessment;
- MUSIC models have been created for water quality assessment;
- Permanent water quality treatment measures have been proposed; and
- Construction phase erosion and sediment control proposed for construction staging design.

3.2 CROSS DISCIPLINE REVIEW

The cross-discipline review (CDR) has been undertaken in parallel with the review of the draft 80% Concept Design issued on the 28/10/2017 by package owners and discipline team leaders to verify appropriate integration of other disciplines design components.

A CDR matrix has been included in Appendix H.

3.3 DESIGN VERIFICATION AND REVIEW

Design verification has been undertaken prior to this submission.

An Independent Verification matrix and review documents have been included in Appendix I.

3.4 DESIGN NON-CONFORMANCES

The design developed in the present document has been undertaken to comply with all relevant standards and criteria as detailed in Section 2.

Identified minor concessions such as cover and grade concessions (non-conformances) for resolution in the next design phase or agreement with RMS are detailed in the non-conformances register included in Appendix D.

3.5 DESIGN ALTERNATIVES FOR CONSIDERATION

The following alternatives can be considered in the design:

- Where pits are closely spaced, ACO drain can be used in its place instead to control the flow width.

3.6 FURTHER DESIGN DEVELOPMENT

The following summarises the design development requirements beyond the current 80% Concept Design which are needed to be addressed within the Detail Design Phase of the project. All chainage references within this report are based on road control string MCNB.

3.6.1 GENERAL ISSUES

- All existing pit and pipe details were referenced from detailed survey, Council drainage GIS information and RMS drawings, some areas of survey are ongoing;
- Potential clashes with utilities to be further investigated in the next design phase;
- Capacity of the existing swales on south bound carriageway currently being retained as there is no significant increase in drained catchments. The future 6 lane option has the potential to increase drained catchment and impact the current capacity of the existing swale. The magnitude of this will need to be assessed at the next design stage, along with associated upgrade works, as required; and
- Pit spacing will be optimised as the road design is refined in the next design phase;

3.6.2 WATER QUALITY

- Stream Erosion Index to be investigated as part of the Mt Gilead Development proposals for ultimate discharges to Noorumba Reserve.

3.6.3 AREA 1 (CH0 TO CH1880)

- Consultation with Cardno and Mount Gilead developer will be required in next design phase to confirm tie-in points and levels from proposed road drainage system to proposed subdivisions drainage system, and drainage arrangements during construction phase; and
- Points of discharge of existing swales along the southbound carriageway of Area 1 are assumed. Impacts of future six-lane to existing properties to be reviewed and adjustment of flows at Outfall 1 to be updated as appropriate in next design phase.

3.6.4 AREA 2 (CH1880 TO CH3520)

- Drainage within Area 2 discharges into the floodway channel at CH2900. The following information have been provided by Campbelltown City Council:
 - o 100 year ARI flow downstream of Oswald Reserve– 13.3m³/s;
 - o 100 year ARI flood level downstream of Oswald Reserve – 130.3m AHD; and
 - o Required freeboard level – 130.8m AHD.

- Clarification has been sought from the Council regarding the location of flow calculation and 100yr ARI flood extents for flows discharge downstream of Oswald Reserve. Details of the two RFIs issued to Council can be found in Appendix L. Requirement for detention basin will be assessed upon the receipt of further information from the Council. The following works to the proposed drainage system discharging to this location are outstanding:
 - o The floodway channel side slopes will need minor regrading works to accept the proposed drainage lines to daylight. Earthworks modelling for the proposed floodway modification will be undertaken at the next design phase;
 - o Cover to drainage pipe lines near sag point at CH 2900 will be further investigated. Road model will be refined further to provide greater cover to pipe; and
 - o Drainage requirement at the top of the retaining wall between CH 3300 and CH 3650 will need to be assessed and provided accordingly.
 - Geotechnical assessment of the flood bund at Oswald Reserve required to assess potential impacts from proposed road works;
 - Drainage works, described in section 4.5.1.2, will be required outside of the limit of works, downstream of the floodway channel at Kellerman Drive, subject to approval from Council (if not feasible, property acquisition and on-site stormwater detention may be required). These will need to be reviewed at the next stage of design.
-

3.6.5 AREA 3 (CH3520 TO CH4250)

- Drainage works will be required adjacent to the northbound and southbound carriageway between CH4350 and CH4470. It is proposed to discharge road runoff into bio-retention swales and a HumeCeptor® prior to discharge into Springs Creek to allow for water quality targets to be achieved. Additional topographic survey for east side swale has been requested.
 - The proposed drainage works potentially impacts existing utilities (e.g., existing light poles). Drainage design will be reassessed to avoid impacting utilities during the next design stage.
-

3.6.6 AREA 4 (CH4900 TO CH5800)

- A HumeCeptor®, has been proposed at the outlet of the drainage located at CH5600 adjacent to the northbound carriageway. The HumeCeptor® is currently proposed in steep terrain. The suitability of this location will be investigated at the next design phase and the HumeCeptor® will be relocated if required.

4 DESIGN DESCRIPTION

4.1 DESIGN ASSUMPTIONS

The 80% Concept Design has been prepared based on the following assumptions:

- Where the drainage survey is incomplete, several assumptions have been made regarding the size, location and depth of the existing drainage;
- In the absence of complete 100 year ARI flow information from Campbelltown City Council such as existing flow calculation details, flood extents and freeboard levels, the design has utilised available detailed survey and as-built drawings to assess impacts due to proposed works. An RFI has been raised to the Council requesting clarification. Refer to Appendix L for RFI details;
- If additional flow is not being discharged to existing swales on the eastern side of Appin Road, upgrade is not required;
- Consultation has been undertaken with Cardno regarding the locations of stormwater discharge points from Appin Road into the Mount Gilead sub-division. It is assumed that the developer shall provide appropriate attenuation and water quality treatment measures where required. Any flooding impacts in this area due to proposed works (including potential noise walls) will be assessed by Cardno. Further coordination with Cardno will be undertaken in the next design stage; and
- The existing drainage pits, pipes and headwalls are in good structural condition and the existing pipes are free from blockages.

4.2 CONCEPT DRAINAGE DESIGN STRATEGY

4.2.1 LONGITUDINAL DRAINAGE

The project's intention is to retain the existing southbound lane pavement and all the infrastructure east side of this lane (except at the intersections), hence no new longitudinal drainage has been proposed on the east side of Appin Road, except in certain areas where the existing infrastructure (i.e. pits, pipes, and swales) are not sufficient to cater to the increase in flow resulting from the road upgrade to four lanes. As all the west side infrastructure (i.e. kerb and gutter lines) are proposed, longitudinal drainage has been proposed predominantly on the west side of Appin Road.

Longitudinal drainage design has been undertaken based on the input from the survey with regards to locations of final discharge points and longitudinal drainage catchment delineations. This exercise has been done in 12d and preliminary hydrology and hydraulic analysis has been undertaken to assess pit and pipe capacity based on the 10 year ARI.

The catchments draining into the longitudinal drainage networks consist of the main Appin Road carriageways and footways, local roads' intersection areas, and the batter faces in cut areas. The intent of the longitudinal drainage design is to divert pavement runoff away from the roadway traffic so that at least one flood-free travel lane is maintained for rainfall events up to 100 year ARI.

Longitudinal drainage networks are provided where there is gutter along the edge of pavement on the Appin Road carriageways and are typically comprised of a carrier pipe running underneath the kerb with RMS standard pits at a maximum of 80m spacing. ACO drain has been proposed on some medians and noses where the road runoff in superelevated areas encroaches into the travel lane and it is not practical to place pits at very close intervals.

The pipes have been sized for possible future six-lane arrangement of Appin Road, while the pit spacing has been done to the currently proposed four-lane arrangement for the proposed widening works. Future six-lane impacts on the southbound lanes, where widening is not proposed, will be assessed during the next design phase. Predominantly, SO and SA gutters are proposed along the edge of pavement on the proposed Appin Road carriageways for the current four-lane arrangement. In the future six-lane arrangement, the entire outside kerb will be replaced by SA kerb, and one additional lane in each direction will be built on the median.

In all the raised islands, SF kerbs have been proposed, and where flow width issues occur, ACO drains are proposed. It is proposed for flows from the median to be transferred into the main longitudinal pipes on the outside.

The longitudinal drainage lines eventually discharge into existing surface drainage lines (i.e. channels, creeks, and watercourses). Where the final discharge point is located on the other side of the road, the flows are transferred across existing or proposed transverse drainage structure.

The longitudinal drainage system pipe outlet inverts have been generally set at levels that enable discharge either at or above the existing surrounding natural surface levels, into a surface drainage line. If it is not possible to discharge at ground surface, a channel has been graded from the culvert outlet to a low point in the topography further downstream.

4.2.2 TRANSVERSE DRAINAGE

The majority of the proposed transverse drainage structures within the project are extensions of existing structures.

Where possible, proposed transverse drainage has been designed to maintain the existing drainage regime. The proposed transverse drainage will also cause minimal disruption to the existing natural surface and limits the diversion of flow into adjoining catchments, i.e. the existing flow regime is maintained outside the project boundary except for areas whereby existing catchments are redirected to a particular transverse drainage structure.

In some locations, transverse drainage has been integrated into the longitudinal drainage system where it was not possible to separate the two systems.

Transverse drainage is designed on a case by case basis accounting for the project constraints, road immunity, afflux, downstream impacts and project corridor. It is proposed to provide a cross drainage system that will be capable of conveying external catchment flows so that one travel lane stays flood-free for events up to 100 year ARI.

4.2.3 WATER QUALITY MANAGEMENT SYSTEMS

Using a combination of existing and proposed vegetated swales, bio-retention swales and HumeCeptors®, the percentage reduction in pollutants for baseline targets can be generally achieved. The baseline targets are noted in section 4.6.2.3. At this stage of the design, proposed water quality treatments are not expected to require additional land acquisition.

4.2.4 ON-SITE DETENTION BASINS

The impact of the proposed works on the existing flow regime has been considered. There has been an increase in peak flow rates due to the proposed works. Peak flow rate will need to be controlled where the proposed drainage discharges upstream of existing drainage infrastructure. This can be done by proposing on-site detention (OSD) basins.

Proposed flow rates are discussed in Section 4.5. It is assumed the proposed Mount Gilead subdivision will incorporate OSD into their footprint. No OSD basins have been proposed at the current Concept Design phase.

4.3 HYDROLOGIC & HYDRAULIC ASSESSMENT

The hydrologic and hydraulic assessment has been broken down into four areas. The hydrologic and hydraulic assessment for each of these areas has been completed using the DRAINS modelling software package. An existing case and post road upgrade arrangement have been modelled for each catchment (with the assumption of full six lanes being used for the future road upgrade arrangement).

The general procedure involved in undertaking the hydrologic and hydraulic assessment is outlined below:

- 1 Identify external catchments;
- 2 Obtain and review Council's local catchment flow data;
- 3 Identify and propose stormwater drainage discharge points;
- 4 Determine flow changes at all discharge points; and
- 5 Assess any impacts of flow and drainage regime caused by the additional impervious road catchment area.

A comparison has been made of existing case and post road upgrade flows to identify any potential impacts on adjacent properties and infrastructure because of increased flow due to the project. Where there are adverse impacts resulting from increase in flows, suitable mitigation measures have been identified and detailed in Section 4.5.

4.3.1 DRAINS MODELLING

DRAINS is a simulation program which converts rainfall patterns to stormwater runoff and generates discharge hydrographs. These hydrographs are then routed through networks of piped drainage systems, culverts, storages and open channels to calculate hydraulic grade lines and calculate the flows. Several hydrologic sub-models are available within the DRAINS software to simulate the conversion of rainfall to runoff. The ILSAX sub-model was selected for this project, as it is well suited to the urbanised nature of this area.

Adopted ILSAX sub-model parameters have been based on guidance within Campbelltown City Council Engineering Design Guide. ILSAX uses the Horton loss modelling approach which does not require the user to input a continuing loss rate. Instead, a soil type and antecedent moisture condition (AMC) are used to define the continuing loss over time. The soil type was set to 3, which corresponds with a soil of comparatively high runoff potential while an AMC of 3 was adopted reflecting rather wet conditions prior to the onset of runoff producing rainfall. Parameters for area depression storage for impervious, supplementary and pervious areas were set to 1mm, 1mm and 5mm respectively.

The time of concentration and flows from sub-catchments were calculated in DRAINS using the in-built kinematic wave function by entering the associated flow path length, flow path slope and retardance coefficient, n^* .

The following DRAINS input parameters were adopted from Campbelltown City Council's Engineering Design for Development Manual:

- Percentage impervious for various land-uses:
 - o 5% impervious for rural lands;
 - o 70% impervious for residential lands with lot size 600-1000 m²; and
 - o 80% impervious for residential lands with lot size 400-600 m².
- Pit blockage factors:
 - o 50% blockage used for sag pits; and
 - o 20% blockage used for on-grade pits.

- n^* values for use with kinematic wave equation:
 - o $n^* = 0.01$, for road and paved areas;
 - o $n^* = 0.15$, for parkland; and
 - o $n^* = 0.06$, for medium density residential areas.

The Design Intensity Frequency Duration (IFD) data and storm temporal patterns have been derived in accordance with AR&R1987. IFD (1987) data was obtained from the Bureau of Meteorology (BOM) website and was used to derive design rainfall events for use in the hydrological analysis of the Appin Road road-widening project. The location of the IFD data was taken at the latitude and longitude coordinates of -34.121223, 150.796167. IFD data can be found in Table 4-1 below.

Table 4-1 IFD data from BOM

DURATION	1 YEAR	2 YEARS	5 YEARS	10 YEARS	20 YEARS	50 YEARS	100 YEARS
5Mins	82.5	106	135	151	174	202	224
6Mins	77.1	99.1	126	142	162	189	210
10Mins	63.1	81	103	116	133	155	172
20Mins	46.2	59.4	75.7	85	97.4	113	126
30Mins	37.6	48.3	61.6	69.1	79.3	92.4	102
1Hr	25.3	32.5	41.6	46.8	53.7	62.7	69.5
2Hrs	16.3	21	27	30.4	35.1	41.1	45.6
3Hrs	12.4	16	20.7	23.4	27	31.8	35.3
6Hrs	7.73	10	13.1	14.9	17.3	20.4	22.8
12Hrs	4.88	6.35	8.37	9.57	11.1	13.2	14.8
24Hrs	3.15	4.09	5.42	6.21	7.23	8.59	9.63
48Hrs	2.01	2.61	3.46	3.97	4.63	5.5	6.17
72Hrs	1.49	1.94	2.58	2.96	3.45	4.11	4.61

Note: AR&R 2016 has not been used for this assessment as this does not align with Council standards nor the current flow information received from Council.

4.3.2 CATCHMENT AREAS

The existing Appin Road (pre-upgrade) predominantly consists of two lanes, with the exception at some junctions. With the proposed road-widening to four lanes, and future-proofing of six lanes, the impervious footprint of Appin Road will increase significantly.

Outside catchments for each area were delineated by examining the contours from the 2m LiDAR, 1m LiDAR and detailed topographical survey. The existing and proposed case catchment delineation drawings for the 4-lane scenario are shown in Appendix K. Road catchments of each area were delineated by examining the contours from the survey and proposed road model.

In the four-lane arrangement option, typically the existing southbound lane pavement and all the infrastructure on the east side of the road are retained, and the additional southbound lane, median, and the two new northbound lanes are graded towards the west side where all the proposed longitudinal drainage will be located.

The six-lane arrangement option will comprise of three southbound lanes, one of which will utilise the existing southbound lane pavement with the additional two lanes graded to the outside of the road. Hence there is an increase in paved area where majority of the increase will drain towards the median. The three northbound lanes consist entirely of proposed widening hence paved area has replaced the existing verge and vegetated areas along the western side.

The proposed works area is split into four main catchments based on their outfall points:

- Area 1 (CH0 to CH1880): This area is located between the south limit of works up to the crest point at CH1880 and includes two new intersections, discharge points into the proposed subdivision at CH350, CH900, CH1500 and a transverse drainage structure at CH1700;
- Area 2 (CH1880 to CH3520): This area is located between the two crest points at CH1880 and CH3520 and includes one existing intersection (Copperfield Drive-Kellerman Drive) and the drainage discharge sag point at CH2880;
- Area 3 (CH3520 to CH4250): This area is located between the crest point at CH3520 and the limit of works at CH4250 and includes one existing intersection (Fitzgibbon Lane-Kellerman Drive) and drainage discharge points at CH4330 and CH4350. This area covers the swales on both sides of the road which drain toward Spring Creek; and
- Area 4 (CH4900 to CH5800): This area is located between the two limits of works at CH4900 and CH5800 and includes the existing St Johns Road intersection and drainage discharge point at CH5530.

A comparison between the grassed (pervious) and paved (impervious) catchment areas for the existing and proposed case of each section are tabulated below.

4.3.2.1 AREA 1

Pervious and impervious catchments for Area 1 comprise of the road, adjacent verges and upstream grassed areas (external catchments). The existing catchments were delineated to determine the total runoff being discharged to the eastern and western roadside swales along Appin Road from both the northern side and southern sides of the sag point at CH1700. Delineation of catchment areas and 100yr ARI flows for the existing and proposed cases are illustrated in Appendix K.

In the proposed scenario, catchments have been redistributed into four main areas discharging runoff into the proposed Mount Gilead development at CH350, CH900, CH1500 and CH1700.

The total catchment area in the proposed scenario is greater than the existing condition due to the redistribution of catchments along Appin Road. In the existing case, runoff on the western side of Appin Road sheet flows away from the road and thus does not contribute to the total catchment area of the road corridor. As such, the proposed points of discharge to the future Mount Gilead development have not been considered in the existing case. In the proposed scenario, the runoff which initially flows westwards away from the site will be built over and included in the total footprint area of the road corridor.

4.3.2.2 AREA 2

Pervious and impervious catchments for Area 2 comprise of the road, adjacent verges, Oswald Reserve and medium density residential areas. Catchments for Area 2 were delineated to determine the amount of runoff discharged to the sag point at CH2880 from the south-east, north-east, south-west and north-west sides of Appin Road - "south-east" denotes the catchment area flowing towards the drainage infrastructure on the eastern side of Appin Road originating from the southern side of the road sag. Delineation of catchment areas and 100yr ARI flows for the existing and proposed cases are illustrated in Appendix K.

Catchments from the residential area upstream of Oswald Reserve were also delineated as runoff from these areas directly interact with the runoff generated from the proposed road-widening works. These residential catchments utilise Oswald Reserve as an attenuation basin during major storm events.

From examining the cadastral drawing, it was found that the majority of the residential lot sizes within this medium density residential catchment were between 400m² and 1,000m². Percentage impervious for various land uses, of the Campbelltown City Council, Engineering Design for Development guidelines, a percentage impervious of 75% was chosen.

4.3.2.3 AREA 3

Pervious and impervious catchments for Area 3 comprise of the road, adjacent verges and grassed areas. The proposed works at Area 3 does not include a sag point, and as such, catchments were delineated to the extent of the proposed road-widening works to determine the total existing and proposed flows draining towards the existing eastern and western roadside swales immediately adjacent Appin Road. Delineation of catchment areas and 100yr ARI flows for the existing and proposed cases are illustrated in Appendix K.

The total catchment area in the proposed scenario differs from the existing case due to catchment redistribution. In the existing case, runoff collected along the east side swale between CH3900-4100 is discharged to the council drainage system at Holman Place. It is proposed to collect runoff from this catchment into the Appin Road drainage system and discharge into Spring Creek.

4.3.2.4 AREA 4

Pervious and impervious catchments for Area 4 comprise of the road, adjacent verges and grassed areas. The proposed works at Area 4 does not include a sag point, and as such, catchments were delineated to the extent of the proposed road works between CH5100 and CH5580 to determine the total existing and proposed flows draining towards the existing council drainage outlet located on the western side of the road at CH 5600. Delineation of catchment areas and 100yr ARI flows for the existing and proposed cases are illustrated in Appendix K.

The total catchment area draining to the existing network on St Johns Road is less than that of the existing case due to the redistribution of catchments from St Johns Road to Appin Road. Runoff from Appin Road in the proposed case shall be diverted northwards and is assumed to discharge towards the existing channel alongside Therry Road without contributing any flows to the drainage system on St Johns Road.

4.4 EXISTING DRAINAGE SITUATION

The proposed Appin Road upgrade works lie within two catchments. The southern portion of the proposed works is situated within Nepean River catchment while the northern portions is located within the Georges River catchment. Appin Rd is generally located on a ridge line between the two catchments at the southern end, and as such, no named water course or drainage lines have been identified along the extent of the proposed upgrade. Project works along Appin Road does cross Spring Creek.

In terms of regional flooding, the proposed Appin Road upgrade works are located along the ridge bordering the Nepean River catchment and the Georges River catchment. The study area is not at or below the level of a 100-year ARI flood event, plus 0.5 metre freeboard, and subsequently not considered to be flood prone land from regional flooding. Therefore, the proposed works is not expected to impact on the flood storage and flood conveyance of the regional floodways. The expected impact will be on the increase in runoff due to increased impervious areas.

4.4.1 AREA 1 (CH0 TO CH1880)

4.4.1.1 OVERVIEW OF AREA 1

Area 1, the southernmost catchment, drains runoff from the local road and overland flows from external catchments East of Appin Road. Appin Road is predominantly located on the ridge line of the catchment. The northbound carriageway runoff gets collected in a swale/bund located towards the west of the road and the southbound carriageway runoff gets captured by a vegetated swale before crossing the road via the culvert at CH1700. External catchments on the eastern side of the road also discharge into this swale. There is a farm dam located west of the road immediately downstream of the existing transverse culvert, which then drains through Noorumba Reserve and towards Menangle Creek. Menangle Creek is a tributary of the Nepean River.

Figure 4-1 below shows the aerial schematic of the existing flow regime in this area.



Figure 4-1 Area 1 Schematic

4.4.1.2 EXISTING DRAINAGE NETWORKS OF AREA 1

The existing drainage systems serving the catchment of Area 1 consist of the following:

- The road corridor and adjacent external catchments are drained by table drains and swales, and no formal pit and pipe drainage network has been identified along Appin Road in Area 1, apart from two existing SO pits on the east and west sides of Appin Road at CH 190 and an existing 375mm dia. transverse drainage culvert located at the Area 1 sag point, CH 1700, draining from east to west;
- From the topographical survey and site visit, it appears that the existing road has segmented bunds and roadside swales with turnouts directing runoff away from road catchment at some locations;
- (Note: investigation of turn-out locations is ongoing. Currently, it is assumed that all flows from the existing road (CH 1050 – 1880) and adjacent grassed areas discharge towards sag point at CH 1700); and
- Runoff downstream of transverse drainage structure at CH 1700 is discharged to a farm dam, then through Noorumba Reserve and ultimately to Menangle Creek.

4.4.2 AREA 2 (CH1880 TO CH3520)

4.4.2.1 OVERVIEW OF AREA 2

Area 2 collects runoff from Appin Road, between two crests located at CH1920 and CH3520, and catchment to the west of Appin Road; which consists of the local roads, Oswald Reserve and residential area upstream of Oswald Reserve. The runoff eventually discharges to the existing floodway channel on the east side of Appin Road, opposite Oswald Reserve, at CH2850. This floodway channel discharges into Mansfield Creek downstream, which is a tributary of Georges River.

The playing field at Oswald Reserve acts as a detention basin which discharges to a pit and pipe drainage system that crosses Appin Road at CH2850 and runs underneath the floodway channel on the east side of Appin Road. In the absence of survey data to the east of the floodway channel at Kellerman Drive, it is assumed that this system discharges into Mansfield Creek downstream.

Directly on top of the pit and pipe system described above, there is a major flow system that consists of two sets of triple-cell 750mm dia. pipe culverts underneath the Oswald Reserve embankment and Appin Road carriageways. This system conveys surface/high flows from Oswald Reserve and the catchments west side of Appin Road when the pipe network capacity underneath is exhausted. The culverts discharge the flows into the floodway channel on the east side of the road. The floodway channel then discharges into Mansfield Creek further downstream.

Figure 4-2 below shows the aerial schematic of the existing flow regime in this area.



Figure 4-2 Area 2 Schematic

4.4.2.2 EXISTING DRAINAGE NETWORKS OF AREA 2

The following existing drainage features have been identified within the catchment of Area 2 and drain towards the 3x750mm dia. reinforced concrete pipe (RCP) culverts at Oswald Reserve at sag point CH2880.

NOORUMBA RESERVE VICINITY

The southernmost section of the catchment in Area 2 generally falls towards Outfall 2, at road sag located at CH2880. However, due to limited drainage systems and insufficient capacity, not all flows will ultimately discharge to Outfall 2. This is described in more detail below:

- There are no formal drainage systems along the northbound carriageway of Appin Road for Area 2. Therefore, runoff from the road surface sheets off towards the west to the adjacent Noorumba Reserve;
- The existing swale along the east side of Appin Road drains both the eastern carriageway and the adjacent grassed catchment area. This existing swale is potentially under capacity. There is potential for runoff generated from the upstream catchment in less frequent storm events to spill across the road and towards Noorumba Reserve to the west; and
- Currently, it is assumed that runoff from the grassed area to the east is collected by the eastern swale and is drained towards Outfall 2, at the Oswald Reserve.

SOUTH OF SAG POINT (CH 1920-2880)

- The eastern swale between CH1920-2240, utilises a single 450mm dia. RCPC transverse road drainage culvert at CH2240, conveying runoff from the southbound carriageway to the swale along the western side of Appin Road;
- The eastern swale between CH2240-2420, discharges northwards and is culverted under Copperfield Drive with a single 450mm dia. RCPC at CH2420. The culvert discharges to a downstream swale on the eastern side and flows continue to drain north;

- The existing swale along the west side of Appin Road between CH2120-2420, discharges northwards through a single 450mm dia. RCPC at CH2420, crossing under Kellerman Drive and conveys runoff to the downstream western swale starting at CH2500;
- The eastern roadside swale between CH2500-2580, discharges runoff westwards through a 450mm dia. RCPC beneath Appin Rd at CH2580; flows are collected by a swale along the western side of Appin Road;
- The southbound carriage way road runoff and flows from the service station is collected by a pit and pipe system located between the southbound carriageway and the service station. This line ties into the downstream headwall of the culvert at CH 2880; and
- The western swale between CH2500-2880, discharges runoff to the 3x750mm dia. RCPC at CH2880 which directs the flows to the floodway channel.

NORTH OF SAG POINT (CH3520-2880)

There are no pit and pipe drainage networks that have been identified at this location. Runoff is conveyed by swales immediately adjacent to the southbound and northbound carriageways of Appin Road, which flow south towards outfall 2.

A turnout from the swale adjacent to the western side of Appin Road was identified at CH3300. Flows from this turnout and the northbound carriageway swale discharge into the 3x750mm dia. pipes at CH2880.

OSWALD RESERVE AND DOWNSTREAM FLOODWAY CHANNEL

The Oswald Reserve playing field west of Appin Road between CH2700 and CH2900 acts as a detention basin with a major and minor storm network draining the upstream residential catchment. Runoff from the upstream residential catchments drain towards Oswald Reserve via existing pit and pipe networks and discharges into Oswald Reserve at 3 locations, the north-east, north-west and south-west boundaries of the playing field via headwalls.

The minor storm pipe network at Oswald Reserve consists of a pit immediately downstream of the 3 headwall outlets which convey low flows via a single 375mm dia. pipes, converging at the pit located at CH2860. The low-flow network continues under Appin Road (west to east) via a 750mm dia. pipe conveying flows to the minor storm network under the major floodway channel.

During major storms, runoff will overflow from the pits immediately downstream of the 3 headwall outlets onto the footpath surrounding the playing field. Flow from the major storm is contained within the playing field by a bund surrounding the footpath and is discharged through the bund via 3x750mm dia. pipe culverts at CH2880. Runoff from this culvert is then conveyed to the major floodway channel by a second set of 3x750mm dia. pipe culverts (west to east) running under Appin Road at CH2880.

A drawing received from Campbelltown Council, dated 03/04/1990, shows the as-built details of the detention basin and corresponding flood levels for the 5 year and 100 year ARI flood events. These were used to compare model results in the pre-development scenario model. However, the design parameters, and allowance for future development the upstream catchment draining to the basin are unknown.

The major storm floodway channel located immediately downstream (east) of Appin Road at CH2880 incorporates a minor pit and pipe drainage system to convey flows from less frequent storm events. Runoff from major storms flows east along the grassed floodway swale and through twin box culverts under Kellerman Drive which discharges to a gabion apron immediately downstream of the twin box culverts. Information received from Council has stated that the 100-year ARI storm event inundates Kellerman Road by 300mm. The original source of this information has not been provided, nor what upstream characteristics and parameters have been assumed.

Low flows are conveyed east through the pit and pipe network which continue through Kellerman Drive. This drainage network forms the upper reach of Mansfield Creek and is ultimately discharged into Georges River.

4.4.3 AREA 3 (CH3520 TO CH4250)

4.4.3.1 OVERVIEW OF AREA 3

Area 3 drains runoff from crest point at approx. CH3520 all the way to Spring Creek at approx. CH4550, which includes the pit and pipe systems underneath Kellerman Drive - Fitzgibbon Lane – Appin Road intersection. Surface flows come from local roads, properties and adjacent verges, which are collected by swales along both sides of Appin Road flowing north towards Spring Creek. South of the intersection, the swales discharge to pit and pipe networks that convey flows across the intersection and discharges into swales immediately north of the intersection.

The western swale drains the northbound carriageway and discharges flow into the upstream side of the box culvert at CH4550.

The eastern swale drains along the east side of Appin Road for approx. 100m before being intercepted by an existing drainage pit at approx. CH4150. This pit discharges into a council drainage system which goes underneath existing private properties east of Appin Road and into pit and pipe system underneath Holman Place local residential road. Any surface flow not captured by the pit continues to travel on the swale northward for approx. 680m before eventually discharges into Spring Creek downstream at CH4550. Spring Creek eventually discharges into Georges River.

Figure 4-3 below shows the aerial schematic of the existing flow regime in this area.



Figure 4-3 Area 3 Schematic

4.4.3.2 EXISTING DRAINAGE NETWORKS OF AREA 3

A summary of the existing drainage features which convey runoff to the existing swales at CH 4120 is given below:

- Existing swales are located immediately adjacent to Appin Road on both sides, located between CH 3520-3820, discharge runoff to drainage pits located at CH 3820 on both sides of the road;
- The eastern drainage pit at CH 3820 conveys runoff through a 375mm dia. pipe, crosses under Kellerman Drive and is discharged into east side swale starting at CH 3920;
- The drainage pit at the western side of Appin Road located at CH 3750 drains runoff from the western swale to the median drainage system. Bypass flows from this pit continue down the western roadside swale to the drainage pit at CH 3820;
- The local pit and pipe network on the western side of Appin Road starting at CH 3820 connects with drainage system from Fitzgibbon Lane and conveys runoff north under the intersection via a 375mm dia. pipe to the western roadside swale starting at CH 3900;
- The median drainage system from CH 3720-3850 comprises of a type SF gutter and pits along the median. Runoff from the median is conveyed eastwards to the drainage pit at CH 3850 on the eastern kerb of Appin Road;
- Type SF gutter and pits along median drain, from CH 3910-4100, conveys runoff eastward to the drainage pit in the eastern roadside swale at CH 4100 and towards the local pipe network at Holman Place:
 - Bypass flows from the type SF median gutter continue along a depressed grassed median to the median pit at 4100 which discharges runoff to the eastern roadside swale;
- East and west side swales north of the Appin Road, Fitzgibbon Lane and Kellerman Drive intersection continue along Appin Road from CH 3900-4550 to sag point at CH 4550 and discharges runoff Spring Creek; and
- Runoff from Spring Creek at CH 4550 is conveyed eastward to the natural watercourse at the forest area of St Helens Park and is ultimately discharged to Georges River.

A discrepancy regarding the alignment of the existing drainage network was noted between the provided council extracts and RMS as-built drawings. Council plans indicate drainage at the intersection of Appin Road and Kellerman Drive conveys runoff eastwards onto Kellerman Drive, whereas the RMS as-built drawings indicate a pipe conveying runoff northwards under Kellerman Drive and discharging into the existing swale at CH 3920. Detailed survey corresponds to the RMS as-built drawings, hence this has been used in the analysis and calculations.

4.4.4 AREA 4 (CH4900 TO CH5800)

4.4.4.1 OVERVIEW OF AREA 4

Area 4 is in the vicinity of St Johns Road – Appin Road intersection, approximately 650m north of Area 3 limit of works. Existing grounds adjacent to the road fall away from the road, hence there is no external catchment draining towards the road within this area.

Road catchments that flow towards the outside of the road are captured by existing SO gutter that run along the edge of pavements which then discharge into pit and pipe systems. At the intersection, the majority of the road catchment flows down towards St Johns Road and gets picked up by the existing pit and pipe system on St Johns Road.

Flows from the southbound carriageway south of the intersection is captured by a pit at CH5340 which diverts flow into the median. The drainage system under the median crosses the northbound carriageway at CH5500 to the final discharge point. Flow in the SO gutter north of the intersection is picked up by the pit that connects into the transverse pipe at CH5500. These flows, along with the flow from the west side SO dish drain eventually discharge into the existing watercourse on the west side of Appin Road at approx. CH5600.

Figure 4-4 below shows the aerial schematic of the existing flow regime in this area.



Figure 4-4 Area 4 Schematic

4.4.4.2 EXISTING DRAINAGE NETWORKS OF AREA 4

A summary of the existing drainage features which convey runoff to the existing watercourse at CH5600 is given below:

- The northbound carriageway SO gutter starts at CH4900 beyond the limit of works. This SO gutter ends at approx. CH5520 where it discharges into a pit and a 525mm dia. pipe system;
- The upstream end of the southbound carriageway SO gutter is beyond the limit of works south of CH4900. This drain ends at approx. CH5300 where it discharges into a pit and 375mm dia. pipe system that carries the flow across the southbound Appin Road carriageways and into the median;
- 375mm dia. pipe system crosses the southbound lane at approx. CH5300 and runs underneath the median from CH5300 to CH5500 where it connects to the existing 450mm-dia. transverse pipeline;
- The upstream end of the SO gutter at the southbound carriageway north of the intersection is at the intersection approx. CH5400. This drain ends beyond the north limit of works, however it is intercepted at approx. CH5500 where it discharges into a pit and 450mm dia. pipe system that carries the flow across Appin Road and onto the western side;

- 450mm dia. pipe system crossing the whole Appin Road at approx. CH5500 running from east to west where it connects to the existing longitudinal 525mm dia. pipeline; and
- 525mm dia. pipe system running alongside the northbound carriageways of Appin Road between CH5520 and CH5600. This pit and pipe system discharges at the bottom of the batter at CH5600 into a grassed area.

4.5 IMPACT ASSESSMENT

The existing drainage infrastructure was modelled in DRAINS with catchment areas input to their respective nodes. It is to be noted that all parameters of the existing drainage infrastructure including cover level, invert level, slope and length were referenced from the information provided from council extracts of existing drainage, RMS as-built drawings and detailed survey. The existing and proposed case flow results for the 2yr, 10yr, 50yr and 100 year ARI storm events are tabulated below.

4.5.1.1 AREA 1

Flows in Area 1 comprise of runoff generated by the road, adjacent verges and an external grassed land upstream of the existing cross-drainage structure at CH1700. In the existing case, it is assumed that all flows discharge towards this existing cross-drainage structure. “South-East” in the table below denotes the flow from the east side swale south of the sag point.

Table 4-7a Existing flows from Area 1

	EXISTING FLOWS (M ³ /S)			
LOCATION	2yr ARI	10yr ARI	50yr ARI	100yr ARI
South-East	0.059	0.122	0.200	0.242
North-East	0.062	0.161	0.295	0.358
South-West	0.046	0.096	0.171	0.206
North-West	0.055	0.116	0.201	0.244

After consultation with Cardno was undertaken, the proposed case shall discharge runoff into the proposed Mount Gilead subdivision at CH350, CH900, CH1500 and CH1700. These flows are tabulated below.

Table 4-7b Proposed flows from Area 1

	PROPOSED FLOWS (M ³ /S)			
LOCATION	2yr ARI	10yr ARI	50yr ARI	100yr ARI
CH350	0.198	0.298	0.387	0.435
CH900	0.342	0.523	0.681	0.765
CH1500	0.419	0.645	0.872	0.991
CH1700	0.389	0.589	0.793	0.881

To accommodate the increase in flows for the 100 year ARI storm event, the existing 375mm dia. cross-drainage pipe at CH1700 will need to be increased to a 750mm dia. pipe. This will also provide the road with a flood immunity for 100 year ARI. Channels discharging into the 750mm dia. pipe will also need to be modified. Flooding impacts downstream of Appin Road will be undertaken as part of the Mt Gilead sub-division works.

Further consultation with Cardno and the Mount Gilead development designer shall be undertaken in the next design stage regarding the permanent tie-in points, levels and flows to subdivisions drainage system, drainage arrangements during the construction stage and water quality mitigation measures.

4.5.1.2 AREA 2

Flows in Area 2 comprise of runoff generated by the road, adjacent verges, Oswald Reserve and upstream residential areas. These flows are conveyed to the sag point at CH 2880 and discharged to the floodway channel immediately east of Appin Road. The residential area on the eastern side of the road discharges runoff into the floodway channel.

The land-use of residential area upstream of Oswald Reserve is classified as a medium density residential area. The Retardance coefficient, $n^* = 0.06$ was adopted and input into DRAINS in accordance with the parameters outlined in Table 4.4, n^* Values for Use with Kinematic Wave Equation, of the Campbelltown Engineering Design for Development manual. Flows from the upstream residential catchment are shown in the table below.

Oswald Reserve serves as a detention basin catering for the upstream residential flows during major storm events. The proposed works does not impact on Oswald Reserve as flows discharge directly into the floodway channel on the eastern side of the road downstream of Oswald Reserve. "South-East" in the table below denotes the flow from the east side swale south of the sag point.

Table 4-8 Existing and proposed flows for catchments in Area 2

	2YR ARI		10YR ARI		50YR ARI		100YR ARI	
LOCATION	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)
South-East	0.119	0.277	0.180	0.453	0.267	0.619	0.299	0.704
North-East	0.123	0.213	0.189	0.332	0.251	0.437	0.284	0.494
South-West	0.129	0.336	0.228	0.620	0.322	0.912	0.370	1.060
North-West	0.163	0.309	0.296	0.491	0.441	0.653	0.519	0.740
US Residential South	2.290		4.060		6.100		7.040	
US Residential Mid	1.550		2.580		3.770		4.310	
US Residential North	1.000		1.660		2.410		2.750	
Oswald Reserve Only	0.125		0.303		0.545		0.659	
DS Residential South	1.710		2.980		4.420		5.100	
DS Residential North	1.780		3.020		4.400		5.050	
Flow at US of Floodway*	2.79	2.95	4.17	4.5	5.21	5.81	5.62	6.28
Flow at DS of Floodway*	5.96	6.03	9.63	10.03	13.57	14.27	15.67	16.48

*Total flow calculations consider flows discharging into Oswald Reserve that has been modelled as a detention basin.

In the existing case, flows generated from the southbound carriageway are diverted across the road to the grassed table drain west of Appin Road at CH 2240 and 2580. The proposed case flows were analysed with all southbound and northbound flows discharging into their respective eastern and western drainage infrastructures and ultimately cross Appin Road via independent culvert crossings at CH2880.

From the DRAINS analysis, flows differ from 13.3 m³/s noted by council. However, the basis and parameters of this flow are unknown, as is the extent of upstream developed at the time of analysis. It is assumed this flow was derived at the time the detention basin was designed in 1990 and significant development works have been undertaken since then resulting in the difference in flows.

SENSITIVITY CHECK

An analysis was also carried out to confirm the existing 100 year ARI flood level at Oswald Reserve. The Works as Executed (WAE) drawings from 1990 provided by Council indicate a flood level of RL 131.97 mAHD for 100-year ARI storm event at Oswald Reserve. This differs from the DRAINS existing case analysis of 132.296 mAHD. Due to the difference in flood levels from the WAE plans and DRAINS analysis, a sensitivity check was carried out to determine the relative downstream impact from the proposed road-widening works.

In the sensitivity analysis, the upstream residential catchments were reduced by 28.5% to match the existing flood level as indicated on the WAE drawings. This gave a flood level of 131.973 mAHD. Using this reduced residential catchment model as the base, the proposed case catchment areas were input and downstream impacts assessed.

The total runoff downstream of the 3x750mm dia. RCPC at the floodway channel and twin box culverts at Kellerman Drive was analysed to determine the relative impact from the proposed road widening. From the DRAINS analysis, the existing and proposed total flows at the upstream end of the floodway channel for the 100-year ARI are 5.620 m³/s and 6.280 m³/s respectively. This is an increase of 11.7%. Investigation of the difference in analysis results and council information are ongoing.

The table below shows a comparison of the existing and proposed case water levels at Kellerman Drive with the sensitivity analysis for the 28.5% reduced upstream residential catchments.

Table 4-9a Existing and proposed case water levels at Kellerman Drive

	100 YR ARI WATER LEVEL (M AHD)		
	EXISTING	PROPOSED	INCREASE
Analysis Results	130.551	130.657	0.106
Sensitivity check	130.377	130.596	0.219

The increase in flood level is below the required freeboard level of 130.8 mAHD, provided by Campbelltown City Council. This implies that the adjacent properties are above the 130.8 mAHD level and are therefore not impacted the proposed flow increase, however, flood extents mapping for water level at 130.3 mAHD, illustrated in Appendix L – RFI 2, indicate adverse impacts to adjacent properties. Clarification is being sought from Campbelltown City Council regarding the freeboard level of 130.8 mAHD as detailed in Appendix L.

Furthermore, information received from Campbelltown City Council indicate a flow of 13.3 m³/s in a 100 year ARI storm event measured at the upstream end of the floodway channel. This is significantly higher than the DRAINS analysis. Coordination with the Council for further information regarding the floodway channel and further analysis of the DRAINS model is being undertaken. Refer Appendix L for RFI correspondence.

PROPOSED WORKS

Further investigation is required to analyse the capacity of the existing floodway channel and the impact these water level increases are having on the upstream systems (that drain toward the channel), downstream, and surrounding residential areas. However, for the 80% concept design, it is proposed to add an additional 1200mm dia. pipe parallel to the existing twin box culverts under Kellerman Drive. This option mitigates the inundation experienced by Kellerman Drive at the twin box culverts and alleviates potential adverse impacts to surrounding properties. The resultant flood level is 30.245 m AHD. If this option is not feasible, an attenuation basin (and subsequently, property acquisition) within the area will be required.

4.5.1.3 AREA 3

Flows in Area 3 are predominantly comprised of runoff generated by the road and adjacent verges. Currently, flows are conveyed to the existing eastern and western roadside swales adjacent to Appin Road at CH3910 and CH3900 respectively.

The eastern side of Appin Road has residential properties, whereas the western side doesn't. Therefore, the proposed scenario diverts all road runoff to the western side of Appin Road at CH4050, thus reducing any potential adverse impacts to existing properties along the southbound carriageway. It is also proposed to disconnect the Appin Road drainage system from the Campbelltown City Council drainage system discharging to Holman Place at CH4100, subject to Council's approval.

Existing and proposed case flows experienced by the east side and west side swales at CH4350 are tabulated below.

Table 4-10 Existing and proposed flows from Area 3

	2YR ARI		10YR ARI		50YR ARI		100YR ARI	
LOCATION	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)
East side swale	0.142	0.077	0.245	0.121	0.344	0.165	0.424	0.186
West side swale	0.282	0.619	0.502	1.010	0.717	1.400	0.852	1.590
Flow to Holman Place at 4100	0.183	0.000	0.264	0.000	0.326	0.000	0.344	0.000

From the DRAINS results, flows in the west side swale increase due to the flow diversion discussed above. This has resulted in reduction of flows in the east side swale. The 100-year ARI flow on the west side swale increases from the 0.852 m³/s to 1.590 m³/s, and the east side swale decreases from 0.424 m³/s to 0.186 m³/s.

It is proposed for the existing east and west side swales to be regraded at CH4325 and CH4350 respectively, such that the drainage outlets can be accommodated for. Flows from these outlets shall be discharged into proposed bio-retention swales for water quality treatment.

Although the proposed scenario generates increased flows in the west side swale, the proposed bio-retention swale and existing downstream swale will have sufficient capacity to cater for the 100-year ARI storm event. The 100-year ARI capacity of the existing swales was calculated by considering the cross-sectional area of the swale itself plus the additional cross-sectional area of the road whilst allowing one free travel lane. The west side swale has an average capacity of 3.025 m³/s, which is sufficient for a proposed 100-year ARI flow of 1.590 m³/s. This means that the 100-year ARI flow is contained within the channel and is in compliance with the requirements outlined in section 5.4.2 – pavement spread and gutter flow limits, of the Austroads Guide to Road Design Part 5A guidelines for both the 4-lane and 6-lane options.

The east and west swale discharge to the existing formalised channel of Spring Creek, which is conveyed under Appin Road by a triple cell box culvert. Redistribution of flows to Spring Creek is assumed to have minimal impact given the size of overall catchment.

4.5.1.4 AREA 4

Flows in area 4 are predominantly comprised of runoff generated by the road. In the existing condition, these flows are conveyed to the existing northbound and southbound carriageway SO drains, and via SA gutter on both sides of St Johns Road. Southbound flows south of the intersection are conveyed to the existing Council drainage network on St Johns Road. It is proposed to divert runoff from the southbound carriageway south of the intersection away from the drainage system on St Johns Road into the Appin Road drainage system. The existing and proposed flows are tabulated below.

Table 4-2 Existing and proposed flows from Area 4

	2YR ARI		10YR ARI		50YR ARI		100YR ARI	
LOCATION	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)	EXISTING FLOW (m ³ /s)	PROPOSED FLOW (m ³ /s)
East side	0.183	0.098	0.278	0.161	0.353	0.284	0.393	0.348
West side	0.346	0.442	0.505	0.665	0.631	0.76	0.706	0.810

The decrease in the eastern side flows, as tabulated above, can be attributed to the diversion of Appin Road flows away from St Johns Road as discussed above.

The increase in proposed flows on the western side is due redistribution of catchments away from St Johns Road and proposed widening of the southbound carriageway of Appin Road. Runoff from the southbound carriageway of Appin Road sheet flows into swales located north and south of the intersection adjacent to the road. The swales discharge into proposed pit and pipe system conveying flow to the outlet located at the western side of the road at CH5600. The drainage system outlets into an open area. Runoff sheet flows north towards the channel adjacent to Therry Road. The increase in 100 year ARI flow depth immediately downstream is approximately 2mm which is not significant.

4.6 WATER QUALITY ASSESSMENT

4.6.1 CONSTRUCTION PHASE

4.6.1.1 ASSESSMENT APPROACH

The construction assessment considered:

- Local soil character and weather conditions;
- Construction methods, staging and duration; and
- Earthwork and excavation extents and volumes.

Management of the construction water is required and the need for temporary basins shall be assessed using the Blue Book calculations.

4.6.2 OPERATIONAL PHASE

4.6.2.1 OVERVIEW

The operational phase water quality assessment considered:

- Road geometry (widths, heights and alignments);
- stormwater drainage design;
- site rainfall conditions; and
- the stormwater management and design principles of the Procedure for Selecting Treatment Strategies to Control Road Runoff (Roads and Maritime, 2003), with the aim of managing stormwater as close to its source as possible to minimise changes to the water regime.

Once the proposed road upgrade is built, including rehabilitation of exposed areas with amenity vegetation planting, there would be minimal areas of bare ground. This would minimise the potential or risk of soil erosion and its transport to either the Nepean River or Georges River catchments via the road's stormwater drainage.

Operational water quality impacts would be largely associated with pollutant road runoff, which could typically include:

- Sediments from pavement wear and atmospheric deposition;
- Heavy metals such as lead, zinc, copper, cadmium, chromium and nickel attached to particles washed off the road pavement;
- Oil, grease and other hydrocarbon products;
- Rubber from tyre wearing;
- Brake pad dust, which could potentially include asbestos from older brake pads; and
- Nutrients such as nitrogen and phosphorus.

These deposits build up on road surfaces and pavement areas during dry weather and can be washed off and transported to waterways during rainfall periods. This initial runoff is heavily polluted and is usually called 'first flush' flow. Again, if the road is maintained in accordance with the Operational Environment Management Plan (OEMP) and its design specifications, then the impacts would be safeguarded and minimised.

A stormwater runoff quality assessment for Appin Road has been completed to enable a review of requirements for management measures to be incorporated into the drainage design. This assessment has been completed using the MUSIC modelling software and has comprised of an assessment of both existing and post road upgrade water quality draining to each of the catchment outlets. The MUSIC modelling software was then used to review suitable measures to incorporate into the drainage network to ensure effective treatment and prevent water quality impacts at the discharge locations. Further details of this assessment are provided below.

4.6.2.2 MUSIC MODELLING

MUSIC modelling was developed to assess the likely water quality impacts from stormwater runoff from the upgraded road. Total suspended solids (TSS) and nutrients (total nitrogen (TN) and total phosphorous (TP)), are key indicators for management of the water quality impacts of road stormwater runoff, and are the focus of this assessment.

The rainfall data was taken at the Bringelly (067015) location with rainfall data for the continuous period of 10 years with a daily time step between 1981-1991. Base and storm flow concentration parameters and pollutant source node

parameters were defined based on the “Parameters to be used in MUSIC modelling” document provided by Campbelltown City Council. Potential Evapotranspiration (PET) data was taken from the average annual and monthly evapotranspiration maps from the BOM website.

Users are required to input pollutant source nodes, with their respective catchment areas with percent pervious and impervious, and treatment nodes into the MUSIC model to determine the pollutant loading and percent reduction of each pollutant. A simplified block catchment method was used to determine the total amount of pollution caused by the road-widening. The impervious (paved) and pervious (grassed) catchment areas are tabulated below.

Table 4-12 MUSIC model area inputs for Area 1

LOCATION	PAVED AREA (HA)	GRASSED AREA (HA)
East side from South	0.137	1.573
East side from North	0.606	4.900
West side from South	1.781	4.155
West side from North	0.000	0.290

Table 4-13 MUSIC model area inputs for Area 2

LOCATION	PAVED AREA (HA)	GRASSED AREA (HA)
East side from South	1.501	5.646
East side from North	0.879	0.517
West side from South	1.849	0.019
West side from North	1.242	1.242

Table 4-3 MUSIC model area inputs for Area 3

LOCATION	PAVED AREA (HA)	GRASSED AREA (HA)
Total to East	0.350	0.150
Total to West	2.661	3.339

Table 4-4 MUSIC model area inputs for Area 4

LOCATION	PAVED AREA (HA)	GRASSED AREA (HA)
South of St Johns Road	0.573	0.000
North of St Johns Road	0.212	0.000

4.6.2.3 WATER QUALITY MANAGEMENT MEASURES REQUIRED

Water Sensitive Urban Design (WSUD) is generally the method used for treating new release areas. Generally, WSUD requires integration of stormwater treatment into the landscape by incorporating multiple-use/open space corridors and wetlands, which maximise the management of stormwater quality, while at the same time enhancing the visual and recreational amenity of the development. Provision will need to be made to integrate these strategies into the development footprint, and land will need to be made available to locate these facilities as off-line structures to the creeks and riparian corridors.

Campbelltown City Council provided the target reductions in mean annual loading for pollutants of TSS, TP and TN. These targets are tabulated below.

Table 4-5 Campbelltown City Council target parameters

REDUCTION IN THE MEAN ANNUAL LOADING OF POLLUTANT	BASELINE AND PERFORMANCE TARGET (FOR AREAS 2, 3 AND 4)	STRETCH TARGET (FOR AREA 1)
Total Suspended Solids (TSS)	85%	90%
Total Phosphorous (TP)	65%	85%
Total Nitrogen (TN)	45%	65%

Generally, the following water quality measures are adopted and for the treatment of pollutants:

- Existing and proposed vegetated swales;
- Proposed bio-retention swales; and
- Proposed HumeCeptor®, which is a primary treatment system designed to capture and retain gross pollutants such as litter, coarse grit and sediments and associated oils;

From the analysis, it was found that Total Nitrogen showed a relatively higher resistance towards treatment measures. A breakdown of water quality treatment measures with results of total percent reduction for each area are listed below.

AREA 1 (CH400-1920)

Due to the land constraints within the road corridor, additional treatment measures in Area 1 cannot reasonably be provided. Consultation will be undertaken with the Mt Gilead development design to incorporate water quality treatment measures within the development proposals.

AREA 2 (CH1920-3520)

The following water quality treatment measures were input into the MUSIC model for flows discharging towards the grassed floodway channel at CH 2880 and ultimately through the twin box culverts at Kellerman Drive:

- HumeCeptor® provided at the outlet of long drainage line located to the south of the sag point;
- HumeCeptor® provided at the outlet of long drainage line located to the north of the sag point; and
- 250m of the existing grassed floodway channel;

Adopting the above water quality treatment measures obtains the following results:

	Sources	Residual Load	% Reduction
Flow (ML/yr)	45.9	29.2	36.4
Total Suspended Solids (kg/yr)	15500	409	97.4
Total Phosphorus (kg/yr)	24.9	3.8	84.8
Total Nitrogen (kg/yr)	107	41.9	60.9
Gross Pollutants (kg/yr)	1120	0	100

Figure 4-5 Pollutant reductions for Area 2

Runoff is treated by the HumeCeptor® before being discharged into the major floodway channel. By utilising the HumeCeptor® along with the floodway channel, the required pollutant percentage reductions can be met.

AREA 3 (CH3520-4120)

The following water quality treatment measures were input into the MUSIC model for flows discharging towards to Spring Creek at CH4550:

- HumeCeptor® provided at the outlet of the southbound carriageway at CH4340;
- 75m of bio-retention swale at CH4350 adjacent to the southbound carriageway;
- 65m of existing grassed swale adjacent to the southbound carriageway;
- 50m of bio-retention swale at CH4330 adjacent to the northbound carriageway; and
- 90m of existing grassed swale adjacent to the northbound carriageway.

Adopting the above water quality treatment measures obtains the following results at Spring Creek:

	Sources	Residual Load	% Reduction
Flow (ML/yr)	31.8	30.4	4.5
Total Suspended Solids (kg/yr)	8760	449	94.9
Total Phosphorus (kg/yr)	14.9	4.01	73.1
Total Nitrogen (kg/yr)	67.9	35.9	47.1
Gross Pollutants (kg/yr)	635	0	100

Figure 4-6 Pollutant reductions for Area 3

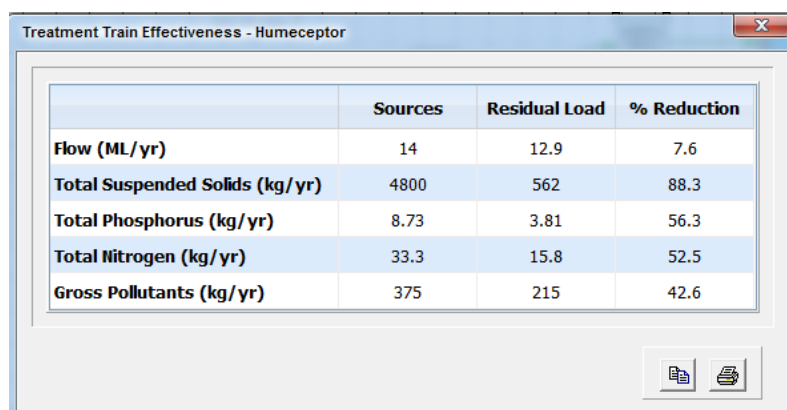
The combined treatment of bio-retention swales and HumeCeptor® before being discharged into Spring Creek at CH 4550 meets all the required baseline reductions for TSS, TP and TN.

AREA 4 (CH5000 - 5650)

The following water quality treatment measures were input into the MUSIC model for flows discharging towards the existing outlet at the northbound carriageway at CH5650:

- 200m of grassed swale adjacent to the southbound carriageway at CH5100;
- 50m of bio-retention swale adjacent to the southbound carriageway at CH5300;
- 50m of bio-retention swale adjacent to the southbound carriageway at CH5450; and
- HumeCeptor® provided CH 5600 at the outlet of longitudinal drainage line.

Adopting the above water quality treatment measures obtains the following results:



	Sources	Residual Load	% Reduction
Flow (ML/yr)	14	12.9	7.6
Total Suspended Solids (kg/yr)	4800	562	88.3
Total Phosphorus (kg/yr)	8.73	3.81	56.3
Total Nitrogen (kg/yr)	33.3	15.8	52.5
Gross Pollutants (kg/yr)	375	215	42.6

Figure 4-7 Pollutant reductions for Area 4

The combined treatment of the bio-retention swale and HumeCeptor® before being discharged to the grassed land at CH 5600 meets all the required baseline reductions for TSS, TP and TN.

4.7 EROSION AND SEDIMENTATION

To address erosion and sedimentation (ERSED) control during construction of roadworks in accordance with the *Managing Urban Stormwater: Soils and Construction Volume 1* publication (Blue Book), the roadworks are split up into a number of work zones, accordingly to the locations of cross-drainage structures and known flow discharge points.

4.7.1 KEY FACTORS

In developing the ERSED requirements the following key factors have been considered:

- The road is located along a ridge line with flow generally falling to either side of the carriageway to existing table drains and travelling north or south following the natural topography. There is very little interaction with off-site water;
- There is very little formal drainage currently and flow is generally via sheet flow off the carriageway into unlined table drains on the outside;
- Due to the proposed staging of works, runoff from adjacent existing road areas may naturally fall into the construction site (i.e. through barriers). This will need to be accommodated in the ERSED design;
- The road construction is working within constrained project boundaries;

- The road works are a brown field construction and limited to reworking of the existing carriageway and new areas of road. There are no significant ground level alteration proposed. Primary erosion sources for the works are related to the excavations for new services, drainage and pavement;
- The majority of sediment generating works will be in excavated areas located below existing ground levels with limited potential for spill outside the works site. Management of water caught within the excavations prior to discharge (if required) will be critical;
- Where feasible the newly constructed drainage system will be utilised to manage the discharge of site water; and
- There are no immediate sensitive receptors in the vicinity of the works and enhanced Blue Book sediment erosion controls are not required. This is pending further investigation on the sensitivity of downstream systems (i.e. Spring Creek, Mansfield Creek, and Georges River).

4.7.2 CONSTRUCTION BASIN ASSESSMENT

An assessment for the requirement of temporary basins during the construction phase was undertaken in accordance with the Blue Book specifications. The total areas of new roadworks and the existing areas that are falling toward the work zones were used in the calculation.

The assessment was done based on the 85th percentile five-day rainfall event and using the Revised Universal Soil Loss Equation (RUSLE) equation. A site management length of 80 m was adopted to represent typical site practices. Based on the guideline provided in the Blue Book, catchments generating less than 150m³ of soil loss annually only require local sediment control measures.

The table below shows the breakdown of the work zones with their corresponding catchment areas and soil loss figures.

Table 4-17 Erosion and Sediment Control Calculations

WORK ZONES	CATCHMENT AREAS (HECTARES)	SOIL LOSS (M ³ /YEAR)
CH0 TO CH200	0.383	25.3
CH200 TO CH600	1.267	44.0
SIDE ROAD STUB - CH350	0.115	5.2
CH600 TO CH1275	1.896	85.1
CH3500 TO CH4250 - WEST SIDE (INCLUDING FITZGIBBON LN)	1.640	112.5
CH3500 TO CH4200 - EAST SIDE	0.896	45.5
KELLERMAN DR STUB - CH3950	0.355	10.2
STAGE 1 - CH1275 TO 1700	0.832	45.8
STAGE 1 - CH1850 TO 1700	0.337	13.1
STAGE 1A - CH1275 TO 1475	1.382	45.6
STAGE 1A - CH1475 TO CH1700	0.657	46.2
STAGE 1A - CH1800 TO 1700	0.278	10.8
STAGE 1B - CH1275 TO 1700	0.822	36.9
STAGE 1B - CH1850 TO 1700	0.308	5.5

WORK ZONES	CATCHMENT AREAS (HECTARES)	SOIL LOSS (M ³ /YEAR)
STAGE 2A - CH1850 TO CH 2450	1.588	51.1
STAGE 2A - CH2460 TO CH 2860	1.177	69.8
STAGE 2A - CH3450 TO CH 2860	1.450	86.0
STAGE 2A - CH3450 TO CH 3725	0.815	22.2
STAGE 2B - CH1850 TO CH 2450	1.511	48.6
STAGE 2B - CH2460 TO CH 2860	1.026	60.8
STAGE 2B - CH3450 TO CH 2860	1.449	85.9
STAGE 3A - CH5320 TO CH5380	0.119	24.0
STAGE 3A - CH5380 TO CH5510	0.447	21.2
STAGE 3B - CH5360 TO CH5420	0.008	0.3

The calculations show that the soil loss does not exceed 150m³/yr for any work zones. The contractor is to incorporate local measures in accordance with the Blue Book as part of the progressive sediment erosion control plans for the works. Localised barrier measures could include compacted earth, gravel, sand bags, silt fences and straw bales.

5 DESIGN INTEGRATION

5.1 KEY INTERFACES

During the design process for the Hydrology and Drainage package, all relevant discrete design elements have been considered to provide a well-coordinated, integrated, economic, safe and easily constructible design solution. Table 5-1 identifies the design interfaces that have influenced the current Hydrology and Drainage design.

Table 5-1 Design Interface Coordination

DISCIPLINE	INTERFACE	RESULTING DESIGN OUTCOME
Environmental	Clearing	Drainage has been designed to reduce impacts on clearing within the project boundary as far as practicable.
Road Alignment	Pits	Locations where kerbs are required were identified and included in road design model. Drainage pits were adjusted to suit road gutters.
	Open drains	Open drains have been located ensuring that there is no impact to the road embankment.
Pavements and Sub-surface Drainage	Pavement Type	Pavement depth has been assumed to be 750mm including the select material zone (SMZ) to assess cover to proposed pipes.
	Subsurface Drainage	Pavement design depth and type have been assumed for the drainage design. The pavement drainage pipes have been provided with sufficient depths where possible to ensure that sub surface drains can discharge into the drainage pits and the subsurface drainage lines do not clash with the drainage pipes.
Structures	Retaining walls	The location of drainage pits has been cognisant of interfacing with retaining wall footing. Linear drainage such as ACO drain has been provided to avoid any potential clash with retaining wall footing and pipes have been proposed perpendicular to retaining walls.
Geotechnical	Soil type	There are no soft soil locations currently identified in South Zone.
Utilities	Longitudinal drainage and open drains	Utility services models have been incorporated in the 12D drainage model. Checks for potential clashes of drainage elements with existing and proposed utility services. Relocation of drainage or utilities have been carried out where required.
Property Adjustments	Project Boundary	Drainage designs has been reviewed to ensure that works are contained within and in close proximity to the project boundary. Property acquisitions have been identified where required.
Street Lighting	Interchanges and Intersections	Street lighting features have been assessed for spatial conflicts with the drainage design.
Signage and Line Marking	Line Marking	Lane lines have been considered in the drainage design. Pits have been spaced based on the location of the lane lines.
Urban Design and Landscaping	Visual Impact	Open drains are to be vegetated to urban design and landscaping requirements.
Construction Staging and Temporary Works	Temporary Road Works	Drainage design for temporary works has not been included in this. Erosion and sediment control design, however, will be based on construction staging design.

6 ENVIRONMENTAL CONSIDERATIONS

6.1 ENVIRONMENTAL CRITERIA

The concept design recognises the importance of the existing environment within Appin Road study area. The design has considered the environmental constraints including biodiversity, noise, soils, heritage and visual and urban design and tried to avoid.

6.1.1 ENVIRONMENTAL CONSTRAINTS

6.1.1.1 BIODIVERSITY

Two critically endangered ecological communities (listed under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Biodiversity Conservation Act 2016* (BC Act)) were recorded in the study area, comprising Shale Sandstone Transition Forest and Cumberland Plain Woodland.

Threatened fauna species, or evidence of them, identified within the study area include:

- Cattle Egret (*Ardea (Bulbulcus) ibis*) listed as Migratory under the EPBC Act;
- Little Lorikeet (*Glossopsitta pusilla*) listed as Vulnerable under the BC Act;
- Cumberland Plain Land Snail (*Meridolum corneovirens*) listed as Vulnerable under the BC Act; and
- Scots of Koala (*Phascolarctos cinereus*) listed as Vulnerable under both the BC and EPBC Act.

Based habitat characteristics of the study area, a further eight threatened flora species and 26 threatened fauna species are considered to have a moderate or high likelihood of occurrence. The study area, or parts of it, is classified as “core koala habitat” under the State Environmental Planning Policy No. 44 – Koala Habitat Protection (SEPP 44). Mitigation measures would be required for Koalas.

No habitat for threatened aquatic species was identified and the proposal does not intersect a class 1 (Major fish habitat) or class 2 (Moderate fish habitat) watercourse.

The proposal is not expected to have impacts on migratory species due to the minimal habitat and the mobile nature of migratory species.

No groundwater dependent ecosystems were identified during the preparation of the REF.

6.1.1.2 NOISE

Noise sensitive receivers will include residential properties, educational facilities, commercial/industrial premises, outdoor recreational areas and other land uses. Noise mitigation measures will be required for the proposal.

6.1.1.3 SOILS

The potential for acid sulphate soils (ASS) was assessed by the REF as being of extremely low probability of occurrence. Therefore, the presence of ASS is not considered to be a risk for the proposal. The majority of the proposal occurs in areas of low salinity potential with isolated areas of high salinity potential. Soil salinity testing will need to be carried out prior to construction to further assess salinity risks and implement appropriate controls.

Surface lying wastes such as construction materials, domestic waste and general litter were observed in the road reserve. The concentration of these materials was greatest in the southern portion. Asbestos, in the form of asbestos containing materials (ACM), synthetic mineral fibres (SMF), in the form of insulation, was also identified in two

location within this southern area. Measures to remediate areas containing surface lying wastes, including the identified areas of ACM and SMF would be required prior to construction.

6.1.1.4 ABORIGINAL HERITAGE

There are no previously registered Aboriginal sites located within the study area and no new Aboriginal sites were recorded during the survey preparation of the REF.

The road corridor and surrounding areas were found to generally have high levels of disturbance, with the study area found to have a low Aboriginal archaeological potential.

The Roads and Maritime *Standard Management Procedure: Unexpected Heritage Items* (March 2015) would be put in place for all works within the corridor.

6.1.1.5 EUROPEAN HERITAGE

Two sites were identified close to the road, comprising the State Heritage Register (SHR) listed Denfield (SHR #00540) and the locally listed Silos (LEP #I5). The road is also adjacent to the locally listed Glen Lorne Landscape and Archaeological Site (LEP #I55). The road design has included considerations to avoid impact to or encroachment upon the heritage curtilages of these sites.

The proposal would have neutral impacts Glen Lorne Landscape and Archaeological Site (LEP #I55) and no direct impacts to the Denfield (SHR #00540) site. The proposal would result in a moderate physical impact to the Silos (LEP #I5).

Approval would be needed from the Heritage Council through a Section 60 permit should the project impact the Denfield (SHR #00540) site prior to any works. Consultation with Campbelltown City Council would be required under the provisions of State Environmental Planning Policy (Infrastructure) 2007 (ISEPP), prior to works resulting in impact to the locally listed Silos heritage item (LEP #I5).

6.1.1.6 LANDSCAPE CHARACTER AND VISUAL IMPACT

The proposal would have a high impact landscape character and visual impacts due to the extensive additional width of the roadway and the significant loss of existing mature roadside trees.

Mitigation measures required would rely on a high standard of built form design of elements such as walls and fences. Street furniture should be aggregated wherever possible and locations chosen to minimise impacts where functional effectiveness permits. Planting on that land adjoining the roadway may assist in compensating for the absence of viable planting for visual impact mitigation in the corridor itself.

6.1.1.7 SOCIO-ECONOMIC, PROPERTY AND LAND USE

Land surrounding the northern portion contains predominantly residential dwellings. Whilst land surrounding the southern portion of the study area is predominantly utilised for agricultural purposes, it is noted that the western area is currently subject to a proposal for residential subdivision.

The design has incorporated measures to avoid or minimise impacts to private property where possible, including the use of retaining walls where potential impacts to property have been identified.

6.1.2 *CLEARING LIMITS*

The design footprint has been developed to minimise clearing, maintaining as much established vegetation as practical while ensuring adequate area is available to deliver project infrastructure, including sufficient working room, associated access tracks and laydown areas. Much of the vegetation on the eastern side on Appin Road is to be retained (subject to the final outcomes of the noise assessment/ mitigations).

Due to existing conditions and project constraints, such as the proximity of property boundaries, there are instances where it is not possible to achieve the required clearing offsets. As the design is further developed, opportunities to retain native vegetation will be reviewed with regards to environmental matters, constructability issues and value engineering.

7 CONSTRUCTION AND MAINTENANCE CONSIDERATIONS

7.1 KEY CONSTRUCTABILITY ISSUES

A Constructability workshop was held on 3 October 2017 prior to this submission and the outcomes of the constructability workshop are presented in document number 2113521_DM_REP_004_RevA.

The key constructability issues are contained in the Appendix F - constructability register.

Key constructability issues are detailed below:

- Based on information available, existing and proposed utilities have been considered in the development to minimise service relocations where possible;
- The timing and interface of construction between Appin Road and Mount Gilead subdivision to accept flows from Appin Road; and
- Wherever possible, in cuttings, carriageway pits have been connected to the central pipework in the median to avoid running networks under the gutter along the toe of cut batter.

7.2 MAINTENANCE ACCESS STRATEGY

7.2.1 MAINTENANCE ACTIVITIES

Maintenance activities may be carried out on the following facilities on completion of the project as follows:

- Permanent drainage basins (not required at this stage);
- Landscaping and vegetation;
- Road furniture;
- VMS signs and associated furniture;
- Signs, sign posts and line marking;
- Street lighting;
- Drainage structures;
- Retaining walls; and
- Utilities.

7.2.2 ACCESS PROVISIONS FOR MAINTENANCE

Consideration has been given to the ongoing inspection and maintenance activities that will be required throughout the design life of the drainage assets. In consideration of this, several features have been incorporated into the design to minimise the amount of required maintenance and to provide safe inspection and maintenance of the components.

The following maintenance features have been incorporated into the design:

- Pavement drainage pipes have been designed with a minimum grade of 0.5 percent to allow for self-cleansing and reduce maintenance requirements; and
- Standard Roads and Maritime drainage pits have been provided for access into pits for maintenance.

Table 7-1 details drainage elements which will require regular maintenance to ensure the drainage elements function adequately and meet the durability requirements.

Table 7-1 Drainage Maintenance Diary

DRAINAGE ELEMENT	MAINTENANCE WORK	PREDICTED MAINTENANCE FREQUENCY
Drainage pit/grate/headwall structures	Clean out the structures if blockage has occurred.	12 months
Open drains	Remove sediments from the swale invert Maintain overgrown vegetation by mowing	12 months
Linear drains such as ACO drain	Remove sediment and clean out with a high pressure water jet	12 months
Water quality treatment device such as GPT	Over a period, sediments become deposited on the bottom of the water quality treatment device and need to be removed by using vacuum trucks and transported to water transfer depots.	Once every two years

8 SAFETY IN DESIGN

The Safety in Design (SiD) process must satisfy Lendlease management procedures, WHS Laws and Regulations, and more importantly, ensure the safety of people during construction, operation and maintenance phases is maximised by developing all elements of the design with safety in mind.

To satisfy these requirements design development must incorporate SiD principles including conducting formal SiD workshops during the design period to coordinate multi-disciplinary input, to identify health and safety hazards and as far as is reasonably practicable, eliminate them. Where it is not reasonable or practicable to eliminate a hazard, the objective is to minimise the risk it presents to health and safety by the application of other controls selected in order of preference according to the hierarchy of control.

A Safety in Design workshop was held after completion of the 40% Concept Design. The workshop included the identification of risks and hazards during the construction, maintenance, and operation. Particular emphasis was placed on health and safety hazards that can be eliminated, minimised or controlled in the design process. Each design element was included in the assessment of WHS risks at each stage of the project.

The outcomes of this workshop are presented in document number 2113521-HS-REP-001-RevA.

The Safety in Design register is contained in Appendix C and will continue to be updated as the design progresses.

8.1 ROAD SAFETY AUDIT

A Road Safety Audit stage 2 was undertaken to inform the final 80% Concept Design. The findings from this audit have been included in the Road Design Report.

9 DURABILITY

9.1 DESIGN LIFE REQUIREMENTS

Assets and sub-assets have been appraised during the design process. Durability of the existing pits and pipes will depend on the remaining life of the existing structures. The design life for different drainage assets on the project have been proposed based upon accessibility of asset, operational requirements and maintenance plans. The specific design life for each drainage asset is listed in Table 9-1.

Table 9-1: Asset Items and Minimum Design Life

ITEM	ASSET/SUB-ASSET ITEM DESCRIPTION	MINIMUM DESIGN LIFE	SUB-ASSET DESIGN LIFE TO FIRST MAINTENANCE
(i)	Inaccessible drainage elements	100 years	
	Drainage pipes		100
	Deep drainage pits		100
(ii)	Drainage elements that are accessible for refurbishment and maintenance including water quality basins	20 years	
	Stormwater channels/swales		20
	Grates, covers and accessible fixtures & fittings		40
	Water quality basins		40
	Accessible drainage pits		40
	Water Quality Improvements Devices (WQID)		40

10 VALUE ENGINEERING

The Value Engineering workshop was held on the 2nd November 2017. During this workshop, the issues and opportunities for improvements were identified for further discussion.

The outcomes of this workshop are presented in document number 2113521-DM-REP-005_RevA_VE Workshop Report.

The Value Engineering register is contained in Appendix G - Value Engineering Register, which includes the issues identified and their assessment.

11 FUTURE WORKS

11.1 DESIGN PHILOSOPHY

The alignment has been designed to facilitate the future widening to 6 lanes of this section of Appin Road, to incorporate the following:

- Spring Farm Parkway intersection when built;
 - Federal funding project – South-end of the works; and
 - Great Macarthur expansion.
-

11.2 PROVISION FOR FUTURE WIDENING

Future third lane scenario has been considered in the drainage design. Adding a third travel lane in the median will increase the catchment to the outside kerb when the road has normal crossfall. As pit spacing has been optimised for the current lane configuration it can be expected that flow spread will extend beyond the road shoulder in some locations when future widening occurs. This can be remedied by adding additional pits in the gutter and connecting the pits to the nearest pit along the same length of gutter. Such a retrofit would not necessitate laying pipes beneath the road pavement. As the minimum transverse pipe size is a 450mm dia. pipe at the start of the drainage line, the existing lines will have the capacity to carry the runoff from the additional catchment back under the main alignment to the trunk line within the median.

In situations where the pipe network drains to a trunk line laid within the median, that trunk line will need to cross beneath the main line pavement to discharge. In the event of future widening, the catchment to the trunk line will generally not change but the percentage of impervious cover will increase. This may necessitate an upsizing of the trunk line. To overcome the need to upsize the trunk line beneath the pavement, the current 4-lane design included the catchment for the 6 lanes option for each pit. The transverse pipes have been sized to accommodate the additional catchments. Provisions noted are for the north-bound carriageway. The south-bound carriageway shall remain as per the existing condition during the 4-lane upgrade, with the exception of intersections. Capacity of the south-bound drainage infrastructure shall be assessed and designed for in the next design stage.

12 ISSUES OUTSTANDING OR TO BE ADDRESSED DURING NEXT PHASE

The following items will be addressed in the Detailed Design submission:

- Respond and close out comments originating from concept design review;
- Closure of minor concessions and/or moving to departures from standards;
- Provision of special detail drawings;
- Provision of long-section drawings, set-out information, and calculations;
- Assess any risks for aquaplaning;
- Proposed downstream works of floodway channel at Kellerman Drive;
- Capacity requirements for existing southbound swale to accept 6-lane upgrade;
- Additional survey;
- Council confirmation and response of RFI's, see Appendix L;
- Confirmation of Mt Gilead's acceptance of final drainage discharge locations and water quality devices;
- Coordination with geotech team to assess any impacts on the existing flood bund of Oswald reserve;
- Coordination with road geometry Design Lots RG-01;
- Coordination with utilities Design Lot UT-01;
- Coordination with property adjustment works in Design Lot PA-01;
- Coordination with street lighting Design Lot LT-01;
- Coordination with pavement and subsoil Design Lot PT-01; and
- Coordination with other projects in the area, to ensure projects correctly interface.

APPENDIX A

DESIGN DRAWINGS (NOT USED)

APPENDIX B

CONCEPT DESIGN DRAWING LIST

DRAWING NUMBER	DISCIPLINE	DRAWING TITLE	SHEET
2113521-DR-DRG-00001	DRAINAGE	DRAWING COVER SHEET	1 OF 1
2113521-DR-DRG-00002	DRAINAGE	KEY PLAN	1 OF 3
2113521-DR-DRG-00003	DRAINAGE	KEY PLAN	2 OF 3
2113521-DR-DRG-00004	DRAINAGE	KEY PLAN	3 OF 3
2113521-DR-DRG-00006	DRAINAGE	DRAWING INDEX	1 OF 1
2113521-DR-DRG-00010	DRAINAGE	LEGEND AND NOTES	1 OF 1
2113521-DR-DRG-00101	DRAINAGE	GENERAL ARRANGEMENT PLAN	1 OF 48
2113521-DR-DRG-00102	DRAINAGE	GENERAL ARRANGEMENT PLAN	2 OF 48
2113521-DR-DRG-00103	DRAINAGE	GENERAL ARRANGEMENT PLAN	3 OF 48
2113521-DR-DRG-00104	DRAINAGE	GENERAL ARRANGEMENT PLAN	4 OF 48
2113521-DR-DRG-00105	DRAINAGE	GENERAL ARRANGEMENT PLAN	5 OF 48
2113521-DR-DRG-00106	DRAINAGE	GENERAL ARRANGEMENT PLAN	6 OF 48
2113521-DR-DRG-00107	DRAINAGE	GENERAL ARRANGEMENT PLAN	7 OF 48
2113521-DR-DRG-00108	DRAINAGE	GENERAL ARRANGEMENT PLAN	8 OF 48
2113521-DR-DRG-00109	DRAINAGE	GENERAL ARRANGEMENT PLAN	9 OF 48
2113521-DR-DRG-00110	DRAINAGE	GENERAL ARRANGEMENT PLAN	10 OF 48
2113521-DR-DRG-00111	DRAINAGE	GENERAL ARRANGEMENT PLAN	11 OF 48
2113521-DR-DRG-00112	DRAINAGE	GENERAL ARRANGEMENT PLAN	12 OF 48
2113521-DR-DRG-00113	DRAINAGE	GENERAL ARRANGEMENT PLAN	13 OF 48
2113521-DR-DRG-00114	DRAINAGE	GENERAL ARRANGEMENT PLAN	14 OF 48
2113521-DR-DRG-00115	DRAINAGE	GENERAL ARRANGEMENT PLAN	15 OF 48
2113521-DR-DRG-00116	DRAINAGE	GENERAL ARRANGEMENT PLAN	16 OF 48
2113521-DR-DRG-00117	DRAINAGE	GENERAL ARRANGEMENT PLAN	17 OF 48
2113521-DR-DRG-00118	DRAINAGE	GENERAL ARRANGEMENT PLAN	18 OF 48
2113521-DR-DRG-00119	DRAINAGE	GENERAL ARRANGEMENT PLAN	19 OF 48
2113521-DR-DRG-00120	DRAINAGE	GENERAL ARRANGEMENT PLAN	20 OF 48
2113521-DR-DRG-00121	DRAINAGE	GENERAL ARRANGEMENT PLAN	21 OF 48
2113521-DR-DRG-00122	DRAINAGE	GENERAL ARRANGEMENT PLAN	22 OF 48
2113521-DR-DRG-00123	DRAINAGE	GENERAL ARRANGEMENT PLAN	23 OF 48
2113521-DR-DRG-00124	DRAINAGE	GENERAL ARRANGEMENT PLAN	24 OF 48
2113521-DR-DRG-00125	DRAINAGE	GENERAL ARRANGEMENT PLAN	25 OF 48
2113521-DR-DRG-00126	DRAINAGE	GENERAL ARRANGEMENT PLAN	26 OF 48
2113521-DR-DRG-00127	DRAINAGE	GENERAL ARRANGEMENT PLAN	27 OF 48
2113521-DR-DRG-00128	DRAINAGE	GENERAL ARRANGEMENT PLAN	28 OF 48
2113521-DR-DRG-00129	DRAINAGE	GENERAL ARRANGEMENT PLAN	29 OF 48
2113521-DR-DRG-00130	DRAINAGE	GENERAL ARRANGEMENT PLAN	30 OF 48
2113521-DR-DRG-00131	DRAINAGE	GENERAL ARRANGEMENT PLAN	31 OF 48
2113521-DR-DRG-00132	DRAINAGE	GENERAL ARRANGEMENT PLAN	32 OF 48
2113521-DR-DRG-00133	DRAINAGE	GENERAL ARRANGEMENT PLAN	33 OF 48
2113521-DR-DRG-00134	DRAINAGE	GENERAL ARRANGEMENT PLAN	34 OF 48
2113521-DR-DRG-00135	DRAINAGE	GENERAL ARRANGEMENT PLAN	35 OF 48

2113521-DR-DRG-00136	DRAINAGE	GENERAL ARRANGEMENT PLAN	36 OF 48
2113521-DR-DRG-00137	DRAINAGE	GENERAL ARRANGEMENT PLAN	37 OF 48
2113521-DR-DRG-00138	DRAINAGE	GENERAL ARRANGEMENT PLAN	38 OF 48
2113521-DR-DRG-00139	DRAINAGE	GENERAL ARRANGEMENT PLAN	39 OF 48
2113521-DR-DRG-00140	DRAINAGE	GENERAL ARRANGEMENT PLAN	40 OF 48
2113521-DR-DRG-00141	DRAINAGE	GENERAL ARRANGEMENT PLAN	41 OF 48
2113521-DR-DRG-00142	DRAINAGE	GENERAL ARRANGEMENT PLAN	42 OF 48
2113521-DR-DRG-00145	DRAINAGE	GENERAL ARRANGEMENT PLAN	43 OF 48
2113521-DR-DRG-00146	DRAINAGE	GENERAL ARRANGEMENT PLAN	44 OF 48
2113521-DR-DRG-00147	DRAINAGE	GENERAL ARRANGEMENT PLAN	45 OF 48
2113521-DR-DRG-00148	DRAINAGE	GENERAL ARRANGEMENT PLAN	46 OF 48
2113521-DR-DRG-00149	DRAINAGE	GENERAL ARRANGEMENT PLAN	47 OF 48
2113521-DR-DRG-00150	DRAINAGE	GENERAL ARRANGEMENT PLAN	48 OF 48

APPENDIX C

SAFETY IN DESIGN REGISTER

Highlighted cells are revised

ID	Life Cycle Phase	Guideword	GMR	Description	Area/ Owner	Consequence	Likelihood	Inherent Risk	Design Controls Identified	High risk, novel or complex?	Design Actions and Outcomes (Design Verification)	Residual Risk Controls (other than design) to be investigated (O&M and / or Constructor Related Controls)	Consequence		Likelihood		Residual Risk Level	Status	Status Rationale /SFAIRP Argument (consider hierarchy of control)
25	O&M	14. Environmental:	4.10 Occupational health exposure	Both North and South side of Oswald Reserve area (NB side of Appin Rd) vegetated natural swales are existing which improves the existing road run off water quality. In case of new divided road significant amount of impervious area will be added and due to tight boundary conditions there could be hardly any room to run any vegetated swales. New road upgrade around this location will introduce significant water quality issue	Drainage and Hydrology	2 Minor	2 Unlikely	16 Class 1 / H	Water quality treatments are considered during the design phase. Maintenance strategy (considering safety) to be ensured for any proposed water quality treatment	NO	Water quality treatment measures have been proposed to cater for the increase in impervious catchment areas and to meet the water quality targets set by Campbelltown City Councils. Measures include the use of gross pollutant traps (i.e. Humeceptors or equivalent) and vegetated swales	Adequate maintenance strategy to be considered for the permanent water quality device during the operation phase	2 Minor	2	1 Rarely	1	20 Class 1 / H	Under Review	N/A
46	Operation	5. Position / Location:	4.14 Vehicle and plant incident (public areas)	Proposed headwall, water quality treatment plants/items, and/or drainage feature located roadside causing safety hazards for vehicles and pedestrians	Drainage and Hydrology	3 Moderate	2 Unlikely	12 Class 2 / M	Proposed hazard imposing infrastructure to be located outside the clear zone. Where this is not possible, safety barriers and pedestrian fencing are to be introduced	YES	There are a number of locations whereby proposed infrastructure are within the clearzone. Safety barriers and fencing to protect vehicles from these items will be proposed in the next stage of design.	Nil	1 Insignificant	1	1 Rarely	1	25 Class 1 / H	Under Review	N/A

APPENDIX D

DESIGN NON-CONFORMANCES

Date: 15/12/2017										PENDING - Item captured in register but not yet active ACTIVE - Item presently under review CLOSED - Item "signed off"/accepted/agreed WITHDRAWN - Item no longer an non conformance						
Ref No	Design Lot(s)	Discipline	Date Raised	Location	Carriageway	Control Line	Chainage / Area	Non-conformance description	Reference / Correspondence	Discussion and Response	Owner	Agreed Disposition	Status			
													Designer	LLC	RMS	CCC
0014	DR-01	Longitudinal Drainage	24/10/2017	Mainline	NB	MCNB1	CH2900 to CH3000	Pipe covers are below the minimum limit of 600mm (including the transverse pipe)	Austroads Guide to Road Design part 5A Table 6.1	Potential solutions include: - increasing the material class of the pipes from Class 4 to Class 6 - increasing the road elevation in these areas to achieve compliant cover - changing the pavement details in these areas to a special detail	RMS		Active	Active	Active	N/A
0015	DR-01	Longitudinal Drainage	24/10/2017	Mainline	NB	MCNB	CH2900 to CH3000	Pipe longitudinal grades are below the minimum limit of 0.5% (including the transverse pipe)	RMS Supplement to Austroads Guide to Road Design part 5A, clause 6.5.4	Potential solutions include: - regrading the outfall points in the floodway channel opposite Oswald Reserve so pipe invert outlets can be deeper - exploring other outfall options that has lower invert level	RMS		Active	Active	Active	N/A

APPENDIX E

ISSUES REGISTER

Appin Road - Design Issue Register		
Proj No.	2113521	
Client	Lendlease	
Date	15/12/2017	

Item	Subject	Location	Date	Priority	Design Lot	Action	Responsibility	Comments	Status	Further Responses
21	Extension of (3x) 750mm drainage pipes near Oswald Reserve: interface with utilities (might have to go under pipes and hence inaccessible), condition/remaining life of existing pipes	Near Oswald Reserve	6/10/2017	High	DR-01	Consider if a bridge is required across Oswald-Mansfield Creek. Obtain flood information from council how often Oswald Reserve floods.	Drainage	This is pending asset condition assessment of the existing (3x)750mm-dia. pipe culverts. In terms of hydraulics, there is no issue with the extension.	Open	
22	Longitudinal drainage: interface with utilities and impact of future 6L. Pipe sizing to be as per future 6L, pit spacing as per 4L (so that drainage lines doesn't have to be rebuilt during 6L). Pavement crown to be retained as per existing. Drains in the median to discharge towards long drainage	Project wide	6/10/2017	Medium	DR-01	To be analysed further and incorporated into the design.	Drainage	This item has been addressed as part of 80pc Concept Design, with the exception of interface with utilities which will be done in the next design stages	Open	
44	Need to extend existing cross drainages under NB carriageway	NB carriageway	16/10/2017	Medium	DR-01	To be incorporated in the design	Drainage	This has been completed in affected areas.	Closed	
52	Drainage / flooding / Oswald reserve.	Oswald reserve area	16/10/2017	Medium	DR-01	Ensure this is captured in surface water management plan	Drainage	Flooding impact assessments, drainage design, and sensitivity checks have been performed, and the outputs have been made available to the Environmental team to be considered within CEMP. An RFI has been sent to Campbelltown City Council to clarify the existing flood depth, flows, and afflux requirement to ensure that the proposed mitigation measures commensurate with the impacts. WSP is currently awaiting reply.	Open	
56	Additional points of discharge of existing swales along eastern side of between CH0 to CH1700 to be reviewed and drainage design to be adjusted if required.	CH0 to CH1700	25/10/2017	Medium	DR-01	Outlet proposed drainage at available points of discharge to reduce pipe size.	Drainage		Open	
57	Coordination with sub-division designer (Cardno) required for the following items: — Proposed points of discharge and accommodation of Appin Road Upgrade flows to the proposed developments stormwater network; and — Sizing of detention basin and stretch water quality requirements that can be accommodated within the Mt Gilead development proposals.	CH0 to CH1700	25/10/2017	Medium	DR-01	Ensure that proposed flows is supplied to Cardno.	Drainage	Coordination with Cardno has been undertaken regarding proposed points of discharge into subdivision and incorporated into 80pc CD. Sizing of detention basins and stretch water quality requirements shall be taken at next design stage.	Open	
58	Drainage works will be required outside of the limit of works adjacent to the southbound carriageway between CH4350 and CH4600 to allow proposed drainage to discharge into Springs Creek and to allow for water quality treatment. The proposed drainage works impacts an existing electricity pole.	CH4350 to CH4600	25/10/2017	Medium	DR-01	Coordinate drainage design with utilities	Drainage		Open	
59	A Humeceptor has been proposed at the outlet of the drainage located at CH 5650 adjacent to the northbound carriageway. The is currently proposed in steep terrain.	CH5650	25/10/2017	Medium	DR-01	The suitability of this location to be investigated at the next design phase and the GPT will be relocated if required.	Drainage		Open	
71	A Humeceptor has been proposed at the outlet of the drainage located near CH 2850 adjacent to existing 11KV OH power line. Location of HC should be carefully decided and to be kept away from any OH location to facilitate access for heavy maintenance vehicle	CH2850	13/12/2017	Medium	DR-01	The suitability of this location to be investigated at the next design phase and the GPT will be relocated if required.	Drainage		Open	

APPENDIX F

CONSTRUCTABILITY REGISTER



Constructability Register Appin Road Upgrade - Mt Gilead

ID	Discipline	Description	Rank H, M, L	Recommended measures	Follow up actions identified	Date Identified
019	Drainage	Stormwater Management	Low	All proposed drainage infrastructure (including pit and pipe systems, water quality treatment measures, existing drainage adjustments, and on-site detention basins if required) are to be designed for ease of construction.	Coordination with contractor (client) is to be undertaken and any review comment considered in the design.	4/10/2017
050	Drainage	Timing of construction between Appin Road and Mount Gilead subdivision for stormwater discharge into proposed development.	Medium	Develop construction programme for timing and interface between Appin Road and Mt Gilead subdivision.	Coordination with developer is to be undertaken.	13/12/2017

APPENDIX G

VALUE ENGINEERING REGISTER



No.	Design Lot	Location	Component/Areas of opportunity/issue	Initial design	Alternative to resolve the issue, improve constructability, reduce safety impacts, reduce costs, etc.	Date Raised	Action Responsibility	Action Taken	Closed?
3	DR-01	Sub-division area	Detention basin and water quality arrangements for run off of the road	Currently detention basins and water quality of run off for the road will be addressed as part of and within the subdivision development. No detention basins in the road reserve	No better way identified Adv: Developer bears cost and water quality treatment within the subdivision before draining to the creek. Saves on duplication of separate facilities in the road reserve	2/11/2017		No action required	Y
12	DR-01	Oswald Reserve area	Requirement of any attenuation/ detention basin around the Oswald Reserve to avoid any property acquisition	Regrade floodway channel to accommodate existing pipes (approx. 150m long). Pipes (1050mm dia) have only 0.3% grade with shallow cover (approx. 800mm). This is subject to RFI for council to confirm existing flood freeboard levels Utilities could be impacted by reggrading. Provide additional 1200mm dia. pipe under Kellerman Drive, parallel to existing twin box culverts. Water quality to be treated by HumeCeptor and vegetation in existing channel.	• Consider: 1) Raising road levels Adv: Allows additional cover to pipes Disadv: Potential work outside project boundaries 2) Lowering the flood channel 3) Consider entry protection to pipes Adv: Provides better safety for children, etc. Disadv: Greater cost • 4) No better way identified	2/11/2017		1) 2) 3) 4) No action required	1) 2) 3) 4) Y

APPENDIX H

CROSS-DISCIPLINE REVIEW



To review

o

Review Optional

m

Review Mandatory

x

Review Not Required

DESIGN DISCIPLINE	DESIGN LOT	DESIGN LOT DESCRIPTION	RESPONSIBLE ORGANISATION	REVIEW BY / COPY TO	WSP Design team									Subconsultants			LLC/LLE			PROJECT VERIFIER	
					PAVEMENT	DRAINAGE	ROADS	GEOTECH	ENVIRONMENT CONSTRAINTS	CONSTRUCTION STAGING	ROAD FURNITURE	PROPERTY ADJUSTMENTS	UTILITIES	CLOUSTON - URBAN DESIGNERS	TRAFFIC SIGNALS - TUP	LIGHTING - POWER SOLUTIONS	COST ESTIMATORS	LLC	LLE CONSTRUCTABILITY	DRAFT DESIGN (27/10/2017)	DESIGN (24/11/2017)
					Jeong Yoon	Manisha Dhungel	Michael James	Aaron Rastall	Emma Dean	Ody Murlianto	Jacinta Halim	Nick Reedy	Keting Zhou	Martin O'Dea	Lisa Tulau	Daniel Walton					
Road Geometry	RG-01	Geometric Road Design – typical cross sections, plans, long sections, cross sections and intersection layout	WSP		m	m	N/A	m	m	o	m	m	m	m	m	m	m	m	m	N/A	m
Drainage	DR-01	Longitudinal/cross drainage details, plans and report	WSP		m	N/A	m	o	m	o	m	m	m	o	m	m	m	m	m	N/A	m
Road Furniture	RF-01	Road Furniture, Line Marking and signs	WSP		m	m	m	o	o	o	N/A	m	m	m	m	m	m	m	m	N/A	m
Traffic Signals	TS-01	Traffic Signal Design	WSP		o	m	m	o	o	o	m	o	m	o	N/A	m	m	m	m	N/A	m
Street Lighting	RL-01	Street Lighting	WSP		o	m	m	o	o	o	m	o	m	m	m	N/A	m	m	m	N/A	m
Urban and Landscape Design	LS-01	Urban Design – Visual impact and significant features, landscape design	WSP		o	m	m	o	m	o	m	m	m	N/A	o	m	m	m	m	N/A	m
Pavements	PT-01	Pavement Design – Plans and report	WSP		N/A	m	m	m	m	o	o	x	x	x	x	o	m	m	m	N/A	m
Geotechnical	GT-01	Geotechnical Investigation	WSP		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	GT-02	Geotechnical Reporting	WSP		m	o	m	N/A	m	m	m	o	o	x	x	x	m	m	m	N/A	m
Utilities	UT-01	Utilities Coordination	WSP		m	m	m	o	x	m	m	m	N/A	o	m	m	m	m	m	N/A	m
Environment	EV-01	Environmental Assessment	WSP		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Temporary Traffic Works / Staging	CS-01	Construction staging	WSP		m	m	m	m	m	N/A	o	o	m	x	x	x	m	m	m	N/A	m
Property Adjustment	PA-01	Property Adjustments	WSP		x	m	m	m	m	m	o	N/A	m	m	x	x	m	m	m	N/A	m



Cross-Discipline Design Coordination Check

DESIGN PACKAGE DETAILS

Design Package (LOT no) / Lot Description	DR-01	Flooding and Drainage		
Responsible Designer	Manisha Dhungel/Daniel Suwito		Review end Date:	3/11/2017
Design Stage	☒ CD (80%)	☐ DD (80%)	☐ DD (100%)	
QUANTITIES IMPACT?	Yes ☒ No ☐		If yes, section documented (or "attached"): N/A	

REVIEWER RECORD AND SIGN-OFF

Discipline	Reviewer (PRINT NAME)	Review	REVIEWED BY			REVIEWER CLOSE OUT		
			Initial	Date	Review type see note 1	Initial	Date	Comments See Note 2
WSP	Road Geometry	Michael James	m	15/11/17	M	TM	15/12/17	
	Flooding & Drainage	Manisha Dhungel	n/a					
	Road Furniture	Jacinta Halim	JH	2/11/17	M	JH	15/12/17	
	Pavements	Jeong Yoon	m					
	Geotechnical	Aaron Rastall	o					
	Utilities	Keting Zhou	m	10/11/17	M	SC/PP	15/12/17	
	Environment	Emma Dean	m					
	Temporary traffic works/ staging	Ody Murlianto	o					
	Property Adjustments	Nick Reedy	m	11/11/17	M	NR	15/12/17	
Subconsultant	Traffic Signals	TUP- Lisa Tulau	m					
	Street Lighting	Power Solutions - Daniel Walton	m					
	Urban and landscape design	Clouston - Martin O'Dea	o					
LLE/LLC								
Discipline Lead		Sanjoy Chatterjee	m	SC	12/11/17	M/A	SC	14/12/17
Project Manager		Nuno Muralha	m					

Design Discipline Lead Sign-Off and record capture		Signature
1. Design Discipline Lead:	Sign off this form upon closeout / incorporation of comments by Designer	
2. Design Manager:	Check against final output for sign off Design Package Release	Date
3. Document Controller:	Scan all closeout documentation and transfer to electronic record	
Comments / Exceptions to submission e.g. for incorporation next issue (give explanation)		

WHO NEEDS TO REVIEW?

- For some submissions, input may not be required from ALL disciplines listed on this form.
- Designer and/or Document Controller to indicate required reviews in Review column prior to circulation, based on the Design Distribution Matrix.
- Review Key: m=mandatory; o=optional; x=not required; n/a=not applicable (package owner)
- ** Distribution and collation of comments from Site Team shall be managed by LEND LEASE Document Controller

NOTES FOR REVIEWERS FOR MAKING DOCUMENTATION

MARKUPS PROTOCOL

- Queries/comments to be in lower case.
- Changes to Drawing Notes in UPPERCASE.
- INSTRUCTIONS to Designer to be circled
- NO POST-IT-NOTES

COMPLETION OF THIS CHECKLIST FOR "REVIEWED BY" AND NOTE 1 ACTIONS

Note 1 Review type to be indicated as:

M = Drawing/Report Mark-ups

E = Emailed comments

A = Notes have been appended in the General Comments section OVERLEAF

N = Reviewed with No Comments

ALL REVIEWERS TO INITIAL WHEN REVIEW COMPLETED AND NOTE THE DATE IN THE DESIGNATED COLUMNS

REVIEW SETS MUST BE RETURNED TO DOCUMENT CONTROLLER FOR SCANNING TO PROJECT FOLDERS AS
REQUIRED BY PROJECT MANAGEMENT PLAN

NOTES FOR DESIGNER/REVIEWERS TO CLOSE OUT COMMENTS

CLOSING OUT COMMENTS

- Comments and mark-ups which have been incorporated (all documentation under this checklist) to be highlighted GREEN

- Comments relating to issues of significance NOT INCORPORATED are highlighted PINK and must be discussed with reviewer for resolution. Outcome/action must be noted at the site of the comment by Designer

COMPLETION OF THE CHECKLIST FOR "REVIEWER CLOSE OUT" AND NOTE 2 ACTIONS

Note 2 Comments to be completed

Following designer incorporation (or other treatment) of reviewer comments and agreement with reviewer:

- REVIEWER initials and dates under "Reviewer close-out" column when satisfied comments have been dealt with appropriately.
- REVIEWER / DESIGNER to note any appropriate carryover action items under DESIGNER CLOSEOUT RESPONSES/NOTES overleaf.

GENERAL

- Resist requests for redesign or modification of information based on PERSONAL PREFERENCES / STYLE / OTHER PROJECTS worked on (please, instead, raise these concerns with Design Manager/ CAD Managers).
- ALL REQUESTS FOR CHANGE must comply with relevant Standards, SWTC and other project-related Technical Criteria.
- Note the "COURTESY RULES" posted in the review room and provide your reviews within the time frame provided.

Please turn over for General comments and attachments sheet

- Check the capacity of the existing sockets running to the S side of Appin ground intersection. Locations with the following marked off - SC
- Check ACO drain requirements near to any travel lane.
- Potential safety issue and hard to maintain.
- For use different line type or depressed median.
- Treatment of potholes, coordinate with BOO design - SC

- Southern ~~area~~ now has total 4 discharge pts into subdivision at CH350, CH900, CH1500 and CH1700. - VW

APPENDIX I

INDEPENDENT VERIFICATION



Independent Verification Record

Documentation Details

Project Name:	Appin Road Upgrade, Mt Gilead.		Project no:	2113521	
Package/Deliverable no:	DR-01 package (drawings and report)		Nominated reviewer:	Ian Wilcock	
Package title:	Hydrology and Drainage				
Design Phase:	80% Concept Design	Package Designer:	Manisha Dhungel	Date submitted:	11/12/15
Design Manager:	Nuno Muralha	Discipline Leader:	Sanjoy Chatterjee	Review due date:	11/12/15

Verification Details

Review required (To be completed by producer of output with advice from the Discipline Leader)			
☒	Comparison with proven design	☐	Geometric check
☐	Check calculations / estimates	☒	Readability / completeness / accuracy (reports, specifications)
☐	Independent proof calculations / estimates	☐	Independent spot calculations / estimates
☐			

Items requiring check and confirmation by Verifier (Items identified for review/action are to be checked and commented on by Verifier as part of the process)			
The project inputs are adequate and consistent	☐	The output complies with local and statutory requirements.	☐
The output complies with and is traceable to the inputs	☐	The design methods, references, systems and equipment used are appropriate/current	☐
The output complies with client specified requirements	☐	The output is of a satisfactory standard and appropriate to the project requirements.	☐
Has Safe Design been considered	☐	The interfaces on multidiscipline projects have been coordinated	☐
Project Technical Risk Register has been reviewed and considered	☐	The output is economical	☐
The output complies with relevant standards and codes	☐	The output is consistent with other design and construction activities on the project.	☐

Results (Verifier to tick appropriate outcome)		Sign-off (Verifier to sign when Verification is complete-see*)	
☐	1 Reviewed without comments	Verified by:	Ian Wilcock.
☒	2 Reviewed with general comments. Proceed to the next activity/phase taking into consideration the comments low	Date Completed:	14/12/15
☐	3 Reviewed with comments that must be addressed before the next activity/phase or before issued to the client - see Verification Record following, to close out comments.	Signature:	

*Designer responses are closed and initialled by verifier (in the case of item 3)



Independent Verification Record

Verification Record - comment summary, designer response and verifier close out						
Item No	Date	Drawing (include Rev) / Section / Other Reference	Verifier Comment	Designer Response	Close out	
					Status	Date
1	11/12/2016	Report	For general comments refer to mark up	Updated	Closed	15/12/2017
2	11/12/2016	Drawings	For general comments refer to mark up	Updated	Closed	15/12/2017
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Outstanding items - for incorporation / closeout at next phase (use corresponding Item No from schedule above)						
Item No	Details of further action required to close				Close out	
					Status	Date
1						
2						
3						

APPENDIX J

STAKEHOLDERS REVIEW COMMENTS

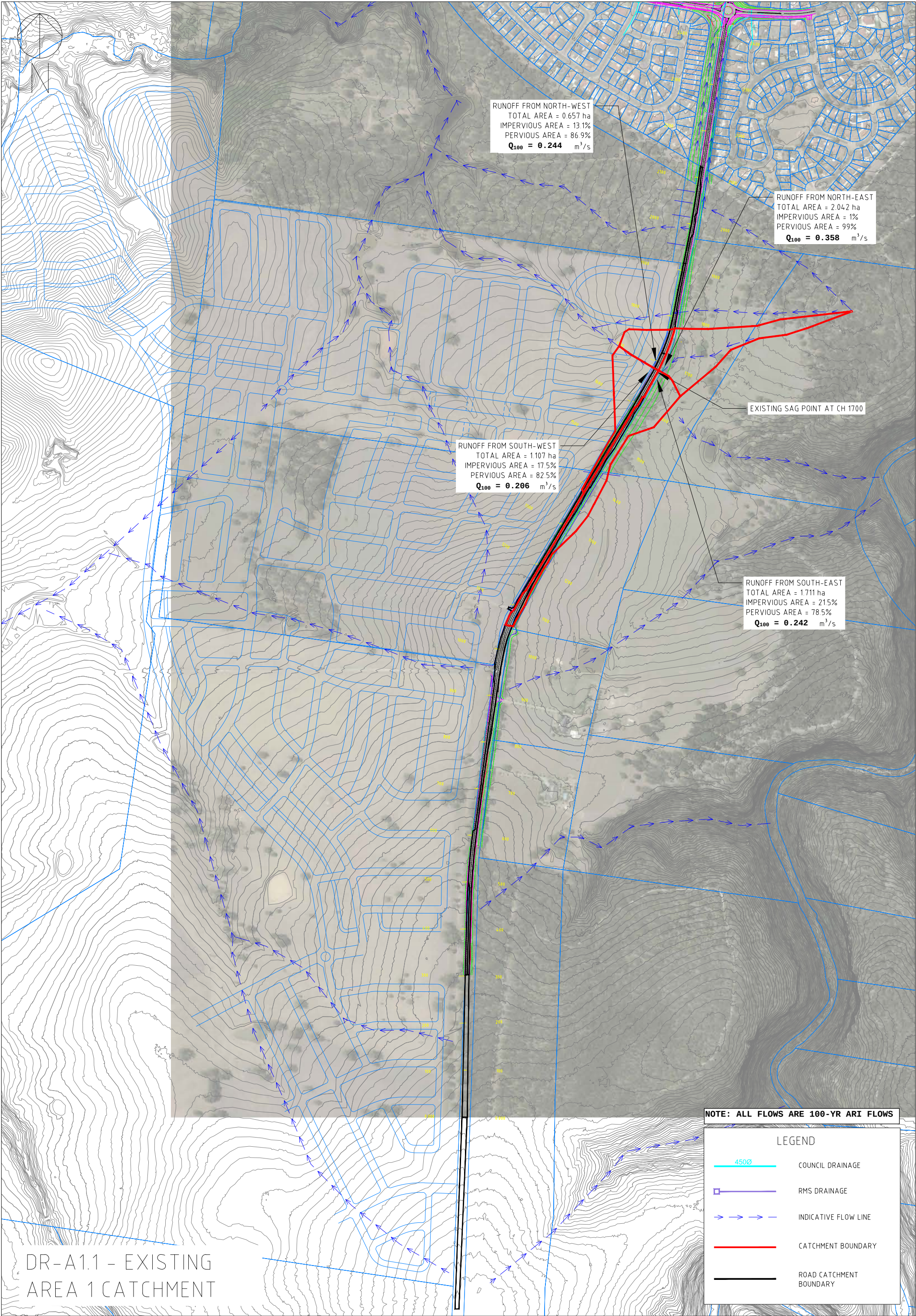
DESIGN REVIEW RECORD

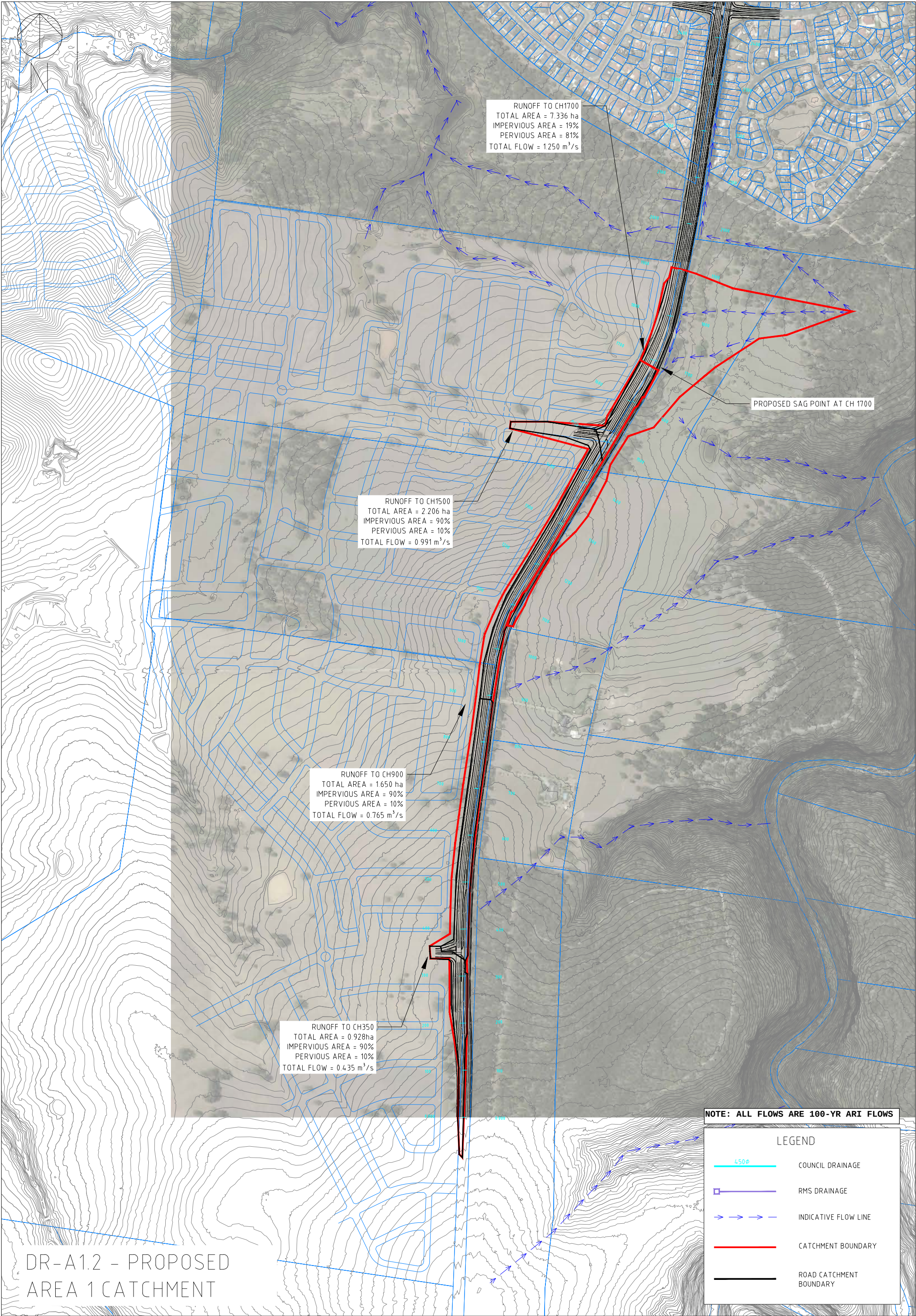
Project Title: MR177 Appin Road Widening to four lanes from Mount Gilead to St Johns Road, Bradbury		
RMS Registration Number	DS2017 / 002518	
Design Stage	Concept	
Dated	28.10.17	
Draft 80% Concept	X	
Engineering Risk Review		
RMS Peer Reviewers	Trent Stevenson (TS), Martin Davies (MD), Peter Wassell (PKW), David Adams (DCA), Neil Walker (NW), Jorge Sales Lois (JSL), Robin Huang (RH), Brendon Beime (BB), David Blackmore (DB), Kit Wong (KTW), Allan Chan (AC), Louise Moran (LMM)	
Review Date	06.11.17	

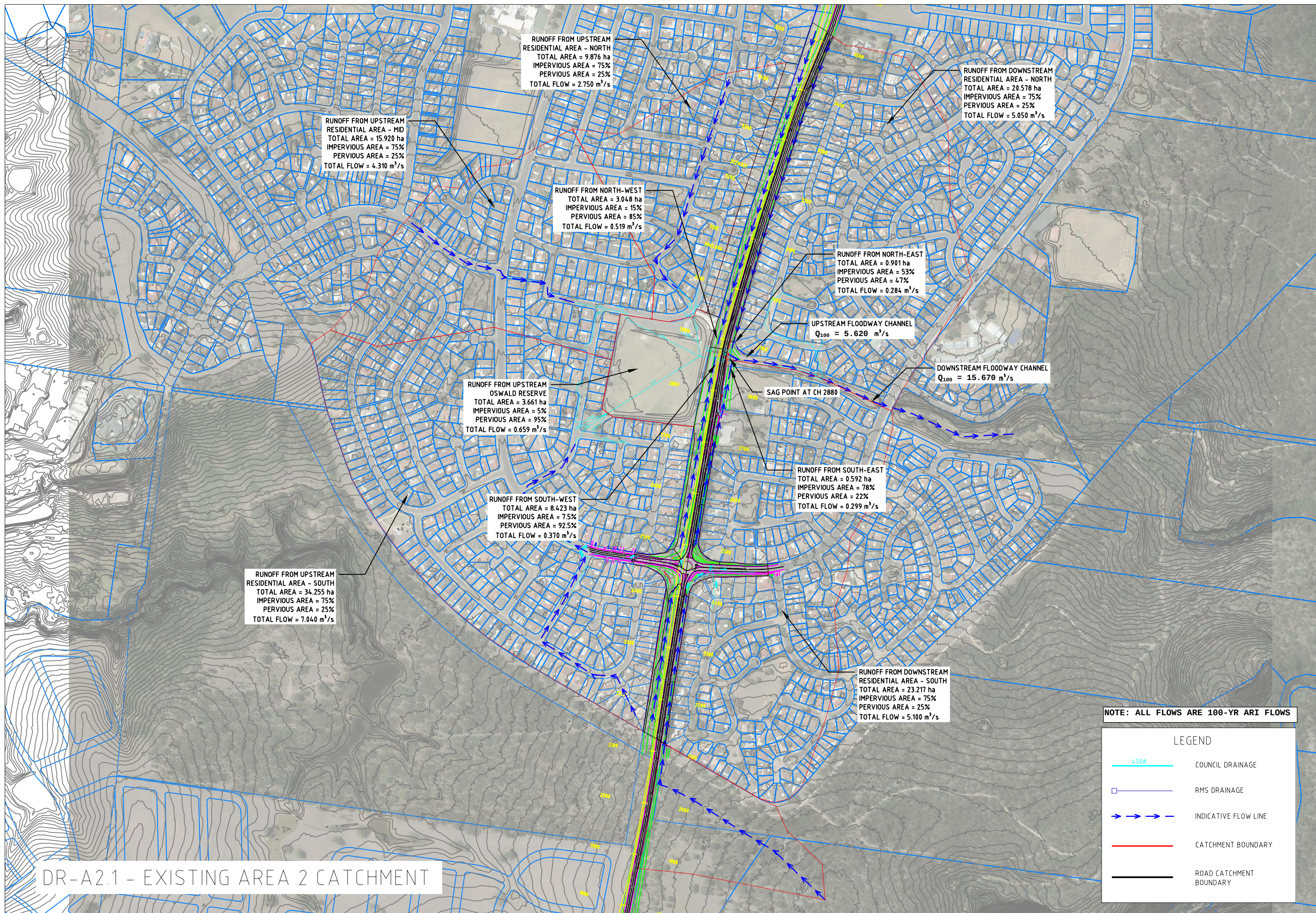
ID	Drawing / Document No.	Revision	Aspect	Reviewer	Requirement(s)	Review Comments	Package	Response from Package Owner	By	Date	Reviewer Closed Comments	Closed Out (Y/N)	Date Closed
21	Drainage report p16 of 86.	01		KTW	Public Utilities	There are multiple GPT's proposed so far. CH5650 (p16 of 86) area two, which appears to be at the "St Johns Road" intersection area. 2 off in CH1920-CH3520 (p39 of 86) – which would appear to be in the Oswald Reserve area. A GPT has been proposed at CH5650. (I believe) that general experience within RMS shows that GPTs don't work and are difficult to maintain.	DR-01	Humeceptor has been proposed at the four locations which remove gross pollutants as well as hydrocarbons and fine suspended solids. They have been proposed at these locations due to space constrains. MUSIC modelling has been undertaken and pollutant reduction criteria has been met. Point noted regarding maintenance. Maintenance strategy has been proposed in Table 7-1 of the report and will be refined during the detailed design phase.	Manisha Dhungel	12/12/2017			
22	Drainage report p16 of 86.	01		KTW	Public Utilities	Who owns the land on which the GPT is located? If it is private land, who obtains the land?	DR-01	The Humeceptor will be located in RMS land. The exact location within the RMS land will be shown in the final 80% concept design drawings.	Manisha Dhungel	12/12/2017			
23	Drainage report p16 of 86.	01		KTW	Public Utilities	Who will maintain the GPT? If it is Council, are they happy to maintain it?, or do they prefer a different type of water quality system?	DR-01	As the Humeceptor is located in RMS land, RMS is to maintain it.	Manisha Dhungel	12/12/2017			
24	Drainage report p16 of 86.	01		KTW	Public Utilities	How will access to the GPT be restricted for the general public (safety/vandalism etc.)?	DR-01	The Humeceptor unit is like any other inspection pit, only deeper. It is buried with only a maintenance access lid exposed. The maintenance access lid is locked to prevent access by the general public.	Manisha Dhungel	12/12/2017			
25	Drainage report p16 of 86.	01		KTW	Public Utilities	Maintenance (Table 7-1, p47 of 86) indicates that the a vacuum truck will be required to remove sediment every two years. Is this site specific, based on a hydrology / erosion & sedimentation study? (Volume of water, sediment content). A maintenance access bay or similar will be required for the truck to park.	DR-01	The maintenance frequency provided in Table 7-1 provides a general requirement. Manufacturer's maintenance guide will need to be followed and a reference to the guide will be included in the table.	Manisha Dhungel	12/12/2017			
43	RG-00302	01	Design	DCA		Will the proposed shallow drain in the depressed median be lined as water could seep into the pavement for the northbound carriageway. This comment applies to all areas of shallow drain in the depressed median.	DR-01	This will be reviewed and incorporated as a part of the Detail Design.	Manisha Dhungel	12/12/2017			
44	RG-00308 and RG-00309	01	Design	DCA		What happens to the drainage at chainages 800 and 850 as the drain in the depressed median is very shallow?	DR-01	This will be reviewed and incorporated as a part of the Detail Design.	Manisha Dhungel	12/12/2017			
45	RG-00313	01	Design	DCA		What happens to the drainage at chainages 1250 as the drain in the depressed median is very shallow?	DR-01	This will be reviewed and incorporated as a part of the Detail Design.	Manisha Dhungel	12/12/2017			
47	RG-00319	01	Design	PKW		The invert of the depressed median is shallow and close to the northbound carriageway. There is a the risk of stormwater overtopping and spilling across the northbound carriageway. However, the proximity to the vertical crest may mitigate against this occurring.	DR-01	Final concept design adresses this issue	Manisha Dhungel	12/12/2017			
56	DR-00113	01	Drainage	PKW		The sag pits are not at the low point (Ch 1694)	DR-01	Final concept design adresses this issue	Manisha Dhungel	12/12/2017			
63	DS2017/002518 sheets DR-00118 and 00119	01		NW	Does the green string between ch 2475 - 2600 represent grated pavement trench or kerb drains?	Fixed-invert grated pavement trench or kerb drains are a proprietary product well suited to certain asset risk and performance environments, e.g. pedestrian malls, railways station platforms, private property. Their translation into the different risk environment of arterial road pavements is inappropriate as they block up frequently from debris and silt up where the surface grade does not support self-cleaning. This creates: risk of extra frequency of exposure to arterial traffic risks for maintenance workers, road safety risks from skid resistance and aquaplaning for arterial traffic and loss of asset serviceability from maintenance road occupancies for arterial traffic. Use of such products has occurred on arterial roads as a maintenance solution in exceptional circumstances only, e.g. to fix a clash between stormwater and utilities on old standard legacy sites. Their use in new arterial roadworks presents an unacceptable WHS issue.	DR-01	Final concept design adresses this issue	Manisha Dhungel	12/12/2017			

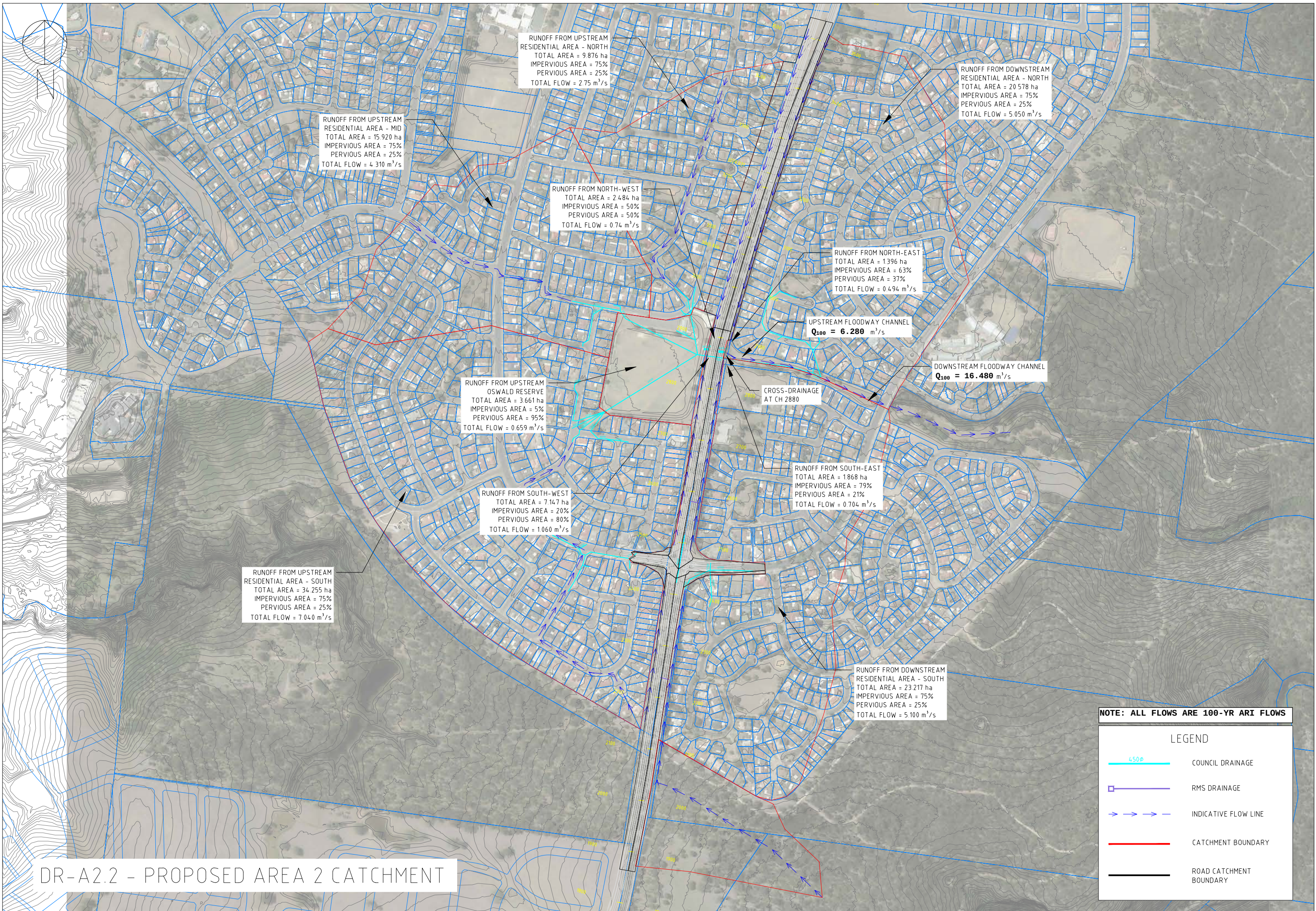
APPENDIX K

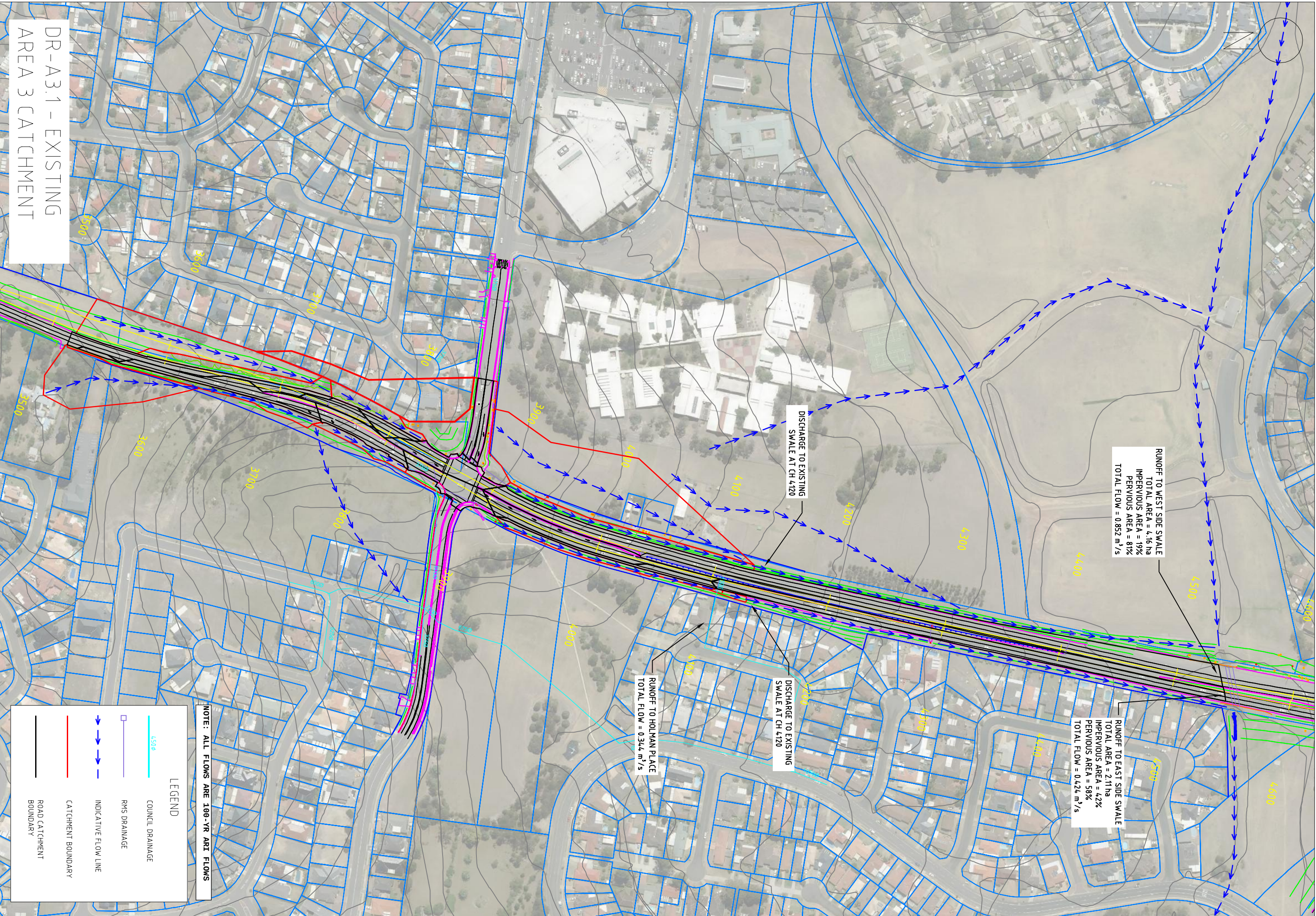
CATCHMENT PLANS











RUNOFF TO WEST SIDE SWALE
TOTAL AREA = 4.16 ha
IMPERVIOUS AREA = 19%
PERVIOUS AREA = 81%
TOTAL FLOW = 0.852 m³/s

RUNOFF TO EAST SIDE SWALE
TOTAL AREA = 2.11 ha
IMPERVIOUS AREA = 42%
PERVIOUS AREA = 58%
TOTAL FLOW = 0.424 m³/s

DISCHARGE TO EXISTING
SWALE AT CH 4.120

DISCHARGE TO EXISTING
SWALE AT CH 4.120

RUNOFF TO HOLMAN PLACE
TOTAL FLOW = 0.344 m³/s

NOTE: ALL FLOWS ARE 100-YR ARI FLOWS

LEGEND

COUNCIL DRAINAGE

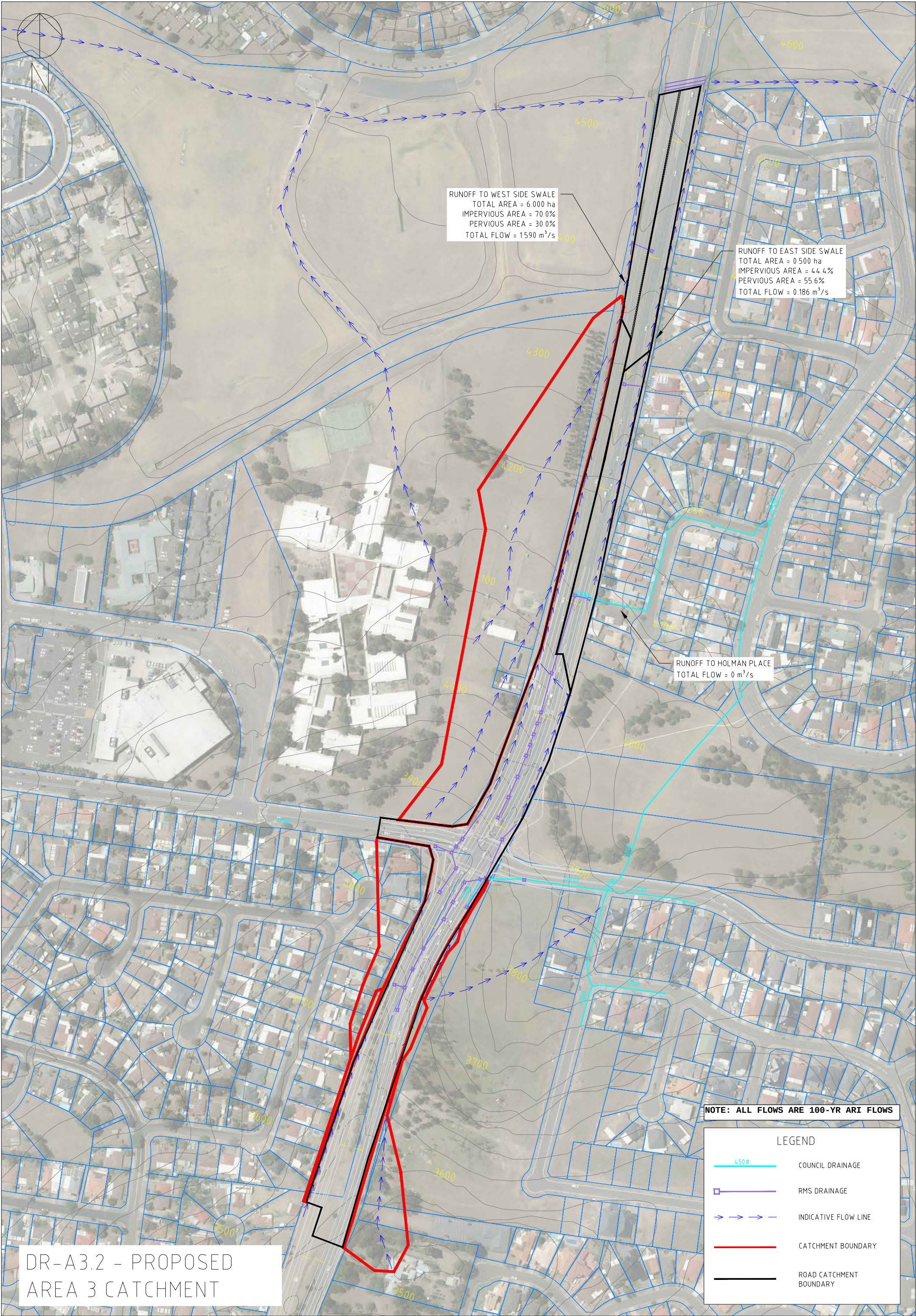
RMS DRAINAGE

INDICATIVE FLOW LINE

CATCHMENT BOUNDARY

ROAD CATCHMENT BOUNDARY

DR-A3.1 - EXISTING
AREA 3 CATCHMENT



RUNOFF TO WEST SIDE SWALE
TOTAL AREA = 6.000 ha
IMPERVIOUS AREA = 70.0%
PERVIOUS AREA = 30.0%
TOTAL FLOW = 1590 m³/s

RUNOFF TO EAST SIDE SWALE
TOTAL AREA = 0.500 ha
IMPERVIOUS AREA = 44.4%
PERVIOUS AREA = 55.6%
TOTAL FLOW = 0.186 m³/s

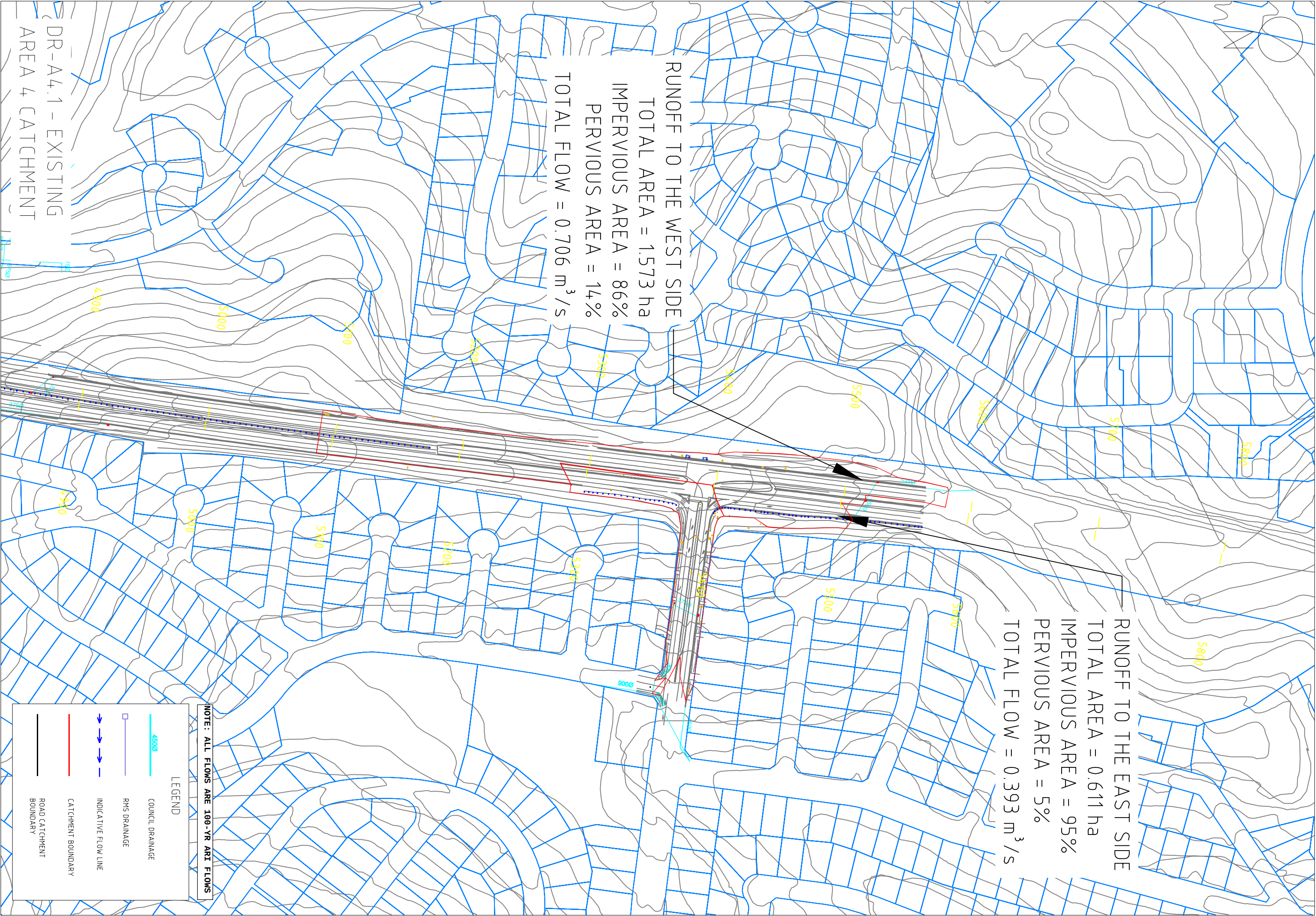
RUNOFF TO HOLMAN PLACE
TOTAL FLOW = 0 m³/s

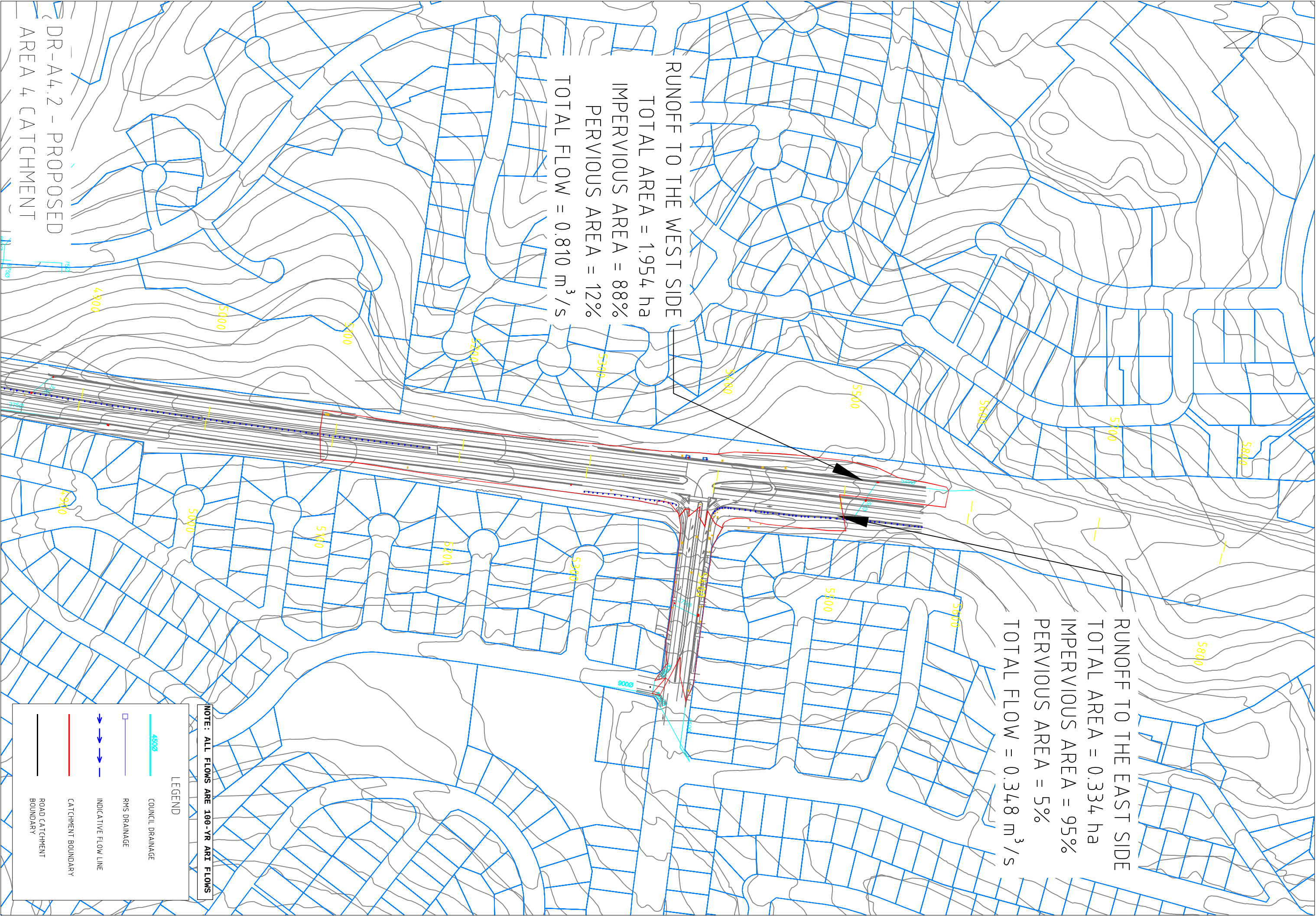
NOTE: ALL FLOWS ARE 100-YR ARI FLOWS

LEGEND

- 4500 COUNCIL DRAINAGE
- RMS DRAINAGE
- INDICATIVE FLOW LINE
- CATCHMENT BOUNDARY
- ROAD CATCHMENT BOUNDARY

DR-A3.2 - PROPOSED
AREA 3 CATCHMENT





APPENDIX L

REQUEST-FOR-INFORMATION (RFI) TO
CAMPBELLTOWN CITY COUNCIL

There are four areas within the Appin Road project that we need further clarification on from the information that Campbelltown City Council provided dated 18/7/2017. Please see below for details -

RFI - 1 – Near Oswald Reserve Area

The approximate 1% AEP Flow was noted as 13.3m³/s (as shown on the Council supplied snapshot below). From this snapshot, it is implied that this flow measurement was taken directly downstream of the (3x)750mm culverts (i.e. immediately east of Appin Road, upstream of the floodway channel).



However, there is a discrepancy of more than 7m³/s between this flow figure and the result of our model of existing drainage (5.7m³/s, as shown on the attached catchment plan PDF). [No attachment found – please supply.](#) The second measurement taken downstream of the floodway channel (i.e. immediately west of Kellerman Drive) shows that the total flow we are getting is 14.3m³/s (taking into account catchment flows from areas east of Appin Road). This still shows a discrepancy with the 13.3m³/s Council figure, albeit less.

We have also run a separate exercise whereby we tweaked the catchment areas to match the Council provided 100 year flood levels within the Oswald Reserve basin and we obtained a flow figure of 13.4m³/s downstream of the floodway channel. However, to arrive at this result, we had to reduce the total catchment areas by 34%, which is quite a sizeable decrease.

Therefore, could you please clarify the following items:

1. Please confirm the location of your 13.3m³/s flow measurement. Was it taken east of Appin Road (upstream of floodway channel) or west of Kellerman Drive (downstream of floodway channel)? [More work required to clarify as the engineer who provided this information is on extended leave.](#)
2. Can you please review the attached catchment plan and confirm that this matches Council's catchment plan? It is worth noting that this catchment plan was developed using information from LiDAR 1m contour survey. [No attachment](#)

3. Can you please confirm the 100 year ARI flood level and the flood immunity of Kellerman Drive? The project aims not to worsen this situation. [Information regarding Kellerman Drive was sent separately I believe.](#)
4. If possible, please provide information such as: the type of model e.g. DRAINS, XPSWMM, Tuflow etc. , stage volume relationship and outlet structures losses or arrangement assumptions that was adopted in the modelling which predicted the basin 1% AEP level and flow downstream of the basin so that we can have a better understanding of the numbers provided. [These areas were developed by Landcom. As such we have plans but no models. Council has not yet undertaken any modelling in this area.](#)

Please kindly reply to us as the results of modelling in this area will determine the need for (and hence the size of) an attenuation basin to be potentially constructed between the (3x)750mm culverts and Kellerman Drive.

RFI - 2 – Near Oswald Reserve Area

This RFI is related to freeboard in Area 2 in the vicinity of Oswald Reserve.

The following information was received from Council on 21st September 2017:

With respect to the Kellerman Drive creek crossing downstream of Oswald Reserve, the 1% AEP flood level at this location is 130.3m AHD (this assumes 50% blockage of the culverts consistent with Council policy). The required freeboard to properties is 130.8m AHD as per councils available information.

The flood extent based on the 1% AEP flood level of 130.3m AHD provided by the Council can be found below. Please note that the extent below is based on the detailed topographical survey of the floodway channel and LiDAR survey outside of the floodway



As shown in the snapshot above, the 1% AEP flood level of 130.3m AHD extends into the properties to the western side of Kellerman Dr around the area between Appin Rd and Kellerman Dr and therefore providing no freeboard.

Therefore, could the Council please clarify where the freeboard level of 130.8m AHD was measured? Was it taken:

- immediately east of Appin Road (upstream end of the floodway channel) where the properties do not appear to be impacted by the 1% AEP flood? or
- west of Kellerman Drive (downstream end of the floodway channel) where the properties appear to be impacted by the 1% AEP flood?

This is based on the information provided by Landcom at the time of subdivision. Landcom being a government body at the time were allowed "Nil conditions consent" for all their work, hence some of their subdivisions are not to the same standard as we could achieve with a private developer. The 50% blockage scenario is our current standard and additional calculations were undertaken due to Council's concerns with the possible impact blockage could have on the adjoining properties.

RFI - 3 – Between Fitzgibbon Lane intersection and Springs Creek

On the west side, as we are changing the kerb configuration on Appin Road, drainage will need to be proposed underneath the new gutter and eventually discharge into the existing table drain on the outside batter (shown in light blue in the screenshot below).

Can Council please clarify the capacity of this table drain and its immunity? No sorry. We have no information as this is an RMS road. This will need to be part of your assessment. Generally, no flows should enter any property. Preferably all flows plus freeboard should be contained within any table drain. For flows <300mm, the freeboard is 300mm.





On the East side, the assumption is all the road catchment flows between the Fitzgibbon Lane intersection and the 450mm cross-pipe are captured by this 450mm cross-pipe which then ties into the Council drainage on Holman Place downstream, and the flows from the road catchment north of this cross pipe will flow onto the existing table drain between the road and the property boundary.

Can Council please clarify if this is the correct assumption and as such, what is the immunity and flow figures on the system downstream of this 450mm cross-pipe (i.e. what is the flow figure that we need to achieve in order for us not to worsen the existing situation?). as we indicated in our advice, Appin Road is an RMS road and we DO NOT have full details of their system. We have provided all the pipe information we have and details (line, location and level) will need to be verified by survey.



RFI - 4 – St Johns Road intersection

Site inspection shows that there is a pipe underneath the SO gutter on the east side of Appin Road, south of the St Johns Road intersection (photo below).



There is no information on where this pipe ends up (i.e. whether it discharges towards St Johns Road or it goes across St Johns Road and ties into the 450mm cross-pipe north of the intersection as shown in light blue below).

Can Council please clarify the alignment of this pipe? As the intention of the proposed drainage is to tie into the existing 450mm cross-pipe, can Council please also clarify what is the immunity and flow figures on the system downstream of this 450mm cross-pipe? (i.e. what is the flow figure that we need to achieve in order for us not to worsen the existing situation?) [we also have no information regarding this pipe. Suggest you ask RMS.](#)

