

Our Ref: 8201720801 – Letter 002 Ver 2
Contact: Nathan Pomfret

13 July 2017

University of Wollongong
Via Email: egarbayo@uow.edu.au

Attention: Ms Erika Garbayo

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

Level 1, 47 Burelli Street
Wollongong NSW 2500
Australia

Phone: 61 2 4228 4133
Fax: 61 2 4228 6811

www.cardno.com.au

RE: UOW ARTS AND SOCIAL SCIENCES BUILDING – PRELIMINARY FLOOD REMEDIATION OPTIONS ASSESSMENT

1. Introduction

The University of Wollongong (UOW) has engaged Cardno (NSW/ACT) Pty Ltd to provide preliminary advice for the proposed Arts and Social Sciences Building (ASSB) to be located at UOW's Wollongong campus. This letter presents the outcome of the assessment of preliminary flood remediation options to inform the SEAR's (or DA) application as well as to highlight potential requirements of the proposed building defined in Chapter E13 – Floodplain Management of Wollongong City Council's (WCC's) Development Control Plan (DCP).

1.1 Site Description

The site is situated in the north west of UOW's Wollongong campus on Northfields Avenue in Keiraville. The site fronts a car parking area, has direct access to the Ring Road and backs onto the riparian corridor of an upper tributary of Fairy Creek. The proposed ASSB is to replace a group of existing demountable buildings and some ground level carpark area.

1.1.1 Existing Flood Scenario

In the existing scenario 100 year ARI and Probably Maximum Flood (PMF) flood waters are predicted to back up behind the Robson's Road Culvert, before overtopping the road and continuing through the western carpark as overland sheet flow. This overland flow travels among the existing demountable buildings (proposed development site) onto the Ring Road. In the 100 year ARI event, flow is contained in the Fairy creek catchments, however in the PMF event, flows split at the Ring Road and some flow is diverted into the Cabbage Tree Creek Catchment. This overland flow is not caused by the tributary of Fairy Creek (the watercourse) being overcapacity, but rather the Robsons Road culverts being undersized (when accounting for blockage).

Overland flow results in the requirement for a flood planning level (FPL) of 40.5 m AHD for the North Wing and a FPL of 38.9 m AHD for the East Wing of the proposed ASSB without flood mitigation works. Further information on the existing scenario can be found in Cardno's previous letter (UOW ARTS AND SOCIAL SCIENCES BUILDING – PRELIMINARY FLOOD ASSESSMENT, 15 June 2017)

1.2 Flood Remediation Options

Four flood remediation options are proposed to contain or divert overland flow into the watercourse at the western extent of the western carpark, instead of allowing it to continue as overland sheet flow through the carpark. All options investigated result in the proposed ASSB being considered flood free in the 100 year ARI event considering WCC's "risk management" blockage factors. Only option 4 diverts all PMF flows back to the watercourse and results in the proposed ASSB being flood free. All options could be modified to achieve a flood free building area in the PMF event with an increase in remediation works.

A description of each option is given below, and further detail can be found in the enclosed sketches. UOW's preferred option can be further modified/optimised at the design stage to minimise extents, cost and to meet any additional design requirements.

1.2.1 Option 1 - Swale

Option 1 involves the construction of a swale along the western edge of the carpark to return flood waters to the creek. The swale has a depth of approximately 0.8 m, a top width of approximately 12 m and 1 in 4 side slopes. This option would require the removal of approximately 10 parking spaces. A cost has been allowed to reconstruct these parking spaces elsewhere within the Campus. The swale could be shaped to avoid the more significant trees between the carpark and the creek. A pedestrian bridge is proposed to maintain the existing footpath access.

1.2.2 Option 2 - Carpark Grading

Option 2 is to regrade the western end of the carpark and some of the area between the carpark and Fairy Creek. The carpark area to be regraded would be approximately 1800 m², however this may be reduced at design stage (pending UOW's carpark design requirements). This option would not cause any parking spaces to be lost, however some trees between the carpark and the creek may need to be removed.

1.2.3 Option 3 - Culvert Upgrade

Option 3 is to upgrade the existing 1.8m pipe culvert under Robsons Rd to a 3.6 m x 1.8 m box culvert. Increasing the capacity of this culvert prevents floodwater from overtopping Robson's Rd during the 100 year ARI event. This option has the added advantage of improving trafficability on Robson's Rd in all flood events. This option would not require the loss of parking spaces and would minimise disturbance to the operation of UOW's western carpark.

1.2.4 Option 4 – Swale and Wall

Option 4 would be to employ a swale similar to option 1 with the addition of an 800 mm high flood training wall along the eastern edge of the swale. This would return all flows up to the PMF to the watercourse. Like option 1, option 4 would require the removal of approximately 10 parking spaces from the western end of the carpark. A cost has been allowed to reconstruct these parking spaces elsewhere within the Campus. A pedestrian bridge is proposed to maintain the existing footpath access.

2. Hydraulic Modelling

2.1 Existing Scenario

A 2D TUFLOW model was established over a 2 m grid with elevations extracted from detailed survey and ALS data. The model grid extent covers the entire UOW Campus and the adjacent sub-catchments.

Culverts and pipes inspected within the study area were modelled in accordance with WCC's new blockage policy as detailed in the Review of Conduit Blockage Policy Summary Report (WMA, May 2016).

2.2 Developed Simulation Results

2.2.1 100 year ARI event

For all options, returning flows during the 100 year ARI event to the watercourse results in very similar flood extents. As a result of remediation works, all floodwater in the vicinity of the proposed ASSB location is contained completely within Fairy Creek (Refer **Figure 2-1**). Option 2 has the largest flood extents as the area of regraded carpark is also inundated. Option 3 has an additional benefit of removing flow completely from Robsons Road.

The proposed ASSB location is out of the medium flood risk precinct for all options and therefore FPLs are not required for any option.

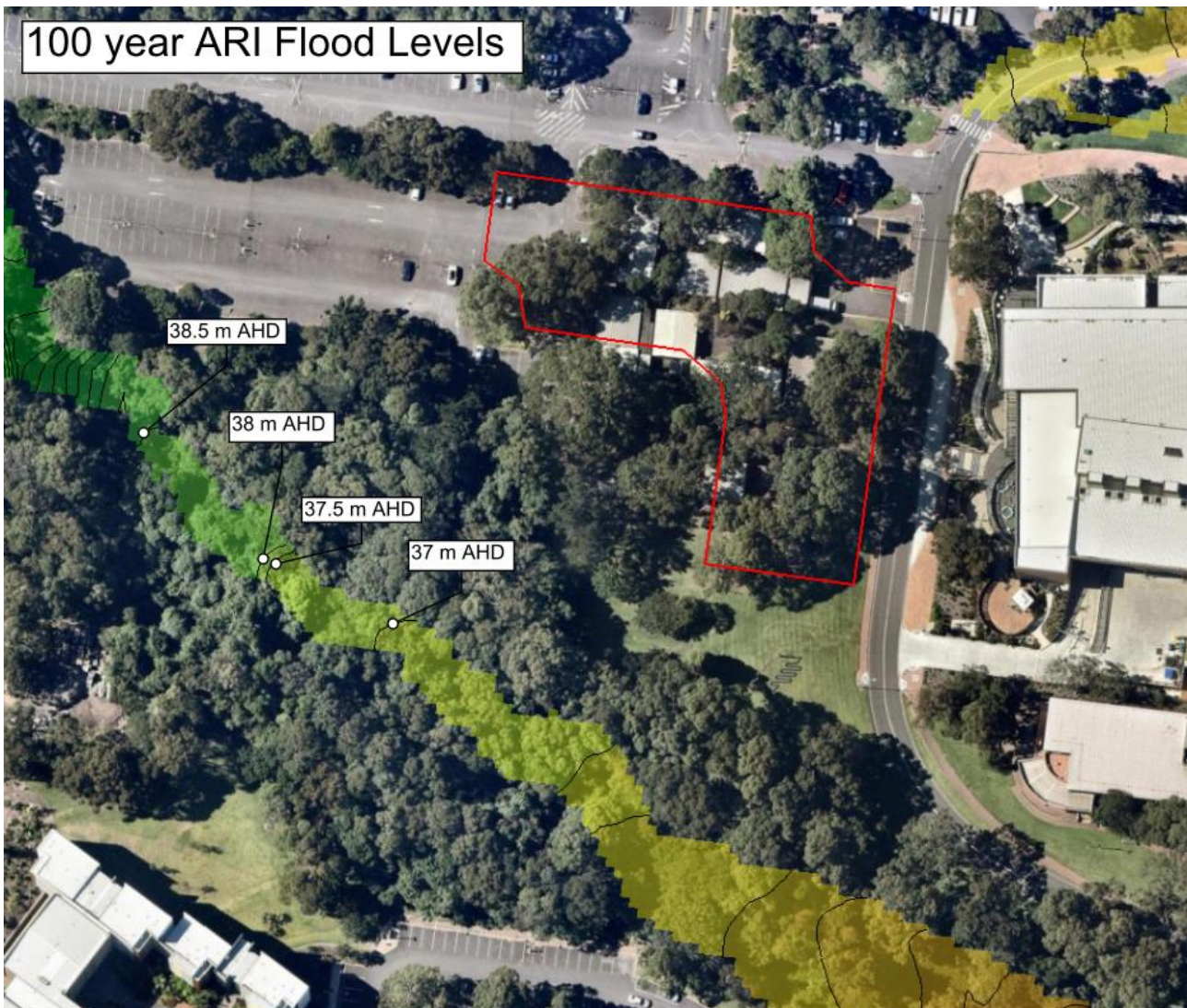


Figure 2-1: Typical Mitigated 100 year ARI flood Extents

2.2.2 PMF Event

During the PMF event, flood extents are similar for options 1, 2 and 3. The ASSB will be in the Low Flood Risk Precinct for options 1, 2 and 3 and as a result, WCC DCP flood related development controls for Option 1, 2 and 3 will apply, including:

- > **Flood Affectation**
 - The impact of the development on flooding elsewhere [is] to be considered.
- > **Evacuation**
 - The development is to be consistent with any relevant flood evacuation strategy or similar plan.

Option 4 is flood free in the PMF event and does not require any flood related development controls.

3. Discussion

3.1 Efficacy of Proposed Mitigations

It was initially envisaged that the flood remediation works would divert all flows up to and including the PMF event into the watercourse. Further modelling has found that this would require a substantial increase in the amount of civil works for options 2 and 3. Option 4 is an extension of option 1 which diverts all PMF flows into the watercourse without increasing the footprint of the remediation works.

3.1.1 PMF Impacts

As a result of the construction of Robsons Road and the western carpark, flows from the Fairy Creek Catchment are being diverted into the Cabbage Tree Creek Catchment area. This is demonstrated in the flood modelling by flows from the western carpark heading both north and south on the Ring Road.

All flood remediation options (excluding option 3), return this flow back into the watercourse. Although this is generally a good outcome, this results in additional flows being conveyed through the southern portion of the campus as well as a corresponding reduction in flows through the northern portion of the campus in the PMF event. This results in both increases and decreases in the PMF flood level throughout the campus. It is noted that as this occurs in the PMF event only (not the 100 year ARI) and does not affect design requirements such as floor levels of any existing buildings on Campus.

All options except option 3 (which shows downstream impacts during the 100 year ARI event and not the PMF) generally show impacts within the UOW campus that would be acceptable to WCC. These impacts will not have any effect on flood planning levels of campus buildings. Therefore, it is up to UOW to decide if these downstream impacts are acceptable. All options also show some minor changes in PMF flood levels on Northfields Avenue. This area of Northfields Avenue is not trafficable in the existing scenario and it is expected that WCC would accept these impacts as non-detrimental. Additional flood mitigation works immediately adjacent to the proposed ASSB could be designed to redistribute PMF flows into the Cabbage Tree Creek catchment and reduce the PMF flood impacts through the Campus.

Option 4 is the most extreme remediation case as it diverts all PMF flows. All sites downstream of UOW will assume they are receiving all flows from the Fairy Creek Catchment in the PMF event and will therefore not be affected by these remediation works. WCC are more likely to support these works and assess impacts differently if they are presented as remediation works intended to return flow to its natural flow path. If Option 4 is UOW's preferred option, it is recommended that a pre-lodgement meeting is undertaken with the assessing authority to discuss the flood remediation works and their assessment.

3.1.2 Option 1

Results for option 1 show that during the 100 year ARI event there are no detrimental impacts and all floodwater adjacent to the ASSB and the Western Carpark are contained entirely within Fairy Creek (refer **Figure 3-1**). During the PMF event, the northern half of the campus demonstrates reductions in flood levels, as well as on the western carpark (refer **Figure 3-2**). As discussed in **Section 3.1.1**, the southern portion of the campus and some of Northfields Avenue demonstrate an increase in flood levels, which will not affect planning requirements for campus buildings or the trafficability of Northfields Avenue. Reduction of PMF flood levels on the Western Carpark additionally improves trafficability and reduces the risk to damage to cars in a flood.

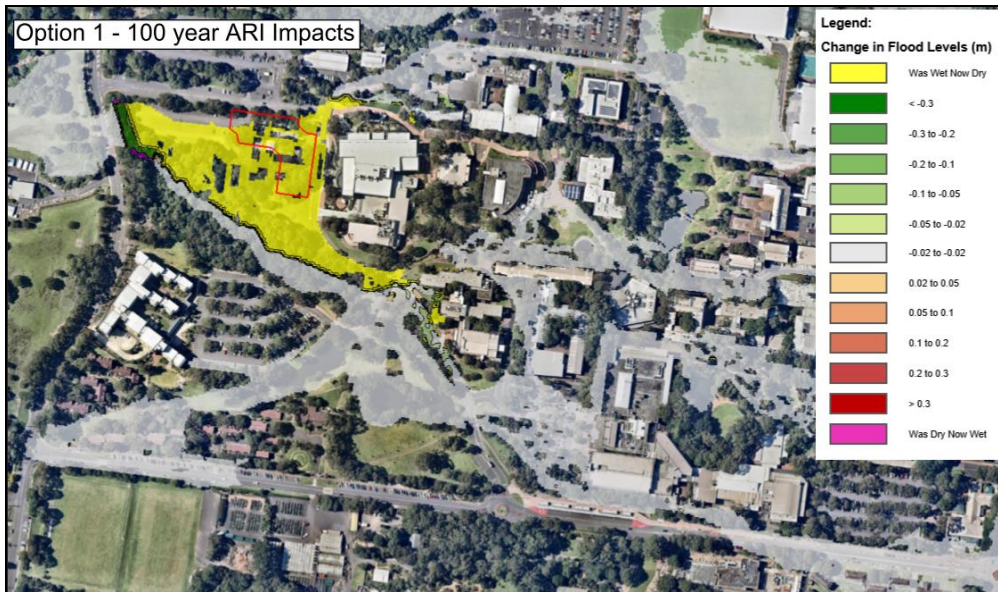


Figure 3-1

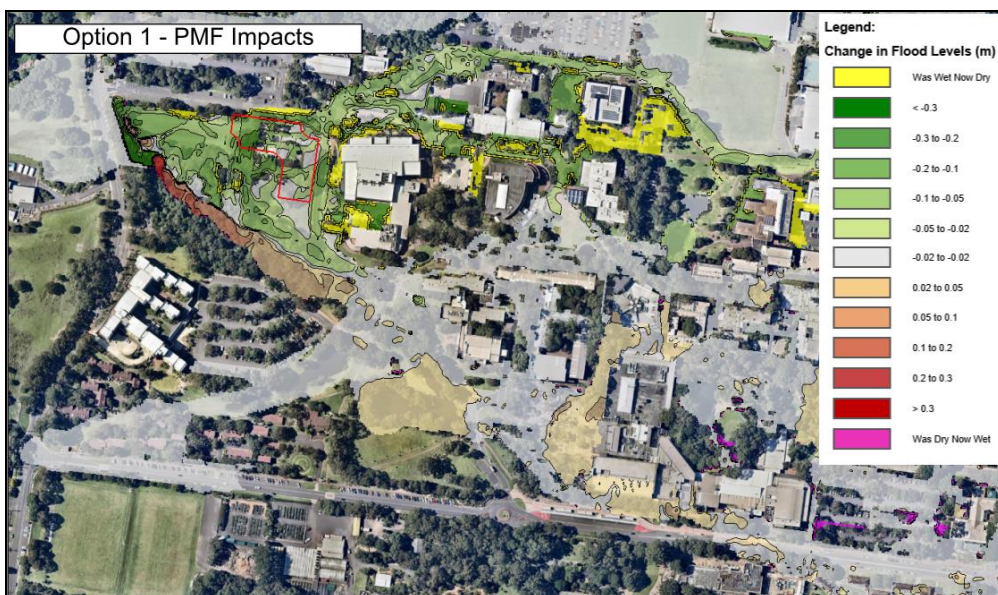


Figure 3-2

3.1.3 Option 2

Results for option 2 show that during the 100 year ARI event there are no detrimental impacts and all floodwater adjacent to the ASSB and the Western Carpark is contained entirely within Fairy Creek except for the regraded area of the Carpark (refer **Figure 3-3**). The inundated area of the carpark is trafficable during the 100 year ARI event. During the PMF event, the northern half of the campus demonstrates reductions in flood level, as well as on the western carpark (refer **Figure 3-4**). As discussed in **Section 3.1.1**, the southern portion of the campus and some of Northfields Avenue demonstrate an increase in flood levels, which will not affect planning requirements for campus buildings or the trafficability of Northfields Avenue. Reduction of PMF flood levels on the Western Carpark additionally improves trafficability and reduces the risk to damage to cars in a flood.



Figure 3-3



Figure 3-4

3.1.4 Option 3

Results for option 3 show that during the 100 year ARI event Robsons Road, the Western Carpark and the ASSB are all flood free. However, flood impacts occur through the campus down to Northfields Avenue (refer **Figure 3-5**). These impacts are caused by the reduction in utilisation of the “OSD basin” to the west of Robsons Rd. The impacts adjacent to UOW buildings may be considered to be detrimental and may affect FPLs. This option may still be viable with the implementation of a new OSD storage downstream of the Robsons Road culvert to reduce the flow rate to existing and mitigate these impacts. If option 3 is selected as UOWs preferred option, the design of this OSD can be explored at the design stage. It should be noted that the cost estimate has not accounted for construction of any additional OSD. PMF impacts are considered to be acceptable for this option (refer **Figure 3-6**).



Figure 3-5



Figure 3-6

3.1.5 Option 4

Results for option 1 show that during the 100 year ARI event there are no detrimental impacts and all floodwater adjacent to the ASSB and the Western Carpark are contained entirely within Fairy Creek (refer **Figure 3-7**). During the PMF event, the western carpark and ASSB location are flood free. The northern half of the campus still demonstrates reductions in flood levels (refer **Figure 3-8**). As discussed in **Section 3.1.1**, the southern portion of the campus and some of Northfields Avenue demonstrate an increase in flood levels which are greater than that of options 1 and 2, however will still not affect planning requirements for campus buildings or the trafficability of Northfields Avenue.



Figure 3-7



Figure 3-8

3.2 Costing

As part of this investigation preliminary budget estimates for the options listed above have been prepared. The cost estimate has been prepared from the preliminary engineering sketches and available industry information. The current cost estimate has inherent limitations, which will be further developed in the future stages of design.

A summary of the cost breakdown is provided in **Table 3-1**. These costs have been applied to the Multi Criteria Analysis, with the cheapest option (1) given a score of 10, the most expensive (2) given a score of 1 and the remaining scores have been scaled between these two.

Table 3-1 Options Cost Estimates

	Option 1	Option 2	Option 3	Option 4
General	\$12,500	\$22,500	\$45,000	\$17,500
Earthworks	\$ 20,300	\$ 47,660	\$ 7,000	\$ 20,300
Roadworks, Footpaths, Concrete, Landscaping	\$ 0	\$ 174,210	\$ 14,685	\$ 0
Stormwater Structures	\$ 5,390	\$ 0	\$ 95,000	\$ 36,190
Professional Fees	\$ 53,300	\$ 64,600	\$ 64,600	\$ 62,700
Replace Car Spots	\$200,000	\$0	\$0	\$200,000
Pedestrian Bridge	\$70,000	\$0	\$0	\$90,000
Sub Total	\$361,490	\$308,970	\$226,285	\$426,690
Contingency (30%)	\$108,447	\$92,691	\$67,886	\$128,007
Total	\$469,937	\$401,661	\$294,171	\$554,697

3.3 Floodplain Management

3.3.1 Flood Compatible Buildings Materials and Structural Soundness

A structural soundness certificate will be required for options 1-3 as part of the Construction Certificate to demonstrate that the proposed works can withstand the force of floodwater, debris and buoyancy up to and including the PMF.

3.3.2 Evacuation and Safe Access

Evacuation and safe access will need to be considered for options 1 - 3 at the design stage.

3.3.3 Floodplain Storage

Floodplain storage will need to be assessed at the design stage. WCC generally requires no net floodplain storage loss during development.

4. Safety in Design

There is an existing footpath and stairs from Robsons Road into the western carpark adjacent to the watercourse. Options 1 and 4 will make this access unsafe during large storm events. A pedestrian bridge has been accounted for in these designs to minimise this safety issue.

Option 2 has been designed so the carpark will remain trafficable in the 100 year ARI design event. Option 2 reduces the extent of flood flow through the western carpark and hence generally improves safety. Option 3 reduces the volume of flow through the carpark in all flood events and hence generally improves safety.

5. Multi-criteria Analysis

Based on the assessment of available options, the following analysis has been undertaken to assist in the determination of the mitigation option that best meets UOW's strategic goals. Each of the options has been ranked against the criteria on a score out of 10 as presented in **Table 1**.

Table 1: MCA Analysis

Criteria	Weighting	Score out of 10 (1 = bad, 10 = good)			
		Option 1	Option 2	Option 3	Option 4
Cost - Capital	30%	3	6	10	1
Flood Planning Level	20%	10	10	10	10
Flood Impacts	10%	9	9	3	5
Potential for Impact on Existing Services	5%	7	5	9	6
Flood Immunity	5%	2	2	4	10
Site Constraints	10%	5	2	5	8
Safety in Design	10%	8	8	10	8
Flooding on Robsons Road	10%	4	4	10	4
TOTAL SCORE	100%	5.95	6.45	8.45	5.60

The MCA preliminary MCA assessment finds option 3 to be the most suitable based on Cardno's weightings and Criteria. UOW is encouraged to update the MCA particularly the Criteria and weighting to better suit the University's strategic goals. Cardno will provide a digital copy of the MCA for UOW's further manipulation and analysis.

6. Conclusions

It can be concluded that:

- > All flood remediation options would be effective at returning 100 year ARI flows back to Fairy Creek.
- > Options 1, 2 and 3 result in the ASSB being considered in the Low Flood Risk Precinct and therefore Flood Planning Levels do not apply. Only minor DCP flooding related planning controls will apply.
- > Option 4 results in the ASSB being considered flood free (FPL not required).
- > Options 1, 2 and 4 result in reduction of flood levels on the northern portion of the campus and increase in the flood levels on the southern portion of the campus and some of Northfields Avenue during the PMF event. These impacts will not impact existing building FPLs or the trafficability of Northfields Avenue.
- > Option 3 results in downstream impacts during the 100 year ARI event adjacent to UOW buildings and on Northfields Avenue. These impacts could be mitigated by the implementation of an OSD downstream of the Robsons Road culvert.

7. Recommendations

It is recommended that:

- > UOW review this assessment and determine their preferred method of moving forward.

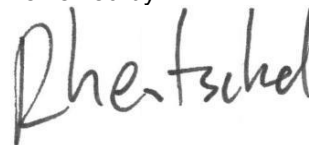
- > A pre lodgement meeting is undertaken with the assessing authority to assist with the approval process
- > Consideration is given to undertaking additional survey of the existing Robsons Road culvert and upstream area
- > The preferred design is refined and optimised including civil design to a level suitable for DA submission.

Prepared by
for and on behalf of
CARDNO (NSW/ACT) PTY LTD



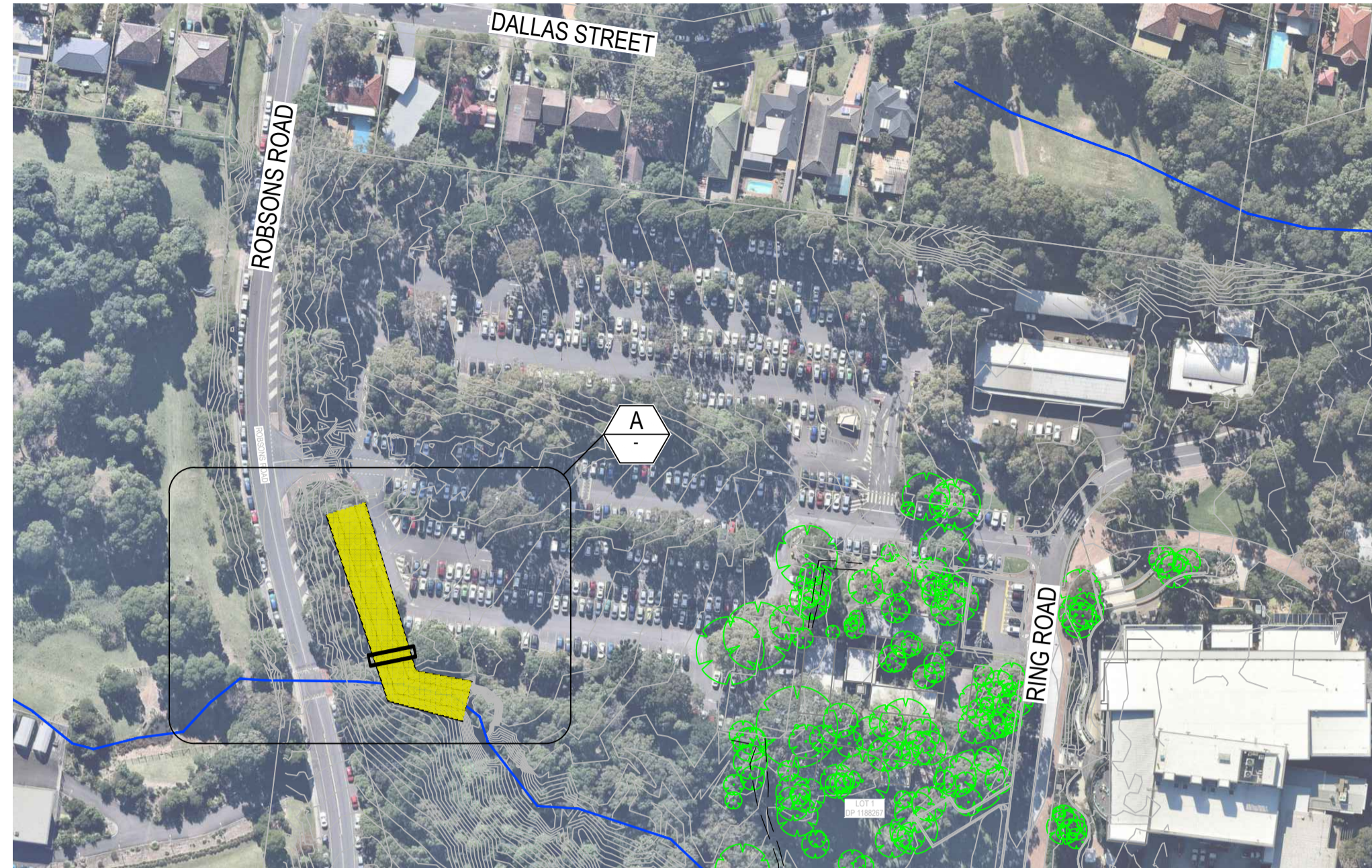
Nathan Pomfret
Water Engineer

Reviewed by



Rory Hentschel
Manager - Water

Enclosed:
Mitigation Sketches
MCA (Digital Copy)

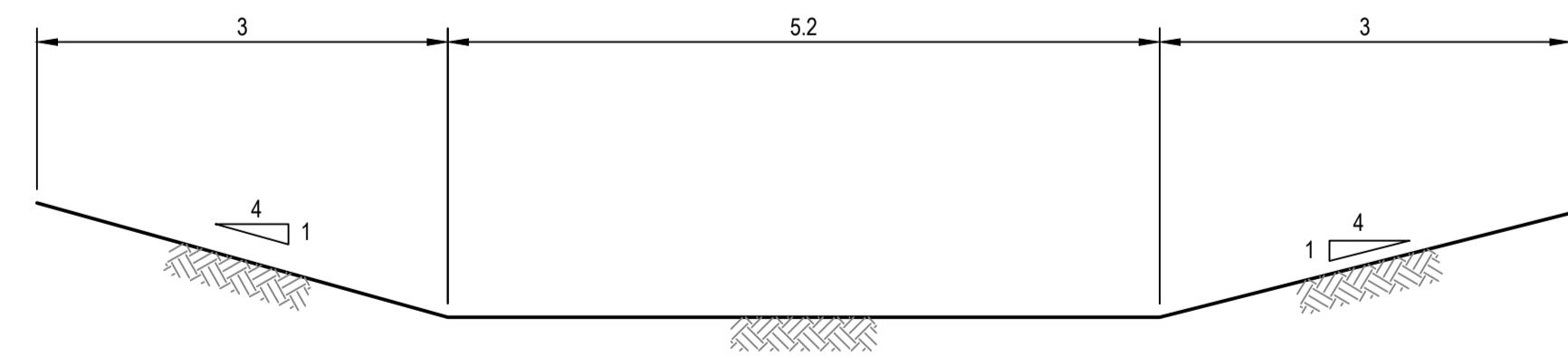


LOCALITY PLAN
SCALE 1:1500



UOW ASSB FLOOD REMEDIATION - OPTION 1
SCALE 1:250

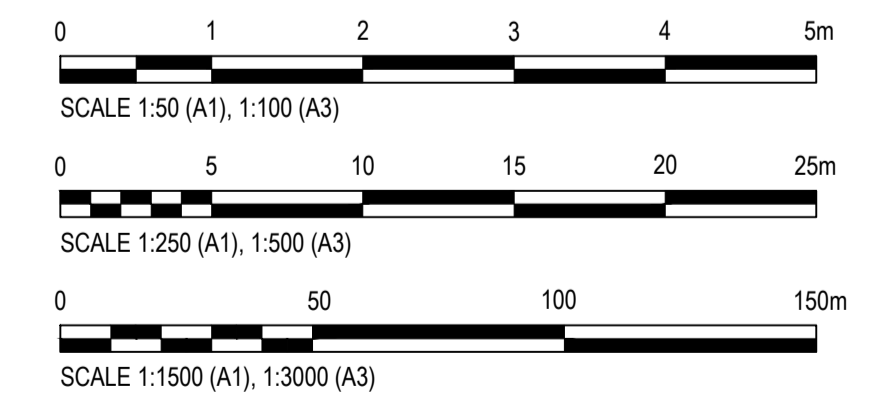
DETAIL A
SCALE 1:250



TYPICAL SWALE SECTION
SCALE 1:50

SECTION 1
SCALE 1:50

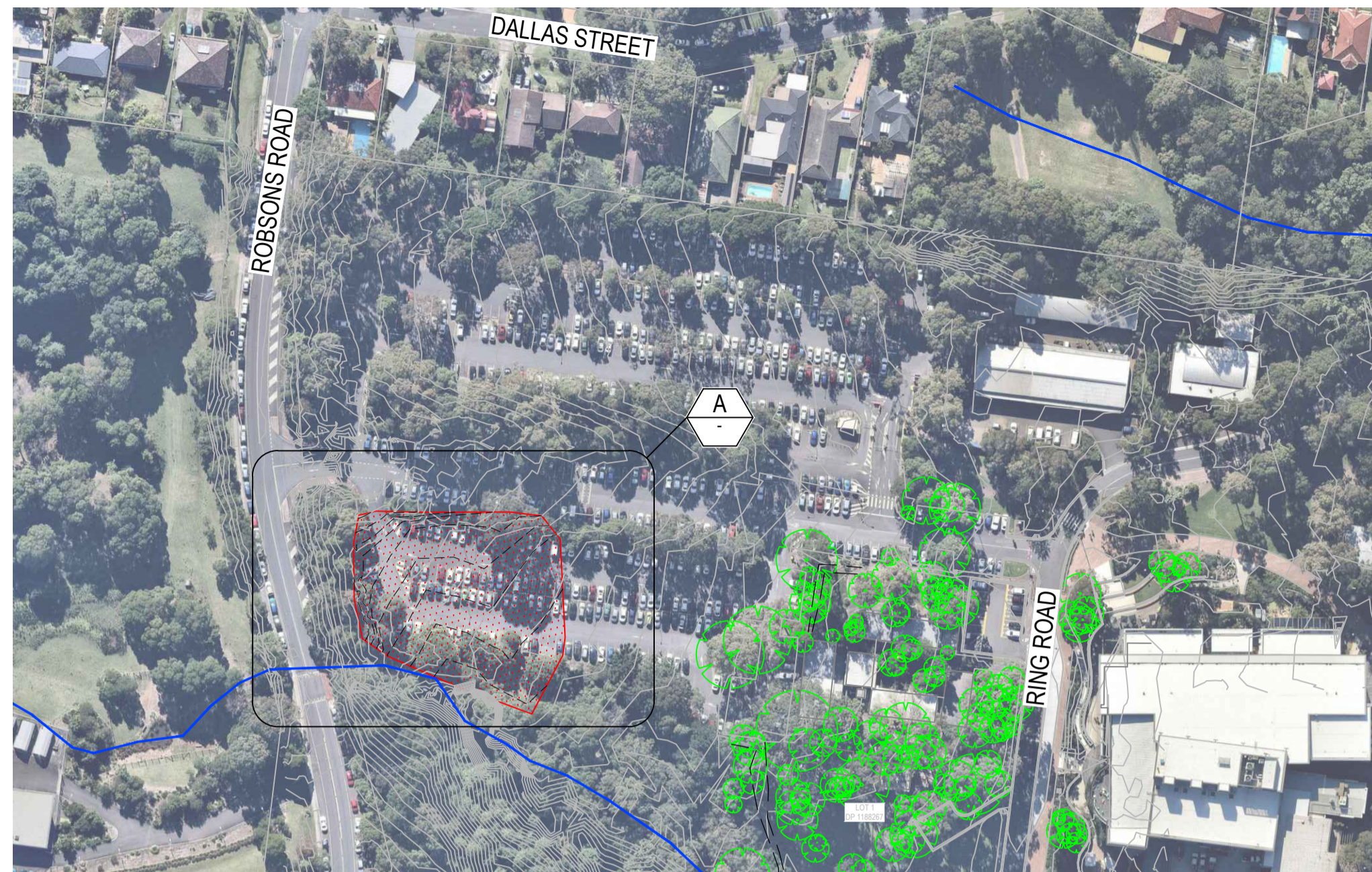
LEGEND	
	SWALE SURFACE CONTOURS
	EXISTING SURFACE CONTOURS
	EXISTING WATERCOURSE
	SWALE EXTENTS



© Cardno Limited All Rights Reserved.
This document is produced by Cardno Limited solely for the benefit of and use by the client in accordance with the terms of the retainer. Cardno Limited does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

Cardno (NSWIACT) Pty Ltd | ABN 95 001 145 035
Level 1, 47 Burelli Street
Wollongong NSW 2500
Tel: 02 4228 4133 Fax: 02 4228 6811
Web: www.cardno.com.au

UNIVERSITY OF WOLLONGONG			
UOW ASSB FLOOD REMEDIATION			
OPTION 1			
DATUM	Date	Scale	Size
A.H.D.	5/07/2017		A1
Drawing Number			Revision
8201720801-001 SK001			2

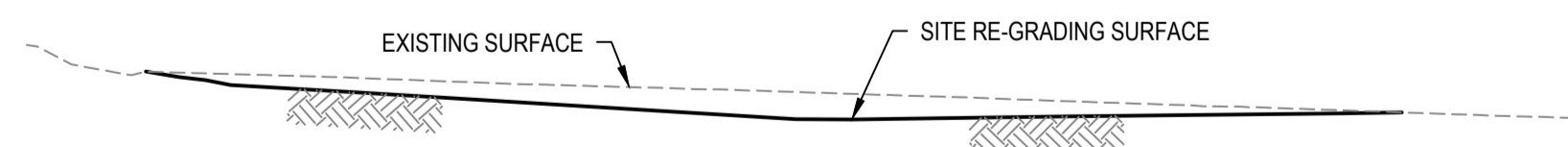


LOCALITY PLAN
SCALE 1:1500



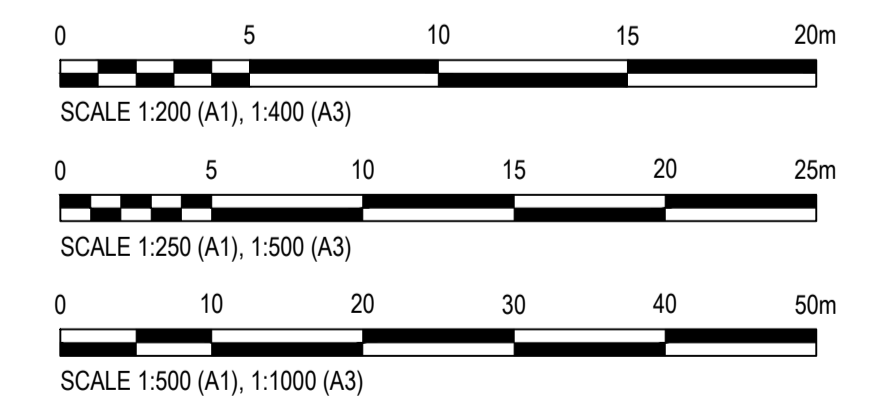
UOW ASSB FLOOD REMEDIATION - OPTION 2
SCALE 1:250

DETAIL A
SCALE 1:250



SECTION 1
SCALE 1:200

LEGEND	
	SWALE SURFACE CONTOURS
	EXISTING SURFACE CONTOURS
	EXISTING WATERCOURSE
	OPTION 2 SITE RE-GRADING AREA



© Cardno Limited All Rights Reserved.
This document is produced by Cardno Limited solely for the benefit of and use by the client in accordance with the terms of the retainer. Cardno Limited does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

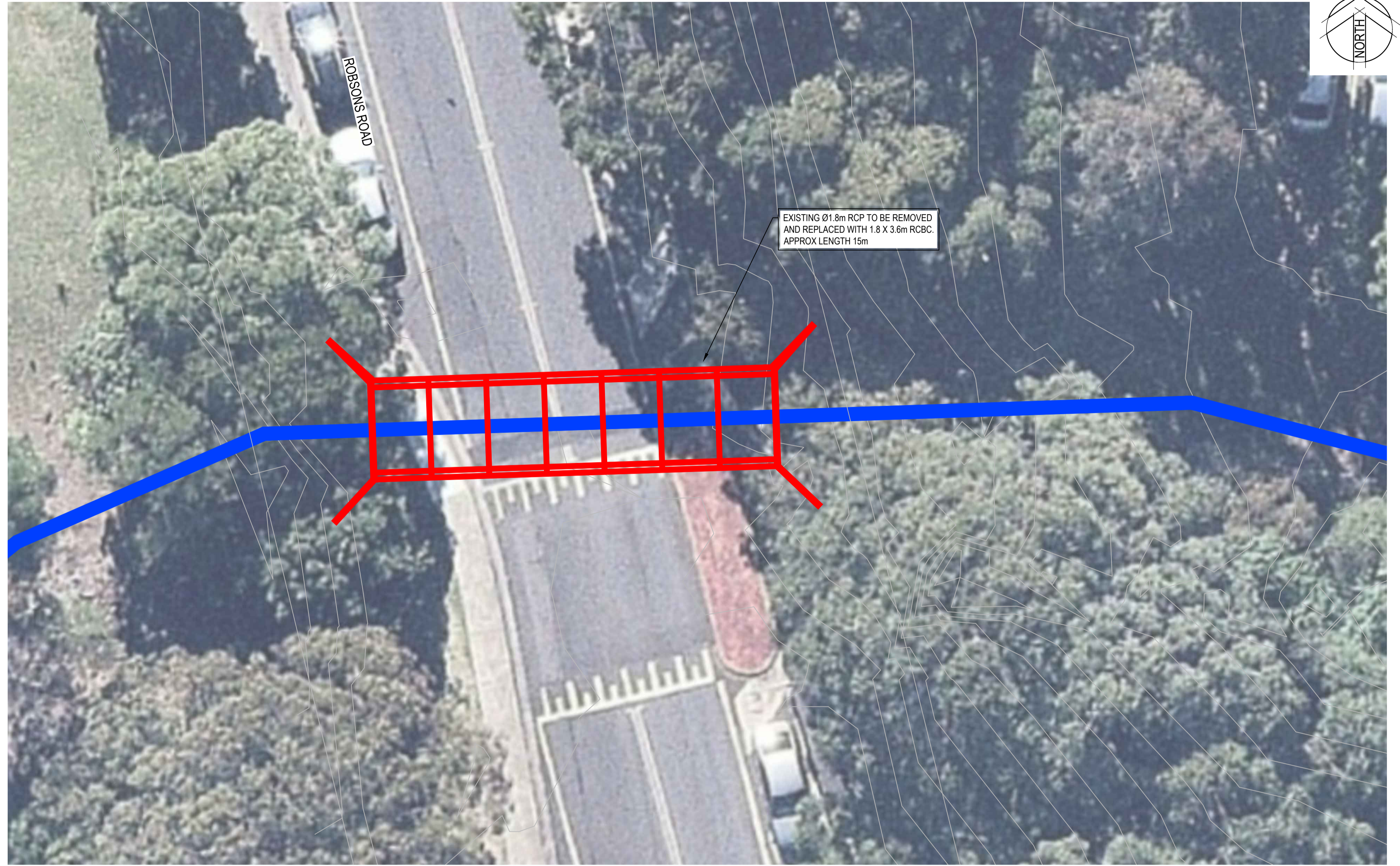
Cardno
Shaping the Future

Cardno (NSW/ACT) Pty Ltd | ABN 95 001 145 035
Level 1, 47 Burrelli Street
Wollongong NSW 2500
Tel: 02 4228 4133 Fax: 02 4228 6811
Web: www.cardno.com.au

UNIVERSITY OF WOLLONGONG			
UOW ASSB FLOOD REMEDIATION			
OPTION 2			
DATUM	Date	Scale	Size
A.H.D.	5/07/2017		A1
Drawing Number			Revision
8201720801-001 SK002			1



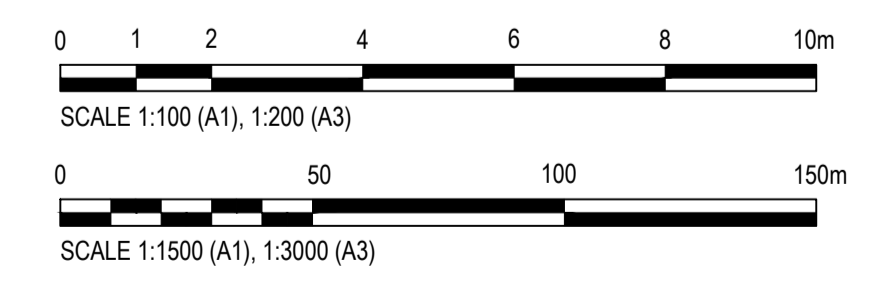
LOCALITY PLAN
SCALE 1:1500



UOW ASSB FLOOD REMEDIATION - OPTION 3
SCALE 1:100

DETAIL A
SCALE 1:100

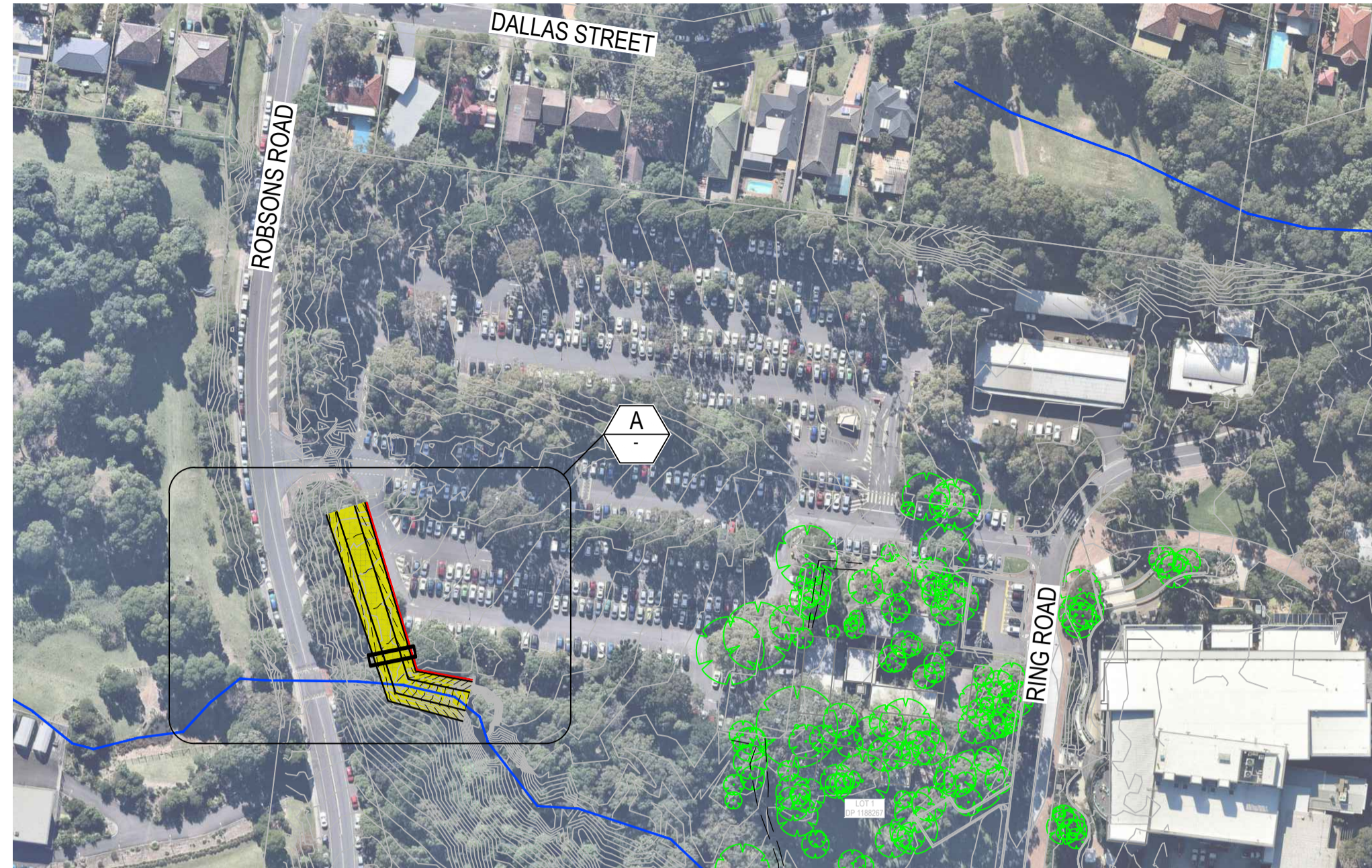
LEGEND	
	SWALE SURFACE CONTOURS
	EXISTING SURFACE CONTOURS
	EXISTING WATERCOURSE



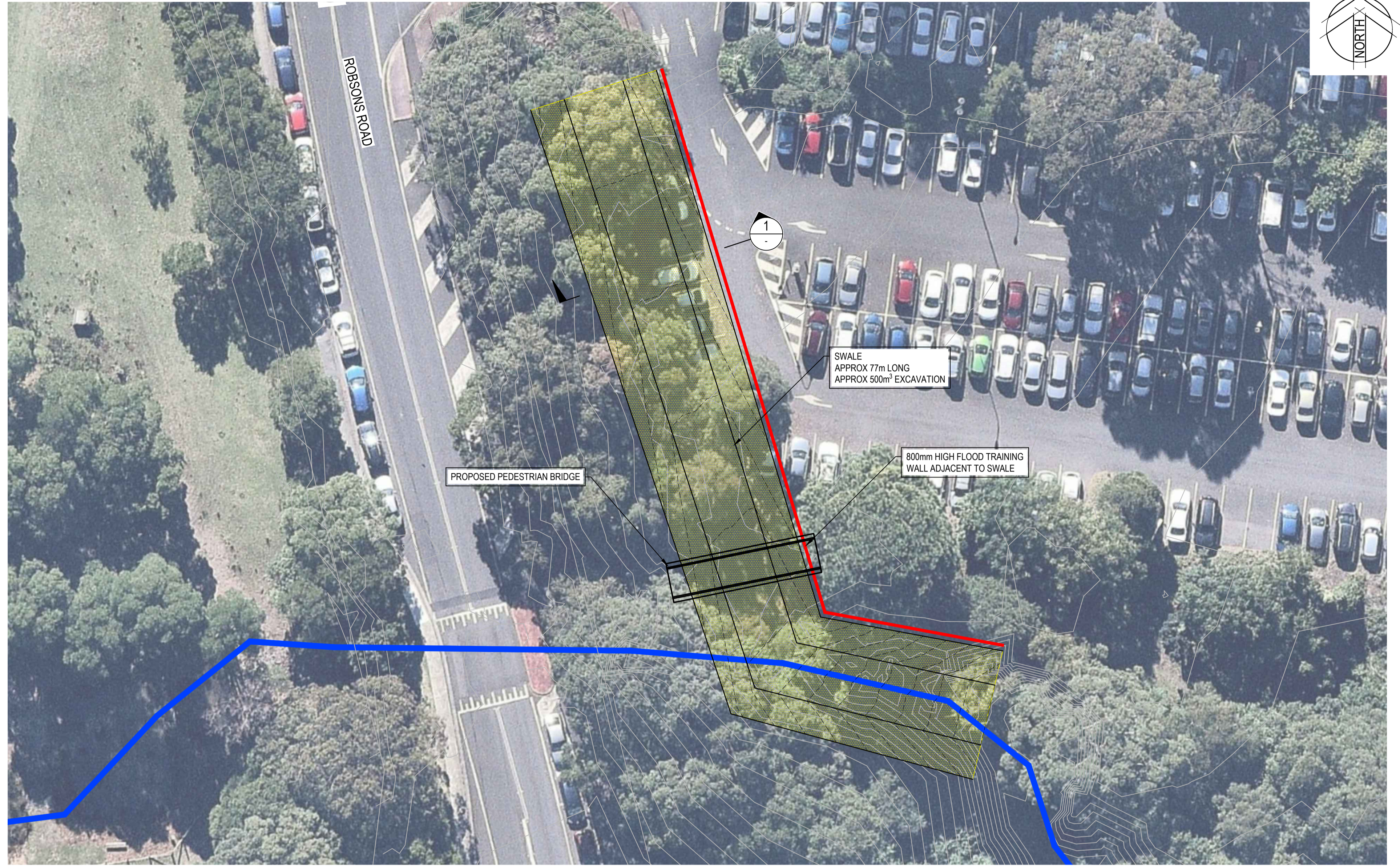
© Cardno Limited All Rights Reserved.
This document is produced by Cardno Limited solely for the benefit of and use by the client in accordance with the terms of the retainer. Cardno Limited does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

Cardno (NSWIACT) Pty Ltd | ABN 95 001 145 035
Level 1, 47 Burrell Street
Wollongong NSW 2500
Tel: 02 4228 4133 Fax: 02 4228 6811
Web: www.cardno.com.au

UNIVERSITY OF WOLLONGONG UOW ASSB FLOOD REMEDIATION OPTION 3			
DATUM	Date	Scale	Size
A.H.D.	5/07/2017		A1
Drawing Number			Revision
8201720801-001 SK003			1



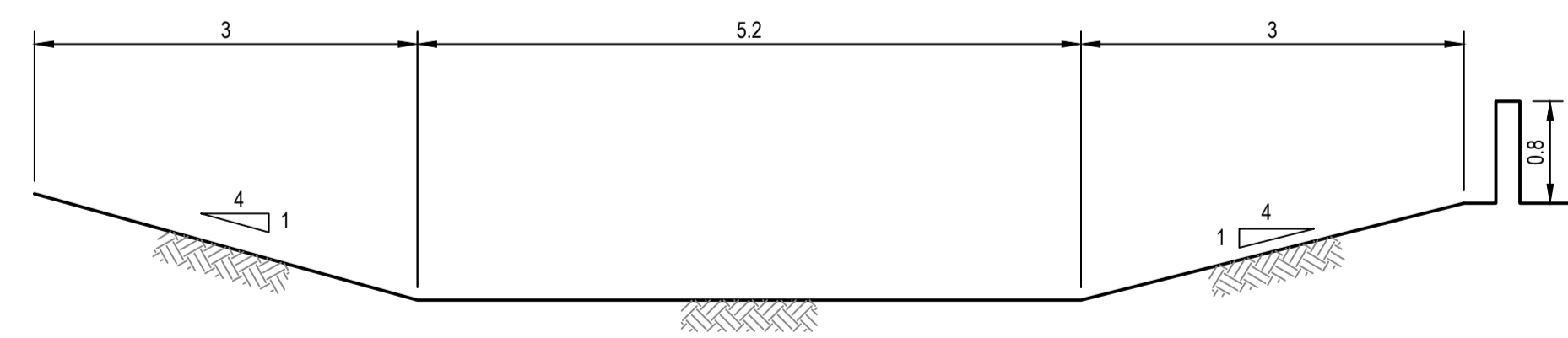
LOCALITY PLAN
SCALE 1:1500



UOW ASSB FLOOD REMEDIATION - OPTION 4
SCALE 1:250

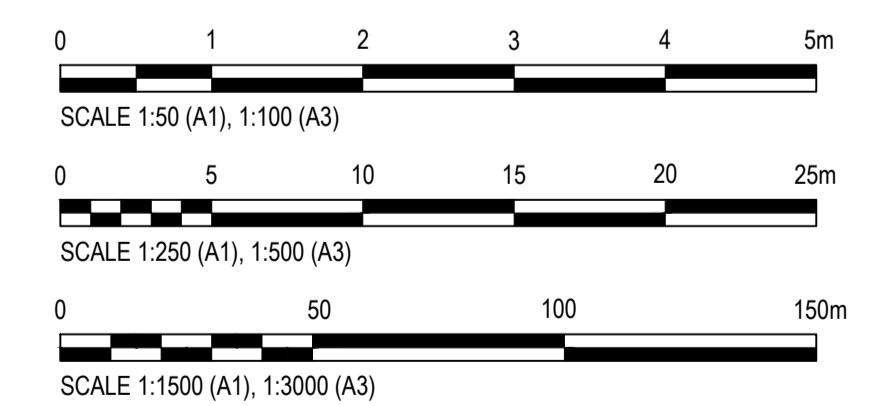
DETAIL A
SCALE 1:250

LEGEND	
	SWALE SURFACE CONTOURS
	EXISTING SURFACE CONTOURS
	EXISTING WATERCOURSE
	800mm HIGH FLOOD TRAINING WALL
	SWALE EXTENTS



TYPICAL SWALE SECTION
SCALE 1:50

SECTION 1
SCALE 1:50



© Cardno Limited All Rights Reserved.
This document is produced by Cardno Limited solely for the benefit of and use by the client in accordance with the terms of the retainer. Cardno Limited does not and shall not assume any responsibility or liability whatsoever to any third party arising out of any use or reliance by third party on the content of this document.

Cardno
Shaping the Future

Cardno (NSWI) Pty Ltd | ABN 95 001 145 035
Level 1, 47 Burrelli Street
Wollongong NSW 2500
Tel: 02 4228 4133 Fax: 02 4228 6811
Web: www.cardno.com.au

UNIVERSITY OF WOLLONGONG			
UOW ASSB FLOOD REMEDIATION OPTION 4			
DATUM	Date	Scale	Size
A.H.D.	5/07/2017		A1
Drawing Number			Revision
8201720801-001 SK004			2