Flood Impact Assessment

Proposed Aged Care Facility at Bulli

8201813802

Prepared for

Anglicare

17 August 2018

Cardno®

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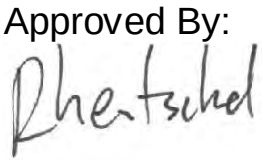

Rory Hentschel
Manager Water

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1 Introduction

1.1 Background

Anglicare are proposing to develop an aged care facility at lot 2 & 3 DP 1176767 at Bulli, NSW. Cardno has been commissioned to carry out a flood impacts assessment to support the concept plan modification application for the subject development.

1.2 Study Area

The site proposed for the development is located in Geragthy Street in Bulli. The subject site is bounded with Geragthy Street and railway line to the west (railway line runs immediately upstream and parallel to Geragthy Street), Wilkies Street to the north and Sandon Drive to the south. Refer to **Figure 1-1** for locality of the subject site.

Tramway Creek runs along the southern side of the subject site and joins Woodland Creek further downstream before discharging into the ocean. Cookson Creek (a tributary of Tramway Creek) runs through the middle of the site.

The subject site generally falls in an easterly direction (towards the ocean). However, the northern part of the site is located on a hill side and has a steep southerly fall towards Cookson Creek running through the middle of the site. The site levels vary between RL26.8m AHD in north-western corner of the site and RL5.2m AHD in the eastern side of the site and within the Cookson Creek.

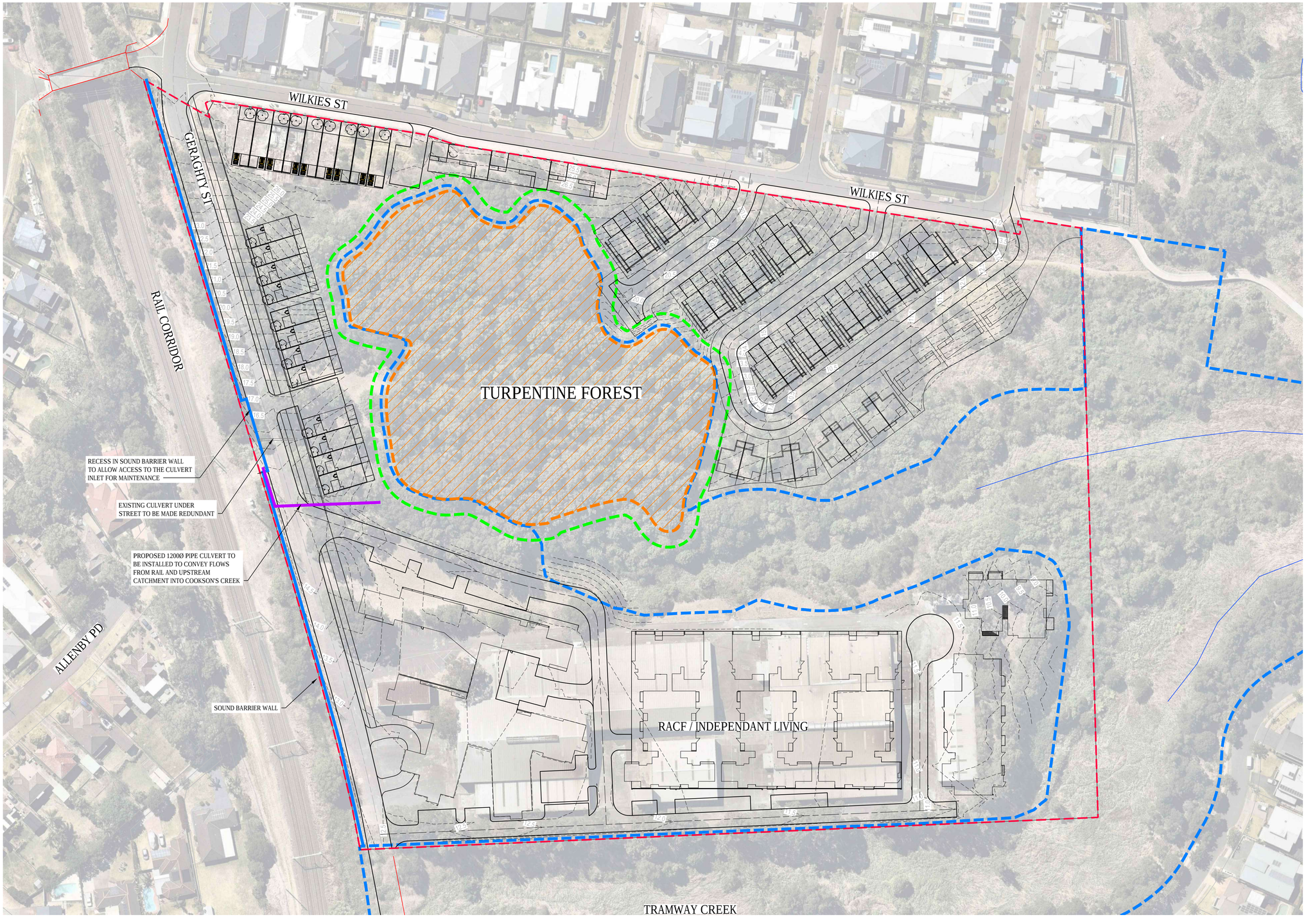
Based on the topography, Cookson Creek collects a local catchment mostly comprising the subject site with some area to the western side of the railway line.

1.3 Purpose of this Report

The main objective for this report is to undertake a flood study for Tramway Creek and an impacts assessment for the proposed aged care facility development. Specifically, this flood study aims to:

- Determine the flood behaviour on the development site (flood extent, flood levels, flood depth and flood velocities) for a range of design events up to and including 100 year ARI design event and PMF.
- Ensure that the majority of land within the development site will be located on land above the PMF and as such is not subject to flood related planning controls or located on flood prone land.
- Ensure that no detrimental offsite impacts are created in the 1% AEP and PMF events as a result of the proposed development.
- Review the previous drainage concept from the concept approval and update it to reflect the currently proposed layout.

Figure 1-1 Proposed Development Plan



NEARMAP IMAGE SOURCED DEC 2017

WATER MANAGEMENT LAYOUT

SCALE 1:750

LEGEND

- PROPERTY BOUNDARY
- APZ BOUNDARY
- E2 ZONING BOUNDARY
- EXISTING FOREST
- EXISTING WATER COURSE
- 10.0 DESIGN SURFACE CONTOURS
- PROPOSED ACOUSTIC WALL
- PROPOSED CULVERT

0 15 30 45 60 75m

SCALE 1:750 (A1), 1:1500 (A3)

Rev.	Date	Description	Des.	Verif.	Appd.
1	14/08/2018	ISSUED FOR INFORMATION	BAH	AD	

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Drawn	BAH	Date 6/08/2018
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Designed	BAH	Date 10/08/2018
Verified	AD	Date 14/08/2018
Approved		

Client: ANGLICARE

Project: SANDON POINT RETIREMENT VILLAGE

Title: WATER MANAGEMENT LAYOUT PLAN

Status: FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DATUM	Scale	Size
AHD	1:750	A1

Drawing Number: 82018138-001-SK008

Revision: 1

2 Available Data

2.1 Topographic data

2.1.1 Aerial Laser Scanning (ALS) Survey

ALS (taken in 2013) data was sourced from Land and Property Information (LPI) and used for undertaking the catchment delineation, hydrology modelling and hydraulic modelling for this study.

2.1.2 Ground Survey

Detailed survey data within the site was captured by Dennis Smith Surveyors on the 19th January 2006 and has been incorporated into the hydraulic model to better represent the topography of the study area. A pdf copy of the survey is included in **Appendix D**.

2.2 Previous Studies

2.2.1 Review of Hewitt Creek Flood Study (WBNM, August 2015)

Review of Hewitt Creek Flood Study (RHCFS) was prepared for Wollongong City Council (WCC) to determine the flood behaviour in the Hewitt Creek study area and consider influence of potential climate change on future flood behaviour.

The RHCFS developed a WBNM model for hydrological assessment of the study catchment. The WBNM model was calibrated and validated to April 1988, August 1998 and February 2013 events. A TUFLOW two-dimensional hydraulic model was developed as part of this study. The TUFLOW model was also calibrated and validated similarly.

RHCFS is relevant to this current study as it covers the site, the Tramway Creek catchment and Slacky Creek catchment which are relevant to this current study.

The catchment plan provided in RHCFS have been used as a basis in undertaking the catchment delineation for this current study. The hydrological parameters (such as rainfall loss values and routing lagging factors) have been adopted consistent with RHCFS for this current study.

This report has been also used a basis for comparison of our modelling results in terms of general parity in the flooding extent.

2.2.2 Addendum to Flood Study Report for Anglican Retirement Village (GHD, May 2006)

This report was also reviewed as one of the earliest hydraulic studies prepared for the proposed development.

This study adopted the boundary conditions from the Hewitt Creek Flood Study (an earlier version) and then developed a HEC-RAS model for Tramway Creek reach extending up to just downstream of the railway and the culvert underneath of it.

This study was not identified suitable for comparison of our model results because of the followings:

- The GHD report does not cover the Cookson's Creek
- It does not account for the hydraulic constraints imposed by the railway culvert on Tramway Creek

3 Hydrology

3.1 Catchment Description

The proposed development site is located within the downstream reaches of Tramway Creek. Tramway Creek runs parallel to the southern boundary of the site. Cookson Creek, a tributary of Tramway Creek, runs through the site and joins the Tramway Creek just downstream of the site. Tramway Creek then joins the Woodland Creeks Creek just before discharging to the ocean.

Cookson Creek mostly drains the site with some external catchment to the west of Geragthy Street and the Illawarra Railway totalling a catchment area of approximately 12ha. Levels in Cookson Creek catchment varies between approximately RL 4m AHD in the confluence point with Tramway Creek to RL 35m AHD to adjacent to the Illawarra Railway.

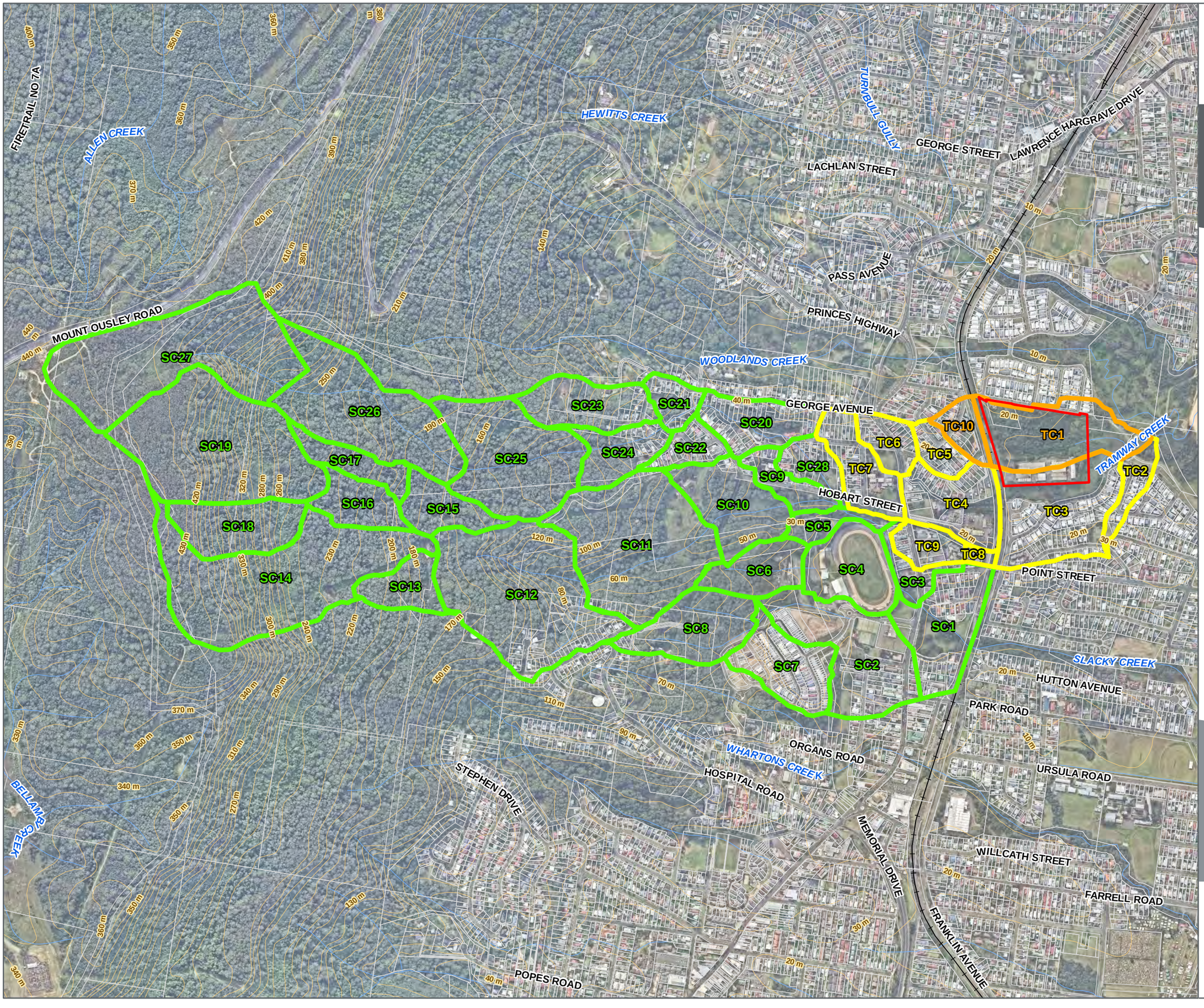
Tramway Creek drains a larger catchment extending from Tramway Creek and Woodlands Creek confluence just east of the site to areas to the west of the Princes Highway, north of Bulli Showground and Racing Complex and north of Hobart Street. Tramway Creek totals a catchment area of approximately 30ha. The elevations in Tramway Creek catchment variy between RL4 m AHD at the confluence with Cookson Creek to RL42 m AHD at the north-western end of the catchment.

Slacky Creek covers an area of approximately 248ha. There are a number of drainage structures along Slacky Creek including the Hobart Street culverts crossing, old coal haulage railway culverts crossing, Princes Highway Culverts Crossing and Illawarra Railway Culvert crossing. The Hobart Street Culverts crossing and old coal haulage railway culverts crossing provide significant obstruction against Slacky Creek conveyance and divert significant flows into the Tramway Creek catchment. Further break outs from Slacky Creek are predicted to occur just to the north east of the Bulli Showground and Racing Complex.

The Slacky Creek catchment has been included in this study to allow quantification of this cross catchment from between Slacky Creek and the Tramway Creek catchment. Slacky Creek catchment has been modelled down to the Illawarra Railway crossing.

Figure 3-1 shows the catchment delineation for the study area including Cookson Creek, Tramway Creek and Slacky Creek.

Figure 3-1 Catchment Plan



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Catchment Sub-Delineation Plan

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- 10m Contours (LPI)
- Cadastre (DFSI-SS, 2018)

Catchment Sub-Delineation

- Slacky Creek
- Cookson's Creek
- Tramway Creek

FIGURE 3-1

1:12,000 Scale at A3

m
0 150 300 450 600

N

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Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-14 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-002_SubCatchment.mxd 04
Aerial imagery supplied by nearmap (May, 2018)

3.2 Hydrological Model Selection

The computer model 'Watershed Bounded Network Model' WBNM2007 v104 (Boyd et al, 2007) was used for hydrological modelling of the study area. WBNM is an advanced storage-routing model that allows simulation of complex catchment behaviour. This particular model was considered most appropriate to the task of modelling the study area, given its ability to model a wide range of catchment characteristics and its local development, the model allowed peak flows to be established at various locations throughout the subject site.

3.3 Model Input

3.3.1 Sub-Catchment Topology

Sub-catchment topology for the constructed model reflected input from:

- ALS data purchased from LPI to represent the existing surface.
- Aerial photography from NearMap for the establishment of impervious/pervious areas across the floodplain

Sub-catchments were delineated from the total catchment (290 ha) in order to accurately model the peak flows and flood extents over the site.

The sub-catchment delineation developed and used in the hydrologic model is presented in **Figure 3-1**. There is a generally parity between the catchment delineation undertaken by Cardno and the catchment delineation presented in WBNM report.

3.3.2 Impervious Fraction

The impervious area for each sub-catchment was estimated using the most recently available aerial photography from nearmap. The surface area of impervious features was determined as a percentage of the individual sub-catchment areas and an impervious factor was assigned to each, which represented the type and density of impervious features present. It was assumed that the impervious fraction of residential areas was approximately 70%.

The WBNM data presented in **Appendix A** shows the final estimated impervious fractions for each sub-catchment (Pre-Development Scenario).

3.3.3 Rainfall data

Rainfall data for the site was sourced from the Bureau of Meteorology (BOM). The data used to generate the design storm bursts in the WBNM model is presented in **Table 3-1**.

Table 3-1 Rainfall data

Parameter	Value
2 Year 1 Hour Intensity	46 mm/hr
2 Year 12 Hour Intensity	11.1 mm/hr
2 Year 72 Hour Intensity	4.15 mm/hr
50 Year 1 Hour Intensity	102 mm/hr
50 Year 12 Hour Intensity	26.3 mm/hr
50 Year 72 Hour Intensity	9 mm/hr
F2 Geographic Factor	4.28
F50 Geographic Factor	15.8
Location Skew Coefficient	0.0

3.3.4 Hydrological parameters

The hydrological parameters used for input to the WBNM model are listed in **Table 3-2**.

Table 3-2 WBNM Parameters

Parameter	Values	Comment

Initial loss (pervious surface)	0 mm	Conservatively taken as zero.
Initial loss (impervious surface)	0 mm	Conservatively taken as zero.
Continuing loss (pervious surface)	2.5 mm/hr	AR&R recommends 2.5 mm/hr for ungauged NSW catchments
C (Catchment Lag parameter)	1.29	Regional calibration value
Impervious Lag	0.1	WBNM default value
Stream Lag	1.0	Model default

3.4 Design Storm Results

The WBNM hydrological model was simulated against a range of design storm events to determine the critical design storm duration. The ARI storm events analysed in this study included the 100 year ARI design events and the probable maximum flood (PMF). The identified critical durations to assess the proposed development were 2 hours for 100 year ARI storm events and 60 minutes for the PMF.

Results from the WBNM model is provided in **Appendix B**.

4 Hydraulics

4.1 Selection of Hydraulic Model

The TUFLOW 2D model was used in the hydraulic assessment of the study area. A 2D model was selected to model the floodplain in order to better represent the complex hydraulics associated with floodplain areas. The model extent was determined based on review of the topography of the study area and review of the previous flood studies to ensure that significant hydraulic controls and flow break out points are incorporated. The downstream boundary was set up at a location downstream of the site to ensure that an accurate tailwater condition is established.

4.2 Model Geometry, Boundary Conditions and Roughness

The TUFLOW model was established over a 2.5 meter grid, with elevations extracted from the topographic data discussed in **Section 2.1**.

The flood behaviour on the proposed development site is generally controlled by Tramway Creek running parallel to the southern boundary of the site and Cookson Creek (a tributary of Tramway Creek) running through the site. The Tramway Creek system is expected to be of higher importance as it conveys a significantly greater catchment compared to Cookson Creek.

The Slacky creek system was also incorporated to the TUFLOW model to an extent downstream enough (just downstream of Princes Highway) to ensure that any diversion and break out from Slacky Creek to Tramway Creek is simulated.

The outflow boundary condition has been set up at the location of the confluence of Cookson Creek and Tramway Creek which is upstream from the ocean discharge. A H_Q outflow boundary condition has been defined in TUFLOW model for this boundary. The outflow boundary was set at a location far enough downstream of the site to ensure that the model establishes an accurate tailwater condition. A number of sensitivity scenarios were set up and run to investigate the potential impacts tidal changes on the flood behaviour around the study area. The results of the sensitivity scenarios show that the flood levels at the proposed development site are not anticipated to be impacted by the tide significantly. Therefore, no tidal downstream boundary condition was set for this model.

Inflow hydrographs from the WBNM model were applied to the upstream catchments, ensuring enough routing time/distance, to allow the model to stabilise and accurately predict flooding behaviour at the site. The hydraulic model schematisation for the TUFLOW model is shown in **Figure 4-1**.

Roughness areas across the TUFLOW modelling domain were digitised based on aerial imagery and site inspection. The Manning's roughness values adopted in the hydraulic model are presented in **Table 4-1**. The spatial distribution of Manning's n adopted in the TUFLOW model are shown in **Figure 4-2**.

Table 4-1 Manning's n Values

Land Use Type	Manning's n Value
Forests/Dense vegetation	0.09
Open Space/Parkland	0.04
Lumped Urban Residential	1.0
Creek-Lightly Vegetated	0.05
Creek-Heavily Vegetated	0.09
Rail Corridor	0.08
Roads/Pavement	0.02
Buildings	1.0

4.3 Existing Hydraulic Structures Modelled

The major existing hydraulic structures within the study areas were identified and incorporated to the pre-development scenario. The location and description of the structures is shown on **Figure 4-1**. The configuration of the proposed culvert structures is provided in **Table 4-2**. The information regarding the hydraulic structures was sourced from RHCFS and was verified by a site visit undertaken to observe all of these structures.

Table 4-2 Existing Culverts Configurations

Structure ID	Watercourse	Street or Landmark	Structure Type	Culvert Configurations
1	Cookson Creek	Geragthy Street	Culvert	(1×) 675 RCP
2	Cookson Creek	Illawarra Railway	Culvert	(1×) 600 RCP
3	Tramway Creek	Illawarra Railway	Culvert	(1×) 2100 RCP
4	Slacky Creek	Illawarra Railway Underpass	Culvert	(1×) 4800×4050 RCBC
5	Slacky Creek	Illawarra Railway	Culvert	(1×) 4800×5900 RCBC
6	Slacky Creek	Footbridge	Culvert	(2×) 2850×3000 RCBC
7	Slacky Creek	Princes Highway	Culvert	(4×) 2440×1680 RCBC
8	Slacky Creek	Old Coal Haulage Railway	Culvert	(3×) 2750×1700 RCBC
9	Slacky Creek	Hobart Street	Culvert	(3×) 1200 RCP

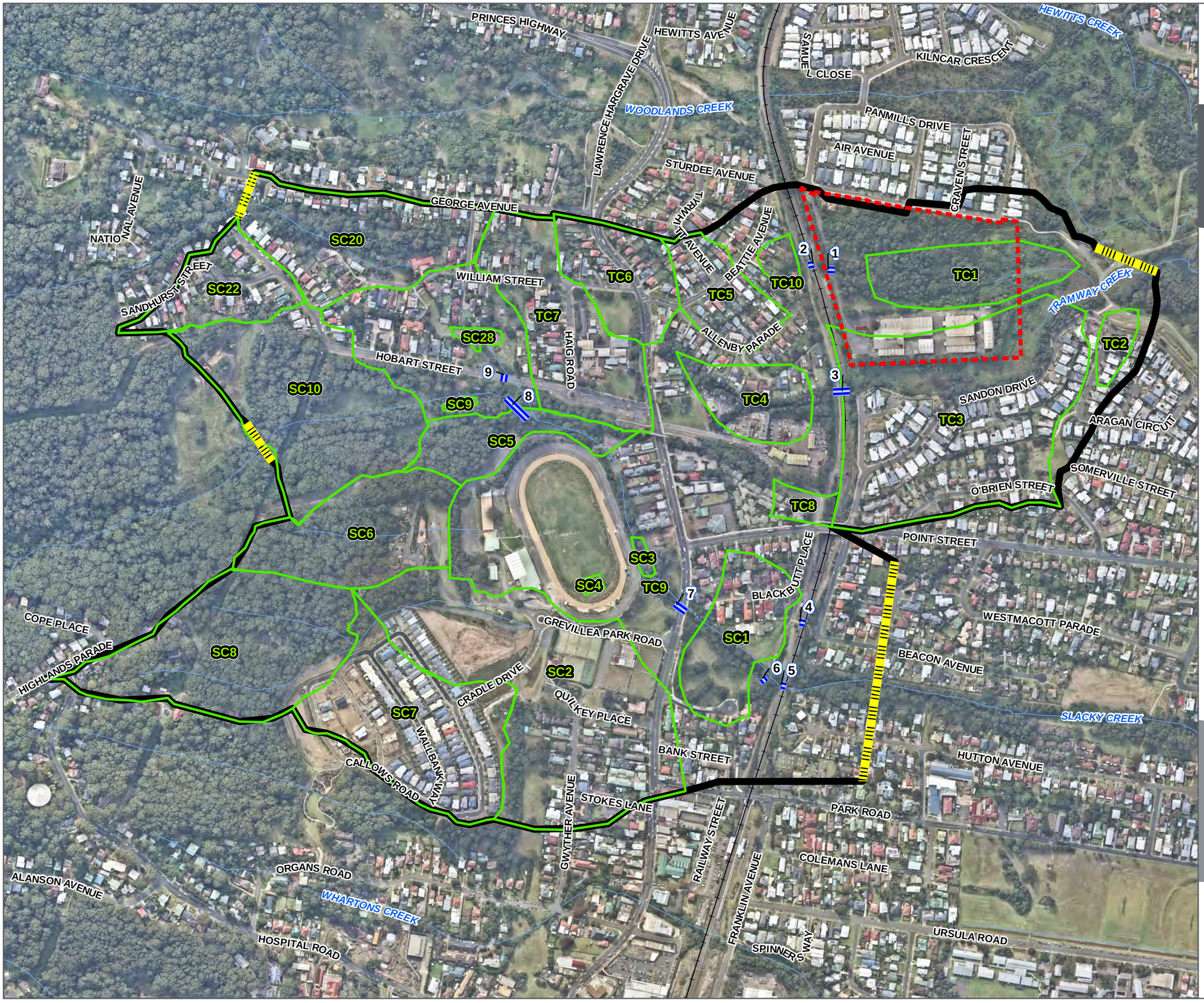
4.4 Culverts Blockage

The hydraulic assessment in our study included a blockage scenario applied to the culverts for both pre-development and post development scenarios.

The blockage factors applied to the culverts are in accordance with Wollongong City Council's Review of Conduits Blockage Policy Summary Report-Final dated June 2016.

Two scenarios of blocked and un-blocked were run for the pre-development and post-development scenarios with the worst case scenario extracted and presented in the results and maps.

Figure 4-1 Hydraulic Model Schematization



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Hydraulic Model Schematization

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Inflow / Outflow Boundary Condition
- Existing Culvert Structure
- Source Area Boundary Condition
- Hydraulic Model Extent

FIGURE 4-1

1:6,000 Scale at A3

m
0 50 100 150 200

N

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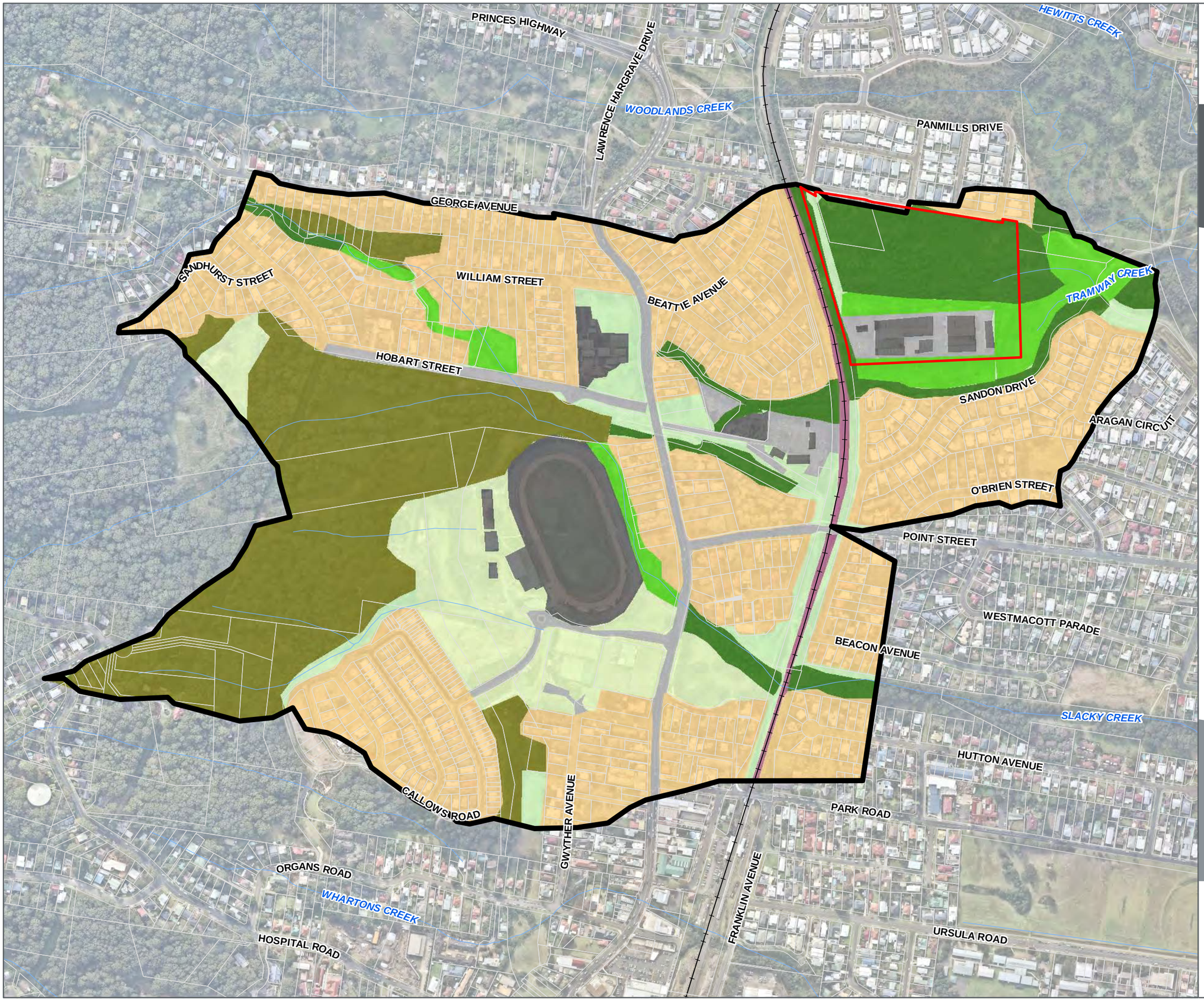
Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-14 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-003_HydraulicModel.mxd 03
Aerial imagery supplied by nearmap (May, 2018)

Figure 4-2 Spatial Distribution of manning's n



Anglicare

Spatial Distribution of Mannings n

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Cadastre (DFSI-SS, 2018)
- Hydraulic Model Extent

Materials Used For Modelling (Manning's n)

- Building (n = 1.00)
- Creek Heavy Vegetation (n = 0.09)
- Creek Light Vegetation (n = 0.05)
- Forest / Dense Vegetation (n = 0.09)
- Open Space / Parkland (n = 0.04)
- Rail Corridor (n = 0.08)
- Road, Concrete, Pavement (n = 0.02)
- Urban Residential (n = 1.00)

FIGURE 4-2

1:6,000 Scale at A3

m
0 50 100 150 200

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-004_Mannings.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

4.5 Pre-Development Scenario

The model set up for the pre-development scenario was run for the 100 year ARI design event and the PMF. The pre-development simulation results are presented in **Appendix C**.

The existing culverts under the Illawarra Railway and Geraghty Street do not have sufficient capacity to convey the 100 year ARI design event. Therefore, it is predicted that the Illawarra Railway and Geragthy Street will be overtopped by the 100 year ARI design event from Cookson's Creek catchment. The flow conveyed by the culverts is predicted to discharge into Cookson's Creek. The flows overtopping the railway embankment are predicted to flow south along Geragthy Street and then flood the site in a 100 year ARI design event. A more severe flooding of the site from Cookson's creek catchment is anticipated in PMF.

The flood behaviour in Tramway Creek represents a more complex situation. Significant flows from Slacky Creek are predicted to be diverted into the Tramway catchment in a 100 year ARI design event and greater events up to and including PMF. This is a result of the controls imposed by the culverts under Hobart Street and the disused Bulli Colliery railway. The flows diverted from Slacky Creek and the flows from the Tramway Creek are directed into a single 2.1m RCP pipe culvert under the Illawarra Railway just upstream of the proposed development site. Significant headwater is predicted upstream of this culvert in a 100 year ARI design event. However, no overtopping of the rail at the location of this culvert is predicted in the flows up to and including 100 year ARI design event. Significant overtopping of the Illawarra Railway is expected at this location in PMF. Tramway Creek is predicted to overtop the rail embankment in PMF and then flood the proposed development site.

4.6 Post-Development Scenario

A post-development scenario was set up based on the pre-development scenario and incorporating the following updates:

- The design surface levels for the proposed development. The residential development level was determined based on the PMF flood level.
- Incorporate the sound barrier wall to the western boundary of the site. A sound barrier wall was required to be installed between the proposed development site and the railway corridor. However, this wall will be designed to act as flood barrier as well.
- Make the existing pipe under the Geragthy Street redundant (due to conflict with the proposed layout) and incorporate a new culvert to discharge into the Cookson's Creek within the site in a location to the south of the existing discharge point. Refer to **Figure 1-1** (proposed development plan) for more details on the culverts modifications arrangement).

The post-development scenario was run for the 100 year ARI design event and the PMF. The flood result maps for the post development scenario as well as the impact maps are in Appendix C.

The proposed sound barrier is predicted to provide significant flood mitigation benefits for the proposed development in 100 year ARI design event and PMF. Flows overtopping the railway from the Tramway Creek will be diverted from the proposed site by the wall from the site into the railway drain and ultimately into the Tramway Creek. The flows overtopping the rail from Cookson's creek catchment will be collected by a proposed culvert system behind the wall and will convey the flows into the Cookson's Creek within the site.

4.6.1 Impacts

An impacts assessment was undertaken by comparing the post-development results to the pre-development results for 100 year ARI design event and PMF.

The proposed development is expected to result in increases in Maximum Water Surface Elevation of generally less than 100mm and up to 250mm is limited spots along the Cookson Creek (within the site) in a 100 year ARI design events. No impacts is predicted within the rail corridor as a result of the proposed development in a 100 year ARI design event.

Increases in Maximum Water Surface Elevation of up to 100mm are predicted within Cookson's Creek within the site as a result of the proposed development in PMF. Increase in Maximum Water Surface Elevation of generally less than 100mm (and up to 350mm in localised areas) is anticipated within Tramway Creek as a result of the proposed development (to the south of the proposed site) in PMF. Increases in Maximum Water Surface Elevation of up to 1000mm are expected against the proposed sound barrier wall within the rail corridor. However, these impacts are limited to the drains within the rail corridor with no impacts on the rail formation level in PMF.

5 Stormwater Drainage Concept

A stormwater drainage concept has been prepared based the proposed architectural layout, road design and existing survey/contour information available. It consists of the following components:

- Pit and piped drainage for Geraghty Street
- Internal road pit and pipework for the retirement village area
- Vegetated swale drainage for the southern end of the retirement village
- Vegetated swale drainage for the western properties adjacent to the turpentine forest
- Water quality treatment using raingardens/bio-retention for individual properties and isolated parking areas
- Two on site detention and water quality basins at the eastern end of the property adjacent to Cookson's Creek outside the 100 year flood extents
- Internal road pit and pipework for the RACF /independent living area (as referred to in the layout plans provided by architects) including raingardens for water quality treatment
- Gross pollutant traps at the south east and south west corners of the development

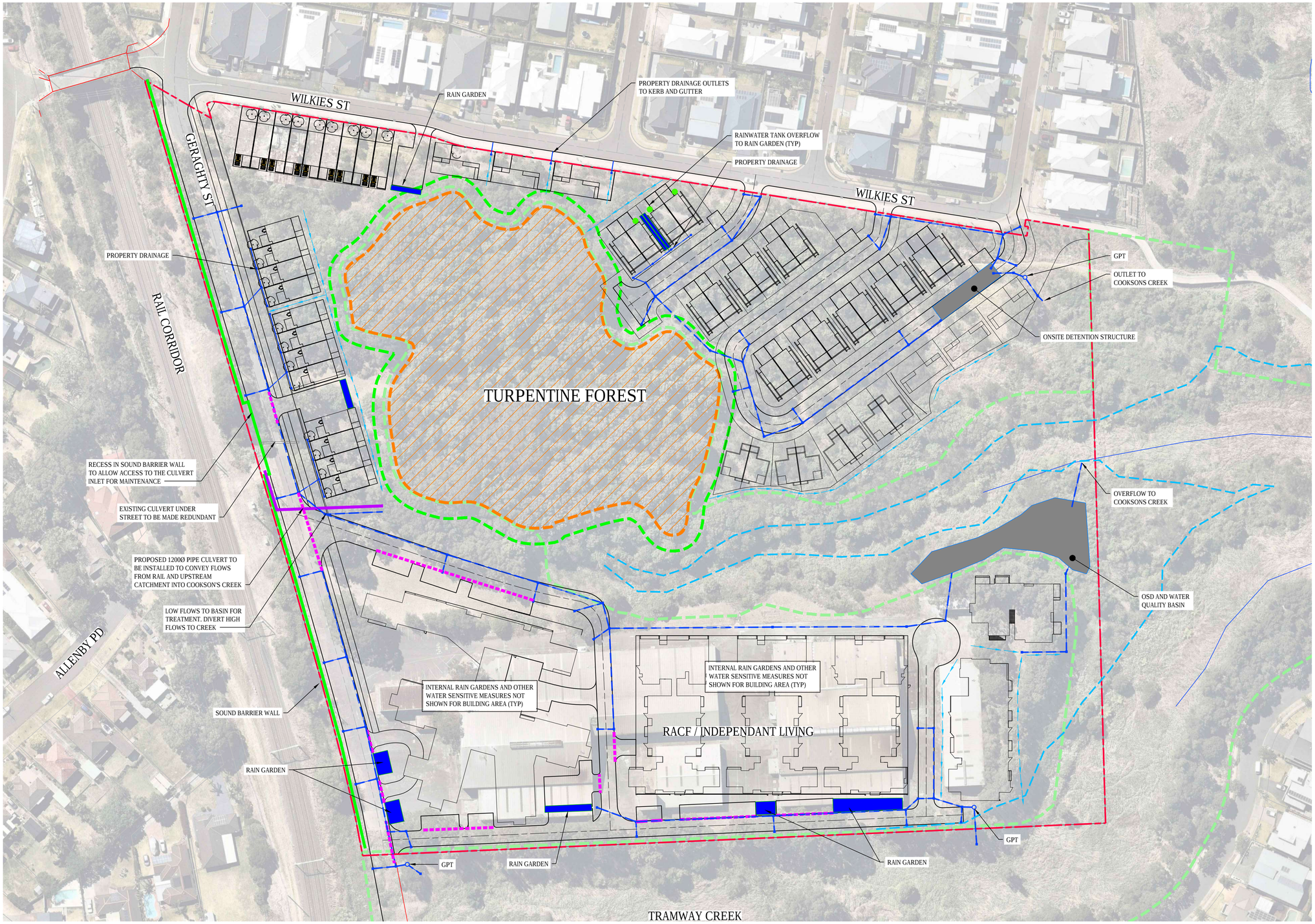
The internal site drainage discharges mainly to the two basins which outlet to Cookson's Creek. Geraghty Street, Western residences, and the lower southern portion of for the RACF independent living area discharges to Tramway Creek. A small portion of the proposed residences along the northwest corner of the property discharge to Wilkies Street and outlet to the kerb and gutter. **Figure 5-1** illustrates the stormwater drainage arrangement.

The concept shown by GHD Anglican Retirement Villages - Surface Water Management Report – May 2006 stormwater management plan differs to the proposal submitted by Cardo. Main differences are:

- Only one water quality basin nominated centrally near Cookson's Creek (in the flood plain).
- The previous proposal does not take into account the natural contours of the site or adjacent roads.
- The architectural and road layout has changed
- A bridge no longer connects the two sides of the development
- Overland flow directions have been confirmed by ground survey
- Water quality requirements are still the same as per the GHD report but rainwater tanks overflow to a raingarden where possible before connecting into the piped system

In general, the drainage concept is consistent with the concept proposed by GHD and has been updated to reflect the latest updates to the proposed development layout.

Figure 5-1 Drainage Concept Plan



NEARMAP IMAGE SOURCED DEC 2017

LEGEND

- PROPERTY BOUNDARY
- APZ BOUNDARY
- E2 ZONING BOUNDARY
- EXISTING FOREST
- APPROX. 100YR FLOOD EXTENTS
- EXISTING WATER COURSE
- CONCEPT DISH DRAIN LOCATION
- CONCEPT RAIN GARDEN LOCATION
- CONCEPT VEGETATED SWALE
- CONCEPT STORMWATER LINE
- CONCEPT STORMWATER STRUCTURE
- EXISTING STORMWATER STRUCTURE
- 10.0 DESIGN SURFACE CONTOURS
- PROPOSED ACOUSTIC WALL
- PROPOSED CULVERT

CONCEPT STORMWATER LAYOUT PLAN

SCALE 1:750

0 15 30 45 60 75m

SCALE 1:750 (A1), 1:1500 (A3)

Rev.	Date	Description	Des.	Verif.	Appd.
1	14/08/2018	ISSUED FOR INFORMATION	BAH	AD	

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Drawn	BAH	Date 10/08/2018
Checked	MPR	Date 10/08/2018
Designed	BAH	Date 10/08/2018
Verified	AD	Date 14/08/2018
Approved		

Client: ANGLICARE

Project: SANDON POINT RETIREMENT VILLAGE

Title: CONCEPT STORMWATER LAYOUT PLAN

Status: FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

DATUM		Scale	Size
AHD		1:750	A1

Drawing Number: 82018138-001-SK009

Revision: 1

6 Conclusion

The current study can be concluded as follows:

- The current study has been undertaken for Anglicare to support their concept plan modification application for an aged care facility in Bulli, NSW.
- A WBNM model was developed to determine the flow hydrographs for the study catchment.
- A two-dimensional TUFLOW model was developed to predict the flood behaviour on the site.
- The runoff from the Cookson's Creek catchment is predicted to overtop the railway and then flood the Geragthy Street and the site in pre-development scenario in a 100 year ARI design event and PMF. Tramway Creek is anticipated to overtop the rail in pre-development scenario in 100 year ARI design event and flood the site.
- The proposed development scenario raises the site levels to PMF, incorporates a sound barrier wall along the western boundary of the site and proposes replacement of the culvert under the Geragthy Street due to constraints imposed by the proposed development layout. The proposed development is predicted to result in a development which is above the PMF flood levels.
- Increases in MWSE of up to 1m are predicted against the proposed sound barrier wall and within the rail corridor. However, this increase is limited to the drain area and no impacts on the rail formation or closure time of the track is predicted. No impacts are predicted elsewhere as a result of the proposed development in the flood events up to and including PMF.
- A concept drainage has been prepared based on the updated layout (refer to Figure 5-1 for a copy of the concept drainage plan). In general, the drainage concept has been prepared consistent with the approved concept previously proposed by GHD with updates to reflect the changes to the development layout and taking into the account the site constraints.

APPENDIX

A

WBNM INPUT PARAMETERS

2. Catchment Details

Steps 2.1 to 2.4: Enter Data for each Subarea in the Model, including Topology, Surface and Flowpath Blocks and Loss Details

Catchment Statistics

Total Area [ha]	289.5
Total Impervious Percent [%]	18.3
No. of Subareas	41
No. of Subareas with WC Factor	41

2.1 Catchment Details

Routing Options | Sort Subareas | Import Mid/Mif

2.2 Lag Parameters

Populate

2.3 Flowpaths

Populate

2.4 Rainfall Losses

Continuing Loss Rate | Populate

								C	Imp Lag	Type	Value	IL	CLR	Imp IL	
								1.29	0.1	R	1	0	2.5	0	0
Subarea Name	D/S Subarea	Area	CG Coords (MGA)		Outlet Coords (MGA)		Imp Fraction								
		ha	E	N	E	N	%					mm	mm/hr	mm	
SC27	SC26	21.72	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC26	SC25	15.35	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC25	SC24	13.82	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC24	SC21	4.58	0	0	0	0	24	1.29	0.1	R	1	0	2.5	0	
SC23	SC21	6.23	0	0	0	0	19	1.29	0.1	R	1	0	2.5	0	
SC21	SC20	2.37	0	0	0	0	37	1.29	0.1	R	1	0	2.5	0	
SC22	SC20	2.66	0	0	0	0	70	1.29	0.1	R	1	0	2.5	0	
SC20	SC28	5.59	0	0	0	0	60	1.29	0.1	R	1	0	2.5	0	
SC28	SC5	2.89	0	0	0	0	46	1.29	0.1	R	1	0	2.5	0	
SC19	SC16	20.96	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC18	SC16	6.91	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC16	SC15	4.13	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC17	SC15	3.38	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC15	SC12	4.24	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC14	SC13	22.31	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC13	SC12	3.79	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC12	SC11	20.8	0	0	0	0	17	1.29	0.1	R	1	0	2.5	0	
SC11	SC10	18.73	0	0	0	0	3	1.29	0.1	R	1	0	2.5	0	
SC10	SC9	7.79	0	0	0	0	5	1.29	0.1	R	1	0	2.5	0	
SC9	SC5	3.02	0	0	0	0	38	1.29	0.1	R	1	0	2.5	0	
SC5	SC3	2.25	0	0	0	0	1	1.29	0.1	R	1	0	2.5	0	
SC6	SC4	4.77	0	0	0	0	2	1.29	0.1	R	1	0	2.5	0	
SC4	SC3	6.96	0	0	0	0	7	1.29	0.1	R	1	0	2.5	0	
SC3	SC1	2.25	0	0	0	0	45	1.29	0.1	R	1	0	2.5	0	
SC8	SC7	7.51	0	0	0	0	13	1.29	0.1	R	1	0	2.5	0	
SC7	SC2	6.68	0	0	0	0	70	1.29	0.1	R	1	0	2.5	0	
SC2	SC1	12.24	0	0	0	0	40	1.29	0.1	R	1	0	2.5	0	
SC1	dummy1	8.58	0	0	0	0	41	1.29	0.1	R	1	0	2.5	0	

TC7	TC4	5.27	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC6	TC4	2.91	0	0	0	0	58	1.29	0.1	R	1	0	2.5	0
TC5	TC4	2.18	0	0	0	0	70	1.29	0.1	R	1	0	2.5	0
TC8	TC4	0.54	0	0	0	0	31	1.29	0.1	R	1	0	2.5	0
TC9	TC4	2.7	0	0	0	0	70	1.29	0.1	R	1	0	2.5	0
TC4	TC3	6.96	0	0	0	0	60	1.29	0.1	R	1	0	2.5	0
TC3	TC1	12.15	0	0	0	0	51	1.29	0.1	R	1	0	2.5	0
TC10	TC1	2.29	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC2	TC1	2.31	0	0	0	0	5	1.29	0.1	R	1	0	2.5	0
TC1	dummy2	9.68	0	0	0	0	13	1.29	0.1	R	1	0	2.5	0
dummy1	dummy3	0	0	0	0	0	0	1.29	0.1	R	1	0	2.5	0
dummy2	dummy3	0	0	0	0	0	0	1.29	0.1	R	1	0	2.5	0
dummy3	SINK	0	0	0	0	0	0	1.29	0.1	R	1	0	2.5	0

APPENDIX

B

WBNM RESULTS

6. Results-Tables

View Results in Tabular Format

Results for Runfile: N:\Oran Park\Projects\FY18\138_Anglicare Bulli Redevelopment\Des-An\Hydrology\WBNM\temp03_Meta.out

6.1 Results

View Results at Location: Stream Top | Flowrates | Volumes | Time to Peaks | Structures

Storm No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ARI	**100**	**100**	**PMF**	**PMF**											
Duration	90	120	30	60											
Catchment Area	289.5	289.5	289.5	289.5											
Impervious percent (%)	18.3	18.3	18.3	18.3											
Rainfall Depth (mm)	139.51	159.33	221.41	325.22											
Excess Rainfall (mm)	136.45	155.24	220.39	323.18											
Runoff Depth (mm)	133.07	149.22	218.71	320.42											
Time to Rain Peak (mins)	30	35	10	10											
VOLUMES at Outlet [m3]															
SC27	29225	33044	47676	69857											
SC26	49710	56083	81305	119115											
SC25	67987	76546	111497	163336											
SC24	73977	83204	121475	177928											
SC23	8495	9648	13726	20138											
SC21	85522	96205	140334	205562											
SC22	3680	4197	5879	8631											
SC20	96531	108531	158377	231992											
SC28	100206	112550	164604	241089											
SC19	28214	31905	46016	67427											
SC18	9366	10619	15196	22295											
SC16	43101	48726	70262	102987											
SC17	4587	5206	7444	10912											
SC15	53335	60254	86986	127506											
SC14	30010	33928	48971	71749											
SC13	35072	39620	57277	83919											
SC12	115938	130628	189708	277988											
SC11	140208	157497	230413	337493											
SC10	150009	168168	247186	361994											
SC9	153652	172035	253593	371344											
SC5	256279	286985	422822	619143											
SC6	6473	7344	10500	15401											
SC4	15909	18028	25807	37860											
SC3	274595	307388	453236	663689											
SC8	10216	11596	16531	24256											
SC7	19440	22081	31287	45919											
SC2	36153	41006	58238	85480											
SC1	320807	358929	529530	775481											
TC7	7253	8257	11637	17077											
TC6	4013	4574	6427	9434											
TC5	3016	3440	4818	7073											
TC8	739	841	1190	1746											
TC9	3735	4260	5967	8761											
TC4	28360	32288	45419	66680											
TC3	45038	51192	72221	106040											
TC10	3151	3590	5055	7419											
TC2	3141	3565	5087	7461											
TC1	64418	73052	103628	152127											
dummy1	320807	358929	529530	775481											
dummy2	64418	73052	103628	152127											
dummy3	385224	431982	633158	927608											
PEAK FLOWRATES [m3/s]															
PEAK Stream Top															
SC27	0	0	0	0											
SC26	10.083	10.005	23.68	21.675											
SC25	13.857	14.52	36.839	36.25											
SC24	17.431	18.122	46.955	48.704											
SC23	0	0	0	0											
SC21	20.498	21.277	55.512	58.581											
SC22	0	0	0	0											
SC20	21.661	22.508	58.741	62.932											
SC28	22.75	23.443	61.182	67.311											
SC19	0	0	0	0											
SC18	0	0	0	0											
SC16	13.816	13.536	31.738	28.39											
SC17	0	0	0	0											
SC15	16.009	16.468	39.988	36.285											
SC14	0	0	0	0											
SC13	10.295	10.224	24.21	22.218											
SC12	27.765	28.795	71.546	66.632											
SC11	30.97	31.92	83.157	84.581											
SC10	34.327	35.215	91.456	99.594											
SC9	35.609	36.717	93.484	105.674											
SC5	58.818	60.685	154.596	177.052											
SC6	0	0	0	0											
SC4	2.947	2.753	6.271	5.429											
SC3	62.314	64.313	163.271	188.938											
SC8	0	0	0	0											
SC7	4.628	4.262	9.641	8.415											
SC2	8.268	7.814	17.865	15.696											
SC1	69.736	72.088	183.002	214.224											
TC7	0	0	0	0											
TC6	0	0	0	0											
TC5	0	0	0	0											
TC8	0	0	0	0											
TC9	0	0	0	0											
TC4	10.574	9.85	20.866	16.903											
TC3	12.931	12.589	28.831	24.453											
TC10	0	0	0	0											
TC2	0	0	0	0											
TC1	20.534	20.073	47.622	41.795											
dummy1	71.144	73.694	182.698	218.689											
dummy2	21.404	22.07	55.236	50.872											
dummy3	85.013	87.745	225.175	263.053											
PEAK Stream Bottom															
SC27	0	0	0	0											
SC26	7.762	8.104	20.773	20.943											
SC25	12.621	13.076	33.784	35.327											

SC24	17.127	17.726	45.856	48.378
SC23	0	0	0	0
SC21	20.354	21.089	54.771	58.361
SC22	0	0	0	0
SC20	21.38	22.07	57.385	62.446
SC28	22.63	23.314	60.722	67.133
SC19	0	0	0	0
SC18	0	0	0	0
SC16	12.075	12.469	30.58	28.234
SC17	0	0	0	0
SC15	15.06	15.611	38.903	36.11
SC14	0	0	0	0
SC13	9.09	9.432	23.299	22.112
SC12	24.078	24.966	64.249	64.514
SC11	28.815	29.658	76.594	82.419
SC10	33.65	34.66	88.683	98.809
SC9	35.45	36.566	92.648	105.239
SC5	58.719	60.581	153.849	176.608
SC6	0	0	0	0
SC4	2.2	2.269	5.655	5.143
SC3	62.212	64.223	162.569	188.488
SC8	0	0	0	0
SC7	3.526	3.625	8.941	8.068
SC2	6.108	6.337	15.864	14.873
SC1	69.277	71.671	179.457	212.208
TC7	0	0	0	0
TC6	0	0	0	0
TC5	0	0	0	0
TC8	0	0	0	0
TC9	0	0	0	0
TC4	8.116	8.151	18.973	16.145
TC3	10.216	10.487	25.948	23.057
TC10	0	0	0	0
TC2	0	0	0	0
TC1	17.121	17.657	44.304	40.646
dummy1	71.144	73.694	182.698	218.689
dummy2	21.404	22.07	55.236	50.872
dummy3	85.013	87.745	225.175	263.053
PEAK Local Perv				
SC27	9.891	9.865	23.395	21.455
SC26	7.543	7.431	17.492	15.636
SC25	6.941	6.811	15.983	14.197
SC24	2.221	2.063	4.732	4.033
SC23	3.054	2.884	6.546	5.717
SC21	1.053	0.949	2.178	1.822
SC22	0.597	0.547	1.206	0.992
SC20	1.508	1.373	3.173	2.675
SC28	1.096	0.986	2.271	1.901
SC19	9.623	9.586	22.717	20.759
SC18	3.945	3.771	8.655	7.588
SC16	2.552	2.387	5.453	4.684
SC17	2.146	1.99	4.569	3.89
SC15	2.61	2.444	5.58	4.803
SC14	10.097	10.08	23.917	21.992
SC13	2.37	2.208	5.057	4.319
SC12	8.34	8.255	19.487	17.559
SC11	8.68	8.607	20.34	18.389
SC10	4.212	4.038	9.295	8.158
SC9	1.289	1.163	2.693	2.262
SC5	1.503	1.368	3.162	2.665
SC6	2.862	2.693	6.128	5.319
SC4	3.767	3.593	8.23	7.21
SC3	0.889	0.805	1.823	1.521
SC8	3.797	3.623	8.301	7.273
SC7	1.369	1.239	2.867	2.412
SC2	4.185	4.012	9.229	8.101
SC1	3.062	2.892	6.564	5.733
TC7	1.743	1.598	3.687	3.12
TC6	0.88	0.796	1.802	1.503
TC5	0.498	0.458	1.008	0.816
TC8	0.296	0.276	0.601	0.468
TC9	0.605	0.554	1.222	1.007
TC4	1.829	1.681	3.875	3.284
TC3	3.512	3.339	7.624	6.672
TC10	0.829	0.752	1.693	1.411
TC2	1.484	1.349	3.119	2.628
TC1	4.687	4.516	10.437	9.179
dummy1	0	0	0	0
dummy2	0	0	0	0
dummy3	0	0	0	0
PEAK Local Imp				
SC27	0.193	0.187	0.371	0.285
SC26	0.137	0.133	0.263	0.203
SC25	0.123	0.12	0.237	0.183
SC24	0.931	0.889	1.832	1.39
SC23	1	0.954	1.969	1.497
SC21	0.749	0.717	1.469	1.114
SC22	1.545	1.466	3.055	2.353
SC20	2.709	2.552	5.373	4.231
SC28	1.118	1.066	2.204	1.681
SC19	0.186	0.18	0.358	0.276
SC18	0.062	0.061	0.119	0.092
SC16	0.037	0.036	0.071	0.055
SC17	0.031	0.03	0.058	0.045
SC15	0.038	0.037	0.073	0.057
SC14	0.198	0.192	0.381	0.293
SC13	0.034	0.033	0.065	0.051
SC12	2.849	2.682	5.651	4.459
SC11	0.487	0.468	0.95	0.723
SC10	0.341	0.329	0.662	0.506
SC9	0.971	0.927	1.91	1.451
SC5	0.02	0.02	0.039	0.03
SC6	0.086	0.083	0.164	0.127
SC4	0.424	0.408	0.825	0.63
SC3	0.86	0.823	1.691	1.281
SC8	0.831	0.794	1.632	1.235
SC7	3.716	3.484	7.368	5.886
SC2	3.881	3.637	7.696	6.161
SC1	2.835	2.669	5.623	4.436
TC7	2.153	2.034	4.266	3.327
TC6	1.406	1.336	2.778	2.133

TC5	1.277	1.215	2.52	1.929
TC8	0.149	0.145	0.287	0.221
TC9	1.567	1.487	3.099	2.388
TC4	3.337	3.134	6.62	5.261
TC3	4.852	4.531	9.61	7.782
TC10	0.969	0.925	1.906	1.448
TC2	0.103	0.101	0.198	0.153
TC1	1.061	1.012	2.09	1.591
dummy1	0	0	0	0
dummy2	0	0	0	0
dummy3	0	0	0	0
PEAK Directed to Btm				
SC27	0	0	0	0
SC26	0	0	0	0
SC25	0	0	0	0
SC24	0	0	0	0
SC23	0	0	0	0
SC21	0	0	0	0
SC22	0	0	0	0
SC20	0	0	0	0
SC28	0	0	0	0
SC19	0	0	0	0
SC18	0	0	0	0
SC16	0	0	0	0
SC17	0	0	0	0
SC15	0	0	0	0
SC14	0	0	0	0
SC13	0	0	0	0
SC12	0	0	0	0
SC11	0	0	0	0
SC10	0	0	0	0
SC9	0	0	0	0
SC5	0	0	0	0
SC6	0	0	0	0
SC4	0	0	0	0
SC3	0	0	0	0
SC8	0	0	0	0
SC7	0	0	0	0
SC2	0	0	0	0
SC1	0	0	0	0
TC7	0	0	0	0
TC6	0	0	0	0
TC5	0	0	0	0
TC8	0	0	0	0
TC9	0	0	0	0
TC4	0	0	0	0
TC3	0	0	0	0
TC10	0	0	0	0
TC2	0	0	0	0
TC1	0	0	0	0
dummy1	0	0	0	0
dummy2	0	0	0	0
dummy3	0	0	0	0
PEAK OUTLET Inflow				
SC27	10.083	10.005	23.68	21.675
SC26	13.857	14.52	36.839	36.25
SC25	17.431	18.122	46.955	48.704
SC24	18.453	19.07	49.452	52.579
SC23	4.054	3.661	8.349	7.136
SC21	20.987	21.751	56.597	60.501
SC22	2.142	2.013	4.26	3.346
SC20	22.75	23.443	61.182	67.311
SC28	23.293	23.967	62.47	69.571
SC19	9.809	9.721	22.992	20.972
SC18	4.008	3.815	8.745	7.668
SC16	14.164	14.6	35.674	32.632
SC17	2.177	2.011	4.62	3.933
SC15	16.928	17.552	43.805	40.576
SC14	10.295	10.224	24.21	22.218
SC13	10.963	11.345	27.824	26.076
SC12	30.97	31.92	83.157	84.581
SC11	34.327	35.215	91.456	99.594
SC10	35.609	36.717	93.484	105.674
SC9	36.067	37.249	93.624	107.571
SC5	59.204	61.102	154.845	178.425
SC6	2.947	2.753	6.271	5.429
SC4	6.123	6.049	14.397	12.707
SC3	62.664	64.725	163.186	190.147
SC8	4.628	4.262	9.641	8.415
SC7	8.268	7.814	17.865	15.696
SC2	13.299	13.1	30.876	27.85
SC1	71.144	73.694	182.698	218.689
TC7	3.896	3.582	7.703	6.447
TC6	2.286	2.133	4.531	3.636
TC5	1.774	1.673	3.528	2.745
TC8	0.445	0.421	0.888	0.679
TC9	2.172	2.041	4.321	3.396
TC4	12.931	12.589	28.831	24.453
TC3	17.149	17.17	41.441	36.458
TC10	1.798	1.677	3.563	2.859
TC2	1.587	1.424	3.293	2.774
TC1	21.404	22.07	55.236	50.872
dummy1	71.144	73.694	182.698	218.689
dummy2	21.404	22.07	55.236	50.872
dummy3	85.013	87.745	225.175	263.053
PEAK OUTLET Outflow				
SC27	10.083	10.005	23.68	21.675
SC26	13.857	14.52	36.839	36.25
SC25	17.431	18.122	46.955	48.704
SC24	18.453	19.07	49.452	52.579
SC23	4.054	3.661	8.349	7.136
SC21	20.987	21.751	56.597	60.501
SC22	2.142	2.013	4.26	3.346
SC20	22.75	23.443	61.182	67.311
SC28	23.293	23.967	62.47	69.571
SC19	9.809	9.721	22.992	20.972
SC18	4.008	3.815	8.745	7.668
SC16	14.164	14.6	35.674	32.632
SC17	2.177	2.011	4.62	3.933
SC15	16.928	17.552	43.805	40.576
SC14	10.295	10.224	24.21	22.218

SC13	10.963	11.345	27.824	26.076
SC12	30.97	31.92	83.157	84.581
SC11	34.327	35.215	91.456	99.594
SC10	35.609	36.717	93.484	105.674
SC9	36.067	37.249	93.624	107.571
SC5	59.204	61.102	154.845	178.425
SC6	2.947	2.753	6.271	5.429
SC4	6.123	6.049	14.397	12.707
SC3	62.664	64.725	163.186	190.147
SC8	4.628	4.262	9.641	8.415
SC7	8.268	7.814	17.865	15.696
SC2	13.299	13.1	30.876	27.85
SC1	71.144	73.694	182.698	218.689
TC7	3.896	3.582	7.703	6.447
TC6	2.286	2.133	4.531	3.636
TC5	1.774	1.673	3.528	2.745
TC8	0.445	0.421	0.888	0.679
TC9	2.172	2.041	4.321	3.396
TC4	12.931	12.589	28.831	24.453
TC3	17.149	17.17	41.441	36.458
TC10	1.798	1.677	3.563	2.859
TC2	1.587	1.424	3.293	2.774
TC1	21.404	22.07	55.236	50.872
dummy1	71.144	73.694	182.698	218.689
dummy2	21.404	22.07	55.236	50.872
dummy3	85.013	87.745	225.175	263.053

TIME to Peaks [mins]

TIME Stream Top

SC27	0	0	0	0
SC26	30	40	20	35
SC25	34	43	25	35
SC24	40	46	25	40
SC23	0	0	0	0
SC21	40	45	25	40
SC22	0	0	0	0
SC20	41	46	26	40
SC28	44	49	28	42
SC19	0	0	0	0
SC18	0	0	0	0
SC16	30	40	20	30
SC17	0	0	0	0
SC15	32	41	20	30
SC14	0	0	0	0
SC13	30	40	20	35
SC12	34	43	22	34
SC11	40	48	25	39
SC10	46	53	30	43
SC9	49	58	31	45
SC5	50	59	31	45
SC6	0	0	0	0
SC4	30	40	15	25
SC3	51	60	32	45
SC8	0	0	0	0
SC7	30	40	15	25
SC2	30	40	20	25
SC1	51	60	31	45
TC7	0	0	0	0
TC6	0	0	0	0
TC5	0	0	0	0
TC8	0	0	0	0
TC9	0	0	0	0
TC4	30	35	10	20
TC3	30	40	16	21
TC10	0	0	0	0
TC2	0	0	0	0
TC1	30	40	20	25
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	58	30	45

TIME Stream Bottom

SC27	0	0	0	0
SC26	40	47	27	40
SC25	44	51	29	42
SC24	44	51	29	42
SC23	0	0	0	0
SC21	43	49	28	41
SC22	0	0	0	0
SC20	45	51	30	43
SC28	46	52	30	44
SC19	0	0	0	0
SC18	0	0	0	0
SC16	33	42	22	34
SC17	0	0	0	0
SC15	36	45	24	35
SC14	0	0	0	0
SC13	34	43	23	36
SC12	43	50	29	41
SC11	48	55	32	45
SC10	50	58	33	46
SC9	52	60	33	46
SC5	52	60	33	46
SC6	0	0	0	0
SC4	34	43	22	31
SC3	53	61	33	47
SC8	0	0	0	0
SC7	33	42	22	30
SC2	35	44	24	35
SC1	55	63	34	48
TC7	0	0	0	0
TC6	0	0	0	0
TC5	0	0	0	0
TC8	0	0	0	0
TC9	0	0	0	0
TC4	31	41	17	23
TC3	35	44	22	29
TC10	0	0	0	0
TC2	0	0	0	0
TC1	35	44	24	32
dummy1	55	63	33	47
dummy2	33	42	22	31

dummy3	48	58	30	45
TIME Local Perv				
SC27	30	40	20	35
SC26	30	40	20	30
SC25	30	40	20	30
SC24	30	40	15	20
SC23	30	40	15	25
SC21	30	35	15	20
SC22	30	35	10	20
SC20	30	40	15	20
SC28	30	35	15	20
SC19	30	40	20	35
SC18	30	40	20	25
SC16	30	40	15	25
SC17	30	40	15	20
SC15	30	40	15	25
SC14	30	40	20	35
SC13	30	40	15	20
SC12	30	40	20	30
SC11	30	40	20	30
SC10	30	40	20	25
SC9	30	40	15	20
SC5	30	40	15	20
SC6	30	40	15	25
SC4	30	40	20	25
SC3	30	35	15	20
SC8	30	40	20	25
SC7	30	40	15	20
SC2	30	40	20	25
SC1	30	40	20	25
TC7	30	40	15	20
TC6	30	35	15	20
TC5	30	35	10	20
TC8	30	35	10	20
TC9	30	35	10	20
TC4	30	40	15	20
TC3	30	40	20	25
TC10	30	35	15	20
TC2	30	40	15	20
TC1	30	40	20	25
dummy1	0	0	0	0
dummy2	0	0	0	0
dummy3	0	0	0	0
TIME Local Imp				
SC27	30	35	10	10
SC26	30	35	10	10
SC25	30	35	10	10
SC24	30	35	10	20
SC23	30	35	10	20
SC21	30	35	10	10
SC22	30	35	10	20
SC20	30	35	10	20
SC28	30	35	10	20
SC19	30	35	10	10
SC18	30	35	10	10
SC16	30	35	10	10
SC17	30	35	10	10
SC15	30	35	10	10
SC14	30	35	10	10
SC13	30	35	10	10
SC12	30	35	10	20
SC11	30	35	10	10
SC10	30	35	10	10
SC9	30	35	10	20
SC5	30	35	10	10
SC6	30	35	10	10
SC4	30	35	10	10
SC3	30	35	10	20
SC8	30	35	10	10
SC7	30	35	10	20
SC2	30	35	10	20
SC1	30	35	10	20
TC7	30	35	10	20
TC6	30	35	10	20
TC5	30	35	10	20
TC8	30	35	10	10
TC9	30	35	10	20
TC4	30	35	10	20
TC3	30	35	10	20
TC10	30	35	10	20
TC2	30	35	10	10
TC1	30	35	10	20
dummy1	0	0	0	0
dummy2	0	0	0	0
dummy3	0	0	0	0
TIME Directed to Btm				
SC27	0	0	0	0
SC26	0	0	0	0
SC25	0	0	0	0
SC24	0	0	0	0
SC23	0	0	0	0
SC21	0	0	0	0
SC22	0	0	0	0
SC20	0	0	0	0
SC28	0	0	0	0
SC19	0	0	0	0
SC18	0	0	0	0
SC16	0	0	0	0
SC17	0	0	0	0
SC15	0	0	0	0
SC14	0	0	0	0
SC13	0	0	0	0
SC12	0	0	0	0
SC11	0	0	0	0
SC10	0	0	0	0
SC9	0	0	0	0
SC5	0	0	0	0
SC6	0	0	0	0
SC4	0	0	0	0
SC3	0	0	0	0
SC8	0	0	0	0

SC7	0	0	0	0
SC2	0	0	0	0
SC1	0	0	0	0
TC7	0	0	0	0
TC6	0	0	0	0
TC5	0	0	0	0
TC8	0	0	0	0
TC9	0	0	0	0
TC4	0	0	0	0
TC3	0	0	0	0
TC10	0	0	0	0
TC2	0	0	0	0
TC1	0	0	0	0
dummy1	0	0	0	0
dummy2	0	0	0	0
dummy3	0	0	0	0
TIME OUTLET Inflow				
SC27	30	40	20	35
SC26	34	43	25	35
SC25	40	46	25	40
SC24	42	49	27	41
SC23	30	40	15	20
SC21	42	48	27	41
SC22	30	35	10	20
SC20	44	49	28	42
SC28	45	52	30	44
SC19	30	40	20	35
SC18	30	40	20	25
SC16	32	41	21	32
SC17	30	40	15	20
SC15	35	44	23	34
SC14	30	40	20	35
SC13	33	42	22	35
SC12	40	48	25	39
SC11	46	53	30	43
SC10	49	58	31	45
SC9	52	60	33	46
SC5	52	60	33	46
SC6	30	40	15	25
SC4	30	40	20	26
SC3	53	61	33	46
SC8	30	40	15	25
SC7	30	40	20	25
SC2	30	40	20	30
SC1	55	63	33	47
TC7	30	35	15	20
TC6	30	35	10	20
TC5	30	35	10	20
TC8	30	35	10	20
TC9	30	35	10	20
TC4	30	40	16	21
TC3	30	40	20	26
TC10	30	35	10	20
TC2	30	35	15	20
TC1	33	42	22	31
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	58	30	45
TIME OUTLET Outflow				
SC27	30	40	20	35
SC26	34	43	25	35
SC25	40	46	25	40
SC24	42	49	27	41
SC23	30	40	15	20
SC21	42	48	27	41
SC22	30	35	10	20
SC20	44	49	28	42
SC28	45	52	30	44
SC19	30	40	20	35
SC18	30	40	20	25
SC16	32	41	21	32
SC17	30	40	15	20
SC15	35	44	23	34
SC14	30	40	20	35
SC13	33	42	22	35
SC12	40	48	25	39
SC11	46	53	30	43
SC10	49	58	31	45
SC9	52	60	33	46
SC5	52	60	33	46
SC6	30	40	15	25
SC4	30	40	20	26
SC3	53	61	33	46
SC8	30	40	15	25
SC7	30	40	20	25
SC2	30	40	20	30
SC1	55	63	33	47
TC7	30	35	15	20
TC6	30	35	10	20
TC5	30	35	10	20
TC8	30	35	10	20
TC9	30	35	10	20
TC4	30	40	16	21
TC3	30	40	20	26
TC10	30	35	10	20
TC2	30	35	15	20
TC1	33	42	22	31
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	58	30	45

APPENDIX

C

FLOOD RESULT MAPS

Anglicare

Pre-Development Flood Extent 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- 1m Flood Height Contour
- Cadastre (DFSI-SS, 2018)

Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-005_Pre_FloodExtentAEP.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Pre-Development Flood Extent PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- 1m Flood Height Contour
- Cadastre (DFSI-SS, 2018)

Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-006_Pre_FloodExtentPMF.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Pre-Development Flood Velocity 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Cadastre (DFSI-SS, 2018)

Flood Velocity (m/s)

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-007_Pre_FloodVelocityAEP.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Pre-Development Flood Velocity PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Cadastre (DFSI-SS, 2018)

Flood Velocity (m/s)

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-008_Pre_FloodVelocityPMF.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Post-Development Flood Extent 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- 1m Flood Height Contour
- Cadastre (DFSI-SS, 2018)

Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-009_Post_FloodExtentAEP.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Post-Development Flood Extent PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- 1m Flood Height Contour
- Cadastre (DFSI-SS, 2018)

Flood Depth (m)

- 0 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.25
- 1.25 - 1.50
- > 1.50

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-010_Post_FloodExtentPMF.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Post-Development Flood Velocity 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Cadastre (DFSI-SS, 2018)

Flood Velocity (m/s)

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-011_Post_FloodVelocityAEP.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Post-Development Flood Velocity PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Cadastre (DFSI-SS, 2018)

Flood Velocity (m/s)

- 0 - 1
- 1 - 2
- 2 - 3
- > 3

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-012_Post_FloodVelocityPMF.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Flood Impacts 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Cadastre (DFSI-SS, 2018)

Change in Flood Levels (m)

- Was Wet Now Dry
- < -0.1
- -0.1 to -0.05
- -0.05 to -0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- > 0.1
- Was Dry Now Wet

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-013_Post_FloodImpactsAEP.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

Anglicare

Flood Impacts PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Cadastre (DFSI-SS, 2018)

Change in Flood Levels (m)

- Was Wet Now Dry
- < -0.1
- -0.1 to -0.05
- -0.05 to -0.02
- -0.02 to 0.02
- 0.02 to 0.05
- 0.05 to 0.1
- > 0.1
- Was Dry Now Wet

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2018-08-07 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-014_Post_FloodImpactsPMF.mxd 02
Aerial imagery supplied by nearmap (May, 2018)

APPENDIX

D

SITE SURVEY

STURDEE AVENUE

Illawarra

Vacant

2

DP 595478

1
DP 224431
7544m²

2
DP 224431
7.36ha

Turpleties forest
area 1.87ha

DP 1048602

Vacant

DRIVE

SANDON

Railway

Vacant land and
Various residences
under construction

Vacant land and
Various residences
under construction

DP 1048602

Vacant

NOTES:

See page 1

PLAN: Site plan, Lot 2 DP 224431. Sturdee Avenue, Bulli.

DENNIS SMITH SURVEYS

P.R.: 5224 - 22 - B
SCALE 1:800
DATE: 19th January 2006

SHEET 5 of 5
DATUM A.H.D.

Datum Origin:	Drawn By
P.M. 17180 R.L. 27.202	M.J.B.