Flood Impact Assessment

Proposed Aged Care Facility at Bulli

8201813802

Prepared for
Anglicare

31 May 2019

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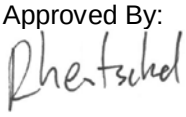

Rory Hentschel
Manager Water

Date Approved 31/05/2019

Document History

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1	08 August 2018	Issued for S75W	Ali Djozan	Rory Hentschel
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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. Refer to **Figure 1-1** for a copy of the proposed development layout.

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 1-2** 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.

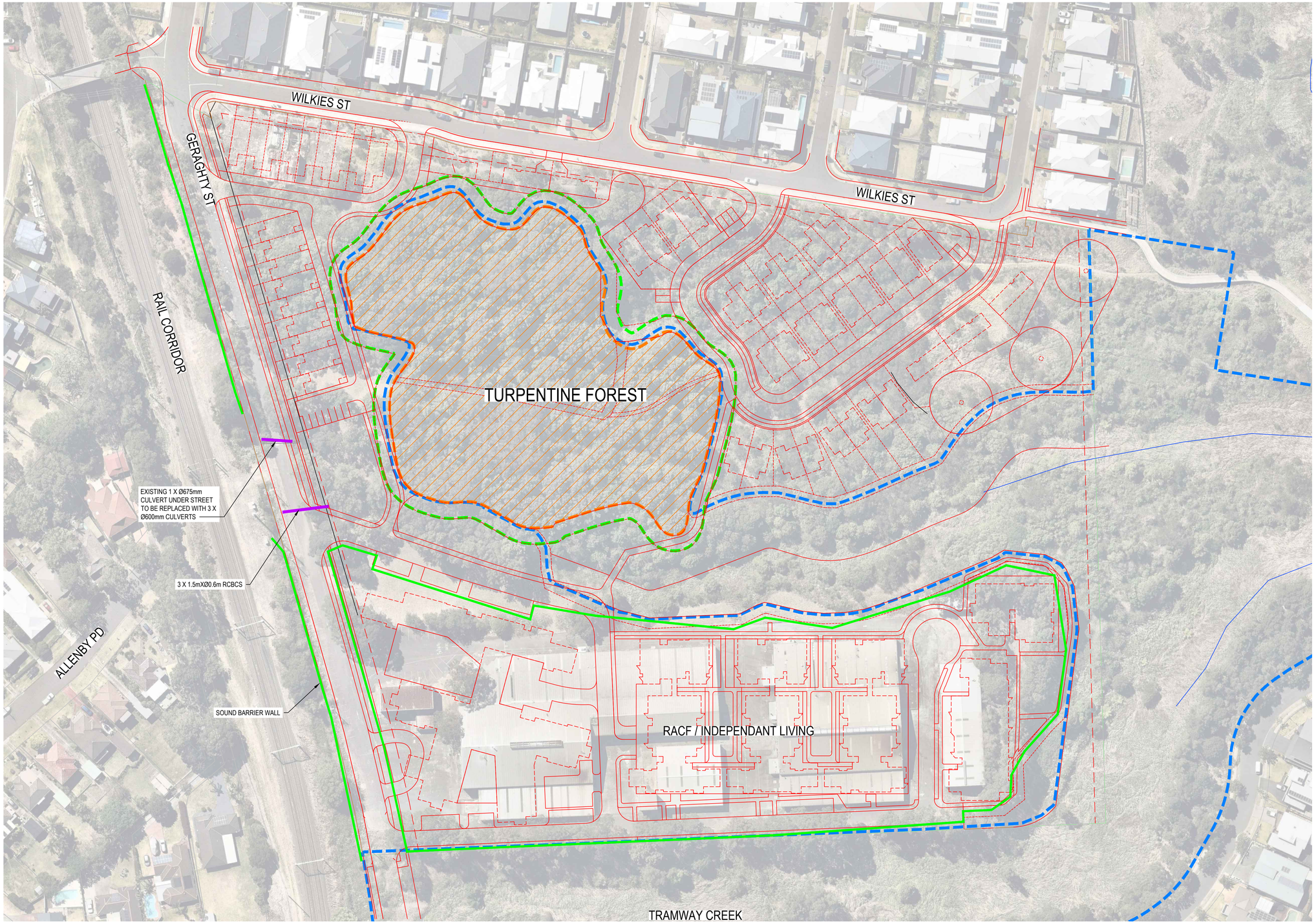
Based on the topography, Cookson Creek collects a local catchment mostly comprising the subject site with some area to the western side of the railway line.

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.
- Address the request for further information

Figure 1-1 Proposed Development Plan



NORTH

LEGEND

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

NEARMAP IMAGE SOURCED DEC 2017

WATER MANAGEMENT LAYOUT

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	

REVISION IN PROGRESS

CHECK PRINT ONLY

	PRELIMINARY ☐ FINAL ☐	INITIAL	DATE	INITIAL	DATE
	MARKUP				
	BACKDRAFTED / CORRECTED				
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Drawn	BAH	6/08/2018
Checked	MPR	10/08/2018
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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

Figure 1-2 Site Locality Plan

Anglicare

Site Locality Plan

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- 2m Contours (LPI LiDAR, 2013)
- Cadastre (DFSI-SS, 2018)

FIGURE 1-1

1:5,000 Scale at A3

m
0 50 100 150 200

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-23 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-001_SitePlan.mxd 02
Aerial imagery supplied by nearmap (March, 2019)

2 Response to Wollongong City Council RFIs

Cardno Wollongong has been instructed by EPM Projects Pty Ltd to address the issues raised by Wollongong City Council, Office of Environment and Heritage (OEH), Department of Planning and Environment (DPE) and the public upon submission of previous report dated 17 August 2018. Table 2-1 provides a summary of the issues raised and our response to address them.

Table 2-1 Agency Submissions

RFI Item ID	Description	Response
Item 1-**DPE 5A**	The Department of Planning and Environment (DPE) shares Council's concerns that the proposed flood/sound barrier along the western boundary may result in unacceptable impacts on adjoining properties. Updated flood modelling must be provided demonstrating that overland and floodwater flows would not result in any diversion of floodwater or increase flooding impacts on adjoining properties or rail infrastructure.	Our previous study focused on major flooding from Tramway Creek and Cookson Creek. This item of submission requires assessment of impacts of the proposed sound barrier on overland flows as well. In order to assess the overland flows, the catchments immediately upstream of the site has been analyzed in more detailed to allow for determination of the overland flows. This included further sub-delineation of the catchment, re-running the WBNM model and updating the TUFLOW model accordingly. Please refer to section 5.6.4 for more information. Our study shows impacts in southern adjoining property but within riparian corridor and western property within rail corridor. However, the impacts are not expected to translate to reduction in immunity or increase in closure time of the rail in the events up to PMF. Please refer to Section 5.6.4 for more information.
Item 2-**DPE 5B**	Please provide updated flood modelling which includes climate change considerations, as recommended by OEH.	A TUFLOW model was set up and run to assess the impacts of climate change in a 100 year ARI design event. Refer to Section 5.6.2 for further discussions.
Item 3-**OEH 1E**	It is suggested that further clarity be sought on the following floodplain risk management matters: • Flood impacts comparing existing with developed conditions for both existing and future implementation of relevant flood mitigation measures identified in Council's Hewitts CreekFRMP; • Climate change considerations; • Implications for the ecology of the upper reach of Cookson Creek resulting from diversion of flows; • Whether increased flows and associated afflux in the rail corridor is acceptable in terms of existing drainage infrastructure and agreeable to the land and asset owner; and	• We have reviewed the management schemes presented in Council's Hewitts CreekFRMP. We have identified that schemes SB and TB1 is more relevant to this current study as they may result in changes to the flows entering Tramway Creek. The elements of these schemes which seemed relevant were further investigated. TUFLOW model was set up and run to assess if the measures were anticipated to have reverse impacts on the flooding behavior on and around the site. Refer to Section 5.6.3 for more information. • The ecological implications to be addressed by others. • A TUFLOW model was set up and run to assess the impacts of climate change in a

	• Whether reasonable attempts have been made to seek the preferable approach of reconfiguring the layout to accommodate the existing creek.	100 year ARI design event. Refer to Section 5.6.2 for further discussions. • We have undertaken an assessment of the increased flows due to climate change and potential impacts on the rail corridor as requested by this RFI. A memo can be prepared to the rail authority to acquire their agreement if required. Please refer to Section 5.6.4 for further information. • We have removed 4 units from the existing flow path alignment (as advised by WCC), proposed a gap in the sound barrier wall and updated the TUFLOW model. The impacts assessment, flood maps and the report have been updated accordingly. Please refer to Figure 1-1 for latest development layout.
Item 4-**OEH 1F**	We recommend that water quality objectives be established for the development proposal to guide the design of stormwater treatment measures and demonstrate the influence of water quality impacts on coastal wetlands. This includes the additional impact upon water quality of any potential contaminants within the revised concept layout footprint, consistent with the relevant policy and legislative framework for the coastal environment	Water quality objectives have been established and included in this report. Refer to Section 6.1 for further information.
Item 5-**WCC 6A**	The proposed concept layout requires filling and re-aligning of an existing watercourse channel and culvert (i.e. upper portion of Cookson's Creek) to facilitate the southern-most four units of the Hilltop Precinct. This proposal is contrary to Section 10.3.7 of Chapter E14 of the Wollongong DCP2009. Also, the proposal to re-align a watercourse/culvert/overflow path with a near 90 degree bend is considered contrary to good floodplain management practice. These four units need to be removed from the proposal in order to maintain the existing watercourse and negate the need for any watercourse filling/re-alignment.	These 4 units have been removed from the layout and the TUFLOW model and the report has been updated accordingly.
Item 6-**WCC 6B**	The proposal includes filling and a sound/flood barrier along the western boundary of the property, which will obstruct overland flows and floodwater flows entering the site. This outcome is also evidenced by the submitted flood modelling, which shows significant flood level increases on the adjoining land as a result of the design. This proposal is contrary to Performance	It is noted that impacts would be anticipated as a result of a proposed development within a floodplain. However, these impacts can be alleviated to an acceptable limit. The flood maps attached to our previous study shows that no impacts in the surrounding properties are predicted as a result of the proposed development in flood events up to 100 year ARI design events. Some impacts

	Criteria 6.4.2(d) of Chapter E13 and Section 11.3.17 of Chapter E14 of the Wollongong DCP2009. The concept plan and flood modelling needs to be amended to demonstrate acceptance of overland flows and floodwater flows onto the site in a way that replicates existing conditions, and management of these flows in a way that ensures no diversion of floodwater and no increase in flooding elsewhere. It appears that engineered measures will be required within the site to accept and convey the contributing flows, and adequate space will need to be set aside in the concept plan to facilitate these measures.	are expected in rail corridor in PMF. However, this is not expected to impact on the rail formation or estimated time of submergence. Also, some impacts are predicted within the southern boundary, which is contained within the riparian corridor. However, WCC requires the proposal be modified to be more consistent with the existing flood behavior, which is compromised by the proposed diversion of flows away from Cookson Creek to facilitate 4 units and proposed installation of sound barrier. As a result, further modifications to the layout, sound barrier and the drainage system was applied to achieve a development flood behavior which is more consistent with existing case in this submission. This included the deletion of the 4 units and incorporation of a gap to the sound barrier wall. The flood model, maps and report were updated accordingly. Refer to Figure 1-1 for amended layout plan and Appendix C for the updated flood maps.
Item 7-**WCC 6C**	The concept stormwater plan includes works outside the site within the adjoining land (Lot 500 DP 1161858). Owners consent and an easement to drain water over the adjoining land (in accordance with Section 11.3.6 of Chapter E14 of the Wollongong DCP2009) would be required to facilitate this work.	The concept drainage plan was update to remove the works outside the site. Refer to concept drainage plan.
Item 8-**WCC 6D**	The proposed road off Wilkies St (between Wakefield St and Craven St) is in conflict with an existing stormwater pit. The existing system will need to be modified and a new pit will need to be constructed by the developer as part of the works, to ensure design function of the system is maintained.	The existing drainage in Wilkies Street was updated to avoid clash with the access road. Refer to concept drainage plan.
Item 9-**WCC 6E**	It is unclear why On-site Stormwater Detention (OSD) is proposed. As the site is located within an OSD concession zone and runoff from the site discharges directly to receiving waters without passing through intervening property, OSD is not required for this development. However, measures to address water quality are supported subject to further detail.	OSDs were removed from the concept drainage plans
Item 10-**WCC 8E**	Cut and fill to achieve the proposed access roads and dwellings will be significant and may adversely impact upon the existing Turpentine Forest	We have highlighted the proposed retaining wall locations and their approximate levels. Refer to bulk

	and the area of Aboriginal Heritage Significance. Retaining walls must be designed to mitigate visual impacts and allow feasible maintenance access.	earthwork plans (Refer to Appendix F for bulk earthwork plans) The visual impact to be addressed by the architect.
Item 11-**WCC 10A**	The Concept Bulk Earthworks Layout Plan Drawing Number Revision 82018138-001-SK010 by Cardno (2018a) by Cardno (2018) is noted. The plan clearly shows cut and fill on the southern boundary of the subject site to Lot 500 DP 1161858 which is owned by Stockland and proposed for dedication to Council. Any future Bulk Earthworks Layout Plan prepared for a development application must include the detail of the cut and fill to reflect the proposed Sandon Point Drive connection and Tramway Creek road bridge and having consideration to heritage, environment, flooding and equitable access matters. It is requested that any approval incorporate conditions requiring that any such crossing be constructed as by Anglicare and not by Stockland or Wollongong City Council.	The Bulk Earthworks extent has been contained within our site boundary. We have included the southern boundary on SK012 to help highlight the extent of earthworks within our boundary. The intent of Stockland is unknown. Heritage and Environmental consultants will need to address their items.
Item 12-**WCC 11A**	The proposed onsite detention and water quality basins and gross pollutant traps are clearly depicted in Figure 5-1 Drainage Concept Plan. The flood impact assessment has proposed constructed elements in the riparian zone on Lot 500 DP 1161858. In addition the following content is noted from Councils Stormwater Referral: • The concept stormwater plan includes works outside the site within the adjoining land (Lot 500 DP 1161858). Owners consent and an easement to drain water over the adjoining land (in accordance with Section 11.3.6 of Chapter E14 of the Wollongong DCP2009) would be required to facilitate this work. • Any changes to vegetation densities within the floodplain as a result of these works may require additional flood modelling in order to accurately reflect the post development flood conditions. It is unclear why On-site Stormwater Detention (OSD) is proposed. As the site is located within an OSD concession zone and runoff from the site discharges directly to receiving	OSD was removed from the proposed development concept. The drainage concept was modified to show most of the discharge structures within the development site to minimize impacts.

	waters without passing through intervening property, OSD is not required for this development. However, measures to address water quality are supported subject to further detail	

Table 2-2 Public Submissions (Flooding)

RFI Item ID	Description	Response
Item 1	The residential aged care facilities and retirement villages are built at the low area that is subject to flood risk. Given the vulnerability of the community at risk, it is not appropriate to locate them at the low side, but locate them at a higher position.	The aged care facility falls within the critical category of Chapter E13: Floodplain Management of Wollongong City Council Development Control Plan. This has been taken into account in determining the minimum development levels. Refer to Section 5.6.5 for further information.
Item 2	The effects of climate change in relation to flooding have not been considered.	Refer to response provided for Item 2 of Table 2-1.

3 Available Data

3.1 Topographic data

3.1.1 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.

3.1.2 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**.

3.2 Previous Studies

3.2.1 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.

3.2.2 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

4 Hydrology

4.1 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 vary 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 4-1 shows the catchment delineation for the study area including Cookson Creek, Tramway Creek and Slacky Creek. **Figure 4-2** shows a magnified extents of the proposed development site for catchment delineation.

Figure 4-1 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 4-1

1:12,000 Scale at A3

m
0 150 300 450 600

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-23 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-002_SubCatchment.mxd 05
Aerial imagery supplied by nearmap (March, 2019)

Figure 4-2 Catchment Plan-Zoomed at Development Site

Anglicare

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 4-2

1:3,000 Scale at A3

m
0 25 50 75 100

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-23 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-015_SubCatchment_Zoom.mxd 01
Aerial imagery supplied by nearmap (March, 2019)

4.2 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.

4.3 Model Input

4.3.1 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 4-1**. There is a generally parity between the catchment delineation undertaken by Cardno and the catchment delineation presented in WBNM report.

4.3.2 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.

4.3.3 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 4-1**.

Table 4-1 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

4.3.4 Hydrological parameters

The hydrological parameters used for input to the WBNM model are listed in **Table 4-2**.

Table 4-2 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

4.4 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**.

5 Hydraulics

5.1 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.

5.2 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 3.1**.

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 of 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 5-1**.

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 5-1**. The spatial distribution of Manning's n adopted in the TUFLOW model are shown in **Figure 5-2**.

Table 5-1 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

5.3 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 5-1**. The configuration of the proposed culvert structures is provided in **Table 5-2**. 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 5-2 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

5.4 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 5-1 Hydraulic Model Schematization

Anglicare

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
- Hydraulic Model Extent

FIGURE 5-1

1:6,000 Scale at A3

m
0 50 100 150 200

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-23 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-003_HydraulicModel.mxd 04
Aerial imagery supplied by nearmap (March, 2019)

Figure 5-2 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 5-2

1:6,000 Scale at A3

m
0 50 100 150 200

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-23 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-004_Mannings.mxd 02
Aerial imagery supplied by nearmap (March, 2019)

5.5 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.

5.6 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. Refer to Section 5.6.5
- 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. A gap is proposed to the sound barrier wall at the location of the Cookson Creek to maintain the natural flows at this location.
- Updating the existing pipe under the Geragthy Street to suit the road development 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 some 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 into the railway drain and ultimately into the Tramway Creek. The flows overtopping the rail from Cookson's Creek catchment will flow in a similar way to the pre-development case.

5.7 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 MWSE (MWSE) of generally less than 100mm and up to 1m is limited spots along the Cookson Creek (within the site) in a 100 year ARI design events. No impacts are predicted within the rail corridor and Tramway Creek as a result of the proposed development in a 100 year ARI design event.

Increases in MWSE of generally up to 100mm and up to 1 m (in some areas) are predicted within Cookson's Creek within the site as a result of the proposed development in PMF. Increase in MWSE 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 MWSE of up to 1.5m 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. Refer to Section 5.6.4 for further discussions.

5.8 Climate Change Impacts

Climate Change can potentially result in sea level rise and increased rainfall intensity in the future. The rise in sea level and increased rainfall intensity may impact on the flooding behaviour of Tramway Creek and Cookson Creek. We have studied the Review of Hewitts Creek Flood Study, Final Report (BMT WBM, August 2016) and set up a worse case climate change scenario based on this report. The climate change scenario for 100 year ARI design event comprises the following:

- Sea Level Rise of 0.9m
- Increased rainfall intensity of 30%

We note that our TUFLOW model incorporates a downstream outflow boundary immediately upstream of the ocean. Therefore, we have increased the initial water condition at the outlet boundary by 0.9m as a conservative approach for the purpose of this study. Sea level rise has been applied to 100 year ARI storm tide of 2.6m AHD in accordance with Review of Hewitts Creek Flood Study, Final Report (BMT WBM, August 2016).

The modelled climate change scenario is predicted to increase the peak flood levels in Tramway Creek (south of the site) by up to 350mm for the proposed development case in a 100 year ARI design event. Increases in maximum flood levels of up to 70mm are expected in Cookson Creek within the site in a 100 year ARI design event.

The maximum flood levels as a result of the modelled climate change is predicted to be less than proposed development PMF flood levels.

Refer to Appendix C for a map showing the predicted impacts of the climate change in the development case scenario in a 100 year ARI design event.

5.9 Hewitts Creek Management Schemes

We have reviewed the mitigation schemes as proposed and discussed in Hewitts Creek Floodplain Risk Management Study and Plan (December 2002). Only a few of the schemes were identified to be potentially relevant as they involve works around the diversion from Slacky Creek to Tramway Creek or updating the culverts over Tramway Creek.

We have only considered the elements of these schemes which could potentially have implication to our study area. These elements are as follows:

- Incorporation of larger culverts to the rail embankment on Tramway Creek - this may result in increasing the flood levels downstream of the railway (Scheme T5). Therefore, this option was further investigated within the TUFLOW model. It should be noted that the proposed development has been previously approved. Therefore, we anticipated that this mitigation scheme should not have any impacts on the proposed development.
- Removal of the diversion from Slacky Creek to Tramway Creek - this is anticipated to reduce the flows into Tramway Creek and potentially reduce the flood levels in Tramway Creek around the site. Therefore, we have not modelled this option.
- Formalization of diversion from Slacky Creek to Tramway Creek - this option is not anticipated to increase the rate of the flows diverted from Slacky Creek to Tramway Creek. Therefore, this option was not modelled as it is not anticipated to have impacts on the development.

5.9.1 Modelled Scheme

Scheme T5 comprises of the construction of a new high level culvert through the railway embankment, 6m wide by 4m high; to the south of the low level culvert (culvert just south west of the proposed development site over Tramway Creek). The pre-development and post-development TUFLOW models were updated by incorporating the proposed culvert and simulated for the PMF event.

Based on the results, the proposed culvert is predicted to convey peak flows of greater than 90m³/s in PMF. The proposed scheme is predicted to reduce the maximum flood levels upstream of the proposed pipe by up to 1.5m in PMF. The proposed scheme is anticipated to significantly reduce flooding at railway location. The maximum flood levels in Tramway Creek downstream of the proposed pipe is predicted to increase by up to approximately 60mm. However, this increase is not anticipated to impact the proposed development level or existing development along the south of Tramway Creek as a 500mm freeboard has been considered in determining the minimum development levels. The proposed scheme is predicted to reduce flooding of the buildings upstream of the rail and rail overtopping in the southern side of the proposed development. Therefore,

the proposed scheme is predicted to improve the flood immunity upstream while not significantly worsening the flooding of the proposed development site.

Difference maps have been prepared showing the impacts on the pre-development scenario and post development scenario as a result of construction of Scheme T5 (refer to Appendix C).

We note that the proposed development has already been approved and that the current study is to address changes to the proposed development layout. Therefore, we believe that the proposed schemes shall not be taken into consideration in the impacts assessment for the proposed development. Assessment of potential impacts of Scheme T5 was undertaken for information of WCC as requested.

A copy of the Floodplain Risk Management Plan extracted from Council's Hewitts Creek FRMP showing the proposed mitigation schemes including Scheme T5 is included in Appendix E of this report.

5.10 Potential Impacts on Rail Corridor

A Sydney Train railway track runs just along the western boundary of the proposed development site. The rail embankment is predicted to be overtopped in a 100 year ARI design event. The overtopping is significant in PMF event.

The overtopping of the rail occurs in two different systems:

- Northern system - Cookson Creek catchment
- Southern system - Greater Tramway Creek catchment (catchment immediately upstream of the Tramway Creek culvert).

DPE requires that the overland flows and flooding of the rail be assessed in more detail in order to determine the impacts on the rail corridor.

We note that the northern system is controlled by a local catchment. Therefore, this catchment was further delineated to allow for a more detailed assessment of the overland flows. The catchment delineation and WBNM hydrological model were updated accordingly and updated inflow hydrographs were extracted to be incorporated to the TUFLOW model. The inflow boundaries within the TUFLOW model were also updated to suit accordingly.

The southern system is controlled by a larger regional catchment. Further delineation of the catchment immediately upstream of the rail at this location will not provide any added benefits in terms of a more detailed impacts assessment.

The development layout and the proposed sound barrier has been modified to eliminate obstruction on Cookson Creek to maintain consistency with pre-development flood behaviour.

However, the sound barrier to the southern system is anticipated to result in a change in flooding regime by blocking the flows towards the proposed development site. Flows would be conveyed along/within the rail corridor drainage and ultimately to Tramway Creek in PMF event as a result of this blockage. No change in flooding regime is predicted in 100 year ARI design event.

A closer assessment of the impacts within the rail corridor was undertaken. The outcome of the assessment can be summarized as follows:

- No impacts in 100 year ARI design event
- No increase in peak water level at rail formation or rail track in PMF event
- Increase in peak flows through the rail corridor drainage by up to 3m^3/s in PMF event
- No increase in peak flow velocities in PMF event and therefore no risk of additional scouring

5.11 Minimum Development levels

The proposed development is for an aged care facility, which falls within the critical category of Chapter E13: Floodplain Management of Wollongong City Council Development Control Plan and requires the following:

- Minimum development level of PMF plus 500mm
- Reliable access is required for pedestrian and vehicles during PMF

6 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
- 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 6-1** 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.

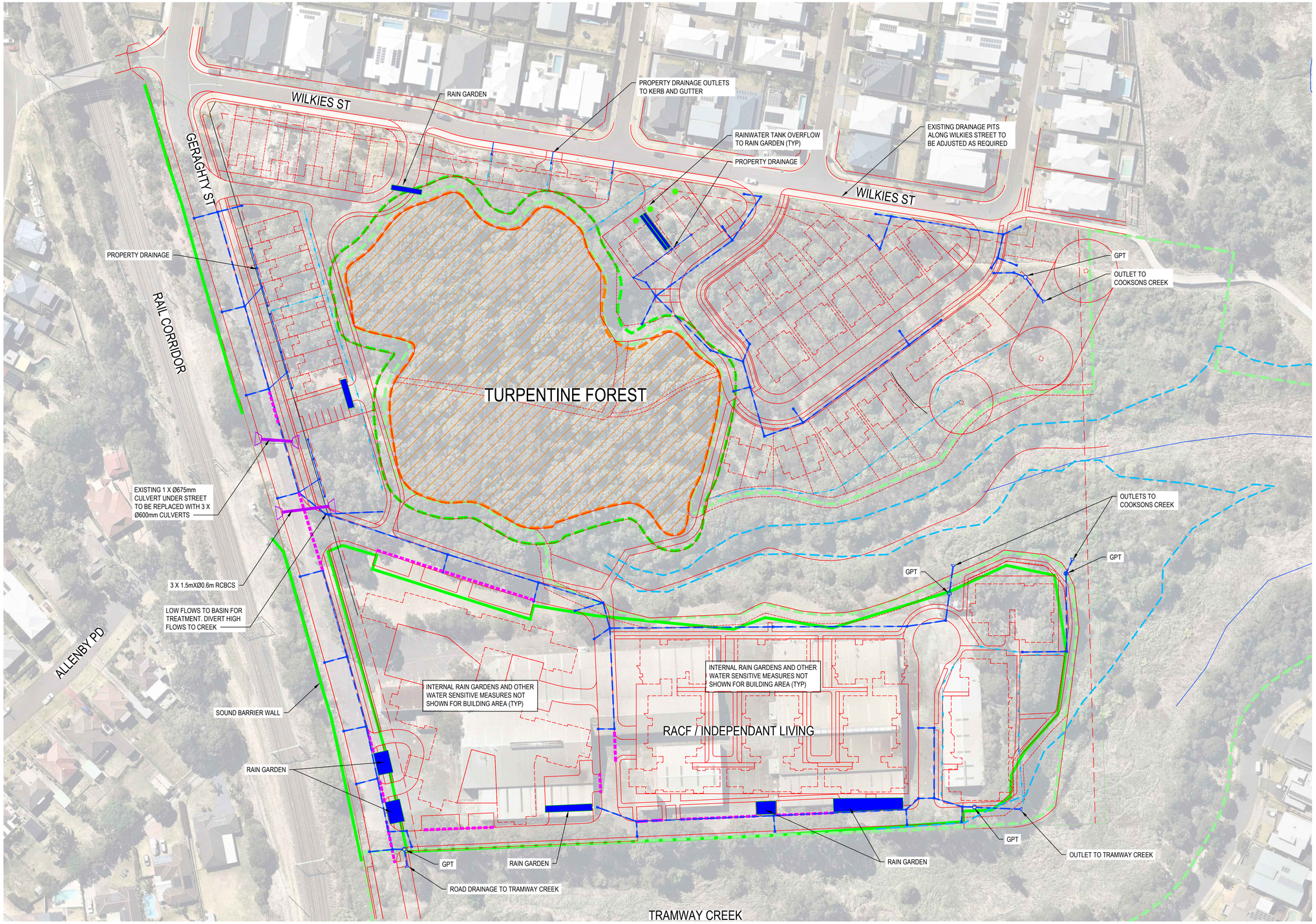
6.1 Stormwater Quality Objectives

We understand that the proposed the development falls within definition of multi-dwelling housing development. Wollongong City Council DCP-Chapter E15: Water Sensitive Urban Design sets the stormwater quality performance target for multi-dwelling housing development as shown in Table 6-1 below.

Table 6-1 WSUD Stormwater Quality Performance Targets

Performance Target Reduction Loads	Multi-Dwelling Housing Development
Gross Pollutants	90%
Total Suspended Solids	80%
Total Phosphorus	55%
Total Nitrogen	40%

Figure 6-1 Drainage Concept Plan



NEARMAP IMAGE SOURCED DEC 2017

NORTH

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	

REVISION IN PROGRESS

CHECK PRINT ONLY

	PRELIMINARY ☐ FINAL ☐	INITIAL	DATE	INITIAL	DATE
	MARKUP				
	BACKDRAFTED / CORRECTED				
	CONFIRMED				
	SELF CHECK				

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

7 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 plus freeboard, 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 1.5m 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.
- Impacts of climate change was assessed by setting up and running a climate change scenario which comprised of raising the sea level by 0.9m and increasing the rainfall intensity by 30%. Based on the results, increases in maximum water levels of up to 350mm are predicted in Tramway Creek as a result of the modelled climate change in a 100 year ARI design event. However, the 100 year ARI flood levels increase as a result of climate change are predicted to be less than PMF flood levels.
- The proposed mitigation schemes investigated in this study are not anticipated to result in significant impacts downstream of the railway. It was demonstrated that the proposed scheme improved the upstream flooding considerably.
- A concept drainage has been prepared based on the updated layout (refer to Figure 6-1 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	50
No. of Subareas with WC Factor	50

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

								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	C	Imp Lag	Type	Value	IL	CLR	Imp IL	
		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
TC10a	TC10b	0.24	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10b	TC10c	0.3	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10c	TC1	0.81	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10h	TC10i	0.14	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10i	TC1	0.23	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10j	TC1	0.19	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10d	TC10e	0.24	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10e	TC10f	0.056	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10f	TC10g	0.043	0	0	0	0	50	1.29	0.1	R	1	0	2.5	0
TC10g	TC1	0.039	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\series2 RFIS 20190508\temp_series3_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)	133.06	149.21	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	48972	71749											
SC13	35072	39620	57277	83919											
SC12	115938	130628	189708	277988											
SC11	140208	157497	230414	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
TC10a	330	376	529	777
TC10b	742	845	1191	1748
TC10c	1855	2114	2978	4372
TC10h	192	219	309	453
TC10i	508	579	816	1198
TC10j	261	298	419	615
TC10d	330	376	529	777
TC10e	407	463	653	958
TC10f	466	531	748	1098
TC10g	519	592	833	1224
TC2	3141	3565	5087	7461
TC1	64411	73045	103621	152117
dummy1	320807	358929	529530	775481
dummy2	64411	73045	103621	152117
dummy3	385217	431974	633150	927598

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	163.272	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
TC10a	0	0	0	0
TC10b	0.21	0.202	0.408	0.312
TC10c	0.448	0.423	0.902	0.682
TC10h	0	0	0	0
TC10i	0.124	0.12	0.239	0.184
TC10j	0	0	0	0
TC10d	0	0	0	0
TC10e	0.21	0.202	0.408	0.312
TC10f	0.255	0.245	0.502	0.382
TC10g	0.288	0.275	0.573	0.437
TC2	0	0	0	0
TC1	20.57	20.095	47.611	41.791
dummy1	71.144	73.694	182.698	218.689
dummy2	21.437	22.098	55.256	50.869
dummy3	85	87.727	225.142	263.038
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
TC10a	0	0	0	0
TC10b	0.188	0.18	0.395	0.303
TC10c	0.376	0.366	0.838	0.678
TC10h	0	0	0	0
TC10i	0.113	0.108	0.233	0.178
TC10j	0	0	0	0
TC10d	0	0	0	0
TC10e	0.205	0.196	0.406	0.31
TC10f	0.25	0.238	0.5	0.382
TC10g	0.281	0.271	0.57	0.436
TC2	0	0	0	0
TC1	17.147	17.68	44.306	40.64
dummy1	71.144	73.694	182.698	218.689
dummy2	21.437	22.098	55.256	50.869
dummy3	85	87.727	225.142	263.038

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
TC10a	0.102	0.097	0.203	0.153
TC10b	0.126	0.12	0.252	0.19
TC10c	0.32	0.298	0.65	0.508
TC10h	0.061	0.059	0.119	0.091
TC10i	0.098	0.094	0.194	0.147
TC10j	0.082	0.078	0.161	0.123
TC10d	0.102	0.097	0.203	0.153
TC10e	0.025	0.024	0.048	0.037

TC10f	0.019	0.019	0.037	0.029
TC10g	0.017	0.017	0.033	0.026
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
TC10a	0.107	0.104	0.206	0.159

TC10b	0.134	0.13	0.257	0.198
TC10c	0.354	0.342	0.688	0.526
TC10h	0.063	0.061	0.12	0.093
TC10i	0.103	0.1	0.197	0.152
TC10j	0.085	0.083	0.163	0.126
TC10d	0.107	0.104	0.206	0.159
TC10e	0.025	0.025	0.048	0.037
TC10f	0.019	0.019	0.037	0.029
TC10g	0.018	0.017	0.034	0.026
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
TC10a	0	0	0	0
TC10b	0	0	0	0
TC10c	0	0	0	0
TC10h	0	0	0	0
TC10i	0	0	0	0
TC10j	0	0	0	0
TC10d	0	0	0	0
TC10e	0	0	0	0
TC10f	0	0	0	0
TC10g	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	190.148
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
TC10a	0.21	0.202	0.408	0.312
TC10b	0.448	0.423	0.902	0.682
TC10c	1.038	0.957	2.118	1.698
TC10h	0.124	0.12	0.239	0.184
TC10i	0.314	0.298	0.624	0.472
TC10j	0.167	0.161	0.324	0.249
TC10d	0.21	0.202	0.408	0.312
TC10e	0.255	0.245	0.502	0.382
TC10f	0.288	0.275	0.573	0.437
TC10g	0.316	0.299	0.637	0.486
TC2	1.587	1.424	3.293	2.774
TC1	21.437	22.098	55.256	50.869
dummy1	71.144	73.694	182.698	218.689
dummy2	21.437	22.098	55.256	50.869
dummy3	85	87.727	225.142	263.038
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	190.148
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
TC10a	0.21	0.202	0.408	0.312
TC10b	0.448	0.423	0.902	0.682
TC10c	1.038	0.957	2.118	1.698
TC10h	0.124	0.12	0.239	0.184
TC10i	0.314	0.298	0.624	0.472
TC10j	0.167	0.161	0.324	0.249
TC10d	0.21	0.202	0.408	0.312
TC10e	0.255	0.245	0.502	0.382
TC10f	0.288	0.275	0.573	0.437
TC10g	0.316	0.299	0.637	0.486
TC2	1.587	1.424	3.293	2.774
TC1	21.437	22.098	55.256	50.869
dummy1	71.144	73.694	182.698	218.689
dummy2	21.437	22.098	55.256	50.869
dummy3	85	87.727	225.142	263.038
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
TC10a	0	0	0	0
TC10b	30	35	10	10
TC10c	30	35	10	13
TC10h	0	0	0	0
TC10i	30	35	10	10
TC10j	0	0	0	0
TC10d	0	0	0	0
TC10e	30	35	10	10
TC10f	30	35	10	10
TC10g	30	35	10	11
TC2	0	0	0	0
TC1	30	40	20	25
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	57	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
TC10a	0	0	0	0
TC10b	30	36	11	15
TC10c	31	39	13	20
TC10h	0	0	0	0
TC10i	30	36	10	13
TC10j	0	0	0	0
TC10d	0	0	0	0
TC10e	30	35	10	11

TC10f	30	36	10	11
TC10g	30	36	10	12
TC2	0	0	0	0
TC1	35	44	24	32
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	57	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
TC10a	30	35	10	10

TC10b	30	35	10	10
TC10c	30	35	10	20
TC10h	30	35	10	10
TC10i	30	35	10	10
TC10j	30	35	10	10
TC10d	30	35	10	10
TC10e	30	35	10	10
TC10f	30	35	10	10
TC10g	30	35	10	10
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
TC10a	30	35	10	10
TC10b	30	35	10	10
TC10c	30	35	10	10
TC10h	30	35	10	10
TC10i	30	35	10	10
TC10j	30	35	10	10
TC10d	30	35	10	10
TC10e	30	35	10	10
TC10f	30	35	10	10
TC10g	30	35	10	10
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
TC10a	0	0	0	0
TC10b	0	0	0	0
TC10c	0	0	0	0
TC10h	0	0	0	0
TC10i	0	0	0	0
TC10j	0	0	0	0
TC10d	0	0	0	0
TC10e	0	0	0	0
TC10f	0	0	0	0
TC10g	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
TC10a	30	35	10	10
TC10b	30	35	10	13
TC10c	30	35	10	20
TC10h	30	35	10	10
TC10i	30	35	10	11
TC10j	30	35	10	10
TC10d	30	35	10	10
TC10e	30	35	10	10
TC10f	30	35	10	11
TC10g	30	36	10	11
TC2	30	35	15	20
TC1	33	42	22	31
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	57	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
TC10a	30	35	10	10
TC10b	30	35	10	13
TC10c	30	35	10	20
TC10h	30	35	10	10
TC10i	30	35	10	11
TC10j	30	35	10	10
TC10d	30	35	10	10
TC10e	30	35	10	10
TC10f	30	35	10	11
TC10g	30	36	10	11
TC2	30	35	15	20
TC1	33	42	22	31
dummy1	55	63	33	47
dummy2	33	42	22	31
dummy3	48	57	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)
- Watercourse (LPI)
- 1m Flood Height Contour (mAHD)
- 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

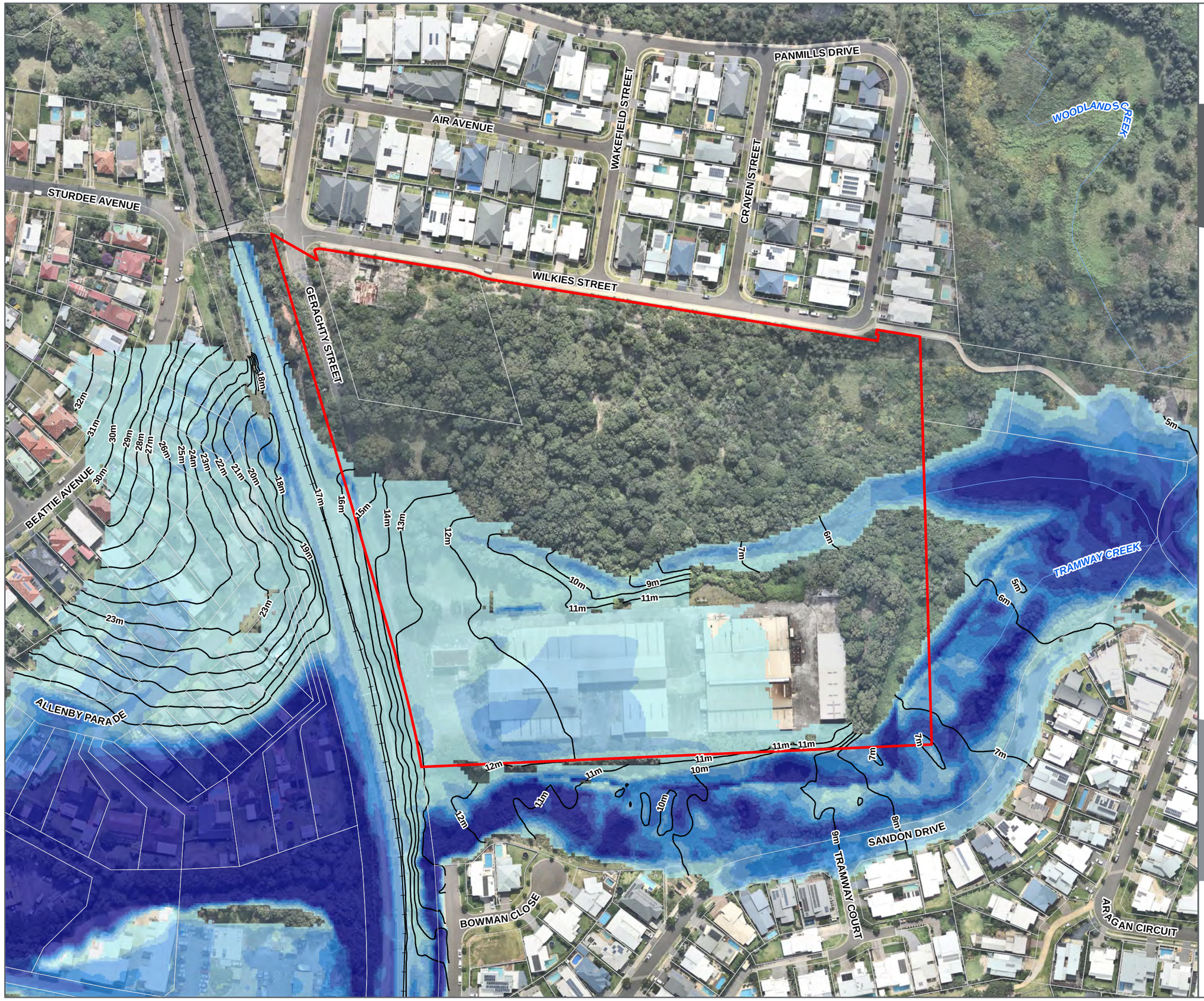
1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-22 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-005_Pre_FloodExtentAEP.mxd 03
Aerial imagery supplied by nearmap (March, 2019)



Anglicare

Pre-Development Flood Extent PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- 1m Flood Height Contour (mAHD)
- 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: 2019-05-22 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-006_Pre_FloodExtentPMF.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Pre-Development Flood Velocity 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Watercourse (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: 2019-05-22 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-007_Pre_FloodVelocityAEP.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Pre-Development Flood Velocity PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Watercourse (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: 2019-05-22 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-008_Pre_FloodVelocityPMF.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Flood Extent 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- 1m Flood Height Contour (mAHD)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-009_Post_FloodExtentAEP.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Flood Extent PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- 1m Flood Height Contour (mAHD)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-010_Post_FloodExtentPMF.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Flood Velocity 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-011_Post_FloodVelocityAEP.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Flood Velocity PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Velocity Vector
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-012_Post_FloodVelocityPMF.mxd 04
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Flood Impacts 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-013_Post_FloodImpactsAEP.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Flood Impacts PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project: 82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-014_Post_FloodImpactsPMF.mxd 03
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Climate Change Impacts

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (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: 2019-05-23 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-016_ClimateChangeImpacts.mxd 01
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Pre-Development Mitigation Scheme Impacts PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (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: 2019-05-23 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-017_Pre_MitigationImpacts.mxd 01
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Mitigation Scheme Impacts PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- 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: 2019-05-27 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-018_Post_MitigationImpacts.mxd 01
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Flood Hazard 1% AEP

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- Cadastre (DFSI-SS, 2018)

Flood Hazard

- Low Hazard
- Medium Hazard
- High Hazard

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-27 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-019_FloodHazardAEP.mxd 01
Aerial imagery supplied by nearmap (March, 2019)

Anglicare

Post-Development Flood Hazard PMF

PROPOSED AGED CARE FACILITY AT BULLI, NSW

Legend

- Site Boundary
- Railway (LPI)
- Watercourse (LPI)
- Proposed Lot Layout
- Proposed Sound Barrier
- Cadastre (DFSI-SS, 2018)

Flood Hazard

- Low Hazard
- Medium Hazard
- High Hazard

1:2,000 Scale at A3

m
0 20 40 60 80

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-05-27 | Project:82018138_02
Coordinate System: GDA 1994 MGA Zone 56
Map: 82018138-02-GS-020_FloodHazardPMF.mxd 01
Aerial imagery supplied by nearmap (March, 2019)

APPENDIX

D

SITE SURVEY

STURDEE AVENUE

Illawarra

Railway

DRIVE

SANDON

Vacant

2

DP 595478

1
DP 224431
7544m²

2
DP 224431
7.36ha

DP 1048602

Vacant

Vacant land and
Various residences
under construction

DP 1048602

Vacant

Vacant land and
Various residences
under construction

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.

APPENDIX

E

COUNCIL FLOODPLAIN RISK

SLACKY CREEK

S1	Construct a coarse debris trap comprising large steel or timber 'bollards' set into the bed of the creek. bollards to be set at 0.5-1m spacings and span full creek width. Provision to be made for maintenance access.
S2	Remove excess boulders and sediment deposited in the August 1998 flood immediately downstream of Rex Ave. Form waterway of similar capacity to that existing Pre 1998 storm.
S3	Modify downstream handrail & headwall structure elevate driveway entrance to No's 21 to 25; & lower kerb. Remove sandstone blockwork obstructing entrance to culvert.
S4	Excavate creek banks to reduce batter, widen where possible. Provide rock armour bank protection as required.
S5	Excavate sediment basin of minimum 2000 m3 volume, offline to creek, include provision for maintenance access.
S6	Modify the access road embankment including provision of a PMF safe spillway & clay lining of upstream faces. Optimisation of basin outlet by reducing outlet size. Provide a debris control structure upstream of basin outlet.
S7	Remove twin 1800 dia. culvert & access road immediately downstream of Hobart St; Construct debris control structure; & regrade Hobart St, between the Slacky Creek culvert & Haig Rd.
S8	Partially fill the northern basin outlet to elevate overtopping level. Construct flow training walls upstream of main culvert to improve hydraulic characteristics.
S9	Construct a flow training wall at RL 4.00m (approx) along the rear boundary of properties on the south bank to reduce breakout of flow. Levee to extend downstream from No 16 Hutton Ave. (final extent to be determined at detail design stage).
S10	Implement an opening policy requiring Council to clear sand from the creek outlet once a critical level (RL 2.8m) of sand "build up" is reached.
S11	Owner of Old Bulli Mine site to expedite rehabilitation works including stabilization of mine platform.

TRAMWAY CREEK

T1	Construct grass lined swale along Hobart St. (south side) to provide overland flow path. Lower Haig Rd. roundabout. Swale to extend between culvert proposed at Highway (refer T2) & Slacky Creek diversion (refer S7)
T2	Construct a (6m min.diagonal opening) culvert beneath the Highway (adjacent Hobart St. intersection) to connect the overland flow path at T4 to swale at T1. Provision to be made for debris control on the upstream side.
T3	Purchase properties at eastern end of Hobart St (No's 177 & 171-175), demolish &/or remove all structures to facilitate construction of overland flow path between Princes Highway & Tramway Creek (refer T4)
T4	Construct an overland flow path between the Highway (opposite Hobart St) & Tramway Creek (to the rear of 19 Allenby Pde). Construction to include enlargement of existing channel & excavation of a new channel (where required)
T5	Construct a new high level culvert through the railway embankement, 6m wide by 4m high,to the south of the existing low level culvert.
T6	Implement an opening policy requiring Council to clear sand from the creek outlet once a critical level (RL 2.8m) of sand "build up" is reached.

ALL CATCHMENTS
(refer study for more details)

- Implementation of Development Control Plan (DCP) to ensure all future development is compatible with flooding risks.
- Minimum width overflow paths & riparian setbacks for all development adjoining creeks & natural low points.
- Minimum requirements for floor levels & safe access to be elevated above flood levels.
- All new development to incorporate flood compatible structures including flood proof materials & fencing.
- Council to undertake an education & flood awareness program to raise general awareness of flooding behaviour in the local area. This may include flood signage, information leaflets & newspaper articles.
- All data collected and processed in this study be provided to the State Emergency Service (SES) by Wollongong City Council in a format suitable for interpretation by the SES as soon as it is available, for incorporation into the "Wollongong City Local Flood Plan".
- A Riparian Management Study be undertaken within the study area to identify possible sources of sediment, areas of general channel and bank instability and opportunities for improving the overall riparian corridor with the associated benefit of reducing wherever possible the potential for future debris mobilisation.

SUMMARY OF PROPERTIES PROTECTED - RECOMMENDED SCHEME

Creek	No. of Properties Protected									
	20% AEP		5% AEP		2% AEP		1% AEP		PMF	
	Yard	Above Floor	Yard	Above Floor	Yard	Above Floor	Yard	Above Floor	Yard	Above Floor
TOTAL	8	6	91	57	91	59	71	48	42	12
Slacky	0	0	27	1	27	1	27	1	25	1
Tramway	0	0	10	10	11	10	11	11	8	3
Woodlands	0	0	5	4	5	5	5	5	1	0
Hewitts	6	4	48	35	47	39	27	29	8	5
Hewitts (Stream 4)	0	0	0	1	0	1	0	0	0	0
Thomas Gibson	2	2	1	6	2	3	1	2	0	3

SUMMARY OF FINANCIAL BENEFITS - RECOMMENDED SCHEME

Creek	Scheme	Total Damages ($AAD)	Total Benefits $AAD	Total Benefits $NPV	Scheme Cost ($)	Benefit Cost Ratio
TOTAL		$568,750	$429,000	$11,101,907	$8,900,000	1.2
Slacky/ Tramway	SB/TB1	8,750	80,000	2,072,458	3,990,000	0.5
Woodlands/ Hewitts	WA/HA	162,750	241,000	6,290,070	2,800,000	2.2
Hewitts (Stream 4)	HS4A	54,250	39,000	994,378	260,000	3.8
Thomas Gibson	TGB	343,000	69,000	1,745,001	1,850,000	0.9

HEWITTS CREEK

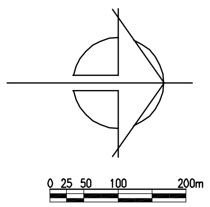
H1	Construct a coarse debris trap comprising large steel or timber 'bollards' set into the bed of the creek. bollards to be set at 0.5-1m spacings and span full creek width. Provision to be made for maintenance access.
H2	Construct a coarse debris trap comprising large steel or timber 'bollards' set into the bed of the creek. bollards to be set at 0.5-1m spacings and span full creek width. Provision to be made for maintenance access.
H3	Construct expanded inlet & debris control structure at culvert entrance & modify local drainage to prevent surcharge of pits (in front of No 25 Virginia Terrace). Rehabilitate creek channel upstream of culvert.
H4	Modify driveway entrance to No's 23 & 25 Virginia Terrace. Provide flood compatible fencing & relocate structures within overflow path. Flow training walls as necessary to protect properties.
H5	Remove excess boulders and sediment deposited in the August 1998 flood upstream of Kelton Lane. Stabilise creek banks.
H6	Excavate & enlarge creek channel & construct low levee at rear of properties in Lachlan St. to contain flows. Construct rock revetment at toe of unstable bank at rear of No 19 George St. Landscape all areas upon completion.
H7	Lower kerb & raise driveways on downstream edge of Lachlan St. (between No 6 & No 14). Construct projecting central pillar & flow training walls.
H8	Make voluntary purchase offer for No 419 Lawrence Hargrave Drive.
H9	Close access road, reconstruct creek channel between Lawrence Hargrave Dr & the rail. Reinstate natural rock pools & ripples; construction of an offline water quality control pond & sediment trap on south bank. Landscape on completion.
H10	Construct a levee at RL 4.50m (approx) along the rear boundary of properies on the north bank. Levee to extend downstream from No 17 Corbett Ave. Levee to comprise combination of earth & masonry wall. Final extent to be determined at detail design stage.
H11	Implement an opening policy requiring Council to clear sand from the creek outlet once a critical level (RL 2.8m) of sand "build up" is reached.
H12	Council to further investigate flood/ stormwater issues within the vicinity of Pass Avenue and High Street.

WOODLANDS CREEK

W1	Excavate basin of minimum 3000m3 volume, offline to creek including provision for water quality controls & landscaping with native species. Incorporate debris control structure upstream of Princes Highway culvert.
W2	Lower safety ramp by approx. 1.0m for a distance of 50m from the entry to the ramp. Excess spoil to be used for construction of levee (refer W3)
W3	Construct a levee at RL 18.50m (approx) along the rear boundary of properties on the north bank. Levee to extend between Lawrence Hargrave Drive & the railway embankment.
W4	Construct a new high level culvert through the railway embankement, 6m wide by 4m high to the north of the existing low level culvert.
W5	Close off diversion of Woodlands into Hewitts by filling existing gabion lined channel using appropriate fill material. Landscape on completion.
W6	Upgrade existing flow path to Tramway Creek by excavating an enlarged channel (where required) providing rock armour bank protection. Landscape on completion.

THOMAS GIBSON CREEK

TG1	Construct a new pipe system with multiple inlets along east side of Phillip St. Construct new "natural" watercourse along Sea Foam Ave. Raise kerb & driveways of properties in Sea Foam Ave. (No's 29-33)
TG2	Raise kerb & driveway entrances along south side of Bath St by 150mm approx. to contain minor flooding within roadway.
TG3	Lower the south bank of Flanagans Creek by up to 1m near bend in The Esplanade. Rehabilitate steep eroding banks. Enlarge table drain along east side of The Esplanade to enhance capacity.
TG4	Modify the entrance to public car park to provide for overflow. Raise kerb & driveways to protect low lying properties. (No's 101 to 105)
TG5	Modify Station St to provide one-way cross fall to south. Enlarge southern table drain to convey major flows towards playing field & into proposed detention basin. Investigate improvements to rail culvert near War Memorial.
TG6	Enlarge & strengthen existing embankment at east end of Thomas Gibson Park. Provide new outlet structure & reinforced spillway to formalise as detention basin. Remove existing diversion into Thomas Gibson Park at Lachlan St (near Uniting Church)
TG7	Modify the inlet to the Macauley St culvert by constructing tapered inlet to enhance hydraulic capacity. Modify watercourse downstream of culvert to enhance capacity. Relocate structures as necessary.
TG8	Improve culvert capacity by constructing an additional culvert or enhancing capacity of existing system. Modify roadway & existing floodgate to reduce diversion northwards to Bath St.
TG9	Implement an opening policy requiring Council to clear sand from the creek outlet once a critical level (RL 2.8m) of sand "build up" is reached.
TG10	Implement an opening policy requiring Council to clear sand from the creek outlet once a critical level (RL 2.8m) of sand "build up" is reached.
TG11	Carry out investigation to determine the capacity & condition of existing drainage infrastructure in the general area. Carry out any improvements determined necessary.



HEWITTS CREEK

Incorporating Slacky, Tramway, Woodlands & Thomas Gibson Creeks

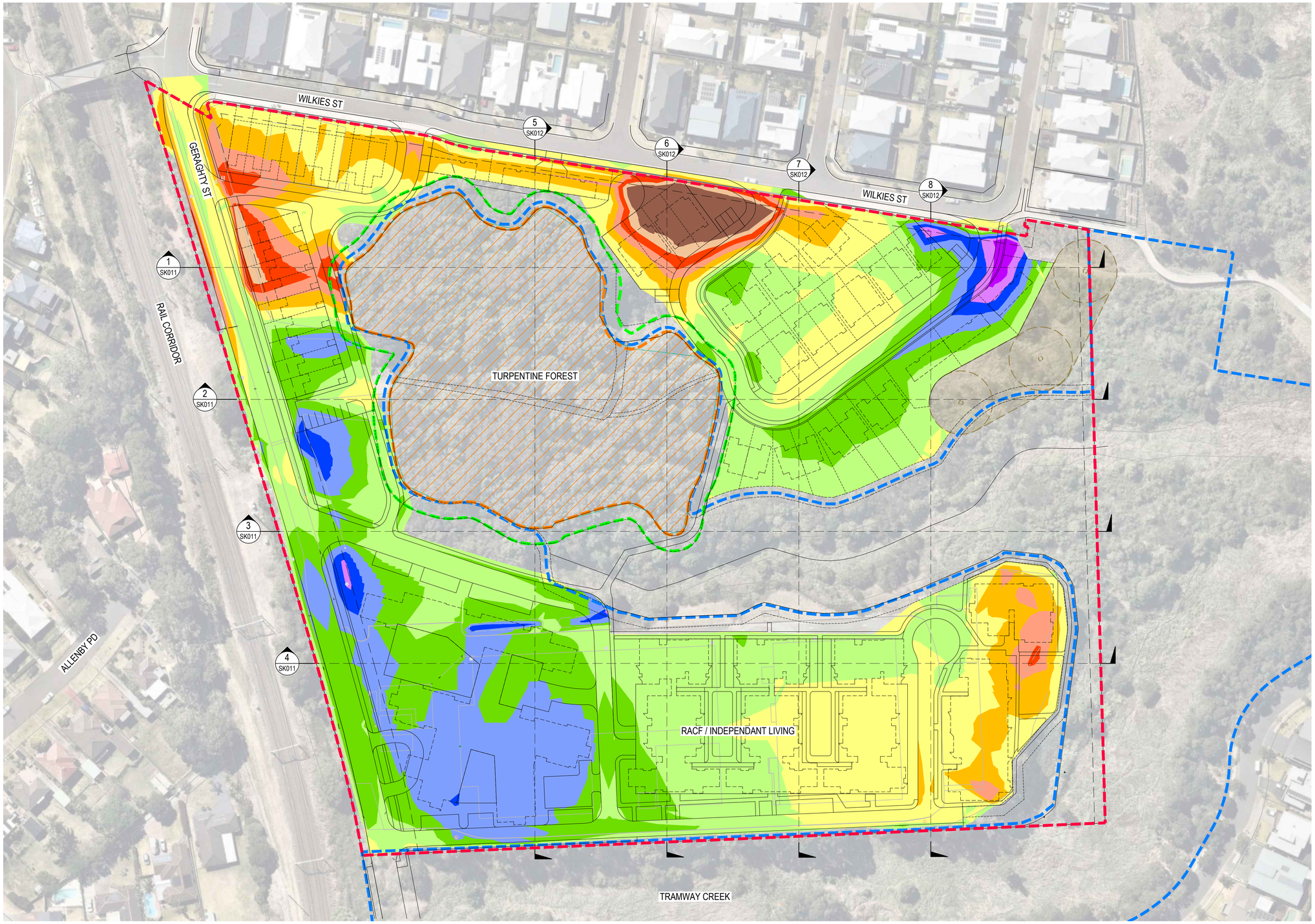
FLOODPLAIN RISK MANAGEMENT PLAN

WOLLONGONG
City of Innovation

APPENDIX

F

BULK EARTHWORK PLANS



CONCEPT EARTHWORKS VOLUMES	
PROPOSED CUT	12,145m³
PROPOSED FILL	18,953m³
BULK EARTHWORKS BALANCE	6,808m³ (FILL)

LEGEND

- SITE BOUNDARY
- APZ BOUNDARY
- E2 ZONING BOUNDARY
- EXISTING FOREST
- EXISTING ABORIGINAL ARCHAEOLOGICAL SITE
- GREATER THAN 2.5m CUT
- 2.0m TO 2.5m CUT
- 1.5m TO 2.0m CUT
- 1.0m TO 1.5m CUT
- 0.5m TO 1.0m CUT
- 0.0m TO 0.5m CUT
- 0.0m TO 0.5m FILL
- 0.5m TO 1.0m FILL
- 1.0m TO 1.5m FILL
- 1.5m TO 2.0m FILL
- 2.0m TO 2.5m FILL
- GREATER THAN 2.5m FILL

NEARMAP IMAGE SOURCED DEC 2017

CONCEPT BULK EARTHWORKS LAYOUT

SCALE 1:750

0 15 30 45 60 75m

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

Rev.	Date	Description	Des.	Verif.	Appd.
4	30/05/2019	REVISED ISSUE FOR APPROVAL	BAH	RJK	
3	12/10/2018	REVISED ISSUE FOR APPROVAL	BAH	RJK	
2	29/08/2018	REVISED ISSUE FOR APPROVAL	BAH	RJK	
1	13/08/2018	ISSUED FOR INFORMATION	BAH	RJK	

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

Client: ANGLICARE

Project: SANDON POINT RETIREMENT VILLAGE

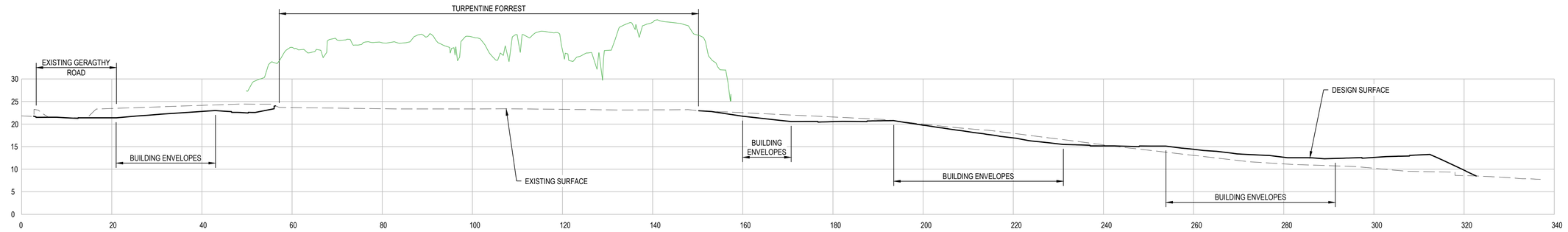
Title: CONCEPT BULK EARTHWORKS LAYOUT PLAN

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

DATUM	Scale	Size
AHD	1:750	A1

Drawing Number: 82018138-001-SK010

Revision: 4



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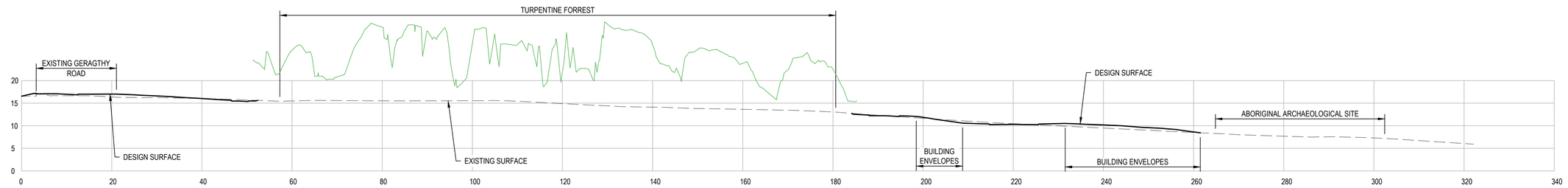

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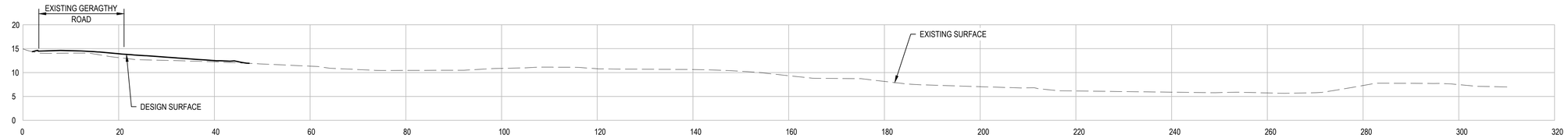

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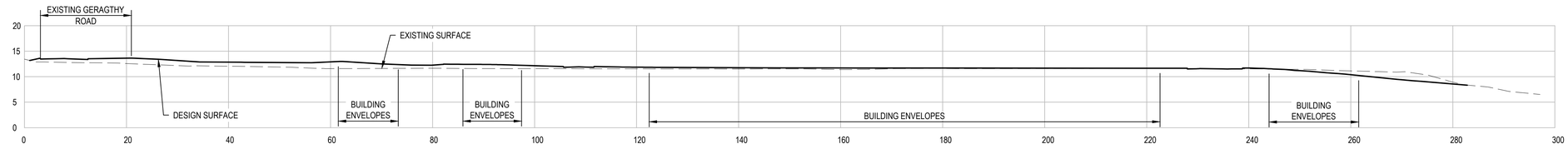

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Rev.	Date	Description	Des.	Verif.	Appd.
4	30/05/2019	REVISED ISSUE FOR APPROVAL	BAH	RJK	
3	7/11/2018	REVISED ISSUE FOR APPROVAL	BAH	RJK	
2	12/10/2018	ISSUED FOR INFORMATION	BAH	RJK	
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Verified	RJK	Date 13/08/2018
Approved		

Client ANGLICARE

Project SANDON POINT
RETIREMENT VILLAGE

Title CONCEPT BULK EARTHWORKS SECTIONS
SHEET 1 OF 2

Status FOR INFORMATION ONLY
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DATUM		Scale	Size
AHD		1:500	A1

Drawing Number 82018138-001-SK011

Revision 4

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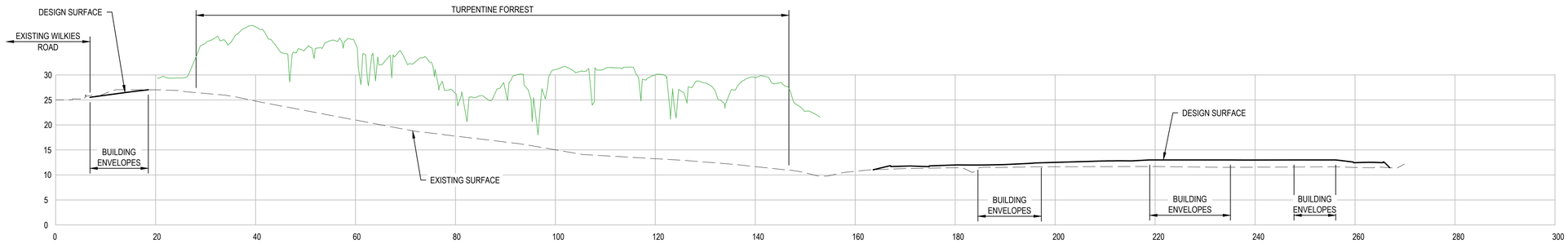

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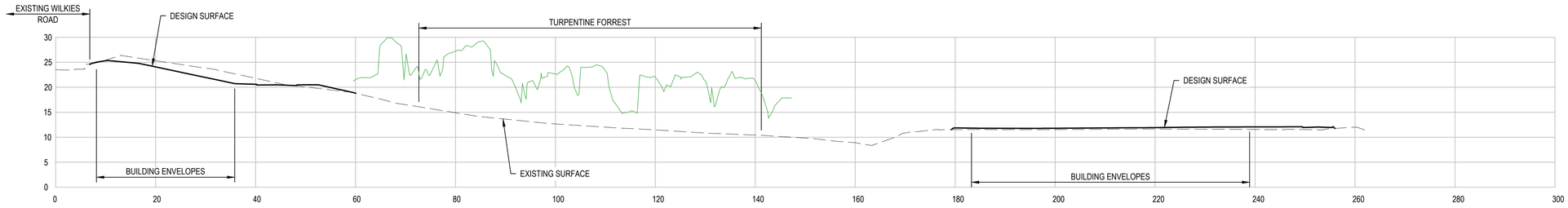

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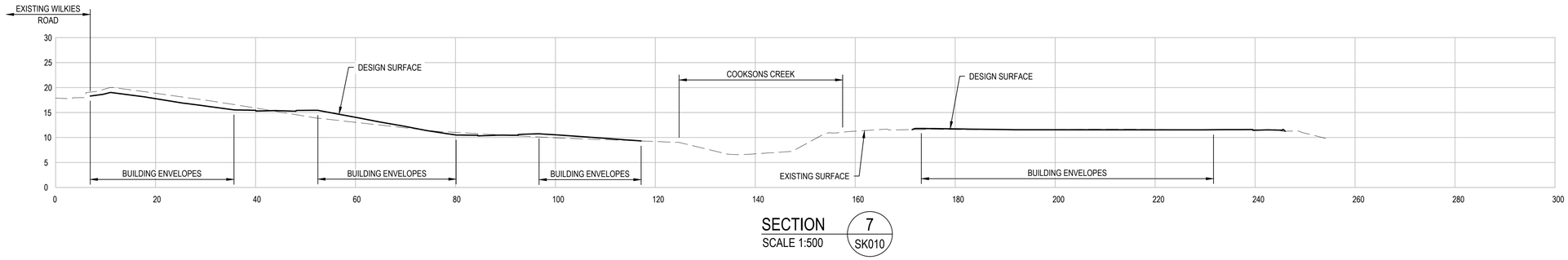

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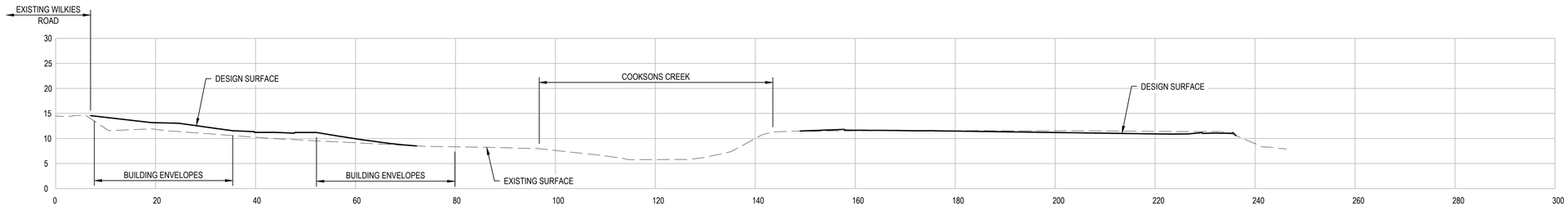

SECTION 8
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Rev.	Date	Description	Des.	Verif.	Appd.
3	30/05/2019	REVISED ISSUE FOR APPROVAL	BAH	RJK	
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Verified	RJK	Date 12/10/2018
Approved		

Client ANGLICARE

Project SANDON POINT
RETIREMENT VILLAGE

Title CONCEPT BULK EARTHWORKS SECTIONS
SHEET 2 OF 2

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DATUM	Scale	Size
AHD	1:500	A1

Drawing Number 82018138-001-SK012

Revision 3