Stormwater Management Strategy

4 Cypress Lane, Torquay

March 2024

Loetis Pty Ltd
Version: Rev08

Contact Information

Loetis Pty Ltd
ABN 74 665 148 630

PO Box 867
Geelong, Vic 3220

Email: info@Loetis.com.au
Web: www.Loetis.com.au

Document Control

Version	Date	Description of Revision	Prepared By	Reviewed By
Rev01	17 June 2021	Cardno SSMP	Cardno	
Rev02	11 May 2023	Rev 02 SSMS (Internal Issue)	LP	IC
Rev 03	12 May 2023	Rev 03 SSMS	LP	IC
Rev 04	10 July 2023	Not Issued		
Rev 05	1 November 2023	Rev 05 SSMS	LP	IC
Rev 06	1 February 2024	Rev 06 SSMS (Internal Issue)	LP	IC
Rev 07	1 March 2024	Rev 07 SSMS (Internal Issue)	LP	IC
Rev08	4 March 2024	Rev 08 SSMS	LP	IC

Document Information

Prepared For	**Jedi Building Group**
Report Title	**Stormwater Management Strategy**
Loetis Reference	**J10004**
Author	**Leigh Prossor**
Approved By	**Isaac Clarey**
Loetis Reference	**J10004**

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

Contents

List of Figures

1 Background

1.1 Introduction

Loetis has been engaged by Jedi Building Group to complete an updated Stormwater Management Strategy to accompany the planning permit application for a proposed retirement village application at 4 Cypress Lane Torquay. This property will be herein referred to as the 'subject site'.

We note the earlier Site Stormwater Management Plan (SSMP) version V01 prepared by CardnoTGM and issued in June 2021 was prepared for the site. Since the time of this earlier report preparation significant stakeholder discussion and amendment to the stormwater quality strategy has been undertaken. Additionally, the Cypress Lane Flood Impact Assessment prepared by Water Technology has been prepared and issued in November 2021, this report by Water Technology is still considered as current. However, it is intended that this Site Stormwater Management Strategy prepared by Loetis supersedes the earlier report prepared by Cardno and should be read as such.

The Rev 05 version of the report has been updated to reflect the ownership of the existing Cypress Court road reserve and Council reserve being retained in Council ownership. This has resulted in minor alterations to the layout and an adjustment in the number of proposed units. To assist in review by those familiar with the report, all alterations to the report since version 03 have been highlighted in blue text.

Revisions 06 to 08 of the report has been updated to reflect the latest Rev K architectural site plans which result in extremely minor alterations to the version V05 SSMP which have no impact on the stormwater strategy outlined in this report.

It is noted that Surf Coast Shire Engineers in response to the reviewing the Version V05 SSMP advised that,

"The Stormwater Management Plan has been amended to reflect the revised layout. The overall concept of the stormwater strategy is essentially the same as was proposed with the original layout."

Additionally, also enclosed to the V08 version of this report is the earlier Flood Impact Assessment Report and subsequent correspondence from Water Technology.

The site is a located approximately 1 km north of the Torquay township and currently zoned as low density residential under the Victorian Planning Provisions. The site is proposed to operate under an owner's corporation style arrangement resulting in all assets within the site being managed by the owner / developer.

The subject site has a total area of 5.6 hectares. The site slopes in a south easterly direction from the northern extent - adjacent Coombs Road, to the south-east corner directly adjacent Deep Creek and the Surf Coast Highway. Deep Creek is a designated water way managed by the Corangamite Catchment Management Authority (CCMA) and any works proposed within the waterway corridor are to be approved by the CCMA.

Development of the site will include construction of approximately 116 residential dwellings along with a number of apartment buildings, and associated road network along with open space and garden / landscaped areas.

The subject site can be seen in Figure 1 below.

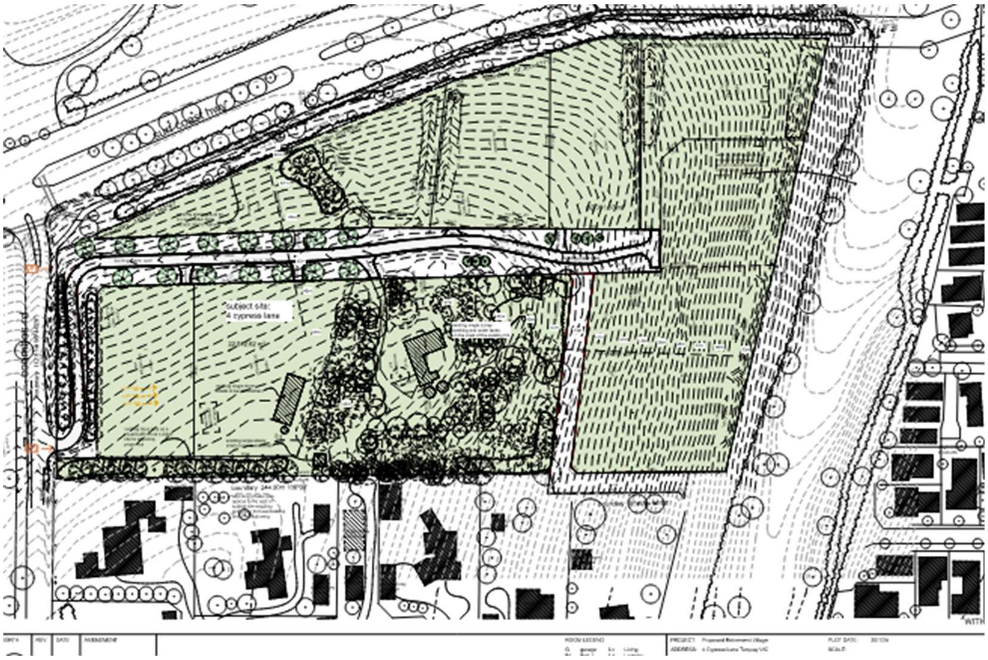


Figure 1 - Site Location and Exsting Context

The proposed development will result in an increase in impervious surface area, which if not mitigated will result in an increase in stormwater runoff volumes, flowrates and contaminant loading. This report demonstrates a stormwater assessment based on development expectations and discusses the water quality and quantity measures proposed to be implemented to ensure the development delivers best practice stormwater treatment objectives.

This report has been prepared in accordance with the requirements outlined in the Surf Coast Shire adopted Infrastructure Design Manual, Australian Rainfall and runoff and the provisions and requirements of the planning scheme. This report is considered to meet all objectives required by these documents and is considered to meet best practise requirements.

1.2 Stakeholder Engagement

The conceptualisation of a stormwater strategy for the subject site has been workshopped with Council over several meetings since the original SSMP prepared by CardnoTGM in June 2021 was submitted to accompany the original application to develop the site. It has been acknowledged that the earlier proposed distributed treatment train utilising onsite swales and bioretention 'rain gardens' to achieve the required treatment for stormwater quality deliverables was not supported and as such an alternate treatment approach is more suitable.

Following relevant authority requests for further information and feedback on the earlier proposal, this report has been prepared to respond to them. It is noted that included in these discussions have been requests as to the site discharge location and there has been desire expressed to utilise the existing stormwater infrastructure if possible.

Following the changes to the layout resulting from the Council retention of the road reserve ownership, the development team liaised with the Council officers on any impacts to the stormwater requirements for the site that this change may have. This report reflects the considerations identified.

2 Study Objectives

The objective of this Stormwater Management Strategy is to demonstrate a proposal for stormwater treatment as a part of development works which accord to local authority and best practice guidelines for stormwater quality and stormwater quantity treatment. This will enable the subdivision to meet anticipated conditions and requirements to be set in the planning permit for stormwater management and ensure that stormwater quality and quantity targets are achieved and maintained.

The site is located within Surf Coast Shire (SCS) municipality boundary, as such stormwater objectives are based on local regulatory requirements as outline in the Infrastructure Design Manual, and our professional understanding of Council's preferred infrastructure delivery mechanisms for stormwater treatment in infill developments.

Stormwater runoff generated within the site will be captured and conveyed via a combination of the underground drainage network and overland flow paths (road network) to the integrated stormwater treatment nodes to discharge to the site Legal Point of Discharge (LPOD).

Specific objectives are detailed below.

2.1 Site Stormwater Objectives

The site stormwater objectives are:

1. Best Practice reductions for Water Quality

   - 80% reduction in Suspended solids (SS)
   - 45% reduction in total nitrogen (TN)
   - 45% reduction in total phosphorus (TP)
   - 70% reduction in gross pollutants (GP)

2. Stormwater Conveyance

   Conveyance of flows up to and including the 1% AEP flows to the Legal Point of Discharge (LPOD).

   Note: refer discussion point outlined in point 3 below.

3. Stormwater Quantity

   As outlined in earlier correspondence, the LPOD for the site is to Deep Creek adjacent to the south side of the site, via the existing stormwater pipe network. As documented in the Water Technology Flood Impact Assessment, no detention is proposed to be provided as part of the development as any detention may result in a worsened scenario by pushing the site runoff closer to the peak flow within the creek. We note the correspondence advising that this approach has been agreed to by the CCMA and Council. Please refer to the Cypress Lane Flood Impact Assessment prepared by Water Technology.

   As such we note that stormwater quantity mitigation and conveyance is not covered under this report apart from the assessment of the capacity of the existing outlet pipe system.

Throughout this report the '20% AEP Storm Event' and '1% AEP Year Storm Event' will be referred to as the minor and major storm events respectively.

The following stormwater management strategy will provide details on the stormwater treatment nodes and associated infrastructure requirements for the mitigation of runoff from the development to ensure stormwater discharge targets are achieved at the designated LPOD.

One of the identified changes due to the retained ownership of Cypress Court road reserve and its council owned stormwater assets, was a requirement to clearly identify the ownership of all stormwater assets and the associated maintenance responsibilities.

3 Catchment Assessment

3.1 Existing Site Conditions

The subject site has a total area of 5.6 hectares. The site slopes in an easterly and southerly direction, with currently three separate catchments discharging from the site.

There is a 'northern' catchment of approximately 1.84Ha extent. This catchment generally falls to the northeast corner of the site at the junction of Coombes Rd and Surf Coast Highway. Its eastern extent is the existing road and kerb and channel of Cypress Lane. The flows in lower events are captured by a series of side entry pits in Cypress Lane which discharge via a 300mm stormwater pipe, this pipe connects to the Council stormwater network at the corner of Coombes Rd and Surf Coast Highway, it is understood that this network discharges east across Surf Coast Highway and discharges into the existing waterway running southeast before joining Deep Creek. The size & details of this Council pipe network is not fully known. Larger flow events beyond the pipe networks capacity flow overland along a similar route.

There is a 'eastern' catchment of some 1.65Ha in size that discharges as sheet flow across the eastern boundary of the site. This flow generally runs through the plantation reserve and onto the unsealed pedestrian path and then to the highway. Some flows appear to be captured and conveyed southwards along the path and remining are generally conveyed southwards along the Surf Coast Highway road formation. There is evidence of erosion occurring currently throughout this vicinity in the public land. Figure 2 below depicts some of these images.

The 'southern' catchment is some 2.99Ha in size. There is a 300mm pipe that conveys flows from the south end of Cypress Court and discharges directly to Deep Creek, however the majority of this catchment discharges directly to Deep Creek as sheet flow across the southern boundary and into the drainage reserve. There is also evidence of erosion in this vicinity due to this sheet flow running down the incised banks of Deep Creek.

Deep Creek is a designated water way managed by the Corangamite Catchment Management Authority (CCMA) and any works proposed within the waterway corridor are to be approved by the CCMA.

The existing site conditions & catchments for the subject site can be seen in Figure 3.

Figure 2 – Photos external to the east side of site of existing erosion from runoff from site
(2nd photo courtesy of Google maps)

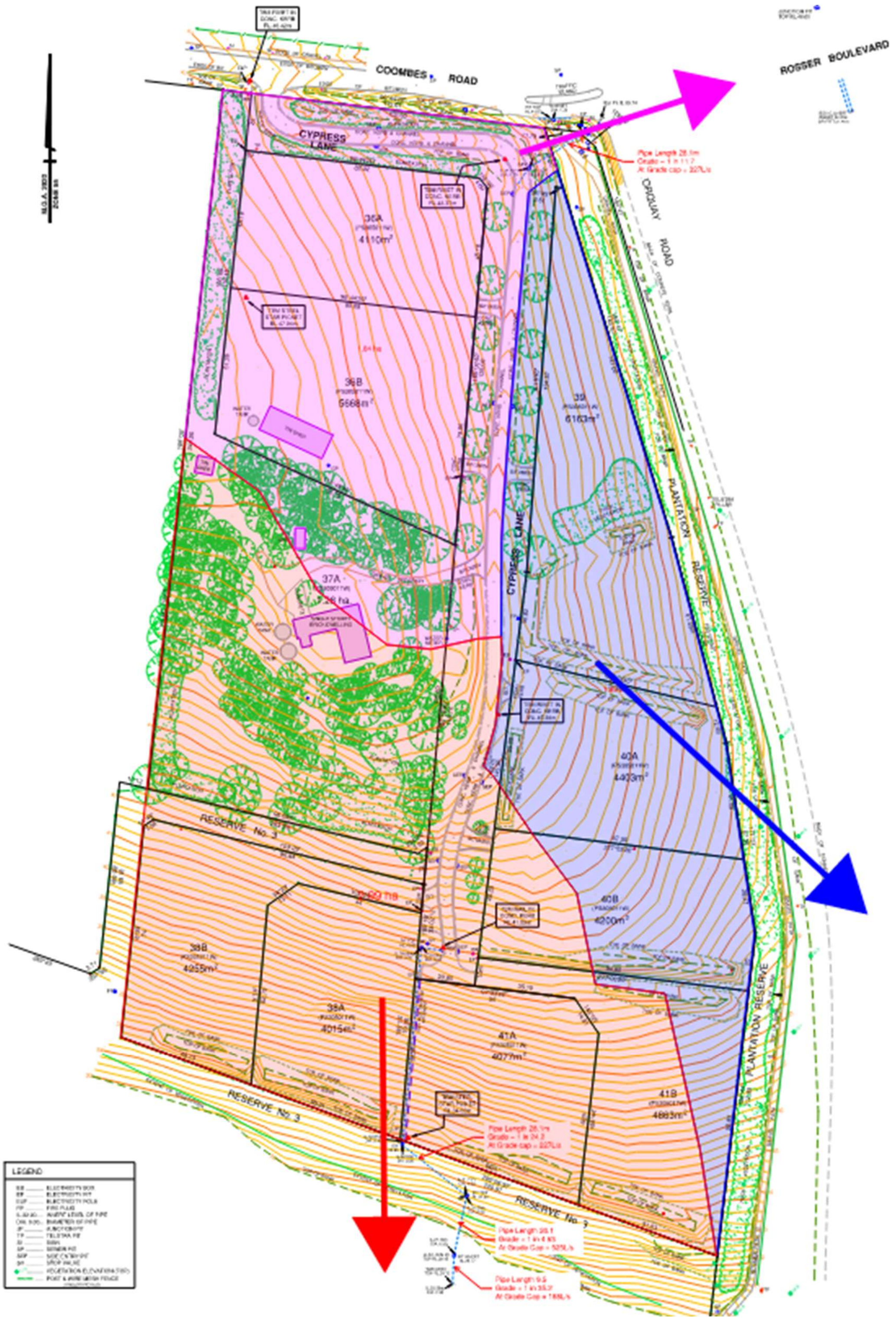


Figure 3 – Existing Site Conditions & Catchments

3.2 Developed Site Conditions

Development of the site will include construction of approximately 116 residential dwellings along with three apartment buildings and associated road network along with open space and garden / landscaped areas

The proposed development layout is demonstrated in figure 4 below.

Figure 4 – Proposed Development Layout (GKA Architects, Rev K)

4 Proposed Stormwater Discharge

Flows are directed to the Legal Point of Discharge through a combination of an underground drainage network and above ground flow paths. The underground drainage network is predominantly sized for the minor storm event, with major flows conveyed via the road network and drainage swales located within the landscaped areas.

We note that the earlier CardnoTGM SSMP identified a single LPOD for the site which was to Deep Creek adjacent to the south east corner of the site. However, with the wish to utilise the existing stormwater network for the design scenario outfalls, this single point of discharge is no longer considered feasible.

With the altered scenario of the existing road reserve being retained, it is identified that the earlier proposed catchments and treatment strategy with two proposed treatment nodes would result in a scenario whereby stormwater flows would transit from a private asset, into a Council asset and then be required to transit back to a private asset for treatment. This is not considered a desirable outcome.
Accordingly, it is proposed to revise the treatment train such that the water is collectively treated and if necessary detained before it enters the Council owned assets in Cypress Lane.

4.1 Northern Catchment (Catchment 1)

It is proposed to direct a northern catchment discharging to the 300mm dia. pipe in Cypress Lane in the northeast corner of the site. This catchment in the developed case is proposed to be reduced in size from the current 1.84Ha with the revised catchment area sized to replicate the predeveloped flows to this location.

Based on the rational method, the predevelopment 1%AEP flows for this catchment are approximately 190L/s. The existing pipe has a grade of approximately 1 in 12, giving it an at grade capacity of 327L/s, noting that the details of the downstream network and their capacity are not known at this time.

It is not proposed to detain flows on this catchment, instead using the reduction in size of the catchment discharging to this location to compensate for the increased imperviousness of the development. Detailed sizing of this catchment is being undertaken by Water Technology utilising their RORB model for the site and the larger catchment. Indicative sizing utilising the Rational method indicates that a catchment in the order of 1Ha being able to discharge to the existing 300mm dia. pipe.

4.2 Southern Catchment (Catchments 2 & 3)

The remaining portion of the site is labelled a the 'southern catchments'. The size of the catchment 2 will be dependent on the outcome of the sizing for the northern catchment, with the southern catchment number 2 taking up all of the residual land west of Cypress Court not included in the northern catchment. Based on the indicative northern catchment being in the order of 1Ha, the southern catchment number 2 would be in the order of 1.25Ha.

The southern catchment number 3 will take up all of the land to the east and south of Cypress Lane, this is an area of 3.25Ha

The southern catchment has an existing pipe network discharging from the site, this is detailed in Figure 4 below. The existing pipe network has three separate pipe legs sitting outside the site extents. It is proposed to adopt the at grade capacity of pipe leg Pit C – Pit D for the nominal capacity of 227L/s for this pipe network, noting that Leg Pit B – Pit C has a significantly higher at grade capacity. Pipe leg EW A to Pit B has a nominal capacity slightly lower, however due to the 3.39m drop in Pit B, there is significant capacity for this pipe to convey a flow above the nominal at grade capacity.

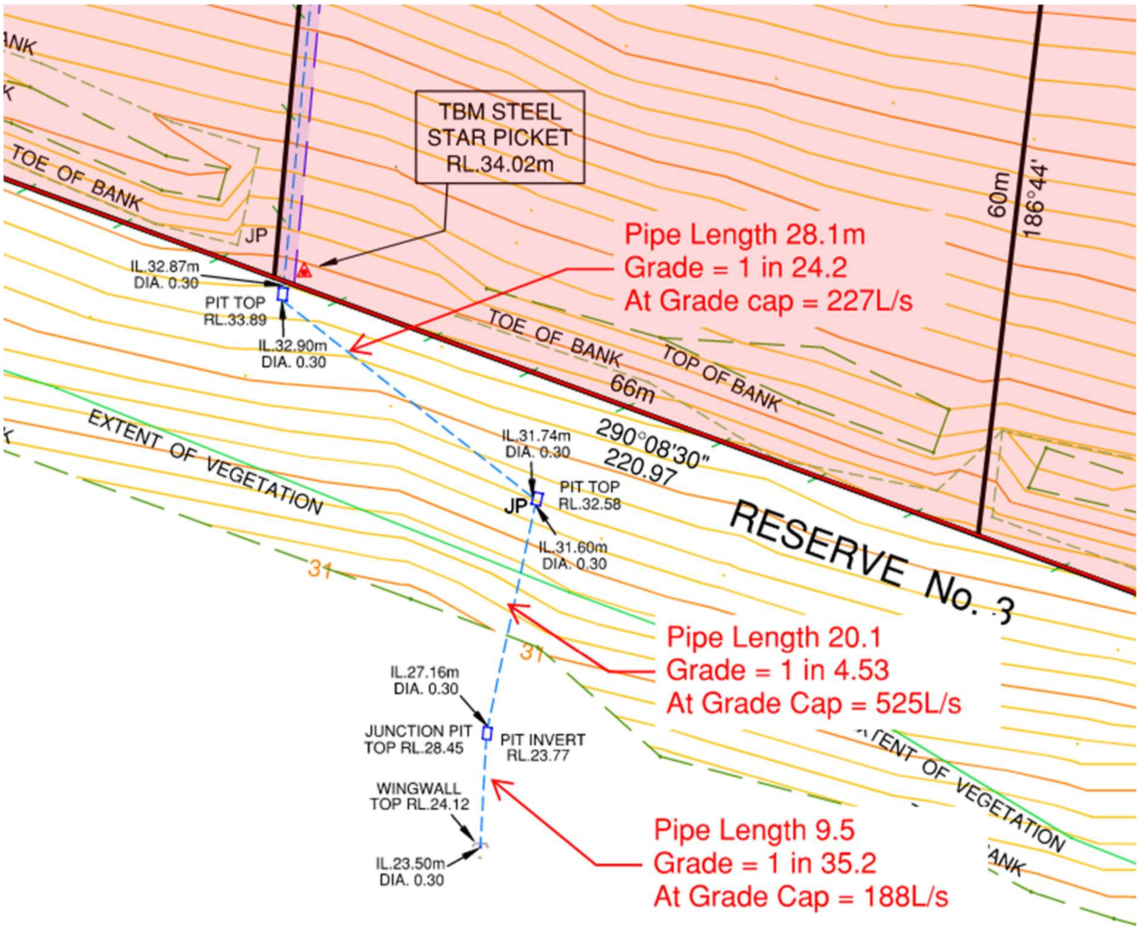


Figure 5 – Southern Outfall Existing Pipe Network

The current pipe outfall discharges into a somewhat unique arrangement in the base of the waterway, with the outfall from the Cypress Court site discharging at right angles to the waterway flow and directly opposing a mirroring outfall from a catchment on the south side of Deep Creek from the vicinity of Moonah Place and Briody Drive. These two pipe outlets are some 1.5m apart and directly face each other, it is considered that they would both be running at similar time periods during and following rainfall events. It is considered that these opposing flows and velocities entering the waterway would result in a complex hydraulic environment at the headwall location, but to a large degree cancel out any significant velocity issues in this area. The current vegetation and lack of erosion are considered to support this judgement.

The endwall area is shown in the photo in Figure 6 below. This photo is taken from slightly downstream of the outlets looking west upstream along Deep Creek, the Cypress Court endwall is on the right.

Figure 6 – Existing endwall and pipe outfalls

Noting the work being undertaken by Water Technology to accurately determine the size of the northern catchment, it is considered that the resulting area of the southern catchment will be of a size that when fully developed generates a flow in excess of the existing outlet pipe capacity.

Accordingly, it is proposed to provide a detention storage on the southern outlet to restrict the flow to the capacity of the existing pipe network. The exact sizing of this storage will form part of the work by Water Technology, however it is noted that utilising the rational method, this storage will be in the order of 500m^3+.

It is considered that a staged approach to the delivery of this infrastructure will allow initial stages discharging to this pipe to be delivered up to the pipes capacity before the detention storage is required to be delivered. It is noted that the existing pipe will need to be realigned in the section of the site between Cypress Lane and the Deep Creek reserve to facilitate the proposed development layout.

It is recommended that the development permit be worded such that should additional approvals processes be undertaken, and approvals be received, the permit retains the flexibility to upsize the existing pipe network and remove the need for detention storage, subject to the responsible authorities approvals.

The three catchments and their nominal sizes, outfall points and treatment trains are shown below in Figure 7

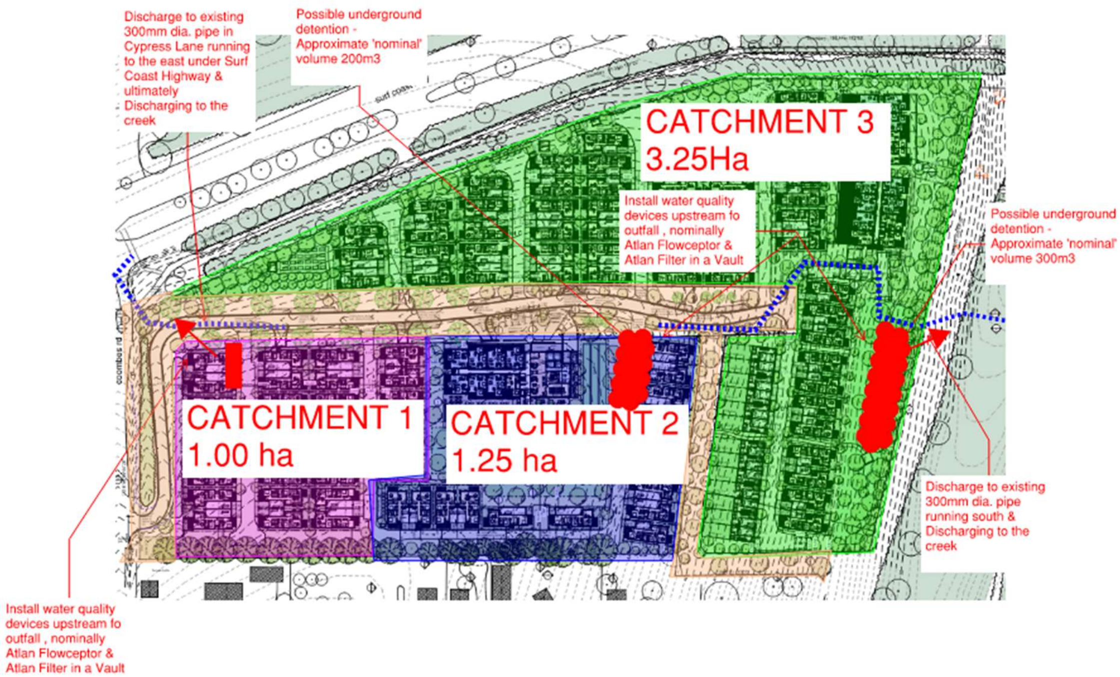


Figure 7 – Proposed Development Catchments

It is noted that this proposed arrangement whereby all flows are directed to the existing stormwater pipes will reduce the currently occurring sheet flows out of the existing eastern and southern catchments. The net result from this will be a reduction in the currently occurring erosion at these locations.

It is noted that the treatment locations and sizes are schematic only and not shown to scale or the exact location.

5 Proposed WSUD Assets

The earlier CardnoTGM SSMP proposed to achieve the stormwater water quality treatment through a combination of Grassed and Vegetated Swales along with Bioretention Basin(s) / rain gardens. These swales and raingardens were proposed to be dispersed throughout the development.

Council has advised that,

Bio-retention system *- In order to suitably replace the filter media, significant excavation can be required, including the existing plant species. The systems then need to be replaced, ensuring the design objectives are met via the complex mix of specific filter media and plant species. There is also the issue of invasive plant species, which prevent nutrient uptake.*

SQID Units *- The SQID units such as SPELFilters simply require the pits to be periodically cleaned, and the cartridge replaced at the end of service life. We believe this to be a better solution and will likely result in suitably treated stormwater discharging the property for an extended period of time.*
The proposal should be amended to consider the use of a SQID unit explored as we do not agree regarding the amount of maintenance required for bio-retention system vs SQID units. There are more variables in regard to the bio-retention systems.

Whilst we do not necessarily agree in entirety with the view expressed by Council of the negatives of the bioretention systems, we do acknowledge that they do typically require ongoing maintenance to operate in the manner that they are designed. However it is considered that in a high amenity and highly maintained environment like this retirement village, we consider that bioretention systems are a reasonable approach to achieving the water quality requirements.

In saying that, we are comfortable with deleting the bio-retention / rain gardens from the proposed development stormwater treatment train and replacing them with a proprietary system. To this end we have undertaken preliminary investigation and sizing of treatment devices, however note that at this time the proposed devices are not an optimized design and pending further commercial negotiations wish to keep alive the ability to alter the exact unit and type specified, subject both achieving or exceeding the required treatment targets, and subject to Council approval of the end product.

Noting Council comments following a peer review of this stormwater report, the proposed treatment train has been adjusted to consist of

Noting all of the above, it is proposed to revise the treatment trains to consist of;

The Northern Catchment (Catchment 1) treatment train consists of:

- **1 x Atlan Flowceptor OL.4115.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

The Southern Catchment (Catchment 2) treatment train consists of:

- **1 x Atlan Flowceptor OL.4115.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

The Southern Catchment (Catchment 3) treatment train consists of:

- **1 x Atlan Flowceptor OL.4230.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

6 Stormwater Quality Modelling

6.1 Stormwater Quality Model

Developed site condition MUSICX models were used as the method for assessing stormwater quality. The model was generally produced in accordance with Melbourne Water's MUSIC Modelling Guidelines (2018) and CoGG Design Note 3.

It is noted that the CoGG Design Note 3 along with the use of the North Geelong Station data was used in the absence of more detailed inputs for the Surf Coast Shire and specifically Torquay. As per earlier correspondence with Council, this approach is considered acceptable.

The following catchment parameters were assigned for the model.

Northern Catchment (Catchment 1):

1.00Ha, ~55% Impervious, ~45% pervious

Southern Catchment (Catchment 2):
1.25Ha, ~55% impervious, ~45% pervious:

Southern Catchment (Catchment 3)
1.25Ha, ~55% impervious, ~45% pervious:

It is noted that the impervious area has altered slightly with the latest site layout, however the areas are generally still similar. Given the excess in treatment under the proposal below, it is considered reasonable that the treatment approach proposed will be appropriate for the proposed development. Updated calculations based on the final development layout should be undertaken and approved by the responsible authority in the detail design phase.

The proposed that the treatment train is proposed to consist of;

The Northern Catchment (Catchment 1) treatment train consists of:

- **1 x Atlan Flowceptor OL.4115.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

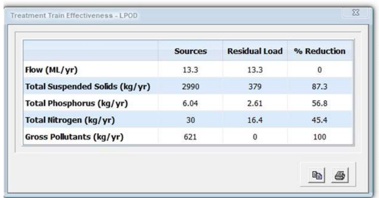
The Southern Catchment (Catchment 2) treatment train consists of:

- **1 x Atlan Flowceptor OL.4115.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

The Southern Catchment (Catchment 3) treatment train consists of:

- **1 x Atlan Flowceptor OL.4230.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

The following image depicts the treatment train schematic design and also the pollutant reduction outputs from MUSIC, demonstrating that the water quality objectives are achieved.


Treatment Train Effectiveness - LPOD

	Sources	Residual Load	% Reduction
Flow (ML/yr)	13.3	13.3	0
Total Suspended Solids (kg/yr)	2990	379	87.3
Total Phosphorus (kg/yr)	6.04	2.61	56.8
Total Nitrogen (kg/yr)	30	16.4	45.4
Gross Pollutants (kg/yr)	621	0	100

Figure 8 – MUSICX Model Layout

It is noted that that the above figure shows a simplified catchment plan of the site and does not reflect the actual site extents and parameters entered into the model, please refer to figure 6 for the design catchments.

Please refer to Appendix A for the standard drawings for the flowceptor and ATLANfilter treatment devices.

6.2 Modelling Results

The end-of-line efficiencies for the treatment train described above are as follows:

Table 1 – Stormwater Quality Treatment Efficiencies

	Reduction (%)	
Criteria	**Result**	**Target**
Total Suspended Solids (kg/yr)	85.2	*80*
Total Phosphorus (kg/yr)	53.3	*45*
Total Nitrogen (kg/yr)	52.5	*45*
Gross Pollutants (kg/yr)	100	*70*

7 Conclusion & Recommendations

The site stormwater objectives for the development of 4 Cypress Lane, Torquay can achieve stormwater quality pollutant removal targets by adopting a treatment train strategy as follows:

The Northern Catchment (Catchment 1) treatment train consists of:

- **1 x Atlan Flowceptor OL.4115.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

The Southern Catchment (Catchment 2) treatment train consists of:

- **1 x Atlan Flowceptor OL.4115.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

The Southern Catchment (Catchment 3) treatment train consists of:

- **1 x Atlan Flowceptor OL.4230.C1 (Formally SPEL Stormceptor)** – Primary / Secondary Treatment | https://atlan.com.au/flowceptor/
- **1 x Atlan Filter 850mm in a Vault** – Tertiary Treatment | https://atlan.com.au/atlan-filter/

Detailed sizing of the three developed catchments and the stormwater detention on the southern catchment should be subject of future works in the Water Technology report, however generally as outlined in this report.

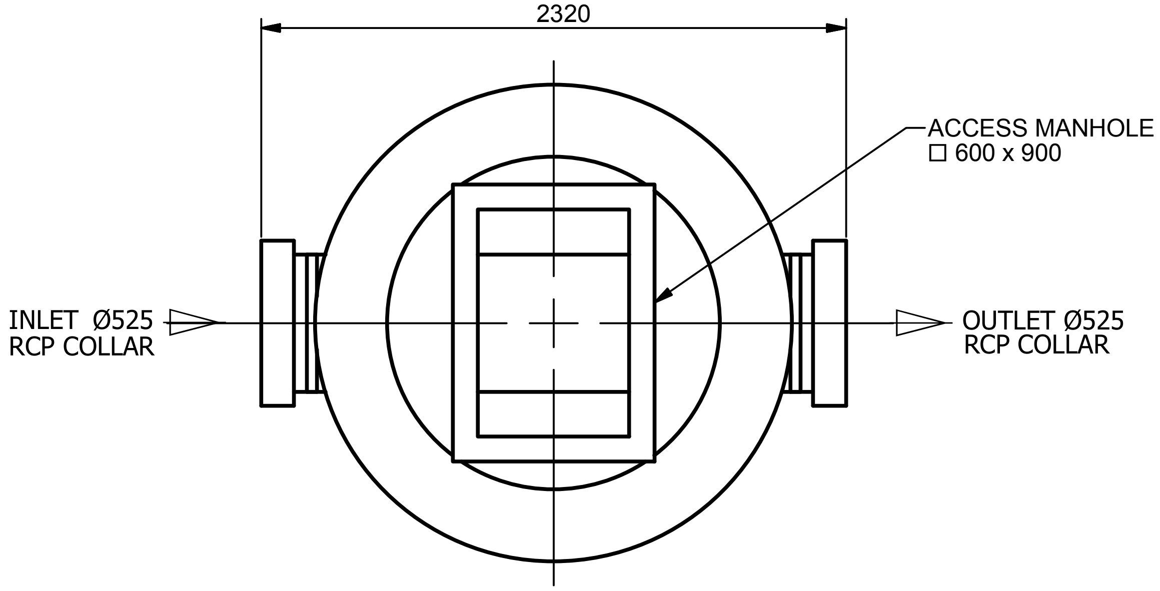
7.1 Delivery Mechanism

It is suggested that the above recommendations should be adopted and that the future planning permit include conditional requirement for delivery of stormwater infrastructure in accordance with this Stormwater Management Strategy. Detailed design specifications will be subject to Engineering approval prior to works commencing.

LOETIS

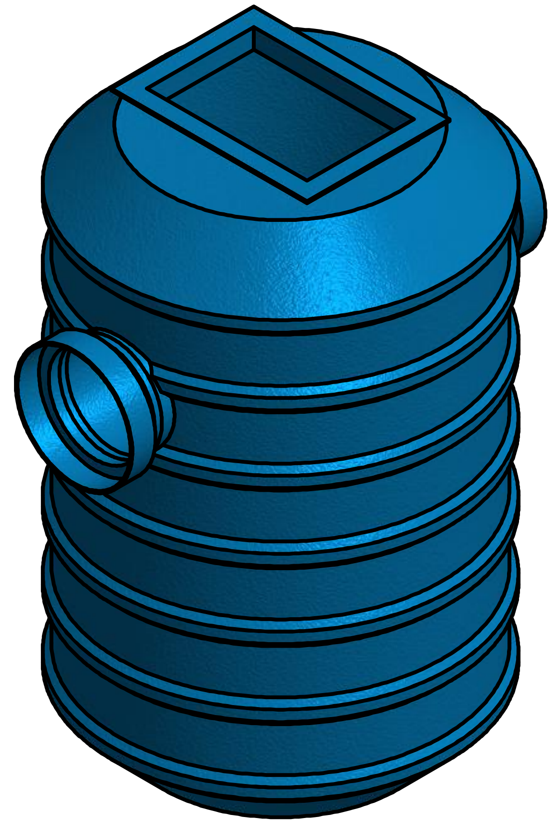
Appendix A – Ecoceptor Standard Drawing

REVISION HISTORY				
REV	DESCRIPTION	DESIGNER	CREATION DATE	CHECKED BY
1	INITIAL RELEASE	P.Z.	05-01-16	

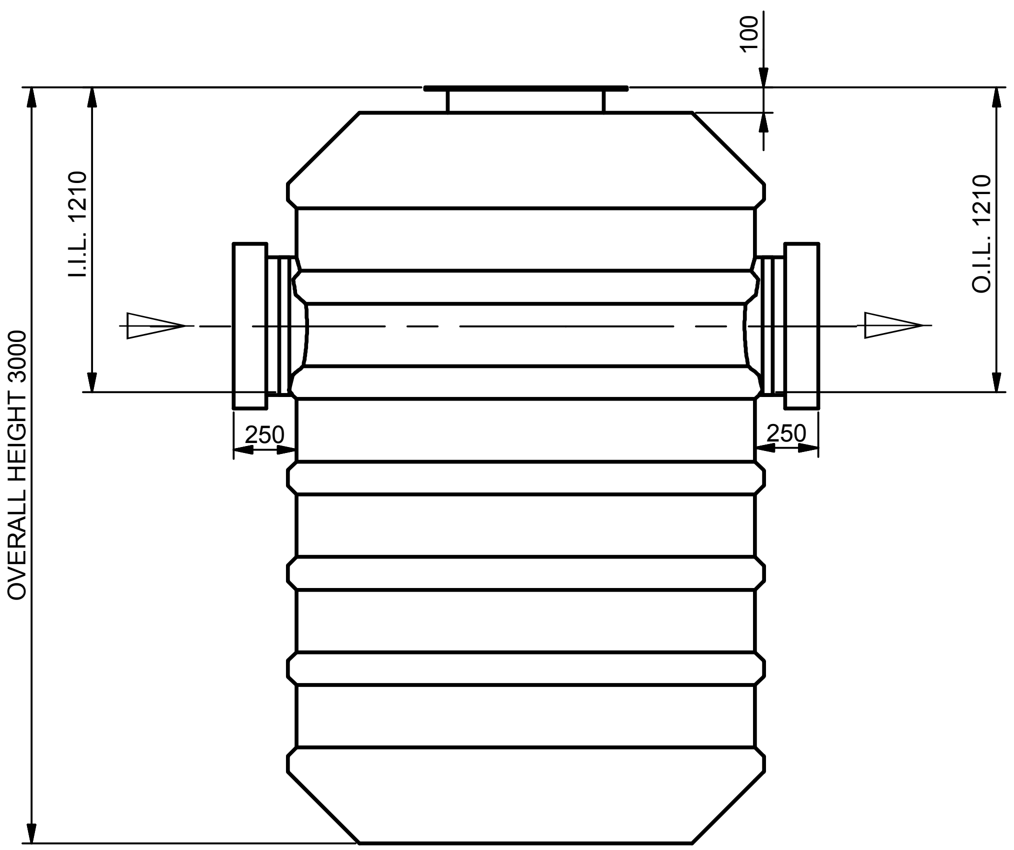


PLAN VIEW

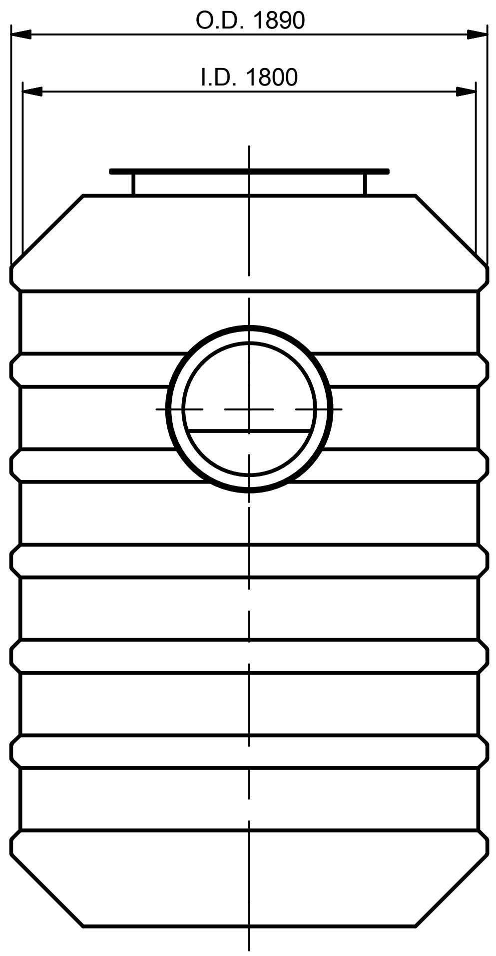
Site Level Confirmation	
Finished Surface Level (FSL)	RL:
Access Cover Thickness	mm
Inlet Invert Level	RL:
Outlet Invert Level	RL:
Company:	
Name:	
Date:	



ISOMETRIC VIEW



ELEVATION VIEW



SIDE VIEW

ISSUE FOR APPROVAL
NOT FOR CONSTRUCTION

APPROVED.................. ☐
NAME................................
SIGNED.............................
DATE........../........../..........

C:\Vault Working Folder\Designs\SPEL\PRODUCTS\ECOCEPTOR\ECOCEPTOR\4000 Series\ECOCEPTOR 4000 STANDARD\E.600-405252 - RCP\SP16-EC12880-S.idw

TOLERANCE: ALL DIMENSIONS 10mm UNLESS OTHERWISE STATED.

CLIENT:

SURF COAST SHIRE COUNCIL
Planning Department
6/03/2024
21/0333 / D24/42573

DISTRIBUTOR :

Drawn P.Z.	Date 05-01-16
Check	Date
Verified	Date
Approved	Date
Request No. RN2222	

SPEL ENVIRONMENTAL
INTEGRATED WATER SOLUTIONS

100 Silverwater Road Silverwater NSW 2128
PH: 1300 773 500 | E: sales@spel.com.au
www.spel.com.au

PROJECT :

TITLE SPEL ECOCEPTOR
4000 SERIES - E600/405252.RCP
GENERAL ARRANGEMENT

SCALE N.T.S	SIZE A3	SHEET 1	REV 1
CUSTOMER CODE :	DWG No. SP16-EC12880-S		

LOETIS

Appendix B – Cypress Lane Flood Impact Assessment – Deep Creek, Water Technology

Cypress Lane Flood Impact Assessment

Deep Creek

Coombes Rodd Pty Ltd

March 2022

Document Status

Version	Doc type	Reviewed by	Approved by	Date issued
V01	Draft	B Hughes	B Hughes	15/11/2021
V02	Report	J Theilemann	J Theilemann	22/3/2022

Project Details

Project Name	Cypress Lane Flood Impact Assessment
Client	Coombes Rodd Pty Ltd
Client Project Manager	Leigh Prosser (Cardno)
Water Technology Project Manager	Johanna Theilemann
Water Technology Project Director	Ben Hughes
Authors	Johanna Theilemann
Document Number	22010191_CypressLane_FIA

15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365
ACN 093 377 283
ABN 60 093 377 283

Certified System Quality ISO 9001 SAI GLOBAL
Certified System Environment ISO 14001 SAI GLOBAL
Certified System Health & Safety AS 4801 SAI GLOBAL

CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Overview

Watch Technology was engaged to undertake an assessment of existing and developed conditions flow and flood impact for a 1% AEP flood event for a proposed development in Torquay (the subject site). The subject site is located within the township of Torquay, adjacent to the Surf Coast Highway on Cypress Lane. The location of the subject site is shown in Figure 1. The flood assessment was undertaken to define flood risk and inform potential development surface water management strategies within the property. The focus of the assessment is to understand the impact on flooding risk in Deep Creek if flows from the proposed development are not retained onsite in line with current planning policy requirements. The assessment included modelling of catchment hydrology using RORB. Flows developed as part of the RORB model were used as inflow boundaries to a TUFLOW 1D-2D hydraulic model to define flood depth, extent and velocity during the 1% and 10% AEP flood events.

FIGURE 1 DEVELOPMENT SITE

1.2 Study Area

The study area is within the Deep Creek catchment, which includes several small tributaries upstream of the proposed development area. The Deep Creek catchment is shown by the red outline in Figure 2 and covers an area of approximately 6.3 km^2.

Deep Creek is a small ungauged waterway within the Torquay area. The creek begins within rural land west of the Surf Coast Highway and passes through low density residential land, before passing under the Surf Coast Highway through a more densely populated urban area, finally discharging to Zeally Bay.

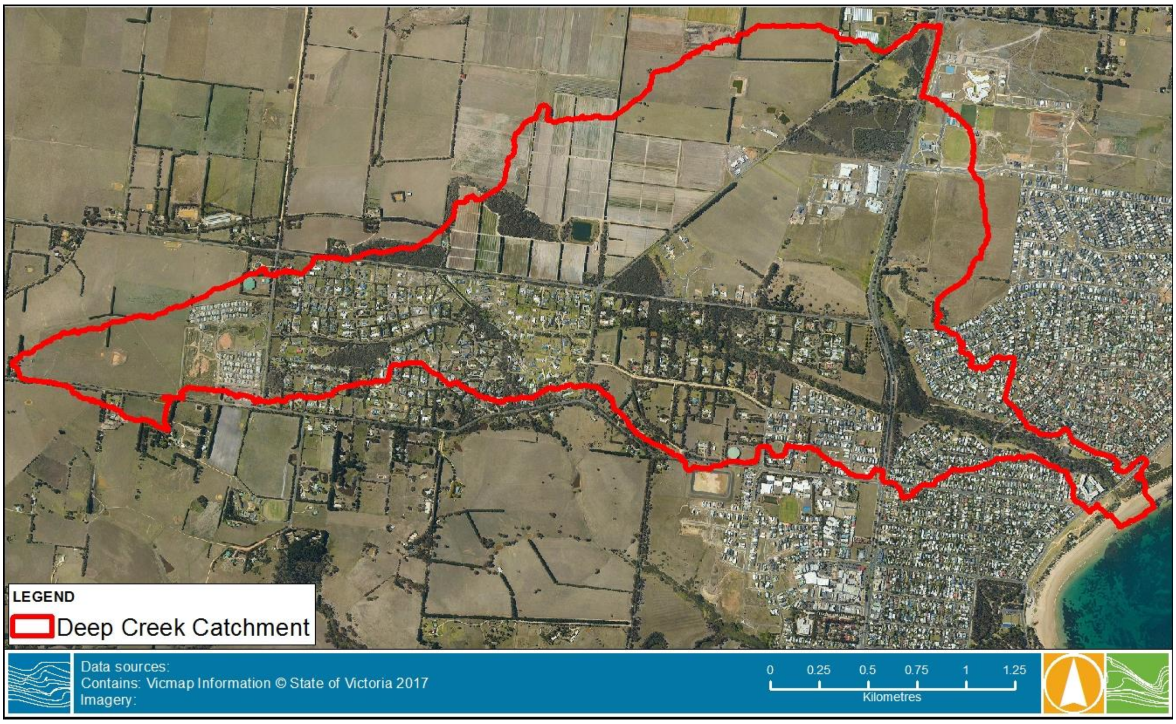


FIGURE 2 DEEP CREEK CATCHMENT

1.3 Available Data

The investigation utilised several existing datasets available from the Department of Environment, Land, Water and Planning (DELWP) and Corangamite CMA, including:

- Topography – Light Detection and Ranging (LiDAR), 5m resolution, flown 2015-2016 (DELWP).
- Digital Aerial Photography – Flown Feb 2015-2016 (DELWP).
- Spatial Data – VicMap – 2021 (DELWP).

2 HYDROLOGY

2.1 Overview

A hydrologic model of the Deep Creek catchment was developed to determine design flow hydrographs at several locations, which were then used as inflow boundary conditions in the hydraulic model.

RORB is a non-linear rainfall runoff and streamflow routing model for calculation of flow hydrographs in drainage and stream networks. The model requires catchments to be divided into subareas, connected by a series of conceptual reaches and storage areas. Observed or design rainfall is input to the centroid of each subarea. Specific initial and continuing losses are then deducted, and the excess runoff is routed through the reach network.

The adopted methodology described below was based on current guidelines described in the 2019 revision of Australian Rainfall and Runoff (ARR2019). An Ensemble approach was used in this assessment. The Ensemble approach modelled 10 available temporal patterns for each duration recommended in ARR2019 with the temporal pattern which determined the median peak flow for each duration adopted.

2.2 RORB Modelling

2.2.1 Model Setup

2.2.1.1 Sub-area and Reach Delineation

Sub-area boundaries and reaches were delineated based on the available LiDAR data, using ArcHydro. Nodes were placed at areas of interest (to extract flow hydrographs), the centroid of each sub-area and the junction of any two reaches. Nodes were then connected by RORB reaches, each representing the length, slope and reach type between nodes. The RORB model had 57 sub-areas ranging in area from 0.07 – 0.6 km^2. The sub-catchment delineation and reach network is shown in Figure 3. Smaller sub-catchments and two interstation areas were established for the eastern and western portions of the development catchment.

The RORB model was constructed using MiRORB (MapInfo RORB tools), RORB GUI and RORBWIN V6.45.

2.2.1.2 Fraction Impervious

Fraction Impervious (FI) values were calculated using MiRORB. Default sub-area FI values were based on an assessment of current Surf Coast Shire Planning Scheme Zones (current November 2021) and aerial imagery. The spatial distribution of the FI data is shown in Figure 5. It can be seen there is a considerable difference in FI between the urban areas of the catchment and the upper, agricultural areas.

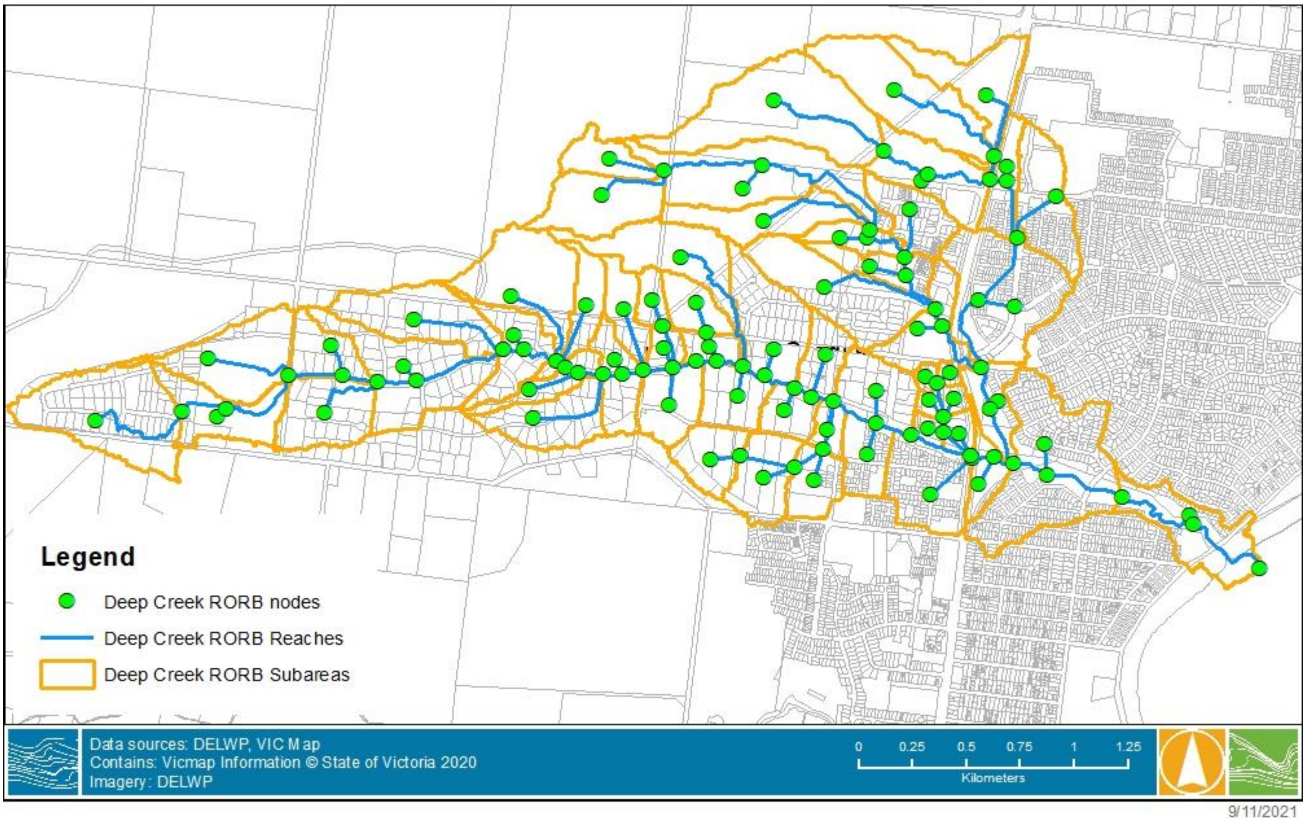


FIGURE 3 RORB MODEL SCHEMATISATION

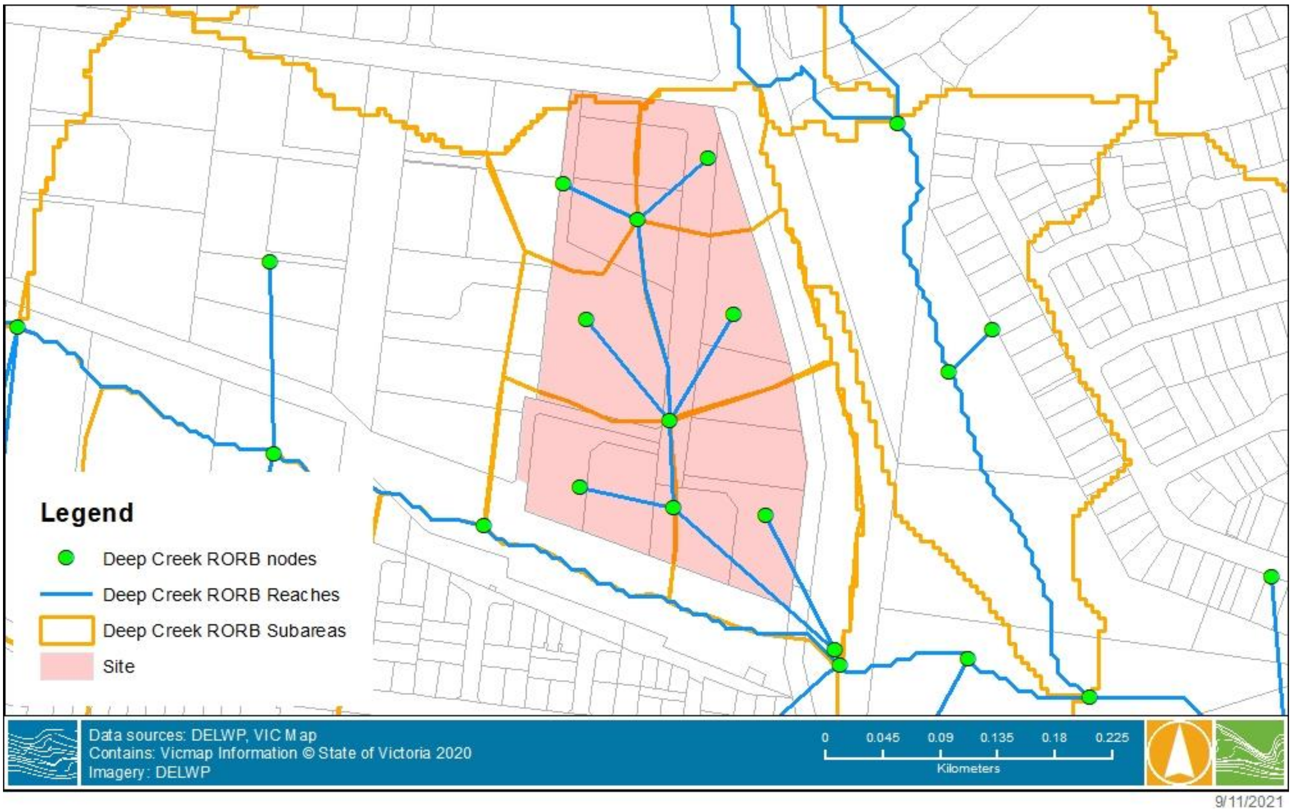


FIGURE 4 SITE – RORB MODEL SCHEMATISATION (EXISTING)

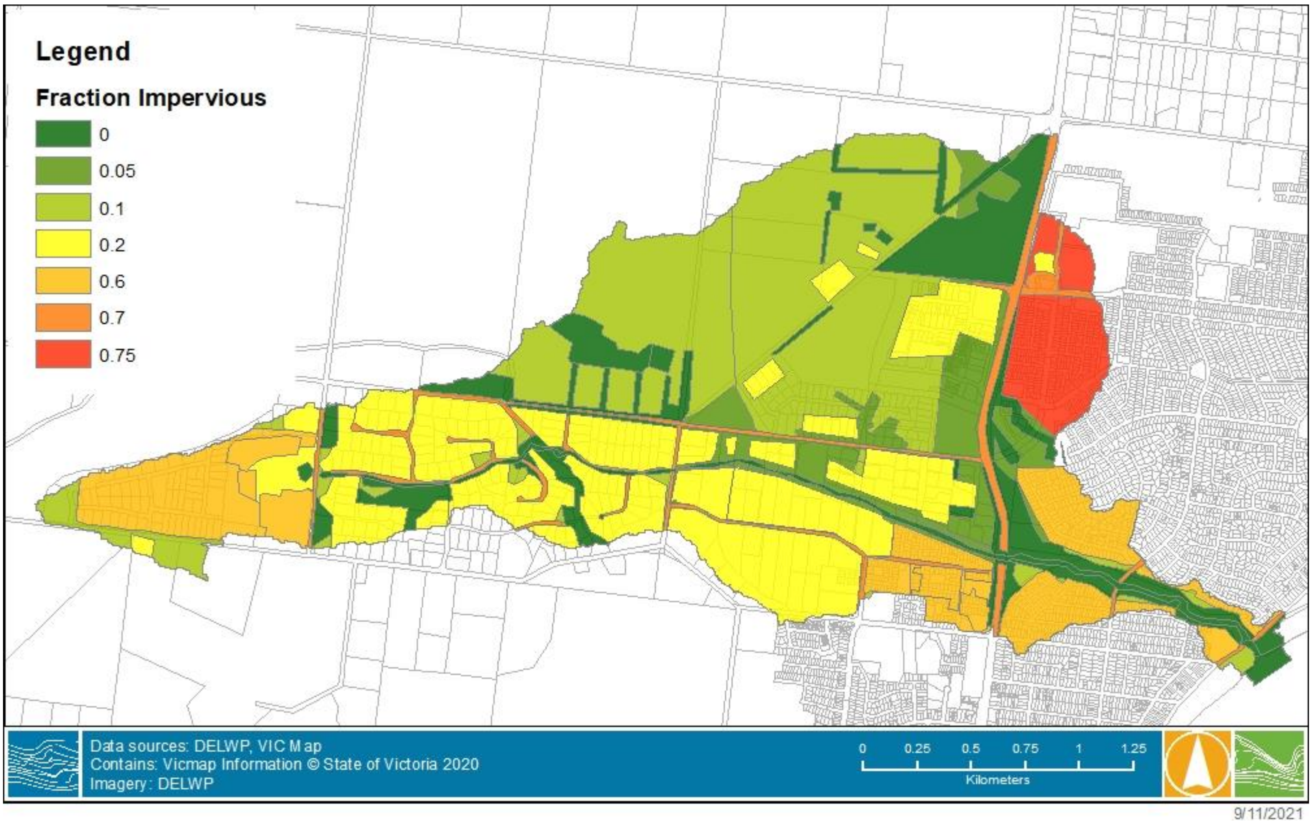


FIGURE 5 FRACTION IMPERVIOUS DISTRIBUTION IN THE DEEP CREEK CATCHMENT

Design rainfall depths were determined using the Bureau of Meteorology online IFD tool[1]. The rainfall Intensity Frequency Duration (IFD) parameters were generated for a location in the approximate centre of the Deep Creek catchment (38.31S, 144.31E) and are shown in Table 2-1 below.

TABLE 2-1 DESIGN RAINFALL DEPTH (MM) FOR STORM FREQUENCY AND DURATION

Duration	EY	Annual Exceedance Probability (AEP)					
	1EY	50%	20%	10%	5%	2%	1%
1 hour	10.6	12.3	17.7	21.7	25.8	31.3	35.8
2 hour	14.0	16.1	22.6	27.3	32.1	38.5	43.6
3 hour	16.7	19.0	26.3	31.5	36.7	43.9	49.6
6 hour	22.9	25.6	34.5	40.8	47.2	56.3	63.6
12 hour	30.9	34.4	45.8	53.9	62.2	74.5	84.5
24 hour	39.7	44.4	59.9	71.0	82.3	99.2	113
48 hour	47.4	53.8	74.7	89.9	105	127	145
72 hour	51.2	58.4	82.4	99.9	118	142	161
96 hour	53.9	61.6	87.1	106	125	150	169
120 hour	56.4	64.2	90.1	109	128	154	173

[1] Bureau of Meteorology Web Tool, http://www.bom.gov.au/water/designRainfalls/revised-ifd/?year=2016

2.2.1.3 Temporal Patterns

Temporal patterns from ARR2019 were utilised in the analysis and extracted from the AR&R data hub. As previously described, an Ensemble approach was undertaken. The range of temporal patterns modelled are included in Appendix A, with relevant ID numbers assigned as referred to in the RORB model output. The Southern Slopes (Vic/NSW) Zone of temporal patterns was utilised. The ARR2019 temporal patterns are based on historical storms using the extensive network of pluviograph data collected by the Bureau of Meteorology (BoM).

The ARR2019 design temporal patterns were broken into several AEP groupings, these included:

- Very Rare – Rarest 10 within region.
- Rare – Suitable AEP range 3.2% AEP and rarer.
- Intermediate – Suitable for AEP range 3.2% - 14.4%.
- Frequent – Suitable for AEP range more frequent than 14.4%.

Previous assessments would have used a single temporal pattern across all design events (in accordance with Australian Rainfall and Runoff 1987). The ARR2019 approach recommends at least 10 temporal patterns be used for each event. These 10 temporal patterns change depending on the duration and the event considered.

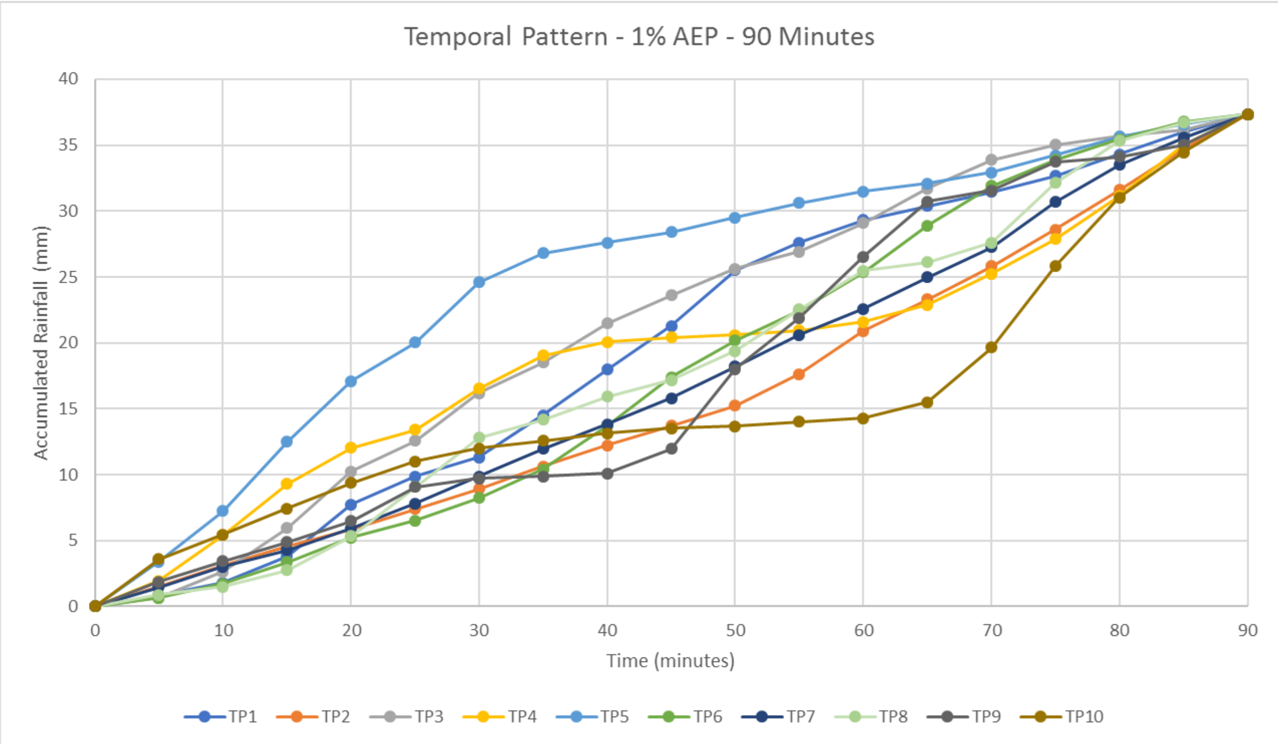


FIGURE 6 TEMPORAL PATTERN VARIATION

2.2.1.4 Areal Reduction Factors

Areal reduction factors were used to convert point rainfall to areal estimates, and were used to account for the variation of rainfall intensities over a large catchment. AR&R2019 areal reduction factors were applied to the catchment area and extracted from the AR&R data hub[2]. The catchment lies within the Southern Temperate Zone of aerial reduction factors, and these were applied for all design modelling.

2.2.1.5 Regional *kc*

kc is the primary routing parameter in RORB. As Deep Creek is an ungauged catchment with no streamflow record, it was not possible to calibrate the RORB model against known catchment flows and rainfall records. As such, a comparison between empirical regional equation estimates was made and a reasonable value within this range adopted. The *Pearse et. al.*[3] kc prediction equation method is based on Victorian data and has been shown to provide an accurate match to Flood Frequency Analysis (FFA) across several Victorian flood investigations[4] and was used in this project, adopting a *kc* value of 4.61.

TABLE 2-2 CALCULATED KC PARAMETERS

kc Equations	K_c
Default RORB Eqn.	5.46
Victoria data (Pearse et al, 2002)	**4.61**
Aust Wide Dyer (1994) (Pearce et al)	4.21
Victoria Mean Annual Rainfall > 800mm	5.82

This is further validated in later sections of this report when comparing adopted and previous design flows. The RORB model was separated into three interstation areas, adopting a varying *kc* value for each.

- Whole of Catchment – *kc* = 4.61
- Site – Catchment – *kc* = 0.36

2.2.1.6 Routing Parameter – m

The RORB 'm' value is typically set at 0.8 as recommended in the RORB User Manual. This value remains unchanged and is an acceptable value for the degree of non-linearity of catchment response (Australian Rainfall and Runoff, 1987). It is rare to vary the 'm' value and there were no reasons to do so in this study, particularly given the lack of calibration data.

2.2.1.7 Design Losses

ARRR2019, Book 5 Chapter 5 (Hill and Thomson, 2015) contains new recommended initial and continuing losses, as shown below. A web tool has also been developed to derive initial and continuing loss values[5], which was used to extract loss values for this project. The information generated from this web tool in shown in Table 2-3 for the Deep Creek catchment.

---

[2] AR&R 2016 Data Hub, http://data.arr-software.org/
[3] RORB Runoff User Manual, Monash University and Hydrology and Risk Consulting Pty Ltd, 2010
[4] Natimuk Flood Investigation (Water Technology, 2014), Hydrology and Hydraulics Assessment, Western Highway Duplication Section 3 (Water Technology, 2017).
[5] ARR2019 - http://data.arr-software.org

TABLE 2-3 DESIGN LOSS PARAMETER ESTIMATES

Source	IL (mm)	CL (mm/h)
ARR 2016 (VIC)	24	4.4
Adopted	22	2.5

Where - BFI (Baseflow Index) = 0.38, MAR (Mean Annual Rainfall) = 729 mm, PET (Mean Annual Potential Evaporation) is 1275 mm.

Pre-burst loses identified by the ARR datahub indicated median pre-burst losses ranged from 0.9 – 3.3 mm. A uniform pre-burst loss of 2mm was adopted for this catchment with the resulting adopted initial loss reducing to 22mm.

In line with recent academic papers (NSW Department of Environment and Heritage[6]), continuing losses as shown by the datahub are likely to be overestimated. This has been verified in several recent studies undertaken by Water Technology[7]. In consideration of this and a comparison of calibrated local flood models a reduced continuing loss of 2.5 mm/hr was adopted (considering regional data).

2.2.1.8 Spatial Patterns

The ARR2019 guidelines recommend for non-uniform spatial patterns for catchment areas of more than 20 km^2. The Deep Creek catchment and the upstream catchment of the area of interest are well below this threshold and as such a uniform rainfall spatial pattern was adopted.

2.2.2 Existing Conditions

2.2.2.1 RORB – Ensemble

Peak flows for the 1% and 10% Annual Exceedance Probability (AEP) flood events were calculated within the RORB model for durations between 15 minutes and 48 hours. An ensemble of the 10 available temporal patterns applicable to the 1% and 10% AEP events were run and the event with the median peak flow for each of the modelled durations was adopted.

The whisker plot below shows the upper and lower limits of the calculated peak flows for each of the 10 temporal patters for each duration of the 1% AEP event, along with the corresponding median for each storm duration.

[6] NSW Office of Environment and Heritage, Review of ARR design Inputs, 2019
[7] Lara Flood Study, Gnarr Creek and Yarrowee River Flood Mapping Update (Water Technology, 2019)

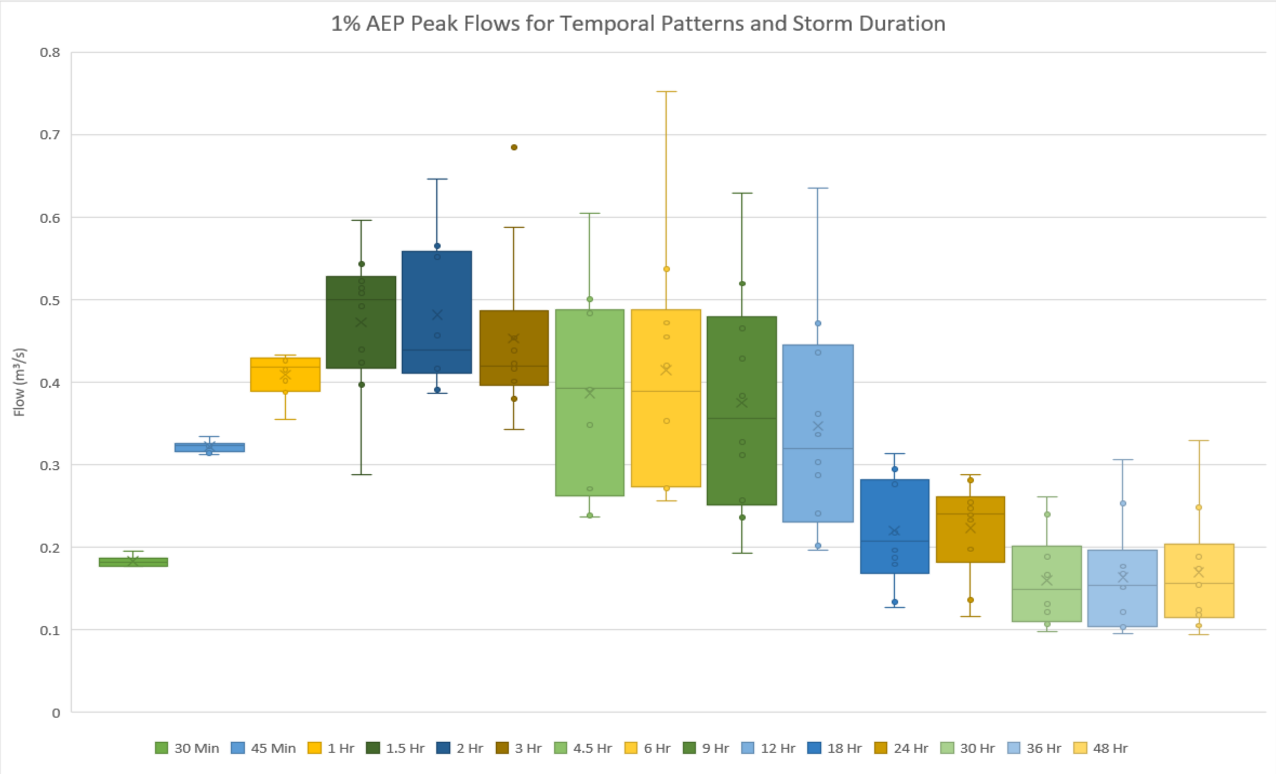


FIGURE 7 1% AEP TEMPORAL PATTERN AND PEAK FLOWS – SITE (LOCAL CATCHMENT)

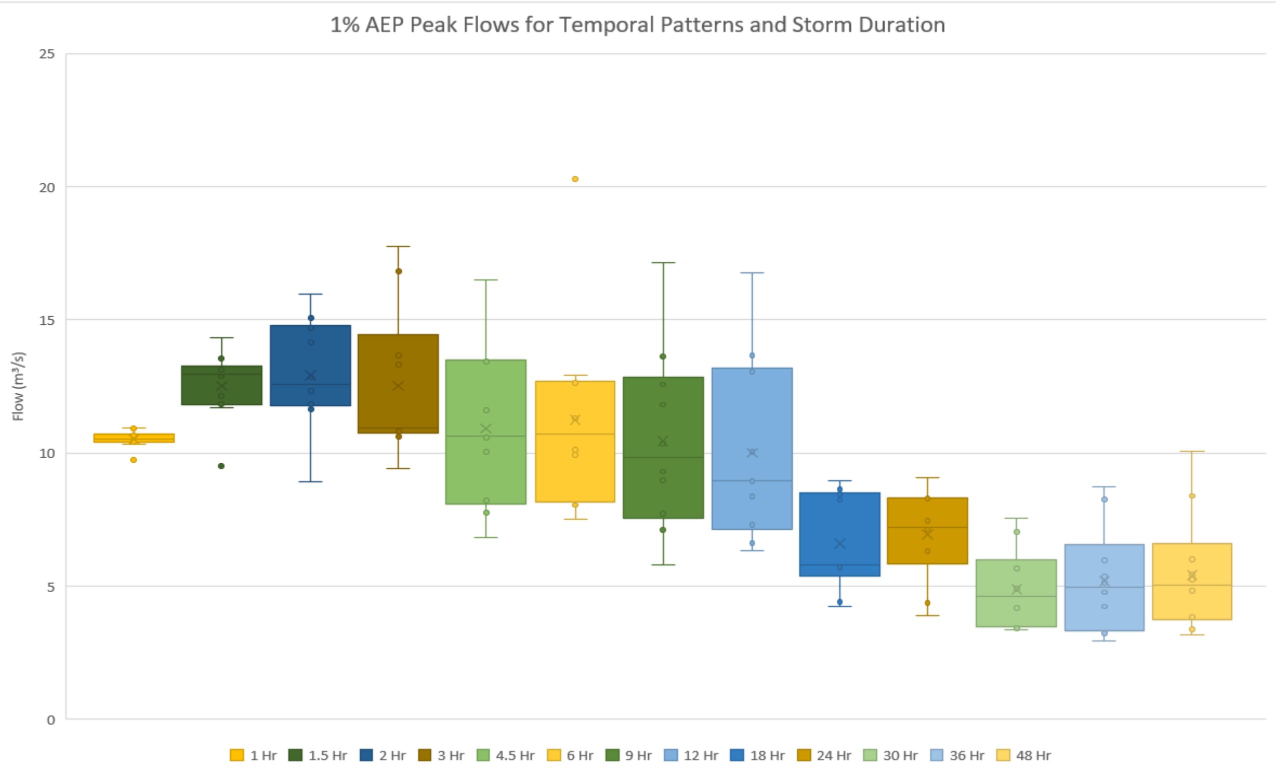


FIGURE 8 1% AEP TEMPORAL PATTERN AND PEAK FLOWS – DEEP CREEK @ SITE

The event duration which yielded the highest median peak flow was 1.5 hrs. Within the ensemble of temporal patterns, the temporal pattern which gives the peak flow closest (above) the median was TP28. The ensemble outputs for the 1% AEP event in existing conditions are shown in Table 2-4. The highest median results from the ensemble modelling is shown in red and forms the hydrologic input for the modelled 1% AEP peak flows.

This process of modelling the ensemble of temporal patterns, identifying the maximum of the median ensemble results and selecting the best fit single storm duration and temporal pattern was also undertaken for the 10% AEP event shown in Table 2-4 for the key locations including at the site itself and on the Deep Creek adjacent to the site. The adopted peak flows, temporal patterns and critical durations for each of the modelled durations is shown in Table 2-5.

TABLE 2-4 1% & 10% AEP EXISTING CONDITIONS RORB ENSEMBLE OUTPUT (MEDIAN FLOWS)

	1% AEP		10% AEP	
Duration	Deep Creek @ Site (m^3/s)	Site (m^3/s)	Deep Creek @ Site (m^3/s)	Site (m^3/s)
30min	5.53	0.18	1.65	0.03
45min	8.54	0.32	2.00	0.04
1hr	10.53	0.42	2.23	0.04
1.5hr	**12.95**	**0.50**	3.28	0.08
2hr	12.59	0.44	4.27	0.14
3hr	10.94	0.42	**5.64**	**0.20**
4.5hr	10.63	0.39	4.77	0.16
6hr	10.72	0.39	5.50	0.19
9hr	9.82	0.36	4.75	0.16
12hr	8.95	0.32	4.05	0.13
24hr	5.78	0.21	2.96	0.10
30hr	7.22	0.24	2.93	0.10
36hr	4.62	0.15	2.03	0.07
48hr	4.96	0.15	2.22	0.07

TABLE 2-5 ADOPTED FLOWS AND TEMPORAL PATTERNS

	Deep Creek @ Site (Peak Flow, TP)	Site (Peak Flow, TP)
1% AEP (Crit durn 1.5Hr)	13.01 m^3/s, TP28	0.51 m^3/s, TP28
10% AEP (Crit durn 3Hr)	5.88 m^3/s, TP14	0.21 m^3/s, TP14

2.2.2.2 Flow Verification

The Deep Creek catchment is ungauged, in the place of observed data the adopted design flows were compared against a range of other flow estimate methods including Rational Method, Regional Flood Frequency Estimation Tool (RFFE) and the Grayson Method, as shown in Table 2-6. The estimation methods (VicRoads and Grayson) produced similar peak outflows to the RORB model for the catchment area immediately upstream of the development site. Whilst these estimation methods are considered to have high uncertainty, they demonstrate that based on the adopted catchment RORB parameters, reasonable flows have been produced. It is important to note that whilst the RORB flows are higher than the verification methods presented the existing catchment is not considered to be a typical rural or undeveloped catchment. With areas within the upper catchment having undergone significant intensification including the construction of Kithbrooke Park Lifestyle Facility.

TABLE 2-6 DESIGN FLOW COMPARISON

Determination Method	Flow (m^3/s)	
	1% AEP (m^3/s)	10% AEP (m^3/s)
Rational (Adams)	4.28	NA
Rational (VicRoads)	8.33	3.27
RFFE (Rural)*	5.49	2.39
Grayson (Rural)	11.07	NA
Grayson (Urban)	22.98	

*It should be recognised that flood estimates generated by the RFFE Model are limited in application as detailed in Appendix C.

Adopted Design Flood Hydrographs

Flows on Deep Creek were extracted at three locations within the catchment boundary. Most critical to the subject site was the model boundary immediately upstream of the development area. Flows for both the 1% and 10% AEP flood events were extracted for several durations including that which produced the maximum peak flow. The respective durations and peak flows for each of the modelled events are shown in Table 2-7 below.

TABLE 2-7 DESIGN FLOWS

AEP	Critical Duration/ Temporal Pattern	Peak Flow Upstream	Peak Flow Site
1%	1.5hr / TP28	13.01 m^3/s	0.51 m^3/s
10%	3hr / TP14	5.88 m^3/s	0.21 m^3/s

2.2.3 Developed Conditions

2.2.3.1 Overview and assumptions

The subject site has been identified for future development, including a lifestyle village. An indicative layout of the proposed development is provided in FIGURE 9. For the purposes of modelling the proposed development and assessing its impact, the following assumptions were made:

- Fraction Impervious for the development site was set at 0.8 based on an estimated lot size of less than 300m^2.
- Site catchment boundaries were refined in line with existing topographic features and the proposed layout draining to the south and east, towards Deep Creek and the Surf Coast Highway waterway crossing.

The modelled critical durations were consistent with the existing conditions modelling.

FIGURE 9 PROPOSED DEVELOPMENT LAYOUT

2.2.3.2 RORB model modifications

A revised catchment layout was developed, updating the FI values within the development site, altering the breakdown of sub-catchment areas consistent with likely drainage layout and road alignment and changes reach types within the catchment from natural to excavated/unlined consistent with current practice.

The updated RORB model layout for the developed conditions is shown FIGURE 10. Interstation areas consistent with the existing conditions model were included to provide consistent flow comparison and input with the existing conditions modelling. Minor changes to the catchment layout respective to existing topography and proposed layout were used as the basis for determining the developed catchment layout. The developed catchment was broken down (as per existing conditions modelling).

It was assumed that the development site will have a single direct connection discharging to Deep Creek. The developed conditions catchment delineation and estimated outlet location is shown in **Error! Reference source not found.**.

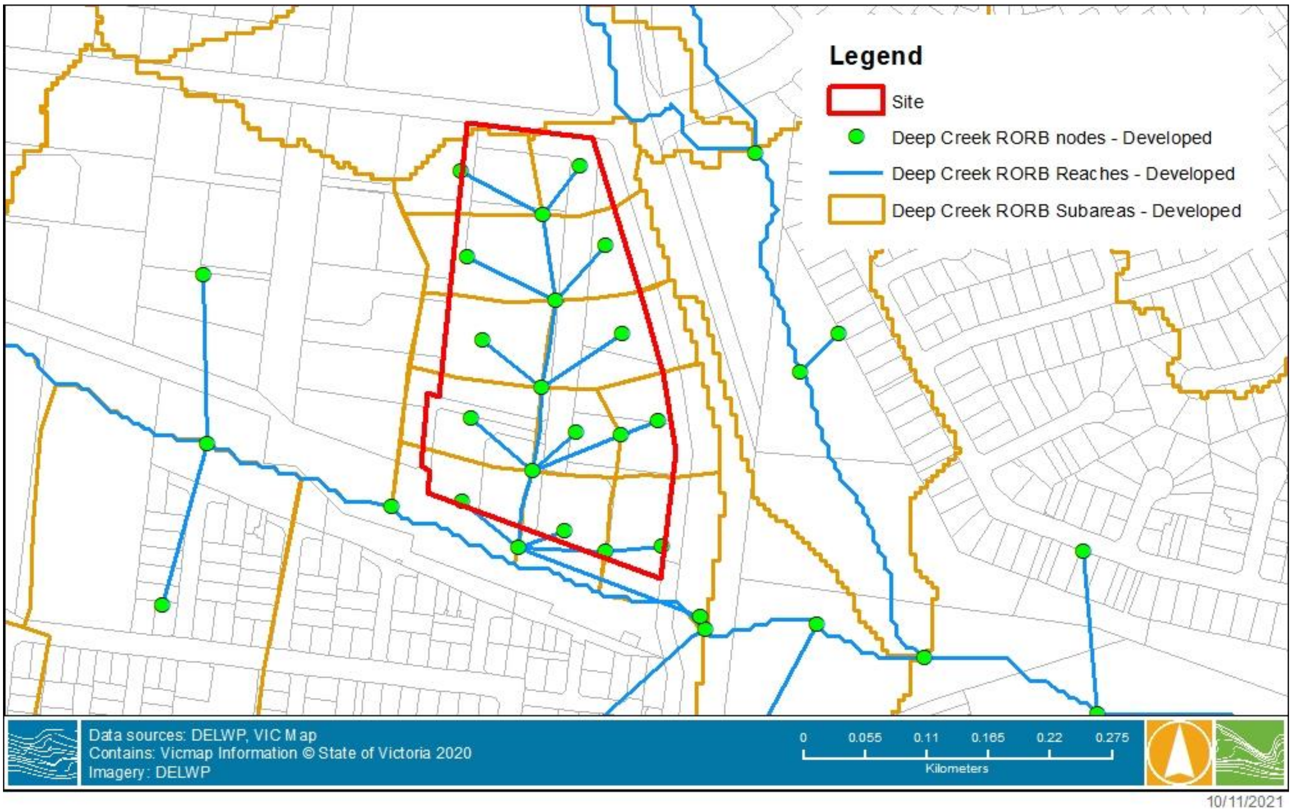


FIGURE 10 RORB- DEVELOPED CATCHMENT LAYOUT

For the purposes of this assessment, a developed scenario was assessed which ***did not*** consider any potential retention or retardation of flows onsite.

The RORB model was run for all temporal patterns and storm durations ranging from 15min – 48 hours for each of the three AEPs as outlined for existing conditions. Peak flows for the 1% and 10% AEP events were calculated. Peak flows and critical durations from the developed conditions model were then selected based on the highest median peak at each of the critical inflow locations.

Table 2-8 shows the Ensemble outputs for the 1% AEP event in developed conditions. The developed conditions results shown in this table do not include proposed retardation of stormwater from the site. The results indicate development of the subject site shortens the critical duration from the development area. The 1% AEP existing conditions peak flow from the site occurred during the 1.5hr storm duration, while the 1% AEP peak flow in developed conditions was shortened to 1hr, with 45 minutes the next highest.

Peak flow at the outlet of the site were increased during all modelled AEP events. During a 1% AEP event, peak flow for the developed catchment was increased from 0.5 m^3/s to 1.02 m^3/s. During a 10% AEP events peak flow for the developed catchment was increased from $0.2m^3/s$ to 0.33 m^3/s.

TABLE 2-8 1% & 10% AEP DEVELOPED CONDITION RORB ENSEMBLE OUTPUT (MEDIAN FLOWS)

Duration	1% AEP		10% AEP	
	Deep Creek @ Site (m^3/s)	Site (m^3/s)	Deep Creek @ Site (m^3/s)	Site (m^3/s)
30min	5.53	0.64	1.65	0.13
45min	8.54	0.93	2.00	0.17
1hr	10.53	**1.02**	2.23	0.19
1.5hr	**12.95**	0.91	3.28	0.30
2hr	12.59	0.84	4.27	0.29
3hr	10.94	0.63	**5.64**	**0.33**
4.5hr	10.63	0.61	4.77	0.24
6hr	10.72	0.49	5.50	0.24
9hr	9.82	0.39	4.75	0.20
12hr	8.95	0.39	4.05	0.17
24hr	5.78	0.22	2.96	0.10
30hr	7.22	0.30	2.93	0.11
36hr	4.62	0.16	2.03	0.08
48hr	4.96	0.16	2.22	0.08

TABLE 2-9 ADOPTED FLOWS AND TEMPORAL PATTERNS

	Deep Creek @ Site (Peak Flow, TP)	Site (Peak Flow, TP)
1% AEP (Crit durn 1.5Hr)	13.01 m^3/s, TP28	1.03 m^3/s, TP25
10% AEP (Crit durn 3Hr)	5.88 m^3/s, TP14	0.35 m^3/s, TP15

3 HYDRAULIC MODEL DEVELOPMENT

3.1 Model Extent and Topographic Resolution

TUFLOW was used to develop the hydraulic model, with the model extending from west of the subject site to the ocean, including a small tributary entering at the north of the site. Topography of the Deep Creek catchment was available from the 2008 Victorian State Wide LiDAR Project and was used as the basis for a 2 m resolution topography, covering approximately 1.3 km^2. At this grid resolution the width of the creek was appropriately represented. Features such as waterway banks, roads and general floodplain features were well represented by the model. The selected grid size allowed accurate modelling of the site and creek while maintaining manageable model run times.

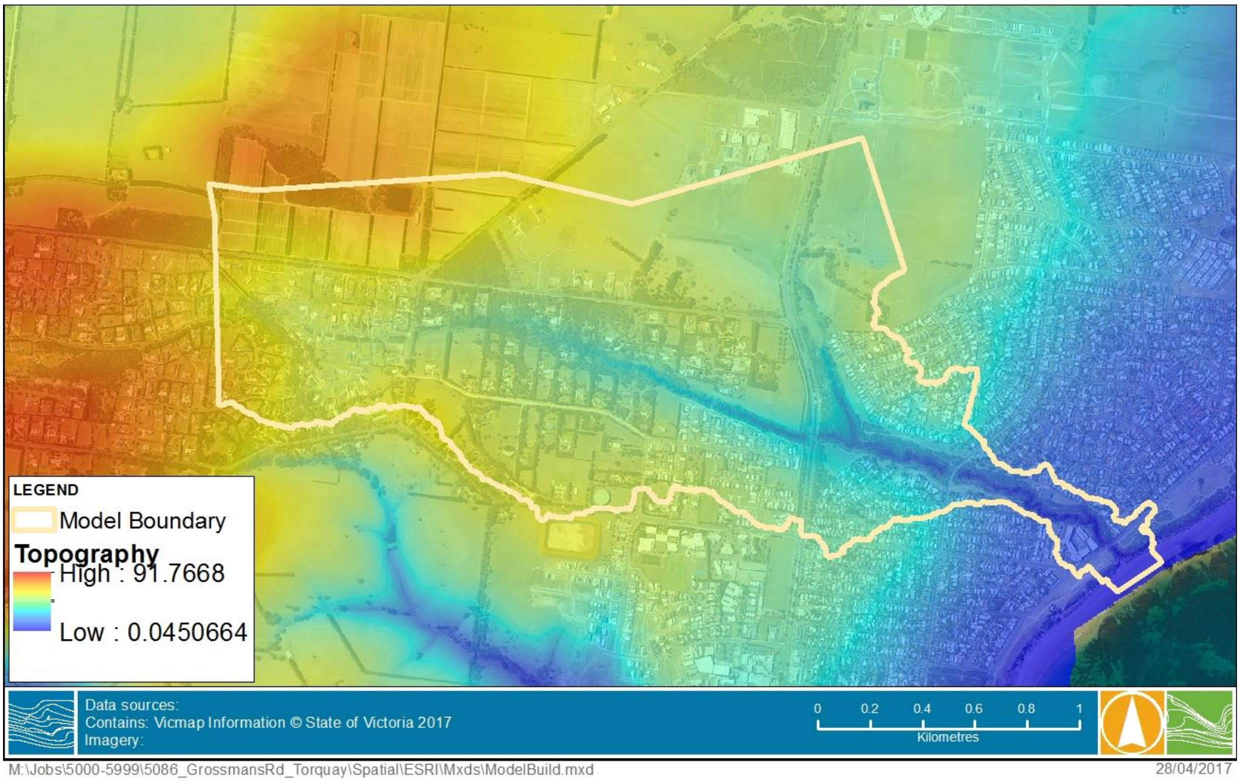


FIGURE 11 DEEP CREEK– TOPOGRAPHY

3.1.1 Manning's Roughness

Manning's 'n' was adopted as a representation of floodplain roughness, and has an important impact on flood velocities, flow paths, flood depths and extents. Manning's 'n' values were derived from photographs from the site visit, aerial photography and appropriate industry standard literature (Australian Rainfall and Runoff, Chow (1959), etc).

TUFLOW '*2d_mat'* files were produced based on land use zones, with further refinement through the use of high-resolution aerial photographs and findings from the site visit. The Manning's values were specified in the .tmf (TUFLOW model file). The final layout of Manning's roughness is provided as a model check file and is shown in Table 3-1. They are listed in Table 3-1.

TABLE 3-1 LAND USE MANNING'S 'N' ROUGHNESS VALUES

Material	Manning's 'n' Roughness
Pasture/Cleared farmland	0.04
Medium density vegetation	0.075
Dense vegetation	0.100
Caravans, Semi Permanent structures	0.300
Waterway, cobbled and rocky (upstream)	0.050
Waterway, sandy (Lower reaches)	0.040
Sealed roads	0.020
Tanks	1.000
Buildings	0.300
Rock flats on beach	0.040
Sand/estuary/ocean	0.030

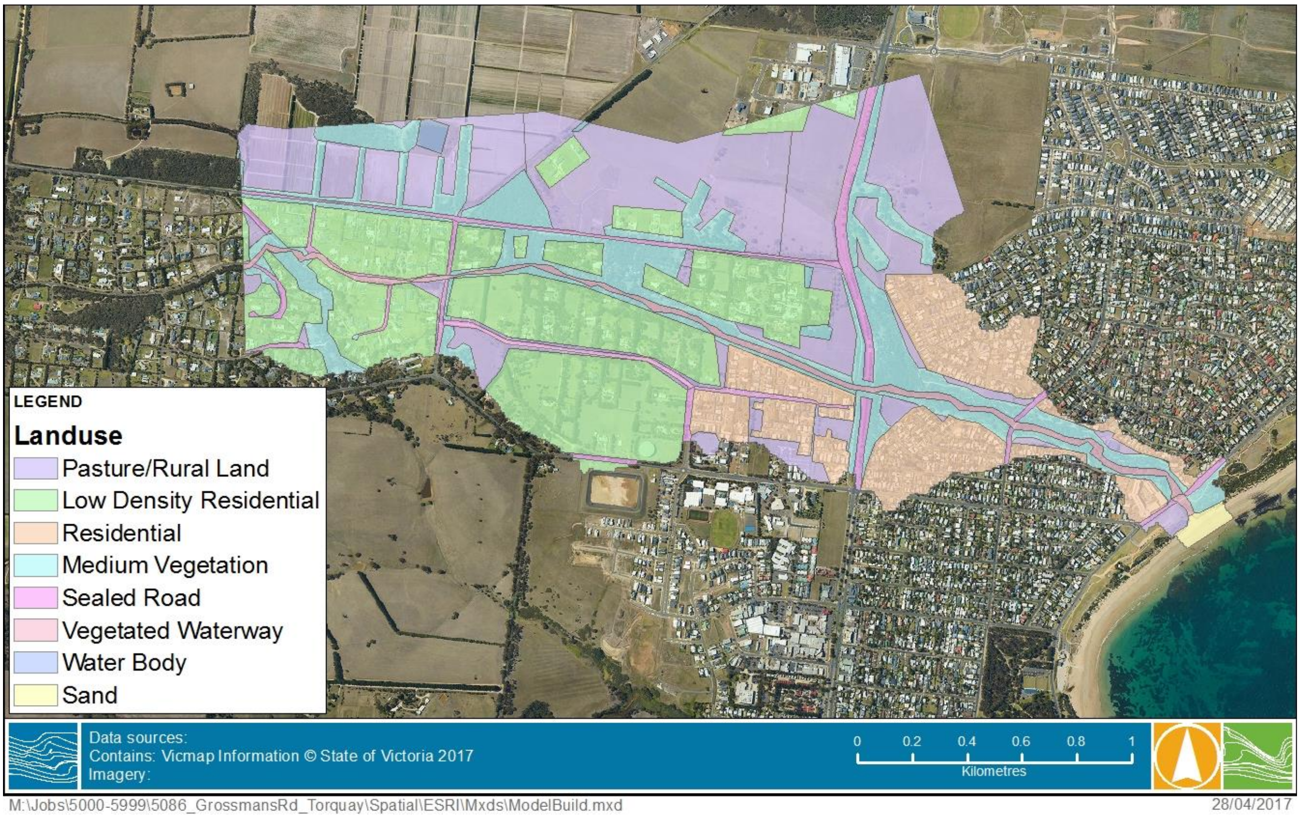


FIGURE 12 DEEP CREEK TUFLOW MODEL MANNING'S ROUGHNESS (EXISTING)

3.1.2 Key Hydraulic Structures

There were several key hydraulic structures within the model area. Structural information was unavailable within the model extent. To ensure waterway crossings were represented reasonably within the model, culvert sizes were estimated and included. Large bridge structures had the bridge decks removed from the LiDAR. Any backwater will not affect the site as these structures are far enough downstream. Sensitivity testing was undertaken to ensure the assumptions regarding these structures did not impact on flood extents through the site. Plans to verify the size of these structures were obtained from VicRoads. The estimated structures included:

- Surf Coast Highway – single 1200 mm culverts under the Surf Coast Highway and 900mm under the northern reach of the deep creek tributaries which enters the creek downstream of the Surf Coast Highway.
- Fischer Street cut out of LiDAR as on major flow path and structural information not available.

3.1.3 Boundary Conditions

3.1.3.1 Inflow Boundaries

Hydrographs from the RORB model were used as major inflow boundaries including Deep Creek, upstream of the development, and two secondary inflows identified to the east of the site based on the local drainage lines. Source Area (SA) boundaries were applied to accurately represent the inflows. Two additional inflows to represent the site discharges for both developed and mitigated flooding conditions were included in the model. Under both the developed and mitigated developed conditions inflows were included directly within the waterway corridor to mimic what would be a form drainage system and outlet structure into the creek. Under existing conditions, the inflow boundary for the eastern catchment of the site was input at Briody Drive. Figure 13 displays the boundaries applied to the Deep Creek model.

3.1.3.2 Downstream Boundary

The downstream end of the model, located at the outfall to Zeally Bay, utilised a Height/Time (HT) boundary to model the flow of water from the waterway to the ocean. The boundary location is shown in purple in Figure 13. A Storm Tide Height of 1.69 m AHD at Lorne, and LiDAR showing the downstream boundary around 1.4 m AHD was used to determine an initial water level of 1.5 m AHD. This was considered a conservative estimate. The development site is considered far enough upstream that the ocean boundary conditions would not cause any impact at the subject site in a large flood event.

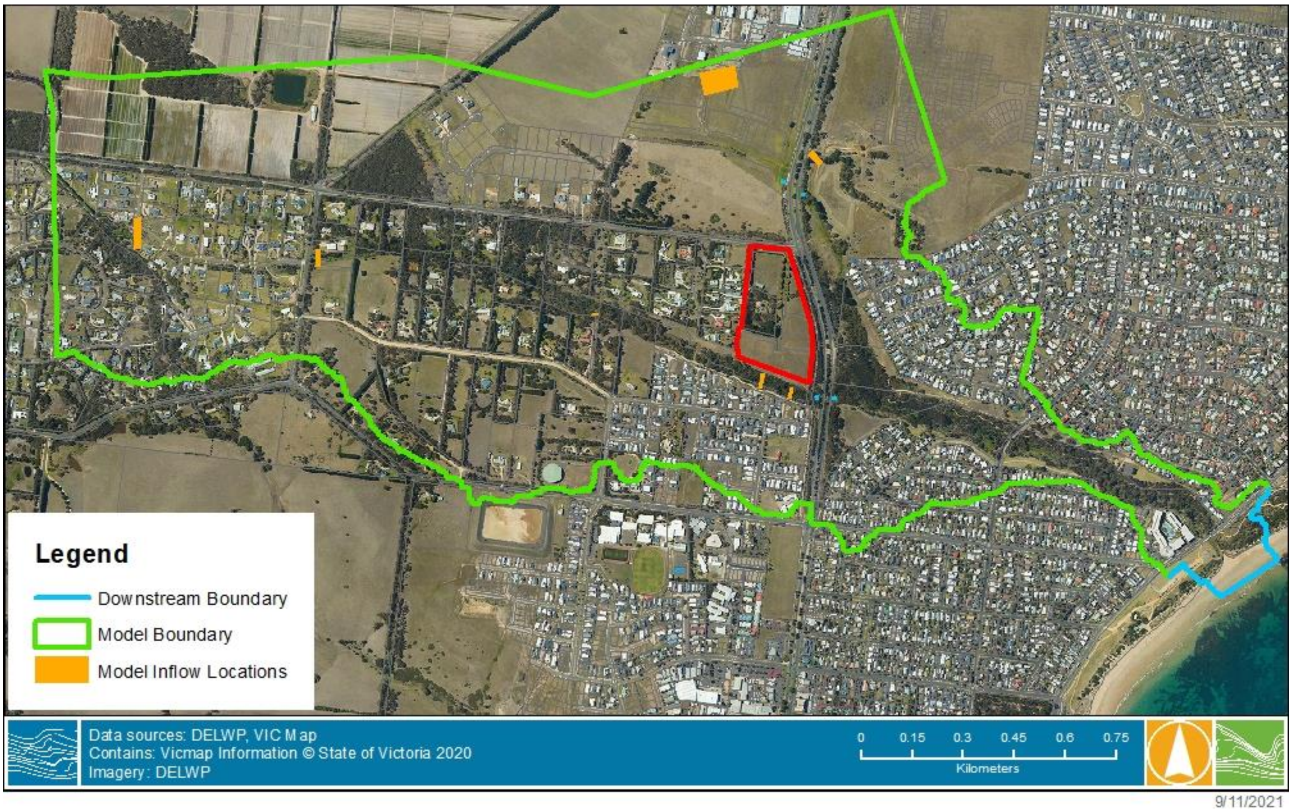


FIGURE 13 DEEP CREEK MODEL –BOUNDARIES

3.2 Existing Conditions Model Results

Hydraulic modelling of Deep Creek has produced flood depth, height and velocity data for the 1% AEP and 10% AEP flood events. Flood depths during a 1% AEP flood event are shown in Figure 14. The flood extent of Deep Creek is largely confined to the channel, with small areas of shallow depths along the banks. Deep Creek passes along the southern boundary of the subject site where inundation depths during 1% AEP flood event range up to in excess of 2 metres. The available mapping indicates that during the 1% AEP flood event the flooding extent does not impact of the proposed development parcel.

Comparatively, inundation extents during minor flooding events, including the 10% AEP events are not greatly different to the 1% AEP event. This is likely due to the local sloping topography and defined bed and banks of Deep Creek along the reach of Deep Creek leading up to the Surf Coast Highway.

FIGURE 14 DEEP CREEK 1% AEP FLOOD DEPTH

FIGURE 15 10% AEP FLOOD DEPTH

SURF COAST SHIRE COUNCIL
Planning Department
6/03/2024
21/0333 / D24/42573

4 DEVELOPED CONDITIONS

4.1 Hydraulic Modelling Results

4.1.1 Developed Conditions

Modelling of Deep Creek under developed conditions was completed for the 1% and 10% AEP flood events. Each of the modelled scenario assumed that the development provides no stormwater retardation and a single drainage connection into Deep Creek.

Figure 16 and Figure 17 show the resulting flood depths from the combined maximum envelope of the 1% AEP and 10% AEP flood events for developed conditions.

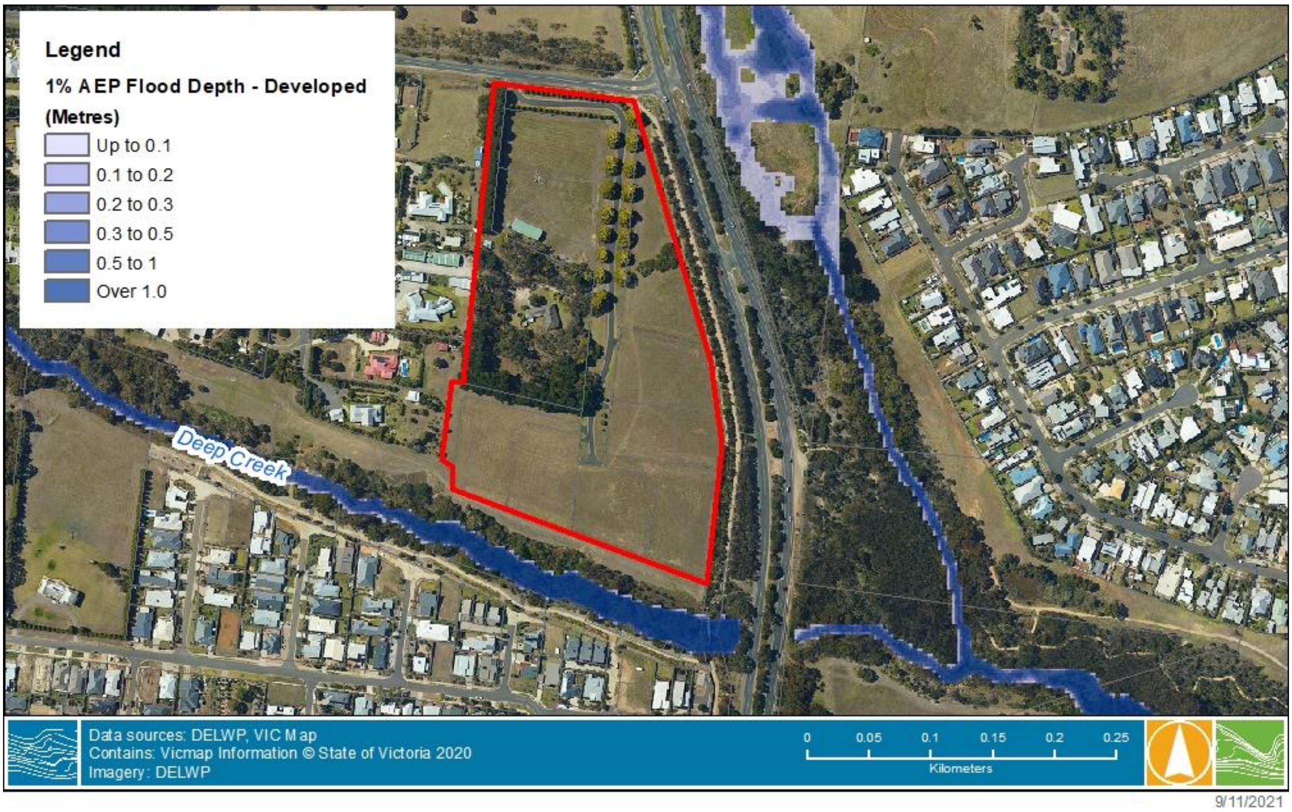


FIGURE 16 1% AEP FLOOD DEPTH – DEVELOPED CONDITIONS

FIGURE 17 10% AEP FLOOD DEPTH – DEVELOPED CONDITIONS

4.1.2 Discussion – Result Comparison

A comparison of the modelled 1% AEP flood depths indicates a minor increase in flood depth within Deep Creek for the developed scenario. Figure 18 shows the 1% AEP flood depth difference between existing and developed conditions. Noting the most significant increase in depth is immediately upstream of the Surf Coast Highway culvert, where depths have decreaed by up to 3-4 cm.

Whilst development of the site increases the impervious area and rate of runoff from the site, and as such flows do peak quickly, they are able to pass through the culverts prior to the peak of the larger upper Deep Creek catchment reaching the culverts .

A comparison of the 1% AEP 1.5Hr flood levels at the site and immediately downstream of the Surf Coast Highway is provided in . The comparison shows minor variation in levels along the creek with the greatest variation on the upstream side of the Surf Coast Highway. This indicates flows are attenuated on the upstream of the Surf Coast highway with the only passing structure being the 1200mm pipe culvert.

The channel within this portion of the creek is well defined with a bed level estimated to be at least 5 metres below bank level. This means the modelled increase in both flow and volume from the developed 1%, 10% AEP events are maintained within the waterway corridor and only provide for a minor increase in depth with minor increases to modelled extent between the existing and developed scenarios. The flow hydrograph from the culvert under the Surf Coast Highway also indicates sustained high flows of around 5m^3/s for some time, indicating attenuation of flooding on the upstream side of the highway (Figure 21). This figure also shows the impact of the developed site drainage with a small increase in peak runoff prior to the main waterway peak. This assessment does not consider the cumulative impact of unretarded stormwater flows and or any increase in runoff volume within the catchment.

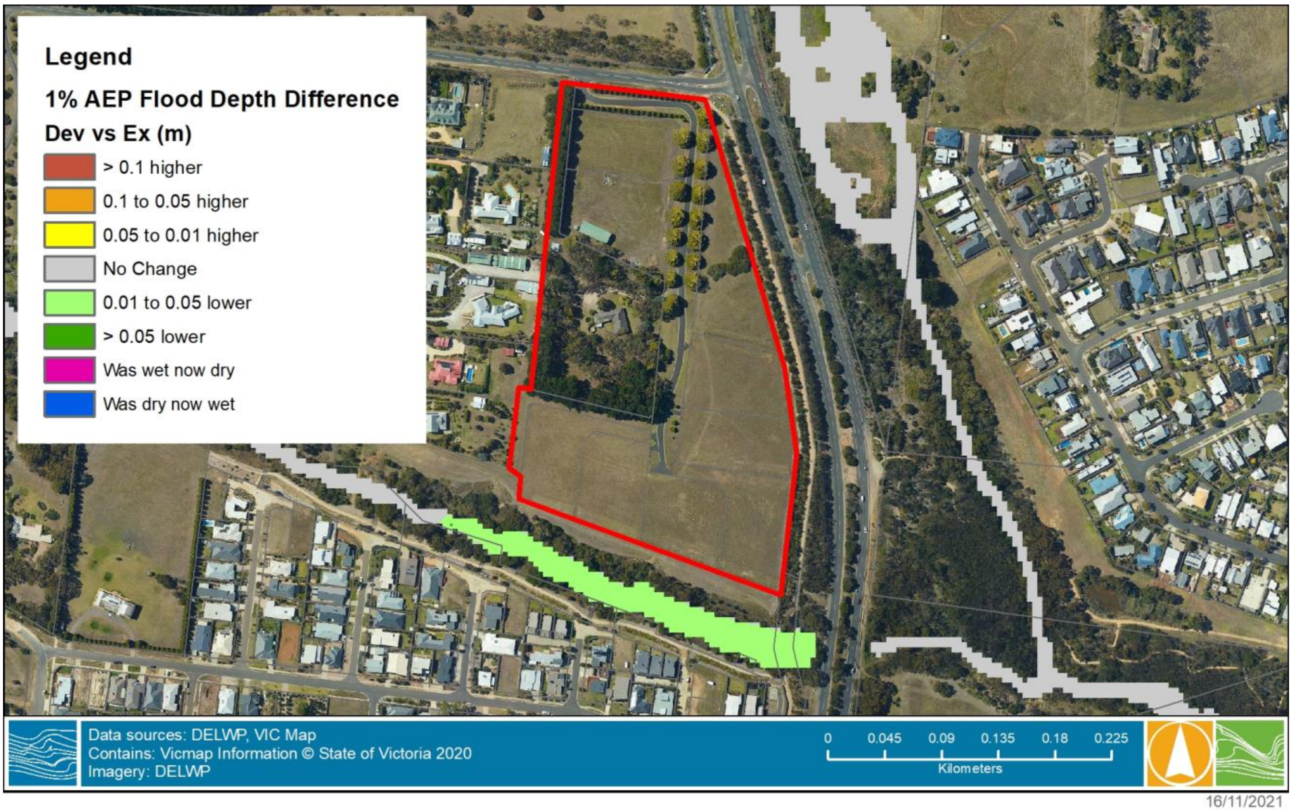


FIGURE 18 1% AEP FLOOD DEPTH DIFFERENCE DEVELOPED MINUS EXISTING

FIGURE 19 10% AEP FLOOD DEPTH DIFFERENCE DEVELOPED MINUS EXISTING

Location	1 (m AHD)	2 (m AHD)	3 (m AHD)	4 (m AHD)	5 (mA AHD)
Existing	28.16	28.15	28.15	22.75	20.18
Developed	28.12	28.11	28.11	22.75	20.18

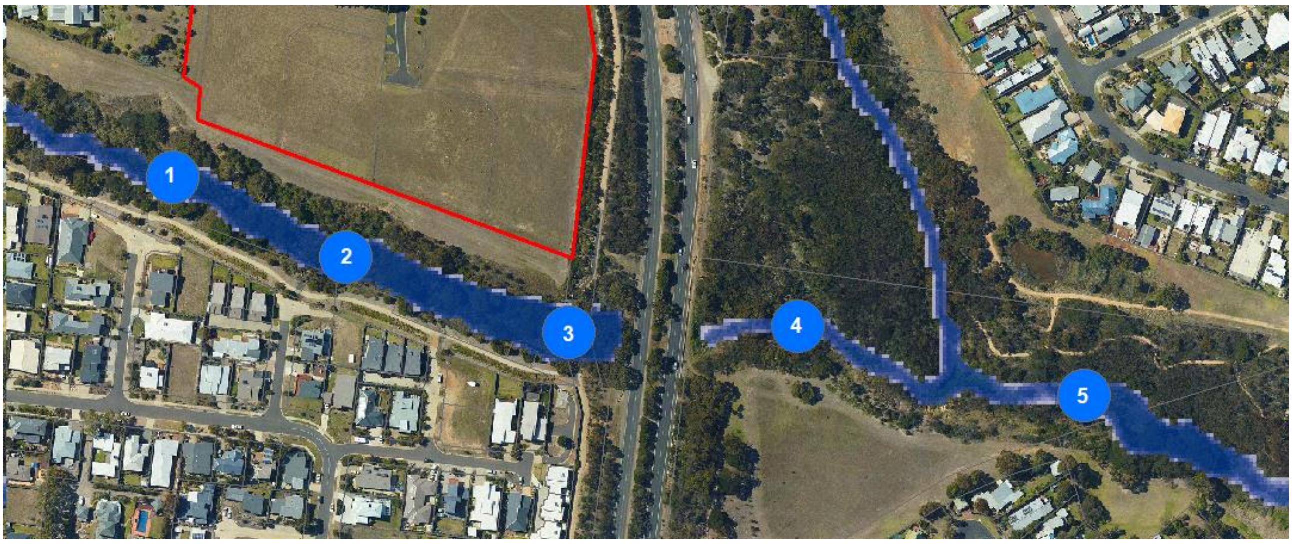


FIGURE 20 FLOOD DEPTH LOCATION

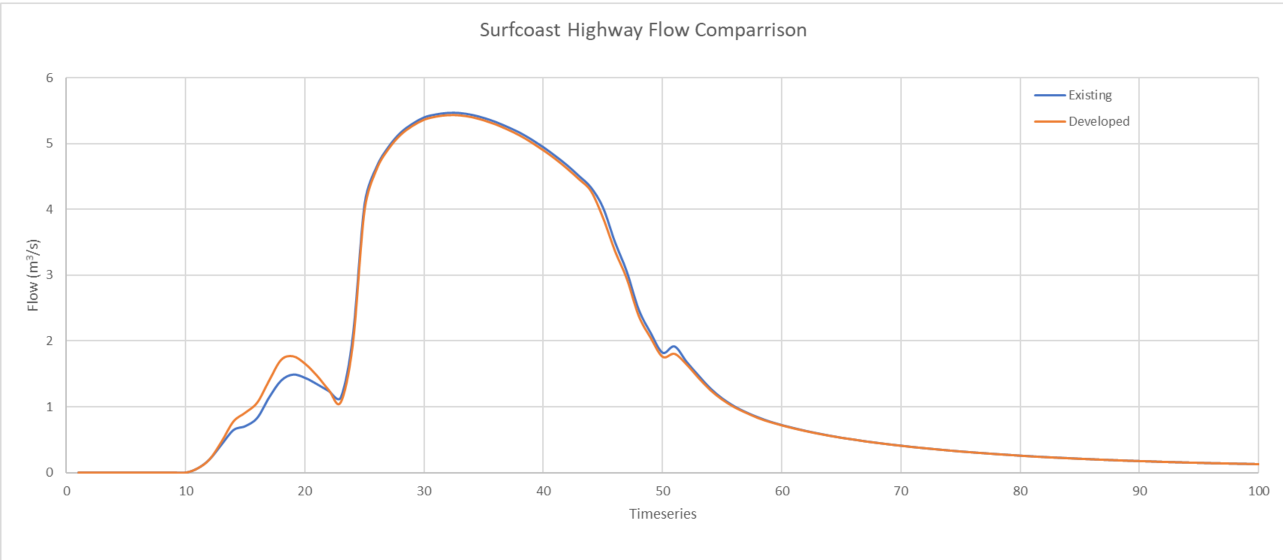


FIGURE 21 SURFCOAST HIGHWAY FLOW HYDROGRAPH – 1% AEP 1.5HR

APPENDIX A
AR&R DATA HUB OUTPUT

APPENDIX B RORB MODEL INPUTS

ARF Parameters
[LONGARF]
Zone,Southern Temperate
a,1.58E-01
b,2.76E-01
c,3.72E-01
d,3.15E-01
e,1.41E-04
f,4.10E-01
g,1.50E-01
h,1.00E-02
i,-2.70E-03
[LONGARF_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_LONGARF]

Storm Losses
[LOSSES]
Initial Losses (mm),24.0
Continuing Losses (mm/h),4.4
[LOSSES_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_LOSSES]

Temporal Patterns
[TP]
CODE,SSmainland
LABEL,Southern Slopes (Vic/NSW)
[TP_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_TP]

#10% Preburst Depths
[PREBURST10]
min (h)¥AEP(%),50,20,10,5,2,1,
60 (1.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
90 (1.5),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),

120 (2.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
180 (3.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
360 (6.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
720 (12.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
1080 (18.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
1440 (24.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
2160 (36.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
2880 (48.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
4320 (72.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
[PREBURST10_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_PREBURST10]

#25% Preburst Depths
[PREBURST25]
min (h)¥AEP(%),50,20,10,5,2,1,
60 (1.0),0.1 (0.009),0.1 (0.004),0.0 (0.001),0.0 (0.0),0.1 (0.002),0.1 (0.004),
90 (1.5),0.0 (0.001),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
120 (2.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
180 (3.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
360 (6.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
720 (12.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
1080 (18.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
1440 (24.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
2160 (36.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
2880 (48.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
4320 (72.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),
[PREBURST25_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_PREBURST25]

#75% Preburst Depths
[PREBURST75]
min (h)¥AEP(%),50,20,10,5,2,1,
60 (1.0),12.0 (0.977),11.3 (0.644),10.9 (0.507),10.5 (0.411),13.0 (0.422),15.0 (0.424),
90 (1.5),6.9 (0.481),10.2 (0.504),12.4 (0.506),14.5 (0.502),13.9 (0.4),13.5 (0.342),
120 (2.0),9.1 (0.566),10.5 (0.468),11.4 (0.423),12.3 (0.389),12.5 (0.328),12.6 (0.292),
180 (3.0),10.5 (0.553),12.8 (0.492),14.4 (0.462),15.9 (0.437),12.9 (0.296),10.6 (0.216),

360 (6.0),4.8 (0.189),8.3 (0.24),10.5 (0.258),12.7 (0.27),16.4 (0.291),19.1 (0.3),
720 (12.0),1.7 (0.048),4.5 (0.097),6.4 (0.117),8.2 (0.13),12.9 (0.171),16.5 (0.192),
1080 (18.0),0.3 (0.008),3.9 (0.072),6.4 (0.098),8.7 (0.116),13.1 (0.145),16.4 (0.16),
1440 (24.0),0.2 (0.005),3.1 (0.051),5.0 (0.069),6.8 (0.081),7.8 (0.077),8.6 (0.074),
2160 (36.0),0.0 (0.0),0.7 (0.01),1.2 (0.014),1.6 (0.016),2.8 (0.023),3.6 (0.027),
2880 (48.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.5 (0.004),0.9 (0.006),
4320 (72.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.0 (0.0),0.1 (0.001),0.2 (0.001),
[PREBURST75_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_PREBURST75]

#90% Preburst Depths
[PREBURST90]
min (h)¥AEP(%),50,20,10,5,2,1,
60 (1.0),19.0 (1.552),20.9 (1.191),22.2 (1.035),23.4 (0.92),26.4 (0.855),28.6 (0.812),
90 (1.5),23.2 (1.622),24.9 (1.233),26.1 (1.065),27.2 (0.942),24.4 (0.701),22.3 (0.564),
120 (2.0),22.9 (1.431),25.1 (1.121),26.6 (0.985),28.0 (0.884),27.2 (0.714),26.5 (0.615),
180 (3.0),19.9 (1.053),26.7 (1.025),31.2 (1.001),35.5 (0.977),34.3 (0.79),33.4 (0.681),
360 (6.0),18.1 (0.705),28.3 (0.819),35.0 (0.859),41.5 (0.88),41.0 (0.728),40.6 (0.639),
720 (12.0),12.6 (0.363),16.8 (0.363),19.6 (0.359),22.3 (0.354),30.2 (0.4),36.2 (0.422),
1080 (18.0),11.1 (0.272),13.7 (0.25),15.4 (0.238),17.1 (0.228),22.7 (0.251),26.8 (0.262),
1440 (24.0),7.9 (0.175),12.2 (0.199),15.0 (0.206),17.7 (0.21),19.7 (0.193),21.1 (0.182),
2160 (36.0),7.9 (0.154),9.7 (0.138),11.0 (0.13),12.2 (0.123),19.2 (0.161),24.5 (0.18),
2880 (48.0),5.9 (0.106),5.6 (0.073),5.4 (0.058),5.2 (0.048),7.0 (0.053),8.3 (0.055),
4320 (72.0),0.2 (0.003),0.7 (0.008),1.0 (0.009),1.3 (0.01),15.1 (0.103),25.4 (0.153),
[PREBURST90_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_PREBURST90]

Interim Climate Change Factors
[CCF]
2030,0.719 (3.6%),0.739 (3.7%),0.822 (4.1%),
2040,0.925 (4.6%),0.915 (4.6%),1.119 (5.6%),
2050,1.123 (5.6%),1.085 (5.4%),1.449 (7.2%),
2060,1.271 (6.4%),1.294 (6.5%),1.865 (9.3%),
2070,1.394 (7.0%),1.526 (7.6%),2.333 (11.7%),
2080,1.477 (7.4%),1.778 (8.9%),2.776 (13.9%),
2090,1.527 (7.6%),2.009 (10.0%),3.21 (16.1%),

[CCF_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
Note,ARR recommends the use of RCP4.5 and RCP 8.5 values
[END_CCF]

Baseflow Factors
[BASEFLOW]
DOWNSTREAM,0.0
AREA_SQKM,908.982
CATCH_NO,11245.0
R3RUNOFF,0.212
R1RUNOFF,0.041
[BASEFLOW_META]
Time Accessed,19 April 2017 11:31AM
Version,2016_v1
[END_BASEFLOW]

[ENDTXT]

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX C
AR&R – REGIONAL FLOOD FREQUENCY ESTIMATION TOOL

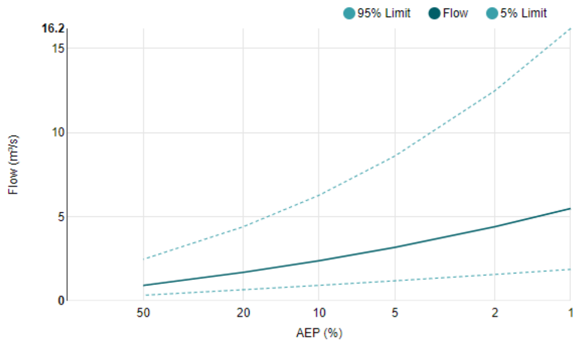
AR&R (2016) has developed a new Regional Flood Frequency Estimate (RFFE) (Rahman, et al, 2015[8]). This method was used to compare Deep Creek flows to other regional methods. The online tool uses the catchment centroid, catchment outlet and size to estimate peak flow outputs for a range of flood magnitudes. The tool was developed utilising data based on gauged catchments to form region based flood relationships.

The RFFE tool has several limitations to its application and should be avoided where:

- The catchment includes greater than 10% urban,
- Catchment storage significantly altered the natural rainfall runoff behaviour,
- Catchment where large scale clearing has taken place,
- Catchments which are greatly affected by irrigation activity and or drainage.

The reliability of the tool is also considered less accurate for catchment less than 0.5 km^2 and or greater than 1,000 km^2 or where a catchment exhibit atypical characteristics.

Results | Regional Flood Frequency Estimation Model



*The catchment has unusual shape. Results have lower accuracy and may not be directly applicable in practice.

AEP (%)	Discharge (m^3/s)	Lower Confidence Limit (5%) (m^3/s)	Upper Confidence Limit (95%) (m^3/s)
50	0.910	0.330	2.47
20	1.70	0.660	4.41
10	2.39	0.920	6.28
5	3.18	1.19	8.61
2	4.41	1.57	12.5
1	5.49	1.87	16.2

Input Data	
Date/Time	2021-11-15 12:00
Catchment Name	Catchment1
Latitude (Outlet)	-38.319
Longitude (Outlet)	144.319
Latitude (Centroid)	-38.317
Longitude (Centroid)	144.297
Catchment Area (km^2)	3.1
Distance to Nearest Gauged Catchment (km)	25.59
50% AEP 6 Hour Rainfall Intensity (mm/h)	4.295056
2% AEP 6 Hour Rainfall Intensity (mm/h)	9.401045
Rainfall Intensity Source (User/Auto)	Auto
Region	East Coast
Region Version	RFFE Model 2016 v1
Region Source (User/Auto)	Auto
Shape Factor	1.1*
Interpolation Method	Natural Neighbour

FIGURE 22 DEEP CREEK - RFFE

[8] AR&R (2016) - http://data.arr-software.org

SURF COAST SHIRE COUNCIL
Planning Department
6/03/2024
21/0333 / D24/42573

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Melbourne
15 Business Park Drive
Notting Hill VIC 3168
Telephone (03) 8526 0800
Fax (03) 9558 9365

Brisbane
Level 3, 43 Peel Street
South Brisbane QLD 4101
Telephone (07) 3105 1460
Fax (07) 3846 5144

Wangaratta
First Floor, 40 Rowan Street
Wangaratta VIC 3677
Telephone (03) 5721 2650

Perth
PO Box 362
Subiaco WA 6904
Telephone 0407 946 051

Geelong
PO Box 436
Geelong VIC 3220
Telephone 0458 015 664

Gippsland
154 Macleod Street
Bairnsdale VIC 3875
Telephone (03) 5152 5833

Wimmera
PO Box 584
Stawell VIC 3380
Telephone 0438 510 240

www.watertech.com.au

info@watertech.com.au

Appendix C – Cypress Lane Torquay – FIA, RFI Response 10 May 2023, Water Technology

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

10 May 2023

Nick Abbott
c/Leigh Prosser
Loetis
PO Box 867
Geelong VIC 3220

Via email: leigh.p@loetis.com.au, jedibuildinggroup@gmail.com

Dear Nick

Our ref: 22010191

Re: 4 Cyress Lane Torquay – Flood Impact Assessment RFI Response

In response to the query from Surf Coast Shire in relation to the impacts of increased stormwater flows from the subject site under developed conditions the following comments have been provided.

During the 1% AEP storm events un-retarded flows from the site were modelled using TuFLOW. The results show that flood levels within the waterway are not increased within Deep Creek adjacent to the site during the event. This occurs as under developed conditions the site drains more quickly to Deep Creek prior to the larger upstream peak reaching this location. This is shown in the figure below taken from the Flood Impact Report (Figure 18). The figure shows the change in flood levels within deep creek as a result of post development flows. Noting the decreased in flood levels of up to 5cm.

*Figure -**Error! No text of specified style in document.**-1 1% AEP Flood Depth Difference (Dev vs Ex)*

As a result it is highly unlikely that the change in event based flows associated with the site peaking and discharging more quickly to Deep Creek at this location will adversely impact on the ecological values within the creek at this location. Primarily because the variation in flows is short lived and the ultimate peak is less than what occurs during existing conditions. This is further illustrated by the hydrograph presented in the Flood Impact Report (Figure 21) (Water Technology, 2022). Which shows the difference in flow rate between existing and post development upstream of the Surf Coast Highway.

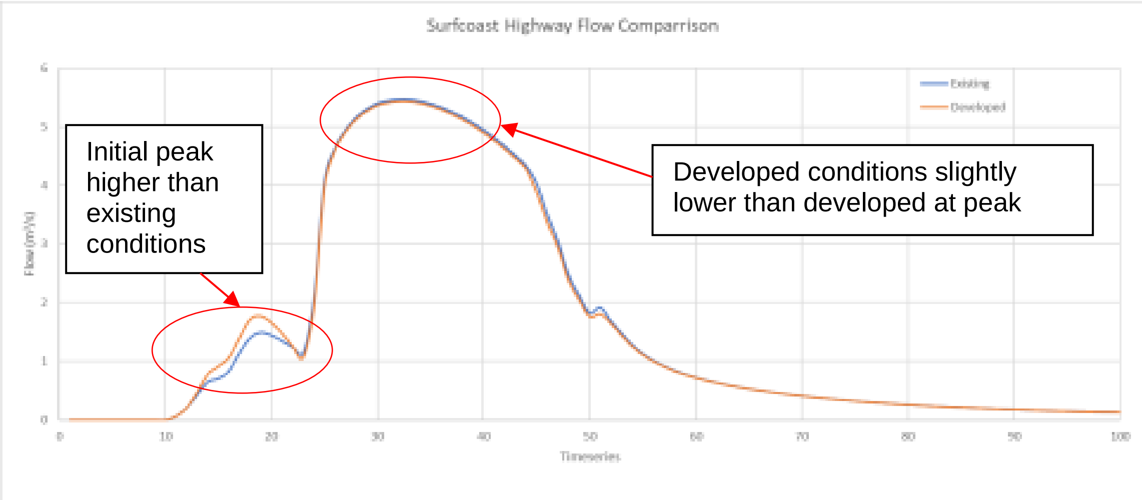


Figure 1-2 Upstream Surfcoast Highway Flow Hydrograph Comparison

It is also understood that Surf Coast Shire may have concerns regarding the nature of additional seasonal flows from the site to Deep Creek. It is understood that the Deep Creek Nature reserve is located downstream of the point at which the site stormwater will discharge. Acknowledging that the nature reserve is a highly valued community space with environmentally sensitive areas in accordance with the Deep Creek Master Plan. Noting that Deep Creek is not recognised by the Corrangamite CMA Waterway Strategy.

The watercourse through the reserve to the ocean outfall is well defined with no significant storage areas or wetlands within the corridor. Having regards to this, low flows (seasonal volume changes) within the waterway are largely passing and do not contribute notably to any disturbance of the ecological values within the reserve. The area is significantly more vulnerable to increases in peak flow which would impact and inundate fringing vegetation and risk erosions. As the site will not increase peak flows within Deep Creek, it is highly unlikely that the development of this site will adversely impact the environmental values downstream.

Yours sincerely

Johanna Theilemann
Senior Principal Engineer
Johanna.Theilemann@watertech.com.au
WATER TECHNOLOGY PTY LTD

LOETIS

Appendix D – Water Technology Letter of Review, 7 February 2024

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

7 February 2024

Surf Coast Shire Council
1Merrijig Drive
Torquay Victoria Australia 228

Via email: info@surfcoast.vic.gov.au

Dear To whom it may concern

Our ref: 24010294

Development Layout Update – Cypress Lane

Water Technology have reviewed the updated development layout dated 8/11/2023 and the Stormwater Management Plan (SWMP) dated November 2023.

Whilst changes have been made to the proposed development layout within the property in accordance with these plans, I note that this does not change the impervious fraction of the developed conditions.

Your assessment and revised SSMP has indicated a fraction impervious value of 55%, consistent with previous SSMP assessments.

It should also be noted that as part of the flood impact assessment a conservative much higher fraction impervious (in the order of 75-80%) was adopted for developed conditions, which means that any minor change in fraction impervious associated with design alterations is accounted for within the flood modelling and is unlikely to change the resulting flood impact assessment.

If you have any further questions, please feel free to contact me on the email below.

Yours sincerely

Johanna Theilemann
Senior Principal Engineer
Johanna.Theilemann@Watertech.com.au
WATER TECHNOLOGY PTY LTD

Water Technology pays respect to all First Nations peoples, their cultures and to their Elders, past and present.

[Choose address from the ribbon]