

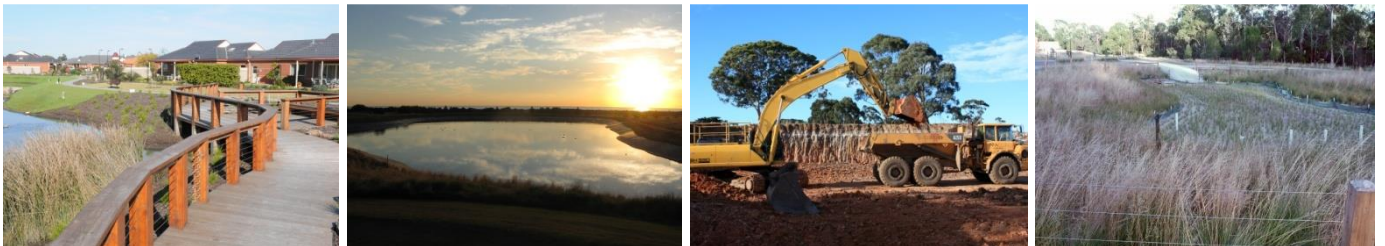


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STORMWATER MANAGEMENT STRATEGY

6280 Great Ocean Road, Apollo Bay

19 December 2019

BW REF: 3313

DOCUMENT CONTROL DATA

 <p>Beveridge Williams Melbourne Office 1 Glenferrie Road Malvern Vic 3144 PO Box 61 Malvern Vic 3144 Tel: (03) 9524 8888 Fax: (03) 9524 8899 www.beveridgewilliams.com.au</p>	Title	Stormwater Management Strategy – 6280 Great Ocean Road, Apollo Bay
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	Synopsis	<i>Stormwater strategy for the proposed residential development of 6280 Great Ocean Road, Apollo Bay</i>

Reference: 3313

Client: Australian Tourism Investments No. 5 Pty Ltd

Revision Table

Rev	Description	Date	Authorised
0	Internal Draft for review/comment prior to finalisation	15/04/15	A.M
1	Issue to Client for comment	23/04/15	N.F
2	Final for Planning Permit Application	20/11/15	N.F.
3	Amended for Council and CMA comments	29/01/16	C.C.
4	Further amendments for Council comments	25/07/16	C.C.
5	Updates to reflect changes to drainage reserve arrangements in Version 36 of the Overall Development Plan	19/12/19	M.F.

Distribution Table

Date	Revision	Distribution
15/04/15	0	Aram Manjikian
23/04/15	1	Client, Nicole Faulkner
20/11/15	2	Planning Permit Application
29/01/16	3	Colac Otway Shire Council, Corangamite CMA, Client, BW
25/07/16	4	Colac Otway Shire Council, Corangamite CMA, Client, BW
18/09/19	5	Colac Otway Shire Council, Corangamite CMA, Client, BW

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APPENDIX H. ENVISS PIT INFORMATION

Glossary of terms

Alphabetical list of terms and abbreviations used in report

ARI	Average Recurrence Interval - <i>The average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration.</i> ¹
Authorities	Organisations responsible for supply and management of sewer, water, gas, electricity and telecommunications, roads and transport
Client	Australian Tourism Investments No. 5 Pty Ltd
CCMA	Corangamite Catchment Management Authority
Council	Colac Otway Shire Council
DEPI	Department of Environment and Primary Industries
SEPP	State Environment Protection Policy
IDM	Infrastructure Development Manual
BPEMG	Best Practice Environmental Management Guidelines
WSUD	Water Sensitive Urban Design
RB	Retarding Basin

1 INTRODUCTION

Beveridge Williams has been commissioned by Australian Tourism Investments No. 5 Pty Ltd (the Developer) to prepare a Stormwater Management Plan (SWMP) for a proposed Residential Estate located at 6280 Great Ocean Road, Apollo Bay.

This SWMP is intended to provide sufficient evidence that the proposed Residential Development can meet Stormwater Best Practice Environmental Management Guidelines (BPEMG) and provide supporting evidence that the stormwater discharges from the proposed subdivision shall be to the satisfaction of the Responsible Authority.

The site totals approximately 40.96 ha in area as shown in Figure 1. The site is bounded by the Great Ocean Road to the southeast, private properties adjacent to Wild Dog Creek to the northeast, rural conservation land to the northwest and the Pisces Holiday Park to the southwest.

The location of the site is below.



Figure 1: Location Plan

1.1 Site overview

The site lies within the Apollo Bay Settlement Boundary Plan area and at the time of writing this report part of the land has been designated for neighbourhood residential development (zoned NRZ1) whilst the land generally above the 40m contour remains zoned rural conservation zone (RCZ) due to the risk of land slippage.

The site rises at an approximate grade of 1 in 10 from the south-east boundary to the 40 m contour, at which point the grade steepens to approximately 1 in 4, and continues as such to the north-western site boundary. Figure 2 illustrates the general site topography.

Dams are located in the north-eastern corner and along the existing drainage networks which traverse the site. An existing dwelling is located near the mid-point of the south-west boundary. The site is generally clear of vegetation, excluding scattered trees and a concentration of native vegetation in the north-east corner.

The main low point of the site is located along the Great Ocean Road, which records a level of approximately 5.5 AHD. Refer to Appendix A for the Site Plan.



Figure 2: Site Topography (Source: Apollo Bay Settlement Boundary & Urban Design Review)

1.2 Development Proposal

The site is proposed to be developed as standard density residential including three drainage reserves of approximately 2.76 ha in total and a drainage area for swales of 0.24 ha.

The proposed subdivision is shown in the Overall Development Concept Plan V36 (below – also in Appendix B). The arrangement of lots is currently being completed to form residential lots of an average lot size of 626m².

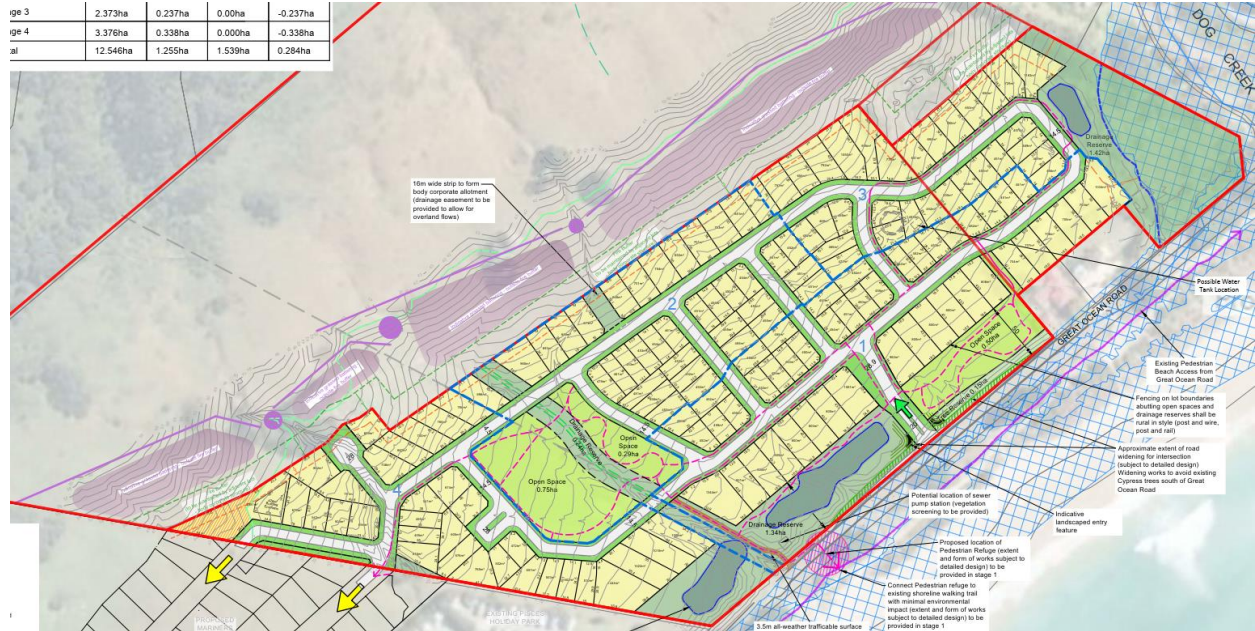


Figure 3: Overall Development Plan

1.3 Design Intent

It is proposed to base the Site Stormwater Management Strategy on the requirements as outlined in the Infrastructure Design Manual and to the satisfaction of Colac Otway Council and the Catchment Management Authority.

The strategy aims to reflect the existing site conditions where possible and incorporate natural drainage features into the design. The following summary shows the proposed stormwater management for the site:

- Stormwater flows generated within the development for events up to 1 in 3 month ARI event to be treated using WSUD elements such as sediment basins and wetlands;
- Internal stormwater flows for events up to 1 in 5 year ARI event to be conveyed via conventional stormwater drainage infrastructure;
- External stormwater flows to be intercepted by catch swales and conveyed through the site using roads and drainage reserve as overland flowpaths;
- Detention of post-developed internal flows generated by the 1 in 100 year ARI event back to pre-developed 1 in 100 year ARI discharge using multiple above ground detention basins across the site; and
- Conveyance of internal and external stormwater flows between 1 in 5 year ARI event and 1 in 100 year ARI event via road reserves and drainage channels.

2 HYDROLOGY

2.1 Existing Catchment

Catchments and overland drainage paths used in the calculation of existing stormwater flows are shown below in Figure 4– Predevelopment Catchment Plan and Appendix D.

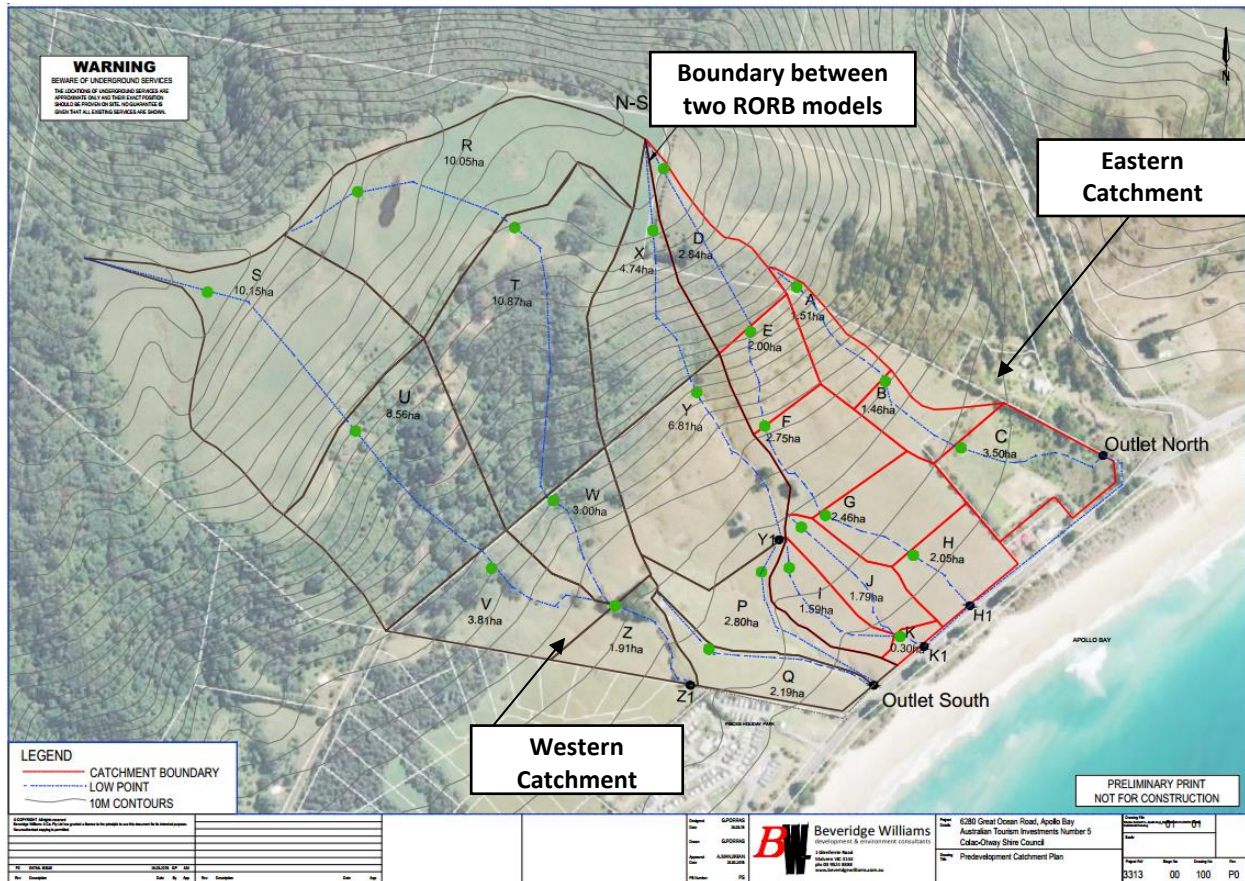


Figure 4: Predevelopment Catchment Plan, also Appendix D.

The sub-area details are enclosed in the RORB inputs and outputs report in Appendix E.

2.2 Developed Catchment

The developed condition proposes two points of drainage discharge at Outlets East and West to enable comparison to the existing conditions model. It is proposed to discharge the both catchments into the Apollo Bay foreshore via a culvert under Great Ocean Road, which is the current outfall for the site as shown below in Figure 5 and Appendix D- Developed Conditions Catchment Plan.

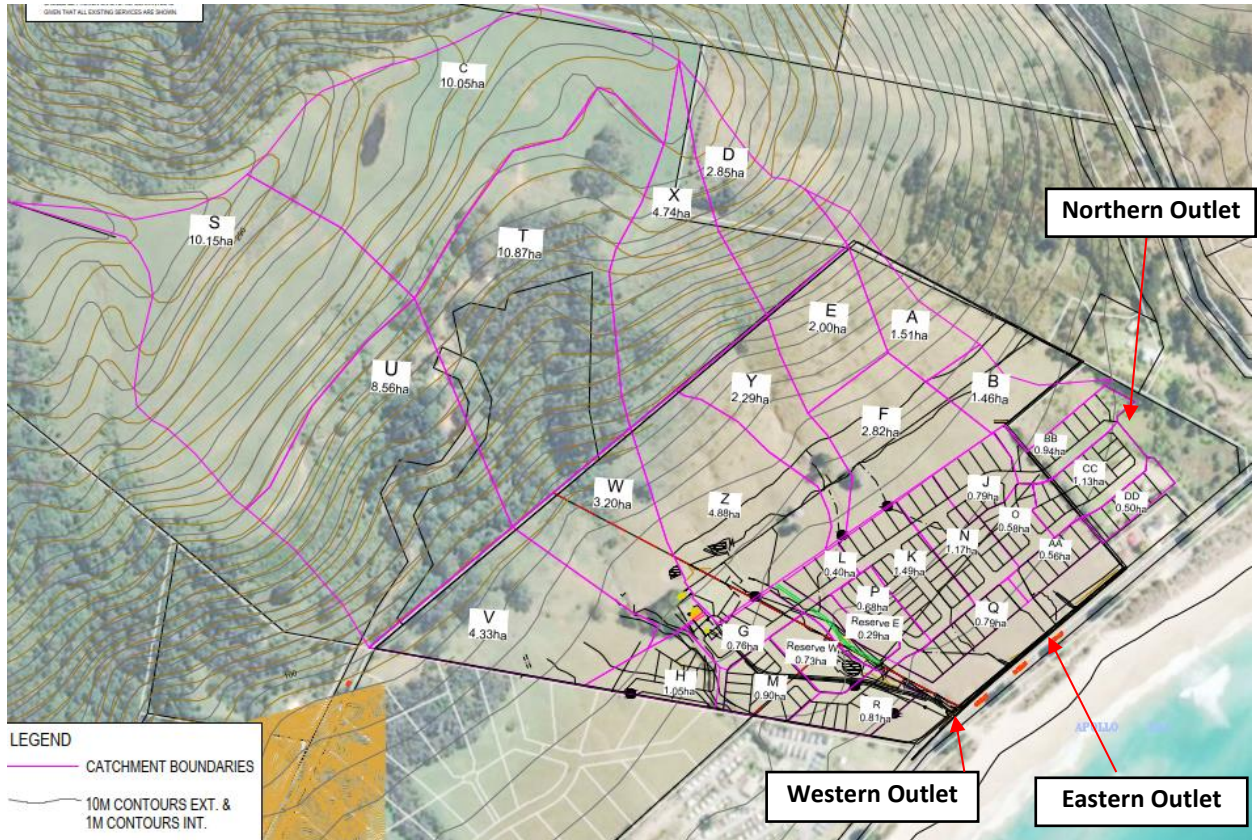


Figure 5: Developed Catchment Plan.

The sub-area details are enclosed in the RORB inputs and outputs report in Appendix E.

2.3 RORB model setup for existing catchment

The peak discharges for existing conditions have been modelled using RORB and two models have been developed to confirm the flows at the East and West catchments. The RORB parameters used for each model are the following:

Table 1: RORB Parameters used for the Northern and Southern catchment models

RORB Parameters	Eastern Catchment	Western Catchment
m	0.8	0.8
Kc	1.6	3
RoC 100 year	0.6	0.6
Initial Loss	15	15
Fraction Impervious for rural	0.1	0.1

The RORB models were calibrated using the total area flows calculated by the Rational Method under the existing conditions for the 100 year event. The Kc value that best represented the catchment conditions was determined to be 1.6 and 3 for the east and west catchments respectively as per Table 1 above. A copy of the RORB Inputs and Outputs Report and the rational method calculation is included in Appendix E.

2.4 RORB model setup for developed catchment

The peak discharges for developed conditions have been modelled using RORB and retarding basins sized to match the pre-developed flows at corresponding outlets for the East and West catchments. The RORB parameters used for the model are the following:

Table 2: RORB Parameters used for the Northern and Southern catchment models

RORB Parameters	Developed Catchment
m	0.8
Kc	2.8
RoC 100 year	0.6
Initial Loss	15
Fraction Impervious for rural	0.1
Fraction Impervious for developed	0.6

The RORB model was calibrated using the flows calculated by the pre-developed RORB models for the 100 year event at points where the existing upstream catchment enters the development extent. A single RORB model was created for the developed conditions as the two existing catchments are combined within the development based on the road layout. The outlets from the development were kept in similar locations to the existing conditions for comparison.

The Kc value that best represented the catchment conditions was determined to be 2.8 as per Table 2 above.

2.5 RORB Results

Table 3 shows the RORB modelling results for the peak flows of the pre-developed and post-developed scenarios as described above at the two outfall locations. The total outlet flows demonstrate that the developed condition discharges will be less or equal to the existing condition flows during the 100 year event with the retarding basins operating at capacity.

RORB Model	Western Outlet	Eastern Outlet	Northern Outlet
1. Existing Conditions	0.83 (2 hr)	1.24 (2 hr)	0.57 (2 hr)
2. Developed Conditions	0.83 (1 hr)	1.23 (1 hr)	0.50 (25 min)

Table 3: Peak Discharges for varying ARI (m3/s). Critical durations in parenthesis.

The Retarding Basins, WSUD Concept Design and Interim Drainage Proposals are further described in section 4 and 5 respectively.

A copy of the RORB Inputs and Outputs Report is included in Appendix E.

2.6 Retarding basin sizing

The RORB model included 3 separate RB's at different points of the development in order to fit in better with the site topography and avoid having a large centralized basin that would have been inefficient and unsightly. RB 3 over-detains the development areas upstream of the northern drainage reserve in order to offset the un-detained flows from sub-catchment DD (Figure 5) due to the topography

The locations of the RB's are shown on Figure 6, and the sizing of each RB is listed in Table 4.



Figure 6: RB locations.

Table 4: RB sizing

	Peak Water Volume (m ³)	Outlet pipe diameter (mm)
RB1	745	2 x 600, 1 x 450
RB2	1,650	3 x 600
RB3	190	600

The RB sizing has been modelled for the 100 year ARI storm event. The outlet configuration of the RB's will also provide detention for smaller events, and will be designed at the detailed design phase, tailored to each RB.

2.7 Existing culverts under Great Ocean Road

There are three small culverts under the Great Ocean Road opposite the frontage of the site, as shown in Figure 7 with their respective diameters.



Figure 7: Existing culvert locations

Based on the sizes and grades of the culverts, the combined capacities is approximately 0.83 m³/s. Using the rule of thumb for estimating design flows from the 100 year ARI value in Section 2.5, it was determined that this flow equates to the 1 in 5 year ARI flow for existing conditions.

All flows greater than the 1 in 5 year ARI storm event continue along the swale on the side of the Great Ocean Road to the Wild Dog Creek, then flow over the road to the foreshore on the other side once the swale capacity is exceeded.

3 SUBJECT SITE OVERLAND FLOW

Overland flows from the site will be directed via the road network to connect to the retarding basins on site and eventually discharge to the road drainage prior to discharging onto the Apollo Bay foreshore. The road design and lot shaping within the site is to be designed to ensure flows from the site do not discharge into the neighbouring Pisces Caravan Park.

Narrow drainage reserves with proposed swales have been allowed in the layout to cater for the overland flow paths from external catchments. External catchments will be intercepted and directed through the site via grassed swales and road reserves without changes in direction for efficiency in conveyance. Cut-off swales along the northern lot boundaries will protect those lots and will be incorporated with the design of the landslip protection bund.

The internal roads for the development, and associated lot finished surface levels will be designed during detailed design to ensure that the 1 in 100 year ARI overland flows through the location of the site are within the safe hydraulic capacity of road floodways. The development will be designed to avoid trapped low points and areas of high risk associated with blockages, and care will be taken where flows converge to ensure downstream capacity is available.

The indicative overland flow paths are shown in Figure 8 and Appendix C.

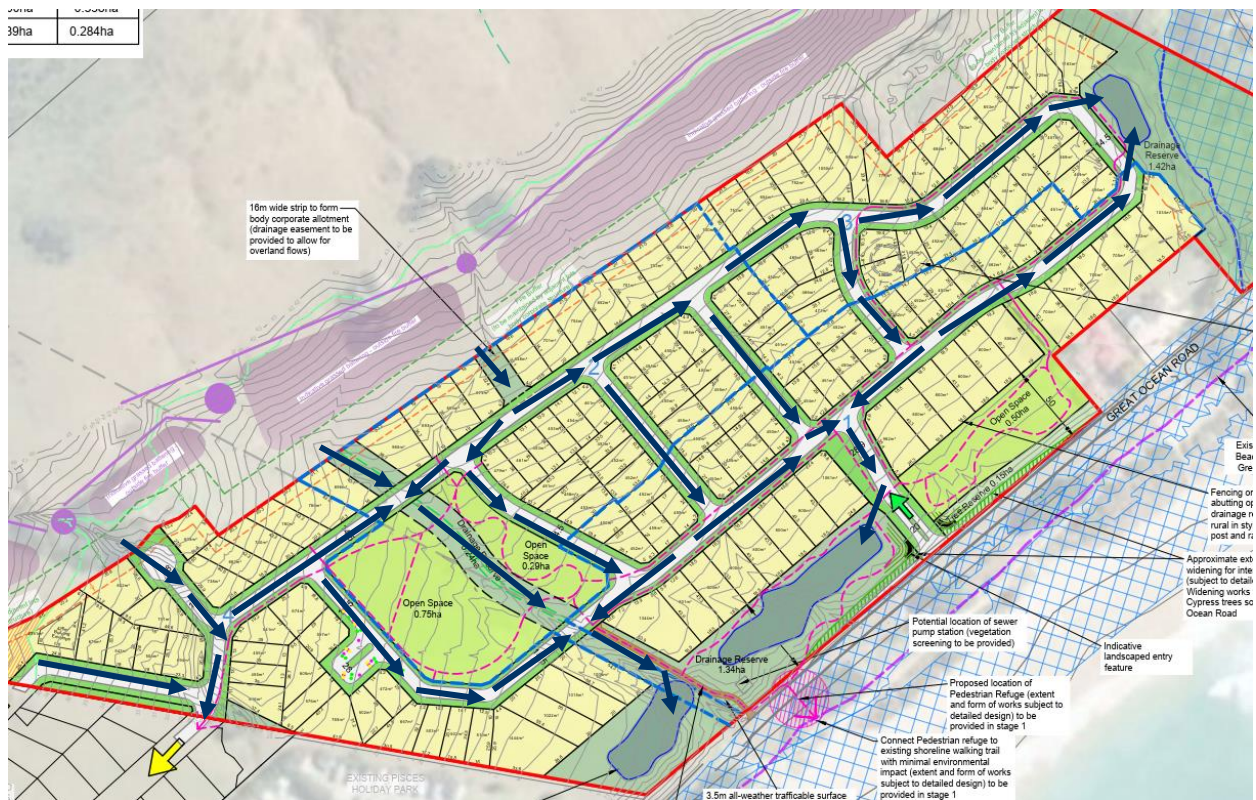


Figure 8: Indicative Overland Flow Paths

4 DRAINAGE CONCEPT DESIGN INFORMATION

The Overall Development Plan prepared for the 6280 Apollo Road site shows a total drainage area of 3.06 ha which is composed of 2.76 ha for retarding and treatment area and 0.30 ha designated for grassed swales.

4.1 Retarding Basins and Stormwater treatment systems

The drainage reserves have been designed as per the IDM design requirements with the following design response:

- 4 metre access/share path will be provided to facilitate future maintenance of the assets
- All batters are at least 1 in 5. Where available, 1 in 6 batters and up to 1 in 8 batters have been provided where the asset abuts the pedestrian access.
- Freeboard of 300mm above the 100 year flood level is achieved within the drainage reserve
- A mix of sediment basins, wetlands and proprietary products for stormwater treatment will be installed, including end of line GPT's and permeable pavement with modular filter media.

The darker green shaded areas shown within the drainage reserves in Figure 3 and Appendix B show the extents of the detention basin battering, with treatment assets located within the same footprint. The indicative design information for the drainage reserves are outlined in Table 5.

Table 5: Drainage reserves design

Concept design data		Drainage Reserve 1 (RB1)	Drainage Reserve 2 (RB2)	Drainage Reserve 3 (RB3)
Retarding surface area	Basin	1,490 m ²	2,550 m ²	765 m ²
Retarding Q100 storage	Basin	745 m ³	1,650 m ³	190 m ³
Retarding Q100 peak level	Basin	9.6 m AHD	8.7 m AHD	7.3 m AHD
Retarding Outlet configuration	Basin	2 x 600 mm pipes and 1 x 450 mm pipe I.L 9.0 m AHD	3 x 600 mm pipes I.L 8.0 m AHD	450 mm Pipe I.L 6.5 m AHD
Area available for stormwater treatment assets		725 m ²	1,250 m ²	260 m ²

The permeable pavement proprietary product is proposed to be the Rocla Envis Sentinel pit modular system. The filter media and product specifications are indicated in Appendix H in the brochure produced by Rocla.

4.2 Drainage Swales

The following drainage swales are proposed for the development:

- Grassed swales to allow for the overland flow path from the upstream catchment. As per the IDM requirements for floodways within urban developments, a minimum reserve width of 16 m has been provided. The swale base will be at least 2 m wide.
- Swales will have a series of pools and riffles to control velocities through the development.

Detailed design of the swales will be in accordance with Council and the CMA standards based on the IDM and the technical sources available. Figure 10 shows the location of the drainage swales.

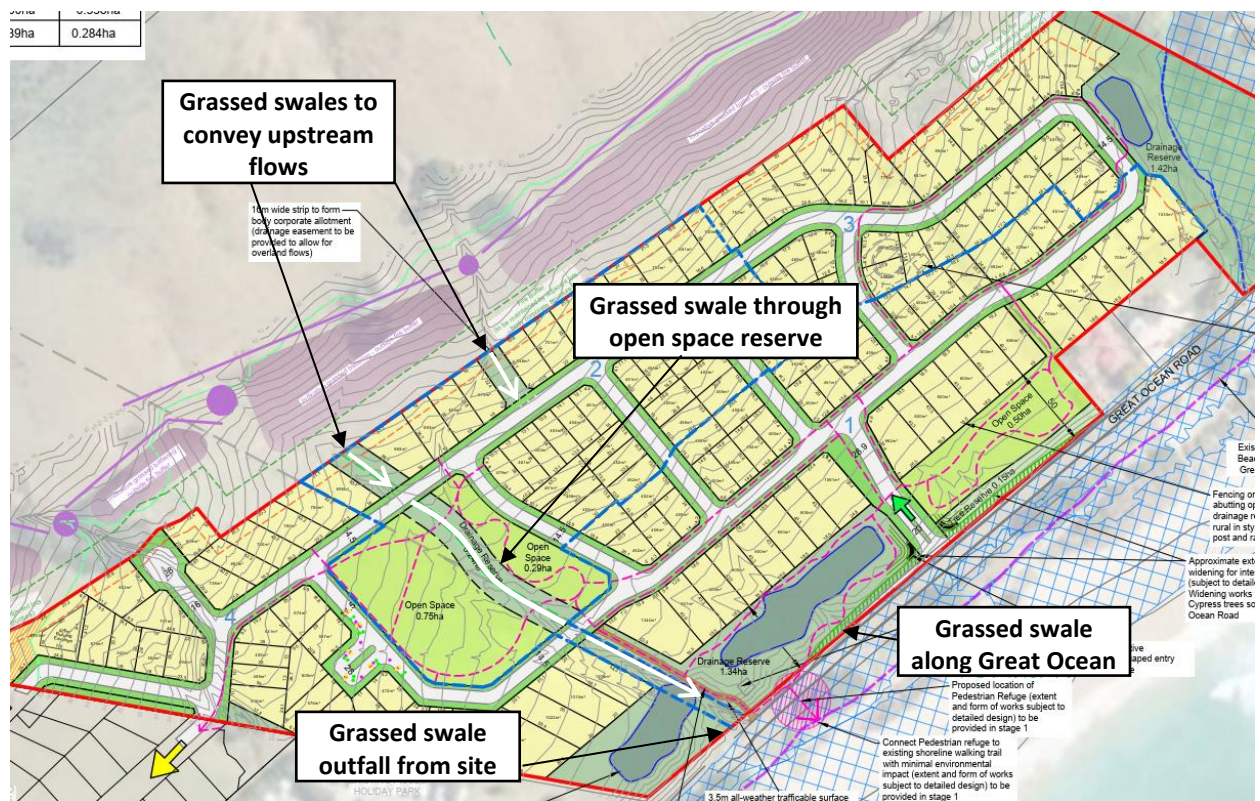


Figure 9: Drainage Swale Locations

4.3 Stormwater Treatment

The proposal aims to achieve current best practice standards, quoted as percentage removal of the typical urban loads of Gross Pollutants/Total Suspended Solids/Total Phosphorus/Total Nitrogen (GP/TSS/TP/TN) are 70/80/45/45 per cent.

The treatment train within each of the retarding basins are proposed as follows:

- RB1 - GPT, sediment basin, wetland, and grassed swale which receives the flows from the retarding basin outlet
- RB2 - GPT, sediment basin, wetland, and grassed swale which receives the flows from the retarding basin outlet
- RB3 – GPT, permeable pavements with filter media, and grassed swale which receives the flows from the retarding basin outlet.

The stormwater treatment assets will be located within the base of the RB's to better utilise space in the reserves.

The design of the WSUD elements will be in accordance with the specific technical details contained in the design and construction WSUD Technical Manual, and relevant industry guidelines such as Melbourne Water's Constructed Wetland Guidelines.

A MUSIC model of the overall catchment has been prepared, with the model structure shown in Figure 10 below.

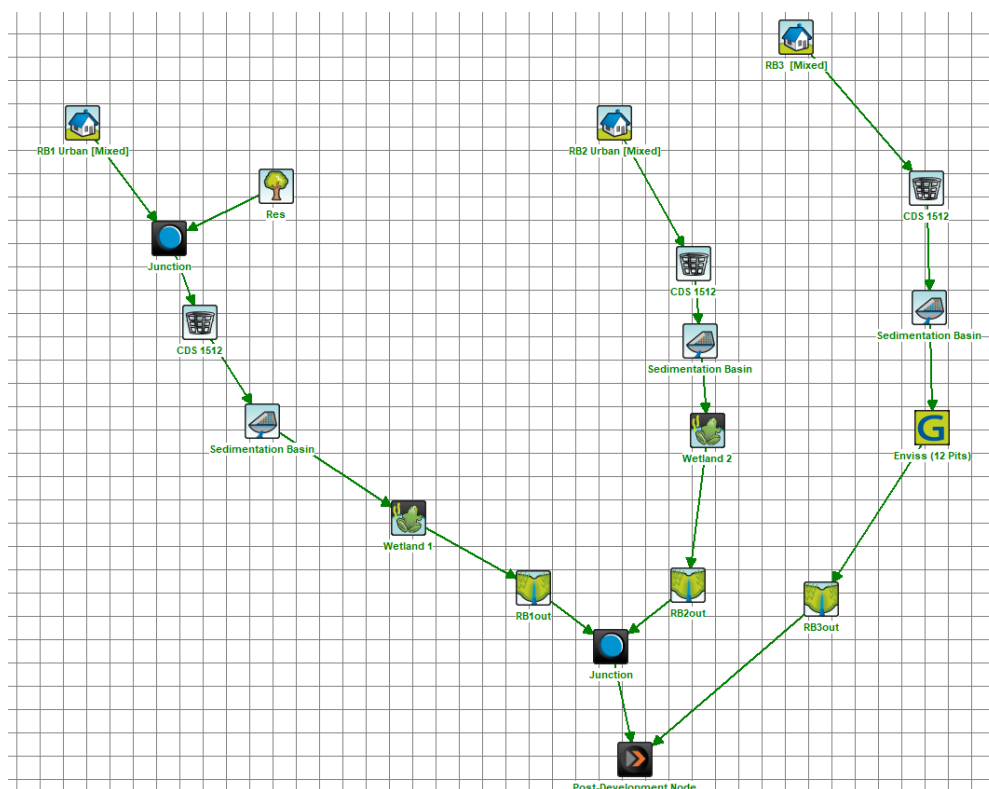


Figure 10: Music Model for the temporary drainage scenario

The output from the MUSIC model is shown in Table 6.

	Catchment Source Input Loads	Residual Load	% Load Removal in system to Outlet
Suspended Solids (Kg/yr)	5,070	469	90.7
Total Phosphorus (Kg/yr)	10.3	3.37	67.3
Total Nitrogen (Kg/yr)	71.7	39.1	45.5

Table 6: MUSIC Model Results

The results in Table 6 show that best practice is achieved for all pollutant targets with TN removal of 45.5 % being the limiting pollutant.

The source input loads are considering the internal catchment only, without considering the external undeveloped catchment of 11.94ha, which is not required to be treated as part of the development.

The final arrangement and mix of proprietary products will be confirmed during the detailed design phase, and will be determined based on site constraints, access considerations, and costs. The MUSIC modelling shows that the drainage reserves are adequate to fit in the required sizes of the treatment assets.

It can be concluded that the stormwater treatment proposal presented is found suitable for the site and that the ultimate stormwater infrastructure will be provided as per the development progresses.

For the MUSIC Model inputs and outputs report please refer to Appendix G.

5 STAGING AND SEQUENCING

The drainage reserves will be constructed as each stage of the development progresses according to the stages shown in the Overall Development Plan. Stage 1 has the largest of the detention basins included within its boundary and will be constructed as part of the early works, therefore negating the need to provide interim measures for detention and treatment and the early stages of development.

The drainage reserve has been situated such that overland flows from upstream catchments will enter the retarding basin and be managed away from the developed lots. A cut-off swale will be formed along the northern lot boundaries to prevent upstream flows from impacting the lots, and flows are directed into the drainage reserve. Each additional stage will also incorporate cut-off swales to protect northern boundaries of lots until the ultimate cut-off swale is completed as described in Section 3.

As each stage progresses, the relevant RB that it drains to will be included in the construction ensuring that each stage is self-sufficient in achieving BPEMG targets. This approach will avoid the need for temporary construction phase drainage assets throughout.

6 CONCLUSION

This report has identified an overall drainage management strategy for the proposed residential development located at 6280 Great Ocean Road, Apollo Bay.

The strategy provides a methodology for the management of stormwater on the subject site which would result in:

- Conveyance of external catchment flows through the site in accordance with Council standards;
- Construction of drainage to meet the likely requirements of the CCMA and Council, including 1 in 100 year ARI capacity retarding basins and underground drainage for the 1 in 5 year ARI storm event as needed;
- Construction of treatment assets to meet the water quality treatment requirements prior discharging into Apollo Bay.

By constructing the ultimate basins on the development along with the staging of lots, water quality and water quantity requirements for the development are able to be achieved during the development of the property without the need for interim measures.

The above strategy can be implemented and all of the CCMA and Council's development requirements can be achieved, in accordance with the IDM with no net effect on the adjacent properties.

BEVERIDGE WILLIAMS & CO PTY LTD

Prepared by

Approved for issue by

Aram Manjikian

Mark Fleming


Manager Water Resources Engineering

Manager Engineering



APPENDIX A. Site Plan

NOTES

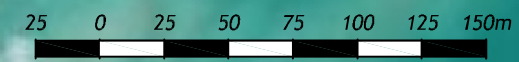
This plan is to be used to illustrate the area for site investigation, including the entire parcel bounded by Site Boundary border 

Title boundaries are indicative only and subject to verification by survey

Base information is taken from the several surveys and is approximate only

All survey information supplied is assumed to be correct

Existing tree locations are approximate only



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Site Plan
6280 & 6230 Great Ocean Road, Apollo Bay
Australian Tourism Investments No. 5 Pty Ltd

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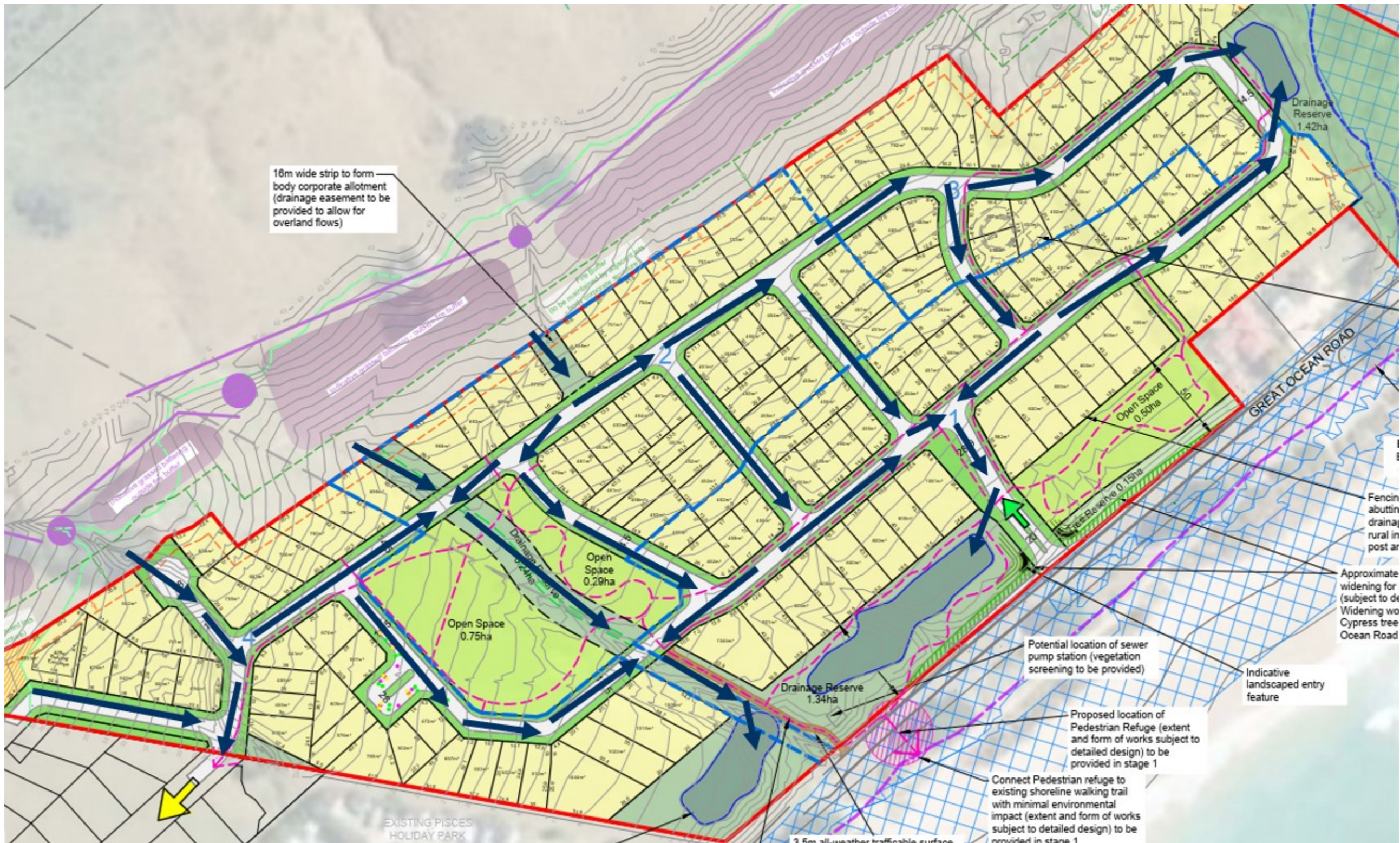
**APPENDIX B. Indicative Development
Plan**





APPENDIX C. Overland Flow Path Plan





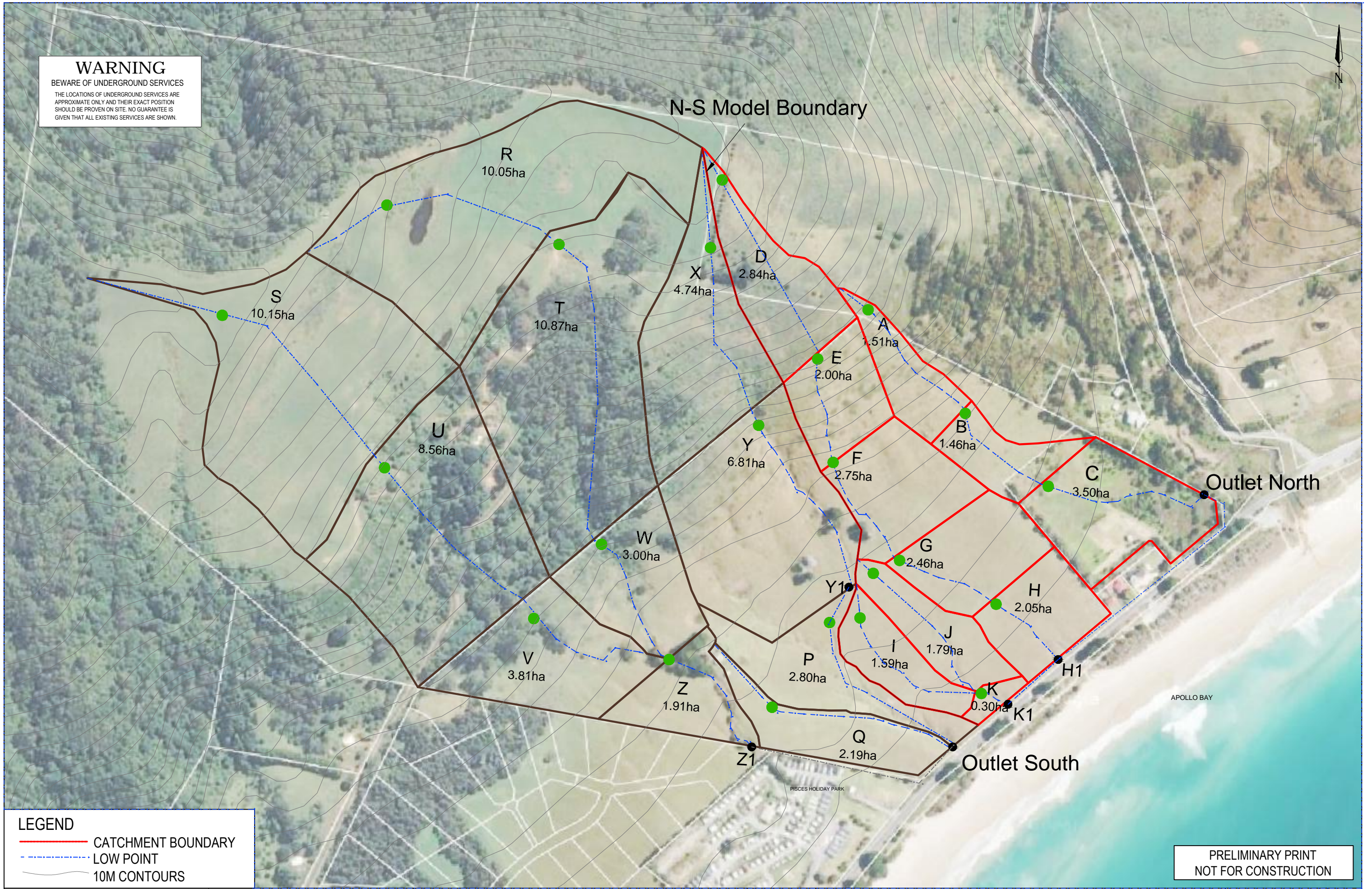


APPENDIX D.

Catchment Plans



WARNING
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 THE LOCATIONS OF UNDERGROUND SERVICES ARE APPROXIMATE ONLY AND THEIR EXACT POSITION SHOULD BE PROVEN ON SITE. NO GUARANTEE IS GIVEN THAT ALL EXISTING SERVICES ARE SHOWN.



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Designed	G.PORRAS
Date	26.03.15
Drawn	G.PORRAS
Approved	A.MANJIKIAN
Date	26.03.2015
PS Number	PS

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Drawing Title	Predevelopment Catchment Plan

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Date	20.11.15
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Project Details	6280 Great Ocean Road, Apollo Bay Australian Tourism Investments Number 5 Colac-Otway Shire Council
Drawing Title	Postdevelopment Catchment Plan

Project Ref	3313	Stage No	00	Drawing No	101	Rev	P1
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APPENDIX E.

RORB Inputs and Outputs Report

APPENDIX E RORB INPUTS AND OUTPUTS REPORT REPORT

Date: 16/12/2019

By: JW

CATCHMENT DETAILS

EXISTING

Subarea Name	Area(Sqkm)	Area (ha)	Existing Land Type	Fraction Impervious Existing
D	0.03	2.800	External - Rural Conservation	0.1
E	0.02	2.000	External - Rural Conservation	0.1
F	0.03	2.700	External - Rural Conservation	0.1
G	0.03	2.500	Internal - Rural Conservation	0.1
H	0.02	2.100	Internal - Rural Conservation	0.1
J	0.02	1.800	Internal - Rural Conservation	0.1
I	0.02	1.600	Internal - Rural Conservation	0.1
K	0.00	0.300	Internal - Rural Conservation	0.1
Total Area	0.16	15.800		

DEVELOPED

Subarea Name	Area(Sqkm)	Area (ha)	Planning Land Zone Use	Fraction Impervious Developed
C	0.101	10.1	External - Rural Conservation Zone (RCZ)	0.1
D	0.028	2.8	External - Rural Conservation Zone (RCZ)	0.1
E	0.020	2.0	External - Rural Conservation Zone (RCZ)	0.1
F	0.028	2.8	External - Rural Conservation Zone (RCZ)	0.1
G	0.008	0.8	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
H	0.010	1.0	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
J	0.008	0.8	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
K	0.015	1.5	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
L	0.004	0.4	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
M	0.009	0.9	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
N	0.012	1.2	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
O	0.006	0.6	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
P	0.007	0.7	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
Q	0.008	0.8	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
R	0.008	0.8	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
S	0.102	10.2	External - Rural Conservation Zone (RCZ)	0.1
T	0.109	10.9	External - Rural Conservation Zone (RCZ)	0.1
U	0.086	8.6	External - Rural Conservation Zone (RCZ)	0.1
V	0.043	4.3	External - Rural Conservation Zone (RCZ)	0.1
W	0.030	3.0	External - Rural Conservation Zone (RCZ)	0.1
X	0.047	4.7	External - Rural Conservation Zone (RCZ)	0.1
Y	0.072	7.2	External - Rural Conservation Zone (RCZ)	0.1
Z	0.049	4.9	External - Rural Conservation Zone (RCZ)	0.1
AA	0.001	0.1	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
BB	0.009	0.9	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
CC	0.011	1.1	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
DD	0.001	0.1	Internal - Neighbourhood Residential Zone 1 (NRZ1)	0.6
Res E	0.003	0.3	Internal - Public Park and Recreation Zone 1 (PPRZ)	0.1
Res W	0.007	0.7	Internal - Public Park and Recreation Zone 1 (PPRZ)	0.1
Total Area	0.741	74.1		

Reach Existing	Reach Type	Reach Length (km)	Reach Slope %
D-E	2. Excavated but unlined	0.348	25.86
E-F	2. Excavated but unlined	0.165	42.42
F-G	2. Excavated but unlined	0.173	23.12
G-H	2. Excavated but unlined	0.135	11.53
H-H1	2. Excavated but unlined	0.154	7.14
J-K	2. Excavated but unlined	0.266	9.02
I-K	2. Excavated but unlined	0.273	7.32
K-K1	2. Excavated but unlined	0.054	11.11
K1-H1	2. Excavated but unlined	0.098	1.00
H1-Outlet	2. Excavated but unlined	0.102	1.00

Reach Developed	Reach Type	Reach Length (km)	Reach Slope %
1	2.Excavated but unlined	0.348	25.86
2	2.Excavated but unlined	0.165	42.42
3	2.Excavated but unlined	0.173	23.12
4	3.Lined	0.11	10
5	3.Lined	0.16	5.5
6	3.Lined	2.02	2.9
7	3.Lined	0.1	6
8	3.Lined	0.14	0.5
9	3.Lined	0.095	5.8
10	3.Lined	0.14	5.7
11	3.Lined	0.065	4.5
12	2.Excavated but unlined	0.518	17.37
13	2.Excavated but unlined	0.305	39.34
14	2.Excavated but unlined	0.259	22.78
15	2.Excavated but unlined	0.478	26.15
16	2.Excavated but unlined	0.394	27.92
17	2.Excavated but unlined	0.26	20
18	2.Excavated but unlined	0.22	20
19	5.Dummy	0.05	10
20	2.Excavated but unlined	0.175	20
21	2.Excavated but unlined	0.03	10
22	2.Excavated but unlined	0.05	10
23	2.Excavated but unlined	0.11	20
24	2.Excavated but unlined	0.135	7.2
25	5.Dummy	0	0
26	5.Dummy	0	0
27	5.Dummy	0	0
28	1.Natural	0.1	0
29	3.Lined	0.095	5.8
30	2.Excavated but unlined	0.1	0
31	3.Lined	0.05	11
32	3.Lined	0.155	7.7
33	2.Excavated but unlined	0.02	5
34	3.Lined	0.15	7.3
35	3.Lined	0.14	0.5
36	3.Lined	0.135	2.9

DAM INPUT DATA

Discharge Relations Options for Upstream Dam

0. Storage Formula
1. S-Q Table
2. Weir & Pipe Formula
3. Weir Formula

RB1

Option 2: Weir and Pipe formula

Spillway

No of Spillways	1
Weir Coefficient	1.7
Crest Elevation (m AHD)	9.8
Effective length (m)	20

Pipe Outlet

Entrance Loss Coefficient	0.5
Bend Loss Coefficient	0.5
No of pipe outlets	3
Diameter (m)	1 x 0.45, 2 x 0.6
Invert (m AHD)	9
Slope%	1.0
Length (m)	20

H-S (Stage Storage values) from 12d

H (m)	S (m3)
9.00	0
9.10	120
9.20	240
9.30	350
9.40	490
9.50	610
9.60	780
9.70	920
9.80	1100
9.90	1280
10.00	1500

RB2

Option 2: Weir and Pipe formula

Spillway

No of Spillways	1
Weir Coefficient	1.7
Crest Elevation (m AHD)	8.8
Effective length (m)	20

Pipe Outlet

Entrance Loss Coefficient	0.5
Bend Loss Coefficient	0.5
No of pipe outlets	3
Diameter (m)	0.6
Invert (m AHD)	8
Slope%	1.0
Length (m)	20

H-S (Stage Storage values) from 12d

H (m)	S (m3)
8.00	0
8.10	240.0
8.20	400.0
8.30	600.0
8.40	840.0
8.50	1100.0
8.60	1362.4
8.70	1610.8
8.80	2075.2
8.90	3413.0
9.00	5003.6

RB3

Option 2: Weir and Pipe formula

Spillway

No of Spillways	1
Weir Coefficient	1.7
Crest Elevation (m AHD)	7.5
Effective length (m)	20

Pipe Outlet

Entrance Loss Coefficient	0.5
Bend Loss Coefficient	0.5
No of pipe outlets	1
Diameter (m)	0.6
Invert (m AHD)	6.5
Slope%	1.0
Length (m)	20

H-S (Stage Storage values) from 12d

H (m)	S (m3)
6.50	0.00
6.60	16.77
6.70	35.99
6.80	57.67
6.90	81.87
7.00	108.62
7.10	137.95
7.20	169.89
7.30	204.25
7.40	240.74
7.50	279.37
8.00	500

RORB MODEL PARAMETERS

Rainfall location: Apollo Bay

Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)

Spatial pattern : Uniform

Areal Red. Fact. : Based on Siriwardena and Weinmann formulation

Loss factors : Constant with ARI

PREDEVELOPMENT MODEL PARAMETERS

kc= 2.1 m=0.8

Average Dist= 0.81 km

Initial loss= 15 mm

Runoff coeff. 100 year 0.6

Runoff coeff. 10 year 0.4

Runoff coeff. 5 year 0.3

Runoff coeff. 1 year 0.2

POSTDEVELOPMENT MODEL PARAMETERS

kc= 2.8 m=0.8

Average Dist= 0.68 km

Initial loss 15 mm

Runoff coeff. 100 year 0.6

Runoff coeff. 10 year 0.4

Runoff coeff. 5 year 0.3

Runoff coeff. 1 year 0.2

SCENARIO 1. PREDEVELOPMENT 100 YEAR

RORBWin Batch Run Summary

Program version 6.15 (last updated 30th March 2010)
Copyright Monash University and Sinclair Knight Merz

Date run: 15 Jun 2015 15:57

Catchment file : K:\Jobs Data\3313 - Apollo Bay_Eng\00\Models\RORB\RORB_East\3313 Apollo Bay Predevelo
Rainfall location: Apollo Bay
Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)
Spatial pattern : Uniform
Areal Red. Fact. : Based on Siriwardena and Weinmann formulation
Loss factors : Constant with ARI

Parameters: kc = 2.10 m = 0.80

Loss parameters Initial loss (mm) Runoff coeff.
10.00 0.60

Peak Description

- 1 Calculated hydrograph, Ext Catchment
- 2 Calculated hydrograph, Leaving the site

Run	Dur	ARI	Rain(mm)	ARF	Peak0001	Peak0002
1	10m	100y	21.67	0.97	0.2939	0.3575
2	15m	100y	26.34	0.98	0.3888	0.5329
3	20m	100y	29.9	0.98	0.4469	0.6659
4	25m	100y	32.81	0.98	0.4779	0.7686
5	30m	100y	35.22	0.98	0.486	0.8367
6	45m	100y	40.84	0.98	0.511	0.9516
7	1h	100y	45	0.99	0.5358	1.005
8	1.5h	100y	51.4	0.99	0.5381	0.9702
9	2h	100y	56.27	0.99	0.5638	0.9894
10	3h	100y	63.71	1	0.407	0.8108
11	4.5h	100y	72.04	1	0.4409	0.8627
12	6h	100y	78.63	1	0.3825	0.7634
13	9h	100y	89.02	1	0.3412	0.6633
14	12h	100y	97.25	1	0.29	0.5898
15	18h	100y	124.27	1	0.1665	0.3667
16	24h	100y	147.66	1	0.1961	0.424
17	30h	100y	168.52	1	0.1377	0.294
18	36h	100y	187.42	1	0.1288	0.2818
19	48h	100y	220.73	1	0.1501	0.3025
20	72h	100y	274.52	1	0.124	0.2418

Elapsed Run Time (hh:mm:ss) = 00:00:00

SCENARIO 2. POSTDEVELOPEMENT 100 YEAR FLOWS

RORBWin Batch Run Summary

Program version 6.15 (last updated 30th March 2010)
 Copyright Monash University and Sinclair Knight Merz

Date run: 15 Jun 2015 16:38

Catchment file : K:\Jobs Data\3313 - Apollo Bay_Eng\00\Models\RORB\RORB_East\3313 Apollo Bay Postdevelopment Section A only Opt2.catg
 Rainfall location: Apollo Bay
 Temporal pattern : AR&R87 Volume 2 for zone 1 (filtered)
 Spatial pattern : Uniform
 Areal Red. Fact. : Based on Siriwardena and Weinmann formulation
 Loss factors : Constant with ARI

Parameters: kc = 2.59 m = 0.80

Option 2 Option 3

Loss parameters Initial loss (mm) Runoff coeff.
 10.00 0.60

Peak Description

- 01 Calculated hydrograph, Upstream Y
- 02 Special storage : RB2 - Outflow
- 03 Special storage : RB2 - Inflow
- 04 Calculated hydrograph, Middle
- 05 Special storage : RB1 - Outflow
- 06 Special storage : RB1 - Inflow
- 07 Calculated hydrograph, West side
- 08 Calculated hydrograph, Upstream VW
- 09 Special storage : RB3 - Outflow
- 10 Special storage : RB3 - Inflow
- 11 Calculated hydrograph, East side
- 12 Calculated hydrograph, Outlet

Run	Dur	ARI	Rain(mm)	ARF	Peak0001	Peak0002	Peak0003	Peak0004	Peak0005	Peak0006	Peak0007	Peak0008	Peak0009	Peak0010	Peak0011	Peak0012
1	10m	100y	21.67	1	1.507	0.3663	1.2586	0.3663	0.3282	0.8501	0.3282	0.4553	0.3904	0.6907	0.3972	1.136
2	15m	100y	26.34	1	1.5784	0.6179	1.6851	0.6179	0.5067	0.9673	0.5067	0.7998	0.4609	0.7587	0.4685	1.881
3	20m	100y	29.9	1	1.3893	0.808	1.83	0.808	0.6332	1.034	0.6332	1.0765	0.4874	0.7606	0.4952	2.4893
4	25m	100y	32.81	1	1.611	0.9197	1.9209	0.9197	0.7122	1.0986	0.7122	1.3159	0.4893	0.7304	0.4977	2.9128
5	30m	100y	35.22	1	1.4986	0.9987	1.7759	0.9987	0.7394	1.0079	0.7394	1.4956	0.4577	0.682	0.4655	3.2237
6	45m	100y	40.84	1	1.2526	1.174	1.727	1.174	0.7868	0.9687	0.7868	1.9098	0.4312	0.626	0.4383	3.9074
7	1h	100y	45	1	1.562	1.2266	2.0878	1.2266	0.8331	1.1356	0.8331	2.1074	0.4557	0.5543	0.4637	4.1536
8	1.5h	100y	51.4	1	1.6971	1.1891	2.227	1.1891	0.8095	1.1898	0.8095	2.1301	0.4495	0.5492	0.4572	4.0828
9	2h	100y	56.27	1	1.8022	1.2037	2.1542	1.2037	0.8201	1.1805	0.8201	2.1674	0.4511	0.5991	0.4583	4.1698
10	3h	100y	63.71	1	0.9583	1.0324	1.3484	1.0324	0.618	0.727	0.618	1.9322	0.2699	0.3563	0.2746	3.6208
11	4.5h	100y	72.04	1	1.121	1.0971	1.546	1.0971	0.6543	0.826	0.6543	1.8997	0.2696	0.2844	0.2743	3.6679
12	6h	100y	78.63	1	0.9091	0.9908	1.2147	0.9908	0.577	0.6128	0.577	1.947	0.1895	0.2095	0.1927	3.4483
13	9h	100y	89.02	1	0.8745	0.9801	1.129	0.9801	0.528	0.5595	0.528	1.8469	0.1696	0.1695	0.1726	3.4131
14	12h	100y	97.25	1	0.8227	0.8476	1.0074	0.8476	0.4324	0.5052	0.4324	1.6539	0.1622	0.1752	0.165	3.0325

Results of routing through special storage RB 1 (1hr storm)

Peak elevation= 9.58 m AHD
 Peak outflow = 0.83 m³/s (pipe flow)
 Peak storage = 742 m³

Results of routing through special storage RB 2 (1hr storm)

Peak elevation= 8.71 m AHD
 Peak outflow = 1.23 m³/s (pipe flow)
 Peak storage = 1,640 m³

Results of routing through special storage RB 3 (25min storm)

Peak elevation= 7.30 m AHD
 Peak outflow = 0.49 m³/s (pipe flow)
 Peak storage = 203 m³



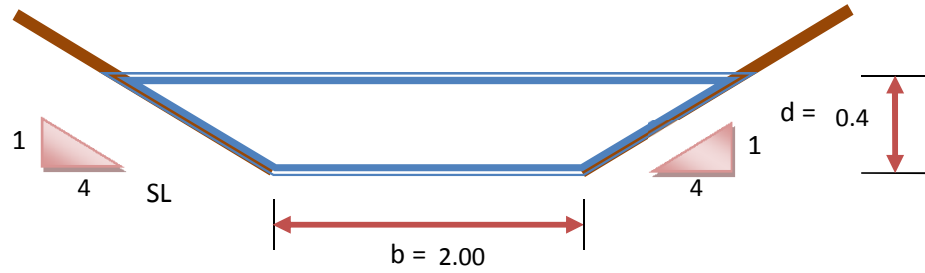
APPENDIX F.

**Drainage Swales Concept Design
Information**





Manning's Calculator for Open Channel Capacity - 2



Location

Job Number

Date

Input Channel bed Slope

Input Depth of Water

Input Width of Base

Input Reciprocal of Left Cross-slope

Input Reciprocal of Right Cross-slope

Choose A or input B for Manning's N value

S =	50	1 in X
d =	0.4	m
b =	2.00	m
SL =	4	1 in X
SR =	4	1 in X

A. Channel type	Lined - Vegetal
B. Input n	

Selected n =	0.035	
A =	1.44	m ²
P =	5.30	m
R =	0.272	m
V =	1.695	m/s

Q Capacity

Velocity at Q Capacity

Q _{CAPACITY}	2.441	m ³ /sec
V	1.695	m ³

Formula Used

$$Q = \left(\frac{1}{n}\right) \times A \times R^{2/3} \times S^{1/2}$$

Q is flowrate (m³/s)

A is the cross-sectional area of flow (m²)

V is velocity (m/s)

P is wetted perimeter of flow (m)

R is hydraulic radius (m), equal to A divided by P

S is longitudinal slope (m/m)

n is a roughness coefficient (see below)



APPENDIX G. MUSIC Model Inputs and Outputs Report



APPENDIX G MUSIC REPORT

Location: 6230-6280 Great Ocean Road, Apollo Bay
Stormwater Quality

Date: 19/12/2019

Catchment Details

90167 Winchelsea Station - Reference year 1998, 6 min.

Urban Nodes- Catchment	Area (ha)
RB1 Urban	4.60
RB2 Urban	4.59
RB3 Urban	3.1
Reserve	1.02

Treatment Nodes Details

Grassed Swale Properties	RB1 out	RB2 out	RB3 out
Length (m)	20	20	20
Bed Slope (%)	2	2	2
Bed Width (m)	1	1	1
Top Width (m)	5	5	5
Depth (m)	0.50	0.5	0.5
Vegetation Height (m)	0.25	0.25	0.25
Exfiltration Rate (mm/hr)	0.30	0.30	0.00

Sediment Basin Properties	Sediment Basin 1	Sediment Basin 2	Sediment Basin 3
Water Surface Area (m ²)	150	200	100
Extended Detention Depth (mm)	350	350	350
Permanent Pool Volume (m ³)	120	170	80
Notional Detention Time (hours)	11.8	12.2	12.2

Wetland Properties	Wetland 1	Wetland 2
Water Surface Area (m ²)	400	800
Extended Detention Depth (mm)	350	350
Permanent Pool Volume (m ³)	150	250
Notional Detention Time (hours)	70.5	77.4

Treatment Train effectiveness

	Catchment Source Input Loads	Residual Load	% Load Removal in system to Asset Outlet
Suspended Solids (Kg/yr)	5,070	469	90.7
Total Phosphorus (Kg/yr)	10.3	3.37	67.3
Total Nitrogen (Kg/yr)	71.7	39.1	45.5



APPENDIX H.

Enviss Pit Information



ENVISS™ SENTINEL TECHNICAL SPECIFICATIONS



enviss™ sentinel

Stormwater Filtration System

DESIGN

Criteria	Specification
Application:	Stormwater source control
Filter Type: (1) Permeable paving (2) Sediment trap (3) Enviss media	Three stages of stormwater filtration: - Removal of Gross pollutants and coarse sediment - Removal of coarse and fine sediment - Removal of dissolved and complex pollutants
Lid Type:	Steel grate lid with permeable paving infill
Load Rating:	Class B or Class D
Hydraulic Conductivity:	2000 mm/ Hr
Ponding Depth (Min.):	50 mm
Treatable Area (impervious)	77 m ²
Maintenance Period:	Replace sediment module and filter media every 2 years
Maintenance Type:	Remove lid and remove and replace all sediment and media.
Lifting requirements:	2 x 1.3t swift lift anchors

PERFORMANCE

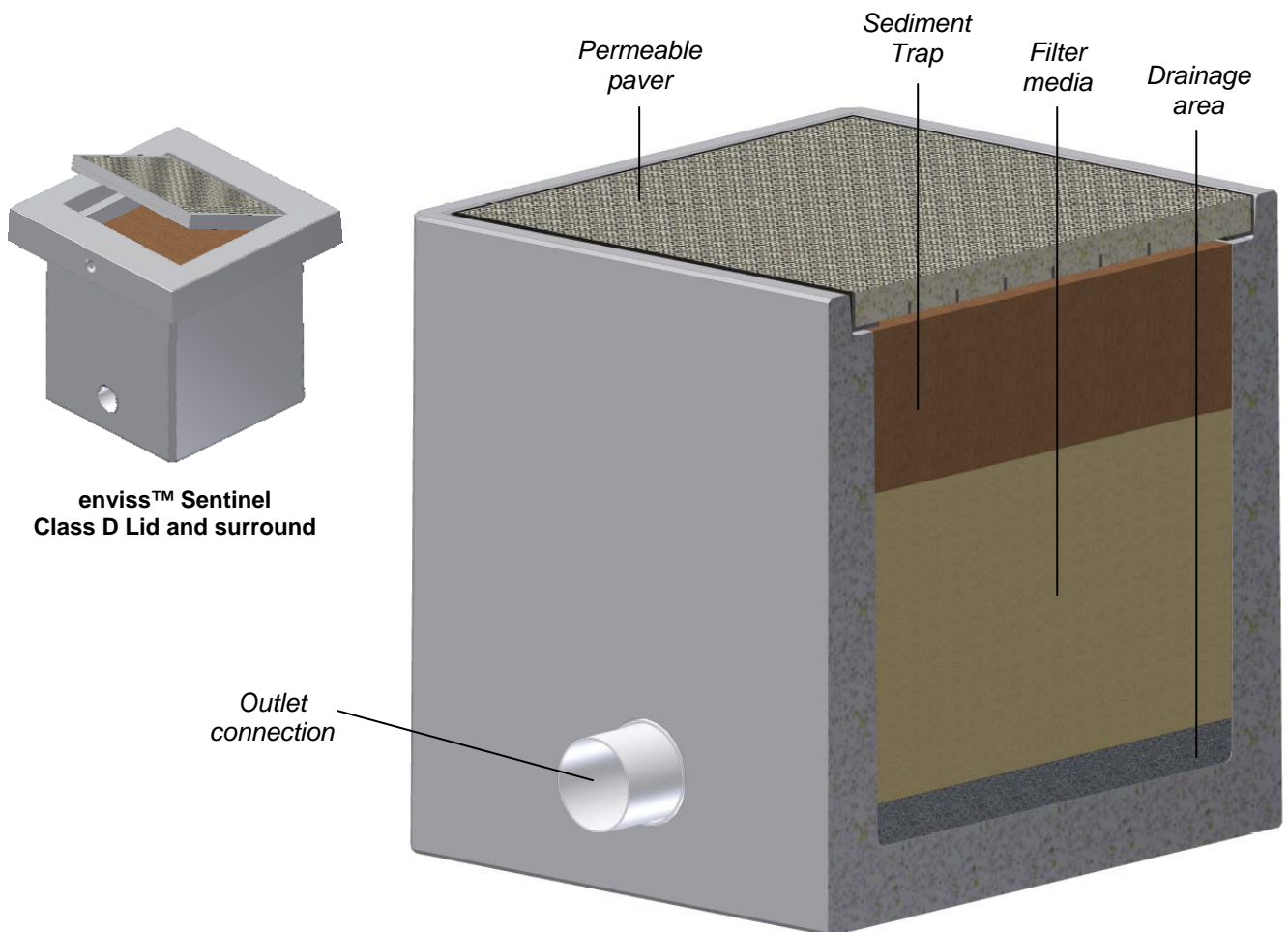
Pollutant [Group]	% Removal Rate * [MUSIC Nodes]
Gross pollutant removal	100%
Total suspended solids	96%
Hydrocarbons (dissolved organics)	99%
Heavy metals - lead - zinc, manganese - copper - nickel	81% 94% 88% > 67%
Total nitrogen	79%
Total phosphorus	67%

* Mean pollutant removal performance figures based on laboratory testing at Monash University and verified in field testing at a purpose built stormwater harvesting system in Melbourne 2009 utilising auto-sampling of the stormwater inflows and outflows. The water samples were tested and the results compared against the laboratory results. To further ensure the testing of the filter media has been completed to a high standard, the methods and results of the testing have been scrutinised by peer review and presented at national and international conferences.

ENVISS™ SENTINEL TECHNICAL SPECIFICATIONS

TECHNICAL

Criteria	Dimensions/ Weight	
Load Rating:	Class B (80 kN)	Class D (210 kN)
Nominal Dimensions:	600mm x 600mm x 650mm RKO pit	600mm x 600mm x 650mm RKO pit plus 150mm surround
Clear Opening:	596mm x 596mm	
External Dimensions:	763mm x 763mm 740 (deep)	763mm x 763mm 890 (deep)
Effective filter area:	0.36 m ²	
enviss™ filter media depth:	360mm	
Sediment trap depth:	170mm	
Outlet pipe size:	DN100 PVC socket connection	
Nominal Depth to Invert:	650mm	800mm
Nominal Mass:	900kg	1100kg



**enviss™ Sentinel Stormwater Filtration Pit Assembly
Class B lid (surround not required)**

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