Report

Q25-50011 Messmate Road Future Growth Area Stormwater / Waterway Management Strategy: Developed Conditions Assessment

Surf Coast Shire Council

19 September 2025

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- *Seven circles representing each of the States and Territories in Australia where we do our work*
- *Blue dots between each circle representing the waterways that connect us*
- *The animals that rely on healthy waterways for their home*
- *Black and white dots representing all the different communities that we visit in our work*
- *Hands that are for the people we help on our journey*

19 September 2025

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Dear Barabara

Q25-50011 Messmate Road Future Growth Area Stormwater / Waterway Management Strategy: Developed Conditions Assessment

Please find enclosed the *Developed Conditions Assessment* report for the Messmate Road Growth Area. This report documents the adjustments made to the existing conditions models to simulate future conditions in the growth area. This report also contains the results of the developed conditions modelling.

The report informs the accompanying *Stormwater / Waterway Management Strategy* which focuses on the recommended mitigation measures, developed in response to the findings of the developed conditions assessment.

Yours sincerely

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EXECUTIVE SUMMARY

This report documents the adjustments made to the existing conditions hydrology and hydraulic models to simulate future conditions in the growth area. This report also contains the results of the developed conditions hydrology and hydraulic modelling and stormwater quality treatment and volume reduction modelling. Lastly, the report discusses the hydrology and hydraulic model results in the context of Deep Creek, highlighting the three scenarios being explored: existing conditions, developed conditions *without* mitigation measures in place and developed conditions *with* mitigation measures in place.

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1 INTRODUCTION

Council have prepared a preliminary urban design for the Messmate Road Growth Area Figure 1-1. This *Developed Conditions Assessment* simulated the effect of Council's preliminary urban design on the hydrology and hydraulics of the growth area catchment and Deep Creek, and on the opportunities for stormwater quality treatment and volume reduction.

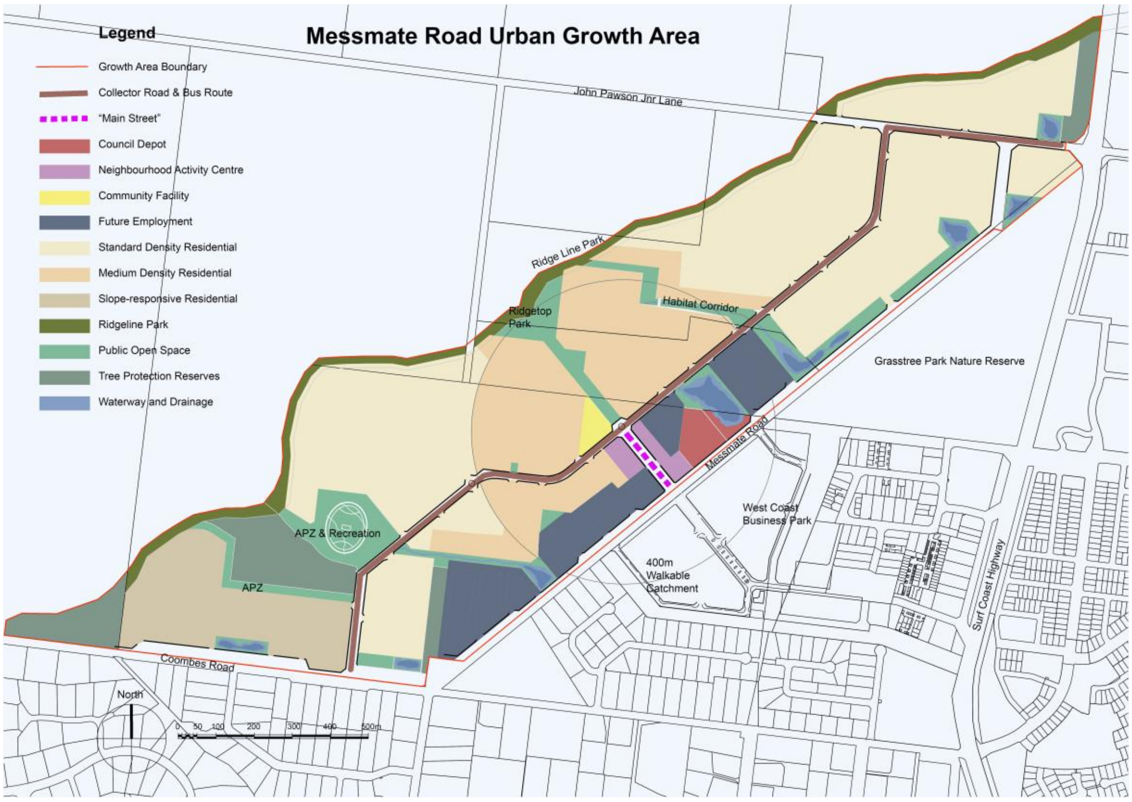

Figure 1-1 Preliminary urban design (source: Surf Coast Shire Council)

Table 1-1 Areas (Ha) set aside in the preliminary layout for different land uses

Proposed Land Use	Area (Ha)
Neighbourhood Activity Centre	0.98
Commercial	8.70
Community	0.78
Stormwater management	5.90
Public Open Space	10.60
Council Depot	1.23
Remnant vegetation	7.05
Ridge Park	7.66
Habitat corridor	1.4
Residential	138.2
Total	**182.5**

1.1 Annual Exceedance Probabilities (% AEP)

This report refers to critical events in terms of % AEP. These events are defined in relation to Figure 1-2 below.

For example, the:

- 1-in-100-year event is referred to as the 1% AEP.
- 1-in-10-year event is referred to as the 10% AEP.
- 1-in-2-year event is referred to as the 50% AEP.
- 1-in-1.5-year event is referred to as the 63% AEP.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	20
	0.02	2	50	50
	0.01	1	100	100
Very Rare	0.005	0.5	200	200
	0.002	0.2	500	500
	0.001	0.1	1000	1000
	0.0005	0.05	2000	2000
Extreme	0.0002	0.02	5000	5000
			↓	
			PMP/ PMPDF	

Figure 1-2 Australian Rainfall and Runoff Version 4.2 adopts new terminology for flood risk (see Book 1, Chapter 2.2.5). Preferred terminology is provided in Figure 1.2.1. and consists of AEP and EY.

1.2 How climate change has been addressed in the modelling

The stormwater retention basins in this strategy have been designed in accordance with *Australian Rainfall and Runoff* (ARR v4.2 2019), which recommends scaling rainfall Intensity–Frequency–Duration (IFD) data from the Bureau of Meteorology to 'present day' conditions by accounting for the change in temperature since the recording of the data. The basins have been sized for the year 2030 design horizon according to the Shared Socio-economic Pathway (SSP5-8.5), consistent with current best practice guidance and recommendations from the Corangamite Catchment Management Authority. Although the basins have a design life of many decades, adopting 2030 projections provides an appropriate balance between robustness, practicality, and the uncertainties associated with longer-term projections (e.g., 2050–2070). Further, adopting 2030 aligns with the likely timing of the detailed design and delivery of the stormwater management infrastructure because it allows five years from the date of the strategy for growth area planning processes to be completed.

This approach ensures that:

- ARR v4.2 guidance is met as near-term climate scaling factors are sufficient to ensure the functional life of stormwater assets is not compromised by early climate change impacts.
- Additional freeboard of 300 mm is provided, adding resilience to manage uncertainties and incremental intensification of rainfall–runoff beyond 2030.
- Location within public open space ensures any exceedance of basin capacity is managed safely, with no adverse impacts on private property or critical infrastructure.

The basins have also been designed with consideration of exceedance behaviour under climate change:

- Spillways are incorporated into each basin to safely manage flows that exceed storage capacity, directing overflow along controlled pathways within open space.
- Exceedance frequency is expected to remain low, even as rainfall intensity increases through this century. The combination of freeboard, controlled spillways, and strategic siting provides a safe and robust means of accommodating rare high-intensity storms.

This approach reflects a risk-based, adaptive design philosophy consistent with ARR v4.2. Assets are designed to remain effective and resilient under foreseeable climate conditions from 2030, with allowances and safeguards to sustain their function through their service life. Should longer-term climate change impacts exceed current projections, the basins' design and siting ensure they can continue to operate safely within the urban landscape.

1.3 Adopted scaling factors

In this strategy, the latest recommendations from *Australian Rainfall and Runoff* (ARR v4.2) for climate change conditions for periods since the collection of the Intensity–Frequency–Duration (IFD) data has been considered. IFD data available from the Bureau of Meteorology is based on rainfall depths collected between 1961-1990, newly referred to as baseline. Scaling of the baseline IFD's is required to consider the changes in global temperatures since the baseline data was collected and is commonly referred to as 'Present Day'. Present Day for this assessment has assumed the design horizon of the year 2030 under the IPCC Shared Socioeconomic Pathway (SSP) 5-8.5, with a Global Warming Level (GWL) of 1.3°C. Scaling factors of rainfall depths are applied on an event duration basis, which is summarised in Table 1-2 below.

The scaling factor is applied such that for a 1.5hr event, for example, present day rainfall depth = baseline rainfall depth multiplied by 1.18.

Table 1-2 Present Day Depth Scaling Factors

Duration	≤ 1-hr	1.5 hr	2-hr	3-hr	4.5-hr	6-hr	9-hr	≥ 12-hr
Scaling Factor	1.2	1.18	1.17	1.16	1.14	1.13	1.13	1.12

1.4 Retention basin design overview

The scaled present day (as at 2030) rainfall depth data have been used to size the volume of the retention basins required to manage runoff from the growth area at each of the catchment outlets (1-11) in all events up to and including a 1% Annual Exceedance Probability (AEP) event. As such, each retention basin has sufficient volume to store *inflows* from its developed catchment up to and including its design capacity.

Outlets from the retention basins can be designed to control *outflows* for different events, depending on what the objectives of mitigating outflows to downstream areas are. This could be to control flows to the capacity of downstream infrastructure in specified events, or to protect downstream receiving environments (e.g., Grasstree Park and Deep Creek).

Retention basins are also designed to have a spillway and a freeboard level 300mm above the maximum design water level to provide additional storage capacity for larger than design events. And once this larger than design event capacity is exceeded, the spillway will engage, and excess water will flow downstream. This proves protection to adjacent areas within the development.

By sizing basins for 2030 rainfall-runoff conditions, including freeboard, and incorporating spillways, they will have a functional design life that extends for many decades into the future even with climate change.

2 STORMWATER QUANTITY MANAGEMENT

2.1 Future conditions modelling

Details on the development of the hydrological (RORB) and hydraulic (TUFLOW) models for this assessment have been discussed in an earlier report (Messmate Growth Area SWMS Existing Conditions Report[1]). Changes made to the existing RORB and TUFLOW models to enable the assessment of the developed conditions of the Messmate Road Growth Area are listed below, with an overview of the RORB and TUFLOW model builds included in 5Appendix A

The follow changes have been made:

- RORB
  - Existing Conditions (Pre-developed)
    - The *External Catchment* identified in the Messmate Growth area has been routed into Outlet 4.
      - A review of the preliminary development layout and LiDAR data indicated that the topography in the upper reaches of Outlet 4 was misrepresented, and hence incorrectly directing flows north away from Messmate Road.
      - The pre-developed conditions RORB model was updated to include the External Catchment into the Outlet 4 catchment.
  - Developed Conditions (Post-developed)
    - Updated fraction impervious values for subareas within the Messmate Growth Area.
      - FI was split into directly and indirectly connect impervious areas (DCIA and ICIA, respectively).
    - Reach types in the growth area were revised by changing from Type 1 (natural) to Type 2 (excavated unlined)
    - Sizing and inclusion of eight (8) storages at the key outlet points of the growth area
    - Diversion of the Karaaf catchments into the Deep Creek catchments.
- TUFLOW
  - The hydraulic model extent was expanded to include the Messmate Growth Area, the Karaaf catchments, the Quay Estate and any areas between Messmate Road and Deep Creek.
    - The upstream boundary of Deep Creek was moved further west to commence in the basins north of Enfield Drive (upstream of Frog Hollow Drive).
  - Pits and pipes outside of the Deep Creek have been included to convey stormwater runoff from the contributing catchments.
  - The inflow regime has been revised due to the expanded model extent and the presence of urban stormwater infrastructure.
    - Previously, hydrographs were applied directly to the Deep Creek.
    - Now, contributing catchments have their rainfall excess routed in the hydraulic model by applying the rainfall either directly to grid or to the pits.

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[1] Water Technology, 2025, '*Q25-50011 Messmate Road Future Growth Area Stormwater / Waterway Management Strategy: Existing Conditions Report*', Surf Coast Shire

- Revised inflow regime in the model to accommodate for urbanised catchments by routing runoff through the hydraulic model towards the Deep Creek.
  - Inflows in urbanised areas are applied to pits (directly into the stormwater network).
  - Inflows from Messmate applied to outlet locations.
  - This approach allows for better evaluation of the impacts diverting the Karaaf catchments has on water levels and characteristics of flows downstream (i.e., in stormwater infrastructure or Deep Creek.

2.2 Future conditions hydrology model

Figure 2-1 shows the preliminary urban layout for the growth area[2] overlain with the RORB (hydrology model) sub catchments and flow paths derived from the existing topography[3] of the growth area catchment. The figure also shows the location of the eight (8) outlet points from the overall growth area. These outlets are where flows from their contributing sub catchments will naturally converge based on topography.

It should be noted that the placement of reserves and their alignment with the outlet locations do not match for all locations. Due to the nature of this assessment being to determine the required detention volume for each catchment, and to not produce a detailed stormwater concept, the differences in alignment are appropriate.

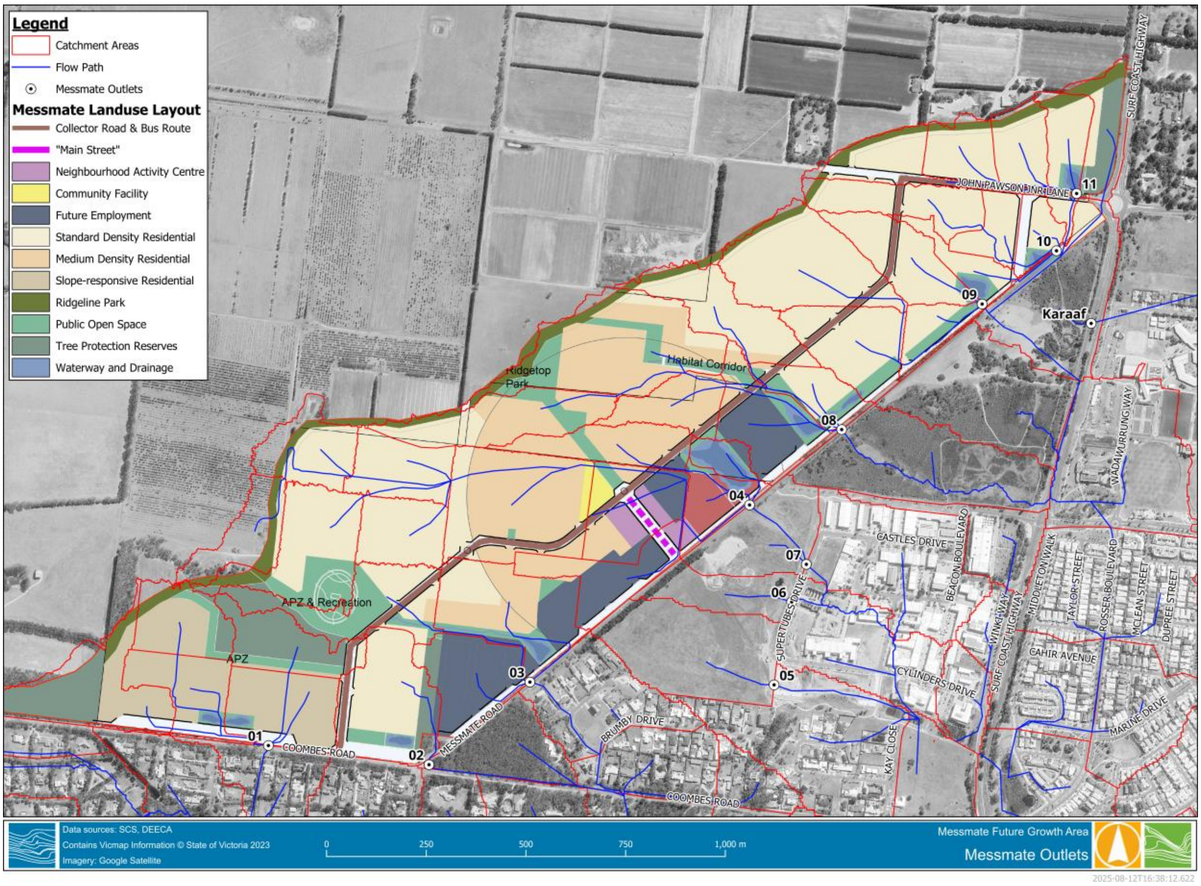

Figure 2-1 Model sub catchment, flow paths and outlets superimposed on Council's preliminary urban design

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[2] developed by Council
[3] derived from a high-resolution Digital Elevation Model (DEM)

The preliminary development layout indicates industrial and commercial zoning around outlet four (4) of the Messmate Road Growth Area. Outlet 4 features a catchment that is high in directly connected impervious area compared to the rest of the growth area as well as being the largest catchment area.

Storage volume requirements have been calculated for this outlet point as part of this assessment; however, the preliminary layout does not include a suitable reserve area. It is understood that future works between Outlet 4 and Outlet 7 could address this, and/or that the zoning in this area needs to be revised to provide adequate space for the required storage and treatment assets.

2.2.1 Fraction imperviousness

Table 2-1 shows the fraction impervious (FI) values adopted for the RORB model according to the land uses included in the preliminary urban layout for the growth area. The adopted FI values were then split into Directly Connected Impervious Area (DCIA) and Indirectly Connected Impervious Area (ICIA) based on the following criteria shown in Section 5.2 above.

Table 2-1 Fraction imperviousness values adopted for the hydrological modelling according to land use

	Fraction Impervious (FI)				Split FI	
Land Uses	Lower Range	Mid-Range	Upper Range	Adopted	Directly Connect Impervious Area	Indirectly Connected Impervious Area
Neighbourhood Activity Centre	0.7	0.9	0.95	0.9	0.63	0.27
Industrial 3	0.7	0.9	0.95	0.9	0.63	0.27
Commercial / Employment	0.7	0.9	0.95	0.9	0.63	0.27
Medium Density Residential	0.6	0.8	0.9	0.8	0.56	0.24
General Residential	0.4	0.75	0.8	0.75	0.45	0.3
Public Conservation & Resource Zone	-	0.05	-	0.05	0	0.05
Public Open Space	-	0.1	-	0.1	0	0.1

2.2.2 Resulting storage volumes and areas

A summary of the required storage volumes to maintain pre-development flow rates for the 1% AEP (2030 SSP5) event are summarised in Table 2-2 below. additionally, indicative sizing of the basins surface area at the freeboard water level mark is also shown and compared against the available reserve area.

Table 2-2 Required storage volumes and water surface areas

Outlet	Required Storage Volume (m^3)	Surface Area at freeboard level (m^2)	Available Reserve Area (m^2)	
1	4,830	5,492	4,320	
2	1,380	1,862	15,892	
3	4,270	4,616	27,958	
4	13,400 *(14,200)* *	13,512 *(14,320)* *	3,800	
8	8,070	8,310	26,933	
9	6,910	7,369	11,185	
10	2,950	3,495	52,537	
11	4,200	4,765	0	

* *Sizing based on ARR2016 Baseline Peak flow for existing conditions and 2030 SSP5 Developed Conditions*

2.2.2.1 Preliminary Basin Sizing Assumptions

The water surface areas were calculated based on the following assumptions.

- 1 in 5 Batter Slopes
- 1.2 m deep basins (excluding freeboard)
- 0.3 m freeboard adopted for each basin.

2.2.2.2 Likely total asset areas required

Using the water surface area as the starting point, a 'rule of thumb' calculation of twice the water surface area is used at the conceptual strategy stage to indicate the likely total area required including appropriate batter slopes, maintenance access (i.e., tracks to, around and into assets such as BRS, sediment ponds, wetlands and storage basins), and maintenance activities, such as mowing, litter and sediment removal

Note: these storage areas *do not* include what surface area may be required for harvesting storages. Depending on the design of the re-use scheme, and the intent to use above or below ground storages, or a combination thereof, and at which outlets, will influence the areas required to be set aside for this purpose.

Table 2-3 Likely total surface area requirements for the *retention* storages at each outlet

Outlet	Water Surface Area (m^2)	Total Surface Area (m^2)	Available Reserve Area (m^2)	
1	5,492	10,984	4,320	⚠
2	1,862	3,724	15,892	✓
3	4,616	9,232	27,958	✓
4	13,512 *(14,320)* *	27,024 *(28,640)* *	3,800	⚠
8	8,310	16,620	26,933	✓
9	7,369	14,738	11,185	⚠
10	3,495	6,990	52,537	✓
11	4,765	9,530	0	⚠

** Sizing based on ARR2016 Baseline Peak flow for existing conditions and 2030 SSP5 Developed Conditions*

3 CATCHMENT AND CREEK HYDROLOGY AND HYDRAULICS

3.1 Overview

This section outlines the findings of the developed conditions assessment of the Messmate Growth Area and the diversion of the Karaaf Wetlands catchments into the Deep Creek. Creek Hydrology Results

Peak flows and hydrographs at key locations in the Deep Creek and outlets from the Messmate Growth Area were extracted from the RORB model. Flows for a range of scenarios have been extracted, including:

- Pre-development (existing conditions)
- Post-development without storage
- Post-development with storage

The inclusion of the post-development **without** storage was done to demonstrate the impacts on downstream flows if suitable detention measures were not put in place. It also highlights the change in runoff behaviour from a catchment that now has a higher degree of imperviousness, often leading to a faster response time in runoff and quicker decrease in flows after the peak. When detention is included, runoff typically remains higher than pre-development conditions after the peak has been reached. This is due to the storage slowly releasing water after the peak flow has been achieved.

Peak flows and hydrographs were extracted at four (4) locations for the 1% and 10% AEP events. These locations and their significance are as follows:

- Deep Creek – downstream of culvert 3
  - This location was identified during the site inspection to be sensitive to increased flows as a significant head cut downstream of the culvert was identified.
  - This location is located downstream of the Briody Drive development and a stormwater pipe that discharges flows from a sizable, low-density residential area north of Coombes Road.
- Downstream Rosser Boulevard
  - This location features in the rock chute at the outlet of the Quay Estate and is downstream of the West Coast Business Park.
  - Observation of flows here is critical in understanding how the developed conditions may impact the existing rock chut, its function and the behaviour of flows into the start of the natural watercourse.
- West Coast Business Park Inflow
  - Immediately downstream of the largest of the catchments within the Messmate Growth Area, this location is important as it needs to consider the capacity of the existing infrastructure.
- Diversion Junction
  - The location where flows from the Karaaf catchments of the northern Messmate Growth Area will be diverted to (under this proposed strategy).
  - Oversizing of the upstream basins was needed to ensure peak flows under pre-development (existing) conditions were not exceeded.

Hydrographs for each of the above locations are presented in Figure 3-1 to Figure 3-8 below.

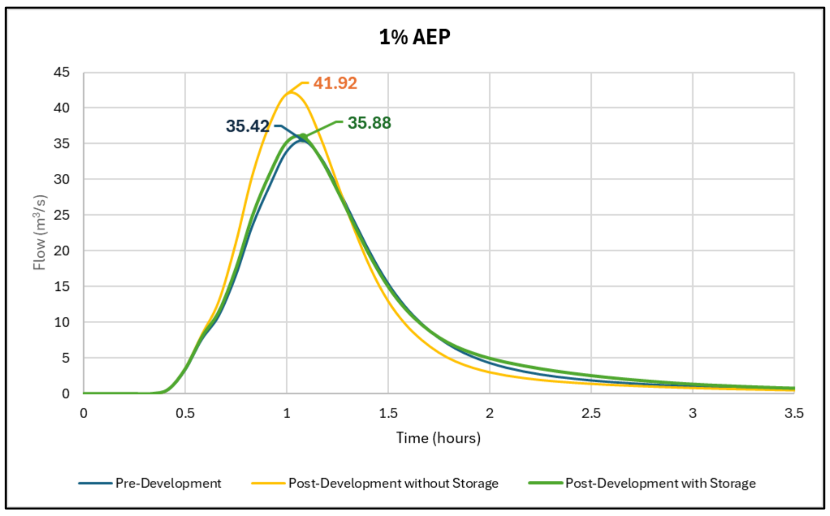

Figure 3-1 Upstream of Head Cut – 1% AEP Storm Event

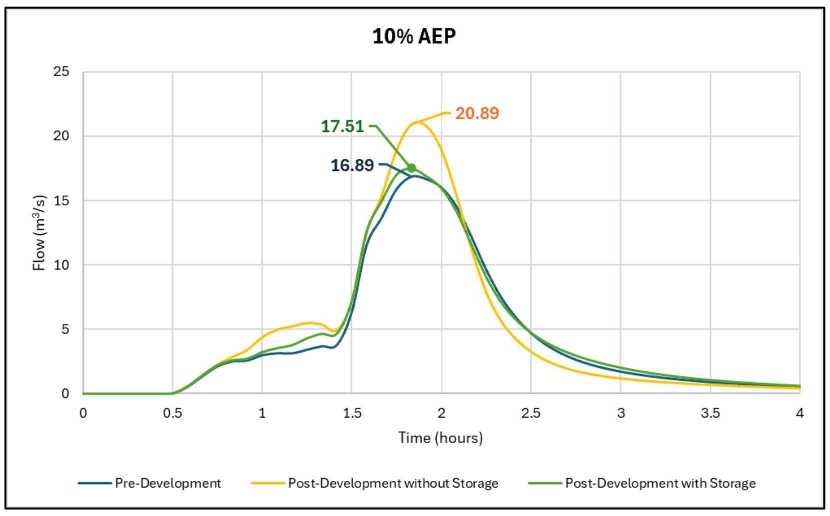

Figure 3-2 Upstream of Head Cut – 10% AEP Storm Event

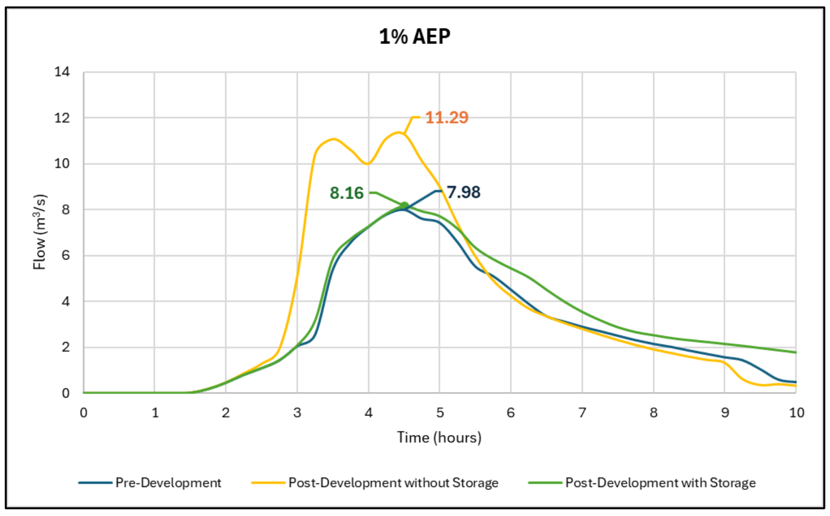

Figure 3-3 Downstream Rosser Boulevard – 1% AEP Storm Event

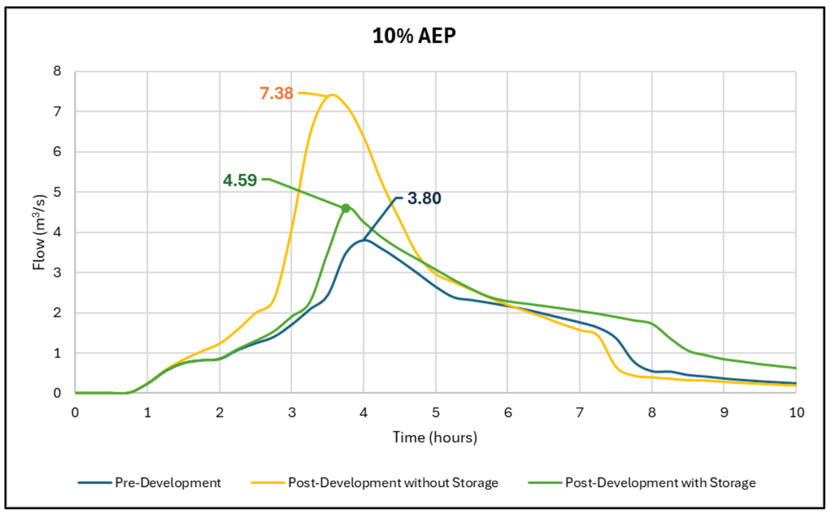

Figure 3-4 Downstream Rosser Boulevard – 10% AEP Storm Event

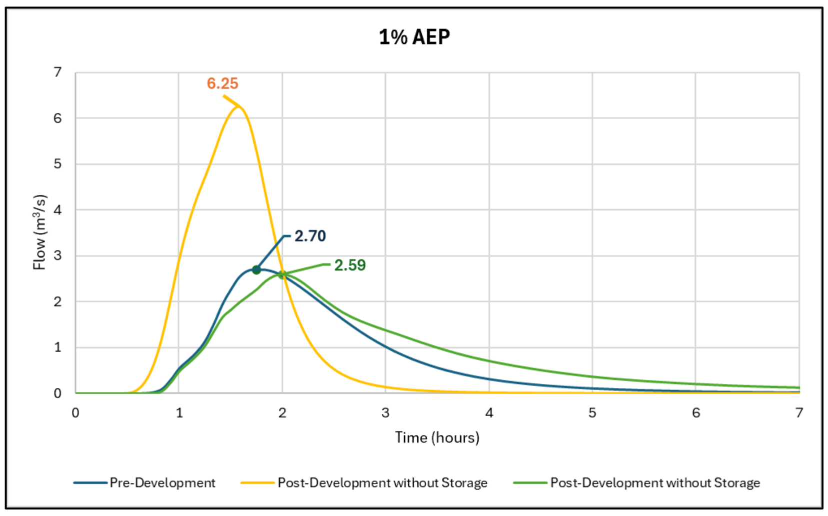

Figure 3-5 West Coast Business Park Inflow – 1% AEP Storm Event

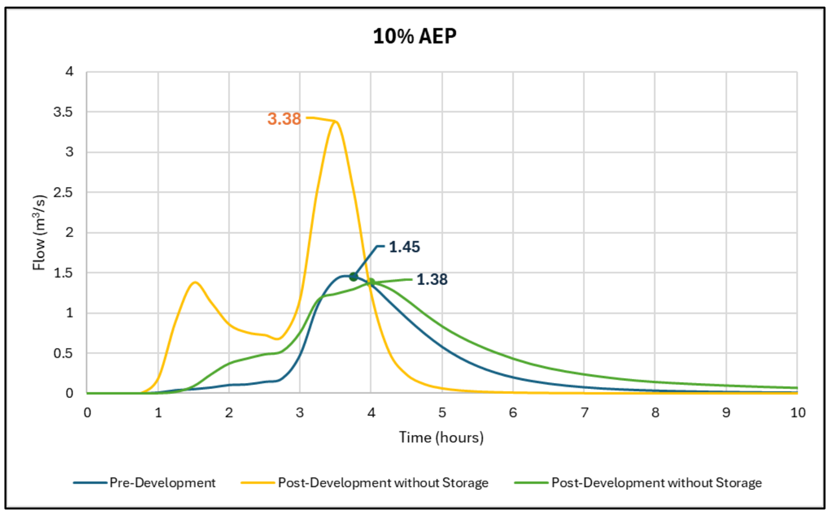

Figure 3-6 West Coast Business Park Inflow – 10% AEP Storm Event

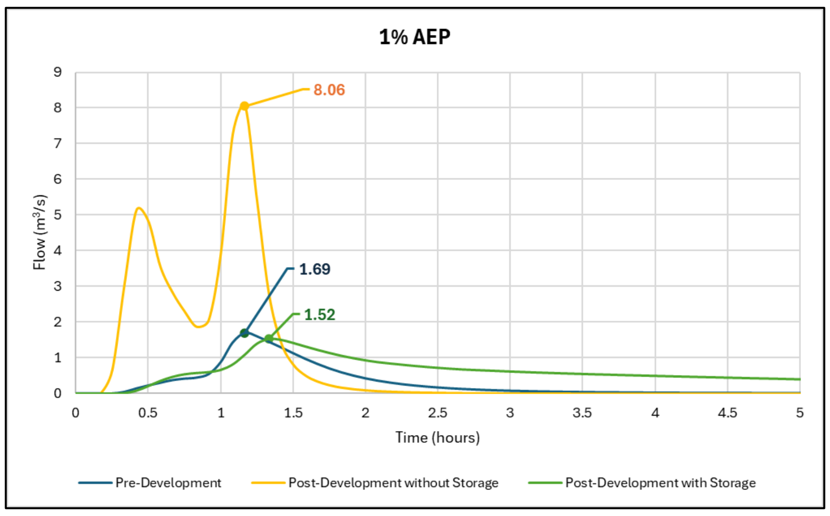

Figure 3-7 Diversion Junction – 1% AEP Storm Event

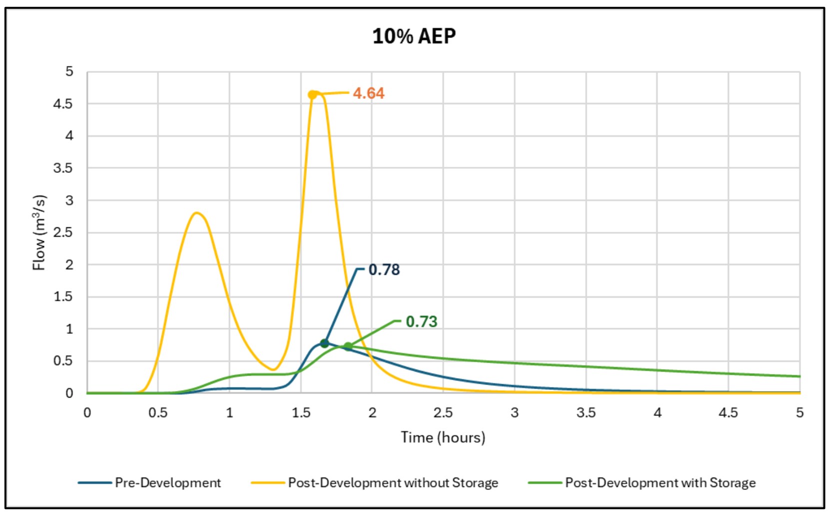

Figure 3-8 Diversion Junction – 10% AEP Storm Event

3.2 Hydraulic Results

Hydraulic modelling of pre- and post-development conditions was completed for the 1%, 5% and 50% AEP storm events. Two key hydraulic parameters, flow velocity and bed shear stress, were investigated to observe the impacts on the Deep Creek from the Messmate Growth Area development. Additionally, afflux mapping for flood depth and extents was completed for the Karaaf catchments now draining into the Deep Creek catchment, and bed shear stress was completed to observe changes in the Deep Creek itself.

3.2.1 Karaaf Catchment Diversion

Flood depth and velocity vector outputs for the pre-development conditions were extracted for the 1% AEP storm event. Figure 3-9 below illustrates how runoff from the Grasstree Park Nature Reserve and Messmate Outlets 10 and 11 flow into the Karaaf Wetlands catchment east of the Surf Coast Highway. This is via two 1.2m x 0.3m reinforced concrete box culverts underneath the highway which connect into the stormwater network in Hillside Parade road reserve. Under existing conditions (pre-development), overland flows through Grasstree Park Nature Reserve and downstream of Outlet 9 split between the Karaaf catchment and the Deep Creek catchment.

Under post-development conditions, runoff from Messmate Outlets 10 and 11 are diverted towards Messmate 9 outlet. To ensure runoff from the Messmate Growth Area is completely direct toward the Deep Creek, formalising of an overland flow path is likely needed to ensure no flows from the Outlet of 9 re-enter the Karaaf catchment. Modelling of a formalised overland flow path (i.e., channel) was not included in this modelling scenario, however afflux mapping for the 1%, 5% and 50% AEP events have been completed and are presented below in Figure 3-10 to Figure 3-12.

The key takeaway from the afflux mapping is that levels and extents are expected to decrease through Grasstree Park Nature Reserve and east of the Surf Coast Highway because of Messmate Outlets 10 and 11 been diverted. More importantly, levels and extents downstream of outlet 9 show no signs of increase for the 1% and 5% AEP events as they are within the design events for maintaining peak flows to pre-development.

During the 50% AEP event, detention has not been included in the proposed basins which leads to increased runoff during the storm event. This increase in runoff is notices in Figure 3-12 below where extents and depths downstream of Outlet 9 increase. Retardation of flows during the 50% AEP event will be impacted by water sensitive urban design infrastructure, such as wetlands, but these were not considered in the hydraulic model.

> *The catchment diversion is feasible however the resulting outflows flows through Grasstree Park need further consideration in relation to alternative mitigation measures to protect the integrity of soils and vegetation in the park.*

Flow vectors are provided for the 1% event under existing (pre-developed) conditions to illustrate the flow paths stormwater runoff takes once it leaves the Messmate Road catchment (Figure 3-9). The following series of difference maps illustrate the effectiveness of the proposed stormwater diversion via retention basins 11, 10 and 9, relative to the existing outflows from these basin locations in the 1% (Figure 3-10), 5% (Figure 3-11) and 50% (Figure 3-12) AEP events. In all events up to and including the 1% AEP, areas that are wet under existing conditions are dry under future conditions.

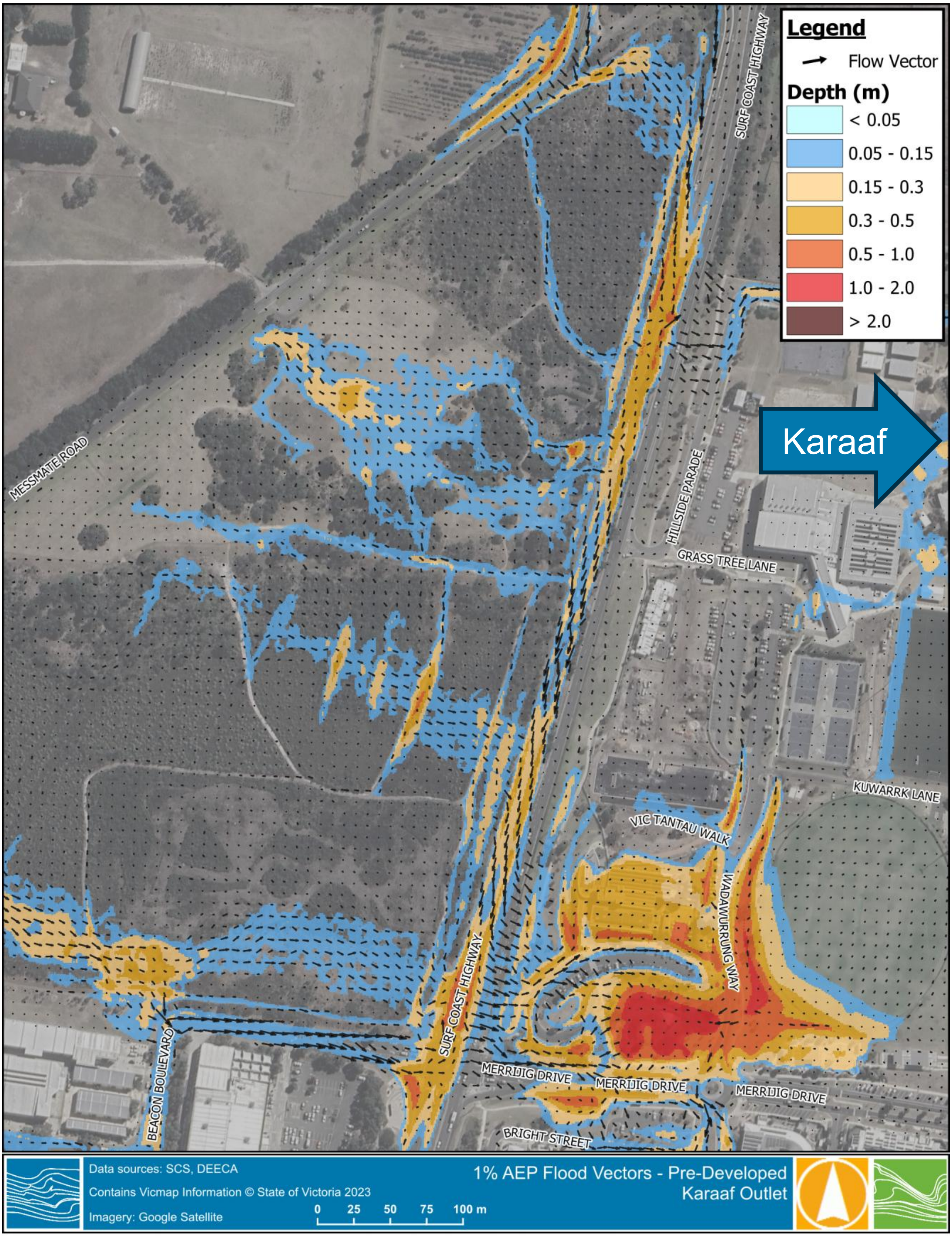

Figure 3-9 1% AEP Flood Depth & Velocity Vectors – Pre-Development

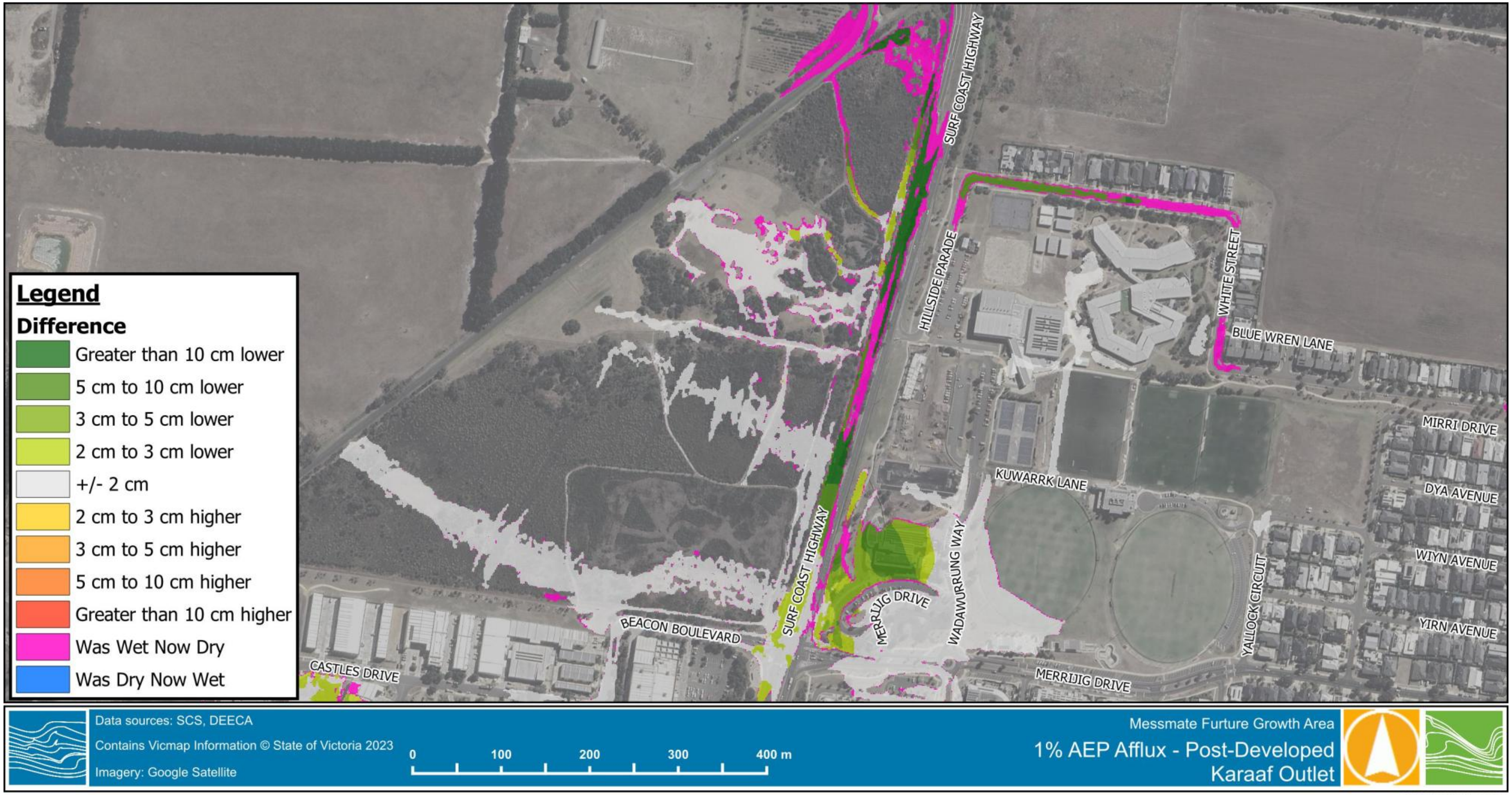

Figure 3-10 1% AEP afflux difference map (developed conditions) showing flow paths through Grasstree Park Nature Reserve

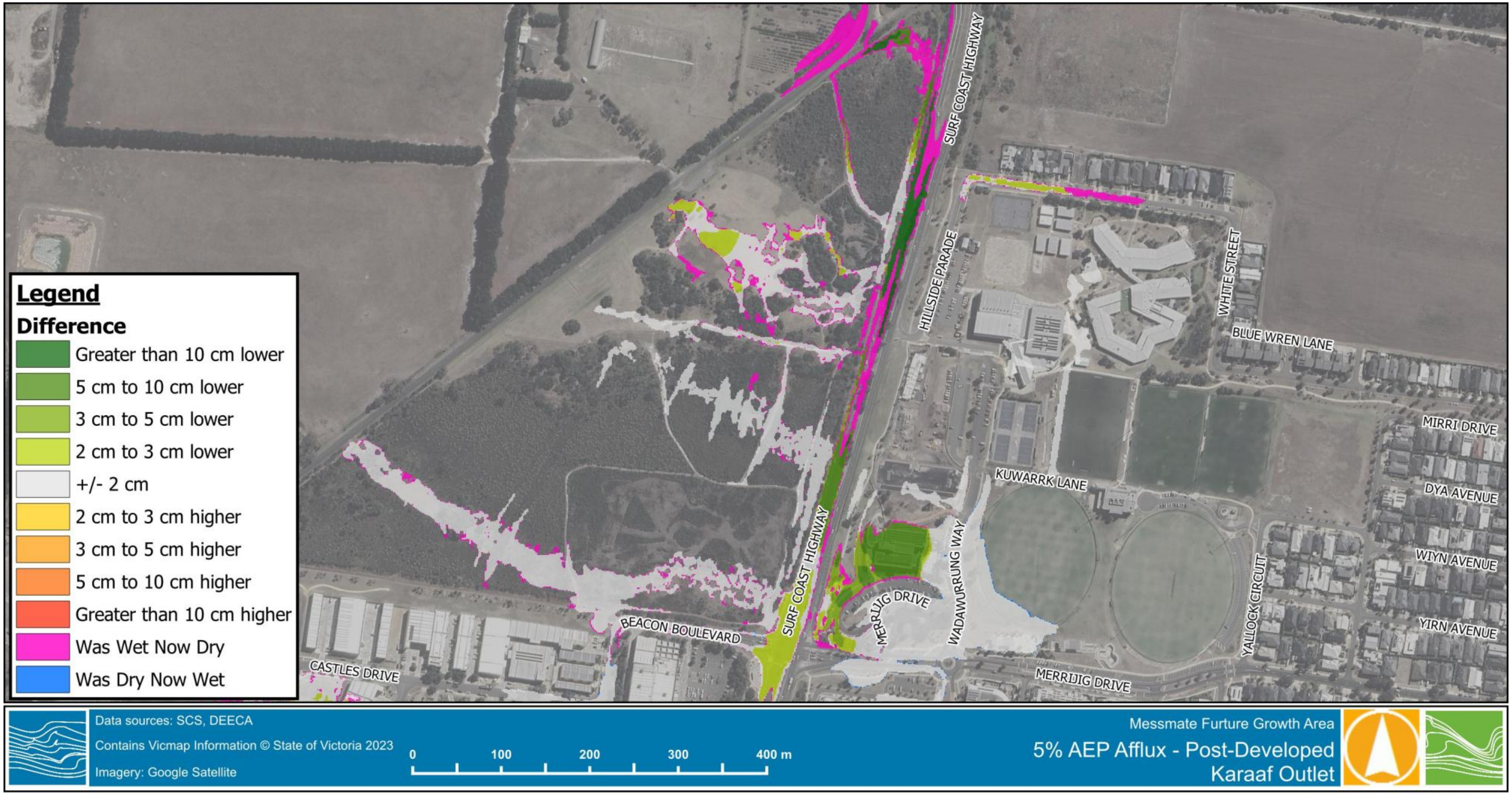

Figure 3-11 5% AEP afflux difference map (developed conditions) showing flow paths through Grasstree Park Nature Reserve

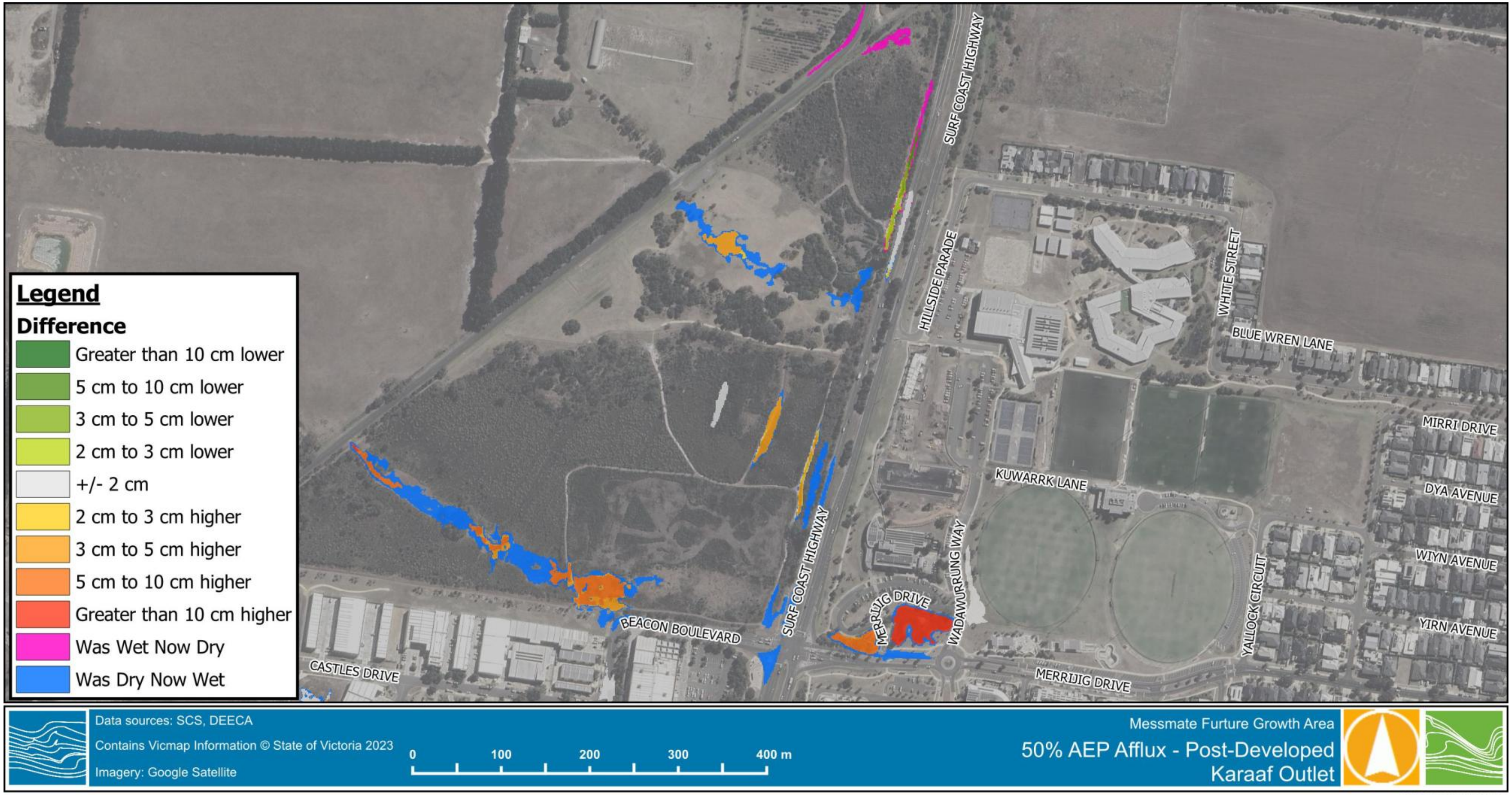

Figure 3-12 50% AEP afflux difference map (developed conditions) showing flow paths through Grasstree Park Nature Reserve

3.2.2 Deep Creek Bed Shear Stress

Hydraulic modelling of the bed shear stresses through Deep Creek under develop conditions with stormwater peak flow retention in place for the 1%, 10% and 50% AEP events show negligible increases (<5-10N/m^2) in bed shear stress relative to existing conditions for most sections along Deep Creek.

Figure 3-13, Figure 3-14 and Figure 3-15 present the difference between developed and existing conditions for the 50% AEP event. For the northern branch and the sections of creek downstream of the confluence with the northern branch the difference is <2N/m^2. For the section downstream of the highway and the confluence, and for most of the western branch upstream of the highway to Messmate Road, increases of no more than 5N/m^2 overall are experienced with only local increases of <10N/m^2 (e.g., in proximity of existing head cuts) except for the dam upstream of Piper Lane, where increases are 10-20N/m^2 or higher. This section is actively incising under existing conditions (refer existing conditions report for details).

Field assessment of the northern branch indicated several small head cuts however the risk of developed flows causing accelerated rates of incision is considered low, especially as the creek form through this section is highly confined by the steeply sloping valley sides leaving little room for lateral adjustment with deepening.

It is recommended that peak flow retention in key events including the 50% AEP is included in the *Stormwater / Waterway Management Strategy* and that consideration is given to targeted in-stream works to address observed erosion issues along the western branch of Deep Creek.

Figure 3-13 50% AEP Bed Shear Stress Afflux – Downstream Rosser Boulevard

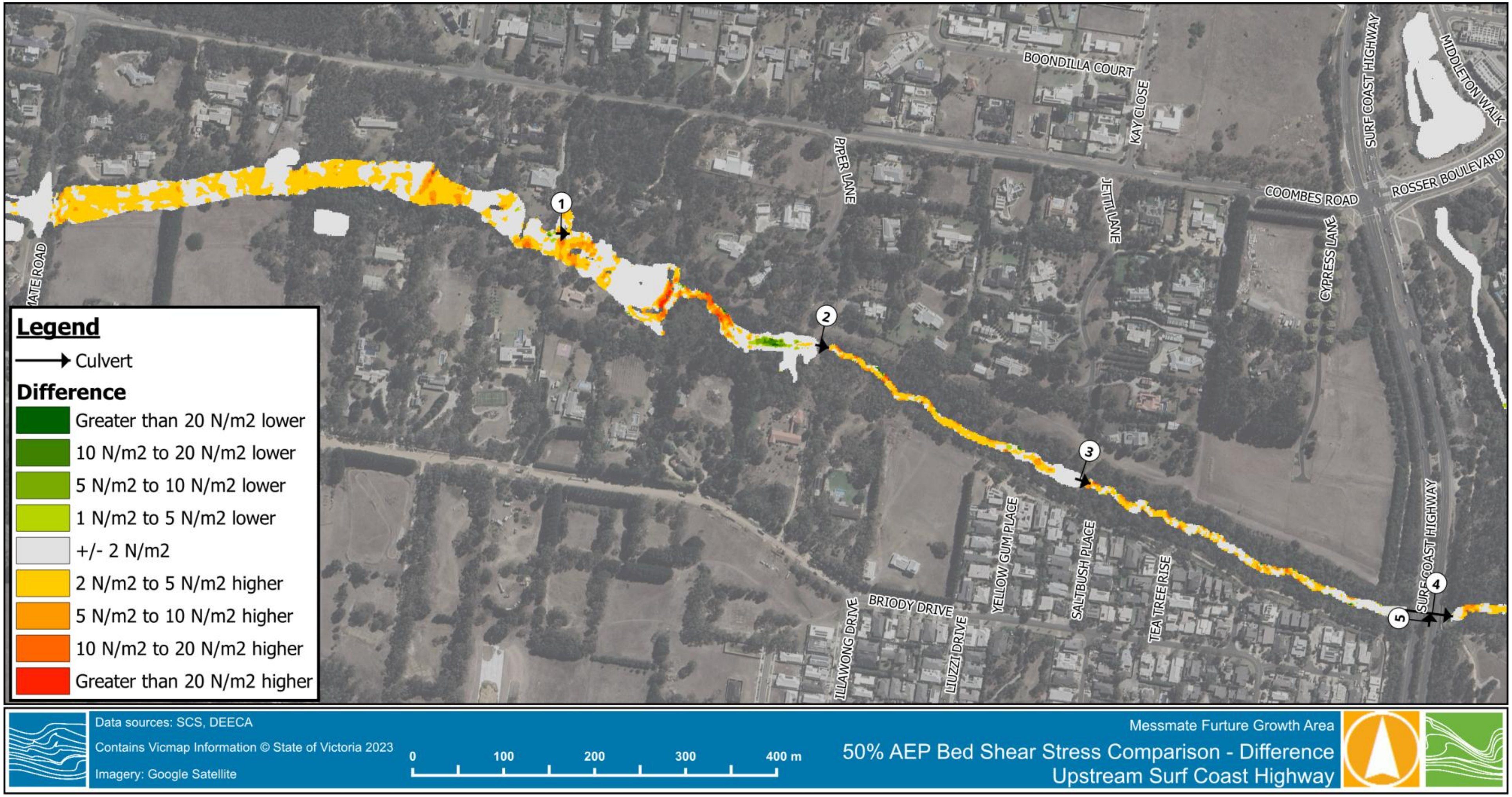

Figure 3-14 50% AEP Bed Shear Stress Afflux – Upstream Surf Coast Highway

Figure 3-15 50% AEP Bed Shear Stress Afflux – Downstream Surf Coast Highway

4 STORMWATER QUALITY MANAGEMENT

A high-level MUSIC model was developed, and end-of-catchment treatment assets were sized so that runoff from the development can reach water quality targets. Two high level options were also developed to decrease the volume of runoff from the site to reduce the adverse impact of development on the downstream receiving environment.

4.1 MUSIC Model

The base case MUSIC model was developed using the 20year_GeelongNorth_1971-1990_6min_sqz climate template provided by Geelong City Council[4]. The RORB model catchment template was used and simplified by merging all the catchments that contribute to an outlet. It is noted that small external catchment contributions to the West of the development area (0.6 ha) not included in the MUSIC model. This is expected to have little effect on the model as the external contributions are small and do not add to the impervious area. The catchments were named to align with the outlet naming convention. Overall, 9 catchments were identified. Figure 4-1 shows the catchment delineation, and Table 4-1 identifies the area and fraction impervious (FI) values associated with each catchment.

Figure 4-1 MUSIC Catchment Delineation

Table 4-1 Catchment area and FI

Catchment	Area	FI
C_External	0.69	18.68
C3	0.62	17.44
C4	0.79	25.64

[4] https://www.geelongaustralia.com.au/common/Public/Documents/8cf4f273fe1120f-wsud-designnote3-musicguidelines-november2019d19-604309.PDF

Catchment	Area	FI
C8	0.65	29.40
C9	0.73	18.89
C1	0.54	19.36
C2	0.57	6.61
C10	0.45	12.00
C11	0.58	9.89

A base case model was developed which includes end-of-catchment treatment with either bioretention basins or wetlands to treat the stormwater to water quality standards. This base model was then built upon to explore the feasibility of two stormwater volume runoff management scenarios: standard and maximum reuse. Standard reuse involved modelling of lot-scale rainwater tanks and 1.3ha of open space. Maximum reuse involved modelling of lot scale rainwater tanks, 1.3ha of open irrigated space and passively irrigated street trees.

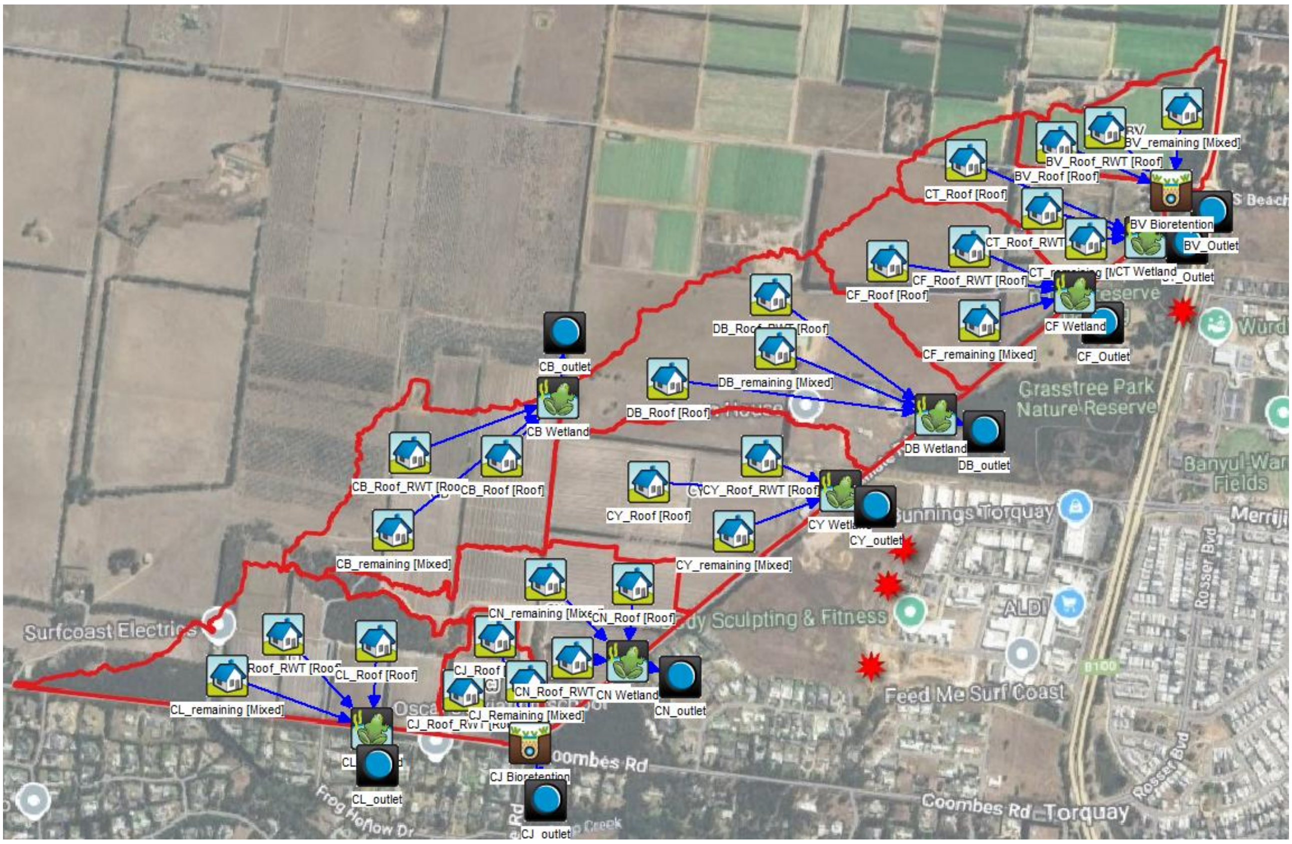

Figure 4-2 Base Case Music Model

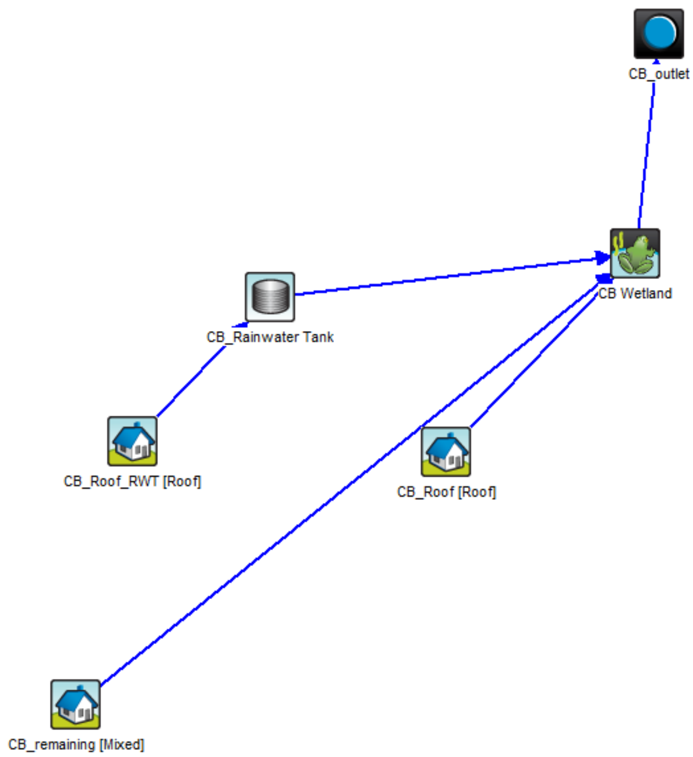

Figure 4-3 Example of the Catchment Scale Set up for the standard reuse scenario

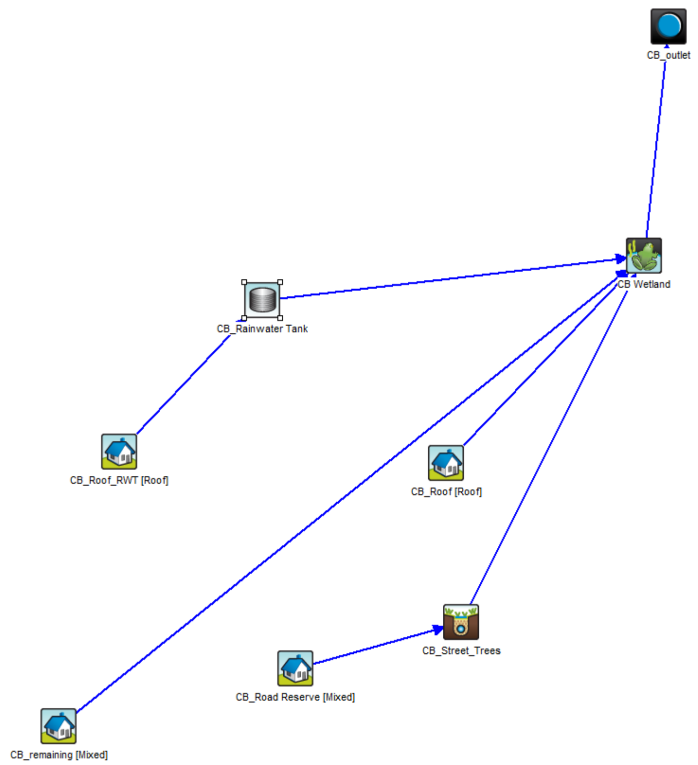

Figure 4-4 Example of the Catchment Scale Set up for the maximum reuse scenario

4.2 Stormwater Quality Treatment

In the base case model, end-of-catchment assets were sized to reach the BEPM water quality targets for post-development impervious runoff:

- 80% retention of the post-development annual load for Total Suspended Solids (TSS)
- 45% retention of the post-development annual load for Total Phosphorus (TP)
- 45% retention of the post-development annual load for Total Nitrogen (TN)
- 70% retention of the post-development annual load for Gross Pollutants (GP)

Wetlands were used to treat catchments >10ha, and bioretention basins were used to treat catchments <10ha. Standard wetland and bioretention basin sizing was applied as aligned with the Melbourne Water MUSIC guidelines (2024). Table 4-2 lists the characteristics of each asset that was used to treat the runoff from the catchment.

Table 4-2 End-of-catchment treatment type

Catchment	Treatment Type	Surface area (m^2)
C_External	Wetland	4519
C3	Wetland	3700
C4	Wetland	7691
C8	Wetland	6600
C9	Wetland	4700
C1	Wetland	3700
C2	Bioretention Basin	500
C10	Wetland	2000
C11	Bioretention Basin	400

The asset characteristics were not changed between model scenarios. Instead, the stormwater harvesting options were added to the base case model. As such, the assets are oversized for the two reuse scenarios as the amount of runoff that needs to be treated is reduced. This is shown in Table 4-3 below.

Table 4-3 % Reduction of post-development water quality parameters

Parameter	Base Case	Option 1	Option 2
TSS load reduction %	82	84	89
TP load reduction %	68	70	76
TN Load reduction %	52	57	63

4.3 Stormwater Volume Management

Two options for managing the volume of stormwater runoff were modelled. Option 1 was the standard stormwater reuse scenario and modelled the use of:

- 1725 2kL lot scale rainwater tanks to supply water for toilet flushing
- Stormwater runoff to irrigate 1.3ha of open irrigated space

Option 2 was the maximum reuse scenario and modelled the use of:

- 1725 4Kl lot scale rainwater tanks to supply water for toilet flushing and laundry
- Stormwater runoff to irrigate 1.3ha of open irrigated space
- 1368 Passively irrigated street trees at 15m spacing.

Table 4-4 Stormwater Management Assumptions

Number	Assumption
1	Roof area is 60% of the lot
2	50% of the roof area is connected to the rainwater tanks
3	General residential lot size of 400m^2. Medium density residential lot size of 300m^2.
4	Average household size is 2.6 people[5]
5	Toilet flushing takes 20L/person/day (MW MUSIC guidelines 2024)
6	Laundry takes 80L/household/day (MW MUSIC guidelines 2024)
7	Typical reuse demand for the open space irrigation is 3.2ML/Ha/yr[6]
8	Average road width in the catchment is 20m
9	Average tree spacing is 15m, tree trench area is 1m^2 (City of Melbourne Guidelines)

The volume reduction achieved through both options is reported in Table 4-5 below. The results were then compared to the EPA urban stormwater management flow performance objectives for priority and non-priority areas (Table 4-6 and Table 4-7).[7] Not enough stormwater can be harvested or infiltrated within the development to reach these targets. As such, the additional volume of external harvesting and reuse required so that these objectives can be met was calculated.

[5] https://abs.gov.au/census/find-census-data/quickstats/2021/LGA26490
[6] https://www.geelongaustralia.com.au/common/Public/Documents/8cf4f273fe1120f-designnote3-musicguidelines-nov24.pdf
[7] 1739.1: Urban stormwater management guidance | Environment Protection Authority Victoria

Table 4-5 Reuse Model Results

Parameter	Base case	Option 1	Option 2
Imp. Stormflow Out (ML/yr)	438	438	438
Lot Scale Reuse (ML/yr)	0	31	66
Open Space Irrigation Reuse (ML/yr)	0	3	3
ET Loss via wetlands/bioretention/street trees (ML/yr)	47	47	50
Infiltration Loss (ML/yr)	0	0	0
Total harvesting volume (ML/yr)	47	81	119
% Impervious Runoff harvested	11%	19%	27%
% Impervious Runoff infiltrated	0%	0%	0%

Table 4-6 EPA Non-priority Area Targets and Model Results Comparison

Parameter	Base Case	Option 1	Option 2
EPA Non-priority Area Target Objectives			
Impervious runoff to be harvested (%)	31%		
Impervious runoff to be infiltrated (%)	4%		
Combined total of impervious runoff (%)	35%		
Impervious runoff to be harvested (ML/yr)	136		
Impervious runoff to be infiltrated (ML/yr)	18		
Combined total of impervious runoff (ML/yr)	154		
Model Results			
Harvested volume (ML/yr)	47	81	119
Infiltrated volume (ML/yr)	0	0	0
% Impervious Runoff harvested	11%	19%	27%
% Impervious Runoff infiltrated	0%	0%	0%
Additional Volume Required to meet the Target			
Additional external harvest (ML/yr)	88	55	17
Additional external infiltrate (ML/yr)	18	18	18
Additional external volume total (ML/yr)	106	72	34

Table 4-7 EPA priority Area Targets and Model Results Comparison

Parameter	Base Case	Option 1	Option 2
EPA Non-priority Area Targets			
Impervious runoff to be harvested (%)	77%		
Impervious runoff to be infiltrated (%)	4%		
Combined total of impervious runoff (%)	35%		
Impervious runoff to be harvested (ML/yr)	136		
Impervious runoff to be infiltrated (ML/yr)	18		
Combined total of impervious runoff (ML/yr)	154		
Model Results			
Harvested volume (ML/yr)	47	81	119
Infiltrated volume (ML/yr)	0	0	0
% Impervious Runoff harvested	11%	19%	27%
% Impervious Runoff infiltrated	0%	0%	0%
Additional volume required to meet the Target			
Additional external harvest (ML/yr)	290	256	218
Additional external infiltrate (ML/yr)	22	22	22
Additional external volume total (ML/yr)	311	278	240

5 SUMMARY

The findings of this *Developed Conditions Assessment* have informed the subsequent *Stormwater / Waterway Management Strategy for the Messmate Road Growth Area (Water Technology, 2025).*

In summary, the findings are:

- Stormwater retention basins can mitigate the peak flow volumes in key events under developed conditions, so that they closely approximate existing conditions.
  - Note: The location of the required retention basins and their sizing needs to be accommodated in the urban layout. This can be achieved by revising the preliminary urban design in locations that don't presently cater appropriately for retention storage.
- Designing stormwater retention basins to mitigate peak flow volumes under developed conditions for the 50%, 5% and 1% AEP events create outflow hydrographs in Deep Creek that closely approximate existing conditions. The 50% AEP is particularly important as it represents the frequent flows that have the capacity to geomorphic work on the creek bed and banks (i.e., cause scour if above key thresholds).
  - As such, there is negligible change in bed shear stresses in these events.
    - Bed shear stress is the primary indicator of likely scour in the creek because of urbanised flows.
  - It is important to note that bed shear stress exceeds thresholds in several locations along Deep Creek (refer existing conditions report) in the 50% AEP event. Modelling suggests that mitigating future urban runoff under developed conditions doesn't not make the existing conditions any worse in this event. However, there may still be the need for in-stream works to mitigate the current erosion issues identified in the existing conditions field assessment and as supported by existing conditions shear stress model results. Notable locations are along the western branch of Deep Creek.
- Stormwater retention along does not address the increase in stormwater volumes entering Deep Creek and this can be seen in the developed conditions hydrographs.
  - To further protect Deep Creek from the effects of urbanised flows from Messmate Road growth area catchment it is recommended to reduce stormwater volumes in various ways, including the adoption of a re-use scheme to remove as much stormwater as is pragmatic to do so.
    - Modelling in relation to the EPA Guidelines suggests that between 34ML/year and 240ML/year is available for a re-use scheme.
- Stormwater can be treated to meet or slightly exceed current Best Practice Environmental Management (BPEM) standards.
- Under developed conditions, stormwater retention basins can be sized so that stormwater can be successfully diverted from draining towards the Karaaf Wetlands, as is the case under existing conditions.
  - Diverting stormwater from the Karaaf catchment re-routes urban runoff through Grasstree Park based on topography and existing flow paths. This is not desired by Council and as such further investigation is required to determine the options for better managing urban runoff to protect Grasstree Park.
    - Note: The *Stormwater / Waterway Management Strategy* presents the diversion of stormwater away from the Karaaf Wetlands and through Grasstree Park and acknowledges the need for further investigation to inform improved flow management and protection of Grasstree Park.
- The preliminary urban design will need amending to cater appropriately for the recommended network of stormwater quality treatment and volume management assets. This is discussed in the closing sections of the *Stormwater / Waterway Management Strategy (Water Technology, 2025).*

APPENDIX A
EXISTING CONDITIONS RORB AND TUFLOW MODEL BUILD SUMMARY

5.2 Hydrology Model Development

The catchment runoff routing model, RORB, was used as the primary tool to model the hydrology of the catchment and the receiving waters of Deep Creek. The model was constructed using QGIS, ArcRORB and RORB V6.52 and according to the Australian Rainfall and Runoff Guidelines Version 4.2.

Contributing catchments to outlet points from the proposed Messmate Growth Area and to Deep Creek were delineated based on (i) available LiDAR data captured in 2020 (surfcoast-lidar_2020_dem1m) and (ii) on the existing drainage networks. Consideration was also given to overland flow paths which convey runoff away from the Deep Creek and towards the Karaaf Wetlands in events where the stormwater network is beyond capacity (assumed to be great than the 10% AEP event); and to development plans for numerous residential and commercial developments with water treatment and detention infrastructure.

Subarea and Reach Delineation

Subareas and reaches were delineated using plugins within QGIS and revised as necessary based on the provided development plans and stormwater drainage network. The delineation was based on the available LiDAR data, with major roads burnt out of the terrain to permit continuous flow through the catchment. Nodes were placed areas of interest (to extract flow hydrographs), the centroid of each subarea and the junction of any two reaches. Nodes were then connected by RORB reaches each representing length, slope and reach type. The RORB catchment model had a total of 134 subareas ranging in area from 0.013 – 0.13 km^2. Four storages were included in the model which reflected the major detention systems at the following locations:

- West Coast Business Park Stage 3
- West Coast Business Park Stage 4
- They Quay Stage 2
- Lincoln Avenue
- Surf Coast Highway embankment

The subarea delineation, reach network and storages is shown in Figure A-1 below.

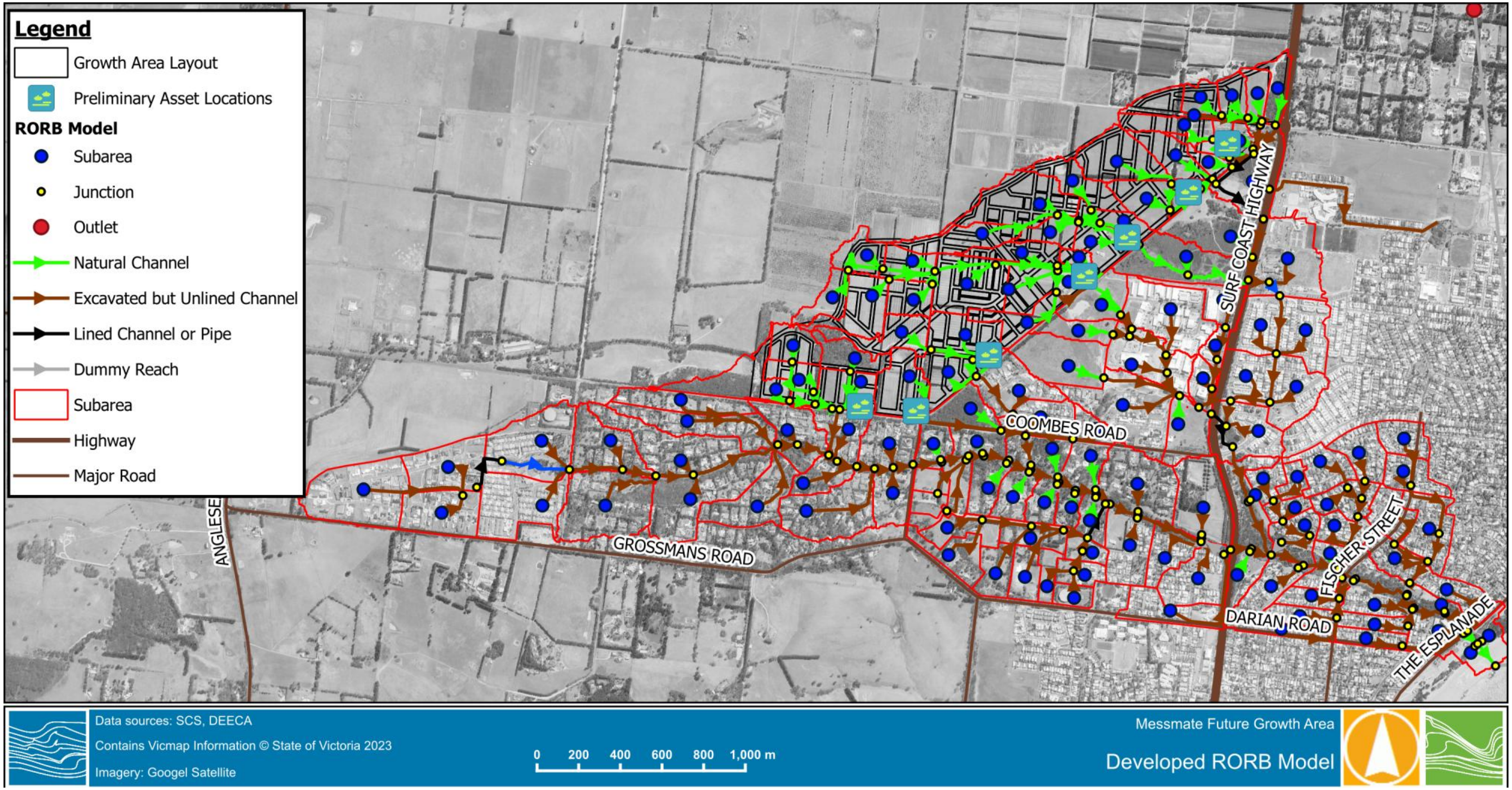

Figure A-1 Deep Creek & Messmate RORB Model Overview

Deep Creek Storages

Key storages within the Deep Creek catchment were included in the RORB model as *Special Storages*, adopting a stage-storage relationship with a weir and pipe discharge relationship. Stage storage relationships were based on 'As Constructed' design plans submitted to the Council on behalf of the developers, with the exception the Surf Coast Highway storage. Provided plans did not include the design stage-storage table, so a linear relationship was assumed for each of the storages. The Surf Coast Highway was included in the RORB model as a storage due to the highway impose a significant choke point along the Deep Creek that results in the overtopping of the highway. The estimated storage volume of the Surf Coast Highway was determined using LiDAR data and the elevation of the highway as its spillway.

Model Parameters

The RORB model parameters were determined as the following:

- The catchment impervious fractions for different surface types were determined. Firstly, Total Impervious Area (TIA) fraction values were determined for each land use type based on typical fraction impervious values outlined in the Melbourne Water MUSIC guidelines (Melbourn Water November 2018). Catchment fractions were then determined based on the TIA value using the below formula:

$$When\ FI \leq 0.2, \qquad DCIA = 0$$
$$ICIA = FI$$

$$When\ FI \geq 0.8, \qquad DCIA = FI \times 0.7$$
$$ICIA = FI \times 0.3$$

$$Otherwise, \qquad DCIA = FI \times 0.6$$
$$ICIA = FI \times 0.4$$

- Five different reach types are available in RORB (1 = Natural, 2 = Excavated & Unlined, 3 = Lined Channel or Pipe, 4 = Drowned Reach, 5 = Dummy Reach). The reach types in this RORB model were set as follows:
  - Type 1: Natural – for "natural' runoff being conveyed through non-formalised drainage paths (i.e., grassed slope without channel.
  - Type 2: Excavated & Unlined – for runoff being conveyed via open channel (grassed or earthen and roads.
  - Type 3: Lined Channel or Pipe – for runoff being conveyed through assets sized to convey the 1% AEP (or greater) flow event.
  - Type 4: Drowned – for runoff being conveyed through large bodies of water (i.e., large wetland systems).
  - Type 5: Dummy – to connect two nodes without imposed losses or routing that would be typically conveyed through other reach types.
- The initial and continuing losses shown in Table A-1 were used in the RORB model, in accordance with ARR V4.2

Table A-1 Adopted Initial and Continuing Loss Assumptions

	Initial Loss (mm)	Continuing Loss (mm/hr)
Pervious Area	24	4.4
DCIA	1.5	0.0
ICIA	16.8	3.08

- From the ARR Data Hub, rural losses are 24 mm and 4.4 mm/hr for the initial and continuing loss, respectively, for Deep Creek. A review into the ARR recommended losses for the Deep Creek loss region (Region 3) found that Data Hub losses tend to be too large, thus leading to modelled flow estimates being too low. Recommendations from the Technical Report[8] are that using the 75th percentile value, rather than the median is the best available solution for offsetting the recommended losses. This is only to be implemented when no other catchment/gauge data is available to calibrate/validate the modelled flows.
- Consideration for the latest recommendations by ARR V4.2 for climate change conditions for periods since the collection of the IFD data has been considered. IFD data available from ARR is based on rainfall depths collected between 1961-1990, newly referred to as baseline. Scaling of the baseline IFD's is required to consider the changes in global temperatures since the baseline data was collected and is commonly referred to as 'Present Day'. Present Day for this assessment has assumed the design horizon of the year 2030 under the IPCC Shared Socioeconomic Pathway (SSP) 5-8.5, with a Global Warming Level (GWL) of 1.3°C. Scaling factors of rainfall depths are applied on a duration basis, which is summarised in Table A-2 below.

Table A-2 Present Day Depth Scaling Factors

Duration	≤ 1-hr	1.5 hr	2-hr	3-hr	4.5-hr	6-hr	9-hr	≥ 12-hr
Scaling Factor	1.2	1.18	1.17	1.16	1.14	1.13	1.13	1.12

- Determination of an appropriate Kc value (Table A-3) was undertaken by comparing various methods that derive design flow rates and comparing their respective flows and derived Kc values. Pearse et al. (2002) has been found to frequently reflect an appropriate Kc value for catchments within Victoria. Given the absences of nearby studies and calibrated models, the adoption of Pease et al. (2002) was made, as it also resides within the other two methods considered.

Table A-3 RORB Routing Parameter Kc

Method	Kc Source/Regional Equation	Application	Kc
RORB Default	$Kc = 2.2 \times A^{0.5}$	RORB Default Equation	5.88
VIC MAR<800	$Kc = 0.49 \times A^{0.65}$	Areas with annual rainfall < 800 mm	1.76
Pearse et al. (2002)	**$Kc = 1.25 \times D_{av}$**	**Victoria**	**3.97**

The scaled baseline IFD data and the selected Kc value were used to run the RORB model for the 50%, 5% and 1% AEP events across the ensemble of temporal patterns and a range of durations from 20-minutes to 72-hours.

[8] Hughes, E. Stephens, D. 2020, HARC, *Benchmarking ARR2019 for Victoria,* Melbourne Water

5.3 Hydraulic Model Development

A combination of direct inflow to the models 2D domain and 1D domain was adopted, which represented rainfall direct to grid and flows applied directly to the stormwater network, respectively. Inflow hydrographs were extract from the developed RORB models rainfall excess files and printed. Model scenarios were completed using TUFLOW Build 2023-03-AF Single Precision with HPC (Highly Parallelised Computations) scheme on a GPU server utilising Sub-Grid-Sampling (SGS).

The hydraulic model was developed to assess runoff from the Messmate Growth Area, its flows through existing precincts and flows into and along the Deep Creek waterway. To do so, land use, cadastral, topography, aerial imagery, and photographs to identify varying land uses were used to inform the hydraulic characteristics of the Deep Creek catchment and waterway. These characteristics defined the surface roughness of the hydraulic model. Hydraulic structures within the study area were collated from Surf Coast Shire's database and information gathered during the site inspection.

The hydraulic model adopted the following setup:

Inflows

Hydrographs generated from the RORB model were used to represent inflows into the hydraulic model for internal and external (2d_sa) inflow regimes.

Internal inflows adopted either an SA ALL approach, or an SA PITS approach. These a described in more detail below:

- SA ALL
  - Rainfall excess from the respective subarea is applied to full extent of the subarea, similar to direct rainfall on grid.
- SA PITS
  - Rainfall excess is applied to the stormwater pit network. Any pits located within the subarea will have flows (evenly distributed by the number of pits) applied directly into the stormwater network.

Outflows

- The hydraulic model featured an outflow control where the Deep Creek discharges into the ocean, downstream of the Esplanade. The outflow control (2d_bc) adopted a sloped outlet based on the LiDAR data and was modelled as 0.01 m/m.

Topography

- The topography of the hydraulic model was based on LiDAR data captured in 2020 and featured a grid cell size of 1-metre and vertical accuracy of ±10cm. representation of the Deep Creek was suitable for this assessment as the LiDAR had not captured any water within the waterway, meaning the full profile of the Deep Creek was captured and not obscured by water levels.
- The hydraulic model adopted a grid resolution of 2-metres to maintain reasonable model run times and file output sizes.
- Sub-Grid-Sampling (SGS) was utilised as it allows for the capacity of open channels and narrow flow paths to be represented in the hydraulic model on a finer resolution. This allows for a better representation of overland flows that interact with culverts. The input LiDAR is a limiting factor for the SGS sample frequency, which was set to 1-metre.

Hydraulic Controls

- The hydraulic model included a total of 801 pipes/culverts and 759 stormwater pits in the stormwater network (1d_nwk).
- Culverts were represented in the hydraulic mode as either pipes (C) or box Culverts (R) with their sizes based on SCS asset details or measurements obtained during the site inspection. Invert levels were not available from the asset database and were assumed based on the LiDAR elevations.
- Inlets and outlets of each culvert were connected to the 2D domain by SX points or SXCN lines (2d_bc).

An overview of the modelling pit and pipe network in the Deep Creek catchment is shown in Figure A-1 below.

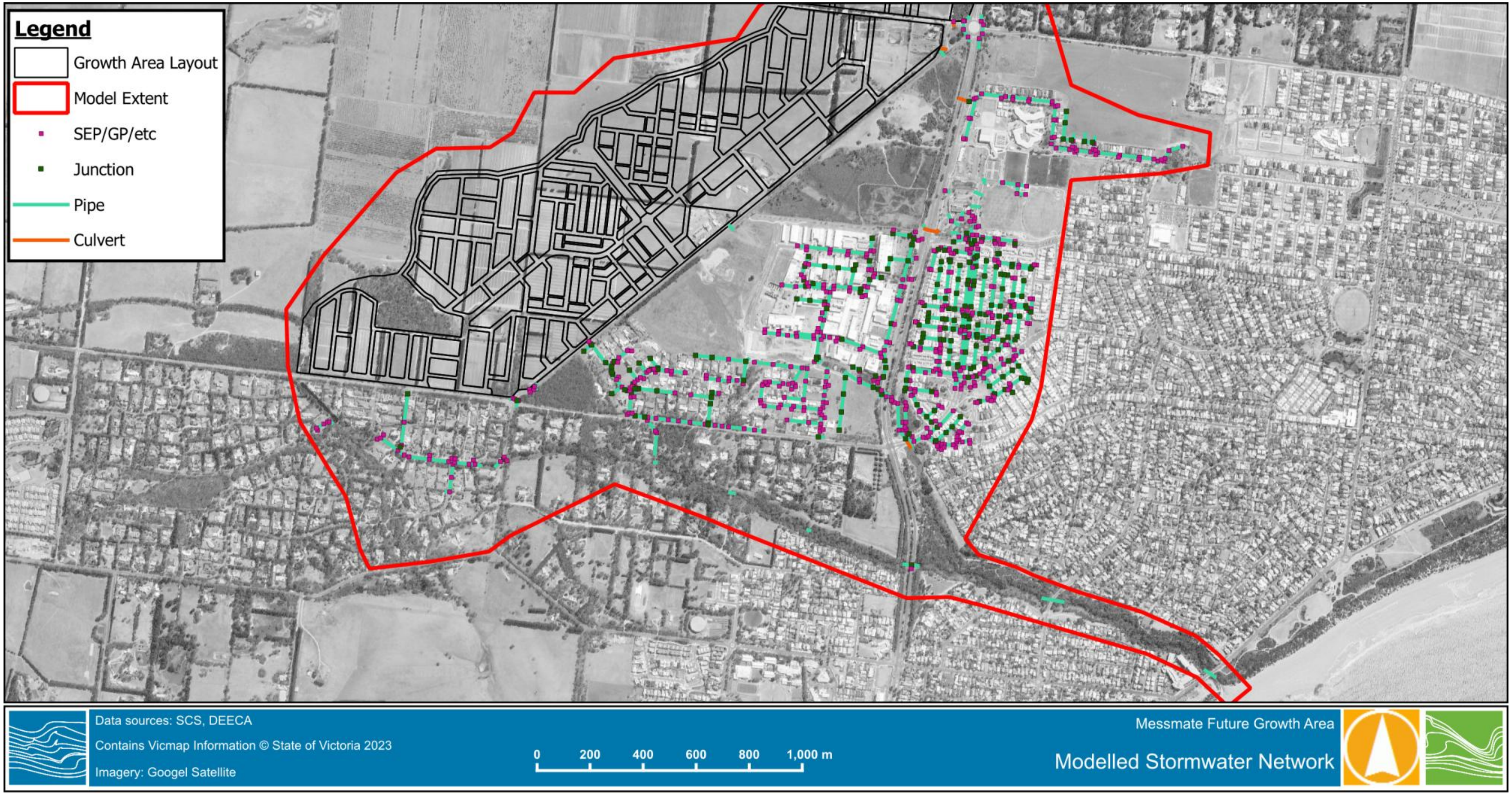

Figure A-1 Overview of Modelled Pit and Pit Network

Surface Roughness

- A Manning's (n) Roughness layer was developed based on aerial imagery, land use layers and observations from the site visit to assigned zones of appropriate roughness. The roughness represents how course or smooth to make a cell and affects the velocity and depths of water travelling across the surface. For instance, flows across a smoother surface (i.e., concrete) travel faster when compared to a rougher surface (i.e. thick vegetation). Table A-1 below summarises the adopted roughness values for each surface type.

Table A-1 Manning's (n) Roughness Values

Surface Type	Manning's (n) Value
Grassed / Open Field	0.040
Grass / Open Field – Mod. Foliage	0.050
Low Density Residential	0.150
Medium Density Residential	0.200
High Density Residential	0.300
Medium Vegetation	0.090
Road Reserve	0.020
Vegetated Waterway	0.075
Water Body	0.030
Sand	0.060
Rock Chute	0.140
Industrial / Commercial	0.350

- An overview of the modelled roughness extents is shown below in Figure A-2.

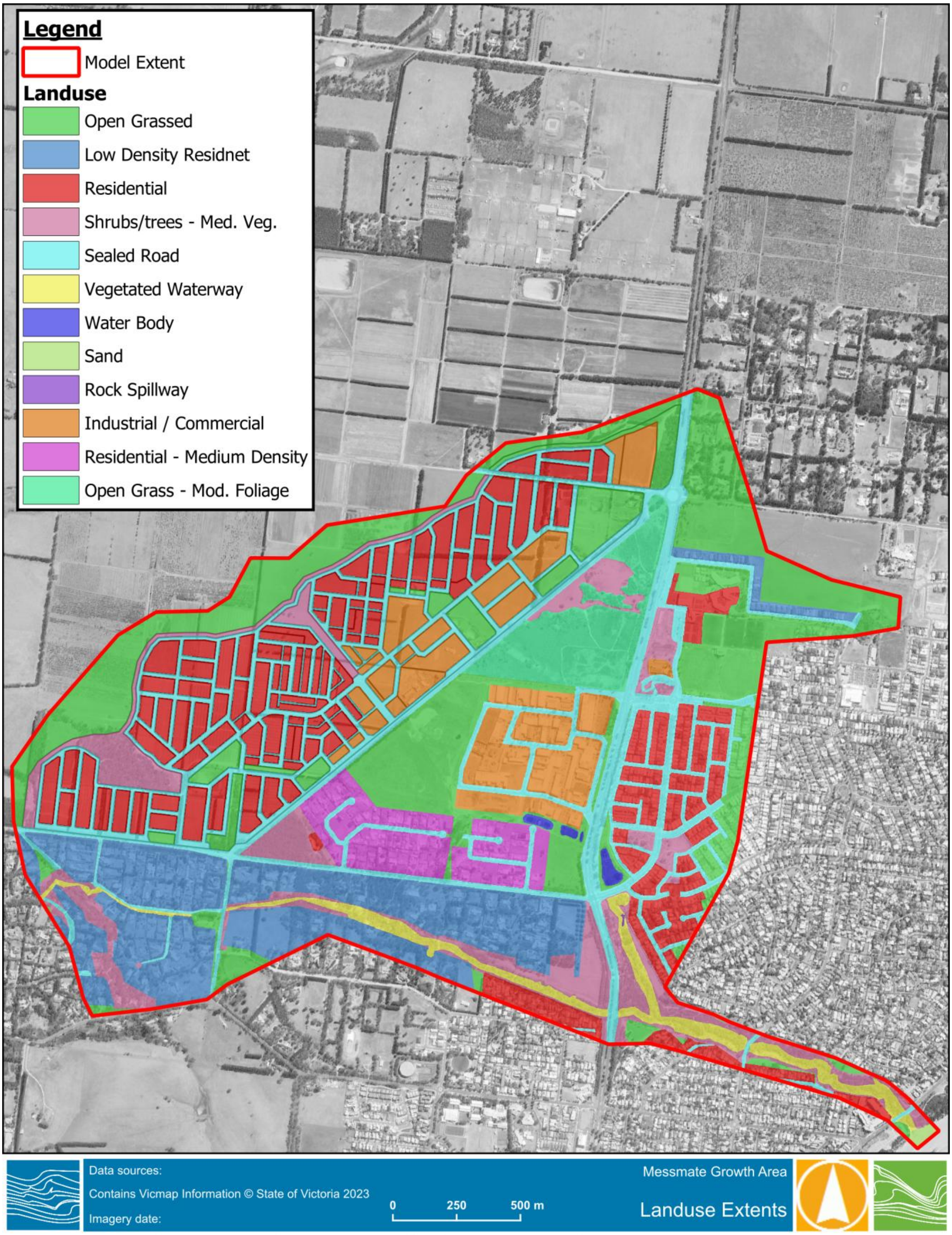

Figure A-2 Adopted Hydraulic Modell Roughness Extents

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Melbourne
15 Business Park Drive
Notting Hill VIC 3168

Sydney
Suite 3, Level 1, 20 Wentworth Street
Parramatta NSW 2150

Brisbane
Level 5, 43 Peel Street
South Brisbane QLD 4101

Adelaide
1/198 Greenhill Road
Eastwood SA 5063

Perth
Level 1, 21 Adelaide Street
Fremantle WA 6160

New Zealand
7/3 Empire Street
Cambridge New Zealand 3434

Wangaratta
First Floor, 40 Rowan Street
Wangaratta VIC 3677

Geelong
51 Little Fyans Street
Geelong VIC 3220

Wimmera
597 Joel South Road
Stawell VIC 3380

Gold Coast
Suite 37, Level 4, 194 Varsity Parade
Varsity Lakes QLD 4227

Darwin
5/5 Goyder Road
Parap NT 0820

Sunshine Coast
Office #4 of the Regatta 1 Business Centre
2 Innovation Parkway
Birtinya QLD 4575

1300 198 413

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