21-000403

INYADDA DRIVE, MANYANA

INTEGRATED WATER CYCLE STORMWATER MANAGEMENT REPORT

Prepared for **Heir Asquith**

Document information

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1 INTRODUCTION

1.1 Purpose

The purpose of this assessment is to determine the potential surface water quality and hydrology impacts that may be generated by construction and operation of the project and present a proposed approach to the management of these impacts. The study will canvass both construction and operational water quality and flow management strategy that guided the design.

1.2 Background

The subject site is formally known as Lot 1 DP 1161638, Lot 2 DP 1121854, and Lot 106 DP 755923 and is located at Manyana. The site is located within jurisdiction of Shoalhaven Council and is currently zoned as R1 - General Residential, E3 - Environmental Management and R5 – Large Lot Residential land under the Shoalhaven Local Environmental Plan (LEP) 2014. The site is in proximity of the Tasman Sea.

FIGURE 1 – SITE LOCATION

The development known as Inyadda Drive involves the subdivision of the site and construction of associated roadway and utilities, and stormwater mitigation structures. The layout of the proposed development is shown in figure below.

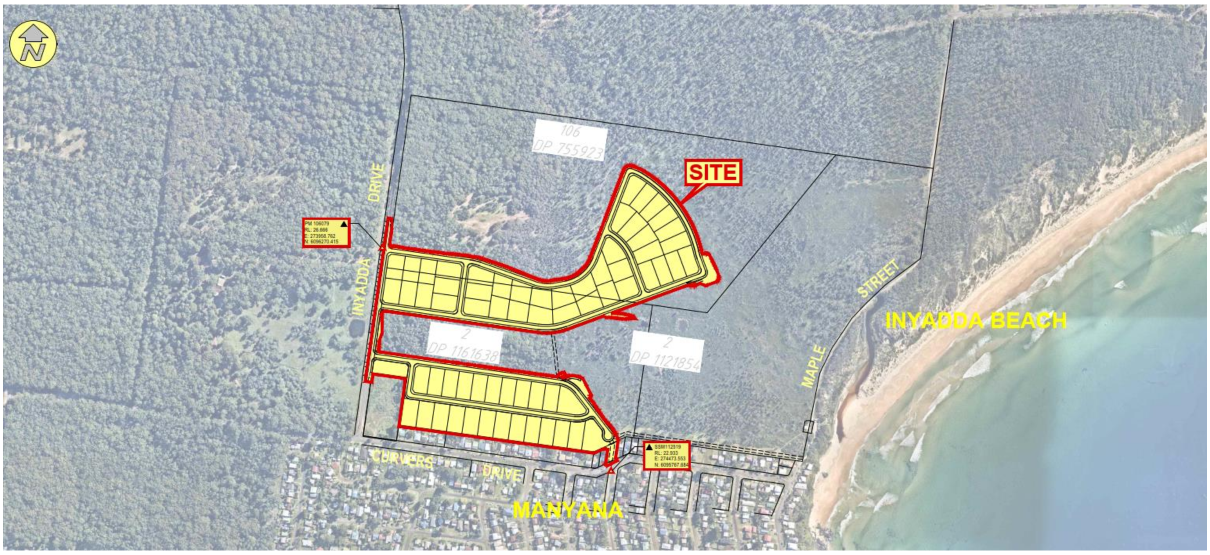

FIGURE 2 – PROPOSED SUBDIVISION DEVELOPMENT

1.3 Overview of potential impacts

The development would involve range of activities including clearing of land, site grading, establish site amenities, site access road, and construction of new lots. The construction activities have the potential to impact on various aspects of the water quality and hydrology including:

- Erosion and sedimentation of soils
- Reduced water quality from elevated turbidity, increased nutrients, and other contaminants.
- Changes to flow rates, volume, and flow paths within drainage lines.
- Changes to flood levels, flows and velocities caused by alteration of flood flows, and the impact in neighbouring properties.

The potential impacts are common on construction projects and with the application of standard mitigation measures outlined herein, any potential impacts on surface water quality and quantity are considered as minor and manageable.

1.4 Scope

The scope of the study is listed below:

- Assessment of pre and post development hydrology, identification of any impacts on the existing hydrology and constraints and opportunities associated with the hydrological management.
- Assessment of the post development water quality using MUSIC modelling and water quality mitigation measures.
- Sizing and concept design documentation of water quality treatment devices.
- Assessment of pre and post development flood behaviour, ensuring there are no exaggerating of flood levels on adjacent properties.

2 RELEVANT GUIDELINES

2.1 Shoalhaven Council Requirements

The site is located within the Shoalhaven Council local government area (LGA).

2.1.1 Engineering Design Specification - D5 Stormwater Drainage (Shoalhaven Council 1999)

This specification contains technical design data for the calculation of flows, flood elevations and velocities along with technical standards for the design of drainage infrastructure. The hydrologic parameters include rainfall intensity charts and runoff parameters for flow estimation. The document also outlines hydraulic parameters and design requirements for pits, culverts, and pipes.

2.1.2 Engineering Design Specification - D7 Erosion Control and Stormwater Management Design (Shoalhaven Council 1999)

This specification contains technical design associated with Erosion and Sediment Control and management of stormwater during construction.

2.1.3 Shoalhaven Development Control Plan 2014 – Chapter G2: Sustainable Stormwater Management and Erosion/Sediment Control

The Shoalhaven DCP applies to all land within the Shoalhaven LGA. The DCP sets the water quality and quantity targets and the modelling requirements. The policy also addresses the erosion and sediment control. The document identified that WSUD measure located on private property typically require a positive covenant and restriction on the use under a Section 88B of the Conveyancing Act 1919.

2.1.4 Development Construction Specification C23 – Drainage Structures (Shoalhaven City Council), Development Construction Specification C221 – Pipe Drainage (Shoalhaven City Council) and Construction Specification C220 – stormwater Drainage (Shoalhaven City Council)

The documents provide specifications for the drainage structures and pipe drainage within the Shoalhaven LGA.

2.2 Water Management Act 2000

The key NSW legislation governing the management of the state’s water resources are the Water Management Act 2000 and the Water Act 1912. The Water Management Act 2000 is progressively replacing the Water Act 1912, which represented outdated principles in water management.

The objective of the Water Management Act 2000 is to provide sustainable and integrated management of water resources for the benefit of both present and future generations (NSW Office of Water, 2014). The NSW Office of Water administers the Water Management Act 2000 and regulates controlled activities carried out around and on waterfront land.

3 STORMWATER MANAGEMENT OBJECTIVES

As part of the development of the Manyana property, a stormwater strategy was prepared. This report presents a stormwater and trunk drainage strategy based on WSUD principles set out in the Shoalhaven Development Control Plan 2014. The stormwater strategy has adopted the key objectives and include:

- Link water infrastructure effectively to minimise impact of the development upon the water cycle.
- Mitigate the impacts of development on the water quality and quantity.
- Ensure no exaggerating of flood levels on adjacent properties.

- Provide water quality management.
- Meet relevant stormwater policies and guidelines outlined in this report.

3.1 Stormwater Management Strategy

The proposed stormwater strategy includes the combination of Bio-Swales and Bioretention Basins.

3.1.1 Basin Layouts

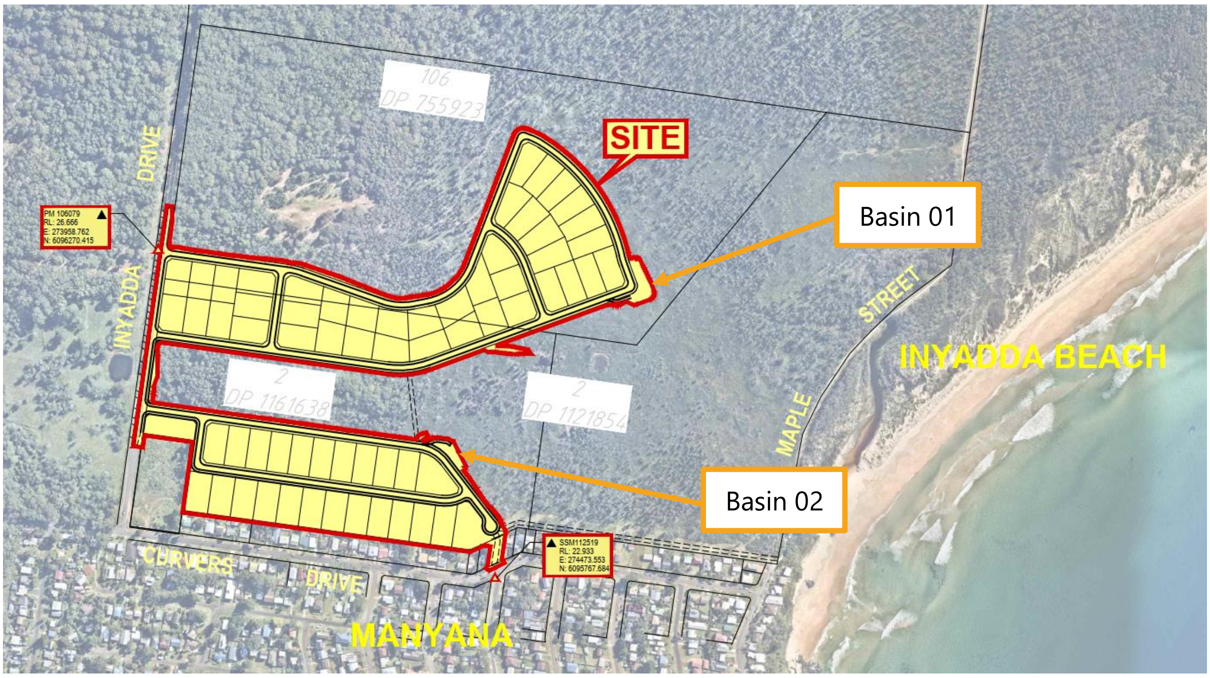

FIGURE 3 – BASIN LAYOUT

3.1.1.1 Basin 01

Basin 01 is located on road No.01 and has been sized to treat the road catchments for the northern catchments. The layout of Basin 01 is shown in Figure 4. The basin design includes a maintenance access ramp.

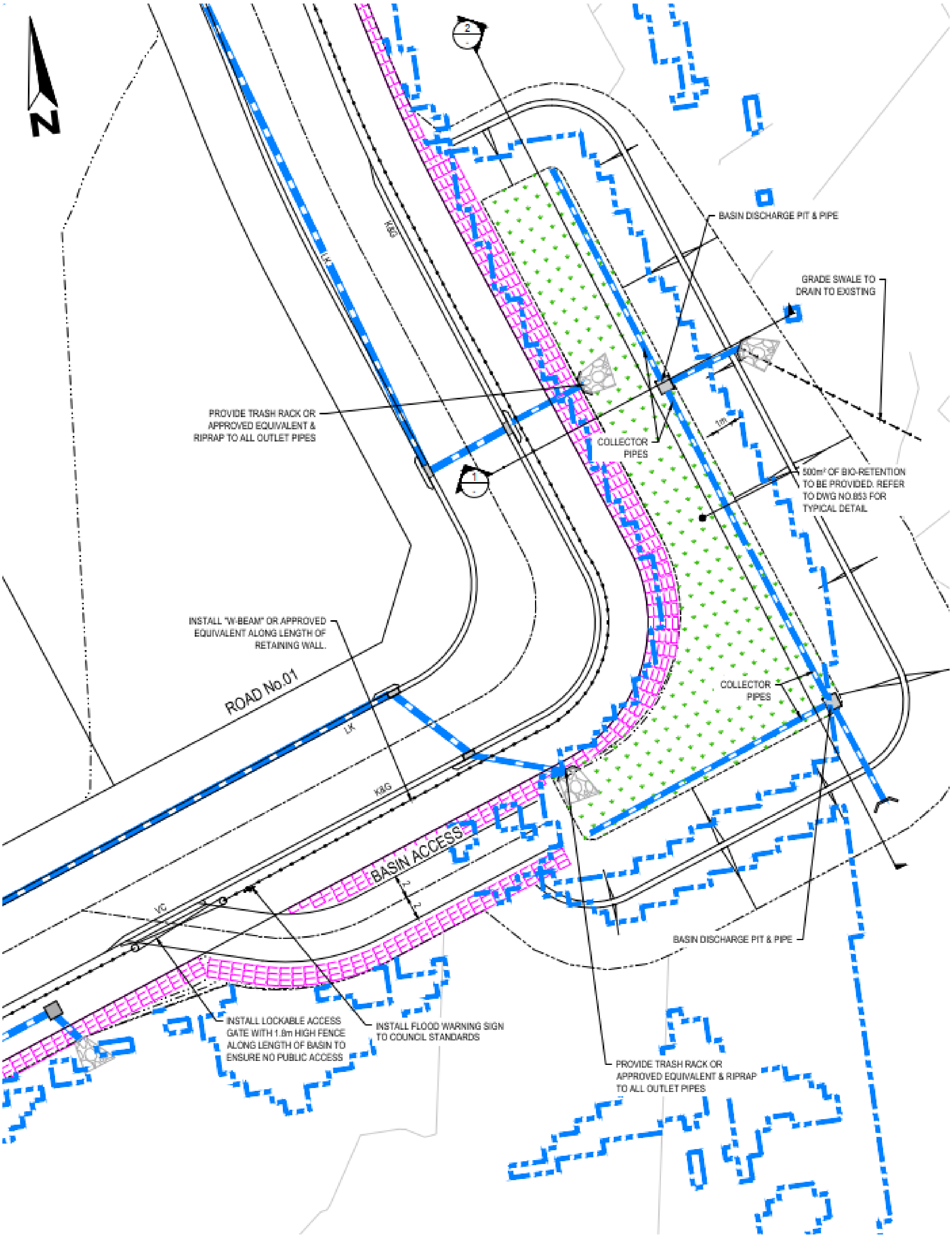

FIGURE 4 – BASIN 01 LAYOUT

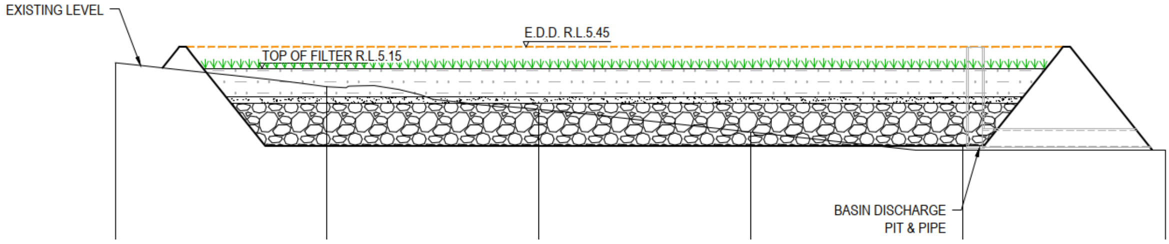

FIGURE 5 – BASIN 01 PLAN AND DETAILS

3.1.1.2 Basin 02

Basin 02 is located on road No.06 and has been sized to treat the road catchments for the southern catchments. The layout of Basin 02 is shown in Figure 6. The basin design includes a maintenance access ramp.

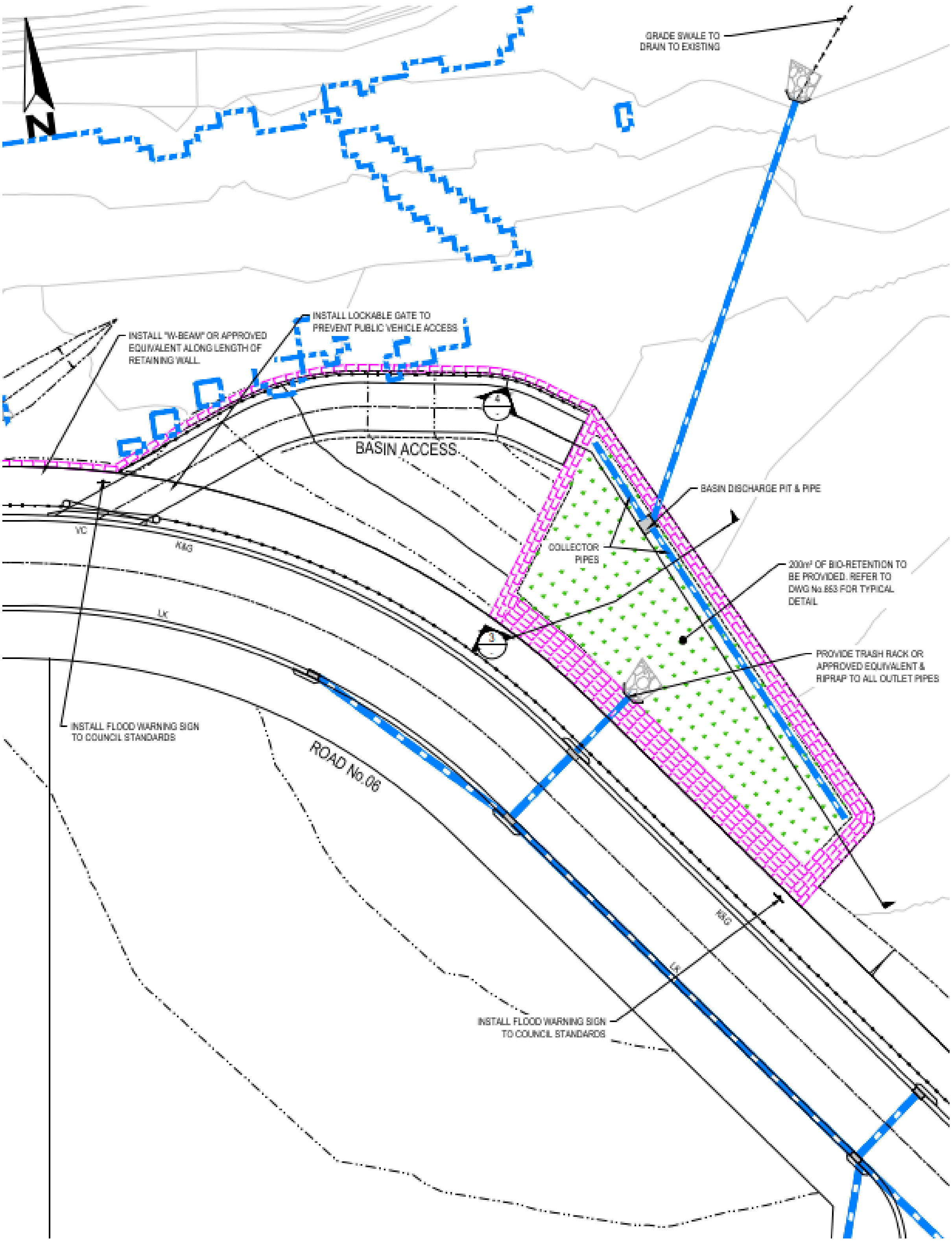

FIGURE 6 – BASIN 02 LAYOUT

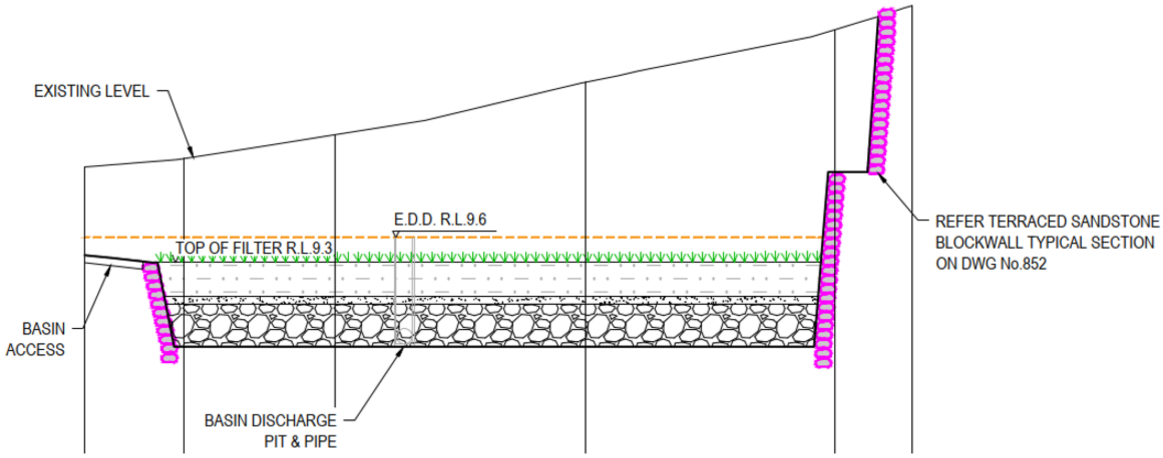

FIGURE 7 – BASIN 02 PLAN AND DETAILS

4 STORMWATER QUANTITY MANAGEMENT

The proposed development includes large residential lots (>2000m^2), the strategies utilise the large lots to reduce the burden of stormwater managing on the public infrastructure. The strategy adopts road side swales and end of line basins prior to discharge into the waterways. The site is located immediately upstream of the ocean outflow and therefore the proposal will exclude detention to avoid the risk of aligning peaks with the upstream contributing catchment. The proposal allows for the provision of directing larger storm events to discharge directly to waterways and bypass water treatment. See Figure 8 for the development catchment breakdown of Inyadda Drive.

4.1 Stormwater Quantity Modelling

The local stormwater flows from the Inyadda Drive catchment will be managed by the minor and major drainage network (pit and pipe and road reserve overland flow). The stormwater strategy will not require OSD due to the close proximity to the ocean as shown in Figure 8 and the modelling results. The site will drain out by the time the upstream catchments come through; this is supported by the detailed flood modelling presented in Section 5.3.

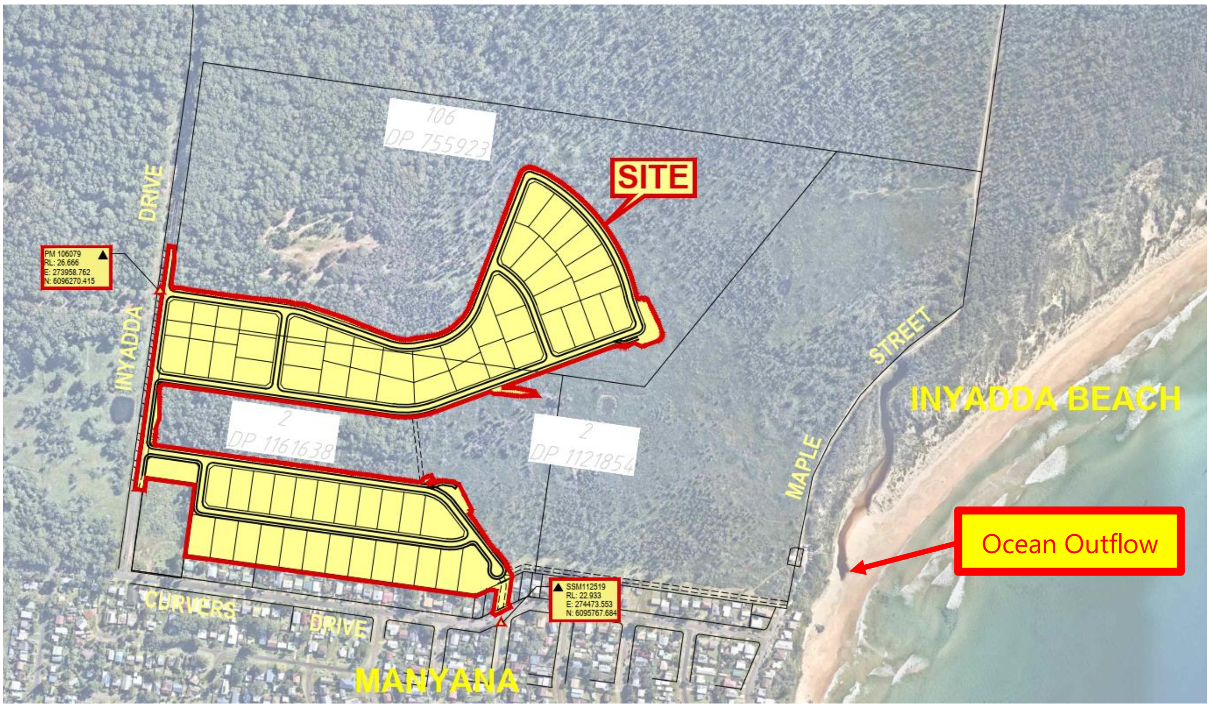

FIGURE 8 – AERIAL WITH OCEAN OUTFLOW

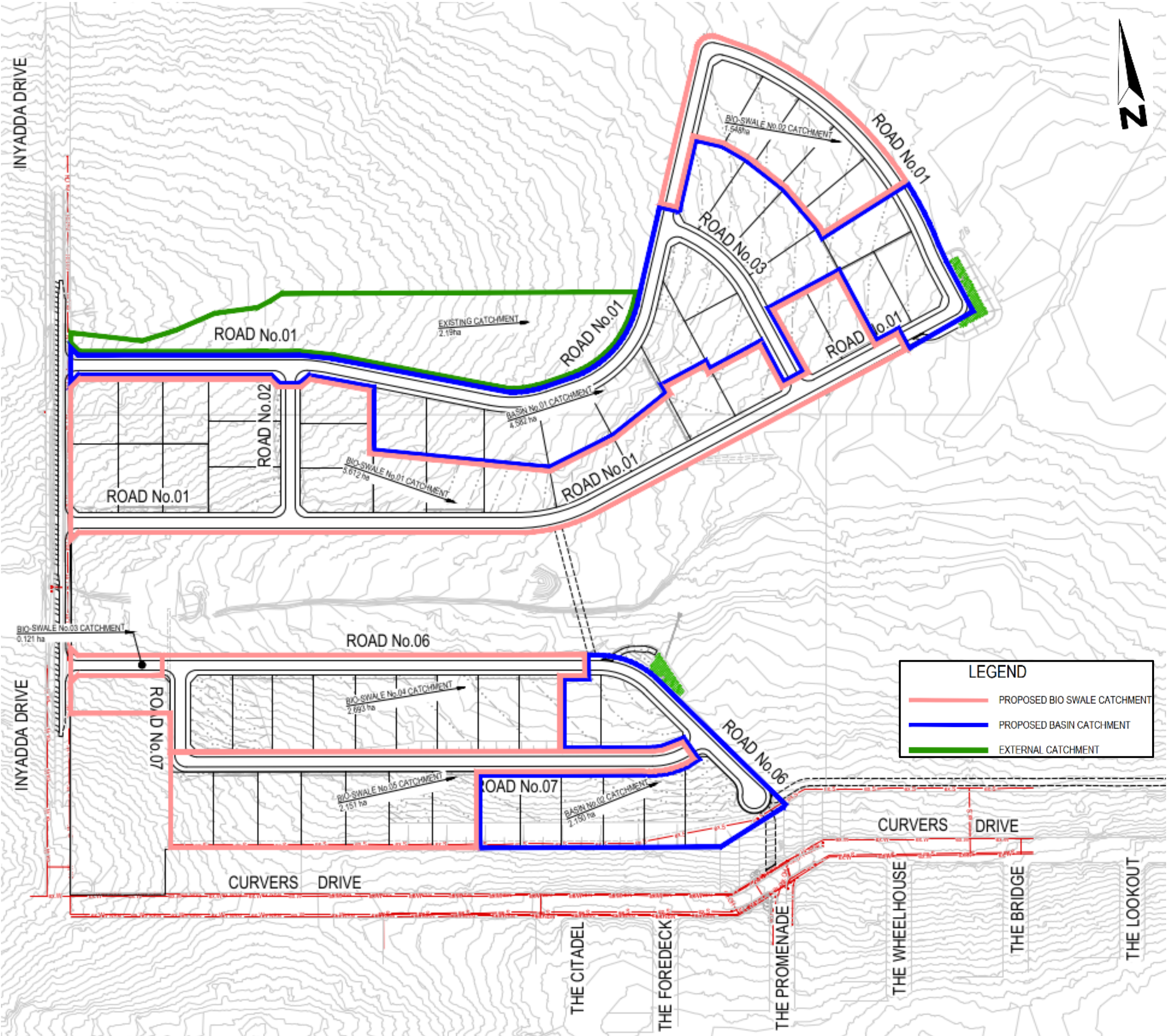

FIGURE 9 – INYADDA DRIVE, CATCHMENT PLAN

The XPRAFTS model prepared for the flood modelling (refer to figure 8) was prepared to reflect the pre and post developed. Catchments C4, C5 and C7 were updated in the post development model to reflect the proposed development impervious area. The results for the 1% AEP is as follows:

- Predeveloped 28.47m3/s
- Post developed 28.44m3/s

The results showed the changes as a result of the development allow the flows to pass through the waterway prior to the upstream 75.55ha catchment arrive.

4.1.1 Catchment Mapping / Rain on Grid

The watershed's draining to the site were mapped but breakdown of these into smaller catchments was not undertaken. The methodology used in this modelling and analysis is known as the rain-on-grid method.

In undertaking a rain-on-grid model, the rainfall pattern for each storm is created using data obtained from the Australian Bureau of Meteorology website. This rainfall pattern is then applied to the entire model for each time step. This allows the material roughness and terrain geometry to determine the direction and velocity of any overland flow path.

Since the rain-on-grid model applied the storm event to the entire watershed, and the physical terrain controlled the timing of the flow paths, breakdown of the area into sub-catchments is not required. Watershed catchments are presented on Figure 10.

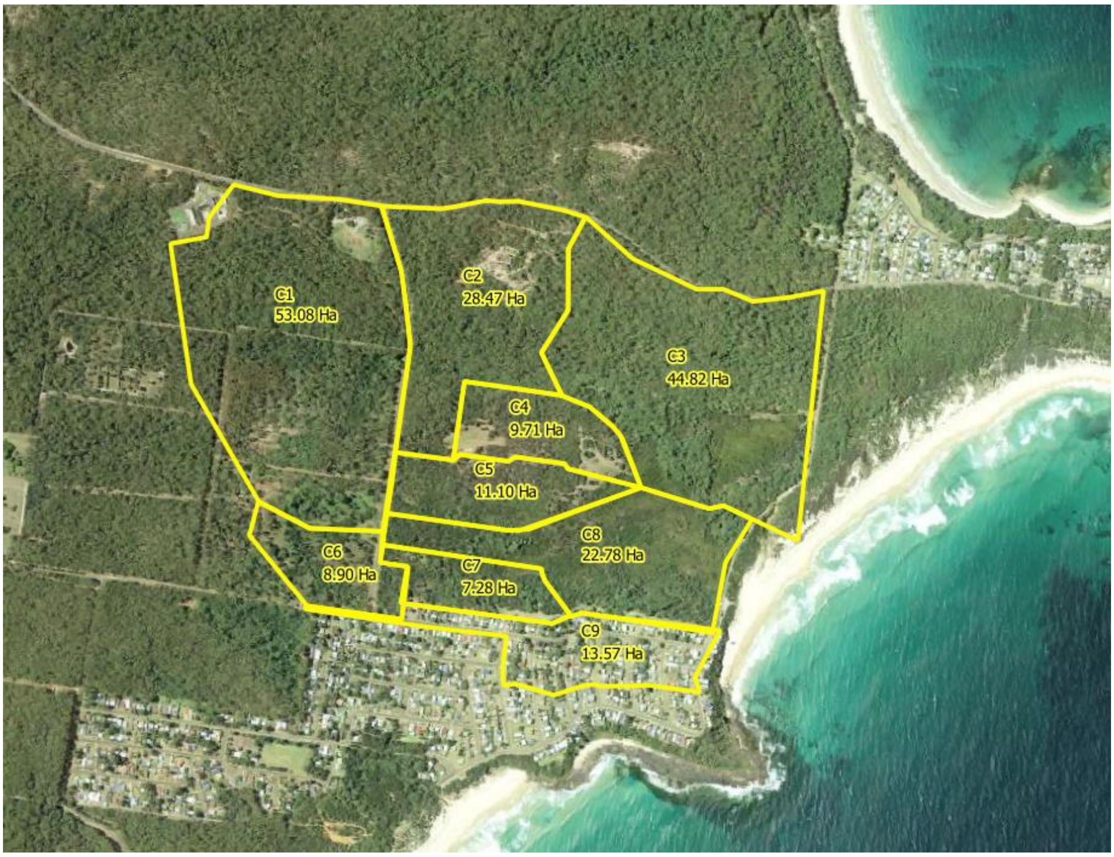

FIGURE 10 – CATCHMENT LAYOUT

5 STORMWATER QUALITY MANAGEMENT

Shoalhaven Council Strategy for stormwater quality control requires reduction of these major pollutants. Shoalhaven Council describes the stormwater pollutant and reduction to be achieved by Music Model program for the proposed subdivision as shown in Table 1 below:

TABLE 1 – POLLUTANT REDUCTION TARGET AS PER SHOALHAVEN COUNCIL

Pollutant	% Post development average annual load reduction
Gross Pollutants	90
Total Suspended Solids	80
Total Phosphorous	45
Total Nitrogen	45

5.1 Water Quality Modelling

The performance of the proposed water quality treatment strategy has been modelled using the MUSICX program. To ensure the satisfaction of the minimum pollutant load reductions required by Council DCP, Bioretention Basins and Bio-Swale proposed at side of the road have been proposed.

The approximate location and approximate size of Bio-Swales and Bio-Retention Basins along with catchment area is shown in Figure 11 below which is subject to be detailed in future.

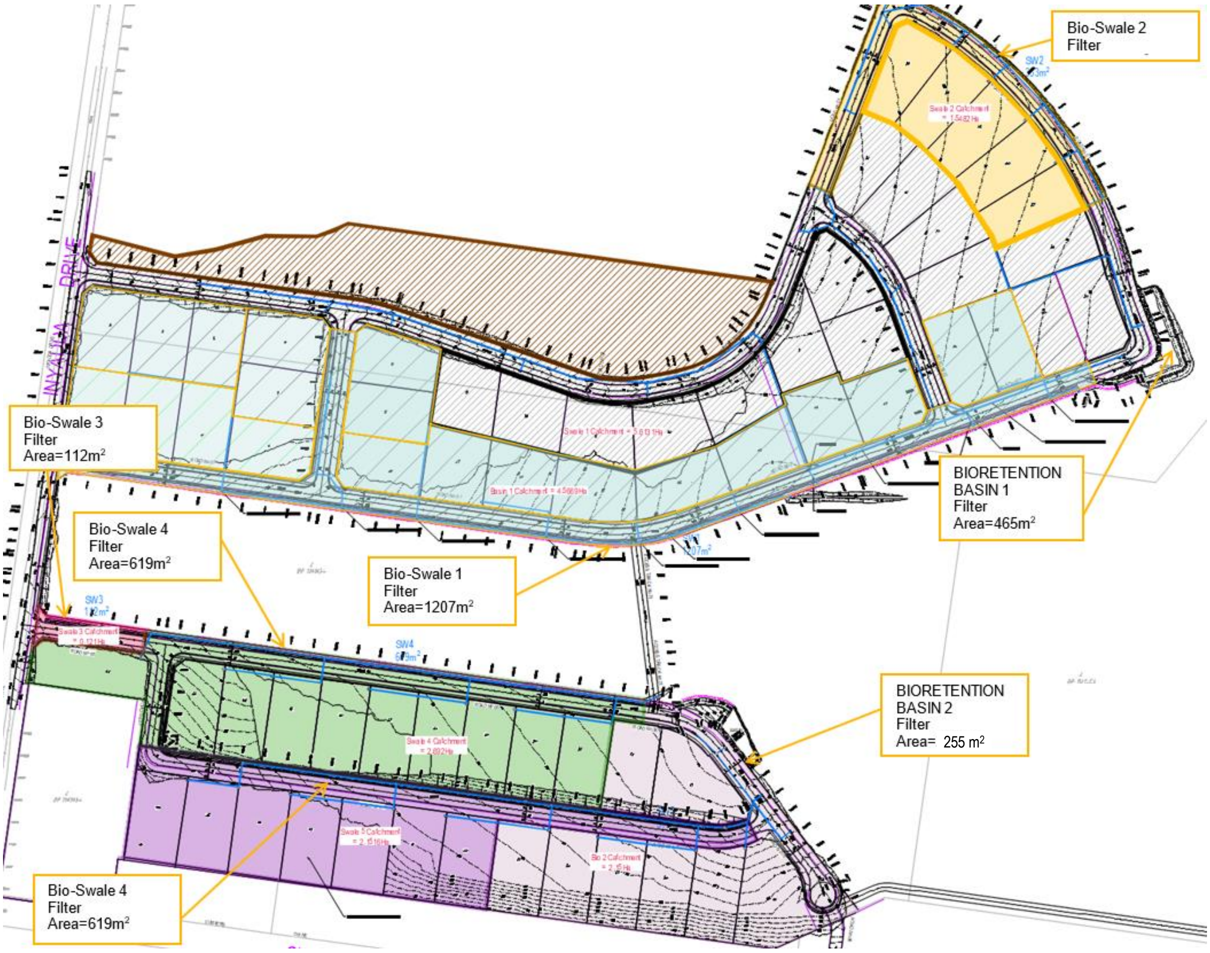

FIGURE 11 – LOCATION AND APPROXIMATE SIZE OF BIORETENTION BASIN ALONG WITH CATCHMENT AREA

The MUSICX model layout with treatment nodes and catchments is presented in Figure 12 below:

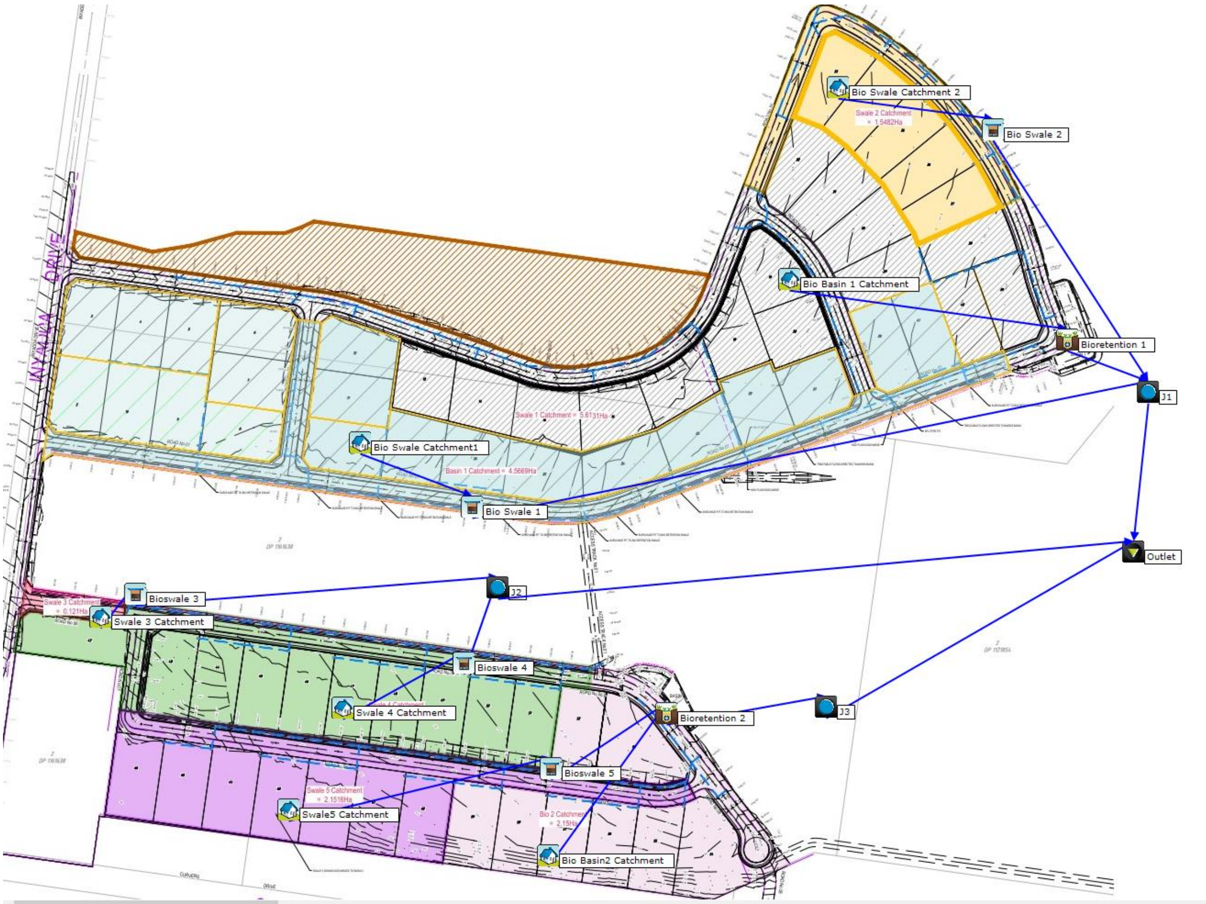

FIGURE 12 – MUSIC MODEL LAYOUT

The catchment areas Bio-Swale 1 Catchment, Bio-Swale 2 Catchment, Bio-Basin 1 Catchment, Bio-Swale 3 Catchment, Bio-Swale 4 Catchment, Bio-Swale 5 Catchment, and Bio Basin 2 Catchment will be treated by the respective Bioretention Basins and Bio-Swales. The bioretention basins configuration is summarised in Table 2 below.

TABLE 2 – BIORETENTION BASINS SUMMARY

Bio-Basin and Bio-Swale	Filter Area (m^2)	Surface Area (m^2)	Extended Detention Depth (mm)	Filter Media Depth (mm)
Bioretention Basin 01	465	571	300	500
Bioretention Basin 02	255	331	300	500
Bioswale 1	1207	1473	250	600
Bioswale 2	333.2	406.7	250	600
Bioswale 3	110	135	250	600

Bioswale 4	619	755	250	600
Bioswale 5	390	536	250	600

The surface area provided is measured to the top of EDD for the Bioretention Basin and for the Bio-Swale it is measured to half of the EDD.

5.2 Stormwater Quality Performance

The Bioretention Basins and Bio-Swale will receive major and minor flows from the whole site. The water quality treatment train pollutant removal is shown in Table 3 below.

TABLE 3 – POLLUTANT REMOVAL RATES - MUSIC MODELLING RESULTS

Pollutant	Water Quality Targets (% removal)	Sources (kg/year)	Residual Load (kg/year)	Removal Rate Achieved (%)
Total Suspended Solids	80	3,2300	3,901	87.92
Total Phosphorous	45	51.42	16.09	68.7
Total Nitrogen	45	380.1	208.7	45.09
Gross Pollutants	90	3,885	0	100

Table 3 illustrates that the stormwater runoff from the proposed subdivision will meet the pollutant removal targets set in Council DCP outlined in Table 1.

5.3 Gross Pollutant Traps / Trash Racks

Gross pollutant traps (GPT's) will consist of trash racks prior to discharge into the bioretention basins unless otherwise approved by Council. GPTs are typically sized to the capture the 3-month stormwater runoff through the pipe network, hence the type and performance of the GPTs will be determined once the stormwater network for the remaining stages is designed.

6 FLOOD MANAGEMENT

The Inyadda Drive site is located upstream of Inyadda Beach, with a number of existing tributaries draining the proposed development. The flood modelling addresses the changes in the flood regime as a result of the proposed development, modelling the density of development and changes of materials, the development has been represented with the development terrain being included along with changes to impervious ratios and developed surface roughness.

6.1 Tuflow Modelling

Calibre has run Tuflow modelling of the existing terrain adjacent to Inyadda Drive to gauge the impact of the 1% AEP and PMF storms on the surrounding development. The Tuflow model was run for multiple storm durations – the critical storm duration for each was selected based on the extent and depth of flooding.

6.2 Data Sources

This section of the document outlines the sources of data used in the hydrology and hydraulic analysis of the site.

6.2.1 Topographic Data

Initial topographic data for the base model was obtained from the ELVIS (Elevation and Depth – Foundation Spatial Data) web portal as operated by the Intergovernmental Committee on Surveying and Mapping (ICSM). The ELVIS web portal provides access to data from contributing state government bodies including NSW Spatial Services and ACT Government.

From the EVLIS web portal, Digital Elevation model (DEM) tiled data with a 1 metre horizontal resolution was downloaded for the four tiles required to cover the development area. The DEM tiles were created by NSW Spatial Services and are based on the latest Light Detection and Ranging Systems Technology (LiDAR) and was obtained by state government May 2011.

6.2.2 Survey Data

In addition to the LiDAR, the survey terrain was read into the model over LiDAR to ensure that the terrain was recent and correctly modelling the site, as the most recent LiDAR data would not account for any changes in the development area since May 2011.

6.3 Hydrologic Modelling Data

Modelling of the site has not previously been undertaken. Therefore, Calibre had to determine the watershed draining to each of the structures and calculate the flows at the site based on the rainfall patterns for the required events, using the ARR 2019 methodology.

6.3.1 Rainfall

Since there is no existing regional hydraulic or hydrologic modelling for catchment, a model was prepared for the catchment based on rainfall data. This base data was obtained from the Australian Rainfall and Runoff (ARR) 2019 Data Hub website. The software package QGIS has a plugin provided by the makers of TuFLOW, this plugin provides an automated method to log-in to the ARR Data Hub website and extract the data from the website for the selected storms in a format that the TuFLOW model can readily read and process.

Rainfall Intensities were extracted from the web site the modelled storm events and temporal patterns as required in Council's specification and ARR 2019 methodology. This analysis was undertaken for the rainfall intensities for the Annual Exceedance Probability (AEP) for the 100Y.

Initially, 1% AEP was modelled in XP-RAFTS for the 20, 30, 45, 60, 120, 180, 270 and 360 minute durations for the ten temporal patterns as specified in the revised method in ARR (2019) and the critical storm event selected. No assessment of the impacts of climate change on rainfall patterns has been undertaken as part of this study.

6.4 Hydraulic Modelling Data

The hydraulic modelling for this investigation used the requirements specified by Shoalhaven Council's scope of works specification for this site.

6.4.1 Boundary Conditions

No upstream boundary conditions were modelled as a rain-on-grid inflow methodology was utilised for this modelling.

Separate downstream boundary conditions were provided in the model to represent the ocean water located to the east and south of the Manyana site. These were located to ensure any potential impacts from these boundary conditions on localised water levels occur far downstream and far enough to limit or remove the impact these may have on the site.
The ocean surface level was set using information provided in Section 5.2 of *Floodplain Risk Management Guide: Modelling the interaction of Catchment flooding and Oceanic Inundation in Coastal Waterways* (State of NSW and Office of Environment and Heritage 2015).

6.4.2 Land Use Categorisation (Roughness)

The catchment land use characteristics were identified using analysis of aerial photography. As part of this preliminary investigation a uniform floodplain roughness of n = 0.1 was used for the entire existing catchment as the catchment as high vegetated land. This value is in line with manning's n values in *ARR Project 15: Two-Dimensional Modelling in Urban and Rural Floodplains and Chow (1959) Open-Channel Hydraulics*.

The developed site was modelled using a generic uniform roughness to account for buildings, fences, and other development structures. This method was adopted as the location of the buildings and other structures that may impede surface flow have yet to be designed and finalised. This developed roughness was set to a manning's n = 0.1. This method and value selected are in line with ARR Project 15.

Roadways and other hardstand areas were not modelled since it was determined that the catchments were mostly rural or pasture land in the existing case.

6.5 Catchment Analysis

This section discusses the TuFLOW modelling used in the investigation of the four structures undertaken to provided information required to allow for the detailed design of replacement structures.

6.5.1 Hydrologic (XP-RAFTS) Modelling

Hydrologic mapping for the catchments were modelled using the XP-RAFTS (Version: 2018.1.3) software package. This methodology was utilised given the large number of storm durations and temporal patterns required under ARR 2019. This large number of possible storms was time prohibitive to run via the TuFLOW flood modelling engine, as the TuFLOW models take several orders of magnitude longer to run than the equivalent XP-RAFTS catchment.

These models were then run for the 1% AEP storm for each of the durations as specified in Section 6.3.1. The results of the XP-RAFTS model were then analysed to determine the critical storm duration and temporal pattern for the development area. The critical storm duration and temporal pattern was determined to be the 30 minute storm using temporal pattern 1.
This storm hyetograph was then imported to TuFLOW and applied using a rain-on-grid method to apply the rainfall

pattern to the watershed and allowing the digital terrain model to determine the slope and location of flow paths within the watershed and thereby the timing of flows.

6.5.2 Hydraulic (TuFLOW) Modelling

The hydraulic modelling for this investigation was undertaken using the TuFLOW (Build: 2018-03-AE-iSP-w64) flood modelling software package utilising the HPC engine.

The results of the hydraulic modelling undertaken for this investigation is discussed in Section 7. This modelling investigation uses the critical storm as determined in the hydrologic modelling (Section 6.5.1, along with a discussion of the data input and parameters discussed in Section 6.2).

7 RESULTS AND MAPPING

The results of the model were refined by exclusion of flows of depth less than 0.15 metres. This process, also referred to as 'nulling', is required to remove areas of flooding and ponding not considered reportable. Flood depths less than 0.15 metres have been nulled for this set of maps, this can result in the appearance of ponds unconnected to major flow paths.
Flows shallower than 0.15 metres are outside the levels of accuracy of the methodology used to carry out this investigation. This nulling of flows below 0.15 metres is recommended in the Floodplain Development Manual. It should be noted that the accuracy of the LiDAR used in this investigation is quoted as 95% confidence interval within ± 0.3 metres vertical and 95% confidence interval within ± 0.8 metres horizontal.

This section provides a summary of the results of the flood modelling for existing and developed conditions, along with a discussion of the impacts on flooding that would result from the development of the Manyana site.

Flood depths below 150mm have not been shown for clarity as is reflected in the flood depth, afflux, and velocity maps.

7.1 Existing Depth

The Tuflow model results for the 1% AEP storm are shown below in Figure 13. The critical duration was determined to be the 30-minute storm. Figure 13 shows that the flood extents are conveyed within the tributaries, with some encroachment to the northern side.

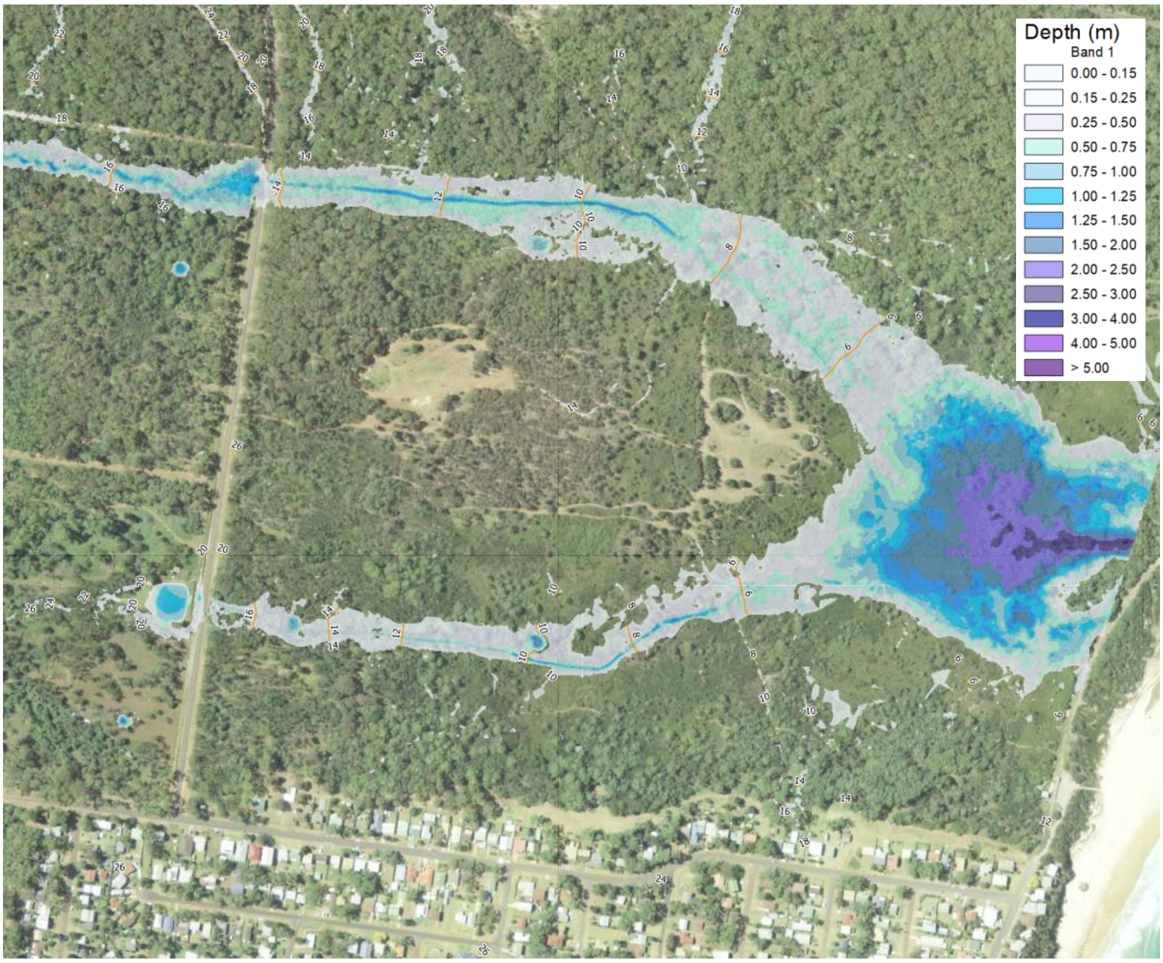

FIGURE 13 – 1% AEP EXISTING FLOOD DEPTH

7.2 Developed Depth

The Tuflow model results for the 1% AEP storm are shown below in Figure 14. The critical duration was determined to be the 30-minute storm. The site remains mostly outside the existing 100-year ARI flood, and the development directs the flows away from the site along the northern side.

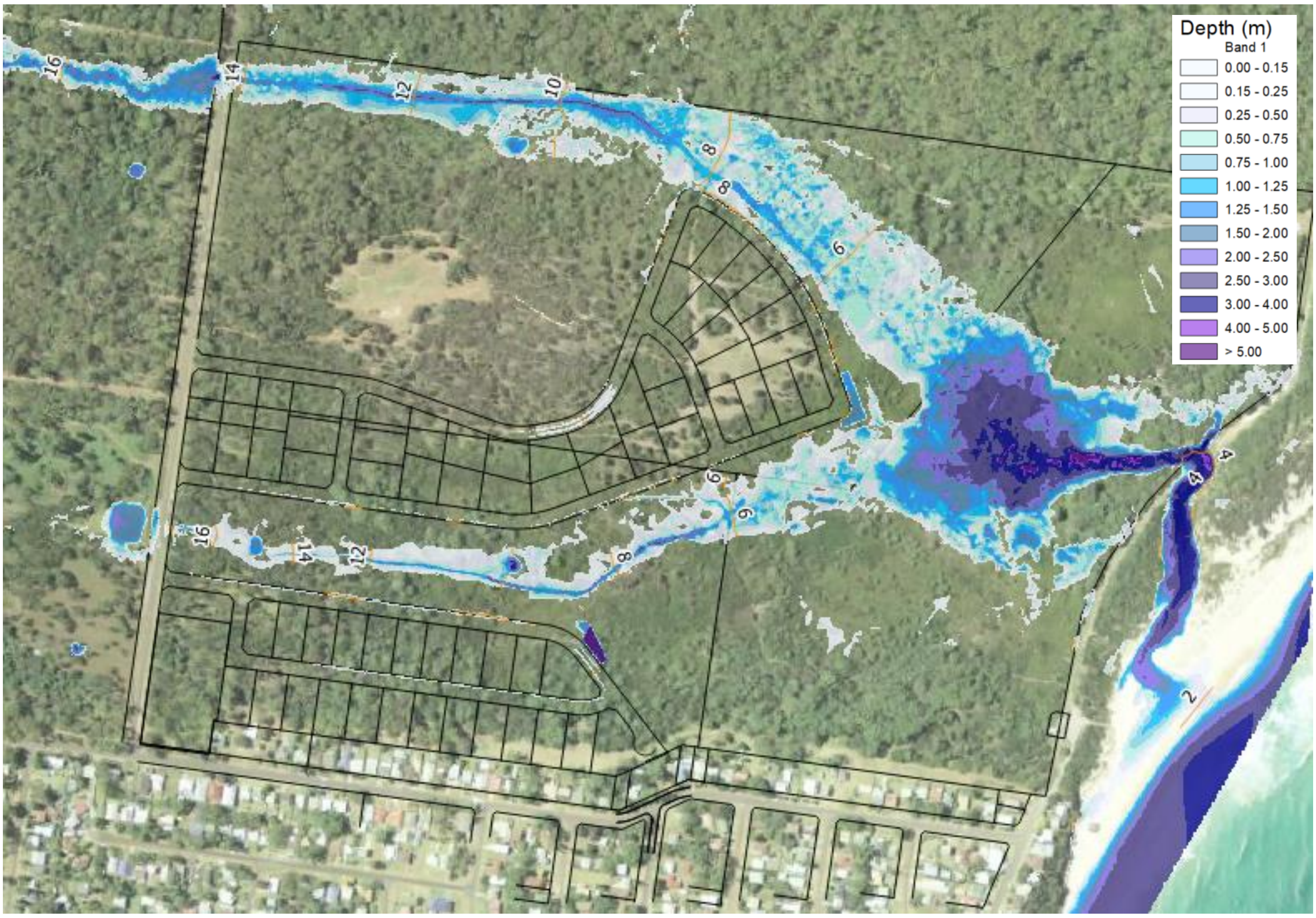

FIGURE 14 – 1% AEP DEVELOPED FLOOD DEPTH

7.3 Afflux

The afflux on the 1% AEP storm between the developed and undeveloped scenario, in relation to Inyadda Drive is shown in Figure 15.

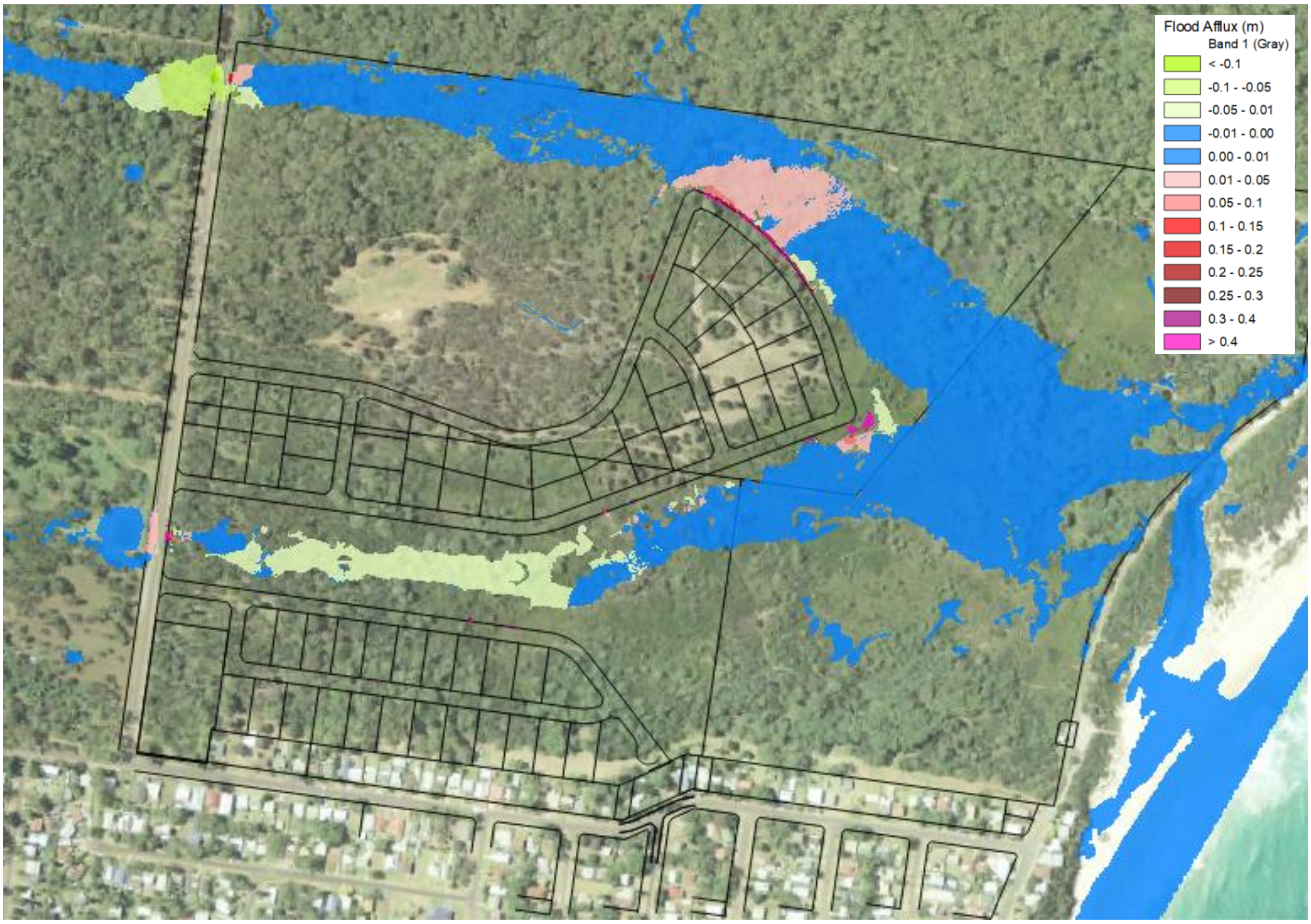

FIGURE 15 – 1% AEP AFFLUX

Figure 15 indicates that there is less afflux generated along the northern side in the developed condition of the site between existing conditions. Therefore, the development does not aggravate the existing flood levels surrounding the site. All flood level changes are contained within the site. As a result, the Inyadda site will not experience any significant impacts from the afflux generated in the developed condition.

7.4 Existing Velocity

The results in Figure 16 demonstrates that the existing flows within the site and in the adjacent areas and lots are below 1.0 metre per second with most flows being below 0.5 metres per second. These velocities are suitable for most areas or at most approach the threshold for silts and fine sand (see Table 4 for reference). Since this is the underlying geology for the surrounding area, this means that flows discharging from the site should not pose a risk of causing major erosion.

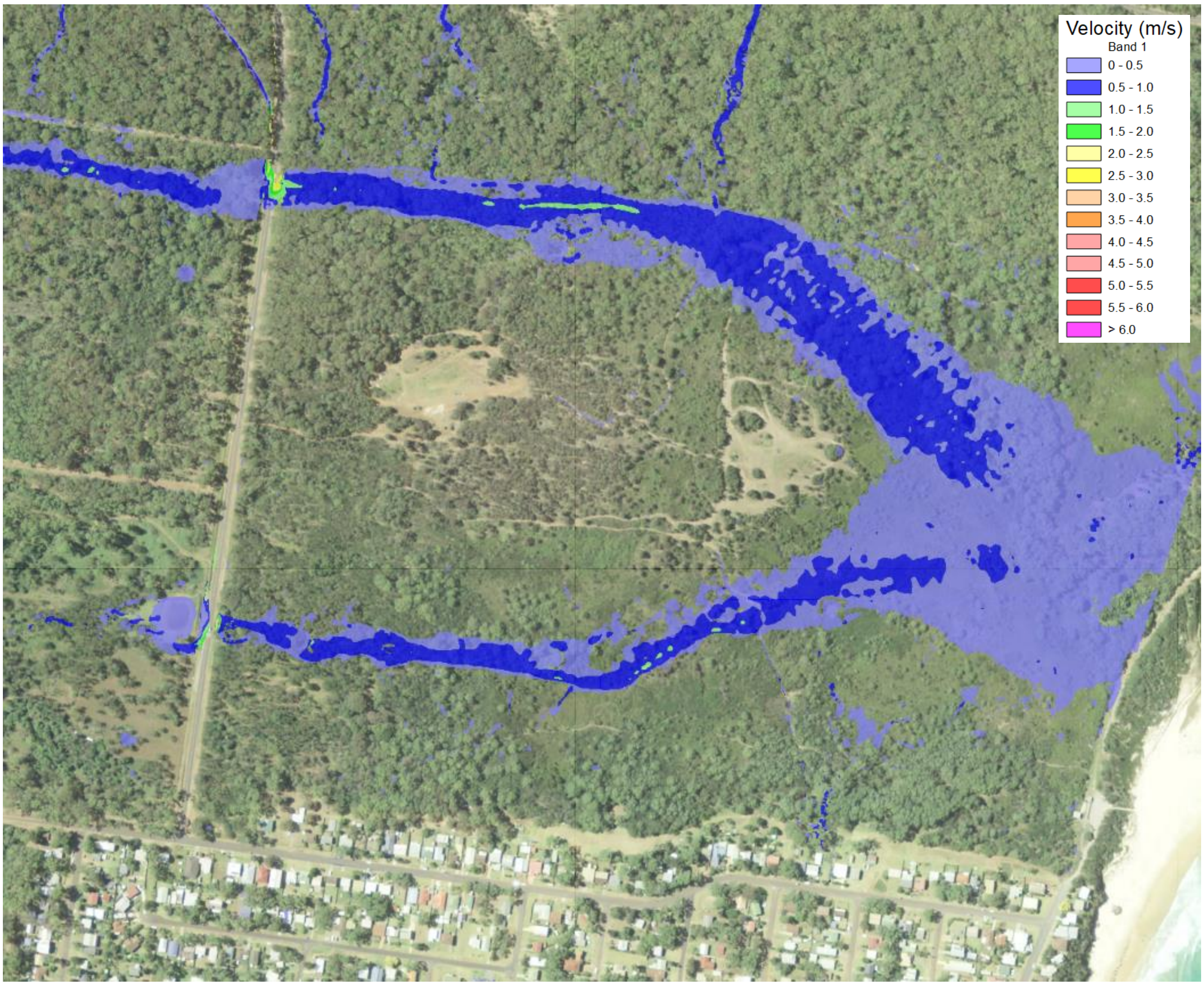

FIGURE 16 – 1% AEP EXISTING VELOCITY

7.5 Developed Velocity

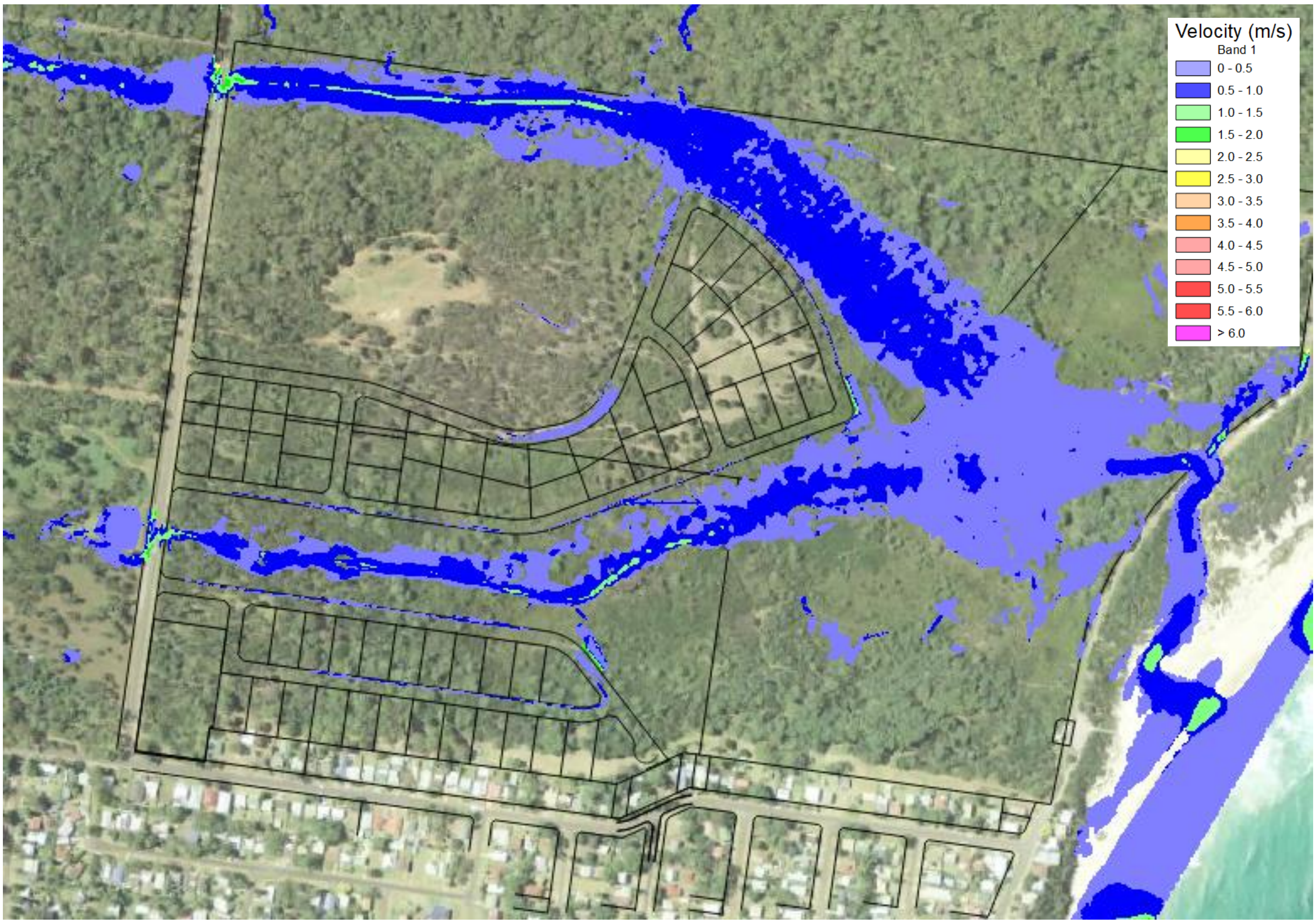

FIGURE 17 – 1% AEP DEVELOPED VELOCITY

The results in Figure 17 demonstrates that the developed flows within the site and in the adjacent areas and lots are below 1.0 metre per second with most flows being below 0.5 metres per second. There are some flows generated in the developed site, due to rain being introduced on all cells as part of rain-on-grid modelling. However it is below 0.5 metres per second, therefore, these velocities are suitable for most areas or at most approach the threshold for silts and fine sand (see Table 5-1 for reference). Since this is the underlying geology for the surrounding area, this means that flows discharging from the site should not pose a risk of causing major erosion.

TABLE 4 – PEAK FLOOD VELOCITY CATEGORIES

Velocity (m/s)	Category
0 - 0.5	OK for most areas
0.5 - 1.0	Threshold for silt, fine sands and fine gravels
1.0 - 1.5	Threshold for clays and gravels up to 25mm
1.5 - 2.0	Threshold for gravels up to 50mm
2.0 - 2.5	Threshold for gravels up to 150mm
2.5 - 3.0	
3.0 - 3.5	Threshold for riprap with d50 = 150-225mm
3.5 - 4.0	Threshold for gravels and riprap with d50 = 300mm
4.0 - 4.5	
4.5 - 5.0	Threshold for gravels and riprap with d50 = 450mm
5.0 - 5.5	
5.5 - 6.0	Threshold for riprap with d50 = 600mm, gabions and concrete
> 6.0	High velocity for most areas

7.6 Climate Change

Additionally, the existing and developed model were run for the 2090 RCP8.5 Climate Change scenario. These scenarios resulted in flood levels either matching or increasing by no more than 10mm within the site. The additional ocean water levels specified by Council for use during the climate change scenario do not impact the draining of the site, nor cause any backwater to enter the site due to the level difference between the site and the coastline. Sanity checks were carried out at the outlet under various climate change conditions and there was no effect on the development. No further analysis was required.

8 COASTAL ENGINEERING

The outlet at the beach is not going to change therefore the outlet for the flood modelling is assumed to be adequate. Refer to report letter sent by Horton Coastal Engineering, '*Coastal Engineering Advice on ICOLL near proposed subdivision at Inyadda Drive, Manyana.*'

9 CONCLUSION

A stormwater management strategy has been designed to protect the receiving waters of the Inyadda Beach catchment from both water quantity and quality impacts from Inyadda Drive.

The design includes permanent bio retention basins to treat the road areas and lot based bioretention for the surface stormwater flows off each lots. The proposed basins are as follows:

- The minimum bioretention of $465m^2$ to treat the northern catchment roads
- The minimum bioretention of $255m^2$ to treat the southern catchment roads
- Road side swales

This strategy will ensure that the water quality targets are met and the flood modelling undertaken has demonstrated that the project will manage flooding throughout the site extending down to Inyadda beach.

Existing and Developed flood depth, afflux and velocity mapping have been presented for the 1% AEP 30 minute critical duration storm. These results demonstrate that there is no additional impact on adjoining properties during the developed scenario and would be managed by the stormwater strategy.

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