Flood Impact Assessment

Argyll Estate, Coffs Harbour

NW30163

Prepared for
Land and Housing Corporation

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Cardno

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Executive Summary

A Planning Proposal has been prepared to support a proposal to renew the Argyll Estate Rezoning Investigation Area (the site) to provide for a range of housing types including low rise medium density housing such as dual occupancies (duplex style dwellings) and mid-rise apartments.

The purpose of this report is to assess the impact of the Planning Proposal development. This report also addresses the relevant planning considerations.

Flood Risks and Mitigation Options

The flood impact assessment was informed by the assessment of design flood levels, velocities and hazards under Benchmark conditions as described in Cardno, 2021 (refer **Section 2.1**).

The 2021 Flood Risk Assessment report (Cardno, 2021a) and Memorandum (Cardno, 2021b) provided a high-level understanding of the opportunities and constraints within Argyll Estate due to flooding. While the Argyll Estate experiences significant flooding in a 9 hour storm burst the maximum flood depths and velocities are experienced in a 2 hour storm burst ie. Argyll Estate is subject to flash flooding with limited warning times of flooding.

As defined by the 2005 Floodplain Development Manual, mitigation options can include:

- **property modification (non-structural) measures** including development controls in new areas, and voluntary purchase and house raising in developed areas;
- **response modification measures** such as evacuation and associated operational logistics; and
- **flood modification (structural) measures** including levees and bypass channels

This flash flooding informed the assessment of property flood modification, property modification and response modifications options for the Argyll Estate. These various assessments that were undertaken are described in **Appendices B, C, D, E** and **F.**

The Planning Proposal

The Planning Proposal outlined in Section 1.3 was based on the adoption of Scenario E3 (refer **Appendix F**).

Given the flood affectation within the site and the potential issues around safe evacuation, the proposal takes a conservative approach to managing flooding as follows:

- Areas proposed to be rezoned to R3 Medium Density Housing are limited in area and have generally avoided areas impacted by the 100-year flood level
- All future habitable floor levels would be raised above the probable maximum flood level to ensure that residents can refuge in place during all flood events up to the probable maximum flood level
- Dual occupancies would be limited to areas where the habitable ground floor level would not need to be raised by more than around 1.5m to be above the probable maximum flood level.

The flood modelling undertaken indicates that some dual occupancies within the precinct which would be required to be raised above the probable maximum flood would need to have voids underneath the ground floor level to allow to ensure overland flow paths to be maintained. This would be addressed at DA stage, and a site specific DCP provision is proposed to ensure this is a matter for consideration.

Flooding under Future Conditions

The adopted Planning Proposal layout is plotted in **Figure 2**.

It is based on changes to building footprints on selected properties within the Planning Proposal area. Consequently, the assessment of flooding under Future Conditions was based on minor modifications of the floodplain model assembled in the 2018 Coffs Creek and Park Beach Flood Study.

Under the Planning Proposal the building footprints on the identified properties were adjusted to the proposed built form. The roughness value for most buildings was the value adopted in the 2018 Coffs Creek and Park Beach Flood Study. The roughness value for selected buildings only along Bray Street, Kurrajong Street and Argyll Street was reduced based on a void being created under the ground floor to permit flood flow.

Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels, extents and depths under Future Conditions are plotted respectively in **Figures 4, 6, 8** and **10**.

Flood Hazard Categories

The flood hazard categories on the Argyll Estate in a 5% AEP, 1% AEP, 0.2% AEP and PMF under Future Conditions are plotted respectively in **Figures 5, 7, 9** and **11**.

Flood Impact Assessment

The impacts of the Planning Proposal on the 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels are plotted respectively in **Figures 12, 13, 14** and **15.**

In the 1% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form increase slightly. If the impacts are of concern, then the built form could be modified to include a void under the ground floor to permit flood flow.

(ii) There is a slight increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in the extent of local increases in flood levels in a section of Argyll Street;

(iv) There is a general slight lowering of flood levels in a series of properties in Bray Street, Kurrajong Street, Elm Street and Argyll Street;

(v) There are small pockets of local increases in flood levels on some properties which are attributed to the change in building footprints.

It is considered that the Planning proposal will not result in significant flood impacts to other properties in the 1% AEP flood which is adopted for flood planning purposes.

Evacuation versus Shelter in Place

As discussed in Section 1.3.4 under the Planning Proposal, it is proposed, in part, to require that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place and to avoid the flood damages in extreme floods similar to the flood damages experienced recently in Lismore and other north coast communities.

Consequently, any decision to evacuate from dwellings will be informed by a number of considerations including but not limited to:

(i) the availability of flood warnings,

(ii) whether emergency services are able to mobilise and respond within the timeframes of flash flooding;

(iii) any road closures that would impede evacuation to the west eg. Argyll St and W Argyll

(iv) the time available before it becomes unsafe to evacuate via local roads, and

(v) the period of time that it would be unsafe to drive on inundated local roads.

Flood Evacuation

The proposed approach to evacuation within Argyll Estate is for:

(i) residents to shelter-in-place within each dwelling at a level higher than the PMF level.

(ii) while residents with vehicles could consider evacuating from the Argyll Estate to the west by vehicle this could be only until it becomes unsafe to drive on local roads and/or at key road intersections and it is preferred that residents shelter-in-place within each dwelling.

To inform local residents as to whether it is safe to drive on the local roads a series of colour coded flood markers should be installed beside roads at key locations (eg. intersections, low points, etc). The coding could be:

Green: up to a flood depth on the road of 0.3 m which would be safe for both small and large vehicles subject to velocities less than 1 m/s (H1 conditions);

Amber: flood depths on the road between 0.3 m and 0.5 m which would be safe for large vehicles subject to velocities less than 1 m/s (H2 conditions); and

Red: flood depths on the road greater than 0.5 m (H3 or greater conditions)

Flood Emergency Response

Council's website provides the Flood and Storm emergency services and information which is overviewed. Also overviewed are the Coffs Harbour City Council Disaster Dashboard and the Coffs Harbour City Council Flood Warning System.

Assessment of Planning Controls

The special flood consideration clause does not currently apply to the site and accordingly the Planning Proposal is consistent with the clause. However, it is understood that a separate Planning Proposal is currently being progressed to include the clause in the Coffs Harbour LEP.

The Argyll Estate Planning Proposal will permit an increase in the dwelling density on land between the flood planning area and the PMF. The Planning Proposal takes a conservative approach whereby more intensive development such as residential flat buildings would be largely located outside areas affected by the 1% AEP flood, with only modest renewal of dual occupancies to be allowed within areas up to the PMF. Given the flood evacuation constraints in the road network, the proposal seeks to apply a shelter in place strategy where all habitable floor levels would be located above the PMF level to ensure residents can shelter in place safely in all flood events.

The approach outlined is consistent with the NSW Government Policy Considering Flooding in Land Use Planning (DPE July 2021), which allows for the implementation of special flood considerations in areas outside the flood planning area (but below the PMF level) on land that, in the event of a flood, may cause a particular risk to life and require the evacuation of people or other safety considerations. In particular, it highlights that these may apply where vertical evacuation for short duration flooding is required such as where the rate of rise of floodwater prohibits safe evacuation from the land.

Accordingly, the Planning Proposal seeks to apply the Special Flood Considerations Clause to the site, to enable controls to apply up to the PMF level.
The proposed development has been assessed against each of the considerations set out in Section 9.1(2) of the EP&A Act 1979, Section 4.1 Flooding and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and that the Planning Proposal complies with intent of the Section 9.1(2) Direction and any provisions of the Planning Proposal that are inconsistent are of minor significance.

The Planning Proposal has been also assessed against each of the considerations set out in relevant Coffs Harbour flood planning controls and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and the complies with intent of:

- Clause 5.21 Flood Planning of the Coffs Harbour LEP 2013; and
- Chapter E4 Flooding of the Coffs Harbour Development Control Plan (DCP) 2015.

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Future Conditions

1 Introduction

1.1 Purpose of this Report

As described on the LAHC website[1]:

> *The NSW Government will be exploring opportunities for new housing in the local area south of Bray Street to Argyll Street (including Deborah Close, Maple Street and Argyll Place) and from Frederick Street to Elm Street, Coffs Harbour, referred to as the 'Argyll Estate'.*
>
> *This area includes 127 properties and two vacant land lots owned by the NSW Land and Housing Corporation (LAHC) and the Aboriginal Housing Office (AHO).*

A Planning Proposal has been prepared to support a proposal to renew the Argyll Estate Rezoning Investigation Area (the site) to provide for a range of housing types including low rise medium density housing such as dual occupancies (duplex style dwellings) and mid-rise apartments.

The purpose of this report is to assess the impact of the Planning Proposal development. This report also addresses the relevant planning considerations.

The flood impact assessment was informed by the assessment of design flood levels, velocities and hazards under Benchmark conditions as described in Cardno, 2021 (refer **Section 2.1**).

1.2 Location

The location of the LAHC properties is indicated in **Figure 1**.

1.3 The Planning Proposal

As described, in part, in the Planning Proposal report (CHCC, 2022):

> *This Planning Proposal has been prepared to support a proposal to renew the Argyll Estate Rezoning Investigation Area (the site) to provide for a range of housing types including low rise medium density housing such as dual occupancies (duplex style dwellings) and mid-rise apartments. The proposal is consistent with the Coffs Harbour Local Growth Management Strategy released in 2020 which identifies the Argyll Estate as being within a renewal precinct with the potential for increased housing due to its location close to transport, services and facilities.*
>
> *The Planning Proposal seeks to amend the Coffs Harbour LEP to facilitate the renewal of the site, and proposes site specific controls for inclusion in the Coffs Harbour Development Control Plan 2015 (Coffs Harbour DCP) to guide future development.*
>
> *The Urban Design Study outlines a vision for Argyll Estate to be a renewed as a mixed tenure residential neighbourhood, offering a variety of housing options for the diverse existing and future community, surrounded by a unique natural setting, and resilient to environmental impacts.*
>
> *This is supported by a structure plan, preferred growth scenario, and proposed amendments to the Coffs Harbour LEP and DCP which are outlined below.*

[1] https://www.dpie.nsw.gov.au/land-and-housing-corporation/regional/argyll-estate-coffs-harbour

1.3.1 Structure Plan

The land use and built form approach outlined in the Urban Design Study has informed a structure plan which highlights the following

- *areas suitable for rezoning to R3 Medium Density Housing to allow for diverse housing types including residential flat buildings*
- *Areas to be retained as R2 Low Density Residential which are suitable for renewal as dual occupancies, or to be retained or renewed as single dwellings where environmental constraints would not allow more intensive renewal*
- *Potential areas of existing open space to be embellished and potential streetscape and public domain upgrades to support to support future renewal. ……*

1.3.2 Indicative Growth Scenario

An indicative growth scenario has been prepared based on the structure plan to inform the population growth that is likely to result from the Planning Proposal. The indicative growth scenario indicates the likely maximum approach to renewal across the precinct in accordance with the structure plan, lot amalgamation potential and the proposed planning controls for the site and is considered to represent a growth scenario consistent with Council's LGMS for the area.

The indicative growth scenario would deliver up to 263 additional dwellings within the precinct ….

1.3.3 Proposed LEP Amendments

To implement the proposal, the following amendments are proposed to the Coffs Harbour LEP:

- *Rezoning of parts of the site to R3 Medium Density residential to allow for development of residential flat building and dual occupancies*
- *Amendment of the built form controls in the proposed R3 zoned area, to align with controls in other R3 zoned areas in the Coffs Harbour LGA:*
  - *Maximum height of buildings: 15.5 m*
  - *Minimum lot size: 1,200 sqm*
- *Amendment of clause 4.1B of the Coffs Harbour LEP to exclude the application of the clause from the site. This will enable dual occupancies to be developed on sites down to 400sqm consistent with the Low Rise Housing Diversity Design Guide*
- *Adoption of Clause 5.22 Special Flood Consideration of the Standard LEP to apply to the site to enable flood controls to be applied in the DCP above the flood planning level.*

1.3.4 Proposed DCP Amendments

The DCP amendments that are proposed include, in part:

- *Requirements to manage flood hazard and ensure safe flood evacuation, including:*
  - *All habitable floor levels to be above the probable maximum flood level*
  - *Raising of floor levels is to ensure a good urban design and accessibility outcome with ground floors not typically raised more than 1 m to 1.5 m above ground level*
- *-Future development within the site to demonstrate that an appropriate level of flood conveyance will be maintained for any overland flow path.*

1.4 Terminology

Book 1, Chapter 2, Section 2.2.5. Adopted Terminology in Australian Rainfall & Runoff, 2016 describes the adopted terminology as follows:

> *To achieve the desired clarity of meaning, technical correctness, practicality and acceptability, the National Committee on Water Engineering has decided to adopt the terms shown in Figure 1.2.1 and the suggested frequency indicators.*
>
> *Navy outline indicates preferred terminology. Shading indicates acceptable terminology which is depends on the typical use. For example, in floodplain management 0.5% AEP might be used while in dam design this event would be described as a 1 in 200 AEP.*
>
> *As shown in the third column of Figure 1.2.1, the term Annual Exceedance Probability (AEP) expresses the probability of an event being equalled or exceeded in any year in percentage terms, for example, the 1% AEP design flood discharge.*
>
> *There will be situations where the use of percentage probability is not practicable; extreme flood probabilities associated with dam spillways are one example of a situation where percentage probability is not appropriate. In these cases, it is recommended that the probability be expressed as 1 in X AEP where 100/X would be the equivalent percentage probability.*
>
> *For events more frequent than 50% AEP, expressing frequency in terms of annual exceedance probability is not meaningful and misleading, as probability is constrained to a maximum value of 1.0 or 100%. Furthermore, where strong seasonality is experienced, a recurrence interval approach would also be misleading. An example of strong seasonality is where the rainfall occurs predominately during the Summer or Winter period and as a consequence flood flows are more likely to occur during that period.*
>
> *Accordingly, when strong seasonality exists, calculating a design flood flow with a 3 month recurrence interval is of limited value as the expectation of the time period between occurrences will not be consistent throughout the year. For example, a flow with the magnitude of a 3 month recurrence interval would be expected to occur or be exceeded 4 times a year; however, in situations where there is strong seasonality in the rainfall, all of the occurrences are likely to occur in the dominant season.*

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 1.2.1. Australian Rainfall and Runoff Preferred Terminology

Consequently, events more frequent than 50% AEP should be expressed as X Exceedances per Year (EY). For example, 2 EY is equivalent to a design event with a 6 month recurrence interval when there is no seasonality in flood occurrence

The terminology adopted herein depends on the edition of Australian Rainfall and Runoff provide the IFD data. In the case of assessments based on ARR1987 the ARI terminology was adopted for design floods. In the case of assessments based on ARR2019 the AEP terminology was adopted design floods.

2 Flooding under Existing Conditions

2.1 2021 Flood Risk Assessment

The purpose of the 2021 Flood Risk Assessment report (Cardno, 2021a) was to provide a high-level understanding of the opportunities and constraints within Argyll Estate due to flooding and to inform the development strategy for Argyll Estate based on an assessment of flooding under Existing Conditions.

Flooding under Existing Conditions was as described in the 2018 Coffs Creek and Park Beach Flood Study.

As described in part by BMT WBM (2018)

> *The primary objective of the Flood Study is to define the flood behaviour within the Coffs Creek catchment through the establishment of appropriate numerical models. The study has produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions. Specifically, the study incorporates:*
>
> - *Compilation and review of existing information pertinent to the study and acquisition of additional data including survey as required;*
> - *Development and calibration of appropriate hydrologic and hydraulic models;*
> - *Determination of design flood conditions for a range of design event including the 5% AEP, 2% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and PMF event; and*
> - *Presentation of study methodology, results and findings in a comprehensive report incorporating appropriate flood mapping.*

2.1.1 Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels and extent and depths are plotted respectively in **Figures 3, 4, 5** and **6** in Cardno, 2021a. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree of inundation of individual properties in each flood.

2.1.2 Hydraulic Categories

As described, in part, in Section 4.2.3 Hydraulic Roughness by BMT WBM (2018):

> *There are no prescriptive methods for determining what parts of the floodplain constitute flood ways, flood storages and flood fringes. Descriptions of these terms within the NSW Floodplain Development Manual (DIPNR, 2005) are essentially qualitative in nature. ……..*
>
> *The hydraulic categories as defined in the Floodplain Development Manual are:*
>
> - ***Floodway** – Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.*
> - ***Flood Storage** – Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood Storage areas, if completely blocked would cause peak flood levels to increase by 0.1m and/or would cause the peak discharge to increase by more than 10%.*

- ***Flood Fringe*** *– Remaining area of flood prone land, after Floodway and Flood Storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.*

The mapping of hydraulic categories in a 1% AEP flood is given in **Figure 7** in Cardno, 2021a. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the hydraulic categories.

2.1.3 True Hazard and Flood Risk Precincts

As described, in part, in Section 7.6 True Hazard by BMT WBM (2018):

> *….. The Coffs Creek Floodplain Risk Management Study (Bewsher Consulting, 2005) specifically defined four categories of true hazard or flood risk, with guidance to the appropriate level of planning control applicable to each category.*
>
> *The true hazard categories, as defined by Bewsher (2005), are as follows:*
>
> - ***High Flood Risk*** *– Area within the 1% AEP event flood extent that is classified as high hydraulic hazard (see Section 7.4) and/or where there are significant evacuation difficulties. The high flood risk area is where high flood damages, potential risk to life, or evacuation problems are anticipated. Most development should be restricted with stringent development controls within this area.*
> - ***High Flood Risk Flow Corrido****r – A high flow corridor exists within the high flood risk area. It is defined as the area between the main creek banks and/or where the velocity * depth product exceeds 1.0* m^2/s*.*
> - ***Medium Flood Risk*** *– Area within the 1% AEP event flood extent that is not classified as high hydraulic hazard and where there are no significant evacuation difficulties. The potential for damages can be minimised by the application of appropriate development controls.*
> - ***Low Flood Risk*** *– Area within the PMF flood extent that is not classified as high or medium flood risk. The risk of damage is low and most land uses would be permitted within this area.*

The mapping of true hazard and flood risk precincts is given in **Figure 8** in Cardno, 2021a. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the risk precincts.

2.2 Climate Change

As described, in part, in Section 7.6 true Hazard by BMT WBM (2018):

> *The potential impacts of future climate change were considered for the 1% AEP design event. There are potential impacts associated with both an increase in rainfall intensities and an increase in sea level rise. Table 7-5 summarises the climate change scenarios modelled. The impact of potential sea level rise extends as far upstream along the Coffs Creek Main Arm as the Pacific Highway bridge.*

BMT WBM (2018) tabulated estimated 1% AEP flood levels at selected locations under a range of climate change scenarios.

The locations relevant to the LAHC properties are:

Table 7-5 Climate Change Scenarios

Modelled Simulation	Boundary Conditions
Adopted 1% AEP Design Event	*1% AEP rainfall 5% AEP ocean event*
1% AEP + 2050 SLR	*1% AEP rainfall* *5% AEP ocean event + 0.4m*
1% AEP + 2100 SLR	*1% AEP rainfall* *5% AEP ocean event + 0.9m*
1% AEP + 10% rainfall	*0.5% AEP rainfall 1% AEP ocean event* *(i.e. Adopted 0.5% AEP Design Event)*
1% AEP + 10% rainfall + 2050 SLR	*0.5% AEP rainfall* *1% AEP ocean event + 0.4m*
1% AEP + 10% rainfall + 2100 SLR	*0.5% AEP rainfall* *1% AEP ocean event + 0.9m*
1% AEP + 30% rainfall	*0.2% AEP rainfall 1% AEP ocean event* *(i.e. Adopted 0.2% AEP Design Event)*
1% AEP + 30% rainfall + 2050 SLR	*0.2% AEP rainfall* *1% AEP ocean event + 0.4m*
1% AEP + 30% rainfall + 2100 SLR	*0.2% AEP rainfall* *1% AEP ocean event + 0.9m*

The estimated 1% AEP flood levels at locations H, I and J under a range of climate change scenarios are given in **Table 1**.

It is concluded that 1% AEP flood levels in the Argyll Estate are estimated to increase up to 0.1 m only under a range of climate change scenarios which is well within Council's adopted freeboard of 0.5 m.

Table 1 Summary of Model Sensitivity Results (Source: Table 7-7, BMT WBM (2018))

ID	Location	Modelled Peak Flood Level (m AHD)								
		1% AEP	1% AEP w 0.4mSLR	1% AEP w 0.9mSLR	1% AEP +10%RF (0.5%AEP)	0.5% AEP w0.4m SLR	0.5% AEP w0.9m SLR	1% AEP +30%RF (0.2%AEP)	0.2% AEP w0.4m SLR	0.2% AEP w0.9m SLR
H	Bray Street	7.1	7.1	7.1	7.1	7.1	7.1	7.2	7.2	7.2
I	Pacific Hwy, NT's	4.4	4.4	4.4	4.4	4.4	4.4	4.5	4.5	4.5
J	Orlando St, NT's	4.5	4.5	4.5	4.6	4.6	4.6	4.7	4.7	4.7

2.3 2021 Memorandum

A Memorandum dated 17 August 2021 was prepared subsequent to the 2021 Flood Risk Assessment (Cardno, 2021b). It is attached in **Appendix A.**

This Memorandum provides a discussion of the flood risks and the solutions that may be available and what measures may be available to get above the flood levels, specifically relating to site access issues. While the Argyll Estate experiences significant flooding in a 9 hour storm burst the maximum flood depths and velocities are experienced in a 2 hour storm burst ie. Argyll estate is subject to flash flooding with limited warning times of flooding. This flash flooding will inform the available measures and approaches to respond to the flood risks.

In relation to flood risks, it presented additional information as follows (refer **Appendix A**):

> *See also additional Flood Hazard Category mapping appended in Attachment B. It is noted that*
>
> - *H1 conditions would be trafficable for small vehicles.*
> - *H1 and H2 conditions would be trafficable for larger vehicles.*
> - *Evacuation of eastern properties towards the west via local roads could be a challenge due to H3 areas on sections of local roads. Evacuation would be more of a challenge in the PMF.*
>
> *See also hazardous conditions at five locations on local roads appended in Attachment C.*
>
> - *The duration of hazardous conditions at several key locations on local roads was estimated by extracting the depth v time and velocity v time at the locations identified in Figure C.1.*
> - *The maximum flood depth and velocity at the five locations are given in Table C.1 for the 1% AEP 2 hour and 9 hour storm bursts and 2 hour, 3 hour and 6 hour Probable Maximum Precipitation Design Floods (PMF)*
> - *The indicative durations during which conditions at the five locations exceed H1 conditions are given in Table C.2. It is noted that Location P5 is highly problematic which accords with its mapping as a floodway.*

- *Table C.3 summarise the indicative elapsed time between the start of the design storm burst and the onset of H1 Conditions at the five locations. This is an indicator of the time available to evacuate in the absence of a flood warning based on a rainfall forecast.*

Figure C.1 Road Reference Locations

Table C.1 Maximum Depth (m) and Velocity (m/s) at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP		PMF			
	2 hr Burst	9 hr Burst	2 hr PMP	3 hr PMP	6 hr PMP	
P1	0.458	0.425	1.134	1.037	1.007	Depth (m)
	1.225	1.173	1.431	1.496	1.386	Velocity (m/s)
P2	0.63	0.608	1.172	1.237	1.45	Depth (m)
	0.861	0.833	1.345	1.303	1.225	Velocity (m/s)
P3	0.603	0.585	1.307	1.528	1.741	Depth (m)
	1.126	1.096	1.259	1.207	1.233	Velocity (m/s)
P4	0.842	0.757	1.843	1.805	1.959	Depth (m)
	0.649	0.593	0.93	0.921	0.897	Velocity (m/s)
P5	1.229	1.144	2.224	2.169	2.051	Depth (m)
	0.466	0.374	1.976	1.867	1.666	Velocity (m/s)

Table C.2 Indicative Durations (hours) that H1 Conditions are exceeded at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP		PMF		
	2 hr Burst	9 hr Burst	2 hr PMP	3 hr PMP	6 hr PMP
P1	1.25	1.5	2.25	3.0	5.25
P2	2.0	2.5	4.0	5.0	7.0
P3	2.0	4.5	4.5	5.5	7.0
P4	2.5	5.0	4.75	5.75	7.5
P5	>5	>9	7.5	7.5	8.75

Table C.3 Indicative Time (hours) between Start of Storm Burst and H1 Conditions being exceeded at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP		PMF		
	2 hr Burst	9 hr Burst	2 hr PMP	3 hr PMP	6 hr PMP
P1	0.75	5.0	0.5	0.8	1.25
P2	0.75	4.75	0.5	0.8	1.25
P3	0.75	3.0	0.5	0.75	1.25
P4	1.0	3.0	0.5	0.75	1.5
P5	1.0	2.75	0.5	1.0	1.5

3 Assessments of Flood Mitigation Options

The 2021 Flood Risk Assessment report (Cardno, 2021a) and Memorandum (Cardno, 2021b) provided a high-level understanding of the opportunities and constraints within Argyll Estate due to flooding.

While the Argyll Estate experiences significant flooding in a 9 hour storm burst the maximum flood depths and velocities are experienced in a 2 hour storm burst ie. Argyll Estate is subject to flash flooding with limited warning times of flooding.

As defined by the 2005 Floodplain Development Manual, mitigation options can include:

- **property modification (non-structural) measures** including development controls in new areas, and voluntary purchase and house raising in developed areas;
- **response modification measures** such as evacuation and associated operational logistics; and
- **flood modification (structural) measures** including levees and bypass channels

The assessments of a range of property flood modification, property modification and response modification options for the Argyll Estate are overviewed as follows.

3.1 Concept Flood Mitigation Options / Schemes 1A, 1B, 2A, 2B, 3A, 3B and 3C

The assessments of concept Flood Mitigation Options / Schemes 1A, 1B, 2A, 2B, 3A, 3B and 3C are described in Flooding Discussion Paper No. 1 dated 18 January 2022 which is attached in **Appendix B**. These assessments are summarised as follows (Cardno, 2022a):

> *A visit to Argyll Estate was undertaken on 14 December 2021. During this visit several potential options to mitigate the flooding and/or flood risk in Argyll Estate were identified and were analysed to assess the 1% AEP flood level differences and which properties may be adversely impacted under each option.*
>
> *A series of concept options were identified as summarised in **Table 4.***
>
> *The aim of the Option 1A runs was to assess the impact if any of additional overbank flood storage upstream of Bray Street. The aim of Option 1B v1, v2 and v3 runs were to assess the impact if any of additional overbank flood storage north of Bray Street and its ability to mitigate the impacts of Option 1A v2. The aim of the Option 2A and 2B runs were to assess the impact if any of re-grading the low point in Argyll Street to reduce the flood hazard in the low point. The aim of the Scheme 3A and 3B runs were to assess the degree to which the impacts of Option 1A v2 could be mitigated by diverting the overland flows that spill through the Kurrajong Street open space via culverts to the Argyll Branch. It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.*
>
> *The options assessment disclosed that measures which would stop overflows from the Bray Street Arm that spill through the open space into Kurrajong Street in a 1% AEP flood would benefit residents in Kurrajong Street and Argyll Street but that this would be to the detriment of downstream properties fronting Bray Street, Hughes Close, Grant Close and Elm Street.*

It was found that concept regrading of Argyll Street alone would have a very minor impact at the intersection of Raymond Street and Argyll Street but that the local impact on 1% AEP flood levels are sensitive to filling of parts of the residential lots south of Argyll Street in the vicinity of the low point.

The scheme which minimise but does not eliminate the impacts on 1% AEP flood levels downstream of the Bray Street crossing would be Scheme 3A.

The concept schemes have been formulated without any consideration of capital costs nor of the associated benefit cost ratio.

While Scheme 3A may be deemed feasible from an engineering perspective and that the benefits of flood risk reduction in Kurrajong Street, Elm Street and Argyll Street outweigh the local minor increases in 1% AEP flood levels elsewhere downstream of the Bray Street crossing, it me be determined that the capital costs outweigh the benefits to current and future residents.
If this is the case, then the only available approach is to redevelop LAHC properties in a manner which responds to the current flood risks and which aims to minimise any local impacts of re-development on 1% AEP flood levels. …..

Table 4. Concept Flood Mitigation Options / Schemes for Argyll Estate

ID	Concept Option/Scheme	Comments
Kurrajong Street Reserve		
1A v1	This is a low levee along the rear property boundaries along Kurrajong Street tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. See **Figure A2.**	A concept 1.8 m levee height is notional only so that the actual 1% AEP depths along the levee can be estimated to refine the actual levee height. The aim is to assess 1% AEP flood level differences and which properties may be adversely impacted.
1A v2	This is a low levee along the rear property boundaries along Kurrajong Street and to include additional open space before the levee is tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. A swale is included to drain floodwaters that would be otherwise trapped. See **Figure A3.**	The aim is to assess the impact if any of additional overbank flood storage upstream of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v1	This is Option 1A v2 + an additional shallow free draining storage area north of Bray Street. See **Figure A4.**	The aim is to assess the impact if any of additional overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v2	This is Option 1A v2 + an additional deeper free draining storage area north of Bray Street. See **Figure A5**.	The aim is to assess the impact if any of additional deeper overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.

1B v3	*This is Option 1B v2 + a hydraulic connection to an existing natural basin.* *See **Figure A6**.*	*The aim is to assess the impact if any of connecting two overbank flood storages north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.*
Argyll St Low Point		
2A	*This option is re-grading the low section of Argyll Street to reduce the 1% AEP flood hazard and to maintain vehicular evacuation along Argyll Street albeit through shallow floodwaters. See **Figure A7**.*	*The aim is to assess the impact if any of re-grading a section of Argyll Street on 1% AEP flood level differences and which properties may be adversely impacted.*
2B	*This is Option 2A + additional filling of parts of selected properties to reduce flood hazard and the hydraulic category of selected properties. See **Figure A8**.*	*The aim is to assess the impact if any of re-grading a section of Argyll Street as well as partial filling of selected lots on 1% AEP flood level differences and which properties may be adversely impacted.*
Bray St Arm to Argyll Street Arm diversion Scheme		
3A	*Option 1A v2 + Option 2A + Diversion* *Diversion properties:* • *2 x1.2 (H) x 1.8m (W) RCBCs* • *D/S IL approx 5.5 m AHD* • *U/S IL approx 3.4 m AHD* • *Length = 380 m* • *Roughness = 0.015* • *Inlet loss = 1.0* • *Outlet loss = 2.0* *See **Figure A9**.*	*The aim of the scheme is to mitigate the impact of Option 1A v2 by diverting the overland flow that spills through the park to the Argyll Branch via culverts.* *It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.* *The inlet and outlet losses account for intermediate bend losses.* *AS with the previous options we want to assess 1% AEP flood level differences and which properties may be adversely impacted.*
3B	*This is Option 3A with 2 x1.5 (H) x 1.8m (W) RCBCs instead of 2 x1.2 (H) x 1.8m (W) RCBCs. All other properties were unchanged.*	*The aim is to assess the impact if any of increasing the capacity of the diversion scheme on 1% AEP flood levels.*

A further scheme was also assessed as follows:

3C	*Scheme 3A + additional bund* *Diversion properties:* • *2 x1.2 (H) x 1.8m (W) RCBCs* • *D/S IL approx 5.5 m AHD* • *U/S IL approx 3.4 m AHD* • *Length = 380 m* • *Roughness = 0.015* • *Inlet loss = 1.0* • *Outlet loss = 2.0*	*The aim of the scheme is to mitigate the impact of Scheme 3A downstream of Bray Street by constructing a new bund in the open space north of Bray Street to confine the flows to the Bray St watercourse.* *The intent is to reduce downstream impacts while limited impacts upstream of Bray Street to the protected zone between Bray Street and Frederick Street as far as possible.*

3.2 Scenarios A and B

The assessments of Scenarios A and B are described in Flooding Discussion Paper No. 2 dated 4 March 2022 which is attached in **Appendix C**.

These assessments are summarised as follows (Cardno, 2022b):

> *Based on the outcomes of the assessments of potential structural measures to mitigate the flooding and/or flood risk in Argyll Estate, consideration has been given to an alternative approach which is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures.*
>
> *Architectus has prepared our (4) redevelopment scenarios in which all new buildings have floor levels above the PMF. The four scenarios are:*
>
> - *Low Scenario – A* *220 additional precinct dwellings*
> - *Low Scenario – B* *218 additional precinct dwellings*
> - *High Scenario – A* *382 additional precinct dwellings*
> - *High Scenario – B* *426 additional precinct dwellings*
>
> *In order to assess a likely upper bound of flood impacts arising from redevelopment, High Scenario – B was adopted for assessment purposes. This was named **Scenario A**. A variant on High Scenario – B was also assessed and this was named **Scenario B**.*
>
> ***Figure C1** appended in Annexure C discloses that Scenario B has a local impact on 1% AEP flood levels in Elm Street and in the vicinity of the Argyll Street intersection over and above the impacts of Scenario A. **Figure C2** appended in Annexure C discloses that Scenario B has negligible impact on the PMF levels the Argyll Estate and surrounds over and above the impacts of Scenario A.*
>
> *It is also apparent from the 1% AEP flood levels tabulated in **Annexure D** that:*
>
> *(i) Scenario A and Scenario B have the same adverse impacts on 1% AEP flood levels; and that*
>
> *(ii) On balance these impacts are slightly greater than under Scheme 3C particularly in the industrial estate west of the Pacific Highway.*

Consideration may need to be given to a Low Scenario or possibly an Intermediate Scenario given Council's expressed concerns regarding the impacts of Scheme 3C on 1% AEP flood levels.

3.3 Scenarios C and D

The assessments of Scenarios C and D are described in Flooding Discussion Paper No. 3 dated 9 March 2022 which is attached in **Appendix D**.

These assessments are summarised as follows (Cardno, 2022c):

*Two further scenarios were also assessed. **Scenarios C** and **D** combined the Scenario B building footprints with a culvert flow diversion from the north arm to the south arm which was previously assessed as a component of structural schemes.*

*It is apparent from the 1% AEP flood levels tabulated in **Annexure E** that:*

(i) Scenario A and Scenario B have the same adverse impacts on 1% AEP flood levels; and that

(ii) On balance these impacts are slightly greater than under Scheme 3C particularly in the industrial estate west of the Pacific Highway;

(iii) Scenario C significantly reduces the impact of the Scenario B building footprints on 1% AEP flood levels on the identified properties;

(iv) Scenario D reduces the impact of the Scenario B building footprints on 1% AEP flood levels on the identified properties to within acceptable values;

(v) The are some zones of adverse impact which were outside of the previous area of interest and therefore do not appear in Annexure E;

(vi) These local impacts appear to be associated with changed building footprints on properties outside of the planning proposal.

Consideration could be given to limiting the changed building footprints to only those properties included within the planning proposal.

3.4 Scenarios E1 and E2

Based on the outcomes of the assessments of Scenarios A, B, C and D a further Scenario E was formulated based on limiting the changed building footprints to only those properties included within the boundary of the planning proposal.

As discussed in Section 2.2, in relation to climate change scenarios:

- 0.5% AEP rainfall is viewed as equivalent to 1% AEP + 10% rainfall; while
- 0.2% AEP rainfall is viewed as equivalent to 1% AEP + 30% rainfall.

Additional Scenarios E1 and E2 were assessed under both the 1% AEP and 0.2% AEP floods. The results of these assessments are attached in Appendix E and are summarised as follows.

Attachment E-001 provides the layout of building footprints limited to those properties within the Planning Proposal boundary. All buildings outside the defined boundary reverted to the building footprint adopted in the 2018 Coffs Creek and Park Beach Flood Study.

Attachment E-002 is a plot of 1% AEP flood level differences under Scenario E1.

Attachment E-003 is a plot of 0.2% AEP flood level differences under Scenario E1.

Scenario E2 a modified version of Scenario E1. In this scenario the roughness of selected buildings only along Bray Street and Kurrajong Street were reduced based on a void being created under the ground floor to permit flood flow. **Attachment E-004** provides the layout of Scenario E2.

Attachment E-005 is a plot of 1% AEP flood level differences under Scenario E2.

Attachment E-006 is a plot of 0.2% AEP flood level differences under Scenario E2.

Attachment E-007 is a tabulation of the 1% AEP flood level differences at a series of reference locations under Scenarios E1 and E2 compared to Existing Conditions. These reference locations were identified during the assessment of concept Flood Mitigation Options / Schemes 1A, 1B, 2A, 2B, 3A, 3B and 3C.

Attachment E-008 is a tabulation of the 0.2% AEP flood level differences at reference locations under Scenarios E1 and E2 compared to Existing Conditions.

3.5 Scenario E3

Council reviewed the Scenario E1 and E2 results are provided the following comments, in part:

- *Scenario E2 with the raised properties provides a much better outcome for the properties to the North of Bray Street, however has some localised around Kurrajong Street;*
- *Some further conveyance once flood waters cross Bray St is probably required to minimise these more local impacts. The area between Kurrajong and Argyll St, is the main flow conveyance path so I would also like to see this designated as an area for sites requiring a void at ground level*

Based on Council's comment Scenario E3 was formulated.

Scenario E3 a modified version of Scenario E2. In this scenario the roughness of selected buildings only along Bray Street, Kurrajong Street and Argyll Street were reduced based on a void being created under the ground floor to permit flood flow. **Attachment F-001** provides the layout of Scenario E3.

Attachment F-002 is a tabulation of the 1% AEP flood level differences at a series of reference locations under Scenarios E1, E2 and E3 compared to Existing Conditions.

The Planning Proposal outlined in Section 1.3 has been based on the adoption of Scenario E3.

4 Flooding under Future Conditions

The adopted Planning Proposal layout is plotted in **Figure 2**.

Scenario E3 is based on changes to building footprints on selected properties within the Planning Proposal area. Consequently, the assessment of flooding under Future Conditions was based on minor modifications of the floodplain model assembled in the 2018 Coffs Creek and Park Beach Flood Study.

Under the Planning Proposal the building footprints on the identified properties were adjusted to the proposed built form. The roughness value for most buildings was the value adopted in the 2018 Coffs Creek and Park Beach Flood Study. The roughness value for selected buildings only along Bray Street, Kurrajong Street and Argyll Street was reduced based on a void being created under the ground floor to permit flood flow.

The spatial extent of the zones of adopted hydraulic roughness are plotted in **Figure 3.**

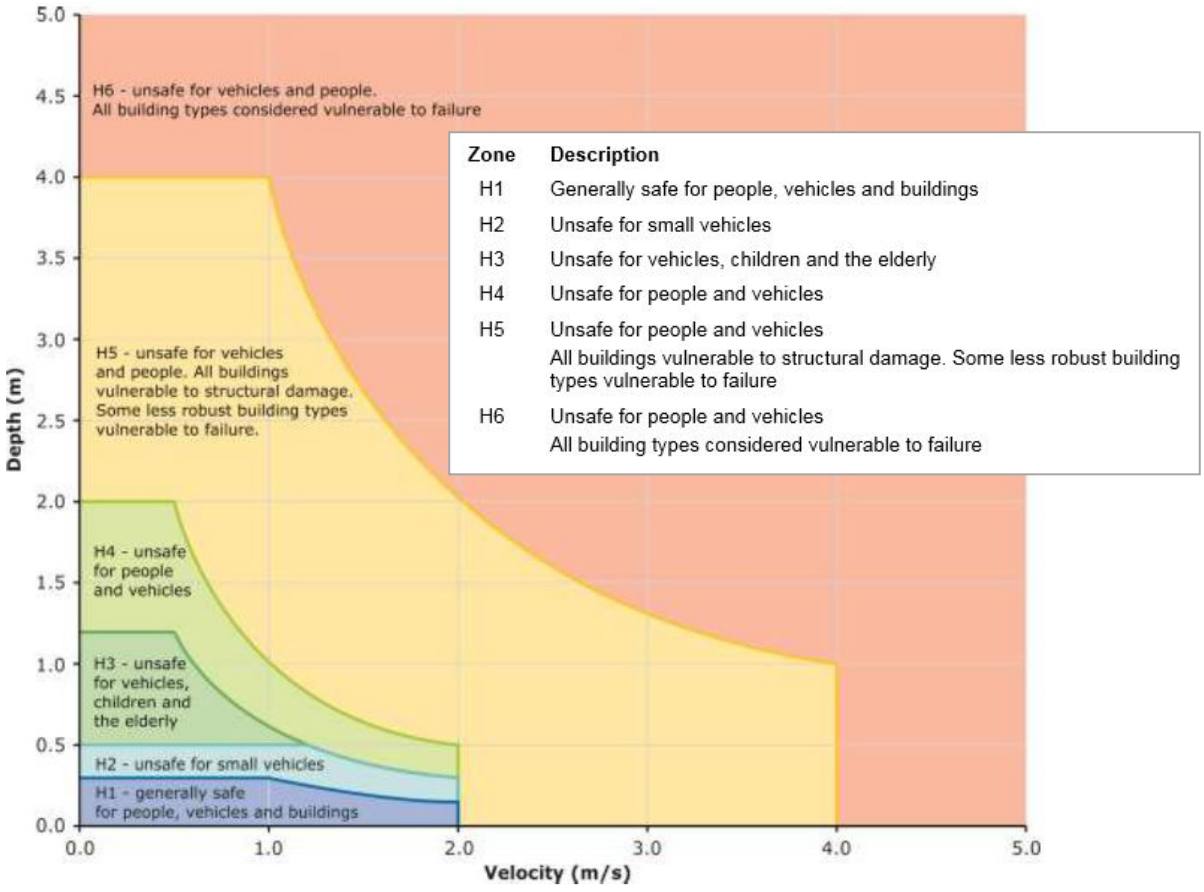
4.1 Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels, extents and depths under Future Conditions are plotted respectively in **Figures 4, 6, 8** and **10**.

4.2 Flood Hazard Categories

Flood hazard vulnerability curves based on six categories H1 – H6 are as shown below.

It is noted that H1 conditions would be trafficable for small and large vehicles while H2 conditions would be trafficable for larger vehicles only.



The flood hazard categories on the Argyll Estate in a 5% AEP, 1% AEP, 0.2% AEP and PMF under Future Conditions are plotted respectively in **Figures 5, 7, 9** and **11**.

4.3 Flood Impact Assessment

The impacts of the Planning Proposal on the 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels are plotted respectively in **Figures 12, 13, 14** and **15.**

In the 5% AEP flood it was noted:

(i) There are local impacts on flood levels on several lots at the northern end of Frederick St associated with the change in built form;

(ii) There are very minor local impacts on flood levels at the southern end of Deborah Close which may be associated with the proposed change in built from on three lots on the eastern side of Deborah Close;

(iii) There are local increases in flood levels in a section of Argyll Street; and

(iv) There is a general slight lowering of flood levels in Kurrajong Street and Elm Street and on some lots.

In the 1% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form increase slightly. If the impacts are of concern, then the built form could be modified to include a void under the ground floor to permit flood flow.

(ii) There is a slight increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in the extent of local increases in flood levels in a section of Argyll Street;

(iv) There is a general slight lowering of flood levels in a series of properties in Bray Street, Kurrajong Street, Elm Street and Argyll Street;

(v) There are small pockets of local increases in flood levels on some properties which are attributed to the change in building footprints.

In the 0.2% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form further increase;

(ii) There is a slight further increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in tin flood levels in Maple Street;

(iv) There is a further increase in the extent of local increases in flood levels along Argyll Street;

(v) There is a general slight lowering of flood levels in a series of properties in Bray Street and Kurrajong Street, Elm Street and Argyll Street;

(vi) There are local increases in flood levels on some properties which are attributed to the change in building footprints.

In the PMF it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form further increase;

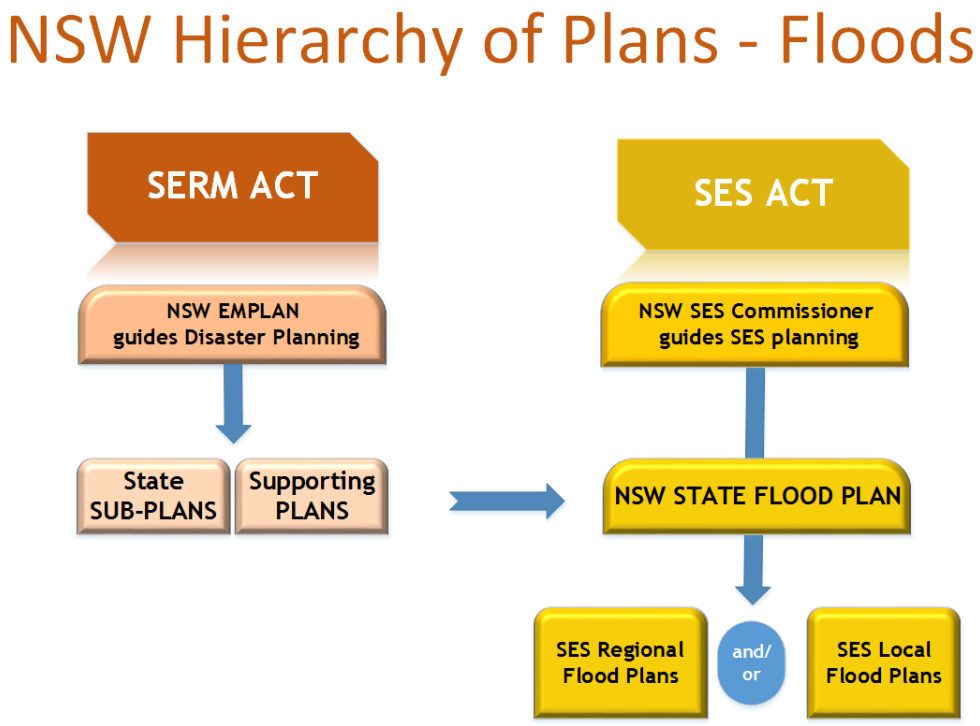
(ii) There is a zone of flood level increase towards the centre of the Estate including in Kurrajong Street, Bradley Street, Argyll Street, Deborah Close;

(iii) There is a general slight lowering of flood levels in a series of properties in Bray Street and the eastern side of Frederick Street;

(iv) The ground floor levels adopted for new development within the Planning Proposal area will need to account the estimated PMF levels under Future Conditions.

5 Emergency Planning

The hierarchy of flood emergency plans is NSW is as follows:



5.1 2018 New South Wales State Emergency Management Plan

The NSW State Emergency Management Plan (EMPLAN) is overviewed as follows:

5.1.1 Aim

The State Emergency Management Plan (EMPLAN) describes the New South Wales approach to emergency management, the governance and coordination arrangements and roles and responsibilities of agencies. The Plan is supported by hazard specific sub plans and functional area supporting plans.

5.1.2 Objectives

Consistent with the State Emergency and Rescue Management Act 1989 (SERM Act), the objectives of the EMPLAN are to:

a) provide clarity as to command and control, roles and coordination of functions in emergency management across all levels
b) emphasise risk management across the full spectrum of prevention, preparation, response and recovery
c) emphasise community engagement in the development and exercise of plans as well as in their operational employment
d) ensure that the capability and resourcing requirements of these responsibilities are understood.

The Plan promotes a comprehensive approach based on:

Prevention:	*to eliminate or reduce the level of the risk or severity of emergencies*
Preparation:	*to enhance capacity of agencies and communities to cope with the consequences of emergencies*
Response:	*to ensure the immediate consequences of emergencies to communities are minimised*
Recovery:	*measures which support individuals and communities affected by emergencies in the reconstruction of physical infrastructure and restoration of physical, emotional, environmental and economic well-being.*

5.2 2021 New South Wales State Flood Plan

The NSW State Flood Plan is overviewed, in part, as follows:

5.2.1 Purpose

The purpose of this plan is to set out the state level multi-agency arrangements for the emergency management of flooding in New South Wales including Lord Howe Island

5.2.2 Scope

The Plan sets out the state level emergency management arrangements for prevention, preparation, response, and initial recovery for flooding at the strategic level.

In this plan a flood is defined as a relatively high-water level which overtops the natural or artificial banks in any part of a stream, river, estuary, lake, or dam, and/or local overland flooding associated with drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves (including tsunami) overtopping coastline defences. …..

5.2.3 Types of Flooding

Riverine Flooding

a) *'Riverine' flooding differs in characteristics between the coastal and inland areas of the state. Maps of Inland and Coastal Rivers can be found in the State Flood Plan Supplementary and Supporting Documentation on the NSW SES Website …..*

Flash Flooding

a) *Flash flooding occurs quickly (within 6 hours) after rain causing overland flood and rapid stream rises. It can occur anywhere in the state when the intensity of the rainfall overwhelms natural or artificial drainage systems*

b) *Larger urban areas of Sydney, Newcastle, the Central Coast and Wollongong and in near-coastal environments where communities have been developed on, and immediately below, steep escarpments (such as at Coffs Harbour) are at risk of flash flooding. Flash flooding also occurs when urban drainage systems are overwhelmed by intense rainfall and roads become "rivers" with flooding occurring at their low points. In steeply sloping areas such flooding can have dangerously high flow velocities.*

c) *Whilst flash flooding is quick to occur, when it occurs in the low-lying, flat, western parts of the state, floodwaters may take long periods of time to dissipate due to a lack of flow of water towards main rivers.*

5.3 2018 North Coast Regional Emergency Management Plan

The North Coast Regional Emergency Management Plan is outlined, in part, as follows:

5.3.1 Purpose

Details arrangements for, prevention of, preparation for, response to and recovery from emergencies within the Emergency Management Region covered by this plan. ……

5.3.2 Scope

The plan describes the arrangements at Regional level to prevent, prepare for, respond to and recover from emergencies and also provides policy direction for the preparation of Sub Plans and Supporting Plans. Further:

- *This plan relies on effective implementation of the Governance framework for Emergency Management;*
- *Arrangements detailed in this plan are based on the assumption that the resources upon which the plan relies are available when required; and*
- *The effectiveness of arrangements detailed in this plan are dependent upon all involved agencies preparing, testing and maintaining appropriate internal instructions, and/or standing operating procedures.*

5.3.3 Principles

The following principles are applied in this plan:

a) *The Emergency Risk Management (ERM) process is to be used as the basis for emergency planning in New South Wales. This methodical approach to the planning process is to be applied by Emergency Management Committees at all levels.*
b) *Responsibility for preparation, response and recovery rests initially at Local level. If Local agencies and available resources are not sufficient they are augmented by those at Regional level.*
c) *Control of emergency response and recovery operations is conducted at the lowest effective level.*
d) *Agencies may deploy their own resources from their own service from outside the affected Region if they are needed.*
e) *The Regional Emergency Operations Controller (REOCON) is responsible, when requested by a combat agency, to co-ordinate the provision of resources support. EOCONs would not normally assume control from a combat agency unless the situation can no longer be contained. Where necessary, this should only be done after consultation with the State Emergency Operations Controller (SEOCON) and agreement of the combat agency and the appropriate level of control.*
f) *Emergency preparation, response and recovery operations should be conducted with all agencies carrying out their normal functions wherever possible.*
g) *Prevention measures remain the responsibility of authorities/agencies charged by statute with the responsibility.*

5.4 2017 Coffs Harbour Local Flood Plan

The Coffs Harbour Local Flood Plan is outlined, in part, as follows:

5.4.1 Purpose

This plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Coffs Harbour City LGA. It covers operations for all levels of flooding within the council area.

5.4.2 Description of Flooding and Its Effects

The NSW SES maintains information on the nature of flooding and effects of flooding on the community in the Coffs Harbour City LGA.

5.4.3 Preparedness, Response and Recovering

The plan sets out the responsibilities for Preparedness, Response and Recovering for:

- NSW SES Coffs Harbour Local Controller.
- NSW SES Coffs Harbour City and Corindi Unit Controllers
- NSW SES Coffs Harbour City and Corindi Unit Members
- NSW SES Operations Officer / Flood Contact, Nana Glen/Coramba
- Coffs Clarence Local Emergency Operations Controller (LEOCON)
- Coffs/Bellingen Local Emergency Management Officer
- Coffs Harbour City Council (CHCC)
- Community Members

5.4.4 Development of Warning Systems

Council, OEH, NSW Water and the Bureau of Meteorology have installed hardware and software to monitor rainfall and water levels in the Coffs Local Government area. Data gathered from the Flash Flood and Riverine Warning System provides NSW SES and Coffs Harbour City Council with a procedure to estimate flood levels at:

a. Coffs Creek;
b. Newports Creek;
c. North Tributary Coffs Creek (Bray Street);
d. Boambee Creek;
e. Woolgoolga Creek;
f. Middle Creek (Sawtell);
g. Bonville Creek;
h. Corindi Creek;
i. Orara River.

5.5 Evacuation versus Shelter in Place

While the Argyll Estate experiences significant flooding in a 9 hour storm burst the maximum flood depths and velocities are experienced in a 2 hour storm burst ie. Argyll Estate is subject to flash flooding with limited warning times of flooding.

As discussed in Section 1.3.4 under the Planning Proposal it is proposed, in part, to require that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place and to avoid the flood damages in extreme floods similar to the flood damages experienced recently in Lismore and other north coast communities.

Any decision to evacuate from dwellings will be informed by a number of considerations including but not limited to:

(i) the availability of flood warnings,

(ii) whether emergency services are able to mobilise and respond within the timeframes of flash flooding;

(iii) any road closures that would impede evacuation to the west eg Argyll St and W Argyll

(iv) the time available before it becomes unsafe to evacuate via local roads, and

(v) the period of time that it would be unsafe to drive on inundated local roads.

The hazardous conditions at five locations on local roads are discussed in Section 2.2 and in Attachment C of the 2021 Memorandum in **Appendix A.**

The proposed approach to evacuation within Argyll Estate is for:

(i) residents to shelter-in-place within each dwelling at a level higher than the PMF level.

(ii) while residents with vehicles could consider evacuating from the Argyll Estate to the west by vehicle this could be only until it becomes unsafe to drive on local roads and/or at key road intersections and it is preferred that residents shelter-in-place within each dwelling.

To inform local residents as to whether it is safe to drive on the local codes a series of colour coded flood markers should be installed beside roads at key locations (eg. intersections, low points, etc). The coding could be:

Green: up to a flood depth on the road of 0.3 m which would be safe for both small and large vehicles subject to velocities less than 1 m/s (H1 conditions);
Amber: flood depths on the road between 0.3 m and 0.5 m which would be safe for large vehicles subject to velocities less than 1 m/s (H2 conditions); and
Red: flood depths on the road greater than 0.5 m (H3 or greater conditions)

6 Flood Emergency Response

6.1 CHCC Flood and Storm Emergency Services and Information

Council's website provides the following Flood and Storm emergency services and information:

Visit: Flood and storm emergency services and information | Coffs Harbour City Council (nsw.gov.au)

1 Flood and storm emergency services and information

2 Emergency response

Residents requiring emergency help in floods and storms should call the SES on 132 500

Not sure whether to call? Watch the SES video on When to call the SES

Deaf and hearing impaired can use the National Relay Service

In life-threatening emergencies call 000

3 Disaster Dashboard

Council's Disaster Dashboard is an online warehouse of real-time, local emergency information supported by Resilience NSW's Regional Disaster Preparedness Program.

On the Dashboard you will find:

- *Real-time information related to live emergencies*
- *Information to help you prepare for an emergency*
- *Guidance on the assistance you can access to recover from a recent emergency*

Visit the NSW SES Advice tab of the Disaster Dashboard

4 Road conditions

Please note that road conditions change frequently during flooding and road users should exercise caution at all times.

Never enter or drive through floodwaters.

You can find up-to-date information on road closures and conditions in our region at MyRoadInfo

5 Information services

Information on how to prepare for and what to do in an emergency can be found on the SES website.

The official emergency broadcaster is ABC radio and you can listen to ABC radio live here.

- *Bureau of Meteorology warnings*
- *Coffs Harbour river and rainfall conditions*
- *Council's Newsroom*
- *Council's social media CHCC Facebook and CHCC Twitter*
- *Agricultural and Animal Services Hotline 1800 814 647*

6 Recovery and support services

Find information and support available to people, businesses and farmers recovering from floods.

Flood Recovery Portal

6.2 Coffs Harbour City Council Disaster Dashboard

Council's Disaster Dashboard is an online warehouse of real-time, local emergency information supported by Resilience NSW's Regional Disaster Preparedness Program.
On the Dashboard you will find:

- *Real-time information related to live emergencies*
- *Information to help you prepare for an emergency*
- *Guidance on the assistance you can access to recover from a recent emergency*

Visit the NSW SES Advice tab of the Disaster Dashboard

6.3 Coffs Harbour City Council Flood Warning System

Council's Flash Flooding Warning System is described by Council as follows:

Councils existing flash flood warning system includes a number of real time rainfall and river level gauges which provide automated SMS alerts and emails to the SES and certain Council staff based off rainfall and water level triggers. It is then the SES's responsibility to provide any community messaging/evacuation orders.

The Disaster Dashboard currently only provides access to the river level data available, and also provides details of road closures due to water over the road. The trigger levels and SMS/email alerts from Council's flash flood warning system are not built into the dashboard. For the moment other than any direct messaging from the SES, notices of road closures on the dashboard, and Bureau of Meteorology (Severe weather/flood) warnings, local residents are not provided with any real time automated flood warning/alerting from Council systems via the Dashboard.

Council has recently obtained a grant to expand and improve the flood warning system, of which one of the objectives is to provide automated flood warning/alerting to the community most likely via an opt in sign up via the Disaster Dashboard website. The full details of this improved system, and its relationship with the Disaster Dashboard will come to light as part of the project funded by the NSW Floodplain Management Grant Scheme. This project is expected to be completed by late 2022/early 2023 if all goes to plan.

7 Assessment of Planning Controls

7.1 Section 9.1(2) of the EP&A Act 1979, Section 4.1 Flooding

On 1 March 2022 the list of Directions issued by the Minister for Planning to relevant planning authorities under section 9.1(2) of the Environmental Planning and Assessment Act 1979 was amended. These directions apply to planning proposals lodged with the Department of Planning and Environment on or after 1 March 2022.

The compliance of the Planning Proposal with these requirements is assessed as follows.

Focus area 4: Resilience and Hazards

4.1 Flooding

Objectives

The objectives of this direction are to:

(a) *ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005, and*
(b) *ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts both on and off the subject land.*
(c) *Application*

This direction applies to all relevant planning authorities that are responsible for flood prone land when preparing a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.

Direction 4.1

(1) *A planning proposal must include provisions that give effect to and are consistent with:*

(a) *the NSW Flood Prone Land Policy,*

(b) *the principles of the Floodplain Development Manual 2005,*

(c) *the Considering flooding in land use planning guideline 2021, and*

(d) *any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.*

Flood risk can be defined as being existing, future or residual risk:

- **Existing flood risk** - the existing problem refers to existing buildings and developments on flood prone land. Such buildings and development by virtue of their presence and location are exposed to an 'existing' risk of flooding.
- **Future flood risk** - the future problem refers to buildings and developments that may be built on flood prone land in the future. Such buildings and developments may be exposed to a 'future' flood risk, i.e. a risk would not materialise until the developments occur.

- **Continuing risk of flooding** - the continuing problem refers to the 'residual' risk associated with floods that exceed management measures already in place, i.e. unless a floodplain management measure is designed to withstand the Probable Maximum Flood, it will be exceeded by a sufficiently large flood at some time in the future.

Measures available for the management of flood risk can be categorised according to the way in which the risk is managed. As a result, there are three types of measures for the management of flooding:

- Flood Modification Measures (for the existing risk)
- Property Modification Measures (for the future risk)
- Emergency Response Modification Measures (for the residual risk).

Existing Flood Risks

The flood risks experienced in the Argyll estate are outlined in Section 2.1 and are described in 2021 Flood Risk Assessment report (Cardno, 2021a).

Future Flood Risk

The future flood risk is addressed by the proposed form of development. As discussed in Section 1.3.4 under the Planning Proposal it is proposed, in part, to require that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place and to avoid the flood damages in extreme floods similar to the flood damages experienced recently in Lismore and other north coast communities.

Continuing Flood Risk

The proposed form of development requires that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place. This means that residents currently exposed to flood risks in dwellings with floor levels lower than the PMF level would no longer be exposed to these flood risks. While the number of persons indirectly at risk will increase, the Planning Proposal will reduce the number of person directly at risk in all floods up to the PMF.

As noted in the 2021 Memorandum (**Appendix A**) one or more generic Flood Emergency Response Plans could be prepared to inform all residents living in LAHC properties of the flood risks and how to safely respond to floods.

It is considered that the Planning Proposal is consistent with the aforementioned policy and guidelines.

(2) *A planning proposal must not rezone land within the flood planning area from Recreation, Rural, Special Purpose or Conservation Zones to a Residential, Business, Industrial or Special Purpose Zones.*

The Planning Proposal complies with this requirement.

(3) *A planning proposal must not contain provisions that apply to the flood planning area which:*

(a) *permit development in floodway areas,*

The mapping of floodways in a 1% AEP flood is given in Figure 7 in the 2021 Flood Risk Assessment report (Cardno. 2021a). This discloses that the is no development proposed in any floodway areas.

(b) *permit development that will result in significant flood impacts to other properties,*

The assessed impacts of the Planning proposal on flooding is discussed in Section 4.3 above.

In the 1% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form increase slightly. If the impacts are of concern, then the built form could be modified to include a void under the ground floor to permit flood flow.

(ii) There is a slight increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in the extent of local increases in flood levels in a section of Argyll Street;

(iv) There is a general slight lowering of flood levels in a series of properties in Bray Street, Kurrajong Street, Elm Street and Argyll Street;

(v) There are small pockets of local increases in flood levels on some properties which are attributed to the change in building footprints.

It is considered that the Planning proposal will not result in significant flood impacts to other properties in the 1% AEP flood which is adopted for flood planning purposes.

(c) *permit development for the purposes of residential accommodation in high hazard areas,*

The mapping of true hazard or flood risk precincts is given in Figure 8 in the 2021 Flood Risk Assessment report (Cardno. 2021a). This discloses that the is no development proposed in any high hazard areas.

(d) *permit a significant increase in the development and/or dwelling density of that land,*

The proposed form of development requires that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place. While the proposed development remains within the Flood Planning Area the form of development means that residents currently exposed to flood risks in dwellings with floor levels lower than the PMF level would no longer be directly exposed to these flood risks. Residents would remain indirectly at risk because unsafe conditions would be encountered if any residents sought to leave their flood refuge prior to the flood receding. While the number of persons indirectly at risk will increase, the Planning Proposal will reduce the number of person directly at risk in all floods up to the PMF.

While it is considered that the Planning Proposal complies with the intent of this requirement by reducing the number of person directly at risk in all floods up to the PMF and allowing future residents to safely shelter-in-place, the Planning Proposal could be deemed to be inconsistent with this requirement. This is discussed further below.

(e) *permit development for the purpose of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*

The Planning Proposal complies with this requirement.

(f) *permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,*

The Planning Proposal complies with this requirement.

(g) *are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but are not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities, or*

The proposed form of development is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures ie. requiring that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place.

The proposed approach to evacuation within Argyll Estate is for:

(i) residents to evacuate the Argyll Estate to the west by vehicle up until the time it becomes unsafe to drive on local roads and/or at key road intersections,

(ii) any remaining residents to shelter-in-place within each dwelling at a level higher than the PMF level until such time that it is safe resume driving on the local roads.

To inform local residents as to whether it is safe to drive on the local codes a series of colour coded flood markers should be installed beside roads at key locations (eg. intersections, low points, etc). The coding could be:

Green: up to a flood depth on the road of 0.3 m which would be safe for both small and large vehicles subject to velocities less than 1 m/s (H1 conditions);
Amber: flood depths on the road between 0.3 m and 0.5 m which would be safe for large vehicles subject to velocities less than 1 m/s (H2 conditions); and
Red: flood depths on the road greater than 0.5 m (H3 or greater conditions)

Consequently, there will be no substantially increased requirement for government spending on flood mitigation measures or infrastructure arising from the proposed form of development.

(h) *permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.*

The Planning Proposal complies with this requirement.

(4) *A planning proposal must not contain provisions that apply to areas between the flood planning area and probable maximum flood to which Special Flood Considerations apply which:*

(a) *permit development in floodway areas,*

(b) *permit development that will result in significant flood impacts to other properties,*

(c) *permit a significant increase in the dwelling density of that land,*

(d) *permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*

(e) *are likely to affect the safe occupation of and efficient evacuation of the lot, or*

(f) *are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.*

The special flood consideration clause does not currently apply to the site and accordingly the Planning Proposal is consistent with the clause. However, it is understood that a separate Planning Proposal is currently being progressed to include the clause in the Coffs Harbour LEP.

The Argyll Estate Planning Proposal will permit an increase in the dwelling density on land between the flood planning area and the PMF. The Planning Proposal takes a conservative approach whereby more intensive development such as residential flat buildings would be largely located outside areas affected by the 1% AEP flood, with only modest renewal of dual occupancies to be allowed within areas up to the PMF. Given the flood evacuation constraints in the road network, the proposal seeks to apply a shelter in place strategy where all habitable floor levels would be located above the PMF level to ensure residents can shelter in place safely in all flood events.

The approach outlined is consistent with the NSW Government Policy Considering Flooding in Land Use Planning (DPE July 2021), which allows for the implementation of special flood considerations in areas outside the flood planning area (but below the PMF level) on land that, in the event of a flood, may cause a particular risk to life and require the evacuation of people or other safety considerations. In particular, it highlights that these may apply where vertical evacuation for short duration flooding is required such as where the rate of rise of floodwater prohibits safe evacuation from the land.

Accordingly, the Planning Proposal seeks to apply the Special Flood Considerations Clause to the site, to enable controls to apply up to the PMF level.

(5) *For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.*

Consistency

A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Planning Secretary (or their nominee) that:

(a) *the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or*

(b) *where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or*

(c) *the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or*

This flood impact assessment satisfies this requirement as it has been prepared in accordance with the principles of the Floodplain Development Manual 2005. It includes assessments of flood mitigation options for the Argyll Estate comprising a range of structural measures and non-structural actions which informed the adoption of the proposed approach to redevelop lots in a manner that responds to the flood risks without reliance on any structural measures.

(d) *the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.*

The proposed development has been assessed against each of the considerations set out in Section 9.1(2) of the EP&A Act 1979, Section 4.1 Flooding and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and that the Planning Proposal complies with intent of the Section 9.1(2) Direction and any provisions of the Planning Proposal that are inconsistent are of minor significance.

***Note**: In this direction:*

(a) *"flood prone land" "flood storage" "floodway" and "high hazard" have the same meaning as in the Floodplain Development Manual 2005.*

(b) *"flood planning level" "flood behaviour" and "flood planning area" has the same meaning as in the Considering flooding in land use planning guideline 2021.*

(c) *Special flood considerations are outlined in the Considering flooding in land use planning guideline 2021 and an optional clause in the Standard Instrument (Local Environmental Plans) Order 2006.*

(d) *Under the floodplain risk management process outlined in the NSW Government's Floodplain Development Manual 2005, councils may produce a flood study followed by a floodplain risk management study and floodplain risk management plan.*

Issued to commence 1 March 2022 (replaces previous Direction 4.3)

7.2 Coffs Harbour Local Environmental Plan 2013

In relation to flood planning the relevant clause in the Coffs Harbour LEP 2013 are given below. The compliance of the Planning Proposal with these requirements is assessed as follows.

5.21 *Flood planning*

(1) *The objectives of this clause are as follows—*

(a) *to minimise the flood risk to life and property associated with the use of land,*

(b) *to allow development on land that is compatible with the flood function and behaviour onthe land, taking into account projected changes as a result of climate change,*

(c) *to avoid adverse or cumulative impacts on flood behaviour and the environment,*

(d) *to enable the safe occupation and efficient evacuation of people in the event of a flood.*

The Planning Proposal addresses these objectives though:

(i) The proposed form of development which is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures ie. requiring that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place

(ii) Excluding development from floodway areas and from areas of high hazard;

(iii) Assessing the impacts of the Planning Proposal on the 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels (refer Section 4.3 above). As discussed in Section 2.2, 0.2% AEP rainfall is viewed as equivalent to 1% AEP + 30% rainfall ie. an upper bound climate change scenario.

(iv) Consideration of evacuation issues (in Section 5.5) leading to the proposed approach to evacuation within Argyll Estate which is for:

- residents to evacuate the Argyll Estate to the west by vehicle up until the time it becomes unsafe to drive on local roads and/or at key road intersections,
- any remaining residents to shelter-in-place within each dwelling at a level higher than the PMF level until such time that it is safe resume driving on the local roads.

(v) Informing local residents as to whether it is safe to drive on the local codes by installing a series of colour coded flood markers beside roads at key locations (eg. intersections, low points, etc).

(2) *Development consent must not be granted to development on land the consent authorityconsiders to be within the flood planning area unless the consent authority is satisfied thedevelopment—*

(a) *is compatible with the flood function and behaviour on the land, and*

The Planning Proposal excludes development from floodway areas and from areas of high hazard and is compatible with the flood function and behaviour on the land.

(b) *will not adversely affect flood behaviour in a way that results in detrimental increases in thepotential flood affectation of other development or properties, and*

The assessed impacts of the Planning proposal on flooding is discussed in Section 4.3 above.

In the 1% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form increase slightly. If the impacts are of concern, then the built form could be modified to include a void under the ground floor to permit flood flow.

(ii) There is a slight increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in the extent of local increases in flood levels in a section of Argyll Street;

(iv) There is a general slight lowering of flood levels in a series of properties in Bray Street, Kurrajong Street, Elm Street and Argyll Street;

(v) There are small pockets of local increases in flood levels on some properties which are

attributed to the change in building footprints.

It is considered that the Planning proposal will not result in significant flood impacts to other properties in the 1% AEP flood which is adopted for flood planning purposes.

(c) *will not adversely affect the safe occupation and efficient evacuation of people or exceed thecapacity of existing evacuation routes for the surrounding area in the event of a flood, and*

The proposed form of development requires that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place. This means that residents currently exposed to flood risks in dwellings with floor levels lower than the PMF level would no longer be exposed to these flood risks. This has the potential to reduce the number of residents attempting to evacuate under unsafe conditions along local roads.

Consideration of evacuation issues (in Section 5.5) lead to the proposed approach to evacuation within Argyll Estate which is for:

- residents to evacuate the Argyll Estate to the west by vehicle up until the time it becomes unsafe to drive on local roads and/or at key road intersections,
- any remaining residents to shelter-in-place within each dwelling at a level higher than the PMF level until such time that it is safe resume driving on the local roads.

(d) *incorporates appropriate measures to manage risk to life in the event of a flood, and*

The proposed form of development is based on redeveloping lots in a manner that responds to the flood risks and does not rely on any structural measures ie. it requires that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place.

(e) *will not adversely affect the environment or cause avoidable erosion, siltation, destruction ofriparian vegetation or a reduction in the stability of river banks or watercourses.*

Given that the Planning Proposal limits development to existing residential lots only, it is considered that it will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

(3) *In deciding whether to grant development consent on land to which this clause applies, theconsent authority must consider the following matters—*

(a) *the impact of the development on projected changes to flood behaviour as a result of climatechange,*

Assessing the impacts of the Planning Proposal on the 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels (refer Section 4.3 above). As discussed in Section 2.2, 0.2% AEP rainfall is viewed as equivalent to 1% AEP + 30% rainfall ie. an upper bound climate change scenario.

(b) *the intended design and scale of buildings resulting from the development,*

This consideration is addressed elsewhere in the Planning Proposal

(c) *whether the development incorporates measures to minimise the risk to life and ensure thesafe evacuation of people in the event of a flood,*

The proposed form of development requires that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place. This means that residents currently exposed to flood risks in dwellings with floor levels lower than the PMF level would no longer be

exposed to these flood risks. This has the potential to reduce the number of residents attempting to evacuate under unsafe conditions along local roads.

Consideration of evacuation issues (in Section 5.5) lead to the proposed approach to evacuation within Argyll Estate which is for:

- residents to evacuate the Argyll Estate to the west by vehicle up until the time it becomes unsafe to drive on local roads and/or at key road intersections,
- any remaining residents to shelter-in-place within each dwelling at a level higher than the PMF level until such time that it is safe resume driving on the local roads.

(d) *the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.*

This consideration has informed the identification of selected properties where it is proposed that a void be created under the ground floor to permit flood flow in order to manage local flood impacts across the Argyll Estate.

(4) *A word or expression used in this clause has the same meaning as it has in the ConsideringFlooding in Land Use Planning Guideline unless it is otherwise defined in this clause.*

(5) *In this clause—*
***Considering Flooding in Land Use Planning Guideline** means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021* (refer **Appendix C**)

***flood planning area** has the same meaning as it has in the Floodplain Development Manual.*

***Floodplain Development Manual** means the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.*

5.22 *Special flood considerations*

[Not adopted]

7.3 Coffs Harbour Development Control Plan 2015

Chapter E4 Flooding of the Coffs Harbour Development Control Plan (DCP) 2015 details the flooding planning requirements. The compliance of the Planning Proposal with these requirements is assessed as follows.

Section E4.1 Flood Planning Requirements - General states:

Objectives

To provide clear guidelines for development and subdivision proposals on land with a flood hazard to ensure that the provisions of Clause 7.3 Flood Planning, of Coffs Harbour LEP 2013 are satisfied. To minimise the flood risk to life and property associated with the use of land.

Requirements

(1) Development is to be designed and located so that it is free from any land that is at or below the 100- year Average Recurrence Interval flood level.

As disclosed in the 2021 Flood Risk Assessment *Cardno, 2021) and in this report the Planning Proposal proposed development on a number of existing residential lots that already experience flooding in floods up to the 100 yr ARI flood. While the Planning Proposal does not comply with this requirement it does comply with its intent by requiring that all new habitable floor levels be

above the PMF level to allow future residents to safely shelter-in-place. This means that residents currently exposed to flood risks in dwellings with floor levels lower than the PMF level would no longer be exposed to these flood risks.

(2) Development is to be designed and located so that it is free from any floodways.

The Planning Proposal excludes development from floodway areas and from areas of high hazard and is compatible with the flood function and behaviour on the land.

(3) Development is not to comprise the external storage of any materials below the 100-year Average Recurrence Interval flood level that are potentially hazardous or that may cause pollution.

This requirement is noted.

(4) Development is not to result in an increase in flood levels on adjoining or surround land.

The assessed impacts of the Planning proposal on flooding is discussed in Section 4.3 above.

In the 1% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form increase slightly. If the impacts are of concern, then the built form could be modified to include a void under the ground floor to permit flood flow.

(ii) There is a slight increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in the extent of local increases in flood levels in a section of Argyll Street;

(iv) There is a general slight lowering of flood levels in a series of properties in Bray Street, Kurrajong Street, Elm Street and Argyll Street;

(v) There are small pockets of local increases in flood levels on some properties which are attributed to the change in building footprints.

It is considered that the Planning proposal will not result in significant flood impacts to other properties in the 1% AEP flood which is adopted for flood planning purposes.

(5) Operational access to the development is to provide a level of service commensurate with the zoning and proposed use with consideration to both on site and off site access.

The current level of operation access to the Argyll estate is maintained under the Planning Proposal.

Exceptions

- *Development (including fill) may be supported below the 100-year Average Recurrence Interval flood level provided that:*
  - *the measures specified in this Chapter for specific development types are satisfied; and*
  - *no net filling is undertaken with the Coffs Creek Catchment west of the highway excluding balanced earthworks which may be supported subject to a merit assessment; and*

The proposed form of development is to set the ground floor levels of all new residential buildings at or above the PMF level. For a number of properties this would be achieved by filling within the building footprint. It is also proposed that a void be created under the ground floor of selected buildings to permit flood flow in order to manage local flood impacts across the Argyll Estate. To date the net filling has not been estimated because the floor levels of all buildings with the planning area have not been surveyed. Consequently, it is not possible to calculate the change in volume on a dwelling by dwelling basis. However, the potential impact of the concept filling has been assessed and is discussed in Section 4.3 above.

It is considered that the Planning Proposal complies with the intent of this requirement, namely, to limit adverse impacts of proposed development on flooding.

- *basement car parks (where relevant) have weir protection from the 100-year Average Recurrence Interval flood level plus 100mm freeboard.*

This requirement is noted.

- *Development proposals resulting in an increase in flood levels on adjoining land may be supported where consent is obtained from affected land owners agreeing to such increases. In this regard, written confirmation of acceptance of changed flood conditions from all adversely affected land owners is required to accompany the relevant development application. Proposals of this nature will be assessed on merit taking into account existing land uses, zoning and predicted impacts on adjoining land. Low intensity land uses including land zoned for rural, recreational and environmental purposes under Coffs Harbour LEP 2013 have additional merit.*

This consideration is noted.

- *Open parking areas are to be assessed on merit, taking into account adjoining land uses and flood levels, access constraints and fill requirements.*

This consideration is noted.

Notes:

- *Flood controls are also contained within the National Construction Code, Volumes 1 & 2 – Building Code of Australia and Australian/New Zealand Standard AS/NZS 3500.2:2003 – Sanitary Plumbing and Drainage.*
- *Safe and reliable access for pedestrians may be required from development to an area of refuge above the Probable Maximum Flood Level, either on or off the site.*

Section E4.2 Flood Planning Requirements - Residential and Tourist Development states, in part:

Requirements

(1) Buildings are to be designed and located so that they are free from any high hazard flood area.

The Planning Proposal complies with this requirement.

(2) Development is to be designed and located with consideration to impacts from any high hazard flood area on access to the development and the operation of the development.

The Planning Proposal complies with this requirement.

(3) Development applications for development at or below the 100-year Average Recurrence Interval flood level are to be accompanied by a flood study prepared by a suitably experienced and qualified engineer to substantiate that the development will not increase upstream or downstream flood levels or change flood behaviour to the detriment to any other property.

The 2021 Flood Risk Assessment (Cardno, 2021a) and this study satisfy this requirement.

(4) The minimum finished floor level of all habitable room(s) is to be at the height of the 100-year Average Recurrence Interval flood level plus 0.5 metre freeboard.

The Planning Proposal exceeds this requirement. By requiring all habitable floor levels to be above the PMF level

(5) The minimum finished floor level of all non-habitable room(s) is to be at the height of the 100-year Average Recurrence Interval flood level.

This requirement is noted.

Exceptions

- *Infill development and/or changes of use are to be assessed on merit, taking into account adjoining land uses and flood levels, access constraints and fill requirements. A flood study may be required in certain situations.*
- *The minimum floor level for alterations and additions to existing residential accommodation shall be as close to the flood planning level as practical and no lower than the existing floor level; and*
  - *where the existing floor level is < the 100-year Average Recurrence Interval flood level, alterations and additions are not to exceed 50m2; or*
  - *where the existing floor level is > the 100-year Average Recurrence Interval flood level but below the 0.5 metre freeboard level, alterations and additions are not to exceed 100m2.*
- *Alterations and additions to existing tourist and visitor accommodation is to be assessed on merit, taking into account adjoining land uses and flood levels, access constraints and fill requirements.*
- *A reduction in the 0.5 metre freeboard requirement may be supported for habitable rooms on land above the 100-year flood level but still affected by the Flood Planning Level (FPL) where adequate flood information is available. Flood behaviour and other points of considerations for a freeboard reduction include low flood flow volumes and velocities, flat flood gradient, compatibility with adjoining development and access issues.*
- *A reduction in the minimum finished floor level of all non-habitable room(s) buildings may be supported on merit taking into consideration compatibility with adjoining land use, access issues for the site and associated filling required.*
- *Land affected by the Middle Creek Floodway Limit Line (FLL) may be developed, provided that development only occurs up to the FLL, including fencing, landscaping and fill so as not to impede the passage of floodwaters or cause an afflux in flood levels.*
- *Alterations and additions to existing development beyond the Middle Creek Floodway Limit Line may be supported subject to a merit assessment.*

Notes:

- *Approval may be conditional upon the lodgement of a registered surveyor's certificate certifying the floor level prior to the development proceeding above finished floor level.*
- *Approval may be conditional upon a Flood Safe Plan being prepared in accordance with SES guidelines and implemented during the operational phase of the development.*

This flood impact assessment has been prepared in accordance with the principles of the Floodplain Development Manual 2005. It includes assessments of flood mitigation options for the Argyll Estate comprising a range of structural measures and non-structural actions which informed the adoption of the proposed approach to redevelop lots in a manner that responds to the flood risks without reliance on any structural measures.

The proposed development has been assessed against each of the considerations set out in Section 9.1(2) of the EP&A Act 1979, Section 4.1 Flooding and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and that the Planning Proposal complies with intent of the Section 9.1(2) Direction and any provisions of the Planning Proposal that are inconsistent are of minor significance.

The Planning Proposal has been also assessed against each of the considerations set out in relevant Coffs Harbour flood planning controls and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and the complies with intent of:

- Clause 5.21 Flood Planning of the Coffs Harbour LEP 2013
- Chapter E4 Flooding of the Coffs Harbour Development Control Plan (DCP) 2015

8 Conclusions

A Planning Proposal has been prepared to support a proposal to renew the Argyll Estate Rezoning Investigation Area (the site) to provide for a range of housing types including low rise medium density housing such as dual occupancies (duplex style dwellings) and mid-rise apartments.

The purpose of this report is to assess the impact of the Planning Proposal development. This report also addresses the relevant planning considerations.

8.1 Flood Risk and Mitigation Options

The flood impact assessment was informed by the assessment of design flood levels, velocities and hazards under Benchmark conditions as described in Cardno, 2021 (refer **Section 2.1**).

The 2021 Flood Risk Assessment report (Cardno, 2021a) and Memorandum (Cardno, 2021b) provided a high-level understanding of the opportunities and constraints within Argyll Estate due to flooding. While the Argyll Estate experiences significant flooding in a 9 hour storm burst the maximum flood depths and velocities are experienced in a 2 hour storm burst ie. Argyll Estate is subject to flash flooding with limited warning times of flooding.

As defined by the 2005 Floodplain Development Manual, mitigation options can include:

- **property modification (non-structural) measures** including development controls in new areas, and voluntary purchase and house raising in developed areas;
- **response modification measures** such as evacuation and associated operational logistics; and
- **flood modification (structural) measures** including levees and bypass channels

This flash flooding informed the assessment of property flood modification, property modification and response modifications options for the Argyll Estate. These various assessments that were undertaken are described in **Appendices B, C, D, E** and **F.**

8.2 The Planning Proposal

The Planning Proposal outlined in Section 1.3 was based on the adoption of Scenario E3 (refer **Appendix F**).

Given the flood affectation within the site and the potential issues around safe evacuation, the proposal takes a conservative approach to managing flooding as follows:

- Areas proposed to be rezoned to R3 Medium Density Housing are limited in area and have generally avoided areas impacted by the 100-year flood level
- All future habitable floor levels would be raised above the probable maximum flood level to ensure that residents can refuge in place during all flood events up to the probable maximum flood level
- Dual occupancies would be limited to areas where the habitable ground floor level would not need to be raised by more than around 1.5m to be above the probable maximum flood level.

The flood modelling undertaken indicates that some dual occupancies within the precinct which would be required to be raised above the probable maximum flood would need to have voids underneath the ground floor level to allow to ensure overland flow paths to be maintained. This would be addressed at DA stage, and a site specific DCP provision is proposed to ensure this is a matter for consideration.

8.3 Flooding under Future Conditions

The adopted Planning Proposal layout is plotted in **Figure 2**.

It is based on changes to building footprints on selected properties within the Planning Proposal area. Consequently, the assessment of flooding under Future Conditions was based on minor modifications of the floodplain model assembled in the 2018 Coffs Creek and Park Beach Flood Study.

Under the Planning Proposal the building footprints on the identified properties were adjusted to the proposed built form. The roughness value for most buildings was the value adopted in the 2018 Coffs Creek and Park Beach Flood Study. The roughness value for selected buildings only along Bray Street, Kurrajong Street and Argyll Street was reduced based on a void being created under the ground floor to permit flood flow.

8.2.1 Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels, extents and depths under Future Conditions are plotted respectively in **Figures 4, 6, 8** and **10**.

8.2.2 Flood Hazard Categories

The flood hazard categories on the Argyll Estate in a 5% AEP, 1% AEP, 0.2% AEP and PMF under Future Conditions are plotted respectively in **Figures 5, 7, 9** and **11**.

8.2.3 Flood Impact Assessment

The impacts of the Planning Proposal on the 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels are plotted respectively in **Figures 12, 13, 14** and **15.**

In the 1% AEP flood it was noted:

(i) The local impacts on several lots at the northern end of Frederick St associated with the change in built form increase slightly. If the impacts are of concern, then the built form could be modified to include a void under the ground floor to permit flood flow.

(ii) There is a slight increase in the very minor local impacts at the southern end of Deborah Close;

(iii) There is a slight increase in the extent of local increases in flood levels in a section of Argyll Street;

(iv) There is a general slight lowering of flood levels in a series of properties in Bray Street, Kurrajong Street, Elm Street and Argyll Street;

(v) There are small pockets of local increases in flood levels on some properties which are attributed to the change in building footprints.

It is considered that the Planning proposal will not result in significant flood impacts to other properties in the 1% AEP flood which is adopted for flood planning purposes.

8.4 Evacuation versus Shelter in Place

As discussed in Section 1.3.4 under the Planning Proposal, it is proposed, in part, to require that all habitable floor levels be above the PMF level to allow future residents to safely shelter-in-place and to avoid the flood damages in extreme floods similar to the flood damages experienced recently in Lismore and other north coast communities.

Consequently, any decision to evacuate from dwellings will be informed by a number of considerations including but not limited to:

(i) the availability of flood warnings,

(ii) whether emergency services are able to mobilise and respond within the timeframes of flash flooding;

(iii) any road closures that would impede evacuation to the west eg Argyll St and W Argyll

(iv) the time available before it becomes unsafe to evacuate via local roads, and

(v) the period of time that it would be unsafe to drive on inundated local roads.

8.5 Flood Evacuation

The proposed approach to evacuation within Argyll Estate is for:

(i) residents to shelter-in-place within each dwelling at a level higher than the PMF level;

(ii) while residents with vehicles could consider evacuating from the Argyll Estate to the west by vehicle this could be only until it becomes unsafe to drive on local roads and/or at key road intersections and it is preferred that residents shelter-in-place within each dwelling.

To inform local residents as to whether it is safe to drive on the local roads a series of colour coded flood markers should be installed beside roads at key locations (eg. intersections, low points, etc). The coding could be:

Green: up to a flood depth on the road of 0.3 m which would be safe for both small and large vehicles subject to velocities less than 1 m/s (H1 conditions);

Amber: flood depths on the road between 0.3 m and 0.5 m which would be safe for large vehicles subject to velocities less than 1 m/s (H2 conditions); and

Red: flood depths on the road greater than 0.5 m (H3 or greater conditions)

8.6 Flood Emergency Response

Council's website provides the Flood and Storm emergency services and information which is overviewed. Also overviewed are the Coffs Harbour City Council Disaster Dashboard and the Coffs Harbour City Council Flood Warning System.

8.7 Assessment of Planning Controls

The special flood consideration clause does not currently apply to the site and accordingly the Planning Proposal is consistent with the clause. However, it is understood that a separate Planning Proposal is currently being progressed to include the clause in the Coffs Harbour LEP.

The Argyll Estate Planning Proposal will permit an increase in the dwelling density on land between the flood planning area and the PMF. The Planning Proposal takes a conservative approach whereby more intensive development such as residential flat buildings would be largely located outside areas affected by the 1% AEP flood, with only modest renewal of dual occupancies to be allowed within areas up to the PMF. Given the flood evacuation constraints in the road network, the proposal seeks to apply a shelter in place strategy where all habitable floor levels would be located above the PMF level to ensure residents can shelter in place safely in all flood events.

The approach outlined is consistent with the NSW Government Policy Considering Flooding in Land Use Planning (DPE July 2021), which allows for the implementation of special flood considerations in areas outside the flood planning area (but below the PMF level) on land that, in the event of a flood, may cause a particular risk to life and require the evacuation of people or other safety considerations. In particular, it highlights that these may apply where vertical evacuation for short duration flooding is required such as where the rate of rise of floodwater prohibits safe evacuation from the land.

Accordingly, the Planning Proposal seeks to apply the Special Flood Considerations Clause to the site, to enable controls to apply up to the PMF level.
The proposed development has been assessed against each of the considerations set out in Section 9.1(2) of the EP&A Act 1979, Section 4.1 Flooding and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and that the Planning Proposal complies with intent of the Section 9.1(2) Direction and any provisions of the Planning Proposal that are inconsistent are of minor significance.

The Planning Proposal has been also assessed against each of the considerations set out in relevant Coffs Harbour flood planning controls and it is concluded that the proposed form of development is informed by the principles and guidelines of the Floodplain Development Manual 2005 and the complies with intent of:

- Clause 5.21 Flood Planning of the Coffs Harbour LEP 2013; and
- Chapter E4 Flooding of the Coffs Harbour Development Control Plan (DCP) 2015.

9 References

BMT WBM (2018) “Coffs Creek and Park Beach Flood Study”, *Final Report*, Rev 5, 2 Vols, prepared for Coffs Harbour City Council, May

Cardno (2021a) “Flood Risk Assessment, Argyll Estate, Coffs Harbour”, Draft Final report, prepared for LAHC, July, 20 pp + Apps.

Cardno (2021b) “Argyll Estate – Flood Risk Assessment”, Memorandum, prepared for LAHC, 17 August 2021, 2 pp + Attachments.

Cardno (2022a) “Argyll Estate, Coffs Harbour”, Flooding Discussion Paper, prepared for LAHC, January, 12 pp + Apps.

Cardno (2022b) “Argyll Estate, Coffs Harbour”, Flooding Discussion Paper No. 2, prepared for LAHC, 4 March 2022, 10 pp + Apps.

Cardno (2022c) “Argyll Estate, Coffs Harbour”, Flooding Discussion Paper No. 3, prepared for LAHC, 9 March 2022, 11 pp + Apps.

NSW Government (2018) *New South Wales State Emergency Management Plan*

NSW Government (2018) *North Coast Regional Emergency Management Plan*

NSW Government (2021) *New South Wales State Flood Plan, A Sub Plan of the State Emergency Management Plan (EMPLAN)*

NSW SES (2017) *Coffs Harbour Local Flood Plan, A Sub-Plan of the Coffs Harbour Local Emergency Management Plan (EMPLAN*)

Argyll Estate, Coffs Harbour Flood Risk Assessment

Location of Argyll Estate, Coffs Harbour

Legend

Site Boundary

FIGURE 1

1:35,000 Scale at A3

0 400 800 1,200 1,600 2,000 m

N

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2021-7-19| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Indicative renewal plan

Argyll Estate, Coffs Harbour Flood Risk Assessment

Scenario E3
Planning Proposal

FIGURE 2

Not on Scale

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Indicative renewal plan

Argyll Estate, Coffs Harbour Flood Risk Assessment

Scenario E3
Planning Proposal

FIGURE 2

Not on Scale

0 40 80 120 160 200 m

Cardno now Stantec

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Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Indicative renewal plan

Argyll Estate, Coffs Harbour Flood Risk Assessment

Scenario E3
Planning Proposal

FIGURE 2

Not on Scale

0 40 80 120 160 200 m

Cardno now Stantec

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Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Indicative renewal plan

Argyll Estate, Coffs Harbour Flood Risk Assessment

Scenario E3
Planning Proposal

FIGURE 2

Not on Scale

0 40 80 120 160 200 m

Cardno now Stantec

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Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

Scenario E3
Roughness Zones

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCAN LANE
GILLIES CLOSE
NIOKA PLACE
MYUNA PLACE
NAMOI PLACE
KANE CRESCENT
HUGHES CLOSE
GRANT CLOSE
HANNAFORD PLACE
GOSLING CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL STREET
ARGYLL PLACE
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
BAILEY AVENUE
LUCAS AVENUE

Legend

- Cadastre
- Site Boundary copy

Roughness Zone

- Pasture and Gardens (n=0.06)
- Urban (n=0.06)
- Industrial (n=0.04)
- Road Easement (n=0.03)
- Dense Vegetation (n=0.12)
- Creek (Upper Catchment) (n=0.08)
- Buildings (n=1)
- Creek (Middle Catchment) (n=0.06)
- Heavy Vegetation (n=0.1)
- Buildings Specified (n=0.12)

FIGURE 3

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

5% AEP
Future Conditions
Flood Levels and Flood Depths

Legend

- Cadastre
- Site Boundary
- 0.2m Flood Level Contour (m)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 4

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

5% AEP
Future Conditions
Combine Flood Hazards

Legend

- Cadastre
- Site Boundary

Combined Flood Hazards

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 5

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Future Conditions
Flood Levels and Flood Depths

Legend

- Cadastre
- Site Boundary
- 0.2m Flood Level Contour (m)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 6

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

1% AEP
Future Conditions
Combine Flood Hazards

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCAN LANE
GILLIES CLOSE
NIOKA PLACE
MYUNA PLACE
KANE CRESCENT
HANNAFORD PLACE
GOSLING CLOSE
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL PLACE
ARGYLL STREET
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
LUCAS AVENUE
BAILEY AVENUE

Legend

- Cadastre
- Site Boundary

Combined Flood Hazards

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 7

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

0.2% AEP
Future Conditions
Flood Levels and Flood Depths

Legend

- Cadastre
- Site Boundary
- 0.2m Flood Level Contour (m)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 8

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

0.2% AEP
Future Conditions
Combine Flood Hazards

Legend

- Cadastre
- Site Boundary

Combined Flood Hazards

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 9

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

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Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

PMF
Future Conditions
Flood Levels and Flood Depths

Legend

- Cadastre
- Site Boundary
- 0.2m Flood Level Contour (m)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 10

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

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Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

PMF
Future Conditions
Combine Flood Hazards

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCAN LANE
NIOKA PLACE
GILLIES CLOSE
MYUNA PLACE
KANE CRESCENT
HANNAFORD PLACE
GOSLING CLOSE
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL PLACE
ARGYLL STREET
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
BAILEY AVENUE
LUCAS AVENUE

Legend

- Cadastre
- Site Boundary

Combined Flood Hazards

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 11

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

5% AEP
Future Conditions - Existing Conditions
Water Level Differences

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 12

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCAN LANE
GILLIES CLOSE
NIOKA PLACE
MYUNA PLACE
KANE CRESCENT
HANNAFORD PLACE
GOSLING CLOSE
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL STREET
ARGYLL PLACE
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
BAILEY AVENUE
LUCAS AVENUE

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Future Conditions - Existing Conditions
Water Level Differences

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCAN LANE
GILLIES CLOSE
NIOKA PLACE
MYUNA PLACE
KANE CRESCENT
HANNAFORD PLACE
GOSLING CLOSE
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL STREET
ARGYLL PLACE
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
BAILEY AVENUE
LUCAS AVENUE

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 13

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

0.2% AEP
Future Conditions - Existing Conditions
Water Level Differences

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCAN LANE
GILLIES CLOSE
NIOKA PLACE
MYUNA PLACE
KANE CRESCENT
HANNAFORD PLACE
GOSLING CLOSE
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL STREET
ARGYLL PLACE
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
BAILEY AVENUE
LUCAS AVENUE

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 14

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

PMF
Future Conditions - Existing Conditions
Water Level Differences

TALOUMBI ROAD
MASTRACOLAS ROAD
TOSCANI LANE
NIOKA PLACE
GILLIES CLOSE
MYUNA PLACE
KANE CRESCENT
HANNAFORD PLACE
GOSLING CLOSE
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
DIANNE CLOSE
MICHELLE CLOSE
KATHERINE CLOSE
BRAY STREET
FREDERICK STREET
KURRAJONG STREET
ELM STREET
PACIFIC HIGHWAY
SUSAN CLOSE
RAYMOND STREET
ARGYLL STREET
ARGYLL PLACE
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE
BAILEY AVENUE
LUCAS AVENUE

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 15

1:4,000 Scale at A3

0 40 80 120 160 200 m

N

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

APPENDIX A
MEMORANDUM

Cardno
Shaping the Future

1. What are the Flood Risks and what solutions could be available:

- Understanding the flood risk and Implications (for development and site access)

Flood Risks:

Flood risks are identified in the Flood Risk Assessment, Argyll Estate, Coffs Harbour (Cardno, 2021)

See highlighted properties in Attachment A.

See also additional Flood Hazard Category mapping appended in Attachment B. It is noted that

- *H1 conditions would be trafficable for small vehicles.*
- *H1 and H2 conditions would be trafficable for larger vehicles.*
- *Evacuation of eastern properties towards the west via local roads could be a challenge due to H3 areas on sections of local roads. Evacuation would be more of a challenge in the PMF.*

See also hazardous conditions at five locations on local roads appended in Attachment C.

- *The duration of hazardous conditions at several key locations on local roads was estimated by extracting the depth v time and velocity v time at the locations identified in Figure C.1.*
- *The maximum flood depth and velocity at the five locations are given in Table C.1 for the 1% AEP 2 hour and 9 hour storm bursts and 2 hour, 3 hour and 6 hour Probable Maximum Precipitation Design Floods (PMF)*
- *The indicative durations during which conditions at the five locations exceed H1 conditions are given in Table C.2. It is noted that Location P5 is highly problematic which accords with its mapping as a floodway.*
- *Table C.3 summarise the indicative elapsed time between the start of the design storm burst and the onset of H1 Conditions at the five locations. This is an indicator of the time available to evacuate in the absence of a flood warning based on a rainfall forecast.*

Constraints on Redevelopment

Coffs Harbour DCP, 2015:

- *Development is to be designed and located so that it is free from any land that is at or below the 100- year Average Recurrence Interval flood level.*
- *Exception - Development (including fill) may be supported below the 100-year Average Recurrence Interval flood level provided that:*
  - *no net filling is undertaken with the Coffs Creek Catchment west of the highway excluding balanced earthworks which may be supported subject to a merit assessment*
  - *development proposals resulting in an increase in flood levels on adjoining land may be supported where consent is obtained from affected land owners agreeing to such increases*
- *Development is to be designed and located so that it is free from any floodways.*
- *Development is not to result in an increase in flood levels on adjoining or surround land*

Attachment D indicates that current residential buildings are included within the 1% AEP flood extent but not on lots between the 1% AEP and PMF extent.

Buildings outside the 1% AEP flood extent are not included in Council's floodplain model.

Conclusions

- *Within the 1% AEP flood extent, replacing the current building with a two-storey dwelling of the same footprint would create negligible impact in a 1% AEP flood*
- *Outside the 1% AEP flood extent, any new building would have nil impact on 1% AEP flood levels.*

- What measures can be taken to get above the flood levels, specifically relating to site access issues

Coffs Harbour DCP, 2015:

Exceptions - Development (including fill) may be supported below the 100-year Average Recurrence Interval flood level provided that:

- *no net filling is undertaken with the Coffs Creek Catchment west of the highway excluding balanced earthworks which may be supported subject to a merit assessment*
- *development proposals resulting in an increase in flood levels on adjoining land may be supported where consent is obtained from affected land owners agreeing to such increases*

Approaches to respond to Flood Risks

Flood mitigation options:

- *Reduce hydraulic roughness outside riparian corridor to reduce flood levels by reducing floodplain roughness. Issues could include: environmental impact of removing current vegetation, land ownership, long term maintenance (mowing) of corridors.*
- *Swales in certain areas to capture overland flows and to convey the flows away from properties to an existing open space corridor. Issues could include: available land for swale, driveway crossings, blockage of driveway crossings, long term maintenance (mowing) of swale.*
- *Earthworks within properties to raise ground levels and/or divert overland flows. Issues could include: need to achieve balanced earthworks on individual properties or across contiguous properties owned by LAHC, potential impacts on local flood levels.*

Council may be already assessed one or more of these options?

Evacuation versus Shelter in Place:

Redeveloping properties without resorting to flood mitigations measures ie. redeveloping in a manner which responds to the risk to property and to life.

Considerations include:

Evacuation – The floodplain west of the Highway experiences flash flooding (short duration – hours only). If the aim is evacuation, then is a flash flood warning system in place? If no, who would fund the installation of a system. Who would operate a system? Are there feasible evacuation routes? How quickly do routes become unsafe for small vehicles (H1) or larger vehicles (say H2). Where would be the destination for evacuated residents given the short warning times eg. it would take 24 hours to open an evacuation centre (?) This is of little use unless authorities rely on a long term weather forecast?

Shelter in Place (1-storey or 2-storey) – feasible given duration of flooding before roads become passable again. Attachment E maps the difference between the Flood Planning Level (FPL) and the PMF level. The built form would be guided by Attachment C.

On lots where the FPL is higher than the PMF level (blue zones) then a ground floor level set at the FPL would permit shelter in place on the ground floor

On lots where the PMF is higher than the FPL (orange zones) then a ground floor level set at the FPL would be inundated consequently a second storey would be required to which residents could retreat.

One or more generic Flood Emergency Response Plans could be prepared to inform all residents living in LAHC properties of the flood risks and how to safely respond to floods.

Attachment A

Flood Risks on LAHC Properties

For each LAHC property the following was estimated:

- The fraction of the lot classified as Floodway or Flood Storage or Flood Fringe (from Figure 7, Cardno, 2021), and
- The fraction of the lot classified as Low, Medium or High Flood Risk and/or High Flood Risk Flow Corridor (from Figure 8, Cardno, 2021)

This information is summarised in the attached table.

It is noted from Figure 7 in Cardno, 2021 that a number of roads are mapped as floodways in the 1% AEP flood. These include sections of Argyll Street, Kurrajong Street, Bray Street and Elm Street. Depending on the time it takes for these conditions to be reached in a 1% AEP flood on these streets these conditions have the potential to constrain evacuation of residents from properties during major floods (see also **Attachment B**).

This summary table identifies a number of properties which have significant constraints due the mapped 1% AEP floodway either completely covering the lot (51 Argyll Street and 53 Argyll Street and 10 Maple Street) or covering a significant proportion of the lot (47 Argyll Street, 59 Argyll Street, 61 Argyll Street, 12 Deborah Close and 3 Frederick Street).

The floodway which crosses through 10 Maple Street and across the head of Maple Street also poses a significant challenge to any evacuation of residents from 12 Maple Street and 13 Maple Street.

NW30163 Argyll Estate, Coffs Harbour

Property ID	Address No.	Address Street	1% AEP Hydraulic Category: Floodway 3	Flood Storage 2	Flood Fringe 1	Flood Risk Precinct: High Flow Corridor 4	High 3	Medium 2	Low 1
11	11	Argyll Pl			3			3	98
13	13	Argyll St			4			4	96
14	14	Argyll St			35			35	65
16	16	Argyll St			29			29	71
17	17	Argyll St							100
18	18	Argyll St			43			43	57
22	22	Argyll St			95			95	5
24	24	Argyll St			88			88	12
25	25	Argyll St			5			5	95
28	28	Argyll St			30			30	70
30	30	Argyll St			40			40	60
31	31	Argyll St			1			1	99
32	32	Argyll St			5			5	95
33	33	Argyll St			1			1	99
35	35	Argyll St			0			0	100
38	38	Argyll St			1			1	100
40	40	Argyll St			4			4	96
41	41	Argyll St			13			13	87
42	42	Argyll St			3			3	97
43	43	Argyll St			28			28	72
45	45	Argyll St	5	6	58		5	64	32
47	47	Argyll St	32	10	58	0	32	68	
51	51	Argyll St	99	1		2	97	1	
52	52	Argyll St	1	7	13		1	19	68
53	53	Argyll St	100				100		
56	56	Argyll St	10	11	22		10	33	57
58	58	Argyll St	4	16	26		4	42	53
59	59	Argyll St	45	36	19		45	55	
61	61	Argyll St	56	22	23		56	44	
65	65	Argyll St	11	1	75		11	76	14
67	67	Argyll St			80			80	20
69	69	Argyll St			72			72	28
71	71	Argyll St			71			71	29
73	73	Argyll St			69			69	31
75	75	Argyll St	0		78		0	78	22
76	76	Argyll St			3			3	87
79	79	Argyll St			65			65	35
83	83	Argyll St	0	15	63		0	78	22
3	3	Bradley St			1			1	92
4	4	Bradley St			3			3	97
5	5	Bradley St			3			3	97
17	17	Bray St			79			79	21
21	21	Bray St			73			73	27
23	23	Bray St	1		96		1	96	4
29	29	Bray St	4	7	90		4	96	
33	33	Bray St			46			46	54
35	35	Bray St			15			15	85
37	37	Bray St			7			7	93
39	39	Bray St			1			1	100
43	43	Bray St			100			100	
45	45	Bray St			98			98	2
47	47	Bray St	4		94		4	94	2
3	3	Deborah Cl			14			14	86
8	8	Deborah Cl	4	11	78		4	89	7
9	9	Deborah Cl		0	88			88	12
12	12	Deborah Cl	34	0	63		34	63	3
3	3	Elm St	2		44		2	44	54
5	5	Elm St	1		52		1	52	47
6	6	Elm St	8		70		8	70	22
7	7	Elm St	7		88		7	88	5
8	8	Elm St	7		82		7	82	11
9	9	Elm St			18			18	82
10	10	Elm St	3		91		3	91	6
12	12	Elm St	0		94		0	94	6
15	15	Elm St			76			76	24
3	3	Frederick St	47	21	31	11	35	52	2
4	4	Frederick St	26	45	29		26	74	
5	5	Frederick St	1	15	38		1	53	45
6	6	Frederick St	9	13	75		9	88	3
8	8	Frederick St		0	13			13	84
10	10	Frederick St			0			0	34
14	14	Frederick St							
17	17	Frederick St							11
19	19	Frederick St							9

Property ID	Address No.	Address Street	1% AEP Hydraulic Category: Floodway 3	Flood Storage 2	Flood Fringe 1	Flood Risk Precinct: High Flow Corridor 4	High 3	Medium 2	Low 1
21	21	Frederick St							22
22	22	Frederick St							
23	23	Frederick St							3
24	24	Frederick St							
25	25	Frederick St							
26	26	Frederick St							0
28	28	Frederick St			2			2	54
6	6	Kurrajong St	0		27		0	27	73
7	7	Kurrajong St	1		29		1	29	69
9	9	Kurrajong St	0		37		0	37	63
10	10	Kurrajong St	0		29		0	29	71
14	14	Kurrajong St	0		69		0	69	31
17	17	Kurrajong St			100			100	
18	18	Kurrajong St	0		44		0	44	56
19	19	Kurrajong St			100			100	
20	20	Kurrajong St	0		20		0	20	80
21	21	Kurrajong St	0		100		0	100	
22	22	Kurrajong St			32			32	68
25	25	Kurrajong St	5		95		5	95	1
26	26	Kurrajong St			78			78	22
27	27	Kurrajong St	1		83		1	83	15
30	30	Kurrajong St			92			92	8
31	31	Kurrajong St	0		35		0	35	65
32	32	Kurrajong St			88			88	13
38	38	Kurrajong St			74			74	26
40	40	Kurrajong St			85			85	15
41	41	Kurrajong St							100
42	42	Kurrajong St			77			77	23
51	51	Kurrajong St							98
54	54	Kurrajong St		2	38			40	60
55	55	Kurrajong St							85
58	58	Kurrajong St			31			31	69
60	60	Kurrajong St			35			35	65
61	61	Kurrajong St							99
63	63	Kurrajong St							100
65	65	Kurrajong St							65
66	66	Kurrajong St	0		63		0	63	37
67	67	Kurrajong St							8
68	68	Kurrajong St			18			18	82
70	70	Kurrajong St							100
2	2	Maple St			3			3	97
3	3	Maple St			1			1	99
4	4	Maple St			57			57	43
6	6	Maple St			100			100	
8	8	Maple St	21	20	59		21	79	
10	10	Maple St	91	5	4		91	9	
12	12	Maple St	43	31	25		43	57	
13	13	Maple St	17	52	32		17	83	
5	5	Raymond St							45
6	6	Raymond St							96
7	7	Raymond St							57
8	8	Raymond St							27

Attachment B

Flood Hazard Categories

Figure 11 1% AEP Flood Hazard Category

Figure 12 PMF Hazard Category

The 2013 AEMHS Handbook 7 “Managing the floodplain: a guide to best practice in flood risk management in Australia” *has been developed with consideration of the National strategy for disaster resilience (COAG 2011), and the findings of recent State and national reviews following the multiple flood events of 2010 to 2012 that resulted in widespread flooding. It is intended to provide broad advice on all important aspects in managing flood risk in Australia*.

The supporting document titled “Technical flood risk management guideline: Flood Hazard” includes a plot of flood hazard vulnerability curves based on six categories H1 – H6 as shown below.

The flood hazard categories on the Argyll Estate in a 1% AEP flood and the PMF under Benchmark Conditions are plotted in **Figures 11 – 12** respectively.

It is noted that H1 and H2 conditions would be trafficable for larger vehicles.

Argyll Estate, Coffs Harbour Flood Risk Assessment

Combined Hazard Category
1% AEP

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

Combined Flood Hazard

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 11

1:3,500 Scale at A3

0 40 80 120 160 200 m

N

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Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

Combined Hazard Category
PMF

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

Combined Flood Hazard

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 12

1:3,500 Scale at A3

0 40 80 120 160 200 m

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Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Attachment C

Hazardous Conditions on Local Roads

The duration of hazardous conditions at several key locations on local roads was estimated by extracting the depth v time and velocity v time at the locations identified in Figure C.1.

The maximum flood depth and velocity at the five locations are given in **Table C.1** for the 1% AEP 2 hour and 9 hour storm bursts and 2 hour, 3 hour and 6 hour Probable Maximum Precipitation Design Floods (PMF)

The indicative durations during which conditions at the five locations exceed H1 conditions are given in **Table C.2**. It is noted that Location P5 is highly problematic which accords with its mapping as a floodway.

Table C.3 summarise the indicative elapsed time between the start of the design storm burst and the onset of H1 Conditions at the five locations. This is an indicator of the time available to evacuate in the absence of a flood warning based on a rainfall forecast.

Figure C.1 Road Reference Locations

Table C.1 Maximum Depth (m) and Velocity (m/s) at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP 2 hr Burst	1% AEP 9 hr Burst	PMF 2 hr PMP	PMF 3 hr PMP	PMF 6 hr PMP	
P1	0.458	0.425	1.134	1.037	1.007	Depth (m)
	1.225	1.173	1.431	1.496	1.386	Velocity (m/s)
P2	0.63	0.608	1.172	1.237	1.45	Depth (m)
	0.861	0.833	1.345	1.303	1.225	Velocity (m/s)
P3	0.603	0.585	1.307	1.528	1.741	Depth (m)
	1.126	1.096	1.259	1.207	1.233	Velocity (m/s)
P4	0.842	0.757	1.843	1.805	1.959	Depth (m)
	0.649	0.593	0.93	0.921	0.897	Velocity (m/s)
P5	1.229	1.144	2.224	2.169	2.051	Depth (m)
	0.466	0.374	1.976	1.867	1.666	Velocity (m/s)

Table C.2 Indicative Durations (hours) that H1 Conditions are exceeded at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP 2 hr Burst	1% AEP 9 hr Burst	PMF 2 hr PMP	PMF 3 hr PMP	PMF 6 hr PMP
P1	1.25	1.5	2.25	3.0	5.25
P2	2.0	2.5	4.0	5.0	7.0
P3	2.0	4.5	4.5	5.5	7.0
P4	2.5	5.0	4.75	5.75	7.5
P5	>5	>9	7.5	7.5	8.75

Table C.3 Indicative Time (hours) between Start of Storm Burst and H1 Conditions being exceeded at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP 2 hr Burst	1% AEP 9 hr Burst	PMF 2 hr PMP	PMF 3 hr PMP	PMF 6 hr PMP
P1	0.75	5.0	0.5	0.8	1.25
P2	0.75	4.75	0.5	0.8	1.25
P3	0.75	3.0	0.5	0.75	1.25
P4	1.0	3.0	0.5	0.75	1.5
P5	1.0	2.75	0.5	1.0	1.5

Attachment D

Roughness Zones

Argyll Estate, Coffs Harbour Flood Risk Assessment

Roughness Zone with 1% Flood Extent 1% AEP

Legend

- LAHC Lot Boundary
- Site Boundary
- 1% AEP Flood Extent

Roughness Zone

- Pasture and Gardens (n=0.06)
- Urban (n=0.06)
- Industrial (n=0.04)
- Road Easement (n=0.03)
- Dense Vegetation (n=0.12)
- Creek(Upper Catchement) (n=0.08)
- Buildings (n=1.00)
- Creek(Middle Catchement) (n=0.06)
- Creek Transition (n=0.045)
- Creek/Entrance Transition (n=0.03)
- Heavy Vegetation (n=0.10)
- Entrance (n=0.02)
- Creek/Entrance Transition (n=0.025)

FIGURE 13

1:3,500 Scale at A3

0 40 80 120 160 200 m

N

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Argyll Estate, Coffs Harbour Flood Risk Assessment

Roughness Zone with PMF Flood Extent
PMF

Legend

- LAHC Lot Boundary
- Site Boundary
- PMF Flood Extent

Roughness Zone

- Pasture and Gardens (n=0.06)
- Urban (n=0.06)
- Industrial (n=0.04)
- Road Easement (n=0.03)
- Dense Vegetation (n=0.12)
- Creek(Upper Catchement) (n=0.08)
- Buildings (n=1.00)
- Creek(Middle Catchement) (n=0.06)
- Creek Transition (n=0.045)
- Creek/Entrance Transition (n=0.03)
- Heavy Vegetation (n=0.10)
- Entrance (n=0.02)
- Creek/Entrance Transition (n=0.025)

FIGURE 14

1:3,500 Scale at A3

0 40 80 120 160 200 m

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Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Attachment E

Guide to Built Form to provide Flood Refuge on LAHC Properties

Figure 15 FPL minus PMF Level

Shelter in Place (1-storey or 2-storey) – feasible given duration of flooding before roads become passable again. Attachment C maps the difference between the Flood Planning Level (FPL) and the PMF level.

The built form would be guided by Figure 15:

- On lots where the FPL is higher than the PMF level (blue zones) then a ground floor level set at the FPL would permit shelter in place on the ground floor
- On lots where the PMF is higher than the FPL (orange zones) then a ground floor level set at the FPL would be inundated consequently a second storey would be required to which residents could retreat.

Argyll Estate, Coffs Harbour
Flood Risk Assessment

Flood Planning Level
Less
PMF Flood Level

Legend

- Cadastre
- LAHC
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE 9

1:3,500 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2021-8-17| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

APPENDIX B
DISCUSSION PAPER NO 1

Cardno
Shaping the Future

ARGYLL ESTATE, COFFS HARBOUR

FLOODING DISCUSSION PAPER

18 JANUARY 2022

SUMMARY

A visit to Argyll Estate was undertaken on 14 December 2021. During this visit several potential options to mitigate the flooding and/or flood risk in Argyll Estate were identified and were analysed to assess the 1% AEP flood level differences and which properties may be adversely impacted under each option.

A series of concept options were identified as summarised in **Table 4.**

The aim of the Option 1A runs was to assess the impact if any of additional overbank flood storage upstream of Bray Street. The aim of Option 1B v1, v2 and v3 runs were to assess the impact if any of additional overbank flood storage north of Bray Street and its ability to mitigate the impacts of Option 1A v2. The aim of the Option 2A and 2B runs were to assess the impact if any of re-grading the low point in Argyll Street to reduce the flood hazard in the low point. The aim of the Scheme 3A and 3B runs were to assess the degree to which the impacts of Option 1A v2 could be mitigated by diverting the overland flows that spill through the Kurrajong Street open space via culverts to the Argyll Branch. It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.

The options assessment disclosed that measures which would stop overflows from the Bray Street Arm that spill through the open space into Kurrajong Street in a 1% AEP flood would benefit residents in Kurrajong Street and Argyll Street but that this would be to the detriment of downstream properties fronting Bray Street, Hughes Close, Grant Close and Elm Street.

It was found that concept regrading of Argyll Street alone would have a very minor impact at the intersection of Raymond Street and Argyll Street but that the local impact on 1% AEP flood levels are sensitive to filling of parts of the residential lots south of Argyll Street in the vicinity of the low point.

The scheme which minimise but does not eliminate the impacts on 1% AEP flood levels downstream of the Bray Street crossing would be Scheme 3A.

The concept schemes have been formulated without any consideration of capital costs nor of the associated benefit cost ratio.

While Scheme 3A may be deemed feasible from an engineering perspective and that the benefits of flood risk reduction in Kurrajong Street, Elm Street and Argyll Street outweigh the local minor increases in 1% AEP flood levels elsewhere downstream of the Bray Street crossing, it me be determined that the capital costs outweigh the benefits to current and future residents.

If this is the case, then the only available approach is to redevelop LAHC properties in a manner which responds to the current flood risks and which aims to minimise any local impacts of re-development on 1% AEP flood levels.

1. BACKGROUND

1.1 Location

The location of the LAHC properties is indicated in **Figure 1**.

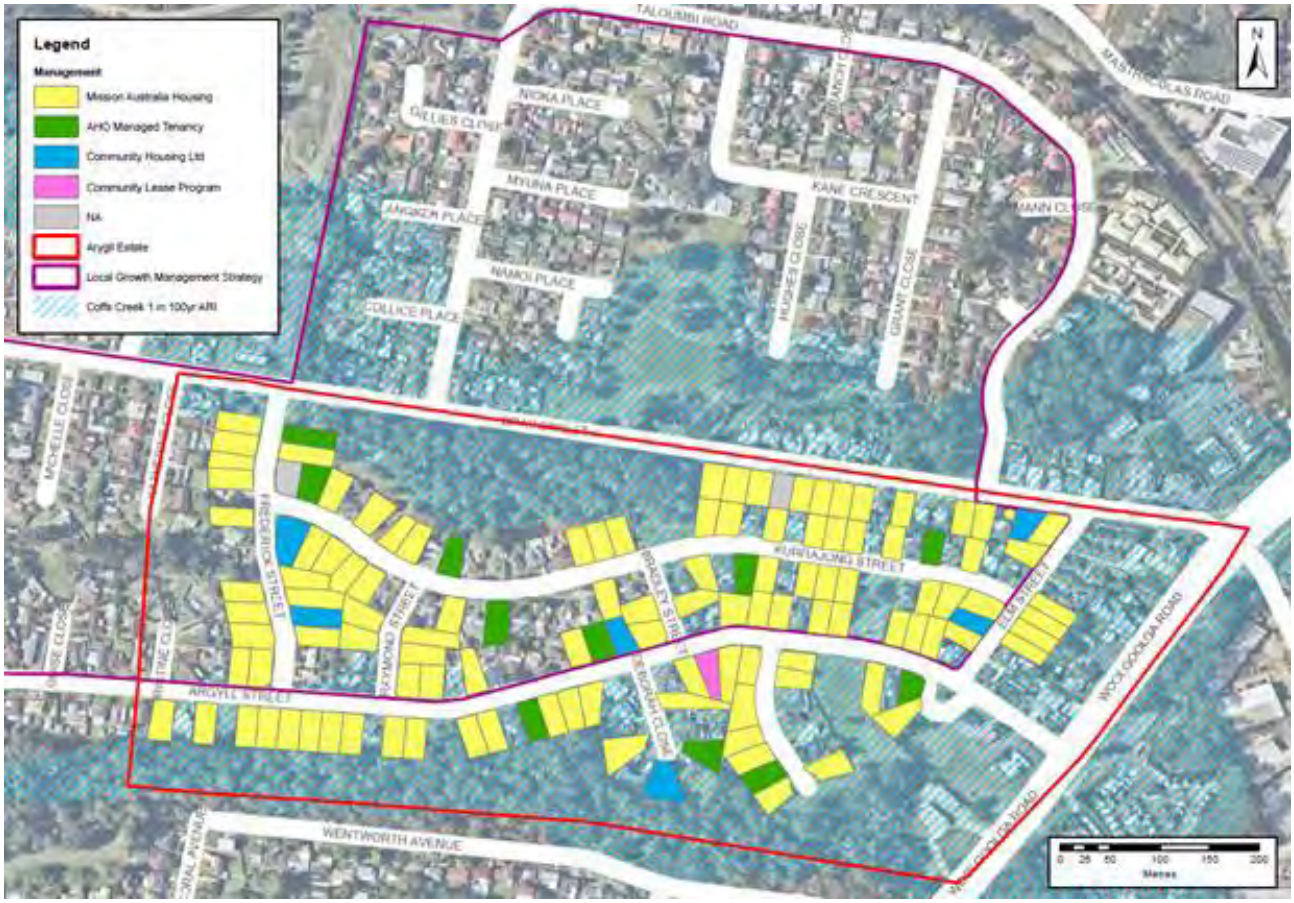


Figure 1 Location of Argyll Estate, Coffs Harbour

1.2 Previous Studies

The previous and current studies include:

- 2018 Coffs Creek and Park Beach Flood Study
- 2020 Coffs Creek Floodplain Risk Management Study and Plan Review

The 2020 study is ongoing and has not yet released updated design flows based on ARR2019.

Consequently, the hydrological and floodplain models assembled for the 2018 Coffs Creek and Park Beach Flood Study have been adopted for assessment purposes in the absence of any updated models from the 2020 Coffs Creek Floodplain Risk Management Study and Plan Review.

It is noted that Council has indicated that it is likely that the updated hydrological modelling will deliver peak design flows which are comparable to the 2018 estimates.

1.3 2018 Floodplain Models

As described in part by BMT WBM (2018):

> *… The hydrological model developed using XP-RAFTS software provides for simulation of the rainfall-runoff process using the catchment characteristics of the Coffs Creek catchment and historical and design rainfall data. The hydraulic model, simulating flood depths, extents and velocities utilises the TUFLOW two-dimensional (2D) software developed by BMT WBM. …..*
>
> *The floodplain topography is defined using a digital elevation model (DEM) derived from topographic, hydrographic and topographic survey data provided by Council. To supplement the available data, additional channel cross section survey of the Argyll Street branch of the Northern Tributaries of Coffs Creek was acquired during the course of the study.*

As described in part in Section 4.2.1 Topography by BMT WBM (2018):

> *For the Coffs Creek catchment, a 2m resolution gridded DEM was principally derived from the 2013 LiDAR data set, with components of the 2007 LiDAR utilised for calibration events.*
>
> *As discussed in Section 3, cross section survey of the watercourses was required to supplement the LiDAR data and provide the necessary detail on channel shape and dimensions for representation in the hydraulic model. The channel topography has been incorporated into the 2D model representation and is discussed further in Section 4.2.4.*

As described in part in Section 4.2.4 Channel Network by BMT WBM (2018):

> *… The approach adopted in this study involved embedding the channel topography within the 2D model domain. …. Due to the different nature of the creek channel upstream and downstream of the Pacific Highway, two different methods were adopted to define the width of the channel bed. Upstream of the Pacific Highway, the channel was lowered by one cell width (4m) to allow for a continuous flow path along the creek alignment.*

As described, in part, in Section 4.2.3 Hydraulic Roughness by BMT WBM (2018):

> *The development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are delineated from aerial photography and cadastral data identifying different land-uses (e.g. forest, cleared land, roads, urban areas, etc.) for modelling the variation in flow resistance. The hydraulic roughness is one of the principal calibration parameters within the hydraulic model and has a major influence on flow routing and flood levels. The roughness values adopted from the calibration process is discussed in Section 5.*

The spatial extent of the zones of adopted hydraulic roughness are plotted in **Figure 2**.

It is noted from Figure 2 that not all residential buildings were included in the floodplain model and instead only residential buildings on lots that experience inundation are included. These were represented as a very high roughness value (n = 1.0) irrespective of the height above ground level of the floor of each building.

Figure 2 Roughness Zones (Source: 2018 Coffs Creek and Park Beach Flood Study)

2. EXISTING CONDITIONS

2.1 Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels and extent and depths are plotted in **Figures 3, 4, 5** and **6** respectively. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree of inundation of individual properties in each flood.

2.2 Floodway, Flood Storage and Flood Fringe

The mapping of hydraulic categories (Floodway, Flood Storage, Flood Fringe) in a 1% AEP flood is given in **Figure 7.** The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the hydraulic categories.

2.3 True Hazard and Flood Risk Precincts

The mapping of true hazard and flood risk precincts is given in **Figure 8**. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the risk precincts.

2.4 Climate Change

BMT WBM (2018) tabulates estimated 1% AEP flood levels at selected locations under a range of climate change scenarios. The locations relevant to the LAHC properties are:

The estimated 1% AEP flood levels at locations H, I and J under a range of climate change scenarios are relevant for Argyll Estate. It is noted that 1% AEP flood levels in the Argyll Estate are estimated to increase up to 0.1 m only under a range of climate change scenarios which is well within Council's adopted freeboard of 0.5 m.

2.5 Flood Planning Area

The LAHC properties are identified in **Figure 9.**

The Flood Planning Area (FPA) identified by Council is mapped in **Figure 10**.

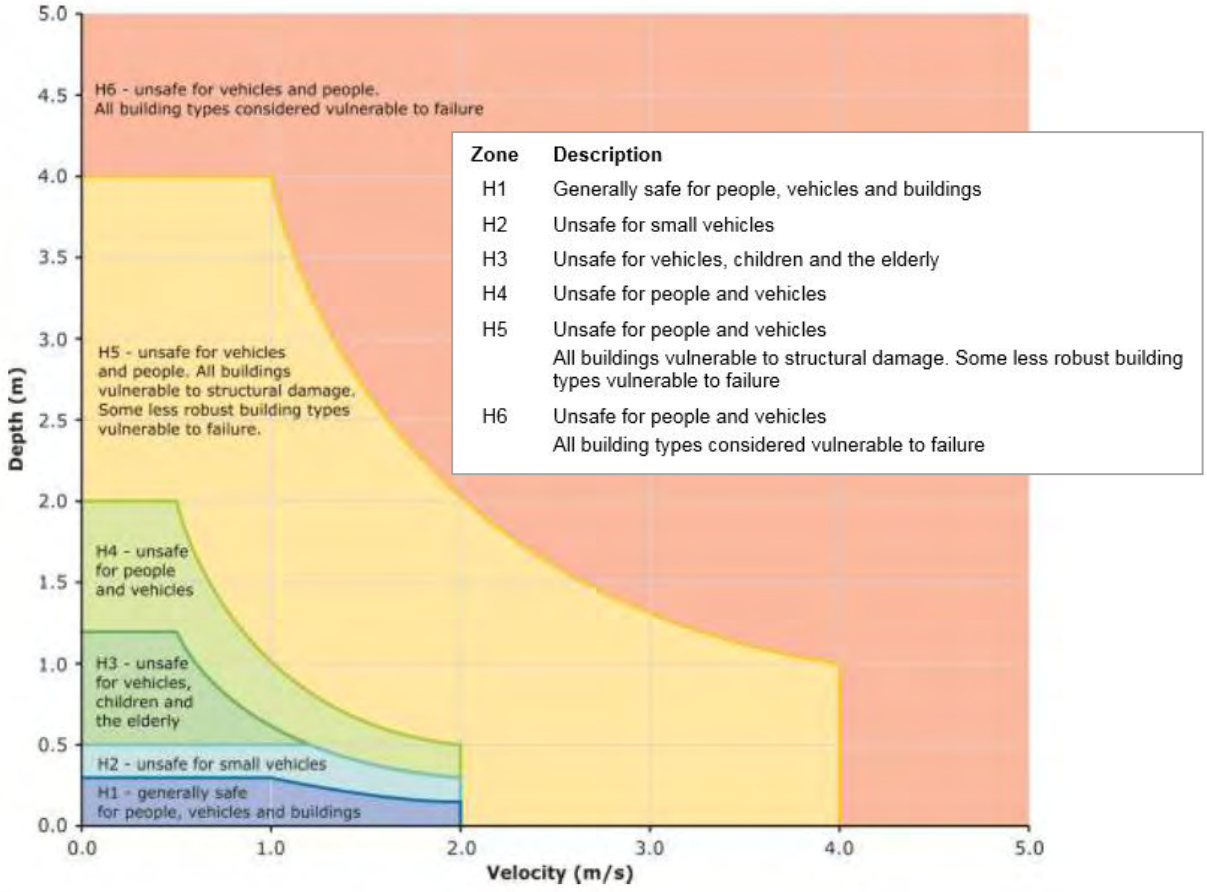
It will be noted that the FPA either partially or completely covers all LAHC properties. Consequently, Council's DCP flood planning requirements outlined in Section 4.3 of the Coffs Harbour Development Control Plan (DCP) 2015 apply to all LAHC properties.

2.6 Flood Hazard Categories

Flood hazard vulnerability curves based on six categories H1 – H6 are as shown below.

The flood hazard categories on the Argyll Estate in a 1% AEP flood and the PMF under Benchmark Conditions are plotted in **Figures 11 – 12** respectively.

It is noted that H1 and H2 conditions would be trafficable for larger vehicles.



2.7 Hazardous Conditions on Local Roads

The critical storm burst durations for 1% AEP flooding are 2 hours and 9 hours. **Figure 13** plots the differences between the 1% AEP flood levels estimated in a 9 hour storm burst in comparison to a 2 hour storm burst. It is noted from **Figure 13 t**hat the 1% AEP 2 hour storm burst is critical west of the Pacific Highway while the 9 hour burst is critical east of the Pacific Highway.

The duration of hazardous conditions at several key locations on local roads was estimated by extracting the depth v time and velocity v time at the locations identified in **Figure 14**.

The maximum flood depth and velocity at the five locations are given in **Table 1** for the 1% AEP 2 hour and 9 hour storm bursts and 2 hour, 3 hour and 6 hour Probable Maximum Precipitation Design Floods (PMF).

The indicative durations during which conditions at the five locations exceed H1 conditions are given in **Table 2**. It is noted that Location P5 is highly problematic which accords with its mapping as a floodway.

Table 3 summarise the indicative elapsed time between the start of the design storm burst and the onset of H1 Conditions at the five locations. This is an indicator of the time available to evacuate in the absence of a flood warning based on a rainfall forecast.

Figure 14 Road Reference Locations

Table 1 Maximum Depth (m) and Velocity (m/s) at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP		PMF			
	2 hr Burst	9 hr Burst	2 hr PMP	3 hr PMP	6 hr PMP	
P1	0.458	0.425	1.134	1.037	1.007	Depth (m)
	1.225	1.173	1.431	1.496	1.386	Velocity (m/s)
P2	0.63	0.608	1.172	1.237	1.45	Depth (m)
	0.861	0.833	1.345	1.303	1.225	Velocity (m/s)
P3	0.603	0.585	1.307	1.528	1.741	Depth (m)
	1.126	1.096	1.259	1.207	1.233	Velocity (m/s)
P4	0.842	0.757	1.843	1.805	1.959	Depth (m)
	0.649	0.593	0.93	0.921	0.897	Velocity (m/s)
P5	1.229	1.144	2.224	2.169	2.051	Depth (m)
	0.466	0.374	1.976	1.867	1.666	Velocity (m/s)

Table 2 Indicative Durations (hours) that H1 Conditions are exceeded at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP		PMF		
	2 hr Burst	9 hr Burst	2 hr PMP	3 hr PMP	6 hr PMP
P1	1.25	1.5	2.25	3.0	5.25
P2	2.0	2.5	4.0	5.0	7.0
P3	2.0	4.5	4.5	5.5	7.0
P4	2.5	5.0	4.75	5.75	7.5
P5	>5	>9	7.5	7.5	8.75

Table 3 Indicative Time (hours) between Start of Storm Burst and H1 Conditions being exceeded at Various Road Locations in 1% AEP Floods and PMFs

Location	1% AEP		PMF		
	2 hr Burst	9 hr Burst	2 hr PMP	3 hr PMP	6 hr PMP
P1	0.75	5.0	0.5	0.8	1.25
P2	0.75	4.75	0.5	0.8	1.25
P3	0.75	3.0	0.5	0.75	1.25
P4	1.0	3.0	0.5	0.75	1.5
P5	1.0	2.75	0.5	1.0	1.5

3. CONCEPT FLOOD MITIGATION OPTIONS

A visit to Argyll Estate was undertaken on 14 December 2021. During this visit several potential options to mitigate the flooding and/or flood risk in Argyll Estate were identified.

Two primary zones were identified which are identified as Zone 1 and Zone 2 in **Figure A1**.

A series of concept options were identified as summarised in **Table 4.**

Table 4. Concept Flood Mitigation Options / Schemes for Argyll Estate

ID	Concept Option/Scheme	Comments
Kurrajong Street Reserve		
1A v1	This is a low levee along the rear property boundaries along Kurrajong Street tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. See **Figure A2.**	A concept 1.8 m levee height is notional only so that the actual 1% AEP depths along the levee can be estimated to refine the actual levee height The aim is to assess 1% AEP flood level differences and which properties may be adversely impacted.

1A v2	This is a low levee along the rear property boundaries along Kurrajong Street and to include additional open space before the levee is tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. A swale is included to drain floodwaters that would be otherwise trapped. See **Figure A3.**	The aim is to assess the impact if any of additional overbank flood storage upstream of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v1	This is Option 1A v2 + an additional shallow free draining storage area north of Bray Street. See **Figure A4.**	The aim is to assess the impact if any of additional overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v2	This is Option 1A v2 + an additional deeper free draining storage area north of Bray Street. See **Figure A5**.	The aim is to assess the impact if any of additional deeper overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v3	This is Option 1B v2 + a hydraulic connection to an existing natural basin. See **Figure A6**.	The aim is to assess the impact if any of connecting two overbank flood storages north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
Argyll St Low Point		
2A	This option is re-grading the low section of Argyll Street to reduce the 1% AEP flood hazard and to maintain vehicular evacuation along Argyll Street albeit through shallow floodwaters. See **Figure A7**.	The aim is to assess the impact if any of re-grading a section of Argyll Street on 1% AEP flood level differences and which properties may be adversely impacted.
2B	This is Option 2A + additional filling of parts of selected properties to reduce flood hazard and the hydraulic category of selected properties. See **Figure A8**.	The aim is to assess the impact if any of re-grading a section of Argyll Street as well as partial filling of selected lots on 1% AEP flood level differences and which properties may be adversely impacted.
Bray St Arm to Argyll Street Arm diversion Scheme		
3A	Option 1A v2 + Option 2A + Diversion Diversion properties: • 2 x1.2 (H) x 1.8m (W) RCBCs	The aim of the scheme is to mitigate the impact of Option 1A v2 by diverting the overland flow that spills through the park to the Argyll Branch via culverts.

	• D/S IL approx 5.5 m AHD • U/S IL approx 3.4 m AHD • Length = 380 m • Roughness = 0.015 • Inlet loss = 1.0 • Outlet loss = 2.0 See **Figure A9**.	It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse. The inlet and outlet losses account for intermediate bend losses. AS with the previous options we want to assess 1% AEP flood level differences and which properties may be adversely impacted.
3B	This is Option 3A with 2 x1.5 (H) x 1.8m (W) RCBCs instead of 2 x1.2 (H) x 1.8m (W) RCBCs. All other properties were unchanged.	The aim is to assess the impact if any of increasing the capacity of the diversion scheme on 1% AEP flood levels.

4. ASSESSMENT OF THE CONCEPT FLOOD MITIGATION OPTIONS

The floodplain model was modified to represent each of the options /schemes in turn and the 1% AEP 2 hour and 9 hour events were re-run. The flood level differences to the 1% AEP benchmark conditions (see Figure 3) were then plotted. The results are discussed as follows.

4.1 Option 1A

The aim of the Option 1A runs was to assess the impact if any of additional overbank flood storage upstream of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.

The 1% AEP flood differences for Options 1A v1 and 1A v2 are plotted respectively in **Figures B1** and **B2**.

It is concluded from **Figure B1** that while the construction of a levee which would stop overflows from the Bray Street Arm that spill through the open space into Kurrajong Street in a 1% AEP flood would benefit residents in Kurrajong Street and Argyll Street this would be to the detriment of downstream properties fronting Bray Street, Hughes Close, Grant Close and Elm Street. The local increases in the 1% AEP flood levels would be unacceptable.

The impact of Option 1A v2 would be a slight reduction of the adverse impacts downstream of the Bray Street crossing. The local increases in the 1% AEP flood levels would be unacceptable.

4.2 Option 1B

The aim of Option 1B v1, v2 and v3 runs were to assess the impact if any of additional overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.

The 1% AEP flood differences for Options 1B v1, 1B v2 and 1B v3 are plotted respectively in **Figures B3, B4** and **B5**.

It was concluded from **Figures B3, B4** and **B5** that:

(i) While Option 1B v1 would lower the 1% AEP flood levels in the basin it would also exacerbate the 1% AEP flood impacts downstream of the Bray Street crossing particularly at the rear of the properties on the western side of Hughes Close;

(ii) Option 1B v2 would further exacerbate 1% AEP flood impacts downstream of the Bray Street crossing particularly at the rear of the properties on the western side of Hughes Close;

(iii) Option 1B v3 would have a similar impact as Option 1B v2;

(iv) None of the basin options reduced the adverse impacts on 1% AEP flood levels along the bray Street Aram downstream of the Bray Street crossing.

(v) The local increases in the 1% AEP flood levels under Options 1B v1, 1B v2 and 1B v3 would be unacceptable.

4.2 Option 2

The aim of the Option 2A and 2B runs were to assess the impact if any of re-grading the low point in Argyll Street to reduce the flood hazard on 1% AEP flood level differences and which properties may be adversely impacted.

The 1% AEP flood differences for Options 2A and 2B are plotted respectively in **Figures B6** and **B7**.

It was concluded from **Figures B6** and **B7** that:

(i) The concept regrading of Argyll Street alone would have a very minor impact at the intersection of Raymond Street and Argyll Street;

(ii) The additional filling of part of the lots south of Argyll Street in the vicinity of the low point would local increase the 1% AEP flood level by around 0.05 m and would locally increase the 1% AEP flood level east from the low point along the Argyll Street corridor by 0.01 m – 0.05 m.

(iii) This indicates that the local impact on 1% AEP flood levels are sensitive to filling of parts of the residential lots south of Argyll Street in the vicinity of the low point.

4.3 Scheme 3

The aim of the Scheme 3A and 3B runs were to assess the degree to which the impacts of Option 1A v2 could be mitigated by diverting the overland flows that spill through the Kurrajong Street open space via culverts to the Argyll Branch. It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.

The 1% AEP flood differences for Schemes 3A and 3B are plotted respectively in **Figures B8** and **B9**.

It was concluded from **Figures B8** and **B9** that:

(i) The flow diversion would significantly reduce the adverse impacts of Option 1A v2;

(ii) While the 1% AEP flood impacts at the rear of the properties on the western side of Hughes Close are reduce to around 0.05 m these would be likely unacceptable;

(iii) There is no discernible difference between the impacts of Options 2A and 2B;

(iv) It is unclear if the apparent nil impact of increasing the height of the twin culverts by 0.3 m is:

- due to local hydraulic constraints in the open space which limit the 1% AEP flow which can be captured by the culverts; and/or
- due to part-full flow in the culverts which would be insensitive to increasing the height of the culvert due to the adopted concept invert levels.

(v) Lowering the concept upstream and downstream invert levels for the Scheme 3B diversion by 0.3 m may increase the flow in the culvert but only if the lowered invert levels still tie into the existing channel/swale levels.

5. DISCUSSION

The options assessment disclosed that measures which would stop overflows from the Bray Street Arm that spill through the open space into Kurrajong Street in a 1% AEP flood would benefit residents in Kurrajong Street and Argyll Street but that this would be to the detriment of downstream properties fronting Bray Street, Hughes Close, Grant Close and Elm Street.

It was found that concept regrading of Argyll Street alone would have a very minor impact at the intersection of Raymond Street and Argyll Street but that the local impact on 1% AEP flood levels are sensitive to filling of parts of the residential lots south of Argyll Street in the vicinity of the low point.

The scheme which minimise but does not eliminate the impacts on 1% AEP flood levels downstream of the Bray Street crossing would be Scheme 3A.

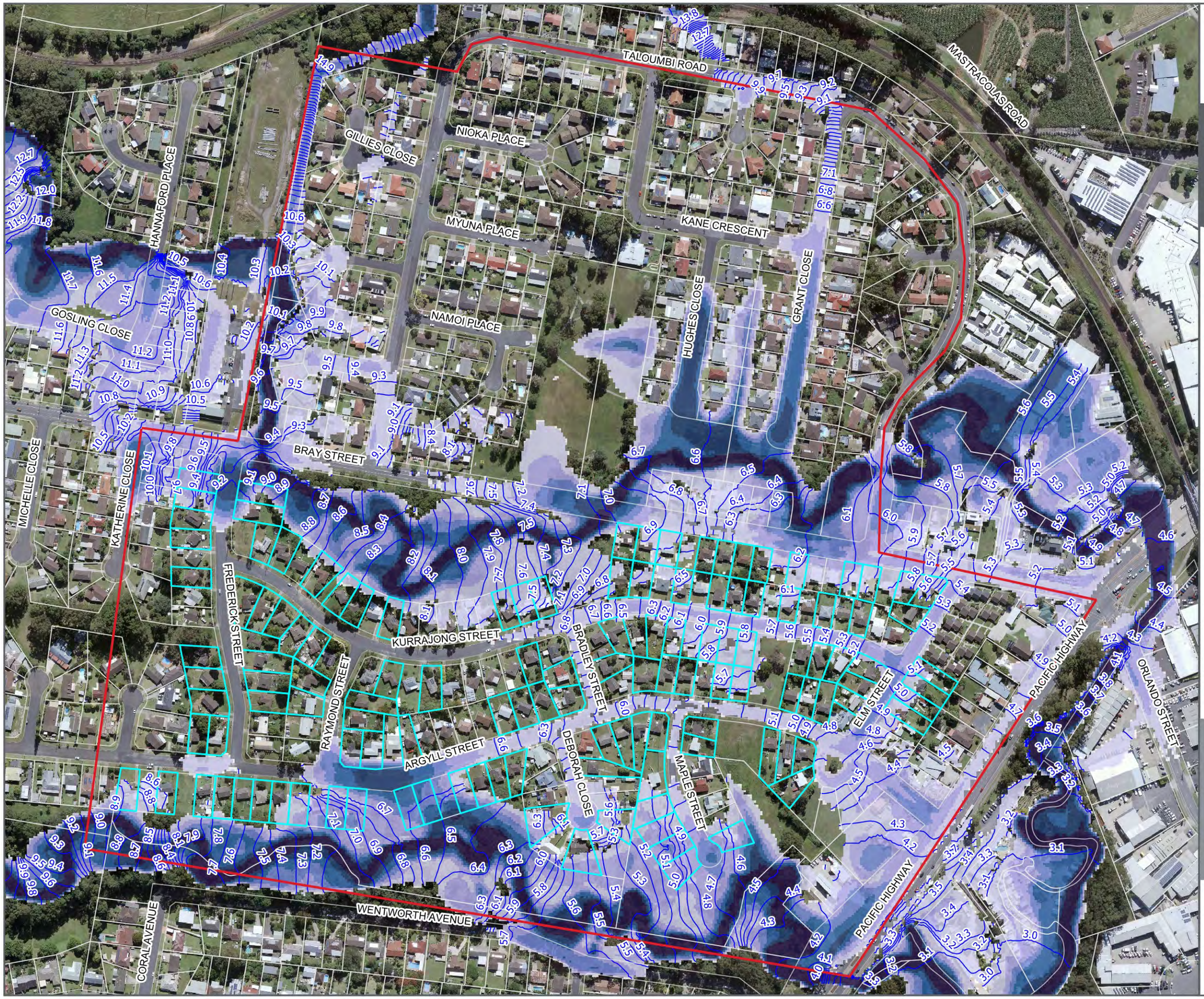
The concept schemes have been formulated without any consideration of capital costs nor of the associated benefit cost ratio.

While Scheme 3A may be deemed feasible from an engineering perspective and that the benefits of flood risk reduction in Kurrajong Street, Elm Street and Argyll Street outweigh the local minor increases in 1% AEP flood levels elsewhere downstream of the Bray Street crossing, it me be determined that the capital costs outweigh the benefits to current and future residents.

If this is the case, then the only available approach is to redevelop LAHC properties in a manner which responds to the current flood risks and which aims to minimise any local impacts of re-development on 1% AEP flood levels.

Argyll Estate, Coffs Harbour
Flood Risk Assessment

Benchmark Condition
Flood Levels and Flood Depths
5% AEP



Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary
- 0.1m Water Level Contour (mAHD)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 3

1:3,500 Scale at A3

0 40 80 120 160 200 m

N

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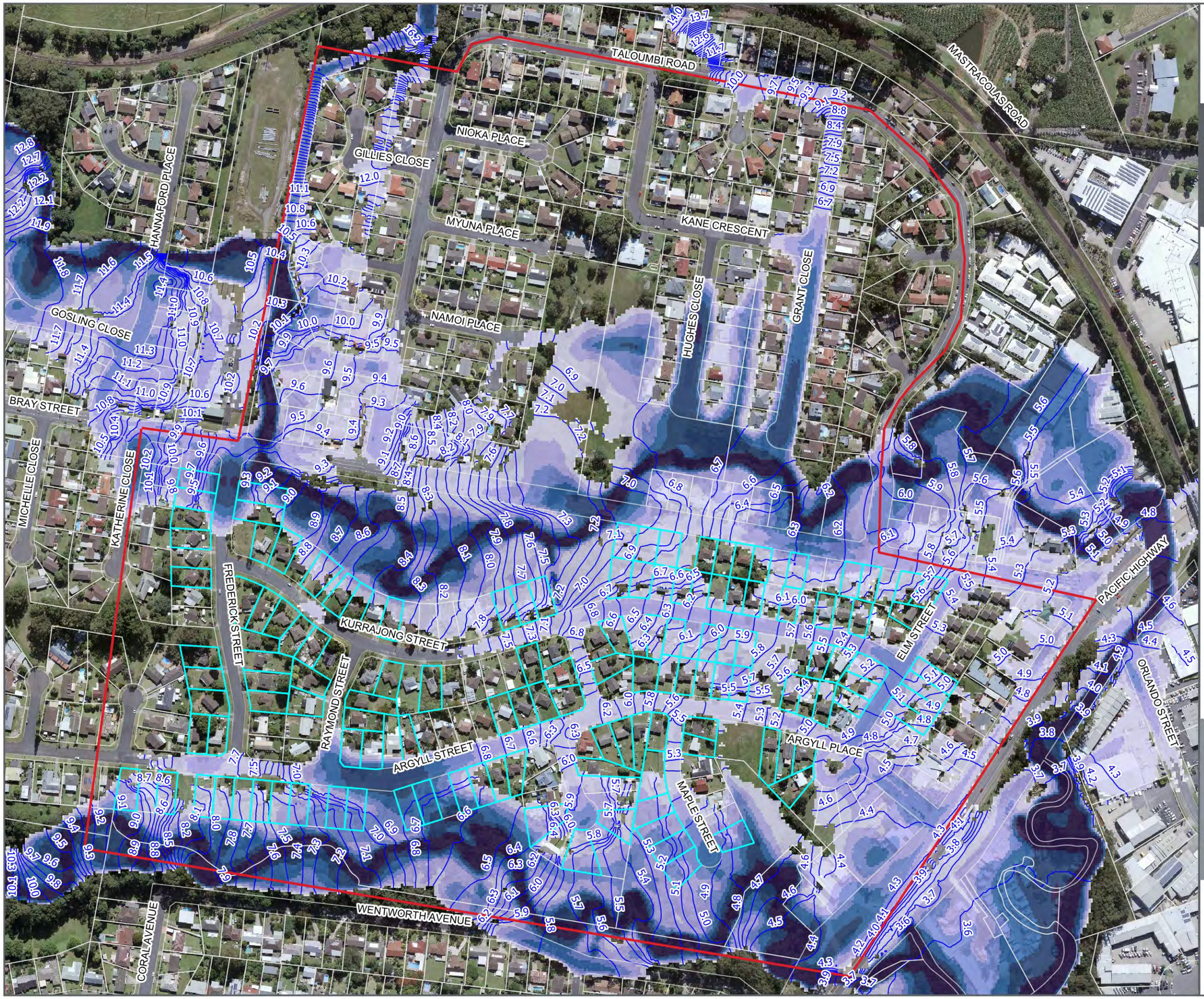
Argyll Estate, Coffs Harbour
Flood Risk Assessment

Benchmark Condition
Flood Levels and Flood Depths
1% AEP



Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary
- 0.1m Water Level Contour (mAHD)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 4

1:3,500 Scale at A3

0 40 80 120 160 200 m

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Argyll Estate, Coffs Harbour
Flood Risk Assessment

Benchmark Condition
Flood Levels and Flood Depths
0.2% AEP

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary
- 0.1m Water Level Contour (mAHD)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 5

1:3,500 Scale at A3

0 40 80 120 160 200 m

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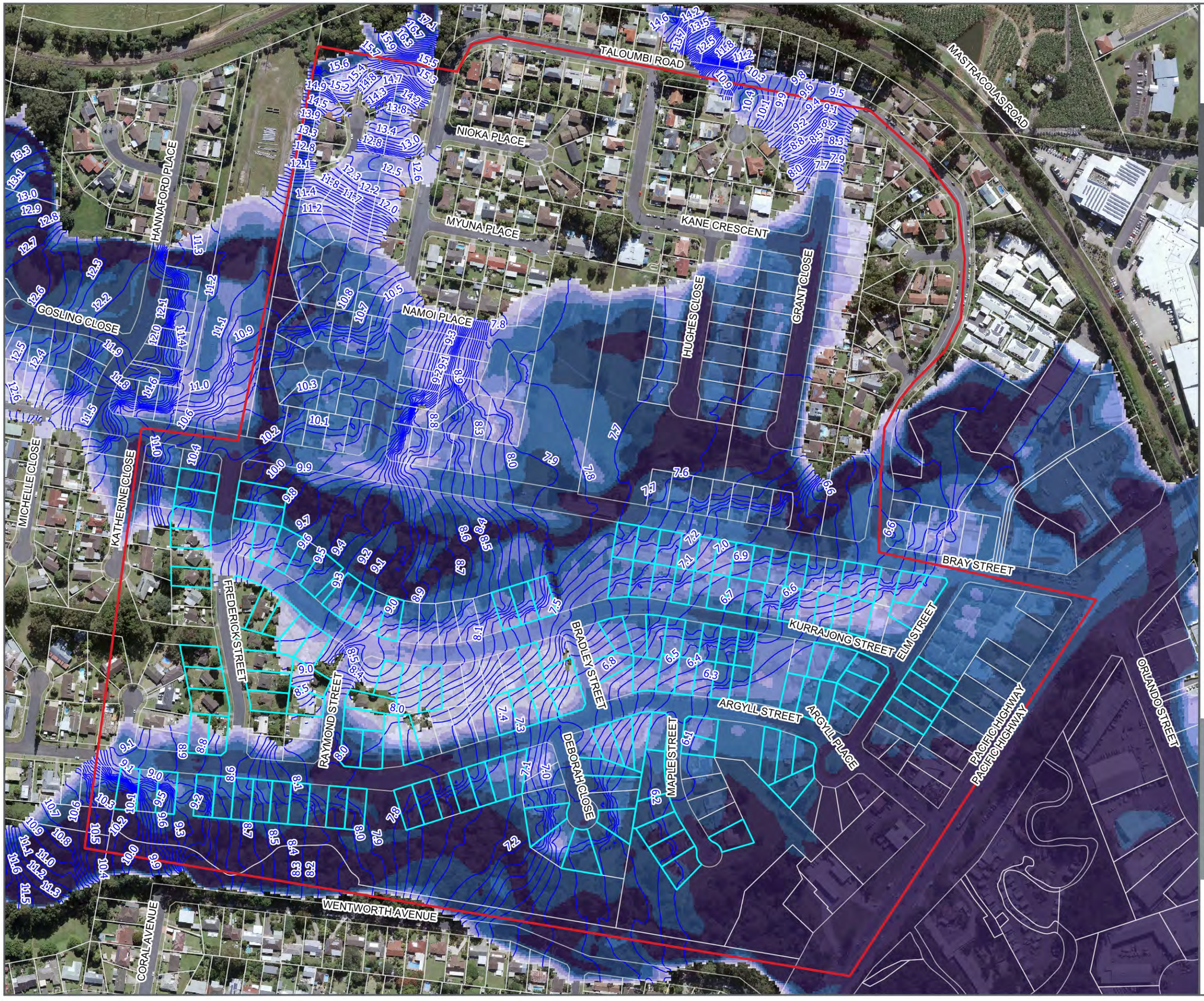
Argyll Estate, Coffs Harbour
Flood Risk Assessment

Benchmark Condition
Flood Levels and Flood Depths
PMF



Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary
- 0.1m Water Level Contour (mAHD)

Flood Depth (m)

- 0.00 to 0.10
- 0.10 to 0.30
- 0.30 to 0.50
- 0.50 to 0.70
- 0.70 to 1.00
- 1.00 to 1.50
- > 1.50

FIGURE 6

1:3,500 Scale at A3

0 40 80 120 160 200 m

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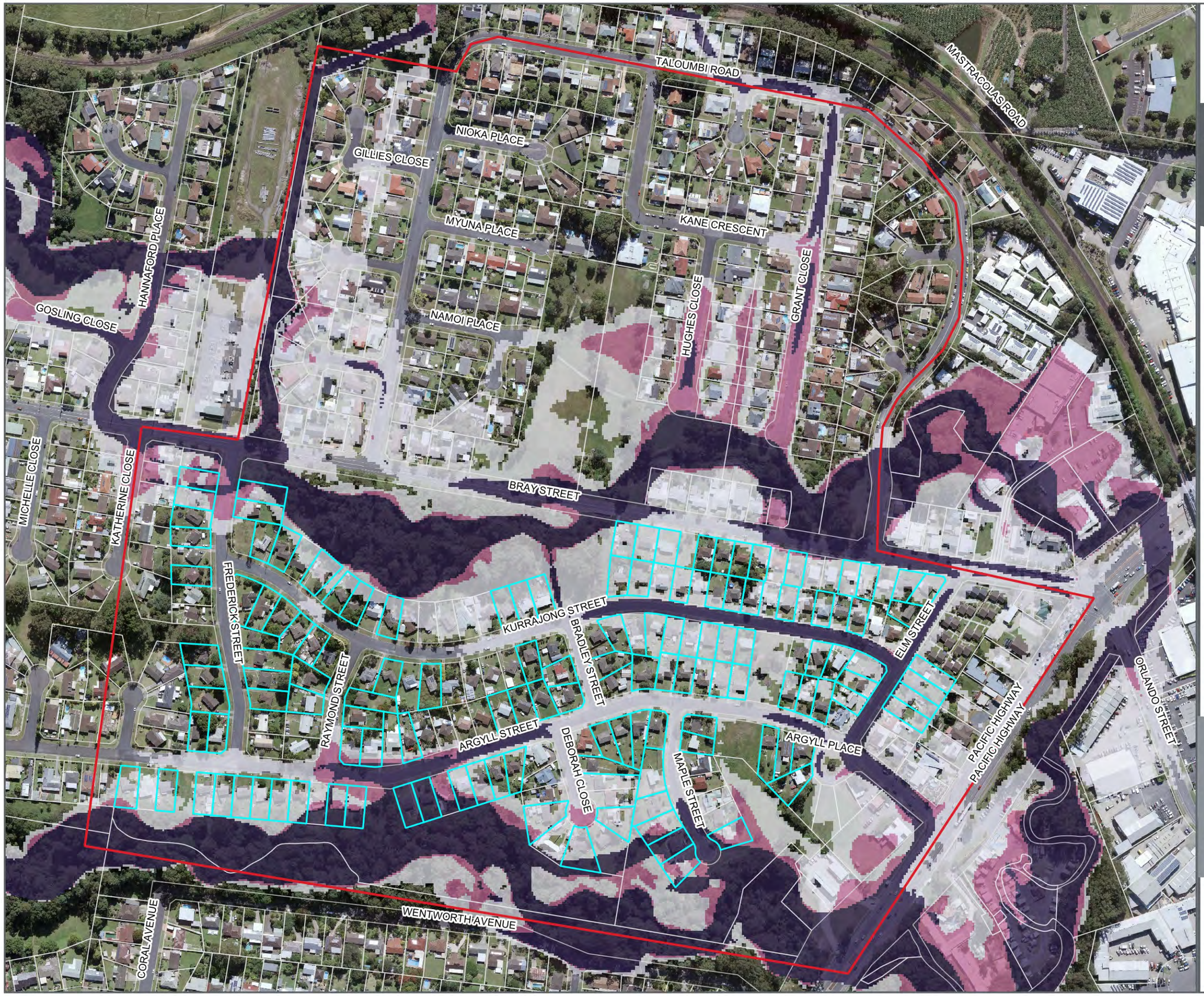
Argyll Estate, Coffs Harbour
Flood Risk Assessment

Benchmark Condition
Hydraulic Category
1% AEP



Legend

- CADASTRE NSW
- LAHC Lot Property
- Site Boundary

Hydraulic Category

- Flood Fringe
- Flood Storage
- Floodway

FIGURE 7

1:3,500 Scale at A3

0 40 80 120 160 200 m

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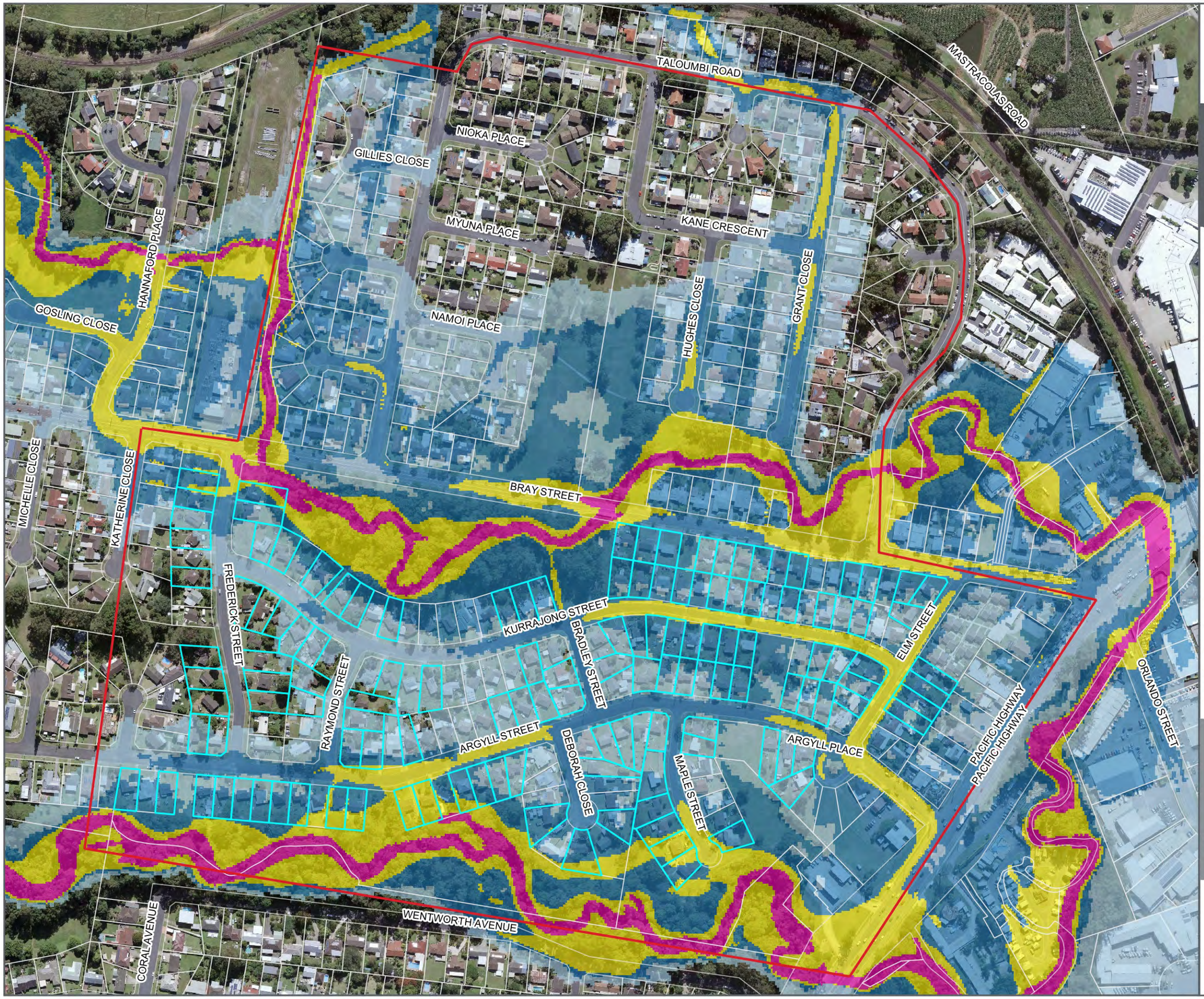
Argyll Estate, Coffs Harbour
Flood Risk Assessment

Benchmark Condition
True Flood Hazard
1% AEP



Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

True Flood Hazard Category

- Low Flood Risk
- Medium Flood Risk
- High Flood Risk
- High Flood Risk Flow Corridor

FIGURE 8

1:3,500 Scale at A3

0 40 80 120 160 200 m

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Argyll Estate, Coffs Harbour Flood Risk Assessment

Benchmark Condition
LAHC Property Addresses

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

FIGURE 9

1:3,500 Scale at A3

0 40 80 120 160 200 m

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Argyll Estate, Coffs Harbour Flood Risk Assessment

Flood Planning Area

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary
- Flood Planning Area

FIGURE 10

1:3,500 Scale at A3

0 40 80 120 160 200 m

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Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

Combined Hazard Category
1% AEP

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

Combined Flood Hazard

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 11

1:3,500 Scale at A3

0 40 80 120 160 200 m

N

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Argyll Estate, Coffs Harbour
Flood Risk Assessment

Combined Hazard Category
PMF

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

Combined Flood Hazard

- H1 - Generally safe for vehicles, people and buildings.
- H2 - Unsafe for small vehicles.
- H3 - Unsafe for vehicles. children and the elderly.
- H4 - Unsafe for vehicles and people.
- H5 - Unsafe for vehicles and people. All buildings vulnerable to structural damage. Some less robust buildings subject to failure.
- H6 - Unsafe for vehicles and people. All building types considered vulnerable to failure.

FIGURE 12

1:3,500 Scale at A3

0 40 80 120 160 200 m

N

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Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Benchmark 1%9hr less 1%2hr Water Level Difference

Legend

- Site Boundary
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE 13

1:5,000 Scale at A3

0 60 120 180 240 300 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

APPENDIX A

CONCEPT FLOOD MITIGATION OPTIONS / SCHEMES

Argyll Estate, Coffs Harbour Flood Risk Assessment

Benchmark Condition
LAHC Property Addresses

Legend

- Cadastre
- LAHC Lot Boundary
- Site Boundary

Figure A1

1:3,500 Scale at A3

0 40 80 120 160 200 m

N

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Date: 2021-7-20| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz


Ground Level Contours
(mAHD)
Zone1
Notional 2 m High Levee
Remove conduit to
prevent backflow
from the creek
0
50
100
metres

Figure A2


Ground Level Contours (mAHD)
Include 1 m wide swale.
Upstream IL = 6.6 m AHD.
Downstream IL = 6.6 m AHD
Include 1 m wide swale.
Upstream IL = 6.6 m AHD.
ownstream IL = 6.6 m AHD
Zone1
Notional 2 m High Levee
Remove conduit to prevent backflow from the creek
0
50
100
metres

Figure A3


Ground Level Contours (mAHD)
Lower Ground level to 6.4 m AHD and tie into creek bank so that it is free draining
Include 1 m wide swale.
Upstream IL = 6.6 m AHD.
Downstream IL = 6.6 m AHD
Notional 2 m High Levee
Zone1
Remove conduit to prevent backflow from the creek
0
50
100
metres

Figure A4


Ground Level Contours (mAHD)
Lower Ground level to 5.8 m AHD and tie into creek bank so that it is free draining
Include 1 m wide swale.
Upstream IL = 6.6 m AHD.
Downstream IL = 6.6 m AHD
Notional 2 m High Levee
Zone1
Remove conduit to prevent backflow from the creek
0
50
100
metres

Figure A5


Ground Level Contours (mAHD)
Lower Ground level to 5.8 m AHD and tie into creek bank so that it is free draining
Include 1 m wide swale.
Upstream IL = 5.8 m AHD.
Downstream IL = 5.8 m AHD
Include 1 m wide swale.
Upstream IL = 6.6 m AHD.
Downstream IL = 6.6 m AHD
Zone1
Notional 2 m High Levee
Remove conduit to prevent backflow from the creek
0
50
100
metres

Figure A6


Ground Level Contours
(mAHD)
0
50
100
metres
Existing Road level
Existing Road level
Existing Road level
Zone2
Grade to 6.2 m AHD across
road here

Figure A7


Ground Level Contours
(mAHD)
0
50
100
metres
Fill to 6.2 m AHD
Existing Road level
Existing Road level
Existing Road level
Zone2
Grade to 6.2 m AHD across
road here
Fill to 6.2 m AHD

Figure A8


Modified Option 1A
Levee v2
Delete swale here
Add new swale to drain low corner of park to the culverts
Option 3 Diversion
2 x1.2 (H) x 1.8m (W) RCBCs
U/S IL approx 5.5 m AHD
D/S IL approx 3.4 m AHD
Length = 380 m
Roughness = 0.015
Inlet loss = 1.0
Outlet loss = 2.0
Option 2A
MYUNA PLACE
KANE CRESCENT
NAMOI PLACE
HUGHES CLOSE
GRANT CLOSE
GOSLING CLOSE
BRAY STREET
MICHELLE CLOSE
KATHERINE CLOSE
KURRAJONG STREET
RAYMOND STREET
ARGYLL STREET
MAPLE STREET
ARGYLL PLACE
ELM STREET
PACIFIC HIGHWAY
ORLANDO STREET
WENTWORTH AVENUE
CORAL AVENUE

Figure A9

APPENDIX B

1% AEP FLOOD LEVEL DIFFERENCE PLOTS

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 1A Leeve v1 Less Benchmark Water Level Difference

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B1

1:4,000 Scale at A3

0 40 80 120 160 200 m

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Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 1A Leeve v2 Less Benchmark Water Level Difference

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 1B Leeve+Basin v1 Less Benchmark
Water Level Difference

MASTRACOLAS ROAD
TOSCANI LANE
TALOUMBI ROAD
GILLIES CLOSE
NIOKA PLACE
KANE CRESCENT
MYUNA PLACE
HANNAFORD PLACE
HUGHES CLOSE
GRANT CLOSE
NAMOI PLACE
PARK BEACH ROAD
BRAY STREET
PACIFIC HIGHWAY
KATHERINE CLOSE
ELM STREET
FREDERICK STREET
RAYMOND STREET
KURRAJONG STREET
ORLANDO STREET
ARGYLL STREET
MAPLE STREET
WENTWORTH AVENUE
DRUITT COURT

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

Figure B3

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 1B Leeve+Basin v2 Less Benchmark
Water Level Difference

MASTRACOLAS ROAD
TOSCANI LANE
TALOUMBI ROAD
GILLIES CLOSE
NIOKA PLACE
KANE CRESCENT
MYUNA PLACE
HUGHES CLOSE
GRANT CLOSE
HANNAFORD PLACE
NAMOI PLACE
PARK BEACH ROAD
PACIFIC HIGHWAY
BRAY STREET
KATHERINE CLOSE
ELM STREET
FREDERICK STREET
KURRAJONG STREET
RAYMOND STREET
ARGYLL STREET
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
DRUITT COURT

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B4

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 1B Leeve+Basin v3 Less Benchmark
Water Level Difference

MASTRACOLAS ROAD
TOSCANI LANE
TALOUMBI ROAD
GILLIES CLOSE
NIOKA PLACE
KANE CRESCENT
MYUNA PLACE
HUGHES CLOSE
GRANT CLOSE
HANNAFORD PLACE
NAMOI PLACE
PARK BEACH ROAD
PACIFIC HIGHWAY
BRAY STREET
KATHERINE CLOSE
ELM STREET
FREDERICK STREET
KURRAJONG STREET
RAYMOND STREET
ARGYLL STREET
MAPLE STREET
ORLANDO STREET
WENTWORTH AVENUE
DRUITT COURT

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B5

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 2A Road Regrading Less Benchmark
Water Level Difference

Legend

- Site Boundary
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B6

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 2B Road Regrading+Lot Filling
Less Benchmark
Water Level Difference

Legend

- Site Boundary
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B7

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-10| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 3A v1 Less Benchmark
Water Level Difference

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B8

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-17| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

Argyll Estate, Coffs Harbour
Possible Mitigation Measures

Option 3B v1 Less Benchmark
Water Level Difference

MASTRACOLAS ROAD
TOSCANI LANE
TALOUMBI ROAD
GILLIES CLOSE
NIOKA PLACE
KANE CRESCENT
MYUNA PLACE
HANNAFORD PLACE
HUGHES CLOSE
GRANT CLOSE
NAMOI PLACE
PARK BEACH ROAD
BRAY STREET
PACIFIC HIGHWAY
KATHERINE CLOSE
ELM STREET
FREDERICK STREET
RAYMOND STREET
KURRAJONG STREET
ORLANDO STREET
ARGYLL STREET
MAPLE STREET
WENTWORTH AVENUE
DRUITT COURT

Legend

- Site Boundary
- Proposed Levee
- Cadastre

Wet & Dry Analysis
- Was Wet, Now Dry
- Was Dry, Now Wet

Water Level Difference (m)
- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Figure B9

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-1-17| Project: XXXXXXXX
Coordinate System: MGA Zone 56
Map: NW30163 Argyll Estate Possible Mitigation Measures.qgz

APPENDIX C
DISCUSSION PAPER NO 2

Cardno
Shaping the Future

ARGYLL ESTATE, COFFS HARBOUR

FLOODING DISCUSSION PAPER NO. 2

4 MARCH 2022

SUMMARY

Based on the outcomes of the assessments of potential structural measures to mitigate the flooding and/or flood risk in Argyll Estate, consideration has been given to an alternative approach which is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures.

Architectus has prepared our (4) redevelopment scenarios in which all new buildings have floor levels above the PMF. The four scenarios are:

- Low Scenario – A 220 additional precinct dwellings
- Low Scenario – B 218 additional precinct dwellings
- High Scenario – A 382 additional precinct dwellings
- High Scenario – B 426 additional precinct dwellings

In order to assess a likely upper bound of flood impacts arising from redevelopment, High Scenario – B was adopted for assessment purposes. This was named **Scenario A**. A variant on High Scenario – B was also assessed and this was named **Scenario B**.

Figure C1 appended in Annexure C discloses that Scenario B has a local impact on 1% AEP flood levels in Elm Street and in the vicinity of the Argyll Street intersection over and above the impacts of Scenario A. **Figure C2** appended in Annexure C discloses that Scenario B has negligible impact on the PMF levels the Argyll Estate and surrounds over and above the impacts of Scenario A.

It is also apparent from the 1% AEP flood levels tabulated in **Annexure D** that:

(i) Scenario A and Scenario B have the same adverse impacts on 1% AEP flood levels; and that

(ii) On balance these impacts are slightly greater than under Scheme 3C particularly in the industrial estate west of the Pacific Highway.

Consideration may need to be given to a Low Scenario or possibly an Intermediate Scenario given Council's expressed concerns regarding the impacts of Scheme 3C on 1% AEP flood levels.

1. BACKGROUND

The assessments described in Flooding Discussion Paper No. 1 dated 18 January 2022 are summarised as follows (Cardno, 2022):

> *A visit to Argyll Estate was undertaken on 14 December 2021. During this visit several potential options to mitigate the flooding and/or flood risk in Argyll Estate were identified and were analysed to assess the 1% AEP flood level differences and which properties may be adversely impacted under each option.*

*A series of concept options were identified as summarised in **Table 4.***

The aim of the Option 1A runs was to assess the impact if any of additional overbank flood storage upstream of Bray Street. The aim of Option 1B v1, v2 and v3 runs were to assess the impact if any of additional overbank flood storage north of Bray Street and its ability to mitigate the impacts of Option 1A v2. The aim of the Option 2A and 2B runs were to assess the impact if any of re-grading the low point in Argyll Street to reduce the flood hazard in the low point. The aim of the Scheme 3A and 3B runs were to assess the degree to which the impacts of Option 1A v2 could be mitigated by diverting the overland flows that spill through the Kurrajong Street open space via culverts to the Argyll Branch. It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.

The options assessment disclosed that measures which would stop overflows from the Bray Street Arm that spill through the open space into Kurrajong Street in a 1% AEP flood would benefit residents in Kurrajong Street and Argyll Street but that this would be to the detriment of downstream properties fronting Bray Street, Hughes Close, Grant Close and Elm Street.

It was found that concept regrading of Argyll Street alone would have a very minor impact at the intersection of Raymond Street and Argyll Street but that the local impact on 1% AEP flood levels are sensitive to filling of parts of the residential lots south of Argyll Street in the vicinity of the low point.

The scheme which minimise but does not eliminate the impacts on 1% AEP flood levels downstream of the Bray Street crossing would be Scheme 3A.

The concept schemes have been formulated without any consideration of capital costs nor of the associated benefit cost ratio.

While Scheme 3A may be deemed feasible from an engineering perspective and that the benefits of flood risk reduction in Kurrajong Street, Elm Street and Argyll Street outweigh the local minor increases in 1% AEP flood levels elsewhere downstream of the Bray Street crossing, it me be determined that the capital costs outweigh the benefits to current and future residents. If this is the case, then the only available approach is to redevelop LAHC properties in a manner which responds to the current flood risks and which aims to minimise any local impacts of re-development on 1% AEP flood levels. …..

Table 4. Concept Flood Mitigation Options / Schemes for Argyll Estate

ID	Concept Option/Scheme	Comments
Kurrajong Street Reserve		
1A v1	This is a low levee along the rear property boundaries along Kurrajong Street tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. See **Figure A2.**	A concept 1.8 m levee height is notional only so that the actual 1% AEP depths along the levee can be estimated to refine the actual levee height. The aim is to assess 1% AEP flood level differences and which properties may be adversely impacted.

1A v2	*This is a low levee along the rear property boundaries along Kurrajong Street and to include additional open space before the levee is tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. A swale is included to drain floodwaters that would be otherwise trapped.* *See **Figure A3.***	*The aim is to assess the impact if any of additional overbank flood storage upstream of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.*
1B v1	*This is Option 1A v2 + an additional shallow free draining storage area north of Bray Street.* *See **Figure A4.***	*The aim is to assess the impact if any of additional overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.*
1B v2	*This is Option 1A v2 + an additional deeper free draining storage area north of Bray Street.* *See **Figure A5**.*	*The aim is to assess the impact if any of additional deeper overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.*
1B v3	*This is Option 1B v2 + a hydraulic connection to an existing natural basin.* *See **Figure A6**.*	*The aim is to assess the impact if any of connecting two overbank flood storages north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.*
Argyll St Low Point		
2A	*This option is re-grading the low section of Argyll Street to reduce the 1% AEP flood hazard and to maintain vehicular evacuation along Argyll Street albeit through shallow floodwaters. See **Figure A7**.*	*The aim is to assess the impact if any of re-grading a section of Argyll Street on 1% AEP flood level differences and which properties may be adversely impacted.*
2B	*This is Option 2A + additional filling of parts of selected properties to reduce flood hazard and the hydraulic category of selected properties. See **Figure A8**.*	*The aim is to assess the impact if any of re-grading a section of Argyll Street as well as partial filling of selected lots on 1% AEP flood level differences and which properties may be adversely impacted.*
Bray St Arm to Argyll Street Arm diversion Scheme		
3A	*Option 1A v2 + Option 2A + Diversion* *Diversion properties:* • *2 x1.2 (H) x 1.8m (W) RCBCs*	*The aim of the scheme is to mitigate the impact of Option 1A v2 by diverting the overland flow that spills through the park to the Argyll Branch via culverts.*

	• *D/S IL approx 5.5 m AHD* • *U/S IL approx 3.4 m AHD* • *Length = 380 m* • *Roughness = 0.015* • *Inlet loss = 1.0* • *Outlet loss = 2.0* *See **Figure A9**.*	*It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.* *The inlet and outlet losses account for intermediate bend losses.* *AS with the previous options we want to assess 1% AEP flood level differences and which properties may be adversely impacted.*
3B	*This is Option 3A with 2 x1.5 (H) x 1.8m (W) RCBCs instead of 2 x1.2 (H) x 1.8m (W) RCBCs. All other properties were unchanged.*	*The aim is to assess the impact if any of increasing the capacity of the diversion scheme on 1% AEP flood levels.*

A further scheme was also assessed as follows:

3C	*Scheme 3A + additional bund Diversion properties:* • *2 x1.2 (H) x 1.8m (W) RCBCs* • *D/S IL approx 5.5 m AHD* • *U/S IL approx 3.4 m AHD* • *Length = 380 m* • *Roughness = 0.015* • *Inlet loss = 1.0* • *Outlet loss = 2.0*	*The aim of the scheme is to mitigate the impact of Scheme 3A downstream of Bray Street by constructing a new bund in the open space north of Bray Street to confine the flows to the Bray St watercourse.* *The intent is to reduce downstream impacts while limited impacts upstream of Bray Street to the protected zone between Bray Street and Frederick Street as far as possible.*

2. EXISTING CONDITIONS

As described, in part, in Section 4.2.3 Hydraulic Roughness by BMT WBM (2018):

> *The development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are delineated from aerial photography and cadastral data identifying different land-uses (e.g. forest, cleared land, roads, urban areas, etc.) for modelling the variation in flow resistance. The hydraulic roughness is one of the principal calibration parameters within the hydraulic model and has a major influence on flow routing and flood levels. The roughness values adopted from the calibration process is discussed in Section 5.*

The spatial extent of the zones of hydraulic roughness adopted under Existing conditions are plotted in **Figure 1**. It is noted from Figure 1 that not all residential buildings were included in the floodplain model and instead only residential buildings on lots that experience inundation are included. These were represented as a very high roughness value (n = 1.0) irrespective of the height above ground level of the floor of each building.

Figure 1 Roughness Zones under Existing Conditions
(Source: 2018 Coffs Creek and Park Beach Flood Study)

2.1 Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels and extent and depths are plotted in **Figures 3, 4, 5** and **6** respectively in Discussion Paper No.1. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree of inundation of individual properties in each flood.

2.2 Floodway, Flood Storage and Flood Fringe

The mapping of hydraulic categories (Floodway, Flood Storage, Flood Fringe) in a 1% AEP flood is given in **Figure 7** in Discussion Paper No.1**.** The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the hydraulic categories.

2.3 True Hazard and Flood Risk Precincts

The mapping of true hazard and flood risk precincts is given in **Figure 8** in Discussion Paper No.1. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the risk precincts.

2.4 Climate Change

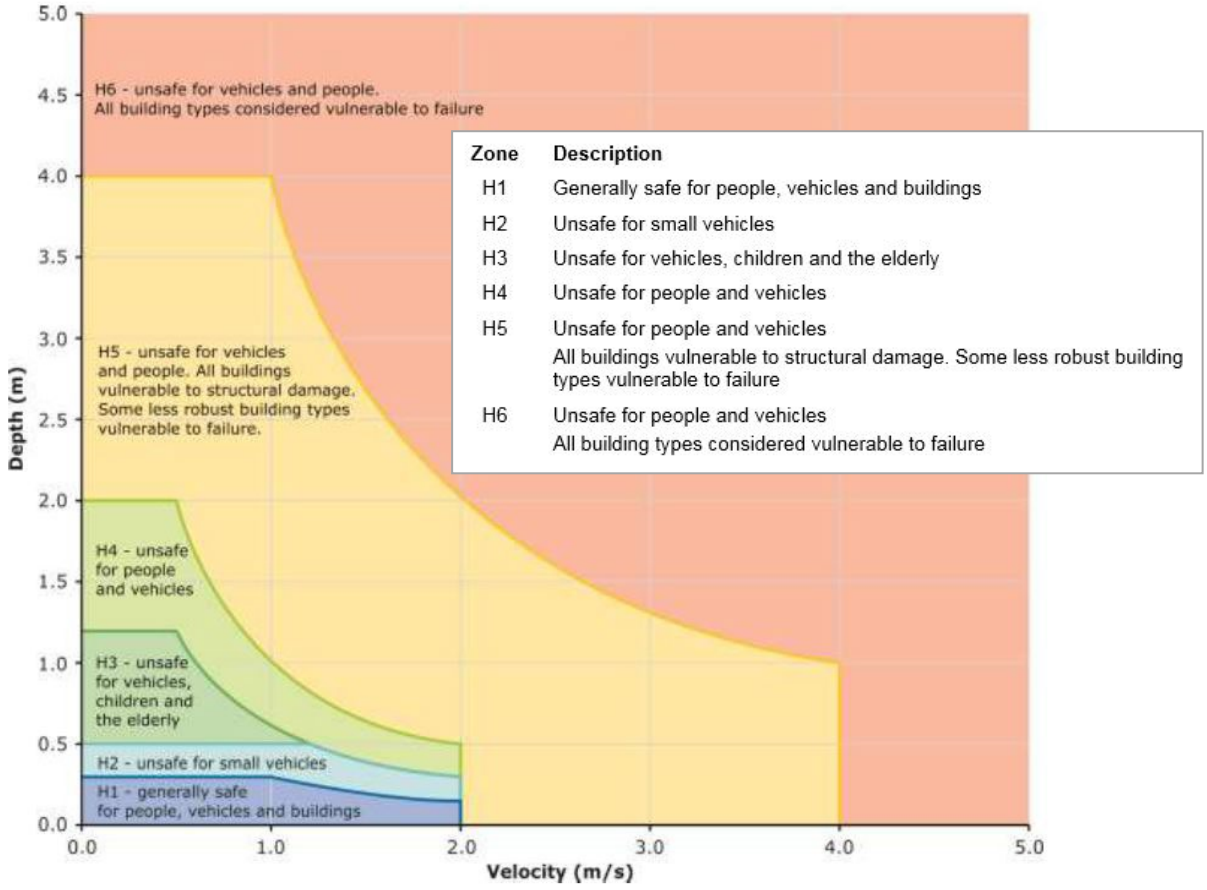
It was noted in Discussion Paper No.1 that 1% AEP flood levels in the Argyll Estate are estimated to increase up to 0.1 m only under a range of climate change scenarios which is well within Council's adopted freeboard of 0.5 m.

2.6 Flood Hazard Categories

Flood hazard vulnerability curves based on six categories H1 – H6 are as shown below.

The flood hazard categories on the Argyll Estate in a 1% AEP flood and the PMF under Benchmark Conditions are plotted in **Figures 11 – 12** respectively in Discussion Paper No.1.

It is noted that H1 and H2 conditions would be trafficable for larger vehicles.



3. CONCEPT BUILDING SCENARIOS

Based on the outcomes of the assessments of potential structural measures to mitigate the flooding and/or flood risk in Argyll Estate, consideration has been given to an alternative approach which is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures.

Architectus has prepared our (4) redevelopment scenarios in which all new buildings have floor levels above the PMF. The four scenarios are:

- Low Scenario – A 220 additional precinct dwellings
- Low Scenario – B 218 additional precinct dwellings
- High Scenario – A 382 additional precinct dwellings
- High Scenario – B 426 additional precinct dwellings

4. ASSESSMENT OF THE CONCEPT REDEVELOPMENT SCENARIOS

In order to assess a likely upper bound of flood impacts arising from redevelopment, High Scenario – B was adopted for assessment purposes. This was named **Scenario A**.

A variant on High Scenario – B was also assessed and this was named **Scenario B**.

The floodplain model was modified to represent each Scenario in turn and the 1% AEP 2 hour and 9 hour events were re-run. The flood level differences to the 1% AEP and PMF benchmark conditions were then plotted. The results are discussed as follows.

4.1 Scenario A

The components of the Scenario A redevelopment are identified in **Figure 2** and in **Annexure A.**

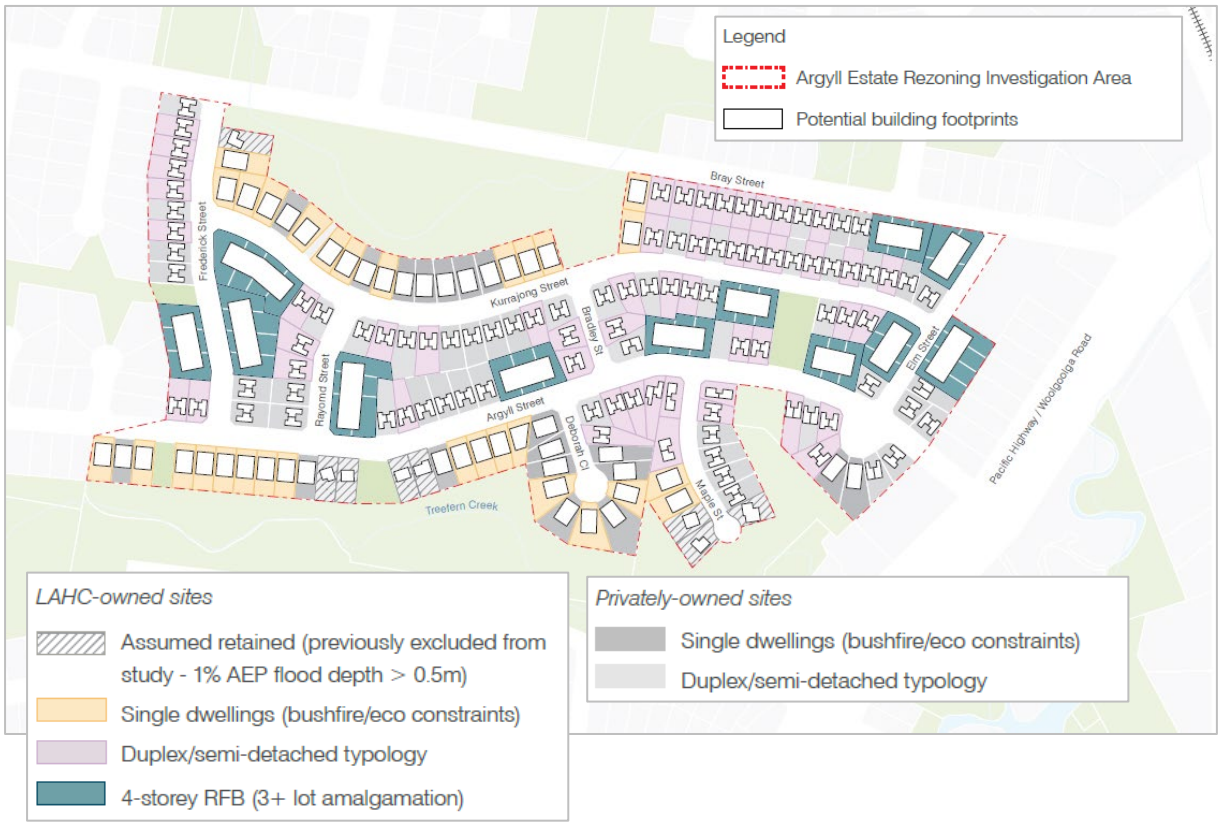


Figure 2 Layout of Scenario A Redevelopment

Figure 3 Roughness Zones under Scenario A

The spatial extent of the zones of adopted hydraulic roughness under Scenario A are plotted in **Figure 3**.

The 1% AEP flood level differences are mapped in **Figure A1** while PMF level differences are mapped in **Figure A2** which are appended in **Annexure A**.

The 1% AEP flood level differences for all non-LAHC properties in the zone of adverse impact are tabulated also in **Annexure D**.

Beyond the zone of impact identified under the structural measures (refer Discussion Paper No. 1) the concept redevelopment also generates local zones of impacts in a 1% AEP flood (see Figure A1):

- In the vicinity of the Bray St / Frederick intersection;
- Southern end of Deborah Close
- South of Argyll Street near the Argyll St / Elm St intersection

Figure A2 discloses that if it is intended that all new floor levels are higher than the PMF then on most lots across the estate it would be necessary to raise the floor levels higher than the PMF level under Existing Conditions to account for increases in PMF levels under Scenario A.

4.2 Scenario B

The components of the Scenario B redevelopment are identified in **Figure 4** and in **Annexure B.**

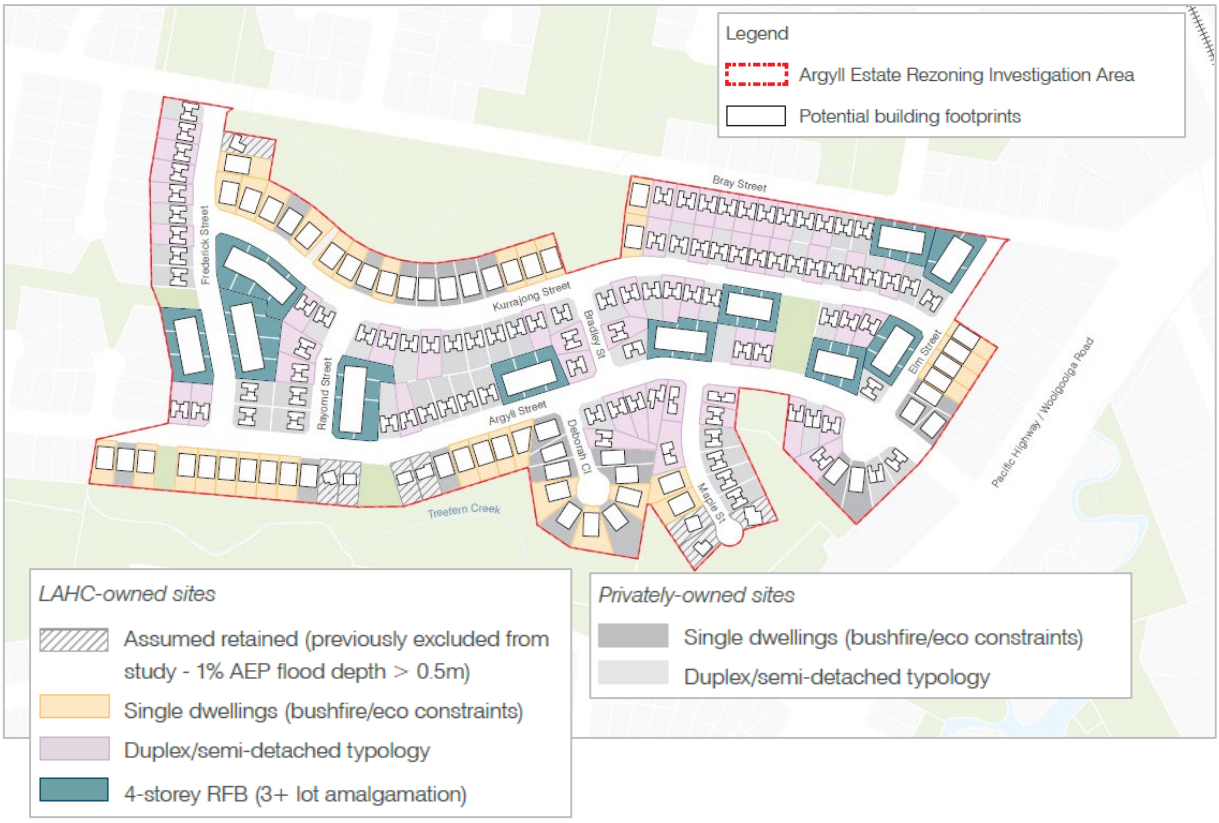


Figure 4 Layout of Scenario B Redevelopment

The spatial extent of the zones of adopted hydraulic roughness under Scenario A are plotted in **Figure 5**.

The 1% AEP flood level differences are mapped in **Figure B1** while PMF level differences are mapped in **Figure B2** which are appended in **Annexure B**.

The 1% AEP flood level differences for all non-LAHC properties in the zone of adverse impact are tabulated also in **Annexure D**.

Beyond the zone of impact identified under the structural measures (refer Discussion Paper No. 1) the concept redevelopment also generates local zones of impacts in a 1% AEP flood (see Figure B1):

- In the vicinity of the Bray St / Frederick intersection;
- Southern end of Deborah Close
- South of Argyll Street near the Argyll St / Elm St intersection

Figure B2 discloses that if it is intended that all new floor levels are higher than the PMF then on most lots across the estate it would be necessary to raise the floor levels higher than the PMF level under Existing Conditions to account for increases in PMF levels under Scenario A.

Figure 5 Roughness Zones under Scenario B

5. DISCUSSION

Figure C1 appended in Annexure C discloses that Scenario B has a local impact on 1% AEP flood levels in Elm Street and in the vicinity of the Argyll Street intersection over and above the impacts of Scenario A.

Figure C2 appended in Annexure C discloses that Scenario B has negligible impact on the PMF levels the Argyll Estate and surrounds over and above the impacts of Scenario A.

It is also apparent from the 1% AEP flood levels tabulated in **Annexure D** that:

(iii) Scenario A and Scenario B have the same adverse impacts on 1% AEP flood levels; and that

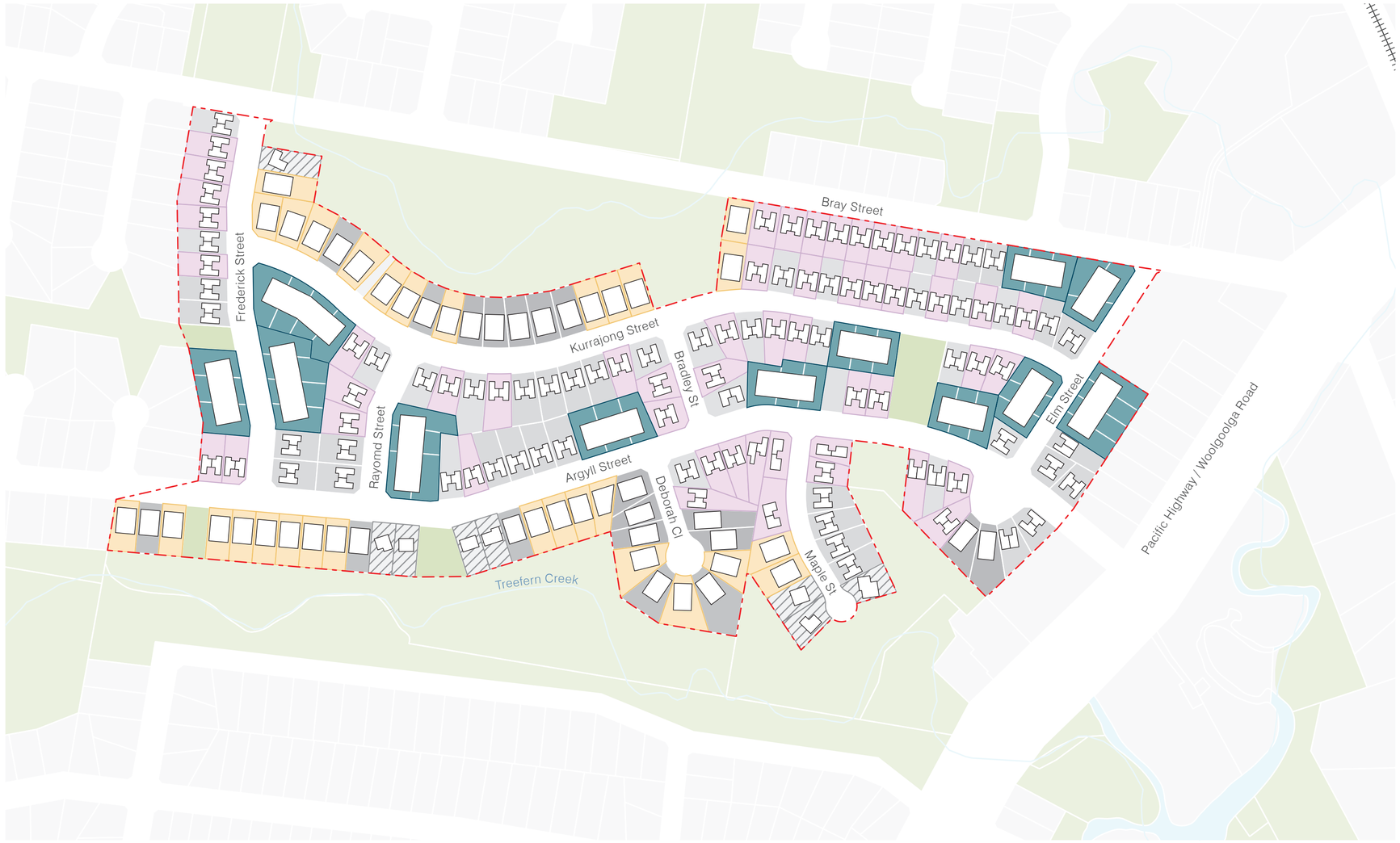
(iv) On balance these impacts are slightly greater than under Scheme 3C particularly in the industrial estate west of the Pacific Highway.

Consideration may need to be given to a Low Scenario or possibly an Intermediate Scenario given Council's expressed concerns regarding the impacts of Scheme 3C on 1% AEP flood levels.

Annexure A

Scenario A Redevelopment

Building footprints - High Growth Scenario A



Legend

- Argyll Estate Rezoning Investigation Area
- Potential building footprints

LAHC-owned sites

- Assumed retained (previously excluded from study - 1% AEP flood depth > 0.5m)
- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology
- 4-storey RFB (3+ lot amalgamation)

Privately-owned sites

- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology

Argyll Estate, Coffs Harbour Flood Risk Assessment

1% AEP
Scenario A – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE A1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

PMF
Scenario A – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE A2

1:4,000 Scale at A3

0 40 80 120 160 200 m

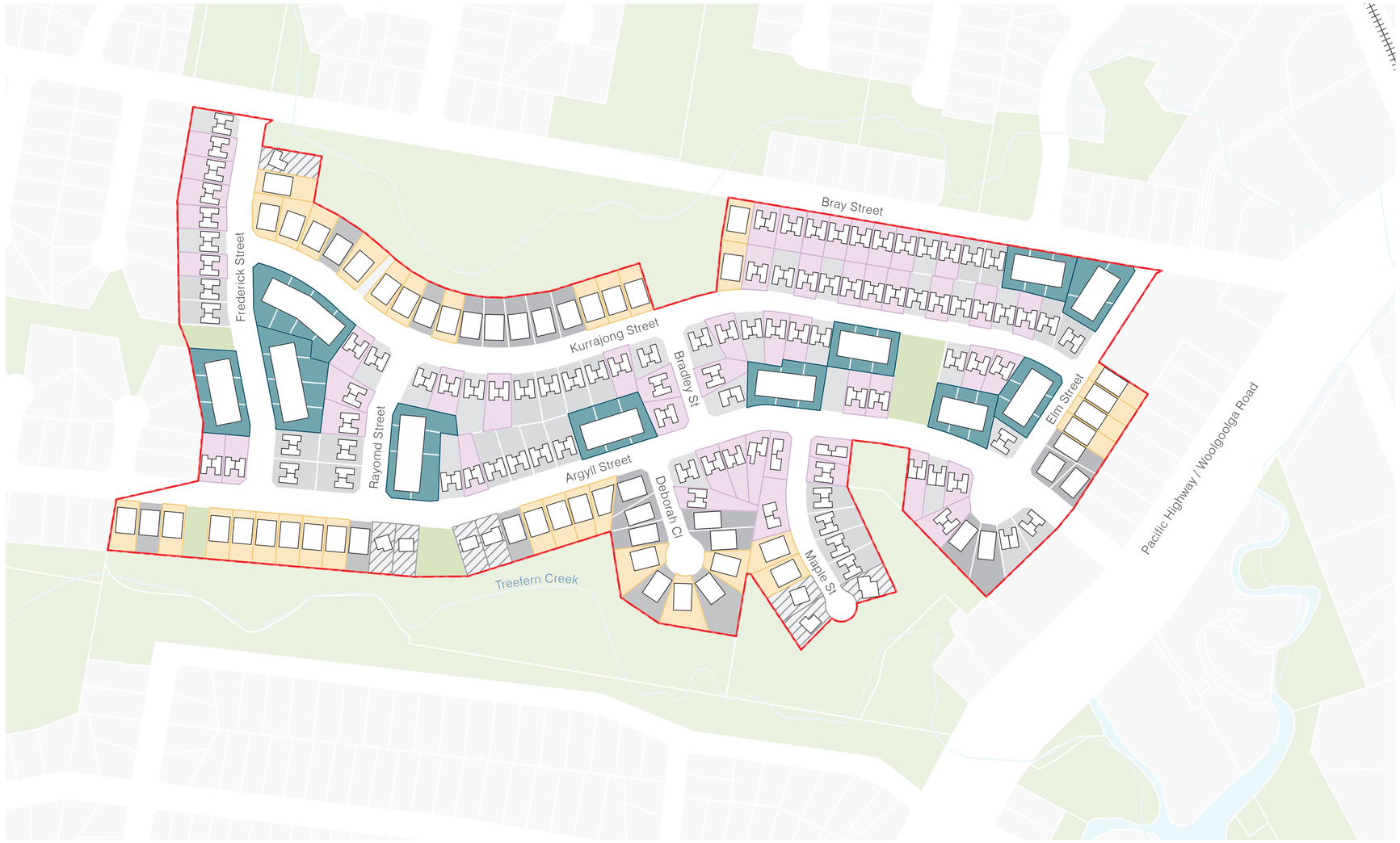
Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Annexure B

Scenario B Redevelopment

Building footprints - High Growth Scenario B



Legend

- Argyll Estate Rezoning Investigation Area
- Potential building footprints

LAHC-owned sites

- Assumed retained (previously excluded from study - 1% AEP flood depth > 0.5m)
- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology
- 4-storey RFB (3+ lot amalgamation)

Privately-owned sites

- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario B – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE B1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

PMF
Scenario B – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE B2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Annexure C

Comparison of Scenario A to Scenario B

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario B – Scenario A
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE C1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

PMF
Scenario B – Scenario A
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE C2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Annexure D

Scenarios C and D

Scenarios C and D = Scenario B Building Footprints + Diversion Culvert(s)

Scenario C Diversion:-
2 x1.2 (H) x 1.8m (W) RCBCs
U/S IL approx 5.5 m AHD
D/S IL approx 3.4 m AHD
Length = 415 m
Roughness = 0.015
Inlet loss = 1.0
Outlet loss = 2.0

Scenario D Diversion:-
1 x1.2 (H) x 1.8m (W) RCBCs
U/S IL approx 5.5 m AHD
D/S IL approx 3.4 m AHD
Length = 415 m
Roughness = 0.015
Inlet loss = 1.0
Outlet loss = 2.0

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario C – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE D1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-8| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario D – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE D2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-8| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

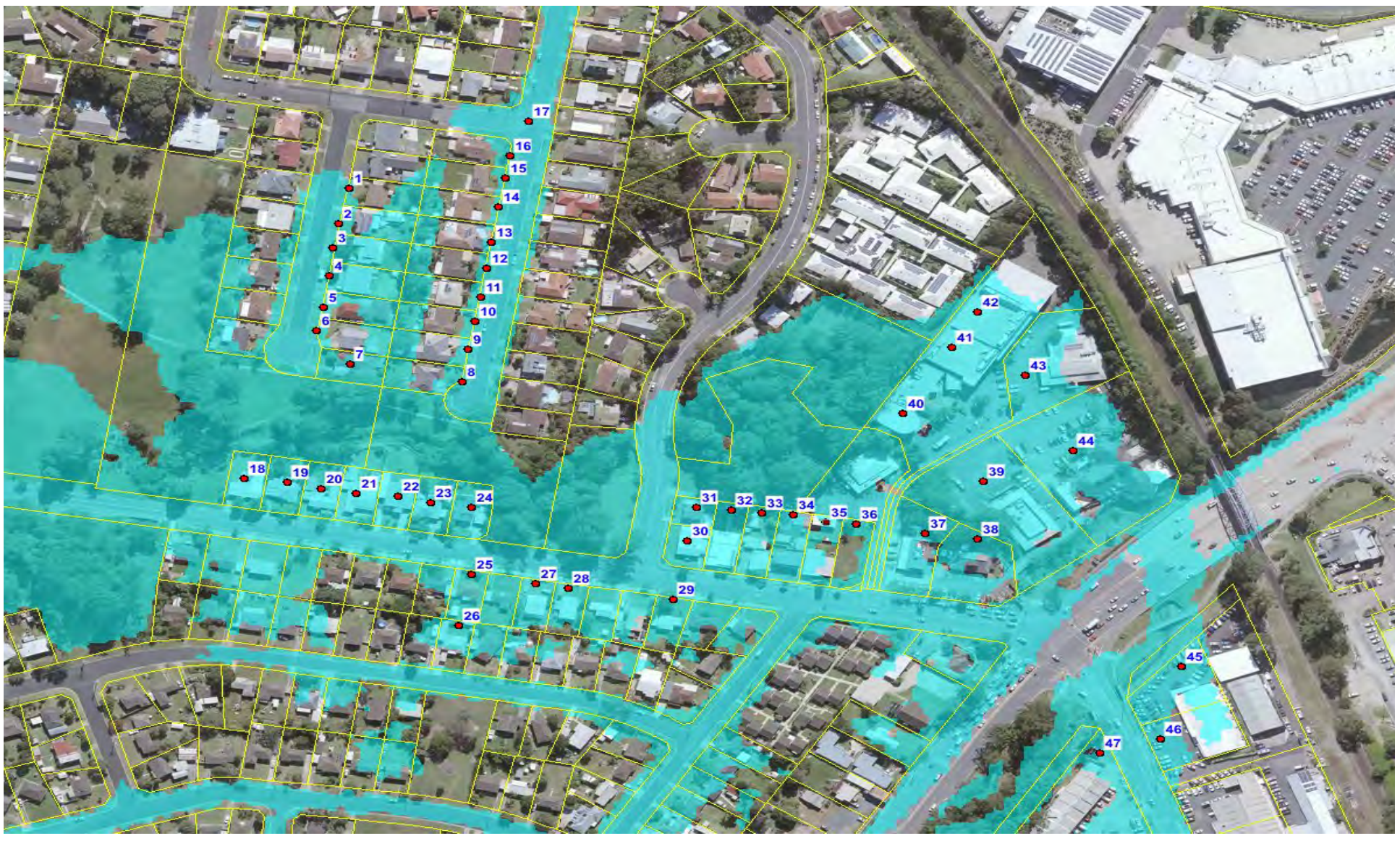
Annexure E

1% AEP Flood Level Differences

NW30163 100yr Flood Level Comparison - Non-LAHC Properties

ID	Existing 2hr (mAHD)	Existing 9hr (mAHD)	Existing Max FL (mAHD) (a)	Scheme 3C 2hr (mAHD)	Scheme 3C 9hr (mAHD)	Scheme 3C Max FL (mAHD) (b)	Difference Rounded (cm) (b)-(a)	High Growth Scenario A 2hr (mAHD)	High Growth Scenario A 9hr (mAHD)	High Growth Scenario A Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	High Growth Scenario B 2hr (mAHD)	High Growth Scenario B 9hr (mAHD)	High Growth Scenario B Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Compared to Scheme 3C (cm)
Hughes Close																	
1	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
2	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
3	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
4	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
5	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
6	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
7	6.73	6.70	6.73	6.75	6.72	6.75	2	6.74	6.71	6.74	1	-1	6.74	6.71	6.74	1	-1
Grant Close																	
8	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
9	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
10	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
11	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
12	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
13	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
14	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
15	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
16	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
17	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
Bray Street (Northside)																	0
18	6.86	6.84	6.86	6.89	6.86	6.89	3	6.87	6.85	6.87	1	-2	6.87	6.85	6.87	1	-2
19	6.76	6.73	6.76	6.78	6.75	6.78	2	6.78	6.75	6.78	2	0	6.78	6.75	6.78	2	0
20	6.73	6.70	6.73	6.75	6.72	6.75	2	6.75	6.72	6.75	2	0	6.75	6.72	6.75	2	0
21	6.67	6.64	6.67	6.69	6.66	6.69	2	6.68	6.66	6.68	1	-1	6.68	6.66	6.68	1	-1
22	6.55	6.53	6.55	6.57	6.55	6.57	2	6.57	6.54	6.57	2	0	6.57	6.54	6.57	2	0
23	6.49	6.47	6.49	6.52	6.49	6.52	3	6.51	6.48	6.51	2	-1	6.51	6.48	6.51	2	-1
24	6.39	6.37	6.39	6.39	6.38	6.39	0	6.41	6.39	6.41	2	2	6.41	6.39	6.41	2	2
Bray Street (Southside)																	
25	6.32	6.30	6.32	6.33	6.31	6.33	1	6.35	6.32	6.35	3	2	6.35	6.32	6.35	3	2
26	6.16	6.15	6.16	6.18	6.16	6.18	2	6.20	6.18	6.20	4	2	6.20	6.18	6.20	4	2
27	6.26	6.25	6.26	6.28	6.26	6.28	2	6.29	6.27	6.29	3	1	6.29	6.27	6.29	3	1
28	6.23	6.21	6.23	6.24	6.23	6.24	1	6.25	6.23	6.25	2	1	6.25	6.23	6.25	2	1
29	6.01	6.00	6.01	6.03	6.01	6.03	2	6.02	6.01	6.02	1	-1	6.02	6.01	6.02	1	-1
Bray Street (Northside)																	
30	6.09	6.08	6.09	6.10	6.09	6.10	1	6.11	6.10	6.11	2	1	6.11	6.10	6.11	2	1
31	6.01	6.00	6.01	6.03	6.01	6.03	2	6.03	6.02	6.03	2	0	6.03	6.02	6.03	2	0
32	5.98	5.97	5.98	5.99	5.98	5.99	1	6.00	5.98	6.00	2	1	6.00	5.98	6.00	2	1
33	5.94	5.93	5.94	5.96	5.94	5.96	2	5.96	5.95	5.96	2	0	5.96	5.95	5.96	2	0
34	5.79	5.78	5.79	5.81	5.79	5.81	2	5.80	5.79	5.80	1	-1	5.80	5.79	5.80	1	-1
35	5.53	5.52	5.53	5.54	5.53	5.54	1	5.55	5.53	5.55	2	1	5.55	5.53	5.55	2	1
36	5.46	5.45	5.46	5.48	5.46	5.48	2	5.48	5.47	5.48	2	0	5.48	5.47	5.48	2	0
Industrial West of Pacific Highway																	
37	5.38	5.37	5.38	5.41	5.39	5.41	3	5.42	5.40	5.42	4	1	5.42	5.40	5.42	4	1
38	5.35	5.33	5.35	5.37	5.35	5.37	2	5.38	5.36	5.38	3	1	5.38	5.36	5.38	3	1
39	5.43	5.41	5.43	5.45	5.43	5.45	2	5.46	5.44	5.46	3	1	5.46	5.44	5.46	3	1
40	5.67	5.66	5.67	5.69	5.67	5.69	2	5.69	5.68	5.69	2	0	5.69	5.68	5.69	2	0
41	5.65	5.64	5.65	5.66	5.65	5.66	1	5.67	5.66	5.67	2	1	5.67	5.66	5.67	2	1
42	5.66	5.64	5.66	5.67	5.66	5.67	1	5.68	5.66	5.68	2	1	5.68	5.66	5.68	2	1
43	5.45	5.43	5.45	5.47	5.45	5.47	2	5.48	5.46	5.48	3	1	5.48	5.46	5.48	3	1
44	5.44	5.43	5.44	5.46	5.45	5.46	2	5.47	5.45	5.47	3	1	5.47	5.45	5.47	3	1
Industrial East of Pacific Highway																	
45	4.59	4.57	4.59	4.60	4.59	4.60	1	4.61	4.60	4.61	2	1	4.61	4.60	4.61	2	1
46	4.36	4.36	4.36	4.38	4.38	4.38	2	4.39	4.39	4.39	3	1	4.39	4.39	4.39	3	1
47	4.34	4.34	4.34	4.36	4.35	4.36	2	4.36	4.36	4.36	2	0	4.36	4.36	4.36	2	0
48	4.35	4.35	4.35	4.36	4.36	4.36	1	4.38	4.37	4.38	3	2	4.38	4.37	4.38	3	2

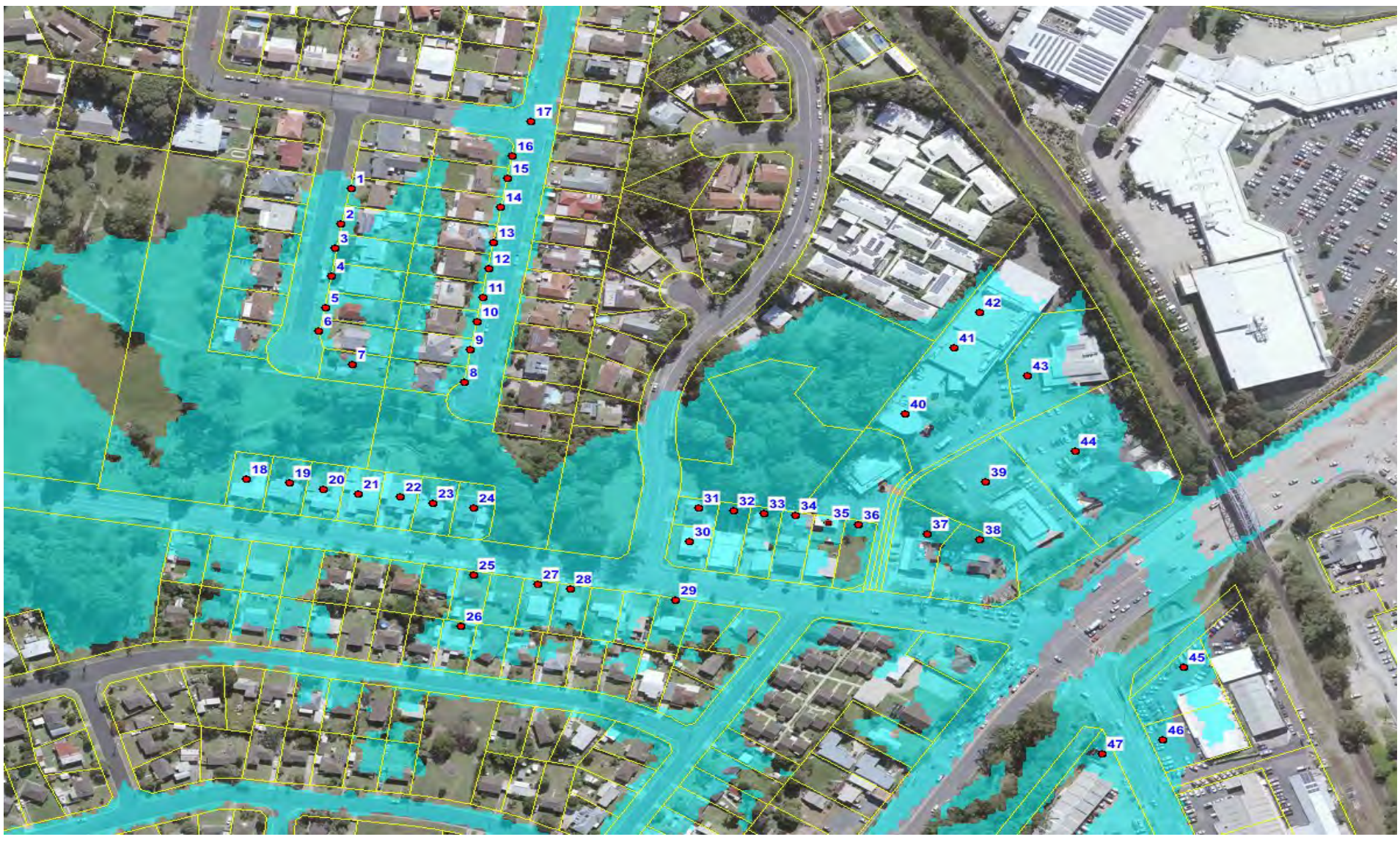
Number of Properties subject to increase in the 1% AEP Flood Level				
	1 cm	9	11	11
	2 cm	35	28	28
	3 cm	3	8	8
	4 cm	0	1	1



NW30163 100yr Flood Level Comparison - Non-LAHC Properties

ID	Existing 2hr (mAHD)	Existing 9hr (mAHD)	Existing Max FL (mAHD) (a)	Scheme 3C 2hr (mAHD)	Scheme 3C 9hr (mAHD)	Scheme 3C Max FL (mAHD) (b)	Difference Rounded (cm) (b)-(a)	Scenario C: High Growth Scenario B + 2 x 1.2 (H) x 1.8 (W) RCBCs 2hr (mAHD)	Scenario C 9hr (mAHD)	Scenario C Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	Scenario D: High Growth Scenario B + 1 x 1.2 (H) x 1.8 (W) RCBCs 2hr (mAHD)	Scenario D 9hr (mAHD)	Scenario D Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Compared to Scheme 3C (cm)
Hughes Close																	
1	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
2	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
3	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
4	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
5	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
6	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
7	6.73	6.70	6.73	6.75	6.72	6.75	2	6.69	6.65	6.69	-4	-6	6.71	6.68	6.71	-2	-4
Grant Close																	
8	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
9	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
10	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
11	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
12	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
13	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
14	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
15	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
16	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
17	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
Bray Street (Northside)																	0
18	6.86	6.84	6.86	6.89	6.86	6.89	3	6.83	6.80	6.83	-3	-6	6.85	6.82	6.85	-1	-4
19	6.76	6.73	6.76	6.78	6.75	6.78	2	6.73	6.68	6.73	-3	-5	6.75	6.72	6.75	-1	-3
20	6.73	6.70	6.73	6.75	6.72	6.75	2	6.69	6.66	6.69	-4	-6	6.72	6.68	6.72	-1	-3
21	6.67	6.64	6.67	6.69	6.66	6.69	2	6.63	6.61	6.63	-4	-6	6.65	6.63	6.65	-2	-4
22	6.55	6.53	6.55	6.57	6.55	6.57	2	6.51	6.49	6.51	-4	-6	6.53	6.51	6.53	-2	-4
23	6.49	6.47	6.49	6.52	6.49	6.52	3	6.45	6.43	6.45	-4	-7	6.47	6.45	6.47	-2	-5
24	6.39	6.37	6.39	6.39	6.38	6.39	0	6.37	6.34	6.37	-2	-2	6.38	6.36	6.38	-1	-1
Bray Street (Southside)																	
25	6.32	6.30	6.32	6.33	6.31	6.33	1	6.31	6.28	6.31	-1	-2	6.32	6.30	6.32	0	-1
26	6.16	6.15	6.16	6.18	6.16	6.18	2	6.16	6.14	6.16	0	-2	6.18	6.16	6.18	2	0
27	6.26	6.25	6.26	6.28	6.26	6.28	2	6.25	6.23	6.25	-1	-3	6.27	6.25	6.27	1	-1
28	6.23	6.21	6.23	6.24	6.23	6.24	1	6.21	6.20	6.21	-2	-3	6.23	6.21	6.23	0	-1
29	6.01	6.00	6.01	6.03	6.01	6.03	2	5.99	5.98	5.99	-2	-4	6.01	5.99	6.01	0	-2
Bray Street (Northside)																	
30	6.09	6.08	6.09	6.10	6.09	6.10	1	6.08	6.06	6.08	-1	-2	6.10	6.08	6.10	1	0
31	6.01	6.00	6.01	6.03	6.01	6.03	2	6.00	5.98	6.00	-1	-3	6.01	6.00	6.01	0	-2
32	5.98	5.97	5.98	5.99	5.98	5.99	1	5.97	5.95	5.97	-1	-2	5.98	5.97	5.98	0	-1
33	5.94	5.93	5.94	5.96	5.94	5.96	2	5.93	5.92	5.93	-1	-3	5.95	5.93	5.95	1	-1
34	5.79	5.78	5.79	5.81	5.79	5.81	2	5.78	5.77	5.78	-1	-3	5.79	5.78	5.79	0	-2
35	5.53	5.52	5.53	5.54	5.53	5.54	1	5.52	5.51	5.52	-1	-2	5.53	5.52	5.53	0	-1
36	5.46	5.45	5.46	5.48	5.46	5.48	2	5.46	5.44	5.46	0	-2	5.47	5.45	5.47	1	-1
Industrial West of Pacific Highway																	
37	5.38	5.37	5.38	5.41	5.39	5.41	3	5.37	5.35	5.37	-1	-4	5.39	5.37	5.39	1	-2
38	5.35	5.33	5.35	5.37	5.35	5.37	2	5.34	5.31	5.34	-1	-3	5.36	5.33	5.36	1	-1
39	5.43	5.41	5.43	5.45	5.43	5.45	2	5.41	5.39	5.41	-2	-4	5.43	5.41	5.43	0	-2
40	5.67	5.66	5.67	5.69	5.67	5.69	2	5.67	5.65	5.67	0	-2	5.68	5.66	5.68	1	-1
41	5.65	5.64	5.65	5.66	5.65	5.66	1	5.65	5.63	5.65	0	-1	5.66	5.64	5.66	1	0
42	5.66	5.64	5.66	5.67	5.66	5.67	1	5.65	5.63	5.65	-1	-2	5.66	5.64	5.66	0	-1
43	5.45	5.43	5.45	5.47	5.45	5.47	2	5.44	5.41	5.44	-1	-3	5.45	5.43	5.45	0	-2
44	5.44	5.43	5.44	5.46	5.45	5.46	2	5.43	5.41	5.43	-1	-3	5.45	5.43	5.45	1	-1
Industrial East of Pacific Highway																	
45	4.59	4.57	4.59	4.60	4.59	4.60	1	4.57	4.56	4.57	-2	-3	4.59	4.57	4.59	0	-1
46	4.36	4.36	4.36	4.38	4.38	4.38	2	4.35	4.35	4.35	-1	-3	4.37	4.36	4.37	1	-1
47	4.34	4.34	4.34	4.36	4.35	4.36	2	4.32	4.32	4.32	-2	-4	4.34	4.34	4.34	0	-2
48	4.35	4.35	4.35	4.36	4.36	4.36	1	4.33	4.33	4.33	-2	-3	4.35	4.35	4.35	0	-1

Number of Properties subject to increase in the 1% AEP Flood Level	1 cm	9	0	9
	2 cm	35	0	1
	3 cm	3	0	0
	4 cm	0	0	0



APPENDIX D
DISCUSSION PAPER NO 3

Cardno
Shaping the Future

ARGYLL ESTATE, COFFS HARBOUR

FLOODING DISCUSSION PAPER NO. 3

9 MARCH 2022

SUMMARY

Based on the outcomes of the assessments of potential structural measures to mitigate the flooding and/or flood risk in Argyll Estate, consideration has been given to an alternative approach which is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures.

Architectus has prepared our (4) redevelopment scenarios in which all new buildings have floor levels above the PMF. The four scenarios are:

- Low Scenario – A 220 additional precinct dwellings
- Low Scenario – B 218 additional precinct dwellings
- High Scenario – A 382 additional precinct dwellings
- High Scenario – B 426 additional precinct dwellings

In order to assess a likely upper bound of flood impacts arising from redevelopment, High Scenario – B was adopted for assessment purposes. This was named **Scenario A**. A variant on High Scenario – B was also assessed and this was named **Scenario B**.

Two further scenarios were also assessed. **Scenarios C** and **D** combined the Scenario B building footprints with a culvert flow diversion from the north arm to the south arm which was previously assessed as a component of structural schemes.

It is apparent from the 1% AEP flood levels tabulated in **Annexure E** that:

(i) Scenario A and Scenario B have the same adverse impacts on 1% AEP flood levels; and that

(ii) On balance these impacts are slightly greater than under Scheme 3C particularly in the industrial estate west of the Pacific Highway;

(iii) Scenario C significantly reduces the impact of the Scenario B building footprints on 1% AEP flood levels on the identified properties;

(iv) Scenario D reduces the impact of the Scenario B building footprints on 1% AEP flood levels on the identified properties to within acceptable values;

(v) The are some zones of adverse impact which were outside of the previous area of interest and therefore do not appear in Annexure E;

(vi) These local impacts appear to be associated with changed building footprints on properties outside of the planning proposal.

Consideration could be given to limiting the changed building footprints to only those properties included within the planning proposal.

1. BACKGROUND

The assessments described in Flooding Discussion Paper No. 1 dated 18 January 2022 are summarised as follows (Cardno, 2022):

> *A visit to Argyll Estate was undertaken on 14 December 2021. During this visit several potential options to mitigate the flooding and/or flood risk in Argyll Estate were identified and were analysed to assess the 1% AEP flood level differences and which properties may be adversely impacted under each option.*
>
> *A series of concept options were identified as summarised in **Table 4.***
>
> *The aim of the Option 1A runs was to assess the impact if any of additional overbank flood storage upstream of Bray Street. The aim of Option 1B v1, v2 and v3 runs were to assess the impact if any of additional overbank flood storage north of Bray Street and its ability to mitigate the impacts of Option 1A v2. The aim of the Option 2A and 2B runs were to assess the impact if any of re-grading the low point in Argyll Street to reduce the flood hazard in the low point. The aim of the Scheme 3A and 3B runs were to assess the degree to which the impacts of Option 1A v2 could be mitigated by diverting the overland flows that spill through the Kurrajong Street open space via culverts to the Argyll Branch. It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.*
>
> *The options assessment disclosed that measures which would stop overflows from the Bray Street Arm that spill through the open space into Kurrajong Street in a 1% AEP flood would benefit residents in Kurrajong Street and Argyll Street but that this would be to the detriment of downstream properties fronting Bray Street, Hughes Close, Grant Close and Elm Street.*
>
> *It was found that concept regrading of Argyll Street alone would have a very minor impact at the intersection of Raymond Street and Argyll Street but that the local impact on 1% AEP flood levels are sensitive to filling of parts of the residential lots south of Argyll Street in the vicinity of the low point.*
>
> *The scheme which minimise but does not eliminate the impacts on 1% AEP flood levels downstream of the Bray Street crossing would be Scheme 3A.*
>
> *The concept schemes have been formulated without any consideration of capital costs nor of the associated benefit cost ratio.*
>
> *While Scheme 3A may be deemed feasible from an engineering perspective and that the benefits of flood risk reduction in Kurrajong Street, Elm Street and Argyll Street outweigh the local minor increases in 1% AEP flood levels elsewhere downstream of the Bray Street crossing, it me be determined that the capital costs outweigh the benefits to current and future residents. If this is the case, then the only available approach is to redevelop LAHC properties in a manner which responds to the current flood risks and which aims to minimise any local impacts of re-development on 1% AEP flood levels. …..*

Table 4. Concept Flood Mitigation Options / Schemes for Argyll Estate

ID	Concept Option/Scheme	Comments
Kurrajong Street Reserve		
1A v1	This is a low levee along the rear property boundaries along Kurrajong Street tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. See **Figure A2.**	A concept 1.8 m levee height is notional only so that the actual 1% AEP depths along the levee can be estimated to refine the actual levee height. The aim is to assess 1% AEP flood level differences and which properties may be adversely impacted.
1A v2	This is a low levee along the rear property boundaries along Kurrajong Street and to include additional open space before the levee is tied into Bray Street. The aim is to prevent overflows from the Bray St Arm into Kurrajong Street. A swale is included to drain floodwaters that would be otherwise trapped. See **Figure A3.**	The aim is to assess the impact if any of additional overbank flood storage upstream of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v1	This is Option 1A v2 + an additional shallow free draining storage area north of Bray Street. See **Figure A4.**	The aim is to assess the impact if any of additional overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v2	This is Option 1A v2 + an additional deeper free draining storage area north of Bray Street. See **Figure A5**.	The aim is to assess the impact if any of additional deeper overbank flood storage north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
1B v3	This is Option 1B v2 + a hydraulic connection to an existing natural basin. See **Figure A6**.	The aim is to assess the impact if any of connecting two overbank flood storages north of Bray Street on 1% AEP flood level differences and which properties may be adversely impacted.
Argyll St Low Point		
2A	This option is re-grading the low section of Argyll Street to reduce the 1% AEP flood hazard and to maintain vehicular evacuation along Argyll Street albeit through shallow floodwaters. See **Figure A7**.	The aim is to assess the impact if any of re-grading a section of Argyll Street on 1% AEP flood level differences and which properties may be adversely impacted.

2B	*This is Option 2A + additional filling of parts of selected properties to reduce flood hazard and the hydraulic category of selected properties. See **Figure A8**.*	*The aim is to assess the impact if any of re-grading a section of Argyll Street as well as partial filling of selected lots on 1% AEP flood level differences and which properties may be adversely impacted.*
Bray St Arm to Argyll Street Arm diversion Scheme		
3A	*Option 1A v2 + Option 2A + Diversion* *Diversion properties:* • *2 x1.2 (H) x 1.8m (W) RCBCs* • *D/S IL approx 5.5 m AHD* • *U/S IL approx 3.4 m AHD* • *Length = 380 m* • *Roughness = 0.015* • *Inlet loss = 1.0* • *Outlet loss = 2.0* *See **Figure A9**.*	*The aim of the scheme is to mitigate the impact of Option 1A v2 by diverting the overland flow that spills through the park to the Argyll Branch via culverts.* *It is intended that the upstream and downstream invert levels tie into the level of the inlet channel and the downstream watercourse.* *The inlet and outlet losses account for intermediate bend losses.* *AS with the previous options we want to assess 1% AEP flood level differences and which properties may be adversely impacted.*
3B	*This is Option 3A with 2 x1.5 (H) x 1.8m (W) RCBCs instead of 2 x1.2 (H) x 1.8m (W) RCBCs. All other properties were unchanged.*	*The aim is to assess the impact if any of increasing the capacity of the diversion scheme on 1% AEP flood levels.*

A further scheme was also assessed as follows:

3C	*Scheme 3A + additional bund* *Diversion properties:* • *2 x1.2 (H) x 1.8m (W) RCBCs* • *D/S IL approx 5.5 m AHD* • *U/S IL approx 3.4 m AHD* • *Length = 380 m* • *Roughness = 0.015* • *Inlet loss = 1.0* • *Outlet loss = 2.0*	*The aim of the scheme is to mitigate the impact of Scheme 3A downstream of Bray Street by constructing a new bund in the open space north of Bray Street to confine the flows to the Bray St watercourse.* *The intent is to reduce downstream impacts while limited impacts upstream of Bray Street to the protected zone between Bray Street and Frederick Street as far as possible.*

2. EXISTING CONDITIONS

As described, in part, in Section 4.2.3 Hydraulic Roughness by BMT WBM (2018):

> *The development of the TUFLOW model requires the assignment of different hydraulic roughness zones. These zones are delineated from aerial photography and cadastral data identifying different land-uses (e.g. forest, cleared land, roads, urban areas, etc.) for modelling the variation in flow resistance. The hydraulic roughness is one of the principal calibration parameters within the hydraulic model and has a major influence on flow routing and flood levels. The roughness values adopted from the calibration process is discussed in Section 5.*

The spatial extent of the zones of hydraulic roughness adopted under Existing conditions are plotted in **Figure 1**. It is noted from Figure 1 that not all residential buildings were included in the floodplain model and instead only residential buildings on lots that experience inundation were included. These were represented as a very high roughness value (n = 1.0) irrespective of the height above ground level of the floor of each building.

Figure 1 Roughness Zones under Existing Conditions
(Source: 2018 Coffs Creek and Park Beach Flood Study)

2.1 Flood Levels and Depths

The estimated 5% AEP, 1% AEP, 0.2% AEP and PMF flood levels and extent and depths are plotted in **Figures 3, 4, 5** and **6** respectively in Discussion Paper No.1.

The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree of inundation of individual properties in each flood.

2.2 Floodway, Flood Storage and Flood Fringe

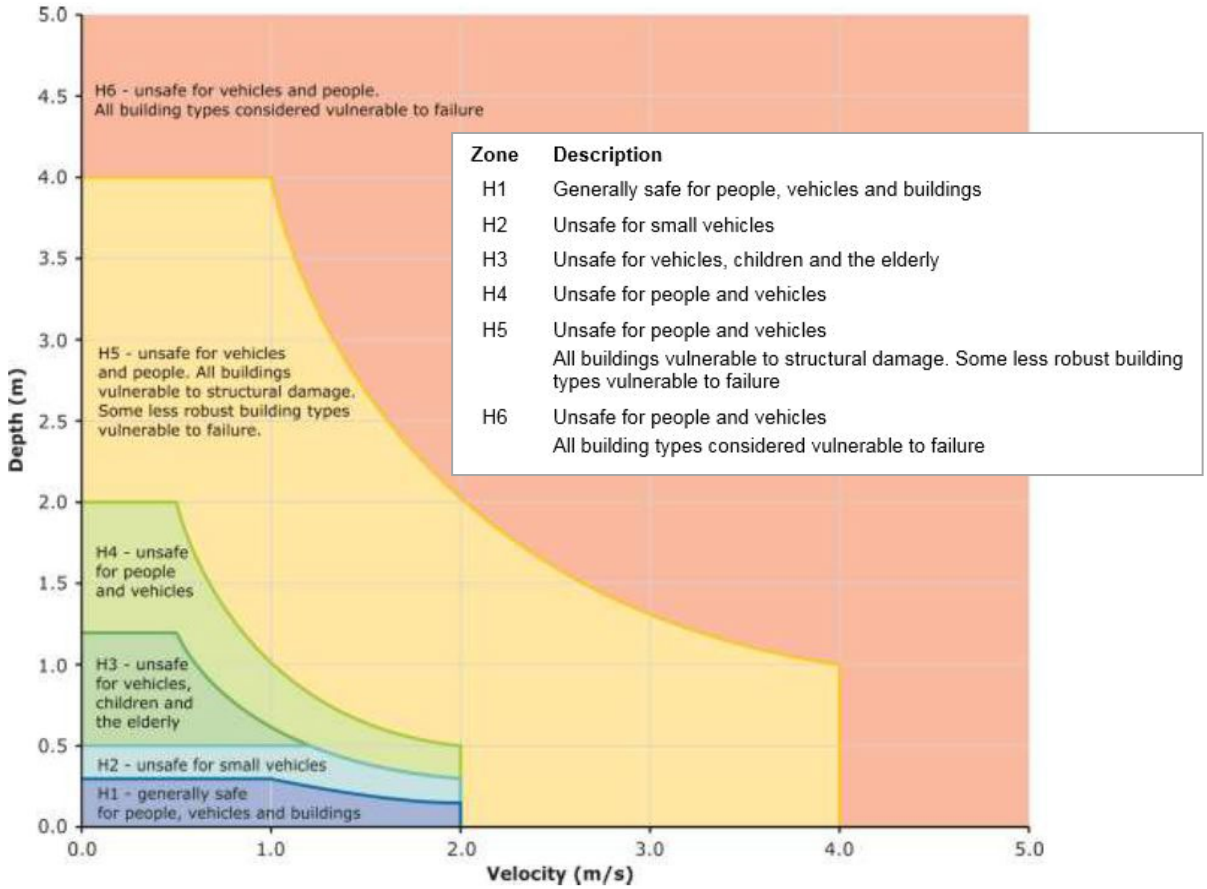
The mapping of hydraulic categories (Floodway, Flood Storage, Flood Fringe) in a 1% AEP flood is given in **Figure 7** in Discussion Paper No.1**.** The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the hydraulic categories.

2.3 True Hazard and Flood Risk Precincts

The mapping of true hazard and flood risk precincts is given in **Figure 8** in Discussion Paper No.1. The LAHC property boundaries are also highlighted to facilitate a visual assessment of the degree to which individual properties are mapped in the risk precincts.

2.4 Climate Change

It was noted in Discussion Paper No.1 that 1% AEP flood levels in the Argyll Estate are estimated to increase up to 0.1 m only under a range of climate change scenarios which is well within Council's adopted freeboard of 0.5 m.



2.6 Flood Hazard Categories

Flood hazard vulnerability curves based on six categories H1 – H6 are as shown above.

The flood hazard categories on the Argyll Estate in a 1% AEP flood and the PMF under Benchmark Conditions are plotted in **Figures 11 – 12** respectively in Discussion Paper No.1.

It is noted that H1 and H2 conditions would be trafficable for larger vehicles.

3. CONCEPT BUILDING SCENARIOS

Based on the outcomes of the assessments of potential structural measures to mitigate the flooding and/or flood risk in Argyll Estate, consideration has been given to an alternative approach which is based on redeveloping lots in a manner that responds to the flood risks in the absence of any structural measures.

Architectus has prepared our (4) redevelopment scenarios in which all new buildings have floor levels above the PMF. The four scenarios are:

- Low Scenario – A 220 additional precinct dwellings
- Low Scenario – B 218 additional precinct dwellings
- High Scenario – A 382 additional precinct dwellings
- High Scenario – B 426 additional precinct dwellings

4. ASSESSMENT OF THE CONCEPT REDEVELOPMENT SCENARIOS

In order to assess a likely upper bound of flood impacts arising from redevelopment, High Scenario – B was adopted for assessment purposes. This was named **Scenario A**.

A variant on High Scenario – B was also assessed and this was named **Scenario B**.

The floodplain model was modified to represent each Scenario in turn and the 1% AEP 2 hour and 9 hour events were re-run. The flood level differences to the 1% AEP and PMF benchmark conditions were then plotted. The results are discussed as follows.

4.1 Scenario A

The components of the Scenario A redevelopment are identified in **Figure 2** and in **Annexure A.**

The spatial extent of the zones of adopted hydraulic roughness under Scenario A are plotted in **Figure 3**.

The 1% AEP flood level differences are mapped in **Figure A1** while PMF level differences are mapped in **Figure A2** which are appended in **Annexure A**.

The 1% AEP flood level differences for all non-LAHC properties in the zone of adverse impact are tabulated also in **Annexure E**.

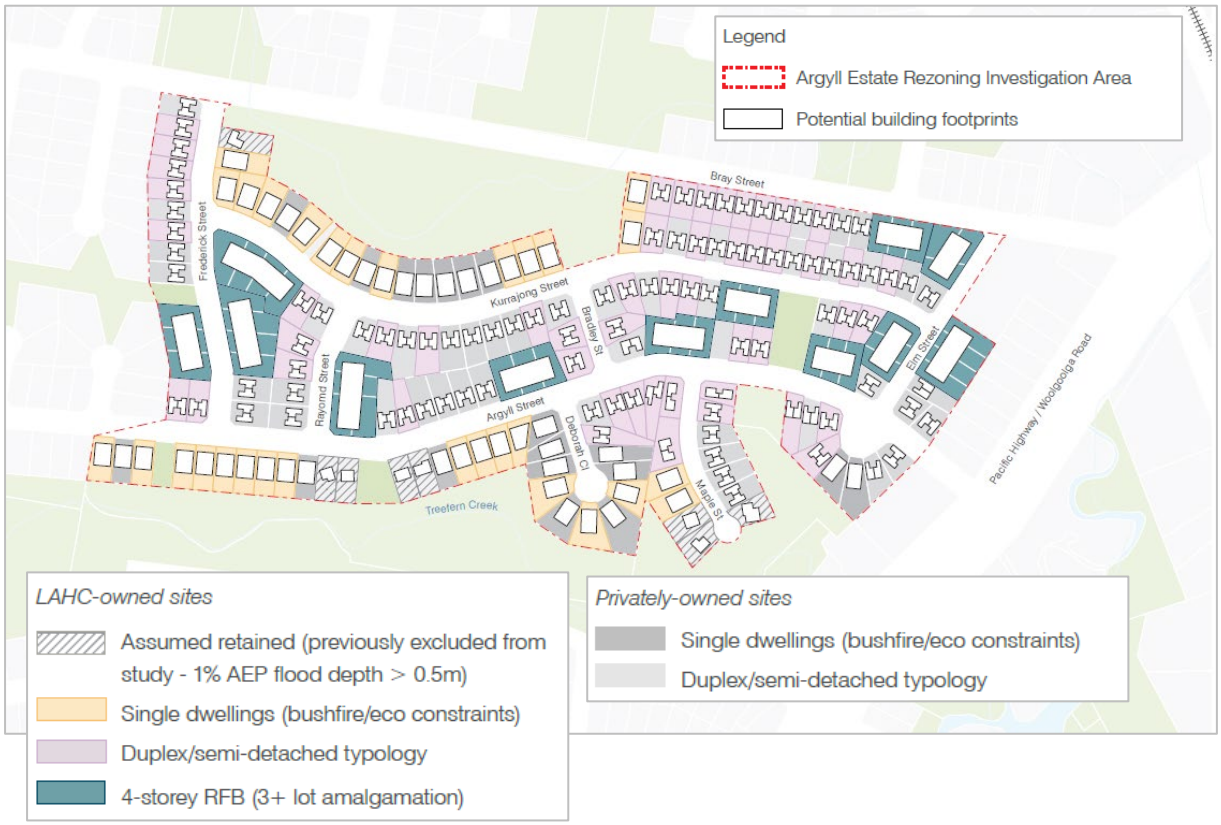


Figure 2 Layout of Scenario A Redevelopment

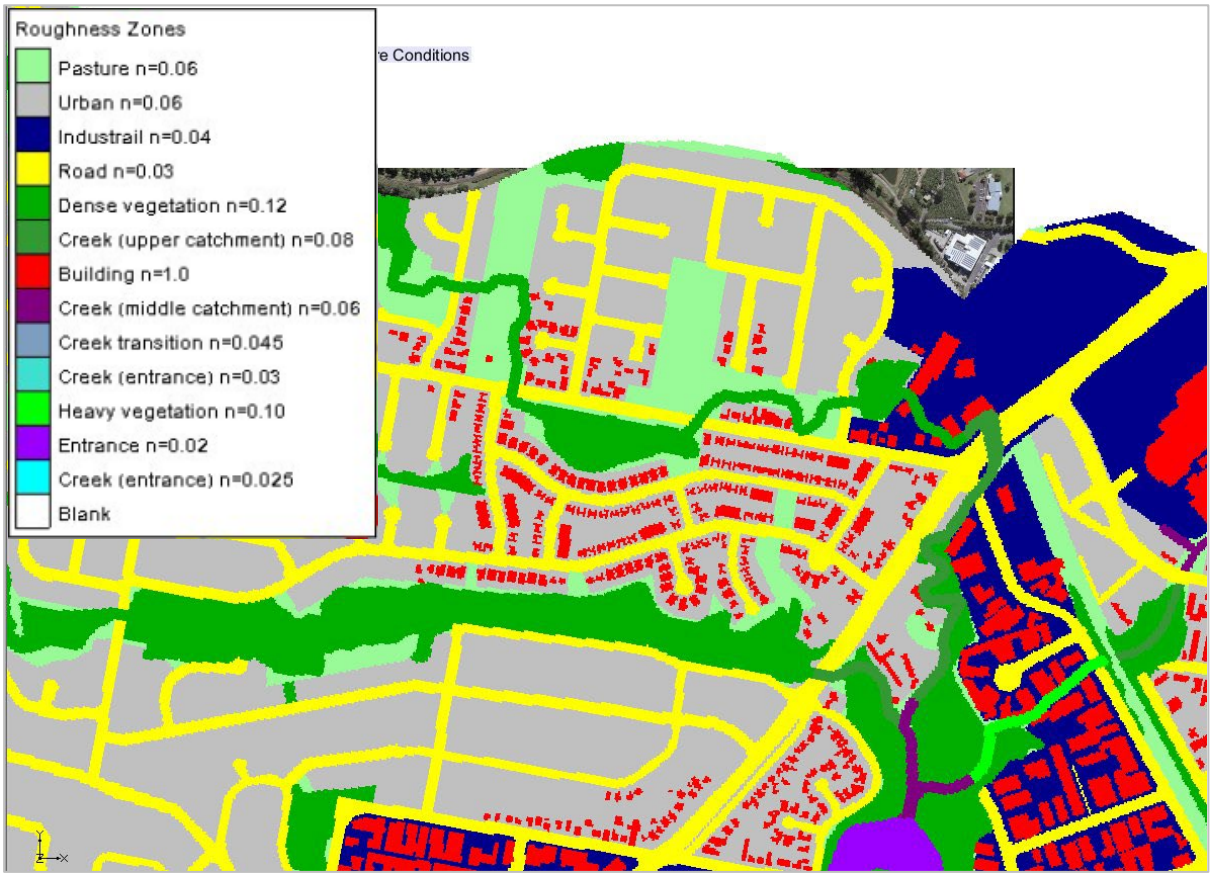


Figure 3 Roughness Zones under Scenario A

Beyond the zone of impact identified under the structural measures (refer Discussion Paper No. 1) the concept redevelopment also generates local zones of impacts in a 1% AEP flood (see Figure A1):

- In the vicinity of the Bray St / Frederick intersection;
- Southern end of Deborah Close
- South of Argyll Street near the Argyll St / Elm St intersection

Figure A2 discloses that if it is intended that all new floor levels are higher than the PMF then on most lots across the estate it would be necessary to raise the floor levels higher than the PMF level under Existing Conditions to account for increases in PMF levels under Scenario A.

4.2 Scenario B

The components of the Scenario B redevelopment are identified in **Figure 4** and in **Annexure B.**

The spatial extent of the zones of adopted hydraulic roughness under Scenario A are plotted in **Figure 5**.

The 1% AEP flood level differences are mapped in **Figure B1** while PMF level differences are mapped in **Figure B2** which are appended in **Annexure B**.

The 1% AEP flood level differences for all non-LAHC properties in the zone of adverse impact are tabulated also in **Annexure E**.

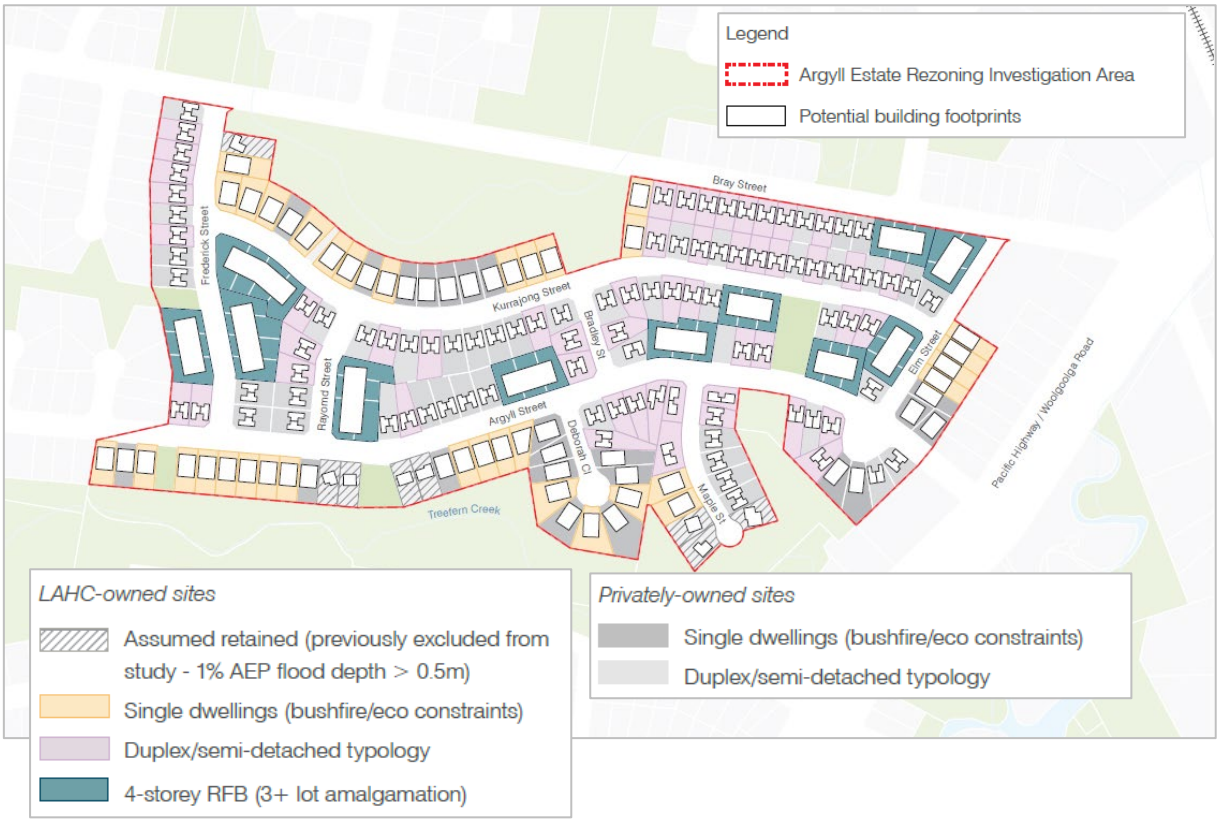


Figure 4 Layout of Scenario B Redevelopment

Figure 5 Roughness Zones under Scenario B

Beyond the zone of impact identified under the structural measures (refer Discussion Paper No. 1) the concept redevelopment also generates local zones of impacts in a 1% AEP flood (see Figure B1):

- In the vicinity of the Bray St / Frederick intersection;
- Southern end of Deborah Close
- South of Argyll Street near the Argyll St / Elm St intersection

Figure B2 discloses that if it is intended that all new floor levels are higher than the PMF then on most lots across the estate it would be necessary to raise the floor levels higher than the PMF level under Existing Conditions to account for increases in PMF levels under Scenario A.

4.3 Scenarios C and D

Given the impacts of the Scenarios A and B, two further scenarios were assessed. The scenarios combined Scenario B building footprints with the culvert diversion from the north arm to the south arm which was previously assessed as a component of structural schemes. The aim was to assess if the diversion mitigates the impacts of Scenario B. The two scenarios were:

Scenario C = Scenario B building footprints = 2 x 1.2 (H) x 1.8 (W) RCBCs

Scenario D = Scenario B building footprints = 1 x 1.2 (H) x 1.8 (W) RCBCs

The alignment of the flow diversion is identified in **Annexure D**.

The 1% AEP flood level differences under Scenario C are mapped in **Figure D1** which is appended in **Annexure D**.

The 1% AEP flood level differences under Scenario D are mapped in **Figure D2** which is appended in **Annexure D**.

The 1% AEP flood level differences for all non-LAHC properties in the zone of adverse impact are tabulated also in **Annexure E**.

5. DISCUSSION

Figure C1 appended in Annexure C discloses that Scenario B has a local impact on 1% AEP flood levels in Elm Street and in the vicinity of the Argyll Street intersection over and above the impacts of Scenario A.

Figure C2 appended in Annexure C discloses that Scenario B has negligible impact on the PMF levels the Argyll Estate and surrounds over and above the impacts of Scenario A.

It is also apparent from the 1% AEP flood levels tabulated in **Annexure E** that:

(vii) Scenario A and Scenario B have the same adverse impacts on 1% AEP flood levels; and that

(viii) On balance these impacts are slightly greater than under Scheme 3C particularly in the industrial estate west of the Pacific Highway;

(ix) Scenario C significantly reduces the impact of the Scenario B building footprints on 1% AEP flood levels on the identified properties;

(x) Scenario D reduces the impact of the Scenario B building footprints on 1% AEP flood levels on the identified properties to within acceptable values;

(xi) The are some zones of adverse impact which were outside of the previous area of interest and therefore do not appear in Annexure E;

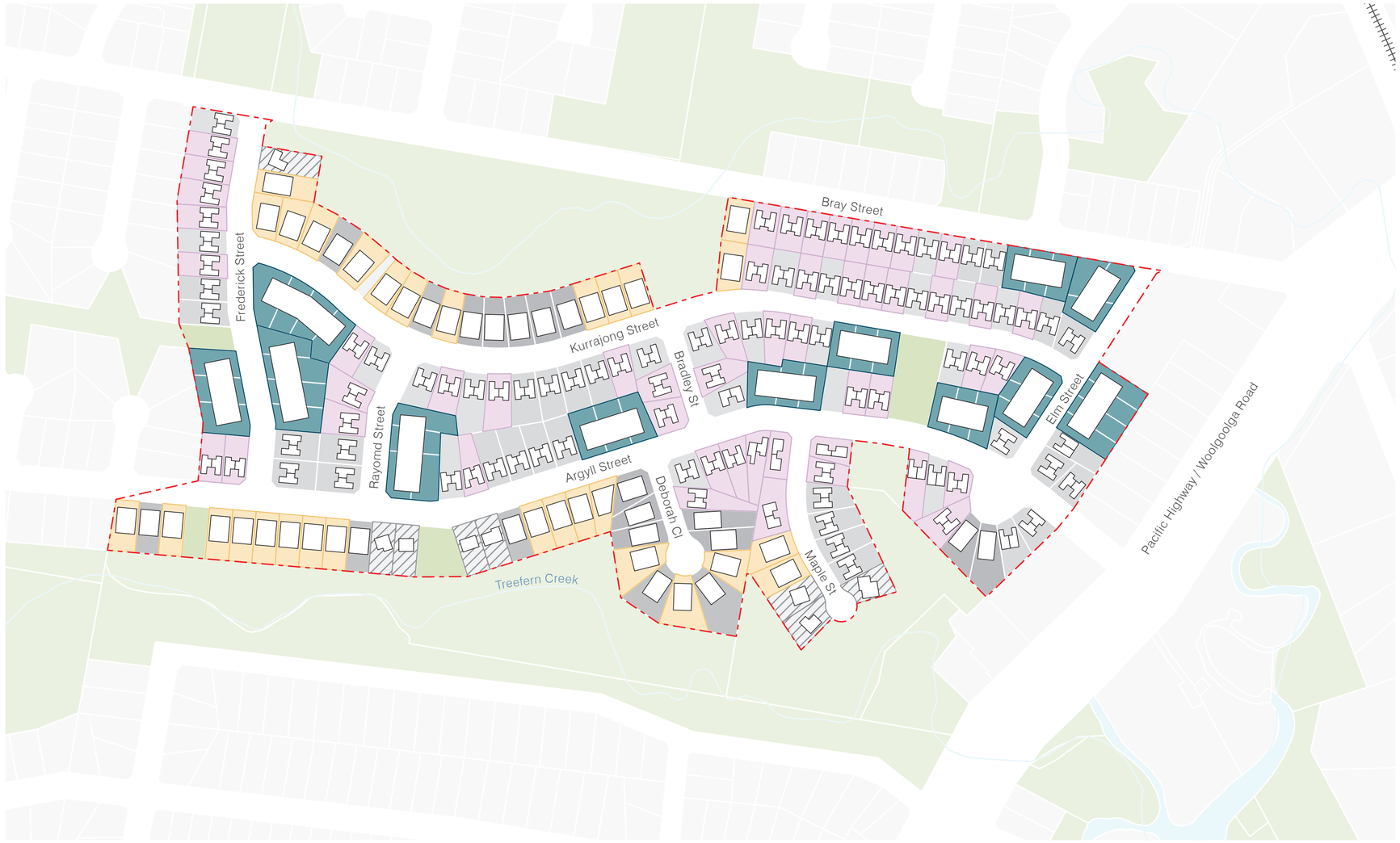
(xii) These local impacts appear to be associated with changed building footprints on properties outside of the planning proposal.

Consideration could be given to limiting the changed building footprints to only those properties included within the planning proposal.

Annexure A

Scenario A Redevelopment

Building footprints - High Growth Scenario A



Legend

- Argyll Estate Rezoning Investigation Area
- Potential building footprints

LAHC-owned sites

- Assumed retained (previously excluded from study - 1% AEP flood depth > 0.5m)
- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology
- 4-storey RFB (3+ lot amalgamation)

Privately-owned sites

- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology

Argyll Estate, Coffs Harbour Flood Risk Assessment

1% AEP
Scenario A – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE A1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

PMF
Scenario A – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE A2

1:4,000 Scale at A3

0 40 80 120 160 200 m

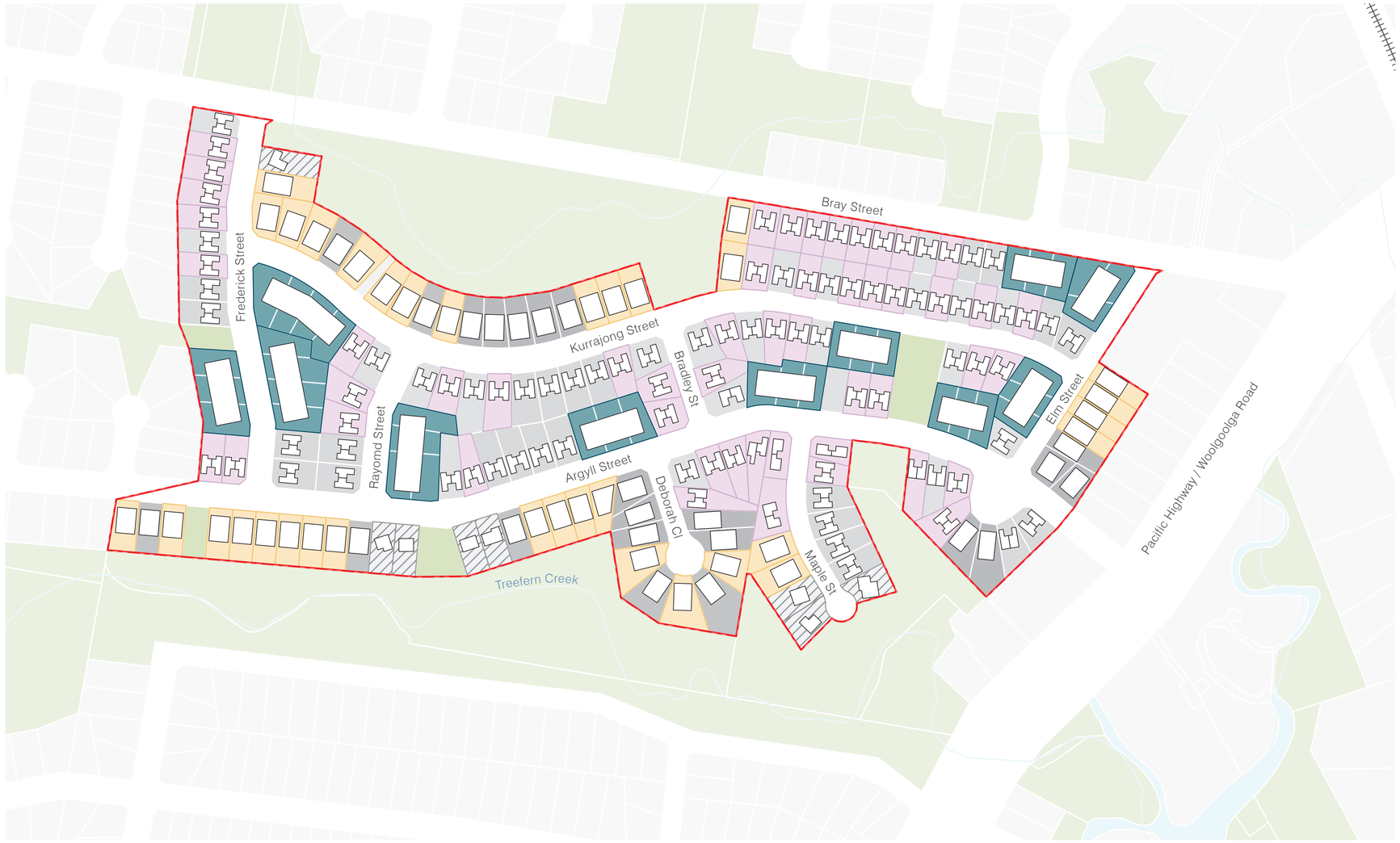
Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Annexure B

Scenario B Redevelopment

Building footprints - High Growth Scenario B



Legend

- Argyll Estate Rezoning Investigation Area
- Potential building footprints

LAHC-owned sites

- Assumed retained (previously excluded from study - 1% AEP flood depth > 0.5m)
- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology
- 4-storey RFB (3+ lot amalgamation)

Privately-owned sites

- Single dwellings (bushfire/eco constraints)
- Duplex/semi-detached typology

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario B – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE B1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

PMF
Scenario B – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE B2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Annexure C

Comparison of Scenario A to Scenario B

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario B – Scenario A
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE C1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour Flood Risk Assessment

PMF
Scenario B – Scenario A
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (mm)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE C2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-3| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Annexure D

Scenarios C and D

Scenarios C and D = Scenario B Building Footprints + Diversion Culvert(s)

Scenario C Diversion:-
2 x1.2 (H) x 1.8m (W) RCBCs
U/S IL approx 5.5 m AHD
D/S IL approx 3.4 m AHD
Length = 415 m
Roughness = 0.015
Inlet loss = 1.0
Outlet loss = 2.0

Scenario D Diversion:-
1 x1.2 (H) x 1.8m (W) RCBCs
U/S IL approx 5.5 m AHD
D/S IL approx 3.4 m AHD
Length = 415 m
Roughness = 0.015
Inlet loss = 1.0
Outlet loss = 2.0

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario C – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE D1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-8| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Argyll Estate, Coffs Harbour
Flood Risk Assessment

1% AEP
Scenario D – Existing
Water Level Difference

Legend

- Site Boundary
- Cadastre

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

FIGURE D2

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno

Map Produced by St Leonards Water (AWE)
Date: 2022-3-8| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

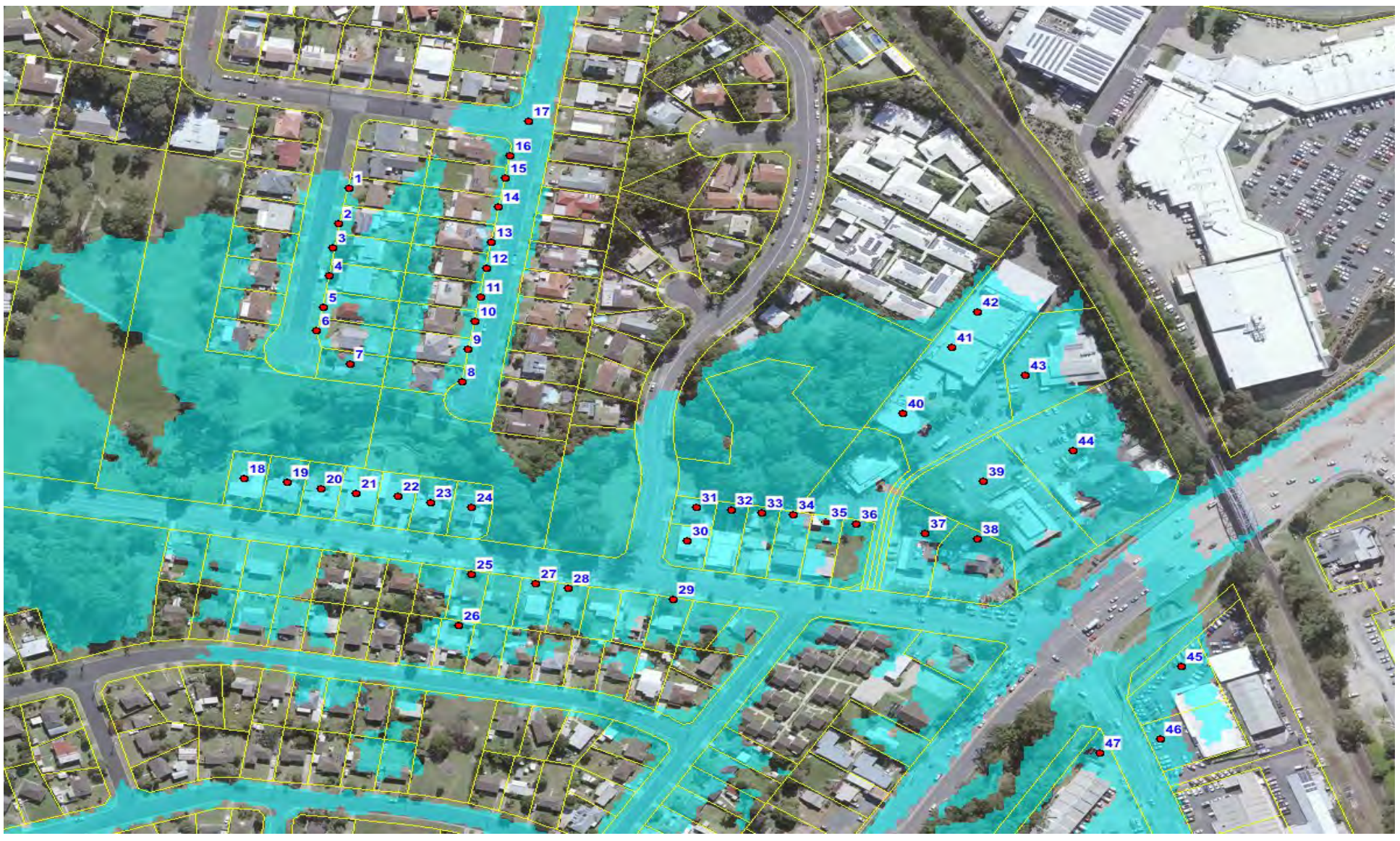
Annexure E

1% AEP Flood Level Differences

NW30163 100yr Flood Level Comparison - Non-LAHC Properties

ID	Existing 2hr (mAHD)	Existing 9hr (mAHD)	Existing Max FL (mAHD) (a)	Scheme 3C 2hr (mAHD)	Scheme 3C 9hr (mAHD)	Scheme 3C Max FL (mAHD) (b)	Difference Rounded (cm) (b)-(a)	High Growth Scenario A 2hr (mAHD)	High Growth Scenario A 9hr (mAHD)	High Growth Scenario A Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	High Growth Scenario B 2hr (mAHD)	High Growth Scenario B 9hr (mAHD)	High Growth Scenario B Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Compared to Scheme 3C (cm)
Hughes Close																	
1	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
2	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
3	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
4	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
5	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
6	6.77	6.74	6.77	6.79	6.76	6.79	2	6.78	6.75	6.78	1	-1	6.78	6.75	6.78	1	-1
7	6.73	6.70	6.73	6.75	6.72	6.75	2	6.74	6.71	6.74	1	-1	6.74	6.71	6.74	1	-1
Grant Close																	
8	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
9	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
10	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
11	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
12	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
13	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
14	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
15	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
16	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
17	6.64	6.62	6.64	6.66	6.64	6.66	2	6.66	6.63	6.66	2	0	6.66	6.63	6.66	2	0
Bray Street (Northside)																	0
18	6.86	6.84	6.86	6.89	6.86	6.89	3	6.87	6.85	6.87	1	-2	6.87	6.85	6.87	1	-2
19	6.76	6.73	6.76	6.78	6.75	6.78	2	6.78	6.75	6.78	2	0	6.78	6.75	6.78	2	0
20	6.73	6.70	6.73	6.75	6.72	6.75	2	6.75	6.72	6.75	2	0	6.75	6.72	6.75	2	0
21	6.67	6.64	6.67	6.69	6.66	6.69	2	6.68	6.66	6.68	1	-1	6.68	6.66	6.68	1	-1
22	6.55	6.53	6.55	6.57	6.55	6.57	2	6.57	6.54	6.57	2	0	6.57	6.54	6.57	2	0
23	6.49	6.47	6.49	6.52	6.49	6.52	3	6.51	6.48	6.51	2	-1	6.51	6.48	6.51	2	-1
24	6.39	6.37	6.39	6.39	6.38	6.39	0	6.41	6.39	6.41	2	2	6.41	6.39	6.41	2	2
Bray Street (Southside)																	
25	6.32	6.30	6.32	6.33	6.31	6.33	1	6.35	6.32	6.35	3	2	6.35	6.32	6.35	3	2
26	6.16	6.15	6.16	6.18	6.16	6.18	2	6.20	6.18	6.20	4	2	6.20	6.18	6.20	4	2
27	6.26	6.25	6.26	6.28	6.26	6.28	2	6.29	6.27	6.29	3	1	6.29	6.27	6.29	3	1
28	6.23	6.21	6.23	6.24	6.23	6.24	1	6.25	6.23	6.25	2	1	6.25	6.23	6.25	2	1
29	6.01	6.00	6.01	6.03	6.01	6.03	2	6.02	6.01	6.02	1	-1	6.02	6.01	6.02	1	-1
Bray Street (Northside)																	
30	6.09	6.08	6.09	6.10	6.09	6.10	1	6.11	6.10	6.11	2	1	6.11	6.10	6.11	2	1
31	6.01	6.00	6.01	6.03	6.01	6.03	2	6.03	6.02	6.03	2	0	6.03	6.02	6.03	2	0
32	5.98	5.97	5.98	5.99	5.98	5.99	1	6.00	5.98	6.00	2	1	6.00	5.98	6.00	2	1
33	5.94	5.93	5.94	5.96	5.94	5.96	2	5.96	5.95	5.96	2	0	5.96	5.95	5.96	2	0
34	5.79	5.78	5.79	5.81	5.79	5.81	2	5.80	5.79	5.80	1	-1	5.80	5.79	5.80	1	-1
35	5.53	5.52	5.53	5.54	5.53	5.54	1	5.55	5.53	5.55	2	1	5.55	5.53	5.55	2	1
36	5.46	5.45	5.46	5.48	5.46	5.48	2	5.48	5.47	5.48	2	0	5.48	5.47	5.48	2	0
Industrial West of Pacific Highway																	
37	5.38	5.37	5.38	5.41	5.39	5.41	3	5.42	5.40	5.42	4	1	5.42	5.40	5.42	4	1
38	5.35	5.33	5.35	5.37	5.35	5.37	2	5.38	5.36	5.38	3	1	5.38	5.36	5.38	3	1
39	5.43	5.41	5.43	5.45	5.43	5.45	2	5.46	5.44	5.46	3	1	5.46	5.44	5.46	3	1
40	5.67	5.66	5.67	5.69	5.67	5.69	2	5.69	5.68	5.69	2	0	5.69	5.68	5.69	2	0
41	5.65	5.64	5.65	5.66	5.65	5.66	1	5.67	5.66	5.67	2	1	5.67	5.66	5.67	2	1
42	5.66	5.64	5.66	5.67	5.66	5.67	1	5.68	5.66	5.68	2	1	5.68	5.66	5.68	2	1
43	5.45	5.43	5.45	5.47	5.45	5.47	2	5.48	5.46	5.48	3	1	5.48	5.46	5.48	3	1
44	5.44	5.43	5.44	5.46	5.45	5.46	2	5.47	5.45	5.47	3	1	5.47	5.45	5.47	3	1
Industrial East of Pacific Highway																	
45	4.59	4.57	4.59	4.60	4.59	4.60	1	4.61	4.60	4.61	2	1	4.61	4.60	4.61	2	1
46	4.36	4.36	4.36	4.38	4.38	4.38	2	4.39	4.39	4.39	3	1	4.39	4.39	4.39	3	1
47	4.34	4.34	4.34	4.36	4.35	4.36	2	4.36	4.36	4.36	2	0	4.36	4.36	4.36	2	0
48	4.35	4.35	4.35	4.36	4.36	4.36	1	4.38	4.37	4.38	3	2	4.38	4.37	4.38	3	2

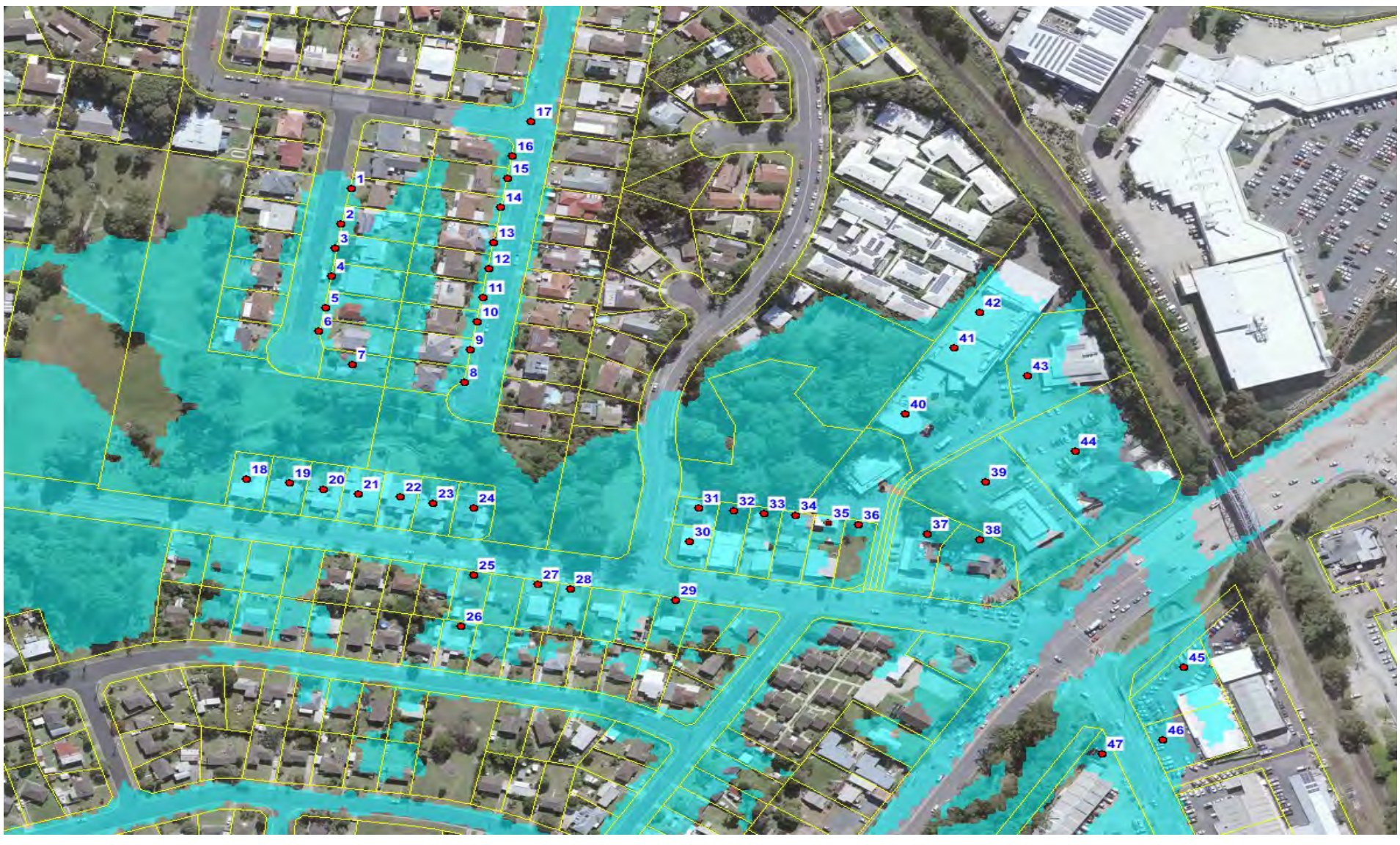
Number of Properties subject to increase in the 1% AEP Flood Level				
	1 cm	9	11	11
	2 cm	35	28	28
	3 cm	3	8	8
	4 cm	0	1	1



NW30163 100yr Flood Level Comparison - Non-LAHC Properties

ID	Existing 2hr (mAHD)	Existing 9hr (mAHD)	Existing Max FL (mAHD) (a)	Scheme 3C 2hr (mAHD)	Scheme 3C 9hr (mAHD)	Scheme 3C Max FL (mAHD) (b)	Difference Rounded (cm) (b)-(a)	Scenario C: High Growth Scenario B + 2 x 1.2 (H) x 1.8 (W) RCBCs 2hr (mAHD)	Scenario C 9hr (mAHD)	Scenario C Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	Scenario D: High Growth Scenario B + 1 x 1.2 (H) x 1.8 (W) RCBCs 2hr (mAHD)	Scenario D 9hr (mAHD)	Scenario D Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Compared to Scheme 3C (cm)
Hughes Close																	
1	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
2	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
3	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
4	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
5	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
6	6.77	6.74	6.77	6.79	6.76	6.79	2	6.73	6.69	6.73	-4	-6	6.75	6.72	6.75	-2	-4
7	6.73	6.70	6.73	6.75	6.72	6.75	2	6.69	6.65	6.69	-4	-6	6.71	6.68	6.71	-2	-4
Grant Close																	
8	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
9	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
10	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
11	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
12	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
13	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
14	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
15	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
16	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
17	6.64	6.62	6.64	6.66	6.64	6.66	2	6.61	6.58	6.61	-3	-5	6.63	6.60	6.63	-1	-3
Bray Street (Northside)																	0
18	6.86	6.84	6.86	6.89	6.86	6.89	3	6.83	6.80	6.83	-3	-6	6.85	6.82	6.85	-1	-4
19	6.76	6.73	6.76	6.78	6.75	6.78	2	6.73	6.68	6.73	-3	-5	6.75	6.72	6.75	-1	-3
20	6.73	6.70	6.73	6.75	6.72	6.75	2	6.69	6.66	6.69	-4	-6	6.72	6.68	6.72	-1	-3
21	6.67	6.64	6.67	6.69	6.66	6.69	2	6.63	6.61	6.63	-4	-6	6.65	6.63	6.65	-2	-4
22	6.55	6.53	6.55	6.57	6.55	6.57	2	6.51	6.49	6.51	-4	-6	6.53	6.51	6.53	-2	-4
23	6.49	6.47	6.49	6.52	6.49	6.52	3	6.45	6.43	6.45	-4	-7	6.47	6.45	6.47	-2	-5
24	6.39	6.37	6.39	6.39	6.38	6.39	0	6.37	6.34	6.37	-2	-2	6.38	6.36	6.38	-1	-1
Bray Street (Southside)																	
25	6.32	6.30	6.32	6.33	6.31	6.33	1	6.31	6.28	6.31	-1	-2	6.32	6.30	6.32	0	-1
26	6.16	6.15	6.16	6.18	6.16	6.18	2	6.16	6.14	6.16	0	-2	6.18	6.16	6.18	2	0
27	6.26	6.25	6.26	6.28	6.26	6.28	2	6.25	6.23	6.25	-1	-3	6.27	6.25	6.27	1	-1
28	6.23	6.21	6.23	6.24	6.23	6.24	1	6.21	6.20	6.21	-2	-3	6.23	6.21	6.23	0	-1
29	6.01	6.00	6.01	6.03	6.01	6.03	2	5.99	5.98	5.99	-2	-4	6.01	5.99	6.01	0	-2
Bray Street (Northside)																	
30	6.09	6.08	6.09	6.10	6.09	6.10	1	6.08	6.06	6.08	-1	-2	6.10	6.08	6.10	1	0
31	6.01	6.00	6.01	6.03	6.01	6.03	2	6.00	5.98	6.00	-1	-3	6.01	6.00	6.01	0	-2
32	5.98	5.97	5.98	5.99	5.98	5.99	1	5.97	5.95	5.97	-1	-2	5.98	5.97	5.98	0	-1
33	5.94	5.93	5.94	5.96	5.94	5.96	2	5.93	5.92	5.93	-1	-3	5.95	5.93	5.95	1	-1
34	5.79	5.78	5.79	5.81	5.79	5.81	2	5.78	5.77	5.78	-1	-3	5.79	5.78	5.79	0	-2
35	5.53	5.52	5.53	5.54	5.53	5.54	1	5.52	5.51	5.52	-1	-2	5.53	5.52	5.53	0	-1
36	5.46	5.45	5.46	5.48	5.46	5.48	2	5.46	5.44	5.46	0	-2	5.47	5.45	5.47	1	-1
Industrial West of Pacific Highway																	
37	5.38	5.37	5.38	5.41	5.39	5.41	3	5.37	5.35	5.37	-1	-4	5.39	5.37	5.39	1	-2
38	5.35	5.33	5.35	5.37	5.35	5.37	2	5.34	5.31	5.34	-1	-3	5.36	5.33	5.36	1	-1
39	5.43	5.41	5.43	5.45	5.43	5.45	2	5.41	5.39	5.41	-2	-4	5.43	5.41	5.43	0	-2
40	5.67	5.66	5.67	5.69	5.67	5.69	2	5.67	5.65	5.67	0	-2	5.68	5.66	5.68	1	-1
41	5.65	5.64	5.65	5.66	5.65	5.66	1	5.65	5.63	5.65	0	-1	5.66	5.64	5.66	1	0
42	5.66	5.64	5.66	5.67	5.66	5.67	1	5.65	5.63	5.65	-1	-2	5.66	5.64	5.66	0	-1
43	5.45	5.43	5.45	5.47	5.45	5.47	2	5.44	5.41	5.44	-1	-3	5.45	5.43	5.45	0	-2
44	5.44	5.43	5.44	5.46	5.45	5.46	2	5.43	5.41	5.43	-1	-3	5.45	5.43	5.45	1	-1
Industrial East of Pacific Highway																	
45	4.59	4.57	4.59	4.60	4.59	4.60	1	4.57	4.56	4.57	-2	-3	4.59	4.57	4.59	0	-1
46	4.36	4.36	4.36	4.38	4.38	4.38	2	4.35	4.35	4.35	-1	-3	4.37	4.36	4.37	1	-1
47	4.34	4.34	4.34	4.36	4.35	4.36	2	4.32	4.32	4.32	-2	-4	4.34	4.34	4.34	0	-2
48	4.35	4.35	4.35	4.36	4.36	4.36	1	4.33	4.33	4.33	-2	-3	4.35	4.35	4.35	0	-1

Number of Properties subject to increase in the 1% AEP Flood Level	1 cm	9	0	9
	2 cm	35	0	1
	3 cm	3	0	0
	4 cm	0	0	0

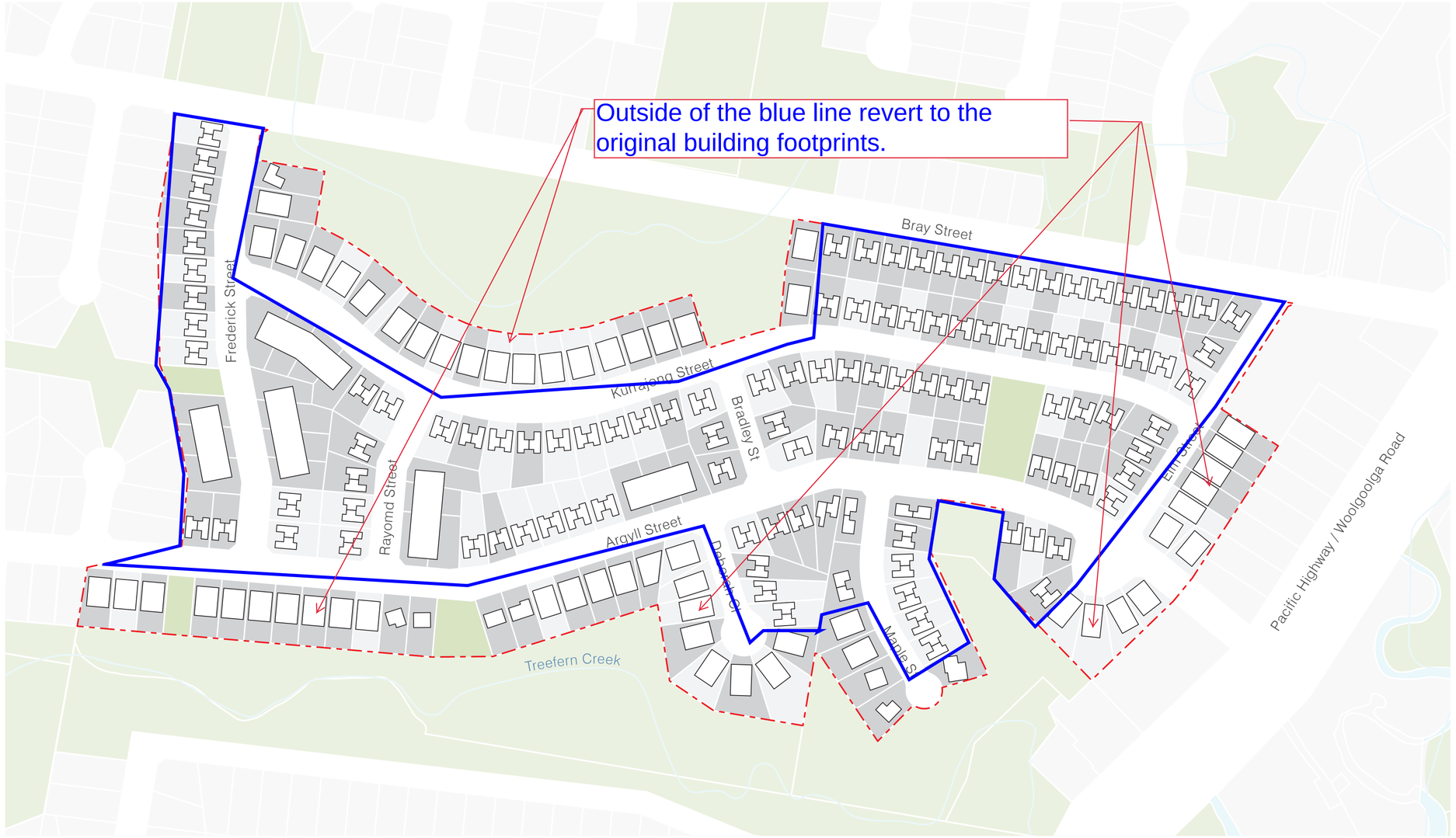


APPENDIX E
SCENARIOS E1 & E2

Cardno
Shaping the Future

Indicative building footprints

Scenario E1



Legend

- Argyll Estate Rezoning Investigation Area
- Lots currently owned by LAHC
- Privately-owned sites

Attachment E-002

Argyll Estate, Coffs Harbour Flood Risk Assessment

1% AEP
Scenario E1 Less Benchmark
Water Level Differences

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 1

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Attachment E-003

Argyll Estate, Coffs Harbour Flood Risk Assessment

0.2% AEP
Scenario E1 Less Benchmark
Water Level Differences

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 2

1:4,000 Scale at A3

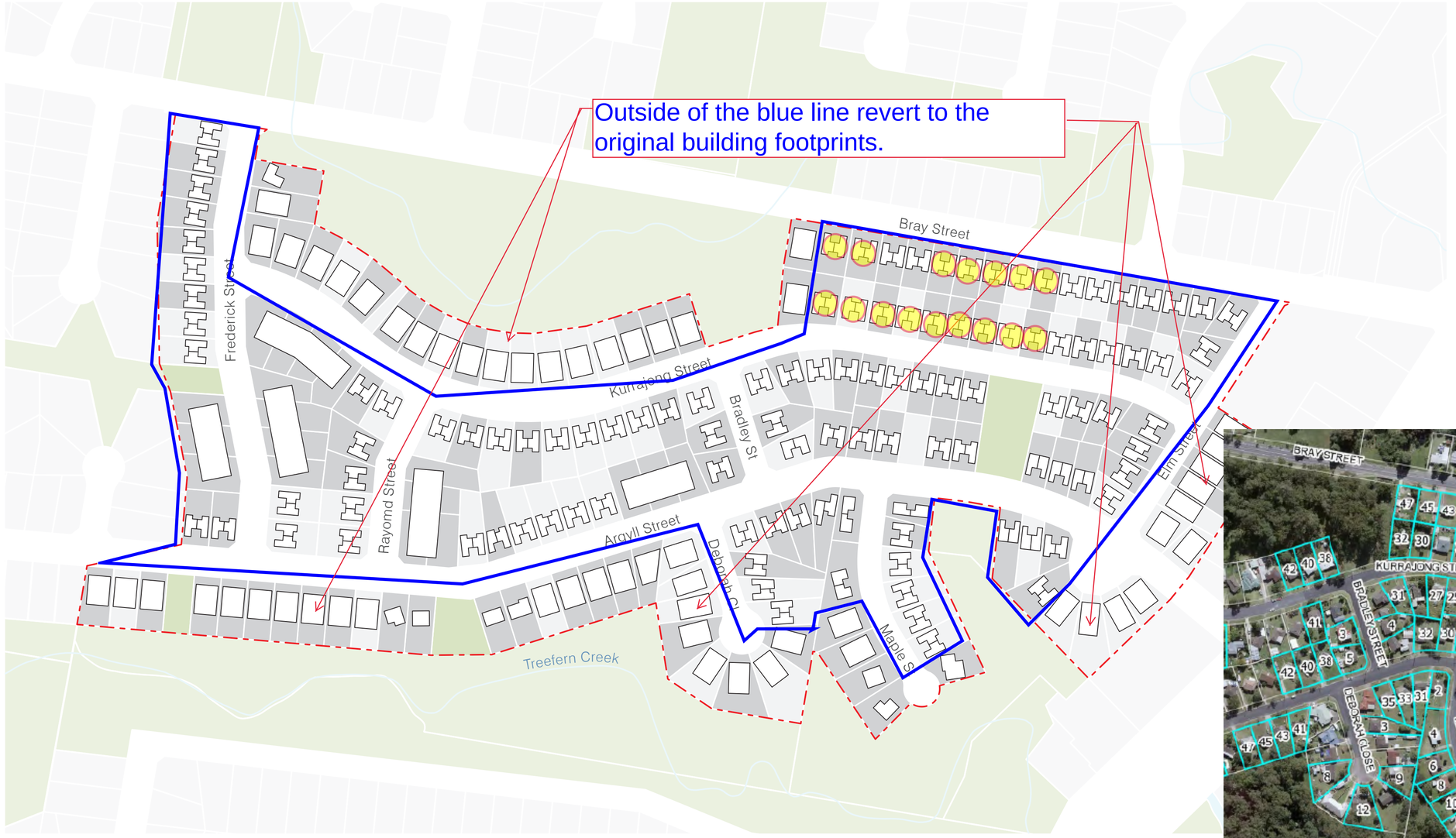
0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Indicative building footprints

Scenario E2



Building Roughness reduced to n = 0.12

Attachment E-005

Argyll Estate, Coffs Harbour Flood Risk Assessment

1% AEP
Scenario E2 Less Benchmark
Water Level Differences

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 3

1:4,000 Scale at A3

0 40 80 120 160 200 m

Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

Attachment E-006

Argyll Estate, Coffs Harbour Flood Risk Assessment

0.2% AEP
Scenario E2 Less Benchmark
Water Level Differences

Legend

- Cadastre
- Site Boundary

Water Level Difference (m)

- < -0.50
- -0.50 to -0.20
- -0.20 to -0.10
- -0.10 to -0.05
- -0.05 to -0.01
- -0.01 to 0.01
- 0.01 to 0.05
- 0.05 to 0.10
- 0.10 to 0.20
- 0.20 to 0.50
- > 0.50

Wet & Dry Analysis

- Was Wet, Now Dry
- Was Dry, Now Wet

FIGURE 4

1:4,000 Scale at A3

0 40 80 120 160 200 m

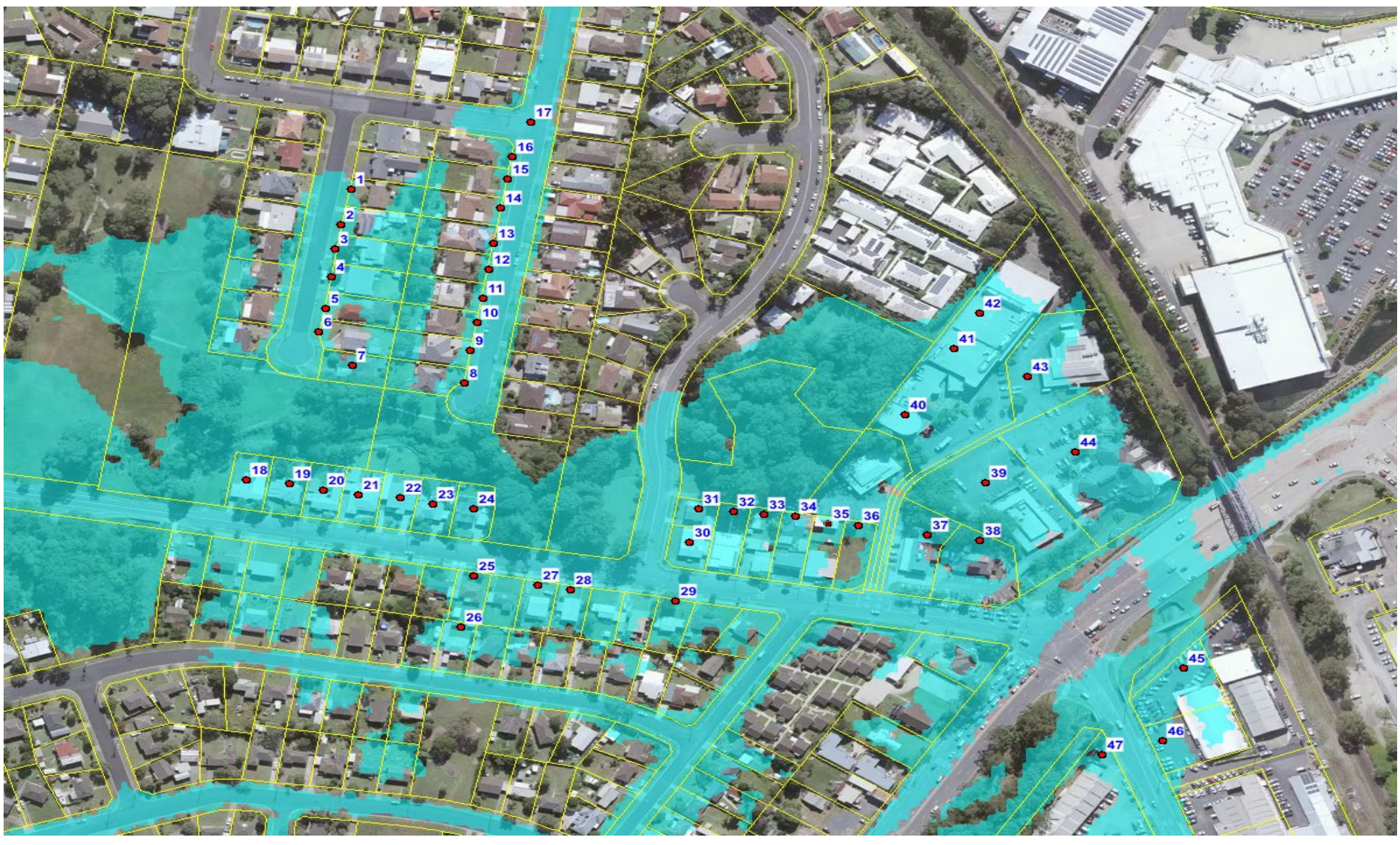
Cardno now Stantec

Map Produced by St Leonards Water (AWE)
Date: 2022-4-5| Project: NW30163 FIA, Argyll Estate, Coffs Habour
Coordinate System: MGA Zone 56
Map: NW30163_Figures.qgz

NW30163 100yr Flood Level Comparison - Non-LAHC Properties

ID	Existing 2hr (mAHD)	Existing 9hr (mAHD)	Existing Max FL (mAHD) (a)	Scheme 3C 2hr (mAHD)	Scheme 3C 9hr (mAHD)	Scheme 3C Max FL (mAHD) (b)	Difference Rounded (cm) (b)-(a)	Scenario E1 2hr (mAHD)	Scenario E1 9hr (mAHD)	Scenario E1 Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	Scenario E2 2hr (mAHD)	Scenario E2 9hr (mAHD)	Scenario E2 Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Difference Actual (cm) (d)-(a)
Hughes Close																	
1	6.77	6.74	6.77	6.79	6.76	6.79	2	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	-0.1
2	6.77	6.74	6.77	6.79	6.76	6.79	2	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	-0.1
3	6.77	6.74	6.77	6.79	6.76	6.79	2	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	-0.1
4	6.77	6.74	6.77	6.79	6.76	6.79	2	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	-0.1
5	6.77	6.74	6.77	6.79	6.76	6.79	2	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	-0.1
6	6.77	6.74	6.77	6.79	6.76	6.79	2	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	-0.1
7	6.73	6.70	6.73	6.75	6.72	6.75	2	6.73	6.70	6.73	0	-2	6.73	6.70	6.73	0	0.0
Grant Close																	
8	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
9	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
10	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
11	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
12	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
13	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
14	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
15	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
16	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
17	6.64	6.62	6.64	6.66	6.64	6.66	2	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	0.0
Bray Street (Northside)																	
18	6.86	6.84	6.86	6.89	6.86	6.89	3	6.87	6.84	6.87	1	-2	6.86	6.84	6.86	0	-0.1
19	6.76	6.73	6.76	6.78	6.75	6.78	2	6.77	6.74	6.77	1	-1	6.76	6.73	6.76	0	0.0
20	6.73	6.70	6.73	6.75	6.72	6.75	2	6.74	6.71	6.74	1	-1	6.73	6.70	6.73	0	0.0
21	6.67	6.64	6.67	6.69	6.66	6.69	2	6.68	6.65	6.68	1	-1	6.67	6.64	6.67	0	0.0
22	6.55	6.53	6.55	6.57	6.55	6.57	2	6.56	6.54	6.56	1	-1	6.55	6.53	6.55	0	0.0
23	6.49	6.47	6.49	6.52	6.49	6.52	3	6.51	6.48	6.51	2	-1	6.49	6.47	6.49	0	0.0
24	6.39	6.37	6.39	6.39	6.38	6.39	0	6.40	6.38	6.40	1	1	6.39	6.37	6.39	0	0.1
Bray Street (Southside)																	
25	6.32	6.30	6.32	6.33	6.31	6.33	1	6.34	6.32	6.34	2	1	6.31	6.30	6.31	-1	0.0
26	6.16	6.15	6.16	6.18	6.16	6.18	2	6.19	6.18	6.19	3	1	6.17	6.15	6.17	1	0.2
27	6.26	6.25	6.26	6.28	6.26	6.28	2	6.28	6.27	6.28	2	0	6.27	6.25	6.27	1	0.5
28	6.23	6.21	6.23	6.24	6.23	6.24	1	6.24	6.23	6.24	1	0	6.23	6.21	6.23	0	0.2
29	6.01	6.00	6.01	6.03	6.01	6.03	2	6.03	6.01	6.03	2	0	6.01	6.00	6.01	0	0.1
Bray Street (Northside)																	
30	6.09	6.08	6.09	6.10	6.09	6.10	1	6.11	6.09	6.11	2	1	6.09	6.08	6.09	0	0.3
31	6.01	6.00	6.01	6.03	6.01	6.03	2	6.03	6.01	6.03	2	0	6.01	6.00	6.01	0	0.2
32	5.98	5.97	5.98	5.99	5.98	5.99	1	5.99	5.98	5.99	1	0	5.98	5.97	5.98	0	0.2
33	5.94	5.93	5.94	5.96	5.94	5.96	2	5.96	5.94	5.96	2	0	5.94	5.93	5.94	0	0.3
34	5.79	5.78	5.79	5.81	5.79	5.81	2	5.80	5.79	5.80	1	-1	5.79	5.78	5.79	0	0.1
35	5.53	5.52	5.53	5.54	5.53	5.54	1	5.54	5.53	5.54	1	0	5.53	5.52	5.53	0	0.3
36	5.46	5.45	5.46	5.48	5.46	5.48	2	5.48	5.46	5.48	2	0	5.46	5.45	5.46	0	0.3
Industrial West of Pacific Highway																	
37	5.38	5.37	5.38	5.41	5.39	5.41	3	5.41	5.39	5.41	3	0	5.39	5.37	5.39	1	0.5
38	5.35	5.33	5.35	5.37	5.35	5.37	2	5.37	5.35	5.37	2	0	5.35	5.34	5.35	0	0.5
39	5.43	5.41	5.43	5.45	5.43	5.45	2	5.45	5.44	5.45	2	0	5.43	5.42	5.43	0	0.4
40	5.67	5.66	5.67	5.69	5.67	5.69	2	5.69	5.67	5.69	2	0	5.67	5.66	5.67	0	0.2
41	5.65	5.64	5.65	5.66	5.65	5.66	1	5.67	5.65	5.67	2	1	5.65	5.64	5.65	0	0.3
42	5.66	5.64	5.66	5.67	5.66	5.67	1	5.67	5.66	5.67	1	0	5.66	5.65	5.66	0	0.3
43	5.45	5.43	5.45	5.47	5.45	5.47	2	5.47	5.45	5.47	2	0	5.45	5.44	5.45	0	0.4
44	5.44	5.43	5.44	5.46	5.45	5.46	2	5.47	5.45	5.47	3	1	5.45	5.43	5.45	1	0.4
Industrial East of Pacific Highway																	
45	4.59	4.57	4.59	4.60	4.59	4.60	1	4.61	4.59	4.61	2	1	4.59	4.58	4.59	0	0.4
46	4.36	4.36	4.36	4.38	4.38	4.38	2	4.38	4.38	4.38	2	0	4.37	4.37	4.37	1	0.4
47	4.34	4.34	4.34	4.36	4.35	4.36	2	4.36	4.36	4.36	2	0	4.35	4.34	4.35	1	0.3
48	4.35	4.35	4.35	4.36	4.36	4.36	1	4.37	4.37	4.37	2	1	4.35	4.35	4.35	0	0.4

Number of Properties subject to increase in the 1% AEP Flood				
	Up to 1 cm	9	28	48
	2 cm	35	17	0
	3 cm	3	3	0
	4 cm	0	0	0

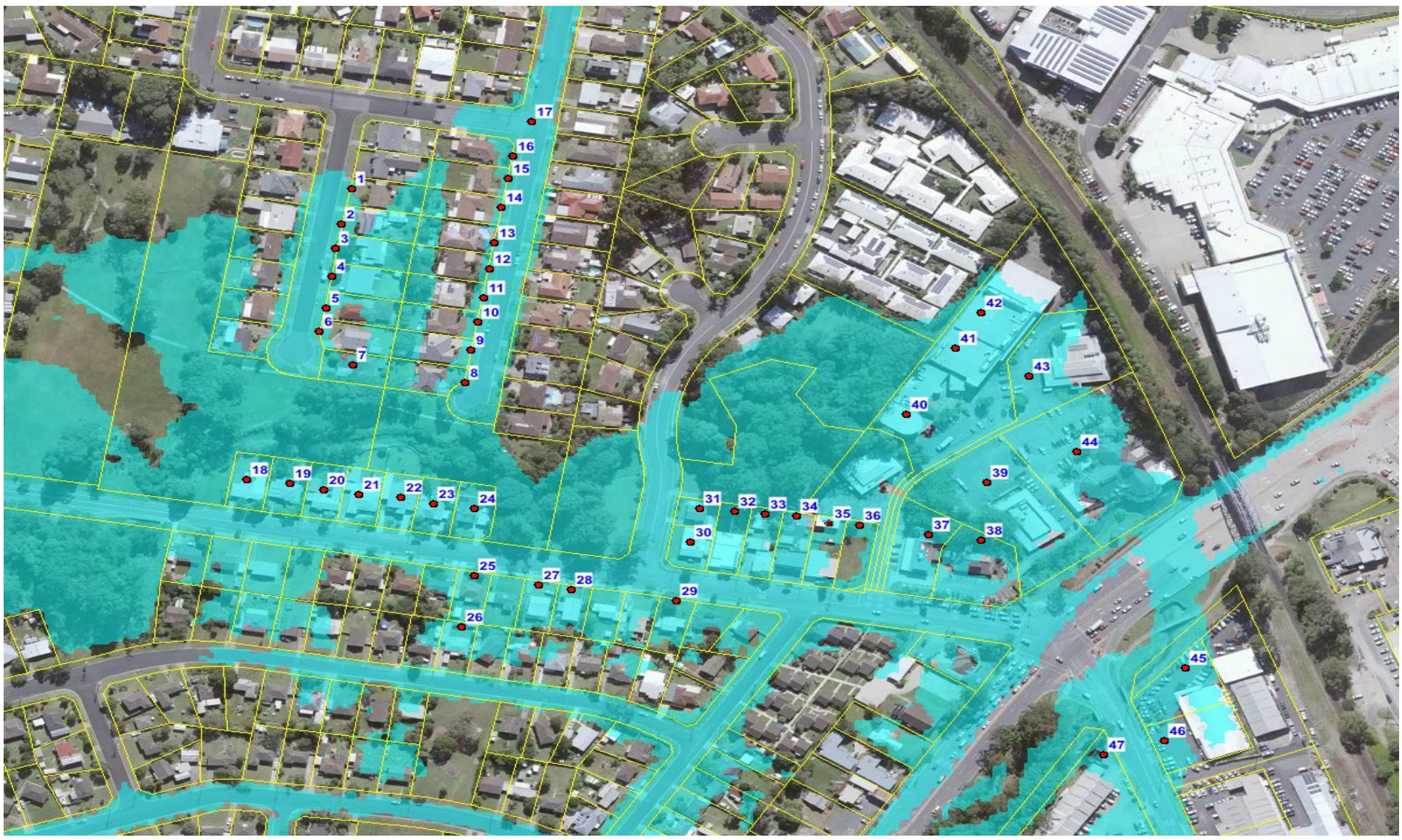


NW30163 500yr Flood Level Comparison - Non-LAHC Properties

Scenario E1 | Scenario E2

ID	Existing 500 yr ARI 2hr (mAHD)	Existing 500 yr ARI 9hr (mAHD)	Existing 500 yr ARI Max FL (mAHD) (a)	Existing 100 yr ARI 2hr (mAHD)	Existing 100 yr ARI 9hr (mAHD)	Existing 100 yr ARI Max FL (mAHD) (b)	Difference Rounded (cm) (a)-(b)	Scenario E1 2hr (mAHD)	Scenario E1 9hr (mAHD)	Scenario E1 Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	Scenario E2 2hr (mAHD)	Scenario E2 9hr (mAHD)	Scenario E2 Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Difference Actual (cm) (d)-(a)
Hughes Close																	
1			6.92	6.77	6.74	6.77	15	6.93	6.87	6.93	1		6.92	6.86	6.92	0	-0.2
2			6.92	6.77	6.74	6.77	15	6.93	6.87	6.93	1		6.92	6.86	6.92	0	-0.2
3			6.92	6.77	6.74	6.77	15	6.93	6.87	6.93	1		6.92	6.86	6.92	0	-0.2
4			6.92	6.77	6.74	6.77	15	6.93	6.87	6.93	1		6.92	6.86	6.92	0	-0.1
5			6.92	6.77	6.74	6.77	15	6.93	6.87	6.93	1		6.92	6.86	6.92	0	-0.2
6			6.92	6.77	6.74	6.77	15	6.93	6.87	6.93	1		6.92	6.86	6.92	0	-0.1
7			6.88	6.73	6.70	6.73	15	6.89	6.84	6.89	1		6.88	6.83	6.88	0	-0.2
Grant Close																	
8			6.81	6.64	6.62	6.64	17	6.82	6.76	6.82	1		6.81	6.75	6.81	0	-0.1
9			6.81	6.64	6.62	6.64	17	6.82	6.76	6.82	1		6.81	6.75	6.81	0	-0.3
10			6.81	6.64	6.62	6.64	17	6.82	6.77	6.82	1		6.81	6.75	6.81	0	-0.1
11			6.81	6.64	6.62	6.64	17	6.82	6.77	6.82	1		6.81	6.75	6.81	0	-0.1
12			6.81	6.64	6.62	6.64	17	6.82	6.77	6.82	1		6.81	6.75	6.81	0	-0.2
13			6.81	6.64	6.62	6.64	17	6.82	6.77	6.82	1		6.81	6.75	6.81	0	-0.1
14			6.81	6.64	6.62	6.64	17	6.83	6.77	6.83	2		6.81	6.75	6.81	0	-0.1
15			6.81	6.64	6.62	6.64	17	6.83	6.77	6.83	2		6.81	6.75	6.81	0	-0.2
16			6.81	6.64	6.62	6.64	17	6.83	6.77	6.83	2		6.81	6.75	6.81	0	0.0
17			6.81	6.64	6.62	6.64	17	6.83	6.77	6.83	2		6.81	6.76	6.81	0	-0.2
Bray Street (Northside)																	
18			6.99	6.86	6.84	6.86	13	7.00	6.95	7.00	1		6.99	6.94	6.99	0	-0.1
19			6.90	6.76	6.73	6.76	14	6.91	6.86	6.91	1		6.90	6.85	6.90	0	-0.1
20			6.88	6.73	6.70	6.73	15	6.89	6.84	6.89	1		6.88	6.83	6.88	0	-0.1
21			6.80	6.67	6.64	6.67	13	6.82	6.77	6.82	2		6.80	6.76	6.80	0	-0.1
22			6.69	6.55	6.53	6.55	14	6.70	6.65	6.70	1		6.69	6.64	6.69	0	-0.1
23			6.65	6.49	6.47	6.49	16	6.67	6.61	6.67	2		6.65	6.60	6.65	0	-0.3
24			6.49	6.39	6.37	6.39	10	6.51	6.47	6.51	2		6.49	6.45	6.49	0	-0.2
Bray Street (Southside)																	
25			6.42	6.32	6.30	6.32	10	6.46	6.42	6.46	4		6.42	6.38	6.42	0	-0.4
26			6.24	6.16	6.15	6.16	8	6.30	6.26	6.30	6		6.25	6.22	6.25	1	1.2
27			6.36	6.26	6.25	6.26	10	6.39	6.36	6.39	3		6.37	6.33	6.37	1	0.7
28			6.31	6.23	6.21	6.23	8	6.34	6.31	6.34	3		6.31	6.28	6.31	0	0.1
29			6.09	6.01	6.00	6.01	8	6.11	6.08	6.11	2		6.09	6.06	6.09	0	0.2
Bray Street (Northside)																	
30			6.17	6.09	6.08	6.09	8	6.20	6.17	6.20	3		6.17	6.15	6.17	0	0.2
31			6.09	6.01	6.00	6.01	8	6.11	6.09	6.11	2		6.09	6.06	6.09	0	0.2
32			6.05	5.98	5.97	5.98	7	6.08	6.05	6.08	3		6.05	6.03	6.05	0	0.2
33			6.02	5.94	5.93	5.94	8	6.04	6.01	6.04	2		6.02	5.99	6.02	0	0.2
34			5.85	5.79	5.78	5.79	6	5.87	5.85	5.87	2		5.85	5.84	5.85	0	0.1
35			5.60	5.53	5.52	5.53	7	5.63	5.60	5.63	3		5.60	5.58	5.60	0	0.3
36			5.54	5.46	5.45	5.46	8	5.57	5.54	5.57	3		5.55	5.52	5.55	1	0.3
Industrial West of Pacific Highway																	
37			5.50	5.38	5.37	5.38	12	5.54	5.50	5.54	4		5.50	5.47	5.50	0	0.4
38			5.46	5.35	5.33	5.35	11	5.49	5.46	5.49	3		5.47	5.43	5.47	1	0.4
39			5.54	5.43	5.41	5.43	11	5.58	5.54	5.58	4		5.55	5.51	5.55	1	0.4
40			5.74	5.67	5.66	5.67	7	5.77	5.74	5.77	3		5.75	5.72	5.75	1	0.2
41			5.73	5.65	5.64	5.65	8	5.76	5.73	5.76	3		5.73	5.71	5.73	0	0.5
42			5.73	5.66	5.64	5.66	7	5.76	5.73	5.76	3		5.74	5.71	5.74	1	0.3
43			5.56	5.45	5.43	5.45	11	5.59	5.55	5.59	3		5.56	5.53	5.56	0	0.4
44			5.55	5.44	5.43	5.44	11	5.59	5.55	5.59	4		5.56	5.52	5.56	1	0.3
Industrial East of Pacific Highway																	
45			4.73	4.59	4.57	4.59	14	4.77	4.73	4.77	4		4.74	4.71	4.74	1	0.6
46			4.53	4.36	4.36	4.36	17	4.56	4.55	4.56	3		4.53	4.52	4.53	0	0.7
47			4.49	4.34	4.34	4.34	15	4.53	4.52	4.53	4		4.50	4.49	4.50	1	0.8
48			4.51	4.35	4.35	4.35	16	4.55	4.53	4.55	4		4.52	4.51	4.52	1	0.8

Number of Properties subject to increase in the 0.2% AEP Flood		Scenario E1	Scenario E2
	Up to 1 cm	17	48
	2 cm	11	0
	3 cm	12	0
	4 cm	8	0

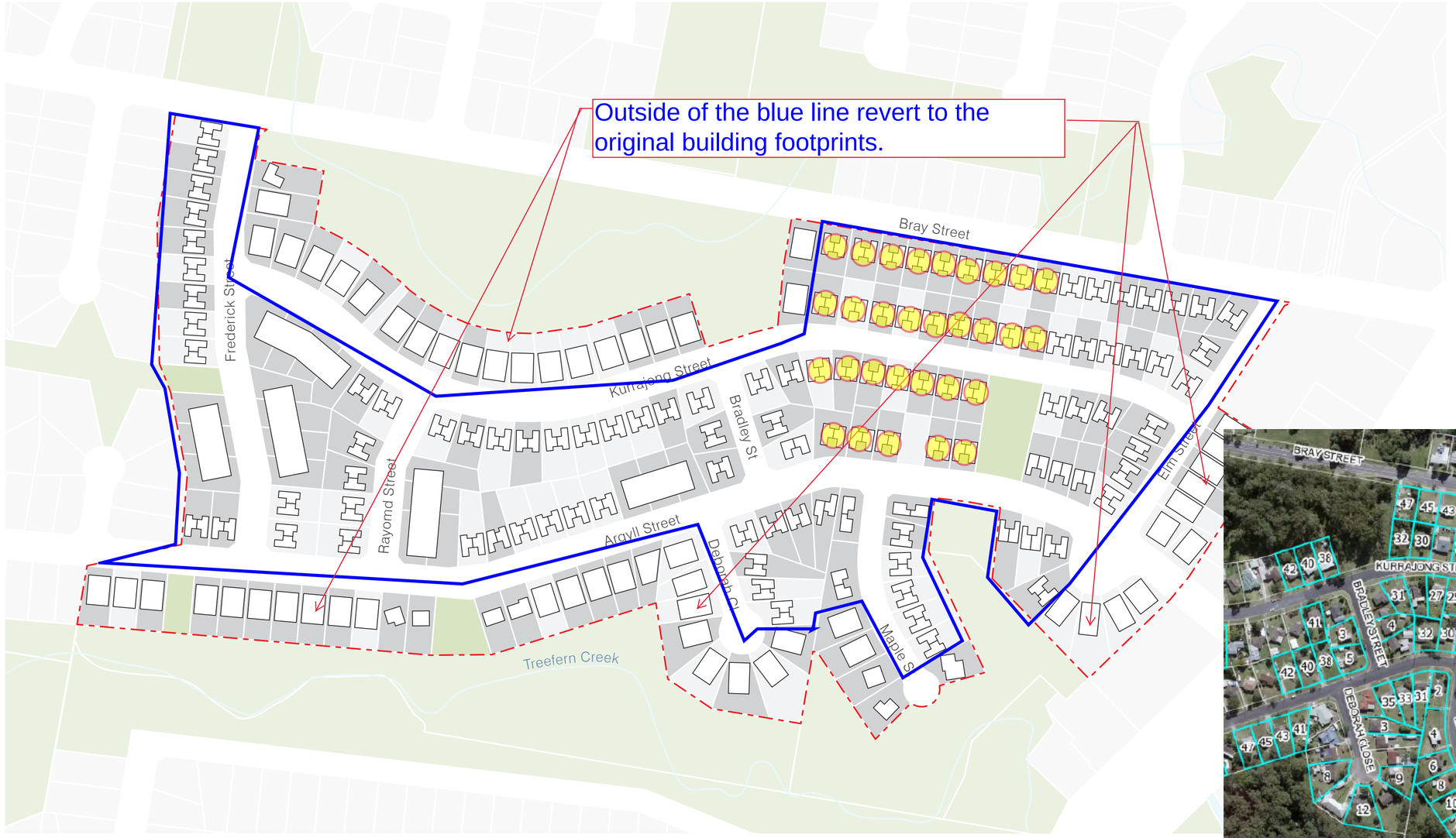


APPENDIX F
SCENARIO E3

Cardno
Shaping the Future

Indicative building footprints

Scenario E3



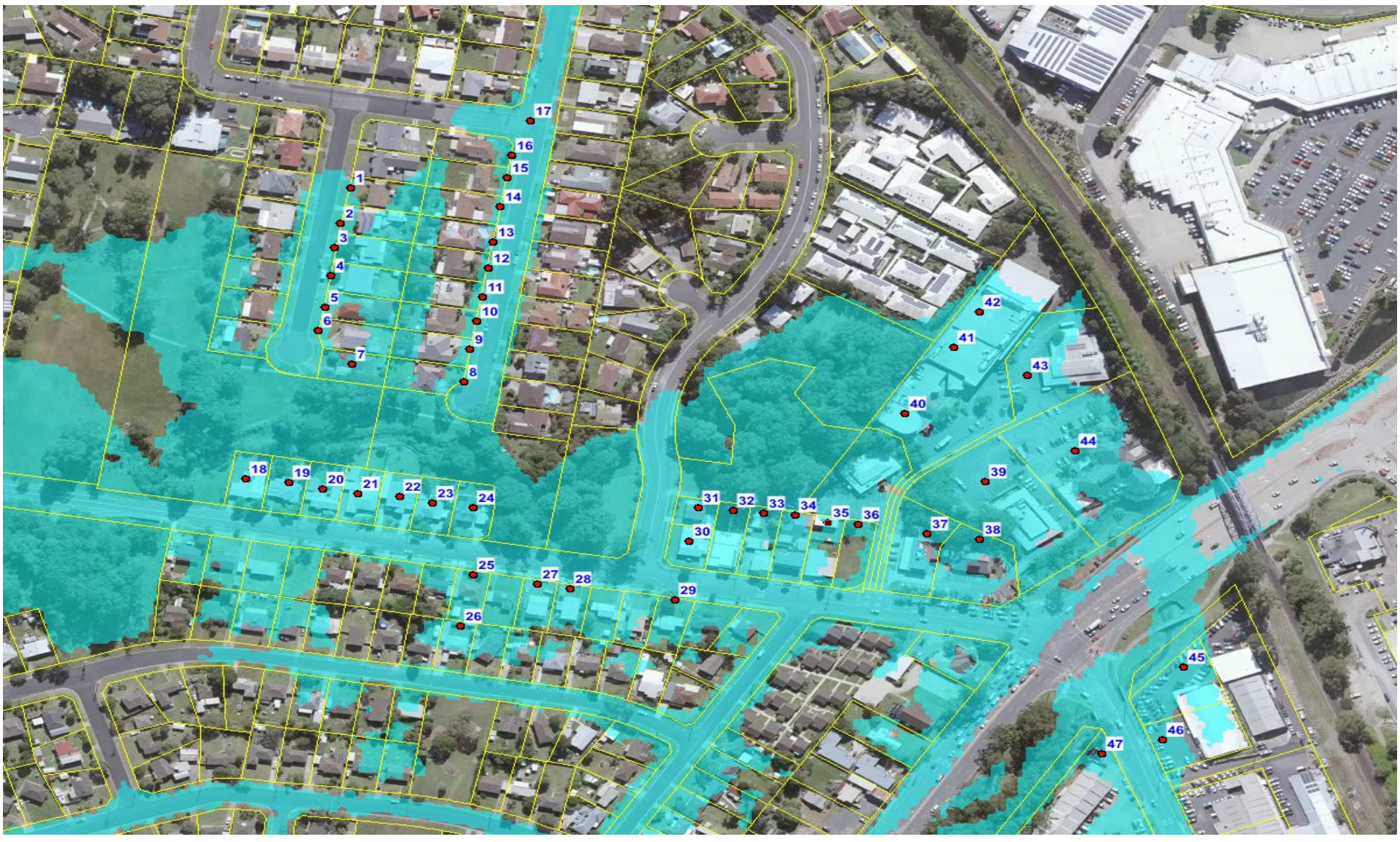
Building Roughness reduced to n = 0.12

NW30163 100yr Flood Level Comparison - Non-LAHC Properties

Attachment F-002

ID	Existing 2hr (mAHD)	Existing 9hr (mAHD)	Existing Max FL (mAHD) (a)	Scenario E1 2hr (mAHD)	Scenario E1 9hr (mAHD)	Scenario E1 Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Compared to Scheme 3C (cm)	Scenario E2 2hr (mAHD)	Scenario E2 9hr (mAHD)	Scenario E2 Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Scenario E3 2hr (mAHD)	Scenario E3 9hr (mAHD)	Scenario E3 Max FL (mAHD) (e)	Difference Rounded (cm) (e)-(a)	Difference Actual (cm) (d)-(a)
Hughes Close																	
1	6.77	6.74	6.77	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	6.77	6.74	6.77	0	-0.1
2	6.77	6.74	6.77	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	6.77	6.74	6.77	0	-0.1
3	6.77	6.74	6.77	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	6.77	6.74	6.77	0	-0.1
4	6.77	6.74	6.77	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	6.77	6.74	6.77	0	-0.1
5	6.77	6.74	6.77	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	6.77	6.74	6.77	0	-0.1
6	6.77	6.74	6.77	6.77	6.74	6.77	0	-2	6.77	6.74	6.77	0	6.77	6.74	6.77	0	-0.1
7	6.73	6.70	6.73	6.73	6.70	6.73	0	-2	6.73	6.70	6.73	0	6.73	6.70	6.73	0	-0.1
Grant Close																	
8	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	-0.1
9	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
10	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
11	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
12	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
13	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
14	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
15	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	0.0
16	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	-0.1
17	6.64	6.62	6.64	6.65	6.63	6.65	1	-1	6.64	6.62	6.64	0	6.64	6.62	6.64	0	-0.1
Bray Street (Northside)																	
18	6.86	6.84	6.86	6.87	6.84	6.87	1	-2	6.86	6.84	6.86	0	6.86	6.84	6.86	0	-0.1
19	6.76	6.73	6.76	6.77	6.74	6.77	1	-1	6.76	6.73	6.76	0	6.76	6.73	6.76	0	-0.1
20	6.73	6.70	6.73	6.74	6.71	6.74	1	-1	6.73	6.70	6.73	0	6.73	6.70	6.73	0	0.0
21	6.67	6.64	6.67	6.68	6.65	6.68	1	-1	6.67	6.64	6.67	0	6.67	6.64	6.67	0	-0.1
22	6.55	6.53	6.55	6.56	6.54	6.56	1	-1	6.55	6.53	6.55	0	6.55	6.53	6.55	0	-0.1
23	6.49	6.47	6.49	6.51	6.48	6.51	2	-1	6.49	6.47	6.49	0	6.49	6.47	6.49	0	0.0
24	6.39	6.37	6.39	6.40	6.38	6.40	1	1	6.39	6.37	6.39	0	6.39	6.37	6.39	0	0.0
Bray Street (Southside)																	
25	6.32	6.30	6.32	6.34	6.32	6.34	2	1	6.31	6.30	6.31	-1	6.31	6.30	6.31	-1	-0.1
26	6.16	6.15	6.16	6.19	6.18	6.19	3	1	6.17	6.15	6.17	1	6.17	6.15	6.17	1	0.2
27	6.26	6.25	6.26	6.28	6.27	6.28	2	0	6.27	6.25	6.27	1	6.27	6.25	6.27	1	0.5
28	6.23	6.21	6.23	6.24	6.23	6.24	1	0	6.23	6.21	6.23	0	6.23	6.21	6.23	0	0.1
29	6.01	6.00	6.01	6.03	6.01	6.03	2	0	6.01	6.00	6.01	0	6.01	6.00	6.01	0	0.1
Bray Street (Northside)																	
30	6.09	6.08	6.09	6.11	6.09	6.11	2	1	6.09	6.08	6.09	0	6.09	6.08	6.09	0	0.2
31	6.01	6.00	6.01	6.03	6.01	6.03	2	0	6.01	6.00	6.01	0	6.01	6.00	6.01	0	0.1
32	5.98	5.97	5.98	5.99	5.98	5.99	1	0	5.98	5.97	5.98	0	5.98	5.97	5.98	0	0.1
33	5.94	5.93	5.94	5.96	5.94	5.96	2	0	5.94	5.93	5.94	0	5.94	5.93	5.94	0	0.2
34	5.79	5.78	5.79	5.80	5.79	5.80	1	-1	5.79	5.78	5.79	0	5.79	5.78	5.79	0	0.1
35	5.53	5.52	5.53	5.54	5.53	5.54	1	0	5.53	5.52	5.53	0	5.53	5.52	5.53	0	0.2
36	5.46	5.45	5.46	5.48	5.46	5.48	2	0	5.46	5.45	5.46	0	5.46	5.45	5.46	0	0.3
Industrial West of Pacific Highway																	
37	5.38	5.37	5.38	5.41	5.39	5.41	3	0	5.39	5.37	5.39	1	5.39	5.37	5.39	1	0.4
38	5.35	5.33	5.35	5.37	5.35	5.37	2	0	5.35	5.34	5.35	0	5.35	5.33	5.35	0	0.3
39	5.43	5.41	5.43	5.45	5.44	5.45	2	0	5.43	5.42	5.43	0	5.43	5.42	5.43	0	0.3
40	5.67	5.66	5.67	5.69	5.67	5.69	2	0	5.67	5.66	5.67	0	5.67	5.66	5.67	0	0.2
41	5.65	5.64	5.65	5.67	5.65	5.67	2	1	5.65	5.64	5.65	0	5.65	5.64	5.65	0	0.2
42	5.66	5.64	5.66	5.67	5.66	5.67	1	0	5.66	5.65	5.66	0	5.66	5.65	5.66	0	0.2
43	5.45	5.43	5.45	5.47	5.45	5.47	2	0	5.45	5.44	5.45	0	5.45	5.44	5.45	0	0.3
44	5.44	5.43	5.44	5.47	5.45	5.47	3	1	5.45	5.43	5.45	1	5.45	5.43	5.45	1	0.2
Industrial East of Pacific Highway																	
45	4.59	4.57	4.59	4.61	4.59	4.61	2	1	4.59	4.58	4.59	0	4.59	4.58	4.59	0	0.3
46	4.36	4.36	4.36	4.38	4.38	4.38	2	0	4.37	4.37	4.37	1	4.37	4.37	4.37	1	0.3
47	4.34	4.34	4.34	4.36	4.36	4.36	2	0	4.35	4.34	4.35	1	4.35	4.34	4.35	1	0.3
48	4.35	4.35	4.35	4.37	4.37	4.37	2	1	4.35	4.35	4.35	0	4.35	4.35	4.35	0	0.3

Number of Properties subject to increase in the 1% AEP Flood		Scenario E1	Scenario E2	Scenario E3
	Up to 1 cm	28	48	48
	2 cm	17	0	0
	3 cm	3	0	0
	4 cm	0	0	0



NW30163 500yr Flood Level Comparison - Non-LAHC Properties

Attachment F-003

ID	Existing 500 yr ARI 2hr (mAHD)	9hr (mAHD)	Max FL (mAHD) (a)	Scenario E1 2hr (mAHD)	9hr (mAHD)	Max FL (mAHD) (c)	Difference Rounded (cm) (c)-(a)	Scenario E2 2hr (mAHD)	9hr (mAHD)	Max FL (mAHD) (d)	Difference Rounded (cm) (d)-(a)	Difference Actual (cm) (d)-(a)	Scenario E3 2hr (mAHD)	9hr (mAHD)	Max FL (mAHD) (e)	Difference Rounded (cm) (e)-(a)	Difference Actual (cm) (d)-(a)
Hughes Close																	
1			6.92	6.93	6.87	6.93	1	6.92	6.86	6.92	0	-0.2	6.92	6.86	6.92	0	-0.2
2			6.92	6.93	6.87	6.93	1	6.92	6.86	6.92	0	-0.2	6.92	6.86	6.92	0	-0.2
3			6.92	6.93	6.87	6.93	1	6.92	6.86	6.92	0	-0.2	6.92	6.86	6.92	0	-0.2
4			6.92	6.93	6.87	6.93	1	6.92	6.86	6.92	0	-0.1	6.92	6.86	6.92	0	-0.2
5			6.92	6.93	6.87	6.93	1	6.92	6.86	6.92	0	-0.2	6.92	6.86	6.92	0	-0.2
6			6.92	6.93	6.87	6.93	1	6.92	6.86	6.92	0	-0.1	6.92	6.86	6.92	0	-0.2
7			6.88	6.89	6.84	6.89	1	6.88	6.83	6.88	0	-0.2	6.88	6.83	6.88	0	-0.2
Grant Close																	
8			6.81	6.82	6.76	6.82	1	6.81	6.75	6.81	0	-0.1	6.81	6.75	6.81	0	-0.2
9			6.81	6.82	6.76	6.82	1	6.81	6.75	6.81	0	-0.3	6.81	6.75	6.81	0	-0.3
10			6.81	6.82	6.77	6.82	1	6.81	6.75	6.81	0	-0.1	6.81	6.75	6.81	0	-0.3
11			6.81	6.82	6.77	6.82	1	6.81	6.75	6.81	0	-0.1	6.81	6.75	6.81	0	-0.3
12			6.81	6.82	6.77	6.82	1	6.81	6.75	6.81	0	-0.2	6.81	6.75	6.81	0	-0.3
13			6.81	6.82	6.77	6.82	1	6.81	6.75	6.81	0	-0.1	6.81	6.75	6.81	0	-0.2
14			6.81	6.83	6.77	6.83	2	6.81	6.75	6.81	0	-0.1	6.81	6.75	6.81	0	-0.2
15			6.81	6.83	6.77	6.83	2	6.81	6.75	6.81	0	-0.2	6.81	6.75	6.81	0	-0.3
16			6.81	6.83	6.77	6.83	2	6.81	6.75	6.81	0	0.0	6.81	6.75	6.81	0	-0.2
17			6.81	6.83	6.77	6.83	2	6.81	6.76	6.81	0	-0.2	6.81	6.75	6.81	0	-0.3
Bray Street (Northside)																	
18			6.99	7.00	6.95	7.00	1	6.99	6.94	6.99	0	-0.1	6.98	6.94	6.98	-1	-0.3
19			6.90	6.91	6.86	6.91	1	6.90	6.85	6.90	0	-0.1	6.90	6.85	6.90	0	-0.1
20			6.88	6.89	6.84	6.89	1	6.88	6.83	6.88	0	-0.1	6.88	6.83	6.88	0	-0.2
21			6.80	6.82	6.77	6.82	2	6.80	6.76	6.80	0	-0.1	6.80	6.75	6.80	0	-0.5
22			6.69	6.70	6.65	6.70	1	6.69	6.64	6.69	0	-0.1	6.68	6.63	6.68	-1	-0.8
23			6.65	6.67	6.61	6.67	2	6.65	6.60	6.65	0	-0.3	6.63	6.59	6.63	-2	-1.3
24			6.49	6.51	6.47	6.51	2	6.49	6.45	6.49	0	-0.2	6.51	6.46	6.51	2	1.6
Bray Street (Southside)																	
25			6.42	6.46	6.42	6.46	4	6.42	6.38	6.42	0	-0.4	6.42	6.38	6.42	0	-0.4
26			6.24	6.30	6.26	6.30	6	6.25	6.22	6.25	1	1.2	6.25	6.22	6.25	1	0.5
27			6.36	6.39	6.36	6.39	3	6.37	6.33	6.37	1	0.7	6.36	6.33	6.36	0	0.4
28			6.31	6.34	6.31	6.34	3	6.31	6.28	6.31	0	0.1	6.31	6.28	6.31	0	0.0
29			6.09	6.11	6.08	6.11	2	6.09	6.06	6.09	0	0.2	6.09	6.06	6.09	0	0.0
Bray Street (Northside)																	
30			6.17	6.20	6.17	6.20	3	6.17	6.15	6.17	0	0.2	6.17	6.15	6.17	0	0.1
31			6.09	6.11	6.09	6.11	2	6.09	6.06	6.09	0	0.2	6.09	6.06	6.09	0	0.0
32			6.05	6.08	6.05	6.08	3	6.05	6.03	6.05	0	0.2	6.05	6.03	6.05	0	-0.1
33			6.02	6.04	6.01	6.04	2	6.02	5.99	6.02	0	0.2	6.02	5.99	6.02	0	0.0
34			5.85	5.87	5.85	5.87	2	5.85	5.84	5.85	0	0.1	5.84	5.82	5.84	-1	-1.7
35			5.60	5.63	5.60	5.63	3	5.60	5.58	5.60	0	0.3	5.60	5.58	5.60	0	0.2
36			5.54	5.57	5.54	5.57	3	5.55	5.52	5.55	1	0.3	5.55	5.52	5.55	1	0.1
Industrial West of Pacific Highway																	
37			5.50	5.54	5.50	5.54	4	5.50	5.47	5.50	0	0.4	5.50	5.47	5.50	0	0.2
38			5.46	5.49	5.46	5.49	3	5.47	5.43	5.47	1	0.4	5.47	5.43	5.47	1	0.3
39			5.54	5.58	5.54	5.58	4	5.55	5.51	5.55	1	0.4	5.54	5.51	5.54	0	0.2
40			5.74	5.77	5.74	5.77	3	5.75	5.72	5.75	1	0.2	5.74	5.72	5.74	0	0.0
41			5.73	5.76	5.73	5.76	3	5.73	5.71	5.73	0	0.5	5.74	5.71	5.74	1	0.6
42			5.73	5.76	5.73	5.76	3	5.74	5.71	5.74	1	0.3	5.74	5.71	5.74	1	0.4
43			5.56	5.59	5.55	5.59	3	5.56	5.53	5.56	0	0.4	5.56	5.53	5.56	0	0.2
44			5.55	5.59	5.55	5.59	4	5.56	5.52	5.56	1	0.3	5.55	5.52	5.55	0	0.2
Industrial East of Pacific Highway																	
45			4.73	4.77	4.73	4.77	4	4.74	4.71	4.74	1	0.6	4.73	4.71	4.73	0	0.2
46			4.53	4.56	4.55	4.56	3	4.53	4.52	4.53	0	0.7	4.53	4.52	4.53	0	0.3
47			4.49	4.53	4.52	4.53	4	4.50	4.49	4.50	1	0.8	4.49	4.48	4.49	0	-0.5
48			4.51	4.55	4.53	4.55	4	4.52	4.51	4.52	1	0.8	4.51	4.51	4.51	0	0.3

Number of Properties subject to increase in the 0.2% AEP Flood				
	Up to 1 cm	17	48	47
	2 cm	11	0	1
	3 cm	12	0	0
	4 cm	8	0	0