Appendix B Flood Frequency Analysis

Review of Raymond Terrace Flood Frequency Analysis

The Lower Hunter River Flood Study (Green Rocks to Newcastle) (PWD, 1994) included a Flood Frequency Analysis (FFA) of water levels at Raymond Terrace. This FFA has been used as the basis for design flood estimation in the Hunter Estuary for all of the studies undertaken since 1994. There is an additional 23 years of complete annual maxima data available at the Raymond Terrace gauge since the original FFA, which is now out of date and in need of review.

As part of ongoing studies in the Lower Hunter, BMT WBM has undertaken an updated FFA at Raymond Terrace. This utilised the historic data detailed in the 1994 study and the continuous gauged data recorded at the site since 1984. The original FFA had been undertaken using recorded water levels, but it is a better approach to use flow data for the basis of an FFA. Rating curves (flow vs. level relationships) were extracted from the TUFLOW model results, in order to determine flow estimates for the recorded water level records. The historic record is reasonably complete back to 1893.

The rating curve at Raymond Terrace is significantly influenced by the floodplain constriction downstream at Hexham. The construction of the railway and New England Highway has reduced the floodplain flow through Hexham Swamp. The railway pre-dates the 1893 flood and it is assumed to have been at a similar level throughout the period of flood record. The current highway configuration was completed in 1964 and is now the control of floodwaters spilling into Hexham Swamp (being a little higher than the railway). Prior to 1964 it has been assumed that the railway would have been the highest control. To derive appropriate rating curves it was therefore necessary to model two separate conditions – one representing the current floodplain topography and another for the historic floods prior to 1964. The resultant curves are shown in Figure 1.

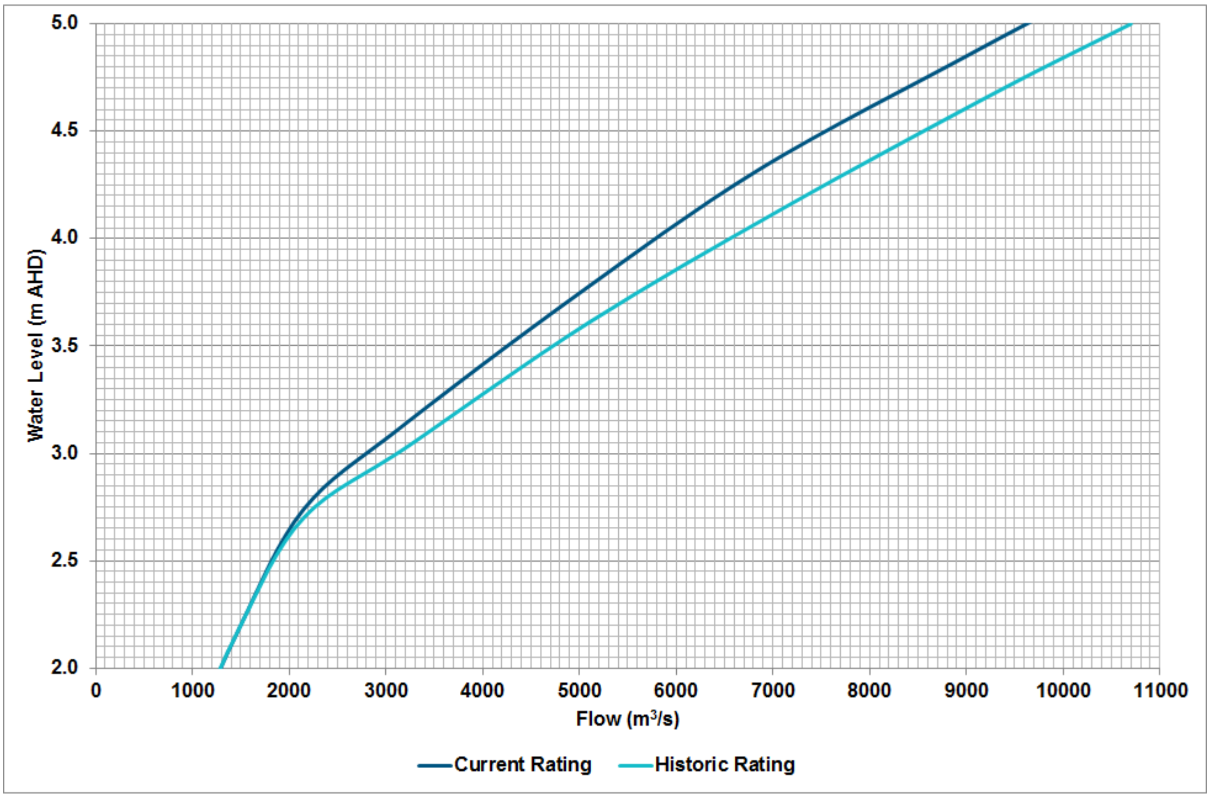


Figure 1 – Current and Historic Rating Curves at Raymond Terrace

The TUFLOW-FLIKE software was used to undertake a revised FFA at Raymond Terrace. This was based on a continuous annual maxima series of 30 years for the period 1984 to 2013. The historic data was incorporated as censored data, providing four floods above a 4,000m^3/s threshold in the 91 years prior to 1984. A flood frequency distribution was then derived using a Bayesian inference method and a Log Pearson

III probability model. The resultant fitted distribution is presented in Figure 2 together with the plotting positions of the 20 largest floods since 1893, determined using the Cunnane formula.

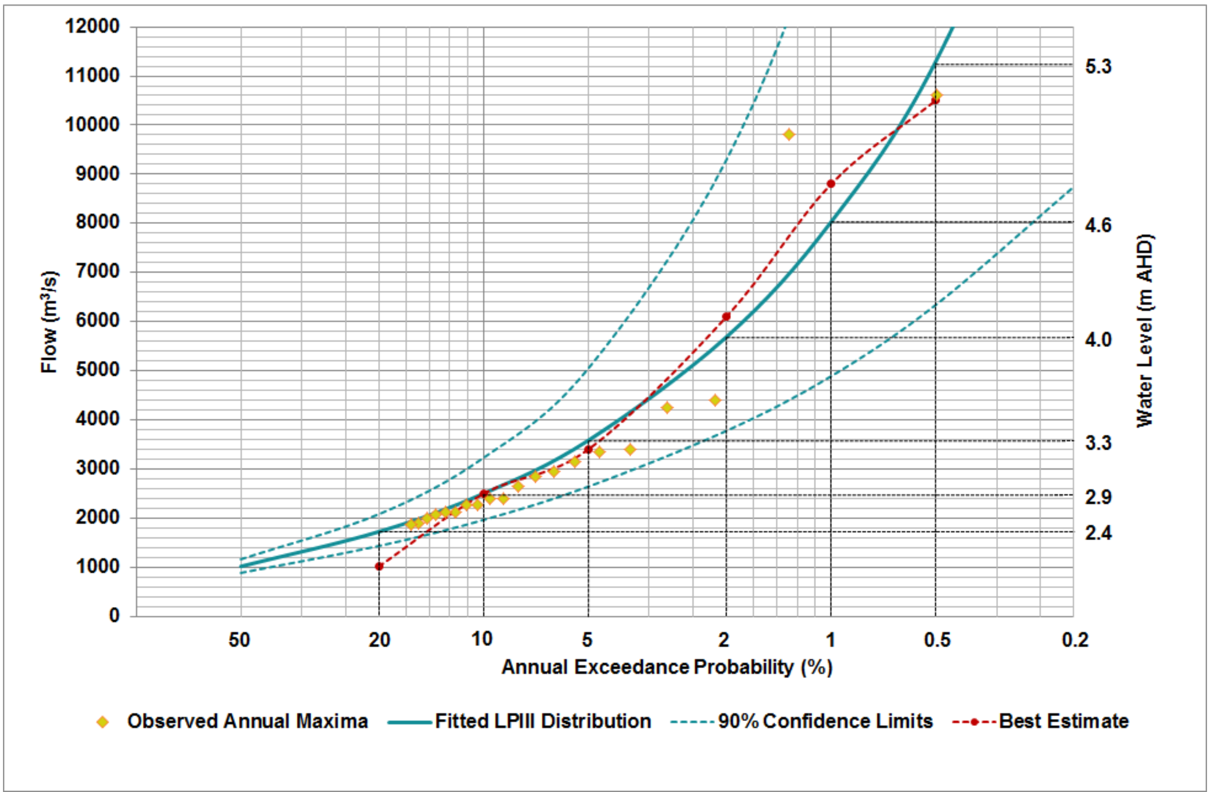


Figure 2 – Revised Flood Frequency Analysis at Raymond Terrace

It can be seen that there is a fairly even spread of flood events between a 2,000m^3/s and 4,000m^3/s magnitude. The two largest events in 1955 and 1893 are substantially larger than the other floods (at around 11,000m^3/s and 10,000m^3/s respectively). Inspection of the respective rainfall distributions for the historic floods shows that the two largest events have significant rainfall across the entire Hunter River catchment. The Hunter River catchment can be split into three broad sub-catchments: Goulburn River (7,800km^2), Upper Hunter (6,600km^2) and Lower Hunter (7,100km^2). The largest flows would be expected to be generated by heavy rainfall across all three. Other major events would likely have rainfall across two of the sub-catchments and events with significant rainfall in only one sub-catchment would be relatively minor.

Table 1 shows the 3-day rainfall distribution across the three Hunter River sub-catchments for five of the largest ten events. The two largest events (1893 and 1955) show significant rainfall across all three sub-catchments. The other three events show significant rainfall in two of the sub-catchments and only moderate rainfall across the Goulburn River catchment.

Table 1 – Historic Event Rainfall Distribution across the Hunter River Sub-catchments

Event	3-day Sub-catchment Rainfall Total (mm)		
	Goulburn River	Upper Hunter	Lower Hunter
1893	200	265	466
1913	123	254	210
1930	107	210	374
1955	310	321	266
1990	82	202	353

The flood flows from the FFA have been converted to water levels using the current rating presented in Figure 1 and were included within Figure 2. A comparison of the design flood levels at Raymond Terrace from the revised FFA with those from the 1994 study is presented in Table 2. The revised levels are typically 0.2m to 0.3m higher than the previous levels, although the revised 1% AEP level is 0.2m lower. There are a number of reasons for the differences between the two, including:

- There is an extra 20+ years of annual maxima data from which to derive the revised FFA;
- The previous FFA was fitted by eye whilst the revised FFA has used the Log Pearson III probability model; and
- The previous FFA was derived from plotting positions calculated using the Weibul formula rather than the Cunane. The latter is more appropriate when derived magnitudes for set return intervals.

The revised FFA is significantly influenced by the step change in historic flood event magnitudes between those events around or below 4,000m^3/s and the two largest events at around 10,000m^3/s. It is difficult to fit a distribution well to both, with the potential to overestimate some more frequent event magnitudes and underestimate some less frequent event magnitudes. A more realistic design flood estimation would incorporate a fitted distribution to the lower magnitude historic events, another fitted to the more extreme historic events and a transition between the two. Although there is a reasonable amount of certainty in fitting to the more frequent flood events, there are only a few historic events (and therefore more uncertainty) from which to derive a representative transition and large magnitude design flood estimate. A “best estimate” has been determined using the statistical FFA and engineering judgement, and has also been presented in Figure 2.

There are inherent uncertainties regarding the estimation of design flood flows, particularly for the large magnitude events. The revised FFA provides for some improvement over that undertaken in 1994 as it has been derived using a larger dataset and with the latest approach recommended by AR&R. To further improve the confidence of the Raymond Terrace FFA would involve significant investment in both catchment modelling and upstream gauge data analysis.

Table 2 – Comparison of Design Flood Levels from the 1994 and Revised FFAs

	Flood Level (m AHD)	
Design Event	1994 FFA	Revised FFA
20% AEP	2.1	2.4
10% AEP	2.7	2.9
5% AEP	3.1	3.2
2% AEP	3.7	4.1
1% AEP	4.8	4.8
0.5% AEP	-	5.2

Appendix C Public Exhibition Submissions

Williamtown/Medowie Flood Strategies Submission.

[redacted]

It is clear from the flood plain mapping provided in the Williamtown flood strategy that much of the coastal plain between the sand dunes up to and including properties on either side of Nelson bay Road stretching from Fullerton Cove through to the sand ridge to the north side of Marsh rd. was originally all part of an extensive coastal flood plain zone. The land was cleared and a series of drains constructed creating grazing pasture that supported numerous dairy farms. We have now reached tipping point with the volumes of water now entering an open drainage systems, apart from the main drainage channels they are not well maintained and in some cases cross tributaries are part filled in. Following repeated subdivisions and rezoning's the resulting hard surfaces, roads, driveways and roofs from multiple small development and larger rural residential estates such as Hideaway in Salt Ash have all helped tip the balance. Following a relatively low rainfall winter with exception of the major event in April the water table in the area has never been higher according to residents who have lived in the area for 50 years plus.

Studies carried out as part of the Williamtown aerospace development reported that drainage in the Williamtown Fullerton Cove area had reached capacity. GWH was required to construct extensive holding ponds as part of its development application approval for an aerospace industrial development at Williamtown airport. Other developments have followed some recommended by staff others not supported but approved by Council i.e. McDonalds fast food outlet. Add the twin garages, additional airport car park capacity, hotels and a potential hotel conference centre and they all seriously add to the local and downstream flooding right down to Fullerton Cove. This impact is now seen as a very high water table in locations such as the Bayway residential village where it is creating serious problems with the storm water drainage system, septic and water supply systems.

The gradual upgrade of the Nelson Bay Rd has contributed to localised flooding preventing water from freely moving across the land towards creeks and rivers, the installation of road underpass culverts and pipes has added to localised flooding problems as these points are easily blocked with vegetation siltation and storm flotsam creating a high demand maintenance problem for Council.

Specific drains.

The Moors drain is an example of a local drain which was built back in the 1940's to take storm water from the Williamtown RAAF base to the Tilligerry creek and ultimately into Port Stephens. This has long ago reached its use by date and a physical walk of the system reveals that around two kilometers from the Tilligerry creek, the storm water just breaks the very low bund created by dredged material and spreads out over the land. This is confirmed with recent water testing that finds the chemicals **PFOS/PFOA** originating from the RAAF base now turning up in water located in Salt Ash property dams.

Council needs to prepare a Drainage study and maintenance plan for the Williamtown drainage system.

- Identify the main drain and role in transfer of storm water to major water ways.

- Identify the side/cross tributaries. Those that contribute to drainage and those that have been dug illegally creating problems downstream or on neighboring properties.

- Determine what works are required to ensure the nominated major drains and tributaries retain their functionality.

- Identify all major culverts and pipeline systems particularly those taking storm water from open drainage systems under roads and manmade structures i.e. Infilling development such as the Cove and Palms resorts at Fullerton Cove.

- Prepare a schedule of maintenance works for open drains, budget and resource same.

- Prepare a maintenance servicing plan and budget for culverts drains and pipes.

- Commence the gradual process of planting out main drains with appropriate vegetation that will readily regenerate, tolerate changes in water levels and are known for their capacity to remove phosphates and nitrogen from contaminated water sources. It may be entirely appropriate to engage Land Care and re- vegetation groups to assist in undertaking these works.

Sustainable Management of Open Drainage Systems (Relevant to Medowie and Williamtown Flood strategies).

Council's current program for maintaining open drainage systems is not sustainable and exacerbates the problem of drains that increase turbidity and water contamination. The methodology of herbicide spraying of the sides and drain proper gives an appearance that the drain system is clear but this approach cultivates and promotes woody weed growth and provides little if any mechanism to adsorb nitrogen content and assist in the breaking down of pathogens before they make to drinking water storage or river systems. Mechanical digging of the drains exacerbates bank collapse and silting leading to creasing risk of culvert and pipe system blocking up and transfer of weed seed into difficult locations to clean out plus increasing water turbidity.

NB. As part of this drain assessment project Council should also be cognisant about determining what contributions should/could be made by the Dept. of Defense to maintain drainage system that takes water from RAAF Williamtown to Port Stephens. Pre-cleaning of the water and removal of potential chemical hazards. The timing will never be better to have Defence take some responsibility for their storm water liability.

30 September 2015

The General Manager
Port Stephens Council

Submission: Williamtown-Salt Ash Floodplain Risk Management Study and Draft Plan

Introduction

TRRA Inc. welcomes Port Stephens Council continuing work in undertaking the The Williamtown-Salt Ash Floodplain Risk Management Study and Draft Plan which is now at Stage 4 of a 5 stage process under the guidelines of the Floodplain Development Manual 2005 required by the NSW Office of Environment and Heritage.

Although TRRA Inc. is primarily concerned with the Tomaree Peninsula we have made a number of submissions to Council regarding Development Applications on Rural zoned land for commercial land uses in the vicinity of Nelson Bay Road, Lavis Lane and Cabbage Tree Road intersection as this is the main gateway for residents and tourist entering the Peninsula. In these submissions, apart from raising what we believe to be incorrect zoning issues and adverse economic and visual impacts, we have also raised the issue of the low lying land resulting in potential problems in the short and long term of the effects of flooding. We have also observed numerous examples of Councillors approving DAs for residential developments on 'filled mounds' in flood prone areas – often against professional planning advice. This is a matter of concern to all Port Stephens ratepayers, not only because it they appear to be poor decisions, but also because of potential financial liability in the event of flooding,

Although the technical nature of the study is beyond our organisation's ability to analyse in any great depth, we support the general underlying theme of recognising the impact of Climate Change in terms of both increasing sea level and increased frequency/extent of river flooding. The Study and Plan emphasise the importance of acting now to manage this issue through Strategic Planning. This should help reduce the need for possibly very expensive mitigation works, and/or legal and financial liability, all at ratepayers expense, resulting from short sighted development approvals in areas likely to have medium to long term flooding problems.

Climate Change

The underlying theme of this draft document is that the risk of flooding will increase using the Government and Council endorsed estimates of sea level rise between now and 2050/2100.

The report states:

> ‘Low-lying coastal areas, such as those surrounding Fullerton Cove and Tilligerry Creek are at particularly high risk to climate change. The potential for future sea level rise is now expected to be the biggest driver for floodplain management around coastal and estuarine systems such as the Hunter Estuary and Port Stephens. The issue of future sea level rise presents particular challenges to future development, as the risks associated with flooding will progressively increase during the lifetime of the development. It may be such that risks do not manifest until the development is nearing the end of its design life.’

This is an issue many Councils are having to face and TRRA Inc. strongly urges that any pressure from landowners or potential developers (or others arguing about economic consequences) to reduce forecast levels be resisted. We are not aware of any peer reviewed scientific evidence to suggest that the estimates used in this Study are anything other than conservative. The ‘Precautionary Principle’ supports the recommendations of the report incorporated in the Draft Plan. The issue needs to be addressed and planned for now and not left as an unfunded burden on future generations that will only become more expensive the longer it is ignored.

TRRA Inc, further endorses the report where it states

> ‘The property inundation statistics confirms the relatively low flood risk exposure under existing floodplain conditions. However, the results also clearly demonstrate the increasing flood risk across the study area and relative vulnerability of the existing community to potential climate change influence. Accordingly, the floodplain risk management for the catchment is likely to have a focus on climate change adaptation rather than immediate flood protection works’.

Floodplain management measures:

The report lists 11 potential measures, **5 have been rated as a High priority**,

- Hunter River Levee Scheme Review
- **Planning and development controls**
- Improved flood awareness through issue of flood information and community flood emergency response planning
- Update of Local Flood Plans with current design flood information and intelligence.
- Improved flood warning system

TRRA Inc. agrees that these are all of a high priority. Specifically we would like to see the recommendations in the area the second set of measures - *Planning and development controls*, be implemented not only within the Williamtown/Salt Ash flood area but throughout the entire Council area. We note that a similar Medowie Study and Draft Plan has been developed and exhibited in parallel with this one – we have not been able to look at that report, but assume that it makes similar sensible recommendations. We also note that similar issues arise in the Corlette foreshore erosion study that is currently on exhibition.

In the report, *Planning and development controls* are described in the Executive Summary as follows:

> 'Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within Williamtown-Salt Ash. This will ensure that new development is compatible with the flood risk, and allows for existing problems to be gradually reduced over time through sensible redevelopment. The Plan has recommended the adoption of the established 1% AEP flood level plus 0.5m freeboard as the flood planning level (maintains the existing design flood standard) and a review of current landuse zoning with respect to Floodway areas. It is noted the adopted FPL includes climate change allowance as per current Council policy. The recommendation also provides for adoption of the updated flood risk mapping including flood planning areas and hydraulic and hazard classifications.'

We endorse the recommended measures in this area as high priority.

The report also lists 3 measures rated as a **medium priority**

- Flood proofing of individual buildings (installation of flood gates at commercial centre)
- Investigate voluntary house raising program
- Regional Floodplain Development Strategy incorporating cumulative development flood impact assessment (including long-term strategic planning and climate change adaption specific to the Williamtown-Salt Ash area)

In relation to Strategic Planning, the report says:

> 'Strategic planning – the study investigated a number of potential large scale redevelopment areas within the Port Stephens LGA. **Investigated in isolation, a number of these areas show potential for future redevelopment (including large scale filling/earthworks) with limited impact on existing flood conditions.** However, **a more coordinated flood impact assessment is recommended comprising a full cumulative development assessment with consideration of regional development** opportunities across the Lower Hunter River floodplain incorporating the Port Stephens and Newcastle LGAs. Such an investigation is likely to consider broader regional land use planning and identify future development areas within the floodplain that duly consider overall flood risk and potential impacts under an ultimate development scenario. The outcomes of this cumulative impact assessment would further inform future LEP and DCP amendments (e.g. rezoning, development controls such as fill limitations).' (**our emphasis**)

We submit that the Strategic Planning measure, currently listed as 'medium priority' should be elevated to **high priority**. TRRA Inc. has long been concerned about piece-meal or isolated development approvals, including specifically in the Williamtown and Salt Ash areas, and we strongly urge Council to consider a "full cumulative development assessment" which will have a far greater long term benefit to the community than the relative minor estimated costs of $50K plus staff costs.

[redacted]
Convenor, Planning Committee
Tomaree Ratepayers & Residents Association Inc.

[redacted]

[redacted]

I wish to make a submission to the Williamtown – Salt Ash flood plan.

Our property: [redacted] Nelson Bay Road Salt Ash. We are frequently flooded by water overflowing low section of the levee bank on the Moors Drain. The low section of the levee is behind Sansom Road Williamtown. The Moors Drain flood water floods properties on Sansom Road and Nelson Bay Road Williamtown, then flows towards Salt Ash flooding properties along Nelson Bay Road, Salt Ash. When the flood water enters our property it flows out to Richardson Road. The flood water is then trapped between Moors Drain levee, Richardson Road and Nelson Bay Road.

We were last flooded in April 2015, the flood water laid in our paddocks until the end of August 2015, flooding 100+ acres of our property at a depth of 1.2 metres to 0.3 metre.

Can this low section of the Moors Drain levee be raised to stop the water over flowing?

Attached a goggle map:

- Red Line Our property boundary 2481 and 2501 Nelson Bay Road, Salt Ash.
- Yellow Line Moors Drain and Tilligerry Creek
- Orange Line Direction of flood water from Moors drain flowing into property along Samson Road and Nelson Bay Road Williamtown and property on Nelson Bay Road Salt Ash and out to Richardson Road.
- Blue Line Farm drains on our property.

Appendix D Stage-Damage Curves for Flood Damages

SITE SPECIFIC INFORMATION FOR RESIDENTIAL DAMAGE CURVE DEVELOPMENT

Version 1.00 | Queries to duncan.mcluckie@dipnr.nsw.gov.au

PROJECT	DETAILS	DATE	JOB No.

BUILDINGS

Regional Cost Variation Factor	1.00	*From Rawlinsons*				
Post late 2001 adjustments	1.70	*Changes in Avge Weekly Earnings - www.abs.gov.au*				
Post Flood Inflation Factor	1.30	*1.0*	*to*	*1.5*		
Multiply overall structural costs by this factor		*Judgement to be used. Some suggestions below*				
	Regional City			*Regional Town*		
	Houses Affected		*Factor*	*Houses Affected*		*Factor*
Small scale impact	*<*	*50*	*1.00*	*<*	*10*	*1.00*
Medium scale impacts in Regional City		*100*	*1.20*		*30*	*1.30*
Large scale impacts in Regional City	*>*	*150*	*1.40*	*>*	*50*	*1.50*
Typical Duration of Immersion	24	hours				
Building Damage Repair Limitation Factor	0.75	*due to no insurance*	*short duration flood*		*long duration flood*	
		Suggested range	*0.75*	*to*	*0.85*	
Average House Size	240	m^2	*240 m^2 is Base*			
Building Size Adjustment	1.0					
Total Building Adjustment Factor	**1.66**					

CONTENTS

Average Contents Relevant to Site	$ 60,000		*Base for 240 m^2 house*	*$*	*60,000*	
Post late 2001 adjustments	1.70	*From above*				
Contents Damage Repair Limitation Factor	0.85	*due to no insurance*	*short duration flood*		*long duration flood*	
Sub-Total Adjustment Factor	0.85	*Suggested range*	*0.75*	*to*	*0.85*	
Level of Flood Awareness	low	*low or high only. Low default unless otherwise justifiable.*				
Effective Warning Time	12	hour				
Interpolated DRF adjustment (Awareness/Time)	0.89					
Typical Table/Bench Height (TTBH)	0.90	*0.9m is typical height. If typical is 2 storey house use 2.6m.*				
Total Contents Adjustment Factor AFD <= TTBH	**0.76**					
Total Contents Adjustment Factor AFD > TTBH	**0.85**					

Most recent advice from Victorian Rapid Assessment Method

Low level of awareness is expected norm (long term average) any deviation needs to be justified.

Basic contents damages are based upon a DRF of	*0.9*				
Effective Warning time (hours)	*0*	*3*	*6*	*12*	*24*
RAM AIDF Inexperienced (Low awareness)	*0.90*	*0.80*	*0.80*	*0.80*	*0.70*
DRF (ARF/0.9)	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*
RAM AIDF Experienced (High awareness)	*0.80*	*0.80*	*0.60*	*0.40*	*0.40*
DRF (ARF/0.9)	*0.89*	*0.89*	*0.67*	*0.44*	*0.44*
Site Specific DRF (SRF/0.9) for Awareness level for iteration	*1.00*	*0.89*	*0.89*	*0.89*	*0.78*
Effective Warning time (hours)	*12*	*24*	*12*		
Site Specific iterations	*0.89*	*0.78*	*0.89*		

ADDITIONAL FACTORS

Post late 2001 adjustments	1.70	*From above*
External Damage	$ 6,700	*$6,700 recommended without justification*
Clean Up Costs	$ 4,000	*$4,000 recommended without justification*
Likely Time in Alternate Accommodation	2	weeks
Additional accommodation costs /Loss of Rent	$ 220	*$220 per week recommended without justification*

TWO STOREY HOUSE BUILDING & CONTENTS FACTORS

Up to Second Floor Level, less than	2.6	m	70%	Single Storey Slab on Ground
From Second Storey up, greater than	2.6	m	110%	Single Storey Slab on Ground

Base Curves

AFD = Above Floor Depths

Single Storey Slab on Ground/Low Set	13164	+	4871		x	AFD in metres
Structure with GST	AFD	greater than	0.0	m		
Validity Limits	AFD	less than or equal to			6	m
Single Storey High Set	16586	+	7454		x	AFD
Structure with GST	AFD	greater than	-1.50	m		
Validity Limits	AFD	less than or equal to			6	m
Contents	20000	+	20000		x	AFD
Contents with GST	AFD	greater than			0	
Validity Limits	AFD	less than or equal to			2	

Floodplain Specific Damage/Aftermath Curves

Allowance for Waves 0 m

Steps in Curve 0.1 m

Single Storey Slab on Ground/Low Set

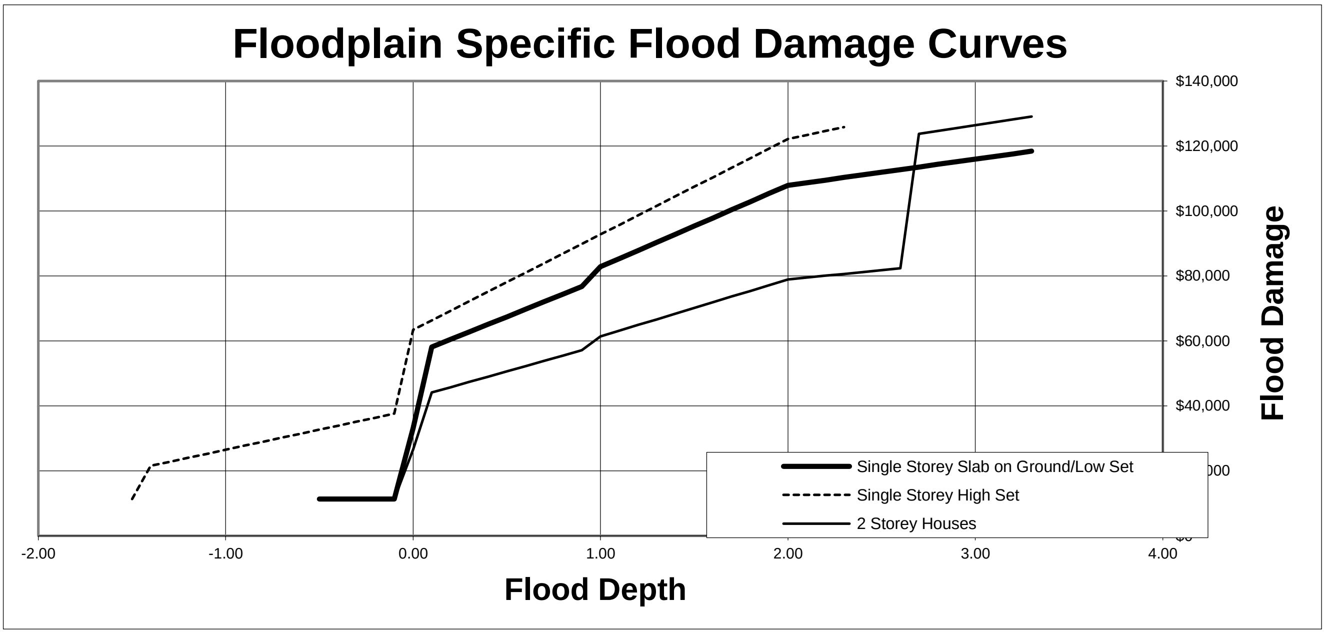
Static AFD	AFD + Wave Action	Damage
-0.50	-0.50	$ 11,390
-0.40	-0.40	$ 11,390
-0.30	-0.30	$ 11,390
-0.20	-0.20	$ 11,390
-0.10	-0.10	$ 11,390
0.00	0.00	$ 33,209
0.10	0.10	$ 58,186
0.20	0.20	$ 60,505
0.30	0.30	$ 62,823
0.40	0.40	$ 65,142
0.50	0.50	$ 67,460
0.60	0.60	$ 69,779
0.70	0.70	$ 72,097
0.80	0.80	$ 74,416
0.90	0.90	$ 76,734
1.00	1.00	$ 82,830
1.10	1.10	$ 85,338
1.20	1.20	$ 87,845
1.30	1.30	$ 90,352
1.40	1.40	$ 92,860
1.50	1.50	$ 95,367
1.60	1.60	$ 97,874
1.70	1.70	$ 100,382
1.80	1.80	$ 102,889
1.90	1.90	$ 105,396
2.00	2.00	$ 107,904
2.10	2.10	$ 108,711
2.20	2.20	$ 109,518
2.30	2.30	$ 110,326
2.40	2.40	$ 111,133
2.50	2.50	$ 111,940
2.60	2.60	$ 112,748
2.70	2.70	$ 113,555
2.80	2.80	$ 114,362
2.90	2.90	$ 115,170
3.00	3.00	$ 115,977
3.10	3.10	$ 116,784
3.20	3.20	$ 117,592
3.30	3.30	$ 118,399

Single Storey High Set

Static AFD	AFD + Wave Action	Damage
-1.50	-1.50	$ 11,390
-1.40	-1.40	$ 21,585
-1.30	-1.30	$ 22,820
-1.20	-1.20	$ 24,056
-1.10	-1.10	$ 25,291
-1.00	-1.00	$ 26,527
-0.90	-0.90	$ 27,762
-0.80	-0.80	$ 28,997
-0.70	-0.70	$ 30,233
-0.60	-0.60	$ 31,468
-0.50	-0.50	$ 32,704
-0.40	-0.40	$ 33,939
-0.30	-0.30	$ 35,175
-0.20	-0.20	$ 36,410
-0.10	-0.10	$ 37,646
0.00	0.00	$ 63,429
0.10	0.10	$ 66,364
0.20	0.20	$ 69,300
0.30	0.30	$ 72,235
0.40	0.40	$ 75,171
0.50	0.50	$ 78,106
0.60	0.60	$ 81,042
0.70	0.70	$ 83,977
0.80	0.80	$ 86,912
0.90	0.90	$ 89,848
1.00	1.00	$ 92,783
1.10	1.10	$ 95,719
1.20	1.20	$ 98,654
1.30	1.30	$ 101,590
1.40	1.40	$ 104,525
1.50	1.50	$ 107,460
1.60	1.60	$ 110,396
1.70	1.70	$ 113,331
1.80	1.80	$ 116,267
1.90	1.90	$ 119,202
2.00	2.00	$ 122,138
2.10	2.10	$ 123,373
2.20	2.20	$ 124,609
2.30	2.30	$ 125,844

2 Storey Houses

Static AFD	AFD + Wave Action	Damage
-0.50	-0.50	$ 11,390
-0.40	-0.40	$ 11,390
-0.30	-0.30	$ 11,390
-0.20	-0.20	$ 11,390
-0.10	-0.10	$ 11,390
0.00	0.00	$ 26,663
0.10	0.10	$ 44,147
0.20	0.20	$ 45,770
0.30	0.30	$ 47,393
0.40	0.40	$ 49,016
0.50	0.50	$ 50,639
0.60	0.60	$ 52,262
0.70	0.70	$ 53,885
0.80	0.80	$ 55,508
0.90	0.90	$ 57,131
1.00	1.00	$ 61,398
1.10	1.10	$ 63,153
1.20	1.20	$ 64,908
1.30	1.30	$ 66,664
1.40	1.40	$ 68,419
1.50	1.50	$ 70,174
1.60	1.60	$ 71,929
1.70	1.70	$ 73,684
1.80	1.80	$ 75,439
1.90	1.90	$ 77,194
2.00	2.00	$ 78,949
2.10	2.10	$ 79,515
2.20	2.20	$ 80,080
2.30	2.30	$ 80,645
2.40	2.40	$ 81,210
2.50	2.50	$ 81,775
2.60	2.60	$ 82,340
2.70	2.70	$ 123,771
2.80	2.80	$ 124,659
2.90	2.90	$ 125,548
3.00	3.00	$ 126,436
3.10	3.10	$ 127,324
3.20	3.20	$ 128,212
3.30	3.30	$ 129,100



Appendix E Cumulative Development Assessment

E.1 Introduction

Section 7.1.8 identified the importance of a strategy to coordinate future development in the Lower Hunter River floodplain in order to manage the potential impacts of cumulative development on flood risk. A number of potential development areas have been identified in consultation with Council. These areas include:

- Cabbage Tree Road – area north of Cabbage Tree Road including local drainage catchment areas (e.g. Dawsons Drain);
- Tomago Road – area adjacent to Tomago Road around Fullerton Cove. There are existing development approvals in this location including the WesTrac Facility and Northbank Enterprise Hub;
- Tomago North – floodplain area to the north of existing industrial development (e.g Tomago Aluminium) at Tomago between Tomago Road and the Pacific Highway; and
- Windeyers Creek - a large proportion of this area lies within the direct backwater influence of the Hunter River.

Large scale filling of the floodplain within these nominal areas has the potential to modify flood behaviour through redistribution of flow and loss in temporary flood storage. The existing models have been applied to assess the relative impact of potential fill scenarios in each of these areas individually (refer Section E2) and the cumulative impact (refer Section E3). Given the focus of the assessment on future planning and development, the relative impacts are considered for the nominal 2100 planning condition incorporating 0.9m sea level rise and flow increase of 20%.

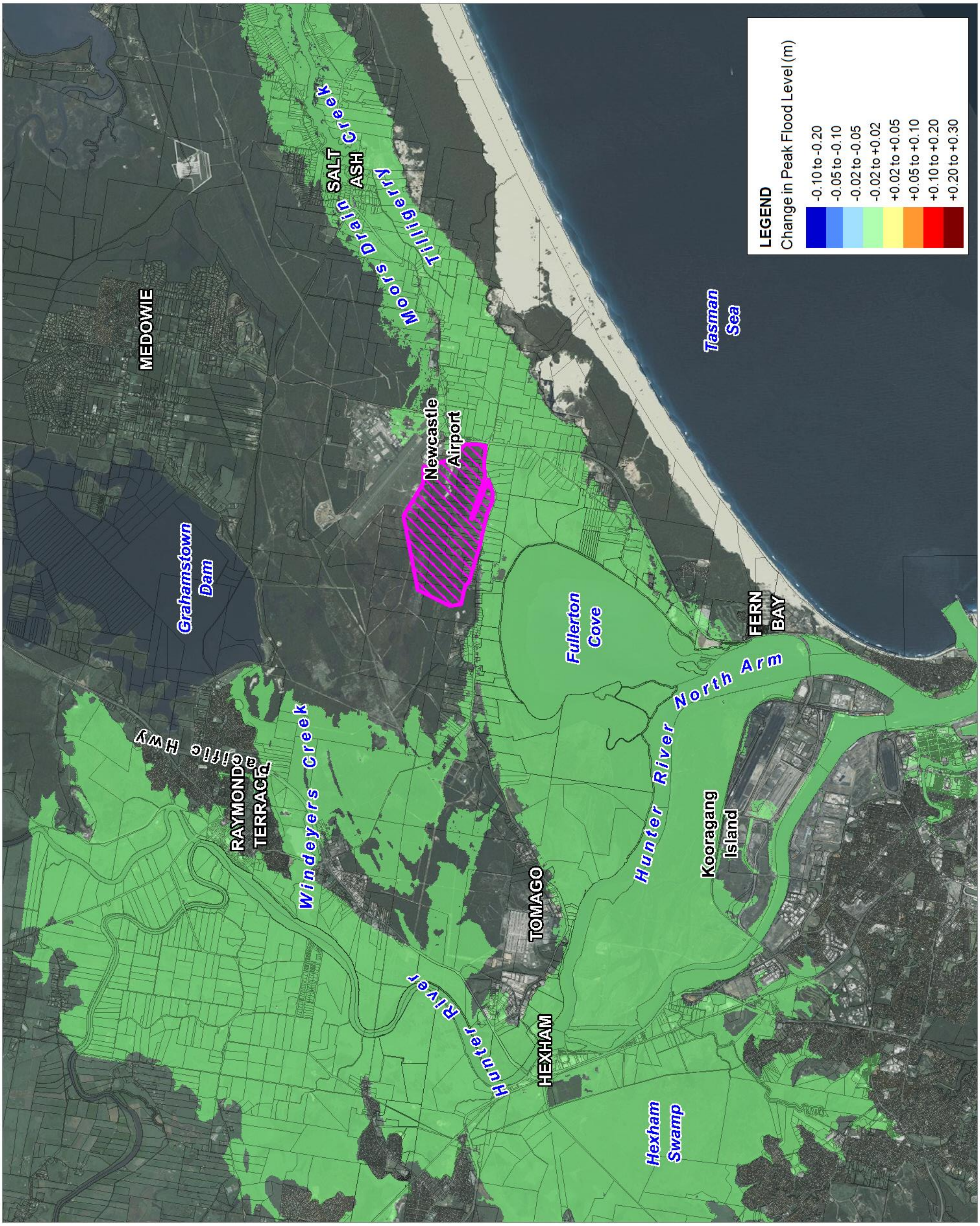
E.2 Individual Development Assessment

Cabbage Tree Road

The area north of Cabbage Tree Road is identified as a potential development area. Located on the northern edge of the Hunter River floodplain at Fullerton Cove, the area is classified as flood storage and is outside the main flow path. No specific development proposal has been incorporated in the assessment. The potential development area considered encompasses the full floodplain extent on the northern side of Cabbage Tree Road.

The assumed development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-1. Potential filling of the area identified has a limited impact on the simulated peak flood inundation. This limited impact is largely due to the total flood storage volume lost being only a relatively small percentage of the total flood volume conveyed throughout the total floodplain for the event.

The assessment has not considered potential increase in local runoff for new development. However, it is expected that existing development controls would be applied accordingly to manage local stormwater runoff and thereby limit any potential adverse changes to existing flood conditions.



Title:

Peak Flood Level Impact - Cabbage Tree Road Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: E-1

Rev: A

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0 2.5 5km

Approx. Scale

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WesTrac Facility and Tomago Industrial Park

Details of the approval for the WesTrac facility and Tomago Industrial Park were presented in Section 0. The approval provides for a multi-staged development. Presently only the Stage 1 works incorporating the WesTrac facility have been constructed to date. For the purpose of the cumulative development assessment the full future development footprint as per the approvals is considered.

The proposed development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-2. The proposed development provides for local increases in peak flood level of 0.15m. Increases in peak flood level of over 0.02m extend for a distance of some 3 to 4 km upstream of the development. The area impacted is largely floodplain and mangrove area between Tomago and Kooragang Island. Some existing industrial property along Tomago Road may also be impacted.

There is no impact across the broader Hunter River floodplain with effectively no major changes to overall flow distribution apart from the local conditions in the vicinity of the development.

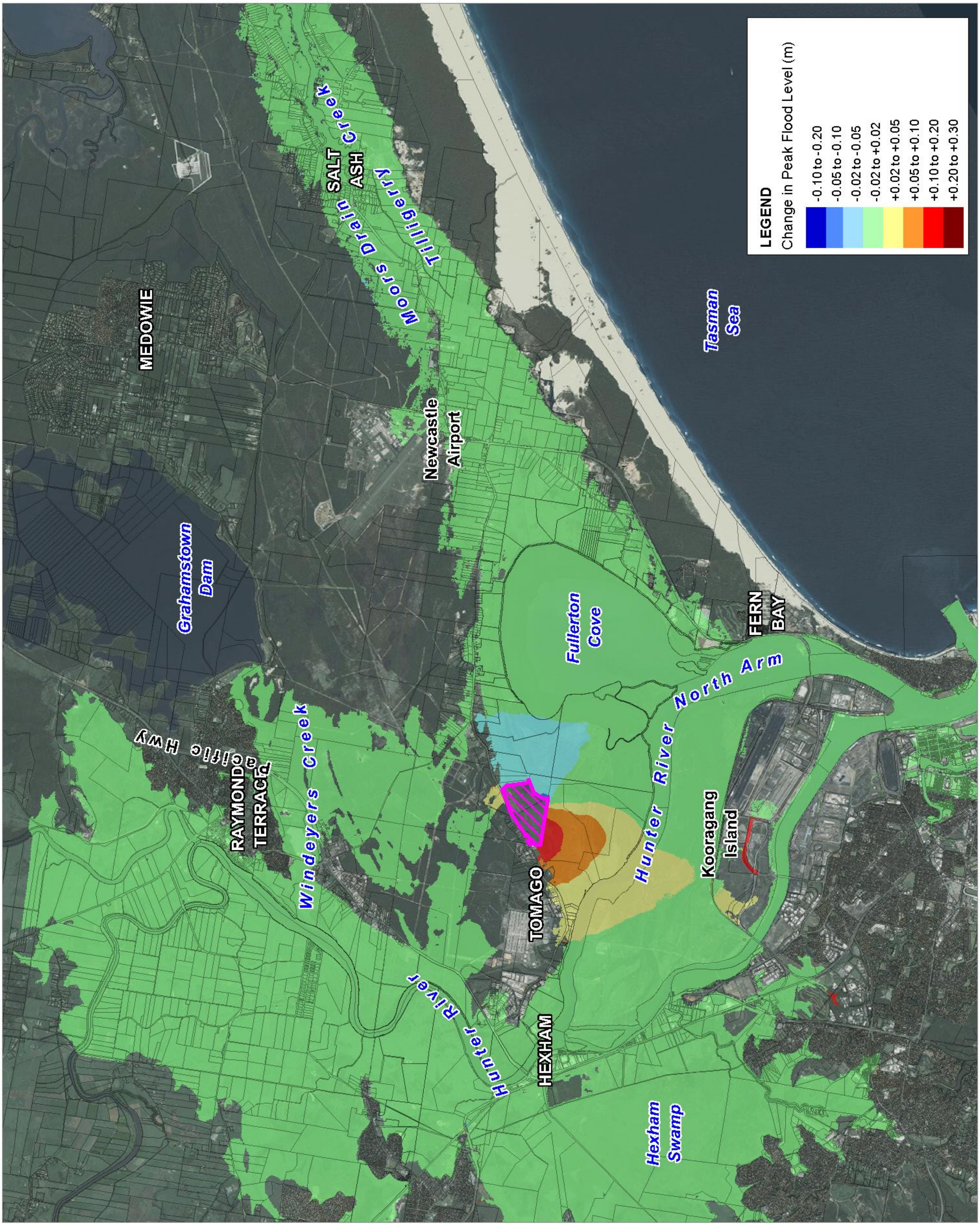
Northbank Entrprise Hub

Details of the approval for the Northbank Enterprise Hub were presented in Section 0. The development application includes a multi-staged development with the existing approval in place for Stage 1. Future stages of the development are subject to further assessment as part of the conditional approval, particularly in regards to flood risk. For the purpose of the cumulative development assessment, the full development footprint as per the development application has been considered. The Northbank assessment also includes the full WestTrac development footprint on the neighbouring lot.

The proposed development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-3. The proposed development provides for local increases in peak flood level of 0.35m immediately upstream of the development. The full extent of flood level increases for this scenario is significant, with the broader Hexham Swamp storage area subject to an increase of the order of 0.1m, and up to 0.02m increase extending upstream of Raymond Terrace across the full Hunter River floodplain.

The principle reason for the significant area of increase flood affectation is due to the redistribution of flow resulting from the development fill area. The fill footprint is located at a reach of the Hunter River where overbank flows are initiated on the left (northern) floodplain of the North Arm adjacent to Tomago Road. These floodplain flows continue through to Fullerton Cove. The proposed development footprint restricts to some degree the magnitude of flow being able to spill onto the floodplain. The redistribution of flow provides for greater volume of floodwater to be conveyed through the broader Hexham Swamp, providing for the increase in peak flood levels. The restriction of the overbank flow at Tomago effectively provides another “pinch point” on the floodplain, resulting in a backwater influence extending to Raymond Terrace.

The flood level impacts shown in Figure E-3 is greater than assessed during the development approval process. This is due to an increased design flow condition adopted in the current study, being the 20% increase in flow from existing conditions. The higher adopted design flows provides



Title:

Peak Flood Level Impact - WestTrac Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: **E-2**

Rev: **A**

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0 2.5 5km

Approx. Scale

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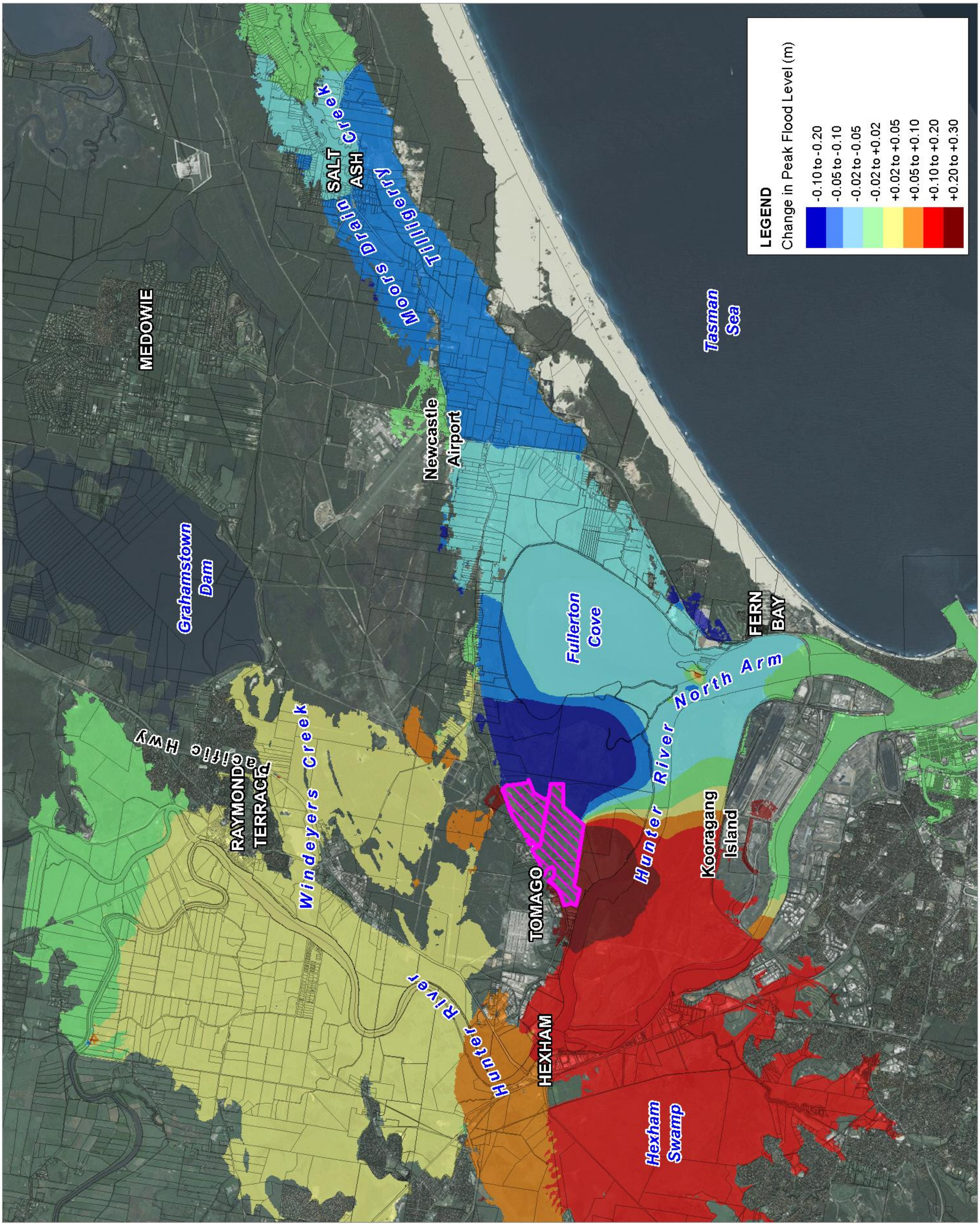

Title:

Peak Flood Level Impact - WestTrac and Northbank Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: E-3

Rev: A

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Approx. Scale

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Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\Flood_Impact_Future_Development_2100_WesTrac.WOR for a similarly higher magnitude of flow redistributions compared to existing conditions, thereby increasing relative impacts. It is noted that development beyond Stage 1 of the approved Northbank development is subject to future approval with consideration of additional flood impact analysis.

Tomago North

There is low-lying floodplain area to the north of existing industrial development at Tomago. The area largely comprises floodplain inundated by backwater from the Hunter River between the Pacific Highway and Tomago Road. The proposed Hunter Corporate Park development encompasses a proportion of the future development area assessed.

The potential development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-4. The simulated results show no extensive flood impact from a potential filling of the indicated floodplain area. The impact is limited given the relative magnitude of the flood storage volume lost in comparison to the total volume of floodwater conveyed through the floodplain for the event.

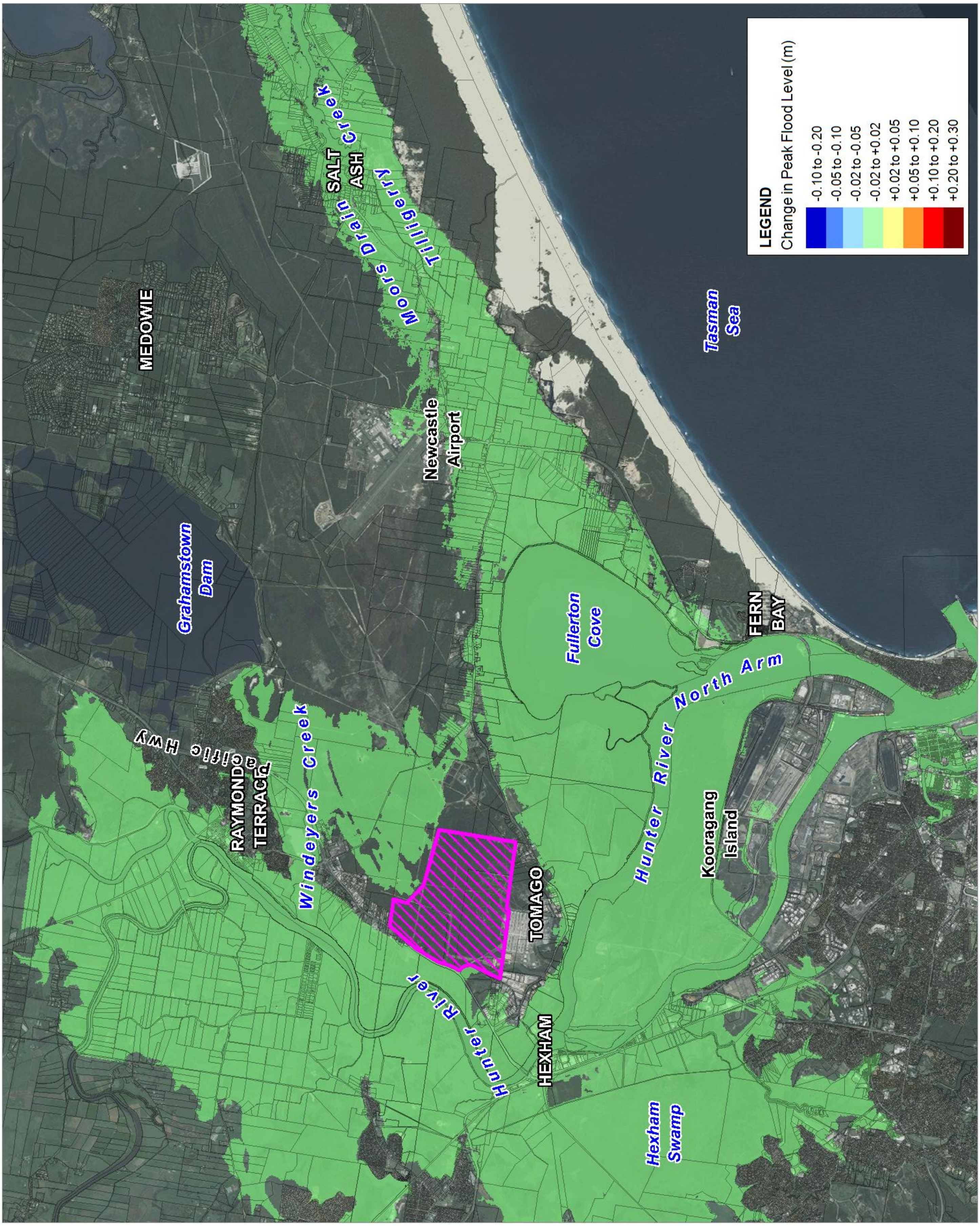
It is noted however, that there are peak flood level increases of the order of 1 to 1.5cm across the broader Hunter River floodplain adjacent to the nominal development area as a result of the loss in storage. Whilst the absolute magnitude of the increase is relatively small, development of this nature is a good example of the significance of incremental development impacts and contribution to cumulative impact of multiple floodplain developments.

Windeyers Creek

Similar to the Tomago North area discussed above, the floodplain area of the Windeyers Creek catchment provides for significant flood storage for Hunter River flooding. Peak flood levels in the Windeyers Creek floodplain are driven by the peak flood levels in the Hunter River. It is understood there are existing development proposals (e.g. Kinross Estate) within this area of the floodplain. The future development assessment has considered potential development across a broad floodplain area classified as a flood storage south of the Pacific Highway. The current development assessment however considers a larger potential development area.

The potential development area extent and the resulting change in peak 1% AEP flood level (2100 planning condition) is shown in Figure E-5. The simulated results provide an increase in peak flood level of 0.08m locally within the Windeyers Creek floodplain. The flood level impact reduces to some 0.06m in the broader Hunter River floodplain adjacent to the Windeyers Creek confluence, but still covers a large area extending between Hexham and Raymond Terrace. A similar broad impact is noted across Hexham Swamp, with peak flood level increase between 0.04-0.05m.

Both the magnitude and extent of the simulated impact indicates significant loss in floodplain storage within the assumed development footprint. Accordingly, the attenuative effect of this storage is lost, thereby providing for increased flows through the adjacent floodplain and a larger flow volumes redistributed to areas such as Hexham Swamp.



Title:

Peak Flood Level Impact - Tomago North Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: **E-4**

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Approx. Scale

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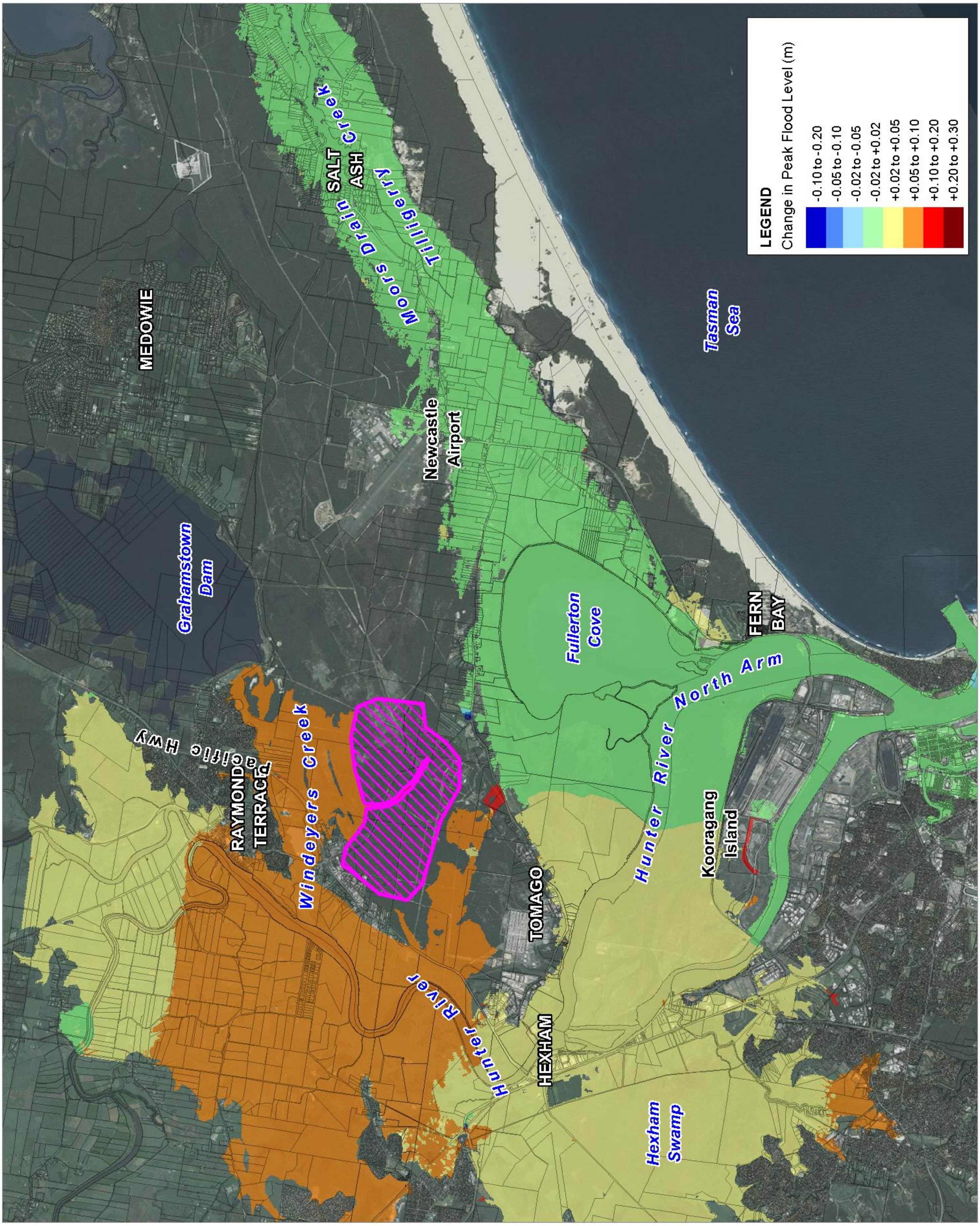
Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\Flood_Impact_Future_Development_2100_TomagoNorth.WOR



Title:

Peak Flood Level Impact - Windeyers Creek Development 1% AEP +0.9m SLR + 20% flow scenario

Figure: E-5

Rev: A

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Approx. Scale

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Filepath : K:\N20209_Williamtown_Salt_Ash_FRMSP\MapInfo\Workspace\Flood_Impact_Future_Development_2100_Windeyers.WOR

E.3 Cumulative Development Assessment

The previous analysis provided an overview of the relative impact of individual developments. The location and scale of the development footprint in relation to the existing flood inundation extents has a significant influence on overall flood impact. A cumulative impact assessment has been undertaken to demonstrate the combined flood impact of potential development.

Figure E-6 shows the cumulative development flood impact as change in peak 1% AEP flood level (2100 planning condition). Each of the development footprints assessed individually in the previous section has been incorporated in the simulation. The peak flood level impact exceeds 0.1m across a large area of the floodplain. This impact effectively extends across the entire floodplain between Raymond Terrace and Kooragang Island, including Hexham Swamp.

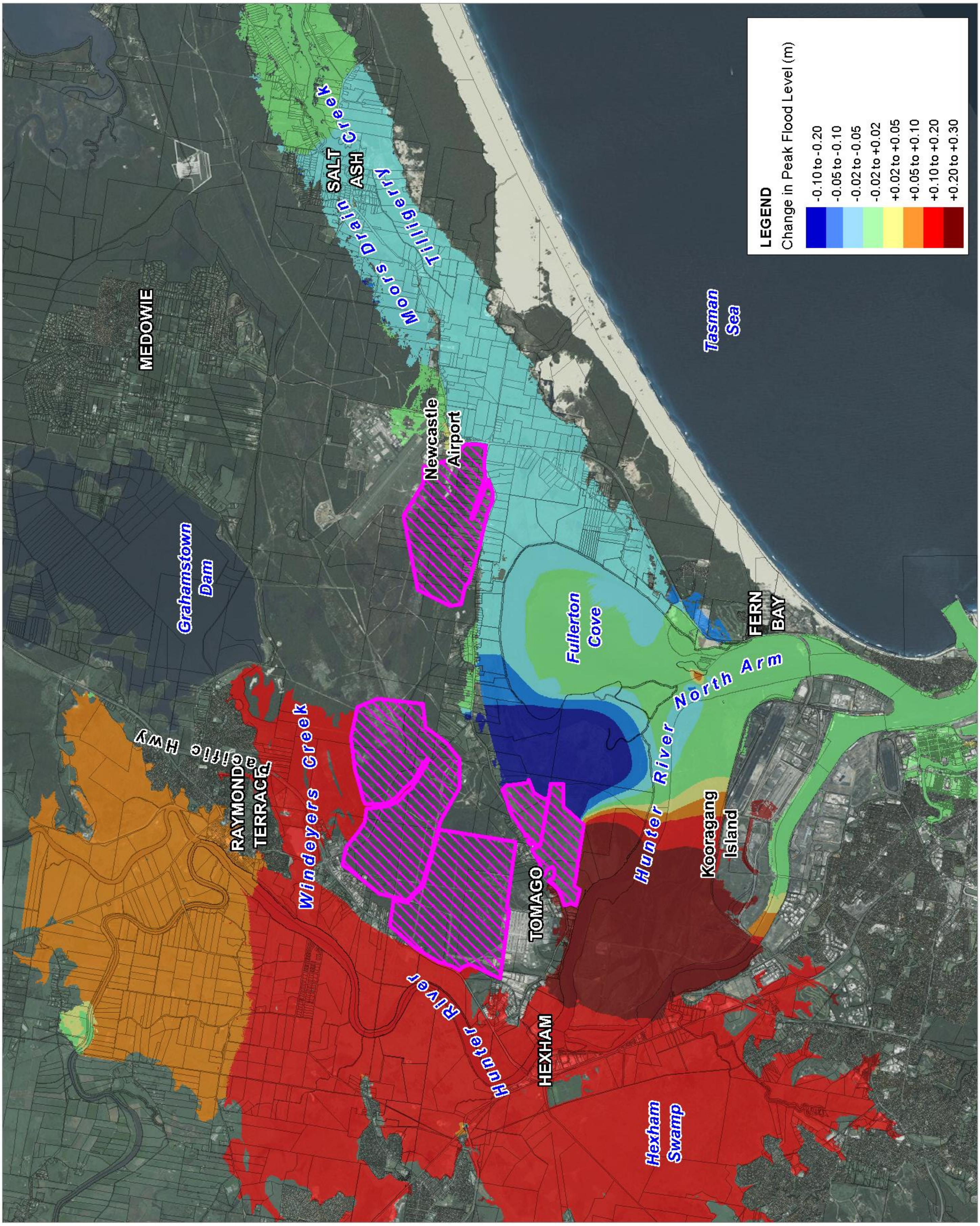
The extensive flood impact is realised through a combination of loss in flood storage and redistribution of flow associated with encroachment of the development footprints into convective flow areas.

The cumulative development scenario shown in Figure E-6 considers only development within the Port Stephens LGA. However, there is potential for development of similar sites within the floodplain within other local government areas. A significant proportion of the Lower Hunter floodplain lies within the Newcastle LGA, however, it is understood there is no existing overarching strategy for future development within this area. A large proportion of the floodplain area encompasses the broader Hexham Swamp. There may be opportunities for some filling around the fringes of the Swamp, however, for the current assessment no major development areas have been considered. There is existing industrial development along the Pacific Highway at Hexham. The cumulative development assessment has considered potential further industrial development on similarly zoned lots along the highway.

Figure E-7 shows a second cumulative development scenario incorporating additional industrial development along the Pacific Highway at Hexham. Some additional industrial development is also included along Tomago Road. As per the other development areas considered, the ground elevations within the fill footprints have been raised above the 2100 planning condition flood levels.

Figure E-7 shows the cumulative development flood impact as change in peak 1% AEP flood level (2100 planning condition). The general pattern of change in the peak flood level distribution is similar to the scenario shown in Figure E-6, albeit with a greater magnitude and extent of impact. Peak flood levels across to Kooragang Island and within Hexham Swamp increased in the order of 0.2-0.3m. The extent of peak flood increase in excess of 0.1m has also extended upstream of Raymond Terrace.

The cumulative development impacts represent significantly greater impacts compared to those provided by the individual developments. The principal area affected by increases in peak flood levels are upstream of the developments at Tomago and Hexham. In the Williamtown-Salt Ash locality, the simulated results show some minor reductions in peak flood levels. This can be attributed to the lower flood volumes spilling over Nelson Bay Road. This is a result of the broader redistribution of flow towards Hexham Swamp as a result of the development footprints, and the corresponding attenuation of flow to the downstream are of Williamtown-Salt Ash.



Title:

Peak Flood Level Impact - Combined Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: E-6

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BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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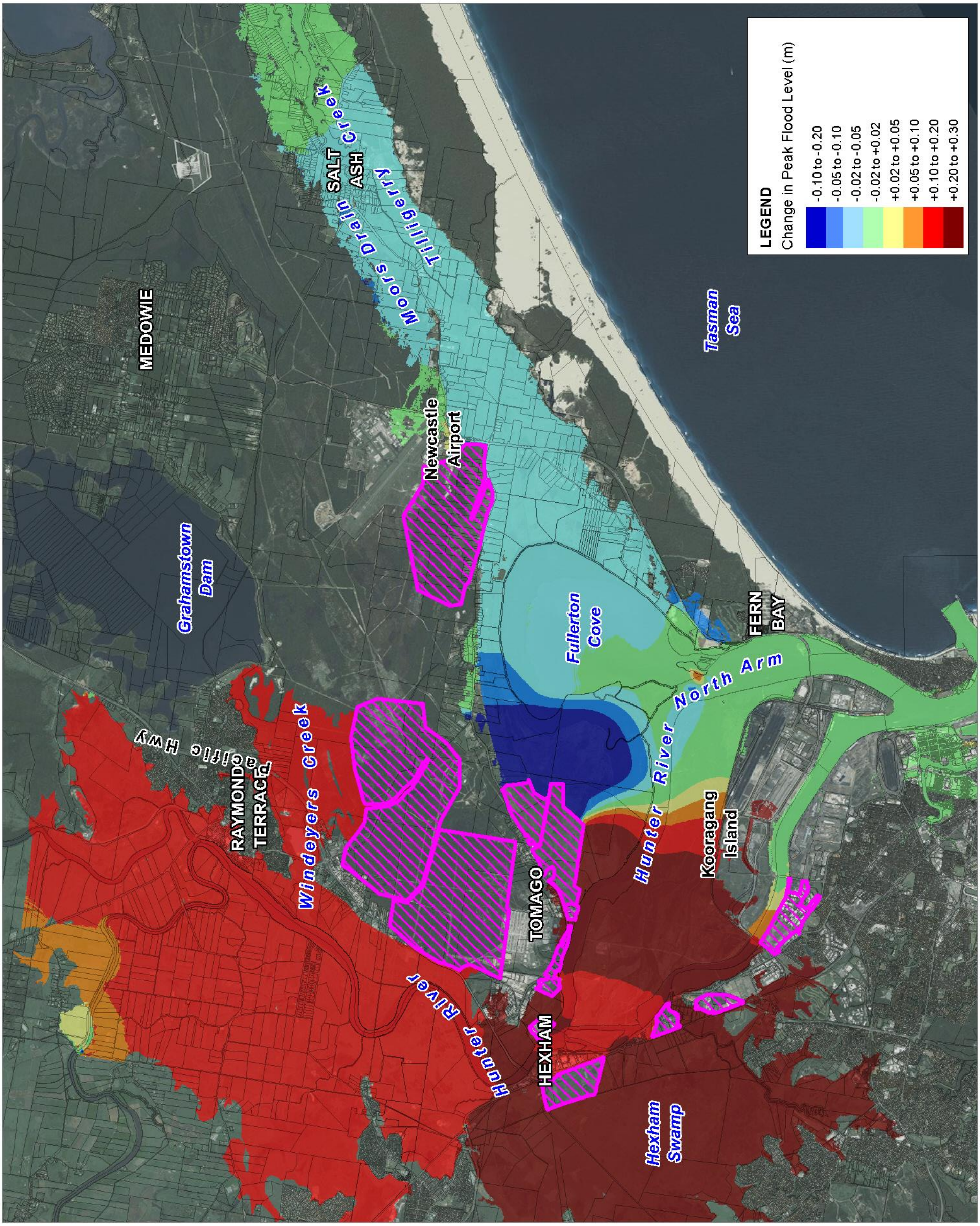

Title:

Peak Flood Level Impact - Combined Development
1% AEP +0.9m SLR + 20% flow scenario

Figure: E-7

Rev: A

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E.4 Summary

As previously noted, it is not the intention of the cumulative impact analysis to demonstrate the appropriateness or otherwise of individual land development areas. The analysis has identified broad areas of potential development (some areas with existing approvals) and determined the relative impact of these developments on peak flood conditions for the 2100 planning scenario. In the least, the analysis has identified the potential development areas that provide the most sensitivity in terms of increases in peak flood levels.

Notwithstanding the above, some lesser development potential may be realised in all of the locations in order to limit flood impacts. However, from a cumulative impact perspective, it is expected an appropriate regional development strategy should be established to guide the cumulative floodplain development.

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