Delfin Lend Lease

Cardno Shaping the Future

Floodplain Risk Management Study

Calderwood Urban Development Project - Concept Plan Application

Project Number: 110026-03/Report 001 Rev 1

Prepared for: Delfin Lend Lease

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Executive Summary

This Floodplain Risk Management Study (FPRMS) has been prepared by Cardno to accompany a Concept Plan Application under Part 3A of the *Environmental Planning & Assessment Act, 1979* (EP&A Act) and a proposal for State significant site listing under Schedule 3 of *State Environmental Planning Policy Major Development 2005* (SEPP Major Development) in relation to the Calderwood Urban Development Project.

The Calderwood Urban Development Project is a master planned community development by Delfin Lend Lease (DLL).

The Calderwood Urban Development Project proposes a mix of residential, employment, retail, education, conservation and open space uses. The development proposes approximately 4,800 dwellings and approximately 50 hectares of retail, education, community and mixed use / employment land. The overall development will accommodate approximately 12,400 people and will deliver an estimated $2.9 billion in development expenditure and create approximately 8,000 full time equivalent jobs by 2031.

The Calderwood Urban Development Project site is located within the Calderwood Valley in the Illawarra Region. It is approximately 706 hectares in area with approximately 600 hectares of land in the Shellharbour LGA and the balance located within the Wollongong LGA.

The Calderwood Valley is bounded to the north by Marshall Mount Creek (which forms the boundary between the Shellharbour and Wollongong LGAs), to the east by the Macquarie Rivulet, to the south by Johnstons Spur and to the west by the Illawarra Escarpment. Beyond Johnstons Spur to the south is the adjoining Macquarie Rivulet Valley within the suburb of North Macquarie. The Calderwood Urban Development Project land extends south from the Calderwood Valley to the Illawarra Highway.
In accordance with the Director General's Requirements, this FPRMS has been prepared following consultation with the following agencies:

- Department of Environment and Climate Change and Water (DECCW)
- Shellharbour City Council
- Wollongong City Council
- Lake Illawarra Authority

A flood study has been undertaken to determine existing flood behaviour across the project area (Rienco, 2009) and this study informs the preparation of this FPRMS. The flood study confirms that in a 1% AEP flood event, Macquarie Rivulet inundates the low lying land along the southern boundary of the site and Marshall Mount Creek inundates the low lying land in the northern side of the site (Rienco, 2009). Flood extents in a Probable Maximum Flood (PMF) event are similar to the 1% AEP flood event extents, due to the steeply sided valley morphology. Rienco (2009) determined a mix of provisional high and low hazard land in some of the low lying portions of the site.

The Floodplain Mitigation strategy proposed for the Calderwood Urban Development Project is centred around a holistic merit-based assessment of floodplain mitigation options. The Floodplain Mitigation strategy is wholly in accordance with the principles of the FPDM (2005). This is a requirement of the DGR's and one supported by Delfin Lend Lease. A number of measures are proposed to mitigate any potential impacts of the proposed development on flooding. These measures mitigate potential impacts of flooding across the site and seek to wherever possible improve flood affectation external to the site as a result of the proposed development. Several flood related mitigation measures have been identified as being required to offset the impacts of the development, viz:

- Optimisation of floodplain hydraulics through reshaping areas of the floodplain
- Construction of bridges throughout the development
- Measures for dealing with riparian roughness increases
- Thorough assessment of evacuation and isolation issues.

Detailed 2-D modelling was undertaken to test the performance of the identified flood mitigation measures. After a review of the results of this modelling, the following can be concluded:

1. The modelling undertaken to support the proposed development shows that the impacts on adjoining property are acceptable in all events up to and including the 1% AEP flood event.
2. The cumulative impacts of continued filling on the floodplain are negligible.
3. The effects of climate change are relatively minor. None of the lots are affected by ocean inundation under even the most extreme climate-change scenario.
4. Flood Planning Levels (FPL's) have been determined in a manner that is wholly consistent with the principles of the FPDM;
5. No occupants will be isolated by any flood event (including the PMF). All new bridge decks will be located above the 1% AEP flood level and will allow uninterrupted road traffic throughout the development (and beyond) during events up to and including the 1% AEP flood. All major spine roads within the development are set at or above the PMF level.

It is recommended the CUDP adopt the recommended management strategies identified in **Table 5.4** for the Concept Plan and future Project Applications.

Table of Contents

Executive Summary ..... **ii**
1 Introduction **1**
1.1 Background 1
1.2 Director General's Requirements 4
1.3 Concurrent Studies 5
1.4 Purpose of this Report 5
1.5 Structure of this Report 5
2 Agency Consultation **6**
2.1 Consultation with DECCW 6
2.2 Consultation with Shellharbour City Council 6
2.3 Consultation with Wollongong City Council 7
2.4 Consultation with the LIA 8
2.5 Consultation with the Community 8
2.6 Consultation with the SES 8
3 Existing Flood Behaviour **9**
3.1 Catchment Description 9
3.2 Existing Flood Levels & Velocity 11
3.2.1 1% AEP Flood Event 11
3.2.2 Probable Maximum Flood (PMF) Event 12
3.3 Provisional Hydraulic Hazard 12
3.4 Identification of Potential Impacts 14
4 Concept Plan Design Development **16**
4.1 Design Philosophy 16
4.2 Flood Management Measures 16
4.3 Flood Model Development 17
4.4 Simulations Undertaken 18
4.5 Summary of Model Results 18
4.5.1 1% AEP Flood Event 18
4.5.2 PMF Event 18
5 Detailed Assessment of Flood Mitigation Measures **19**
5.1 Increases in Flood Levels on Adjoining Property 19
5.2 Floodplain Reshaping 20
5.3 Changes in Riparian Roughness 21
5.4 Climate Change 22
5.4.1 The Global Phenomena 23
5.4.2 Climate Change in Australia 24
5.4.3 Guidelines for Assessing Climate Change 24
5.4.4 Adopted Scenarios 26

5.4.5 Model Results 26
5.4.6 Adaptive Capacity 27
5.5 Determination of Flood Planning Level 27
5.6 Evacuation & Isolation 28
5.7 Summary of Floodplain Management Outcomes 29
6 Conclusions & Recommendations 31
6.1 Conclusions 31
6.2 Recommendations 31
7 References 32

List of Tables

Table 1.1 – Director General Requirements 4
Table 2.1 – Summary of DECCW's Requirements 6
Table 2.2 – Summary of SCC Requirements 7
Table 2.3 – Summary of WCC Requirements 7
Table 2.4 - Summary of LIA Requirements 8
Table 5.1 – Acceptable Flood Impacts due to Development 20
Table 5.2 – Summary of Riparian Related Impacts in 1% AEP Flood Event 22
Table 5.3 – Indicative Change in Extreme Rainfall 1 Day Totals & Evaporation for 2030 & 2070 25
Table 5.4 – Summary of Climate Change Parameters Used for Analysis 26
Table 5.5 – Comparison of Floodplain Management Principles & Outcomes 29

List of Figures

Figure 1 – Location Plan 3
Figure 2 – Hydrologic Catchment Plan 10
Figure 3 – Existing 1% AEP Flood Depths 11
Figure 4 – Existing PMF Depths 12
Figure 5 – Existing 1% Provisional Hydraulic Hazard 13
Figure 6 – Concept Plan Layout 15
Figure 7 – Trend in Australian Mean Annual Rainfall over the Period 1950 to 2002 24
Figure 8 – Indicative Changes in Design ARI as Rainfall Intensity Increases 25

Annexes

A. Catchment Plan
B. Flood Mitigation Plan
C. Hydraulic Model Results
D. Concept Engineering Plans

1 Introduction

1.1 Background

This Floodplain Risk Management Study (FPRMS) has been prepared by Cardno Forbes Rigby to accompany a Concept Plan Application under Part 3A of the *Environmental Planning & Assessment Act, 1979* (EP&A Act) and a proposal for State significant site listing under Schedule 3 of *State Environmental Planning Policy Major Development 2005* (SEPP Major Development) in relation to the Calderwood Urban Development Project.

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The Calderwood Urban Development Project site is located within the Calderwood Valley in the Illawarra Region. It is approximately 706 hectares in area with approximately 600 hectares of land in the Shellharbour LGA and the balance located within the Wollongong LGA.

The Calderwood Valley is bounded to the north by Marshall Mount Creek (which forms the boundary between the Shellharbour and Wollongong LGAs), to the east by the Macquarie Rivulet, to the south by Johnstons Spur and to the west by the Illawarra Escarpment. Beyond Johnstons Spur to the south is the adjoining Macquarie Rivulet Valley within the suburb of North Macquarie. The Calderwood Urban Development Project land extends south from the Calderwood Valley to the Illawarra Highway. Refer to Location Plan at **Figure 1**.

The Calderwood Valley has long been recognised as a location for future urban development, firstly in the Illawarra Urban and Metropolitan Development Programmes and more recently in the Illawarra Regional Strategy (IRS).

The IRS nominates Calderwood as an alternate release area if demand for additional housing supply arises because of growth beyond projections of the Strategy, or if regional lot supply is lower than expected.

In 2008, the former Growth Centres Commission reviewed the proposed West Dapto Release Area (WDRA) draft planning documents. The GCC concluded that forecast housing land supply in the IRS cannot be delivered as expected due to implementation difficulties with the WDRA, and the significantly lower than anticipated supply of housing land to market in the Illawarra Region is now been recognised as a reality.

The GCC Review of the WDRA also recognised that there is merit in the early release of Calderwood in terms of creating a higher dwelling production rate and meeting State government policy to release as much land to the market as quickly as possible. Given the demonstrated shortfall in land supply in the Illawarra Region and the WDRA implementation difficulties highlighted in the GCC Report, the release of Calderwood for urban development now conforms to its strategic role under the IRS as a source of supply triggered by on-going delays in regional lot supply. The Calderwood Urban Development Project can deliver about 12% of the IRS' new dwelling target.

Changes in outlook arising from global, national and regional factors influencing investment and delivery certainty, housing supply and affordability and employment and economic development also add to the case for immediate commencement of the Calderwood Project.

In April 2008 the Minister for Planning issued terms of reference for the preparation of a Justification Report to address the implications of initiating the rezoning of Calderwood for urban development including associated staging, timing and infrastructure considerations.

In February 2009 the Minister for Planning considered a Preliminary Assessment Report for the Calderwood Urban Development Project that provided justification for the planning, assessment and delivery of the project to occur under Part 3A of the EP&A Act, having regard to the demonstrated contribution that the project will have to achieving State and regional planning objectives.

Subsequently, on the 16 April 2009, pursuant to Clause 6 of SEPP Major Development, the Minister for Planning formed the opinion that the Calderwood Urban Development Project constitutes a Major Project to be assessed and determined under Part 3A of the EP&A Act, and also authorised the submission of a Concept Plan for the site. In doing so, the Minister also formed the opinion that a State significant site (SSS) study be undertaken to determine whether to list the site as a State Significant site in Schedule 3 of SEPP Major Development.

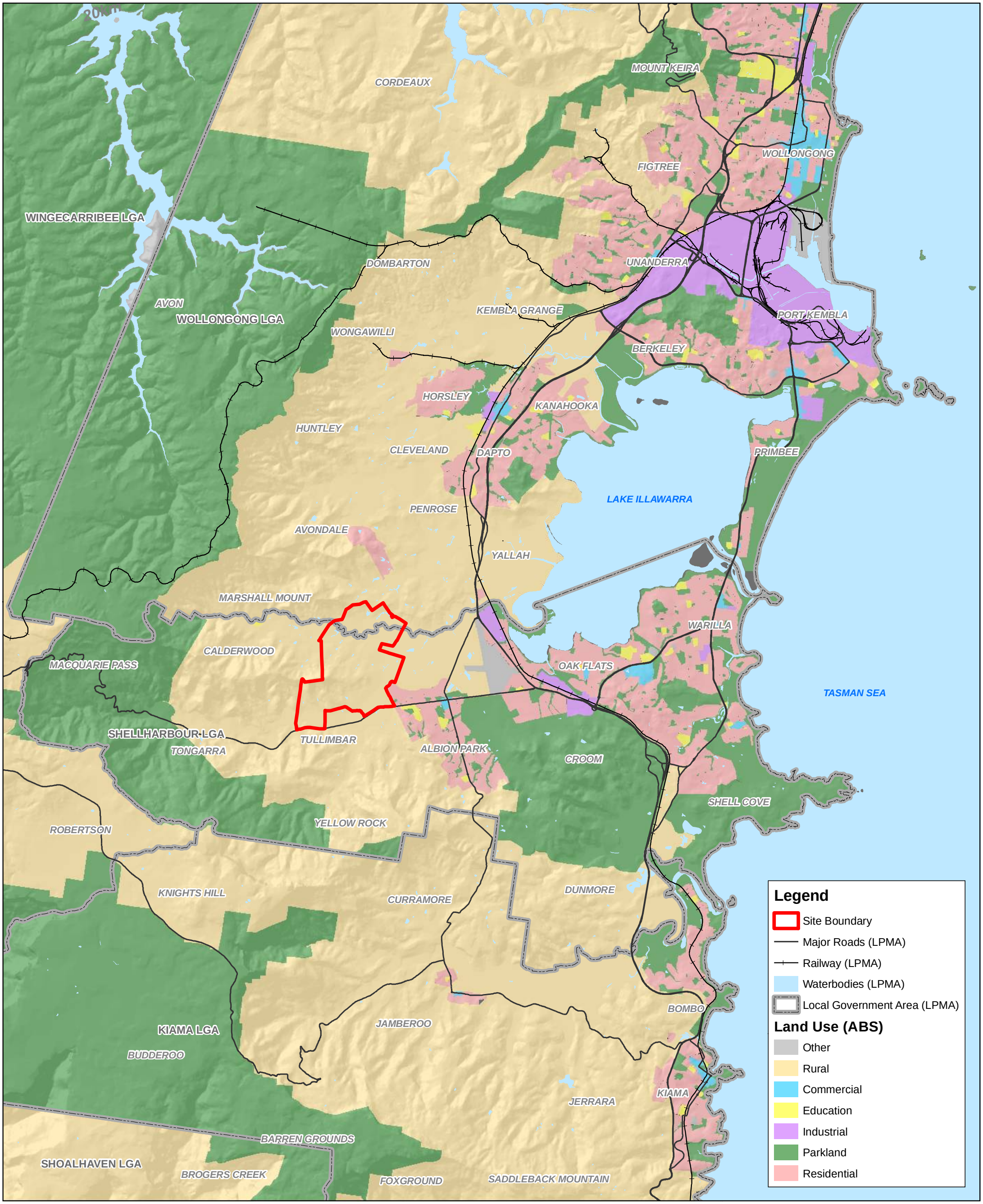
The Part 3A process under the EP&A Act allows for the Calderwood Urban Development Project to be planned, assessed and delivered in an holistic manner, with a uniform set of planning provisions and determination by a single consent authority. Given the scale of the proposal, the Concept Plan and SSS listing provide the opportunity to identify and resolve key issues such as land use and urban form, development staging, infrastructure delivery and environmental management in an integrated and timely manner.

This FPRMS has been prepared to fulfil the Environmental Assessment Requirements issued by the Director General for the inclusion of the Calderwood site as a State Significant Site under SEPP Major Development, and for a Concept Plan approval for the development. Specifically, this FPRMS addresses the Director General Requirements relating to Floodplain Risk Management, as described in Section 1.2 of this report.

In accordance with the Director General's Requirements this FPRMS has been prepared following consultation with the following agencies:

- Department of Environment and Climate Change and Water (DECCW)
- Shellharbour City Council
- Wollongong City Council
- Lake Illawarra Authority

Details of the consultation are further discussed in **Section 2**.



Delfin Lend Lease

N W E S

Scale 1:100,000 (at A3)

Metres

0 1000 2000 3000 4000 5000

Location Plan

FIGURE 1

CALDERWOOD URBAN DEVELOPMENT PROJECT

Cardno

Map Produced by Cardno Wollongong
Date: 15 February 2010
Coordinate System: Zone 56 MGA/GDA 94
GIS MAP REF: 110026-01_18022_LocationPlan.mxd 06

1.2 Director General's Requirements

This study is required to address the DGR's as they relate to floodplain risk management. These DGR's are shown in **Table 1.1**.

Table 1.1 – Director General Requirements

Director General Requirement	Section of this Report where Compliance is Confirmed
Assessment of any flood risk for the site should be conducted in accordance with the NSW Government's Flood Prone Land Policy as set out in the Floodplain Development Manual 2005	Rienco Consulting has been commissioned to prepare a flood risk assessment. This is provided in a separate report.
Flood Study Report for existing conditions is to be prepared to include hydrologic and hydraulic models, calibration against existing local flood records, downstream and upstream conditions, and floodplain characteristics.	Refer to Macquarie Rivulet Flood Study (Rienco, 2009). This study wholly meets the objectives of the DGR's and the principles of the Floodplain Development Manual.
Flood Risk Management Assessment Report for the development including estimation of Flood Planning Levels and Flood Planning Area, extent of flood prone and mapping, flood behaviour, flood risks up to the PMF, evacuation, and impacts of climate change.	This FPRMS addresses the range of issues requested in the DGR's.
Consider Shellharbour Council's Floodplain Risk Management DCP and justify any departure.	Shellharbour Council's Floodplain Risk Management DCP has been explicitly considered in the development of strategies for flood related planning controls presented in **Chapter 5**. Where the DCP is inconsistent with the FPDM, the principles of the FPDM have been used and these instances are documented in **Chapters 4 and 5**.
Consideration of upstream and downstream flows and impacts of development yet to be built.	As all development is required to have no impacts on peak flows upstream or downstream, it has been assumed that any future development would have no impacts on the Calderwood project. This is further described in detail in the Macquarie Rivulet Flood Study (Rienco, 2009) under separate cover.
Assess geomorphic impacts on the watercourses and floodplain area affected by the proposal.	Such an assessment has been undertaken and is issued under separate cover.
Details on any water management structures/dams both existing and proposed including size and storage capacity.	Such an assessment has been undertaken and provided in the Water Cycle Management Study (Cardno, 2010) and is issued under separate cover.
The EA should address drainage and stormwater management issues, including on site detention of stormwater; water sensitive urban design (WSUD) and drainage infrastructure.	Such an assessment has been undertaken and provided in the Water Cycle Management Study (Cardno, 2010) and is issued under separate cover.

1.3 Concurrent Studies

The FPRMS should be read in conjunction with the following studies:

- Flood Study (Rienco)
- State Significant Site Listing and Concept Plan Application (JBA Urban Planning)
- Project Application Stage 1 (Cardno)
- Ecology and Bushfire Studies (Eco Logical Australia)
- Land Capability, Contamination and Geotechnical Studies (Douglas Partners)
- Transport Study (Cardno)
- Landscape and Visual Study (Environmental Partnership NSW)
- Community Facilities and Open Space Study (Elton Consulting)
- European Heritage Study (Eco Logical Australia and Paul Davies)
- Aboriginal Heritage Study (Eco Logical and Austral Archaeology)
- Riparian Consistency Report (Eco Logical Australia)

1.4 Purpose of this Report

The purpose of this study is:

- To review the flooding constraints outlined in the Macquarie Rivulet Flood Study (Rienco, 2009) and their effect on the Concept Plan;
- To provide mitigation options suitable for implementation within the catchment and the Calderwood study area in accordance with the FPDM;
- To address the requirements of the DGR's in relation to flooding and floodplain risk management to support the Concept Plan application

1.5 Structure of this Report

This report has been structured as follows:

Chapter 1 describes the purpose of this study, identifies the DGR's that relate to thuis study and identifies the relationships with other studies.

Chapter 2 describes the initial consultation with stakeholders and the implications on water-related aspects of the project. This chapter also describes the comments made during Consultation by the various agencies, and the specific sections of this report where those comments are addressed.

Chapter 3 describes and summarises the results of the Rienco 2009 flood study.

Chapter 4 describes the development of the floodplain mitigation strategy.

Chapter 5 describes the potential impacts on flooding due to the proposed development and how they have been mitigated throughout the catchment.

Chapter 6 provides recommendations and conclusions.

2 Agency Consultation

2.1 Consultation with DECCW

A meeting with DECCW was held at the DoP offices on 20 October 2009. DECC's comments (combined with notes of the meeting and their comments to DoP) are summarised in **Table 2.1** below; followed by comments relating to which sections of the report address DECCW's comments.

Table 2.1 – Summary of DECCW's Requirements

DECCW's Comment	How and Where Addressed in this Study
The impact of flooding on the development (for example, inundation and structural adequacy)	Inundation maps are presented in **Annexure B**. The impacts of flooding on the development have been quantified and are presented in **Chapters 5 & 6.**
The impact of the development on flood behaviour including any management measures to mitigate adverse flood impacts	The impacts of the development on flood behaviour have been quantified using the same methodology as modeled by Council, DECCW and SES for other regionally significant projects. These impacts have been quantified and are presented in **Chapter 5**.
The implications of climate change on flooding and Flood Planning Levels (FPL)	The impacts of climate change on the proposed site have already been undertaken by Council, DECCW and SES for other regionally significant projects. Our strategies discussed in **Section 5.3** build upon this work.
The impacts of bridges on the flood behaviour including impacts of debris and blockage of waterway openings	These impacts of these structures have been modelled and described in **Section 5.4**.

2.2 Consultation with Shellharbour City Council

A meeting with SCC was held at their offices on 25 November 2009. SCC's comments are summarised in **Table 2.2** below; followed by comments relating to which sections the report address SCC's comments.

Table 2.2 – Summary of SCC Requirements

SCC Comment	How and Where Addressed in this Study
SCC noted that model scenarios for a climate change scenario should include the latest research into increased levels in Lake Illawarra as well as % increases in rainfall intensity	Climate change, taking into account all catchment and Lake related factors, has been undertaken and described in **Section 5.3** of this report.
SCC described the importance of dealing with Soil & Water Management issues both during construction and throughout the life of the development	Soil & Water Management Plans would be provided at the Project Application stage for each development phase.
SCC noted that any large basins should stay below the trigger volumes/sizes for Dam Safety Committee prescription	Basins have been sized such that DSC prescription is not required.
SCC described the need for any floodplain risk management strategy adopted as part of the project to not prejudice any future development (or flood risk management strategy) that may occur as part of Council's future studies in the catchment	Every effort has been made to allow a flexible concept plan design such that any future flood mitigation works undertaken by Council will not be compromised.

2.3 Consultation with Wollongong City Council

A meeting with WCC was held at their offices on 14 December 2009. WCC's comments have been summarised in **Table 2.3** below; followed by comments from CFR relating to which sections of the report address WCC's comments.

Table 2.3 – Summary of WCC Requirements

WCC Comment	How and Where Addressed in this Study
WCC enquired as to any part of the site that may drain to Duck Creek, as WCC have a concurrent study underway in Duck Creek and may need to take into account parts of the proposed development in their study	Cardno confirm that no part of the site drains to Duck Creek.
Model scenarios for a climate change scenario should include the latest research into increased levels in Lake Illawarra (2100 year) as well as 20% increases in rainfall intensity	These requirements have been fully met as described in **Section 5.4** of this report.
The need to consider increased riparian roughness values in the modeling, to ensure that such increases are accounted for in the determination of design flood levels.	These requirements have been fully met as described in **Section 5.3** of this report.

2.4 Consultation with the LIA

A meeting with the LIA was held at their offices on 18 November 2009. The LIA's comments have been summarised in **Table 2.4** below; followed by comments from CFR relating to which sections of the report address LIA's comments.

Table 2.4 – Summary of LIA Requirements

LIA Comment	How and Where Addressed in this Study
LIA noted the potential increase in runoff from urban areas having any flow-on effects in the Lake.	Increased runoff potential has been quantified, and mitigation measures such as On Site Detention proposed, which is described in **Section 5.1** of this report.
LIA noted the requirement for an assessment of climate change and the inclusion of the latest Lake Illawarra Climate Change assessment in the flood study and water cycle management studies.	Climate change, taking into account all catchment and Lake related factors, has been undertaken and described in **Section 5.3** of this report.

2.5 Consultation with the Community

A community consultation session was held at Albion Park Neighbourhood Centre on 18th October 2009. A summary of the communities concerns relating to flooding is presented below:

- The community felt that existing detention basins in the surrounding area did not work. They felt that such basins filled up with flood waters before the main burst of the storms, and as such the basins didn't work. The community felt care was required when designing new basins.

This express concern has been taken into account in the preparation of this report. The specific design procedures and methodology applied for this study (such as the use of the 'Embedded Design Storm' concept) is specifically targeted at estimated runoff volumes more accurately and as such, better informing basin design.

2.6 Consultation with the SES

The SES did not respond to a formal request for consultation. Notwithstanding, the SES (and other agencies) will have the opportunity to comment on the project during the formal exhibition period.

3 Existing Flood Behaviour

3.1 Catchment Description

The Calderwood Valley study area lies within the Macquarie Rivulet catchment, 15kms southwest of Wollongong and part of the Lake Illawarra sub-basin. The Macquarie Rivulet catchment (approx 10,500 ha) is located between the Illawarra Escarpment to the west and Lake Illawarra to the east. Marshall Mount Creek (approx 1,900 ha) joins Macquarie Rivulet downstream of the village of Albion Park (and the proposed development), forming a broad floodplain at and upstream of the junction of the two streams.

The specific study area is broadly contained by the mainstream of Macquarie Rivulet to the south, Marshall Mount Creek to the north and the broad floodplain of the merged streams to the east. It straddles the foothills of a major ridgeline known as Johnson's Spur.

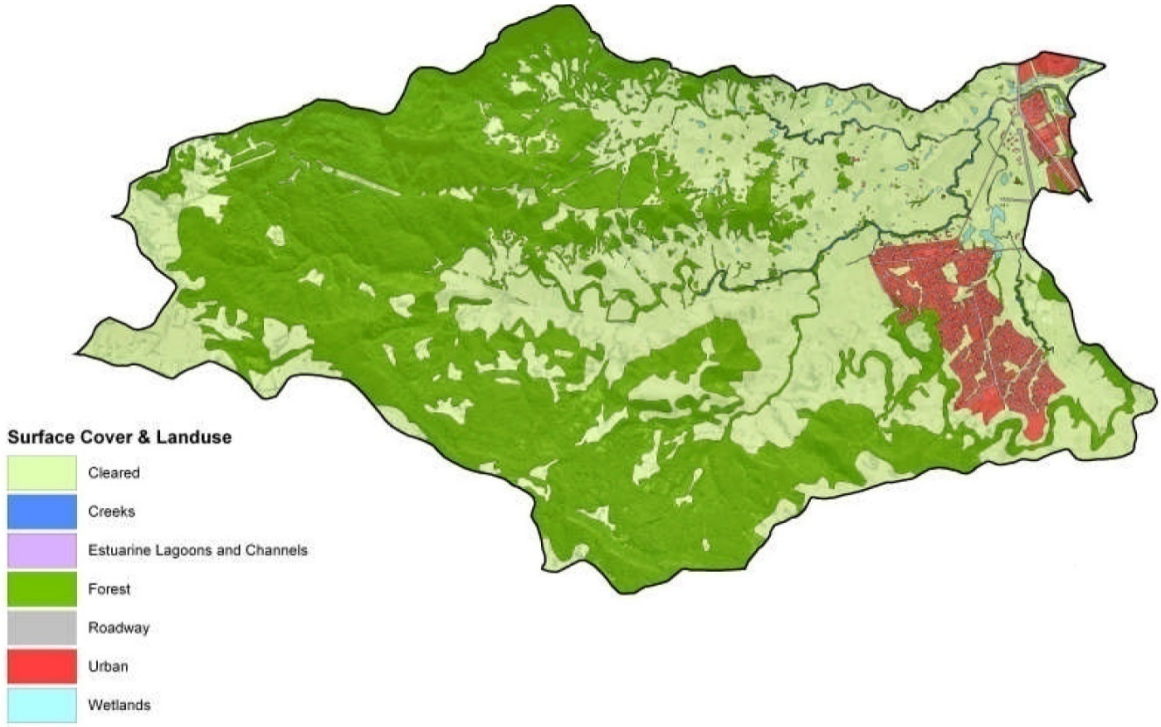
The Macquarie Rivulet catchment is principally rural in character and sustains limited grazing actvites and hobby farms. The headwaters of the catchment, located on the Illawarra Escarpment, retain large tracts of natural forest as these areas were historically considered unsuitable for grazing. Macquarie Rivulet has a stream length of 22.5 km, with total fall from head waters to outlet of 680 metres (Rienco, 2009). The Rivulet's equivalent mainstream slope is 8.4 m/km. The upper reaches are quite steep producing some water falls down the escarpment. For the majority of its length, the stream meanders along a relatively flat river valley with the lower reaches combining on a broad flat flood plain, above the Princes Highway (Rienco, 2009). The combined streams then discharge into Lake Illawarra, where silt deposition has formed a pronounced delta (Rienco, 2009). Marshall Mount Creek is a major tributary of Macquarie Rivulet. Its catchment is similar in character to Macquarie Rivulet though it retains a smaller proportion of forest in its headwaters.

Developments within the combined catchments include the township of Albion Park, the new Haywards Bay residential estate and light industrial areas around Yallah. All these areas are within the lower part of the catchment and drain into Macquarie Rivulet downstream of the proposed Calderwood development site.

Other than Calderwood Valley, another significant future urban development is Tullimbar Village (1,500 lots) which occupies the Hazelton Creek Valley. Hazelton Creek drains into Macquarie Rivulet directly opposite the study area at the western edge of Albion Park Township. At the time of writing this report, approximately 30 dwellings have been constructed. The current zoning permits an additional 1,500 (approx.) dwellings to be located on this tributary.

Figure 2 Hydrologic Catchment Plan (Rienco, 2009, overleaf) shows the relationship within the catchment of the different hydrologic land uses. A more detailed hydrologic catchment plan is included as **Annexure A**.

Figure 2 – Hydrologic Catchment Plan



The stratigraphy of the catchment generally comprises Triassic age, Narrabeen Group sandstone and siltstone (cliffs), overlying Permian age Illawarra Coal Measures (base of cliffs) with talus foothill slopes (mixture of the above). These in turn run down to residual soils and clays overlying a Permian age Shoalhaven Group, Kiama tuff basement. Quaternary deposits of alluvium, sands and silts are present on flood plains and in swamps (Rienco, 2009).

Throughout the Illawarra, this coastal wedge has a similar east-west profile, with the high (600 metre) escarpment to the west, falling sharply to around the 450 metre contour level, at which point the talus slopes commence (Rienco, 2009). These slopes in turn run down at a 15 to 35% grade to around the 100 metre contour level, where residual soils and clays are encountered. In the residual soil/clay zone, surface slopes are typically in the 5 to 15% range. At around the 4 metre contour level, the profile again changes, to an overburden of recently transported sediments deposited on a relatively flat grade (Rienco, 2009).

In the late seventies and early eighties, a series of ash ponds were constructed at Tallawarra power station, infilling part of the flood plain between Macquarie Rivulet and Duck Creek. Wollingurry Creek was diverted to flow around the south eastern corner of these ponds, at this time. During 1996 earthworks began on the 450 lot Hayward's Bay subdivision. At about the same time, Koona Street was extended north over Albion Creek to service a new subdivision (Macquarie Shores) on land east of the railway line and to the immediate south of Macquarie Rivulet (Rienco, 2009).

Over the last decade a considerable amount of new residential development has occurred around the village of Albion Park. Residential, commercial and light industrial development is generally located in the downstream (eastern) portion of the catchment with pasture in the central portion and remnant forest in the upstream (western) portion of the catchment (Rienco, 2009).

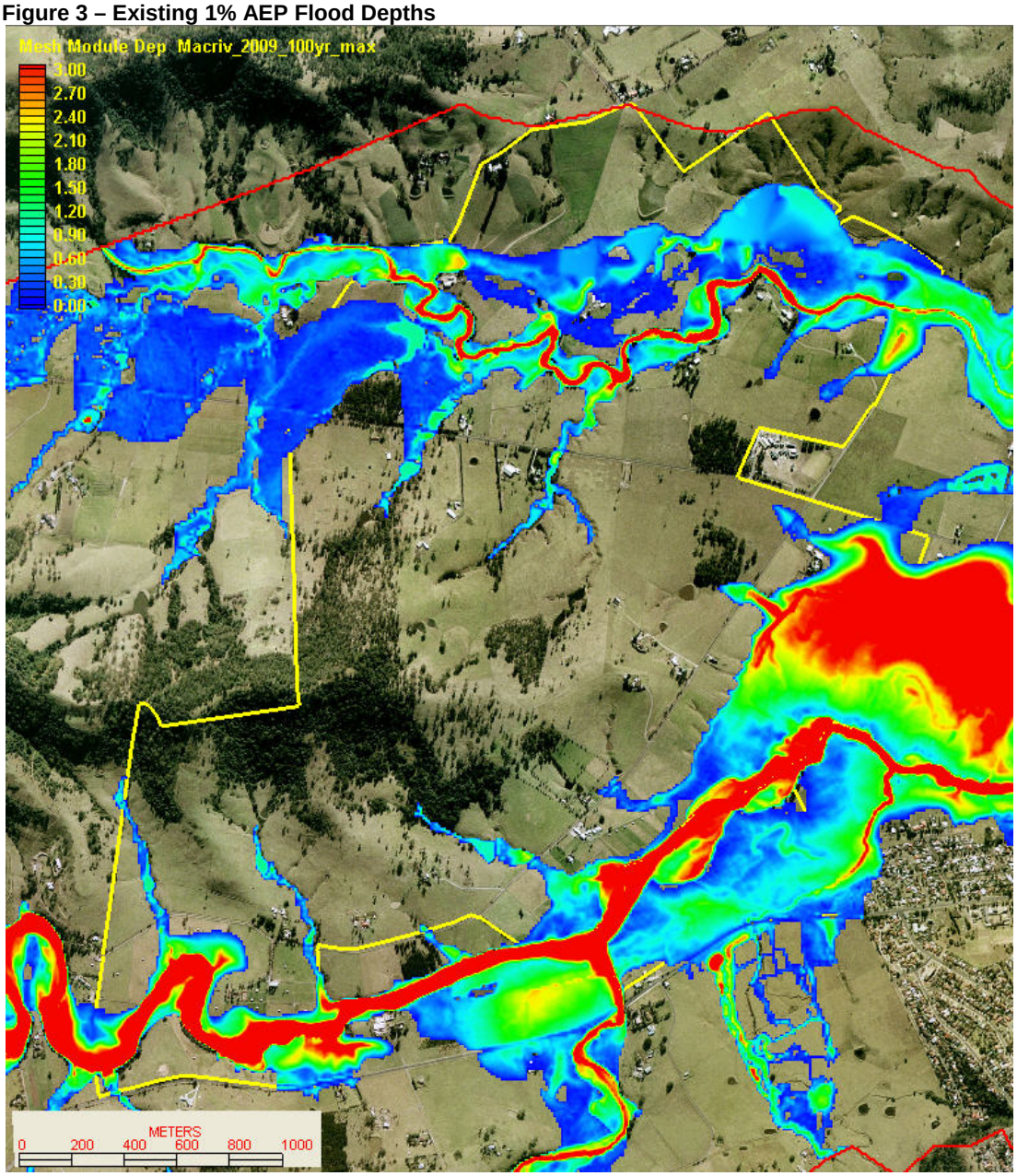
3.2 Existing Flood Levels & Velocity

3.2.1 1% AEP Flood Event

A flood study has been undertaken as part of this project to determine the existing flood behaviour across the project site (Rienco, 2009). This modeling quantified flood levels, velocities, depth, unit flow (conveyance) and provisional hydraulic hazard through and in the vicinity of the proposed development site. In a 1% AEP flood event, Macquarie Rivulet inundates the low lying land along the southern boundary of the site and Marshall Mount Creek inundates the low lying land in the northern side of the site (Rienco, 2009). In both zones of inundation, substantial secondary overland flow paths are evident, flowing at considerable depth and velocity at the peak of a 1% AEP flood.

Figure 3 below (Rienco, 2009) shows the 1% AEP flood depths and levels across the subject site.

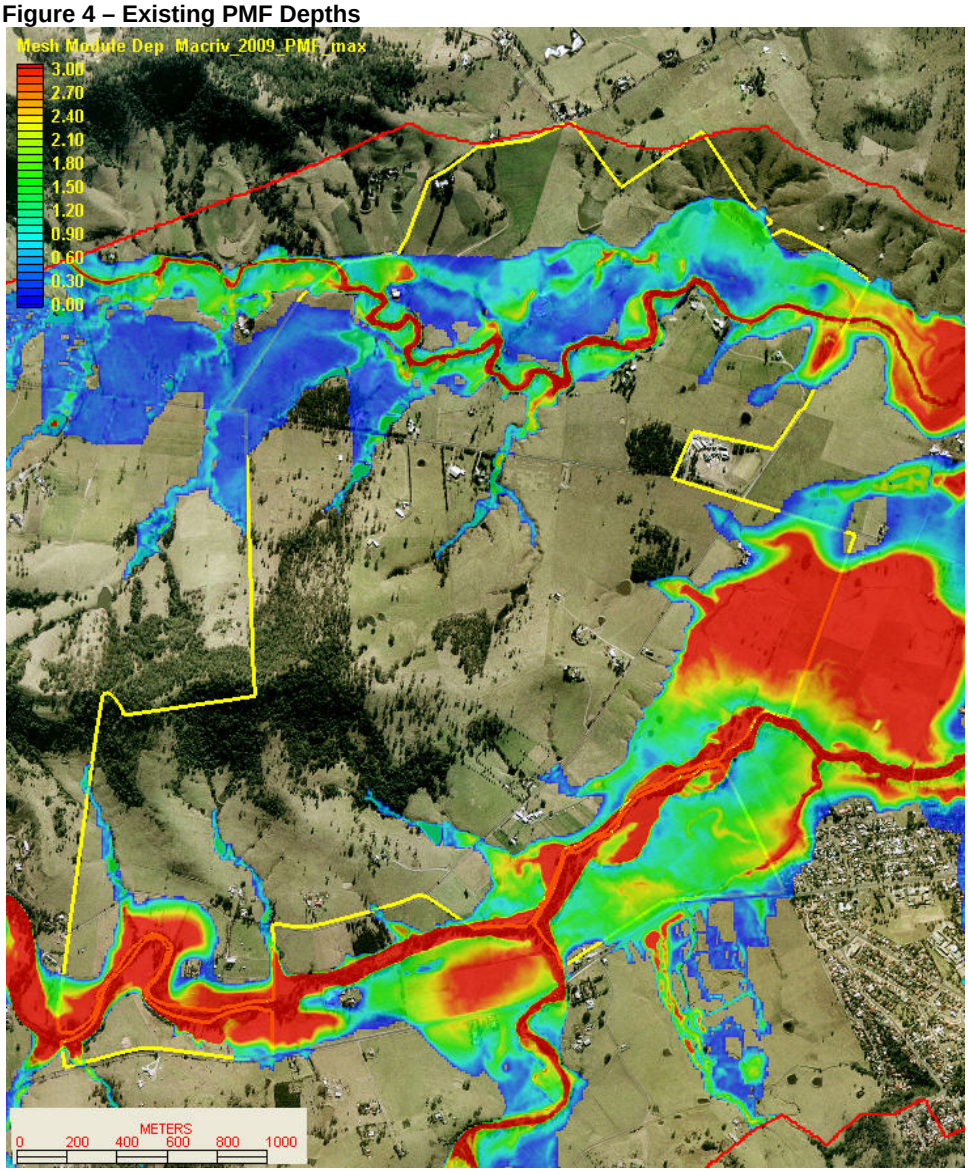
Figure 3 – Existing 1% AEP Flood Depths



3.2.2 Probable Maximum Flood (PMF) Event

While a PMF event more than doubles peak flows in the two creek systems and substantially increases flood depths, velocities and hazard, it does not greatly increase the plan extents of flooding (the extent of 'flood prone' land) near the proposed development site when compared to the 1% AEP flood extent. This is due to the 1% AEP flood extent extending to the valley margins, and therefore considerable increases in flood level does not necessarily equate to commensurate increases in flood extent. **Figure 4** below (Rienco, 2009) shows the PMF depths and levels across the subject site.

Figure 4 – Existing PMF Depths



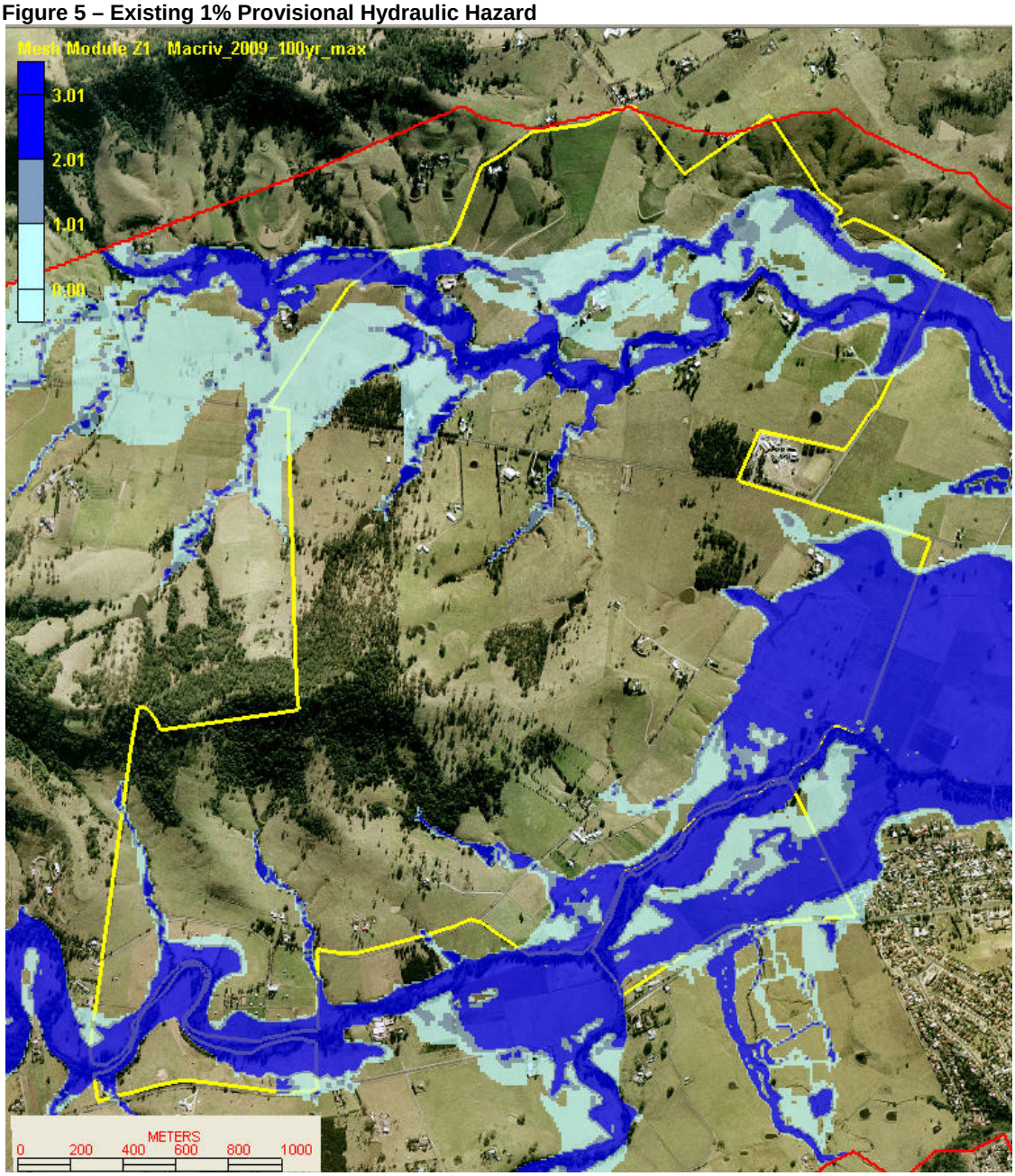
3.3 Provisional Hydraulic Hazard

An assessment of the distribution of provisional hydraulic hazard across the study area was undertaken by Rienco (2009). This assessment reflects the FPDM 2005 provisional hydraulic hazard categories set out in Figure L2 of the manual. The plotted provisional hazard categories are based on the most severe hazard category (from the combination of instantaneous velocity and depth

consideration), occurring throughout the event. As shown in **Figure 5** (Rienco, 2009), the relatively pronounced ground slopes at the edge of the floodplain in both valleys prevents the development of significant zones of low and/or transitional hazard in most locations. Most of the inundated portions of the site would therefore present a 'high' provisional hydraulic hazard to those occupying such land.

Some areas of low provisional hydraulic hazard are however present in both valleys between the mainstream and secondary floodways and on steeper land on the side slopes of tributary streams, particularly on the southern face of the Marshall Mount valley in the vicinity of the western boundary of the site.

Figure 5 – Existing 1% Provisional Hydraulic Hazard



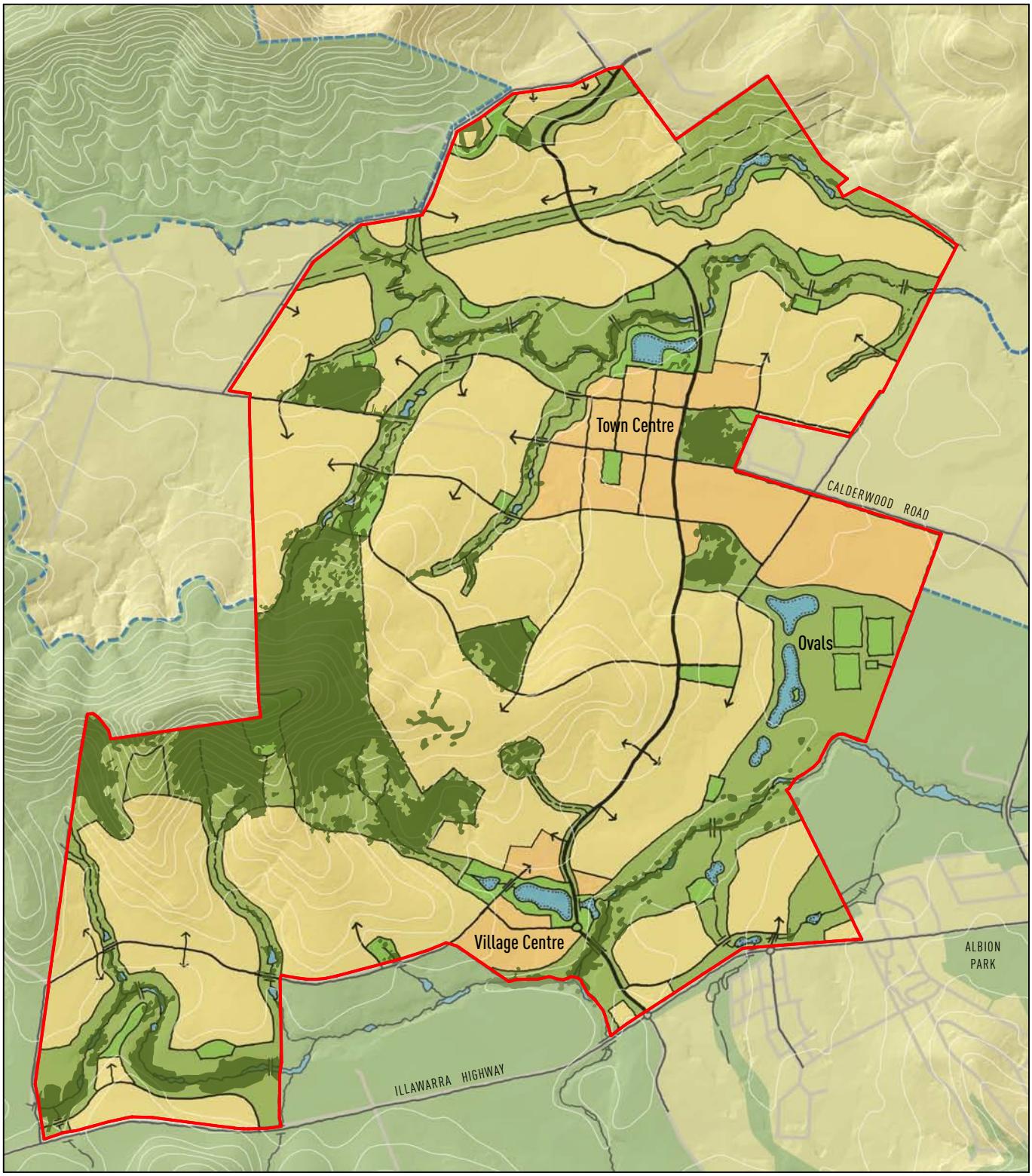
3.4 Identification of Potential Impacts

The Concept Plan for the Stage 1 area can be seen in **Figure 6** below. The potential impacts identified because of the project, or changes within the catchment/environment over time are:

- Climate Change
- Increases in Flood Levels on Adjoining Property (as a result of the development generally)
- Cut and Fill (in offsetting the impacts of various aspects of the development)
- Increases in Riparian 'roughness' leading to an impact on flood levels within, and outside of, the subject site.

The following **Chapter 4** describes the potential impacts and how they have been incorporated into the existing hydraulic model such that their impacts can be determined. This chapter also describes the development of the flood mitigation strategy.

Chapter 5 discusses the management strategies proposed for mitigating these impacts in detail, and provides a critical review of how these measures perform in achieving the desired floodplain outcomes.



Concept Plan

Part 3A | Calderwood Urban Development Project

- Town and Village Centres
  Mixed Uses including Retail, Employment, Residential, Learning and Community Amenities
- Residential Neighbourhoods
- Parks
  eg Citywide, district and local parks
- Principal Open Space and Drainage
  eg Environmental Conservation, Environmental Management and Drainage Corridors
- Indicative Water Bodies

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Subject to verification and detailed site survey 1:20,000 @ A4 10m Contours February 2010

4 Concept Plan Design Development

4.1 Design Philosophy

The Floodplain Development Manual (FPDM) acknowledges the economic and social benefits of development on floodplains and seeks to balance these benefits with flood risk, stating (in section 1.1.1):

'A merit approach shall be adopted for all development decisions in the floodplain to take into account social, economic and ecological factors, as well as flooding considerations'.

One of the key underlying philosophies espoused in the FPDM is to avoid the unnecessary sterilisation of flood prone land. This is highlighted in the Foreword of the Manual, which indicates that the NSW Government's Flood Prone Land Policy promotes:

'the use of a merit approach which balances social, economic, environmental and flood risk parameters to determine whether particular development or use of the floodplain is appropriate and sustainable. In this way the policy avoids the unnecessary sterilisation of flood prone land…

The NSW Government's focus on appropriate and sustainable development of flood prone lands is also reflected in the title of the new (April 2005) Floodplain *Development* Manual (emphasis added) in comparison to its predecessor document which was titled Floodplain Management Manual. The FPDM further reinforces its position on wishing to avoid sterilising land in its discussion on zoning, stating (in section 1.1.1):

'the New South Wales Government's Flood Prone Land Policy does not support the use of zoning to unjustifiably restrict development simply because land is flood prone. Zoning of flood prone land should be based on an objective assessment of land suitability and capability, flood risk, environmental and other factors'.

It also provides the following comment:

'In many cases it is possible to develop flood prone land sympathetically to the natural characteristics of the land without resulting in undue risk to life and property'.

The Floodplain Management strategy adopted for Calderwood is wholly in accordance with the principles of the FPDM (2005). This is a requirement of the DGR's and one supported by DLL. The DGR's also require Shellharbour Council's Floodplain Risk Management DCP to be considered, with any departures justified. Where Shellharbour Council's DCP is inconsistent with the FPDM (2005) and where the inconsistencies affect the project (as noted further in this report) the FPDM has been used instead of the DCP.

4.2 Flood Management Measures

A number of measures are proposed to mitigate and manage any potential impacts of the proposed development on flooding. These measures mitigate potential impacts of flooding across the site and seek to wherever possible improve flood affectation external to the site.

In order for the Concept Plan to be implemented, several flood related mitigation measures have been identified as being required to balance the impacts of the development, including:

- Bridges
- Riparian Roughness Increases
- Optimising floodplain hydraulics through reshaping areas of the floodplain

These measures are described via a plan in **Annexure B**. Increases in peak flows were not considered as part of this assessment. The proposed wetlands and water cycle strategy for the site will ensure that peak flows entering the creek systems will not increase as a result of the development.

A number of design iterations were undertaken by Cardno to create an optimal balance between the extent of works required and the reduction in flood related impacts. A 3-D Digital Terrain Model was constructed of the areas within the floodplain where re-shaping was anticipated. This same model also included the proposed bridges and other aspects of the proposed Concept Plan. These plans are included as **Annexure D**. The following sections describe the flood modelling of this scheme and the model results.

4.3 Flood Model Development

Detailed 2D flood modelling has been undertaken throughout the subject site by Rienco (2009) for the existing conditions. Additional model runs were required in order to quantify the impacts on flood levels and behaviour throughout the catchment. A balance was struck between adding enough detail to the model to ensure robust and realistic results, but also to keep the level of detail commensurate with a Concept Plan. As such, the following methodology was applied across the subject site:

- For fill areas or areas of dense residential development, it was assumed that a 'glass wall' surrounded these areas. This is conservative (i.e. will result in higher impacts) as it over-estimates the loss of floodplain storage and obstructions to flow.
- For cut areas, a concept-level cut plan was modelled in a 3D CAD system and applied to the hydraulic model geometry. This allowed the cut and fill to be modelled at once.

There is one blockage scenario considered, which will be consistent with that adopted in the Macquarie Rivulet Flood Study (Rienco, 2009). This represents the worst case scenario in terms of estimating the most elevated flood levels across the site.

Manning's 'n' surface roughness values are in accordance with the landscape plans by Eco Logical. Generally, this consists of an open, grassy woodland style corridor. We have modelled half of the riparian corridor widths (for each respective category) as having a Manning's 'n' of 0.10 (i.e. the Core Riparian Zone or CRZ), and the remainder of the riparian corridors to have a Manning's 'n' of 0.060, typically associated with low density planting and native grasses.

The proposed bridge across Macquarie Rivulet will be a Rocla M-Lock bridge or approved equivalent.

Internal bridges will be required to span small waterways throughout the site. These have not been modelled as they are of a small nature and the details of road locations is still at a concept level. These structures can be readily designed in future, more detailed applications to a standard suitable to Council.

In terms of obtaining a pre-development and post-development scenario to determine any impacts, the pre-development scenario shall be the site as it exists today, and the post-development scenario shall be the developed site with only the works required to offset this development. The modelling results are described in **Section 4.5**.

4.4 Simulations Undertaken

The following simulations were undertaken as part of the flood modelling:

- **Simulation 1:** Proposed development in all its forms (i.e. Macquarie Rivulet Bridge, cut and fill, riparian revegetation etc) and its impacts on flood levels and behaviour for the 1% AEP flood event.
- **Simulation 2**: Proposed development in all its forms (i.e. Macquarie Rivulet Bridge, cut and fill, riparian revegetation etc) and its impacts on flood levels and behaviour for the PMF event.
- **Simulation 3:** Proposed development in all its forms but without riparian revegetation, and its impacts on flood levels and behaviour for the 1% AEP flood event.
- **Simulation 4:** Impacts on flood levels and behaviour when simply revegetating the riparian CRZ alone, without development, for the 1% AEP flood event.
- **Simulation 5:** Proposed development in all its forms (i.e. Macquarie Rivulet Bridge, cut and fill, riparian revegetation etc) and its impacts on flood levels and behaviour for the Climate Change 1% AEP flood event.
- **Simulation 6**: Proposed development in all its forms (i.e. Macquarie Rivulet Bridge, cut and fill, riparian revegetation etc) and its impacts on flood levels and behaviour for the Climate Change PMF event.

4.5 Summary of Model Results

4.5.1 1% AEP Flood Event

There are negligible increases in flood levels due to the proposed development in the 1% AEP flood event off the site. Increases across the Calderwood site itself are within predominantly in riparian land. There is some affectation of private property upstream of the site; however this is caused by the increased roughness of the riparian corridors, rather than the development itself. This can be seen by reviewing **Annexure C** and the associated impact maps described above, and are further discussed in detail in **Section 5.6**.

It should also be considered that the increases to flood levels, from the development itself or the CRZ revegetation or both, are confined to small areas of the floodplain mostly within riparian land. There is also a decrease in flood levels across a significant proportion of the development site due to the proposed development. What is most important is that the decreases in flood levels occur outside of riparian corridors and within land that is already highly flood prone.

In particular, the highly flood prone section of the Illawarra Highway just west of Yellow Rock Creek will have a lower peak flood level, and decreased duration of overtopping in the 1% AEP flood event as a result of the development and floodplain reshaping. Peak flood levels, and duration of overtopping, are key factors in road safety and the subsequent increase in road safety on the Illawarra Highway, as a result of the proposed development, is a key benefit of the flood mitigation strategy.

4.5.2 PMF Event

Increases in flood levels mainly affecting rural lands can be seen immediately upstream of the proposed Macquarie Rivulet Bridge. The Bridge offers real social benefits such as guaranteed access in the 1% AEP flood event to Calderwood. On balance, there is no net impact on flooding in the PMF when considering triple bottom line outcomes. A flood impact map has been prepared for each of the above simulations and is presented in **Annexure C**.

5 Detailed Assessment of Flood Mitigation Measures

Based on the outcomes of **Chapter 4**, it is clear that from a hydrologic and hydraulic perspective, a range of flood management and mitigation measures are suitable for use in the proposed development.

To determine if these proposed flood mitigation measures/ meet the requirements of the DGR's and other local government DCP objectives, an assessment against these criteria is required. The following sections describe the government requirements (either the DGR or the DCP related requirement) and the capacity of the adopted measures to meet or exceed those requirements.

5.1 Increases in Flood Levels on Adjoining Property

There is no definitive guideline on assessing the acceptable impacts on neighbouring land due to a proposed development. Certain policies (e.g. Shellharbour Council DCP 4) state that no increases are acceptable; whilst other guidelines (FPDM, 2005) purport that certain increases may be acceptable if balanced by other measures. For example, the FPDM (2005) states that triple bottom line outcomes are preferable and some environmental impacts (for example) may be tolerable if they are balanced by social and economic benefits.

Shellharbour Council's Floodplain Risk Management DCP states that *proposed development should not result in any increased risk to human life*. In Neate vs Shellharbour City Council (L&EC Appeal No 10337 of 2006), SC Roseth found the following in relation to the Shellharbour Council DCP's prescriptive criteria:

> *This is expressed in such a categorical form that no proposal could meet it. For example, a building that requires scaffolding will increase risk to human life because workers sometimes fall off scaffolding.*

Other examples of the DCP were also found to be expressed in such a categorical form that no proposal could meet it. As such, whilst every effort has been made to comply with the DCP, there are times when no development could comply with it.

On the other hand, the FPDM (2005) promotes a merit based assessment of flood related impacts. Whilst the FPDM acknowledges that this is not an ideal approach on a site by site basis, given that, the entire Macquarie Rivulet catchment has been studied and taken into account, the impacts of this development (where there are any) have been taken into account on a catchment wide basis.

To ensure an approach that is consistent with the principles of the FPDM (2005) and consistent with other approaches adopted regionally, a merit-based assessment procedure has been adopted to determine the acceptability of flood level related impacts on adjoining land. This approach has been adapted from the preferred and adopted approach in the neighbouring Mullet & Brooks Creek FPRMS&P (2008) and is known as a matrix of "acceptable impacts" provided in **Table 5.1**. This approach is also consistent with the principles of the FPDM (2005).

Table 5.1 – Acceptable Flood Impacts due to Development

Zoning	Increased Flood Levels in a 1% AEP Flood Event		Decreased or Stable Flood Levels
	Within Riparian Corridor	Beyond Riparian Corridor	
Urban	Not Preferred	Unacceptable	Acceptable
Non-Urban	Acceptable	Not Preferred	Acceptable

The Mullet & Brooks Creek FPRMS&P (2008) states that the definitions for use with **Table 5.1** are:

- "acceptable" – through the normal development processes (e.g., fine-tuning the mitigating measures, or by other means such as compensation) these flood impacts can be effectively managed so that third parties are not adversely affected;
- "unacceptable" – indicates that it is unlikely that it will be possible to provide development in a manner that will not adversely affect third parties; and
- "not preferred" – achieving an outcome whereby third parties are not adversely affected may present challenges, though the normal development processes should enable these impacts to be satisfactorily managed.

The Mullet & Brooks Creek FPRMS&P (2008) goes on to state:

According to the matrix, development that results in decreased or stable flood levels is "acceptable", whereas increased flood levels are evaluated depending upon the property zoning and the location relative to the proposed riparian corridor. Increased flood levels affecting urban zoned land (i.e. residential, commercial or industrial) beyond the proposed riparian corridor are considered "unacceptable", whereas increased flood levels affecting non-urban zoned land within the proposed riparian corridor are considered "acceptable". Increased flood levels affecting urban land within the corridor, or non-urban land beyond the corridor, are "not preferred".

The modelling undertaken to support the proposed development shows that in all circumstances and unacceptable outcome can be avoided.

5.2 Floodplain Reshaping

The FPDM (2005) is generally silent on the appropriateness of earthworks across floodplains. However, Shellharbour Council's Floodplain Risk Management DCP provides quite prescriptive requirements on reshaping, stating that *filling in flood prone areas is not permitted unless a report from a suitably qualified civil engineer with expertise in hydrology and hydraulics is submitted to Council that certifies that the development will not increase flood affectation elsewhere*.

The DCP goes on to state that *any proposal to fill a site must be also accompanied by a cumulative impact assessment with an analysis of the effect on flood levels of similar filling of developable sites in the area.* The DCP states that it must be demonstrated through a cumulative impact assessment, that as a result of the fill:

- there is no significant increase in flood levels up to the PMF event
- there is no significant impacts upon flood behaviour on other properties
- there is no increase in risk to life up to the PMF event

As discussed previous in **Section 4.4**, in Neate vs Shellharbour City Council (L&EC Appeal No 10337 of 2006), SC Roseth found that this requirement *is expressed in such a categorical form that no proposal could meet it.* We also consider the above requirement of the DCP to be inconsistent with the principles of the FPDM. To simply prohibit filling across the floodplain because of its (supposed) potential flood level impacts, without taking into account the additional social and economic benefits such filling may provide, is inconsistent with the principles of the FPDM.

The prohibition of filling, or development, on flood prone land due to single issue concerns is also seen unfavourably by the NSW Government. The New South Wales Government's Flood Prone Land Policy, for example, does not support the use of zoning to unjustifiably restrict development simply because land is flood prone. Zoning of flood prone land should be based on an objective assessment of land suitability and capability, flood risk, environmental and other factors (FPDM, 2005).

Notwithstanding the above, a higher order aim and objective of Council's DCP is to *apply a "merit-based approach" to all development decisions which take account of social, economic and ecological as well as flooding considerations.* As such, we have taken these higher order aims and objectives into account in the development of this Concept Plan, rather than the prescriptive development controls which would appear to prohibit any development of flood prone land.

It is also important to note that of the 4,800 (approx.) dwellings proposed, only a small percentage of these are located on what is currently flood prone land. As such, the development is not relying on a reshaping strategy to support itself.

Only a small percentage of the overall development requires some form of cut and fill which will enable the master-planning process to be driven by sound urban design objectives rather than by a relatively minor flooding constraint.

The cumulative impacts of continued filling on the floodplain are considered negligible. The proposed development constitutes the majority of the future urban release area for the Calderwood Valley. Should small portions of land upstream and downstream be developed in the future, they would not likely require floodplain reshaping as they are largely flood free. As such, the proposed development represents the maximum likely urban area to be developed in the catchment and its cumulative impacts are negligible.

5.3 Changes in Riparian Roughness

DECCW (then DIPNR) published a Riparian Corridor Management Study in 2004. This study suggests a riparian corridor width through part of the subject site (Marshall Mount Creek) but this assessment did not extend to Macquarie Rivulet.

The impacts of a revegetated riparian corridor on flooding are considerable. Whilst the increased 'roughness' can have the effect of reducing channel velocity, such a decrease in velocity often leads to a significant increase in flood levels on the floodplain. Such increases are irrespective of any development in the catchment. In other words, if the RCMS was implemented without any other development occurring, flood levels would increase considerably within each of the catchments. Therefore, it is important to consider the many impacts of the revegetation of riparian areas, including social, environmental and economic advantages and disadvantages.

It is noted that when the full RCMS riparian corridor widths were applied to the West Dapto Release Area (WDRA), the impacts of increased flood levels were found by the committee to be unacceptable (Mullet & Brooks Creek FPRMS&P, 2008). The 'acceptability' limits or criteria were those summarised in **Table 5.1** of this report. The Mullet & Brooks Creek FPRMS&P flood model was iteratively run with narrower re-vegetated corridors until an 'acceptable' solution was found. This is succinctly described by Bewsher Consulting in the Mullet & Brooks Creek FPRMS&P (2008), viz:

A series of test runs was conducted with the riparian corridors re-vegetated. Initially the entire width of the riparian corridors was proposed to be re-vegetated. After further input from the TWG a narrower area of re-vegetation to the minimum extent needed to meet the riparian objectives of particular creeks was included in the model. Despite this, it was found that significant increases in the 1% AEP flood levels were still occurring, especially in the area downstream of the Princes Highway. As a consequence it was decided that only the re-vegetated corridor upstream of the Princes Highway would be included in the model (also, that re-vegetation was not acceptable along Dapto Creek upstream of West Dapto Road). In this area, the adverse effects of re-vegetating the floodplain were largely offset by compensatory excavation, and any residual effects were found not to violate the principles for acceptable impacts…

The resultant Mullet & Brooks Creek FPRMS&P (2008) riparian corridor widths are approximately half of that proposed in the RCMS (2004) to ensure 'acceptable' impacts.

A site-specific riparian strategy has been prepared for the Calderwood project in line with the DLL riparian strategy. The resultant corridor widths and revegetation strategy have been determined as part of a triple bottom line assessment and detailed site inspections undertaken by the design team. The proposed riparian corridor widths have been optimised to meet a range of objectives ranging from hydraulic impacts, ecological outcomes and future ownership and maintenance issues.

Table 5.2 – Summary of Riparian Related Impacts in 1% AEP Flood Event

Scenario	Description	Outcome
Simulation #1	Proposed development in all its forms (i.e. Macquarie Rivulet Bridge, cut and fill, riparian revegetation etc) and its impacts on flood levels and behaviour	A balance between increased flood levels and decreased flood levels is found. Increases in flood levels occurs of site but are contained to within riparian land.
Simulation #3	Proposed development in all its forms but without riparian revegetation, and its impacts on flood levels and behavior	A balance between increased flood levels and decreased flood levels is found. No increase in flood levels occurs of site.
Simulation #4	Impacts on flood levels and behaviour when simply revegetating the riparian CRZ alone, without development	Increases in excess of 500 mm occur across the site, and increases in excess of 200 mm occur well beyond the riparian areas and off the site.

Simulation #1 (representing the proposed development in all its forms) is deemed to have acceptable flood related impacts. It is also clear that revegetation of the riparian corridor alone, without compensatory measures such as floodplain reshaping, causes significant flood level increases throughout the site and off the site.

5.4 Climate Change

The DGR's require an appraisal of climate change flood risk on the project. Typically, these assessments are undertaken in accordance with the "DECC Floodplain Risk Management Guide".

The NSW Government's Floodplain Development Manual (2005) also requires that flood studies and floodplain risk management studies consider and where necessary manage climate change implications and associated vulnerabilities, as part of strategic management of flood risk. In this

regard, DECC has published a Floodplain Risk Management Guideline titled Practical Consideration of Climate Change dated 25/10/07 (Version 1.0; Status: Final), which takes into account climate change predictions by the UN Intergovernmental Panel On Climate Change and the CSIRO, and proposes a methodology for assessing climate change impacts through modelling sensitivity analysis.

This assessment (described in detail below) appraises the potential of climate change to increase flood levels resulting from changes in rainfall patterns and from rises in sea levels in accordance with DECCW's October 2007 guideline. The potential impact of climate change on riparian vegetation and associated effects on flood levels is also considered.

5.4.1 The Global Phenomena

There is wide consensus that the earth is experiencing climate change due to global warming. The majority of scientific evidence suggests that this phenomenon is attributable to the greenhouse effect, caused by the burning of fossil fuels at unprecedented rates. Some sceptics however believe that the causes may lie with natural cycles of the earth's climate between cold and warm states. Irrespective of the underlying causes, the phenomenon exists and is already having a significant impact on the world's climate.

Global average surface temperatures have increased since pre-industrial times by some 0.8°C. There was a rapid increase in the 1920s and 1930s followed by some cooling in the 1950s and 1960s, especially in the northern hemisphere. Globally temperatures have risen rapidly since the 1970s. The cooling after World War II was mainly regional around Europe, South and East Asia and North America. It is thought to be due to the scattering of sunlight back into space by particulate pollution, mainly from the burning of sulphur-rich fossil fuels. This led also to severe urban pollution and acid rain, which was brought under control in Europe and North America by switching to low-sulfur fuels, or scrubbing the sulfur emissions out of smokestacks (Pittock, 2007). The rapid warming since the 1970s is believed to be due to the ongoing accumulation of greenhouse gases and the continual reduction of particulate pollution (IPCC, 2001, 2007).

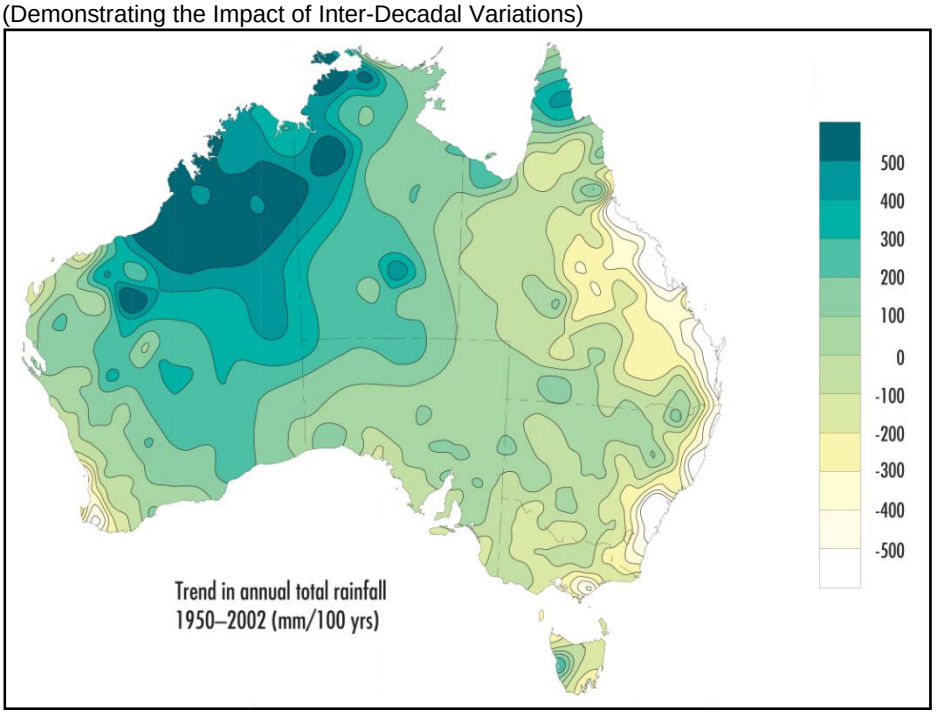
Globally, observations of increases in atmospheric concentrations of carbon dioxide, global average surface temperatures, and sea level rise over the last two decades have all been tracking near the maximum of the range of projections from the 1990s made by the IPCC in 2001 (IPCC, 2001; Rahmstorf et al., 2007). Possible reasons for this more rapid rate of climate change than generally expected are likely due to amplifying processes are not adequately represented in current climate and glaciological models (Pittock, 2007):

- "Global dimming", or cooling due to particulate pollution, is decreasing. This has hidden some of the greenhouse warming, and now the full warming will become evident (Andrae et al, 2005; Delworth et al., 2005).
- Permafrost is melting, leading to increased release of methane and carbon dioxide (greenhouse gases) from unfrozen peat bogs (ACIA, 2004; Nelson, 2003; Overland, 2006)
- Global biomass is turning from a sink or absorber of carbon dioxide into a source, thus accelerating the greenhouse effect (Angert et al, 2005; Bellamy et al., 2005; Candell et al., 2007; Matthews et al., 2005; Scheffer et al, 2006)
- Artic ice and seasonal snow cover are decreasing rapidly, increasing absorption of sunlight (Comiso, 2006; Overland, 2006; Serreze and Francis, 2006).
- Newly observed mechanisms are accelerating outflow glaciers in Greenland and Antarctica, including disintegration of floating ice shelves, surface meltwater penetration, and undercutting of tidewater glaciers (those with valley floors below sea level).

5.4.2 Climate Change in Australia

In Australia, average daily maximum temperatures have increased 0.6°C from 1910 to 2004, and daily minimum temperatures have increased 1.2°C in this period, with most of the increases since 1950 (Nicholls and Collins, 2006). Increased temperatures have been greater inland in drier regions and away from the moderating influence of the oceans. The east coast has experienced decades of below average rainfall in many areas since the 1950's as shown in **Figure 7**.

Figure 7 – Trend in Australian Mean Annual Rainfall over the Period 1950 to 2002
(Demonstrating the Impact of Inter-Decadal Variations)



(Source: BoM (2007) The Greenhouse Effect and Climate Change)

Precipitation changes however are not solely influenced by rising greenhouse gasses (CSIRO, 2007). Current analyses suggest that, despite earlier dry periods, the present long "drought" in southern and eastern Australia may well be part of a long term trend largely associated with the enhanced greenhouse effect, but with the added shorter-term effects of El Nino-induced drought in eastern Australia north of the Victorian dividing range (Pittock, 2007).

Rainfall in eastern Australia is likely to continue to decrease if the trend in recent decades to a more negative Southern Oscillation Index continues; however, there will still be episodic returns to wetter La Nina conditions. Increasingly higher temperatures and evaporative losses, especially in summer, are likely to make drought conditions more acute in El Nino years, and reduce runoff in La Nina years even when rainfall is average or above. In La Nina years, more extreme rainfall is likely to be experienced as a warmer atmosphere can hold more water vapour, and hence at times produce heavier precipitation by way of more intense storm activity with a greater frequency.

5.4.3 Guidelines for Assessing Climate Change

The 2007 DECC Flood Risk Management guideline titled Practical Consideration of Climate Change guidelines (DECC, 2007) recognises that:

Climate change is expected to have adverse impacts upon sea levels and rainfall intensities, both of which may have significant influence on flood behaviour at specific locations.

The DECCW Flood Risk Management guideline indicates a trend for large, rare and extreme events to increase in intensity and storm volume due to climate change impacts. CSIRO predicts changes in rainfall totals for the 40-year average recurrence interval (ARI) 1-day storm event for 2030 and 2070 as shown in **Table 5.2**.

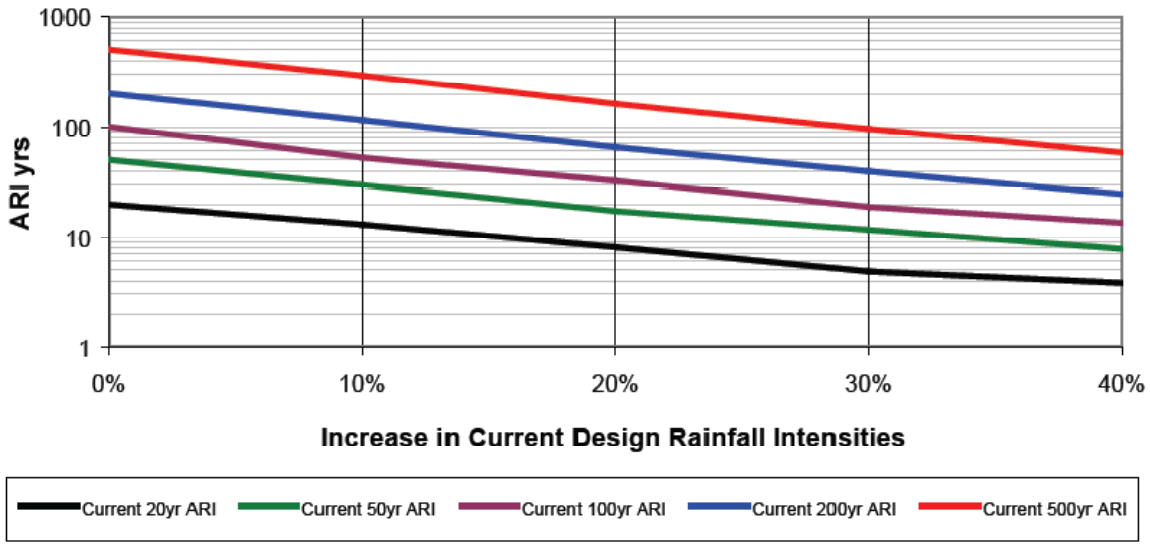
Table 5.3 – Indicative Change in Extreme Rainfall 1 Day Totals & Evaporation for 2030 & 2070

Catchment	Extreme Rainfall (40 Year 1 day rainfall total) Projected Change 2030	Extreme Rainfall (40 Year 1 day rainfall total) Projected Change 2070	Evaporation Projected Change 2030	Evaporation Projected Change 2070
Hawkesbury-Nepean	-3 to +12%	-7 to +10%	-1 to +8%	+2 to +24%
Southern Rivers	+7%	+5%	+1 to +13%	+2 to +24%
Sydney Metropolitan Catchments	-3 to +12%	-7 to +10%	+1 to +8%	+2 to +24%

Table adapted from DECC (2007). Originally sourced from CSIRO, reports prepared for the NSW Government, 2007. Climate Change in NSW Catchments Series.

The DECC Flood Risk Management guideline also describes how increases in rainfall intensities would likely result in a reclassification of design flood events, with rare events becoming more common. This is illustrated in **Figure 8** below in regard to 24-hour rainfalls.

Figure 8 – Indicative Changes in Design ARI as Rainfall Intensity Increases



(Source: Figure 1 of the DECC Oct 2007 Climate Change Guidelines)

DECC (2007) suggests a hydrological model sensitivity analysis of increased rainfall intensity and volume. The suggested increases are +10%, +20% and +30% in peak rainfall and storm volume. This is based on research done by McLuckie et al (2005). Reference to **Figure 7** infers that rainfall intensities experienced for the current climate 1% AEP event (100 year ARI) would be experienced

more frequently during the 'upper bound' (+30% increase in rainfall intensity) climate changed scenario i.e. would it would be a 5% AEP (20 year ARI) event.

In recommending the application of rainfall intensity scaling factors, the DECC guideline only refers to events of ARI between 20 and 500 years, and is silent on allowing for climate change for the Probable Maximum Precipitation (PMP). It is noted that for the PMP event, there is not the physical ability of the atmosphere to transfer sufficient increased volumes of water to achieve a 30% increase in rainfall.

Using BoM methodology (BoM, 2003):

PMP value = (S x DS + R x DR) x MAF x EAF where:

DS is the initial rainfall depth for a smooth terrain, DR is the initial depth for rain on a rough surface, R and S are areal weighted terrain factors (R + S = 1), MAF is the moisture adjustment factor and EAF is the elevation adjustment factor.

To account for increased rainfall intensity under PMP conditions, an increase in temperature of 2.5^{o}C (50th percentile best estimate for the Illawarra) has been adopted in calculation of the Moisture Adjustment Factor (MAF). Using this methodology, PMP intensities increase by approximately 15% under the climate change scenario.

Scaling factors of 20% have thus been applied in this report to rainfall intensities in calculation of peak flows for flood events up to 100 year ARI and 15% for the PMF.

5.4.4 Adopted Scenarios

The recommended values of various parameters for climate change flood risk assessment are summarised in **Table 5.3.**

Table 5.4 – Summary of Climate Change Parameters Used for Analysis

Parameter affecting flood flow calculations	Increase in parameter due to Climate Change	Comments
Rainfall intensities for design 100 year ARI flood event	+ 20%	Value recommended by DECC and commensurate with other climate change assessments on nearby developments of regional significance.
Rainfall intensities for events for PMP	+ 15%	Based on 50th percentile best estimate for temperature change in the Illawarra.
Sea / Lake Level	+ 0.91 m (high range impact)	As recommended in DECC's Oct 2007 Climate Change Guideline and the Lake Illawarra Climate Change Assessment (2009)

5.4.5 Model Results

The results of the model scenarios show that for the 1% AEP flood event, the average increase in flood levels across the existing site are approximately 300 mm. The model scenarios show that for the PMF event, the average increase in flood levels across the existing site is approximately 200 mm.

These results are consistent with other climate change impacts undertaken in neighbouring catchments at a similar catchment wide scale (Bewsher Consulting, 2008), and are thus deemed suitable for use in determining any climate change adaptive measures for the propose development.

5.4.6 Adaptive Capacity

Adaptive capacity measures suitable for a 'greenfield' site that is impacted by climate change depend on the degree of impact and typically include:

- Raising finished surface levels and/or floor levels
- The construction of levees
- Armouring of creek banks (particularly the toe of batters) where flood velocities are increased to levels likely to cause scour.

In the case of the Calderwood Project the effects of climate change are relatively minor. None of the lots are affected by ocean inundation under even the most extreme climate-change scenario. As the proposed lots can be created at any level deemed appropriate by such an assessment, the potential impacts of climate change can be readily taken into account. This is described further in the following **Section 5.5**.

5.5 Determination of Flood Planning Level

The FPDM (s.A2.2) states that:

'The 1% AEP flood event is generally used to limit flood exposure and damage to standard residential development'.

This position has recently been reinforced by the Department of Planning in its Planning Circular relating to the s.117 directions dated 31 January 2007, which indicates that"

'Unless there are exceptional circumstances, Councils should adopt the 100-year flood as the Flood Planning Level for residential development'.

The FPDM also indicates that government policy provides for (s.1.1.2):

'…… a merit based approach to selection of appropriate flood planning levels (FPLs). This recognises the need to consider the full range of flood sizes, up to and including the probable maximum flood (PMF) and the corresponding risks associated with each flood, whilst noting with few exceptions, it is neither feasible nor socially or economically justifiable to adopt the PMF as the basis for FPLs'.

The FPDM (s.K3.1) goes on to state:

Higher Flood Planning Levels (FPLs) may be necessary for aged care facilities and other types of developments with particular evacuation or emergency response issues (discussed in Section L6). Consideration should also be given to using the PMF as the FPL when siting and developing emergency response facilities such as police stations, hospitals, SES headquarters, and critical infrastructure, such as major telephone exchanges, if possible.

In summary, the advice provided in the FPDM and Section 117 directions has been used to determine the 1% AEP flood event (plus freeboard) as the FPL for Calderwood. The Section 117 direction supports this approach unless there are exceptional circumstances. We consider that exceptional flood related circumstances in NSW would be:

- Significant periods (several days) of isolation due to flooding, as occurs in the west of NSW at places such as Nyngan;
- Significant differences in flood levels between flood events of different ARI. For example, the difference between the 1% AEP flood and the PMF in the Hawkesbury River can be in excess of 10 metres;

In the Calderwood Valley, no portions of the site are isolated, and the change in flood surface level between 1% AEP and PMF flood events is approximately 1 metre. It follows that no such 'exceptional circumstances' exist within the catchment. Therefore, the 1% AEP flood level (for the climate change scenario) plus 500 mm freeboard has been adopted as the FPL for the Calderwood Project, in accordance with the FPDM and S.117 directions.

5.6 Evacuation & Isolation

Whilst it is noted that the SES did not wish to consult with DLL over their requirements for the proposed development, Cardno has worked closely the SES on recent projects involving evacuation as a key issue facing development (see Land & Environment Court Proceedings 10337 of 2006 and 11377 of 2005). From this detailed understanding of the SES's requirements for evacuation, it is noted that the SES's most recent advice with regard to evacuation is (Opper, 2008):

- Where occupants of a building are isolated by floodwaters, no new development should occur unless these occupants have effective warning times to self evacuate. SES assisted 'rescues' such as the SES evacuating occupants is extremely undesirable.
- The SES's position in both cases, with respect to isolation, was that isolation is dangerous from the moment it occurs and no duration could be considered safe.
- The SES requires that all sites must be able to be evacuated.

The SES (Opper, 2008) went on to advise that:

A basic principle of emergency management is to separate people from hazards. Given that it is rare to be able to remove the hazard, the most widely accepted method of doing so is to implement evacuation. When the option for evacuation is denied and the hazard cannot be moved then a dangerous situation remains that requires the highest level of monitoring and intervention. This will be at a time when resources are in abnormally high demand.

The SES's most current published Local Flood Plan (2003) covering the site states that:

The nature of flooding experienced in the Wollongong area is that of flash flooding so evacuations will typically be small in number and isolated but be required at very short notice… Some residents may make their own decision to evacuate and move to alternative accommodation using their own transport.

Isolation can at times be difficult to define, however the Lake Illawarra Floodplain Risk Management Committee (which consist of the SES, RTA, Council and DECCW) recently defined isolation as *flooding by more than 300 mm, for more than 24 hours*. This is the definition of isolation we have measured the proposed development against.

The proposed development allows for the above requirements of the SES to be wholly provided for. No occupants will be isolated by the 1% AEP flood event as the site has access to flood free land. All new bridge decks will be located above the 1% AEP flood level and will allow uninterrupted road traffic throughout the development (and beyond) during events up to and including the 1% AEP flood.

In many ways, there is no need for evacuation, as the development will not be isolated. However, should the SES require an evacuation to be undertaken for an unforeseeable reason, occupants of the developed site can safely wait out the short duration flood on site in flood free dwellings, or they can self evacuate at any time to nearby Calderwood town centre via a 1% AEP free road network. This surpasses the standards set for other regionally significant development proposals and neighbouring Floodplain Risk Management Committees, who comprises key agencies such as the SES and DECCW.

The most current SES local flood plan does not provide locations of designated evacuation centres, and previously the SES has advised that they are determined generally 'on the day' of an event when conditions (such as road closures, demands on personnel etc) are known. In this regard, it is entirely feasible that the new development will itself be earmarked as an evacuation centre.

5.7 Summary of Floodplain Management Outcomes

A summary of floodplain management issues has been prepared and is presented below as **Table 5.4**. This table summarises the aspects of floodplain management that are required to be addressed as part of this application. The table provides a description of the floodplain management principles espoused by the FPDM (2005), and the corresponding economic, social and environmental outcomes. The table then describes how the same principles have been employed as part of this development, and the corresponding outcomes that can be achieved.

Table 5.5 – Comparison of Floodplain Management Principles & Outcomes

Impact	Management Principles and Outcomes Proposed in the FPDM (2005)	Management Principles Adopted in the Calderwood Development	Management Outcomes Proposed for the Calderwood Development
Adjoining Land	Principles of the FPDM are that any such impacts are assessed on their merits (i.e. social, environmental and economic).	FPDM (2005) coupled by those principles adopted on other regionally significant sites	Increases in flood levels upstream and downstream need to be evaluated in the context of the economic, social and environmental benefits of the development of Calderwood. Such an assessment is a 'merit based' assessment which is promoted by the Floodplain Development Manual. Increases in flood levels have been assessed and are found to be acceptable.
Cut and Fill	Cut and fill not specifically addressed in the FPDM (2005).	FPDM (2005) coupled by those principles adopted on other regionally significant sites	Where cut and fill is proposed, detailed hydraulic modelling shows minimal off site impact on flood behaviour.

Impact	Management Principles and Outcomes Proposed in the FPDM (2005)	Management Principles Adopted in the Calderwood Development	Management Outcomes Proposed for the Calderwood Development
Climate Change	Climate Change not specifically addressed in the FPDM (2005). The FPRMS&P recognises the need to address climate change and its relationship to minimum floor levels, by setting FFL's above the climate change affected flood level.	DECC (2007) guidelines coupled by those principles adopted on other regionally significant sites	Adaptive measures are proposed which ensure that all development will be designed taking into account changing sea levels and increased rainfall intensities due to climate change.
Riparian Corridor Re-vegetation	Riparian revegetation not specifically addressed in the FPDM (2005).	Increase riparian roughness has been included in the hydraulic modelling	Riparian roughness increases lead to increased flood levels, with or without development. Such increases are generally contained within the existing riparian corridors.
Evacuation	Evacuation not specifically addressed in the FPDM (2005). Some guidance provided by Shellharbour Council's Floodplain Risk Management DCP and the SES.	FPDM (2005) coupled by those principles adopted on other regionally significant sites, as well as adopting the most recent advice from the SES	The most important aspect of this strategy is that evacuation will not be required due to rising flood waters. An overwhelming majority of the development will be located on land above the Probable Maximum Flood, and as such will not be subject to flood related planning controls or located on flood prone land. Where development cannot be located on flood free land, safe evacuation routes will be available in the 1% AEP flood event.

An overall flood mitigation plan is included as **Annexure B**. Concept engineering plans showing more detail surrounding the proposed measures are included as **Annexure D**.

6 Conclusions & Recommendations

6.1 Conclusions

This FPRMS has been prepared by Cardno to accompany a Concept Plan Application under Part 3A of the Environmental Planning & Assessment Act, 1979 (EP&A Act) in relation to the CUDP. It has been prepared in accordance with the DGRs issued by the DoP for the project.

Independent 2D modelling has been undertaken by Rienco Consulting (2009) to define the existing extent of flooding for events up to and including the Probable Maximum Flood (PMF). This modelling has indicated that in a 1% AEP flood event, Macquarie Rivulet inundates most of the low-lying land along the southern boundary of the site and Marshall Mount Creek inundates a substantial portion of the low-lying land in the northern half of the site (Rienco, 2009). In both zones of inundation, substantial secondary overland flow paths are evident, flowing at considerable depth and velocity at the peak of a 1% AEP flood. During a PMF event, increases in flood levels can be seen immediately upstream of the new Macquarie Rivulet bridge. The road itself is free from flooding in the PMF, but the land immediately upstream is affected.

This 2D hydraulic modelling was then modified to simulate the effects of the proposed development. During the 1%, there are no increases of flood levels off site due to the proposed works. Increases across the Calderwood site itself are within riparian land. There is some affectation of private property upstream of the site however, this is caused by the increased roughness of the riparian corridors, rather than the development itself.

In particular, the highly flood prone section of the Illawarra just west of Yellow Rock Creek will have a lower flood level, and decreased duration of overtopping in the 1% AEP flood event as a result of the development. Flood levels, and duration of overtopping, are key factors in road safety and the subsequent increase in road safety on the Illawarra Highway is a key benefit of the flood mitigation strategy.

Importantly, there is a significant proportion of the development site, and the surrounding areas, that will experience a decrease in flood levels due to the proposed development. Moreover, the decreases in flood levels occur outside of riparian land and within existing development, which is highly flood prone.

In the PMF event, increases in flood levels can be seen immediately upstream of the proposed Macquarie Rivulet Bridge. This affected area is predominantly rural land. It is not unreasonable to expect that for such a rare flood event, any works on the floodplain would have an impact.

The proposed Macquarie Rivulet Bridge is economically feasible, and offers real social benefits such as guaranteed access in the 1% AEP flood event to Calderwood and adjoining lands. On balance, there is no net impact on flooding in the PMF when considering triple bottom line outcomes.

The modelling and adopted Floodplain Risk Management principles and outcomes are strictly in accordance with relevant local and state government guidelines and policies. Furthermore, the impacts of climate change can be readily mitigated for the proposed development.

6.2 Recommendations

It is recommended the CUDP adopt the recommended management strategies identified in Table 5.5 for the Concept Plan and future Project Applications.

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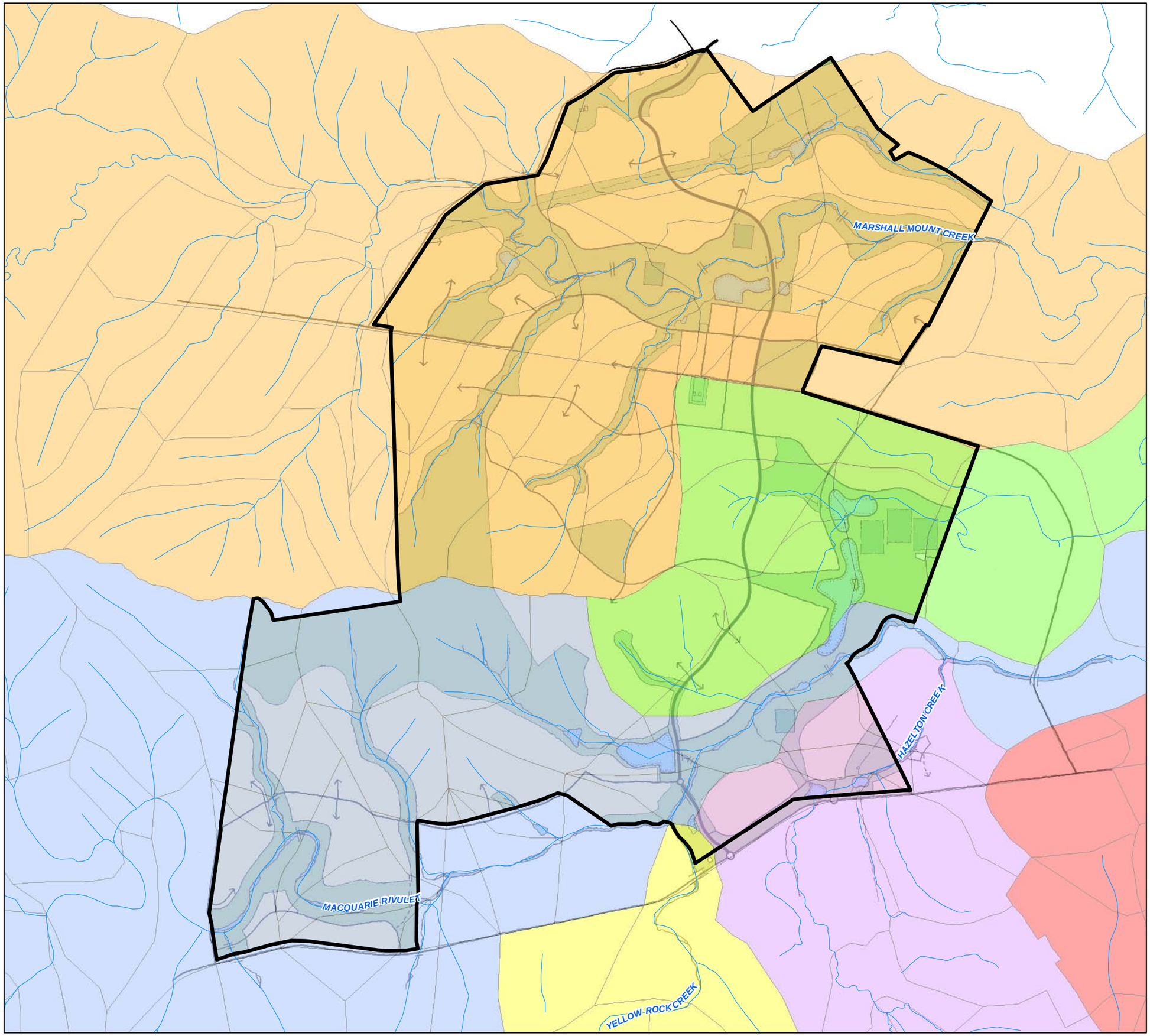
Annex A

A. Catchment Plan



Delfin
Lend Lease

TUFLOW
Catchment Boundaries

CALDERWOOD
URBAN DEVELOPMENT PROJECT

Legend

- Site Boundary

Catchment Boundaries

- Albion Park (Urban Catchment)
- Calderwood Catchment
- Hazelton Creek Catchment
- Macquarie Rivulet Catchment
- Marshall Mount Creek Catchment
- Yellow Rock Creek Catchment

N
W E
S

Scale 1:40,000 (at A3)

Metres
0 200 400 600 800 1,000

Cardno

Map Produced by Cardno Wollongong
Date: 21 January 2010
Coordinate System: Zone 56 MGA/GDA 94
GIS MAP REF: 110026-01_38046_Catchment_Boundaries.mxd 02

Concept Base Plan from Delfin Lend Lease (10/01/2010)

Annex B

B. Flood Mitigation Plan

Delfin
Lend Lease

Flood Mitigation Plan

CALDERWOOD
URBAN DEVELOPMENT PROJECT

Legend

- Site Boundary
- Proposed Bridge
- Proposed Culvert Under Road
- Floodplain Regrade - Increase Elevation
- Floodplain Regrade - Decrease Elevation
- Proposed Increased Roughness

N
W E
S

Scale 1:15,000 (at A3)

Metres
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Cardno

Map Produced by Cardno Wollongong
Date: 5 February 2010
Coordinate System: Zone 56 MGA/GDA 94
GIS MAP REF: 110026-01_38048_FloodMitigationPlan.mxd 03

Imagery supplied by AAM Hatch (2001)

Annex C

C. Hydraulic Model Results