





# Calderwood Urban Development Project

## Section 75W Application

## Water Cycle and Flood Management Strategy Updates

# Post-Exhibition Report

## Lendlease

**April 2019**

SUSTAINABLE CERTIFICATION
ISO9001:2008
AS/NZS 4801:2001
ISO 14001:2004
Endorsed
Integrated Management System

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS

# Document Control

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# 1 GLOSSARY

**12D Model** is a powerful terrain modelling, surveying and civil engineering software package used to develop the underlying surface for the 2D modelling.

**Airborne Laser Survey (ALS)** is a technique for obtaining a definition of the surface elevation (ground, buildings, power lines, trees, etc.) by pulsing a laser beam at the ground from an airborne vehicle (generally a plane) and measuring the time taken for the laser beam to return to a scanning device fixed to the plane. The time taken is a measure of the distance which, when ground truthed, is generally accurate to + 150mm.

**Annual Exceedance Probability (AEP)** is the chance or probability of a natural hazard event (usually a rainfall or flooding event) occurring annually and is usually expressed as a percentage.

**Average Recurrence Interval (ARI)** means the average statistical interval (in years) between occurrences of floods, storms and flows of a particular magnitude.

**Australian Rainfall and Runoff (AR&R)** refers to the current edition of Australian Rainfall and Runoff published by the Institution of Engineers, Australia.

**Digital Terrain Model (DTM)** is a spatially referenced three-dimensional (3D) representation of the ground surface represented as discrete point elevations where each cell in the grid represents an elevation above an established datum.

**Exceedances per Year (EY)** is the number of times a year that statistically a storm flow will be exceeded.

**Flood Planning Level (FPL)** the FPL is a height used to set floor levels for property development in flood prone areas. It is generally defined as the 1% AEP flood level plus 0.5m freeboard

**Floodplain Development Manual (FDM) and Guidelines (April 2005),** the FDM is a document issued by DECCW that provides a strategic approach to floodplain management. The guidelines have been issued by the NSW DoP to clarify issues regarding the setting of FPL's.

**Floodplain Storage Areas** are those parts of a floodplain that are important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.

**Floodway** is the areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.

**Hyetograph** is the distribution of rainfall over time.

**Hydrograph** is a graph that shows how the stormwater discharge changes with time at any particular location.

**Hydrology** The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.

**J. Wyndham Prince Pty Ltd (JWP)** Consulting Civil Infrastructure Engineers and Project Managers undertaking these investigations

**MUSIC** is a modelling package designed to help urban stormwater professionals visualise possible strategies to tackle urban stormwater hydrology and pollution impacts. MUSIC stands for Model for Urban Stormwater Improvement Conceptualisation and has been developed by Cooperative Research Centre (CRC),

**Peak Discharge** is the maximum stormwater runoff that occurs during a flood event

**Probable Maximum Flood (PMF)** is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation coupled with the worst flood producing catchment conditions.

**Probable Maximum Precipitation (PMP)** is the greatest amount of precipitation for a given duration meteorologically possible for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends."

**SEARs** Secretary's Environmental Assessment Requirements

**Triangular Irregular Network (TIN)** is a technique used in the created DTM by developing a mass of interconnected triangles. For each triangle, the ground level is defined at each of the three vertices, thereby defining a plane surface over the area of the triangle

**TUFLOW** is a computer program that provides two-dimensional (2D) and one dimensional (1D) solutions of the free surface flow equations to simulate flood and tidal wave propagation. It is specifically beneficial where the hydrodynamic behaviour, estuaries, rivers, floodplains and urban drainage environments have complex 2D flow patterns that would be awkward to represent using traditional 1D network models.

**WSUD** Water Sensitive Urban Design

**XP-RAFTS** runoff routing model that uses the Laurenson non-linear runoff routing procedure to develop a sub catchment stormwater runoff hydrograph from either an actual event (recorded rainfall time series) or a design storm utilising Intensity-Frequency-Duration data together with dimensionless storm temporal patterns as well as standard AR&R 1987 data.

## 2 EXECUTIVE SUMMARY

This Post Exhibition report is an update to the Water Cycle and Flood Management Strategy previously prepared to support the Section 75W Modification (MOD4) to the 2010 Calderwood Concept Plan Approval (MP09_0082) for the Calderwood Urban Development Project (CUDP). This modification is sought to the Approved Concept Plan to allow for increased and more diverse housing supply at the Calderwood Urban Development Project. The application looks to increase the total number of dwellings within CUDP from approximately 4800 to approximately 6000.

The primary objective of this report is to prepare an updated Water Cycle and Flood Management Strategy to support the MOD4.

Further to the public exhibition by the NSW Department of Planning and Environment (DPE) of the MOD4 to the approved Concept Plan for CUDP in October 2018, a number of public and agency submissions have been received in relation to the proposed modification. A large portion of the submission raised concerns with J. Wyndham Prince's Section 75W Water Cycle Flood Management Strategy Update Report (JWP, July 2018) that supported this application.

This report also addresses key issues 8d and 11 from the Secretary's Environmental Assessment Requirements (SEARs), issued on the 1st February 2018. From a water cycle management perspective, the impact of increased lot density will influence both the water quality and flooding within CUDP. This report provides details of and assesses the proposed amendments to, both water quality and flood management schemes to ensure impacts to the adjoining watercourse are consistent with current policy and flood impacts are comparable to the original 2010 WCFM (Cardno, 2010) approved as part of the original concept plan approved.

Details of the specific SEARS that have been addressed and provided in Table 2.1 below, so that compliance with appropriate water management standards is achieved.

**Table 2-1 – SEARs Requirements**

| SEARs Requirements | Strategy Response |
|---|---|
| **8: Riparian Impacts (d)** | |
| Include details of how the NSW Water Quality and River Flow objectives within the receiving waters of Lake Illawarra will be achieved during the future construction and operational phases of the development. | Given that there are no specific water quality or river flow objectives currently established for the Lake Illawarra, the water quality management for CUDP will be consistent with the documented water quality objectives for both Wollongong City and Shellharbour City Council's, i.e. traditional water quality treatment that delivers post-development flows that achieved an 85% reduction in Total Suspended Solid (TSS), 60% reduction in Total Phosphorous (TP) and 45 % reduction in Total Nitrogen (TN).<br>The water quality management scheme for CUDP also considers the Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions. The proposed water quality treatment system exceeds the minimum load reduction targets required to 'maintain or improve' the health of Lake Illawarra. Section 7 of the report details the water quality assessment completed to support the modification |

| **11: Drainage, Water Quality and Flooding** | |
|---|---|
| Provide an updated assessment of the potential flood risks associated with the proposal in accordance with the NSW Floodplain Development Manual (2005) and consider any new/updated flood studies for the catchment/s and the potential impacts of climate change. | A detailed flood assessment has been undertaken using the latest flood study information from Shellharbour City Council. The assessment has considered the increase in development density and has concluded that comparable flood impacts to that which supported the 2010 concept plan approval and consequent development applications.<br><br>The latest TUFLOW model for the Macquarie Rivulet (WMA Water 2017) has been used for the purposes of this assessment.<br>An assessment of flood impacts for climate change has also been carried out to demonstrate acceptable flood outcomes.<br>Details of the assessment undertaken are provided in Section 8 of this report. |
| Provide a revised Water Cycle Management Study which identifies the impacts of the proposed modification and how water quality and quantity impacts on the drainage system and natural waterways will be managed both internally and externally to the site | The revised Water Cycle and Flood Management study (this report) proposes a treatment train of WSUD elements to manage water quality including on lot controls, gross pollutant traps, wetlands, swales and raingardens, consistent with the concept plan approval and subsequent development applications.<br><br>This system achieves the required water quality objectives. It has been modelled using MUSIC to confirm system performance. Details of the proposed Water Cycle Management system are provided in Section 6 and 7 of this report.<br><br>Detention is not needed to reduce impacts downstream of CUDP as peak discharge flows have not unmanageably increased as a result of the development. Refer to Section 8 of this report for discussion. |

## 2.1 Water Quality

The proposed increase in lot yield from 4,800 to approximately 6,000 will result in an increase in development density. This increase in turn, will increase the pollutant loads generated from the new housing. The necessary changes to the treatment solution to ensure the water quality objectives listed in the original concept plan will be achieved by an increase in the treatment device sizing. This proposed increase device size will ensure the water quality objectives of the original concept plan are maintained.

The amended Water Quality Management Strategy consists of a treatment train including on lot treatment, street level treatment and subdivision/development treatment measures. The structural elements proposed for CUDP consist of:

- Proprietary GPT units at each stormwater discharge point.
- 28 wetlands, or other suitable alternative treatment device scattered across the development ranging in size from 500m$^2$ to 14,000m$^2$.

The treatment system delivers industry best practice water quality result and maintains or improves the water quality discharge to the Macquarie Rivulet and Marshall Mount Creek.

## 2.2 Flooding

Flooding and flood evacuation are also major considerations for CUDP. The current developable footprint will be maintained with the increase in lot density delivered by a change to the housing typology (i.e. small lots) and an increase in density surrounding the Town Centre. Therefore, runoff characteristics from the increased density will have minimal impact on flood affectation in both the Macquarie Rivulet and Marshall Mount Creek, the two major watercourses within the CUDP will be unchanged from the acceptable flood impacts presenting the original CUDP Concept Plan Approval. These impacts will be managed as part of the ongoing development of CUDP.

As part of the S75W assessment, the adopted flood model from Shellharbour City Council (SHCC) has been used in order to establish the updated 'existing' conditions. It is noted that Shellharbour City Council's (SHCC) 2017 flood model did not allow for the CUDP thus a new 'base' condition which includes all approved development has also been determined.

The investigation concludes that the development of CUDP in accordance with this strategy will be consistent with the applicable controls and principles established by the NSW Government and both Shellharbour City Council and Wollongong City Council. The revised water cycle and flood management strategy remains consistent in philosophy with the original 2010 concept approval.

This report provides the basis for detailed design and development of the site to ensure that the environment, urban amenity, engineering and economic objectives for stormwater management can be achieved.

The report supports the proposed amendments to CUDP and provides the framework with which to support the ongoing development from a water cycle and flooding management perspective.

Yours faithfully

**J. WYNDHAM PRINCE**

**DAVID CROMPTON**

Manager - Stormwater and Environment

# 3 INTRODUCTION

Lendlease has engaged J. Wyndham Prince Pty Ltd to prepare a Water Cycle and Flood Management Strategy report for the CUDP.

This Water Cycle and Flood Management Strategy (WCFMS) is to support the proposed S75W Modification (MOD4) Application to the Calderwood Concept Plan Approval (MP09_0082) (Approved Concept Plan) for the Calderwood Urban Development Project (CUDP).

A modification is sought to the Approved Concept Plan to allow for increased and more diverse housing supply at the CUDP site. The increase in housing supply is proposed to ensure that the existing area of residential zoned land at CUDP is efficiently used for the continued supply of a range of housing types and sizes that both meets market demand and will assist address housing affordability pressures in the Illawarra region.

## 3.1 Site Description

The CUDP site is located within the Calderwood Valley in the Illawarra Region. It is approximately 700 hectares in area with approximately 107 hectares of land in the Wollongong LGA (15%) and the balance in the Shellharbour LGA (85%). An aerial photograph of the site is provided in Plate 3-1 below.

The CUDP site is bound to the north by Marshall Mount Creek (which forms the boundary between the Shellharbour and Wollongong LGAs), to the south by the Macquarie Rivulet, to the south-west by Johnston's Spur and to the west by the Illawarra Escarpment. Beyond Johnston's Spur to the south is the adjoining Macquarie Rivulet Valley within the locality of North Macquarie. The CUDP site extends south from the intersection of North Marshall Mount Road and Marshall Mount Road to the Illawarra Highway.

There are a number of 'non-core' landowners within CUDP that Lendlease (LL) will not be developing (refer Plate 3-1 for their location). The development in these non-core lands will remain consistent with the current application and the understanding of the development layouts. The approved concept plan from the 2010 approval is provided in Plate 3-2.

Lendlease has commenced the development of its component of the overall CUDP and will continue to develop the project in stages over an approximately 15+ year period. To date, Lendlease has obtained development consents for some 1,250 dwellings within Stages 1, 2C, 2B and 2C, 3A and 3B South, and lodged development applications for another 480 dwellings of the overall project. Other developers have also lodged development applications for a further 824 lots on land within the Concept Plan boundary that Lendlease does not own or control.


**Plate 3-1 –The Site**
*Source: Lendlease Communities*

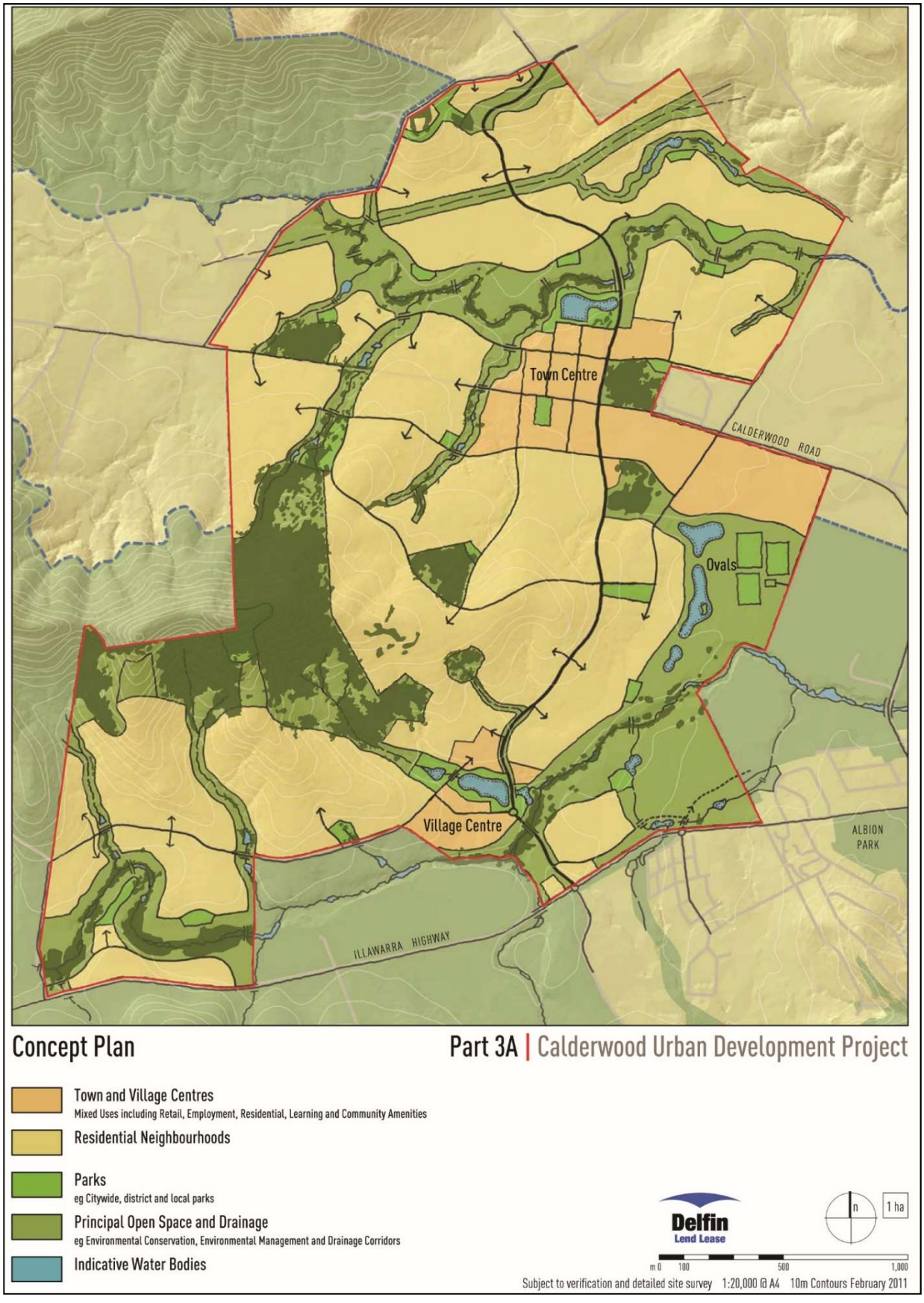



**Plate 3-2 –Approved Calderwood Concept Plan 2010**
*Source: Lendlease Communities*

# Legend

- Site Boundary
- Stage Boundary
- General Residential
- General Residential Town Centre Proximity
- Town Centre and Village Centre Residential
- Town Centre and Village Centre Mixed Use
- Slope Sensitive General Residential
- School
- Heritage
- Environment Conservation - Riparian
- Environment Conservation - Bushland
- Open Space Passive
- Open Space Active
- Open Space Connection
- Drainage
- Major Roads (Escarpment Drive and Calderwood Road)
- Minor Roads
- Electricity Easement
- Infrastructure
- Rural
- Non-Core Lands
- Existing Landholders
- 400m Walkable Catchment
- 800m Walkable Catchment

ROAD
MOUNT
MARSHALL
CALDERWOOD ROAD
HWY
ILLAWARRA
Marshall Mount House
Stage 10
Stage 11
Stage 12
Stage 8
Stage 9
Sports Fields
Stage 7B
Marshall Mount Creek
Stage 7A
Stage 4
Town Centre Residential North
Town Centre
2.0 ha
Stage 7C
Calderwood Road
400m
800m
3.0 ha
6.0 ha
Town Centre Residential South
Leussink
459 dwellings
Stage 3A
Town Centre Residential East
Stage 2B
Stage 2C
Sports Fields
Johnstons Spur
Stage 3B north
Stage 2A
Blissett
142 dwellings
Stage 1D
Stage 3B south
Stage 1C
Stage 5 north
Stage 3C north
Stage 3C south
Stage 5 south
Stage 6
Village Centre
Stage 1B
Stage 1A
Stage 1B
Fischl
262 dwellin

**Source Information:**
**Site boundaries:** Lendlease.
**Allotment Layout:** Lendlease.
**Yield / Dwellings:** Lendlease
**Aerial photography:** Nearmap

Calderwood Valley

**PLAN REF:** 133413 – 85F
**DATE:** 22 MAY 2019
**CLIENT:** Lendlease
**DRAWN BY:** MD/FK/WNW
**CHECKED BY:** PHE/SB

0 60 120 180 240 300 1 : 6,000 @ A1

# CALDERWOOD VALLEY
## Indicative Subdivision Development Pattern

**URBAN DESIGN**
Level 4 HQ South
520 Wickham Street
PO Box 1559
Fortitude Valley QLD 4006
**T** +61 7 3539 9500
**W** rpsgroup.com

## 3.2 Proposed Concept Plan Modification

The proposed modification to the Approved Concept Plan seeks to increase the total provision of housing (approximate number of dwellings) within the overall CUDP to respond to market demand for the provision of smaller housing types / lot sizes at affordable price points and to ensure the efficient use of urban zoned land within this context for the supply of housing.

It is proposed to increase the overall number of dwellings to be delivered within the existing area of land zoned R1 General Residential and B4 Mixed Use and also approved for urban development as shown on the Approved Concept Plan from approximately 4,800 to approximately 6,000 dwellings.

The increased residential yield is predominantly due to affordability pressures that are driving stronger demand for smaller and more diverse housing types. Those stages of development already approved at Calderwood include a more diverse mix of housing types and lot sizes than was supported by the market at the time the Concept Plan which was approved in 2010, both in the Lendlease holdings and those developments in non-core land being progressed by others.

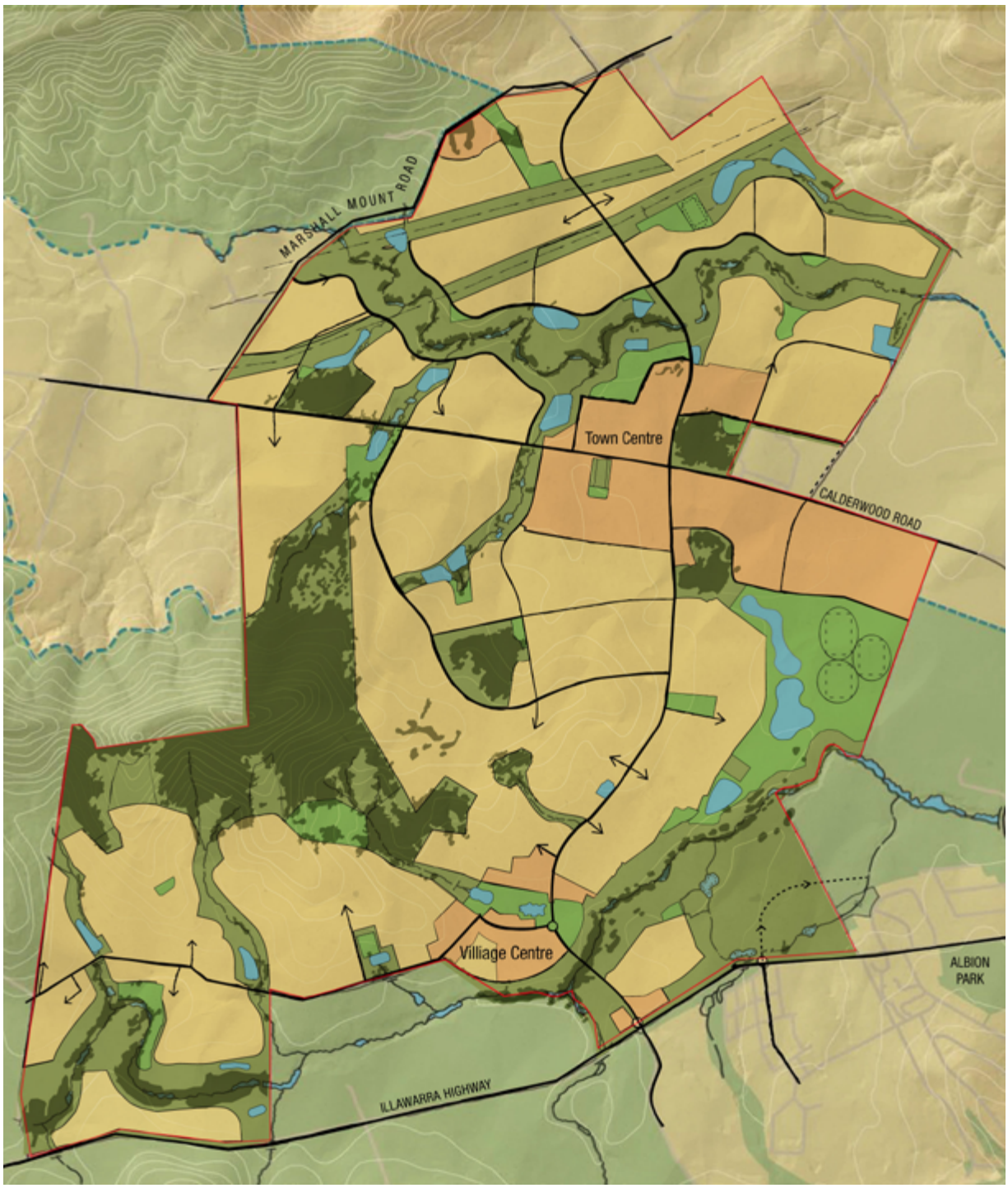
Within the Approved Concept Plan framework, the proposed increased dwelling yield will be achieved via the delivery of a greater diversity of dwelling types and lot sizes within the R1 General Residential and B4 Mixed Use zones generally as follows:

- Within the R1 General Residential zone, additional yields will be achieved through the delivery of a more diverse range of housing types such as seniors housing and integrated housing and also by a different mix of lot sizes than was anticipated at the time of the Approved Concept Plan in 2010 (including a greater number of smaller lots). This change is in response to the changing and more diverse market expectations and housing affordability pressures;
- Within the B4 Mixed Use zone, the number of dwellings to be provided will be increased through the provision of a combination of more shop top housing, mixed use development and stand-alone residential development.

A range of new provisions are proposed to be incorporated into the Development Control Strategy to allow for the broader range of housing typologies, lot sizes and affordable housing options that are proposed to meet current market demand.

Further detail of the statutory framework in which the Concept Plan will be amended will be provided separately to this report.

The proposed modified Concept Plan is shown on Plate 3-4.




Concept Plan (MOD 4 PPR)

**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**

lendlease

n

1 ha

0 100 500 1000m

Subject to verification and detailed site survey 1:20,000 @ A4 10m Contours May 2019

# 4 RELEVANT PREVIOUS DOCUMENTS

A series of reports were reviewed to inform this assessment. Provided below are details of the relevant documents.

## 4.1 Original Concept Plan

### *4.1.1 Flood Modelling report – Macquarie Rivulet below Sunnybank, Rienco Consulting (2009)*

Rienco Consulting was commissioned by Lendlease to investigate existing flood conditions in the lower reaches of the Macquarie Rivulet in order to quantify flood behaviour associated with the CUDP.

A hydrologic model (WBNM) of the Macquarie Rivulet was established in conjunction with a hydraulic model (TUFLOW) spanning from downstream of the Albion Park Gauge to the outlet of the Macquarie Rivulet into Lake Illawarra. The hydrologic model was calibrated to June 1991 flow hydrographs at the Albion Park and Princes Highway gauges on the Macquarie Rivulet. Hydraulic modelling of the study area was undertaken using a 7 x 6 km TUFLOW domain based on a 10 m cell size. Again, calibration of the hydraulic model was based on the June 1991 event due to the availability of data.

The report provided the following information for the 1% AEP (100 year ARI) and PMF events:

- Peak flood levels,
- Velocities and
- Flood hazard categories (Velocity x Depth)

This modelling determined 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. 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."* (Rienco, 2009).

### *4.1.2 Floodplain Risk Management Study, Cardno (March 2011)*

Cardno was commissioned by Lendlease to prepare a Floodplain Risk Management Study (FPRMS) to accompany the original Concept Plan Application for the CUDP. The Reinco Flood model was used to inform these assessments.

The 2D hydraulic modelling (TUFLOW) was then modified to simulate the effects of the proposed development. This included the following changes:

- The DTM has been modified to reflect the developed surface. However, this surface was represented by "vertical walls" where there was limited consideration given to the shape of the future development pad.
- Consideration of the appropriate roughness in all riparian corridors has been included in the assessment, and the TUFLOW manning's has been adjusted to account for this.
- The proposed Macquarie Rivulet bridge was modelled as part of this assessment.
- The hydrological input to this assessment remains unchanged from the original Reinco assessment.

This study was approved under the Concept Plan Approval (CCP JBA, March 2011) and was accepted by the Land and Environment Court (LEC, 2013) as the basis for the current Concept Plan and how the water cycle is to be managed.

## 4.2 Macquarie Rivulet Flood Study (WMAWater 2017)

The Macquarie Rivulet Flood Model provided by Shellharbour City Council was used as the basis for both the hydrologic and hydraulic modelling for this MOD4 assessment. The Macquarie Rivulet Flood Study report (WMAwater, 2017) outlines the approach taken in this model, which is summarised below:

A hydrologic (WBNM, Watershed Bounded Network Model) model was established for the catchment to determine inflows into the hydrodynamic model. Stream gauge data was available within the catchment with a period of record of 63 years thus enabling the use of a flood frequency approach for the estimation of design flows in an appropriate range. The results of the flood frequency analysis were used to calibrate results from the hydrologic models. WBNM parameters (such as loss and stream routing) were adjusted where appropriate to reconcile the WBNM flows against the results of the flood frequency analysis. A factor of 86% was applied to the AR&R87 rainfall data to allow flows to reconcile with the flood frequency analysis.

A combined one and two-dimensional hydrodynamic (TUFLOW) model was used to define the flooding behaviour using ALS, bathymetric and structure survey. The hydrologic and hydraulic models were calibrated to a range of historical events and then used to assess the flood levels and hydraulic hazard for a range of design events.

## 4.3 Public Exhibition Submissions

Further to the public exhibition by the NSW Department of Planning and Environment (DPE) of the Section75W Modification (MOD4) to the approved Concept Plan for the Calderwood Urban Development Project (CUDP) in October 2018, a number of public and agency submissions were received in relation to the proposed modification and J. Wyndham Prince's Water Cycle and Flood Management Strategy Update Report (JWP, July 2018).

A detailed letter was prepared by J. Wyndham Prince (Feb 2019) to address all major issues raised associated with the Water Cycle and Flood Management Strategy Report (WCFM) with specific attention to the following submissions:

- Wollongong City Council
- Shellharbour City Council
- Department of Industry (Lands and Water Division)
- Office of Environment and Heritage
- NSW Environment Protection Authority, Wollongong
- Department of Planning & Environment

The letter has addressed issues raised in relation to the potential flooding impacts associated with the proposal and that the proposal would not result in additional flooding impacts other than the approved impacts in the Concept Plan Approval.

Furthermore, the letter addresses issues raised in relation to Riparian Impacts and Water Quality and demonstrates that the proposal is consistent with the Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions as well Council requirements. Appendix A includes this letter response.

## 4.4 Development Guidelines

The following Documents have been read and reviewed and have formed the basis for the decision making behind this report

- NSW State Rivers and Estuaries Policy
- Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions 2017
- Lake Illawarra Floodplain Risk Management Study and Plan 2012
- Wollongong City Council Development Control Plans
- Shellharbour City Council Development Control Plans

## 5 SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

The NSW Department of Planning and Environment issued a set of Secretary's Environmental Assessment Requirements (SEARs) in order to approve the modification to the Concept plan.

SEARs were issued by the NSW Department of Planning and Environment on the 1st February 2018. The requirements that relate to CUDP that are addressed in this report are key issues 8d and 11. Each requirement and the associated strategy response are summarised below in Table 5-1.

**Table 5-1 – SEARs Requirements.**

| SEARs Requirements | Strategy Response |
|---|---|
| **8: Riparian Impacts (d)** | |
| Include details of how the NSW Water Quality and River Flow objectives within the receiving waters of Lake Illawarra will be achieved during the future construction and operational phases of the development. | Given that there are no specific water quality or river flow objectives currently established for the Lake Illawarra, the water quality management for CUDP will be consistent with the documented water quality objectives for both Wollongong City and Shellharbour City Council's, i.e. traditional water quality treatment that delivers post-development flows that achieved an 85% reduction in Total Suspended Solid (TSS), 60% reduction in Total Phosphorous (TP) and 45 % reduction in Total Nitrogen (TN).<br>The water quality management scheme for CUDP also considers the Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions. The proposed water quality treatment system exceeds the minimum load reduction targets required to 'maintain or improve' the health of Lake Illawarra. Section 7 of the report details the water quality assessment completed to support the modification. |
| **9: Drainage, Water Quality and Flooding** | |
| Provide an updated assessment of the potential flood risks associated with the proposal in accordance with the NSW Floodplain Development Manual (2005) and consider any new/updated flood studies for the catchment/s and the potential impacts of climate change. | A detailed flood assessment has been undertaken using the latest flood study information from Shellharbour City Council. The assessment has considered the increase in development density and has concluded that comparable flood impacts to that which supported the 2010 concept plan approval and consequent development applications.<br><br>The latest TUFLOW model for the Macquarie Rivulet (WMA Water 2017) has been used for the purposes of this assessment.<br>An assessment of flood impacts for climate change has also been carried out to demonstrate acceptable flood outcomes.<br>Details of the assessment undertaken are provided in Section 8 of this report. |

| SEARs Requirements | Strategy Response |
|---|---|
| Provide a revised Water Cycle Management Study which identifies the impacts of the proposed modification and how water quality and quantity impacts on the drainage system and natural waterways will be managed both internally and externally to the site | The revised Water Cycle and Flood Management study (this report) proposes a treatment train of WSUD elements to manage water quality including on lot controls, gross pollutant traps, wetlands, swales and raingardens, consistent with the concept plan approval and subsequent development applications.<br><br>This system achieves the required water quality objectives. It has been modelled using MUSIC to confirm system performance. Details of the proposed Water Cycle Management system are provided in Section 6 and 7 of this report.<br><br>Detention is not needed to reduce impacts downstream of CUDP as peak discharge flows have not unmanageably increased as a result of the development. Refer to Section 8 of this report for discussion. |

Consultation with a series of government authorities was undertaken at the early stage of this investigation. The Environmental Protection Authority (EPA) has provided comments that directly relate to the Water Cycle and Flood Management update. Details of the comments from the EPA are provided in

Table 5-2.

**Table 5-2 – EPA Recommendations for water quality**

| EPA Recommendations | Strategy Response |
|---|---|
| Provide an assessment of any potential impacts of the proposal on the hydrology and hydrogeology in accordance with the OEH/EPA Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions'. Include particular focus on water quality, the extent to which development protects, maintains or restores water health and the community's environmental values and use of waterways also known as the NSW Water Quality Objectives for Lake Illawarra and its supporting catchment. | The OEH/EPA Risk based framework establishes the recommended process for establishing high level goals for water quality and river flow objectives and establishing a framework for how these will be applied in a particular catchment. This guideline indicates that "*the framework is best implemented at the catchment and sub catchment scale by an overall managing authority such as a council or regional or state agency*."<br><br>This Risk based framework was considered for the CUDP and the proposed water quality treatment system proposed exceeds the minimum load reduction targets required to 'maintain' the health of Lake Illawarra. See Section 7 for details.<br><br>The hydrology and water quality solutions proposed and approved for the CUDP were based on compliance with Council, and industry standard objectives that are still relevant in other controls. The modification being sought associated with MOD to the Concept Approval is minor in terms of impacts on water quality and flows, and this study demonstrates that the current planning objectives for these are maintained. |

| EPA Recommendations | Strategy Response |
|---|---|
| A Soil and Water Management Plan should be prepared in accordance with the Managing urban stormwater: soils and construction, vol. 1 (Landcom 2004) and vol. 2 (A. Installation of services; B Waste landfills; C. Unsealed roads; D. Main Roads; E. Mines and quarries) (DECC 2008). | A Soil and Water Management Plan will be provided for all stages of the development as part of the development application submissions. |
| Provide a concept Stormwater Management Plan outlining the general stormwater. | An updated Stormwater Management Plan for the CUDP is provided in Sections 6 and 7. |
| Management measures for the proposal, including the use of sustainability measures such as Water Sensitive Urban Design (WSUD) to create more resilient and adaptable urban environments. This should also include measures for ongoing maintenance including any associated funding approaches for ongoing management. | Details of the proposed Water Cycle Management system, which incorporates WSUD elements are provided in Section 6 and 7 of this report. Maintenance of these facilities will be undertaken by the relevant local Council (public assets) or the property owner (private assets) and involves established maintenance practices. Operation and maintenance plans for the WSUD elements can be developed in support of future development applications. |
| Outline opportunities for the use of integrated water cycle management practices and principles to optimise opportunities for sustainable water supply, wastewater and stormwater management across the development. | The water cycle management strategy proposes the use of on lot rainwater tanks, bioretention systems, traditional floating wetlands and other water quality treatment solutions to provide best practice stormwater management solutions that maximise reuse opportunities. Water supply and wastewater services on the CUDP are provided by Sydney Water Corporation using conventional and proven solutions.<br><br>Details of the proposed Water Cycle Management system are provided in Section 6 and 7 of this report. |
| Provide details of sewage management and an assessment of any potential impacts on the community's uses and environmental values of waterways and public health. | The sewage system will be provided consistent with that which exists across the CUDP and all waterway health is considered as part of the ongoing approval of the sewage management system. The design of this system will ensure that surcharges of effluent to the local waterways is in accordance with the authorities' own guidelines. |

# 6 WATER QUALITY MANAGEMENT OPTIONS

The Water Cycle Management Strategy proposed for the CUDP has been prepared with consideration of the statutory requirements and guidelines listed by the various local government authority. The strategy focuses on mitigating the impacts of the development on the total water cycle and maximising the environmental, social and economic benefits achievable by utilising responsible and sustainable stormwater management practices.

## 6.1 Potential Water Sensitive Urban Design Measures

A critical consideration for the Water Cycle and Flood Management strategy is the long term ecological sustainability of the development and both Marshall Mount Creek and Macquarie Rivulet corridors. To maintain stormwater quality at the required levels, a 'treatment train' approach is proposed where various types of pollutants are removed by a number of devices acting in series.

A range of water sensitive urban design measures may be adopted as part of the proposed development for the management of stormwater runoff. Each of these management measures was evaluated and compared with consideration of a range of environmental, social/amenity, economic, maintenance and engineering criteria. Additional information on these devices is provided in Appendix B.

The devices proposed for the CUDP are as follows:

- **Wetlands** are the preferred option to provide "end of line" treatment prior to discharge to Marshall Mount Creek and Macquarie Rivulet. They will enhance the natural elements of the site and provide an attractive solution.

- **Floating Wetlands** are considered as an alternative to traditional wetlands. Floating wetlands consist of a suspended matrix within a waterbody planted with wetland plants.

- **Bio-retention "raingardens"** are proposed as a viable alternative to Wetlands within the overall Water Cycle Management Strategy for the CUDP where they will provide "end of line" treatment prior to discharge to the Macquarie Rivulet or Marshall Mount Creek and minimise land take.

- **Vegetated Swales** are proposed as a supplement for other devices, as they provide an effective means of removing pollutants, particularly Total Suspended Solids (TSS) while minimising land take. They are suggested as a secondary treatment mechanism within the CUDP.

- **Ponds** are proposed to provide additional pollutant removal as well as to provide an attractive focal design point for the development.

- **Gross Pollutant Traps** are effective in removing gross pollutants from stormwater runoff generated from large urbanised catchments. They provide a single point of maintenance, which is beneficial to the long-term viability and cost effectiveness of the water quality treatment system.

# 7 PROPOSED WATER CYCLE MANAGEMENT STRATEGY

## 7.1 Previous Water Cycle Management Study

This post exhibition assessment which builds upon the July 2018 (JWP 2018) assessment analyses the implications of an increase in the proposed lot yield on water quality management across CUDP.

Part A of the Determination for the 2010 Concept Plan Approval states that the development shall be in accordance with the "Preferred Project Report" by JBA. Appendix L of the JBA report illustrates the approved Water Cycle Management Plan. This plan includes 31 water bodies across CUDP to deliver the water quality needs for CUDP, See Plate 7-1 on the next page for details on the original water management device locations.

The overall inputs and parameters use in this post exhibition assessment have not been significantly changed from those used in the original WCMS Strategy (JBA, 2010). Notwithstanding, minor modifications have been made in this assessment to cater for the increased yield planned.

There has also been some refinement of catchments in the northern parts of CUDP which drain to Marshall Mount Creek. The majority of the proposed increase in density takes place in this northern portion of CUDP, which will primarily impact on Marshall Mount Creek. To cater for the increase in lot density, catchments in the north have been split into smaller catchments to better assess individual treatment devices.

It is important to note that as part of this assessment, the proposed online and offline water quality basin treatment device locations are consistent with the original approved locations. The current assessment proposes a total of 28 stormwater treatment devices across the CUDP, which is a decrease from 31 devices. already approved as part of the Original Concept Plan.

Plate7-2 documents the locations of the proposed/approved water devices for each stage of CUDP.

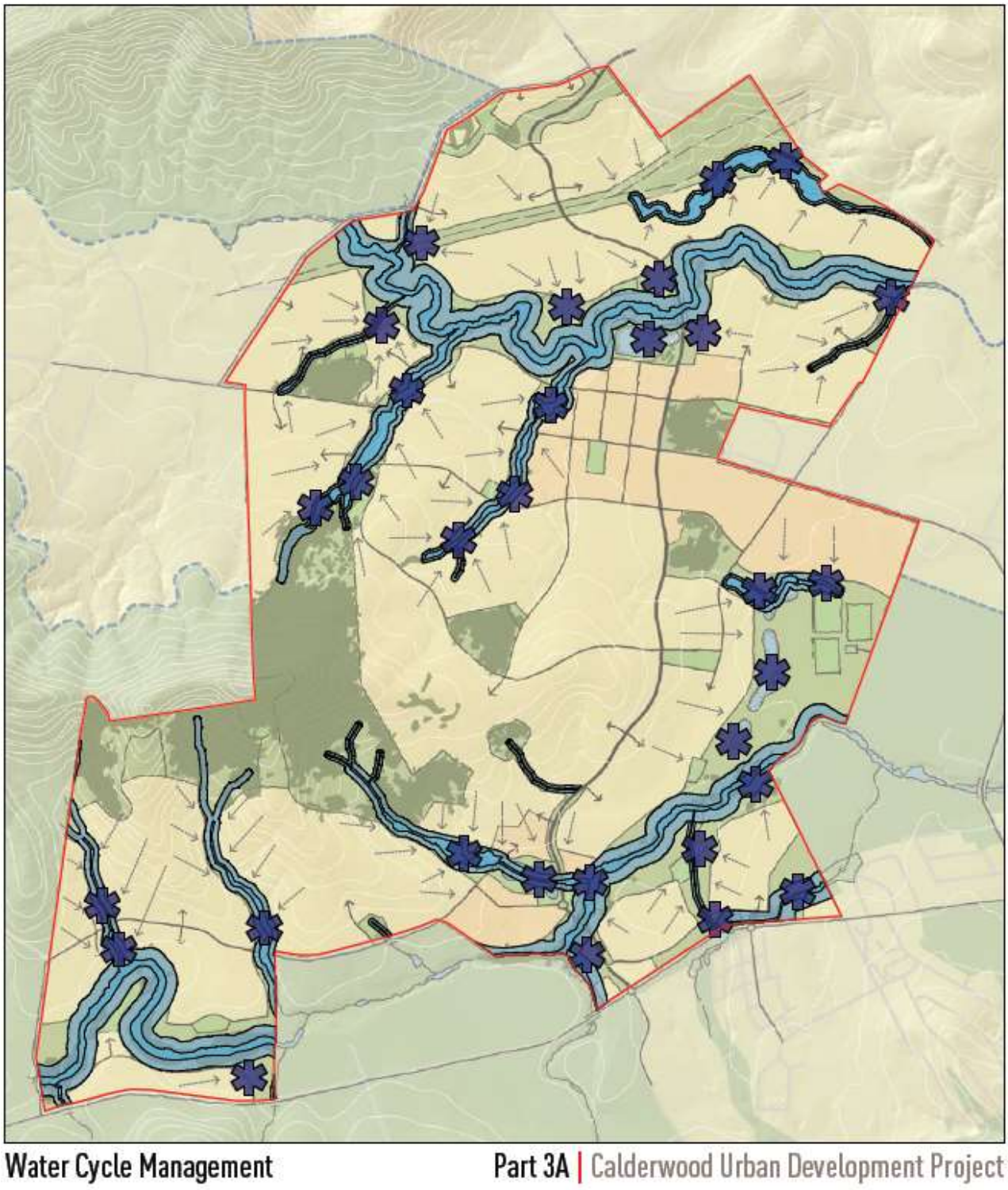



**Plate 7-1 – Original Water Cycle Device Locations**
*Source: Consolidated Concept Plan, Figure 15 (JBA March 2011)*

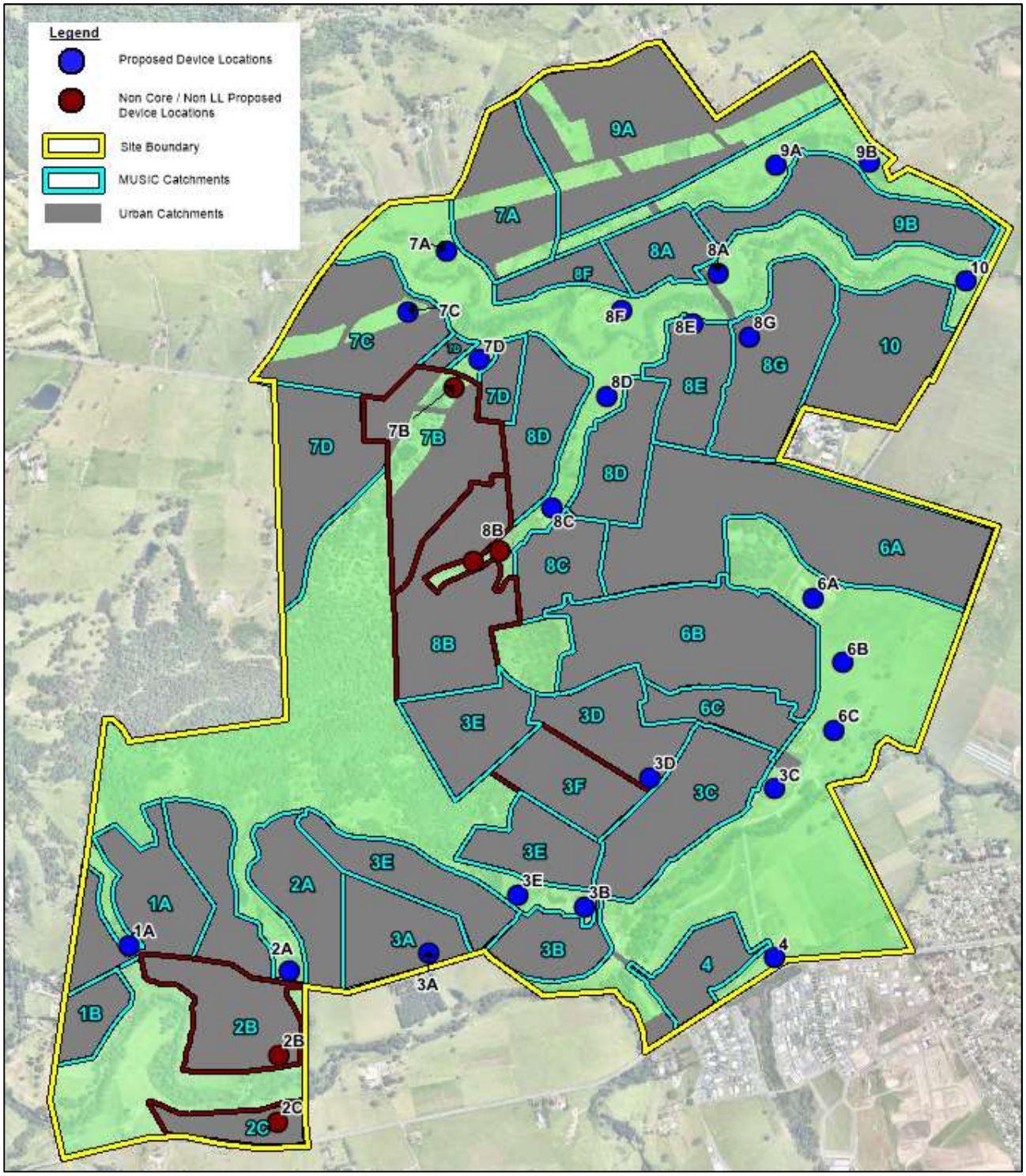



**Plate 7-2 – Proposed Device Locations**

## 7.2 Modifications to the Water Quality Strategy

Since the development of the approved Concept Plan, a number of stages have been delivered across CUDP. Cardno was commissioned by Lendlease to prepare Water Cycle Management Study (WCMS) for the development applications for Stage 1, Stage 2, Stage 2C and Stages 3B South & 3A. Arcadis was commissioned to provide a water quality treatment assessment for Stage 3C on behalf of Lendlease. Fortnum Property, Clover Hill and Sunglow Development Groups have also provided further details of how their developments will manage water quality objectives consistent with the concept plan approval.

Development Consent has been received or is pending approval from SHCC for the above-mentioned stages and non-core landowners. WCMS supporting each development stage will provide more detail on water quality management associated with that stage.

Where the approved devices are not affected by the density uplift, no change is proposed from that submitted as part of the development application for that individual stage. These devices have therefore not been modelled as part of this report. Areas which will be affected by the proposed density uplift and areas draining to Marshall Mount Creek have been remodelled.

Four (4) approaches have therefore been taken to model CUDP and the impacts of MOD 4 and considers the approved water quality treatment devices. The portion of CUDP corresponding to the four (4) different modelling approaches is provided in Plate 7-3. Details of the four (4) approaches is provided below:

1. Developed areas with devices that have been approved/built where some or all of the catchments draining to this device are subject to a density uplift. **These catchments have been reassessed** (red hatched areas on Plate 7-3)**.**

2. Developed areas where the original strategy has changed significantly. **These catchments have been completely remodelled** (purple areas on Plate 7-3)

3. Developed areas with devices that have been approved/ built where no part of the catchment draining to these devices are subject to a density uplift. **Details of the modelling history for these catchments have been included in this report for completeness only** (yellow areas on Plate 7-3).

4. Developed areas that will not change from the original strategy. **For these catchments, the original treatment measure details has been reproduced for completeness only** (dark green areas on Plate 7-3)**.**

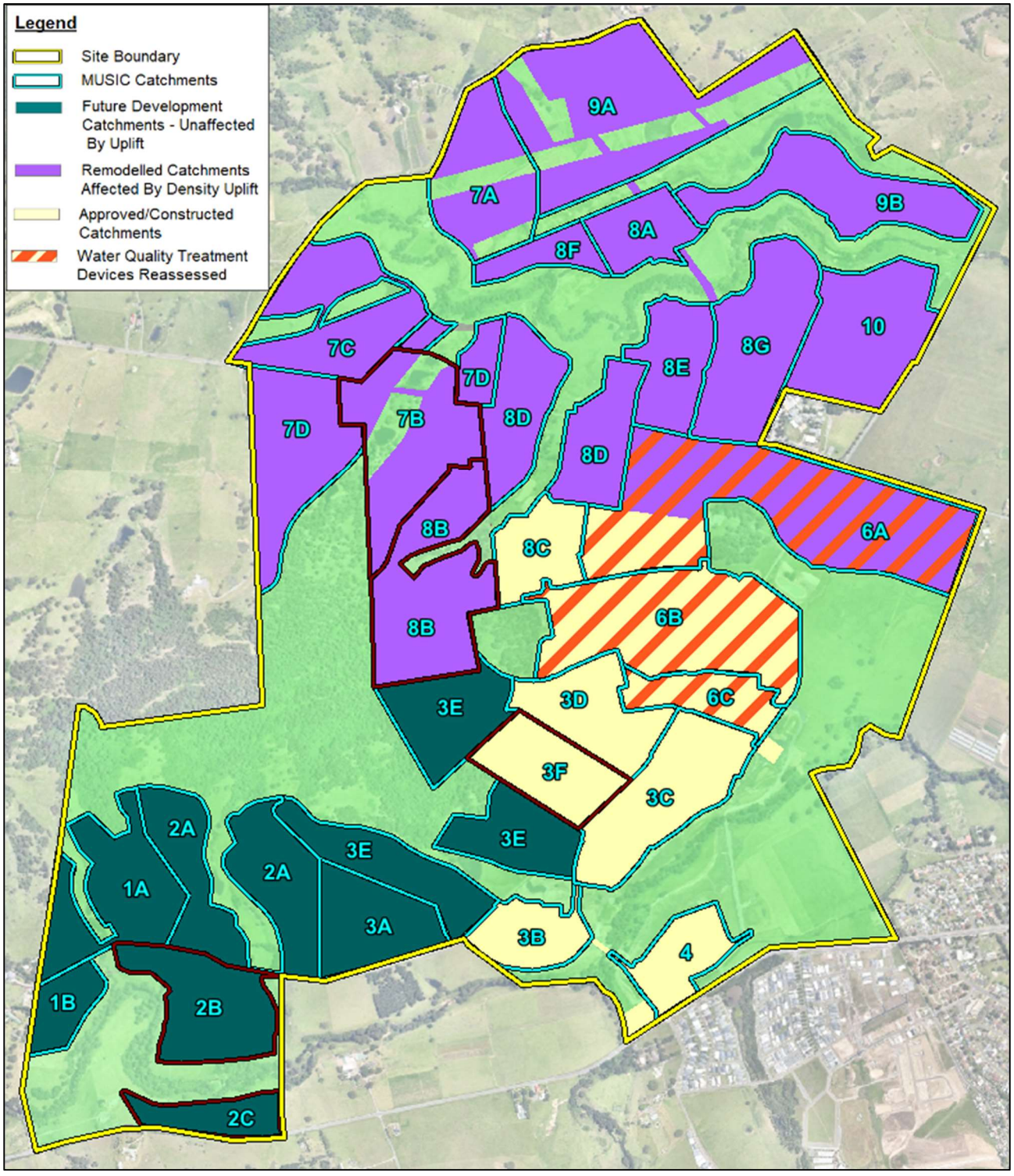



**Plate 7-3 Modelled Catchments**

## 7.3 Water Quality Analysis

The stormwater quality management for this study was undertaken using the Model for Urban Stormwater Improvement Conceptualisation (MUSIC). This water quality modelling software was developed by the Cooperative Research Centre (CRC) for Catchment Hydrology, which is based at Monash University and was first released in July 2002. Version 6.3 was released in 2016 and has been adopted for this study.

The MUSIC software provides several features relevant for the development:

- The model has the ability to assess the potential nutrient reduction benefits of gross pollutant traps, constructed wetlands, grass swales, bio-retention systems, sedimentation basins, infiltration systems, ponds and it incorporates mechanisms to model stormwater re-use as a treatment technique
- The model provides mechanisms to evaluate the performance of water quality against Council objectives.

The modelling has adhered to industry guidelines in order to represent the generation of various pollutant loads for different land uses. A MUSIC model representing the proposed development was prepared to demonstrate compliance with industry standard post development annual load reductions consistent with the original concept plan approval. The target reductions suitable for CUDP are shown in Table 7-1.

**Table 7-1 – Pollutant Removal Targets**

| Pollutant | Target Reduction Required |
|---|---|
| Total Suspended Solids (TSS) | 85% |
| Total Phosphorus (TP) | 65% |
| Total Nitrogen (TN) | 45% |
| Gross Pollutants (GP) | 90% |

It's important to note that SHCC does not have documented water quality reduction targets however, Wollongong City Council has water quality targets consistent those listed in Table 7.1 above.

The proposed increase in lot yield results is an increase in development density and subsequently an increase in impervious areas. This will in turn potentially increase the pollutant loads generated by CUDP which will need to be managed by the treatment measures. Therefore, water quality measures previously proposed as part of the FPRMS approved as part of Concept Plan Approval will need to be increased in order to meet the above-mentioned pollutant targets.

The parameters adopted in this MUSIC model are consistent with the parameters adopted in the original FPRMS. Each catchment was broken up into the following areas: Roads, residential lot areas, open space and special use areas (such as schools and commercial areas).

Details of the various percentages impervious used for the various different land uses are provided below in Table 7.2.

**Table 7-2 – Modelling Input Parameters**

| Area Type | Impervious Area % |
|---|---|
| Proposed Town Centre North | 90% |
| Proposed Town Centre East | 85% |
| Low Density Residential (R1) | 50% |
| Low Density Residential (R2) | 60% |
| Low Density Residential with proposed density uplift (R2) | 75% |
| Education Precinct | 50% |
| Non core-Invividual | 60% |
| Non core-Other Developer | 63% |
| Commercial/industrial | 95% |
| Road Reserve | 90% |
| Active Open Space | 50% |
| Passive Open Space | 10% |
| Forested Lands | 0% |

*Note: All % are to total lot area*

Details of the MUSIC node arrangement used in this assessment are provided in Appendix B.

### *7.3.1 Approach 1 - Catchments with Approved/Built Devices: Water Quality Devices Reassessed*

Stages 2A, 2B and 3A2 have been previously approved along with the treatment devices to manage these stages. These approved stages are located within catchments 6A, 6B and 6C and drain east to devices 6a, 6b and 6c as shown on Plate 7-4 below.

Due to the uplift in density surrounding the proposed Town Centre and Education precinct located in Catchment 6A, the effectiveness of these treatment devices will be affected by the uplift thus requiring a reassessment of the treatment measures.

A MUSIC model was established to demonstrate that the water quality treatment train originally proposed as part of the individual DA's can cater for the increased densities proposed as part of MOD4.

The MUSIC model established for the density uplift for Stages 2A, 2B and 3A2 adopts the approved Stage 2C DA and reassesses the proposed treatment measures. Refer to Plate 7-4 for more information.

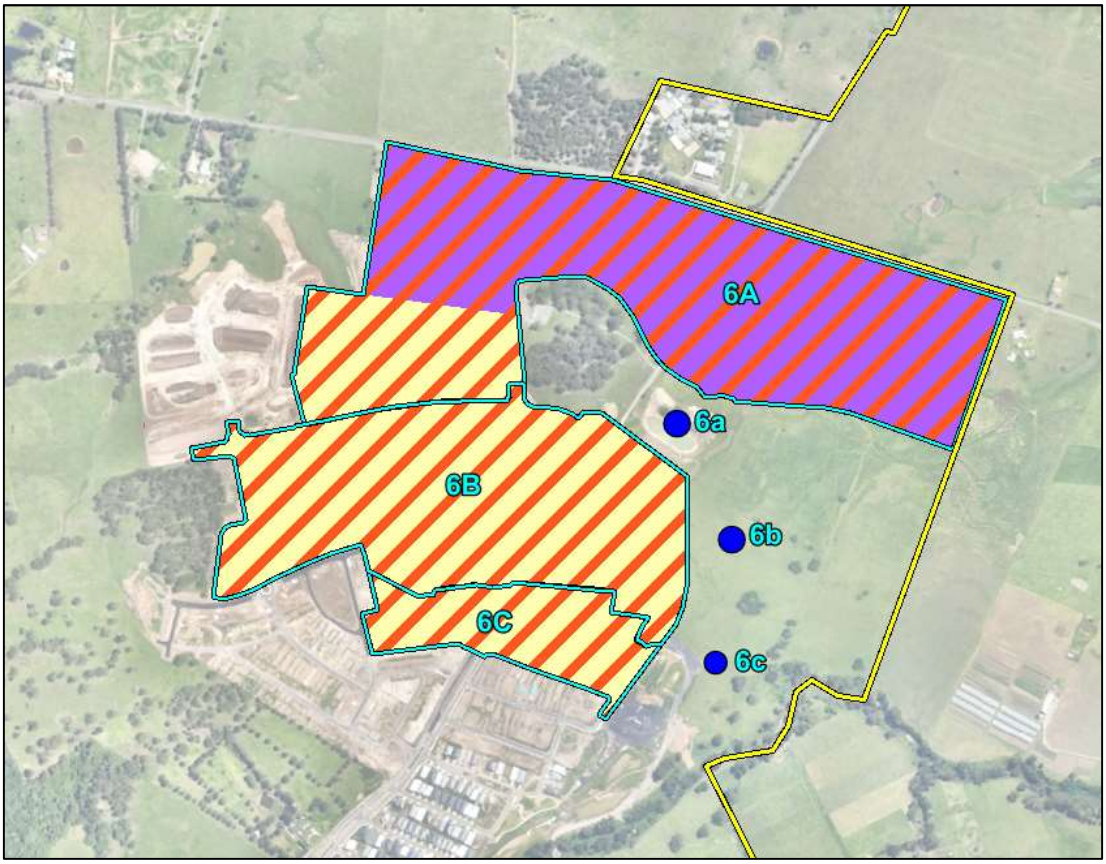



**Plate 7-4 - Water Quality Devices Reassessed**

The proposed treatment measure includes a single Wetland to treat catchments 6A and 6B. As part of previously approved strategies, separate wetlands were proposed to treat the individual catchments. The approved Stage 2C DA for these devices, Wetland 6a and 6b have been merged into one device. Flows from Wetland 6a and 6b cascade into Wetland 6c. Wetlands 6a, 6b and 6c have been modelled based on the treatment device sizes in the latest DA approval.

Details of the approved water quality treatment devices are presented in Table 7.3.

**Table 7-3 – Estimated treatment device sizes**

| Device | Size ($m^2$) |
|---|---|
| Pond 1 | 17,690 |
| Wetland 6a and 6b | 4470 |
| Pond 2 | 21,180 |
| Wetland 6c | 4750 |

As part of the proposed increase in density, Town Centre East, a portion of the main Town Centre and the Education Precinct are all proposed to drain to Wetland 6a and 6b, along with the existing development catchments. To further assess the implications of the increase in density, these areas were initially modelled with 60% impervious area and have been increased to 85% impervious area to cater for the increased lot density.

The MUSIC model layout for this portion of CUDP is shown in Appendix D.

#### 7.3.1.1 Results of Reassessment

The annual pollutant load estimates were derived from the results of the reassessment based on a stochastic assessment incorporating treatment device 6a, 6b and 6c. The estimated amount of pollutant loads and reductions for TSS, TP, TN and Gross Pollutants exiting into the Macquarie Rivulet are presented in Table 7-4.

**Table 7-4 – Estimate Mean Annual Pollutant Loads (Devices 6a-c)**

| Pollutant | Total Developed Source Loads (kg/yr) | Minimum Reduction Required (kg/yr) | Total Residual Load From Site (kg/yr) | Total Reduction Achieved (kg/yr) | Target Reduction Required (%) | Total Reduction Achieved (%) |
|---|---|---|---|---|---|---|
| TSS | 68800 | 58480 | 6690 | 62110 | 85% | 90% |
| TP | 139 | 90.350 | 31.400 | 107.6 | 65% | 77% |
| TN | 978 | 440.10 | 413 | 565 | 45% | 58% |
| GP | 11400 | 10260.0 | 1.87 | 11398.1 | 90% | 100% |

The current sizes for approved Wetlands 6a, 6b and 6c used in this assessment result in targets that exceed minimum water quality standard even with the proposed density uplift. Hence, no increase to the device size is required to support MOD4. This increase performance also addressed the Risk Based framework with an “improved” water quality outcome for this catchment.

### *7.3.2 Approach 2 - Remodelled Catchments Affected by Density Uplift Marshall Mount Creek*

A MUSIC model was established for future developments in the north surrounding Marshall Mount Creek (MMC) which affected by the proposed density uplift. The devices have been sized to accommodate the density uplift in these future stages, with further assessment required once the development layout is better understood. The MUSIC model layout for this portion of CUDP is shown in Appendix D.

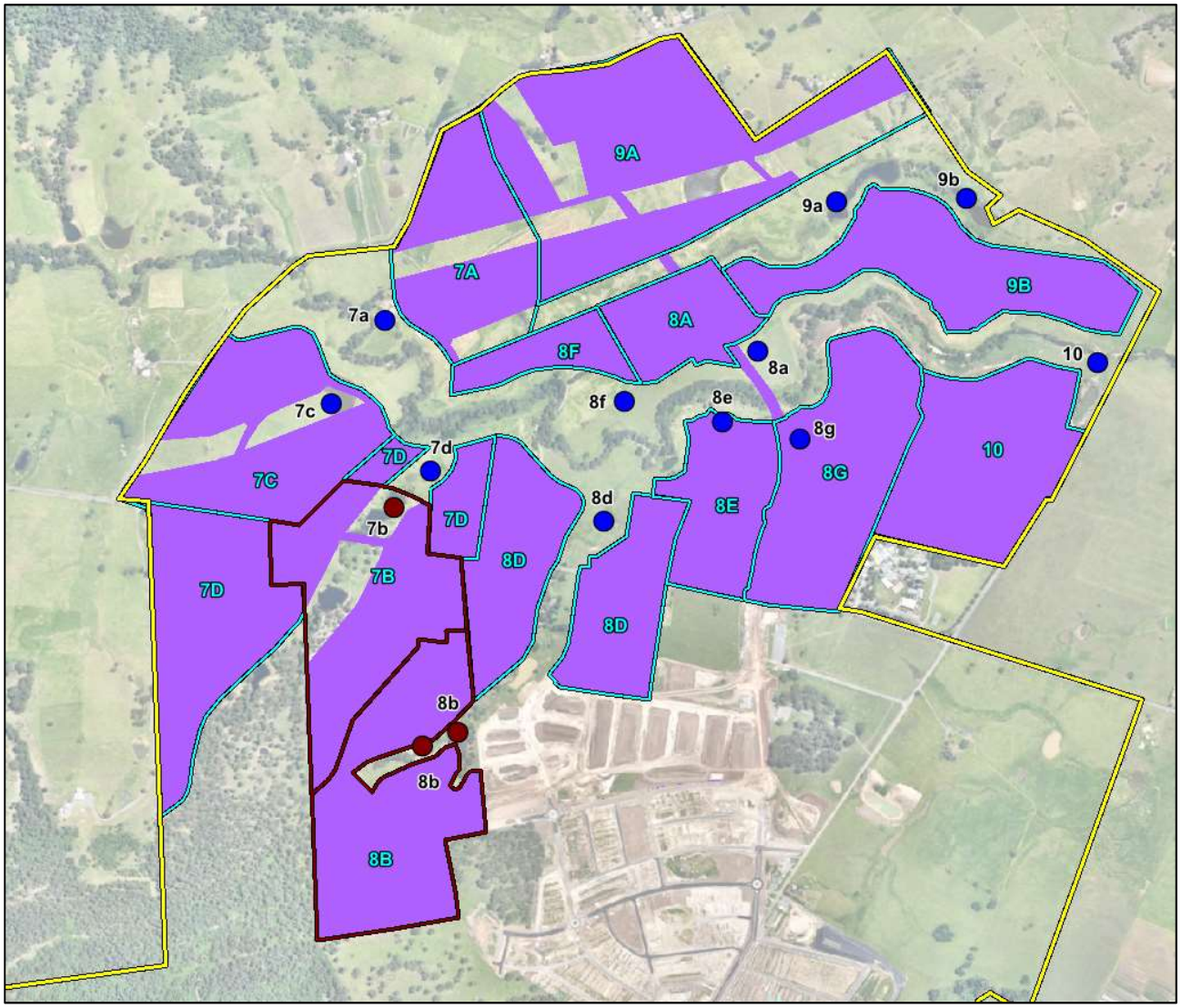



**Plate 7-5 – Remodelled Catchments – Marshall Mount Creek**

The sizes of the proposed water quality devices are shown in Table 7-5 below with the device locations shown in Plate 7.5. It's important to note the wetland pond volume use in this assessment is assumed to have an average depth of 2m (i.e. if the surface area of the pond is 1000m$^2$ the pond volume has been assuming to be 2000m$^3$ (1000m$^2$ x 2m deep))

.

**Table 7-5 – Proposed treatment device sizes**

| Device | Wetland Surface Area | Macrophyte Area | Total Pond Volume | Weir Length | % Cat |
|---|---|---|---|---|---|
| 7A | 4,000 | 2,000 | 8,000 | 11 | 3.5% |
| 7C | 6,000 | 3,000 | 12,000 | 15 | 3.4% |
| 7D | 14,000 | 7,000 | 28,000 | 35 | 5.8% |
| 8A | 2,500 | 1,250 | 5,000 | 9 | 3.5% |
| 8D | 12,000 | 6,000 | 24,000 | 51 | 6.0% |
| 8E | 3,300 | 1,650 | 6,600 | 8 | 3.5% |
| 8F | 1,000 | 500 | 2,000 | 6 | 2.2% |
| 8G | 5,500 | 2,750 | 11,000 | 15 | 4.0% |
| 9A | 10,000 | 5,000 | 20,000 | 27 | 2.8% |
| 9B | 6,000 | 3,000 | 12,000 | 44 | 3.7% |
| 10 | 7,200 | 3,600 | 14,400 | 15 | 4.1% |

#### 7.3.2.1 Results of remodelling

The annual pollutant load estimates were derived from the stochastic assessment of this portion of CUDP are presented in Table 7-6.

**Table 7-6 – Estimate Mean Annual Pollutant**

| Pollutant | Total Developed Source Loads | Minimum Reduction Required | Total Residual Load From Site | Total Reduction Achieved | Target Reduction Required | Total Reduction Achieved |
|---|---|---|---|---|---|---|
| | (kg/yr) | (kg/yr) | (kg/yr) | (kg/yr) | (%) | (%) |
| TSS | 143000 | 121550 | 21000 | 122000 | 85% | 85.3% |
| TP | 291 | 189.2 | 95.2 | 195.8 | 65% | 67.3% |
| TN | 2010 | 904.5 | 1040 | 970 | 45% | 48.3% |
| GP | 20700 | 18630 | 55.4 | 20644.6 | 90% | 99.7% |

Table 7-5 indicates that the required water quality treatment device sizes have increased from the original Concept plan approval in this portion of CUDP. The following reasons are contributing factors to this increase in treatment areas:

- The original assessment (Cardno, 2010) used MUSIC version 3.0, while the current assessment uses version 6.3. In the past eight (8) years there has been significant improvements in the assessment tool, and in turn, the effectiveness of water quality treatment devices is better understood. This, together with the increase in the dataset used in MUSIC, has resulted in an improved understanding the treatment train needs and is considered to be a better representation of the treatment devices sizes required in comparison to the 2010 assessments.

- In 2010, the pollutant removal targets where 80% reduction in TSS, 45% reduction in TP, 45% reduction in TN. The appropriate standard now requires one to improve or maintain an 85% reduction in TSS, 65% reduction in TP, and 45% reduction in TN. This increases the size and configuration of the treatment devices needed to deliver these elevated targets.

- The modelled catchments have been refined to be consistent with constructed or approved development areas and resulted in a larger treated area being assessed when compared to the original Concept Plan.

However, it should be noted that there is no increase in the overall development footprint or the number of devices in comparison to the 2010 concept plan approval.

It is recommended that as the development of CUDP continues, refined water quality modelling be undertaken to support each individual DA to ensure the ongoing development achieves the standards of the day.

### *7.3.3 Approach 3 & 4 - Unmodified Catchments*

The following information is a summary of water quality treatment device sizes for catchments that are not affected by the proposed MOD 4 density uplift. These are included for completeness only. Devices that are yet to be constructed will be modelled in more detail as part of the development application for the corresponding stages.

**Table 7-7 Unmodified Catchments treatment device sizes**

| Refined Devices not affected by uplift | | | | | |
|---|---|---|---|---|---|
| Catchment Name | Urban Catchment Area | Device Size ($m^2$) | % Urban Catchment | Approved/Pending DA's | Approved/ Constructed |
| 1a | 15.66 | 6300 | 4.0% | - | No |
| 1b | 4.88 | | | Fortnum Developments Ltd | No |
| 2a | 21.63 | 8700 | 4.0% | - | No |
| 2b | 13.70 | 6900 | 5.0% | Fortnum Developments Ltd | No |
| 2c | 5.48 | 2800 | 5.0% | Fortnum Developments Ltd | No |
| 3a | 11.07 | 2500 | 2.3% | Stage 3C DA plan | No |
| 3b | 7.50 | 500 | 0.7% | Stage 3B DA plan | Yes |
| 3e | 24.25 | 4750 | 2.0% | Stage 3B South DA plan | Yes |
| 3c | 26.80 | 2306 | 0.9% | Stage 1D & 2 DA plan | Yes |
| 3d | 11.66 | 800 | 0.7% | Stage 1D & 2 DA plan | Yes |
| 4 | 6.62 | 1740 | 2.6% | Stage 1A DA plan | Yes |
| 5 | Development no longer proposed in this area | | | | |

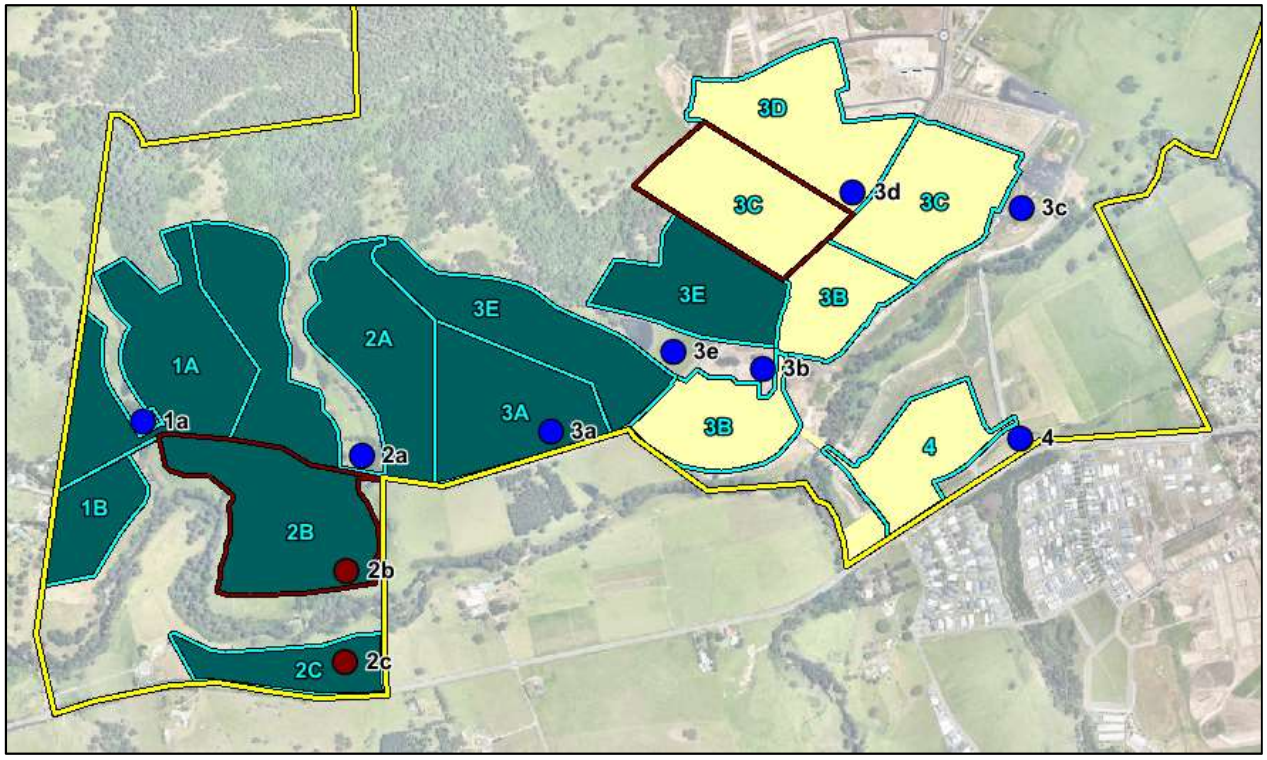



**Plate 7-6 – Unmodified Catchments**

## 7.4 Maintenance of Water Quality Devices

Maintenance of all water quality devices in the core lands will be the responsibility of Lendlease initially with a transition to SHCC and WCC Council's consistent with the relevant DA consent conditions. In accordance with Condition 10 of Statement of Commitment set out in original concept approval, drainage works will be maintained in accordance with industry best practices for a period of 3 years prior to handover to public authority. This transfer will ensure ongoing and effective treatment of stormwater will be maintained.

## 7.5 Risk-Based Framework

The Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions (EPA, 2017) was developed by EPA/OEH to provide management outcomes for the impacts of various land-use activities. It allows decision-makers such as Council's to determine management responses required to meet water health objectives. The purpose of this framework is to:

- Identify waterway objectives that support the community's environmental values and uses
- Identify waterway areas/zones that require protection
- Distinguish catchment areas where cost-effective management responses reduce the impacts of land-use activities on waterways
- Achieve sustainable, practical, socially and economically viable environmental performance levels by supporting management of land-use developments.

The document includes a case study carried out to identify cost-effective stormwater management responses and strategies to accommodate urban growth in the Lake Illawarra catchment while maintaining and/or improving the water quality and health of the lake. A 'benefits map' was developed for this study (see Plate 7-7 below) to assist with the design and implementation of the framework. The benefit maps reflect a trade-off between meeting sustainable loads, Council's management responses and concerns of the ongoing stormwater management. It's important to note that the case study does not provide specific pollution reduction targets for the CUDP, and no such data is currently publicly available.

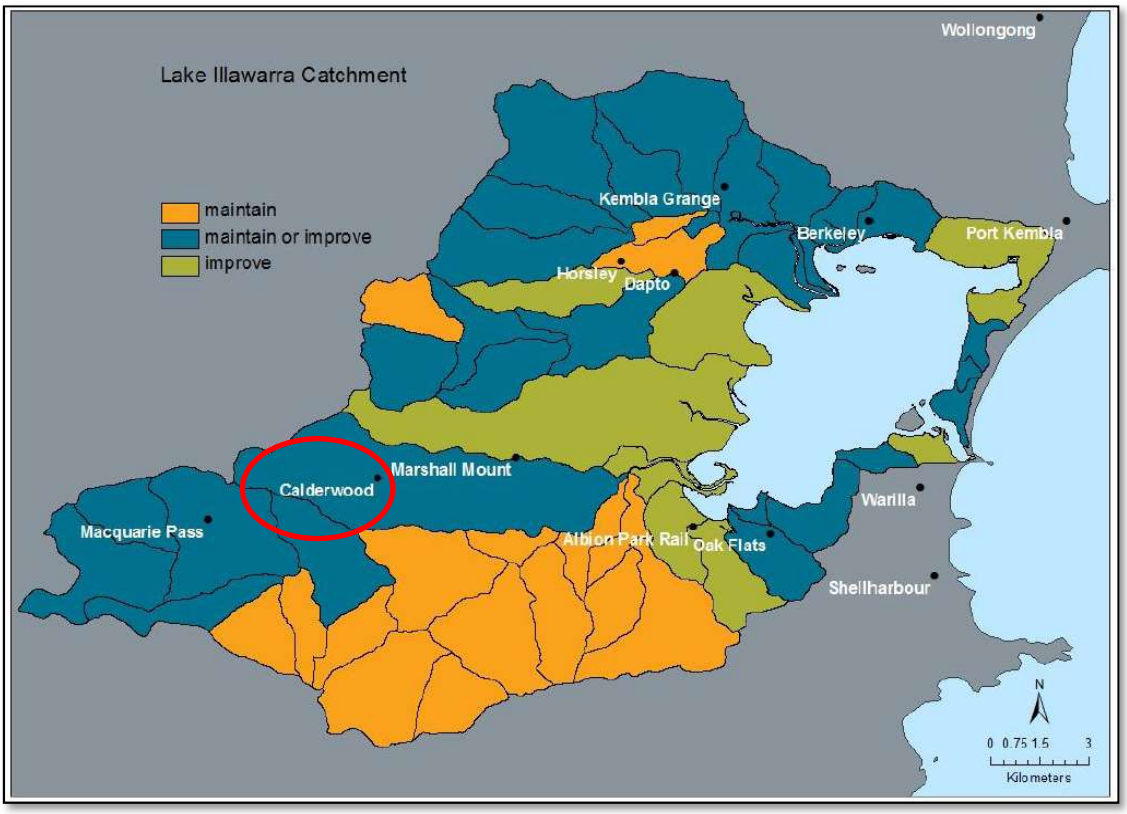



**Plate 7-7 – Benefit map identifying priority areas for cost-effective stormwater management in Lake Illawarra catchment**

Plate 7-7 indicates that CUDP is located in the "blue areas" which have been identified in the case study to 'maintain or improve' stormwater controls and as a minimum to achieve the load reduction targets of the relevant Council.

The minimum pollutant reduction targets required to be achieved in Wollongong Council's WSUD (Water Sensitive Urban Design) guidelines are presented in Table 7.1. Refer to WCC DCP 2009 Chapter 15 which provided further information relevant to this strategy.

Hence, the proposed water quality treatment system detailed in Section 7.3 ensure compliance of this framework.

# 8 FLOOD MANAGEMENT

To assess the flood impacts associated with MOD4 across CUDP, we have undertaken a series of reviews and modelling tasks to support the application. The following design approach has been undertaken:

- Review all available existing flood models in the area including:
  - The Reinco Flood Study (2009)
  - The Cardno Model (2011)
  - The WMAWater Macquarie Rivulet Model (2017) - *Shellharbour City Council's adopted model*

SHCC has confirmed at meeting with J. Wyndham Prince on the 15 March 2018 that the court approved developments need to be established as the new "existing" condition flood extent. Any reported impacts that may be identified as a result of using the new Macquarie Rivulet flood model would, as it was court approved, be acceptable by SHCC. This approach has formed the basis of all assessments within this report.

With this advice and consistent with the SEAR's we have used the latest TUFLOW model for the Macquarie Rivulet and modelled the following two (2) scenarios in both the WBNM and TUFLOW models.

- **Approved Development Conditions** – Includes approved development within the CUDP only in establishes the "new existing", which has been used in this assessment as the basis for all comparisons to assess the impacts associated with MOD4.

- **Proposed Developed Conditions** - Modelling updated to consider the full CUDP concept plan layout.

The developed conditions model was then assessed against the Reinco Flood and Cardno Model to ensure any reported impacts are consistent with the overarching concept plan proposal and/or any Land and Environment Court approval.

## 8.1 Hydrologic Analysis

A Watershed Bounded Network Model (WBNM) was used as the hydrological model for the development, consistent with the Macquarie Rivulet Flood Model (WMA 2017), as well as all other previous modelling approaches. WBNM is widely used throughout Australia and particularly the south coast of NSW. WBNM simulates a catchment and its tributaries as a series of sub-catchment areas linked together to replicate the rainfall and runoff process through the natural stream network. Input data includes the definition of the physical catchment characteristics including area of sub-catchments, proportion of impervious surfaces and temporal and spatial rainfall patterns over the catchment.

- In the approved development conditions, the hydrologic model was kept consistent with the calibrated Macquarie Rivulet Flood model with changes made to the WBNM model to ensure that it accurately reflected the approved development conditions.

- In the Proposed Developed Conditions, the hydrologic model was also kept consistent with the calibrated Macquarie Rivulet Flood model with changes made to the WBNM catchment extent and impervious percentage to ensure that it accurately reflected the developed conditions in support of MOD4:

### 8.1.1 Sub catchment Delineation

The catchment breakup was modified to better reflect the development that has or will potentially occur within CUDP. Refer to Figure 8.01 for the modified catchment breakup for the approved development, and Figure 8.02 for the proposed development.

This was completed using digital terrain models that reflects the existing discharge locations, and ensuring a similar discharge point, considered for both the approved and proposed development conditions.

### 8.1.2 Impervious and Pervious Area

The pervious and impervious areas for the catchment were updated to reflect both proposed and approved developed conditions with detailed provided in Table 8.1 below. The impervious areas percentages in Table 8.1 are consistent with the impervious area's percentage used in the water quality assessment detailed in Table 7.2.

**Table 8-1 – Impervious Percentages used across the site**

| Area Type | Impervious Area % |
|---|---|
| Proposed Town Centre North | 90% |
| Proposed Town Centre East | 85% |
| Low Density Residential (R1) | 50% |
| Low Density Residential (R2) | 60% |
| Low Density Residential with proposed density uplift (R2) | 75% |
| Education Precinct | 50% |
| Non core-Invividual | 60% |
| Non core-Other Developer | 63% |
| Commercial/industrial | 95% |
| Road Reserve | 90% |
| Active Open Space | 50% |
| Passive Open Space | 10% |
| Forested Lands | 0% |

### 8.1.3 WBNM Results

Potential increases in peak flows were considered as part of this assessment. While the proposed wetlands and water cycle strategy for the site will ensure that peak flows entering the creek systems will not influence geomorphic change as a result of the development, a worst-case scenario has been modelled that excludes these devices to determine if there is a need for detention across the site.

A series of comparison points both upstream and downstream of the site on both watercourses have been selected as shown in Plate 8-1 below.

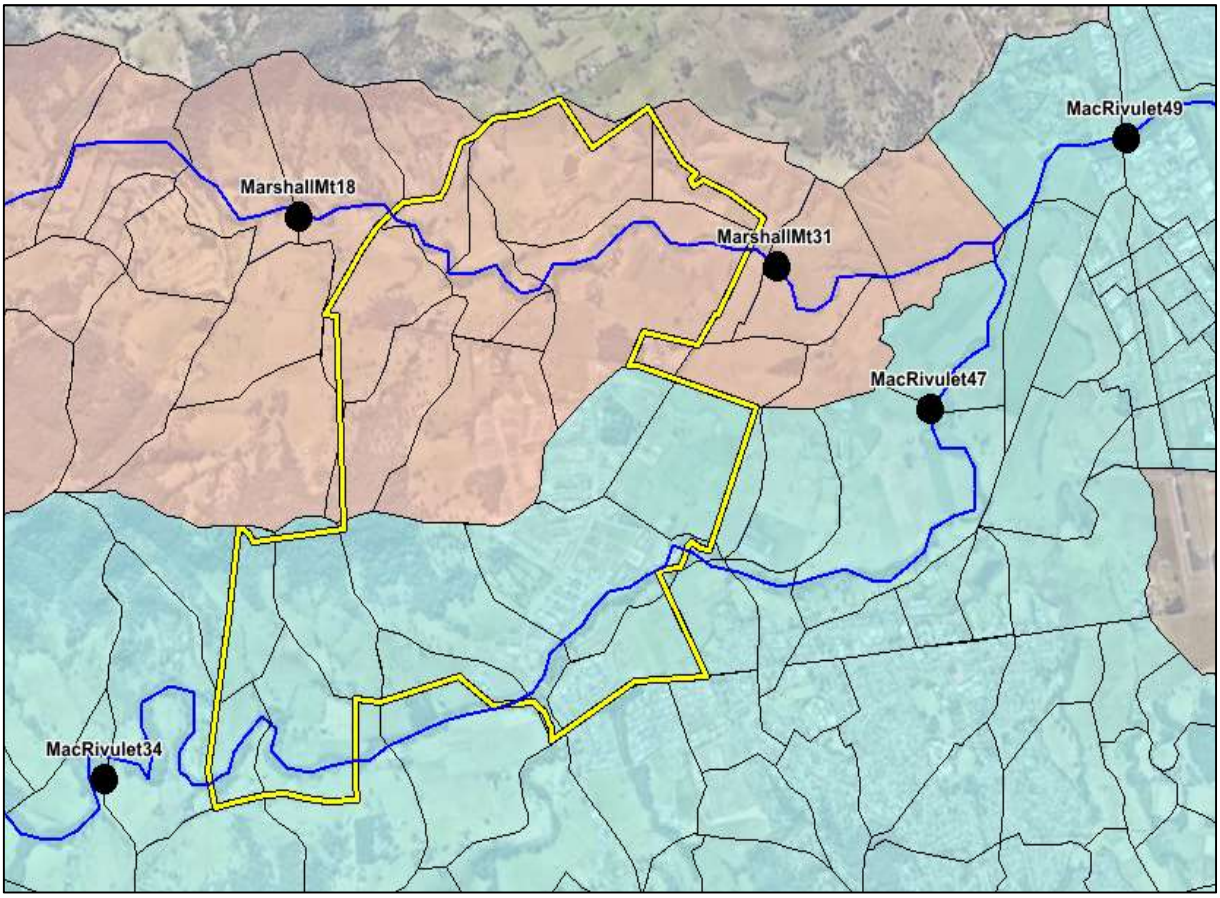



**Plate 8-1 – WBNM flow comparison locations in Marshall Mount Creek**

Our analysis demonstrated that local peaks from the site do not coincide with peak flows from upstream catchment within both the Macquarie Rivulet and Marshall Mount Creek.

Refer to Plate 8-2 and Plate 8-3 that illustrates the change in timing that has occurred in both Macquarie Rivulet and Marshall Mount Creek. A summary of the results is provided in Table 8-2.

**Table 8-2 – Peak Flow Comparison Points**

| Node | | | Flow Change Ratio |
|---|---|---|---|
| | Existing | Developed | Dev / Ex |
| Marshall Mt 18 | 213.27 | 213.27 | 0.0% |
| Marshall Mt 31 | 279.35 | 281.44 | 0.7% |
| Mac Rivulet 47 | 728.80 | 728.80 | 0.0% |
| Mac Rivulet 48 | 1134.77 | 1132.46 | -0.2% |
| Mac Rivulet 49 | 1582.57 | 1581.00 | -0.1% |

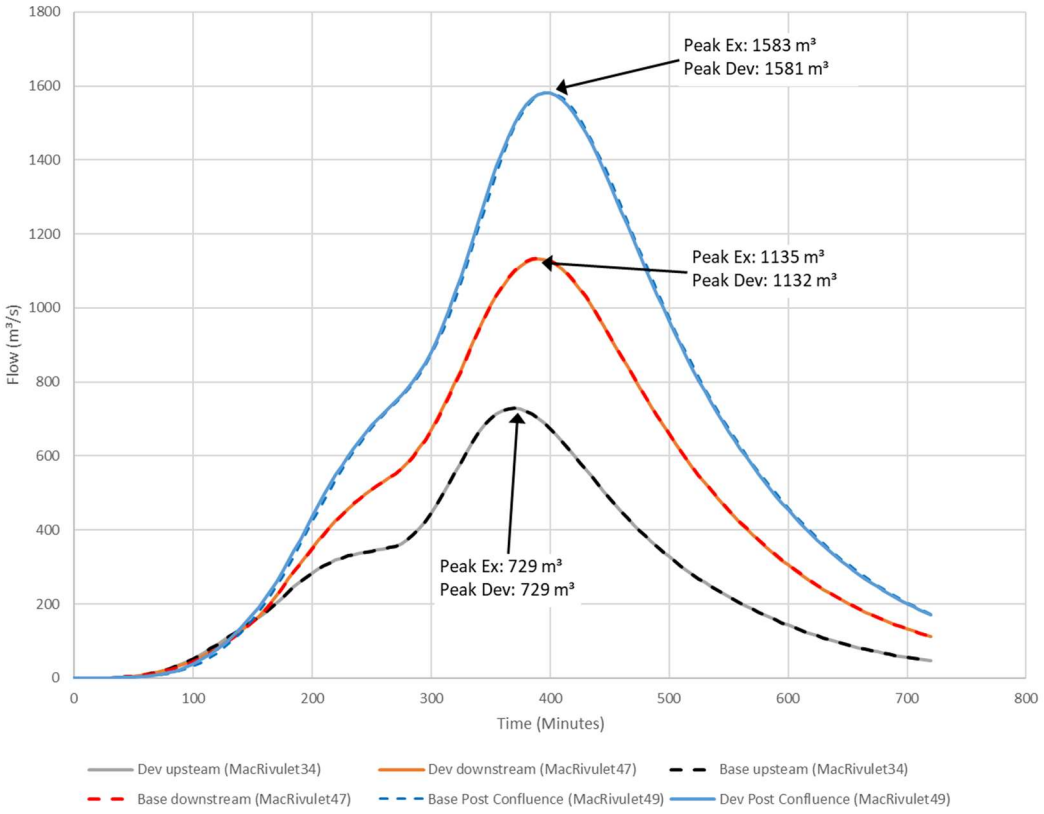



**Plate 8-2 – WBNM flow comparison in the Macquarie Rivulet: 1% AEP 9hr Event**

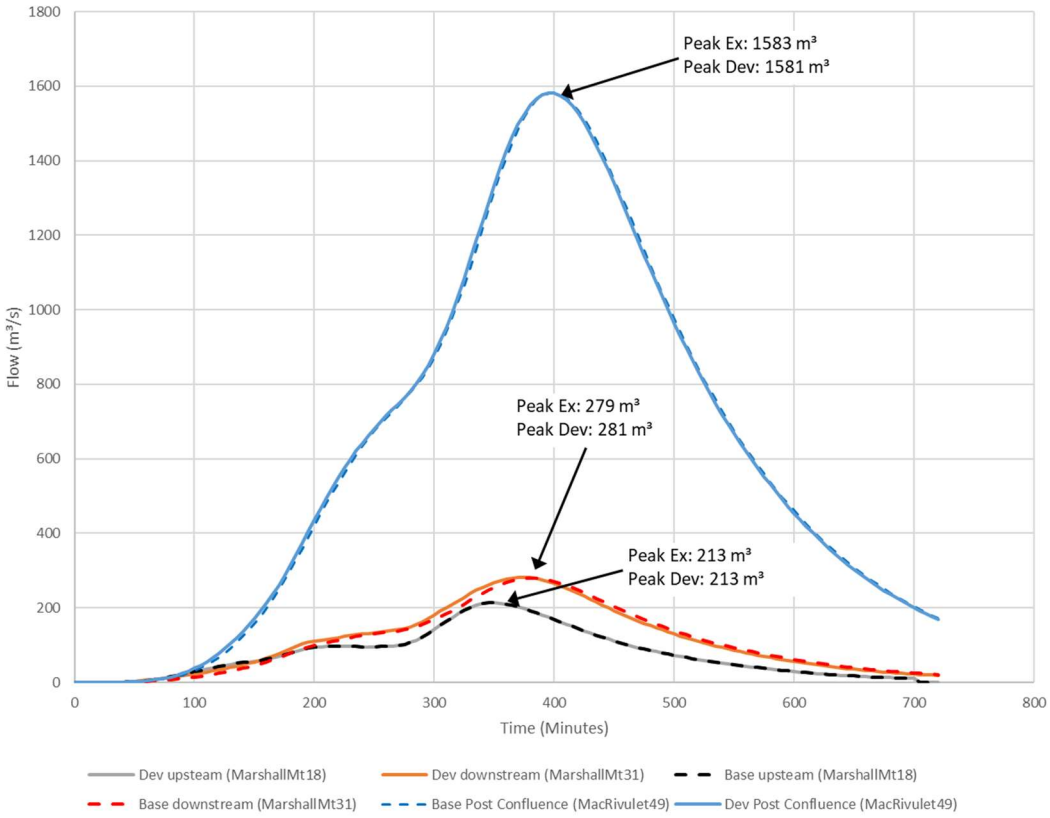



**Plate 8-3 – WBNM flow comparison in Marshall Mount Creek: 1% AEP 9hr Event**

The modelling demonstrates that there is a marginal increase in peak flows downstream of the site of 1.36 m³/s (i.e. Marshall Mount 31 which is 0.5% increase in the 1% AEP event) with no detention. However, the shift in peak timing associated with the earlier release of local flows arising from the urbanisation of the CUDP improves existing flows downstream of the confluence of the Macquarie Rivulet and Marshall Mount Creek.

Modelling indicates that detention is not needed to reduce impacts downstream of the site as peak discharge levels throughout both the Macquarie Rivulet and Marshall Mount Creek are not adversely increased as a result of the CUDP.

This approach is consistent with Approved Water Cycle Management Studies previously carried out by Cardno (Cardno 2010) to support Staged DA's. Cardno has demonstrated that without any detention in the CUDP, the post-development peak flows are lower than the pre-development peak flows due to the development runoff discharging quicker than the peak from the larger upstream catchment.

## 8.2 Hydraulic Analysis

### *8.2.1 Modelling Parameters*

The Macquarie Rivulet TUFLOW model was provided by SHCC. The hydraulic model used to support MOD4 was kept generally consistent with the calibrated Macquarie Rivulet Flood model with the following changes:

- The TUFLOW model was updated to run on TUFLOW Build 2018-03-AC
- Some outdated model components (such as flow constrictions and unsupported shapes) were updated so that the latest version of TUFLOW could be used.
- Models were run using a Heavily Paralelesied Compute (HPC) solver solution instead of a traditional CPU solver to improve run times.
- Additional survey of the Macquarie Rivulet undertaken as part of the original concept plan approval was added to the model to augment the accuracy of this model.
- The Manning's roughness adopted in the assessment was amended to be consistent with the Floodplain Risk Management Study prepared to support the 2010 Concept Plan Approval (Cardno, 2010). The model uses a depth variable Mannings 'n' value based on the flow depth within discrete areas of the floodplain (i.e. roughness reduces with increasing flow depth) to reflect a 'realistic' flood scenario.

### *8.2.2 Approved Development Conditions*

The following changes were made also made to the approved development scenario:

- The approved development catchments from the WBNM model were used to replace existing conditions within CUDP.
- Development with CUDP was represented by surfaces used to inform the DA design for each approved stage.
- The Macquarie Rivulet Bridge was added to the model as a series of layered flow constrictions based on the Work As Executed plans for the bridge
- Riparian planting that will be undertaken in the creek corridors as part of the approved development was represented in the model by a Mannings 'n' roughness consistent with FPRMS.

### *8.2.3 Proposed Development Conditions*

The proposed development model was built upon the "Approved Development Condition" TUFLOW model with the following changes:

- The developed catchments from the WBNM model were used to replace both existing conditions and approved condition catchments within the entire CUDP.
- Fill areas were created for the future development pads, particularly in Marshall Mount Creek to ensure that they are flood free in the 1% AEP event (with 0.5m freeboard) across the site.
- Cut areas were provided within the E2 land adjacent to the creek to improve flow conveyance. The locations of these cut areas are consistent with those proposed in the original concept plan. A cut fill plan showing these changes is shown in Figure 8.10.
- Proposed open space (parks) were raised to be above the 20% AEP flood level

  The Marshall Mount Creek Bridge was added to the model as a layered flow constriction. The bridge deck is proposed to be above the PMF level for Marshall Mount Creek in order to comply with Commitment 41 of the original Concept plan approval.

### *8.2.4 Discussion of Flood Modelling Results*

A series of flood depth and flood difference maps have been prepared. Details of these plans are:

- Figure 8.03 to 8.05 show the extent of flooding across the site during the 1% AEP event for both the approved and developed conditions
- Figure 8.06 to 8.08 show the extent of flooding across the site during the PMF event both for the approved and developed conditions
- Figure 8.09 shows the extent of flooding across the site during the 1% AEP including a 15% increase in rainfall intensities to account for Climate Change

The refined modelling of the northern portion (Marshall Mount Creek) of CUDP confirms that during the both the 1% AEP event and the PMF event (Figures 8.03 to 8.08), flooding within the main channel of Marshall Mount Creek is deeper than in approved conditions, as many of the secondary flowpaths that are present under approved conditions have been redirected back toward the main channel. This results in increased flows in the main section of the creek within the site. Flood difference maps are provided on Figures 8.03 and 8.08.

Flooding within the Macquarie Rivulet has also become more consolidated. There are no impacts upstream or downstream of CUDP, with the exception of a small local increase just downstream of the site in Marshall Mount Creek. This local increase, shown on Figure 8.03, is consistent with the impact documented in the original Concept Plan (Cardno, 2010).

Nearby Albion Park properties have less flood affectation than in the approved case. Thus, CUDP will provide significant flooding benefits for the local community.

In the 1% AEP event, the proposed urban development is flood free (see section 9 for separate discussion on the Stage 1 flooding impact and the Stage 1 bridge), and there are no impacts upstream of the site. There are also no measurable impacts downstream of the site.

During the PMF event, there are no impacts greater than 300 mm external to CUDP which is consistent with the accepted impacts agreed by the Land and Environment Court process (Figure 8.08).

It is noted that portions of the High School site, within the Education Precinct, are flood affected during a PMF event. However, the risks associated with PMF flooding can be managed by either appropriate land use within the school site or raising the site to be flood free in a PMF event.

Therefore, within the site, no critical infrastructure will be flood affected during a PMF event.

### *8.2.5 Climate Change*

An assessment of climate change (rainfall increase) for 1% AEP event was undertaken by increasing rainfall intensities by 15%. Results demonstrated that the 1% AEP with climate change consideration will not result in any significant changes in flood level greater than flood levels of a PMF event. Refer to Figure 8.09

### *8.2.6 Flood Storage Loss*

The loss in flood storage is consistent with the approved 2010 Concept Approval assessment which demonstrated that CUDP does not result in unacceptable flood impacts downstream of CUDP. The 2010 assessment included a similar reduction in floodplain storage which forms part of this assessment.

The current assessment demonstrates that the proposed loss of floodplain storage in the 1% AEP and PMF events does not result in a redistribution of flood flows nor results in flood impacts outside of CUDP in excess of that which has been agreed to under the court approved Concept Plan. Further design at DA stage will be consistent with this approach and will not require a cumulative assessment of floodplain storage.

## 8.3 Flood Evacuation

The safety of people from flood waters during an extreme event is a key consideration for the planning of CUDP.

As indicated in the flood mapping, parts of the Precinct are inundated by mainstream flows from both Marshall Mount Creek and the Macquarie Rivulet during the PMF event. However, as the PMF is a short duration event, a flood evacuation strategy that provides residents with enough time to mobilise and evacuate CUDP is not available, and it is necessary to ensure the safety of the future population that will “shelter in” CUDP.

Therefore, consistent with section 5.6 of the FPRMS (Cardno, 2010), the primary flood evacuation strategy to not evacuate at all and a “shelter in place” strategy is the option that presents the Lowest Risk to Life.

However, with a “shelter in place” strategy, it is important that access to the site is available to emergency vehicles consistent with Commitment 41. As discussed further in Section 9, the Stage 1 bridge has been constructed to be above the PMF with freeboard. The bridge proposed as part of the Escapement Drive construction across Marshall Mount Creek will also ensure that flood free access in the local PMF event is achieved to the northern portion (Wollongong City Council side) of the CUDP.

This will ensure that even during the most extreme rainfall events, safe access for emergency vehicles to all points of the CUDP is provided.

As part of WCC submission on the Mod 4, WCC suggest that CUDP would need to rely on flood evacuation routes through Yallah /Marshall Mount area to support the continuing development of CUDP.

CUDP does not need to rely on any flood evacuation strategy from the adjacent catchment. The original 2010 concept plan approval required that vehicle access to CUDP is to be provided in a PMF event across both Macquarie Rivulet and Marshall Mount Creeks. The Stage 1 approved bridge and the proposed bridge across Marshall Mount Creek (i.e. Escarpment Drive bridge) delivers this requirement.

The design and location of Escarpment Drive bridge, located on Marshall Mount Creek north of the town centre, is still to be finalised, but the flood assessment has included a bridge across Marshall Mount Creek (layered flow constriction in the TUFLOW model) that replicates a flood free access during the PMF event.

### *8.3.1 Structural Safety of buildings within PMF events*

A local PMF assessment has been undertaken to determine the local flow regime in an extreme PMF event to ensure the safety of buildings within the subdivision is maintained even during an extreme rainfall event. A “worst case” scenario was modelled, with a ‘T’ intersection at the foot of a 200m 16% grade road. The potential structural damage was assessed using the Hazard Categorisation outlined in ARR 2016.

Results of this assessment indicate that for local catchments smaller than 7.5ha, high hazard PMF flows are conveyed within the road profile, and that the flood hazard category is suitable for buildings on all lots. As long as each local catchment does not exceed 7.5ha, for the whole of the CUDP all houses will not be subject to high hazard flow.

# 9 STAGE 1 DEVELOPMENT AND STAGE 1 BRIDGE IMPACTS

As part of the public submission process for MOD 4 SHCC raised specific concerns with the potential flood impacts surrounding Stage 1 of CUDP and the associated Stage 1 bridge across the Macquarie Rivulet that the new WMAWater flood assessment indicated. Plate 9.1 below shows that initial flood impacts that were the bases of SHCC concerns.

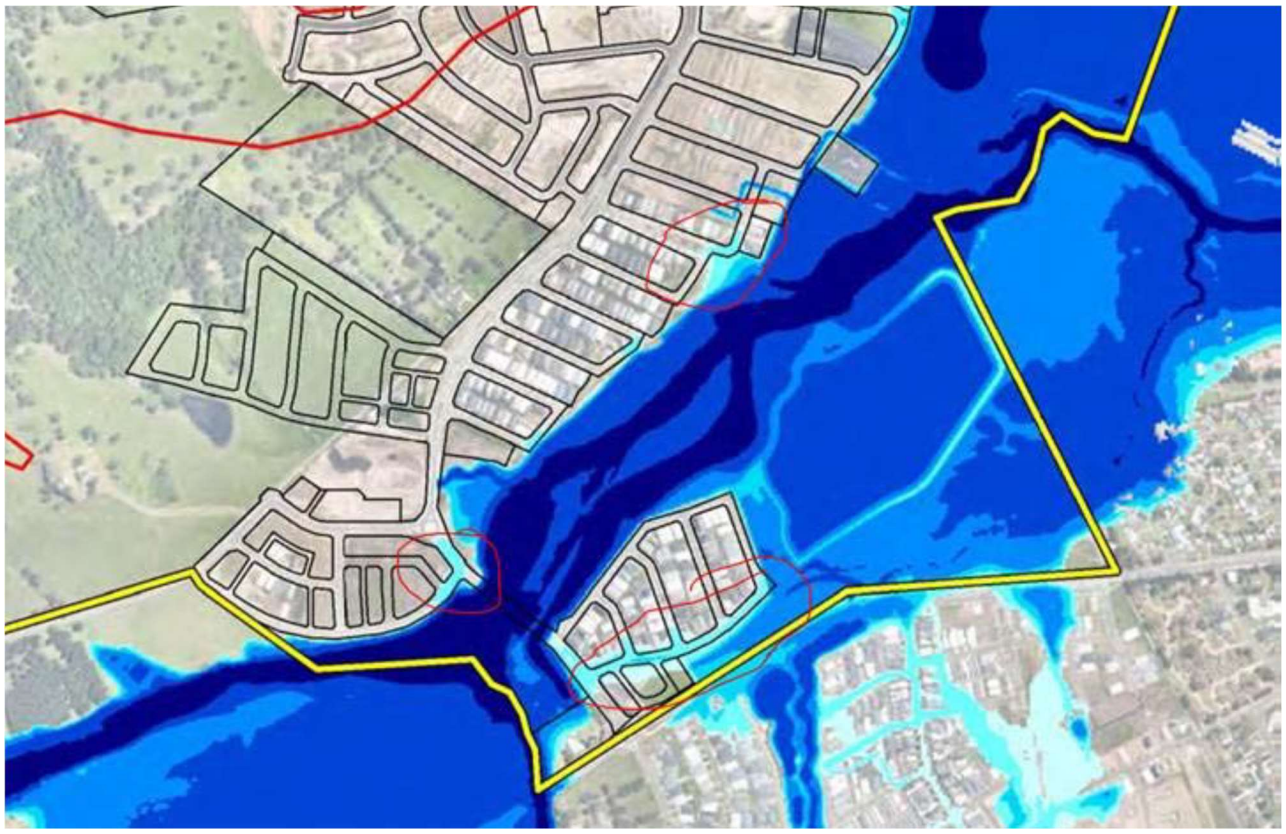


**Plate 9-1- Initial Flooding Concerns surrounding Stage 1**

**(Source: Shellharbour City Council – Detailed Assessment and Comments – Calderwood Modification 4)**

While is noted that the initial flood mapping of the developed conditions which supported the MOD 4 Strategy did show impacts within Stage 1 (Plate 9.1 above), the suggestion that this new assessment renders the MOD 3 and the subsequent construction approved granted by SHCC invalid is unjustified. SHCC's position is that the Stage 1 bridge now needs to be lifted.

The Stage 1 bridge has been granted a series of both development and construction approvals from various authorities before the construction of the bridge in 2016. The construction certificate approval was granted by SHCC and the Subdivision certificate approval was also granted by SHCC in 2016 confirmed that SHCC was of the view even with the knowledge that the WMAWater modelling increased flood flows at this bridge, that the bridge could and was constructed at the levels with the approved documentation.

This approval, therefore, satisfied Commitment 41 of the original concept plans approval and this revised modelling does not change the approval granted by SHCC.

In order to determine why there have been some significant changes to the flood outcomes surrounding the Stage 1 bridge, a detailed review of modelling parameters from both the original Reinco and new WMAWater have been completed and detailed in section 9.1

## 9.1 Reinco Model vs Shellharbour City Council's Macquarie Rivulet Model (WMA, 2017)

The Macquarie Rivulet Flood Model provided by Shellharbour City Council was used as the basis for the hydrologic modelling for this assessment. The Macquarie Rivulet Flood Study report (WMAWater, 2017) outlines the model approach taken and details the results of the comprehensive flood assessment.

It's important to note that the WMAWater 2017 assessment does not consider either the approved nor the future development of CUDP in their modelling even though development had been approved and constructed in CUDP prior to Macquarie Rivulet flood study was being released.

The difference in flood impacts particularly around Stage 1 Macquarie Rivulet bridge is primarily due to the different input data in the hydrologic WBNM models. Table 9.1 below shows that difference in PMF flows at the Stage 1 bridge

**Table 9-1 – PMF flow Comparison at the Stage 1 Bridge**

| PMF Flows | Reinco Model ($m^3/s$) | WMA Model ($m^3/s$) |
|---|---|---|
| Immediately upstream of Stage 1 Bridge | 2310 | 2643 |

A detailed review of the modelling parameters has also been completed to demonstrate the difference in modelling approaches. Table 9.2 documents the difference in the Reinco and WMAWater assessment and provide commentary on the impact of the individual parameters may have on the flood flows.

**Table 9-2 – WMAWater – Reinco Modelling Parameter Comparisons**

| Item | WMAWater Model 2017 | Reinco Model 2010 | Comments |
|---|---|---|---|
| Total Catchment Area | 110 km² | 107 km² | The majority of the extra catchment area in WMAWater model is located downstream of Calderwood (Refer Plate 9.2 below for catchment comparison image). While the catchments do differ, the 0.14% difference is not the key driver for the difference in flows. |
| Catchment Area upstream of the bridge | 6217 Ha | 6226 Ha (approx.) | |
| Catchment Lag 'C' Value adopted | 1.6 | 1.3 | This parameter governs the time taken for rainfall to be converted to runoff. This parameter can have a significant impact on flows through catchments. A higher value can potentially increase runoff from catchments. Notwithstanding, a value of 1.6 adopted by the WMAWater model is a recommended value by the software developer which is based on analysis of historic flow gauge data across the state. |
| Impervious Lag Factor | 1.5 | 0.1 | This parameter is derived from the value of 'C' (see above) and applied to the impervious portion of a catchment. The recommended |

| Item | WMAWater Model 2017 | Reinco Model 2010 | Comments |
|---|---|---|---|
| | | | value of Impervious Lag factor is 0.1. However, Reinco/Cardno adopted the value of 0.1 was tested in the WMAWater model and we found that this change did not impact the flows significantly. |
| Initial Loss for PMF event only | 0 mm | 15 mm | This parameter represents the amount of rainfall that is absorbed by the ground at the beginning of the storm.<br>Reinco model has adopted an initial loss of 15mm which reflects a typical NSW catchment for events other than the PMF.<br>The initial loss of '0' in the PMF event adopted by WMAWater is more appropriate and potentially is one of the contributing factors for increased flows in comparison to the Reinco/Cardno model during the extreme PMF event. |
| Continuing Loss adopted for PMF Event only | 1.0 mm/hr | 2.5 mm/hr | Similar to above, a lower value of 1.0 mm/hr denotes less rainfall is lost into the ground during the storm. However, the lower value adopted by WMAWater is appropriate in the PMF event. |
| Rainfall Gauge Data adopted for Calibration and Validation | 1984, 1988, 1991, 1992, 1998 and 2011 flood events<br><br>Derived ARR 1987 temporal pattern | 1991 flood event only<br><br>Standard ARR 1987 temporal pattern | Reinco/Cardno hydrologic model was calibrated adjacent only one (1) event (1991) due to the limited data available at the time.<br>The WMA hydrologic model has used six (6) flood events to calibrate and validate their model.<br>The WMA model varied the following parameters for each calibration event:<br>• Temporal pattern allocation,<br>• Initial losses, and<br>• Continuing Losses.<br>The WMA model includes more recent data available from flood events in comparison with the Reinco/Cardno model.<br>Calibration to a series of events improves confidence in the design flood results produced by the modelling. |

The modelling completed as part of this assessment is seen as an improvement over the WMAWater assessment and better representation of the flood impacts across CUDP when compared to the Reinco model and is suitable to inform the ongoing development of CUDP with any future approval of the proposed MOD 4 modification.

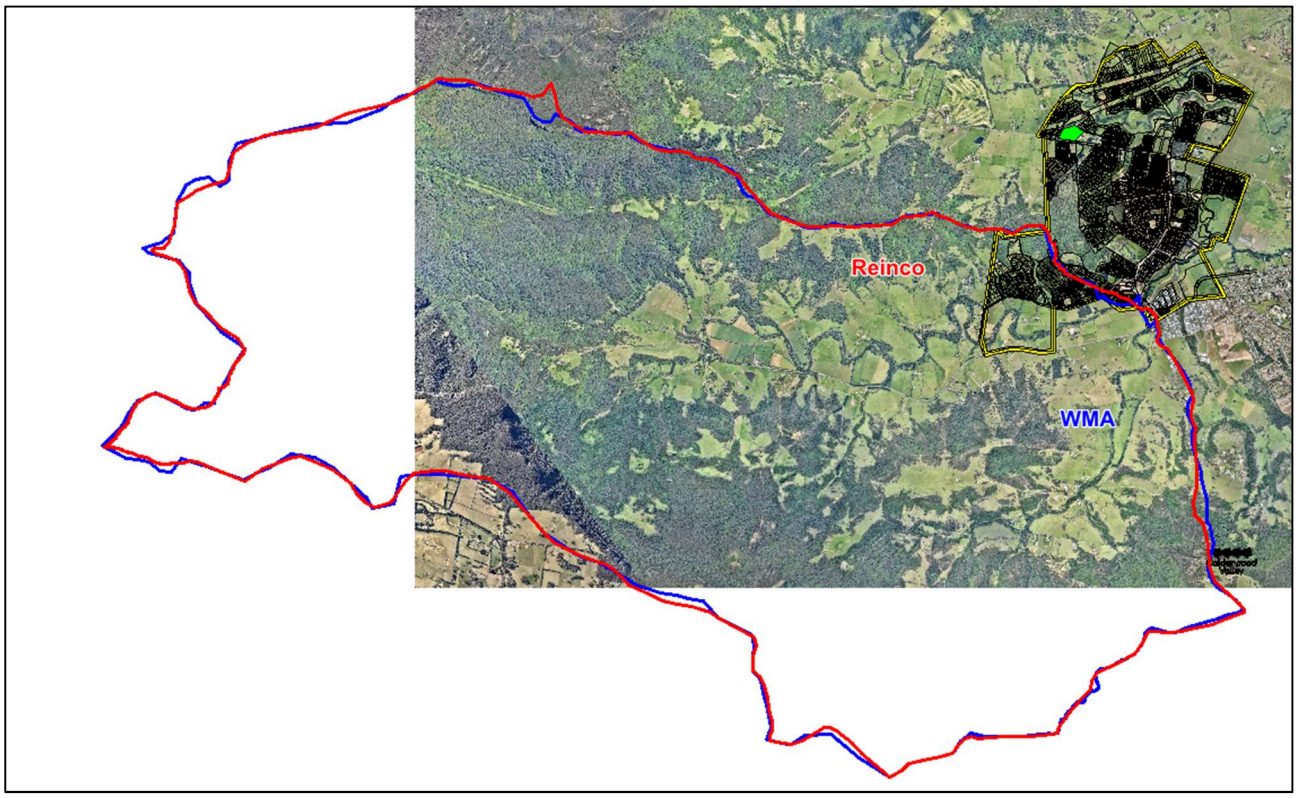



**Plate 9-2 – Model catchment comparison**

Notwithstanding this fact, the Reinco model used and approved as part of MOD3 to the Stage 1 project approval is also still valid. The WMAWater model does not render the Reinco model and the original Stage 1 approval invalid, and therefore Commitment 41 has and continues to be complied with for CUDP.

Appendix F also provides a detailed chronological approval process for Stage 1 Bridge prepared by Cardno, the Flood Engineer and designer of the Stage 1 bridge. The letter documents the approval of the Stage 1 bridge in detail.

As part of addressing in the public submission for MOD 4, further refinements including refining the modelling of the stage 1 bridge based on Work As Executed information has been completed. Full modelling results are detailed in Section 8 of the report; however, focus on the flood results surrounding the Stage 1 bridge is provided below.

The flooding with Stage 1 lots documented in the originals SEARS report that supported MOD4 has been managed by the inclusion of a blade wall on the southern side of Escapement Drive between the Stage 1 bridge and Brushgrove Circuit. The height of the wall varies across its length with a maximum height of 620 mm. This wall eliminates flooding within Stage 1 lots during the PMF event. This wall will form part of a future Development Application for SHCC approval and the resulting flood impacts are provided below in Plate 9-3.

The refinement of the flood modelling information for the Stage1 bridge including the work as executed information now results in the bridge being clear in the PMF and will provide a flood free access to the remainder of the Calderwood development.

Plate 9-4 illustrates the flood level changes over the 140m Macquarie Rivulet corridor and the corresponding freeboards is available.

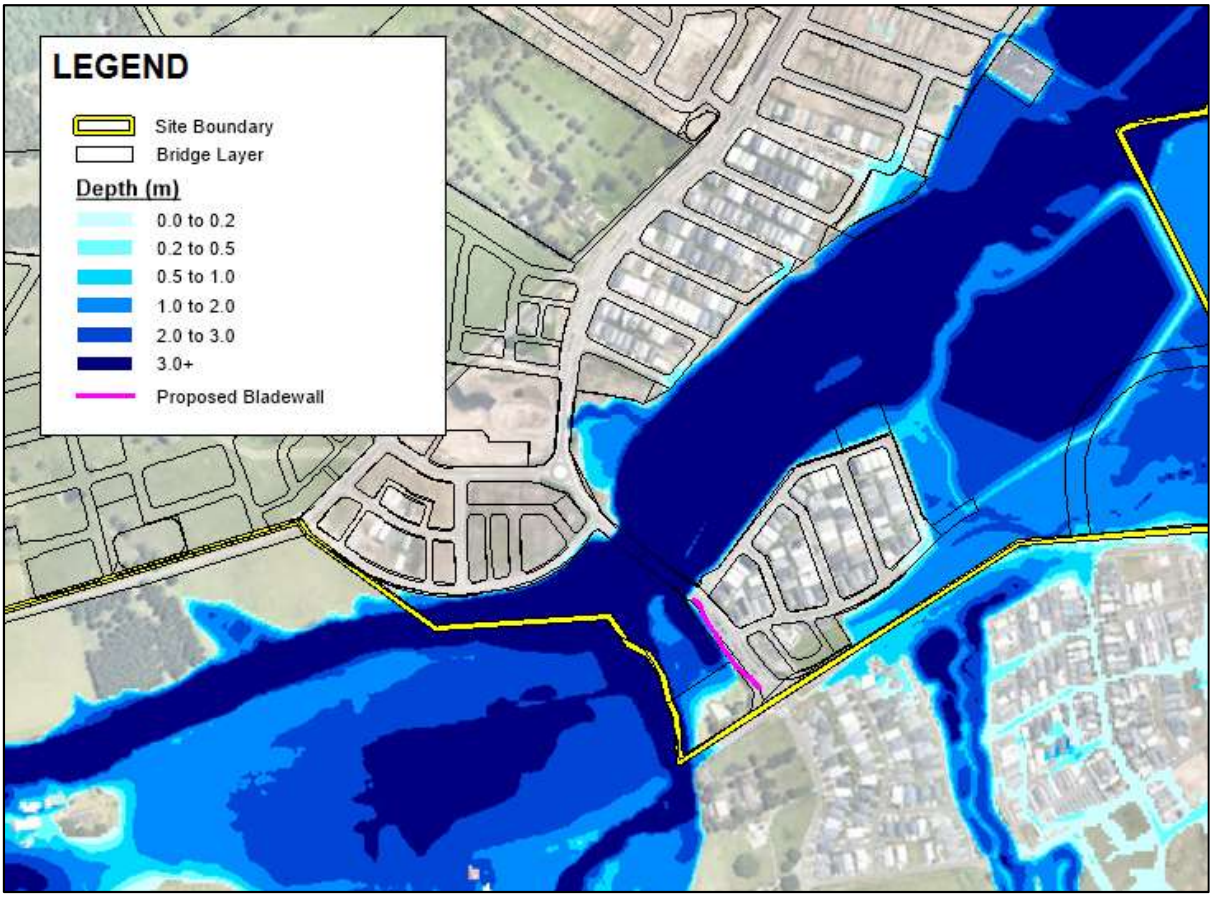



**Plate 9-3 – Updated Flood Impacts for Stage 1**

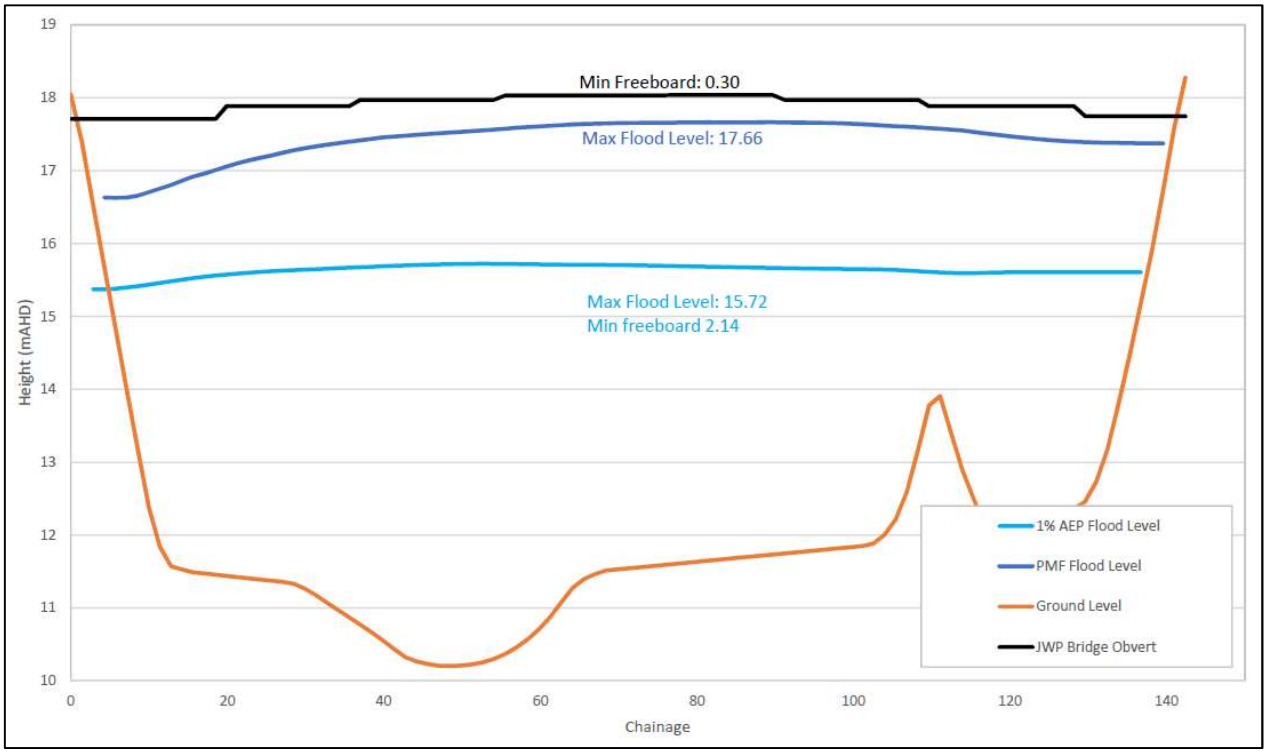



**Plate 9-4 - Stage 1 Bridge Flood levels**

It is our understanding that the 0.5m freeboard requirement for the deck level to being above the PMF flood level as detailed in MOD3 was to cater for the uncertainty that the finalisation of the Macquarie Rivulet modelling may result in. The timing of the MOD3 approval as detailed in Appendix F was such that the MOD 3 approval was granted before the release of the final WMA Water Macquarie Rivulet modelling completed by SHCC thus the reason for the conservative freeboard required included in MOD 3

This current assessment has now removed the uncertainty with the potential impact that the updated WMAWater Macquarie Rivulet modelling may have on the Stage 1 bridge and confirmed that a minimum of 0.3m freeboard is now available to the underside of the bridge during a PMF event consider the full development of the CUDP.

Therefore, it is our view that the intent of Commitment 41 was to ensure the flood free access was provided to CUDP in a PMF and this assessment has confirmed that flood free access is achieved. SHCC's position that the Stage 1 bridge requires amendment is not required.

# 10 RIPARIAN IMPACTS

Minimising riparian impacts is an important consideration for CUDP. The current developable footprint will be maintained as part of MOD4, the increase in lot density will be facilitated by an increase in smaller lots and denser housing product within the Town Centre.

The provided cut/fill plan on Figure 8.10 demonstrates that environmentally sensitive lands are located outside of proposed earthwork areas, so the environmentally sensitive lands will not be additionally impacted as a result of MOD4. The cut and fill plan indicates locations and depths of the proposed cut/fill areas which is generally consistent with the original Concept Plan Approval.

Other than where there are identified environmentally sensitive lands, the existing riparian vegetation is generally sparse or non-existent across the site, which is predominantly grazing pasture. It is proposed that these sparse riparian zones are restored by full structured riparian corridor post construction. Therefore, riparian vegetation conditions will be consistent with the original Concept Plan.

There will be no additional riparian impacts other than those accepted as part of the original Concept Plan.

# 11 CONCLUSION

This post exhibition report is a revision to the Water Cycle and Flood Management Strategy (JWP, July 2018) previously prepared to support the MOD 4 application for the Calderwood Urban Development Project (CUDP). The original WCFM Strategy report has been revised to address major issues raised in both public and agency submissions received in relation to the proposed modification.

Furthermore, Section 7 and 8 addresses key issue 8d and 11 from the Secretary's Environmental Assessment Requirements (SEARs), issued on the 1st February 2018. The key changes to the approved concept plan are detailed below.

## 11.1 Water Quality

The revised Water Cycle and Flood Management Strategy consists of a treatment train approach including on lot treatment, street level treatment and subdivision/development treatment measures. The structural elements proposed for CUDP now consist of:

- Proprietary GPT units at each stormwater discharge point.
- 29 wetlands, or other suitable alternative treatment device scattered across the development. Some of these devices have already been constructed.

The proposed water quality treatment system is consistent with the Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions. The outcomes of the water quality analysis comfortably exceeds the minimum load reduction targets required to 'maintain' health of Lake Illawarra and meets Council's required reduction targets.

## 11.2 Water Quantity

Detention is not required to reduce downstream impacts of the CUDP as indicated by modelling. Peak discharge levels throughout both Marshall Mount Creek and Macquarie Rivulet are not significantly increased as a result of the development.

## 11.3 Flooding

Flooding and flood evacuation are constraints for CUDP. The current developable footprint will be maintained as part of MOD4. However, the increase in lot density will be facilitated by the provision of an increase in smaller lots together with an increase in housing density within the Town Centre.

Therefore, runoff characteristics from the increased density will have minimal impact on flood affectation in both the Macquarie Rivulet and Marshall Mount Creek, the two major watercourses within the CUDP. These impacts will be managed as part of the ongoing development of CUDP.

The investigation concludes that the development of CUDP in accordance with this refined strategy will be consistent with the applicable controls and principles established by the NSW Government and both Shellharbour City Council and Wollongong City Council. Though there has been a refinement of design and solutions offered, the revised water cycle and flood management strategy remains consistent in philosophy with the original 2010 Concept Plan approval.

The report is suitable to support the proposed MOD4 amendments to CUDP and provides the framework with which to support the ongoing development from a water cycle and flooding management perspective.

## 12 REFERENCES.

Australian Rainfall and Runoff (ARR, 2016)

BMT WBM Tuflow Manual 2016

Cardno (Cardno, 2010) Floodplain Risk Management Study – Calderwood Urban Development Project – Concept Plan Application

Rienco Consulting (Rienco 2010) Flood modelling report – Macquarie Rivulet Below Sunnybank

WMA Water (WMA, 2017) Macquarie Rivulet Flood Study - Final

Wollongong City Council DCP (WCC, 2009) Wollongong Development Control Plan Chapter E13 and E14

WCMS Calderwood Urban Development Sage 3A, Cardno, 20 December 2017

WCMS Calderwood Urban Development Stage 3B South, Cardno, 21 December 2016

Calderwood Urban Development Stage 2C Detailed Design, Cardno, 7 February 2018

WCMS Calderwood Urban Development Stage 2, Cardno, 29 July 2016

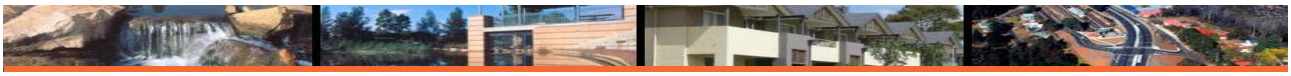
Calderwood Urban Development Project Stage 1, Cardno, Rev 3 March 2011

Calderwood Urban Development Project WCMS, Cardno, February 2010

Calderwood Urban Development Project, JBA Urban Planning, August 2010

# APPENDIX A – J. WYNDHAM PRINCE LETTER RESPONSE TO PUBLIC SUBMISSIONS

J. WYNDHAM PRINCE
CONSULTING CIVIL INFRASTRUCTURE ENGINEERS
& PROJECT MANAGERS



ABN 67 002 318 621

**Our Ref:** 110073-07-Submissions Response Letter.docx
DC:as

11 April 2019

Lendlease
Level 2, 88 Phillip Street
Parramatta NSW 2150

**Attn:** **Sarah Kelly**

**Subject:** **Calderwood Urban Development Project – Section 75W Application - Watercycle and Flood Management**
**Public Exhibition Submission**

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Dear Sarah,

Further to the public exhibition by the NSW Department of Planning and Environment (DPE) of the Section75W Modification (MOD4) to the approved Concept Plan for the Calderwood Urban Development Project (CUDP) in October 2018, a number of public and agency submissions have been received in relation to the proposed modification. A large proportion of the submissions raised concerns with J. Wyndham Prince's Watercycle and Flood Management Strategy Update Report (JWP, July 2018) that supported this application.

This letter details our response to all the major issues raised associated with the Watercycle and Flood Management Strategy Update Report (WCFM) with specific attention to the following submissions:

- Wollongong City Council
- Shellharbour City Council
- Department of Industry (Lands and Water Division)
- Office of Environment and Heritage
- NSW Environment Protection Authority, Wollongong
- Department of Planning & Environment

We have listed each public submission comments (in **bold**) and provided a detailed response to the issues raised below each comment. Full details of our responses are provided in Attachment A.

The WCFM report has also been updated in order to address the major issues raised in the public submissions.

Notwithstanding the further review by DPE of this response letter and the updated WCFM report, it is our view that the current WCFM has already addressed a considerable number of issues raised in the public submissions and delivers a compliant WCFM assessment in order to support the approval of MOD4.

Should you have any queries regarding this matter, please do not hesitate to contact me.

**J. WYNDHAM PRINCE**

**DAVID CROMPTON**

Manager – Stormwater and Environment Group

# ATTACHMENT A
## DETAILED RESPONSES

## Wollongong City Council Submissions (5 Nov 2018)

Wollongong City Council (WCC) has prepared a detailed submission to the proposed modification of CUDP. The submission has commented on a range of issues for planning, transport and community facilities. We have addressed some of the concerns listed at Item 8 – Riparian Impacts as they related to the WCFM together with the concerns raised within Item 11 – Drainage, Water Quality and Flooding.

### WCC Item 8 – Riparian Impacts

**In the absence of demonstrating consistency with objects and provision of the *Coastal Management Act* 2016 detailed impact assessment on the mapped Coastal Wetlands and buffers will be required for future DA's.**

The proposed water quality treatment devices are consistent with the 2010 Concept approval and subsequent approved Staged assessments. Nevertheless, detailed assessment for the treatment devices will be carried out for future Stage DAs. Refer to Section 7 of the revised WCFM for more information.

**At minimum all relevant studies in the EA should have reviewed and incorporated consideration and discussion of the Risk-based framework for considering waterway health outcomes in strategic land-use planning decisions (OEH 2017) to provide consistency with Directions 5.1 and 5.4 of the Illawarra Shoalhaven Regional Plan (DPE, 2015).**

**The Ecological (2018) and JWP (2018) reports have entirely overlooked the Illawarra Water Quality and River Flow Objectives for the Illawarra catchments including but not limited to the Water Quality Objectives for protection of, aquatic ecosystems and secondary and primary recreation contact and River Flow Objectives for maintaining 'natural rates of change in water levels' through measures to, 'Maintain natural flow variability' and 'Manage groundwater for ecosystems' amongst other things.**

The Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions' was developed by EPA/OEH to provide management outcomes for the impact of various land-use activities. It allows decision-makers such as environmental regulators and Councils to determine management responses required to meet waterway health objectives. The purpose of this framework is to:

- Identify waterway objectives that support the community's environmental values and uses
- Identify waterway areas/zones that require protection
- Distinguish catchment areas where cost-effective management responses reduce impacts of land-use activities on waterways
- Achieve sustainable, practical, socially and economically viable environmental performance levels by supporting management of land-use developments.

The document was released in May 2017 and includes a case study carried out to identify cost-effective stormwater management responses and strategies to accommodate urban growth in the Lake Illawarra catchment while maintaining and/or improving the water quality and health of the lake. Design and implementation plans for Lake Illawarra were not developed as part of the case study but are currently being discussed by relevant stakeholders involved in managing Lake Illawarra. However, a 'benefits map' was developed for this case study (see Plate 1), to assist with design and implementation of the framework. The benefit maps reflect a trade-off between meeting the sustainable loads, Council's management responses and concerns of ongoing stormwater management. The case study does not provide specific pollution reduction targets for the CUDP and no such data is publicly available at present. Therefore, the benefits map has been applied for CUDP in order to maintain or improve stormwater controls and the CUDP is consistent with this map.

While it is acknowledged Shellharbour and Wollongong Councils are working together with OEH to have the Risk Based Framework implemented as part of the Draft Lake Illawarra Coastal Management Program (CMP) prior to this implementation, it is suggested the basis in which CUDP

can be assessed against this future framework is by using the case study and the associated "Benefit Map" which forms part of the case study.

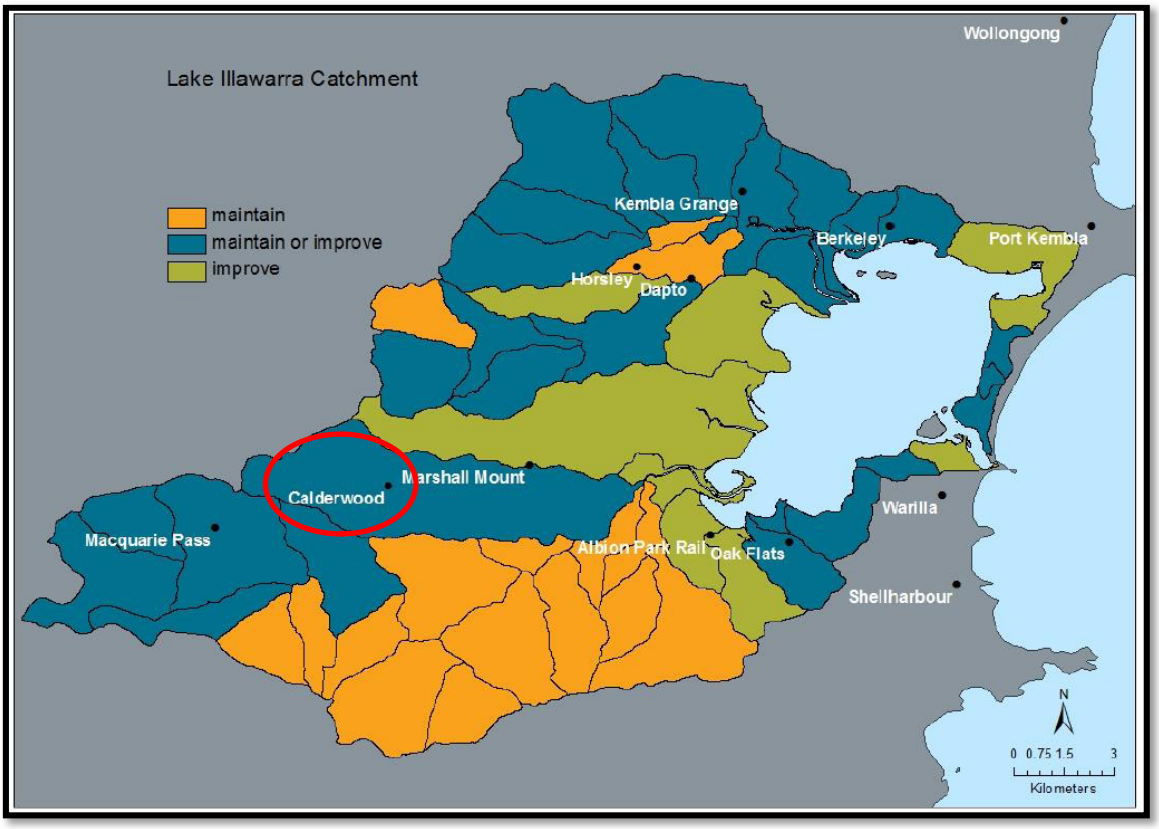



**Plate 1: Benefit map identifying priority areas for cost-effective stormwater management in Lake Illawarra catchment.**

It is evident from Plate 1 that CUDP is located in the "blue areas" which have been identified in the case study to 'maintain or improve' stormwater controls and as a minimum achieve the load reduction targets of the relevant Council. The minimum pollutant reduction targets required to be achieved in Wollongong Council's WSUD (Water Sensitive Urban Design) guidelines are presented in Table 1 below. Refer to WCC DCP 2009 Chapter 15 for further information.

The proposed water quality treatment system proposed as part of MOD4 comfortably exceeds the minimum load reduction targets required to "maintain" the health of Lake Illawarra. Refer to Section 7.3 of the Watercycle and Flood Management Report (JWP, 2018) for the supporting modelling and comprehensive results.

**Table 1: WSUD Stormwater Quality Performance Targets (WCC DCP, 2009)**

| Performance target reduction loads* | Development Type | |
|---|---|---|
| | Residential Subdivisions greater than 20 lots<br><br>Industrial Subdivision<br><br>Business Parks | Multi-dwelling housing development<br><br>Residential Flat Buildings<br><br>Mixed Use Developments<br><br>Minor Residential subdivisions (up to 20 lots)<br><br>Commercial Office Development<br><br>Industrial Development |
| Gross Pollutants | 90% | 90% |
| Total Suspended Solids | 85% | 80% |
| Total Phosphorus | 60% | 55% |
| Total Nitrogen | 45% | 40% |

Therefore, the water quality assessment and management approach proposed as part of the MOD4 assessments not only "maintain" the load reduction required by Wollongong City Council, but the treatment devices exceed the targets. It is noted that CUDP is a State Significant Project and is not subject to local government development and planning controls. MOD4 Water Quality assessment complies and duly considers the Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions and Council's Water Quality objectives as they have been defined at present.

**WCC Item 11 – Drainage, Water Quality and Flooding**

**The report states (page 34) that the Calderwood Urban Development Project (CUDP) is consistent with the controls by Wollongong City Council. However, upon viewing the flood maps provided, it is clear that the development is inconsistent with Wollongong City Council Local Environmental Plan (LEP), 2009 and Wollongong Development Control Plan (DCP), 2009 controls. From an LEP perspective, the development has not demonstrated: (i) suitable evacuation from the land, (ii) maintaining the existing flood regime and flow conveyance capacity, and (iii) avoiding significant adverse impacts on flood behaviour and affectation of other properties. From a DCP perspective (Chapter D16), the development has not demonstrated: (i) the creation of all new residential lots to be above the 1% AEP plus 0.5m freeboard, (ii) no net removal of floodplain storage capacity.**

In 2009, CUDP was declared a State Significant Project under the State Environmental Planning Policy (SEPP) 2005. The SEPP rezoned the land to permit urban development and as a result, removes the need for CUDP to comply with both Wollongong City Council and Shellharbour City Council's Local LEP. The provisions particular to the Project site are found in Part 28 Schedule 3 of the State Environmental Planning Policy (State Significant Precincts) 2005. No local environmental plan is applicable to the Project site (refer to Clause 5 of the SEPP).

Therefore, WCC's LEP and associated guidelines do not apply to the CUDP. CUDP needs to comply with the SEPP and the approved Concept Plan including the relevant Water Cycle Management Report. Therefore, the need to maintain existing flood regimes, flow conveyance or to have no net removal of the floodplain storage capacity up to the PMF as set out in the WCC LEP and DCP and associated guidelines is not applicable.

The flood evacuation strategy has already been approved for all CUDP residents as detailed in Section 5.6 of the Floodplain Risk Management Study - Calderwood (FPRMS) (Cardno, 2010) which detailed that evacuation is not required and therefore a "shelter in place" strategy results in less risk to life. There is no need to determine a flood evacuation strategy for CUDP or Yallah-Marshall Mount area in order to support the MOD 4 modification due to its consistency with the original FPRMS.

**The report states (page 32) that flood free access in the local Probable Maximum Flood (PMF) event for emergency services will be achieved to the north portion of the CUDP within the Wollongong LGA. However, the strategy for flood access has not been determined for the Yallah/Marshall Mount area. There is no current flood free access route from Yallah-Marshall Mount to the CUDP. Council has not seen a design for the Escarpment Drive Bridge over Marshall Mount Creek. Thus, it is unclear how a substantially new development area (CUDP) can rely on a flood access strategy through Wollongong LGA that has not yet been determined. This outcome typically results in additional ongoing pressure on the Emergency Services to assist in times of flood.**

While the specific engineering details are still to be finalised, the WCFM Strategy has tested a proposed bridge structure over Marshall Mount Creek in the hydraulic (TUFLOW) modelling. The result demonstrated that flood free access via Escapement drive can be provide to north portion of CUDP.

As mentioned above, the evacuation strategy for CUDP is for all residents to "shelter in place" therefore there is no need to determine a flood evacuation strategy for CUDP or Yallah-Marshall Mount area in order to support this modification.

CUDP does not need to rely on any flood evacuation strategy from the adjacent catchment. The original FPRMS (Cardno, 2010) required that vehicle access to CUDP is required in a PMF event across both the Macquarie Rivulet and Marshall Mount Creeks. The Stage 1 approved bridge and the proposed bridge across Marshall Mount Creek (i.e. Escarpment Drive bridge) deliver this requirement. The design and location of Escarpment Drive ensures that the bridge provides safe evacuation routes during the PMF event.

It is also understood that WCC are concerned about how emergency service personnel will travel to CUDP during a flood event. The access to CUDP via roads outside of CUDP is not a matter to be dealt with in the MOD 4 application.

The flood assessment completed as part of MOD 4 also complies with Statement of Commitment No. 41. The accepted PMF flood impacts as part of MOD 3 remain consistant in the MOD 4 assessment and there are no additional impacts associated with MOD 4 outside the accepted impacts detailed in the previous MOD. Therefore the MOD 4 has delivered:

- Minimum 0.5m freeboard will be provided to flood affected properties in the 1% AEP event.
- Safe evacuation routes during the 1% AEP flood event have been provided for the development located within the PMF.
- Bridge decks for approved Macquarie Rivulet and proposed Escarpment Drive bridges (across Marshall Mount Creek) have been designed above the 1% AEP flood level to allow uninterrupted road traffic throughout the development during events up to and including the 1% AEP flood, and
- Design and location of all major spine roads (i.e. Escarpment Drive) within the CUDP development are currently at or above the PMF level.

**The report is silent on the potential loss of flood storage for any storm event and also the potential cumulative impacts associated with the proposed land form. These considerations are required as part of undertaking floodplain risk management studies for catchment areas according to the NSW Floodplain Development Manual (2005).**

The loss of flood storage is consistent with the approved 2010 Concept Approval assessment. The 2010 concept design approval demonstrated that CUDP does not result in an unacceptable flood impacts downstream of CUDP. The 2010 assessment included similar reduction in floodplain storage which forms part of this modification application.

The comprehensive flood assessment completed as part of this modification application demonstrates that the loss of floodplain storage does not result in flood impact in either the 1% AEP and PMF event..

Furthermore, the NSW Floodplain Development Manual (2005) discusses the definition of flood storage as *"those parts of the floodplain that are important for the temporary storage of flood waters during a passage of a flood"*. The manual also mentions that the loss of floodplain storage can also cause a significant redistribution of flood flows.

The WCFM Strategy demonstrates that the proposed loss of floodplain storage does not result in a redistribution of flood flows, nor results in flood impacts outside of CUDP in excess of that which has already been approved under the court approved Concept Plan and the Stage 1 Project Approval (NSW Land and Environment, Matter No. 10492 of 2012). Thus, the assessments are compliant with the NSW Floodplain Development Manual (2005)

The assessment has considered the impacts of loss of floodplain storage by modelling the change in landform in the model and modelling the hydrograph from the WBNM model (not a steady state flow). The resultant flood level changes are included in Appendix C and show there are no adverse impacts predicted.

**It is unclear how the effects of climate change, as required by Item 11 of the SEARS, were modelled and implemented across the proposed landform for this modification.**

Given the PMF assessments which are not influenced by climate change impacts, demonstrated acceptable flood outcomes, any minor event with climate change consideration (i.e. 1% AEP) will not result in any measurable changes in flood levels greater than the flood levels of a PMF event. Notwithstanding this position, an assessment of flooding impacts for the 1% AEP including an assessment of the effects of climate change is included in the revised WCFM strategy report.

Figure 8.09 shows that the increase in flood levels with the uplift in dwelling yield under a climate change scenario are less than 0.5m The floodplain development manual states that freeboard is a factor of safety that considers the "changes in rainfall patterns and ocean water levels as a result of climate change".Therefore the 0.5m of freeboard is suitable for accounting for increases in rainfall that could occur in the future due to climate change.

**Figure 3 of the report indicates areas of proposed cut and fill across the site, however does not indicate the maximum depths of cut/fill. In this respect, it is unclear whether the proposal satisfies item 9 of the SEARS relating to potential visual impacts associated with the amount of cut/fill proposed.**

A comprehensive landscape/restoration plan will form part of the future DA for WCC's consideration. A cut and fill plan has been provided as part of the revised WCFM which indicates locations and depths of the proposed cut and fill. Refer to Figure 8.10 for details. Any visual impacts of the proposed cut/fill will be addressed as part of future DA assessments.

**Figure 7 of the report indicates significant flood affectation in the 1% AEP (Annual Exceedance Probability) in Stage 5 south. Apart from being a poor outcome for a greenfield site, no evidence has been provided on how the flood risk to future development will be managed and whether the flood planning level (i.e. 1%AEP + 0.5m) will be achieved.**

Stage 5 south is not flood affected in the 1% AEP and is located on the northern side of North Macquarie Road (refer to Figure 4 Indicative Subdivision Plan in the Environmental Assessment Report prepared by Ethos Urban dated 24 July 2018). WCC is likely referring to the "non-core" land located on the southern side of North Macquarie Road (refer to DA No 577/2017). Nevertheless, the original modelling surface did not account for the proposed development at 128 North Macquarie Road, Calderwood (non-core landowner). The surface information has been updated as part of the revised Watercycle and Flood Management Strategy to reflect this proposed development, and Figure 8.04 indicates that 128 North Macquarrie is now flood free.

**Figure 8 of the report indicates significant flood affectation in the 1% AEP over a road in Stage 5 north. It is unclear how future residents in this location will achieve 1% AEP flood free access during this storm event and compliance with Item 41 of the statement of commitments.**

As mentioned above, the surface information has been updated as part of the revised WCFM strategy report which has resolved any impacts surrounding Stage 5.

**Figures 8 and 13 of the report indicate significant increased flood affectation (>0.4m) downslope of the CUDP for both the 1% AEP and PMF events, with no explanation on how these impacts will be managed. This is contrary to Item 11 of the SEARS report.**

Flood affectation downstream of CUDP for both 1% and PMF events is consistent with the original concept approval that indicated that flood impacts downstream of the site are between 0.02 – 0.2 m. Flood affection in PMF downstream of CUDP is illustrated in Figure 8.08 of the WCFM strategy and complies with the MOD 3 Terms of approval for the Stage 1 Project application: Part B of Condition B26.1, which states to "minimise off-site impacts in the PMF event such that the maximum increase does not exceed 0.3 m".

As this document sets the conditions of consent for the precinct, compliance with these terms is appropriate for the Mod 4 approval.

**Figure 12 shows between 0.5-1.0m of flood affectation in the PMF to the town centre (east) and residential areas Stage 7A, Town Centre and stages 4, 8, 9. It is unclear how the flood risk to future development will be managed for this event.**

**Figure 13 shows significant increased flood impacts in the PMF (>0.4m) within the Wollongong LGA, school site, retirement site and town centre east when compared to the existing scenario. It is unclear how flood risk to future development in these areas will be managed for this event. Also, it is unclear what the maximum increase in flood levels are within the affected areas.**

**Figure 14 shows significant increased flood impacts in the PMF, however it is unclear what the maximum increase in flood levels are for the affected areas.**

While this is acknowledged that flood impacts are present in the PMF event within Stages 8 and 9, it is important to note that, no formal landform design north of Mount Marshall Creek has been completed. Given the depth of inundation in PMF event is only between 0.5 -1.0 m, in Stages 8 & 9 located in WCC LGA, conveyance of PMF flows will be managed by an appropriate road and drainage design as the development progresses and will reduce any "extreme event" impacts. Furthermore, adequate 0.5m freeboard will be provided to flood affected properties in the 1% AEP event through site filling. The maximum increase in flood levels for the PMF event are indicated in Figure 8.08 of the WCFM report.

We have also prepared a detailed local PMF assessment that demonstrates the management of local PMF flows and this is included in Section 8 of the revised WCFM report. Further refinement has also been completed for surface levels for stages 8 & 9 surrounding Mashall Mount Creek which demonstrates that PMF impacts will be reduced once a detail subdivision design is completed.

**A map should be provided indicating the differences between the 1% AEP and PMF events for the CUDP to identify the potential flood affectation beyond the flood planning level of 1% AEP + 0.5m.**

Figure 8.05 and Figure 8.08 provide the 1% AEP, and PMF flood differences maps are provided within the WCFM strategy report. As there is no requirement for lots to be above the PMF, provision of flood affectation maps above the flood planning level is not necessary.

**There is no information in the report on the assumptions made for Manning's roughness and % imperviousness for the proposed development. This information is critical in the assessment of flood reports.**

Table 8-1 of the Watercycle and Flood Management Strategy report details the Manning's roughness used in the assessment, which is consistent with the Floodplain Risk Management Study prepared for the 2010 Concept Plan Approval (Cardno, Mar 2010). The Manning's roughness assumption

used is a depth variable Mannings based on the flow depth within discreet areas of the model (i.e. roughness reduces with increasing flow depth) to reflect a 'realistic' flood scenario.

Percentage impervious are based on those used in the WMA model plus modification as shown in section 8.1.2 of the report.

## Shellharbour City Council Submissions (SHCC) (8 November 2018)

Shellharbour City Council (SHCC) has also made a comprehensive submission to the proposed modification to CUDP. SHCC submission touches on a range of issues in particular Water Cycle and Flood Management. Section 2 of the SHCC "Detailed Assessment and comments" are addressed below:

**A new flood model – as part of this MOD4, Lendlease has engaged a new flood consultant to review the flood modelling undertaken as part of the previous approvals. This new modelling is based on Council's Flood Study (adopted in 2017). Lend Lease's consultant J. Wyndham Prince has incorporated as-constructed aspects of the Calderwood development into the model. It is evident from the model results that various points in the statement of commitments are now shown to be inconsistent with respect to flood risk and management of that risk. (e.g. Commitment 41). Specifically, the bridge over the rivulet built as part of stage 1 was intended to be designed such that it would provide flood free access. However, the new modelling indicates that this is not the case (see image below).**

**Council believes that Lendlease must address this issue and provide details regarding what remedial works they propose to undertake in the floodplain to ensure that the flood free access can be met and that all commitments in the statement of commitments are being satisfied.**

**Furthermore, Council is now examining what notations it should be placing on planning certificates whilst this issue is being resolved. This may include placing a notation on those properties that are now identified as flood prone that under the original Flood Management Strategy were not flood affected.**

The previous modelling indicates that some areas in Stage 1 of CUDP are impacted by floodwater entering the subdivision for the Macquarie Rivulet in the extreme PMF event. This is due to the different input data between the current model and that used as part of the MOD 3 (for Stage 1) assessment.

The current SHCC flood model, which is the adopted flood model of SHCC, suggests that there is an extra 323 $m^3/s$ (14% increase in flows) passing under the Stage 1 bridge during the extreme PMF event in comparison to the flows adopted and approved as part of the Stage 1 court approval.

As part of the consultation process with SHCC, J. Wyndham Prince met with SHCC staff on 15 March 2018. It was agreed at this meeting that the court approved developments needed to form the basis of establishing the "new existing" condition flood extent, and any reported impact that may be identified as result of the using the new Macquarie Rivulet flood model would, as it was court approved, be accepted by SHCC. It is confirmed that the bridge still provides flood free access based on the new flood modelling.

A detailed discussion on the Stage 1 bridge is provided in Section 9 of the WCFM report

**Flood Impacts – It is evident from the flood maps that there may be significant and far reaching impacts in some areas downstream of the development.**

Flood impacts for CUDP and downstream are no greater than what was indicated in the 2010 approved Concept Plan in regard to the 1% AEP event and complient with Condition B26.1 of Mod 3 for the Stage 1 approval. As this document sets the development planning framework, thus compliance with these terms is appropriate for the MOD 4 approval. For the PMF event, impacts are less than 0.3 m external to CUDP is acceptable. Figure 8.05 and Figure 8.08 of the WCFM also illustrates this compliance.

**The Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-Use Planning Decisions is referenced in the Watercycle and Flood Management Strategy and has been recommended by EPA/OEH. The report incorrectly states that**

**"*Neither Shellharbour City nor Wollongong City Councils indicated that this work had already been performed for the Lake Illawarra catchment and did not indicate expectations that the proponent would develop or apply such a framework to the CUDP."***

**Shellharbour and Wollongong Council are working together with OEH to have the Risk based Framework implemented as part of the Draft Lake Illawarra Coastal Management Program (CMP). The Department needs to consider how the Risk Based Framework will be enforced when the Lake Illawarra CMP is approved by the Minister.**

As discussed earlier in relation to the WCC response, the Risk-Based Framework has been considered and the CUDP is compliant with the framework. The CUDP development is located in the "blue area, as shown in Plate 1, which has been identified in the Risk-Based Framework to 'maintain or improve' stormwater controls. The proposed water quality treatment system proposed as part of MOD 4 meets the minimum load reduction targets required to maintain the health of Lake Illawarra. The MOD 4 Water Quality assessment complies with and duly considers, the Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions and Council's Water Quality objectives as it has been defined at present.

Extensive consultation was completed as part of the SEARS preparation with SHCC and WCC. At these meetings, there was no mention by either Council of the Risk Based Framework being a control document that needed to be considered nor was the risk-based framework targets provided by either Council in order to incorporate these amended targets into these assessments.

**The Reinco Flood Model – The MOD4 application proposes to be informed by the new flood modelling (which is based on Council's Adopted Flood Study model). Council is unclear about what this means for the developers within the non-core lands that are currently seeking DA approval for applications that are based on the previous Reinco/Cardno modelling. Are these developers expected to abort all work done using the Reinco model and use only the new JW Prince model that is based on Council adopted flood study? The possible implications of developments currently being assessed should be addressed prior to the determination of the modification to the Concept Plan approval.**

It is recommended that Council carefully consider the updated flood flow and level information in assessing and determining future DA applications. The final flood model including all updates will be provided to SHCC for further use by SHCC as development in Calderwood continues.

It is recommended that all DAs approved and currently under assessment proceed with the previous modelling as they are consistent with the concept approval relevant at the time. It is recommended that the revised modelling be utilised for all DAs moving forward if MOD 4 is approved.

**It's unclear whether Council can reasonably manage the large increase in Stormwater treatment devices that will be handed over to Council as a result of the MOD4 (proposed a total of 27 wetlands which is an increase of 15 wetlands compared to the existing approval) It is likely to have a large impact on Council ability to be Fit For the Future. Comments from the EPA suggest options of ongoing maintenance of Stormwater improvement measures should be investigated, however the report provides no suggested solution other than Council to manage.**

Part A of the Determination for the 2010 Concept Plan Approval states that the development shall be in accordance with the "Preferred Project Report" by JBA[1]. Appendix L of the JBA report illustrates the approved Water Cycle Management Plan. This plan includes 31 water bodies across CUDP to deliver the water quality objective for the development. Refer to Plate 2 below.

[1] Preferred Project Report – Calderwood Urban Development Project, JBA Urban Planning, August 2010

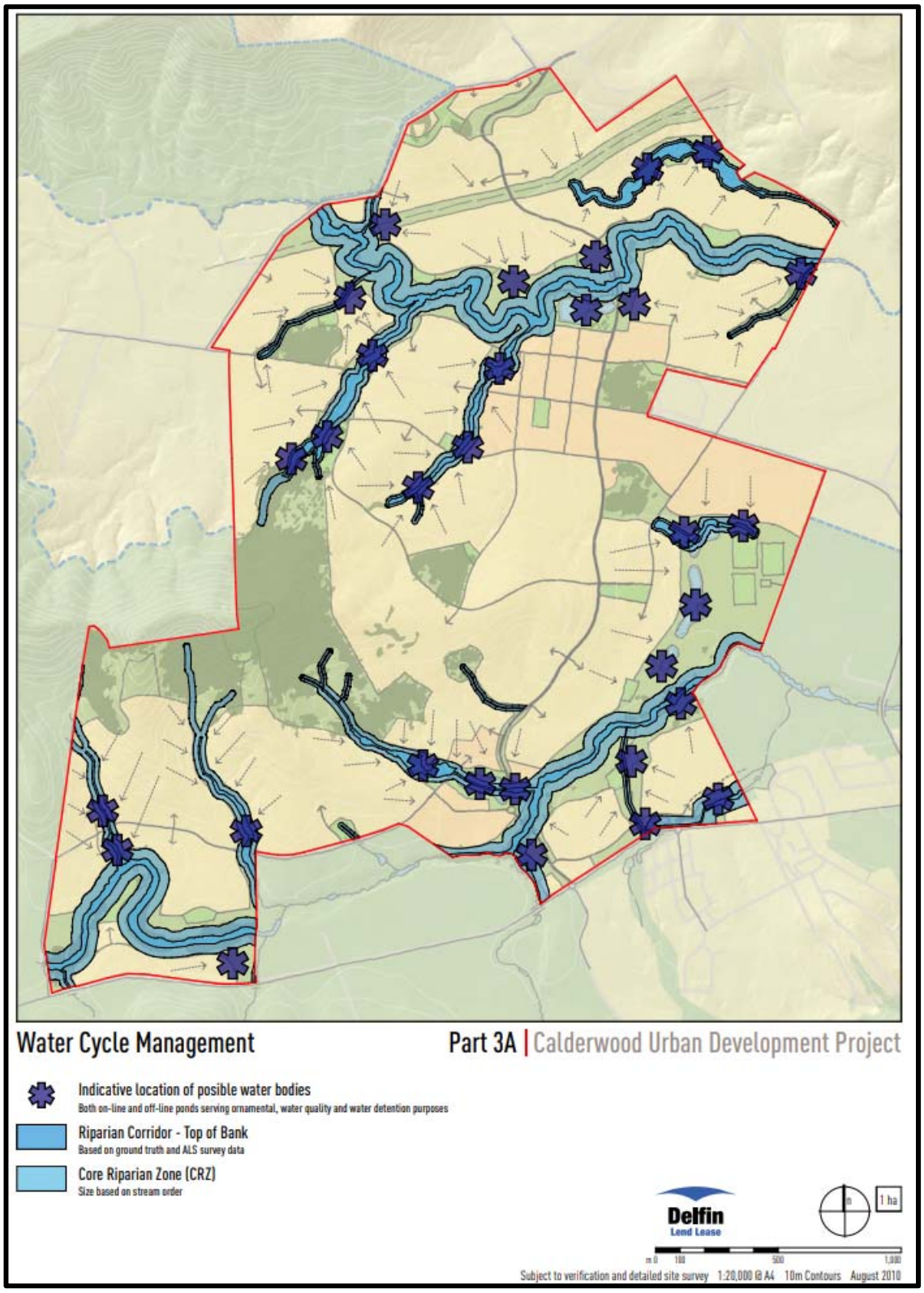



**Plate 2: Figure 15 – Approved Concept Plan Water Cycle Management Concept (*Consolidated Concept Plan, March 2011*)**

Furthermore, the Environmental Assessment Report carried out by Department of Planning Director General in 2010[2] states that "The Water Quality Control measures are considered to be satisfactory

[2] Calderwood Concept Plan Environmental Assessment Report, DoP Director General, November 2010

with regard to water quality both on and off site and address a number of concerns about potential impacts on Lake Illawarra raised by the Lake Illawarra Authority".

The MOD 4 assessment proposes a total of 28 stormwater treatment devices across CUDP which is a decrease from the 31 devices already approved as part of the Original Concept Plan. The proposed device locations assessed in MOD 4 are shown in Plate 4 Below.

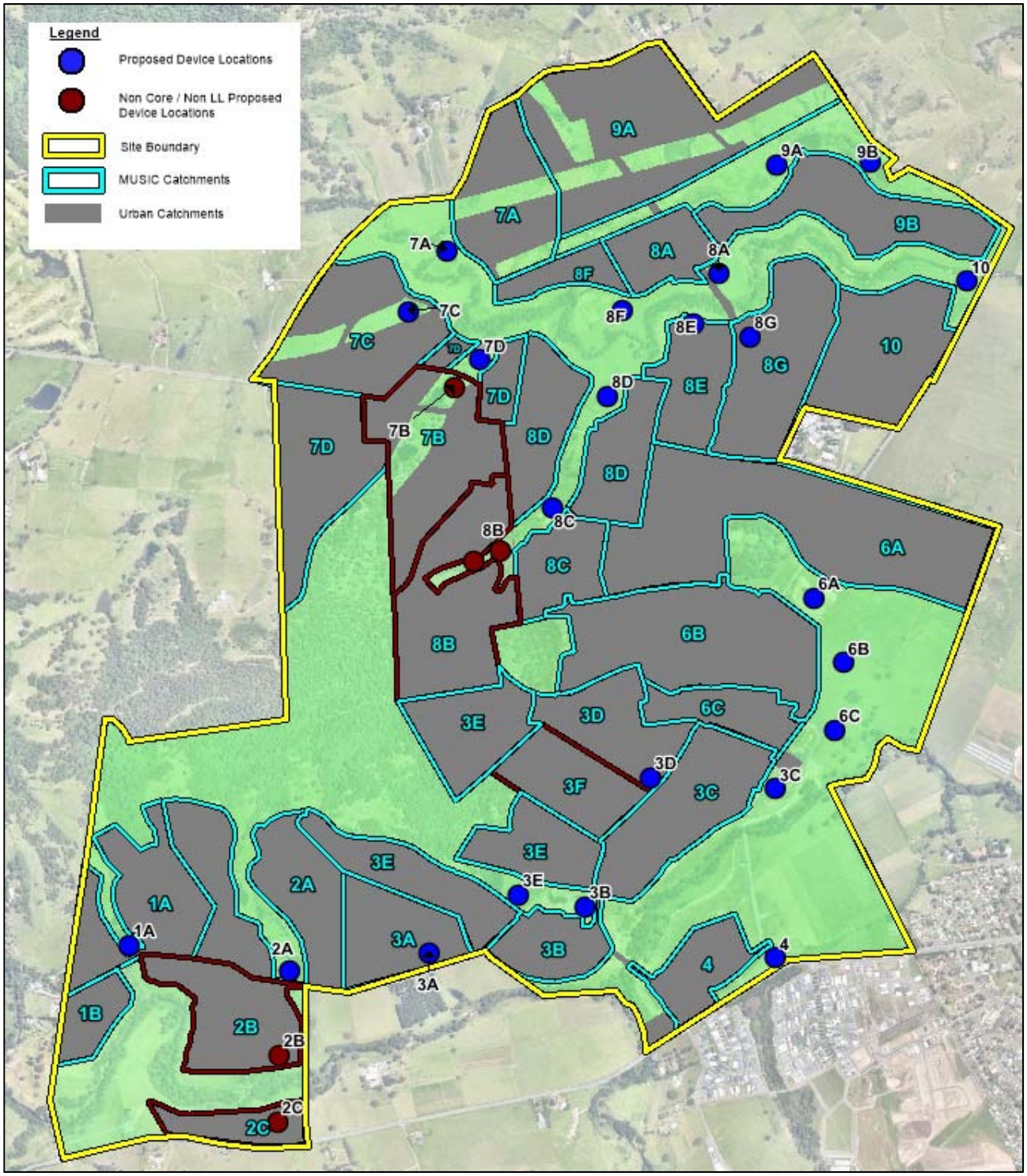



**Plate 3 - Proposed MOD4 device locations (JWP, 2019)**

**The assumed fraction impervious for residential areas appears to be too low (50-60%) Councils experience in Calderwood is that Residential areas typically have a fraction impervious of 70-80%. This would impact the Stormwater Quality Modelling performed as part of this report.**

As part of the proposed increase in density, Town Centre East, a portion of main Town Centre and the Education Precinct were initially modelled as 60% imperviousness as part of the Macquarie Rivulet assessment and increased to 85%-90% as part of the MOD 4 assessments. For other residential areas impacted by the proposed density uplift, these were initially modelled with a 60% impervious and this was increased to 75% (15% increase) for this assessment. Details of the assumed % impervious were detailed in Table 7.3 of the Section 75W Watercycle and Flood Management Strategy Report, J. Wyndham Prince, 2019 and have been reproduced for clarity below.

**Source: Table 7.3 – Modelling Input Parameters (JWP, 2018)**

| Area Type | Impervious Area % |
|---|---|
| Proposed Town Centre North | 90% |
| Proposed Town Centre East | 85% |
| Low Density Residential (R1) | 50% |
| Low Density Residential (R2) | 60% |
| Low Density Residential with proposed density uplift (R2) | 75% |
| Education Precinct | 50% |
| Non core-Invividual | 60% |
| Non core-Other Developer | 63% |
| Commercial/industrial | 95% |
| Road Reserve | 90% |
| Active Open Space | 50% |
| Passive Open Space | 10% |
| Forested Lands | 0% |

**Although Council has licenced our adopted Macquarie Rivulet Flood Model to J. Wyndham Prince for the purpose of undertaking this exercise, Council has had no assurance that there has been any quality assurance checks as to the updates made and any changes made to the model to support this application. It is suggested that a quality assurance check be performed by a peer reviewer to ensure that any changes made to the model are in accordance with industry standards and the TUFLOW user manual and guidelines.**

Section 8.2 of the WCFM strategy update report details the changes that have been made to SHCC model. All modelling files can and will be available for SHCC review and will be made available for any independent peer review if required.

**The flood modelling submitted with the MOD4 does not include any changes to Calderwood Road in terms of alignment (Horizontal and vertical) and form. However, other documentation within the MOD4 indicates that Calderwood road is required to be upgraded to accommodate the new development intensity. Council's knowledge of flooding and the floodplain attributes within Macquarie Rivulet means we have significant concern regarding the impacts detrimental upstream flood impacts that would occur if this road was required to be modified. As a large length of the road currently acts as a significant hydraulic structure, any raising of the road would have a significant and widespread backwater effect and impact on properties outside of the CUDP. This impact must be quantified, and additional information can demonstrate how or if those impacts can be managed prior to any determination of this application.**

Changes to Calderwood Road were incorporated in the latest review, and the flood impacts upstream of Calderwood road are minimal. Calderwood Road is not intended to be raised but may need minor widening in sections in order to support the new development intensity. Figure 8.04 of the Post

Exhibition WCFM report depicts the flood impacts upstream of Calderwood Road which satisfies Council's concern.

**There is little detail in the report about how flood risk above the 1% AEP will be managed and how risk to life is to be mitigated. In this regard, the question arises, will dwellings be subject to unacceptable flood hazard in extreme events and, will they be structurally sound enough to withstand forces of floodwater in extreme events?**

As indicated in the flood mapping, parts of the precinct are inundated by mainstream flows during the PMF event. Due to the short duration of PMF event, a flood evacuation strategy that provides residents with enough time to mobilise and evacuate the development is not available as it is not necessary to ensure the safety of the future population residing within the development. Figure 8.10 shows the hazards within the proposed development during a PMF event. This figure demonstrates that the majority of development areas inundated by PMF floodwaters are considered safe for buildings as they do not exceed category H4.

The MOD 4 assessment is consistent with the approved concept plan where the primary flood evacuation strategy is to "shelter in place" as this option presents the Lowest Risk to Life. The local PMF assessment also demonstrates that Risk to Life can and will be managed appropriately within CUDP. Minimum 0.5m freeboard will be provided to flood affected properties in the 1% AEP event to maintain the structural integrity of the dwellings and to withstand forces of floodwater in the design event.

**There appears to be a real opportunity to incorporate Stormwater Harvesting and reuse within the development area, as there are a number of nearby potential users of harvested stormwater for irrigation (e.g. Sports fields, schools etc.) This would result in a significant reduction in nutrient load and have a positive impact on the receiving waters including Lake Illawarra.**

The inclusion of stormwater harvesting and reuse schemes will be investigated as the detailed design of each stage of CUDP is completed. The proposed water quality treatment train assessed in MOD 4 meets the minimum load reduction targets required to 'maintain' stormwater controls without stormwater harvesting being considered.

It noted that, as part of the requirements for BASIX, each dwelling will be required to have a rainwater tank plumbed into toilets and/or laundry and outside taps. This reduces the volume of runoff and dependence on potable water. This system also results in no maintenance burden on Council.

## Department of Industry Submission (Lands and Water Division) (29 October 2018)

**The stormwater treatment trains proposed to be installed should be maintained over time to ensure ongoing and effective treatment of stormwater.**

Maintenance of all water quality devices will be the responsibility of Lendlease initially within the core lands with a transition to SHCC and WCC consistent with relevant consent conditions. In accordance with Condition 10 of Statements of Commitment, drainage works will be maintained in accordance with industry best practices for a period of 3 years prior to handover to the relevant public authority. This transfer will ensure ongoing and effective treatment of stormwater will be maintained.

## Office of Environment and Heritage Submission (10 October 2018)

**It is suggested that you seek further clarity on flooding impacts on the safety of future occupants, including emergency services accessibility, across the full range of flood events up to the probable maximum flood (PMF) and inclusive of climate change.**

**The proposed reduction in flood protection for significant development areas should also be carefully considered, notably in the development stages north of Marshall Mount Creek. This is particularly the case given the proposed increased density and the existing approved concept plan, which maintains flood-free development areas up to the PMF (hence allowing for climate change).**

**We suggest the proponent consult with Shellharbour City Council as to how water quality objectives and targets for the proposed development will be achieved, consistent with the NSW Government's Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions, coastal management and regional planning frameworks applicable to the Calderwood site.**

No formal landform has been designed for the area to the north of Mount Marshall Creek. The current depth of inundation in the PMF event is between 0.5 – 1.0 m (refer to Figure 13 of WCFM (July 2018)) in Stage 8 and Stage 9. Conveyance of the PMF flows will be managed by road and drainage design as detailed design progresses for these stages. The current assessment was based on an indicative landform to represent the 1% AEP event + 0.5m freeboard. Nevertheless, an indicative landform has been developed and tested for the PMF event which shows reduced flood impacts in the PMF event. Refer to figure 8.07 of the Post Exhibition WCFM Report for details.

The evacuation strategy for the CUDP residents is "shelter in place" which is consistent with the Concept Plan Approval. The original 2010 concept approval required that vehicle access to CUDP is required in a PMF event across both Marshall Mount Creek and Macquarie Rivulet. The Stage 1 approved bridge and the proposed bridge across Marshall Mount Creek deliver this requirement. The design and location of Escarpment Drive ensures that the bridge provides safe evacuation routes during the PMF and allow uninterrupted road traffic throughout the development during events up to and including the 1% AEP.

An assessment of climate change (rainfall increase) for 1% AEP event was undertaken by increasing rainfall intensities by 15%. Results demonstrate that the 1% AEP with a climate change consideration will not result in significant changes in flood levels greater than flood levels of PMF event. Refer to Figure 8.09 for details.

Water Quality objectives and targets are consistent with the approved Concept Plan. In relation to the NSW Government's Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning document, as mentioned previously, CUDP is located within the "blue areas", as shown in Plate 1, which is required to 'maintain or improve' stormwater controls. The current water quality objectives and targets are consistent with this Framework and improves the water quality outcomes for the development. Refer to further discussions above in the WCC response.

## NSW Environment Protection Authority, Wollongong Submission

**The Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions (the Framework) has been developed to provide a structured approach to considering the potential impacts of land use change on a waterway and to identify appropriate management responses to ensure that desired uses of a waterway can be met. The framework brings together existing policy and guidelines in the National Water Quality Management Strategy in a risk-based framework. By using the framework, practitioners can identify least-cost management responses across all sources of waterway impacts to meet specified water quality and river health outcomes in a robust, evidence-based decision-making framework.**

**The Framework is recognised in the Illawarra Shoalhaven Regional Plan, Greater Sydney Regional Plan and supporting District Plans. It was published in May 2017.**

**This framework should be used to help inform water management decisions in relation to the Calderwood modification especially as the proposal is within the Lake Illawarra catchment. The proponent should provide an assessment under this framework for consideration by OEH and EPA.**

As outlined in more detail in the response to WCC Item 11, The Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning and the associated case study has determined the catchment that includes CUDP is to maintain or improve stormwater quality. Figure 2 with the case study indicates for the "blue areas", as shown in Plate 1, is "designed

to provide more flexibility" in the quality outcome. Furthermore, as a "bare minimum" the development within the blue area should apply the load reduction target of the local Councils.

The assessment completed for MOD 4 exceeds the minimum standard thus improves the quality of stormwater runoff and therefore complies with the Risk Based framework.

## Department of Planning & Environment Submission (8 February 2019)

**Please address the issues raised by the NSW Office of Environment and Heritage (OEH) and both local Council regarding the potential flooding impacts associated with the proposal and demonstrate the proposal would not result in any adverse flooding impacts.**

This letter has addressed issues raised by OEH and both Shellharbour City Council and Wollongong City Council regarding potential flooding impacts associated with MOD 4. The flood assessment is consistent with the Approved Concept Plan, and results demonstrate that the proposed changes to the development in MOD 4 would not result in any additional flood impacts.

**Please clearly outline any proposed changes on non-core lands and assess any potential impacts on those lands as well as implications for lodged and /or determined DA's. Please note: owner's consent should be provided for any proposed changes within the non-core lands.**

The current flood model incorporates the information provided by the non-core land developers to reflect their proposed developments. There are no additional changes considered on the non-core land as part of this assessment.

**In accordance with the EPA and Shellharbour Council's recommendations, please provide an assessment of the proposal against the requirement of the *Risk-based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning Decisions.***

The Risk-based Framework has been considered and the CUDP is complaint with the framework. The CUDP development is located in the 'blue area' as shown in Plate 1, which has been identified in the Framework to 'maintain or improve' stormwater controls. The proposed water quality treatment system as part of MOD 4 meets the minimum load reduction targets required to maintain Lake Illawarra's health.

**The submitted cut and fill plan indicates earthworks across the CUDP (including already developed areas). It is unclear which earthworks have already been approved/developed and which are proposed under MOD 4. Please clarify on a plan, including locations and depths of the proposed cut and fill and provide an assessment of the proposed changes.**

A cut and fill plan has been provided as part of the Post Exhibition WCFM which indicates locations and depths of the proposed cut and fill. Refer to Figure 8.10 for details.

## RBWI Pty. Ltd Submission (Clover Hill Developer) (4 October 2018)

**The proposal to shift the wetland serving Clover Hill Estate from the Macquarie Rivulet floodplain to a problematic location within Clover Hill Estate itself. Locating additional wetlands or other stormwater quality treatment devices within Clover Hill Estate is undesirable, as it would be inconsistent with the Approved Concept Plan which favours centralised facilities serving multiple sub-catchments rather than a 'distributed' system involving multiple wetlands serving each sub-catchment.**

Device 3D is located within Stage 2A of Lendlease's development and not within Clover Hill Estate. It is important to note that device 3D is an existing approved and built device. Plate 7.4 in WFCM report depicts the location of the water quality treatment measure which were representative only. Plate 3 above illustrates the proposed location of the water quality devices. The location of the drainage reserve for Lendlease where device 3D is situated is shown on Lot 2201 in Plate 4.


**Plate 4 – Lendlease Plan of Subdivision (Lendlease, 2018)**

**There is a lack of consistency between the natural drainage sub-catchment boundaries shown on Plate 7.1 and the MUSIC catchments shown on Plate 7.3. For example, only a small part of Lend Lease's Stage 3B North drains through Clover Hill Estate (as shown on Plate 7.1), but this natural drainage catchment boundary is omitted from Plate 7.3 with respect to MUSIC sub-catchment 3E.**

Drainage Sub-catchment boundaries presented in Plate 7.1 were produced based on the Concept Plan landform carried out in 2010. These catchments are subject to change as the development progresses. Sub-catchment boundaries provided in Plate 7.3 in the Post Exhibition report better reflect the current development status and are considered appropriate.

**The wetlands/water bodies in the Approved Concept Plan are referred to as 'Devices' in the Wyndham Prince report. Generalised descriptions are given for various devices in Appendix C. Only scant recommendations however are made as to which type of device suits which location and why.**

A range of water sensitive urban design measures have been adopted for the proposed MOD 4 assessment to ensure the best management of stormwater runoff is achieved. All management options will be further assessed at the DA stage to ensure industry best practice is delivered for the development long term.

**Table 7.5 indicates that the size of the proposed 'device' for MUSIC catchment 3C (which contains Clover Hill Estate) is '*consistent with those already sized/approved*', which is at odds with the proposal to install a completely new stormwater quality treatment 'device' within Clover Hill Estate which has not been sized or approved.**

Device 3D located in MUSIC catchment 3C is not a new device proposed within the Clover Hill Estate. This device is located within the approved Stage 2A of Lendlease's development in the Drainage Reserve which is indicated by Plate 4 and Plate 5.


**Plate 5 – Location of Device 3D (Nearmap, 2019)**

## Save Lake Illawarra Action Group Submission (22 July 2018)

**With the increased road system and increased smaller lots with very little open courtyards, there will be no yards to soak in storm water, the additional road network will also add to the large run off of storm water which is all going to finish up in Lake Illawarra, large pollution traps must be installed and maintained by the developer at any storm water pipe system entering into Lake Illawarra.**

**These water creeks will be overwhelmed by the increased amount of stormwater runoff generated by the number of hard surfaces generated by roads and lots being covered by large dwellings in the development.**

**The developer must install stormwater collect pits at the end of all stormwater pipes discharging into the creek systems or have the stormwater pipes discharging into a wetland retention basin.**

The WCFM Strategy includes industry best practice WSUD elements and will ensure both the water quality and quantity management aligns with the approved Concept Plan. A range of water sensitive urban design measures (i.e. wetlands, raingarden and ponds) form part of the the adopted management measures for stormwater runoff. This will allow flexibility to deliver sound water management outcomes moving forward as the development progresses. This will ensure Lake Illawarra is appropriately protected.

## Lake Illawarra Estuary Management Committee Submission

**The committee raised a number of concerns surrounding Stormwater capacity particularly that run off increase will impact on the condition of Lake Illawarra and local waterways. This modification is an opportunity to ensure the OEH/EPA "Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land Use Planning" is in place.**

As mentioned above, the Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning was taken into account throughout the Water Quality assessment (see Wollongong City Council's discussion above for further details.

**Since construction started at the Calderwood development there has been ongoing discussion in the community of increased flooding impacting properties downstream and Lake Illawarra. When considering the Calderwood proposed modification the Committee is hopeful the Dept of Planning will undertake a comprehensive assessment of increased flood risk.**

The detailed flood impact assessments undertaken in conjunction with MOD 4 confirms that flood affectation downstream of CUDP for both 1% and PMF events are no greater than what is approved in the Concept Plan and Condition B26.1 of the NSW Land and Environment Court order to "minimise off-site impacts in the PMF event such that the maximum increase does not exceed 0.3 m. See figure 8.09 in the Post Exhibition WCFM Strategy.

## Planning Pty Ltd on behalf of 347 Calderwood Road Submission (11 October 2018)

**It is assumed that the management of potential additional stormwater created by an increase in impervious area because of the proposed increased density will be managed on the core landholding or at least outside of the Site.**

The proposed increase in density associated with MOD 4 is managed via measures that are located downstream of 347 Calderwood Road. The detailed flood and water quality assessments undertaken demonstrate that these measures will provide appropriate on-site management of stormwater.

## Rienco Consulting on behalf of Ms Joanna Knight No. 23 Calderwood Road Submission (8 October 2018)

**Flood level increase impacts in the PMF event at No 23 Calderwood Road (and many other nearby properties) have been considerably increased from what has been previously indicated in both the Approved Concept Plan and the outcomes of the 2012-13 court case.**

As per Condition B26.1 of the NSW Land & Environment Court approval for Stage 1, flood impacts up to 0.3m are permitted.

Plate 6 from the Rienco submission depicts PMF impacts as per Consolidated Concept Flood Plain Risk Management Study (2010). It is evident from this plate that the part of the site is inundated with depths up to 0.2m in the PMF event.

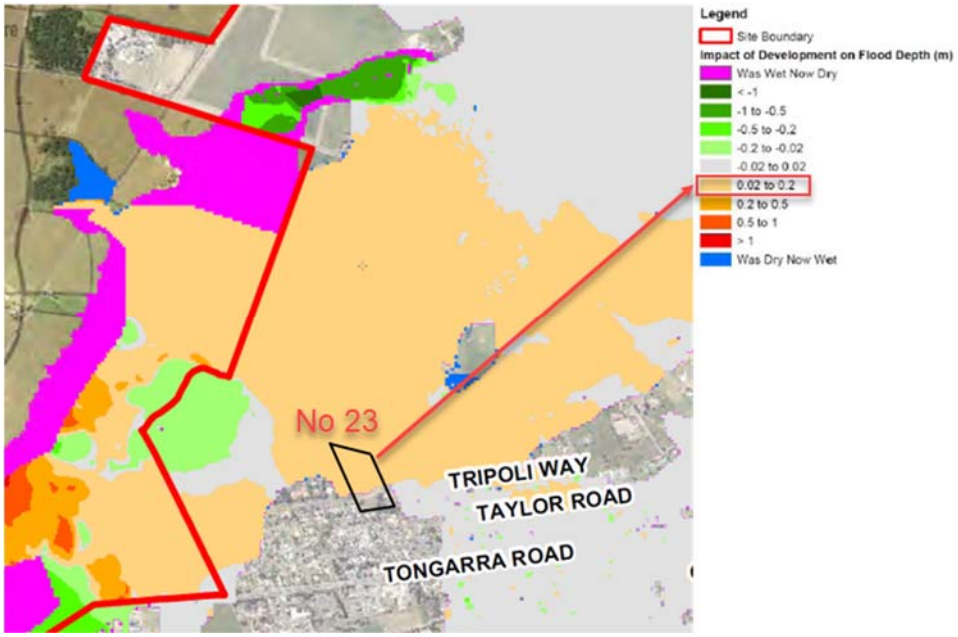



**Plate 6 – PMF Impacts as per Consolidated Concept Plan (March, 2011)**

Figure 11 of WCFM (extract provided below in Plate 7) does not show increased flood levels in PMF along Tripoli Way. It is quite the opposite. The PMF flood depths in Figure 11 are up to 0.1m which is lower than the Approved Concept Plan.

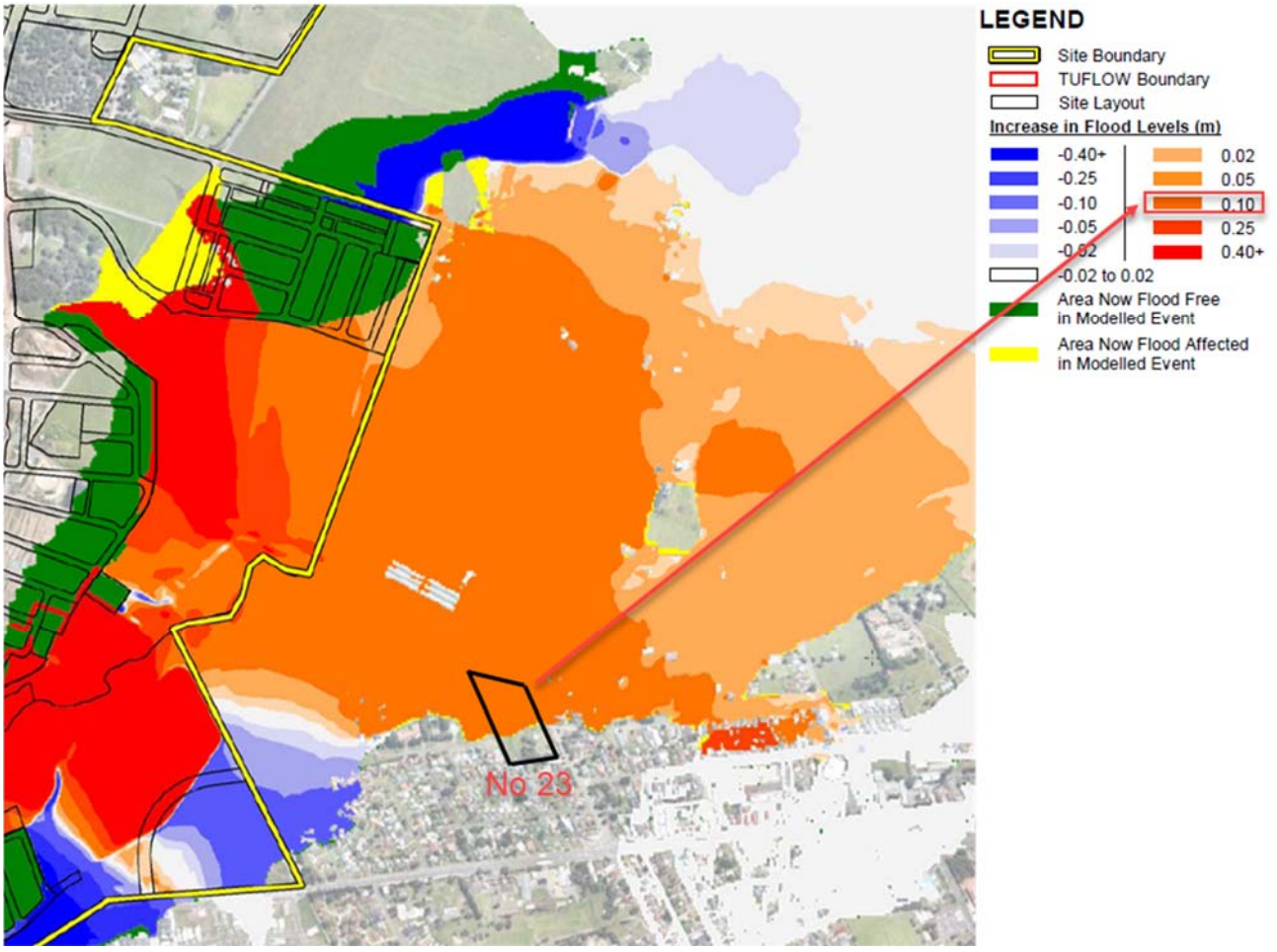



**Plate 7 – PMF Impacts from Watercycle and Flood Management Report (JWP, 2018)**

Rienco have stated that impacts in the PMF event have increased in comparison to the PMF Impacts for Stage 1 Project with the lengthened bridge over Macquarie Rivulet (March 2013). While this is acknowledged, it should be noted that the PMF impacts in WCFM indicated in Plate 8 above is less than the 0.3m agreed flood impacts.

Figure 8.08 demonstrates that PMF impacts are less than 0.3m and consistent with Condition B2.6.1 of the court approval for Stage 1.

**J. Wyndham Prince's Figure 3 (cut and fill plan) is inconsistent with bulk earthworks plans submitted to Shellharbour City Council in support of DA0586-2017 (still under assessment), which show extensive fill within areas designated as cut on the Consolidated Concept Plan Figure C11.**

**J. Wyndham Prince's Figure 3 also indicates substantial changes to cut and fill areas on the floodplain of Marshall Mount Creek in comparison to the approved cut and fill areas on Consolidated Concept Plan Figure C11.**

The cut and fill plan carried out by J. Wyndham Prince is generally consistent with the bulk earthworks plans submitted to SHCC in support of DA0586-2018 which is currently under assessment.

The cut and fill plan within the WCFM Strategy is also consistent with the approved Concept Plan overall.

Minor changes on the cut/fill including south of Macquarie Rivulet adjacent to stage1 have been implemented to facilitate an improved flow management in the corridor which is consistent with the original approval.

See Plate 8 below for details.

Nevertheless, a revised cut and fill plan is present in figure 8.10 the Post Exhibition WCFM report which includes locations and depths of the proposed cut and fill.

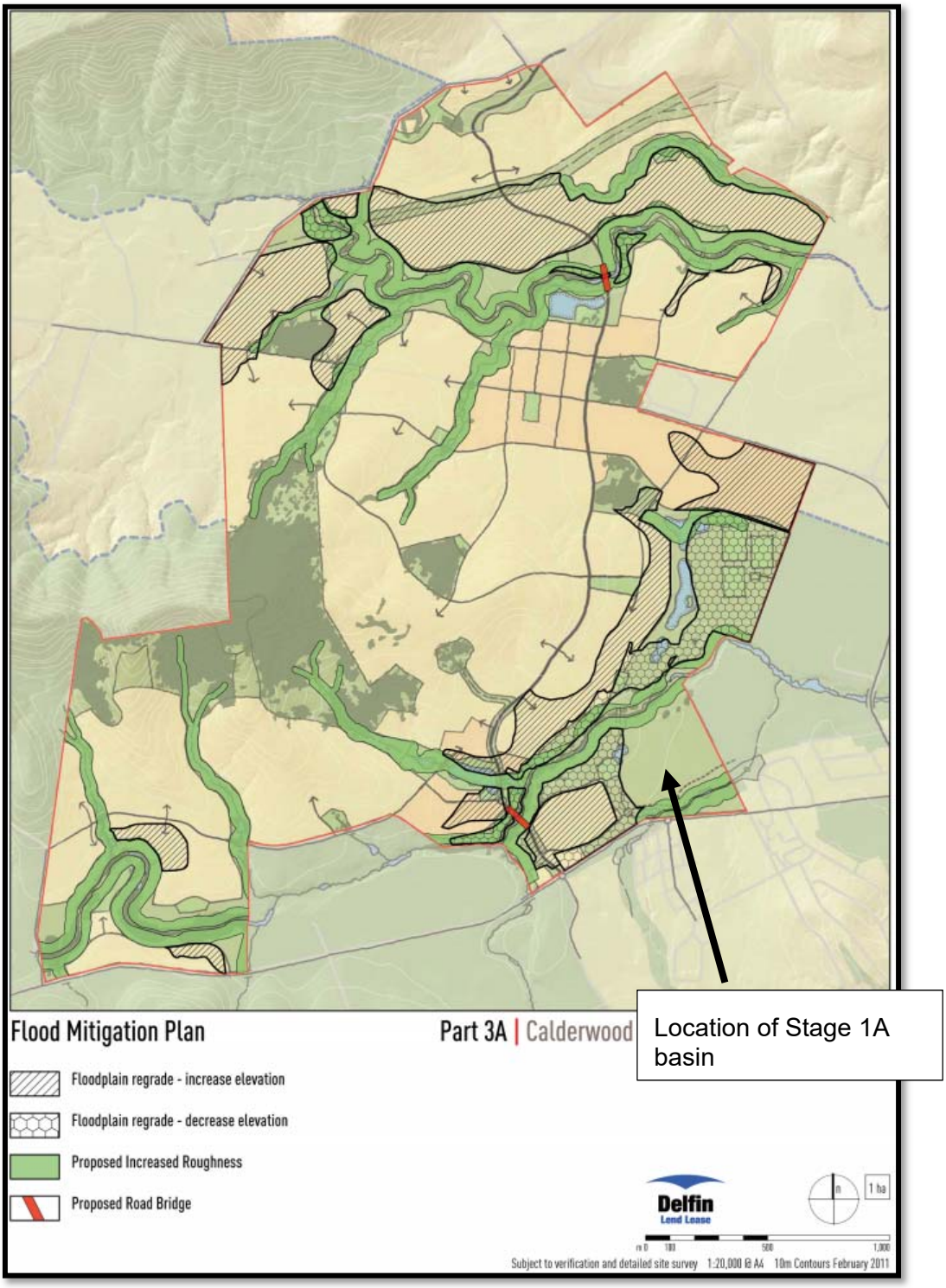



**Plate 8 – Approved Concept Plan Approval Cut and Fill Plan**

**The legend in Wyndham Prince Figure 11 which shows increased flood levels in the PMF event in the vicinity of Tripoli Way and Taylor Road also lacks clarity. A specific water level difference is assigned to each of the various colours used to indicate a change in flood levels, but it is assumed that each colour refers to a water level difference range and the specified water level difference is the lower limit within that range. For instance, there are 5 orange/red colours of increasing intensity used to denote water level increases. The third-ranking such colour, a medium orange colour, is assigned a water level difference of 0.10 m. It is assumed however that what is meant is that this colour represents all areas where the water level difference is between 0.10 and 0.25 m.**

While this is acknowledged, the colour coding implemented in Figure 11 identifies the flood impact graduation which represents flood impacts up to (but not greater than) the specific depth shown.

## Dale Jespon – Albion Park

**As I live close to the Calderwood development I have noticed firsthand the amount of storm water run of in Macquarie rivulet has increased drastically since the development has begun. I live about 100 meters from the rivulet and last time it flooded in the area the water rose to the highest point I have seen in the past 30+ years of being in this location, also the amount of sediment and congestion in the rivers flow has also increased greatly, I am concerned that if this development goes ahead, my home will be flooded as well as further sediment will be deposited in the area further restricting the flow in the river I believe that a lot more storm water drainage must be carried out to take any and all excess storm water from Calderwood directly to lake Illawarra. and not rely on Macquarie Rivulet to be the only way for storm to escape the western area of Albion Park and Calderwood, also I think restoration work needs to be carried out to remove silt from the river and revegetation work to restore the river banks and reduce any further erosion and sediment in the river and its banks, when I was a kid the river was at least 6ft deep in most parts , there where platypus and fish in it, echidnas and wombats where always present. now the only wild life are rabbits and foxes. The river is at most 1 ft deep and in some places so congested with rubbish and fallen trees that the water can't be seen for 50+ meters. What native trees that are left are dying and the weed species are taking over. Please consider all current residents of the area before planning to flood us out, including flora and fauna, as well as the human residents.**

A series of water sensitive urban design measures have been adopted in the CUDP to ensure best practice management of stormwater runoff. The development will ensure appropriate management of the 1% AEP event and the WCFM confirms that no flood impacts greater than the agreed 0.3m occur in even the most extreme events.

## Annie Marlow - Berkeley

**The increased number of dwellings will increase the area of impervious surface, therefore the quantity and velocity of runoff water and its detrimental impacts. The proponent has some planning to expand the stormwater system for the site, though this is referred to as minor in the proposal. There is significant evidence in the wider community of large amounts of sediment and building materials, many were very large items, that were dumped on properties downstream of the Calderwood development and swept into Lake Illawarra during the June 2016 South Coast Low weather event. This weather event occurred at the time that initial Calderwood development was in process. Large items of building materials were dumped along the Lake Heights shoreline in the nth/w of Lake Illawarra at this time as well. Community perception is that these materials came from the Calderwood development, swept down the Macquarie Rivulet and into Lake Illawarra and were driven nth/w by the weather. Given the strength and direction of the prevailing winds across Lake Illawarra at the time the perception is believable. Sedimentation is the biggest threat to Lake Illawarra impacting both infill rate and water quality. It is essential that any further development in its catchment has strictly regulated and enforced sediment control and installation of stormwater systems that have proven neutral or better impacts on the condition of the Lake.**

**This modification is an opportunity to ensure the OEH/EPA "Risk Based Framework for Considering Waterway Health Outcomes in Strategic Land Use Planning" is in place.**

**As sited above, since construction started at the Calderwood development there has been ongoing discussion in the community of increased flooding impacting Lake Illawarra and properties downstream. Given the increased uncertainty of extreme weather events as our climate changes, flood levels and assessment of impacts taken after the June 2016 Sth Coast Low must be used as a bench mark when considering the Calderwood proposed modification.**

The MOD 4 development footprint with the density uplift, will have no additional impacts on the riparian vegetation in comparison to the approved concept plan. Runoff characteristics from the increased density will have minimal impact on flood affectation in both the Macquarie Rivulet and Marshall Mount Creek, the two (2) major watercourses within the CUDP. These impacts will be managed as part of ongoing development of CUDP.

The development consists of a range of treatment devices to ensure the best management of stormwater runoff will be delivered. These include, but are not limited to, on lot treatment, subdivision/development treatment measures and street level treatment including, GPTs, wetlands and ponds.

The June 2016 flood event was a minor event when compared to recorded flood data. In saying this, the MOD 4 application is built upon the best available information (SHCC flood model) and demonstrate that CUDP will not impacts downstream residents.

The Risk-Based Framework for Considering Waterway Health Outcomes in Strategic Land-use Planning was taken into account throughout the Water Quality assessment for the proposed development and is compliant.

## Fortnum Property Development and Consulting Submission

**We are generally supportive of the MOD4 application and we make the following submission regarding the application:**

**Appendix P Watercycle and Flood Management Strategy Updates (JWP)**

**The flood modelling does not appear to consider 128 North Macquarie Rd in its 'Proposed Development' format, noting that the balance of the Lend Lease (core lands) urban footprint appears to be considered. Particular reference is drawn to Figure 7 and Figure 12. It is noted that council are in receipt of DA 577/2017 which includes a Watercycle and Flood Management Study prepared by Cardno Consulting Engineers and details the site in its Proposed Development format and flood considerations in line with the current Calderwood Concept Plan requirements. Further it is noted that Figure 3 appears to remove an area of fill within DA577/2017 Stage 3 (South of the rivulet), which was detailed in the current CCP. This fill will be undertaken and is included in the submitted DA.**

**We seek consultation and confirmation that the JWP flood model utilised does not cause adverse impacts or impediment on the development of 128 North Macquarie Rd.**

**Appendix F Amended Concept Plan Drawings Flood Mitigation Plan**

**It is noted that Flood Mitigation Plan (MOD4) appears to remove an area of fill within DA577/2017 Stage 3 (South of the rivulet), which is detailed in the current CCP. This fill will be constructed and is included in the submitted DA.**

**We seek consultation and confirmation that the removal of this fill area from the CCP does not cause adverse impacts or impediment on the development of 128 North Macquarie Rd.**

The flood model assessed for MOD 4 did not originally account for future development of 128 North Macquarie Road and did not include developed surfaces in this area. Subsequent to MOD4 exhibition, Fortnum Property has provided the developed surfaces of their development which have been incorporated into the model, along with the relevant cut/fill areas. We have carried out an assessment of the flood model which indicates that the flooding impacts at this property will be alleviated. The Post Exhibition WCFM report details this revision.

## 12 Calderwood Road – Albion Park (Mrs. & Mrs. Harrison) (5 October 2018)

**In March of 2017 our property and others in the surrounding area which has always been flood liable, experienced the worst flood in living memory, due we believe, in no small part of the existence of parts of the Calderwood Valley Development which has previously acted as natural detention areas having been filled several feet of earth and other materials.**

**The so-called detention basins, constructed in conjunction with the early stages of the development proved to be ineffective and some 80% of our rural property was inundated with as much as 5feet of water at our Properties lowest point.**

**The creation of roof water runoff from 1700 extra dwellings as well as other impervious areas that are being proposed by the Lendlease Corporation, will obviously increase the already intolerable flooding problem that we believe they have helped to create.**

The MOD 4 development footprint with the density uplift will have no additional flood impacts in comparison to the approved concept plan. Runoff characteristics from the increased density will have minimal impact on flood affectation in both the Macquarie Rivulet and Marshall Mount Creek, the two (2) major watercourses within the CUDP. These impacts will be managed as part of ongoing development of CUDP.

**Robert Grimmett – Tullimbar**

**I am not a flood expert, but simple logic tells me that an increase of 35% in covered area (buildings, paving, hard surfaces etc) on the same footprint, will mean a significant in water runoff and potential for flooding.**

As previously mentioned, the development footprint for proposed MOD 4 with the density uplift, will not have additional flood impacts in comparison to the approved concept plan.

# APPENDIX B – WATER QUALITY TREATMENT DEVICES

## WETLAND

Wetlands are shallow water body systems, densely vegetated with emergent aquatic macrophytes. Wetlands are effective in trapping suspended solids, as well as chemical and biological uptake of pollutants. Constructed wetlands can take the form of either a surface or sub surface system.

- **Surface** – Conventional wetlands
- **Sub Surface** – Gravel filled shallow wetland.

Biological Floating Wetlands are a proprietary option which can either be implemented within a proposed body of water or retrofitted to existing ponds. The suspended media is self-cleaning, which makes it sustainable, with significant savings on cost of life. It uses biological elements, as opposed to chemicals that negatively impact the environment, and has consistently achieved all the necessary bacteria counts and oxygen levels in independent scientific trials and over numerous installation sites.

Floating wetlands have a very low capital investment compared to traditional systems with no operation energy costs and low maintenance costs. Other benefits also include improvement to water quality, self-cleaning, and an increased abundance of wildlife. A typical floating wetland arrangement is shown on Plate B-1.

**Plate B-1 – Typical Floating Wetland Arrangement**

*Comment: Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. Wetlands do require a reasonable amount of maintenance, however can be managed to minimise potential algal blooms via recirculation systems.*

*Floating Wetlands are proposed within the overall Water Cycle Management Strategy for the CUDP. Where the is appropriate land take available, they are the preferred option to provide "end of line" treatment prior to discharge to Marshall Mount Creek and Macquarie Rivulet. They will enhance the natural elements of the site and provide an attractive solution.*

## BIO-RETENTION RAINGARDEN SYSTEMS

Bio-retention raingarden systems consist of a filtration bed with either gravel or sandy loam media and an extended detention zone typically from 100-300 mm deep designed to detain and treat first flush flows from the upstream catchment. They typically take the form of an irregular bed (raingarden) or a linear swale (bio-swale) and are located within the verge area of a road reserve or extend within the bushland corridors or other open space areas. The surface of the bio-retention system can be grassed, or mass planted with water tolerant species. Filtration beds of bio-retention systems are typically 0.4 to 0.6 metres deep. For an example of an established bio-retention raingarden, refer to Plate B-2.

**Plate B-2 – Typical Bioretention Raingarden**

*Comment: Bio-retention systems are an effective and efficient means of treating pollutants from urban development when part of an overall treatment train. Bio-retention systems do however require a reasonable amount of maintenance during the vegetation establishment phase. Within the CUDP, there are opportunities for many of these raingarden devices to be located, which minimises landtake and provides easy access for maintenance (i.e. if located adjacent to a perimeter road or footpaths).*

*Bio-retention "raingardens" are proposed as a viable alternative to Wetlands within the overall Water Cycle Management Strategy for the CUDP where they will provide "end of line" treatment prior to discharge to the Macquarie Rivulet or Marshall Mount Creek and minimise land take.*

## VEGETATED SWALES AND BUFFERS

Swales are formed, vegetated depressions that are used for the conveyance of stormwater runoff from impervious areas. They provide a number of functions including:

- Removing sediments by filtration through the vegetated surface.
- Reducing runoff volumes (by promoting some infiltration to the sub-soils).
- Delaying runoff peaks by reducing flow velocities.

Swales are typically linear, shallow, wide, vegetation lined channels. They are often used as an alternative to kerb and gutter along roadways but can also be used to convey stormwater flows in recreation areas and car parks. A typical vegetated swale arrangement is shown on Plate B-3.

**Plate B-3 – Typical Vegetated Swale Arrangement**

*Comment: The grade of the land within certain portions of Calderwood Valley is suitable for swales and buffers (< 3%). However, changes proposed to the land surrounding the edges of the development will be changed in order to improve flood conveyancing. Swales and buffers within urban residential streets are not recommended due to the large number of culvert crossings required for driveways, safety concerns, increased number of GPT's required and significant maintenance requirements.*

*However, in the right location, away from residential streets, swales are suitable as a supplement for other devices, as they provide an effective means of removing pollutants, particularly Total Suspended Solids (TSS) while minimising land take. They are therefore suggested as a secondary treatment mechanism within the CUDP.*

## SAND FILTERS

Sand filters typically include a bed of filter media through which stormwater is passed prior to discharging to the downstream stormwater system. The filter media is usually sand but can also contain gravel and peat/organic mixtures. Sand filters provide several functions including:

- Removing fine to coarse sediments and attached pollutants by infiltration through a sand media layer.
- Delaying runoff peaks by providing retention capacity and reducing flow velocities.

Sand filters can be constructed as either small- or large-scale devices. Small scale units are usually located in below ground concrete pits (at residential/lot level) comprising of a preliminary sediment trap chamber with a secondary filtration chamber. Larger scale units may comprise of a preliminary sedimentation basin with a downstream sand filter basin-type arrangement. For an example of a typical sand filter, refer to Plate B-4.

**Plate B-4 – Typical Sand Filter Arrangement**

*Comment: Sand filters are suited to confined spaces and where vegetation cannot be sustained (such as underground) and are particularly useful in heavily built-up areas. They are inefficient when compared to bio-retention systems and require frequent maintenance. Sand filters are therefore not included as part of the Water Cycle Management Strategy for the CUDP.*

## PERMEABLE PAVEMENT

Permeable pavements, which are an alternative to typical impermeable pavements, allow runoff to percolate through hard surfaces to an underlying granular sub-base reservoir for temporary storage until the water either infiltrates into the ground or discharges to a stormwater outlet. They provide several functions including:

- Removing some sediments and attached pollutants by infiltration through an underlying sand/gravel media layer.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing retention/detention storage capacity and reducing flow velocities.

Commercially available permeable pavements include pervious/open-graded asphalt, no fines concrete, modular concrete blocks and modular flexible block pavements.

There are two (2) main functional types of permeable pavements:

- Infiltration (or retention) systems – temporarily holding surface water for a sufficient period to allow percolation into the underlying soils.
- Detention systems – temporarily holding surface water for short periods to reduce peak flows and later releasing into the stormwater system.

For an example of a permeable pavement, refer to **Plate B-5**.

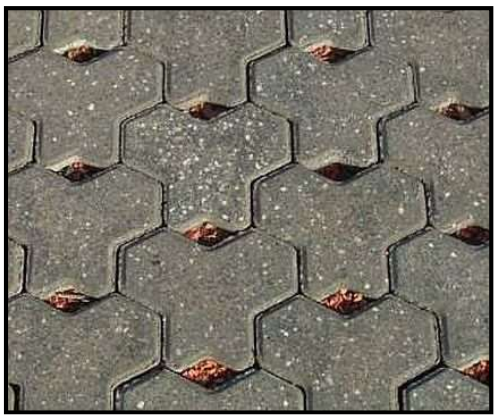


**Plate B-5 – Typical Permeable Pavement Arrangement**

*Comment: Permeable pavements are generally a more 'at source' solution and best suited as an 'on lot' approach or for small roadway catchments. Permeable pavers may possibly be considered at the development application stage for on lot treatment or for areas draining small catchment areas with low sediment loads and low vehicle weights. These systems are also prone to clogging and are not suitable in saline soils similar to those located close to the precinct and therefore not recommended for the CUDP.*

## INFILTRATION TRENCHES

Infiltration trenches temporarily hold stormwater runoff in a sub-surface trench prior to infiltrating into the surrounding soils. Infiltration trenches provide the following main functions:

- Removing sediments and attached pollutants by infiltration through the sub-soils.
- Reducing runoff volumes (by infiltration to the sub-soils).
- Delaying runoff peaks by providing detention storage capacity and reducing flow velocities.

Infiltration trenches typically comprise of a shallow, excavated trench filled with reservoir storage aggregate. The aggregate is typically gravel or cobbles but can also comprise modular plastic cells (similar to a milk crate). Runoff entering the system is stored in the void space of the aggregate material or modular cells prior to percolating into the surrounding soils. Overflow from the trench is usually to downstream drainage system. Infiltration trenches are similar in concept to infiltration basins; however, trenches store runoff water below ground in a pit and tank system, whereas basins utilise above ground storage. For an example of an infiltration trench, refer to **Plate B-6**

**Plate B-6 – Typical Infiltration Trench Arrangement**

*Comment: Infiltration trenches and basins are not appropriate for clay soils or where there is potential for salinity issues. They are inefficient when compared to swales and require frequent maintenance. Infiltration Trenches are not recommended as a proposed solution for the CUDP.*

## PONDS

Ponds are usually deep (>1.5 m) artificial bodies of open water. Many ponds have a small range of water level fluctuation because they are formed by a simple dam wall with a weir outlet structure. Newer systems may have riser-style outlets allowing for extended detention and temporary storage of inflows. Emergent aquatic macrophytes are normally restricted to the pond surrounds because of water depth, although submerged plants may occur in the open water zone.

Water quality improvement in ponds are promoted by a complex array of physical, chemical and biological actions. Whilst not as effective in the removal of pollutants as wetlands, they do still provide benefit an effective means of intercepting pollutants from stored sediments. For an example of a pond arrangement, refer to **Plate B-7**

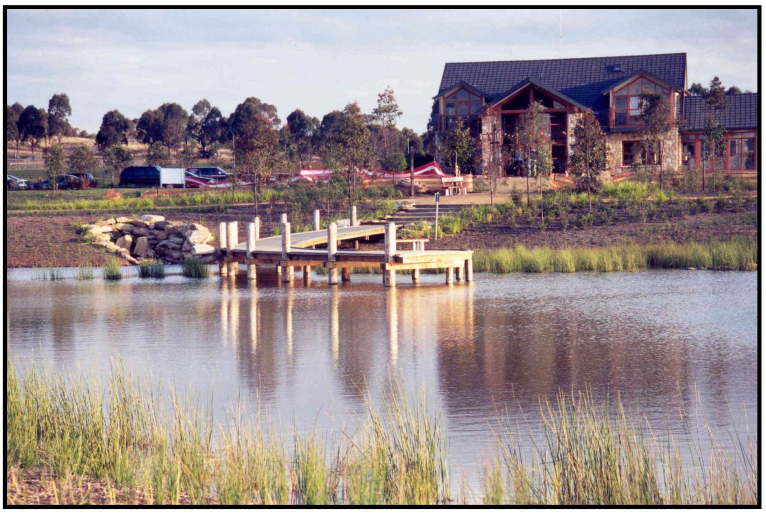


**Plate B-7 – Typical Pond Arrangement**

*Comment: Ponds and Wetlands are effective in removing sediment and nutrient loads typically generated from urban development. However, ponds generally require large landtake to ensure the pollutant treatment capacity of the pond achieves the requires water quality objectives. Where there is sufficient land take available, ponds are proposed to house the floating wetlands to provide additional pollutant removal as well as to provide an attractive focal design point for the development.*

## CARTRIDGE FILTER SYSTEMS

Cartridge filtration systems are underground pollution control devices that treat first flush flows. The unit consists of a vault containing a number of cartridges each loaded with media that targets specific pollutants. Each cartridge has a maximum treatable flowrate of approximately 1 - 1.5 litres per second. For an example of a typical cartridge filter system arrangement, refer to **Plate B-8**

**Plate B-8 – Typical Cartridge Filter System (During Construction)**

*Comment: Cartridge filtration systems are an efficient means of treating pollutants from urban development, as they are typically located underground and therefore do not require additional land take. As cartridge systems have a low treatable flow rate, additional 'buffer' storage is usually provided to keep the capital costs down. Cartridge filtration systems also need to be supplemented with additional treatment devices to achieve pollutant reduction targets. There is a need to provide significant height differences between the inlet to the filtration system and the discharge point from the supplementary system. It also generally results in expensive capital and ongoing maintenance costs.*

*Cartridge Filter systems are not typically suited for large scale developments. However, given the town centre envisaged for the CUDP, cartridge filters are considered as a possible solution for highly dense land uses.*

## INLET PIT FILTER INSERTS AND GROSS POLLUTANT TRAPS (GPTS)

GPT devices are typically provided at the outlet of stormwater drainage lines. These systems operate as a primary treatment to remove litter, vegetative matter, free oils and grease and coarse sediments prior to discharge to downstream (Secondary and Tertiary) treatment devices. They can take the form of trash screens or litter control pits, pit filter inserts or wet sump gross pollutant traps.

In theory, inlet pit filter inserts have several advantages over end of pipe GPT's, such as providing a dry, at source collection of litter, vegetative matter and sediment as well as allowing for staged construction works without having to provide additional / temporary GPT units. Pit filter inserts will provide an at source mechanism for treatment of gross pollutants as development proceeds throughout the site. However, GPTs provide a lower maintenance burden than inlet pit filter inserts, as the location for maintenance is generally in one (1) location within the catchment, rather than at every pit. For an example of a Vortex Style GPT unit, refer to **Plate B-9**

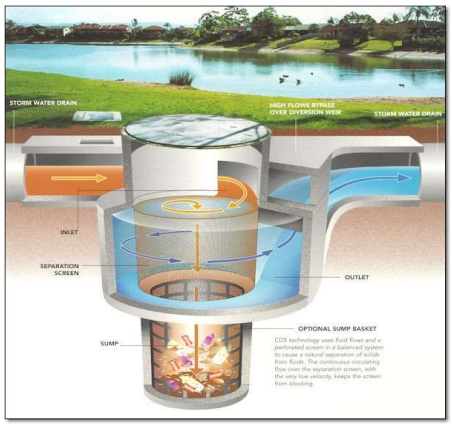



**Plate B-9 – Vortex Style GPT Unit**

*Comment: Gross Pollutant Traps are effective in removing gross pollutants from stormwater runoff generated from large urbanised catchments. They provide a single point of maintenance, which is beneficial to the long-term viability and cost effectiveness of the water quality treatment system. Therefore, Gross Pollutant Traps are included within the proposed Water Cycle Management Strategy for the CUDP.*

## RAINWATER TANKS

Rainwater tanks are sealed tanks designed to contain rainwater collected from roofs.

Rainwater tanks provide the following main functions:

- Allow the reuse of collected rainwater as a substitute for mains water supply, for use for toilet flushing, laundry, or garden watering.
- When designed with additional storage capacity above the overflow, provide some on-site detention, thus reducing peak flows and reducing downstream velocities.

The water collected can be reused as a substitute for mains water supply either indoors (toilet flushing) or outdoors (garden watering). Rainwater tanks can be either above ground or underground. Above ground tanks can be placed on stands to prevent the need of installing a pump to distribute the water. Such systems are referred to as gravity systems. Pressure systems require a pump and can be either above or below ground tanks.

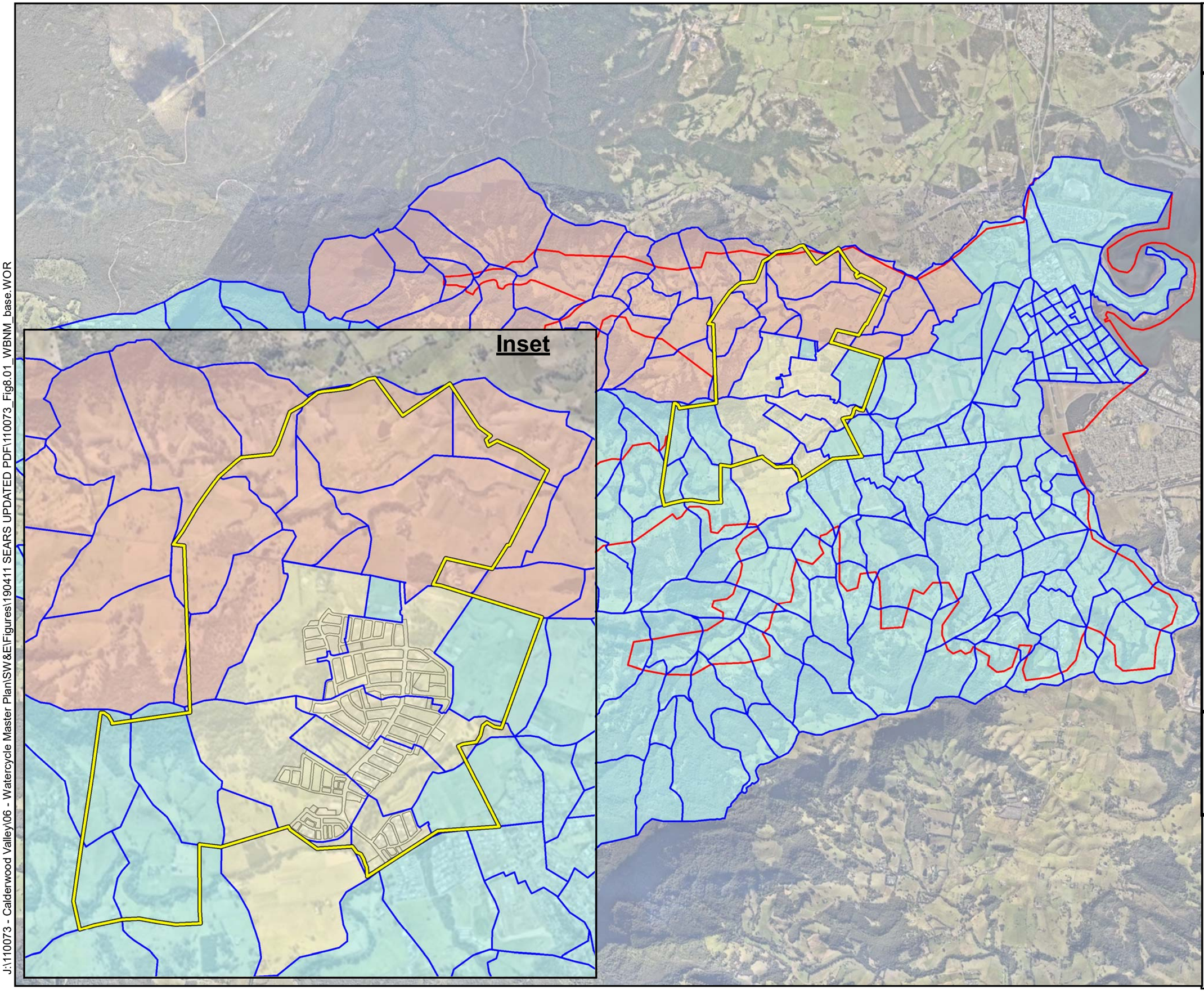
Tanks can be constructed of various materials such as Colorbond™, galvanised iron, polymer or concrete.

**Plate B-10 – Rainwater Tank**

*Comment: Rainwater tanks are effective in removing suspended solids and a small amount of nutrient pollutants. They are also effective in reducing overall runoff volumes. The effectiveness of rainwater tanks is also increased when plumbed in for internal use.*

*Rainwater tanks are recommended within the CUDP for all low-medium development areas. For the purposes of modelling, rainwater tanks are conservatively excluded from medium density residential and commercial.*

# APPENDIX C – FIGURES

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Developed Catchments**

- Macquarie Rivulet
- Marshall Mount Creek
- Updated Catchments

N

0 2,000
metres
Scale 1:50,000 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.01

## Calderwood Urban Development Project

**WBNM Catchments-**
**Approved Development Case**

Date: 11/04/2019 Issue: A

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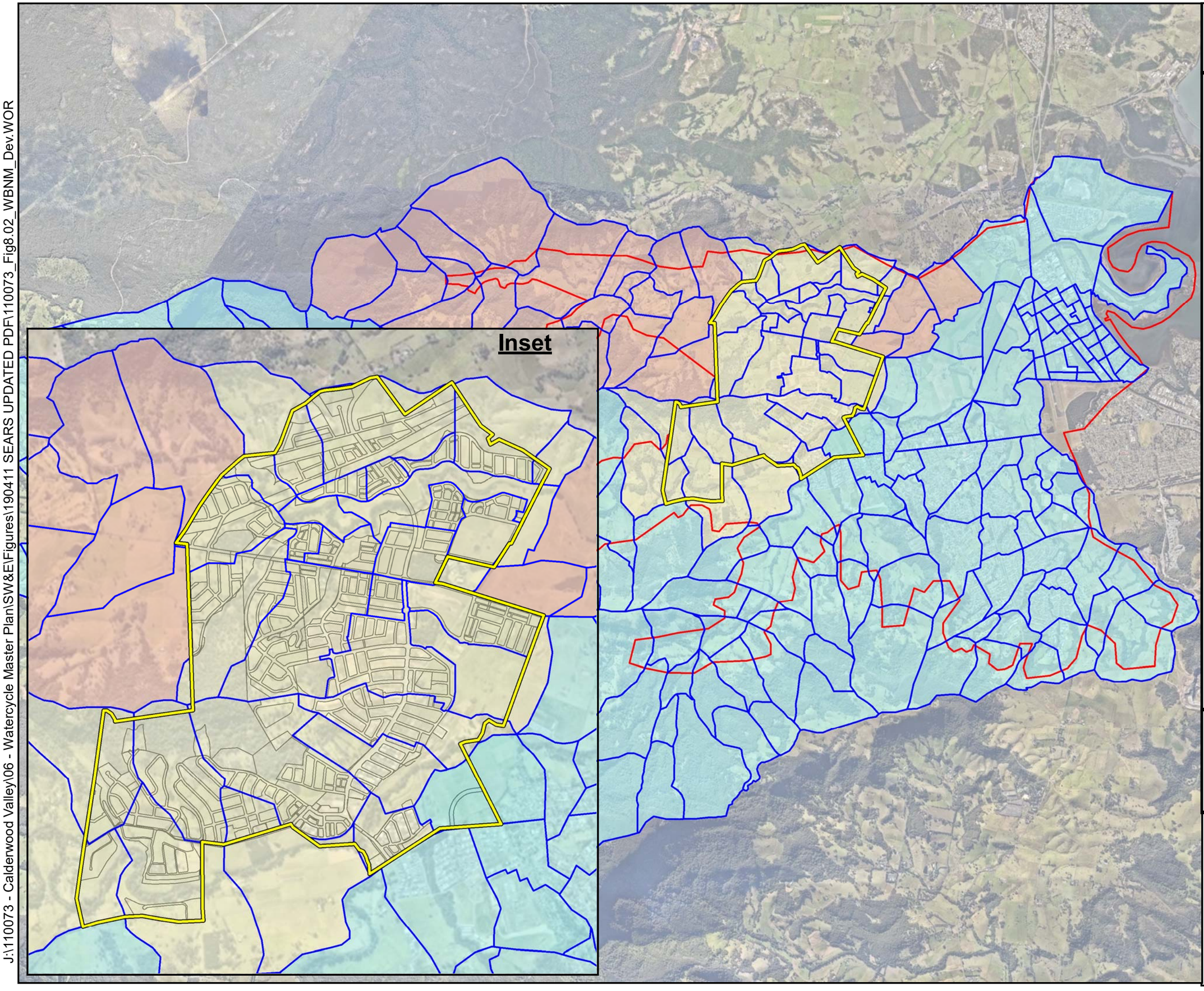


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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Developed Catchments**

- Macquarie Rivulet
- Marshall Mount Creek
- Updated Catchments

N

0 2,000
metres
Scale 1:50,000 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.02

## Calderwood Urban Development Project

**WBNM Catchments-Developed Case**

Date: 11/04/2019 Issue: B

J:\110073 - Calderwood Valley\06 - Watercycle Master Plan\SW&E\Figures\190411 SEARS UPDATED PDF\110073_Fig8.03_100y_Base_depth.WOR

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Depth (m)**

- 0.0 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0+

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.03

## Calderwood Urban Development Project

**1% AEP Event**
**Flood Depth**
**Approved Development**

Date: 11/04/2019 Issue: E

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Depth (m)**

- 0.0 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0+

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.04

## Calderwood Urban Development Project

**1% AEP Event**
**Flood Depth**
**Proposed Developemnt**

Date: 11/04/2019 Issue: E

J:\110073 - Calderwood Valley\06 - Watercycle Master Plan\SW&E\Figures\190411 SEARS UPDATED PDF\110073_Fig8.04_100y_Dev_depth.WOR

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## LEGEND

- Site Boundary
- TUFLOW Boundary
- Site Layout

**Increase in Flood Levels (m)**

| | |
|---|---|
| -0.40+ | 0.02 |
| -0.25 | 0.05 |
| -0.10 | 0.10 |
| -0.05 | 0.25 |
| -0.02 | 0.40+ |

- -0.02 to 0.02
- Area Now Flood Free in Modelled Event
- Area Now Flood Affected in Modelled Event

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.05

## Calderwood Urban Development Project

**1% AEP Event**
**Flood Difference**
**Approved Developement - Proposed**

Date: 11/04/2019 Issue: E

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Depth (m)**

- 0.0 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0+

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.06

## Calderwood Urban Development Project

**PMF Event**
**Flood Depth**
**Approved Development**

Date: 11/04/2019 Issue: E

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Depth (m)**

- 0.0 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0+

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.07

## Calderwood Urban Development Project

**PMF Event**
**Flood Depth**
**Proposed Development**

Date: 11/04/2019 Issue: E

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## LEGEND

- Site Boundary
- TUFLOW Boundary
- Site Layout
- Flood Depths increased by less than 300mm
- Flood Depths increased by more than 300mm
- Area Now Flood Free in Modelled Event
- Area Now Flood Affected by more than 300mm in Modelled Event

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.08

## Calderwood Urban Development Project

**PMF Event**
**Flood Difference**
**Approved Development - Proposed**

Date: 11/04/2019 Issue: E

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Depth (m)**

- 0.0 to 0.2
- 0.2 to 0.5
- 0.5 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0+

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.09

## Calderwood Urban Development Project

**1% AEP Climate Change Event**
**Flood Depth**
**Proposed Developemnt**

Date: 11/04/2019 Issue: E

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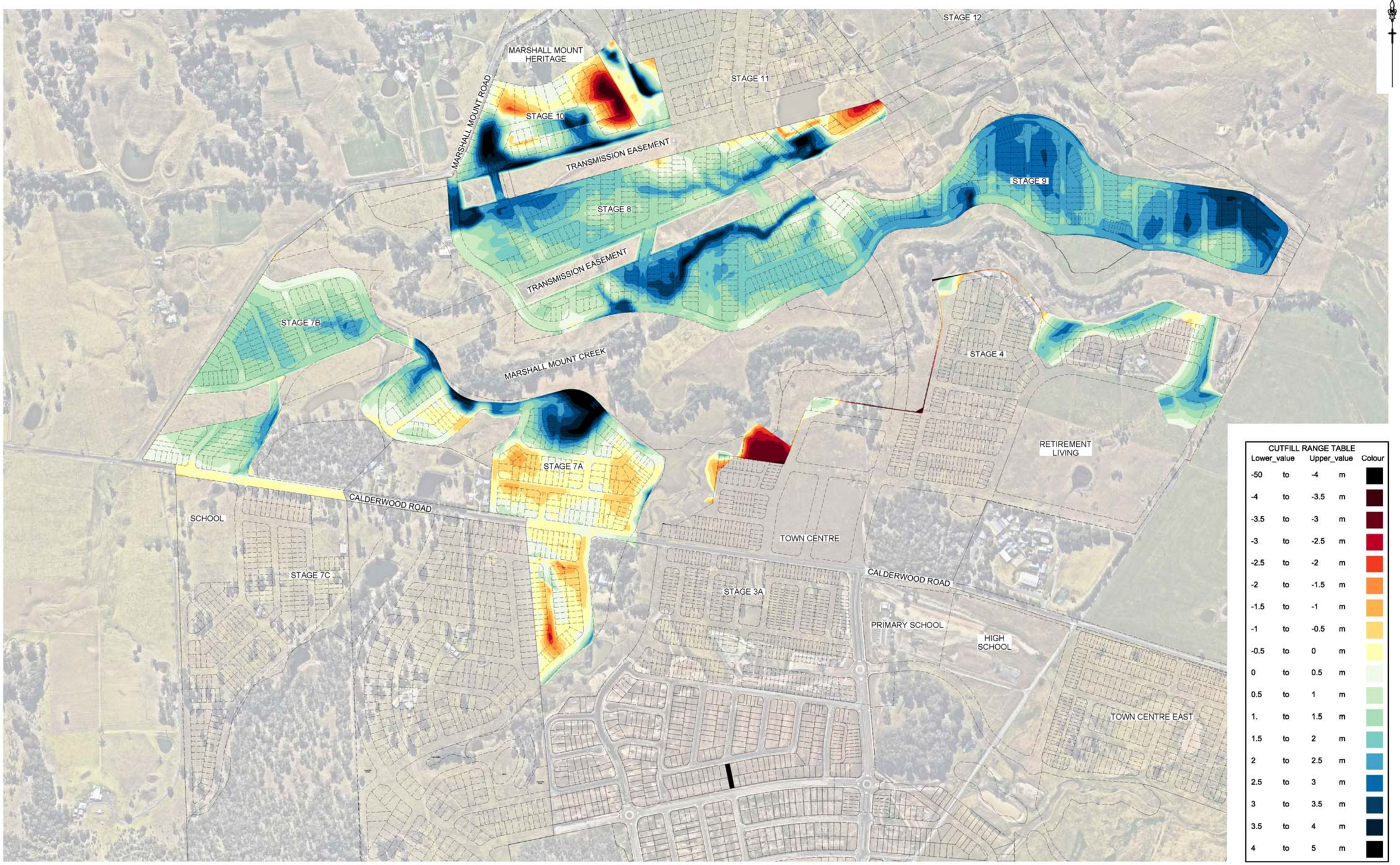


CUTFILL RANGE TABLE

| Lower_value | | Upper_value | | Colour |
|---|---|---|---|---|
| -50 | to | -4 | m | |
| -4 | to | -3.5 | m | |
| -3.5 | to | -3 | m | |
| -3 | to | -2.5 | m | |
| -2.5 | to | -2 | m | |
| -2 | to | -1.5 | m | |
| -1.5 | to | -1 | m | |
| -1 | to | -0.5 | m | |
| -0.5 | to | 0 | m | |
| 0 | to | 0.5 | m | |
| 0.5 | to | 1 | m | |
| 1. | to | 1.5 | m | |
| 1.5 | to | 2 | m | |
| 2 | to | 2.5 | m | |
| 2.5 | to | 3 | m | |
| 3 | to | 3.5 | m | |
| 3.5 | to | 4 | m | |
| 4 | to | 5 | m | |

PLAN
SCALE 1:2500

1:4000 (AT A1)
1:8000 (AT A3)

80 40 0 80 160 240 320 400
METRES

**DRAFT ISSUE ONLY**
PRELIMINARY DESIGNS SUBJECT TO CHANGE

| | | | | | | |
|---|---|---|---|---|---|---|
| 1 | ISSUE FOR INFORMATION | JT | JT | | | |
| | AMENDMENT | DES | DRN | CKD | APR | DATE |

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# CALDERWOOD VALLEY CUTFILL ANALYSIS
DEPTH RANGE PLAN

PLAN No: Figure 8.10 1
FILE No: Figure 8.10
SHEET SIZE: A1 ORIGINAL

Plotted: 11 April, 2019 10:47:13 AM File Name: J:\110073 - Calderwood Valley\08 - Watercycle Master Plan\CD\SK\110073065K17.dwg

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## LEGEND

- Site Boundary
- TUFLOW Boundary

**Hazard Category**

- H1 - Generally safe for people vehicles and buildings
- H2 - Unsafe for small vehicles
- H3 - Unsafe for vehicles, children and the elderly
- H4- Unsafe for people and vehicles
- H5 - Unsafe for vehicles and people. Buildings vulnerable to structural damage. Less robust buildings vulnerable to failure.
- H6 - Unsafe for vehicles and people. All buildings vulnerable to failure.

N

0 500
metres
Scale 1:12,500 @ A3

Projection: GDA 1994 MGA Zone 56

# Figure 8.11

## Calderwood Urban Development Project

**PMF Event**
**Flood Hazard**
**Proposed Development**

Date: 07/05/2019 Issue: A

# APPENDIX D – MUSIC MODELLING INFORMATION

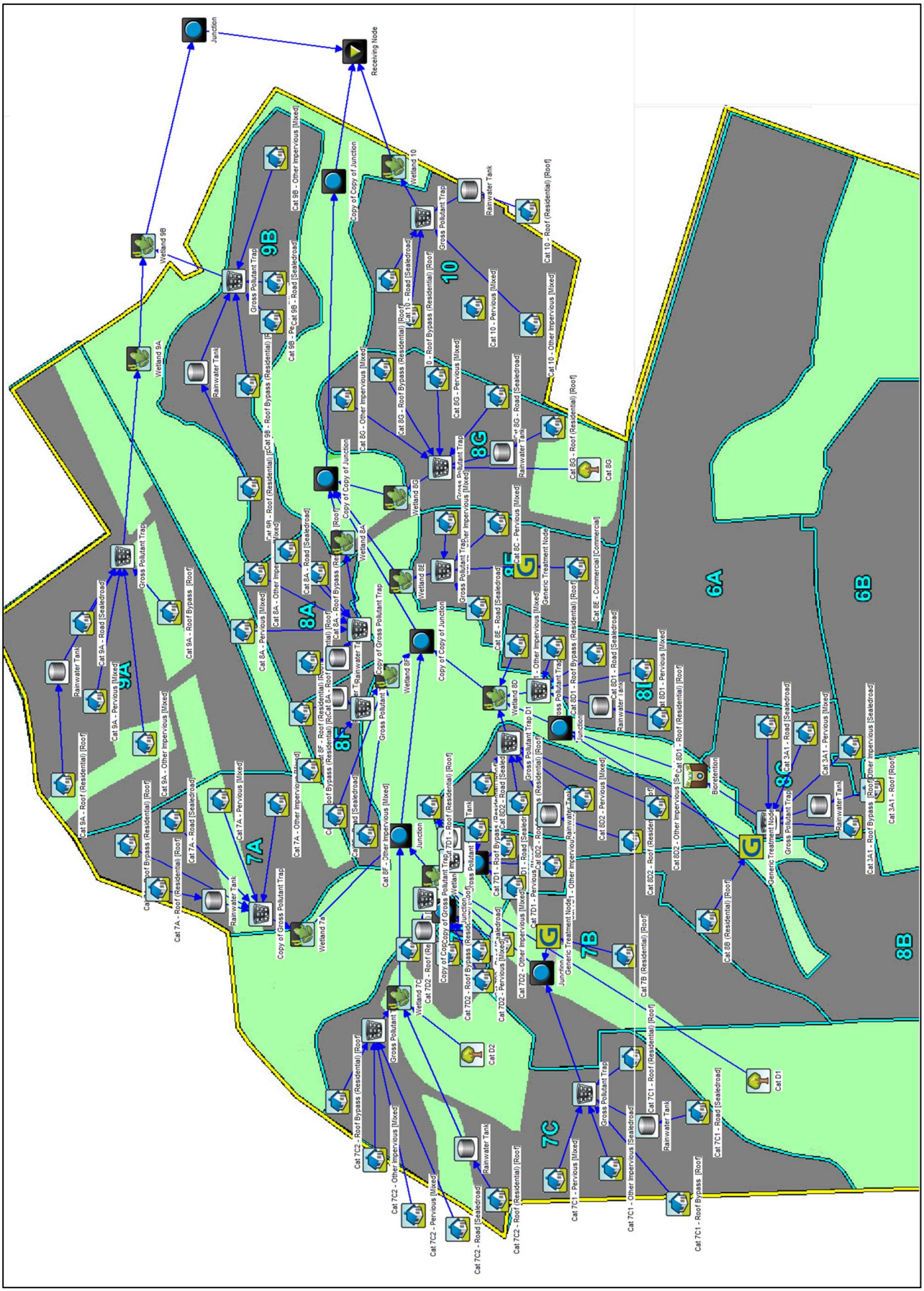


**Plate D-11 – MUSIC Model Layout (Remodelled Catchments Affected By Density Uplift)**

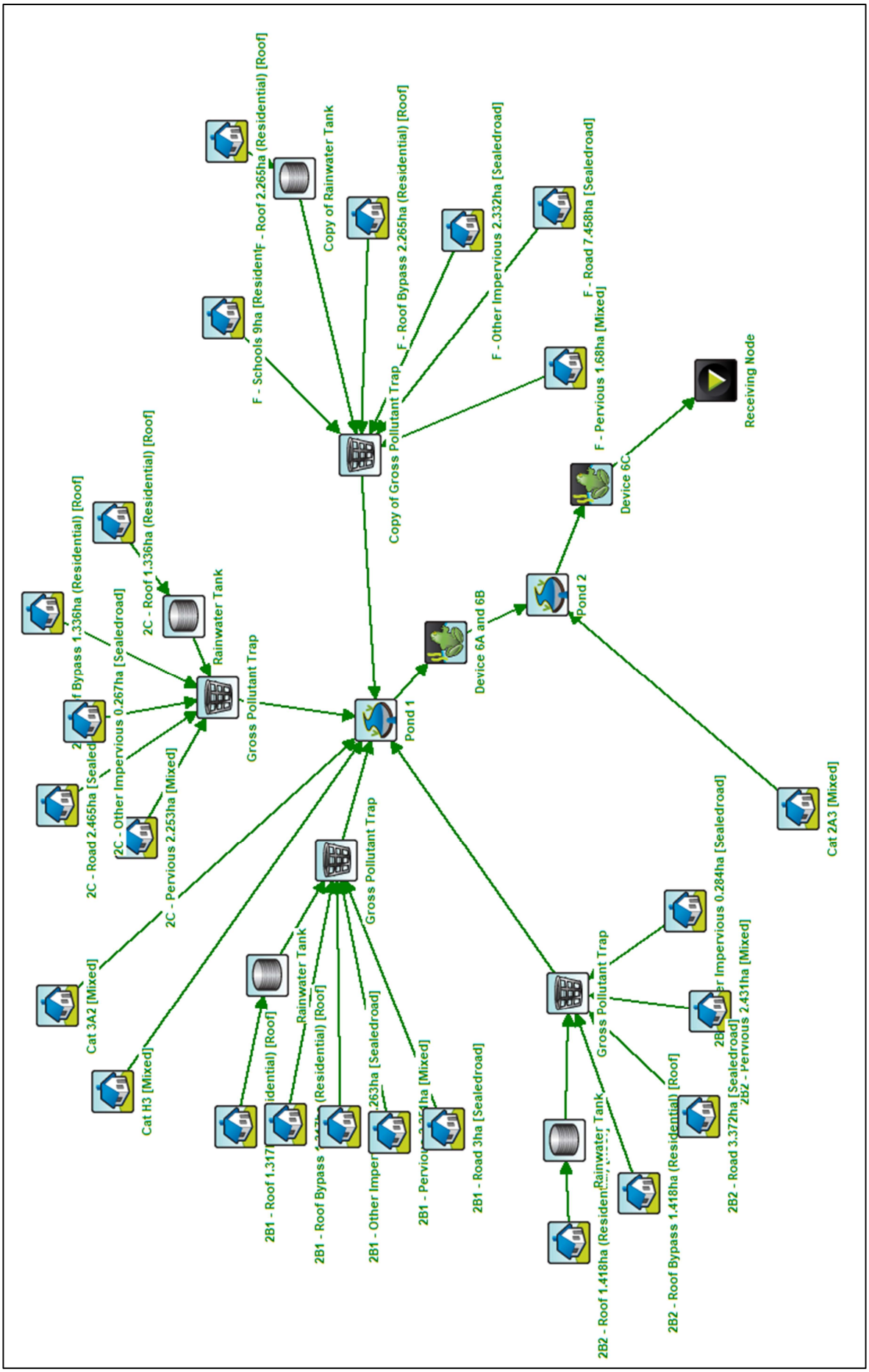


**Plate D-2 – MUSIC Model Layout Water Quality Devices Reassessed**

# APPENDIX E – CARDNO STAGE 1 BRIDGE APPROVAL SEQUENCE

Our Ref: 82018194-01:RJH
Contact: Rory Hentschel

2 April 2019

Department of Planning
GPO Box 39
**Sydney NSW 2001**

Attention: Casey Joshua

Cardno (NSW/ACT) Pty Ltd
ABN 95 001 145 035

16 Burelli Street
Wollongong NSW 2500
Australia

Phone +612 4228 4133
Fax +612 4228 6811

Dear Casey,

**CALDERWOOD URBAN DEVELOPMENT: ESCARPMENT DR BRIDGE**

This letter has been prepared to explain the timeline and history of flood analysis, design and approvals of the Escarpment Drive Bridge over Macquarie Rivulet.

**Stage 1 Project Approval**

The stage one project approval was issued on 15 August 2013, and included a 165m bridge over the Macquarie Rivulet between Stage 1A and Stage 1B/C. Condition A1 of the Stage 1 approval refers to the following report:

- Consolidated Flood Impact Assessment Cardno – Calderwood Urban Development Project Stage 1, dated 26 March 2013

This report summarises the flood analysis completed for the project as part of the Land and Environment Court approval. The flood analysis and bridge design was based on the 2011 Macquarie Rivulet Flood Study by Rienco. The flood model and bridge design were refined as part of the court case following review by flood expert Drew Bewsher as well as a technical review by consultants SKM. The Consolidated Flood Impact Assessment (Cardno 2013), referring to the bridge, states that:

> *"A minimum soffit level of +17.346 m AHD has been adopted, which provides approximately 100 mm freeboard from the maximum PMF headwater level of +17.165 m AHD."*

And:

> *"The above modelling confirms that the works described above deliver flood free access to the Calderwood Urban Development"*

The Stage 1 Project approval included conditions B8-6 which states:

> *"The bridge crossing of the Macquarie Rivulet is to be designed to provide flood free access or safe evacuations routes for the anticipated design flood events in Stage 1C to be carried out before the issue of the first occupation certificate for the area of development known as Stage 1A."*

It is noted that the Shellharbour Council Flood Study was not issued in draft until March 2016.

Based on the Stage 1 Project Approval the requirement for the bridge was to provide flood free access and this was achieved with a 100mm freeboard between the PMF level and the underside of the bridge.

**Calderwood Mod 1**

As part of modification 1 which was approved on 8 April 2015, B8-6 was modified to delay the construction of the bridge:

*"The bridge crossing of the Macquarie Rivulet is to be designed to provide flood free access and safe evacuation routes for the anticipated flood events in Stage 1C. The bridge must be constructed prior to the issue of the first Occupation Certificate for the area of development with Stage 1B or Stage 1C whichever occurs first."*

**Calderwood Mod 3**

Modification 3 of the project was submitted on 9 June 2015 and was approved 13 January 2016. The modification included revised flood analysis and proposed to reduce the span of the Macquarie Rivulet Bridge from 165m to 144m. Condition A1 of the Stage 1 was modified to refer to the following drawings:

- General Arrangement Sheet A 8201504-SB-102 Rev 4 Dated 25/11/2015
- General Arrangement Sheet B 8201504-SB-103 Rev 1 Dated 01/05/2015

These plans are the bridge long section and cross sections which show that as part of Mod 3, the soffit of the bridge was designed to be above the PMF which is consistent with the Stage 1 application report and complies with condition B8/6. This design was based on the Court Approved and peer reviewed flood model used for the Stage 1 project application.

As part of the approval of Mod 3, the conditions of approval were modified to include B1-2, being:

> "*The height of the Macquarie Rivulet Bridge deck shall be raised to ensure the underside of the soffit achieves a minimum freeboard of 0.5m during a PMF event. Detailed engineering plans of the Macquarie Rivulet Bridge illustrating the minimum freeboard requirement shall be submitted to and approved by the certifying authority prior to the release of the relevant Construction Certificate.*"

It is noted that the Shellharbour Council Flood Study was not issued in draft until March 2016, which was after Mod 3 was approved. A submission was received from Shellharbour Council during the approval of Mod 3 that indicated their Macquarie Rivulet flood study was predicting flood levels higher than those predicted in the Court Approved flood model. Although, the model was in pre-draft format, it was reviewed by Cardno at the time and it was found that the differences in flood level between the two models were primarily due to different survey, different manning's roughness values and differences in hydrological modelling. This review was provided to the Department of Planning as part of the response to submissions on the 1st of September. As the Council model had not yet been finalised or reviewed by a 3rd party, the Mod 3 was approved based on the original Court Approval.

Based on the Mod 3 approval, the requirement for the bridge was to provide flood free access. This was supplemented with a requirement to increase the freeboard by 400mm from 100mm, as per the Stage 1 approval to 500mm. Freeboard is added onto a flood level to account for uncertainties and in this case provides a safety factor to ensure that the bridge still meets the original design intention of providing flood free access across Macquarie Rivulet. In this case part of this uncertainty was due to the introduction of new flood modelling in draft format that was supplied by Shellharbour City Council.

**Bridge Approval and Construction**

Shellharbour City Council provided construction certificate approval for the Macquarie Rivulet Bridge on 17 April 2016. As part of the detailed design of the bridge, the design was revised to provide 500mm of freeboard to the PMF level predicted by the Court approved flood model as per condition B1-2.

It is noted that the Shellharbour City Council Macquarie Rivulet Flood study was issued one month prior to the CC being issued for the bridge plans. The bridge construction was completed by 3 March 2017 and the final Shellharbour City Council flood study was issued in February 2017. Based on this information it is considered appropriate that the bridge design was progressed with the Court Approved flood study. The inclusion of the increased freeboard (500mm instead of the initial 100mm) introduced a larger margin of error to ensure that the flood free access is available across the Macquarie Rivulet.

**Mod 4**

As part of the proposed modification to the Calderwood Concept Plan (Mod 4), revised flood modelling of the development and bridge has been undertaken using Shellharbour City Councils Macquarie Rivulet food study which has now been finalised. Based on this modelling, Cardno has been advised that there is 300mm of freeboard between the revised PMF level and the underside of the bridge. This is due to the Shellharbour City Council flood model predicting higher flood levels in the PMF when compared to the Court approved flood model.

In reference to condition A1 and the Consolidated Flood Impact Assessment (Cardno 2013), and condition B8-6, the bridge is consistent with the Stage 1 project approval as there is more than 100mm of freeboard to the underside of the bridge and there is predicted to be flood free access over Macquarie Rivulet.

Condition B1-2, which was introduced in Mod 3, and requiring 500mm of freeboard to the PMF has already been fulfilled as the construction certificate for the bridge has been issued by Shellharbour City Council and

there is still 500mm of freeboard to the PMF levels predicted by the court approved model which was the best available data at the time.

**Bridge Freeboard**

It is noted that the Australian Standard for Bridge Design, AS5100 normally requires 500mm of freeboard to the 100 year ARI flood level with no requirement for freeboard in the PMF. Based on the revised modelling, the bridge achieves at least 2m of freeboard to the 100 year ARI flood level which is beyond the normal requirements for bridge design applied by RMS or Local Councils.

Yours sincerely,

Rory Hentschel
Manager – Water Engineering
for Cardno
Direct Line: +61 2 4231 9638
Email: Rory.Hentschel@cardno.com.au

Enc:

cc: