# Flood Impact Assessment

*for*

## Proposed Rezoning

*at*

## 2514 Illawarra Highway, Tullimbar

Job No: NL166600
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## Report Details

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# 1 Introduction

Northrop Consulting Engineers have been engaged to undertake a flood impact assessment for the proposed rezoning at 2514 Illawarra Highway, Tullimbar (the site).

The objective of this investigation is to determine the feasibility of implementing New South Wales Government and Shellharbour's flooding and water management policies and guidelines, within the context of the proposed new zoning.

Consideration has been given to the following documents throughout the course of this investigation.

- Shell Harbour City Council Development Control Plan (2016);
- Macquarie Rivulet Flood Study Review (WMA Water, 2016);
- NSW Government Floodplain Development Manual (NSW Government, 2005);
- Calderwood Urban Development Project – Section 75W Application – Watercycle and Flood Management Strategy Updated (J Wyndham Prince, 2018);
- Statement of Environmental Effects – North Macquarie Road, Calderwood (Cardno, 2017);
- NSW Government Floodplain Risk Management Guideline - Practical Consideration of Climate Change (NSW Government, 2007); and
- Water Management Act 2000 (NSW Government, 2016).

The following correspondence outlines the methodology used and presents the results of the flood impact assessment.

# 2 Locality Description

## 2.1 Subject Site

The subject site is located within the Macquarie Rivulet catchment at Tullimbar and is known as Lot 7 DP259137. It is bounded by the Illawarra Highway in the south, farmland and rural residential to the west, North Macquarie Road in the north and the Calderwood Urban Release Area to the east. The locality of the proposed site with respect to the surrounding area is shown in Appendix A, Figure A1.

The site is currently used for a range of agricultural purposes including cattle grazing, egg farming and Christmas tree production. A residential dwelling as well as various sheds and out buildings are located within the south-western portion of the site on an elevated mound.

The elevations through the subject site range from approximately 12m AHD to 35m AHD and are shown in the attached Figure A2. On the southern side of the rivulet, the terrain is generally flat with a raised mound containing the existing dwelling. The Macquarie Rivulet is incised and characterised by steep banks. Grades are much steeper on the northern side of the rivulet, in the order of five to ten percent up to North Macquarie Road.

The site is bisected by the Macquarie Rivulet which flows in an easterly direction towards Lake Illawarra. Yellow Rock Creek runs along the eastern boundary of the site and terminates at its confluence with the Macquarie Rivulet to the east of the subject site. An unnamed second order creek also ends at its confluence with the Macquarie Rivulet in the north-western corner of the subject site. A number of additional first order streams also traverse the site, two in the south-western corner, one across the southern boundary and another across the northern boundary.

The watercourses within the site have been classified in accordance with the Department of Primary Industries – Water's guidelines "*Controlled Activities on waterfront land – Guidelines for riparian corridors on waterfront land*". The creek classifications are outlined in the attached Figure A3 while the associated vegetated riparian offsets are summarised in Table 1 below.

**Table 1 – Watercourse Vegetated Riparian Zone offsets**

| Watercourse | VRZ Width (m) |
|---|---|
| First Order Creeks | 10 |
| Second Order Creek | 20 |
| Yellow Rock Creek | 40 |
| Macquarie Rivulet | 40 |

Vegetation is largely pastural grasses commensurate with the current use of the site. Larger wooded vegetation and shrubs are typical of the rivulet and creek banks, while two stands of pine forest are located either side of the rivulet.

Figures showing the elevations, slope and watercourse locations are included in Appendix A, Figures A2-A4.

## 2.2 Proposed Development

It is proposed to rezone the portion of land currently classified as Primary Production to a mixed land use. The proposed developable area is shown in the attached Figure A4.

It is proposed to realign a number of the first order creeks traversing the subject site, in accordance with DPI – Water requirements. The first order creek to the south is proposed to be re-directed to the east towards the proposed compensatory cut area and into the confluence zone between Yellow

Rock Creek and the Macquarie Rivulet. The two first order creeks located to the south west of the subject site is proposed to be directed into a secondary compensatory cut zone which discharges directly to the Macquarie Rivulet. The first and second order creeks to the north are proposed to remain largely unchanged in that the existing riparian offsets and creek alignments are to remain.

It is proposed to offset a portion of the riparian corridor along the northern boundary of the southern fill pad to the east within area where the compensatory cut is proposed. A minimum elevation was set at the 1% AEP design storm event plus 500mm freeboard for the developable areas and has been entered into the two-dimensional model using elevation polygons.

# 3 Methodology

The assessment was undertaken using the following procedure:

- Desktop review of the Shellharbour Development Control Plan (2016) and the Macquarie Rivulet Flood Study (WMA Water, 2016);
- Liaison with Shellharbour Council to obtain upstream hydrographs for the Macquarie Rivulet and Yellow Rock Creek including the downstream tailwater levels to the east;
- Site visit to determine hydraulic roughness of the existing vegetation and ground truth survey information;
- Preparation of a pre-developed XP-RAFTS hydrological and XP-STORM hydraulic model to assess the existing flood level and compare to the results from the DRAFT Macquarie Rivulet Flood Study (WMA Water, 2016); and
- Inclusion of the development into the XP-STORM hydraulic model to assess the impacts of the development on the flood levels on-site and in the adjacent properties;

A description of the hydrological and hydraulic modelling including the parameters and assumptions used are included overleaf.

# 4 Hydrological Model Parameters

Inflow hydrographs from the Macquarie Rivulet Flood Study (WMA Water, 2016) for the "MacRivulet36" and "Yellow25" sub-catchments have been included into the 2D model. These two inflow hydrographs have been used as the majority of the inflow into the two-dimensional model with the exception of the local sub-catchments within the vicinity of the site.

The catchments within the vicinity of the subject site have been modelled using one dimensional nodes and applied directly to the two-dimensional grid. These local catchments are largely made up of those defined in the Macquarie Rivulet Flood Study as "MacRivulet37" to "MacRivulet42" and have been further refined to represent overland flow paths upstream of the subject site. The refined catchments are presented in the attached Figure A2.

A typical impervious percentage of 5% has been applied to the rural residential catchments while 60% has been applied to the downstream Lendlease development. The sub-catchment details are summarised in Table 1 below.

**Table 2– XP-RAFTS Sub-Catchment Data**

| Sub-catchment | Area (ha) | Vectored slope (%) | Fraction Impervious (%) |
|---|---|---|---|
| A | 67.57 | 10.9 | 13.4 |
| B | 16.34 | 11.0 | 5 |
| C | 11.95 | 12.8 | 5 |
| D | 26.59 | 1.0 | 5 |
| E | 23.92 | 8.2 | 5 |
| F | 17.74 | 13.1 | 5 |
| G | 20.28 | 16.5 | 5 |
| H | 5.11 | 27.0 | 5 |
| I | 49.67 | 4.3 | 5 |
| J | 40.492 | 15.0 | 5 |
| K | 56.81 | 13 | 5 |

Typical Manning's roughness values of 0.020 and 0.050 were used for the impervious and pervious catchments respectively. Losses have been represented using the initial and continuing loss model. In this case, no losses have been adopted for both the initial and continuing loss for impervious areas, while an initial loss of 0mm and continuing loss of 2.5mm/hr was used for pervious surfaces.

# 5 Hydraulic Model Parameters

The hydraulic assessment was undertaken using the XP-STORM computer software, featuring the TUFLOW hydrodynamic engine. The parameters used are described below.

## 5.1 Two Dimension Grid Extents and Size

The two-dimensional grid extends to the south of the Illawarra Highway, to the north of North Macquarie Road and projects approximately 900m and 600m upstream and downstream of the subject site respectively. A four-metre grid cell size was adopted to balance run time whilst adequately representing flows through the creek and across the subject site.

## 5.2 Terrain

Terrain data used for the model was a combination of LIDAR and detailed survey. A series of elevation polygons have been entered manually into the model to represent the land surface elevations for the Lendlease development downstream. This information was based on a GIPA application lodged with Council on the 6th of December 2016 and received on the 23rd of December 2016.

The existing terrain is shown in Figure A2 attached.

## 5.3 Boundary Conditions

Inflow hydrographs for the Macquarie Rivulet and Yellow Rock Creek where provided by Council from the Macquarie Rivulet Flood Study (WMA Water, 2016). These hydrographs where entered into the model upstream of the subject site and have been applied to the 2D grid via flow areas and flow boundary's. An outlet head boundary has been entered downstream of the subject site approximately 600m downstream of the confluence of the Macquarie Rivulet and Yellow Rock Creek. The elevation of the outlet head boundary has been based on the flood levels provided in the Macquarie Rivulet Flood Study.

The boundary conditions are shown in Figure A2 Attached.

## 5.4 Catchment Roughness and Building Representation

Catchment roughness was determined from a site visit, review of hydraulic literature and review of the Macquarie Rivulet Flood Study. The values are outlined below in Table 2 and are shown in the attached Figure A5.

**Table 3 – Manning's Roughness**

| Land Use | Manning's Roughness |
|---|---|
| Roads | 0.020 |
| Buildings | 0.300 |
| Yard Landscaping | 0.150 |
| Heavy Vegetation | 0.100 |
| Grass | 0.050 |
| Water Bodies | 0.030 |

## 5.5 Stormwater Infrastructure

A bridge crossing is located adjacent to the south-eastern corner of the site where the Illawarra Highway crosses Yellow Rock Creek. The bridge crossing has been added into the two-dimensional model via a flow constriction with the dimensions provided by detailed survey. A blockage factor of

15% has been added to the flow beneath the deck soffit to resemble the loss in flow conveyance due to the supporting piers. A blockage factor of 100% has been used for flows that come into contact with the bridge deck, while 50% has been used for the guardrail above.

A secondary proposed bridge crossing has been added into the model, spanning the width of the Macquarie Rivulet for the future downstream Lendlease development. The bridge levels have been based on information provided by Council with some assumptions made where information was not available such as the bridge deck thickness of 800mm, 5% blockage for bridge supports and a 1.5m guardrail above. Similar to the Illawarra Highway crossing, a 100% blockage factor has been applied for flows that come into contact with the bridge deck and 50% for the guardrail above have been applied.

An effective blockage factor of 0% has been applied to flows beneath the bridge decks to ensure the pre to post results are not dampened as a result of a high downstream tail water.

A highway culvert crossing has been located crossing the Illawarra Highway adjacent to the western side of number 2469 Illawarra Highway to the south of the subject site. This culvert crossing provides a flow path for the first order creek that flows in a northerly direction into the southern portion of the site. A 450mm reinforced concrete pipe has been assumed for this culvert crossing based on detailed survey invert levels and assumed cover requirements.

Two additional culvert crossings have been identified using Google Street View to be located adjacent to the south-western corner of the site. These culvert crossings have been assumed to be 0.6x1.2m Reinforced Concrete Box Culverts and convey flows from the two first order creeks beneath the Illawarra Highway and across the western edge of the subject site.

On the northern side of the subject site, across North Macquarie Road, a culvert crossing has been identified using Google Street View and dimensions estimated using LiDAR elevation data. This culvert conveys flows from the first order creek beneath North Macquarie Road and bisects the northern portion of the subject site. A 450mm reinforced concrete pipe has also been assumed for this culvert crossing. A typical blockage factor of 50% has been applied to all culvert crossings.

# 6 Results

## 6.1 Critical Storm Duration

The Macquarie Rivulet Flood Study outlines the nine or two-hour storm durations to be critical for the Rivulet during the 1% AEP design storm event. Review of the hydrographs provided by Council suggests that the two-hour event was critical for the Yellow Rock Creek, while the nine-hour event was critical for the Macquarie Rivulet. Both events where analysed and the nine-hour event produced the highest water level around the site and was therefore adopted for the assessment.

Similarly, the Macquarie Rivulet Flood Study suggests the 1.5 and three-hour storm durations are critical for the Probable Maximum Precipitation (PMP) event. Both events where analysed for the assessment and the three-hour event produced the highest water levels around the site and was therefore adopted for the assessment.

## 6.2 Existing Flood Behaviour and Levels

Flooding across the site is largely due to the regional event with runoff produced by the upper Macquarie Rivulet and Yellow Rock Creek catchments.

During the 1% AEP design storm event, flows from the south including runoff from the upper Yellow Rock Creek catchment initially inundate the southern portion of the subject site. Following inundation from the Yellow Rock Creek catchment, the peak event from the Macquarie Rivulet enters from the west and combines with the flow from the south to inundate a large portion of the southern section of the site.

Due to the steep topography in the northern portion of the site, the majority of flows are contained within the creek riparian zones and as such this portion of the subject site generally remains unaffected by the 1% AEP design storm event.

Similar results are observed during the PMF in that the southern portion of the subject site initially becomes inundated from the flows from the south, followed by from the west when the Macquarie Rivulet breaks its banks during the peak event.

The attached Figures B1-B4 present the pre-developed results for both the 1% AEP and PMF design storm events. Water levels through the Macquarie Rivulet range between 20.8m AHD adjacent to the western boundary of the subject site and 16.9m AHD to the east during the 1% AEP. During the PMF event water levels range from 23.4m AHD to the west and 19.0m AHD to the east of the subject site.

Velocities range, during the 1% AEP design storm event, from 1.5-3.5m/s within the Macquarie Rivulet to 0.3-1.5m/s across the southern portion of the subject site. During the PMF velocities range from 2-5m/s within the Macquarie Rivulet to 0.8-2m/s across the southern portion of the subject site.

## 6.3 Development Impact on Flood Behaviour

The attached Figures B5 and B8 present the developed results for the 1% AEP and PMF design storm events respectively. The results for the 1% AEP design storm event shows flows from the Macquarie Rivulet catchment being redirected around the extent of the southern fill pad while flows from the south and south east are directed into the compensatory cut zone between the southern fill pad and the Illawarra Highway. During the PMF, flows above the 1% AEP plus 500mm level are observed passing over the southern fill pad and a small portion of the fill pads to the north.

The development impact on both water level and velocity is presented in the attached Figures B9 to B12 for both the 1% AEP and PMF design storm events. The results show that during the 1% AEP design storm event, an increase in water level of approximately 35mm is observed to the west of the proposed development with a freeboard in excess of 2 meters still available to habitable floor levels in this area. During the PMF an increase of approximately 300mm is observed which extends to the rural dwelling upstream where an increase of up to 125mm is observed. A freeboard depth of

approximately 300-500mm is available to the dwelling floor level in this event and as such this increase is considered not significant.

An increase in water level of approximately 800mm is also observed through the centre of the subject site along the Macquarie Rivulet, however this increase quickly disperses prior to the confluence of the Rivulet and Yellow Rock Creek. An increase of up to 140mm is observed during both the 1% AEP and up to 160mm during the PMF design storm event within the creek near to the Lendlease development adjacent to the north-eastern fill pad. The information provided by Council suggests there is a freeboard in excess of 2 meters available in this area during the 1% AEP design storm event and approximately 300mm during the PMF design storm event.

A localised increase of approximately 65mm and 110mm is also observed just upstream of the Lendlease development to the east of the subject site during the 1% AEP and PMF design storm events respectively. Freeboard to the Lendlease development in this area is in excess of 2 meters during the 1% AEP design storm event and greater than one metre during the PMF. This increase can therefore be considered to have minimal impact on the downstream development.

A decrease in the water level is observed along the Illawarra Highway and within the property to the south of the subject site of up to approximately 170mm in the 1% AEP design storm event and 190mm during the PMF. This decrease will improve access along the Illawarra highway during major events and improve the existing flood impact on the property to the south of the Illawarra Highway.

To the southwest of the subject site, an increase of up to 160mm is observed during the PMF across the Illawarra Highway. This increase reduces freeboard to the property on the southern side of the Illawarra Highway during the PMF, however freeboard to the floor level for this property is also estimated to be in excess of 2 meters and is therefore considered to have minimal impact. No increase is observed in this area during the 1% AEP design storm event.

Velocity changes are observed across the site during the 1% AEP and PMF design storm events due to the changes in topography as part of the development. During both the 1% AEP and PMF design storm events, a decrease in velocity of up to 1.0m/s and increase of up to 1.0m/s is observed within the cut zone to the east and the west of the subject site.

A decrease in velocity during the 1% AEP and PMF design storm events of up to approximately 0.2m/s and 1.0m/s respectively is observed through the centre of the subject site within the Macquarie Rivulet. This decrease in velocity is commensurate with the increase in water level observed. An increase in velocity during the 1% AEP and PMF design storm events of up to approximately 0.4m/s and 1.0m/s respectively is also observed just upstream of the confluence of the Macquarie Rivulet and Yellow Rock creek.

No changes in water level and velocity are observed to the north of the subject site along North Macquarie Road.

# 7 Discussion

## 7.1 Flood Planning Level

As outlined in the NSW Floodplain Development Manual 2005, a Flood Planning Level (FPL), or minimum habitable floor level for non-sensitive developments is to be set at the 1% AEP design storm event plus a freeboard of 500mm. For roads and the associated landscaping, a minimum fill level is to be set at the 1% AEP design storm event.

For sensitive developments such as an aged care or emergency response facilities, the FPL is often set at the PMF. Reductions in the FPL may apply provided it can be demonstrated that the associated risk to life can be appropriately managed in accordance with the NSW Floodplain Development Manual. For such developments, further consideration is required to ensure refuge, evacuation routes and access is available for the site during extreme rainfall events.

## 7.2 Significant Impact

The results presented above indicate a loss in freeboard is observed for several the surrounding properties during the both the 1% AEP and PMF design storm events. Loss of freeboard is considered significant if it is to reduce available freeboard during the 1% AEP design storm event to less than 500mm for non-sensitive sites. During the PMF a loss in freeboard can be considered significant if flooding were to occur over a sensitive facility that did not occur prior to the development of the proposed site. If these scenarios were to occur, the required freeboard outlined within the NSW Floodplain Development Manual is no longer achieved and the impact can therefore be considered significant.

The results from this study indicate that this is not the case and therefore the overall impact is considered not significant.

## 7.3 Section 117 Direction 4.3 – Flood Prone Land

As part of the rezoning application, a submission is required in accordance with the Minister for Planning Section 117 Direction 4.3 – Flood Prone Land. The objectives of this direction are outlined below.

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

As such this flood impact assessment has been developed to analyse the existing and proposed flood behaviour for the site. This study has adopted the principles outlined in the NSW Floodplain Development Manual 2005 and has also assessed the potential flood impacts both on and off the subject site.

## 7.4 Impact on Upstream Residential Land

Under the Major Projects SEPP (2005), the upstream property a mixture of R5 (large lot residential) and R1 (general residential) outside the riparian corridor. No fill in these areas fill was proposed as part of the supporting masterplan study (as outlined in J Wyndham Prince, 2018).

The impact on the residential zoned land is approximately 25mm in the 1%AEP and approximately 200mm in the PMF. It is noted the 1%AEP increase is not considered significant, and the impact in the PMF is similar in magnitude with the impact from the wider Calderwood development on the subject site.

Furthermore, it is expected the rezoned residential land will be made flood free in the 1%AEP event through the introduction of fill (per the Cardno SEE, 2017), thus further reducing the impact of the development of the subject site on upstream residential land.

# 8 Conclusion

A flood impact assessment has been undertaken for the proposed rezoning of 2514 Illawarra Highway, Tullimbar.

It was found that the proposed development has no significant impacts on flood behaviour and affectation in the vicinity of the subject site.

We commend our findings to Council for their review. Should you have any queries regarding this correspondence, please feel free to contact the undersigned on (02) 4943 1777.

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# APPENDIX A