

## 6 ASSESSMENT OF OPERATIONAL HYDROLOGY AND FLOODING IMPACTS

The operational (design) scenario has been incorporated into each of the Duck Creek, Macquarie Rivulet and Horsley Creek flood models, to estimate impacts on hydrology and flooding. Through an iterative process, the design has been optimised to provide a high level of flood immunity, while minimising impacts to hydrology and flooding.

Specific outcomes associated with each of the Duck Creek, Macquarie Rivulet and Horsley Creek catchments are discussed in the following sections. These sections detail the expected flooding impacts from the project, with comparison to existing flood levels.

This is followed by a discussion of potential impacts associated with the contribution of the project to future flooding scenarios, such as climate change and land use change within the catchment.

### 6.1 DUCK CREEK

#### 6.1.1 DESIGN

The proposed motorway follows the existing Princes Highway alignment for the majority of the Duck Creek catchment. It is proposed to widen the existing motorway bridge over Duck Creek to cater for the additional traffic lanes. Proposed road levels at Duck Creek are similar to the existing road levels. At the watercourse to the south of Duck Creek, the road design levels are similar to the existing levels and the existing culvert configuration would be extended under the motorway. At the watercourse to the north of Yallah Road, the motorway crosses the existing road via an overpass. It is proposed to upgrade the existing culverts at this location. Further details of the design are provided in **Table 6-1**.

Transverse drainage for the motorway through the Duck Creek catchment was designed to minimise flooding impacts while achieving the desired flood immunity for the project. The presence of existing road, bridge and culvert infrastructure has also formed a constraint and influenced the design solution as proposed.

The proposed motorway achieves 100 year ARI flood immunity for the extent of the alignment through Duck Creek, with the exception of a low point to the south of the Duck Creek Bridge and at the Yallah Road bridge. At this location, road levels are constrained by the existing levels on the Duck Creek Bridge, which is to be widened by 6m. Immunity from the 50 year ARI design storm is achieved at this location.

A summary of the transverse drainage design approach and flood results at each location for the Duck Creek catchment is provided in **Table 6-1**.

**Table 6-1 Summary of Transverse Drainage Design Approach – Duck Creek Catchment**

| Transverse Drainage Structure | Design (Operational Activity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Results (Operational Impacts)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D1<br>CH 16320                | <p>Both existing bridges are to be duplicated upstream of the existing structures. The lowest soffit level of the widened section of the motorway bridge is 180mm lower than the lowest soffit level of the existing bridge due to the cross fall of the existing bridge. Additional piers are also required to support the widened bridge.</p> <p>The low point of the north bound entry ramp and the Princes Highway north bound lane is 60m south of the Duck Creek bridge abutment. The low point of the motorway is 115m south of the Duck Creek bridge abutment. The road levels of the motorway are constrained at this location due to the need to tie into the existing bridge levels.</p> | <p>The north bound exit ramp and Princes Hwy northbound lane are inundated at the low point to the south of the bridge by up to 1.0m in the 100 year ARI event. This water partially floods the north bound lanes on the motorway but does not overtop the road. Water is up to 0.25m deep on the edge of the motorway which results in two of the three north bound lanes being flooded.</p> <p>The main alignment achieves 50 year ARI immunity at this location.</p> <p>The flood levels upstream of the motorway are higher in the design scenario due to the bridge soffit being lower and the additional piers reducing the water flow under the bridge. In the proposed case the motorway bridge remains partially submerged in the 100 year ARI event.</p> <p>Increases in water level of up to 70mm and 220mm are predicted upstream of the alignment in the 20 and 100 year ARI events.</p> <p>No impacts are predicted in the 20 year ARI events as a result of this configuration. In the 100 year ARI an increase of 120mm is predicted at this location. This increase is a result of additional water being diverted from the structure at D3 rather than the proposed culvert configuration at D2.</p> |
| D2<br>CH 16830                | It is proposed to extend the existing 4x 900mm RCP culverts under the main alignment at this location.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <p>100 year ARI immunity is predicted at this location.</p> <p>No impacts are predicted in the 20 and 100 year ARI events as a result of this configuration.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| D3<br>CH 17050                | It is proposed to replace the existing culverts at this location with a single 2100mm RCP culvert. This culvert crosses the motorway and highway and discharges at the same location as the existing culverts. The single 2100mm RCP culvert has a lower probability of blockage, and has a similar capacity to the existing culverts in an unblocked scenario. At this location the north bound entry ramp is a few meters higher than the existing road levels.                                                                                                                                                                                                                                   | <p>Assuming 100% blockage of this proposed 2100mm RCP culvert (as per Wollongong City Council blockage policy), flood levels pond upstream of the motorway, before flowing north onto the north bound exit ramp and Princes Highway north bound lane. Water on these lanes then ponds which results in water 2.7m deep at the low point on the Princes Highway (just north of the motorway bridge). Water then flows north along the Princes Highway to the low point south of Duck Creek before overflowing towards Duck creek upstream of the motorway. This sequence of flooding occurs for all events with sufficient volume.</p> <p>In the 20 and 100 year ARI events, a flood level increase of 2.5m is predicted upstream of the alignment at this location due to the increased road levels. These changes are due to the proposed motorway being higher than the existing motorway and the assumption of 100% culvert blockage in accordance with Wollongong City Council blockage policy.</p> <p>In the 100 year ARI event, the motorway results in 0.55ha of newly flooded land beyond the project boundary and 0.6ha of newly flooded land within the project boundary.</p>                                |

|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>The impacted property (Property 1) upstream of the motorway is currently zoned as Rural land under Wollongong LEP38. In the draft Yallah Marshall Mount Precinct plan, the property is zoned as rural landscape. Property 1 contains one dwelling house with the surrounding land used for livestock grazing.</p> <p>The dwelling house within Property 1 is not affected by flooding and will remain so under the proposal. Day to day livestock grazing will not be impacted by the project. During a flood, livestock would move to the surrounding high ground and temporarily be unable to graze within the 0.55ha of newly flood affected land.</p> |
| D4<br>CH 17400 | At this location, the proposed motorway is immediately adjacent to the existing culvert under the railway line. The wingwalls of the proposed bridge over the railway line have been set back from the railway line to ensure that this culvert can continue to operate as intended.                                                                                                                                                                                              | Water levels upstream of the railway line are predicted to increase by 20mm in the 20 year ARI event and by 50mm in the 100 year ARI event.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| D5<br>CH 17750 | <p>The alignment is proposed directly on top of the existing watercourse at this location. As such, this watercourse is required to be adjusted from the middle dam to the culvert at D4. A bund is also required at the location of the dams to prevent flooding from this watercourse, as the road alignment transitions from cut to fill at this location.</p> <p>The proposed Yallah Road upgrade crosses the motorway and the watercourse via a bridge at this location.</p> | <p>The motorway achieves 100 year ARI immunity at this location.</p> <p>No impacts are predicted at this location. Water flows along the adjusted watercourse towards the railway line culvert. In the 100 year ARI event, water within the watercourse diversion is up to 1.0m deep with velocity up to 2.0m/s.</p>                                                                                                                                                                                                                                                                                                                                         |

## 6.1.2 FLOOD IMPACTS

Increased flood levels within the Duck Creek catchment are generally localised to where the alignment crosses the three individual watercourses, and are primarily due to changes in conveyance. Although predominately contained within rural land, impacts exceed flooding impacts criteria for the project at D3 and D5.

It is noted that the Wollongong City Council blockage policy was adopted for the existing and proposed scenarios within the Duck Creek catchment, which is consistent with the Duck Creek flood study (BMT WBM, 2012). The policy also requires assessment of the unblocked scenario, which has also been undertaken for the existing and proposed scenarios. Results maps presented in this report were generated as an 'envelope' of the blocked and unblocked cases, to represent a worst case scenario of the two cases. Generally, impacts upstream of the alignment are greater in the blocked case, while impacts downstream are greater in the unblocked case.

The timing and volume of water flowing to Lake Illawarra from the Duck Creek catchment is not predicted to change as a result of the project.

## Flood Level

Flood level increases of up to 70 mm and 220 mm are predicted upstream of the alignment at Duck Creek in the 20 and 100 year ARI events (respectively). In the PMF event, an increase of approximately 300 mm is predicted at this location.

In the 20 and 100 year ARI events, an increase in flood level of 2.5 m is predicted upstream of D3 within the project boundary. New flooding up to 2.2 m deep is predicted over an area of 0.55 ha beyond the project boundary. This new flooding is due to the proposed 2.1 m diameter culvert being assumed as 100% blocked in accordance with Wollongong City Council policy.

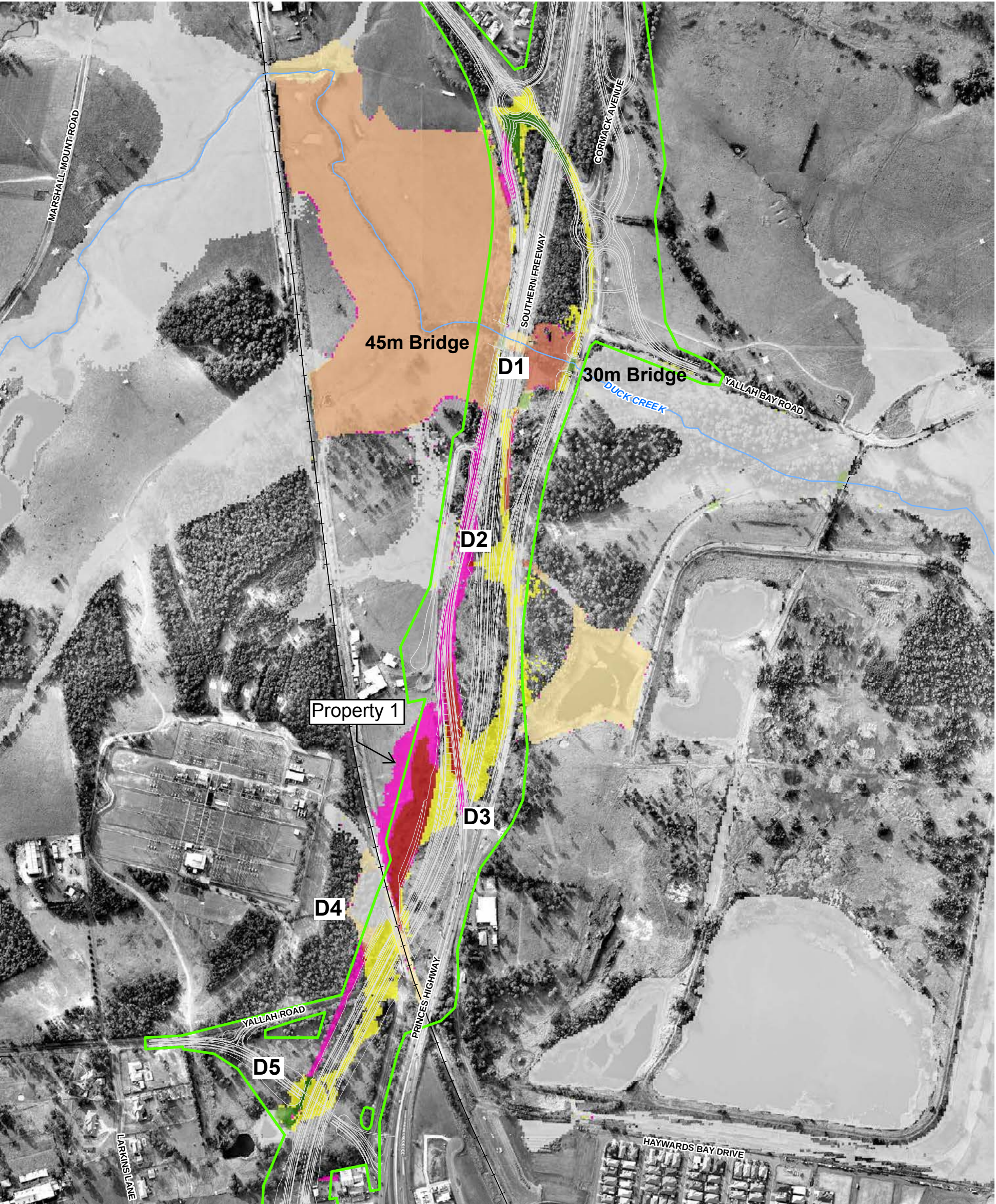
A summary of water level changes within the Duck Creek catchment for the range of flood events modelled is provided in

**Table 6-2.**

**Table 6-2 Change in Water Levels – Duck Creek**

| Location                                                    | 10 year ARI | 20 year ARI | 50 year ARI | 100 year ARI | 200 year ARI | 500 year ARI | PMF    |
|-------------------------------------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------|
| Duck Creek (D1), upstream of motorway at project boundary   | +0.06m      | +0.07m      | +0.13m      | +0.22m       | +0.34m       | +0.45m       | +0.3m  |
| Duck Creek (D1), downstream of motorway at project boundary | +0.01m      | +0.01m      | +0.01m      | -0.01m       | -0.02m       | -0.02m       | +0.13m |
| D2, upstream of motorway at project boundary                | +0.00m      | +0.00m      | +0.05m      | +0.12m       | +0.15m       | +0.17m       | +0.25m |
| D2, downstream of motorway at project boundary              | -0.06m      | +0.11m      | +0.01m      | -0.05m       | -0.09m       | -0.10m       | -0.65m |
| D3, upstream of motorway at project boundary                | +2.52m      | +2.5m       | +2.51m      | +2.52m       | +2.52m       | +2.52m       | +2.54m |
| D3, downstream of motorway at project boundary              | -0.01m      | +0.02m      | +0.04m      | +0.04m       | +0.03m       | +0.04m       | -0.72m |
| D4, upstream of railway line at project boundary            | +0.01m      | +0.02m      | +0.04m      | +0.05m       | +0.06m       | +0.08m       | +0.07m |
| D5, upstream of Yallah Road overpass at project boundary    | +0.00m      | +0.00m      | +0.00m      | +0.00m       | +0.00m       | +0.00m       | +0.00m |

Changes in flood level are illustrated in **Figure 6-1** and **Figure 6-2**, for the 20 year ARI and 100 year ARI events (respectively).



LEGEND

- Site Boundary
- Concept Design
- Major Watercourses
- Railway
- Change in Water Level (m)
- Newly Flooded

|               |                   |
|---------------|-------------------|
| > 0.4         | -0.05 to -0.02    |
| 0.25 to 0.4   | -0.1 to -0.05     |
| 0.1 to 0.25   | -0.25 to -0.1     |
| 0.05 to 0.1   | -0.4 to -0.25     |
| 0.02 to 0.05  | < -0.4            |
| -0.02 to 0.02 | No Longer Flooded |

DUCK CREEK 20 YEAR CHANGE IN WATER LEVEL

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:7,000 @ A3

0 50 100 200  
Metres

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

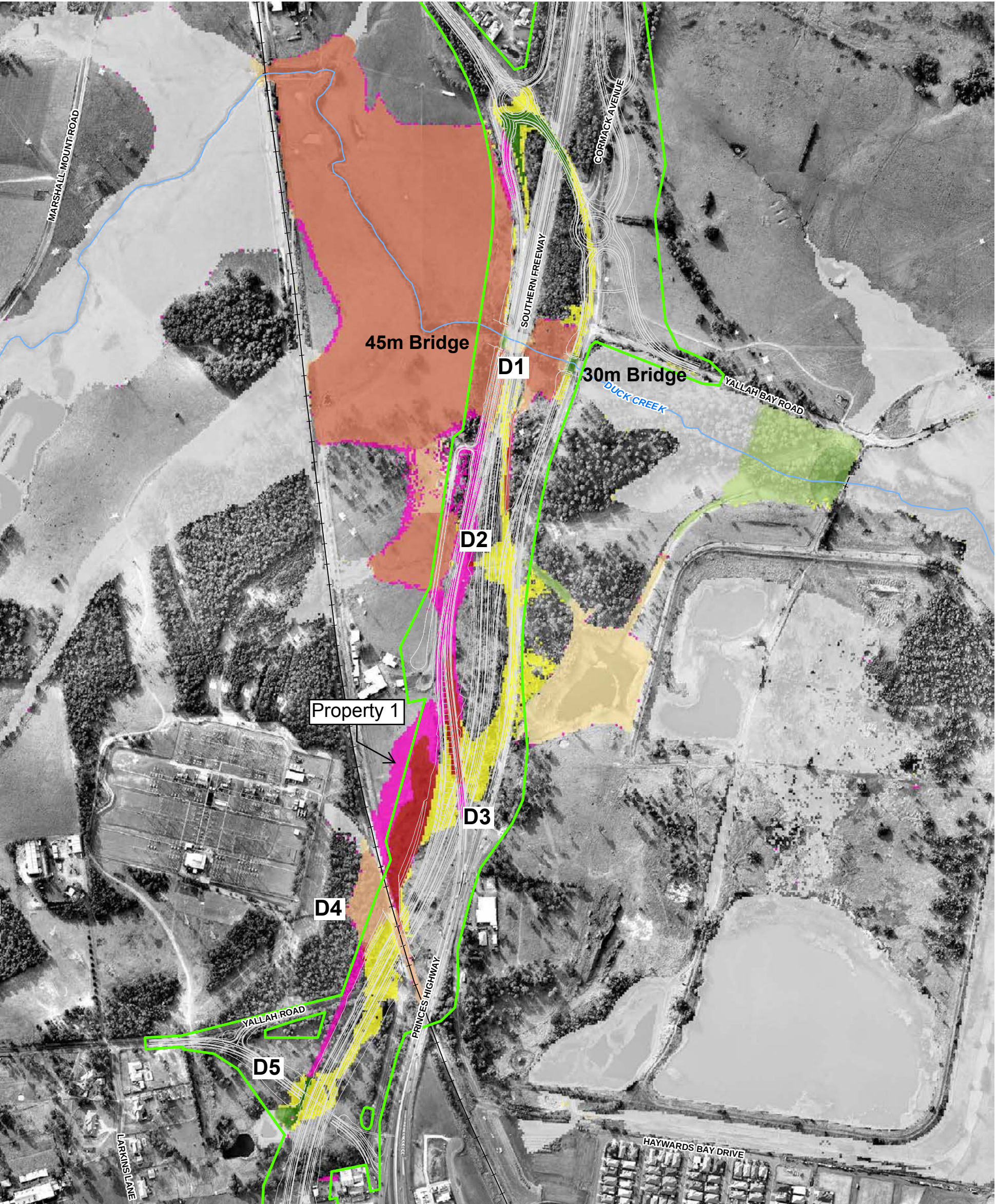
DATE: AUGUST 4, 2015

NSW  
GOVERNMENT

Transport  
Roads & Maritime  
Services

Hyder  
Gardno  
JOINT VENTURE

Figure 6-1



LEGEND

Site Boundary

Concept Design

Major Watercourses

Railway

Change in Water Level (m)

Newly Flooded

> 0.4

0.25 to 0.4

0.1 to 0.25

0.05 to 0.1

0.02 to 0.05

-0.02 to 0.02

-0.05 to -0.02

-0.1 to -0.05

-0.25 to -0.1

-0.4 to -0.25

< -0.4

No Longer Flooded

DUCK CREEK 100 YEAR CHANGE IN WATER LEVEL

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:7,000 @ A3

0 50 100 200

Metres

NSW GOVERNMENT

Transport Roads & Maritime Services

Hyder

Gardno

JOINT VENTURE

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

DATE: AUGUST 4, 2015

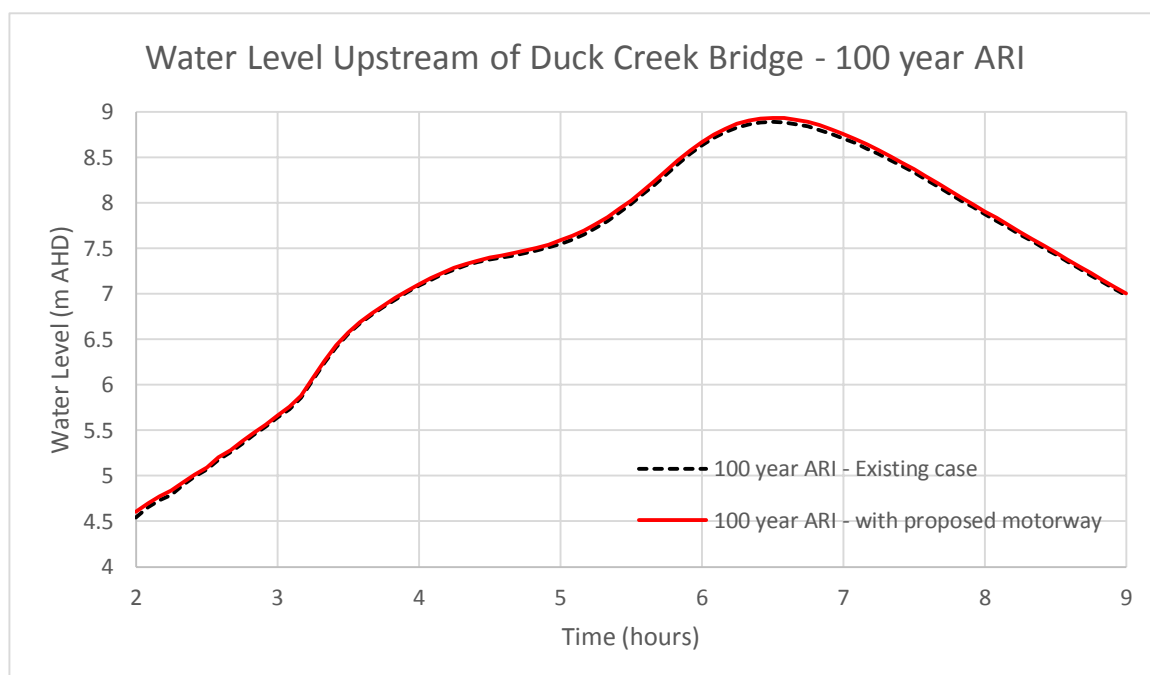
Figure 6-2

## Velocity

There are no substantial changes to velocity within the Duck Creek catchment as a result of the proposed motorway. 100 year ARI velocities within the floodplain upstream of the Duck Creek bridge remain predominately less than 1 m/s (varying by only  $\pm 0.1$  m/s with comparison to existing flood velocities). Average velocities under the existing Duck Creek bridge are predicted to decrease by 0.1 m/s (i.e. from 3.0 m/s to 2.9 m/s). 100 year ARI velocities downstream of the motorway at D3 are predicted to increase from 0.5 m/s to 0.65 m/s. Flood velocity maps for existing and proposed scenarios are provided in **Appendix B**, for the full range of storm events modelled.

## Duration

Flood duration within the Duck Creek catchment is not substantially changed as a result of the project. The flood level upstream of Duck Creek Bridge during a 9 hour 100 year ARI event is presented in the following chart. This graph demonstrates that flood waters will rise and fall in the existing case and in the proposed case in a similar manner. For example, in the existing case, the flood waters are greater than RL 7.0 m AHD for 5 hours and 5 minutes during the 9 hour 100 year ARI event. In the proposed case, this duration increases to 5 hours and 10 minutes. A change of 5 minutes of over a 5 hour duration.



## Direction

Flow direction within the Duck Creek catchment is not substantially changed as a result of the project. Floodwater is conveyed through similar locations as currently occurs for the existing motorway in this area.

## Impacts to Watercourses

The direction and velocity of flows is not expected to change considerably from the existing conditions for the design flood events modelled. For Duck Creek (D1) and the tributary to the south (D2), watercourse crossings are extended at the same size to cater for the motorway, which is unlikely to result in impacts to these watercourses in terms of bed and bank stability and scour. At D3 the culverts are being increased in size, which is not predicted to substantially

change velocities, scour potential or bed and bank stability within the watercourse upstream or downstream.

## 6.1.3 PERFORMANCE AGAINST CRITERIA

Table 6-3 Duck Creek Operational Flooding Performance

| DESIGN CRITERIA                           | MINIMUM DESIGN REQUIREMENT                                                                                                                                                                                                                                        | DESIGN PERFORMANCE AGAINST CRITERIA                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>FLOOD IMMUNITY</b>                     |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Main Carriageways</b>                  | 100 year ARI desirable (excluding allowance for climate change and land use change)<br>20 year ARI minimum (including allowance for climate change and land use change)<br>Flood immunity measured at the edge line of the carriageway. No freeboard requirement. | 50 year ARI immunity achieved on motorway at low point to the South of Duck Creek bridge.<br><br>100 year ARI immunity achieved for remainder of project within Duck Creek catchment.<br><br>20 year ARI immunity is achieved on the motorway under the climate change and land use change scenario.                                                                                                                                                       |
| <b>Other roads</b>                        | Maintain or improve trafficability of the existing local road during floods                                                                                                                                                                                       | Achieved.                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Cycleways</b>                          | Maintain or improve trafficability of cycleways during floods, compared to the existing adjacent local road or path                                                                                                                                               | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>FLOOD IMPACTS</b>                      |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Flood Level (height)</b>               |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Houses, Urban and Commercial Areas</b> | Less than 50 mm increase for the 20 and 100 year ARI flood event.                                                                                                                                                                                                 | N/A. No houses, urban or commercial areas within flooded area.                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Recreational Areas</b>                 | Less than 100 mm increase for the 20 and 100 year ARI event.                                                                                                                                                                                                      | N/A. No recreational areas within flooded area.                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Agricultural Areas</b>                 | Generally less than 250 mm increase with localised increases of up to 400 mm flooding acceptable over small areas (nominally less than 5 ha) in the 20 and 100 year ARI flood event.                                                                              | Not achieved at D3 which predicts a flood level increase of 2.5 m in the 100 year ARI event. This results in 0.55 ha of rural zoned land within Property 1 being temporarily unavailable for grazing during a flood.<br><br>The impacts at this location are due to adoption of Wollongong City Council blockage policy of 100% blockage for openings less than 6m. This additional land beyond the boundary is not flooded if the culvert is not blocked. |
| <b>Flood Velocity</b>                     |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Houses, Urban and Commercial Areas</b> | Velocity-depth to remain in the zone of low hazard for children (i.e. Less than 0.4 m <sup>2</sup> /s based on ARR, Project 10 2011) where                                                                                                                        | N/A                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

| DESIGN CRITERIA           | MINIMUM DESIGN REQUIREMENT                                                                                                                                                                                                                            | DESIGN PERFORMANCE AGAINST CRITERIA |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|
|                           | current flow velocity-depth is currently low hazard.                                                                                                                                                                                                  |                                     |
| <b>Recreational Areas</b> | Velocity to remain below 1.0 m/s where currently below this figure. An increase of not more than 20% where existing velocity is above 1.0 m/s. Appropriate scour and stability protection should be provided where these criteria cannot be achieved. | N/A                                 |
| <b>Agricultural Areas</b> | Velocities to remain below 1.0 m/s where currently below this figure. An increase of not more than 20% where existing velocity is above 1.0 m/s.                                                                                                      | Achieved.                           |

## 6.2 MACQUARIE RIVULET

### 6.2.1 DESIGN

The proposed alignment crosses the Macquarie Rivulet approximately 150m upstream of the existing bridge, and follows the existing Illawarra Highway which divides Macquarie Rivulet and Frazers Creek. Three bridges are proposed along this section, with one crossing of the Macquarie Rivulet and two crossings of Frazers Creek. The central interchange is located in the floodplain between Macquarie Rivulet and Frazers Creek. Fill generally in the order of 2m is required throughout the Macquarie Rivulet catchment to ensure the flood immunity of the road meets the objectives.

To the south of the central interchange, the Albion Park Rail Bypass crosses over Tongarra Road between Frazers Creek and a tributary of Frazers Creek. Existing flooding at this location is up to 0.5m deep in the 100 year ARI event. South of Tongarra Road, the alignment crosses Frazers Creek again, and continues beyond the floodplain towards the Croom Regional Sports Complex. At this crossing it is proposed to adjust the existing watercourse.

Within the Macquarie Rivulet floodplain, the extent of fill required to achieve the desired level of flood immunity reduces floodplain storage. This results in an increase in flood level upstream of the alignment. The volume and extent of the fill material was minimised during the design process. This was achieved by having steeper batter slopes from 4 horizontal to 1 vertical changed to 2 horizontal to 1 vertical which reduced the impact that the project would have on flood storage.

During the flood modelling it was found that increasing the capacity of culverts crossing the north bound on-ramp and south bound off-ramp (M2a) at the central interchange reduced impacts to flooding in the 100 year ARI event. The culvert size at this location was optimised to avoid potential impacts on the Illawarra Highway (north of Taylor Street) during smaller (more frequent) storm events.

A summary of the transverse drainage design approach and flood results at each location for the Macquarie Rivulet catchment is provided **Table 6-4**.

**Table 6-4 Summary of Transverse Drainage Design Approach – Macquarie Rivulet Catchment**

| Transverse Drainage Structure | Design (Operational Activity)                                                                                                                                                                                                                                                                                                                                                                        | Results (Operational Impacts)                                                                                                                                                                                                                                                    |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M1<br>CH 18650                | The proposed motorway is aligned roughly parallel and approximately 150m upstream of the existing highway bridge. A 200m bridge opening (measured at the toe of abutment) is proposed, which would extend across the majority of the floodplain width at this location. The vertical alignment at this location is constrained by the obstacle limitation surface of the Illawarra Regional Airport. | 100 year ARI immunity is achieved at this location.<br><br>Increases in flood levels upstream of the motorway are 140mm in the 20 year ARI event and 150mm in the 100 year ARI event.<br><br>The motorway bridge is partially submerged by up to 0.3m in the 100 year ARI event. |

| Transverse Drainage Structure | Design (Operational Activity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Results (Operational Impacts)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M2<br>CH 19600                | The proposed motorway is aligned parallel and immediately downstream of the existing Illawarra Highway. A 150m bridge opening (measures at the toe of the abutment) is proposed to cross Frazers Creek at this location. This length was found to provide sufficient conveyance of floodwater across the floodplain either side of the alignment.                                                                                                                                                                                                                                                                                                                                                                                                                                                               | 100 year ARI immunity is achieved at this location.<br><br>Increases in flood levels at this bridge are 55mm in the 20 year ARI event and 80mm in the 100 year ARI event.<br><br>Flood level changes upstream and downstream of the bridge are similar, which indicates that the bridge length is sufficient to convey Frazers Creek flows through the alignment. Peak flood levels upstream of the bridge are controlled primarily by flows backing up within the area of floodplain to the west of the alignment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| M2a<br>M2b<br>M2c<br>CH 20600 | The proposed motorway is aligned along the existing Illawarra Highway at this location. The road would be raised to provide the required flood immunity. Raising the road restricts the existing flow behaviour of water flowing over the Illawarra Highway from Macquarie Rivulet to Frazers Creek.<br><br>A (5x) 1200H x 3000W RCBC culvert is proposed at this location in order to maintain the overflow path from Macquarie Rivulet to Frazers Creek. The culvert would convey floodwater from the Macquarie Rivulet through the northbound entry ramp, into the area bounded by the motorway and the northbound exit ramp. Two culvert structures, each (2x) 1200H x 3000W RCBC are proposed to convey floodwater from two low points within this area, under the motorway to the floodplain to the east. | The culverts provide some relief to flooding within the floodplain to the west of the central interchange.<br><br>In the 20 year ARI event, the proposed culverts result in a higher volume of water (in comparison to existing) being conveyed from the Macquarie Rivulet to Frazers Creek at this location. This increases water levels and contributes to increased water levels upstream of bridge M3 via a backwater effect.<br><br>Increases in flood levels between the motorway and the exit/entry ramp are 1.0m in the 20 year ARI event and 1.0m in the 100 year ARI event. These areas of increased flood level are contained within the project boundary and do not impact on private land holdings.<br><br>The culvert size at this location has been designed to provide maximum benefits to flooding within the floodplain while ensuring that impacts on Taylor Road (due to increased flows to Frazers Creek in more frequent events) are avoided.<br><br>Both ramps are immune from flooding in a 20 year ARI event. In a 100 year ARI event, the northbound exit ramp is flooded up to a maximum depth of 0.15m and would be flooded for a total of 1hr 45mins in the 100 year ARI event. The northbound entry ramp is flooded up to a maximum depth of 0.20m and would be flooded for a total duration of 2hrs in the 100 year ARI event. |
| M3<br>CH 21000                | A 90m bridge opening (measured at the toe of abutment) is proposed at this location, which is intended to convey flows within Frazers Creek and the floodplain.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | Flood level increases upstream and downstream of the bridge are similar, indicating that the bridge length is sufficient to convey Frazers Creek flows.<br><br>Increases in flood levels at this bridge are 70mm in the 20 year ARI event and 40mm in the 100 year ARI event.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| M4<br>CH 21200                | A culvert crossing is proposed at this location to convey flows under the motorway to the west.<br><br>The culverts at this location are (3x) 2400H x 3000W RCBC.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | The culvert has sufficient capacity to mitigate impacts upstream for the 20 year and 100 year ARI events. Downstream of the culvert, flood levels are primarily influenced by flow from the tributary to the west and are not sensitive to the culvert size under the alignment at this location.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

| Transverse Drainage Structure | Design (Operational Activity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Results (Operational Impacts)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tongarra Road<br>CH 21450     | The proposed motorway crosses Tongarra Road via an overpass, aligned between Frazers Creek and the tributaries to the west. A bund is proposed between the south bound entry ramp and Frazers Creek to reduce the volume of water breaking out of Frazers Creek and flowing onto Tongarra Road. The bund runs in a north south direction to the south of Tongarra Road and intersects Tongarra Road 85m east of the south bound entry ramp. The bund is 114m long and is up to 1m high.                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <p>Flows tend to break out of Frazers Creek upstream of Tongarra Road and are conveyed along Tongarra Road under the main alignment, towards the low point of Tongarra Road to the west. The proposed bund limits this overtopping and increases the volume of water flowing through the existing bridge. The flow regime for events up to the 2 year ARI event is not predicted to change at the existing bridge and within Frazers Creek at this location. In the 100 year ARI event, velocities through the bridge are increased by 8% from 6.12m/s to 6.65m/s as a result of the proposed bund. Additional scour protection may be required at this bridge and would need to be investigated during the detailed design. It is noted that the scour protection has recently been upgraded at this bridge following the March 2011 flood event.</p> <p>Flood levels upstream of Tongarra Road at Frazers Creek are increased by 220mm in the 20 year ARI event and 200mm in the 100 year ARI event. It is noted that the existing driveway and dwelling to the east of Frazers Creek are not within the floodplain.</p> <p>The inclusion of the bund at this location increases the immunity of Tongarra Road and it is predicted to no longer be flooded in a 10 year ARI event.</p> |
| M5<br>CH 22100                | <p>The proposed motorway is located within the meander of Frazers Creek and traverses the floodplain to the north west.</p> <p>It is proposed to adjust a 390m long section of Frazers Creek to the east of the alignment. The creek adjustment requires cut of up to 5m deep. The motorway would cross the adjusted creek via a 65m bridge opening which spans the diversion channel and provides access to the Croom Regional Sporting Complex. Flooding does not impact on the access at this location, but is contained wholly within the channel at the location of the crossing which is 30m wide at this location. As such from a flood conveyance perspective the bridge length could be reduced to 30 metres wide (measured at the toe of abutment)</p> <p>To convey floodplain flows during larger storm events, to the north of the proposed bridge, (4x) 2100mm RCP culverts are proposed approximately 200m north of the proposed bridge.</p> | <p>Increases in flood levels upstream of the motorway at this location are 0.6m in the 20 year ARI event and 1.0m in the 100 year ARI event. These areas of increased flood level are contained within the project boundary. The culvert and sizing at this location allows additional water volume to be stored to the south of the motorway, providing a flooding benefit to Tongarra Road.</p> <p>In the 100 year ARI event, velocities of up to 2.2m/s and depths of up to 2.6m are predicted within the creek diversion. Scour protection will need to be designed at this location in the detailed design phase to ensure the long term bed and bank stability within the creek diversion.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |

## 6.2.2 FLOOD IMPACTS

Increased flood levels within the Macquarie Rivulet catchment are predicted to extend over the floodplain between Tongarra Road, Marshall Mount Creek and the existing Princes Highway. Within the floodplain area, impacts are due to a loss of floodplain storage due to additional fill within the floodplain. Flood level increases at the upstream side of the motorway (to the north of the Croom Regional Sporting Complex access bridge) are primarily due to changes in conveyance caused by fill within the floodplain and the proposed watercourse diversion.

Tongarra Road currently floods in the 5 year ARI event due to water overflowing from Frazers Creek. The inclusion of the bund at this location increases the immunity of Tongarra Road and it is predicted to no longer be flooded in a 10 year ARI event.

In the 100 year ARI event, a band of flood level increase of 100-150mm is currently predicted to the north west of the central interchange. This is caused by the alignment reducing the volume of flows that would have previously occurred in an easterly direction across the existing Illawarra Highway. It is noted that the existing flood depth in the 100 year ARI range from 1m to 2m at this location. In the 20 year ARI event flood levels are predicted to increase by 50-130mm to the north west of the central interchange.

Impacts within the wider floodplain are primarily due to the reduction in floodplain storage caused by embankment construction within the floodplain. It is noted that only very small increases in flood extent are predicted as a result of the proposed motorway. The ridges to the north of the floodplain towards Marshall Mount and Yallah are fairly steep, with slopes typically falling at 10 horizontal to 1 vertical. A 150mm increase in flood level would equate to an increase in flood extent of 1.5m on this slope. To the east of the floodplain towards the airport, the ground is not as steep, with slopes of around 40 horizontal to 1 vertical. A 150mm increase in flood level would equate to an increase in flood extent of 6m at this location.

In the PMF event, impacts are primarily due to the alignment blocking flows that would have previously occurred in an easterly direction across the existing Illawarra Highway. This causes flood levels to increase by approximately 250-300mm to the west of the alignment and leads to increased volumes of water flowing into developed areas between the airport and Macquarie Rivulet. It is noted that existing flood depths within the majority of the floodplain range from 3m to 5m in the existing case.

Approximately 50ha of residential land within Albion Park Rail is predicted to be impacted by increased water levels in the PMF event. Increases in water levels of up to 0.18m are predicted in the residential area between Shearwater Boulevard and the railway line. Existing PMF depths in this area ranges from 0.3m to 2m. Increases in water levels of up to 0.2m is predicted in the residential area bounded by the airport, the existing Princes Highway and Rosewood Street. Existing PMF depths in this area are between 0.4m to 1m.

PMF water levels within the commercial land to the east of the airport would increase by 0.05m to 0.2m. The largest increase occurs along Miall Way, where increases of up to 0.3m are predicted. Existing PMF depths in this area range from 0.2m to 1m.

In providing new road infrastructure with a substantially higher level of flood immunity than the existing road network, some impact to the conveyance of floodwater during major storms is expected. In the existing case, the Illawarra Highway is overtopped across a length of approximately 1.3km with depths up to 4m. In the proposed case, this flow conveyance between Frazers Creek is provided by a 150m long bridge and a set of culverts with a total span of 30m. This greatly improves the flood immunity of the road, but leads to a reduction in conveyance between the two watercourses and contributes to an increase in flood depths and extents upstream of the alignment.

The timing and volume of water flowing to Lake Illawarra from the Macquarie Rivulet catchment is not predicted to change as a result of the project.

## Flood Level

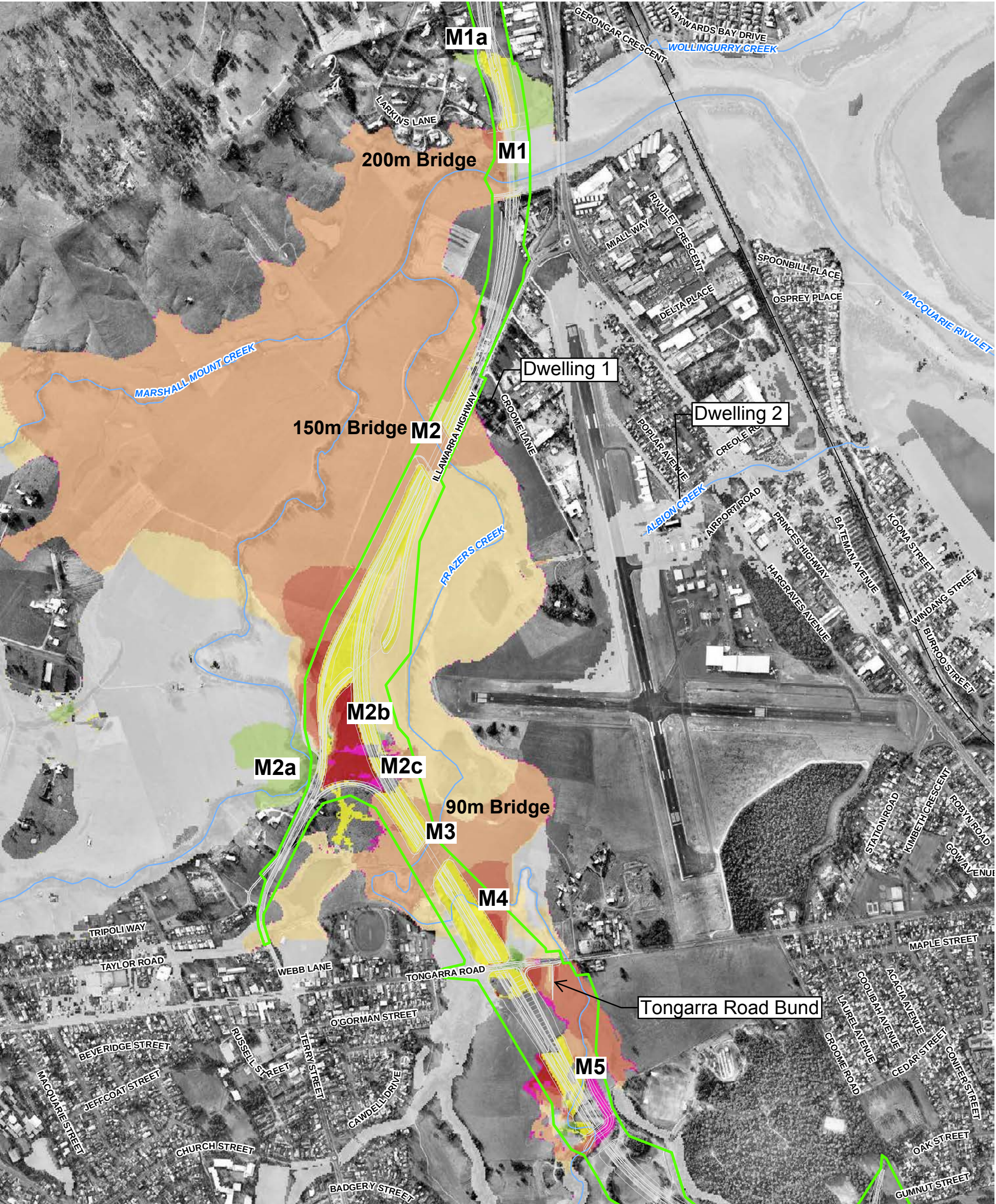
Change in flood levels is illustrated in **Figure 6-3** and **Figure 6-4**, for the 20 year ARI and 100 year ARI design storm events (respectively).

A summary of water level changes within the Macquarie Rivulet catchment for the range of flood events modelled is provided in **Table 6-5**

**Table 6-5 Change in Water Levels – Macquarie Rivulet**

| Location                                                           | 10 year ARI | 20 year ARI | 50 year ARI | 100 year ARI | 200 year ARI | 500 year ARI | PMF    |
|--------------------------------------------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------|
| Macquarie Rivulet (M1), upstream of motorway at project boundary   | +0.08m      | +0.10m      | +0.10m      | +0.12m       | +0.14m       | +0.22m       | +0.33m |
| Macquarie Rivulet (M1), downstream of motorway at project boundary | -0.02m      | +0.00m      | +0.01m      | +0.01m       | +0.00m       | -0.07m       | -0.52m |
| Confluence of Macquarie Rivulet and Frazers Creek                  | +0.04m      | +0.06m      | +0.08m      | +0.09m       | +0.11m       | +0.16m       | +0.24m |
| Frazers Creek (M2), upstream of motorway at project boundary       | +0.04m      | +0.05m      | +0.06m      | +0.07m       | +0.08m       | +0.11m       | +0.06m |
| Frazers Creek (M2), downstream of motorway at project boundary     | +0.04m      | +0.05m      | +0.07m      | +0.09m       | +0.10m       | +0.15m       | +0.21m |
| West of Central Interchange                                        | +0.06m      | +0.09m      | +0.14m      | +0.21m       | +0.24m       | +0.31m       | +0.35m |
| East of Central Interchange                                        | +0.03m      | +0.03m      | +0.05m      | +0.06m       | +0.07m       | +0.09m       | +0.02m |
| Frazers Creek (M3), upstream of motorway at project boundary       | +0.07m      | +0.06m      | +0.01m      | -0.01m       | -0.01m       | -0.02m       | -0.06m |
| Frazers Creek (M3), downstream of motorway at project boundary     | +0.08m      | +0.07m      | +0.04m      | +0.05m       | +0.05m       | +0.07m       | +0.01m |
| Frazers Creek (M4), upstream of motorway at project boundary       | +0.15m      | +0.16m      | +0.19m      | +0.07m       | +0.08m       | +0.09m       | +0.03m |
| Frazers Creek (M4), downstream of motorway at project boundary     | +0.03m      | +0.03m      | +0.04m      | -0.01m       | -0.01m       | -0.01m       | -0.05m |
| Frazers Creek, upstream of Tongarra Road at project boundary       | +0.19m      | +0.22m      | +0.22m      | +0.19m       | +0.15m       | +0.04m       | -0.09m |
| Frazers Creek, downstream of Tongarra Road at project boundary     | +0.02m      | +0.06m      | +0.03m      | +0.03m       | +0.03m       | +0.02m       | +0.01m |

| Location                                                                    | 10 year ARI | 20 year ARI | 50 year ARI | 100 year ARI | 200 year ARI | 500 year ARI | PMF    |
|-----------------------------------------------------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------|
| Tributary west of Motorway, upstream of Tongarra Road at project boundary   | +0.00m      | -0.01m      | -0.01m      | -0.01m       | -0.01m       | -0.01m       | -0.05m |
| Tributary west of Motorway, downstream of Tongarra Road at project boundary | +0.00m      | +0.00m      | +0.01m      | -0.01m       | -0.01m       | -0.01m       | -0.05m |



LEGEND

Site Boundary

Concept Design

Major Watercourses

Railway

Change in Water Level (m)

Newly Flooded

> 0.4

0.25 to 0.4

0.1 to 0.25

0.05 to 0.1

0.02 to 0.05

-0.02 to 0.02

-0.05 to -0.02

-0.1 to -0.05

-0.25 to -0.1

-0.4 to -0.25

< -0.4

No Longer Flooded

MACQUARIE RIVULET 20 YEAR ARI CHANGE IN WATER LEVEL

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:12,500 @ A3

090180360

Metres

NSW GOVERNMENT

Transport Roads & Maritime Services

Hyder

Gardno

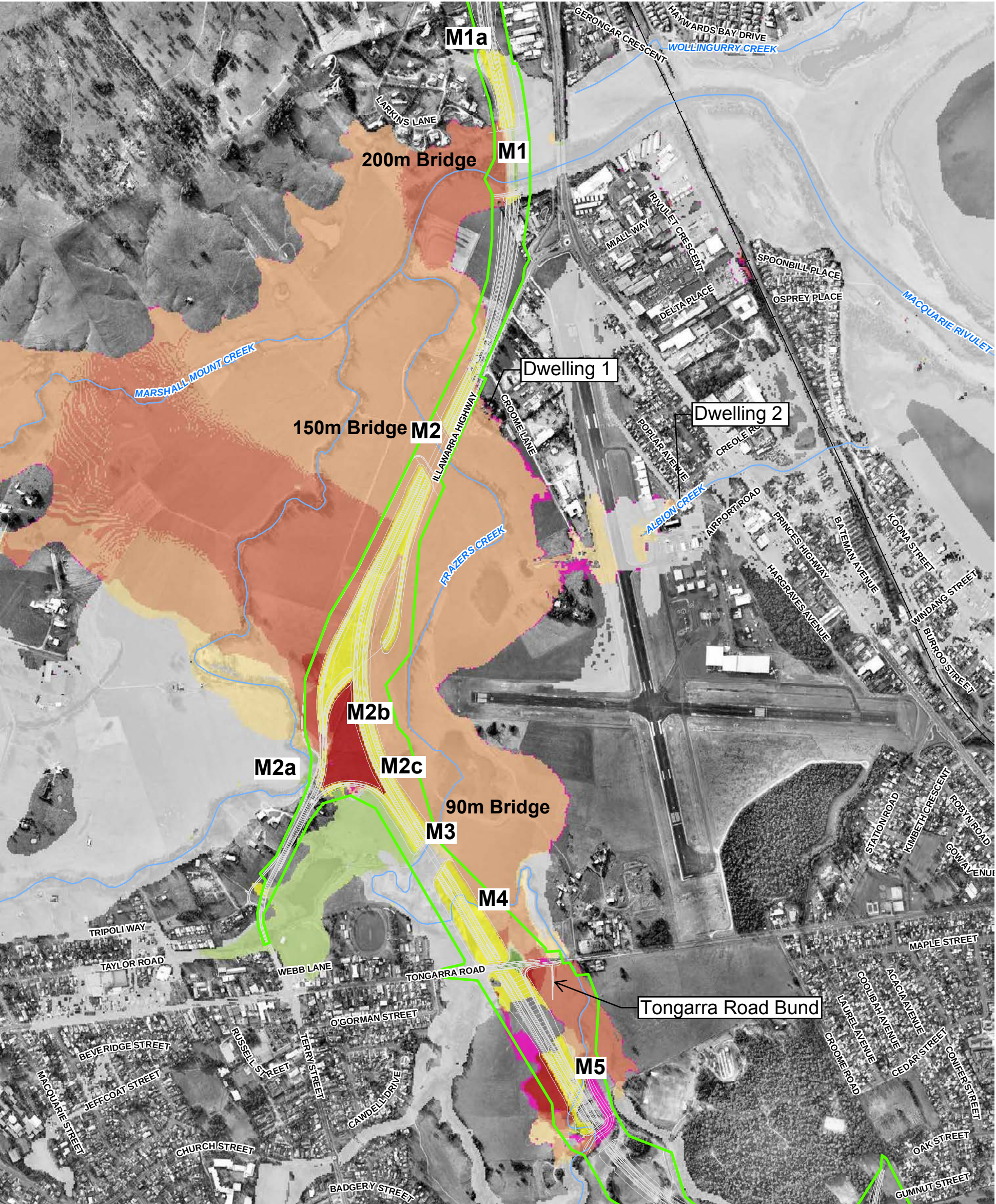
JOINT VENTURE

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

DATE: AUGUST 5, 2015

Figure 6-3



LEGEND

- Site Boundary
- Concept Design
- Major Watercourses
- Railway
- Change in Water Level (m)
- Newly Flooded

|               |                   |
|---------------|-------------------|
| > 0.4         | -0.05 to -0.02    |
| 0.25 to 0.4   | -0.1 to -0.05     |
| 0.1 to 0.25   | -0.25 to -0.1     |
| 0.05 to 0.1   | -0.4 to -0.25     |
| 0.02 to 0.05  | < -0.4            |
| -0.02 to 0.02 | No Longer Flooded |

MACQUARIE RIVULET 100 YEAR ARI CHANGE IN WATER LEVEL

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:12,500 @ A3

0 90 180 360  
Metres

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

DATE: AUGUST 5, 2015

NSW GOVERNMENT  
Transport  
Roads & Maritime  
Services

Hyder  
Gardno  
JOINT VENTURE

Figure 6-4

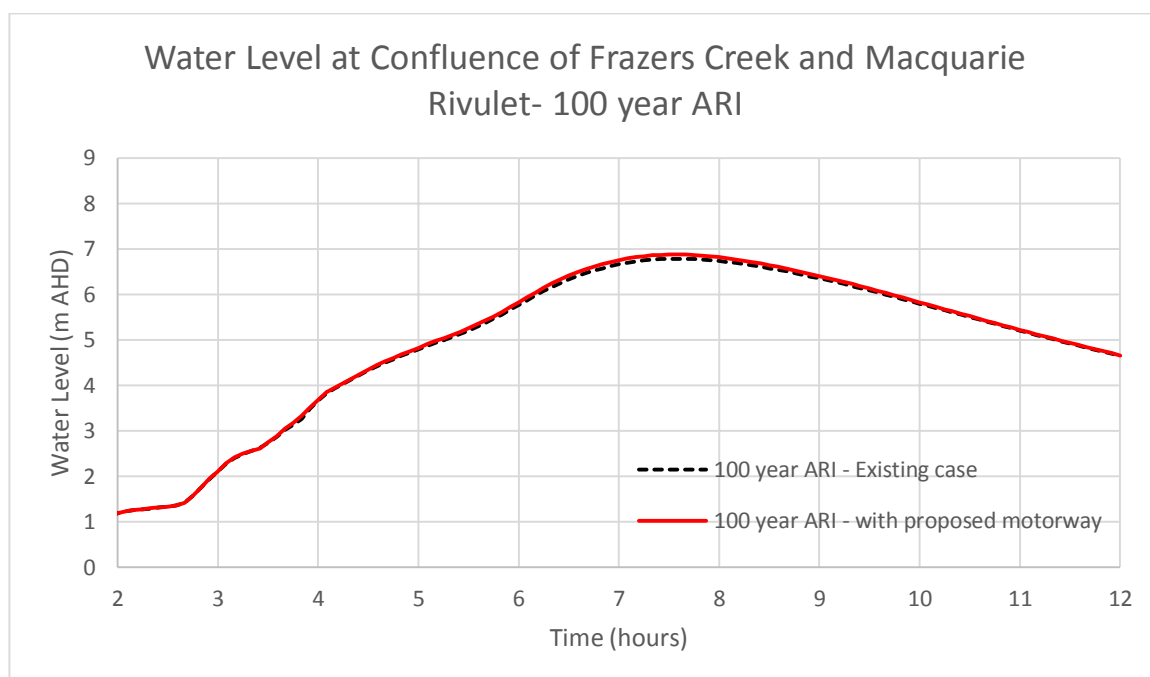
## Velocity

Some increases in velocity are predicted within the floodplain between the main alignment and the Illawarra regional airport. This is due to the alignment directing the flow in the north/south direction and reducing flow in the east/west direction. The change in flow velocity is relatively minor, with an increase of up to 0.2m/s from existing velocities of 0.4m/s to 0.8m/s. Flood velocity maps for existing and proposed scenarios are provided in **Appendix B**, for the full range of storm events modelled.

## Duration

Flood duration within the Macquarie Rivulet catchment is not substantially changed as a result of the project.

The flood level at the confluence of Frazers Creek and Macquarie Rivulet during a 9 hour 100 year ARI event is presented in the following chart. This graph demonstrates that flood waters will rise and fall in the existing case and in the proposed case in a similar manner. For example in the existing case, the flood waters are greater than RL5.0 for 6 hours and 5 minutes during the 9 hour 100 year ARI event. In the proposed case this is increased by 5 minutes to 6 hours and 10 minutes.



## Direction

In major (less frequent) storms, some changes in flow direction are predicted within the Macquarie Rivulet floodplain, due to the road embankment crossing the floodplain at the location of the existing Illawarra Highway. In minor (frequent) storms, existing flow paths are maintained, with the exception of the proposed watercourse diversion at M5.

The direction of flow within the Macquarie Rivulet floodplain is influenced by the timing of flows from Frazers Creek and Macquarie Rivulet. In the existing 100 year ARI event, water from Frazers flows north west across the floodplain prior to the peak within the Macquarie Rivulet. A few hours later the flow from Macquarie Rivulet peaks and flows north across the floodplain. Due to existing hydraulic constraints which limit outflow to Lake Illawarra, this causes water in Frazers Creek to flow upstream for a period, before draining downstream. In the proposed scenario, this behaviour is predicted to continue.

## Impacts to Watercourses

For the majority of the watercourses, the direction and velocity of flows is not expected to change considerably from the existing condition for the design flood events modelled. The main risk of bed and / or bank instability would be associated with the adjustment of Frazers Creek at M5 and the bridge over Macquarie Rivulet which may require piers within the watercourse. At these locations there is a risk of scour of the bed and erosion of the banks, resulting in a decline in water quality and sedimentation of the watercourse. An assessment of the bed and bank stability and potential for scour will be undertaken as part of the detailed design.

### 6.2.3 PERFORMANCE AGAINST CRITERIA

Table 6-6 Macquarie Rivulet Operational Flooding Performance

| DESIGN CRITERIA   | MINIMUM DESIGN REQUIREMENT                                                                                                                                                                                                                                        | DESIGN PERFORMANCE AGAINST CRITERIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|-----------------------|------------|------|------------|------|-------------|---------------|-------------|---------------|-------------|------|--------------|----------------|--------------|----------------|--------------|----------------|
| FLOOD IMMUNITY    |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| Main Carriageways | 100 year ARI desirable (excluding allowance for climate change and land use change)<br>20 year ARI minimum (including allowance for climate change and land use change)<br>Flood immunity measured at the edge line of the carriageway. No freeboard requirement. | 100 year ARI immunity achieved within the Macquarie Rivulet catchment.<br><br>20 year ARI immunity is achieved under the existing scenario and climate change and land use change scenario.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
|                   | Other roads                                                                                                                                                                                                                                                       | Maintain or improve trafficability of the existing local road during floods                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
|                   |                                                                                                                                                                                                                                                                   | <p>The immunity of Tongarra Road is improved from 2-5 year ARI to 10-20 year ARI. This has been achieved by the inclusion of a bund perpendicular to Tongarra Road between Frazers Creek and the southbound entry ramp. This bund prevents water breaking out of Frazers Creek in more frequent flood events.</p> <p>Flood immunity of the Illawarra Highway at the intersection of Taylor Road is slightly less than 2 year ARI and is not expected to change as a result of the bypass. Changes in flood level at Taylor Road for each storm event are summarised below.</p> <table><tr><th>Event</th><th>Change in Flood Level</th></tr><tr><td>2 year ARI</td><td>None</td></tr><tr><td>5 year ARI</td><td>None</td></tr><tr><td>10 year ARI</td><td>30mm increase</td></tr><tr><td>20 year ARI</td><td>30mm increase</td></tr><tr><td>50 year ARI</td><td>None</td></tr><tr><td>100 year ARI</td><td>20mm reduction</td></tr><tr><td>200 year ARI</td><td>30mm reduction</td></tr><tr><td>500 year ARI</td><td>40mm reduction</td></tr></table> | Event | Change in Flood Level | 2 year ARI | None | 5 year ARI | None | 10 year ARI | 30mm increase | 20 year ARI | 30mm increase | 50 year ARI | None | 100 year ARI | 20mm reduction | 200 year ARI | 30mm reduction | 500 year ARI | 40mm reduction |
| Event             | Change in Flood Level                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 2 year ARI        | None                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 5 year ARI        | None                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 10 year ARI       | 30mm increase                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 20 year ARI       | 30mm increase                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 50 year ARI       | None                                                                                                                                                                                                                                                              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 100 year ARI      | 20mm reduction                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 200 year ARI      | 30mm reduction                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |
| 500 year ARI      | 40mm reduction                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |       |                       |            |      |            |      |             |               |             |               |             |      |              |                |              |                |              |                |

| DESIGN CRITERIA                    | MINIMUM DESIGN REQUIREMENT                                                                                          | DESIGN PERFORMANCE AGAINST CRITERIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                |
|------------------------------------|---------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|
|                                    |                                                                                                                     | PMF                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | 75mm reduction |
|                                    |                                                                                                                     | <p>The duration of inundation of Taylors Road is subject to a minor increase of up to 15 minutes in the 2 year ARI, 20 minutes in the 5 year ARI, and 35 minutes in the 50 years ARI events.</p> <p>The changes to the flood depths and duration of inundation are considered minor, and unlikely to change the trafficability of the road.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                |
| Cycleways                          | Maintain or improve trafficability of cycleways during floods, compared to the existing adjacent local road or path | Achieved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                |
| FLOOD IMPACTS                      |                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                |
| Flood Level (height)               |                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                |
| Houses, Urban and Commercial Areas | Less than 50 mm increase for the 20 and 100 year ARI flood event.                                                   | <p>Two properties are currently impacted beyond the project objectives, detailed below:</p> <div><p><b>Dwelling 1</b></p><p>Dwelling 1 is flooded above the floor level in the existing 100 year ARI event and is subject to increase depth of over floor flooding with the project.</p><p>The existing 100 year ARI flood elevation of RL 6.857 m AHD is 14 mm higher than the floor level of RL 6.843 m AHD. The proposed flood level increases by 83 mm to RL 6.94 m AHD which is 99 mm over the floor level. In the existing case, over floor flooding would occur for approximately 25 minutes in the 100 year ARI event. With the project, the duration of over floor flooding would increase to 65 minutes. If this impact is not resolved in the detailed design phase suitable mitigation will need to be negotiated with the property owner. It is noted that this dwelling is not flooded in the 50 year ARI event under existing or proposed conditions.</p><p>The ancillary building located on the property, to the north of the dwelling, is not affected by over floor flooding in the existing condition or with the project.</p></div> <div><p><b>Dwelling 2</b></p><p>Dwelling 1 is not flooded above the floor level in the 100 year ARI event for both the existing condition, and with the project.</p></div> |                |

| DESIGN CRITERIA                           | MINIMUM DESIGN REQUIREMENT                                                                                                                                                                                                                            | DESIGN PERFORMANCE AGAINST CRITERIA                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                           |                                                                                                                                                                                                                                                       | <p>The existing 100 year ARI flood level of RL 3.441 m AHD is 109 mm lower than the floor level of RL 3.550 m AHD. Proposed flooding increases by 54 mm to RL 3.495 m AHD which is 55 mm lower than the floor level.</p> <p>The floor level of the garage associated with this dwelling was not available at the time of undertaking this analysis.</p> <p>The impacts at the above locations will be monitored and reassessed as the Macquarie Rivulet flood model is finalised by Shellharbour City Council, and any final remaining impacts would be addressed at detailed design stage of the project.</p> |
| <b>Recreational Areas</b>                 | Less than 100 mm increase for the 20 and 100 year ARI event.                                                                                                                                                                                          | <p>Achieved.</p> <p>No changes to flood levels are predicted for the existing sporting grounds within the Croom Regional Sporting Complex.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Agricultural Areas</b>                 | Generally less than 250 mm increase with localised increases of up to 400 mm flooding acceptable over small areas (nominally less than 5 ha) in the 20 and 100 year ARI flood event.                                                                  | <p>Achieved.</p> <p>Increases in water level up to 1 m are predicted adjacent to the motorway at the central interchange and upstream of the motorway at M2a. Impacts at this location is contained within the project boundary. All other increases in water level are within the objectives.</p>                                                                                                                                                                                                                                                                                                             |
| <b>Flood Velocity</b>                     |                                                                                                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Houses, Urban and Commercial Areas</b> | Velocity-depth to remain in the zone of low hazard for children (i.e. Less than 0.4 m <sup>2</sup> /s based on ARR, Project 10 2011) where current flow velocity-depth is currently low hazard.                                                       | Achieved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Recreational Areas</b>                 | Velocity to remain below 1.0 m/s where currently below this figure. An increase of not more than 20% where existing velocity is above 1.0 m/s. Appropriate scour and stability protection should be provided where these criteria cannot be achieved. | Achieved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Agricultural Areas</b>                 | Velocities to remain below 1.0 m/s where currently below this figure. An increase of not more than 20% where existing velocity is above 1.0 m/s.                                                                                                      | Achieved                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

## 6.3 HORSLEY CREEK

### 6.3.1 DESIGN

Through the Horsley Creek, the project catchment follows the existing East West Link. In general it is proposed to extend the existing culvert configurations to accommodate the proposed alignment. At the watercourse to the east of the existing Croome Road, the motorway is in cut and is approximately 0.5m lower than the existing road levels. The main alignment crosses the existing Green Meadows Basin, which is located to the south of the existing East-West Link. At this location a new service road is proposed to be built within the existing basin. Culverts would be configured to match the operation of the existing spillway, and excavation is required to ensure that the flood detention capacity of the basin is maintained. At the Oak Flats interchange, existing culverts would be extended to the south to accommodate the proposed upgrade. At most locations along the alignment through the Horsley Creek catchment, it was found that maintaining existing culvert configurations minimised flooding impacts and resulted in an acceptable level of flood immunity for the motorway.

It is proposed to construct a new detention basin within the land bounded by the motorway, Croome Road, and the service road. This detention basin represents an opportunity to provide benefits to flooding in the residential area to the north of the motorway. This basin has been designed to cater for the 10 year ARI event and would be effective up to the 100 year ARI event, storing 19,000 m<sup>3</sup> of water up to 1.6m deep.

The Green Meadows basin requires modification due to the alignment of the Albion Park Rail Bypass and associated service road through the existing basin. To ensure that the flood mitigation capacity of the basin is not affected, the storage-discharge arrangement of the existing basin has been maintained. Furthermore, to ensure that the consequences of a dam break scenario are not increased, the existing depth has not been increased, and the total volume has been maintained. The depth-volume relationship for the Green Meadows basin is designed to remain the same under the proposal.

The main alignment of the bypass achieves 100 year ARI immunity adjacent to the Green Meadows basin. This is an improvement over the existing condition, with the existing East West Link achieving less than 2 year ARI immunity. This is because the existing East West Link was designed as the spillway for the Green Meadows basin. With the project, the new service road adjacent to the Green Meadows basin becomes the spillway for the upgraded basin. The function of this road as a spillway is critical to the proper functioning of the basin, and as such, it is not possible to improve the flood immunity of the service road without either increasing the volume detained in the basin (which would result in an increased risk to downstream residents in a dam break scenario), or by increasing the volume of discharge from the basin (which would worsen flooding of downstream properties).

The stage discharge relationship for the culverts in the Green Meadows basin has been designed to remain the same with the project. The Green Meadows basin has been designed to maintain the same depth, volume and discharge relationships. This ensures that the flood mitigation offered by the basin is not compromised. During subsequent design phases, should the volume or depth be increased to provide additional flood mitigation to downstream properties, a dam break analysis would need to be undertaken to quantify the consequence of dam failure in comparison to the existing case. Any increase in dam failure consequence would need to be weighed against the flooding benefits in consultation with Shellharbour City Council and the NSW Dams Safety Committee.

A summary of the transverse drainage design approach and flood results at each location for the Horsley Creek catchment is provided in **Table 6-7**.

**Table 6-7 Summary of Transverse Drainage Design Approach – Horsley Creek**

| Transverse Drainage Structure                  | Design (Operational Activity)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Results (Operational Impacts)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| H1a<br>H1b<br>H1c<br>H1d<br>CH 23100           | <p>Upstream of the Green Meadows basin, the service road is designed to cross watercourses at H1a via (1x) 1200H x 1500W RCBC and at H1b via (1x) 1200H x 3000W RCBC.</p> <p>The motorway is in cut at this location and would require upslope flow diversion to the proposed culvert, similar to the existing conditions. The culvert at H1c is (1x) 1500H x 3000W RCBC and has been designed to ensure the alignment achieves 100 year ARI immunity. The proposed Croome Road overpass crosses the watercourse downstream of the main alignment at H1d via (1x) 1500H x 3000W RCBC.</p> <p>The design of the motorway results in an area of enclosed land bounded by the motorway, Croome Road and the proposed service road. An opportunity was identified to construct a detention basin within this area, to reduce flooding in the residential land downstream (to the north). A basin has been designed in this area and was included in the hydraulic model. The basin has a footprint of 2.5ha and temporarily stores 19,000m<sup>3</sup> of water up to 1.6m deep in the 100 year ARI event.</p>                                                                          | <p>100 year ARI immunity is achieved for the service road and the motorway at this location.</p> <p>As a result of the proposed new detention basin upstream of the motorway, reductions in flood levels of up to 0.1m are predicted for the residential area downstream of the motorway, with some areas predicted to no longer be flooded. It is predicted that 23 residential properties will no longer be flooded in the 100 year ARI event due to the proposed detention basin.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| H2<br>H3<br>H4<br>H5<br>CH 24000 –<br>CH 24700 | <p>It is necessary to maintain both the volume and maximum water level of the Green Meadows basin, to ensure that current flood mitigation is maintained, without increasing consequences to downstream properties should the embankment fail.</p> <p>The proposed main alignment coincides with the existing East-West Link, while a proposed service road is aligned to the south (through the existing basin storage area).</p> <p>In order to maintain the volume of the basin, an area of excavation across the width of the basin and approximately 200m to the south (from the toe of the service road) is required.</p> <p>It is proposed to extend the existing 900 RCP culverts at H2 and H3. The existing 1200 RCP culvert at H4 is to be extended and the existing 1200 RCP culvert at H5 is required to be replaced with a 1350 RCP culvert. The three culverts being extended (H2-H3) have slightly lower capacity due to the inverts being slightly higher as a result of being extended. This reduction in capacity is balanced by increasing the diameter of culvert H5 from 1200mm to 1350mm. The proposed sizing of these culverts ensures that the low-flow</p> | <p>At this location, the flood model has been configured to include the excavation required to achieve basin storage, the spillway on the service road, the low-flow pipes, and three culvert structures under the main alignment replicating the function of the existing spillway.</p> <p>The motorway achieves 100 year ARI flood immunity at this location. The service road will be flooded by depths of over 0.5m in the 100 year ARI event. In the case of blockage of the low flow culverts in the basin, the service road would achieve an immunity of less than 2 year ARI which is the same as the existing East West link road.</p> <p>The service road will need to be designed to withstand the expected velocities where water overtops the road towards the spillway culverts. Embankment scour protection is also required to withstand the flow velocities during spillway operation.</p> <p>In events greater than the 100 year ARI, the motorway is flooded at a low point 300m west of the existing spillway, to depths of 0.6m.</p> |

| Transverse Drainage Structure | Design (Operational Activity)                                                                                                                                                                                                                                                                                                                                                                                                                                      | Results (Operational Impacts)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                               | <p>capacity of the basin is maintained, while ensuring that flooding conditions downstream of the basin are not worsened.</p> <p>The service road has been designed to match the levels of the existing East-West Link and acts as the spillway in the proposed configuration. Three separate culvert structures (each consisting of (2x) 1500H x 3300W RCBC) convey 100 year ARI flows from the spillway on the service road to the north under the motorway.</p> | <p>Minor differences in basin water level and downstream water level changes are predicted in the 100 year ARI event.</p> <p>Increases in basin water levels in the PMF are predicted, due to the proposed roads being higher than the existing East-West Link.</p> <p>Flood levels downstream of the motorway in the residential area are unchanged, due to the basin performing in a manner similar to the existing basin. Water level increases of up to 150mm are predicted in the recreational area to the north of the motorway. This increase in water level is due to the three sets of spillway culverts resulting in greater concentration of flows than currently occurs with the existing 120m spillway. This would be mitigated through addition of dissipation measures appropriate to the final cross drainage configuration beneath the motorway in this area as part of the detailed design phase</p> |
| H6<br>CH25500                 | It is proposed to extend this existing (1x) 1800H x 3600W RCBC culvert upstream to convey flows under the west bound exit ramp.                                                                                                                                                                                                                                                                                                                                    | The culvert conveys flows up to the PMF event. An increase in flood levels is predicted in the PMF event due to the service road east bound lane being higher than the existing road at this location.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

## 6.3.2 FLOOD IMPACTS

Increased flood levels within the Horsley Creek catchment are generally localised where the alignment crosses individual watercourses and are primarily due to changes in conveyance.

In the Croome Road area, reductions in flood levels are predicted downstream of the motorway in the residential area. Some areas of residential land are also predicted to no longer be flooded. These benefits to flooding are due to the proposed detention basin upstream of the motorway.

Maintaining the function of the Green Meadows flood detention basin is essential to minimising impacts downstream of this location. This has been achieved through maintenance of basin volume and outlet structure capacities.

Increased flood levels in the PMF upstream of the Oak Flats interchange at Horsley Creek are a result of the proposed road levels being higher than the existing road levels.

Impacts to flooding downstream of the Green Meadows basin in the PMF event are due to the high-flow discharge from the basin being distributed differently when compared to the existing configuration. Impacts include both increases and decreases to existing flood levels, with flood levels predicted to decrease for the majority of the area affected. Higher road levels at the western end of the basin reduce flow towards Woollybutt Drive, while increasing flow towards

Jarrah Way. These changes in road level are required to ensure that the motorway achieves immunity in the 100 year ARI event.

During minor (frequent) storm events, limited hydrological impacts are anticipated across the majority of the catchment, given that existing flow paths are proposed to be maintained as part of the project. With the exception of culvert extensions and the adjustment to the Green Meadows basin, it is not proposed to adjust any watercourses within the Horsley Creek catchment area.

Liaison with the NSW Dam Safety Committee and Shellharbour Council has commenced, to seek agreement on the proposed modifications to the Green Meadows basin. This liaison will continue to ensure that the flood mitigation function of the basin is maintained, and the consequences of a dam break scenario are not increased with consideration of the *Emergency Management for Dams* (Dam Safety Committee, 2010).

The timing and volume of water flowing to Lake Illawarra from the Horsley Creek catchment is not predicted to change as a result of the project.

## Flood Level

Changes in flood level are illustrated in **Figure 6-5** and **Figure 6-6**, for the 20 year ARI, 100 year ARI and PMF design storm events (respectively). A summary of water level changes within the Horsley Creek catchment for the range of flood events modelled is provided in **Table 6-8**.

**Table 6-8 Change in Water Levels – Horsley Creek**

| Location                                                              | 10 year ARI | 20 year ARI | 50 year ARI | 100 year ARI | 200 year ARI | 500 year ARI | PMF    |
|-----------------------------------------------------------------------|-------------|-------------|-------------|--------------|--------------|--------------|--------|
| Croome Road Basin (H1b) upstream of Service Road at project boundary  | +0.00m      | +0.00m      | +0.00m      | +0.00m       | +0.00m       | +0.01m       | +0.00m |
| Croome Road (H1d) downstream project boundary                         | -0.16m      | -0.14m      | -0.10m      | -0.08m       | -0.09m       | -0.05m       | +0.00m |
| Green Meadows Basin (H4) upstream of Service Road                     | -0.07m      | -0.08m      | -0.10m      | -0.09m       | -0.05m       | +0.02m       | +0.40m |
| Green Meadows Basin (H4) downstream of motorway at project boundary   | -0.01m      | +0.00m      | -0.01m      | +0.00m       | -0.01m       | -0.01m       | +0.06m |
| Green Meadows Basin (H5) upstream of Service Road at project boundary | +0.11m      | +0.09m      | +0.07m      | +0.17m       | +0.16m       | +0.04m       | +0.42m |
| Green Meadows Basin (H5) downstream of Motorway at project boundary   | +0.24m      | +0.25m      | +0.20m      | +0.16m       | +0.13m       | +0.11m       | +0.20m |
| Horsley Creek (H6), upstream of Motorway at project boundary          | +0.14m      | +0.06m      | +0.07m      | +0.15m       | +0.40m       | +0.71m       | +1.45m |
| Horsley Creek (H6), downstream of Motorway at project boundary        | +0.00m      | +0.00m      | +0.00m      | +0.01m       | +0.01m       | +0.01m       | +0.02m |

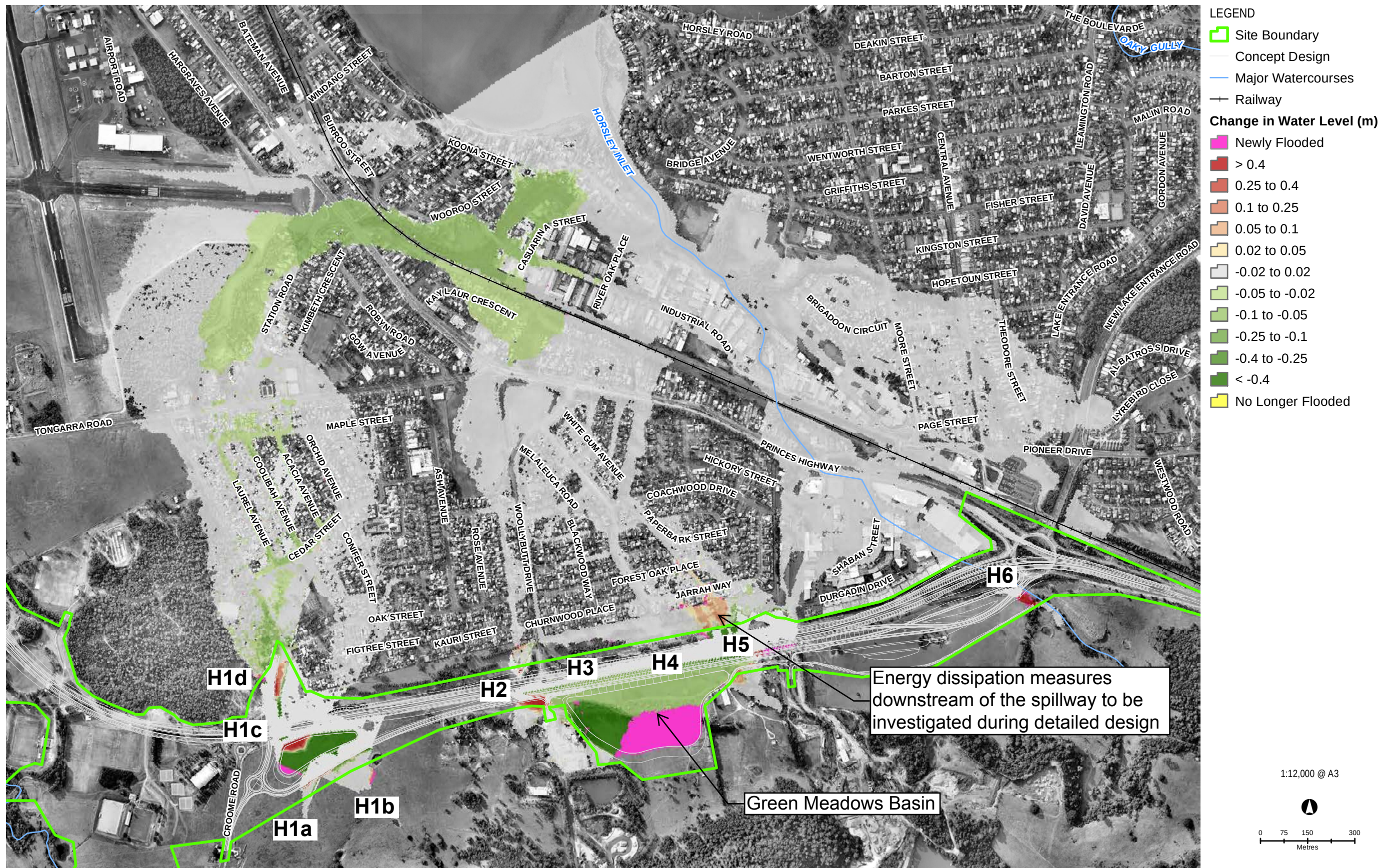


HORSLEY CREEK 20 YEAR CHANGE IN WATER LEVEL

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

Figure 6-5

\\AUWOLCFS01\Proposals\48982014\001\0438 to RMS re Albion Park Bypass\_Corres\Build\Project\GISWA\_0129\_APRB\_G\_03\_20y\_Impact.mxd



HORSLEY CREEK 100 YEAR CHANGE IN WATER LEVEL

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 03  
AUTHOR: RNB

DATE: AUGUST 26, 2015



Figure 6-6

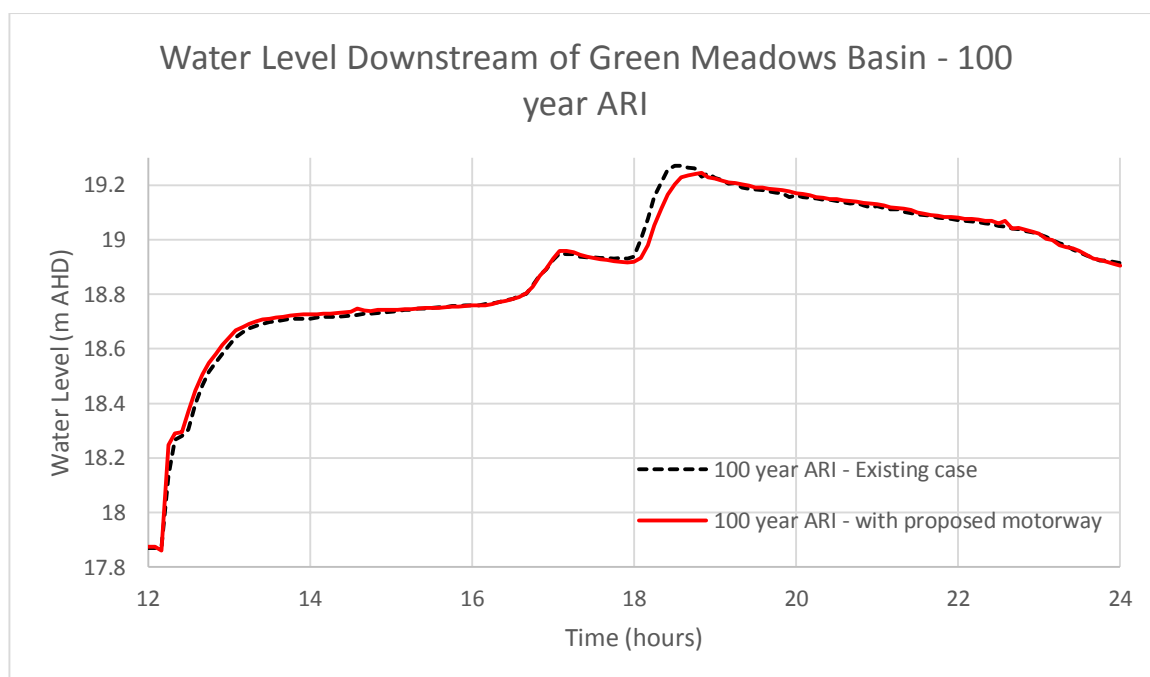
\\AUWOLCF501\Proposals\48982014\001\0438 to RMS re Albion Park Bypass\_Corres\Build\Project\GIS\WA\_0126\_APRB\_G\_03\_100y\_Impact.mxd

## Velocity

Some increase in flood velocity is predicted downstream of the Green Meadows basin spillway culverts. Energy dissipation and scour protection measures would be incorporated to address these issues to ensure that scour problems do not develop as a result. These measures would need to be specifically designed in response to the final cross drainage configuration beneath the motorway. As such these measures will be assessed and incorporated at the detailed design phase of the project. Flood velocity maps for existing and proposed scenarios are provided in **Appendix B**, for the full range of storm events modelled.

## Duration

Flood duration within the Horsley Creek catchment is not substantially changed as a result of the project. The flood level downstream of the Green Meadows basin during a 100 year ARI storm (90 minute storm burst within a 36 hour storm envelope) is presented in the following chart. This graph demonstrates that flood waters will rise and fall in the existing case and in the proposed case in a similar manner. For example, in the existing case, the flood waters are greater than R18.9 for 7 hours and 5 minutes during the 9 hour 100 year ARI event, which is not increased in the proposed case.



## Direction

Flow direction within the Horsley Creek catchment is not substantially changed as a result of the project for events up to 500 year ARI. In the PMF event, water in excess of the capacity of culvert M2d flows onto the motorway and continues west towards Frazers Creek.

## Impacts to Watercourses

The direction and velocity of flows is not expected to change considerably from the existing conditions for the design flood events modelled. For watercourses at H1, H2, H3, H4, and H6, watercourse crossings are extended at the same or similar size to existing to cater for the motorway. As such, this is unlikely to result in impacts to these watercourses in terms of bed and bank stability and scour. At the spillway to the Green Meadows Basin (H5), velocities are predicted to increase from the existing scenario. The increased velocity will be mitigated through

energy dissipation and scour protection. The watercourse at this location is a grassed overland flow path and does not consist of bed and banks.

### 6.3.3 PERFORMANCE AGAINST CRITERIA

Table 6-9 Horsley Creek Operational Flooding Performance

| DESIGN CRITERIA                           | MINIMUM DESIGN REQUIREMENT                                                                                                                                                                                                                                        | DESIGN PERFORMANCE AGAINST CRITERIA                                                                                                                                                                                                                                                                                          |
|-------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>FLOOD IMMUNITY</b>                     |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                              |
| <b>Main Carriageways</b>                  | 100 year ARI desirable (excluding allowance for climate change and land use change)<br>20 year ARI minimum (including allowance for climate change and land use change)<br>Flood immunity measured at the edge line of the carriageway. No freeboard requirement. | 100 year ARI immunity achieved on the motorway.<br>20 year ARI immunity is achieved under the climate change and land use change scenario.                                                                                                                                                                                   |
| <b>Other roads</b>                        | Maintain or improve trafficability of the existing local road during floods                                                                                                                                                                                       | The service road replaces the East-West Link and maintains the same low level of flood immunity.                                                                                                                                                                                                                             |
| <b>Cycleways</b>                          | Maintain or improve trafficability of cycleways during floods, compared to the existing adjacent local road or path                                                                                                                                               | Achieved.                                                                                                                                                                                                                                                                                                                    |
| <b>FLOOD IMPACTS</b>                      |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                              |
| <b>Flood Level (height)</b>               |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                              |
| <b>Houses, Urban and Commercial Areas</b> | Less than 50 mm increase for the 20 and 100 year ARI flood event.                                                                                                                                                                                                 | Achieved.<br>Flood levels within Urban and Commercial areas are not predicted to increase.                                                                                                                                                                                                                                   |
| <b>Recreational Areas</b>                 | Less than 100 mm increase for the 20 and 100 year ARI event.                                                                                                                                                                                                      | Not achieved.<br>Water levels are predicted to increase by 150mm within the recreational land downstream of Green Meadows Basin. This increase is downstream of the culvert outlet of the basin and will be mitigated through design of energy dissipation in the detailed design stage.<br>Achieved at all other locations. |
| <b>Agricultural Areas</b>                 | Generally less than 250 mm increase with localised increases of up to 400 mm flooding acceptable over small areas (nominally less than 5 ha) in the 20 and 100 year ARI flood event.                                                                              | Achieved.<br>Flood levels within agricultural land beyond the project boundary are not predicted to change.                                                                                                                                                                                                                  |
| <b>Flood Velocity</b>                     |                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                              |
| <b>Houses, Urban and Commercial Areas</b> | Velocity-depth to remain in the zone of low hazard for children (i.e. Less than 0.4 m <sup>2</sup> /s based on ARR, Project 10 2011) where current flow velocity-depth is currently low hazard.                                                                   | Achieved.                                                                                                                                                                                                                                                                                                                    |

| DESIGN CRITERIA           | MINIMUM DESIGN REQUIREMENT                                                                                                                                                                                                                            | DESIGN PERFORMANCE AGAINST CRITERIA                                                                                                                                                                                                                   |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Recreational Areas</b> | Velocity to remain below 1.0 m/s where currently below this figure. An increase of not more than 20% where existing velocity is above 1.0 m/s. Appropriate scour and stability protection should be provided where these criteria cannot be achieved. | Not achieved.<br><br>Velocity downstream of the Green Meadows basin spillway culverts range from 2.5 m/s to 3.5 m/s. The velocities will need to be mitigated through design of energy dissipation and scour protection in the detailed design stage. |
| <b>Agricultural Areas</b> | Velocities to remain below 1.0 m/s where currently below this figure. An increase of not more than 20% where existing velocity is above 1.0 m/s.                                                                                                      | Achieved.                                                                                                                                                                                                                                             |

## 6.4 POTENTIAL FUTURE SCENARIOS

All flood impacts presented above are based on existing climatic and hydrological conditions. Analysis of predicted future climate change and land use change scenarios were also carried out, to estimate the level of flood immunity the motorway may achieve in these future scenarios. Motorway immunity in the 20 year ARI combined climate and land use change scenario are noted in the performance against criteria tables for each catchment.

### 6.4.1 CLIMATE CHANGE

A climate change assessment was undertaken to assess the flood immunity of the project under a future climate change scenario in accordance with the design criteria. This took into account an estimated 20% increase in rainfall intensity and a 0.91m increase in water levels at Lake Illawarra potentially associated with climate change. These values are identical to the values used in the climate change assessment undertaken by WBM BMT for the Duck Creek flood study, and are consistent with parameters typically adopted for the assessment of climate change in flood studies. Climate change predictions are based on mid-range estimates provided in the Floodplain Risk Management Guideline titled 'Practical Consideration of Climate Change' (DECC, 2007).

Within the catchments of Duck Creek and Horsley Creek, the estimated increase in rainfall intensity is the primary cause of impacts on the alignment, while the application of increased Lake Illawarra levels does not substantially impact on flooding for the proposed alignment. Within the Macquarie Rivulet catchment, the increase in water level and the increase in rainfall intensity combine to result in increased flooding at the location of the proposed alignment, in the climate change scenario.

For all catchments, the motorway achieves 20 year ARI immunity under the climate change scenario.

#### Proxy Assessment

In accordance with the requirements of the SEARs, the effect of the proposal (including fill) on current flood behaviour was modelled for the range of design events, with the use of the 200 year ARI and 500 year ARI design flood events as proxies for assessing sensitivity to an increase in rainfall intensity due to climate change and land use change.

It is expected that increases in rainfall intensities will occur under climate change conditions. The 200 year ARI and 500 year ARI events are therefore used to assess the flood immunity of the project under a potential future climate change scenario. For the 200 year ARI event, this is roughly equivalent to a 10-15% increase in rainfall intensity when compared to the existing condition (ie no climate change) 100 year ARI flood event. For the 500 year ARI event, this is roughly equivalent to a 25-30% increase in rainfall intensity when compared to the existing condition 100 year ARI flood event.

In the 200 year ARI flood event, the motorway is flooded at the Duck Creek Bridge, however, the rest of the motorway is flood free. In the 500 year ARI flood event, the motorway is flooded at the Duck Creek Bridge, at the Albion Park interchange, and between the Macquarie Rivulet and Frazers Creek bridges.

The motorway is not designed to achieve flood immunity in the 200 or 500 year ARI events, and is predicted to be flooded in these events. When comparing the existing and proposed conditions, the impacts are predicted to be greater when compared to the impacts in the 100 year ARI event. Water level change maps and depth maps for the 200 and 500 year ARI events are included in Appendix B.

## 6.4.2 LAND USE CHANGE

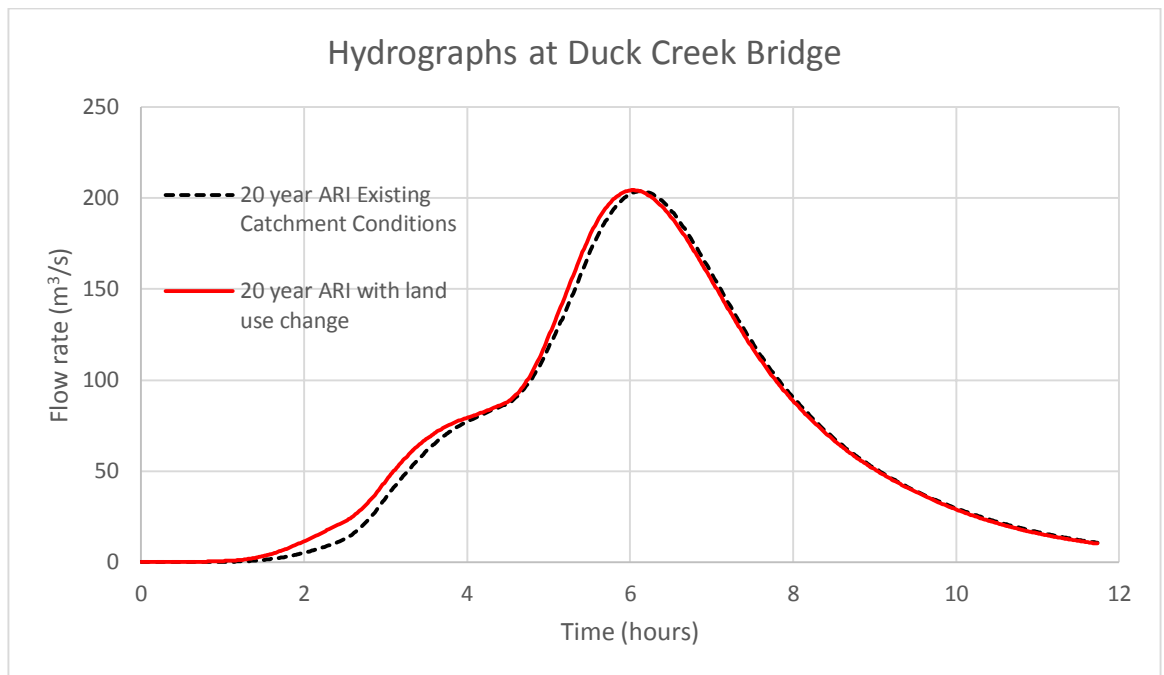
A number of major urban development projects are anticipated within the catchments, generally upstream of the alignment. Hydrological impacts associated with these developments (i.e. additional impervious area, resulting in increased runoff volumes) have been estimated based on current zoning plans, which have been used to create a land use change scenario hydrological model. Future developments included in this assessment are listed in **Table 6-10**, and illustrated in **Figure 6-7**.

As per the design criteria, the proposed alignment is designed to ensure an immunity of 20 year ARI in a combined climate change and land use change scenario.

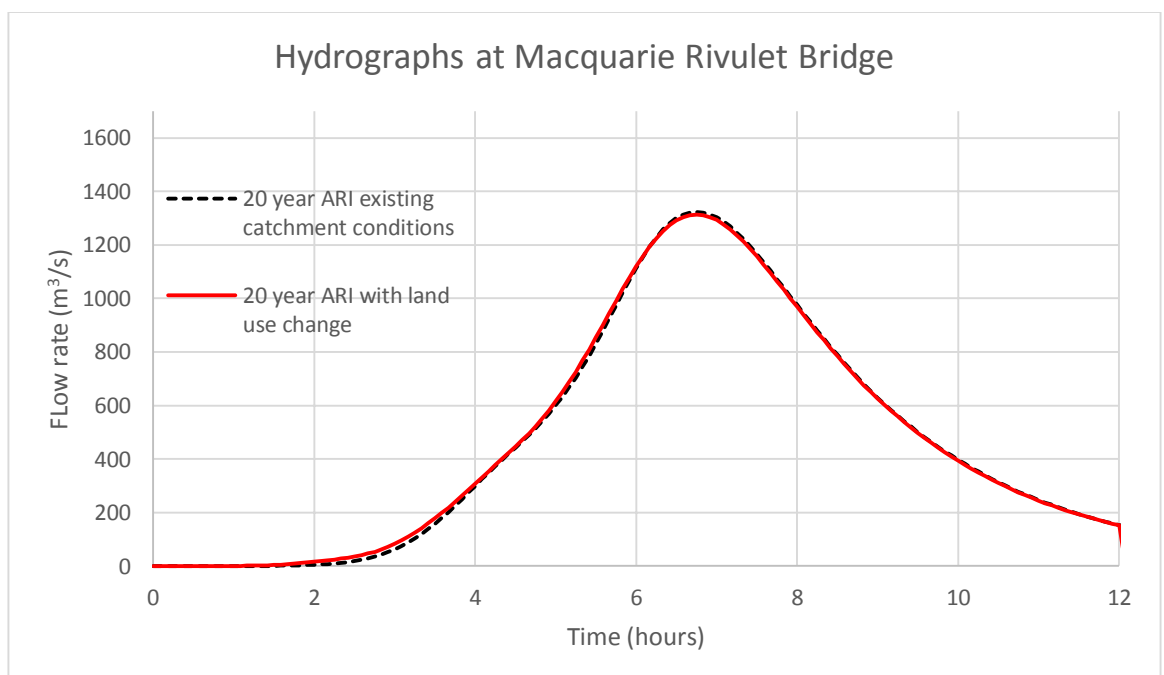
**Table 6-10 Major Developments**

| Catchment         | Land Use Change                                                                                    | Details                                                                                                    |
|-------------------|----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| Duck Creek        | West Dapto Stage 5 Rezoning as per Yallah Marshall Mount Precinct Draft Structure.                 | Rezoning of 10 ha of land which represents approximately 50% of the catchment upstream of the alignment.   |
| Macquarie Rivulet | Calderwood development as per SEPP 2005 Calderwood Land Zoning Plan                                | Total development area of 721 ha representing approximately 6% of the catchment upstream of the alignment. |
|                   | Tullimbar development as per Shellharbour LEP 2000.                                                | 125 ha site to the south of Calderwood development. Partially developed as of 2015.                        |
|                   | Illawarra Regional Business Park as per SEPP 2005 Illawarra Regional Business Park Land Zoning Map | 68 ha site adjacent to the Illawarra Regional Airport.                                                     |
| Horsley Creek     | No substantial rezoning or development appears to be proposed upstream of the alignment.           |                                                                                                            |

The hydrological model was updated to include the effects of the predicted land use change. The 100 year ARI flow rate within Duck Creek at the location of the motorway is shown in the following graph. It is noted that although the peak occurs slightly earlier due to changes in timing of runoff in parts of the catchment (as would be expected), future development within the Duck Creek catchment results in no substantial change in the peak flow rate in the 100 year ARI event.



The 100 year ARI flow rate within Macquarie Rivulet at the location of the motorway is shown in the following graph. While timing of flows changes slightly (e.g. at the start of the storm, runoff occurs quicker), this graphs illustrates that future development within the Macquarie Rivulet catchment results in no substantial change in peak flow rate in the 100 year ARI event.



The results of the land use change analysis show that peak flows within the Macquarie Rivulet and Duck Creek are not predicted to change substantially based on the impacts of the major developments within the catchment. The addition of land use change does not have any major impact on peak runoff rates and is not predicted to contribute to an accumulation of flooding impacts when considered in conjunction with the project. The cumulative impacts of the proposed motorway and land use change (as modelled) is therefore likely to be no worse than the impacts of the motorway as presented.

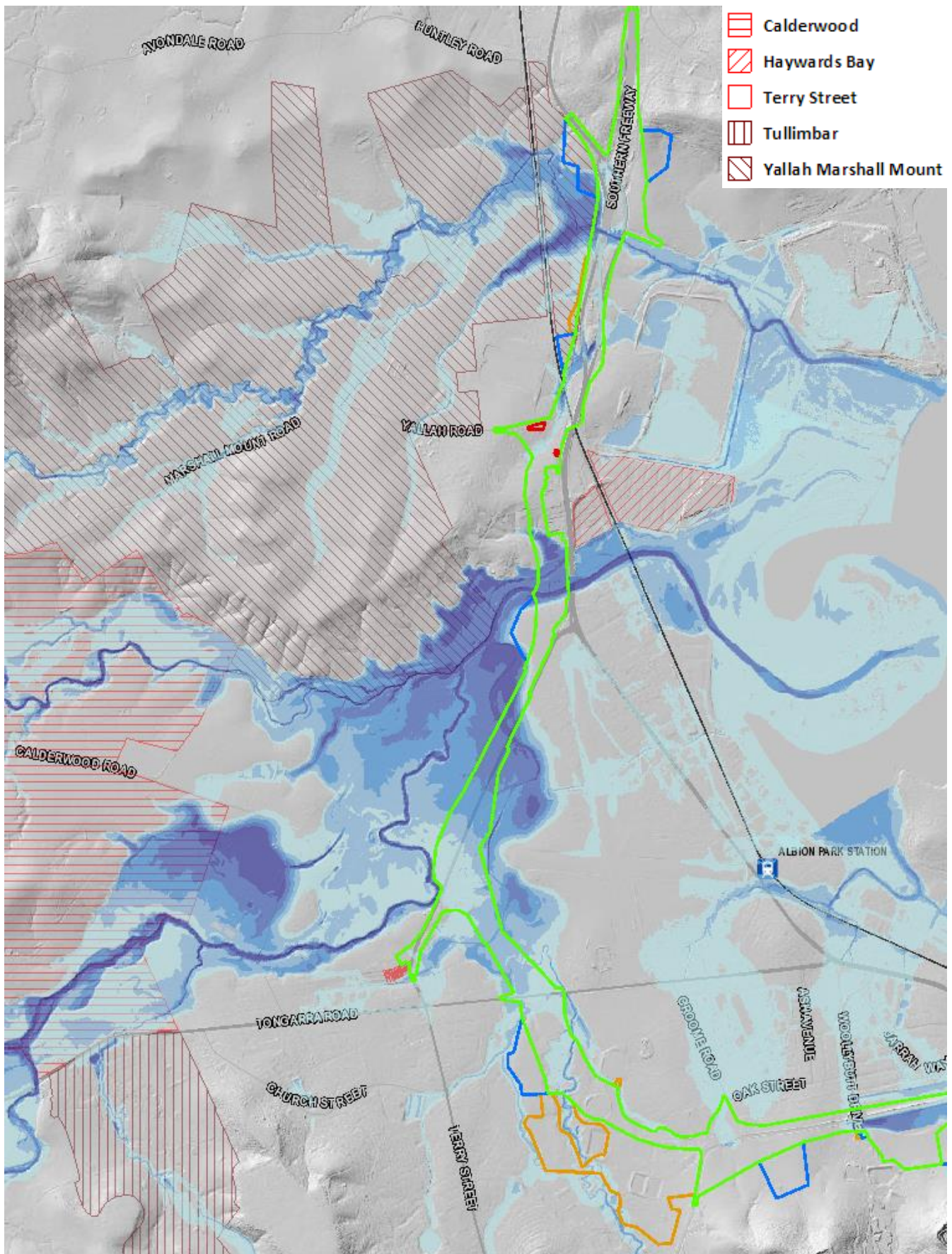


Figure 6-7 Potential Future Developments in Relation to the Albion Park Rail Bypass

## 7 ASSESSMENT OF CONSTRUCTION IMPACTS

### 7.1 RELEVANT CONSTRUCTION ACTIVITIES

The design of the project has carefully considered the requirement to minimise impact on existing traffic, enable safe construction access and egress, and minimise the duration of construction. The key construction activities would include:

- Mobilisation and site establishment
- Relocation and protection of existing services
- Clearing, grubbing and topsoil stripping, including clearing of all areas within the site boundary (except within the nominated environmental protection areas), temporary work areas and local work areas
- Demolition of existing roads and buildings
- Bulk earthwork and haulage of materials
- Construction of the road pavement
- Construction of drainage structures
- Construction of bridges (this would likely include heavy vehicle deliveries of over-size loads)
- Construction of temporary creek crossings
- Relocation and construction of sporting facilities
- Changes to property access
- Signposting
- Installation of lighting and roadside furniture
- Landscaping, waste disposal and rehabilitation of disturbed areas with no future use.

Temporary ancillary facilities would be required to enable the construction of the project. These facilities would be located within the project boundary. To provide the construction contractor with the necessary flexibility in the location of facilities, 13 ancillary sites have been identified and considered within this EIS. This would include the six temporary works areas which would provide the construction contractor with the necessary space to construct the project.

### 7.2 CONSTRUCTION RELATED IMPACTS

A number of construction activities have the potential to impact flooding for the Albion Park Rail Bypass. The inclusion of any temporary fill within the floodplain (e.g. preloading, stockpiles etc.) would reduce floodplain storage, which can result in increased flood elevations. Temporary crossings of the watercourses may be required during the construction and have the potential to impact on flooding. Construction phase impacts to flooding have not been modelled as part of the concept design assessment.

Preloading within areas of soft soils may result in levels of fill within the floodplain that are temporarily higher than the final design levels. This could result in greater flood impacts within the floodplain during the construction phase. This would only be expected to occur for flood events which exceed the flood immunity of the final road elevation at the location. Preloading at

the location of proposed culverts could result temporarily in the obstruction of flow paths within the floodplain and a temporary risk of increased flooding impacts.

If stockpiles are to be located within the floodplain, the obstruction of flow paths and loss of floodplain storage has the potential to cause flooding impacts. Loose material stored within the floodplain has the potential to be mobilised during a flood, especially within the Macquarie Rivulet floodplain. Moving debris such as this can become a substantial hazard during a flood, and may also contribute to blockage of hydraulic structures.

Temporary watercourse crossings may be required for some or all watercourses traversed by the project to facilitate construction activities, particularly where bridges are proposed. If required, these watercourse crossings would likely comprise a temporary causeway with culverts to maintain the low flows, and they would likely be maintained for the duration of construction. Temporary watercourse crossings may result in the following potential impacts:

- Disturbance of the watercourse bed and banks, resulting in erosion and sedimentation
- Partial obstruction of low flows, resulting in minor modification of downstream flows
- Scour of the bed near the culvert inlets and outlets.

## 7.3 MANAGEMENT OF CONSTRUCTION RELATED IMPACTS

It is important to manage construction activities in a way which mitigates the potential to impact flooding within the catchments.

In areas where flood conveyance is critical, preloading may need to be staged to ensure that flooding impacts during the construction do not exceed the flood impacts criteria for the project as identified in **Table 3-2**. Should construction staging require a temporary departure from the design (eg higher embankments for preloading, temporary diversions or temporary crossings), flood impacts will need to be modelled once the detailed design has been developed and the construction program and staging determined. This would involve updating of the design in the existing flood models, re-running the models for the relevant catchments to see if the bulk earthworks impact on flood behaviour, and assessing the flood risk, taking into account the duration of construction of the relevant stage of the works. Given that the motorway is designed to be immune from a 100 year ARI storm event, it follows that preloading of embankments will only potentially cause flooding impacts in events greater than the 100 year ARI. Temporary culverts or watercourse diversions may be required to ensure drainage is maintained while preloading at proposed culvert locations, if these areas are going to be blocked during this time.

Where stockpiles are required within the floodplain, they should be located and sized to ensure that temporary impacts are not greater than those specified in the design criteria. In general, site compounds and stock piles (i.e. ancillary sites) should be located above the 20 year ARI flood extent unless a flood contingency plan is prepared. A full list of ancillary sites and their predicted flood immunity is provided in chapter 8 of the EIS. Eight of the thirteen ancillary sites have a level of flood immunity of less than the 10 year ARI flood event, but greater than the 5 year ARI flood event. The other five ancillary sites are located outside the floodplain.

In the event of inundation of an ancillary site, there is potential for:

- Erosion of exposed soils or stockpiles, and subsequent sedimentation of watercourses
- Inundation of temporary sediment basins, resulting in sedimentation
- Mobilisation of contaminants from any chemical storage areas, re-fuelling stations, generators, plant or machinery that are subject to inundation

- Transport of litter and other loose materials stored on site into watercourses
- Mobilisation of plant or machinery by floodwater, with associated negative impacts on the environment.

For ancillary sites with flood immunity of less than 20 year ARI, a flood contingency plan will need to be prepared. This plan should consider likelihood of flooding, evacuation routes, warning times, and potential impacts from the compound flooding. Recommended actions are as follows:

- The Construction Environmental Management Plan shall identify a designated “Site Flood Controller”;
- The Plan will include relevant emergency contact details, including the SES;
- The Plan will include instruction on monitoring of the Bureau of Meteorology website and/or relevant water level gauges in relation to flooding, if required;
- Procedures to be followed in preparation for, during and after a flood event will be developed for the subject site. A copy of these procedures will be retained on site at all times;
- The Plan will also include details of flood behaviour for the site, including extent and duration of inundation during events;
- Staff inductions will include information on flooding and training in what to do to prepare, during and after a flood event;
- Ensure that copies of the SES’s “Shellharbour City Local Flood Plan” and “Wollongong City Local Flood Plan” are kept on site at all times;
- The Site Flood Controller should familiarise themselves with the Local Flood Plans and advice from the SES to ensure they can execute the site flood plan.

Should construction staging require a temporary departure from the design (e.g. higher embankments for preloading, temporary diversions or temporary crossings), flood impacts would need to be assessed before finalising the approach (e.g. during the detail design phase). No assessment would be required in cases where construction stages are consistent with the operational design (for which impacts have already been assessed in the concept design assessment).

## 8 EMERGENCY MANAGEMENT, EVACUATION AND ACCESS

The project offers significant improvements to some evacuation routes during floods, because flood immunity is improved. **Figure 8-1** shows the level of service of the project in existing and proposed conditions.

Full analysis of flood emergency response for the region is beyond the scope of this report. However, a shelter in place approach is preferred due to the short duration of flooding within the catchments. Hence, the flood immunity improvement is mostly relevant to emergency vehicles.

### Vehicular / Emergency Access

In the existing case, the motorway to the north is flooded at Duck creek in the 50 year ARI event. This is proposed to remain the same.

Access to Albion Park is severely restricted in the existing case, with the Illawarra Highway flooding multiple times per year, Terry Street flooded in a 2 year ARI event and Tongarra Road flooded in a 5 year ARI event. With the proposed bypass, the motorway is flood free in the 100 year ARI event, immunity of Tongarra Road is increased to the 10 year ARI event and flooding at Terry Street is unchanged.

At the existing Green Meadows Basin, the East West Link is flooded in less than a 2 year ARI event (depending on blockage). With the proposed bypass, the motorway at this location is flood free in the 100 year ARI event and the proposed Service Road is flooded in less than a 2 year ARI event (depending on blockage).

The proposed bypass will improve access during a flood within the Macquarie Rivulet and the Horsley Creek catchments. Access during a flood within the Duck Creek catchment is predicted to remain unchanged.

Consultation would be undertaken with the emergency services and the SES once the construction staging and program has been developed, to discuss any potential impacts on emergency access and flood evacuation, and (if required) alternative access / egress routes during construction.

The project also includes provision for Variable Message Signs (VMS), which could be used to warn of flooding if necessary. Further detail is provided in Section 5.17 of the EIS, with indicative locations shown in Figures 5-1 to 5-7 of the EIS document.

### Wollongong City Local Flood Plan

The Wollongong City Local Flood Plan is a sub-plan of the Wollongong Local Disaster Plan developed by the State Emergency Service. The local flood plan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Wollongong City Council area. The plan does not identify existing flood evacuation routes. The Wollongong Local Flood Plan was last updated in June 2010 and does not include any information relating to flooding within Duck Creek due to the Duck Creek flood study being completed in 2012. It is not anticipated that road closures and inundation times will be changed as a result of this project when compared to those presented in the Duck Creek flood study (BMT WBM, 2012).

### Kiama/Shellharbour City Local Flood Plan

The Kiama/Shellharbour City Local Flood Plan is a sub-plan of the Kiama/Shellharbour Local Disaster Plan developed by the State Emergency Service. The local flood plan covers

preparedness measures, the conduct of response operations and the coordination of immediate recover measures from flooding within the Shellharbour City Council and Kiama Council area. The plan does not identify any designated flood evacuation routes. This is likely due to the rapid rate of rise of floodwaters, and large extent of inundation, with many roads in the project area inundated during even small events. The Kiama/Shellharbour City Local Flood Plan was last updated in June 2008 which was prior to the Horsley Creek Flood Study (Reinco, 2011) being finalised. Areas of flooding risk and road closures are provided in the plan based on historical evidence.

A summary of changes to the road closures in the flood plan are provided in **Table 8-1**. Flooding is improved at a number of locations and will improve access for emergency services during a flood.

**Table 8-1 Impacts to Road Closures Included In Kiama/Shellharbour City Local Flood Plan**

| Road              | Location                                     | Comments in Kiama/Shellharbour City Local Flood Plan                                                           | Changes anticipated as a result of this project                                                                 |
|-------------------|----------------------------------------------|----------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| Princes Highway   | Between Mallee St and Airport Rd             | Usually affected for the period of rain fall                                                                   | Unchanged for 2 year ARI to 200 year ARI events.<br>Predicted to be worse for 500 year ARI and PMF              |
| Princes Highway   | Just south of Station Road                   | Usually affected for the period of rain fall                                                                   | Flood levels reduced for all events.                                                                            |
| Princes Highway   | Various locations                            | Storm run-off building up resulting in inundation of numerous traffic lanes in either direction                | N/A                                                                                                             |
| Station Road      | Between Princes Hwy and Black St             | Can be affected by flooding from Horsley Creek                                                                 | Flood levels reduced for all events.                                                                            |
| Illawarra Highway | Between Croome Lane and Taylor road          | Can be affected by flooding from Macquarie Rivulet. During intense rain periods may close for a number of days | Immunity increased from <1 year ARI to 100 year ARI at Frazers Creek.<br>Unchanged at Taylor Road intersection. |
| Tongarra Road     | Between Croome Rd and Stapleton Ave          | Can be affected by flooding in Frazers Creek, or by backup flooding from Macquarie Rivulet                     | Immunity increased from 2- 5 year ARI to 10-20 year ARI.                                                        |
| Calderwood Road   | Between Tripoli Way and North Macquarie Road | Can be affected by flooding from Macquarie Rivulet                                                             | Not predicted to change.                                                                                        |
| Industrial Road   | Various locations                            | Usually affected for the period of rain fall                                                                   | Flood levels reduced for all events within Horsley Creek.                                                       |

## Evacuation from the Development

Much of the project traverses flood affected areas, with flooding often causing road closures at various locations (as described above).

The project will substantially improve flood immunity, and hence evacuation during a flood. The project replaces the section of the Illawarra Highway most affected by flooding, and achieves a 100 year ARI flood immunity across the Macquarie Rivulet floodplain. The project also improves the flood immunity of Tongarra Road, while achieving 100 year ARI flood immunity near the existing Green Meadows Basin.

Evacuation from the development will be inherently improved as a result of the substantial improvements to flood immunity achieved by the project.

## Assessment of PMF

The PMF was estimated using the generalised short duration method (GSDM) developed by the Bureau of Meteorology. The NSW Floodplain Development Manual (2005) advises that the recurrence of the PMF is in the order of 10,000 to 100,000 years. Peak flows of the PMF is generally two to three times larger than the 100 year ARI event. Based on the recurrence of a PMF, it follows that a 100 year ARI flood is in the order of 100 to 1000 times more likely to occur than a PMF in any one year.

During a PMF, the motorway is predicted to be flooded at the following locations:

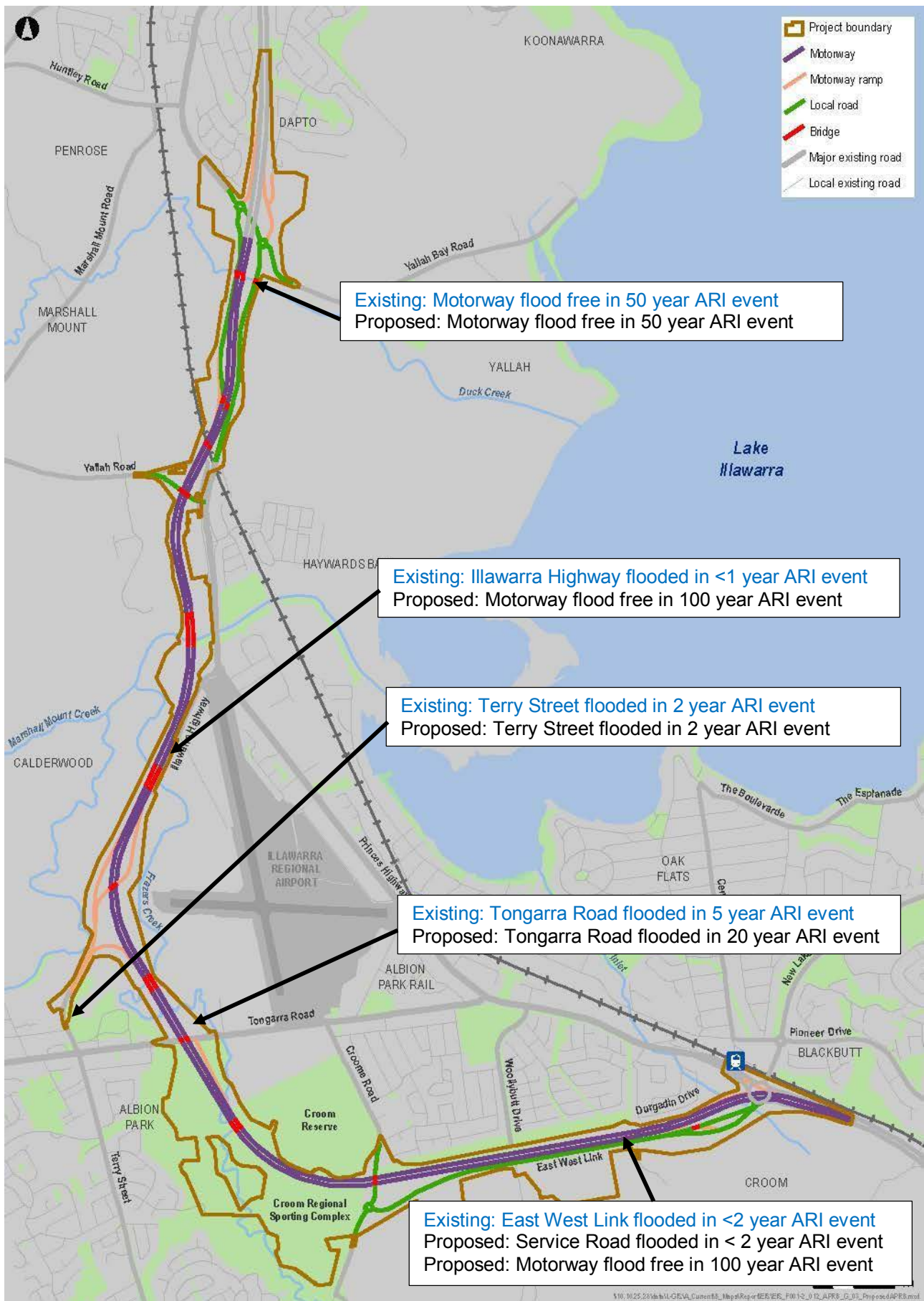
- Between Duck Creek (D1) and Duck Creek (D3)
- Between Macquarie Rivulet (M1) and Frazers Creek (M2)
- At the central interchange (M2b)
- Downstream of the proposed detention basin adjacent to Croom Road (H1)
- Downstream of the Green Meadows Basin (H3 to H4)

The motorway is likely to be flooded for the majority of the critical storm burst, which is between 2 to 3 hours for the catchments traversed by the project. It is noted that the pavement surface, road embankments, culverts and bridges are not designed to withstand a PMF and may not be serviceable following a PMF event. Access and evacuation during a PMF would need to be via alternative vehicular routes or via boat or aircraft.

## Stock Movement

A dairy farm currently operates adjacent to the Illawarra Highway within the Macquarie Rivulet catchment. The dairy currently has access across the Illawarra Highway, which allows cattle to be moved to high ground to the west of the highway and the dairy to continue operation during a flood. The alignment of the project will require that the dairy infrastructure be relocated, while reducing the area of high ground available for cattle to shelter during a flood. In a 20 year ARI event, the area of flood free land between the Illawarra Highway and Macquarie Rivulet is reduced from 7.6 ha to 3.3 ha as a result of the project. It is noted that this reduction in flood free area is primarily due to the land required for the project not due to changes in the flood extent. Access under the motorway to the high ground is provided at Frazers Creek under the bridge at this location. This access utilises the existing Illawarra Highway crossing of Frazers Creek and would be flooded multiple times a year for durations greater than a day during a major flood. Flood free cattle underpasses and/or stock mounds are not proposed as part of the project

The reduction in area of the high ground (and the restricted access to it) impacts on the dairy. Mitigation of these impacts is under ongoing negotiation with the operators of the dairy.



**Figure 8-1 Existing and Proposed Flood Access**

## 9 MITIGATION MEASURES

Flood modelling has been undertaken continually throughout the progression of the design, to identify impacts to hydrology and flooding and incorporate measures to ensure these impacts are minimised or eliminated where possible.

### 9.1 FLOOD CONVEYANCE

Initially, flood modelling was undertaken to reflect numerous design options with various alignment and interchange configurations. Once selected, the preferred option was continually refined to minimise increases to flood levels while achieving a high level of flood immunity. This was achieved primarily through refinement of the bridge locations, bridge spans, and culvert sizes, and also through optimisation of elements such as embankment slopes and the vertical alignment.

**Table 9-1** presents mitigation measures incorporated in the design to ensure that conveyance is maintained.

**Table 9-1 Summary of Flood Structures**

| Transverse Drainage Structure | Description          | Sizing                                                                                                                                          |
|-------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| D1<br>CH 16320                | Duck Creek           | 45m bridge                                                                                                                                      |
| D2<br>CH 16830                | Duck Creek tributary | 6x 900mm RCP culverts                                                                                                                           |
| D3<br>CH 17050                | Duck Creek tributary | 1x 2100mm RCP culvert                                                                                                                           |
| D5<br>CH 17750                | Duck Creek tributary | (2x) 1200H x 2400W RCBC under the Yallah Road upgrade                                                                                           |
| M1<br>CH 18650                | Macquarie Rivulet    | 200m bridge opening (measured at the toe of abutment)                                                                                           |
| M2<br>CH 19600                | Frazers Creek        | 150m bridge opening (measures at the toe of the abutment)                                                                                       |
| M2a<br>M2b<br>M2c<br>CH 20600 | Floodplain           | (5x) 1200H x 3000W RCBC culvert under ramps<br>(2x) 1200H x 3000W RCBC culvert under motorway<br>(2x) 1200H x 3000W RCBC culvert under motorway |
| M3<br>CH 21000                | Frazers Creek        | 90m bridge opening (measured at the toe of abutment)                                                                                            |
| M4<br>CH 21200                | Frazers Creek        | (3x) 2400H x 3000W RCBC culvert                                                                                                                 |

| Transverse Drainage Structure                  | Description             | Sizing                                                                                                                                                                                                 |
|------------------------------------------------|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| M5<br>CH 22100                                 | Frazers Creek           | 65m bridge opening over 30m wide creek diversion<br>(4x) 2100mm RCP culverts 200m north of the proposed bridge                                                                                         |
| H1a<br>H1b<br>H1c<br>H1d<br>CH 23100           | Horsley Creek tributary | (1x) 1200H x 1500W RCBC under service road<br>(1x) 1200H x 3000W RCBC under service road<br>(1x) 1500H x 3000W RCBC under motorway<br>(1x) 1500H x 3000W RCBC under Croome Road<br>New detention basin |
| H2<br>H3<br>H4<br>H5<br>CH 24000 –<br>CH 24700 | Green Meadows Basin     | 1x 900 RCP<br>1x 900 RCP<br>1200 RCP culvert<br>1350 RCP culvert<br>Three sets of (2x) 1500H x 3300W RCBC at spillway                                                                                  |
| H6<br>CH25500                                  | Horsley Creek           | (1x) 1800H x 3600W RCBC culvert                                                                                                                                                                        |

## 9.2 POST CONCEPT MITIGATIONS

In addition the mitigation measures incorporated into the design, the mitigation and management measures provided in **Table 9-2** would be implemented to avoid, minimise or manage impacts on hydrology and flooding.

**Table 9-2 Management of Impacts Relating to Hydrology and Flooding**

| Issue                                          | ID No. | Environmental management measure                                                                                                                                                                                                                                                               | Responsibility | Timing       |
|------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|--------------|
| Impacts on flood behaviour during construction | HF01   | Temporary works will consider flood impacts during construction. Should construction staging require a temporary departure from the design (eg higher embankments for preloading, temporary diversions or temporary crossings), flood impacts will be assessed before finalising the approach. | Contractor     | Construction |
|                                                | HF02   | Where stockpiles are to be located in the floodplain, they will be located and sized to ensure that temporary impacts are not greater than those specified in the design criteria.                                                                                                             | Contractor     | Construction |
| Impact of flooding on                          | HF03   | For ancillary sites with flood immunity of less than 20 year ARI, a flood contingency plan will be prepared. This plan will consider likelihood of                                                                                                                                             | Contractor     | Construction |

| Issue                                        | ID No. | Environmental management measure                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Responsibility                  | Timing          |
|----------------------------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|-----------------|
| construction activities                      |        | <p>flooding, evacuation routes, warning times, and potential impacts from the site flooding. It will include, but not be limited to:</p> <ul style="list-style-type: none"> <li>Any monitoring requirements to ensure advance notice of a flood event</li> <li>Procedures to be implemented in the event of a flood</li> <li>Details of the required training and staff inductions.</li> </ul>                                                                                                                                                                                                                                          |                                 |                 |
| Bed and bank stability during construction   | HF04   | <p>Temporary watercourse crossings will be designed to minimise impacts on hydrology, aquatic habitat and fauna by:</p> <ul style="list-style-type: none"> <li>Maintaining low-flow conditions</li> <li>Being designed with consideration of the potential for flooding during construction</li> <li>Being removed and the area rehabilitated following completion of construction.</li> </ul> <p>These crossings will not be used for Class 1 waterways, and will take into consideration the requirements of the Policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries, 2013).</p> | Contractor                      | Construction    |
| Frazers Creek adjustment                     | HF05   | <p>The Frazers Creek adjustment shall be designed and constructed in a way that mimics natural flow conditions, creates habitat for aquatic animals, and incorporates locally native riparian vegetation, in accordance with the requirements of the Policy and guidelines for fish habitat conservation and management (NSW Department of Primary Industries, 2013) in consultation with NSW Fisheries and the NSW Office of Water.</p>                                                                                                                                                                                                | Contractor                      | Detailed design |
| Operational phase impacts on flood behaviour | HF06   | <p>The potential negative flood impacts on Property 1, Dwelling 1 and Dwelling 2 will be reassessed during the detailed design by flood modelling. If the properties are still impacted, and if mitigation is required, this will be investigated in consultation with the landowner.</p>                                                                                                                                                                                                                                                                                                                                               | Roads and Maritime / Contractor | Detailed design |

| Issue                                               | ID No. | Environmental management measure                                                                                                                                                                                                                                                                                                                                 | Responsibility | Timing          |
|-----------------------------------------------------|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|-----------------|
| Bed and bank stability during the operational phase | HF07   | A geomorphological assessment will be undertaken at the detailed design phase for all watercourses, with an aim to minimise changes to natural stream flow and velocity. This assessment will consider impacts on stream geomorphology from regular stream flows as a result of increased flow velocities, changes to direction of flow and instream structures. | Contractor     | Detailed design |
|                                                     | HF08   | The detailed design of bridges and culverts will consider the requirement for fish passage and scour protection under the Policy and Guidelines for Fish Habitat Conservation and Management (NSW Department of Primary Industries, 2013) and the NSW Office of Water guidelines for Controlled Activities.                                                      | Contractor     | Detailed design |
| Reconfiguration of Green Meadows detention basin    | HF09   | A dam break assessment will be undertaken to assess the risk associated with the Green Meadows Basin.                                                                                                                                                                                                                                                            | Contractor     | Detailed design |
| Flood access                                        | HF10   | Consultation would be undertaken with affected landowners where access to farms is to be temporarily impacted during construction. Property access will be maintained or alternative arrangements made in consultation with the affected landowners.                                                                                                             | Contractor     | Construction    |
| Emergency access and evacuation during construction | HF11   | Consultation would be undertaken with the emergency services and the SES once the construction staging and program has been developed, to discuss any potential impacts on emergency access and flood evacuation, and (if required) alternative access / egress routes during construction.                                                                      | RMS            | Construction    |

## 9.3 WATERWAY IMPACTS

A geomorphic assessment may be required at the detailed design phase for impacted waterways (as relevant), with an aim to minimise changes to natural stream flow and velocity. This assessment would consider impacts on stream geomorphology dictated by regular stream flows, as a result of increased flow velocities, changes to direction of flow and instream bridge piers. NSW Office of Water guidelines would need to be considered at the detailed design phase regarding instream works, outlet structures, riparian corridors, watercourse crossings, and vegetation management plans.

## 9.4 SCOUR

At all locations where water will be conveyed across the highway through culverts or bridges, and in all other locations where project works significantly amend existing flow behaviour (e.g. watercourse diversions), assessments will be undertaken during detailed design to determine the requirements for scour protection measures. Assessments will consider the following factors:

- Flow behaviour, including depth, velocity and direction.
- Resistance of material to scour, including soil shear stress, particle size and vegetation.
- Other land uses (e.g. is access required across scour protection area)

Typical scour protection measures include rock placement, concrete spillways and energy dissipation devices. The appropriate scour protection measures would be selected based on consideration of the above factors and in consultation with the project urban designer.

## 10 CONCLUSIONS

This hydrology and flooding assessment has provided detail on how hydrology and flooding will change with the project in place and the flood immunity achieved for the motorway. In summary:

- Floods tend to peak and subside relatively quickly, because of the topography and catchment size. Flood durations are in the order of hours rather than days or weeks as can occur in larger inland catchments.
- Much of the project traverses flood affected areas. Flooding is therefore a substantial constraint and the design requires a number of bridges and culverts.
- The motorway elevation and configuration of the watercourse crossings has required careful optimisation to ensure that a high level of flood immunity is achieved, while mitigating flooding impacts to an acceptable level.
- Main carriageways of the alignment achieve flood immunity in the 100 year ARI event, with the exception of the low point to the south of Duck Creek on the existing Princes Motorway which achieves immunity in the 50 year ARI event.
- It is predicted that main carriageways would achieve flood immunity in the 20 year ARI event in the combined climate change and land use change scenarios, at all locations.
- During minor (frequent) storm events, hydrological impacts will be limited along the majority of the alignment, because the majority of existing flow paths will be maintained.
- Some impact to the conveyance of floodwater during major storms is expected, as a result of providing new road infrastructure with a substantially higher level of flood immunity than the existing road network.
- The project is not predicted to cause impacts in excess of the acceptable levels specified in the design criteria, with the exception of:
  - Flood level increase of 2.5 m in the 100 year ARI event at D3 resulting in 0.55ha of newly flooded land beyond the project boundary.
  - The two properties within the Macquarie Rivulet floodplain.
  - Water level increases of greater than 150 mm within the recreational land downstream of Green Meadows Basin.
  - Increased velocities downstream of the Green Meadows Basin.
- Increased flood levels within the Duck Creek catchment are generally localised where the alignment crosses the three individual watercourses. These increases are primarily due to the new bridge over Duck Creek and higher road levels to the north of Yallah Road. Impacts are predominately within rural land and are not anticipated to be adverse.
- Increased flood levels within the Macquarie Rivulet catchment are predicted to extend over the floodplain between Tongarra Road, Marshall Mount Creek and the existing Princes Highway. These impacts are primarily due to additional fill within the floodplain.
- Increased flood levels to the north of the Croom Regional Sporting Complex are primarily due to fill within the floodplain and the proposed watercourse diversion.
- Increased flood levels within the Horsley Creek catchment are generally localised and are primarily due to the proposed road embankments.
- Reductions in flooding are predicted downstream of the motorway along Croome Road and within the residential land to the east. This reduction in flooding is due to the proposed detention basin upstream of the motorway.

- A number of construction activities have the potential to impact flooding for the project, such temporary watercourse crossings and temporary fill within the floodplain (e.g. preloading, stockpiles etc.). These need to be identified and mitigation strategies put in place as part of the detailed design and construction of the project.
- To minimise impacts during construction, flow paths are not to be obstructed and additional fill within the floodplain is to be minimised. Temporary crossing design will need to meet flood impact criteria.
- Preloading may need to be staged in areas where flood conveyance is critical. Temporary culverts or watercourse diversions may be required to ensure drainage is maintained at proposed culvert locations.
- Any stockpiles within the floodplain will be located and sized to meet the flood impact criteria.
- This report addressed all Hydrology, Soil and Water SEARs, except the following, which are addressed in other EIS reports:
  - Water quality (e.g. surface water, erosion and sediment control, salinity, spill capture)
  - Ecological impacts / waterway rehabilitation
  - Groundwater impacts
  - Acid sulphate soils / contaminated lands assessment
- This report is subject to the following qualifications:
  - The Macquarie Rivulet Flood Study is under development. The preliminary model obtained for the purposes of this assessment may be subject to change.
  - The base case hydrology uses IFD design rainfall data from the 1987 issue of ARR. Revised IFD data was released by ARR in 2013, based on an updated rainfall data set. This assessment falls within the 2 year transition period set by ARR, during which either 1987 or 2013 IFD data may be adopted.
  - This report uses estimates of sea level rise and increased rainfall provided in Practical Consideration of Climate Change (DECC, 2007) to assess the impacts of climate change. These estimates are the best available at the time of writing.

# 11 REFERENCES

- BMT WBM (2012). *Duck Creek Flood Study*.
- Dams Safety Committee (2010). *Emergency Management for Dams*.
- Department of Environment and Climate Change (2007). *Practical Consideration of Climate Change*.
- Department of Primary Industries (2004). *Policy and Guidelines for Fish Friendly Waterway Crossings*.
- Department of Primary Industries (2013). *Policy and Guidelines for Fish Habitat Conservation and Management – Update 2013*.
- Landcom (2004). *Managing urban stormwater: soils and construction*.
- NSW Government (2005). *Floodplain Development Manual*.
- NSW Office of Water (2012). *Guidelines for instream works on waterfront land*
- NSW Office of Water (2012). *Guidelines for laying pipes and cables in watercourses on waterfront land*.
- NSW Office of Water (2012). *Guidelines for outlet structures on waterfront land*.
- NSW Office of Water (2012). *Guidelines for riparian corridors on waterfront land*.
- NSW Office of Water (2012). *Guidelines for vegetation management plans on waterfront land*.
- NSW Office of Water (2012). *Guideline for watercourse crossings on waterfront land*.
- Pilgrim, DH, (ed) (1987). *Australian Rainfall & Runoff – A Guide to Flood Estimation*. Barton, ACT: Institution of Engineers, Australia.
- Reinco (2011). *Horsley Creek Flood Study*.
- Wollongong City Council (2009). *Wollongong Development Control Plan*.

## APPENDIX A

---

# APPENDIX A: RELEVANT SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

# Secretary's Environmental Assessment Requirements

## Section 115Y of the *Environmental Planning and Assessment Act 1979*

|                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Application Number</b>   | SSI 6878                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Proposal</b>             | Albion Park Rail bypass (including relocation of Croom Regional Sporting Complex facilities)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Location</b>             | Land in the suburbs of Dapto, Yallah, Albion Park Rail, Albion Park and Croom, within the Wollongong and Shellharbour local government areas.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Proponent</b>            | Roads and Maritime Services                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Date of Issue</b>        | 18 March 2015                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>General Requirements</b> | <p>The Environmental Impact Statement (EIS) must be prepared in accordance with, and meet the minimum requirements of, Part 3 of Schedule 2 of the <i>Environmental Planning and Assessment Regulation 2000</i> (the Regulation), including:</p> <ol style="list-style-type: none"> <li>the information required under clause 6 of Schedule 2 of the Regulation.</li> <li>the content listed in clause 7 of Schedule 2 of the Regulation, including but not limited to: <ul style="list-style-type: none"> <li>a statement of the objectives of the proposal, including a description of the strategic need, justification, objectives and outcomes for the proposal, taking into account existing and proposed transport infrastructure and services within the adjoining subregions, and as relevant the outcomes and objectives of relevant strategic planning and transport policies, including, but not limited to, <i>NSW 2021</i>, <i>NSW Government State Infrastructure Strategy</i>, <i>NSW Long Term Transport Master Plan</i> (December 2012), <i>Your Future Illawarra: Draft Regional Growth and Infrastructure Plan</i> (October 2014) and any other relevant plans;</li> <li>an analysis of feasible alternatives to the carrying out of the proposal and proposal justification, including: <ul style="list-style-type: none"> <li>an analysis of alternatives/options considered having regard to the proposal objectives (including an assessment of the environmental costs and benefits of the proposal relative to alternatives and the consequences of not carrying out the proposal), and the provision of a clear discussion of the route development and selection process, the suitability of the chosen alignment taking into account environmental impacts, and consideration of whether or not the proposal is in the public interest, and</li> <li>justification for the preferred proposal taking into consideration the objects of the <i>Environmental Planning and Assessment Act 1979</i>;</li> </ul> </li> <li>a detailed description of the proposal, including: <ul style="list-style-type: none"> <li>the proposed route,</li> <li>design of the alignment (vertical and horizontal), associated structures, interchanges, and road user, pedestrian and cyclist facilities (including street furniture and lighting),</li> <li>land use changes, including resumption of residential, commercial, industrial and recreational lands, and impacts to Crown land,</li> <li>Croom Regional Sporting Complex works and ancillary development;</li> <li>interactions with key utilities and services;</li> </ul> </li> </ul> </li> </ol> |

|                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | <ul style="list-style-type: none"> <li>o location and operational requirements of construction ancillary facilities and access tracks, and</li> <li>o relationship and/or interaction with existing public and freight transport services (including air, rail, and bus services);</li> <li>• an analysis of the proposal including an assessment, with a particular focus on the requirements of the listed key issues, in accordance with clause 7(1)(d) of Schedule 2 of the Regulation (where relevant), including an identification of how relevant planning, land use and development matters (including relevant strategic and statutory matters) have been considered in the impact assessment (direct, indirect and cumulative impacts) and/or in developing management/mitigation measures;</li> <li>• detail how the principles of ecologically sustainable development will be incorporated in the design, construction and ongoing operation phases of the proposal; and</li> <li>• provide an assessment of the cumulative impacts of the proposal, taking into consideration other projects on the Princes Highway and M1 Princes Motorway.</li> </ul> <p>Notwithstanding the key issues specified below, the EIS must include an environmental risk analysis to identify the potential environmental impacts associated with the proposal.</p> <p>Where relevant, the assessment of the key issues below, and any other significant issues identified in the risk assessment, must include:</p> <ul style="list-style-type: none"> <li>• adequate baseline data;</li> <li>• consideration of potential cumulative impacts due to other development in the vicinity; and</li> <li>• measures to avoid, minimise and if necessary, offset the predicted impacts, including detailed contingency plans for managing any significant risks to the environment.</li> </ul> |
| <b>Key Issues</b> | <p><b>Traffic and Transport</b> — including but not limited to:</p> <ul style="list-style-type: none"> <li>• details of how: <ul style="list-style-type: none"> <li>o the preferred alignment, design and staging,</li> <li>o the proposed interchanges and connections to the surrounding road network, and</li> <li>o associated road infrastructure facilities,</li> </ul> meet the traffic and transport objectives of the proposal, taking into account the following local and regional issues: <ul style="list-style-type: none"> <li>o adjacent sensitive land uses,</li> <li>o transport connectivity to and from existing communities and centres (such as East Dapto),</li> <li>o future growth areas (including but not limited to Calderwood, Tallawarra, West Dapto and Tullimbar),</li> <li>o approved and proposed infrastructure projects (including the proposed Albion Park (Tripoli Way) bypass and Yallah Road realignment), and</li> <li>o traffic (vehicular, cyclist and pedestrian) needs;</li> </ul> </li> <li>• an assessment and modelling of operational traffic and transport impacts on the local and regional road network, and the M1 Princes Motorway, including an assessment of road user safety and bus impacts;</li> <li>• impacts on cyclist and pedestrian access and safety, and consideration of opportunities to integrate cycleway and pedestrian elements with surrounding networks;</li> <li>• an assessment of aviation issues associated with the Illawarra Regional Airport (during construction and operation, including proposed future operations), including impact on: <ul style="list-style-type: none"> <li>o communications/navigation/surveillance infrastructure,</li> <li>o the Obstacle Limitation Surface (OLS),</li> </ul> </li> </ul>                                                                                 |

- o Precision Approach Path Indicator (PAPI) Obstacle Assessment Surfaces (OAS),
- o the Procedures for Air Navigational Services — Aircraft Operations Surface (PANS-OPS);
- o road structure generated windshear and turbulence, and
- o lighting distractions and glare to pilots; and
- construction traffic and transport impacts of the proposal (including ancillary facilities) and associated management measures, in particular:
  - o impacts to the road network (including safety and level of service, pedestrian and cyclist access, and disruption to public transport services and access to properties),
  - o access and route identification and scheduling of transport movements,
  - o the number, frequency and size of construction related vehicles (both passenger, commercial and heavy vehicles),
  - o the nature of existing traffic on construction access routes (including consideration of peak traffic times), and
  - o the need to close, divert or otherwise reconfigure elements of the road network associated with construction of the proposal,
 having reference to the cumulative construction impacts of other major projects preparing for or commencing construction.

**Biodiversity** – including, but not limited to:

- an assessment of the potential ecological impacts of the proposal, with specific reference to vegetation and habitat clearing, connectivity, edge effects, weed dispersal, riparian and aquatic habitat impacts, soil and water quality impacts and operational impacts. The assessment must:
  - o make specific reference to impacts on landscape values, biodiversity values of native vegetation and threatened species or populations, including worst case estimates of vegetation clearing and operational impacts;
  - o demonstrate a design philosophy of impact avoidance on ecological values, and in particular, ecological values of high significance, and be consistent with the 'avoid, minimise or offset' principle;
  - o be undertaken in accordance with the *Framework for Biodiversity Assessment* (Office of Environment and Heritage (OEH) 2014) and the *NSW Biodiversity Offsets Policy for Major Projects* (OEH 2014), and by a person accredited in accordance with section 142B(1)(c) of the *Threatened Species Conservation Act 1995*. Impacts on species, populations and ecological communities that will require further consideration and provision of information specified in section 9.2 of the *Framework for Biodiversity Assessment* include those identified by the OEH. Species specific surveys shall be undertaken for those species and in accordance with the survey requirements specified by the OEH (including during further consultation with the OEH);
  - o in relation to aquatic biodiversity be consistent with the draft *Policy and Guidelines for Fish Habitat Conservation and Management – Update 2013* (DPI 2013);
  - o consider impacts to the Croom Voluntary Conservation Agreement; and
  - o where there are potential impacts to the OEH estate reserved under the *National Parks and Wildlife Act 1974* or where the proposal is located upstream of OEH estate, an assessment of the matters to be considered outlined in the *Guidelines for developments adjoining land and water managed by DECCW* (DECCW 2010).

**Hydrology, Soils and Water** - including but not limited to:

- impacts on watercourses and surface water flows, quality, quantity, availability and users (commercial and recreational), with particular

|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>reference to any likely impacts on surrounding water bodies and their catchments (including Macquarie Rivulet, Duck Creek, Horsley Inlet, Frazers Creek and Lake Illawarra), wetlands and their habitats, including how these are to be monitored;</p> <ul style="list-style-type: none"> <li>• identification of water supply, use and disposal;</li> <li>• an assessment of construction and operational water quality impacts, taking into account impacts from both accidents and runoff (i.e. acute and chronic impacts), having consideration to impacts to surface water runoff, soil erosion and sediment transport, mass movement, and spoil and waste management. The assessment of water quality impacts is to have reference to relevant public health and environmental water quality criteria, including those specified in the <i>Australian and New Zealand Guidelines for Fresh and Marine Water Quality</i> (ANZECC/ARMCANZ 2000), any applicable regional, local or site-specific guidelines, water quality objectives, and any licensing requirements;</li> <li>• assessment of waterways to be modified as a result of the proposal, including ecological, hydrological and geomorphic impacts (as relevant), including temporary crossings, and measures to rehabilitate the waterways to preconstruction conditions or better, including fish passage requirements consistent with <i>Policy and Guidelines for Fish Friendly Waterway Crossings</i> (DPI 2004);</li> <li>• identification of potential impacts and benefits of the proposal on existing flood regimes, consistent with the <i>Floodplain Development Manual</i> (Department of Natural Resources 2005), with an assessment of the potential changes to flooding behaviour (levels, velocities and direction) and impacts on bed and bank stability, through flood modelling, including: <ul style="list-style-type: none"> <li>o detailed description, justification and assessment of the flood management objectives, and other design objectives (including bridge, culvert and embankment design),</li> <li>o flood assessment and modelling undertaken in determining the design flood levels and velocities for events, including (as a minimum) the 10%, 2%, 1%, 0.5%, and 0.2% AEP design flood events and the probable maximum flood, or an equivalent extreme event. The assessment is to demonstrate how the assessment, including the use of the modelled events listed above, provides consideration of blockage, climate change and impacts of land use change on flood hydrology, noting below,</li> <li>o modelling of the effect of the proposal (including fill) on current and future flood behaviour for the range of design events identified above, with use of the 0.5% and 0.2% AEP design flood events as proxies for assessing sensitivity to an increase in rainfall intensity due to climate change and, where applicable, identified land use change,</li> <li>o an assessment of afflux and flood duration (inundation period) on land, infrastructure, property and business operations (including agricultural land and stock movement to flood refuges and evacuation routes), hazard, evacuation and emergency service provision within the affected area, and future development potential of upstream and access affected land, and</li> <li>o an assessment of emergency management, evacuation and access, and contingency measures for the development considering the full range of flood risk (based upon the probable maximum flood or an equivalent extreme flood event);</li> </ul> </li> <li>• groundwater impacts, taking into consideration impacts associated with geotechnical ground treatments, deep cuttings and fill locations, and cumulative impacts on regional hydrology. The assessment shall consider: the extent of drawdown, impacts to groundwater characteristics, quality, quantity, and connectivity, discharge and recharge rates, and implications for water courses, groundwater users, groundwater dependent ecosystems, riparian areas and wetlands;</li> </ul> |
|--|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|              |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|              | <ul style="list-style-type: none"> <li>identifying potential impacts of the development on acid sulfate soils in accordance with the relevant guidelines and a description of the mitigation measures proposed to minimise potential impacts; and</li> <li>a contaminated lands assessment in accordance with relevant guidelines.</li> </ul> <p><b>Noise and Vibration</b> – including, but not limited to:</p> <ul style="list-style-type: none"> <li>an assessment of the noise impacts of the proposal during operation, consistent with the <i>Road Noise Policy</i> (EPA 2011) and <i>NSW Industrial Noise Policy</i> (EPA 2000). The assessment must include specific consideration of impacts to receivers (dwellings, child care centres, educational establishments, hospitals, motels, nursing homes, or places of worship), including specific consideration of sleep disturbance and, as relevant, the characteristics of noise (eg. low frequency noise), and identify reasonable and feasible mitigation measures;</li> <li>an assessment of construction noise and vibration impacts, consistent with the <i>Interim Construction Noise Guideline</i> (DECCW 2009) and <i>Assessing Vibration: a technical guideline</i> (DEC 2006). The assessment must have regard to the nature of construction activities (including transport, tonal or impulsive noise-generating works and the removal of operational noise barriers, as relevant), the intensity and duration of noise and vibration impacts, the nature, sensitivity and impact to potentially affected receivers, the need to balance timely conclusion of noise and vibration-generating works with periods of receiver respite, and other factors that may influence the timing and duration of construction activities (such as traffic management), and mitigation and management measures;</li> <li>if blasting is required, addressing the relevant requirements of <i>Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration</i> (ANZEC 1990); and</li> <li>if relevant, an indication of potential for works outside standard working hours, including predicted levels and exceedences, justification for the activity and discussion of available mitigation and management measures.</li> </ul> |
| Other Issues | <p><b>Social and Economic</b> — including, but not limited to:</p> <ul style="list-style-type: none"> <li>impacts on directly affected properties and land uses, including impacts related to access and severance, land use, property acquisition and amenity related changes;</li> <li>social and economic impacts to the community and businesses in the vicinity of the proposal (including agricultural businesses), associated with traffic, access, property, public domain and amenity related changes;</li> <li>social impact assessment for the Croom Regional Sporting Complex, including details of existing uses, nature and duration of impacts to those uses, consideration of relocation options, staging and offsets for affected clubs, and consideration of alternative sites; and</li> <li>a draft Community Involvement Framework identifying relevant stakeholders, procedures for distributing information and receiving/responding to feedback and procedures for resolving community complaints. Key issues that should be addressed in the draft framework should include: <ul style="list-style-type: none"> <li>traffic management (including property access, pedestrian access),</li> <li>social impacts,</li> <li>landscaping/urban design matters,</li> <li>construction activities, including out of hours work, and</li> <li>noise and vibration mitigation and management.</li> </ul> </li> </ul> <p><b>Urban Design and Visual Amenity</b> – including, but not limited to:</p> <ul style="list-style-type: none"> <li>consideration of the urban design and visual amenity implications of the proposal, including supporting infrastructure, during construction and</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

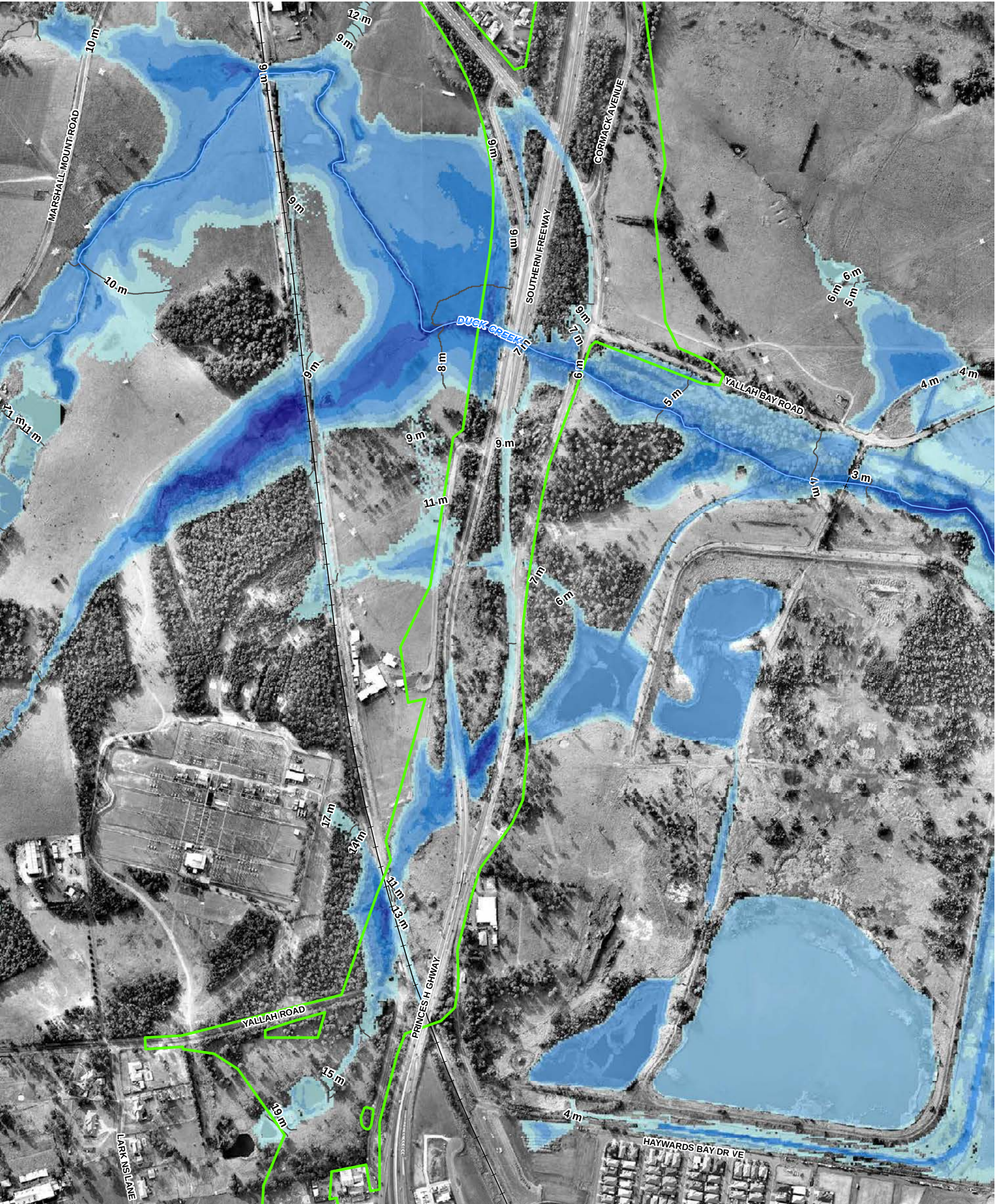
|  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|  | <p>operation. The assessment must identify:</p> <ul style="list-style-type: none"> <li>o urban design and landscaping objectives to enhance the design of the alignment and associated structures (including batters, cuttings, bridge and viaduct structures), interchanges, road infrastructure facilities, and Croom Regional Sporting Complex works,</li> <li>o consider uses for resulting surplus or residual land, and</li> <li>o demonstrate how the proposed hard and soft urban design elements of the proposal would be consistent with the existing and desired future character of the area;</li> </ul> <ul style="list-style-type: none"> <li>• identification and evaluation of the visual impacts and urban design aspects of the proposal (and its components) on surrounding areas;</li> <li>• a consideration of impacts on views and vistas, streetscapes, key sites and buildings;</li> <li>• measures to manage lighting impacts both during construction and operation; and</li> <li>• artists' impressions and perspective drawings of the proposal from a variety of locations along and adjacent to the route.</li> </ul> <p><b>Heritage</b> – including but not limited to:</p> <ul style="list-style-type: none"> <li>• impacts to <i>State and local historic heritage</i> (including conservation areas, built heritage, landscapes and archaeology) should be assessed. Where impacts to State or locally significant historic heritage are identified, the assessment shall: <ul style="list-style-type: none"> <li>o outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the mitigation measures) generally consistent with the guidelines in the <i>NSW Heritage Manual</i> (Heritage Office and DUAP 1996),</li> <li>o be undertaken by a suitably qualified heritage consultant(s) with relevant heritage expertise (note: where archaeological excavations are proposed the relevant consultant must meet the NSW Heritage Council's Excavation Director criteria),</li> <li>o include a statement of heritage impact for all heritage items/conservation areas to be impacted (including significance assessment). This should include detailed mapping of all heritage items and how they are affected by the proposal,</li> <li>o include details of any proposed mitigation measures (architectural and landscape),</li> <li>o consider impacts from, including but not limited to, vibration, demolition, archaeological disturbance, altered historical arrangements and access, landscape and vistas, and architectural noise treatment (as relevant),</li> <li>o where physical archaeological test excavations are proposed, develop an appropriate archaeological assessment methodology, including research design, in consultation with the Department and the Heritage Council of New South Wales, to guide the test excavations, and include the results of these excavations, and</li> <li>o provision of future mitigation strategies for all identified archaeological impacts that would arise from the proposal; and</li> </ul> </li> <li>• impacts to <i>Aboriginal heritage</i> (including cultural and archaeological significance), in particular impacts to Aboriginal objects and potential archaeological deposits (PAD), should be assessed. Where impacts are identified, the assessment shall: <ul style="list-style-type: none"> <li>o outline the proposed mitigation and management measures (including measures to avoid significant impacts and an evaluation of the effectiveness of the measures) generally consistent with the <i>Draft Guidelines for Aboriginal Cultural Heritage Impact Assessment and Community Consultation</i> (DEC 2005) and other relevant guidelines and requirements,</li> </ul> </li> </ul> |
|--|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                           | <ul style="list-style-type: none"> <li>o be undertaken by a suitably qualified heritage consultant(s),</li> <li>o demonstrate effective consultation with Aboriginal communities in determining and assessing impacts and developing and selecting options and mitigation measures (including the final proposed measures),</li> <li>o assess and document the archaeological and cultural significance of cultural heritage values of affected sites, and</li> <li>o undertake appropriate archaeological investigations generally in accordance with the <i>Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW</i> (DECCW 2010), to establish the full spatial extent and significance of any archaeological evidence across each site/area of PAD, and include the results of these excavations. If an alternative excavation method is proposed, it shall be developed in consultation with Office of Environment and Heritage.</li> </ul> <p><b>Environmental Risk Analysis</b> — notwithstanding the above key assessment requirement, the EIS must include an environmental risk analysis to identify potential environmental impacts associated with the proposal (construction and operation), proposed mitigation measures and potentially significant residual environmental impacts after the application of proposed mitigation measures. Where additional key environmental impacts are identified through this environmental risk analysis, an appropriately detailed impact assessment of this additional key environmental impact must be included in the EIS.</p> |
| <b>Consultation</b>                       | <p>During the preparation of the EIS, you must consult with the relevant local, State or Commonwealth Government authorities, service providers, community groups and affected landowners.</p> <p>In particular you must consult with:</p> <ul style="list-style-type: none"> <li>• local, State and Commonwealth government authorities, including the: <ul style="list-style-type: none"> <li>o Environment Protection Authority,</li> <li>o Office of Environment and Heritage (including Heritage Division),</li> <li>o Department of Primary Industries,</li> <li>o NSW Office of Water,</li> <li>o NSW Trains,</li> <li>o TransGrid,</li> <li>o Civil Aviation Safety Authority,</li> <li>o Airservices Australia,</li> <li>o Illawarra Regional Airport,</li> <li>o Shellharbour City Council,</li> <li>o Wollongong City Council, and</li> <li>o emergency services;</li> </ul> </li> <li>• specialist interest groups, including local sporting groups, Illawarra Local Aboriginal Land Council, Aboriginal stakeholders, and pedestrian and bicycle user groups;</li> <li>• utilities and service providers; and</li> <li>• the public, including community groups, businesses, and adjoining and affected landowners.</li> </ul> <p>The EIS must describe the consultation process and the issues raised, and identify where the design of the proposal has been amended in response to these issues. Where amendments have not been made to address an issue, a short explanation should be provided.</p>                                                                                           |
| <b>Further consultation after 2 years</b> | <p>If you do not lodge an EIS for the proposal within 2 years of the issue date of these SEARs, you must consult further with the Secretary in relation to the preparation of the EIS.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |

## APPENDIX B

---

### APPENDIX B: FLOOD MAPS



**LEGEND**

Site Boundary

Major Watercourses

Railway

1m Flood Contours

**Flood Depth (m)**

0 - 0.5

0.5 - 1

1 - 2

2 - 3

3 - 4

4 - 5

>5

DUCK CREEK 10 YEAR ARI FLOOD DEPTH – EXISTING CONDITIONS

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:7,000 @ A3

0 50 100 200

Metres

NSW GOVERNMENT

Transport Roads & Maritime Services

Hyder

Gardno

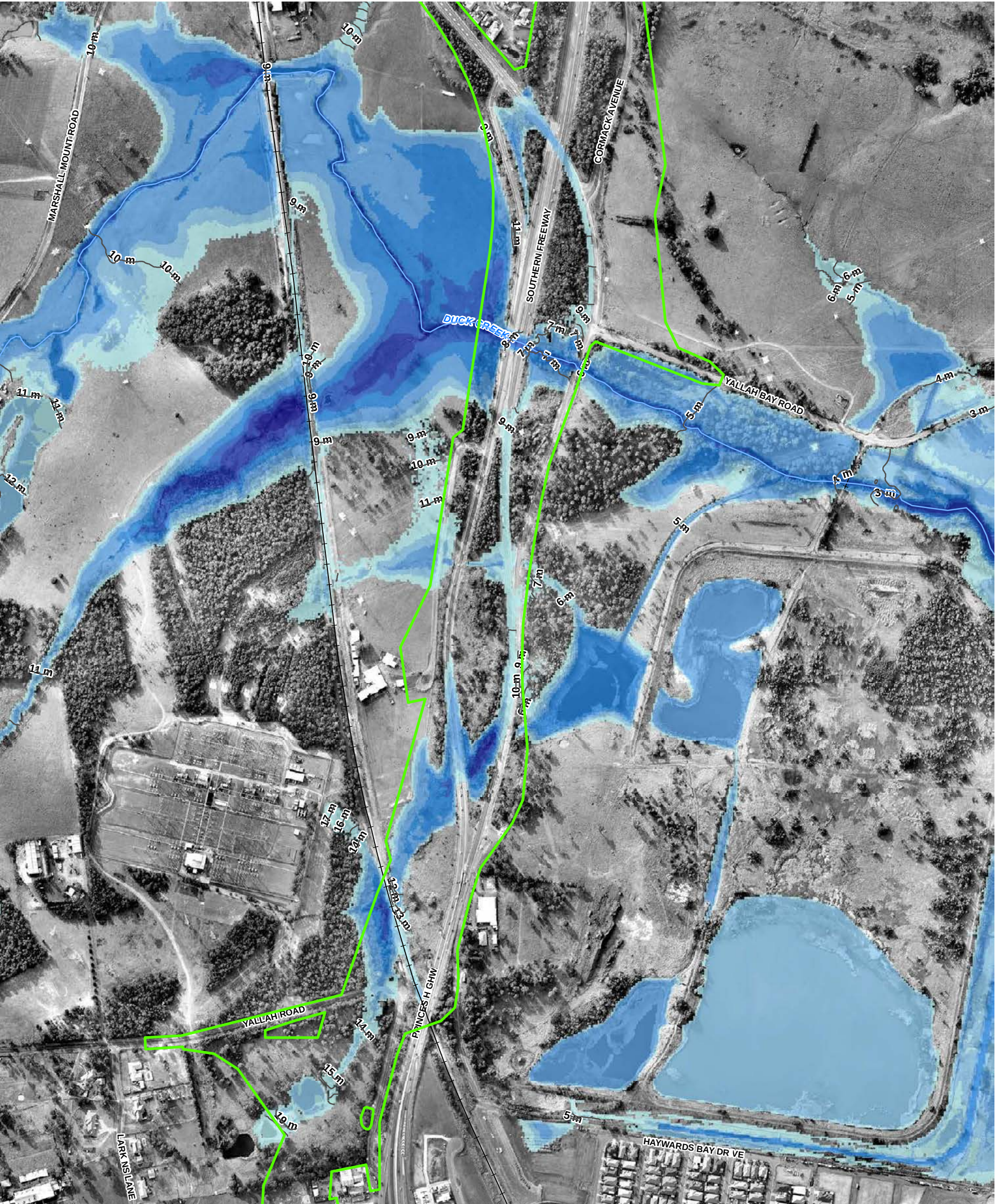
JOINT VENTURE

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

DATE: AUGUST 4, 2015

P:\48982014\00110438 to RMS re Albion Park Bypass\Corres\Build\Project\GIS\WA\_024\_APRB\_G\_02\_10y\_FloodDepth\_Existing.mxd



**LEGEND**

Site Boundary

Major Watercourses

Railway

1m Flood Contours

**Flood Depth (m)**

0 - 0.5

|  |         |
|--|---------|
|  | 0.5 - 1 |
|  | 1 - 2   |
|  | 2 - 3   |
|  | 3 - 4   |
|  | 4 - 5   |
|  | >5      |

DUCK CREEK 20 YEAR ARI FLOOD DEPTH – EXISTING CONDITIONS

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:7,000 @ A3

0 50 100 200  
Metres

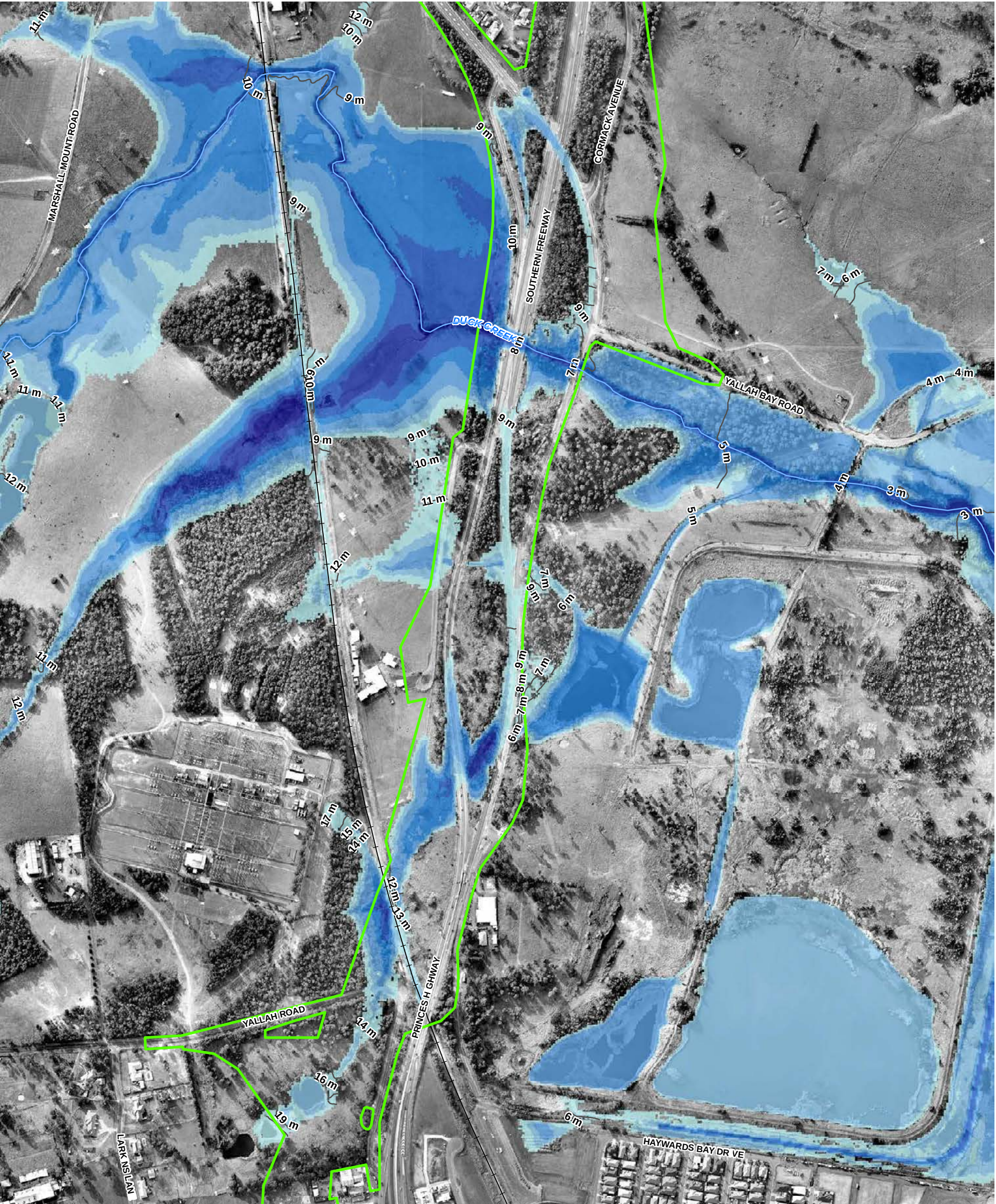
Transport  
Roads & Maritime  
Services

JOINT VENTURE

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

DATE: AUGUST 4, 2015



**LEGEND**

Site Boundary

Major Watercourses

Railway

1m Flood Contours

**Flood Depth (m)**

0 - 0.5

0.5 - 1

1 - 2

2 - 3

3 - 4

4 - 5

>5

DUCK CREEK 50 YEAR ARI FLOOD DEPTH – EXISTING CONDITIONS

ALBION PARK RAIL BYPASS  
NSW ROADS AND MARITIME SERVICES

1:7,000 @ A3

0 50 100 200

Metres

NSW GOVERNMENT

Transport Roads & Maritime Services

Hyder

Gardno

JOINT VENTURE

COORDINATE SYSTEM:  
GDA 1994 MGA ZONE 56

REVISION NUMBER: 02  
AUTHOR: RNB

DATE: AUGUST 4, 2015