Corindi River Flood Assessments

DRAFT REPORT

4 December 2013

PART 3

SINCLAIR KNIGHT MERZ

SKM

7. Design flood events

Design hydrology has been simulated for a range of average recurrence interval (ARI) events. This section details the development of these events and the outputs from the RORB model.

A number of test runs in the model identified that the critical storm duration is the 9 hour storm. The critical storm duration is the duration of a storm event that creates the largest flood peak for a certain probability of occurrence.

7.1 Design rainfall

7.1.1 Rainfall intensities

Design rainfall for the storm return periods of 10, 20, 50 and 100 year ARI were derived for the Corindi River catchment as inputs into the RORB model. Design storm rainfall depths were derived using the methods specified in Australian Rainfall and Runoff (IEAust, 1998) and the revised AR&R Intensity-Frequency-Duration (BoM, 2013). The recently released 2013 IFD curve produces higher rainfall depths for ARI's between the 10 and 100 year ARI's. For the 100 year ARI event, the difference is approximately 18%. **Figure 7.1** shows a comparison of the 1987 and the 2013 rainfall depths for Corindi for a 9 hour storm.

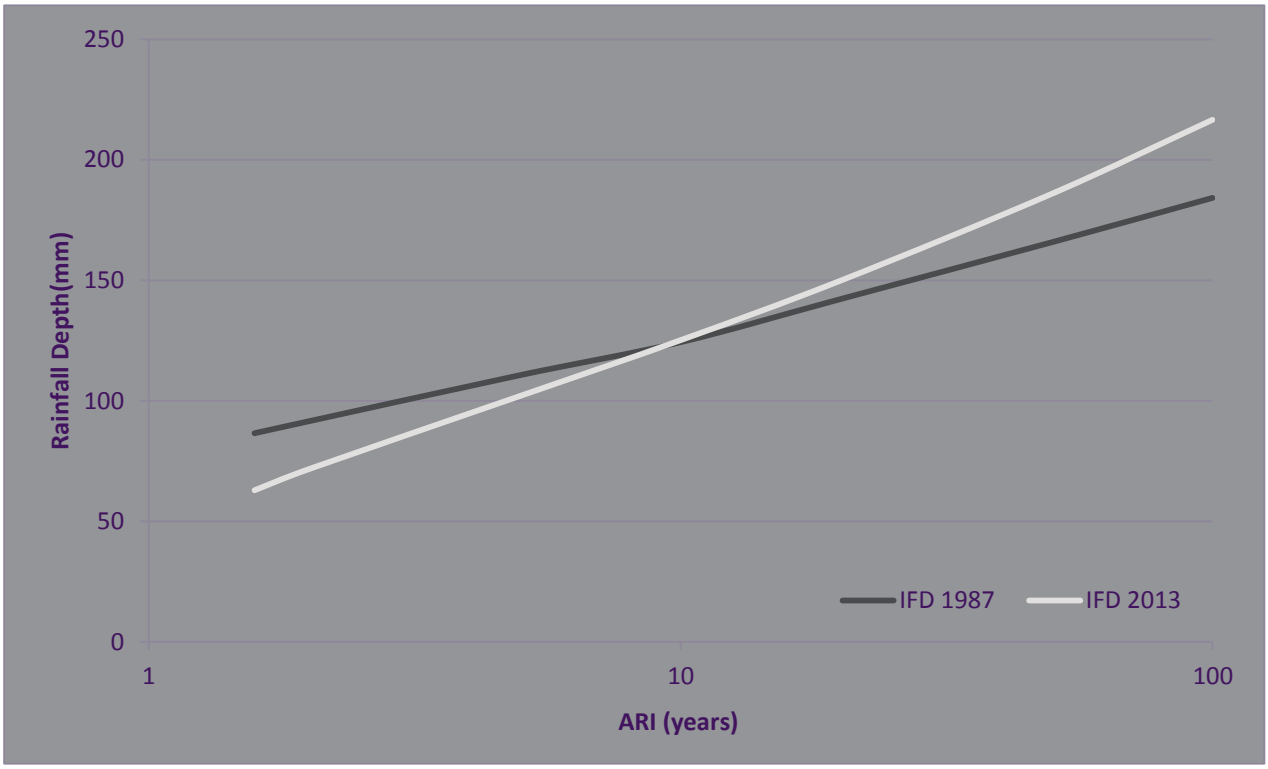


Figure 7.1 : Comparison of 1987 and 2013 point rainfall for Corindi for a 9 hour storm

In comparison with the 1987 IFD estimates, the 2013 IFD estimates have been based on:

- A more extensive dataset, with nearly 30 years of additional rainfall data and data from 2300 extra rainfall stations;
- More accurate estimates, combining contemporary statistical analyses and techniques with an expanded rainfall database;

The 2013 IFD estimates have, therefore, been used as input to the RORB design hydrological model.

7.1.2 Areal reduction factors

The 2013 design rainfall information is made available in the form of point rainfall depths. The flood estimates required for this study refers to the overall Corindi River catchment, which is approximately 103 km^2. Therefore, a factor was applied allowing for the fact that larger catchments are less likely than smaller catchments to experience high intensity storms simultaneously over the whole of the catchment area. This factor is called the areal reduction factor (ARF). **Table 7.1** shows the ARF's used for the Corindi River catchment and the resulting rainfall depths used for the range of 100 year ARI flood events.

Table 7.1 : Areal reduction factors used for the Corindi River catchment design rainfall

Duration (hrs)	Areal reduction factors	Resulting 100 year ARI rainfall depths (mm)
1.0	0.79	87
2.0	0.82	118
3.0	0.84	141
4.5	0.86	168
6.0	0.87	188
9.0	0.89	225
12.0	0.90	253

It should be noted that the values above in **Table 7.1** are catchment-wide average rainfalls whereas the values shown in **Figure 7.1** are for a particular point in the catchment (Corindi). Hence, a direct comparison cannot be made between these two sets of data.

7.1.3 Design temporal patterns

Design rainfall patterns for Zone 1 of Australian Rainfall and Runoff Volume 2 (IEAust, 1998) were adopted for the development of design discharge hydrographs.

7.1.4 Initial losses/continuing losses

Initial rainfall losses for the design storm events were set at 20 mm. Continuing losses were set to 2 mm/hr. These values are typical for coastal NSW catchments.

7.2 Design flow results

The design flow hydrographs produced by the calibrated RORB model are shown in **Figure 7.2**. Also shown on the plot is the January 2012 flow. The flood frequency curve is shown in **Figure 7.4**.

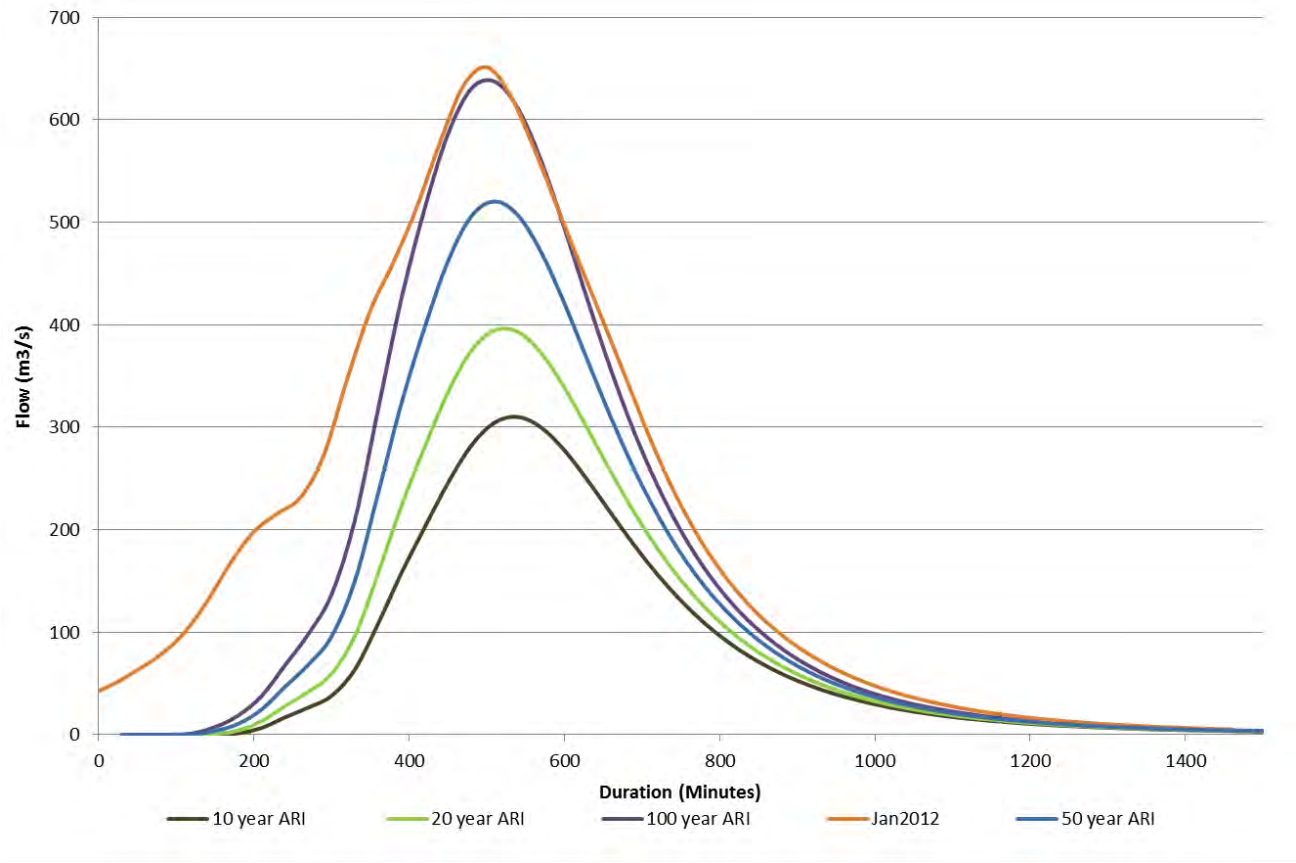


Figure 7.2 : Design flood hydrographs from RORB for Corindi River catchment (upstream of hydraulic model)

7.3 Rarity of the 2012 and 2013 flood events

7.3.1 Rainfall

The design rainfall data for Corindi was compared against a number of sub-daily gauges surrounding the catchment, as well as catchment rainfall, for a sample of sub-catchments, extracted from the RADAR data and scaled, as described in Section 6.2.2.

The closest gauge to the catchment is Barkhut (see **Figure 6.3**), which is located in close proximity to the Pacific Highway. The recorded rainfall at Barkhut for the January 2012 event was close to the 100 year ARI for 6 hour duration and higher than the 100 year ARI events for durations of 1 hour to 5 hours (see **Figure 7.3**).

In terms of the catchment rainfall, the rainfall applied to the four sample sub-catchments displays a consistent pattern. The maximum rainfall depths for durations between 4 hours and 9 hours for the January 2012 event are at or above the 100 year ARI event rainfall depths (**Figure 7.3**).

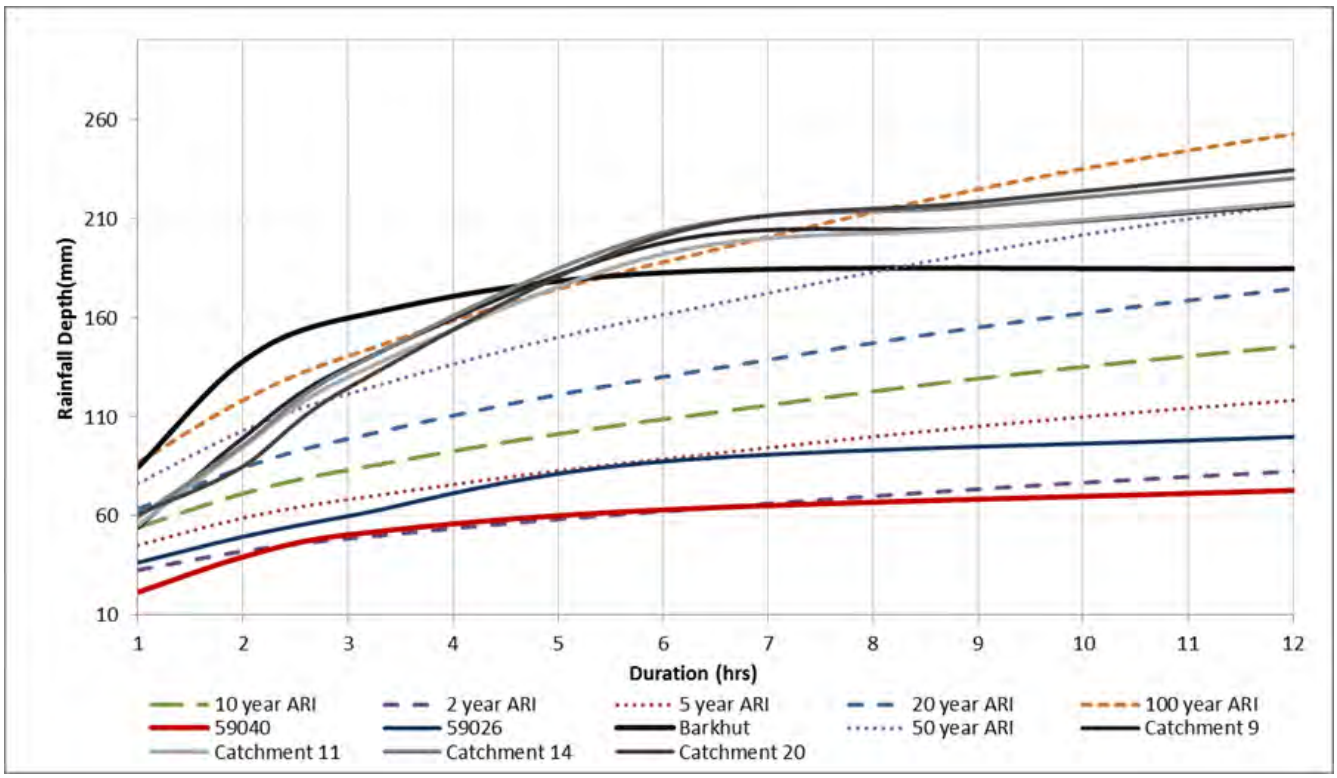


Figure 7.3 : IFD versus January 2012 recorded rainfall data

7.3.2 Flows

Following the design runs, comparisons were made between the design peak flows and the peak flows from the calibration runs for the two historic events (see **Figure 7.2** and **Figure 7.4**). The design and event flows adopted are listed in **Table 7.2**.

Table 7.2 : Design and event flow magnitude

ARI (years)	Design peak flow (m^3/s)
10	310
20	390
50	520
100	640
January 2012	650
February 2013	490

The inflow to the hydraulic model for the January 2012 flood and the 9 hour duration 100 year ARI flood are presented in the same graph in **Figure 7.2**. The two flows have a very similar shape and magnitude. The flow pattern for the January 2012 flood event would suggest that the event could have included a small (probably 5 year ARI flood event) which preceded a 100 year ARI flood event by about 3 hours.

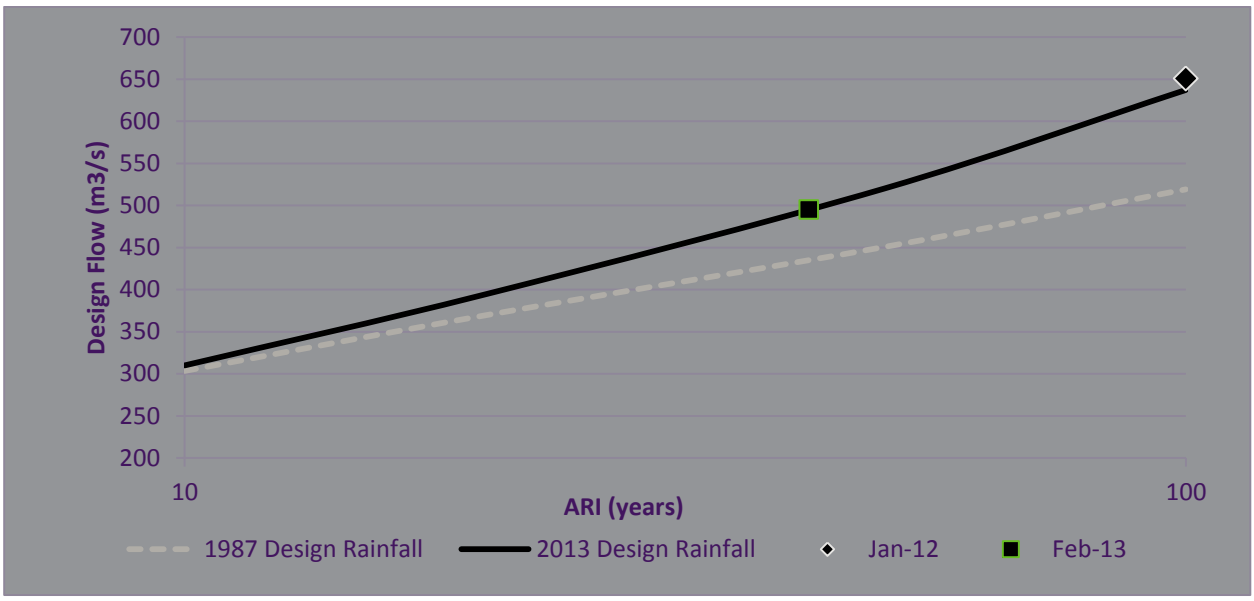


Figure 7.4 : Design flood frequency curve produced from the RORB model (including event peak flows)

This exercise resulted in identifying the rarity of the January 2012 event as about a 100 year ARI event and the February 2013 as about a 40 year ARI event.

The estimate of the rarity of the modelled flow of the January 2012 event is very consistent with the rarity of the rainfall described in the previous section, which identified that the rainfall recorded for that event was approximately equal to the 100 year ARI rainfall.

7.3.3 Possibility of two large flood in consecutive years

This study has established that the rarity for the January 2012 flood event has approximately a 100 year ARI and the February 2013 event has approximately a 40 year ARI. The obvious question is how plausible is it that two large (and therefore somewhat rare) flood events can occur in consecutive years.

In any consideration of flood magnitudes, it needs to be recognised that the occurrence of floods in any given year is somewhat random. Just because a flood with a chance of 1 in 100 (i.e. 1%) of occurring in any year actually occurs does not mean that there will not be any large floods for many years to come. The chance of the same flood occurring in the next year is also 1 in 100 (i.e. 1%).

Historically, in the region of northern New South Wales and south-east Queensland, it is common occurrence that rare floods have occurred within relatively short historic periods (one decade or less).

The Clarence River which is located to the north of the Corindi River has a flood record in excess of 170 years long. A search into occurrences of rare flood events within two or more consecutive years has identified that between the periods 1887-1892, 1946-1954 and 1974-1976 there have been incidents where consecutive events of greater than 10 year ARI have occurred. **Table 7.3** shows that the period of 1887 to 1893 was a period in which large floods occurred in consecutive or near consecutive years. In fact, two floods close to the 100 year ARI flood magnitude occurred within a four year period and three floods close to the 100 year ARI flood magnitude occurred in a seven year period.

Table 7.3 : Occurrence of consecutive years of flooding in the Clarence River

Year	Approximate ARI of event (years)
1887	100
1889	15
1890	100
1892	10
1893	100
1946	10
1948	15
1950	50
1954	50
1974	10
1976	10

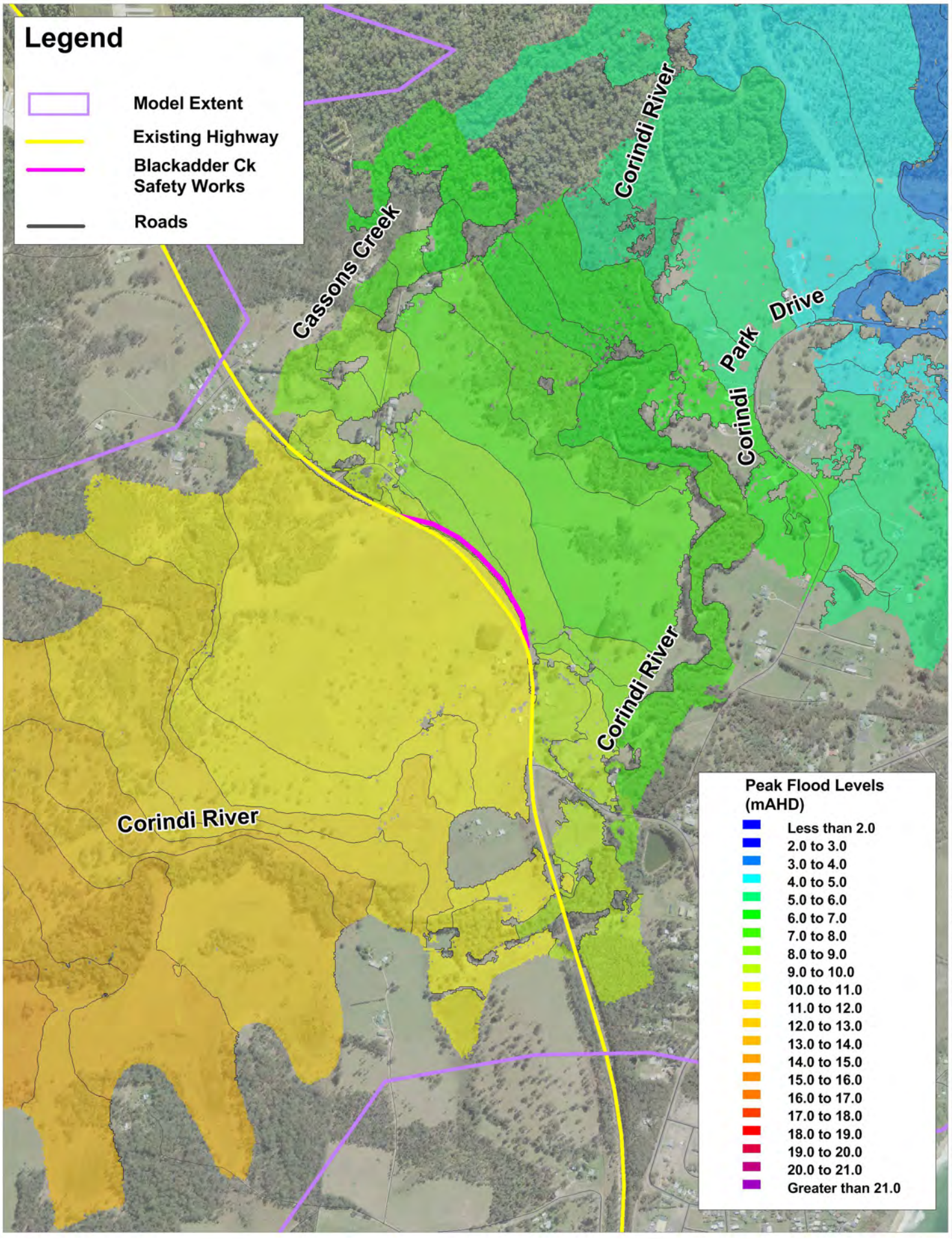
The Brisbane River which also has an extended flood record of approximately 150 years of data experienced three big floods in the period between 1893 and 1898. According to the flow record of the Brisbane River at Mt Crosby, in 1893, a flood with an approximate 150 year ARI happened, followed by a 10 year ARI event in 1896, followed by a 30 year ARI event in 1898. In addition, Brisbane River has experienced two big floods recently. A flood with a magnitude between 50 year ARI to 150 year ARI in 2011 and a flood with a 15 year ARI in 2013. The two later ARI values are still the subject of research and therefore these estimates are preliminary, but without any doubt, both the 2011 and the 2013 floods were rare events.

Furthermore, it needs to be recognised that the 2011 to 2013 period resulted in large flood events (i.e. greater than 20 year ARI) in many parts of northern NSW and south-east Queensland including the Brisbane River, Laidley Creek, Lockyer Creek, Clarence River, Burnett River and the Condamine River. Some of these rivers experienced two large floods in this period (Laidley Creek, Brisbane River, Burnett River).

The above analysis lends support to the assertion that it is not uncommon to experience two or more rare floods within small periods of time in this region of Australia. Rainfall shows substantial decade-to-decade variations, which cannot be attributed to a single cause. Variability of rainfall in the region is due to a number of factors, including the magnitude and position of the El Nino Southern Oscillation (ENSO), which affects rainfall in Queensland and northern NSW, especially during the summer months, from decade to decade. The Inter-decadal Pacific Oscillation (IPO) can also influence rainfall variations over one or more decades. Small scale climatic drivers may also influence the rainfall variability.

7.4 Design flood behaviour

Design flood behaviour in the context of this report is the flood behaviour as simulated by the calibrated flood models (hydrologic and hydraulic) with 100 year ARI design rainfall intensities. **Figure 7.5** to **Figure 7.7** show the flood behaviour for the 100 year ARI 9 hour flood event with the existing terrain (i.e. including BCSW).



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Datum: GDA 94
Projection: MGA Zone 56

Figure 7-5

Existing Case (Post BCSW) Flood Levels 100 year ARI Event

Corindi River Flood Assessments

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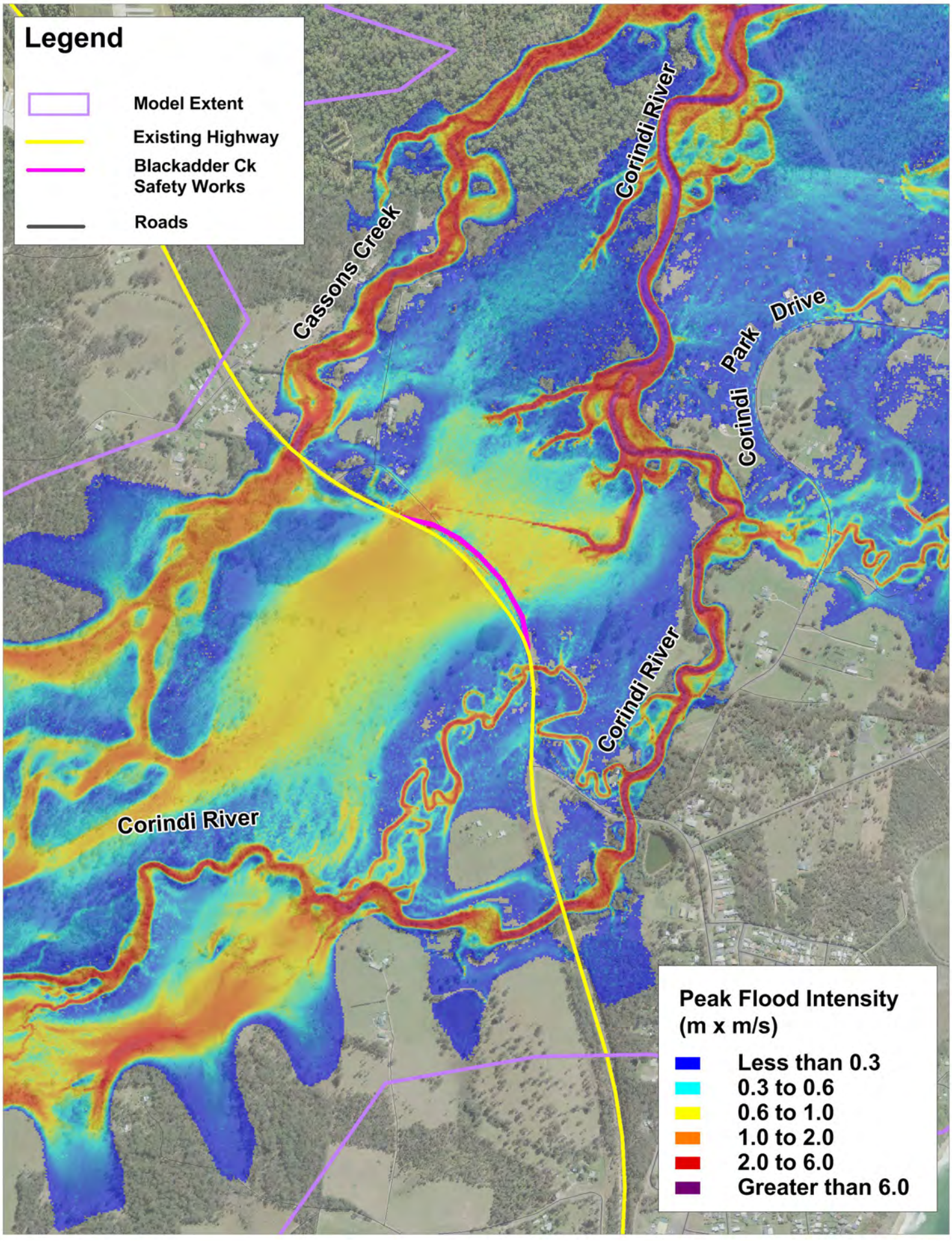

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Figure 7-6

Existing Case (Post BCSW) Vx D 100 year ARI Event

Corindi River Flood Assessments

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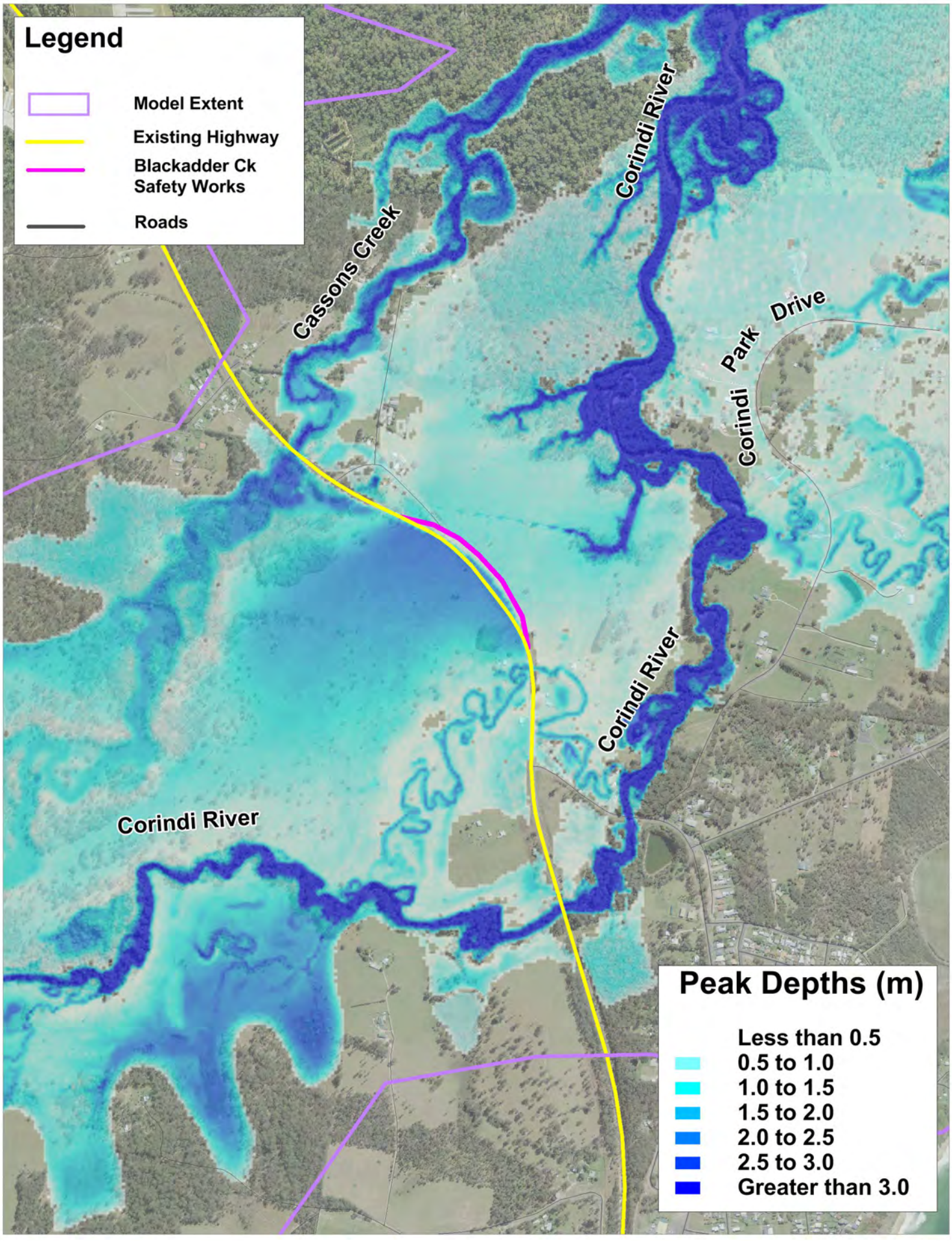

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Figure 7-7

Existing Case (Post BCSW) Flood Depth 100 year ARI Event

Corindi River Flood Assessments

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8. Assessment of Blackadder Creek safety works

8.1 Scenarios assessed for BCSW

The calibrated flood models (hydrologic and hydraulic) were used to assess the impacts of Blackadder Creek Safety Works (BCSW) constructed in 2011. The model was changed so that the highway was represented in its pre-BCSW state. This is about 1m lower than its current level. As well, the culverts constructed with the BCSW were also removed from the flood model. Everything else in the flood model was unchanged (terrain, inflows etc).

The flood model was simulated for this pre-BCSW case (i.e. the base case) for the January 2012 flood and the 100 year ARI flood event. The results of these simulations were then compared with the flood model results for the post-BCSW case (i.e. the existing case).

8.2 Results of flood assessments of BCSW

Peak flood levels for the January 2012 flood event and the 100 year ARI flood event and without Blackadder Creek Safety Works constructed are presented in **Figure 8.1** and **Figure 8.3** respectively. Due to the similar size of these flood events, the peak flood levels are also similar.

Peak flood levels for the study area were compared for the two scenarios (pre BCSW and post BCSW). **Figure 8.2** and **Figure 8.4** show the changes in flood levels due to the construction of the Blackadder Creek Safety Works for the January 2012 flood event and the 100 year ARI flood event respectively.

The distribution of flows on the floodplain for the January 2012 flood event with Blackadder Creek Safety Works constructed is presented in **Figure 8.5** (this is a reproduction of **Figure 5.1**). These can be compared with those in **Figure 8.6** for the case without BCSW.

A summary of the impacts of constructing the Blackadder Creek Safety Works is presented below:

- Flood behaviour 1 km upstream of the Pacific Highway was unchanged by the construction of the Blackadder Creek Safety Works. That is, there was no change to the flood levels, flood velocities and flood flow distributions on the floodplain and in the river channel at this location on the floodplain. The majority of the flow from the catchment had already broken out of the river at this location with over 550 m^3/s (about 85% of the total catchment flow) flowing on the floodplain (in both scenarios).
- Peak flood levels upstream of BCSW increased by up to 1.0m due to the construction of BCSW. Flood levels at one house near Blackadder Creek on the upstream side of the highway experienced an increase in flood level of 0.4m but this increase did not result in inundation of the floor level of this house. No additional houses were inundated as a result of the BCSW.
- This increase in flood levels upstream is primarily due to the small culvert area constructed (about $20m^2$ of culverts) and the large flow rate passing over this raised section of highway (approximately 350 m^3/s). The culverts only convey about 75 m^3/s (albeit at very high velocities). The remaining 275 m^3/s passed over the highway in the January 2012 flood event. Hence, the raised section of highway at BCSW acted as a long weir. Weirs are very efficient at conveying flow. As a guide, for every 100m length of road with weir flow, the flow over the road with a 1m depth of flow over the road is about $170m^3/s$.
- Peak flood levels in the Blackadder Road and Cox Lane area increased by between 0.1m and 0.2m. Most of the Cassons Creek reach downstream of the Pacific Highway experienced increases in flood levels between 0.15m and 0.25m. This is mainly due to the Blackadder Creek Safety Works increasing flood levels upstream of the highway and diverting more flow towards Cassons Creek. Peak flows in Cassons Creek increased 60% from 117 m^3/s to 174 m^3/s. This is a very large increase in flow rate. **Figure 8.7** shows the time series of water levels in this Cassons Creek / Cox Lane area for both cases (pre and post BCSW) for the January 2012 flood event. It is clear from this time series that the BCSW increases the time of flood inundation for this area as well as the speed of floodwater rise. There are a number of houses in the Blackadder Road and Cox Lane which experienced flood inundation around the houses as a result of

the BCSW. Without the BCSW, the model indicates that there would not have been any flood inundation around these houses. The model results also indicate that a shed at a property on Blackadder Road experienced over-floor inundation as a result of the BCSW in the January 2012 flood event. On Cox Lane, model results also indicate that a shed and a verandah experienced over-floor inundation as a result of the BCSW in the January 2012 flood event.

- Peak flood levels in the Corindi Park Drive area were largely unaffected by the Blackadder Creek Safety Works. The main reason for this is that the Corindi Park Drive area is located immediately downstream of the works. Hence, the works diverted some flow (about 65m^3/s) away from the flowpath over the highway at BCSW and towards Casson Creek. Peak flows on the floodplain downstream of BCSW reduced by 15% from 425 m^3/s to 365 m^3/s. This resulted in decreases in the Corindi River flood levels of about 0.1m. These flood levels dictate how much flow overtops the river banks and flows through the Corindi Park Drive area. The small decrease in flood levels in the river at this location resulted in a small decrease in flows through the Corindi Park Drive area of about 15% (140 m^3/s to 120 m^3/s). This resulted in a small decrease in flood levels in this area of about 0.05m. **Figure 8.8** shows the time series of water levels in this area for both cases (pre and post BCSW) for the January 2012 flood event at the south-western part of Corindi Park Drive. **Figure 8.9** shows the same data for the north-eastern part of Corindi Park Drive.
- The following is a discussion on flood volumes. It is presented here to provide context for the volume of 'storage' created by the BCSW in comparison to the volume of the flood event. Flood volumes are expressed here in m^3 and megalitres or ML which are millions of litres or 1,000 m^3. Flood volumes are not to be confused with flow rates which can be considered as the volume passing a point over time (e.g. 1,000 m^3/s is 1,000 cubic metres of water or 1ML passing a location every second):
  - The additional flood volume stored upstream of the BCSW was calculated to be just over 300,000 m^3 (i.e. 300 ML).
  - This volume needs to be considered in relation to the 19,400,000 m^3 (19,400 ML) flowing out of the catchment in the January 2012 flood event and the 7,500,000 m^3 (7,500 ML) flowing over and through the BCSW section of highway.
  - Hence, the additional stored volume upstream of the BCSW constitutes about 4% of the total volume passing through this section of highway and about 1.5% of the total catchment flood volume.

8.3 Consideration of community views on BCSW impacts

It is apparent from previous community consultation that the community believes that the BCSW significantly changed the flood behaviour of the floodplain. Some of these views appear to be supported by the flood assessments in this study.

The residents of Cox Lane and Blackadder Road indicated that the observed flood behaviour in the January 2012 flood event was very different to that observed in previous flood events. This is due to the rarity of the flood event (probably larger than any other flood in living memory) and because the BCSW caused an increase in flow and flood levels in this area.

Similarly, the residents upstream of the BCSW would have experienced worse flooding as a result of the BCSW. Flood levels were increased by up to 1.0m and this is a significant increase in flood levels. As noted above, one house in particular experienced an increase of 0.4m in flood depth around the house.

The views of many of the residents of Corindi Park Drive are that the BCSW resulted in a significant change to the flood behaviour of that area. It is believed that the culverts under the BCSW resulted in high velocity flow and that these high velocity flows caused flow to pass across the Corindi River and into the Corindi Park Drive area. There are three observations from this study that do not support this assertion.

Firstly, **Figure 8.10** shows the directions of the culverts under BCSW (purple lines) and the modelled directions of flow downstream of the BCSW (purple arrows). Also shown are the directions of flow from Corindi River that then broke out of the river and through the Corindi Park Drive area (red arrows). It is apparent from this figure

that the culverts under BCSW are pointed towards a reach of the Corindi River ***downstream*** of the location where flows broke out and flowed through Corindi Park Drive.

Secondly, the velocities of flow exiting the culverts in the January 2012 flood event were high (in the order of 5m/s to 6m/s). As well, the flow through the BCSW culverts was only about 20% of the total flows (i.e. culvert flow of 70m^3/s out of a total flow under/over the highway of 350 m^3/s as there was 280 m^3/s passing over the highway). However, it is highly unlikely that these high velocities for 20% of the flow resulted in sufficient momentum to change the velocities on the floodplain for more than 100m downstream of the culverts.

It is likely that there was significant turbulence and mixing of fast culvert flow (20% of flow at 5.5m/s) and slower flow from over the highway (80% of flow at about 1.2m/s) in this area 100m downstream of the BCSW. This turbulence and mixing of flow would have resulted in scour and erosion of the ground. However, the influence of this high velocity culvert flow would have been limited to this zone and would not have resulted in more flow breaking out of the Corindi River at Corindi Park Drive than without the BCSW. The distance from the BCSW culverts to the Corindi River is 600m to 700m. It is not plausible that high velocity flows from the BCSW culverts (20% of the flow) flowed in isolation from the other floodplain flows (80% of the flow) for 600m to 700m without mixing.

Thirdly, there is high ground between there area of flow from the BCSW and the section of Corindi River where flows broke out in the Corindi Park Drive area (see **Figure 8.10**). Based on the terrain data, this land is between 7.8mAHD and 8.0mAHD. Peak flood levels further upstream from this area were recorded to be 7.86mAHD. Given the flood gradient over the 400m from that recorded flood point (about 0.2m), it is unlikely that significant flow rates passed over this high ground and into the river at this location.

The most plausible explanation of the break-out flow at Corindi Park Drive is that the flows in the river were too large for the capacity of the river and excess flows exited into the Corindi Park Drive area. As discussed in Chapter 5, the flow in the river at this location increases dramatically from about 150m^3/s to 500m^3/s due to the entry of 350m^3/s flow from the highway area. It is important to note that this flow is not generated by the highway (or BCSW) but rather due to the flow passing over/under it. The flow passing over/under the BCSW section of highway is the same flow that breaks out of the river further upstream (independent of the BCSW).

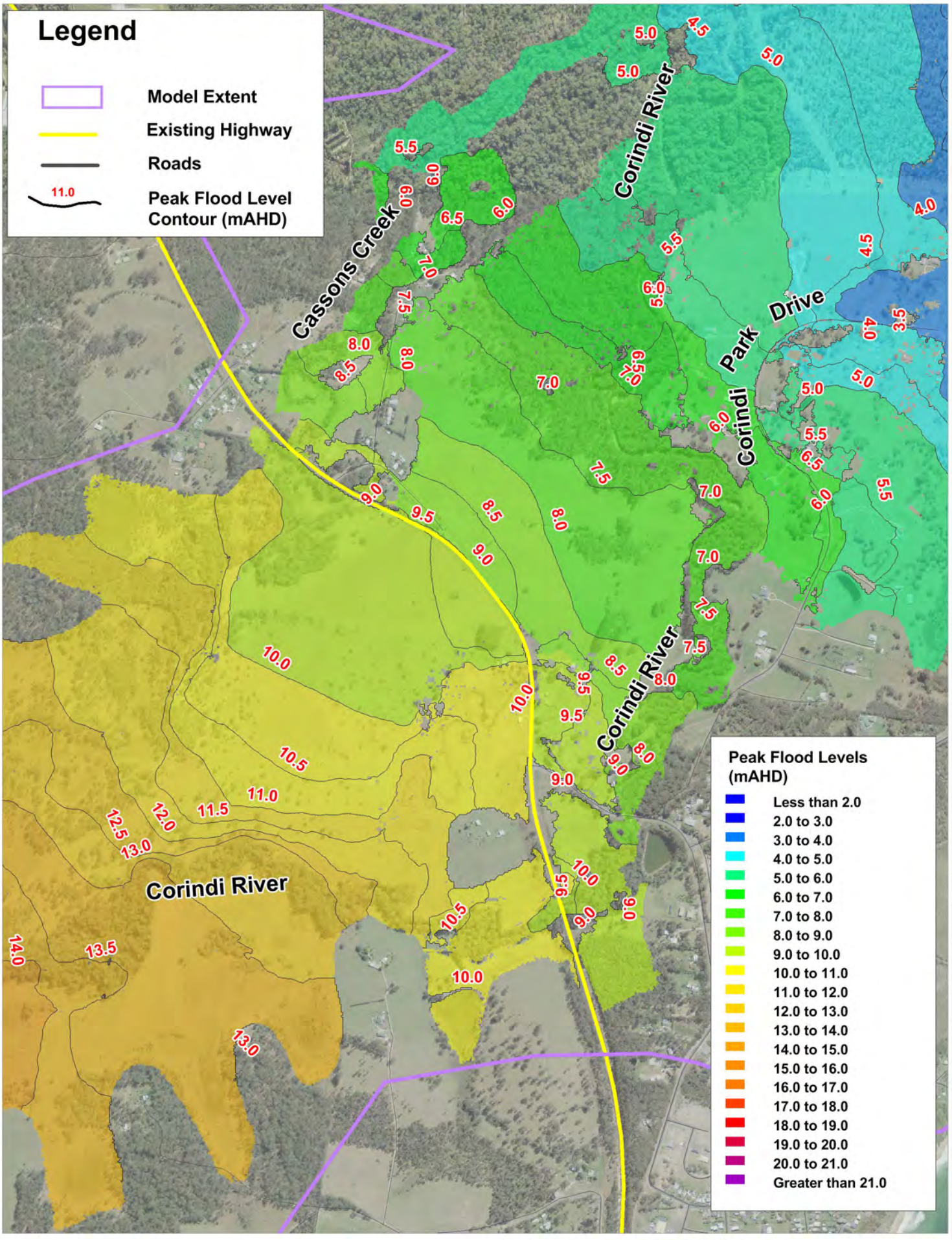

Figure 8-1 Peak Flood Levels Base Case (without BCSW) for January 2012 Flows

Corindi River Flood Assessments

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Datum: GDA 94
Projection: MGA Zone 56

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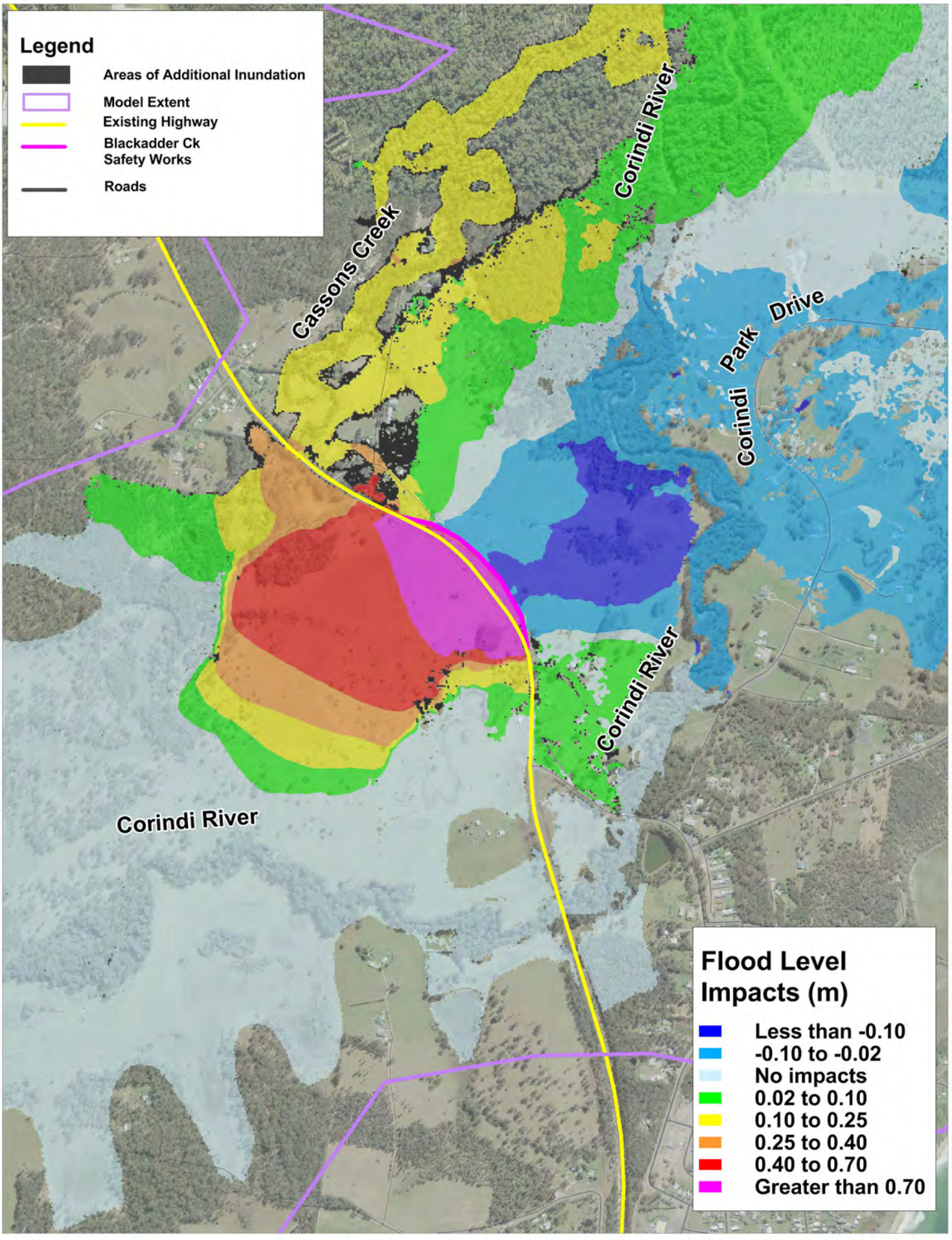

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Figure 8-2

Change in Flood Levels due to BCSW only (base case is without BCSW) for January 2012 Flows

Corindi River Flood Assessments

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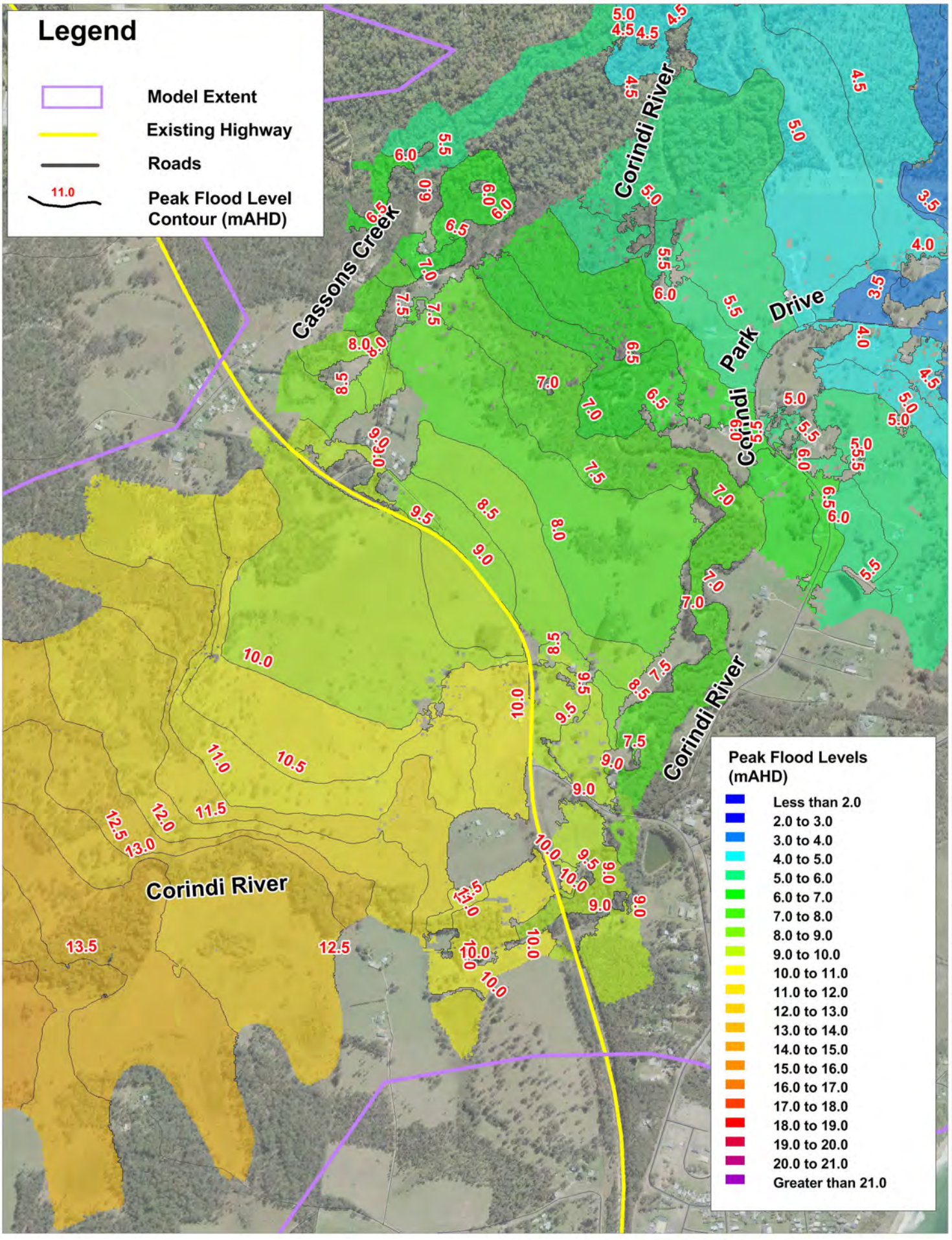

Figure 8-3 **Peak Flood Levels Base Case (without BCSW) for 100 year ARI Flows**

Corindi River Flood Assessments

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Projection: MGA Zone 56

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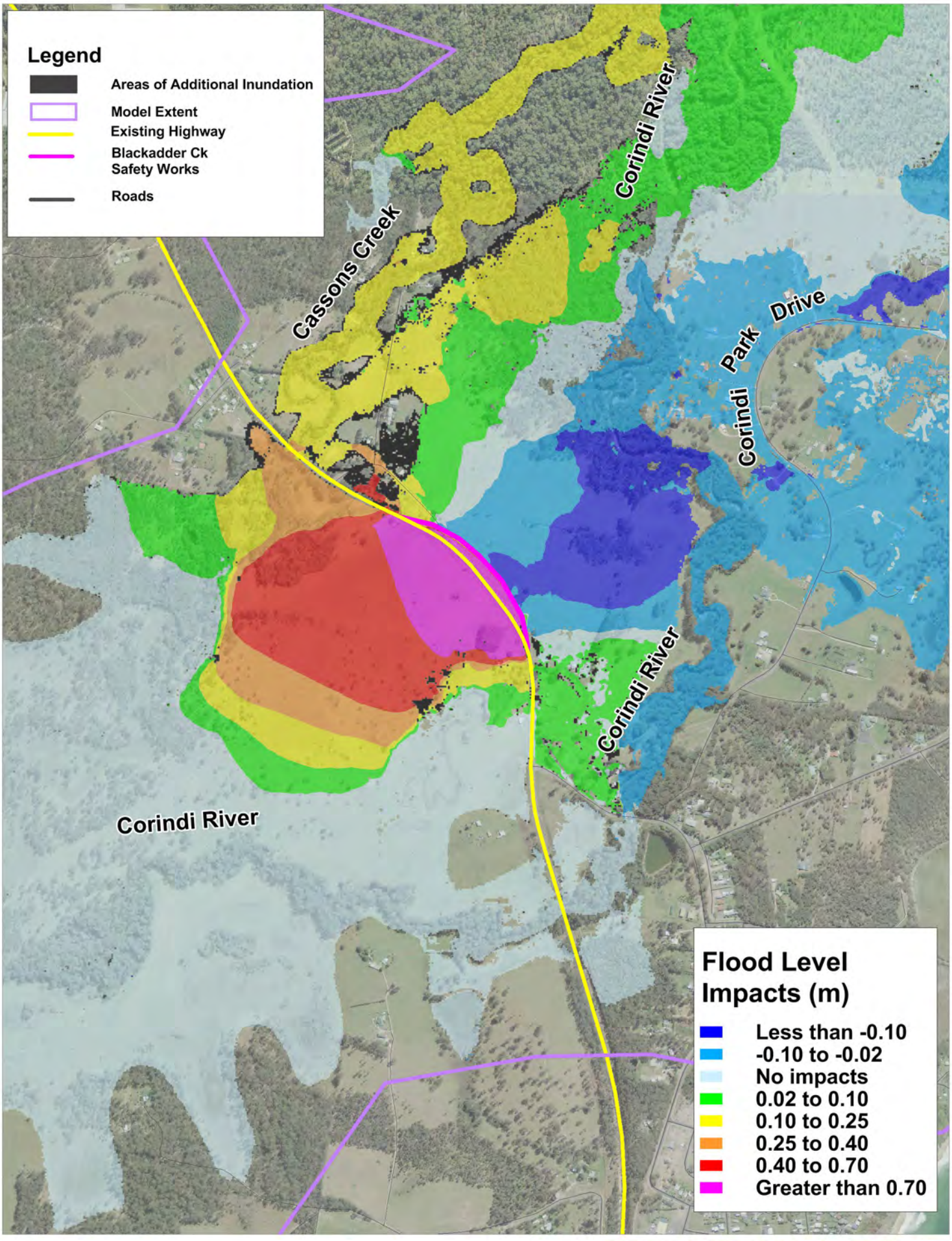

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Figure 8-4

Change in Flood Levels due to BCSW only (base case is without BCSW) for 100 year ARI Flows

Corindi River Flood Assessments

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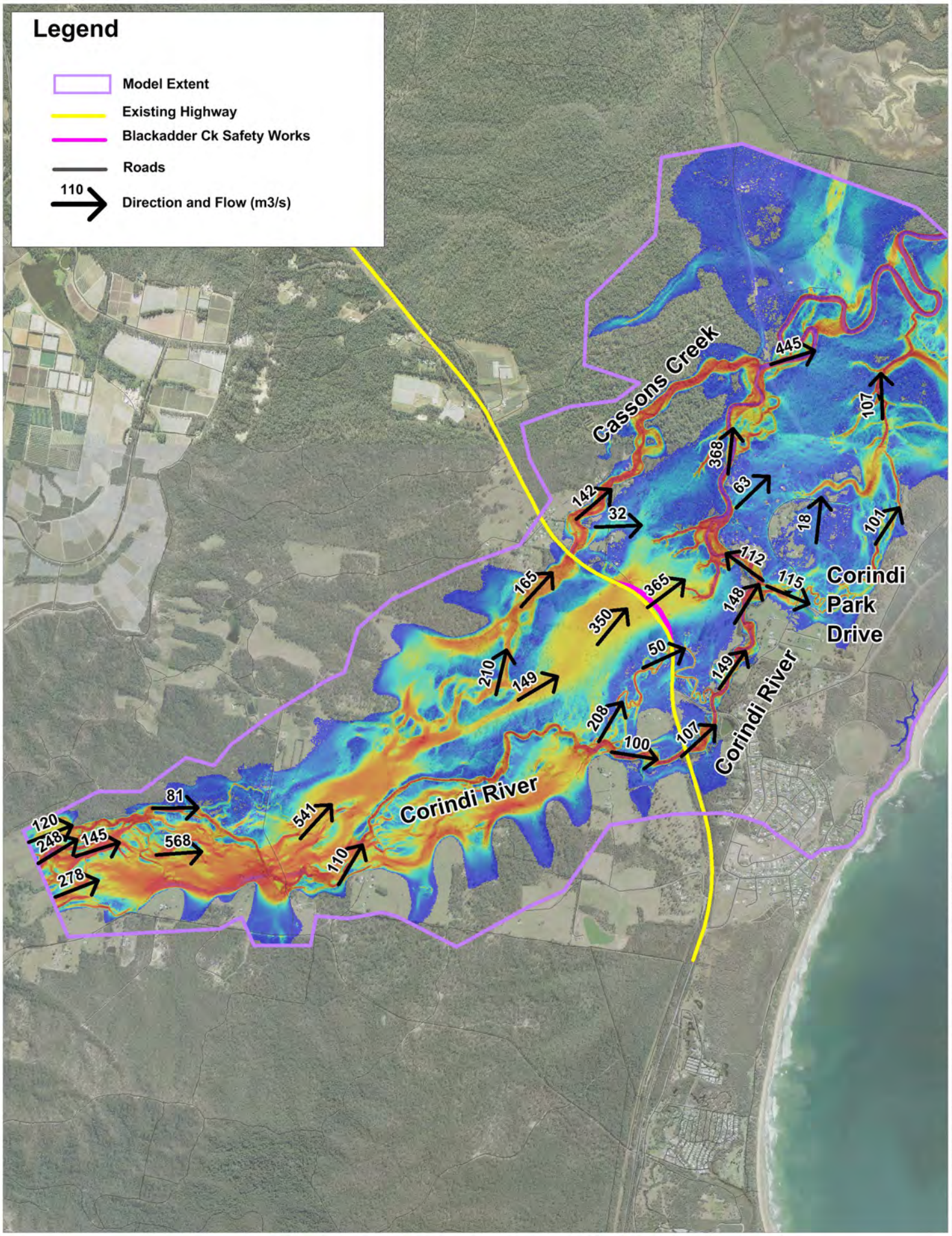

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Projection: MGA Zone 56

Figure 8-5

Flow Distribution for Existing Case (with BCSW) for January 2012 Flows

Corindi River Flood Assessments

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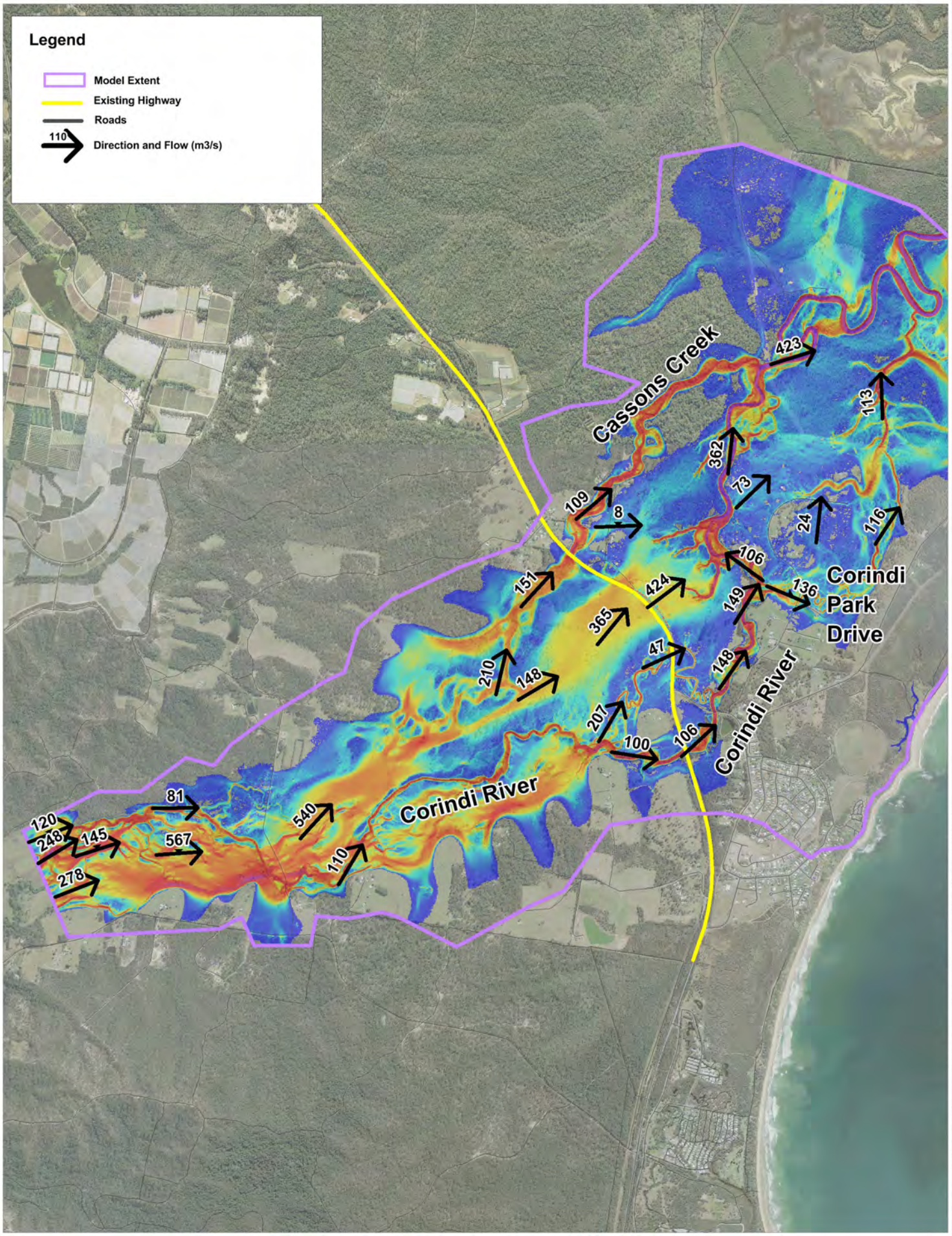

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Figure 8-6

Flow Distribution for Base Case (without BCSW) for January 2012 Flows

Corindi River Flood Assessments

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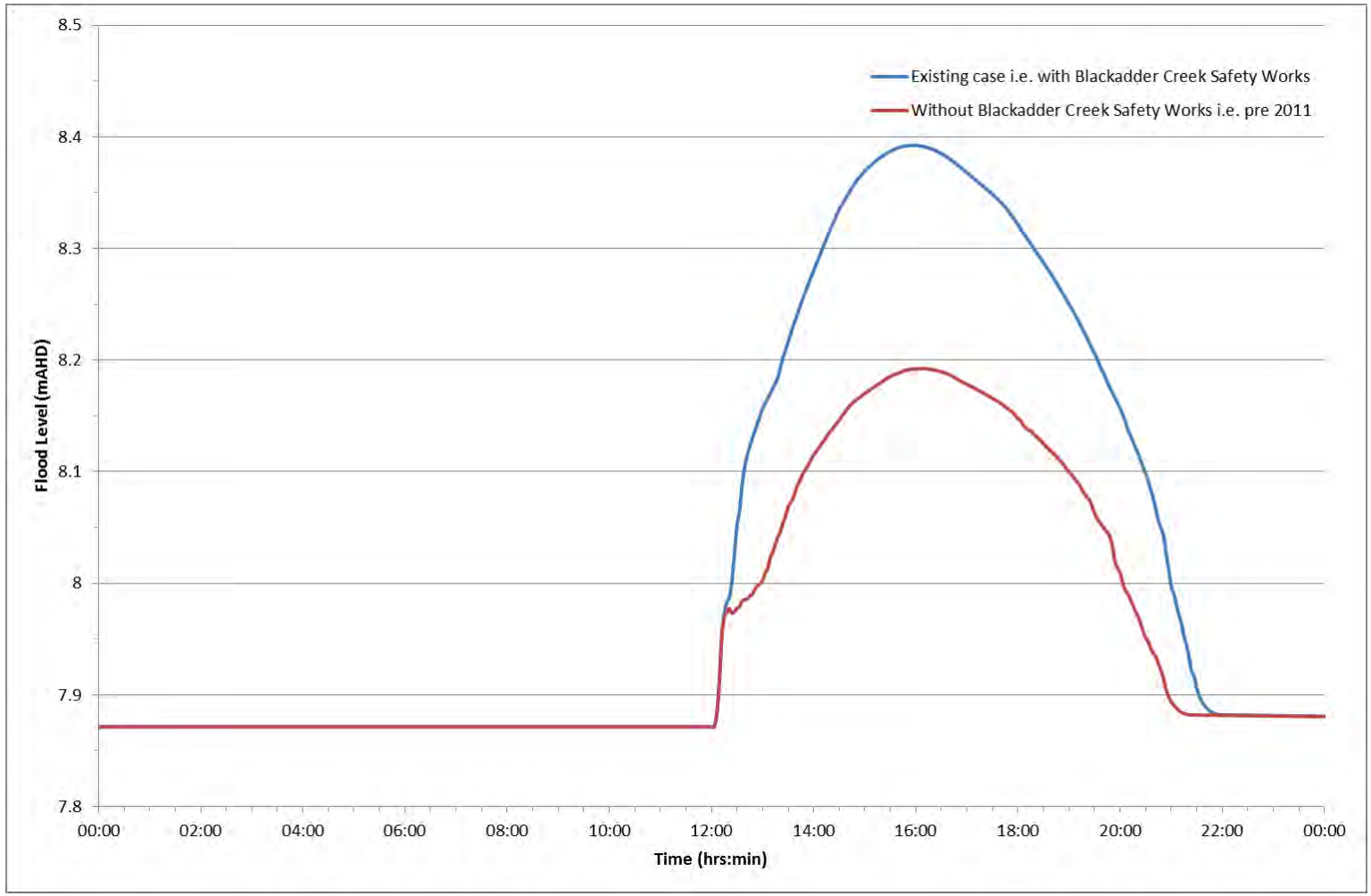

Figure 8.7 : Modelled January 2012 flood levels at Cox Lane: comparison of existing case and pre-BCSW

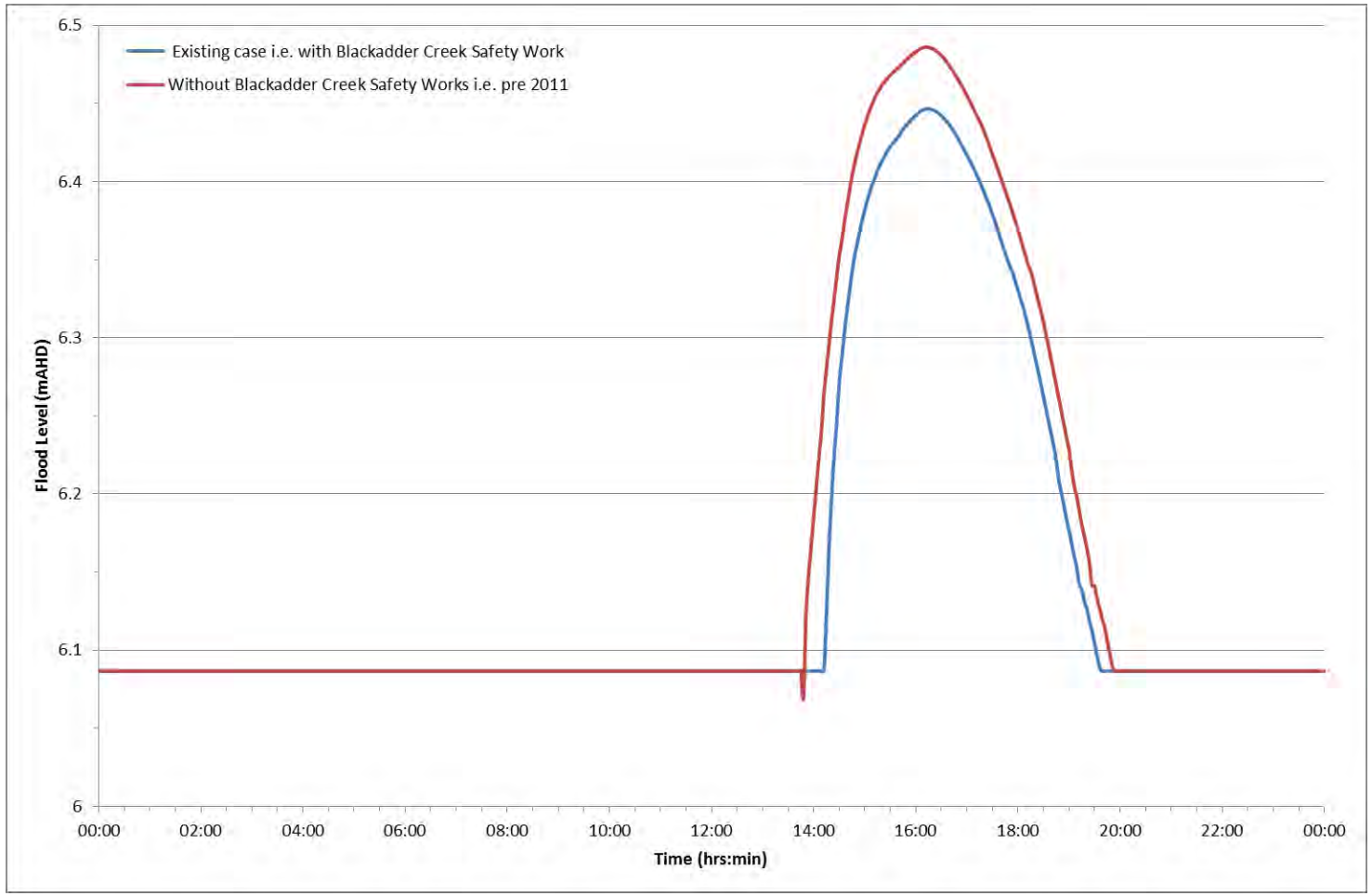

Figure 8.8 : Modelled January 2012 flood levels at SW Corindi Park Drive: comparison of existing case and pre-BCSW

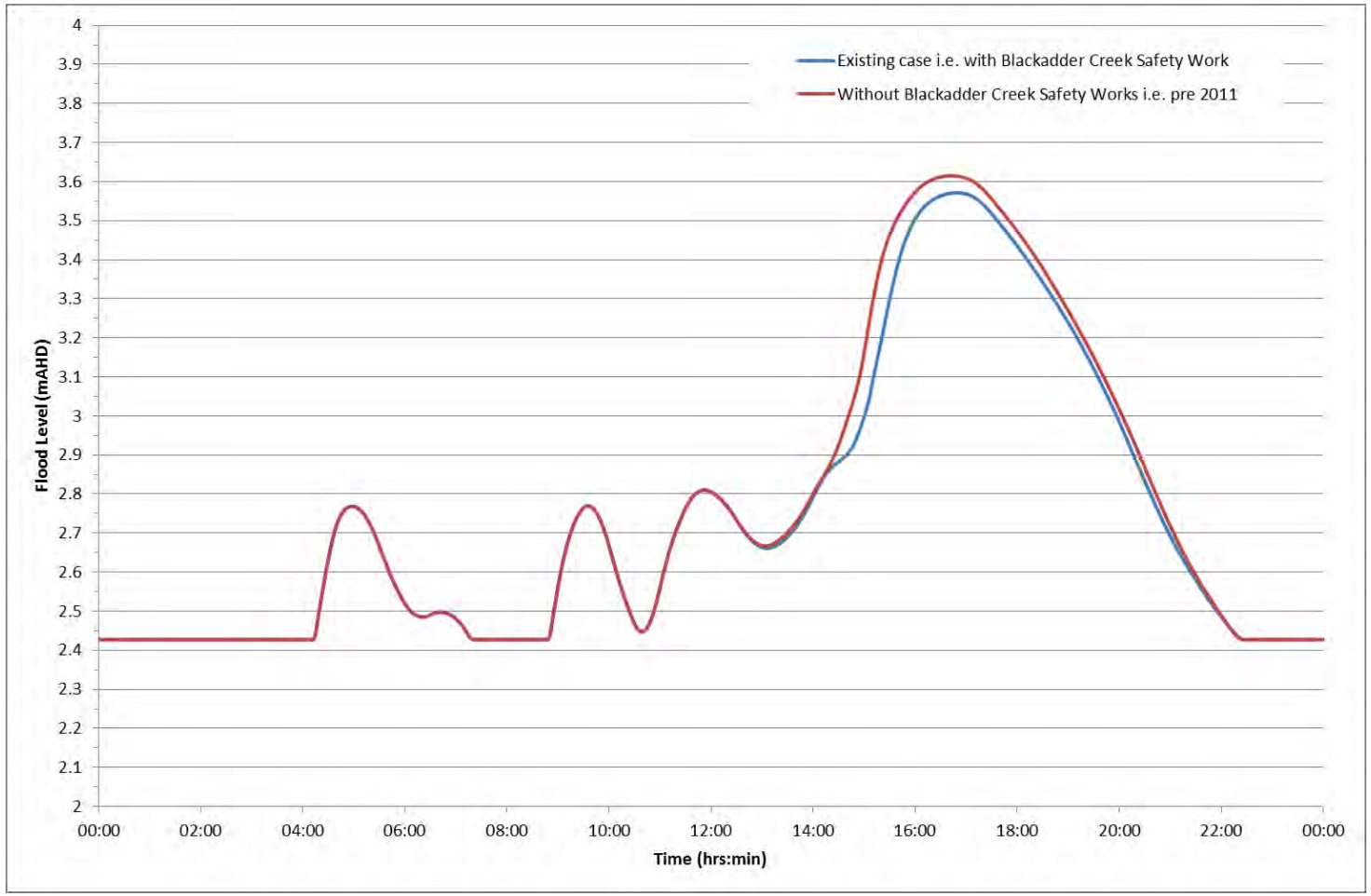

Figure 8.9 : Modelled January 2012 flood levels at NE Corindi Park Drive : comparison of existing case and pre-BCSW

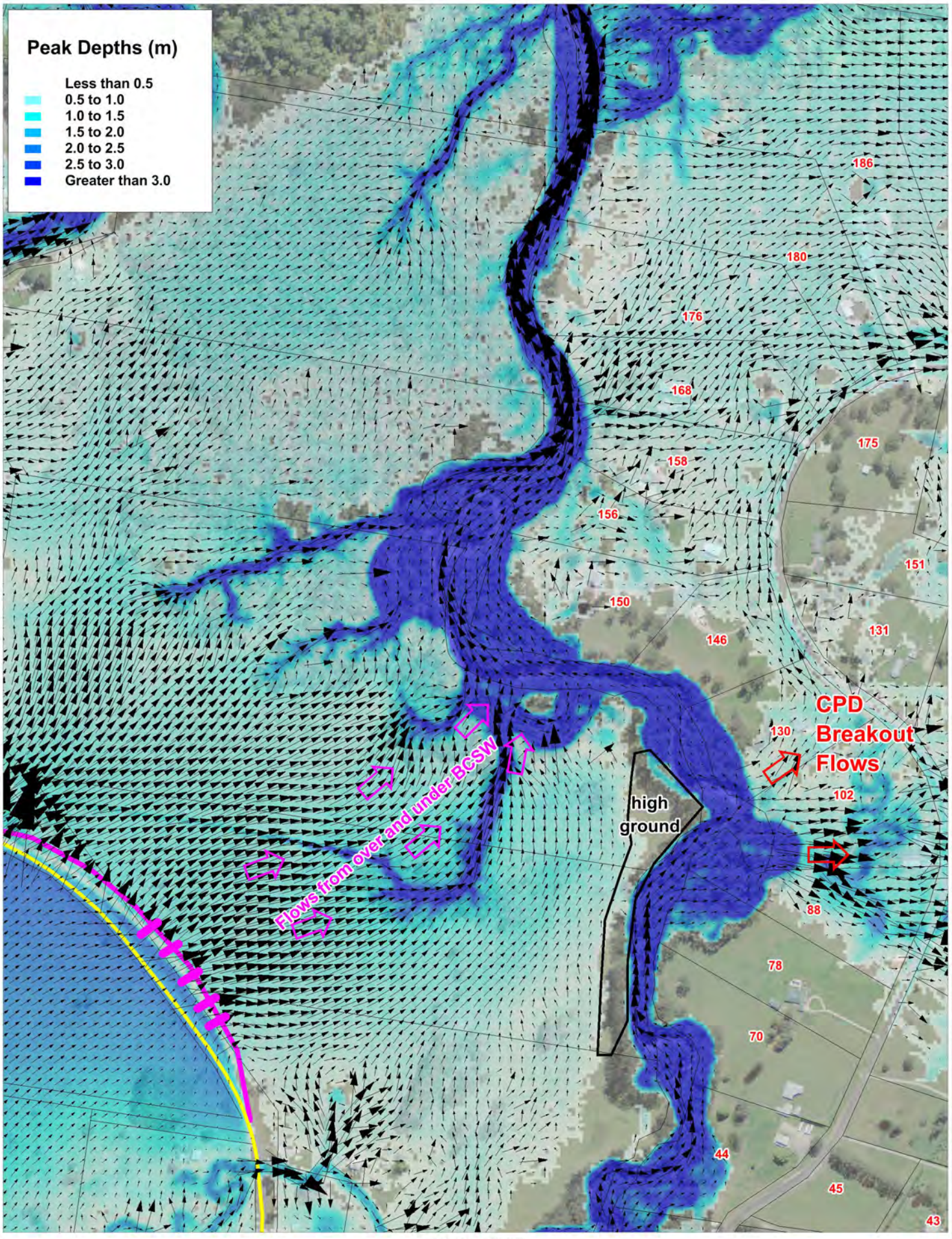

Figure 8-10

SINCLAIR KNIGHT MERZ
SKM

N

0 125 250
metres

Datum: GDA 94
Projection: MGA Zone 56

Flow Directions Downstream of BCSW for January 2012 Flood Event

Corindi River Flood Assessments

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9. Assessment of Pacific Highway Upgrade

9.1 Scenarios assessed

The calibrated flood models (hydrologic and hydraulic) were used to assess the impacts of proposed Woolgoolga to Ballina (W2B) Pacific Highway Upgrade. The model was changed so that the proposed upgrade embankments, bridges and culverts were represented in the flood model. Everything else in the flood model was unchanged (terrain, inflows etc.).

The flood model was simulated for this W2B case for the January 2012 flood event and the 100 year ARI flood event. The results of these simulations were then compared with the flood model results for the pre-BCSW case (i.e. the base case) to derive cumulative impacts of both the proposed W2B upgrade and the BCSW.

For the purposes of this assessment, the bridge openings proposed in the detailed design of the Woolgoolga to Glenugie project were assessed. These openings included:

- Corindi River bridge = 65m
- Corindi River floodplain bridge = 300m
- Casson Creek bridge = 85m

9.2 Results of flood assessments

Peak flood levels for the January 2012 flood and the 100 year ARI flood with the W2B upgrade in place were compared with those of the pre-BCSW case (i.e. the base case).

Figure 9.1 shows the peak flood levels for this assumed base case (ie pre BCSW) for the January 2012 flood flows. **Figure 9.2** shows the changes in flood levels from this base case due to the W2B Pacific Highway Upgrade only. That is, the changes in flood levels shown in this figure are only due to the upgrade and not the BCSW. This figure shows that the impacts of the Pacific Highway Upgrade will be generally experienced upstream of the upgrade route. On the property immediately upstream of the route, impacts will be more than 400mm in some places. On the northern end of the floodplain, impacts will be more than 700mm. However, downstream of the W2B route, the impacts will be minor (in the order of 30mm) and confined to the agricultural areas between the upgrade route and Corindi River (western floodplain).

To provide some context on the cumulative impacts of both the BCSW and the W2B upgrade, **Figure 9.3** shows the changes in flood levels due to the W2B Pacific Highway Upgrade and the BCSW. It is evident from this figure that the BCSW impacts do not significantly add to the impacts of the W2B upgrade upstream of the W2B route.

This assessment of changes in flood level due to the W2B upgrade alone and cumulatively with the BCSW was also assessed for the 100 year ARI flood event. **Figure 9.4** to **Figure 9.6** show this assessment. Similar conclusions are drawn for this flood event as it is similar in magnitude to the January 2012 flood event.

It is suggested that RMS assess these options as part of further design considerations to derive a design that best meets the needs of the project.

However, the assessments carried out as part of this study indicate that there is little or no potential for the W2B project to affect properties downstream adversely.

9.3 Impact of W2B on evacuation routes

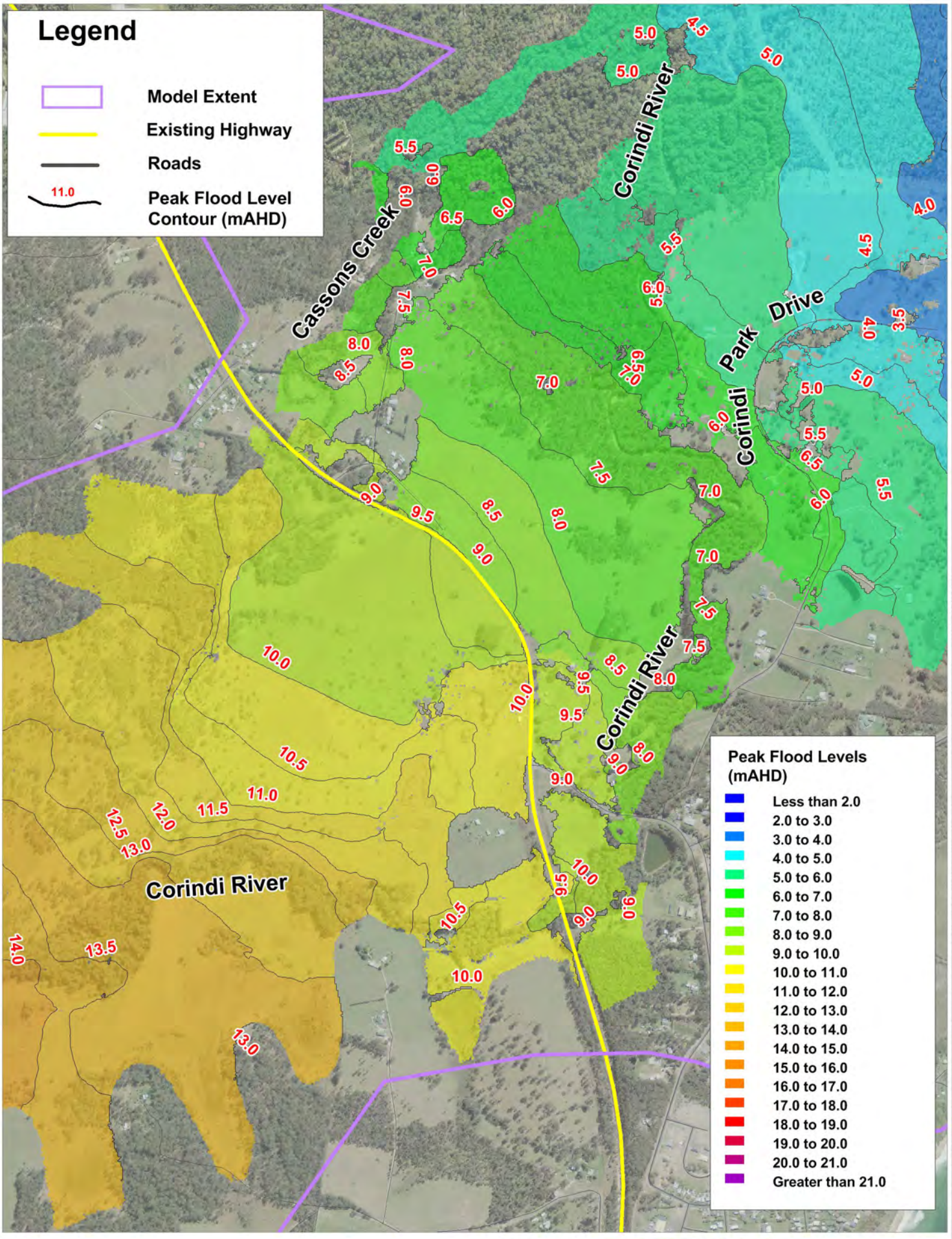
An assessment was undertaken to determine the impact of the Woolgoolga to Ballina Pacific Highway Upgrade on the capacity for residents upstream to evacuate. Upstream of the proposed route, a landholder currently has a flood evacuation through a neighbour's property and then to the existing Pacific Highway.

This evacuation route used during a flood event is shown in **Figure 9.7** with reference points shown as points A to F.

Figure 9.8 to **Figure 9.13** show the differences in modelled levels for the January 2012 flood event based on the existing case and a scenario with W2B upgrade in place. **Table 9.1** shows the difference in peak levels at these six locations. Locations A and B would be most affected by the construction of the W2B upgrade, as the increase in levels are in the order of 0.1m to 0.3m. Location A is a location where the water is already approximately 0.9m deep in the existing case. The only means of passing through this depth of water (0.9m) is walking, as a car cannot negotiate this depth of flow. By increasing this flood depth to 1.2m, it is likely that walking past point A would not be possible (without a significant risk to life). . It is suggested that RMS further assess options for maintaining the level of flood safety for the residents affected by severance of this evacuation route.

Table 9.1 : Difference in peak levels and depths for the January 2012 event

	A	B	C	D	E	F
Ground Level (mAHD)	10.84	11.46	10.98	11.78	12.37	12.91
Water Level (mAHD) for Existing Case	11.45	11.62	11.51	12.06	12.86	13.35
Depth (m) for Existing Case	0.61	0.16	0.53	0.28	0.49	0.44
Water Level (mAHD) for W2B Case	11.76	11.76	11.56	12.07	12.86	13.35
Depth (m) for W2B Case	0.92	0.3	0.58	0.29	0.49	0.44
Difference in water level (m)	0.31	0.14	0.05	0.01	0.00	0.00



SINCLAIR KNIGHT MERZ

SKM

N

0 250 500
metres

Datum: GDA 94
Projection: MGA Zone 56

Figure 9-1 **Peak Flood Levels Base Case (without BCSW) for January 2012 Flows**

Corindi River Flood Assessments

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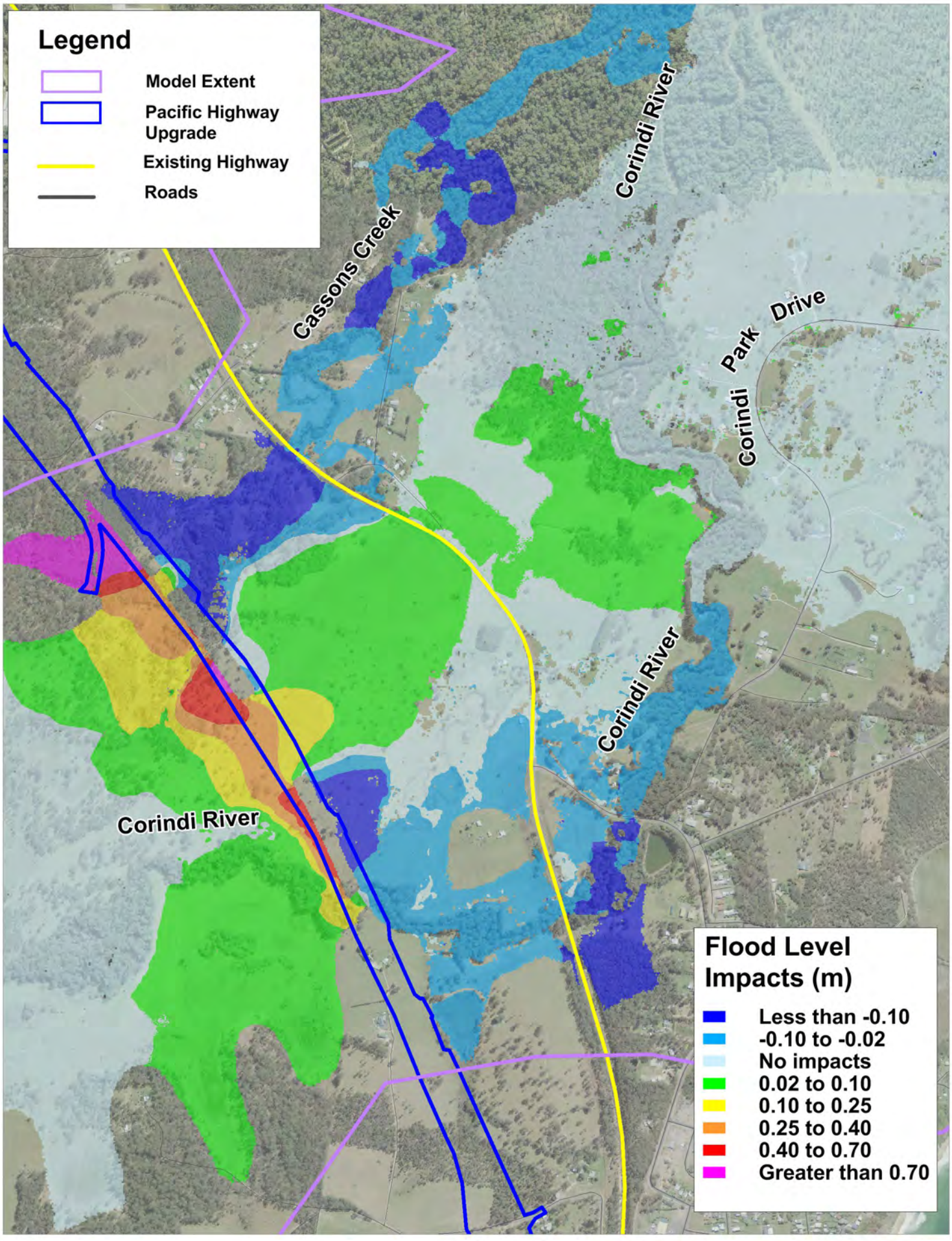

Figure 9-2

Change in Flood Levels due to Pacific Highway Upgrade only (base case is without BCSW) for January 2012 Flows

Corindi River Flood Assessments

SINCLAIR KNIGHT MERZ

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0 250 500
metres

Datum: GDA 94
Projection: MGA Zone 56

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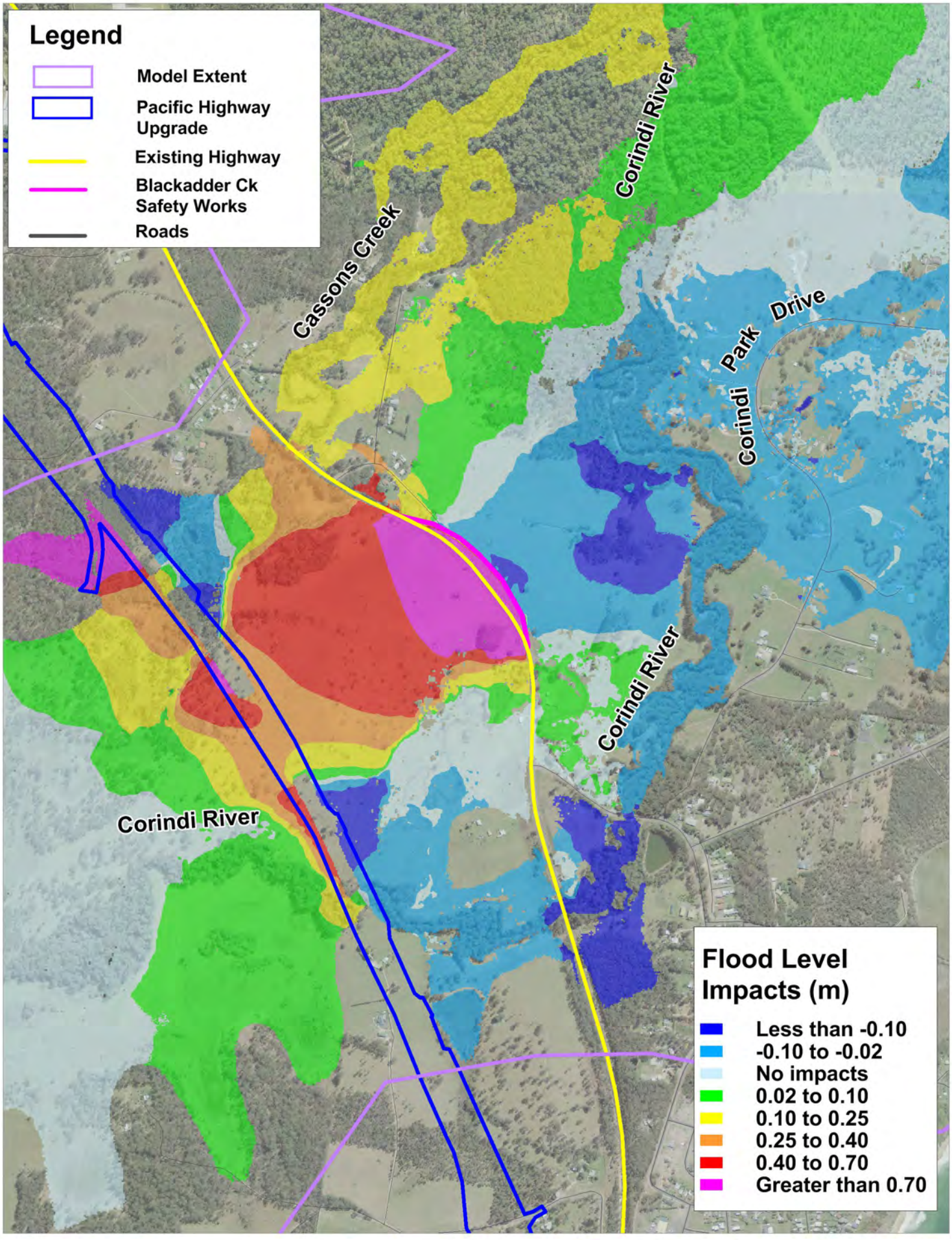

Figure 9-3

Change in Flood Levels due to Pacific Highway Upgrade and BCSW (base case is without BCSW) for January 2012 Flows

Corindi River Flood Assessments

SINCLAIR KNIGHT MERZ SKM

N

0 250 500 metres

Datum: GDA 94
Projection: MGA Zone 56

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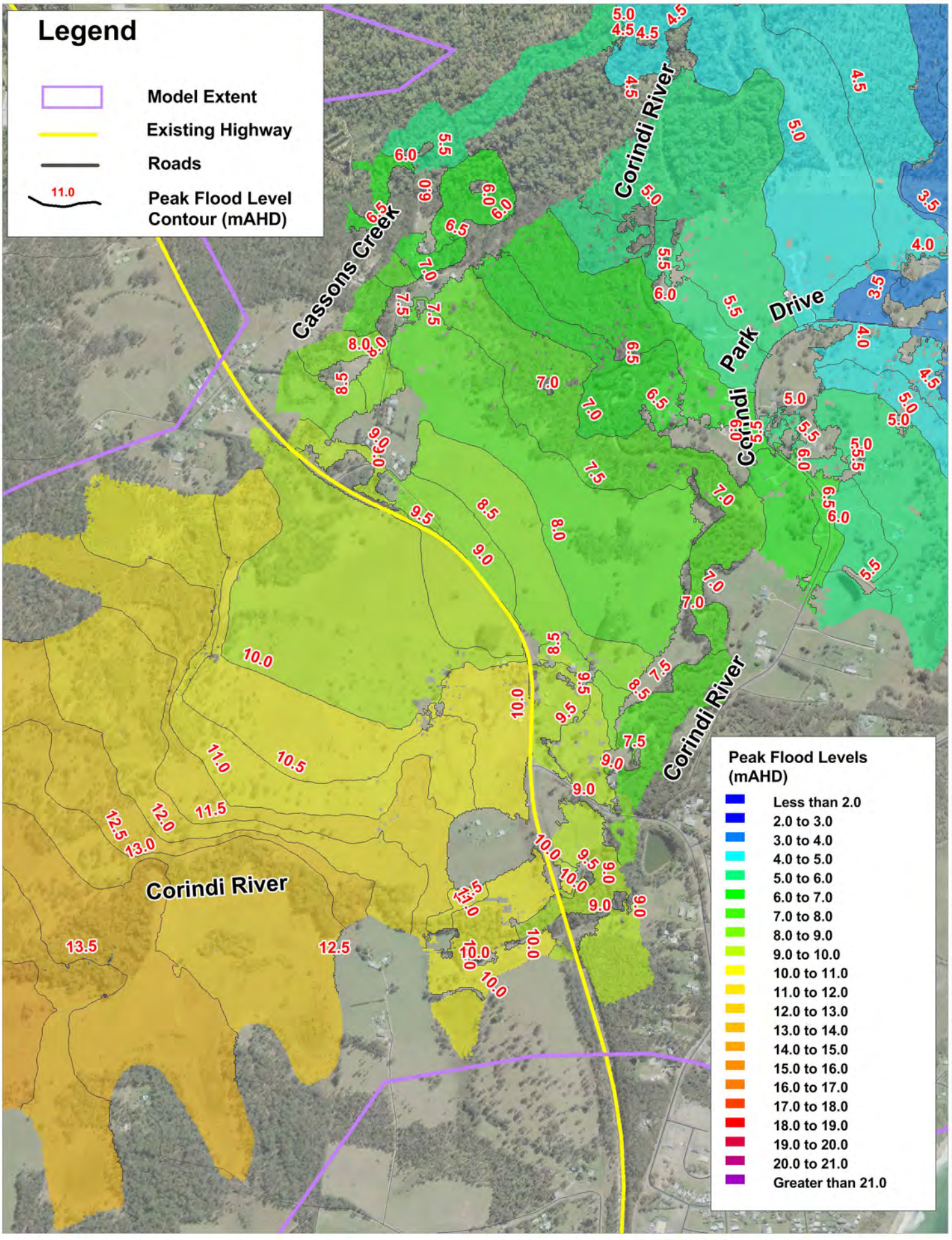

Figure 9-4 **Peak Flood Levels Base Case (without BCSW) for 100 year ARI Flows**

Corindi River Flood Assessments

SINCLAIR KNIGHT MERZ SKM

N

0 250 500 metres

Datum: GDA 94
Projection: MGA Zone 56

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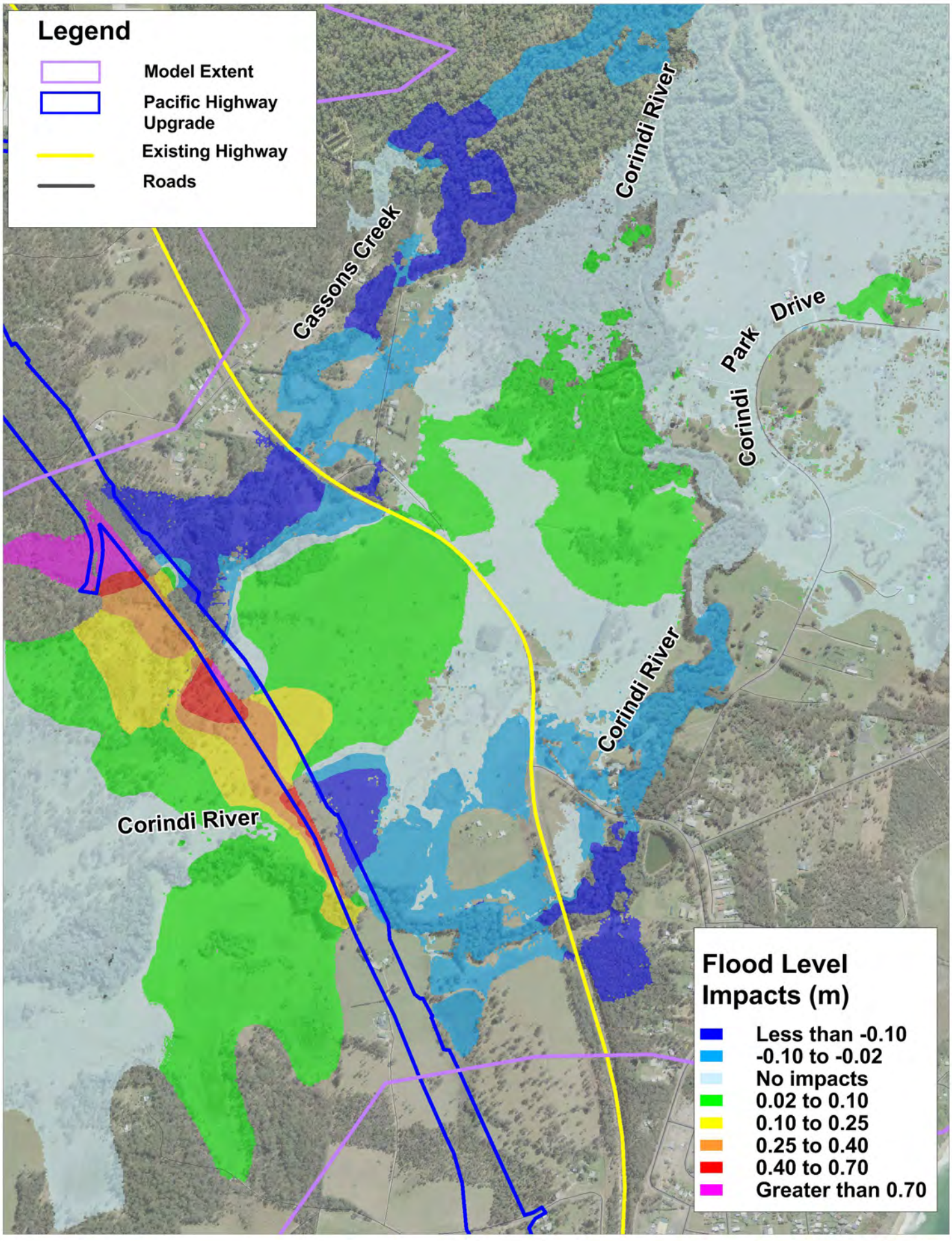

Figure 9-5

Change in Flood Levels due to Pacific Highway Upgrade only (base case is without BCSW) for 100 year ARI Flows

Corindi River Flood Assessments

SINCLAIR KNIGHT MERZ SKM

N

0 250 500
metres

Datum: GDA 94
Projection: MGA Zone 56

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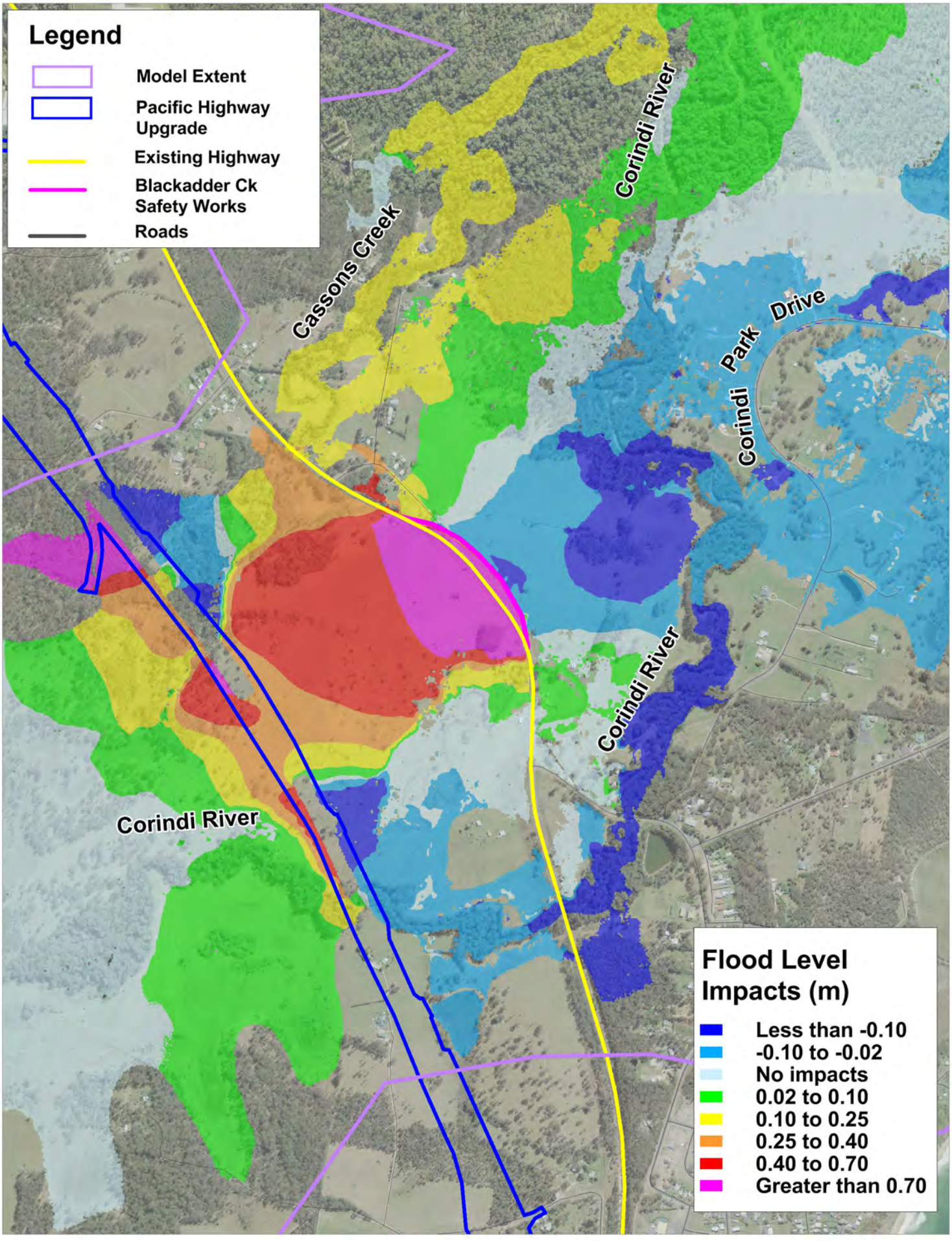

Figure 9-6

Change in Flood Levels due to Pacific Highway Upgrade and BCSW (base case is without BCSW) for 100 year ARI Flows

Corindi River Flood Assessments

SINCLAIR KNIGHT MERZ SKM

N

0 250 500
metres

Datum: GDA 94
Projection: MGA Zone 56

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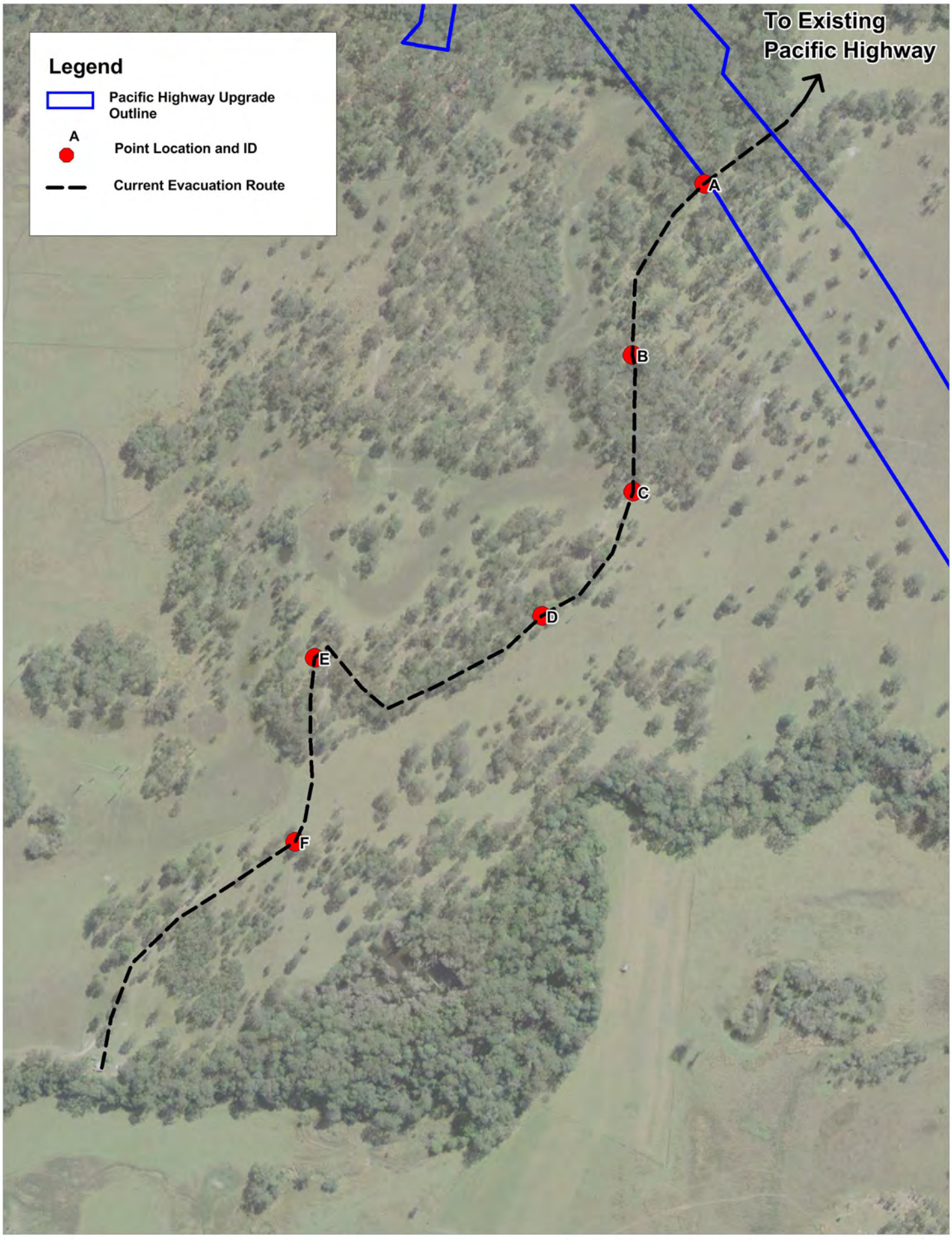

SINCLAIR KNIGHT MERZ

SKM

N

0 100 200
metres

Datum: GDA 94
Projection: MGA Zone 56

Figure 9-7

Existing Evacuation Route with Reference Points

Corindi River Flood Assessments

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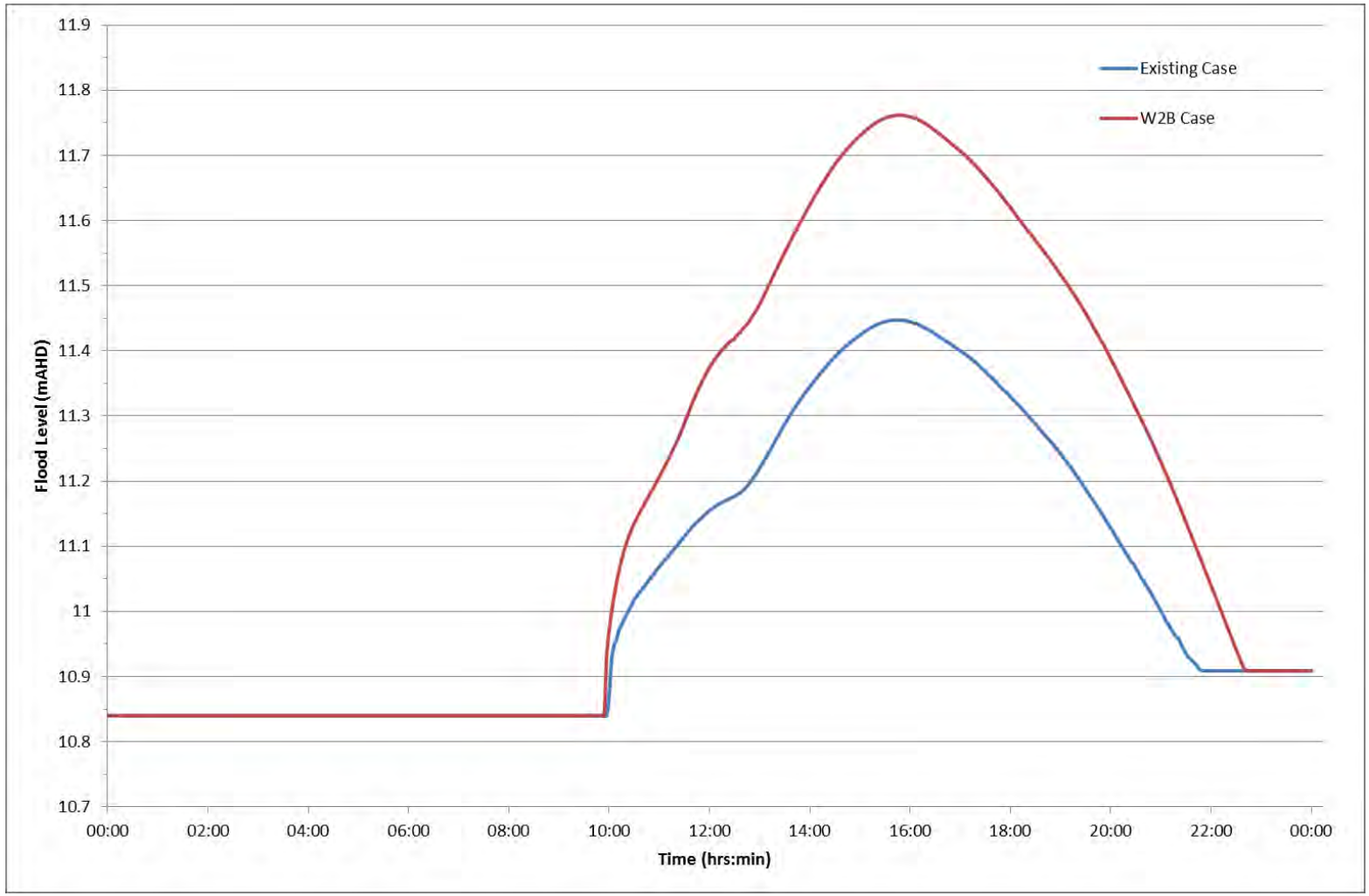


Figure 9.8 : Difference in water level between existing case and W2B case for January 2102 flood event: Location A

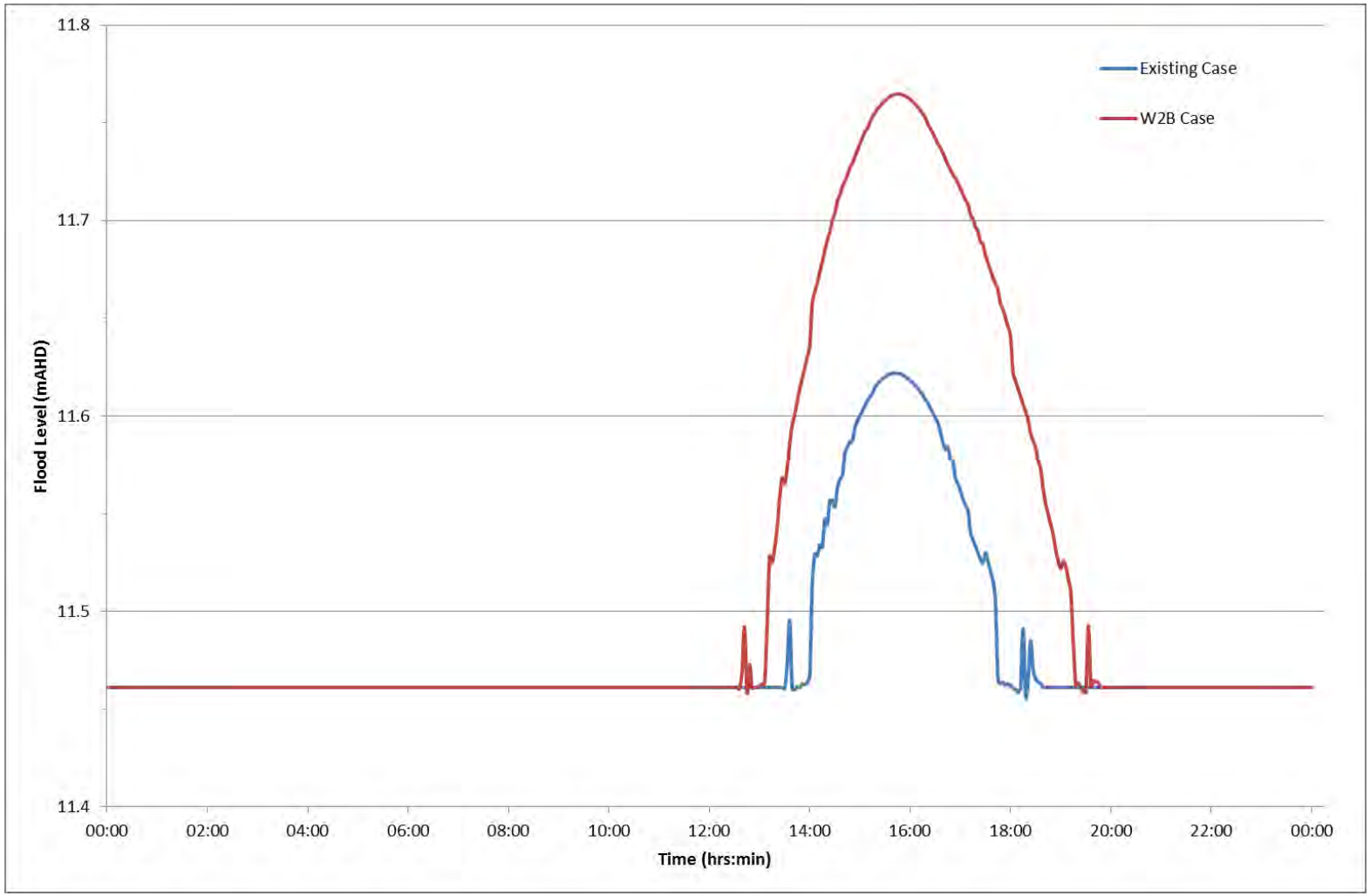


Figure 9.9 : Difference in water level between existing case and W2B case for January 2102 flood event: Location B

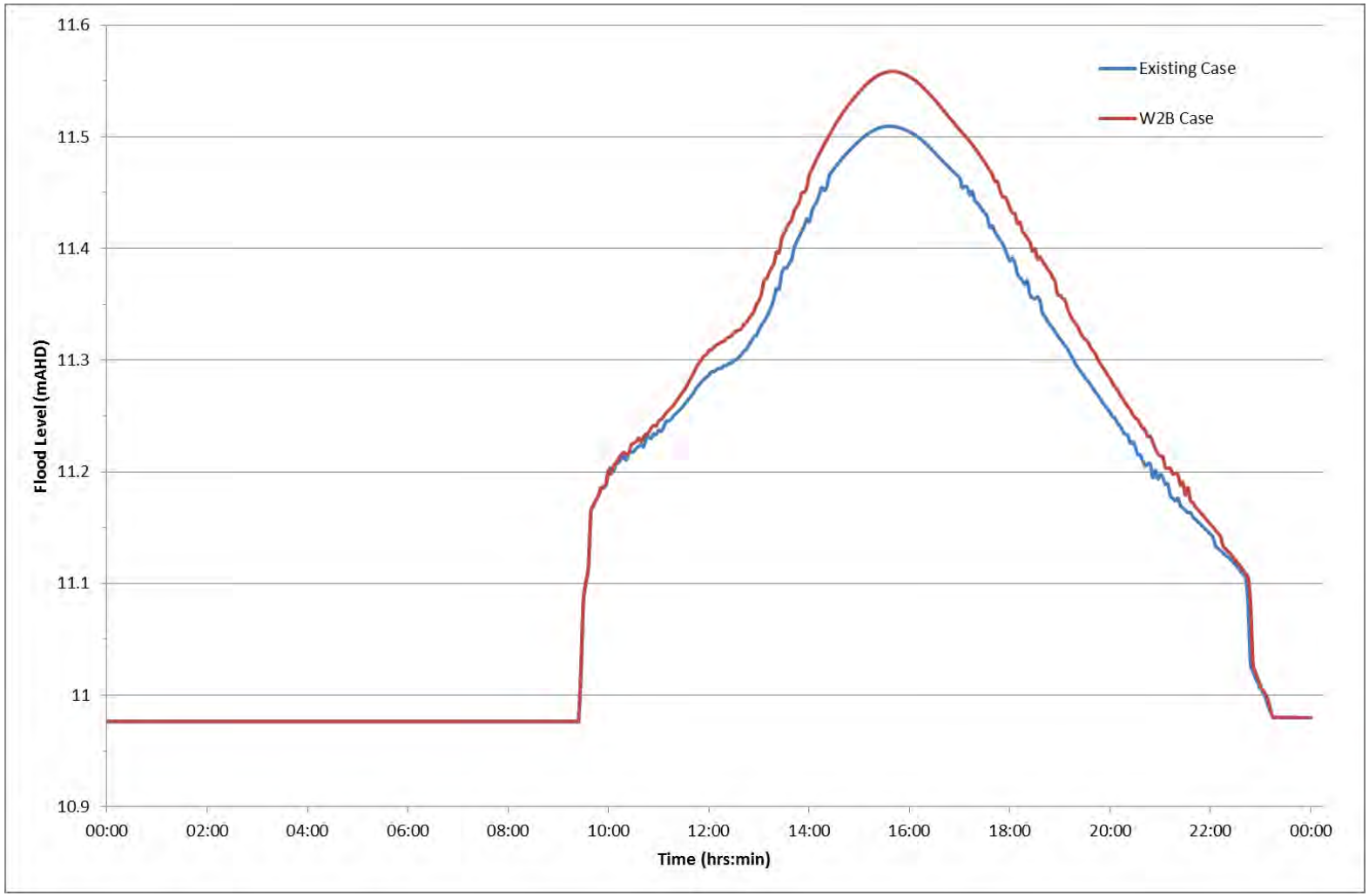


Figure 9.10 : Difference in water level between existing case and W2B case for January 2102 flood event: Location C

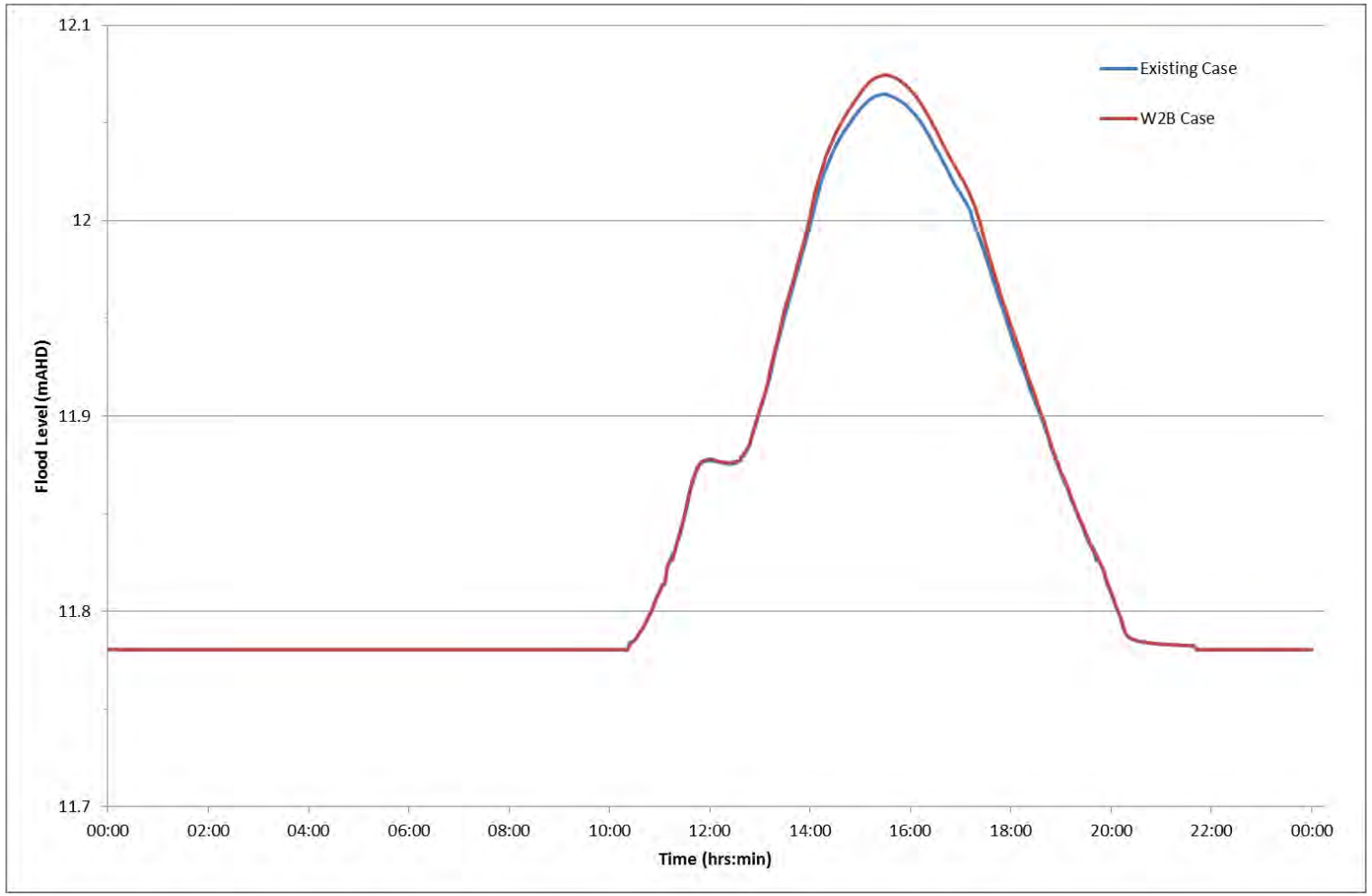


Figure 9.11 : Difference in water level between existing case and W2B case for January 2102 flood event: Location D

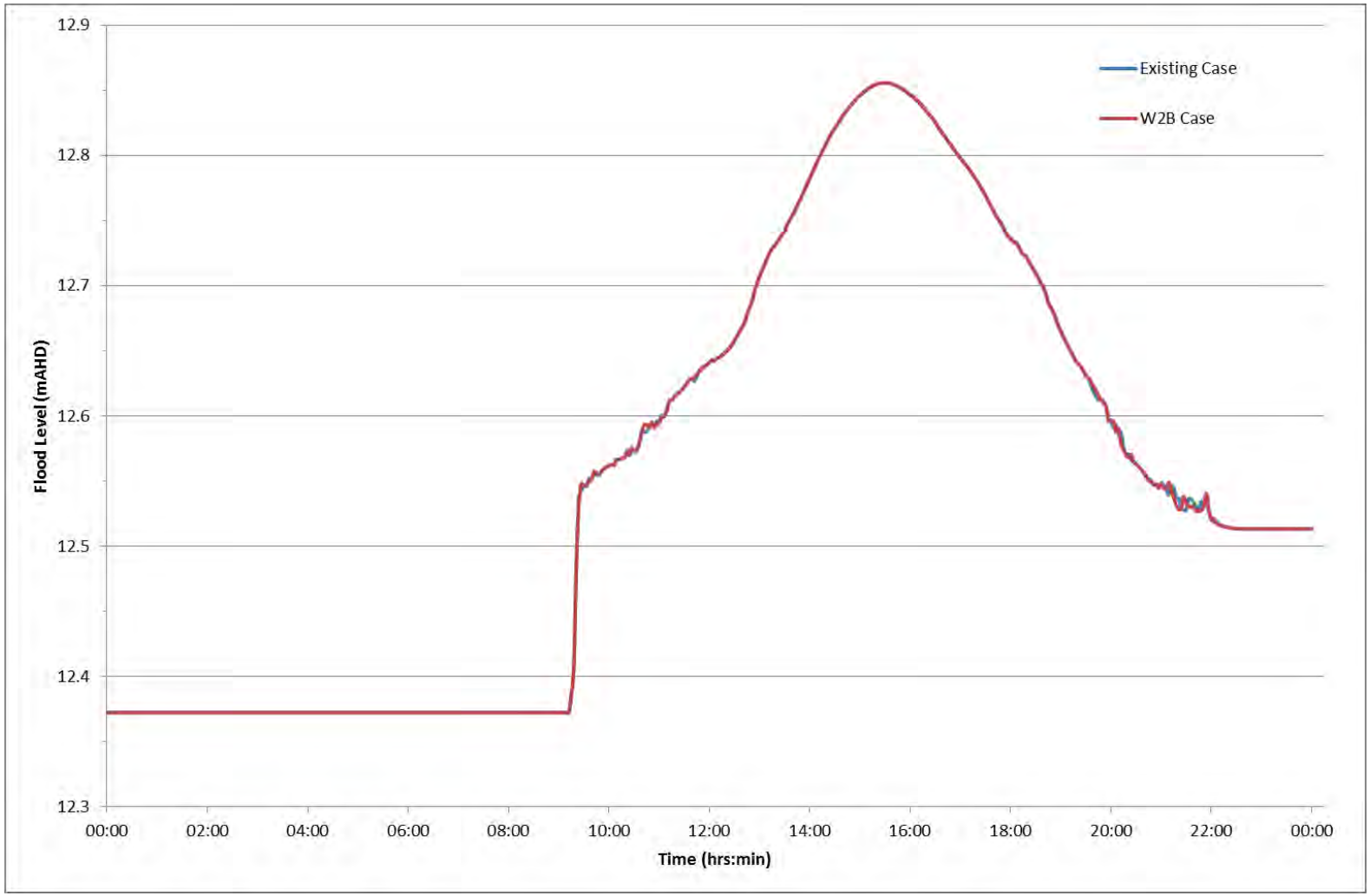


Figure 9.12 : Difference in water level between existing case and W2B case for January 2102 flood event: Location E

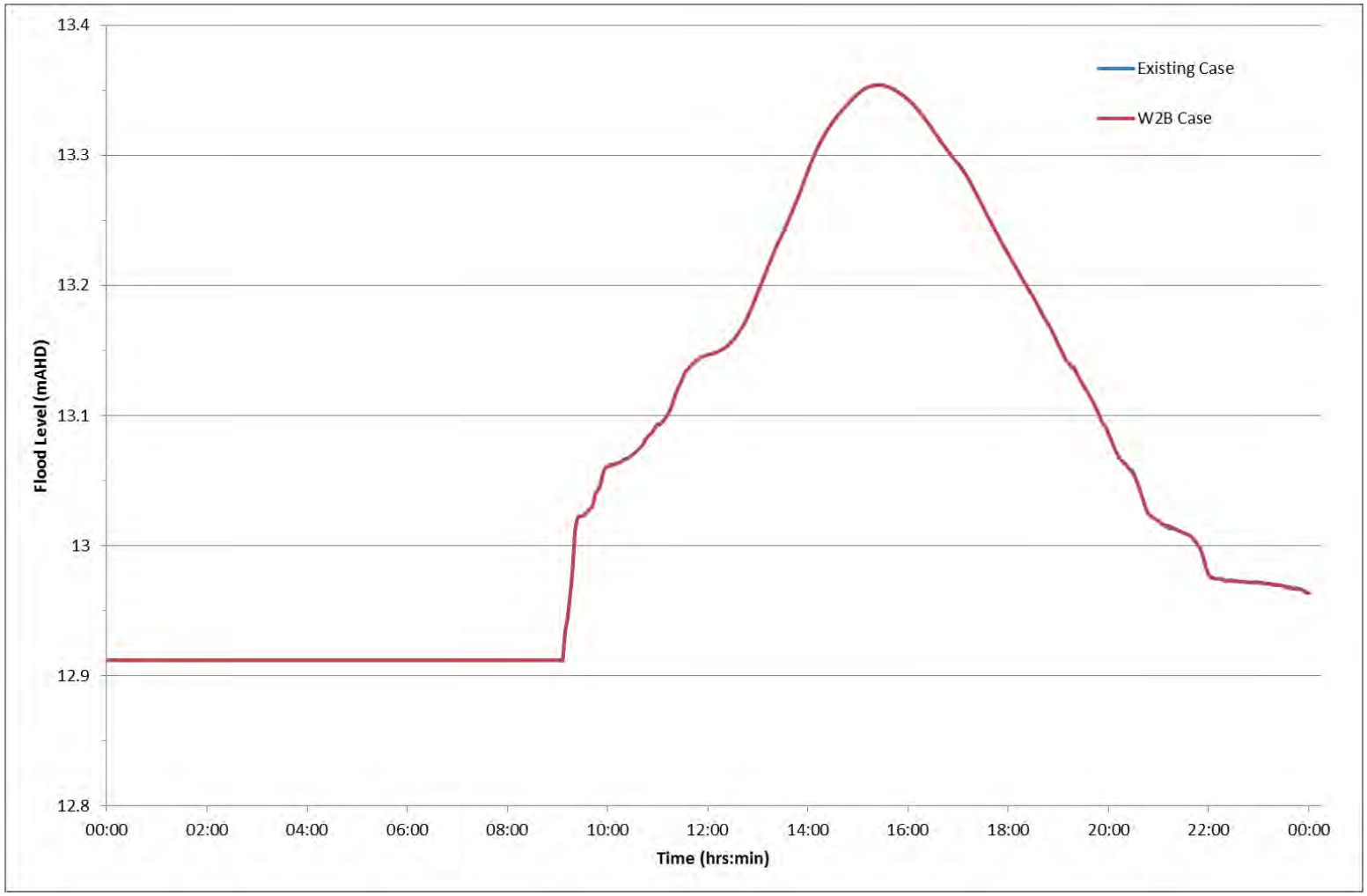


Figure 9.13 : Difference in water level between existing case and W2B case for January 2102 flood event: Location F

10. Conclusions

The following conclusions have been developed based on the results of the hydrologic and hydraulic modelling analysis described within this report.

- Historically, flooding in Corindi River is a common occurrence. A number of events have been recorded in Corindi area since the late 19th century.
- The flood models developed are an adequate representation of the observed flooding behaviour during the January 2012 flood event.
- The January 2012 flood event was similar in magnitude to a 100 year ARI flood event and the February 2013 was similar in magnitude to a 40 year ARI flood event.
- The likelihood of two large flood events occurring in consecutive years is not rare and has occurred in the other catchments in the area previously.
- The Blackadder Creek Safety Works resulted in a redistribution of flows on the floodplain in the vicinity of the Pacific Highway. More flow was diverted to Cassons Creek and increased flows and levels in the Cox Lane and Cassons Creek area.
- The Blackadder Creek Safety Works did not result in adverse effects to the residents of Corindi Park Drive.
- The assessments carried out as part of this study indicate that there is little or no potential for the W2B project to affect properties downstream adversely.

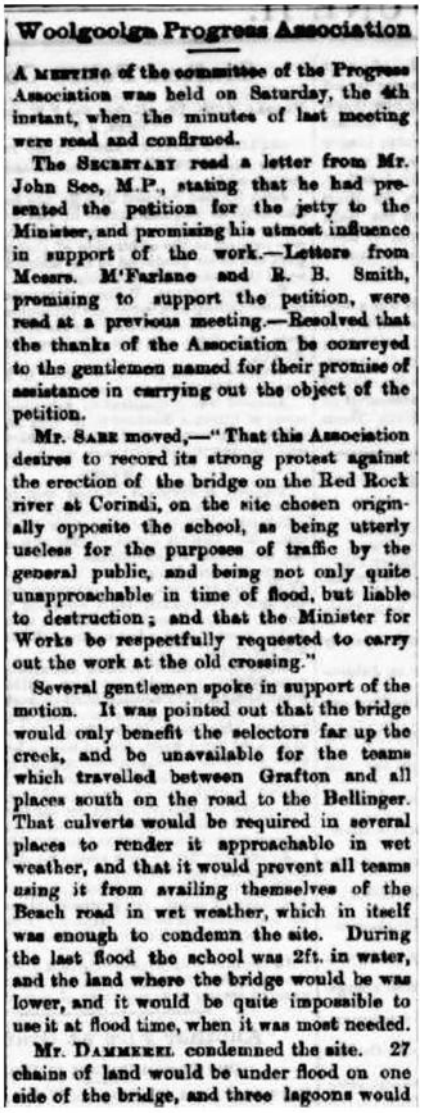
Appendix A. Anecdotal information on flooding history in the area of Corindi

Clarence and Richmond Examiner and New England Advertiser, Saturday 11th June 1887

Mr. SARE moved,-" That this Association desires to record its strong protest against the erection of the bridge on the Red Rock river at Corindi, on the site chosen originally opposite the school, as being utterly useless for the purposes of traffic by the general public, and being not only quite unapproachable in time of flood, but liable to destruction and that the Minister for Works be respectfully requested to carry out the work at the old crossing."

Several gentlemen spoke in support of the motion. It was pointed out that the bridge would only benefit the selectors far up the creek, and be unavailable for the teams which travelled between Grafton and all places south on the road to the Bellinger. That culverts would be required in several places to render it approachable in wet weather, and that it would prevent all teams using it from availing themselves of the Beach road in wet weather, which in itself was enough to condemn the site. During the last flood the school was 2ft. in water, and the land where the bridge would be was lower, and it would be quite impossible to use it at flood time, when it was most needed.

Mr. DAMMEREL condemned the site. 27 chains of land would be under flood on one side of the bridge, and three lagoons would have to be culverted on the other, to make the road passable in wet weather.



Woolgoolga Progress Association

A MEETING of the committee of the Progress Association was held on Saturday, the 4th instant, when the minutes of last meeting were read and confirmed.

The SECRETARY read a letter from Mr. John See, M.P., stating that he had presented the petition for the jetty to the Minister, and promising his utmost influence in support of the work.—Letters from Messrs. M'Farlane and E. B. Smith, promising to support the petition, were read at a previous meeting.—Resolved that the thanks of the Association be conveyed to the gentlemen named for their promise of assistance in carrying out the object of the petition.

MR. SARE moved,—" That this Association desires to record its strong protest against the erection of the bridge on the Red Rock river at Corindi, on the site chosen originally opposite the school, as being utterly useless for the purposes of traffic by the general public, and being not only quite unapproachable in time of flood, but liable to destruction; and that the Minister for Works be respectfully requested to carry out the work at the old crossing."

Several gentlemen spoke in support of the motion. It was pointed out that the bridge would only benefit the selectors far up the creek, and be unavailable for the teams which travelled between Grafton and all places south on the road to the Bellinger. That culverts would be required in several places to render it approachable in wet weather, and that it would prevent all teams using it from availing themselves of the Beach road in wet weather, which in itself was enough to condemn the site. During the last flood the school was 2ft. in water, and the land where the bridge would be was lower, and it would be quite impossible to use it at flood time, when it was most needed.

MR. DAMMEREL condemned the site. 27 chains of land would be under flood on one side of the bridge, and three lagoons would

Clarence and Richmond Examiner and New England Advertiser, Saturday 7th January 1888

Monday, January 2

The Weather - After a long period of dry weather, which has had the effect of completely stopping all farming operations, we have been favoured with a considerable downpour. The rain commenced on Boxing Day, and continued until the river and all the creeks were flooded. At Corindi the water was within a very few feet of the level of the last flood; mail communication, was temporarily suspended, and the farms up the river were submerged, doing some damage to the young corn. It is, however, now fine, and the ground is drying up rapidly. The land is saturated, ploughing will commence, and grass be plentiful, so that the new year commences favourably for all concerned.

Corinda and Woogoolga.

MONDAY, JANUARY 2.

THE WEATHER.—After a long period of dry weather, which has had the effect of completely stopping all farming operations, we have been favoured with a considerable downpour. The rain commenced on Boxing Day, and continued until the river and all the creeks were flooded. At Corindi the water was within a very few feet of the level of the last flood; mail communication was temporarily suspended, and the farms up the river were submerged, doing some damage to the young corn. It is, however, now fine, and the ground is drying up rapidly. The land is saturated, ploughing will commence, and grass be plentiful, so that the new year commences favourably for all concerned.

THE JETTY, WOOGOOLGA.—A petition for the erection of this much-needed work is in course of signature. The want of the jetty is daily becoming more apparent.

PUBLIC SCHOOLS.—On the breaking up the schools at Corinda and Woogoolga, every pupil was presented with a prize in commemoration of the centennary of the colony. The prizes, which consisted of well-chosen books, were the gifts of the teacher (Mr. M'Iver), Mr. C. J. Taylor, and Mr. Thos. M'Callum, and were much appreciated by the children. The liberality of the donors is worthy of all praise and of imitation. It is proposed to give the children a picnic at an early date, weather permitting.

BRIDGES.—The bridges over the creeks at Casson's and Inmon's at Corindi, have been completed, and, as works, are highly creditable to the contractor, Mr. Charles Avery. The road between them, and through the lane, is in a deplorable state, being in places a sheet of slush. This road will require draining, or will soon be quite impassable. The wisdom of the assistant engineer in erecting the bridges, has been amply demonstrated during the recent rains, as without them the flood waters would have been impassable on the line of road. We hope to see the work of erecting the principal bridge over the Red Rock River commenced at an early date.

SHIPPING.—Since last writing, the Fernmount steamer has been to Woogoolga on two occasions, on each of which she took away a considerable quantity of sugar, on account of Mr. W. T. Pullen.

THE SUGAR SEASON.—The season just closed has been favourable. The sugar turned out at Mr. Pullen's mill you have seen. It is only fair to state that Mr. William Sare, who this season again crushed for himself with his small Victor mill, made a considerable quantity of excellent sugar, and hopes for still better results in the future.

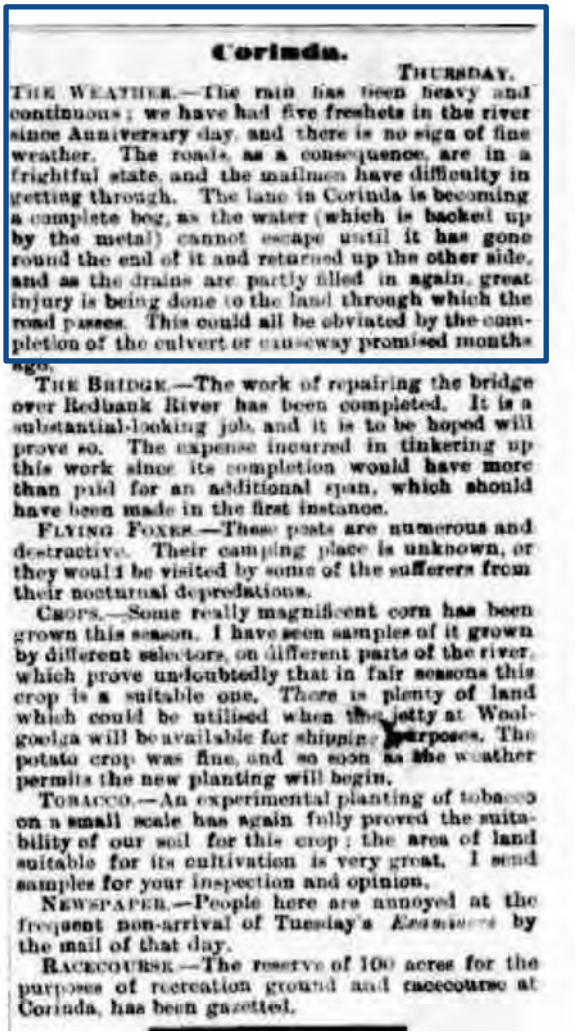
MAIL SERVICE.—The mails under the new contract will be carried by coach and on horseback alternately, once a week each. The establishment of the coach should prove a boon to parties desirous of visiting the coast, and who can obtain accommodation at Corindi. It is to be hoped the present contractor will be moderate in his charges for passenger fares, and that he will be able to carry out his contract, so far as delivery of mails is concerned, in the face of great difficulties, as well as his predecessor succeeded in doing.

THE ROAD SUPERINTENDENT.—It seems hard for public officials to please everybody. The Woogoolga and Moonie Progress Association recently voted thanks to the Superintendent of Roads between Corindi and Fernmount for his prompt attention to suggestions and requirements. In a recent issue, a contemporary of yours devotes a column to the abuse of the same gentleman. I may safely state that in the opinions expressed by the writer of the remarks therein contained, not one person in this part of the district can be found to agree, as we are certain the Superintendent does the best he can, with the limited funds at his disposal.

SPORTS.—Some races for bridles, &c., took place at Corindi on Boxing day, but as they were run in the midst of a heavy downpour of rain, the proceedings were the reverse of enjoyable.

Clarence and Richmond Examiner, Tuesday 4th March 1890

The Weather – The rain has been heavy and continous; we have had five freshets in the river since Anniversary day, and there is no sign of fine weather. The roads, as a consequence, are in a frightful state, and the mailmen have difficulty in getting through. The lane in Corinda is becoming a complete bog as the water (which is backed up by the metal) cannot escape until it has gone round the end of it and returned up the other side, and as the drains are partly filled in again, great injury is being done to the land through which the road passes. This could be obviated by the completion of the culvert or causeway promised months ago.



Corinda.

THURSDAY.

THE WEATHER.—The rain has been heavy and continuous; we have had five freshets in the river since Anniversary day, and there is no sign of fine weather. The roads, as a consequence, are in a frightful state, and the mailmen have difficulty in getting through. The lane in Corinda is becoming a complete bog, as the water (which is backed up by the metal) cannot escape until it has gone round the end of it and returned up the other side, and as the drains are partly filled in again, great injury is being done to the land through which the road passes. This could all be obviated by the completion of the culvert or causeway promised months ago.

THE BRIDGE.—The work of repairing the bridge over Redbank River has been completed. It is a substantial-looking job, and it is to be hoped will prove so. The expense incurred in tinkering up this work since its completion would have more than paid for an additional span, which should have been made in the first instance.

FLYING FOXES.—These pests are numerous and destructive. Their camping place is unknown, or they would be visited by some of the sufferers from their nocturnal depredations.

CROPS.—Some really magnificent corn has been grown this season. I have seen samples of it grown by different selectors, on different parts of the river, which prove undoubtedly that in fair seasons this crop is a suitable one. There is plenty of land which could be utilised when the jetty at Woolgoolga will be available for shipping purposes. The potato crop was fine, and so soon as the weather permits the new planting will begin.

TOBACCO.—An experimental planting of tobacco on a small scale has again fully proved the suitability of our soil for this crop; the area of land suitable for its cultivation is very great. I send samples for your inspection and opinion.

NEWSPAPER.—People here are annoyed at the frequent non-arrival of Tuesday's *Examiner* by the mail of that day.

RACECOURSE.—The reserve of 100 acres for the purposes of recreation ground and racecourse at Corinda, has been gazetted.

Clarence and Richmond Examiner, Saturday 15th March 1890

At Woolgoolga and Bucca Creek the rains commenced to fall on Wednesday, coming down in torrents till Saturday evening, and it had then no sign of abating. The creeks and watercourses were all filled, and most of the culverts and bridges were covered. Between Corinda and Arrawarra one had to traverse through miles of surface water, and the roads from thence to Grafton were almost impassable. Where the traffic was on the road it was boggy, while the ridges wore so saturated as to be quite rotten and unable to bear the weight of a boost. Owing to the bad condition of the roads many of the selectors and others are very short of provisions, with but little prospect of obtaining them. The Halfway Creek bridge on Saturday was above water, but a large portion of the fiat on one side was flooded. Glenugie Creek bridge was also dry, but the western approach was deeply flooded.

Other Parts of the Clarence.

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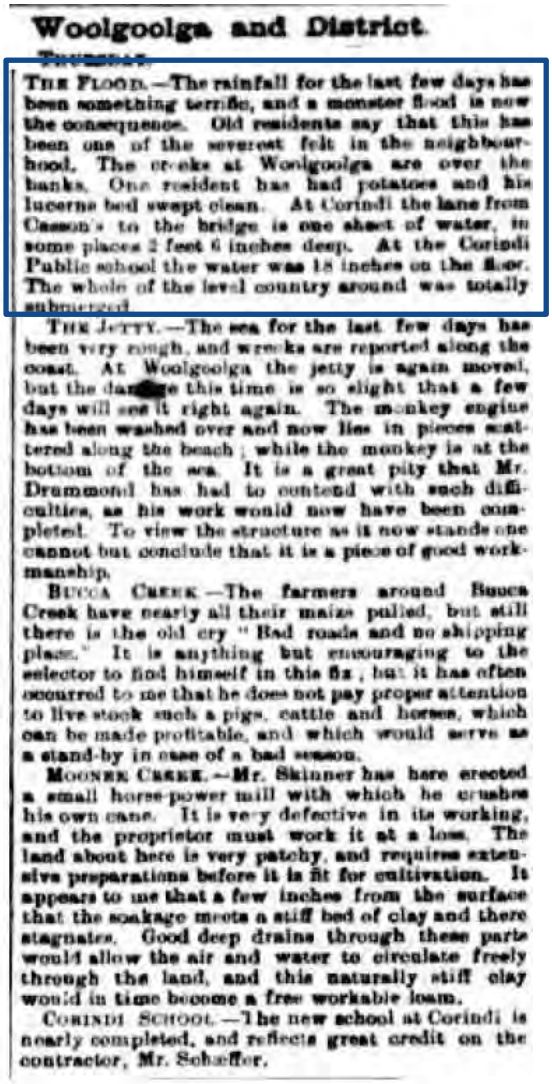
About 40 persons took refuge in the Junction Hotel. It is stated that there was but one small boat to rescue the different families, and it is suggested that a flood boat should be located in that direction. At Carr's Creek the river was not quite up to the 1887 flood. Nearly the whole of the crops were destroyed, and along the main river the maize was levelled by the strong current and in many places covered with driftwood.

At Southgate the water was eight inches higher than in 1887, and an immense amount of damage has been done. The flood boat did much in the way of rescue, and even went over to Ulmarra where the crew took some people from the roofs of houses. Numbers of residents of Southgate took refuge in Mr. Arnold's and the Public school. At Strontian Park the crops were destroyed, but in that locality the farmers saved their stock. About 100 persons found refuge in the school, 20 at Mr. E. Arnold's, 50 at Mr. Boorman's, about the same number in the quarry paddock, 30 or 40 at Mr. Reardon's, about 20 at Mr. D. Stuart's, and fully 100 on the hill at Mr. S. F. Hawkins'.

Clarence and Richmond Examiner, Tuesday 16th June 1891

THE FLOOD.—The rainfall for the last few days has been something terrific, and a monster flood is now the consequence. Old residents say that this has been one of the severest felt in the neighbourhood. The creeks at Woolgoolga are over the banks. One resident has had potatoes and his lucerne bed swept clean. At Corindi the lane from Casson's to the bridge is one sheet of water, in some places 2 feet 6 inches deep. At the Corindi Public school the water was 18 inches on the floor .The whole of the level country around was totally submerged.



Woolgoolga and District.

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THE JETTY.—The sea for the last few days has been very rough, and wrecks are reported along the coast. At Woolgoolga the jetty is again moved, but the damage this time is so slight that a few days will see it right again. The monkey engine has been washed over and now lies in pieces scattered along the beach; while the monkey is at the bottom of the sea. It is a great pity that Mr. Drummond has had to contend with such difficulties, as his work would now have been completed. To view the structure as it now stands one cannot but conclude that it is a piece of good workmanship.

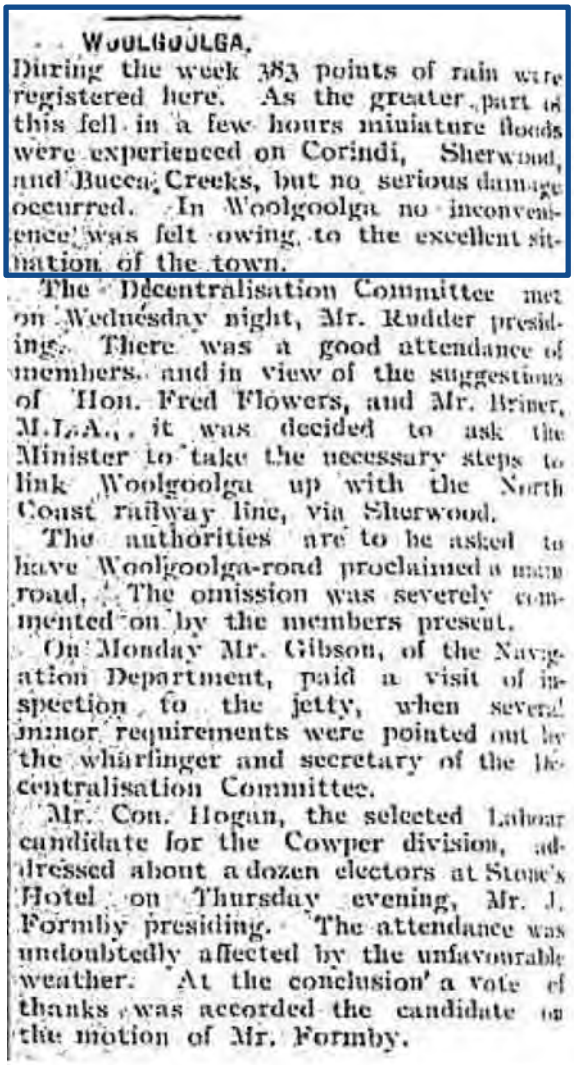
BUCCA CREEK.—The farmers around Bucca Creek have nearly all their maize pulled, but still there is the old cry "Bad roads and no shipping place." It is anything but encouraging to the selector to find himself in this fix; but it has often occurred to me that he does not pay proper attention to live stock such a pigs, cattle and horses, which can be made profitable, and which would serve as a stand-by in case of a bad season.

MOONEE CREEK.—Mr. Skinner has here erected a small horse-power mill with which he crushes his own cane. It is very defective in its working, and the proprietor must work it at a loss. The land about here is very patchy, and requires extensive preparations before it is fit for cultivation. It appears to me that a few inches from the surface that the soakage meets a stiff bed of clay and there stagnates. Good deep drains through these parts would allow the air and water to circulate freely through the land, and this naturally stiff clay would in time become a free workable loam.

CORINDI SCHOOL.—The new school at Corindi is nearly completed, and reflects great credit on the contractor, Mr. Schaffer.

Clarence and Richmond Examiner, Saturday 17th May 1913

During the week 383 points (135.1mm) of rain were registered here. As the greater part of this fell in a few hours miniature floods were experiences on Corindi, Sherwood and Bucca Creeks, but no serious damage occurred. In Woolgoolga no inconvenience was felt owing to the excellent situation of the town.



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The Decentralisation Committee met on Wednesday night, Mr. Rudder presiding. There was a good attendance of members, and in view of the suggestions of Hon. Fred Flowers, and Mr. Briner, M.L.A., it was decided to ask the Minister to take the necessary steps to link Woolgoolga up with the North Coast railway line, via Sherwood.

The authorities are to be asked to have Woolgoolga-road proclaimed a main road. The omission was severely commented on by the members present.

On Monday Mr. Gibson, of the Navigation Department, paid a visit of inspection to the jetty, when several minor requirements were pointed out by the wharfinger and secretary of the Decentralisation Committee.

Mr. Con. Hogan, the selected Labour candidate for the Cowper division, addressed about a dozen electors at Stone's Hotel on Thursday evening, Mr. J. Formby presiding. The attendance was undoubtedly affected by the unfavourable weather. At the conclusion a vote of thanks was accorded the candidate on the motion of Mr. Formby.

Coffs Harbour and Dorrigo Advocate, November 10 1917

Only about flooding in Coffs

Coffs under Water

HUGE FLOOD INUNDATES THE TOWN.

Nearly Seven Inches of Rain in a Night.

Great Damage to Gardens, Etc.

Thrilling Experience at Corambe.

The climax of a week of practically incessant rain came in the early hours of Friday morning, when the water of Coffs Creek overflowed the banks, and flooded the surrounding locality.

It was the biggest flood within the memory of the oldest resident.

The houses in Lowenthal's subdivision suffered most, several families being marooned, while others took refuge with neighbors. Misfortune visited Mrs. Brewis, whose sheds were uprooted, and a quantity of material damaged or lost. Gardens were simply wiped out of existence, while the mortality in the poultry yards was exceedingly heavy.

The heaviest rain set in early on Thursday night, reaching the dimensions of a positive deluge. All the time, of course, the creek was rising rapidly, continuing to do so until the effect of the incoming tide began to be felt. Then the waters overflowed in one great sheet, overwhelming the drains and rushing along Moonee-street like a river. The yards of the various shops and dwellings were soon 3ft. deep in

whelming the drains and rushing along Moonee-street like a river. The yards of the various shops and dwellings were soon 3ft. deep in water. The "Advocate" suffered most, there being a depth of nearly 1ft. in the printing room, while the editorial sanctum also came in for an unwelcome bath.

An unexpected outcome of the inundation of Bray and Co.'s yard was the ignition of a quantity of flax. After some trouble, the outbreak was extinguished before it was able to do any material damage.

The water course that runs through Mr. Carroll's property at the corner of High and Gordon streets, came down a banker, completely destroying Mr. R. H. Rampley's garden, and flattening the fences.

In High-street, only the crown of the roadway remained above a rushing torrent, that bared the metal everywhere; while "Mrs. Wiggs' Cabbage Patch" went [illegible] the home of past, if not forgotten events.

During the height of the storm no less than [illegible] of rain fell, making a total of over 12in. for the week.

At Corambe things were even worse, the flood waters forming a continuous lake from the bridge at Duncan's to the Butter Factory, covering every house and doing an immense amount of damage, the extent of which has not yet been calculated.

Over 8in. fell after 4 p.m. on Thursday, and 15in. for the week.

There were some thrilling experiences.

Mr. E. Brown, who resides on the experimental plot near the Corambe Show Ground spent the night clinging to the chimney of his residence, while quite a number of others were marooned.

There were several exceedingly narrow escapes from drowning. Mrs. P. O. Connor was forced to seek refuge in a tree, while her husband swan and waded a considerable distance to obtain assistance. A named Connolley had a very close call. Even well after daylight the flats in front of Mr. D. Baker's property were completely covered in water. Quite a number of sheds were wrecked.

An idea of the strength of the rushing torrents may be gained by the fact that a waggon loaded with 75 bags of corn was carried over 300 yards, while a hut travelled a mile before it grounded.

A party consisting of Sergeant Sproule, Messrs. A. L. Walsh, W. Gordon, and S. Nelson, took out a boat from Coffs in a car, and were able to rescue some half-dozen people who were huddled on an island near the timber depot this side of Corambe.

The opinion of residents in all parts of the district is that the flood of 1917 was the worst ever experienced in these localities.

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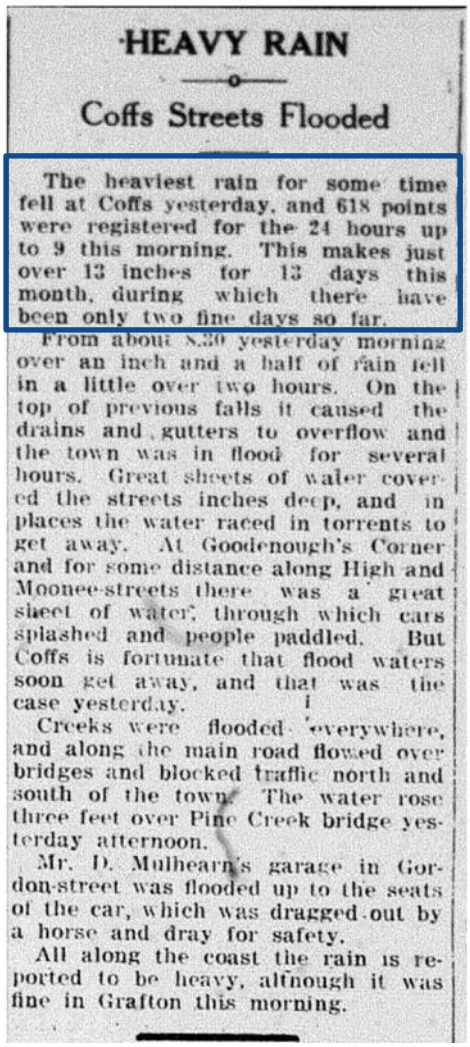
Coffs Harbour and Dorrigo Advocate, Friday April 13 1934

The heaviest rain for some time fell at Coffs yesterday, and 618 points (218mm) were registered for the 24 hours up to 9 this morning.



HEAVY RAIN

Coffs Streets Flooded

The heaviest rain for some time fell at Coffs yesterday, and 618 points were registered for the 24 hours up to 9 this morning. This makes just over 13 inches for 13 days this month, during which there have been only two fine days so far.

From about 8.30 yesterday morning over an inch and a half of rain fell in a little over two hours. On the top of previous falls it caused the drains and gutters to overflow and the town was in flood for several hours. Great sheets of water covered the streets inches deep, and in places the water raced in torrents to get away. At Goodenough's Corner and for some distance along High and Moonee-streets there was a great sheet of water, through which cars splashed and people paddled. But Coffs is fortunate that flood waters soon get away, and that was the case yesterday.

Creeks were flooded everywhere, and along the main road flowed over bridges and blocked traffic north and south of the town. The water rose three feet over Pine Creek bridge yesterday afternoon.

Mr. D. Mulhearn's garage in Gordon-street was flooded up to the seats of the car, which was dragged out by a horse and dray for safety.

All along the coast the rain is reported to be heavy, although it was fine in Grafton this morning.

Sydney Morning Herald, Saturday 14th April 1934

The experience of the party were related to Mr Justice Halse Rogers by the Sheriffs Officer (Mr V Kinchington). He said that they got as far as Bark Hut where they found Corindi River in flood. Horses were procured with a view to crossing the creek but this was found impossible. One person accompanying the jurymen endeavoured to wade across but found he could not reach the other side. The party then proceeded about a mile further down the creek to a log crossing but found that the log had been washed away. They decided to return to Grafton. They were about the middle of Halfway Creek when the car containing the jurors stalled. They pushed it back to the road where they got another car which also stalled and had to be pushed out. The jurors were eventually taken across the creek on top of a sleeper wagon.

JURY'S ROUGH TIME

CROSSING SWOLLEN CREEKS.

ATTEMPT TO INSPECT ROADS.

GRAFTON, Friday.

A jury, which had been out to inspect some roads mentioned in a case in the Supreme Court, was compelled to return to Grafton without completing the inspection, owing to creeks being swollen.

Robert George Jackson sued Frank William Pitman for £1500 for alleged breach of contract in respect of the hauling of logs and the carting of sawn timber to and from plaintiff's sawmill at Bark Hut, in the Woolgoolga district.

After hearing the evidence and the summing-up the jury expressed a desire to see certain roads.

The experiences of the party were related to Mr. Justice Halse Rogers by the Sheriff's Officer (Mr. V. Kinchington). He said that they got as far as Bark Hut, where they found Corindi Creek in flood. Horses were procured with a view to crossing the creek, but this was found impossible. One person accompanying the jurymen endeavoured to wade across, but found he could not reach the other side. The party then proceeded about a mile further down the creek to a log crossing, but found that the log had been washed away. They decided to return to Grafton. They were about the middle of Halfway Creek when the car containing the jurors stalled. They pushed it back to the road, where they got another car, which also stalled, and had to be pushed out. The jurors were eventually taken across the creek on top of a sleeper waggon.

After discussing the situation with counsel, his Honor, with the consent of both sides, adjourned the case, and ordered that an inspection of the roads should be made by the jury under the direction of the Court.

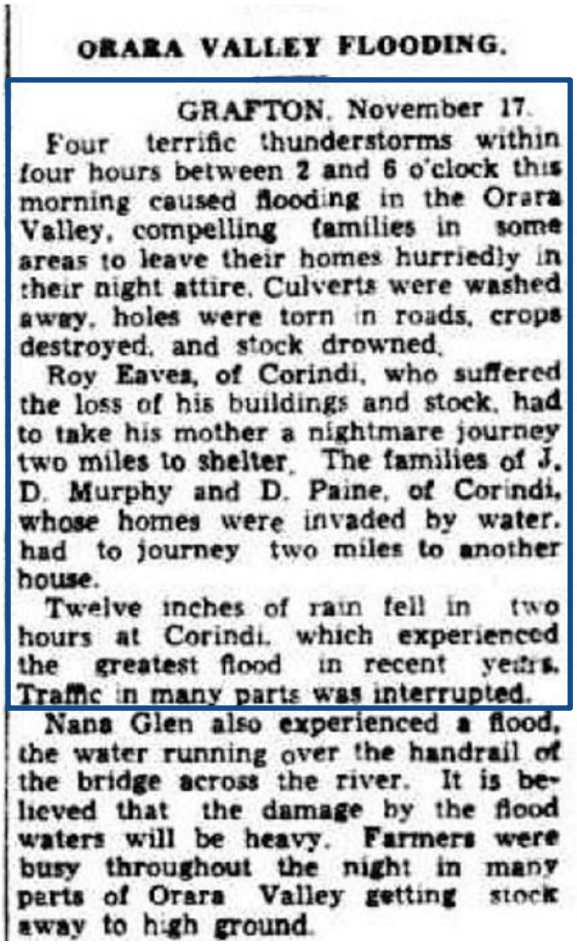
Cairns Post, Thursday 18th November 1943

Grafton, November 17th

Four terrific thunderstorms within four hours between 2 and 6 o'clock this morning caused flooding in the Orara Valley, compelling families in some areas to leave their homes hurriedly in their night attire. Culverts were washed away holes were torn in roads, crops destroyed, and stock drowned.

Roy Eaves, of Corindi, who suffered the loss of his buildings and stock, had to take his mother a nightmare journey two miles to shelter. The families of J. D. Murphy and D. Pairie, of Corindi, whose homes were invaded by water, had to journey two miles to another house.

Twelve inches of rain fell in two hours at Corindi, which experienced the greatest flood in recent years. Traffic in many parts was interrupted.



ORARA VALLEY FLOODING.

GRAFTON, November 17.

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Nana Glen also experienced a flood, the water running over the handrail of the bridge across the river. It is believed that the damage by the flood waters will be heavy. Farmers were busy throughout the night in many parts of Orara Valley getting stock away to high ground.

Barrier Miner (Broken Hill), Thursday 18th November 1943

At Corindi buildings were swept away and cattle were drowned by one of the greatest floods in the history of the North Coast. A foot of rain fell at Corindi in two hours, and homeless people were forced to spend a night of terror in the open.

Tanks Replenished On Stations By Rain At Week End

ALTHOUGH rains during the last week end did not benefit the Broken Hill district which sadly needs it, there were some heavy falls recorded in the country, especially in sections of the Wilcannia district. Some places where the tanks were low had them filled. The rain was not general enough to affect the outback situation in any considerable way, although it will do a great deal of good in the areas which had the heaviest falls.

Broken Hill did not get a point of rain, although the weather here was threatening and uncomfortable. Falls recorded outback were: Dromore up to three inches, Buckalow 105 (most of the tanks filled), Sunnydale a few points (enough to fill tanks), Burta 20, Mazar 30, Wilcannia 87, Menu Murtee 230, Netallie one inch, Yancowinna Glen 50 (all creeks ran), Kinchega 24, Kars 3, Murtee 60, Mt. Murchison 100, Culgoulia 115, Cobrillia 75.

From these falls it is seen that the heaviest rains came in on the lower half of Wilcannia and extended down towards Ivanhoe. Dromore is towards Ivanhoe.

A local stock and station agent said today: "An inch and a half fell at Ivanhoe last week. They have been having a wonderful season there."

"The driest district in the west is the Menindee area and all round Broken Hill," he said. "We need rain badly. The districts up north are faring better now. The Tibooburra stock road has improved. The Wilcannia stock road, however, is still bad because of dry weather conditions.

"Speaking generally, the position outback is that a pretty tight position has been caused by the dry weather. It is not desperate yet and stock losses, if any, would have been light, but we certainly need heavy and beneficial rains."

Over the past few months graziers in many districts have shifted large numbers of their stock through to S.A., or have sent them to the markets. This is a direct result of the drought.

FLOODS ON NORTH COAST OF STATE

SYDNEY.—More than £100,000 worth of damage to stock and property has resulted from disastrous floods in the North coastal areas, which this week was devastated by the heaviest 24 hours' downpour in [illegible] history.

At Corindi buildings were swept away and cattle were drowned by one of the greatest floods in the history of the North Coast. A foot of rain fell at Corindi in two hours, and homeless people were forced to spend a night of terror in the open.

Tuesday 7th May 1996

On the Northern Beaches the picture was the same with Woolgoolga recording 258.6mm from May 1. The heaviest recorded 24 hour period again was Friday with Woolgoolga recording 142.4mm

By MICHAEL SECOMB and LEE McDOUGALL

Much of the Mid North Coast was under flood yesterday as continuing torrential rain sent flooded creeks breaking over their banks, closed roads, washed away bridges and stranded residents.

High seas forced the 20-metre yacht, Millenium, into Coffs Harbour on Sunday after spending 10 days battling rough conditions.

The yacht, from Taree, had been fighting huge seas and was glad to reach the safety of any port, according to Senior Constable Paul Craggs, of the Water Police.

The Promised Land, north of Bellingen, may have been the wettest in the region, if not the State.

A total of 832mm of rain was recorded by Mr Cliff Schofield, who has been taking official readings for 20 years, from the start of May until 9am yesterday.

The heaviest 24-hour recording was up to 9am on Friday morning when Mr Schofield recorded 282mm.

The rain so far this May is four times the total for the entire month of May last year, when Mr Schofield recorded 209mm.

'It's certainly been a wet May although it's not the wettest on record,' Mr Schofield said.

Coffs Harbour has received almost double the May average rainfall of 164.1mm in the first six days of the month.

From May 1 to 9am yesterday, the Coffs Harbour Bureau of Meteorology had recorded a total rainfall of 307mm. Another 56mm fell between 9am and 3pm yesterday.

The heaviest 24-hour rainfall period was Friday when 151.8mm was recorded to 9am.

At Thora and Dorrigo, the rain has continued to fall heavily with Dorrigo recording 532mm from May 1 to 9am yesterday and Thora 432.6mm. Both recorded 193mm in the 24-hour period to 9am on Friday.

On the Northern Beaches the picture was the same with Woolgoolga recording 258.6mm from May 1. The heaviest recorded 24-hour period again was Friday with Woolgoolga recording 142.4mm.

The Pacific Highway yesterday was closed at Shark Creek between Ulmarra and Maclean and at Serpentine bridge north of Maclean.

The highway yesterday also was reduced to one lane at Blackadder Creek, Corindi, with police expecting the highway to be blocked completely today.

Yesterday afternoon, the highway also was closed to traffic at South Grafton and the State Emergency Service warned that a high tide last night meant a temporary levee bank constructed there was expected to break.

The Summerland Way between Grafton and Casino was open but motorists were advised to use caution.

The Bruxner Highway's Ballina-Lismore-Casino stretch was open but closed at Tabulum, while the Gwydir Highway was open. The Kyogle to Woodenbong Road was closed.

The highway was open to the south, while Waterfall Way between Bellingen and Dorrigo kept opening and closing to traffic, as showers sent waterfalls splashing across the narrow road.

Water rose over the North Bellingen bridge yesterday afternoon, stopping traffic.

The New England Highway was open to the Queensland border but the access to Brisbane was closed by a large landslide at Cunninghams Gap.

A heavy downpour about midday yesterday sent water streaming across the highway at Marcia Street, halting traffic which backed up into the City Centre.

While there was no flooding in the City Centre Mall, water in Moonee Street backed up into shops, including

To Page 2

Appendix B. Independent review of SMEC flood model

Memorandum

TO:	Greg Roggenkamp, SKM
FROM:	Rhys Hardwick Jones, Mark Babister
DATE:	12 August 2013
PROJECT NUMBER:	113052

SUBJECT: Corindi River / Blackadder Creek – Preliminary Review of Hydraulic Modelling

1. INTRODUCTION

1.1. Background

An alliance comprising Roads and Maritime Services (RMS), SKM and Aurecon is undertaking environmental impact assessment work for the Woolgoolga to Ballina section of the Pacific Highway upgrade on the NSW north coast. The section includes a crossing of the Corindi River and Blackadder Creek catchments approximately 11 km north of Woolgoolga.

The current Pacific Highway alignment crosses the Corindi River slightly upstream of low density residential areas in Corindi Beach and along Corindi Park Drive. Approximately 800 m further north, the existing road crosses an anabranch of the Corindi River, and then Blackadder Creek a further 1 km north. In February 2011, RMS made some upgrades to the existing Pacific Highway to improve safety on the bend between Blackadder Creek and the Corindi River anabranch, including changes to the bend radius and camber, and installation of safety barriers. The road was also raised to improve the flood immunity of the route, and transverse drainage culverts installed at the location.

Following a major storm event on 26 January 2012, and concern from local residents about the potential impacts of the road works on flood and drainage behaviour, RMS engaged SMEC to undertake an independent Flood Impact Review of the works (Reference 1). SMEC developed a 2D hydraulic model (TUFLOW) of the area.

As part of the ongoing Pacific Highway Upgrade program, it is proposed to realign the highway approximately 600 m further west. SKM are undertaking 2D hydraulic modelling work to assess the potential flood impacts of the revised alignment and proposed bridge configuration. The model developed by SMEC has formed the basis of preliminary environmental assessment work carried out by SKM.

1.2. Scope of Review

WMAwater have been engaged by RMS to undertake an independent review of this modelling. The focus of this review is to identify areas of the modelling that warrant further detail for the next phase of the environmental assessment. This memo documents the outcomes of a preliminary review of the TUFLOW model for existing and proposed conditions, provided by SKM on 13 July. This preliminary review has identified the following points for further investigation and detailed analysis:

- Delineation of the model extent;
- Distribution of inflows and boundary condition location; and
- Creek conveyance capacity.

A detailed review of adopted modelling parameters, model calibration and detailed aspects of model schematisation is beyond the scope of this preliminary review. These aspects will be reviewed in more detail after the next phase of modelling. However as part of the review WMAwater identified some aspects of the model schematisation that should be examined as part of the next phase of more detailed modelling work. It is quite possible that SKM has already investigated some of the issues raised in work currently being undertaken.

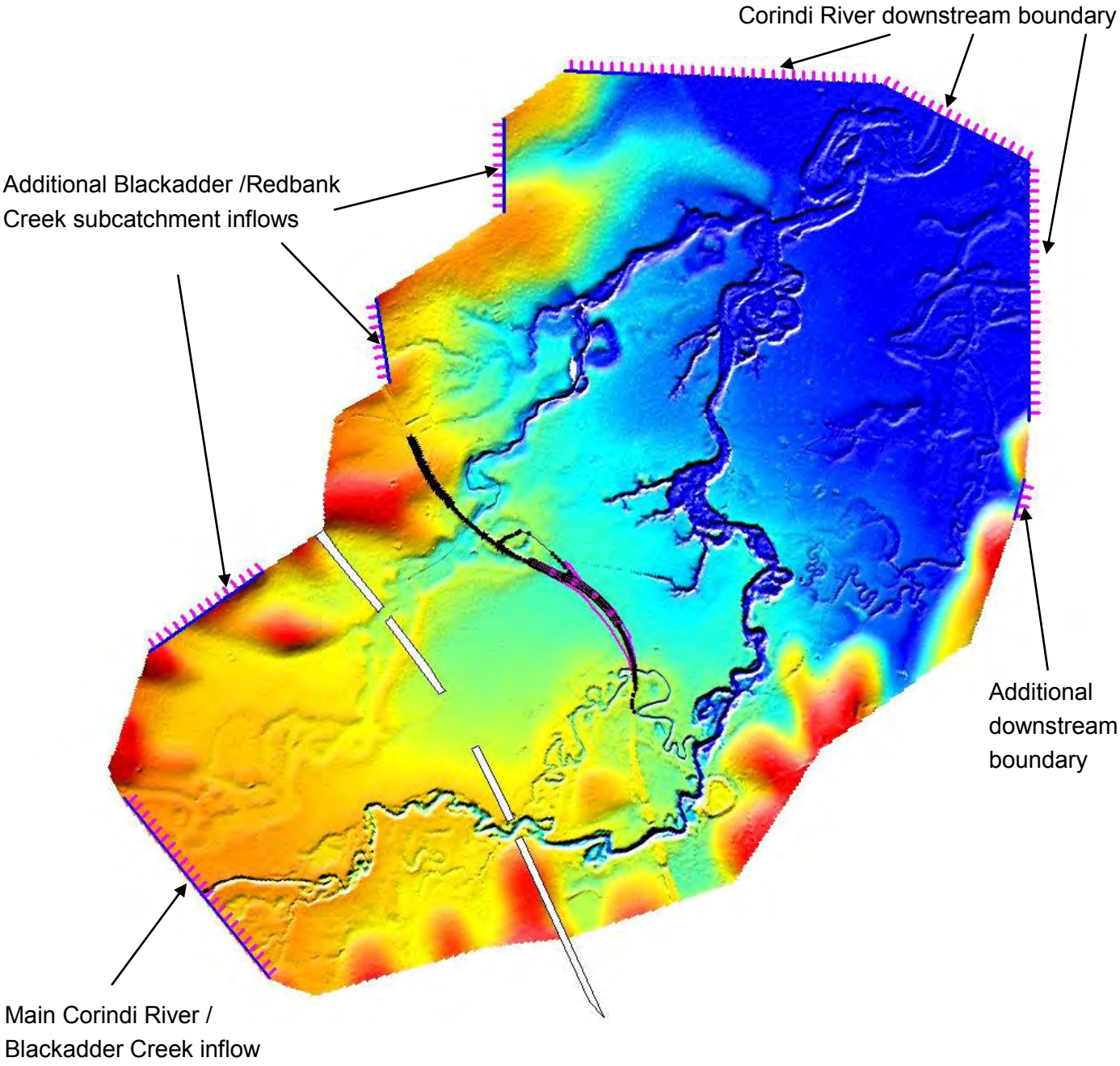
A more detailed treatment of these points is provided below.

2. MODEL REVIEW

2.1. Model Extent

The current model extent, as developed by SKM for assessment of the Blackadder Creek safety works, includes the area approximately 2 km upstream of the existing Pacific Highway alignment. On the downstream side the model extends approximately 2.6 km, or roughly halfway to the Corindi River entrance at the village of Red Rock (see Diagram 1).

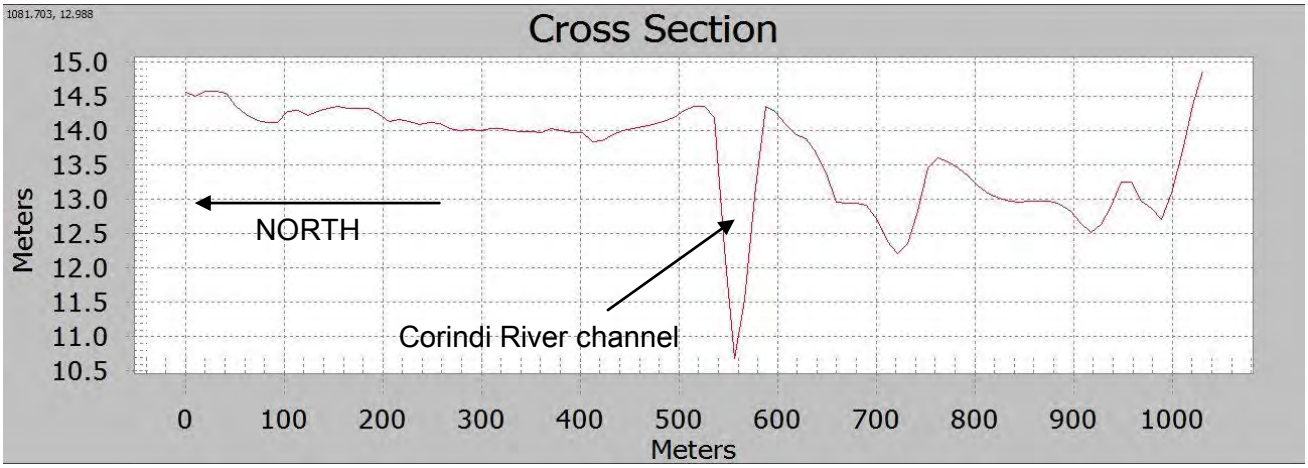
Diagram 1: TUFLOW model extent



The current model extent requires enlargement for further modelling assessment work of the proposed Pacific Highway realignment. The enlargement will be required to enable the key characteristics of the flow behaviour to be reliably understood, particularly the flow split between each of the waterway crossings, and the influence of topographic features such as the dune system and the estuary bathymetry on drainage of the lower Corindi River floodplain.

At the upstream boundary, the Corindi River inflow is currently applied at a single boundary across the floodplain. The inflow is automatically split into various parts of the floodplain by an algorithm within TUFLOW, based on the terrain at the inflow location (see Diagram 2).

Diagram 2: Cross-section at main inflow boundary



The cross-section shows a much larger waterway area to the south of the Corindi River channel (towards the right of the diagram). This results in a relatively large proportion of the inflow being allocated to the southern overbank area of the model.

The current boundary schematisation may provide a good reflection of the actual flow distribution to be expected at this location. However given the importance of the flow distribution for design of the waterway openings and estimation of the flood impacts of the proposed route, it is recommended that the boundary be moved further upstream to reduce the influence of the boundary assumptions on the flow behaviour in the area of interest. If possible, the boundary should be moved sufficiently far upstream that the inflow distribution is clear from catchment delineation.

Similarly, it is recommended that the downstream boundary be extended to include key features of the lower floodplain which may influence flood behaviour. For the purposes of this review, a digital terrain model was only provided within the existing model extent, so WMAwater are not able to identify specifically which features will require inclusion. However currently the model uses a alarge downstream boundary condition that wraps around the eastern edge of the model, and a significant outflow of water occurs through this model boundary. However it may be that the dune system or the effect of Red Rock Road on flow behaviour will require further consideration for the next modelling phase

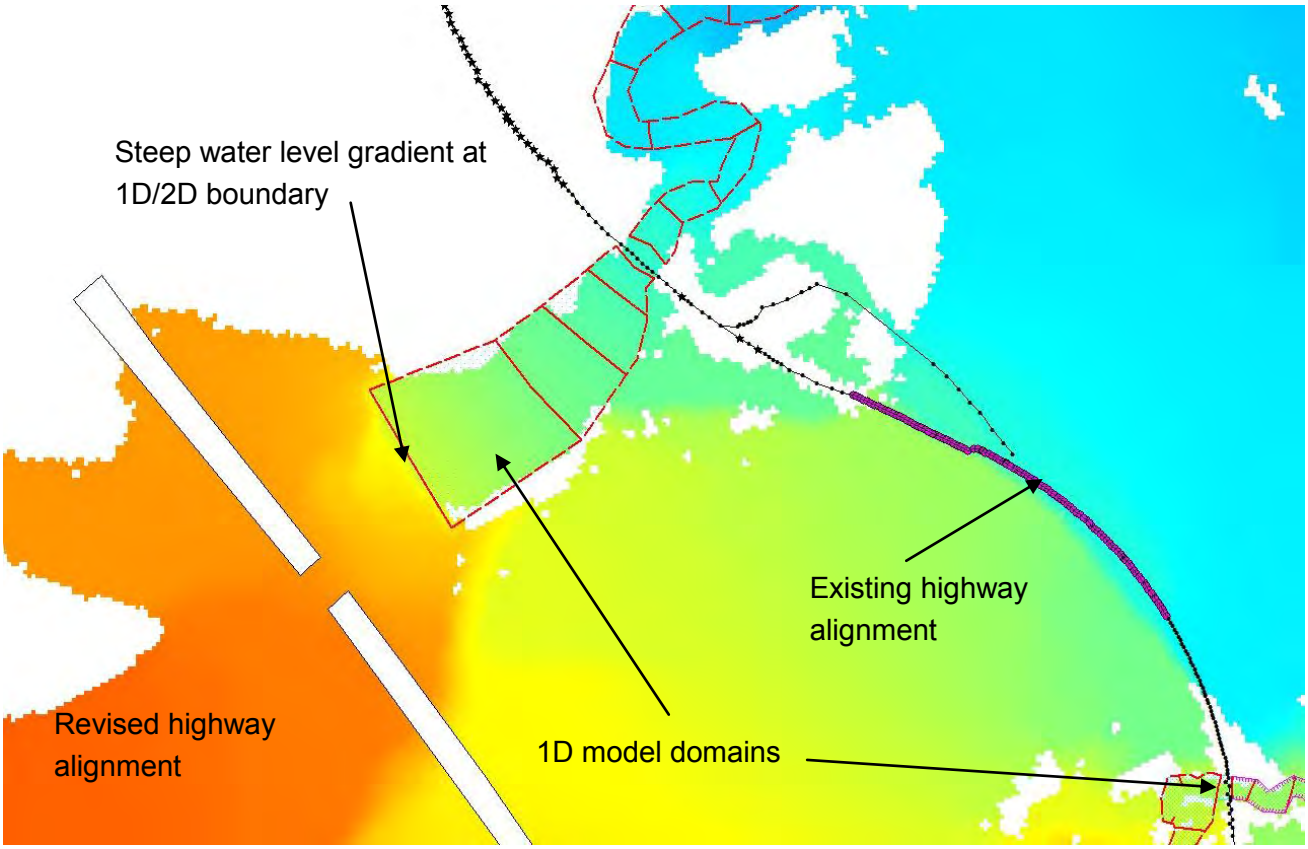
.

2.2. In-Bank Conveyance

The existing model uses a 1D/2D modelling approach to model the in-bank channel capacity of some section of Blackadder Creek and Corindi River. The areas where the 1D approach has been used are limited to the vicinity of the existing Pacific Highway alignment, as this was the main point of interest for the impact assessment undertaken by SMEC (Reference 1). However this schematisation may require adjustment for the further work to be completed by SKM.

For example, the transition from 2D to 1D modelling in Blackadder Creek occurs approximately 400 m upstream of the existing alignment, and 150 m downstream of the proposed route. Diagram 3 below shows modelled peak flood levels (blue through red representing lower levels through higher levels) in the area. It appears that the boundary between the 1D and 2D domains may have an undue influence on flood levels, with the modelled flood profile indicating a relatively steep gradient in the vicinity of the boundary.

Diagram 3: 1D model domain – Blackadder Creek



It is recommended that SKM review the 1D/2D schematisation of the creek and river channels at the road crossings. It is likely that the 1D/2D approach will be necessary to adequately represent the channel conveyance, and that the 1D domain will need to be extended so that the 1D/2D transition boundary does not occur at an area of interest.

2.3. Estuary/Entrance Behaviour

The Corindi River is classified by the Office of Environment and Heritage (OEH) as an Intermittently Closed and Open Lake/Lagoon (ICOLL). The estuary is classified as type III/5 (wave dominated barrier estuary) with a typically open entrance.

The modelling should therefore investigate the sensitivity of the results to different assumptions about entrance condition and ocean tailwater level. At present, the model assumes a normal water surface gradient at the downstream boundary which may not be reflective of the actual estuary capacity.

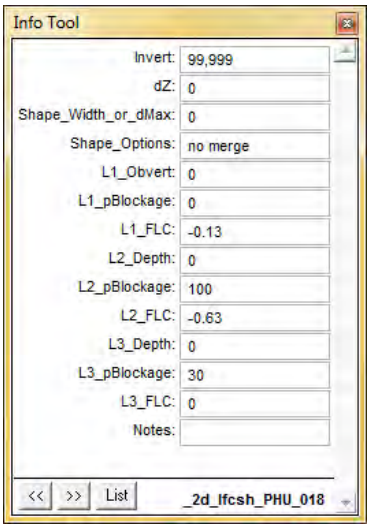
If the estuary condition and the conveyance of the Corindi River estuary prove to have a significant influence on the modelled flood behaviour, it will be necessary to undertake a more detailed assessment of the downstream boundary conditions, and potentially the inclusion of more detailed representation of the river bathymetry in the area downstream of the highway.

Cross-section and bathymetric survey of the Corindi River estuary was collected in March 2004 by the Department of Infrastructure, Planning and Natural Resources as part of the Estuary Management Program. This program is now managed by OEH, and the bathymetry survey data is available for download from the OEH website.[1]

2.4. Bridge Structure Energy Losses

Although a detailed review of the adopted modelling parameters is beyond the scope of this preliminary review, WMAwater identified that the bridge form loss coefficients, used to model the influence of sub-grid scale energy losses such as turbulence at piers, have been set to negative values in the preliminary modelling of the proposed new Pacific Highway alignment (Diagram 4).

Diagram 4: Bridge form loss coefficients



[1] http://www.environment.nsw.gov.au/estuaries/stats/CorindiRiver.htm accessed 12 August 2013

It is recommended that the implementation of these form losses be reviewed and if possible verified by alternative methods (e.g. Bradleys method or HEC-RAS) during the next modelling phase.

3. REFERENCES

1. SMEC

Blackadder Creek Safety Works – Flood Impact Review Final Report
Roads and Maritime Services, July 2012