4.2 Major Arterial Roads

4.2.1 Upper Bohle

There are various important roads across the Upper Bohle area which if flooded would have an impact on the local residents of these communities. An indication of the maximum estimated water depth over these roads within the Upper Bohle model extent is provided in Table 4-3.

Table 4-3 Flooding Affecting Main Roads within the Upper Bohle Section

ARI (year)	Water Depth (m)				
	Riverway Drive (adjacent to Yut Fay Avenue)	Allambie Lane (Spring Creek Floodway)	Allambie Lane (Bohle River Floodway)	Hammond Way (Black's Gully South)	Kelso Drive (Drain adjacent to Hammond Way)
2	-	1.33	2.76	0.23	0.34
5	-	1.78	3.19	0.44	0.48
10	0.14	2.00	3.33	0.52	0.57
20	0.15	2.25	3.52	0.63	0.65
50	0.15	2.43	3.72	0.76	0.73
100	0.15	2.53	3.82	0.85	0.80
200	0.16	2.61	3.94	0.95	0.86
500	0.16	2.72	4.11	1.09	0.95
2000	0.18	2.84	4.24	1.24	1.07
PMF	0.31	3.32	5.01	1.86	1.60

Note: It must be noted that for the purposes of the above table only water depths in excess of 0.1 m have been considered. This is due to the fact that rainfall is directly applied across the vast majority of the model extent and therefore water depths lower than this threshold can be attributed to the use of the rain-on-grid method rather than actual flooding.

4.2.2 Middle Bohle

There are various main roads and highways across the extent of the Middle Bohle model. An indication of the maximum estimated level of flooding over main roads across the Middle Bohle model extent is provided in Table 4-4.

Table 4-4 Flooding Affecting Main Roads within the Middle Bohle Section

ARI (year)	Water Depth (m)						
	Ring Road (Bohle River)	Ring Road (Little Bohle River)	Hervey Range Road (Bohle River)	Hervey Range Rd (Kern Drain)	Dalrymple Road (Bohle River)	Dalrymple Road (Kern Drain)	Shaw Road (Bohle River Tributaries)
2	-	-	0.8	-	5.04	-	-
5	-	-	1.24	-	5.51	-	0.15
10	-	-	1.47	-	5.76	-	0.48
20	-	-	1.72	-	6.04	-	0.83
50	-	-	1.94	-	6.38	-	1.43
100	-	-	2.11	0.35	6.63	0.17	1.81

ARI (year)	Water Depth (m)						
	Ring Road (Bohle River)	Ring Road (Little Bohle River)	Hervey Range Road (Bohle River)	Hervey Range Rd (Kern Drain)	Dalrymple Road (Bohle River)	Dalrymple Road (Kern Drain)	Shaw Road (Bohle River Tributaries)
200	-	-	2.21	0.43	6.84	0.28	2.08
500	0.03	0.38	2.37	0.66	7.17	0.72	2.55
2000	0.98	0.94	2.83	1.11	7.48	1.38	3.33
PMF	1.58	1.57	3.54	2.00	8.76	2.70	4.75

Note: It must be noted that for the purposes of the above table only water depths in excess of 0.1 m have been considered. This is due to the fact that rainfall is directly applied across the vast majority of the model extent and therefore water depths lower than this threshold can be attributed to the use of the rain-on-grid method rather than actual flooding.

4.3 Comparison to Previous Modelling Results

The assessment of the design runs for the Upper and Middle Bohle showed that overall the models produced as part of this study predicted higher water levels than the models developed as part of the *BPFPR 2010.* As a result of the difference in water levels, the flooding mechanism was somewhat changed across the study area.

A series of checks aimed at gaining some understanding into the differences between the two models and provide justification for the difference in flood levels/mechanisms between the previously developed Upper and Lower Bohle River models (*BPFPR 2010*) and the modelling undertaken as part of this project were undertaken. These checks included:

- Comparison between the respective model bathymetries.

  This check highlighted the difference in topography which helps explain the break out flows occurring in the modelling done as part of this study and not evident in the previous modelling (*BPFPR 2010*).

  Ground levels captured in the latest LiDAR data for the area adjacent to the Bohle River between the Ring Road and Hervey Range Road were found to be lower than those used in previous studies and therefore more susceptible to be affected by break out flows. This was investigated and a number of explanations were sort for this difference, these include;

  - More detail within the bathymetry than in the previous modelling in this area due the latest LiDAR being used to represent this area.
  - Checking the aerial photo to ensure the channel bed (Bohle River) was dry when the LiDAR was captured (to ensure the bathymetry was being represented with the most accurate data available)

- Comparison between the respective models roughness values.

  This check showed that generally roughness values were similar between the models but that some refinement had been undertaken for this study, where appropriate.

- Comparison between the boundary conditions (upstream and downstream).

  This check showed that comparable (i.e. largely similar but incorporating minor refinements where needed) boundary conditions were used for both models.

- Comparison between the discharges through the Bohle River main channel at various chainages.

  This check found the flow to be comparable at corresponding locations along the length of the channel.

- Comparison between the catchment inflows.

  This check found a few minor differences between the previously modelled Upper and Lower Bohle River model (*BPFPR 2010*) and the modelling undertaken as part of this project.

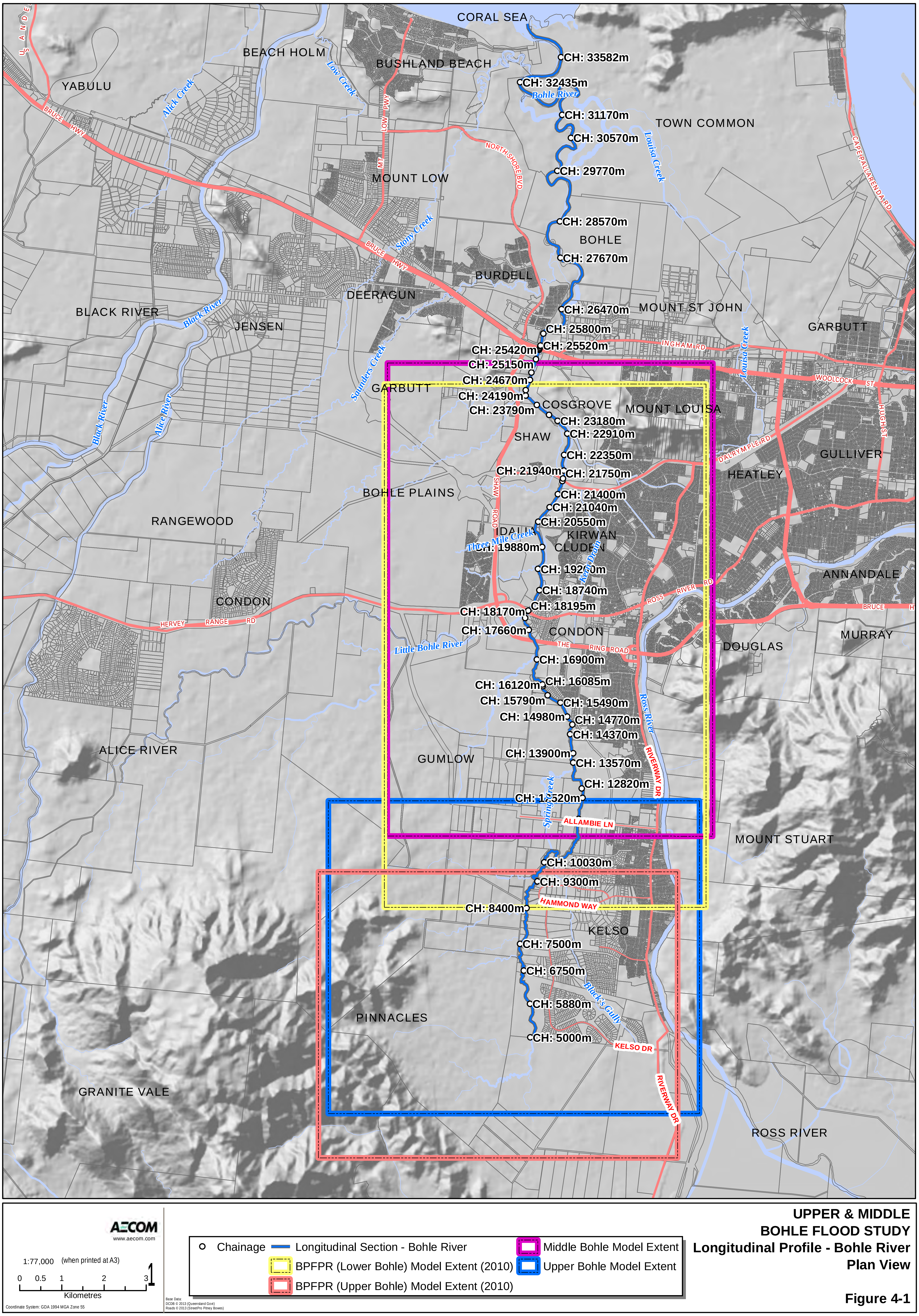
- Comparison between predicted water surface elevations.

  This check found that higher water surface levels along the Bohle River main channel were being predicted as part of this study.

- Comparison of the peak of the inflow discharge for the Bohle River main channel and the Little Bohle River.

  This check identified that for this study the peaks of the inflows occur almost simultaneously whereas during the previous study there was a lag of approximately 4 hours from the Little Bohle River to the Bohle River flow peaks. This was found to be due to the updating of the hydrologic models for these rivers, undertaken as part of this study, to account for recent developments in the area.

Results of the flood modelling undertaken as part of this project have been used to derive hydraulic grade lines for the Bohle River and the Kern Drain feeding into the Bohle River. Long-sections showing these hydraulic grade lines and how they compare to the hydraulic grade line derived for other projects undertaken in the area are shown in Appendix B. Locations of the chainages for these long sections are shown in Figure 4-1 and Figure 4-2.



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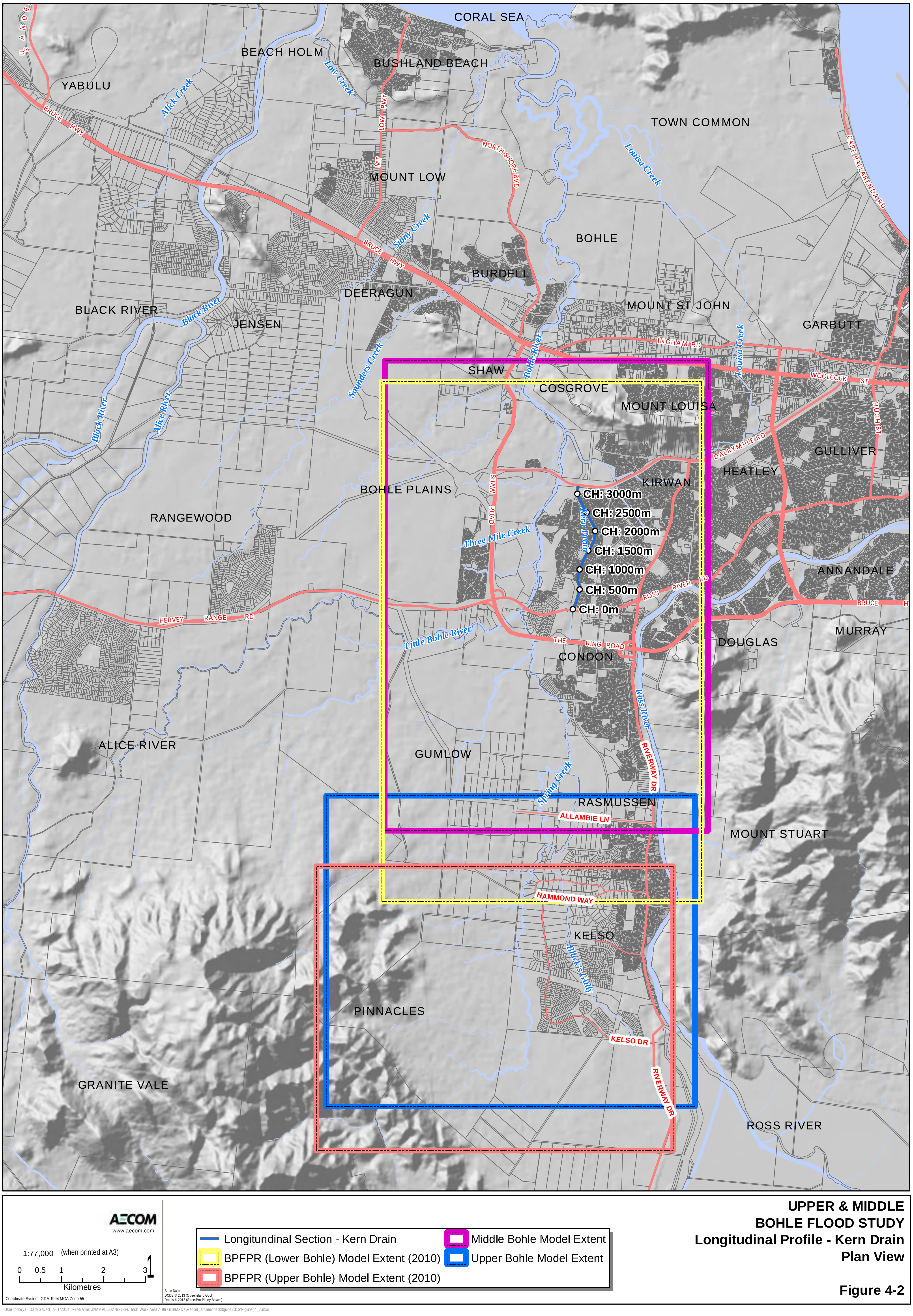
UPPER & MIDDLE BOHLE FLOOD STUDY

Longitudinal Profile - Bohle River Plan View

Figure 4-1



UPPER & MIDDLE BOHLE FLOOD STUDY
Longitudinal Profile - Kern Drain
Plan View

Figure 4-2

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5.0 Conclusions and Recommendations

5.1 Conclusions

The following conclusions are drawn from this study:

- The MIKE FLOOD model created for the Upper Bohle Flood Study was calibrated against the January 2008 storm event. Model results were found to be within an acceptable range of the recorded levels and therefore were deemed acceptable for calibration purposes.
- The MIKE FLOOD model created for Middle Bohle was also calibrated against the January 2008 storm event. Model results were found to be within an acceptable range of the recorded levels and therefore were deemed acceptable for calibration purposes. A comparison of the modelling results against recorded water levels at the Hervey Range Road gauging station for the same event showed a generally good fit thus providing additional confidence in the model.
- The Rain-on-Grid method was used across the majority of the urban areas assessed with the more traditional source points method applied through rural and relatively steep areas across the models.
- The model parameters adopted for roughness as well as initial and continuing losses are in line with those used in other studies undertaken as part of the City Wide Flood Constraints Project in the area.
- The critical durations adopted for all ARI events up to 500-yr were 6 and 12 h for Upper Bohle and 2 and 12 h for Middle Bohle.
- The critical durations adopted for the 2000-yr ARI and PMP storms were 6, 9 and 12 h for Upper Bohle and 2, 12 and 72 for the Middle Bohle.
- Break out flow from the Bohle River is predicted around the Hervey Range Road crossing during events with ARIs of 20-yr or higher.
- Break out flows from Ross River is predicted around the Riverway area during the PMP 72 h duration event (as observed in the RRFSR (*RRFSR 2013*) hydraulic modelling).
- Break out flows into Louisa Creek are expected during events with ARIs of 500 –yr or higher.
- Localised residential areas predicted to flood during events up to 50-yr ARI. Some major inundation seen throughout residential areas for larger events (100-yr ARI and greater).
- Flood levels found to be higher throughout the main Bohle River channel than previously modelled results indicate.
- A detailed review of a number of aspects associated with previous models found the main reasons for these differences to be:
    - The differences in topography between the modelling undertaken as part of this study and the previous models, mainly around the area adjacent to the Hervey Range Road Bohle River crossing, where a break out flow is seen to be occurring in the modelling undertaken in this project.
    - The timing of the peak flows for the inflow discharge hydrographs for the Bohle River and the Little Bohle River. Previously the peaks were seen to occur around 4 hours apart whereas in the modelling undertaken as part of this study the timing of the peaks coincides.

5.2 Recommendations

The following recommendations are made as part of this study:

- That the model is revisited when revised LiDAR data is available in order to provide a better representation of the topography across the study area.
- That a stream gauge is installed within the Upper Bohle section of the river to facilitate calibration of any future revisions/updates of the model.
- Local refinement of the model is undertaken if a site specific assessment of flood risk is needed.

- That opportunities to mitigate flood risk across the affected areas are sought through the implementation of strategic large scale measures such as attenuation basins, levees, etc.
- That a survey of finished floor levels across areas identified as likely to be affected by flooding is carried out / commissioned by Council to facilitate the development of suitable flood risk management strategies.

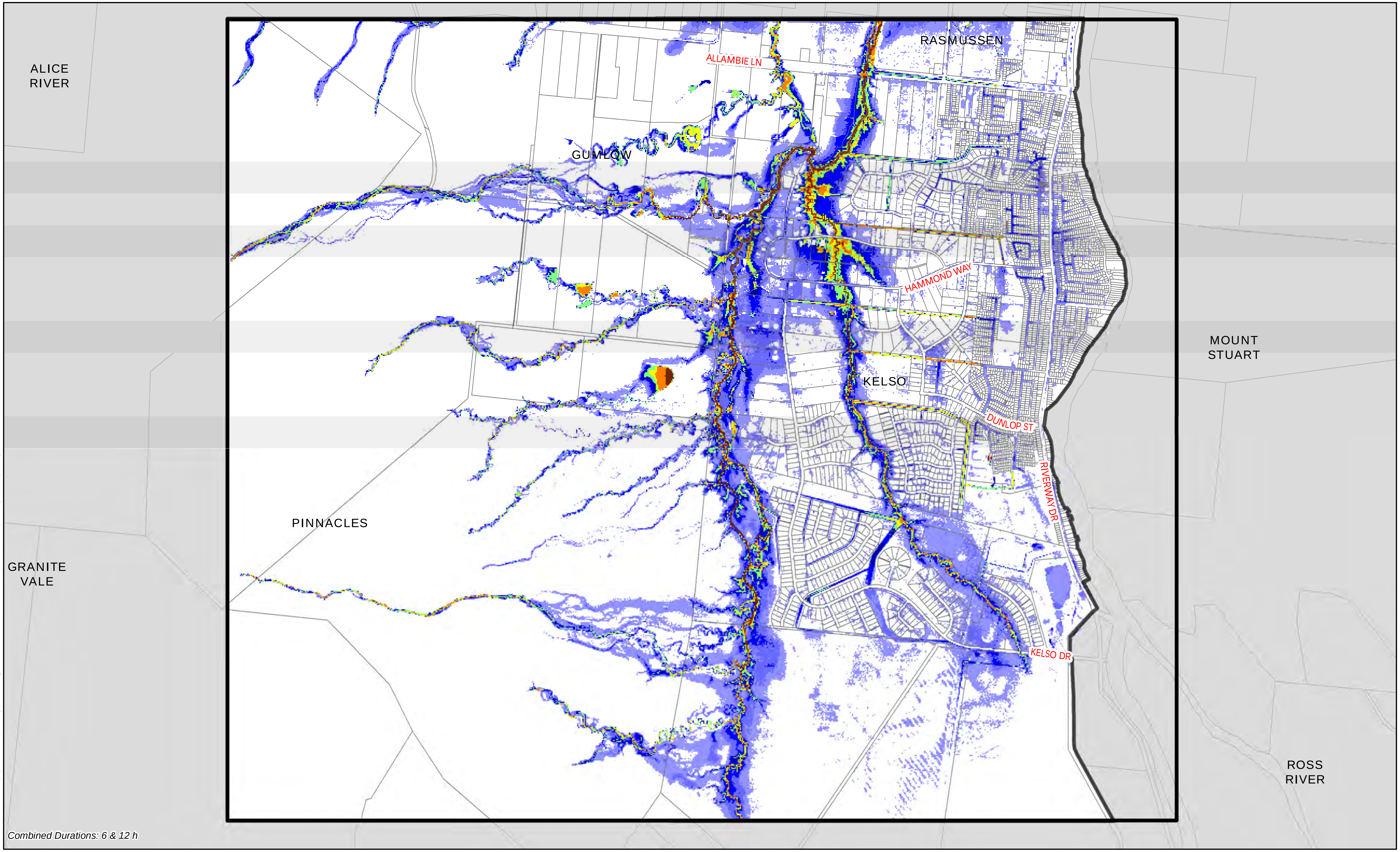
6.0 References

The following publications were used as references during the production of this study:

- Institution of Engineers Australia (1987) "*Australian Rainfall and Runoff, Volumes 1 and 2"*
- Chow (1959) "*Open Channel Hydraulics"*
- Townsville City Council (2010) "*Preparation of Flood Studies and Reports – Guidelines"*
- Bureau of Meteorology - Hydrometeorological Advisory Service (2003) "*The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method"*
- WP Software (1994) "*RAFTS-XP User's Manual"*
- DHI Software (2009) "*MIKE FLOOD 1D-2D Modelling User Manual"*
- Institution of Engineers Australia (2011) "*Rainfall-on-Grid Modelling - a Decade of Practice"*
- Townsville City Council (2013) "Ross River Flood Study Report"
- AECOM Australia Pty Ltd (2010) "*Bohle Plains Flood Planning Report"*
- Maunsell McIntyre Pty Ltd (2001) "*Bohle River Floodplain Management Study"*

Appendix A

Flood Maps



Water Depths (m)

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- 0.30 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

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Coordinate System: GDA 1994 MGA Zone 55

Base Data:
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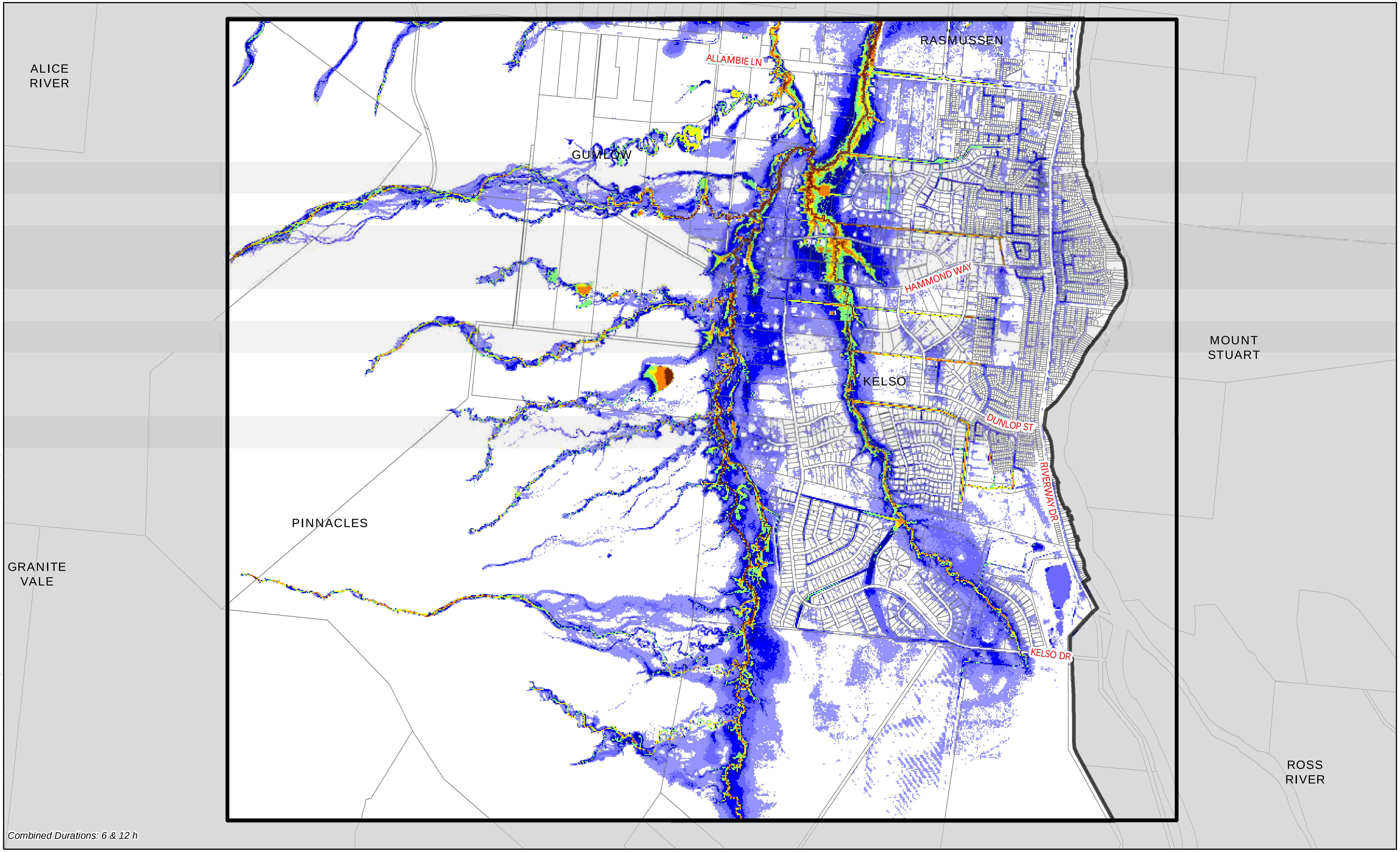
UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
2-yr ARI Base Case

Figure A-1



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Water Depths (m)

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- 0.30 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
5-yr ARI Base Case

Figure A-2

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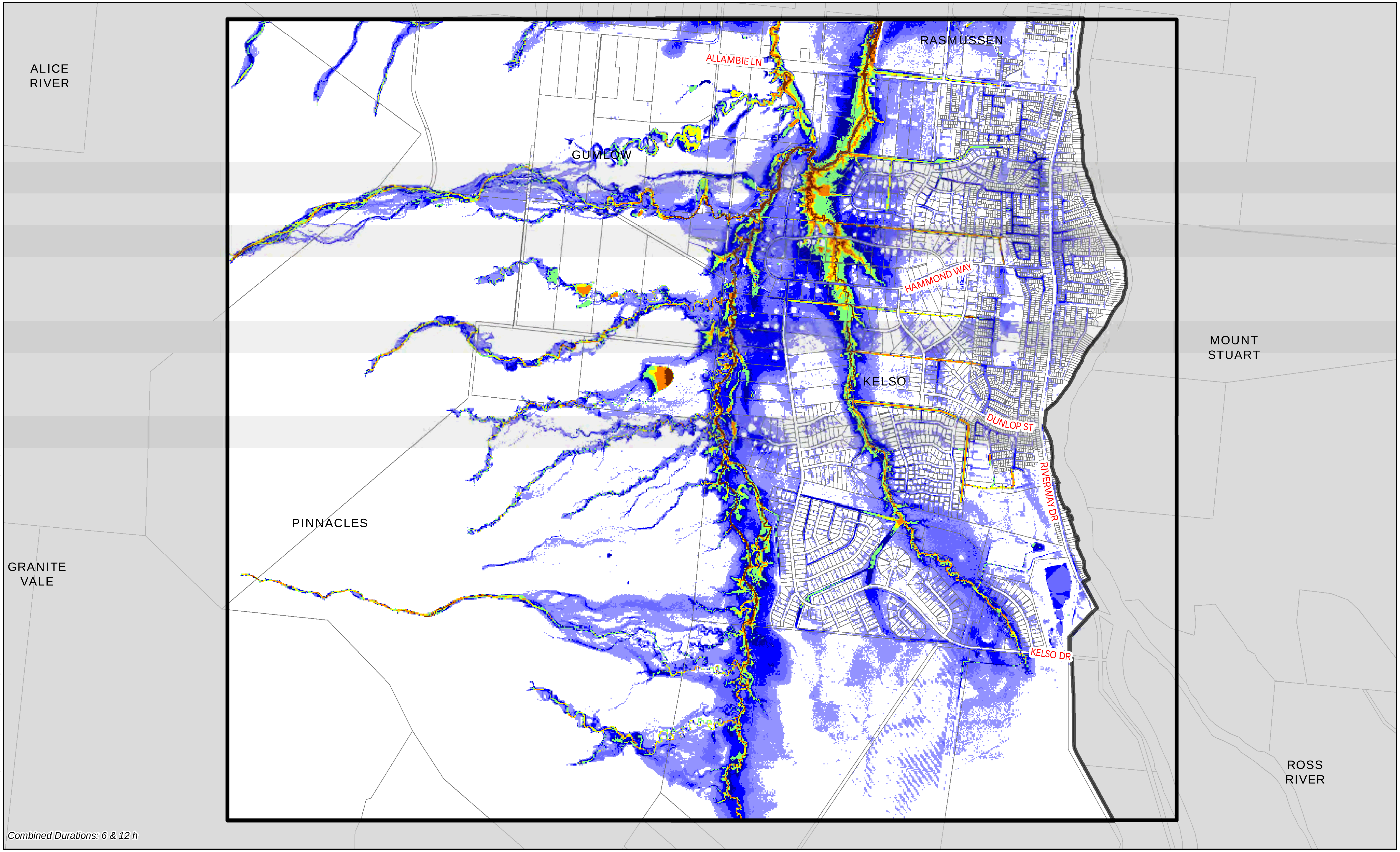

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Base Data:
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Water Depths (m)

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0.30 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
> 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
10-yr ARI Base Case

Figure A-3

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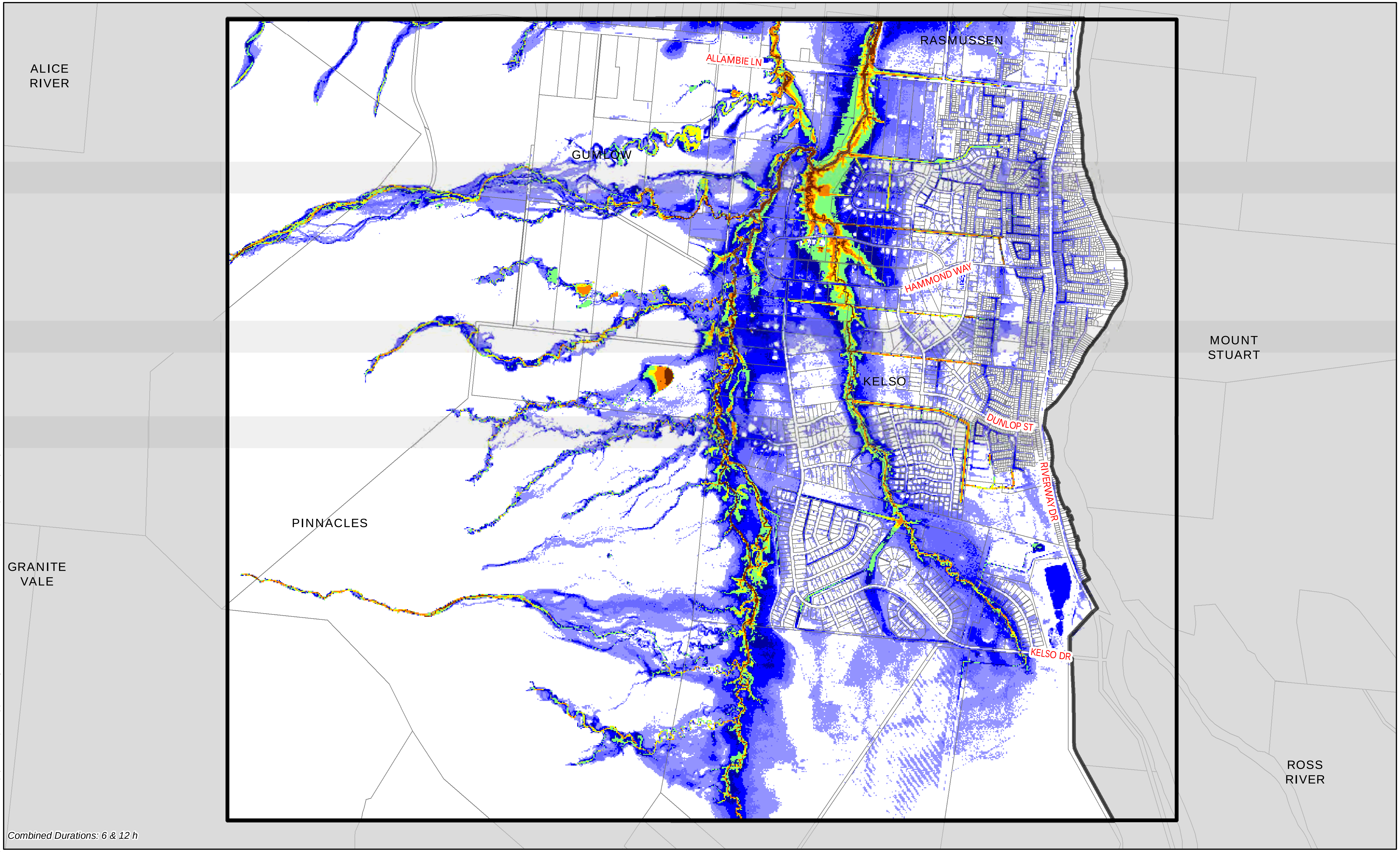
UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
20-yr ARI Base Case

Figure A-4



Water Depths (m)

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- 0.30 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

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Coordinate System: GDA 1994 MGA Zone 55

Base Data:
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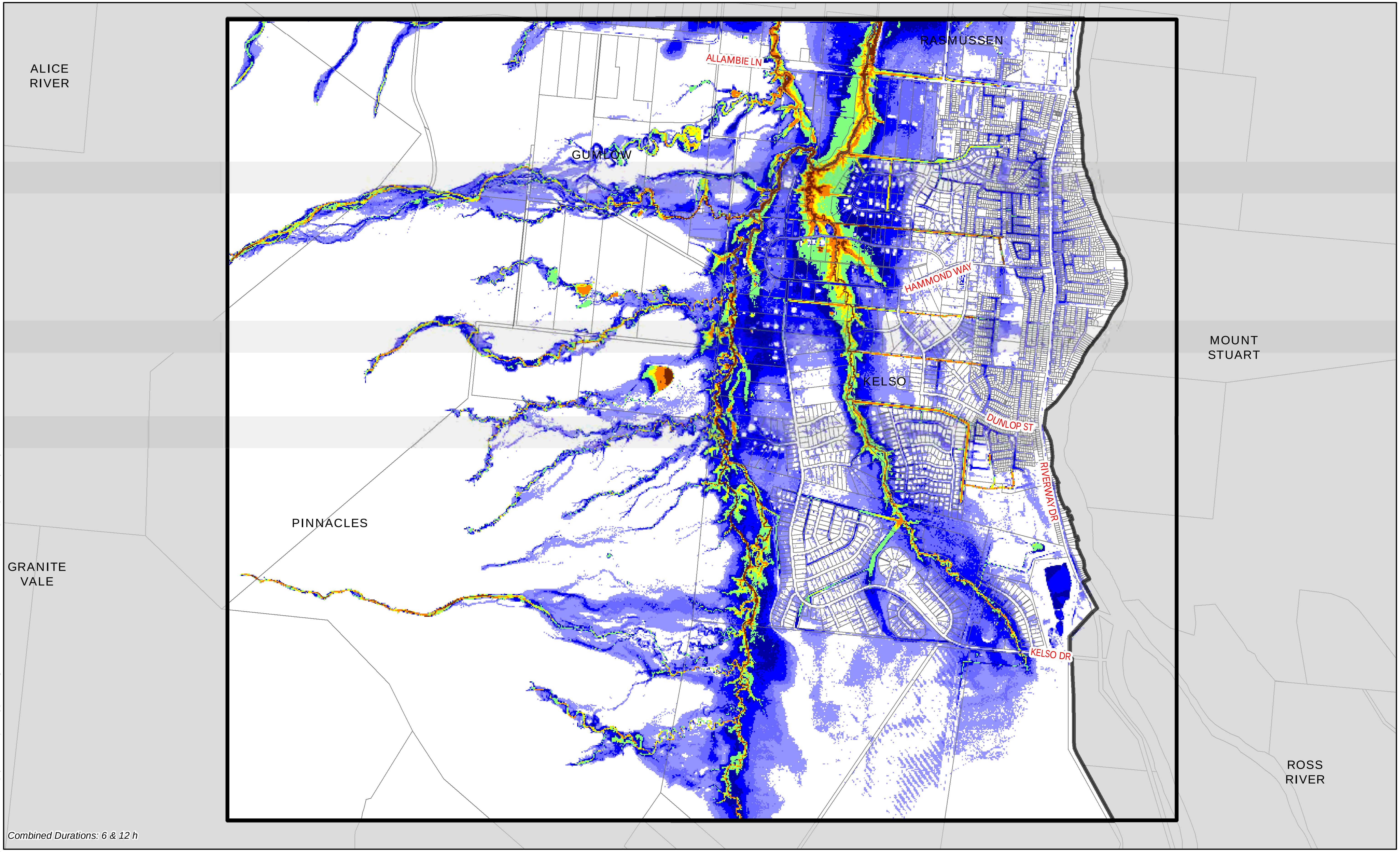

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Coordinate System: GDA 1994 MGA Zone 55

Base Data:
DCDB © 2013 (Queensland Govt)
Roads © 2013 (StreetPro Pitney Bowes)

Water Depths (m)

0.00 - 0.30
0.30 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
> 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
50-yr ARI Base Case

Figure A-5

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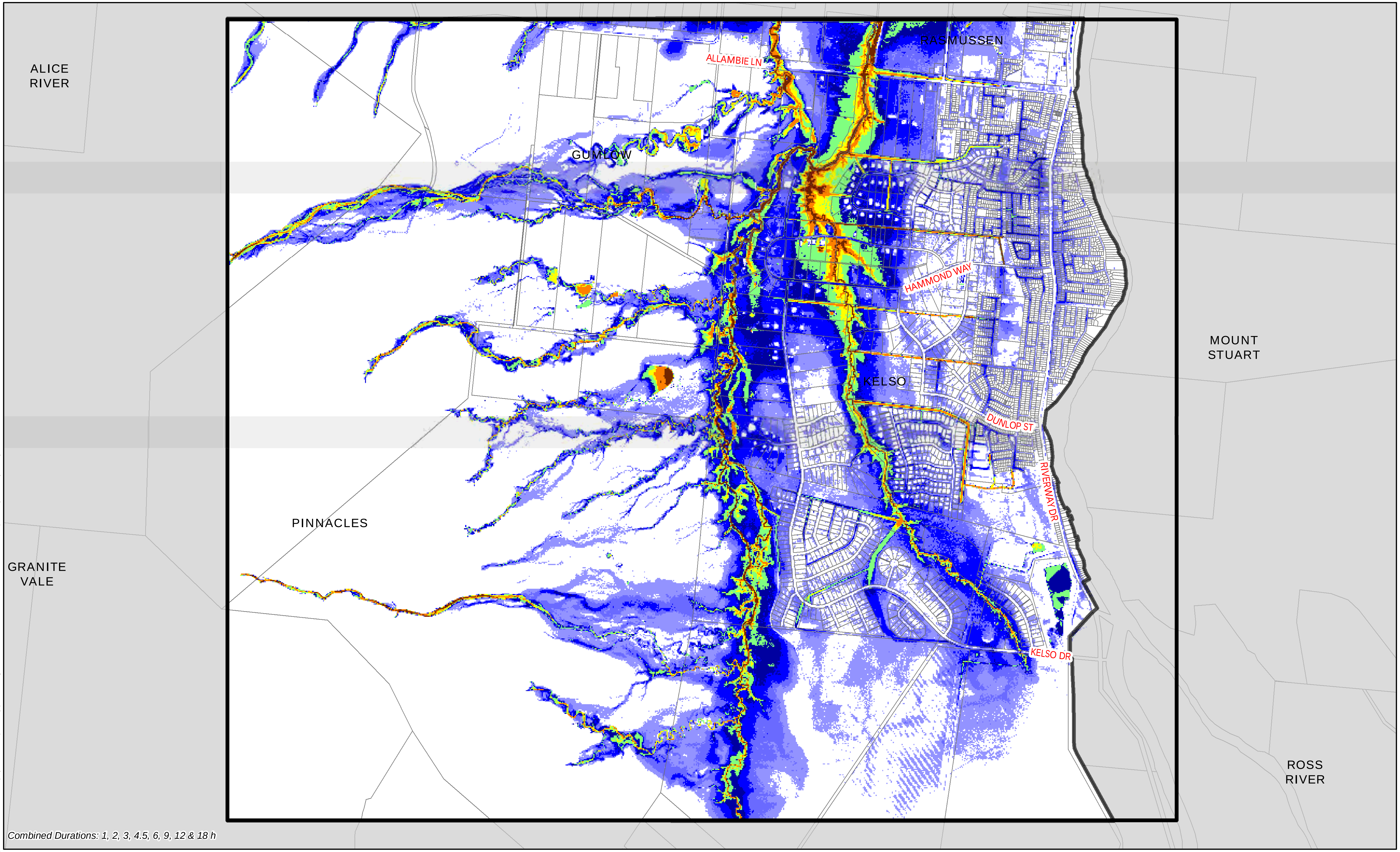

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Coordinate System: GDA 1994 MGA Zone 55

Base Data:
DCDB © 2013 (Queensland Govt)
Roads © 2013 (StreetPro Pitney Bowes)

Water Depths (m)

- 0.00 - 0.30
- 0.30 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- 2.00 - 3.00
- > 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
100-yr ARI Base Case

Figure A-6

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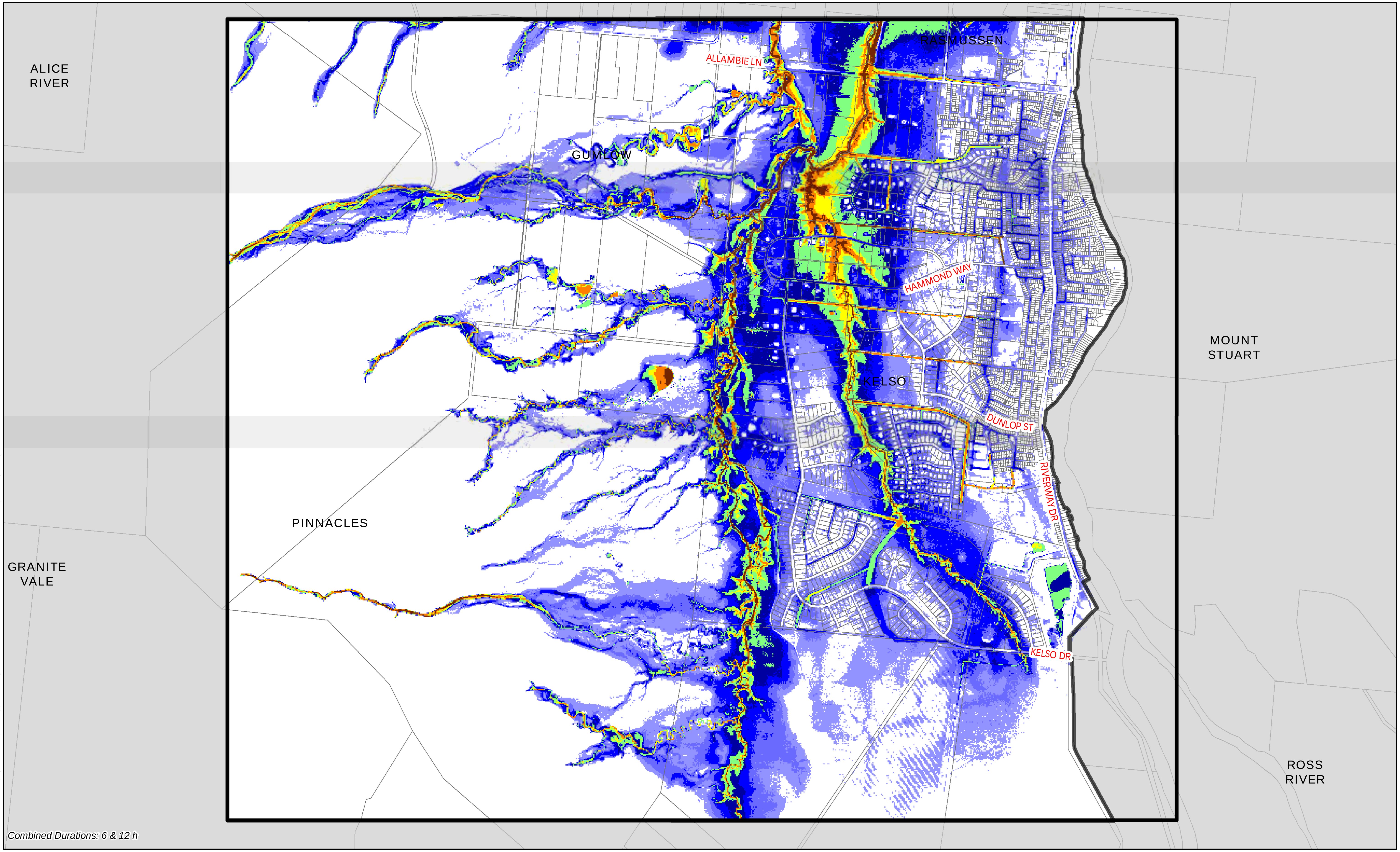

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Kilometres

Coordinate System: GDA 1994 MGA Zone 55

Water Depths (m)

0.00 - 0.30
0.30 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
> 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
200-yr ARI Base Case

Figure A-7

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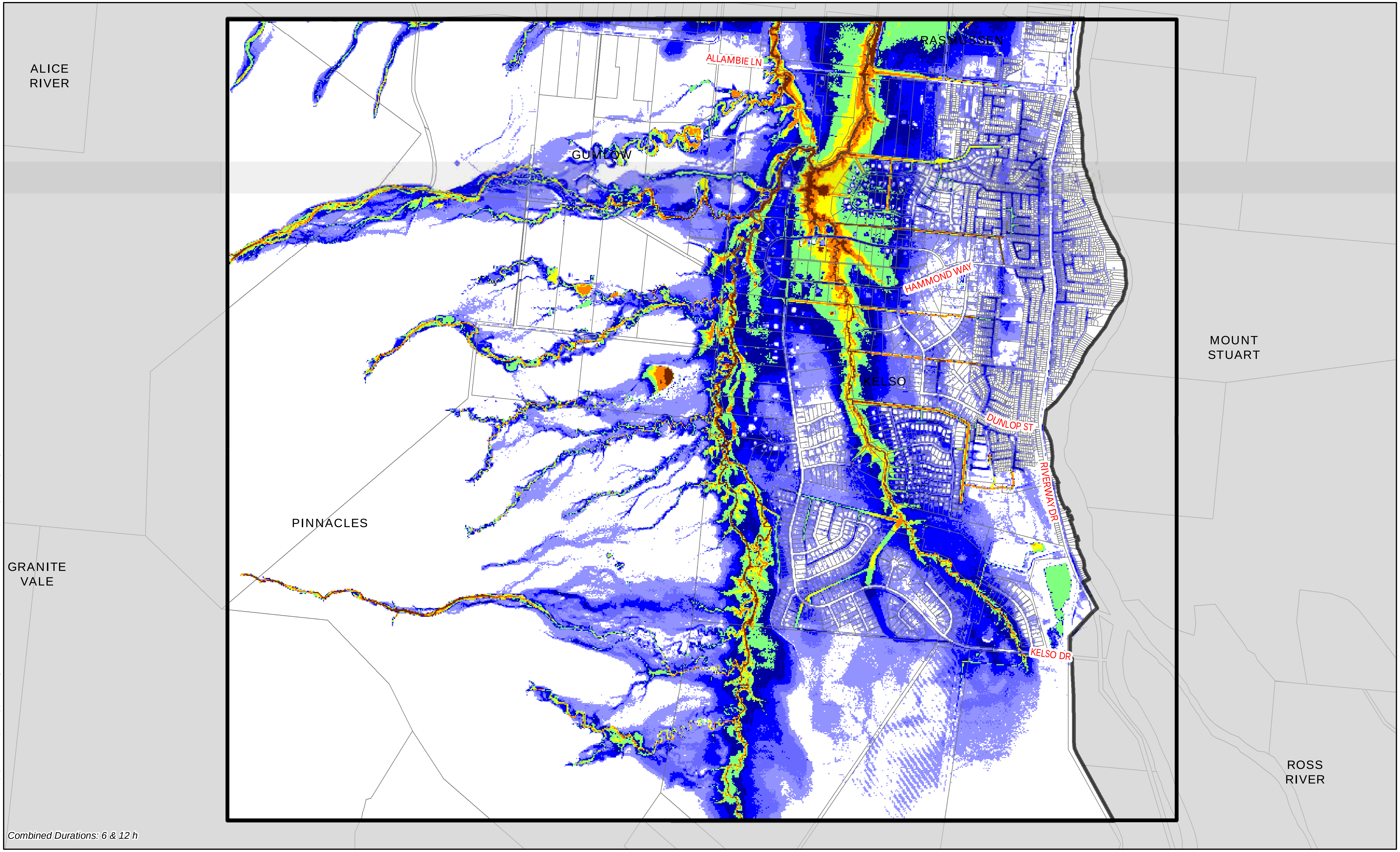

Water Depths (m)

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0.30 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
> 3.00

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Coordinate System: GDA 1994 MGA Zone 55

Base Data:
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UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
500-yr ARI Base Case

Figure A-8

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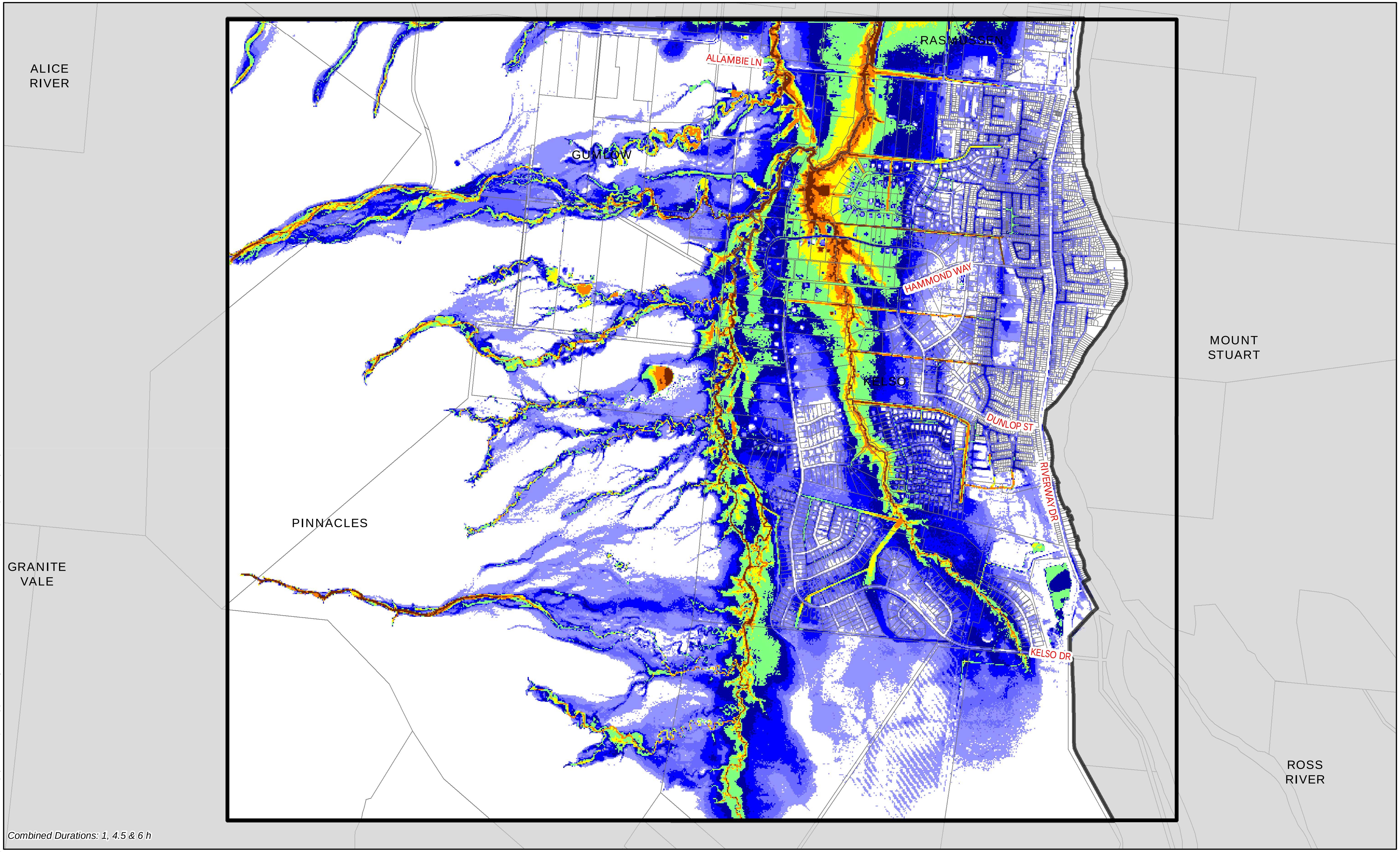

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Kilometres

Coordinate System: GDA 1994 MGA Zone 55

Base Data:
DCDB © 2013 (Queensland Govt)
Roads © 2013 (StreetPro Pitney Bowes)

Water Depths (m)

0.00 - 0.30
0.30 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
> 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
2000-yr ARI Base Case

Figure A-9

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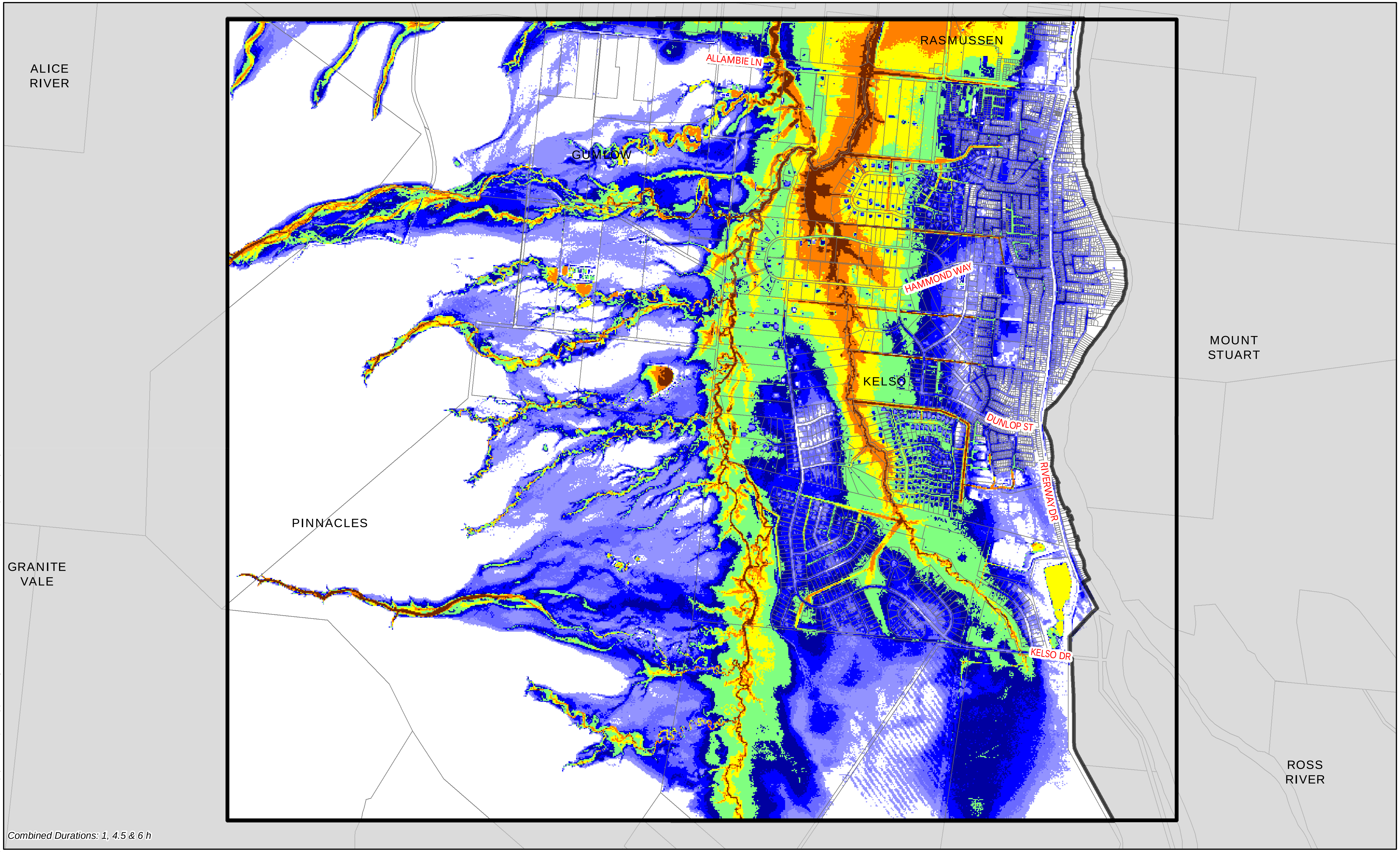

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Kilometres

Coordinate System: GDA 1994 MGA Zone 55

Base Data:
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Roads © 2013 (StreetPro Pitney Bowes)

Water Depths (m)

0.00 - 0.30
0.30 - 0.50
0.50 - 0.75
0.75 - 1.00
1.00 - 1.50
1.50 - 2.00
2.00 - 3.00
> 3.00

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Depths
PMF Base Case

Figure A-10

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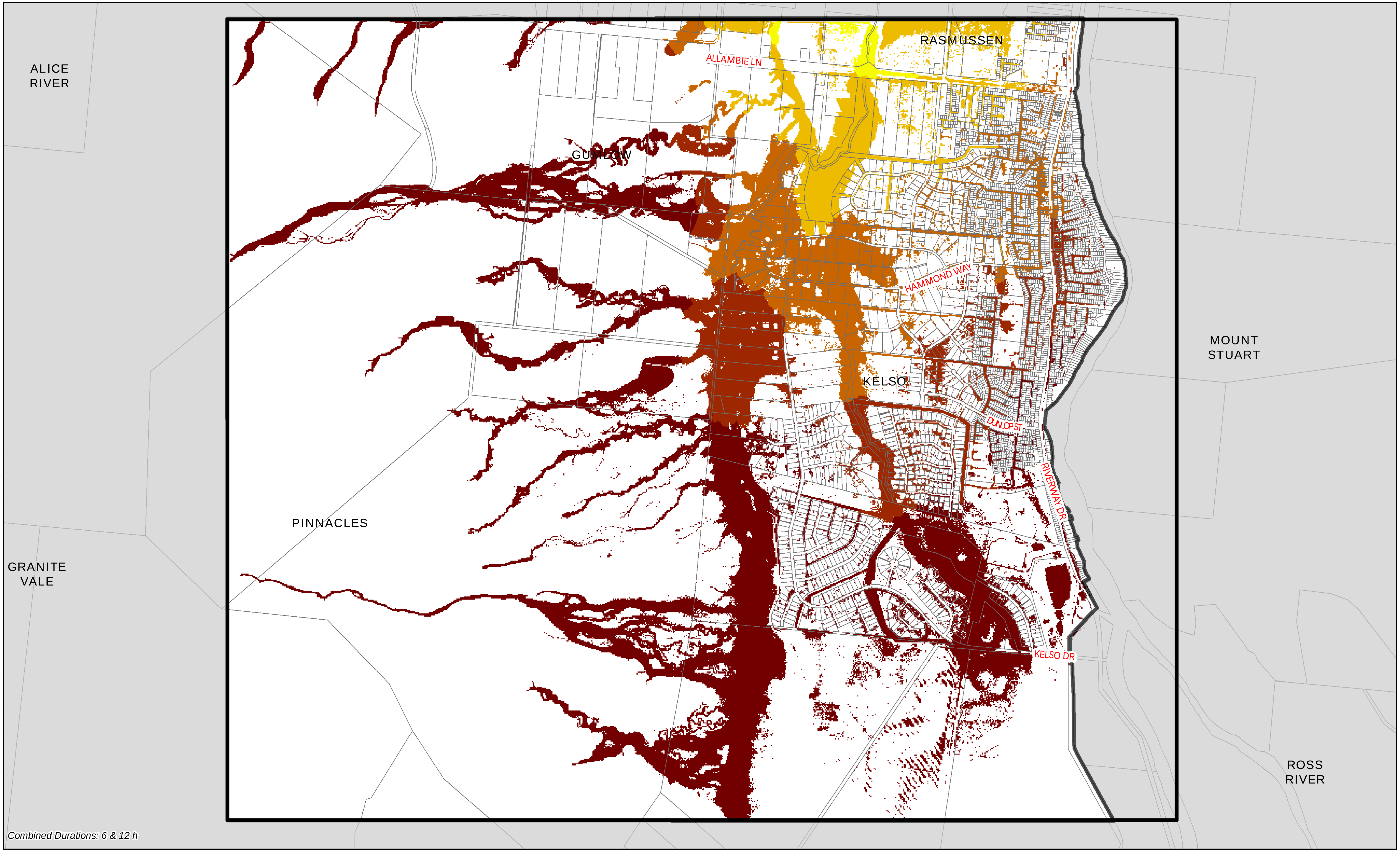

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Kilometres

Coordinate System: GDA 1994 MGA Zone 55

Base Data:
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Roads © 2013 (StreetPro Pitney Bowes)

Water Surface Levels (m AHD)

0.00 - 2.00
2.00 - 4.00
4.00 - 6.00
6.00 - 8.00
8.00 - 10.0
10.0 - 12.0
12.0 - 14.0
14.0 - 16.0
16.0 - 18.0
18.0 - 20.0
20.0 - 22.0
22.0 - 24.0
24.0 - 26.0
> 26.0

UPPER & MIDDLE BOHLE FLOOD STUDY
Upper Bohle: Maximum Water Surface Levels
2-yr ARI Base Case

Figure A-11

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