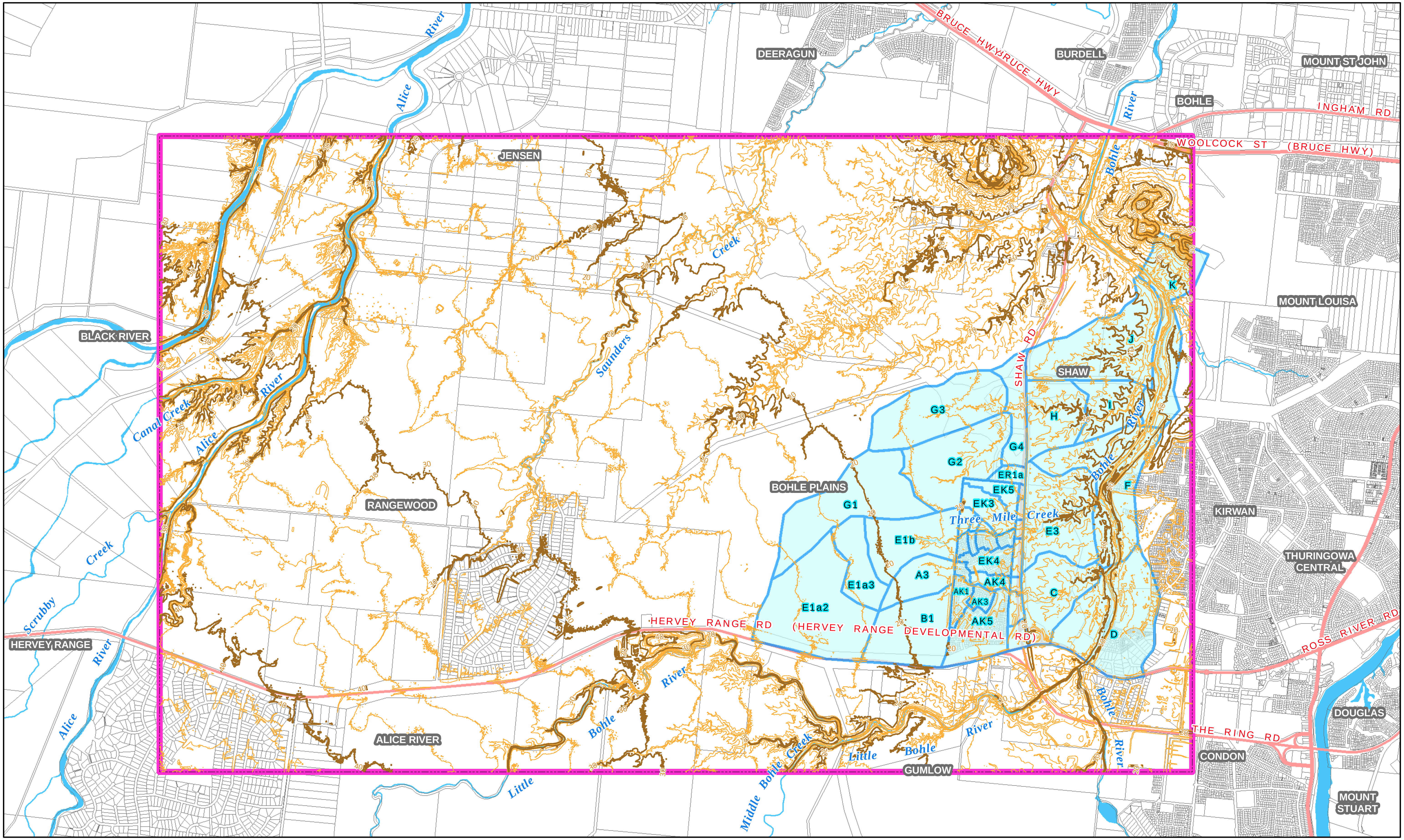

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Legend

- Model Extent
- Bohle River 1 Catchment
- Index Contours (10m)
- Contours (2m)

UPPER BOHLE PLAINS FLOOD STUDY

Bohle River 1 Catchments

Figure 3-6

3.3.2 Design Rainfall

Site specific design rainfall Intensity Frequency Duration (IFD) input parameters were determined from Volume 2 of the *Australian Rainfall and Runoff* report (ARR, 1987) as provided in Table 3-1. Standard techniques from ARR were used to determine rainfall intensities for durations up to 72 hours and up to a 100 year ARI event (Table 3-2). The design rainfall intensities developed correlate with the designed intensities developed in the *LBRFS* report.

Table 3-1 IFD input parameters

Parameter	Value
2 year ARI, 1 hour duration (mm/hr)	55.0
2 year ARI, 12 hour duration (mm/hr)	13.0
2 year ARI, 72 hour duration (mm/hr)	4.0
50 year ARI, 1 hour duration (mm/hr)	105.0
50 year ARI, 12 hour duration (mm/hr)	27.5
50 year ARI, 72 hour duration (mm/hr)	9.5
G	0.05
F2	3.93
F50	17.0
Zone	3

Table 3-2 Design Rainfall Intensities

Duration	1 Year ARI (mm/hr)	2 Year ARI (mm/hr)	5 Year ARI (mm/hr)	10 Year ARI (mm/hr)	20 Year ARI (mm/hr)	50 Year ARI (mm/hr)	100 Year ARI (mm/hr)
5 min	119	153	195	220	253	297	330
6 min	112	144	184	208	239	280	312
10 min	94	121	155	174	201	235	261
12 min	88	113	145	163	187	219	244
15 min	81	104	132	149	171	201	223
18 min	75	96	123	138	159	186	207
20 min	71	92	117	132	152	178	198
24 min	66	85	108	122	140	164	183
30 min	60	77	98	110	127	148	165
1 hr	42.7	55	70	79	91	106	118
1.5 hr	33.8	43.6	56	63	73	86	96
2 hr	28.6	36.9	47.7	54	62	73	82
3 hr	22.5	29.1	37.9	43.1	49.9	59	66
4.5 hr	17.7	23	30.1	34.3	39.9	47.3	53
6 hr	14.9	19.4	25.5	29.2	34	40.5	45.5
9 hr	11.8	15.3	20.3	23.3	27.2	32.5	36.6
12 hr	9.92	13	17.2	19.9	23.3	27.8	31.4
18 hr	7.69	10.1	13.6	15.7	18.5	22.2	25.1
24 hr	6.41	8.42	11.4	13.3	15.6	18.9	21.4
30 hr	5.54	7.3	9.95	11.6	13.7	16.6	18.9
36 hr	4.91	6.48	8.88	10.4	12.3	14.9	17.0
48 hr	4.04	5.34	7.37	8.65	10.3	12.5	14.3
72 hr	3.00	3.98	5.56	6.57	7.86	9.62	11.0

3.3.3 Probable Maximum Precipitation

The Generalised Short Duration Method (GSDM) and the Generalised Tropical Storm Method (GTSM) were used to determine the critical duration of the PMP (ARI of 1 x 10^7) for the Bohle River 1 and Bohle River 2 catchments (Table 3-3). The GSDM was used to calculate the PMP for the 1, 3 and 6 hour durations, while the GTSM was used to calculate the PMP for the 24, 36, 48, 72, 96 and 120 hour durations. The PMPs calculated for Black River, Saunders Creek and Stony Creek catchment correlate with the *LBRFS* report.

Table 3-3 Probable Maximum Precipitation Depths

Duration (hrs)	Probable Maximum Precipitation (mm)	
	Combined Bohle River 1 and Bohle River 2	Black River, Stony Creek and Saunders Creek
1	414	291
3	595	461
6	756	592
24	1655	1500
36	1996	1740
48	2336	2000
72	2969	2450
96	3334	2770

The critical duration for the PMP flood was determined to be 3-hours for the combined catchment of the Black River, Saunders Creek and Stony Creek from the *LBRFS*. The critical storm duration for the combined catchment of Bohle River 1 and Bohle River 2 was determined to be 1-hour (Table 3-4). The difference in critical storm duration for both combined catchments is due to difference in catchment size, topography and roughness.

Table 3-4 PMP Peak flows at combined catchment of Bohle River 1 and Bohle River 2

Peak flow (m3/s)		
Catchment	Bohle River 1	Bohle River 2
Duration	Node k	Node
1	940	1420
3	918	1300
6	689	977
24	348	745

3.3.4 Rainfall Loss

Initial and continuing loss values represent infiltration and storage of runoff in surface depressions within XP-RAFTS. Loss values for the five main catchments in this study were based on those determined through model calibration of the same catchments as documented in the LBRFS and the BPFPS reports (Table 3-5).

Table 3-5 Initial and Continuing Loss Values

Catchment	Initial Loss (mm)	Continuing Loss (mm)
Black River	15	2.5
Stony Creek	15	2.5
Saunders Creek	15	2.5
Bohle River 1	15	2
Bohle River 2	15	2

3.3.5 Channel Routing / Link Lagging

The Muskingum-Cunge routing method was used to route hydrographs between non-urbanised sub-catchments. The method uses a defined channel geometry, length and slope to determine the appropriate routing time for the hydrograph. The parameters were based on previous models used in the *BPFPS, LBRFS* and updated where necessary to accommodate revised catchment delineations and topographic data.

Hydrographs were routed by lagging for the highly urbanised areas. Lagging maintains the hydrograph shape and provides for a lag between sub-catchments, which is characteristic of urban drainage systems. Lag time was determined from channel length and average velocity. Velocities of 0.5 m/s and 1 m/s were used for rural and urban areas, respectively.

3.3.5.1 Urbanised Channel Routing Verification

The Rangewood development was the only development within the study area that had not been re-delineated to account for urbanisation. The Bohle 1 catchment hydrological delineation was refined within the Rangewood development area to better define flows through the development. Channel routing assumptions for the urbanised catchments were verified by comparing peak flows with Rational Method Peak flows (Table 3-6)**.** The verification shows that the XP-RAFTS peak flows are generally less than the Rational Method peak flows, but within an acceptable percentage.

Table 3-6 Rangewood Catchments Verification

Sub-catchment	Peak Runoff [m^3/s]		Differences (%)
	XP-RAFTS	Rational Method	
RW1	13	13	3
RW2	32	34	5
RW3	33	34	3
RW5	8.4	8.4	0

3.3.6 Design Storm Flows

The 1, 3, 6, 12 and 24 hour durations were selected to determine the critical storm duration for the 50 and 100 year ARI storm events (Tables 3-7 through 3-11). Other durations were eliminated based on the upstream *LBRFS* modelling effort. The results indicate that the critical duration for the 50 and 100 year ARI storm event is predominantly 24 hour event, which correlates with the *LBRFS* report. The peak flow results are presented in Table 3-12 for the different ARI storm events

The critical duration for the PMP flood was determined to be 3 hours for the combined catchment of the Black River, Saunders Creek and Stony Creek. The critical storm duration for the combined catchment of Bohle River 1 and Bohle River 2 was determined to be 1 hour. The difference in critical storm duration for both combined catchments is due to difference in catchment size, topography and roughness.

Table 3-7 Base-case peak flows of the Black River

	Peak Flow (m^3/s)			
Node	B6-b-2		A5-1	
Duration (hours)	50 yr ARI	100 yr ARI	50 yr ARI	100 yr ARI
1	1170	1370	971	1090
3	1750	2050	1350	1550
6	1780	2030	1260	1450
12	1810	2050	1280	1470
24	1830	1880	1390	1680

Table 3-8 Base-case peak flows at node S1-7aCL of the Stony Creek

Duration (hours)	Peak Flow (m^3/s)	
	50 yr ARI	100 yr ARI
1	177	208
3	235	272
6	217	253
12	218	252
24	242	281

Table 3-9 Base-case peak flows at node SA-5 of the Saunders Creek

Duration (hours)	Peak Flow (m^3/s)	
	50 yr ARI	100 yr ARI
1	105	123
3	173	201
6	184	214
12	184	215
24	190	224

Table 3-10 Base-case peak flows at node k of the Bohle River 1

Duration (hours)	Peak Flow (m^3/s)	
	50 yr ARI	100 yr ARI
1	138	161
3	205	137
6	193	223
12	196	227
24	217	255

Table 3-11 Base-case peak flows at node B17 of the Bohle River 2

Duration (hours)	Peak Flow (m3/s)	
	50 yr ARI	100 yr ARI
1	186	222
3	278	324
6	247	311
12	283	330
24	296	312

Table 3-12 Base-case peak local flows at downstream extent of major catchments

Catchment	Node	Peak flows(m3/s)						
		2 yr ARI	5 yr ARI	10 yr ARI	20 yr ARI	50 yr ARI	100 yr ARI	PMP
Black River	B6-b-2	736	1140	1390	1730	1830	2050	5030
Black River	A5-1	547	858	1030	1280	1390	1680	4410
Stony Creek	S1-7aCL	177	235	217	218	242	281	693
Saunders Creek	SA-5	69	108	132	165	190	224	599
Bohle River 1	k	138	193	205	196	217	255	918
Bohle river 2	B17	102	166	208	262	296	330	1270

3.3.7 Comparison with Previous Models

Peak flow volumes were compared with the *LBRFS* and updates to previous hydrological models had the following effects:

- increased the overall volume of runoff and peak flow for the Black River catchment by 0.17% and 3.7%, respectively;
- decreased the overall volume of runoff and peak flow for the Stony Creek catchment by 3% and 5.5%, respectively;
- increased the overall volume of runoff and peak flow for the Saunders Creek catchment by 3.2% and 2.1%, respectively due to urbanisation of Rangewood;
- increased the overall volume of runoff and peak flow for the Bohle River 2 catchment by 2.8% and 4.9%, respectively due to urbanisation in Rangewood.

3.4 Future Urbanisation Hydrology

The future urbanised scenario is based on the development of Bohle Plains. It was assumed that any areas less than 15% slope, not currently developed and outside the Gumlow Quadrant are developable. The residential level of development was simulated by decreasing the rough coefficient from 0.05 to 0.025 and changing the impervious area from 0.01 to 70 percent. Sub-catchment parameters are provided in **Appendix A**.

3.4.1 Urbanised Case Design Storm Flows

The 1, 3, 6, 12 and 24 hour durations were selected to determine the critical duration for the 50 and 100 year ARI storm events (Tables 3-13, 3-15, 3-17, 3-19 and 3-20) and difference from the base-case are presented in Tables, 3-14, 3-16, 3-18 and 3-21. Other durations were eliminated based on the upstream *LBRFS* modelling effort. The results indicate that the critical duration for the 50 and 100 year ARI storm event ranges between the 1 and 24-hour events, which correlates with the *LBRFS* report.

Table 3-13 Future urbanisation case peak flows of the Black River

Peak flow (m3/s)				
Node	B6-b-2		A5-1	
Duration (hr)	50 yr ARI	100 yr ARI	50 yr ARI	100 yr ARI
1	1230	1450	1010	1080
3	1860	2010	1360	1560
6	1850	2100	1300	1500
12	1890	2140	1320	1520
24	1950	1890	1440	1690

Table 3-14 Comparison of Downstream extent for critical storm duration - Black River

Sub-catchment	Peak Flow 50 yr ARI		Difference (%)	Peak Flow 100 yr ARI		Difference (%)
	Base-case	Urbanized case		Base-Case	Urbanized case,	
B6-b-2	1829	1954	7	2047	2144	5
A5-1	1394	1441	3	1676	1689	1
OUTLET	3621	3796	5	3996	4094	2

Table 3-15 Future urbanisation case peak flows at node S1-7aCL of the Stony Creek

Peak flow (m3/s)		
Node	S1-7aCL	
Duration	50 yr ARI	100 yr ARI
1	251	289
3	286	326
6	273	310
12	257	296
24	266	304

Table 3-16 Comparison of Downstream extent for critical storm duration - Stony Creek

Sub-catchment	Peak Flow 50 yr ARI		Difference (%)	Peak Flow 100 yr ARI		Difference (%)
	Base-case	Urbanized case		Base-case	Urbanized case,	
S1-7aCL	242	286	18	281	326	16
OUTLET	262	299	14	304	350	15

Table 3-17 Future urbanisation case peak flows at node SA-5 of the Saunders Creek

Node	SA-5	
Duration	50 yr ARI	100 yr ARI
1	257	282
3	303	338
6	276	315
12	277	318
24	305	346

Table 3-18 Comparison of Downstream extent for critical storm duration - Saunders Creek

Sub-catchment	Peak Flow 50 yr ARI		Difference (%)	Peak Flow 100 yr ARI		Difference (%)
	Base-case	Urbanized case,		Base-case	Urbanized case	
SA-5	190	305	60	224	346	55
OUTLET	246	360	46	284	406	43

Table 3-19 Future urbanisation case peak flows at node k of the Bohle River 1

Node	Outlet – BR1	
Duration	50 yr ARI	100 yr ARI
1	262	301
3	279	318
6	262	276
12	243	273
24	266	307

Table 3-20 Future urbanisation case peak flows at node B17 of the Bohle River 2

Node	Outlet – BR2	
Duration	50 yr ARI	100 yr ARI
1	316	371
3	364	416
6	318	370
12	309	362
24	364	422

Table 3-21 Comparison of Downstream extent for critical storm duration - River 1 and Bohle River 2

Sub-catchment	Peak Flow 50 yr ARI		Difference (%)	Peak Flow 100 yr ARI		Difference (%)
	Base-case	Urbanized case,		Base-case	Urbanized case	
K (Bohle River 1)	217	279	28	255	318	25
B17 (Bohle River 2)	296	364	23	330	422	28

4.0 Hydraulic Assessment

4.1 Overview

A MIKE FLOOD hydraulic model for the Upper Bohle Plains area has been constructed to assess flooding for the base-case and future urbanisation scenarios. The extent of the model is shown in Figure 4-1 along with the overlap with the *LBRFS* model extents. The floodplain was modelled using MIKE21 while structures and large open channel drains were modelled in MIKE11. A MIKE21 topographic grid was created from digital elevation data supplied by TCC. Details of structures included in the MIKE11 model were based on as constructed plans and site visits. Flow hydrographs generated from the XP-RAFTS hydrologic model and extracted from the *LBRFS* model for both the existing and future urbanised scenarios were applied at boundaries and source points within the study area.

4.2 MIIKEFLOOD Hydraulic Model

MIKE FLOOD is a numerical hydraulic model developed by the Danish Hydraulic Institute (DHI). The model dynamically couples the one-dimensional river hydraulics model MIKE11 with the two-dimensional surface water model MIKE21. Outputs from MIKE FLOOD include GIS compatible maps of flood extents, water depth, water level, flow and velocities.

4.2.1 MIKE11

MIKE11 is a software package used for the one-dimensional simulation of flows, water quality and sediment transport in estuaries, rivers, irrigation systems, channels and other water bodies. The model is typically used to assess one-dimensional flows through structures such as bridges and culverts for the detailed design, management and operation of both simple and complex river and channel systems where one-dimensional flow predominates.

4.2.2 MIKE21

MIKE21 is a two-dimensional model which determines the flow distribution based on water levels and ground levels at each time step in the model run. The two-dimensional model provides a more accurate determination of the extent, magnitude and direction of the flood flows without the need to pre-determine the flow path.

4.3 Model Development

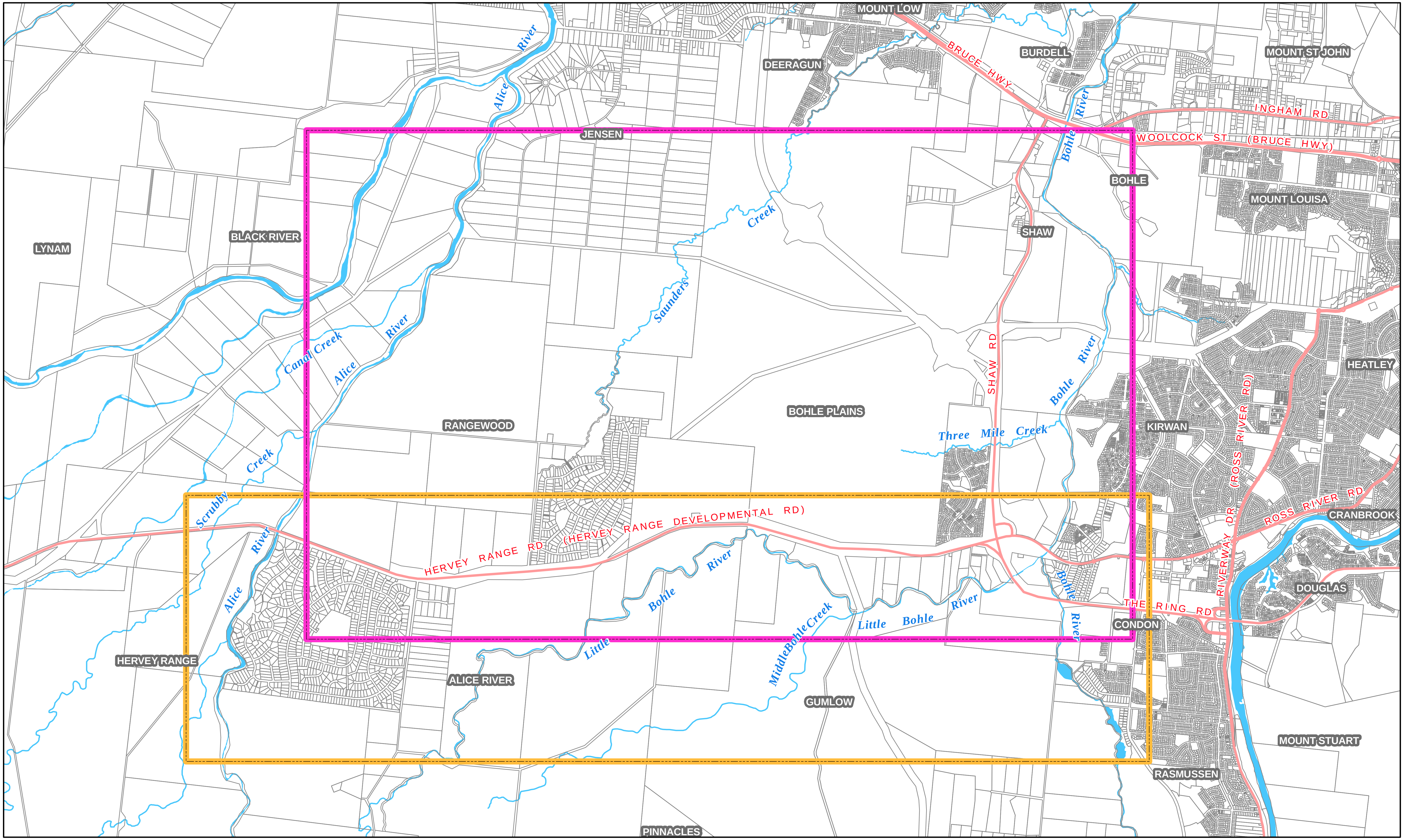
The LiDAR topography supplied by TCC was used to create a 10 m by 10 m topographic grid for the Upper Bohle Plains area (Figure 4-2). The grid is comprised of approximately 886,061 cells that represent the average elevation over each cell area.

4.3.1 Roughness

Catchment roughness (Manning’s n value) is a measure of the resistance to flow and is primarily dependent on land use. Values selected for each land use are provided in Table 4-1 and a roughness map is shown in Figure 4-3. The values were based on and are consistent with the previous *LBRFS* report. A sensitivity analysis was conducted for the adopted values to determine how sensitive the Upper Bole Plains model is with respect to roughness coefficient (Section 4.4)

Table 4-1 Hydraulic Roughness Values

Land Use	Manning's n Value
Bush Land	0.07
River Channel	0.03
Riparian Zone (In existing development)	0.08
Roads/Rail	0.025
Urban Areas	0.06
Open Space	0.05
Dense Forest	0.1
Pond	0.011
Farm Land	0.035



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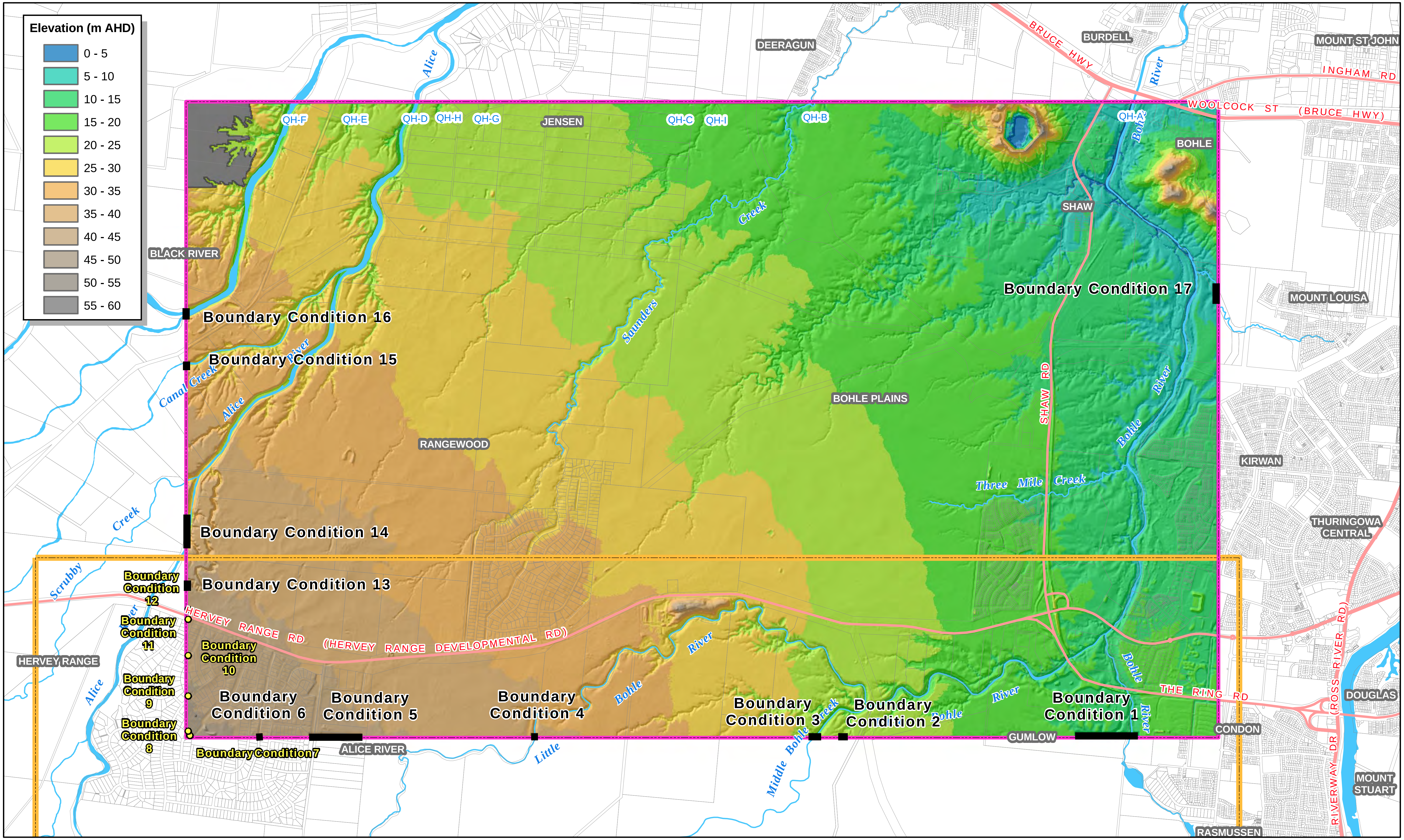
UPPER BOHLE PLAINS FLOOD STUDY
Model Extent

Figure 4-1



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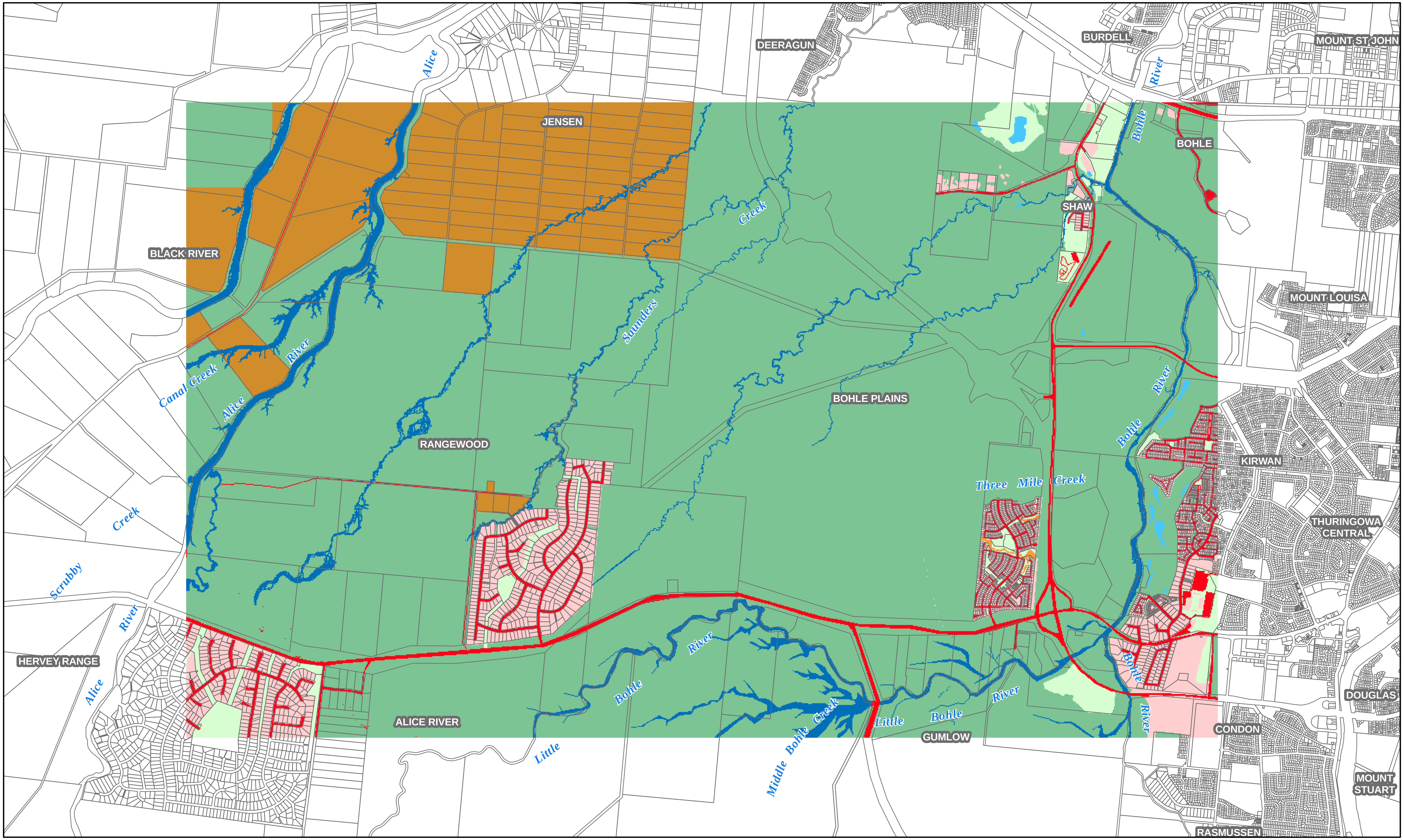
0 500 1,000 2,000 Metres

Legend

- Point Boundary Condition
- Downstream Boundary Conditions
- Linear Boundary Condition
- Upper Bohle Model Extent
- Little Bohle Model Extent

UPPER BOHLE PLAINS FLOOD STUDY
MIKE FLOOD Model Setup and Boundary Conditions

Figure 4-2



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UPPER BOHLE PLAINS FLOOD STUDY

Baseline Roughness Map

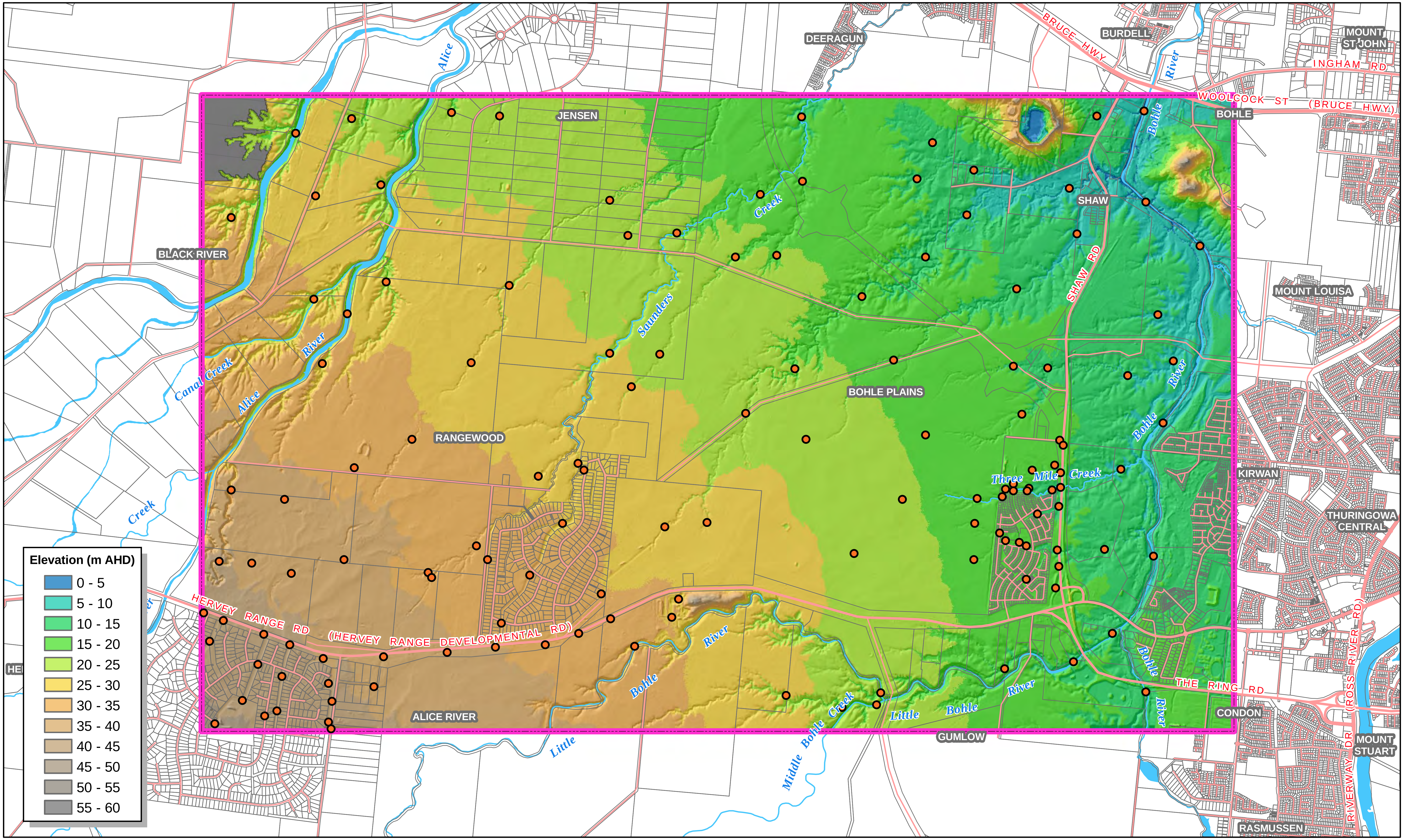
Figure 4-3

4.3.2 Boundary Conditions and Inflow Source Points

Boundary conditions are represented as inflow hydrographs and downstream flow conditions, such as tailwater constraints within the hydraulic model. Inflow hydrograph boundary conditions were developed from the previous *LBRFS* and *BPFPS* flood studies outflow hydrographs (Figures 4-2). Inflow source points were determined from the XP-RAFTS model and applied at the centre of each catchment (Figure 4-4). Outflow boundary conditions were specified as stage discharge relationships at low points (Figure 4-2). The stage discharge relationships were determined by applying Manning's equation for open channel flow. The Manning's roughness coefficient used to calculate the stage discharge relationship was assumed to be 0.03 and the slopes used at the outflow points are summarised in Table 4-2. The model sensitivity to the boundary conditions was tested during the sensitivity analysis developed in Section4.4.

Table 4-2 Stage-discharge slope at downstream boundary conditions

	Slope (%)
QH-A	0.15
QH-B	0.3
QH-C	0.25
QH-D	0.2
QH-E	0.4
QH-F	0.4
QH-G	0.35
QH-H	0.3
QH-I	0.3



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UPPER BOHLE PLAINS FLOOD STUDY
Model Inflow Locations

Figure 4-4

4.3.3 Hydraulic Structures and Open channel drains

Hydraulic structures within the study area were represented using the 1D MIKE11 model elements that were coupled “stamped” into the 2D MIKE21 grid to better represent the structures with respect to geometry and roughness coefficients. All major bridges and culverts along Hervey Range Road, Ring Road, Shaw Road, as well as major culverts in Rangewood and Kalynda Chase developments were added to the model as summarised in Table 4-3 and shown in Figure 4-5. The larger Kalynda Chase open channel drain was also stamped into the 2D grid as LiDAR cross-sections (Figure 4-5).

Table 4-3 Detail of hydraulic structures modelled using MIKE11

Structure	Configuration	Invert level (m AHD)		Length (m)
		US	DS	
02-37-A	3 / 1200 RCP	14.61	13.92	36.6
02-37-B	Irregular Shape Culvert	12.07	11.72	21.6
03-46-A	4 / 1500 RCP	12.46	12.17	25.62
03-47-A	Irregular Shape Culvert	11.76	11.74	16.8
03-47-B	1 / 1200 RCP	13.47	13.46	24.4
03-47-C	1 / 750 RCP	14.13	14	31.72
03-47-D	4 / 1500 RCP	14.5	14.4	19.52
03-48-A	4 / 1200 RCP	14.35	14.34	20.74
03-49-A	5 / 3600 x 2400 SLBC	10.39	10.26	22.8
03-49-C	7 / 1200 x 450 RCBC	13.78	13.71	30
Branch3	3 / 5800 x 1800 RCBC	13.85	13.85	26
GranitevaleRd_Cul	5 / 1200 x 600 RCBC	40.29	40.29	10
HR_Cul2A_ch5535	2 / 1200 x 300 RCBC	21.31	21.18	9.8
HR_Cul2B_ch6035	1 / 750 x 375 RCBC	23.25	23.22	9.8
HR_Cul3B	4 / 1200 x 450 RCBC	30.92	30.7	10.8
HR_Cul4C	3 / 1200 x 450 RCBC	32.22	31.92	10.8
HR_Cul4D	2 / 1200 x 450 RCBC	33.66	33.65	10.8
HR_Cul4F	6 / 1200 x 450 RCBC	34.65	34.62	12
HR_Cul5C	7 / 1200 x 450 RCBC	35.46	35.24	12
HR_Cul5E	4 / 1200 x 450 RCBC	35.67	35.43	10.8
HR_Cul6A	4 / 1200 x 300 RCBC	39.75	39.65	11
HR_Cul6B	4 / 1200 x 900 RCBC	40.65	40.53	11
HR_Cul6C	5 / 1200 x 900 RCBC	40.84	40.65	11
HR_Cul7A	3 / 1200 x 450 RCBC	41.82	41.58	11
HR_Cul7B	4 / 1200 x 450 RCBC	41.75	41.75	11
HR_Culv5D	8 / 1200 x 450 RCBC	37.88	37.72	11
PinnacleQuarries_Bohle	2 / 1500 x RCP	15.46	15.44	10
RP_rdA_ch25	4 / 1200 x 300 RCBC	42.17	42.02	13.4
RPCul_2A	1 / 1200 x 300 RCBC	41.9	41.67	10.8
RPCul_A	19 / 450 x 1200 RCBC	41.71	41.47	12
RR_culv1	6 / 3600 x 3000 RCBC	12.13	11.38	40
RR_culv2	2 / 3600 x 3000 RCBC	12.35	12.17	40
RW1	9 / 2400 x 1100 RCBC	30.78	30.4	8.5
RW2	6 / 1200 x 300 RCBC	32.51	32.37	13.18
Samhord_CulA_ch527	6 / 1200 x 375 RCBC	43.76	43.75	10
Shaw1	3 / 3600 CSHP	2.75	2.75	15
Shaw2	2 / 2550 CSHP	5.43	5.15	15
Tompkins	2 / 900 RCP	5.67	5.2	15
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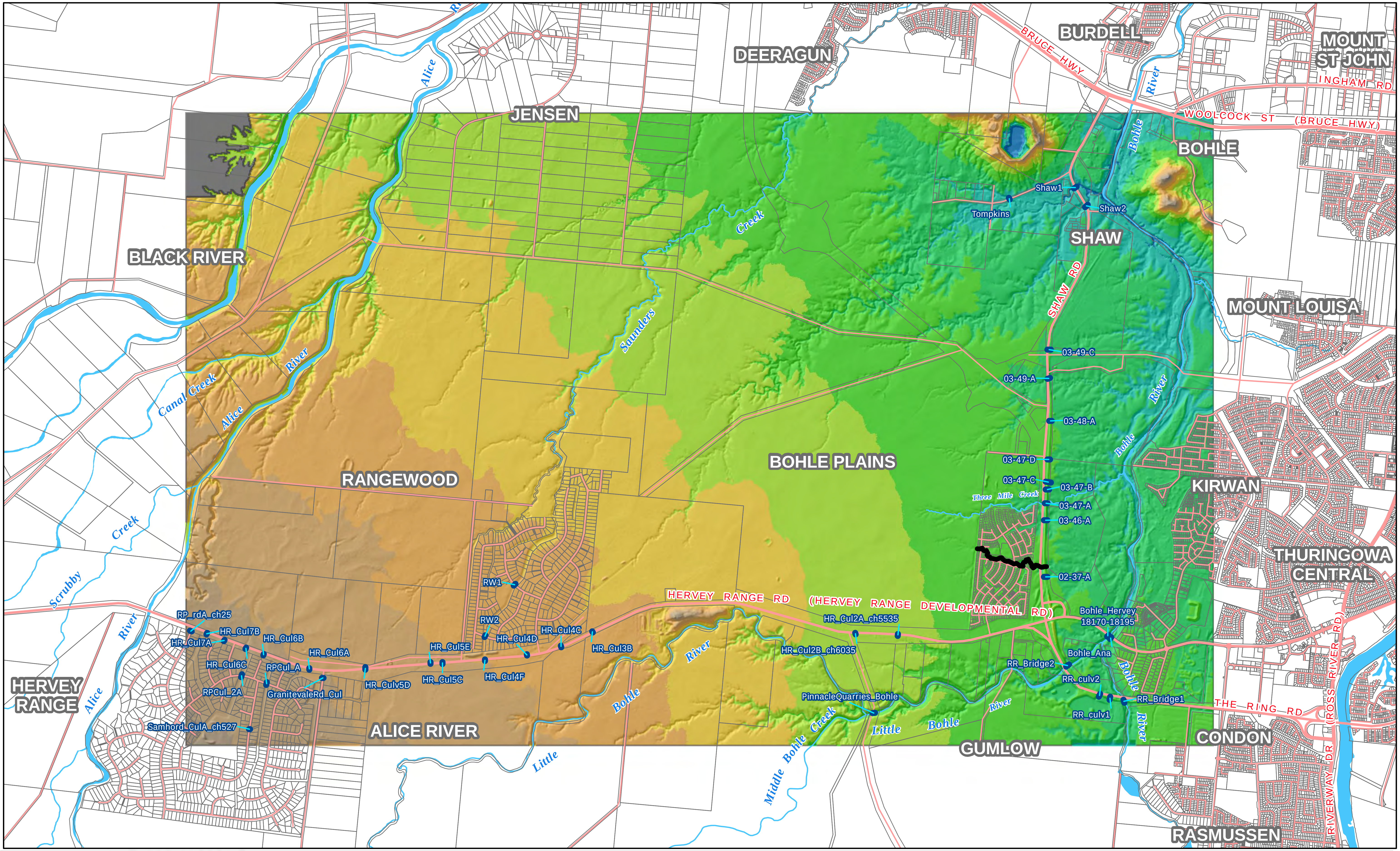
Bohle_Hervey 18170-18195	Bridge			
RR_Bridge1	Bridge			
RR_Bridge2	Bridge			



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0 500 1,000 2,000 Metres

Elevation m (AHD)

0 - 5, 5 - 10, 10 - 15, 15 - 20, 20 - 25, 25 - 30, 30 - 35, 35 - 40, 40 - 45, 45 - 50, 50 - 55, 55 - 60

Legend

Culverts

Table Drain

UPPER BOHLE PLAINS FLOOD STUDY
Table Drain Locations Modelled in MIKE11

Figure 4-5

4.4 Sensitivity Analysis

The hydraulic model was not calibrated due to a lack of stream gauge data within the model extent; however, a sensitivity analysis was completed for the 24-hour duration 50-year ARI storm event to determine the sensitivity of the model to uncertainties in various parameters that were based on previously calibrated models of nearby areas. The analysis included:

- increasing MIKE FLOOD model roughness by 20%;
- decreasing MIKE FLOOD model roughness by 20%;
- increasing the downstream tailwater water surface elevation by increasing Manning's roughness coefficient by 20% and reducing the slope by half;
- decreasing the downstream tailwater water surface elevation by decreasing the Manning's roughness coefficient by 20% and doubling the slope.

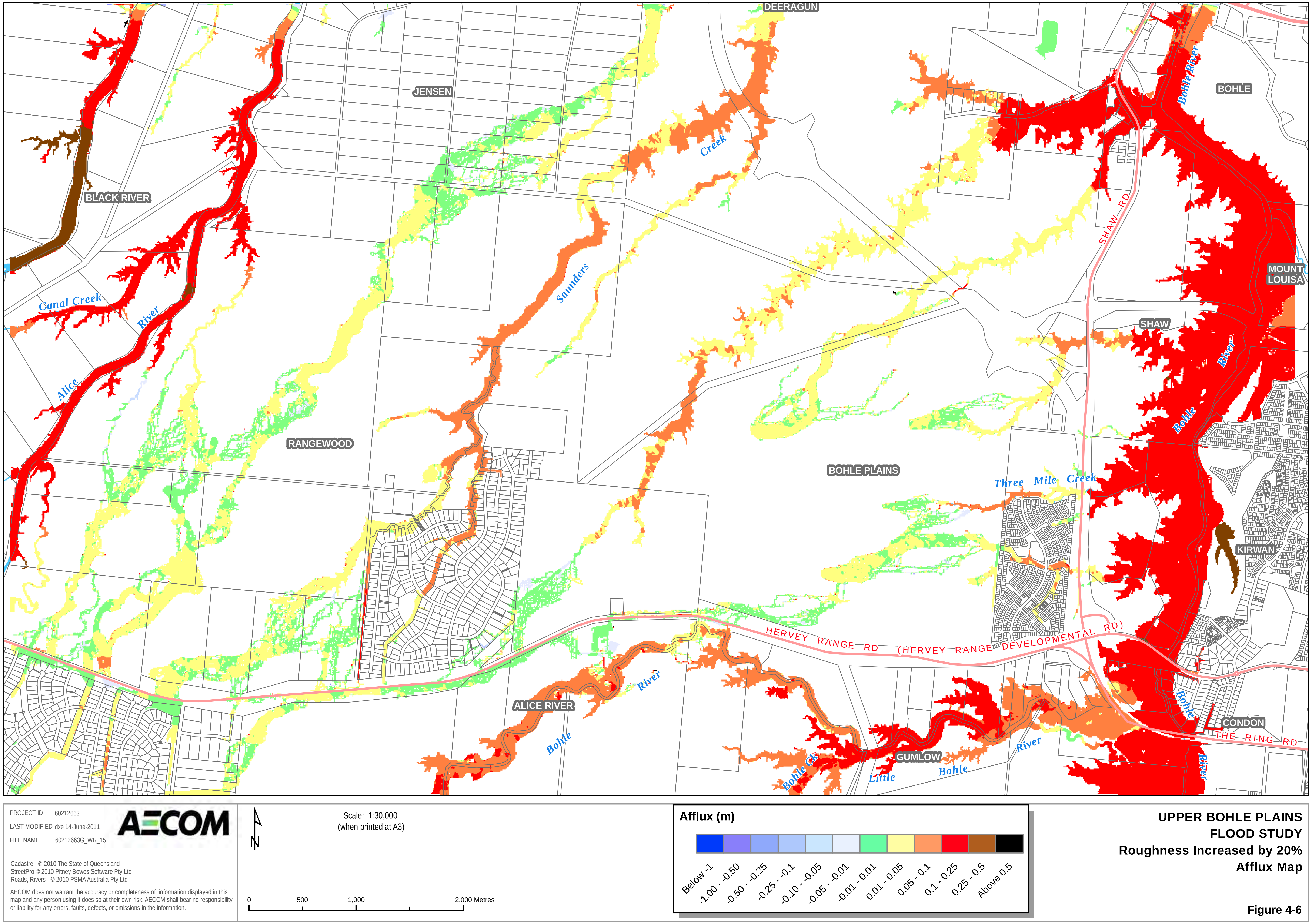
The sensitivity to timing of peaks was also taken into consideration. The *LBRFS* previously analysed timing of peaks at the confluence between the Little Bohle River and the Bohle River for the 24-hour, 50-year ARI storm event. The analysis showed an increase of 0.28 metres at the confluence and additional flooding downstream after matching the timing of peaks with one another. The analysis assumed that rainfall was uniformly distributed over the catchment for the event analysed. No further examination of the timing issues at the confluence were developed as part of this study; however, the confluence of the Bohle River with three tributaries timing issues in the northeast portion of the model was investigated as part of this study. The flow from the tributaries combined is less than 10 percent of the flow in the Bohle River and was considered insignificant.

4.4.1 Roughness

Increasing the model roughness by 20% typically increases flood levels between 0.1 and 0.25 meters along the Bohle River and Alice River and up to 0.1 metre across the rest of the study area (Figure 4-6). Decreasing the model roughness by 20% typically decreases flood levels between 0.1 and 0.25 metres along the lower reaches of the Bohle River and Alice River within the model extent and up to 0.1 metres across the rest of the study area (Figure 4-7). The model is considered insensitive to changes in roughness coefficients plus or minus 20 percent (the typical rage of values).

4.4.2 Tailwater Levels

Increasing the model downstream tailwater boundary conditions typically increases flood levels between 0.01 and 0.25 metres along the Bohle River and Alice River and up to 0.01 metre across the rest of the study area (Figure 4-8). Decreasing the model downstream tailwater boundary conditions typically decreases flood levels between 0.01 and 0.25 metres along the lower reaches of the Bohle River and Alice River within the model extent and up to 0.01 across the rest of the study area (Figure 4-7). The model is considered insensitive to changes in tailwater roughness coefficient by plus or minus 20-percent and changes in slope by plus or minus 50-percent.



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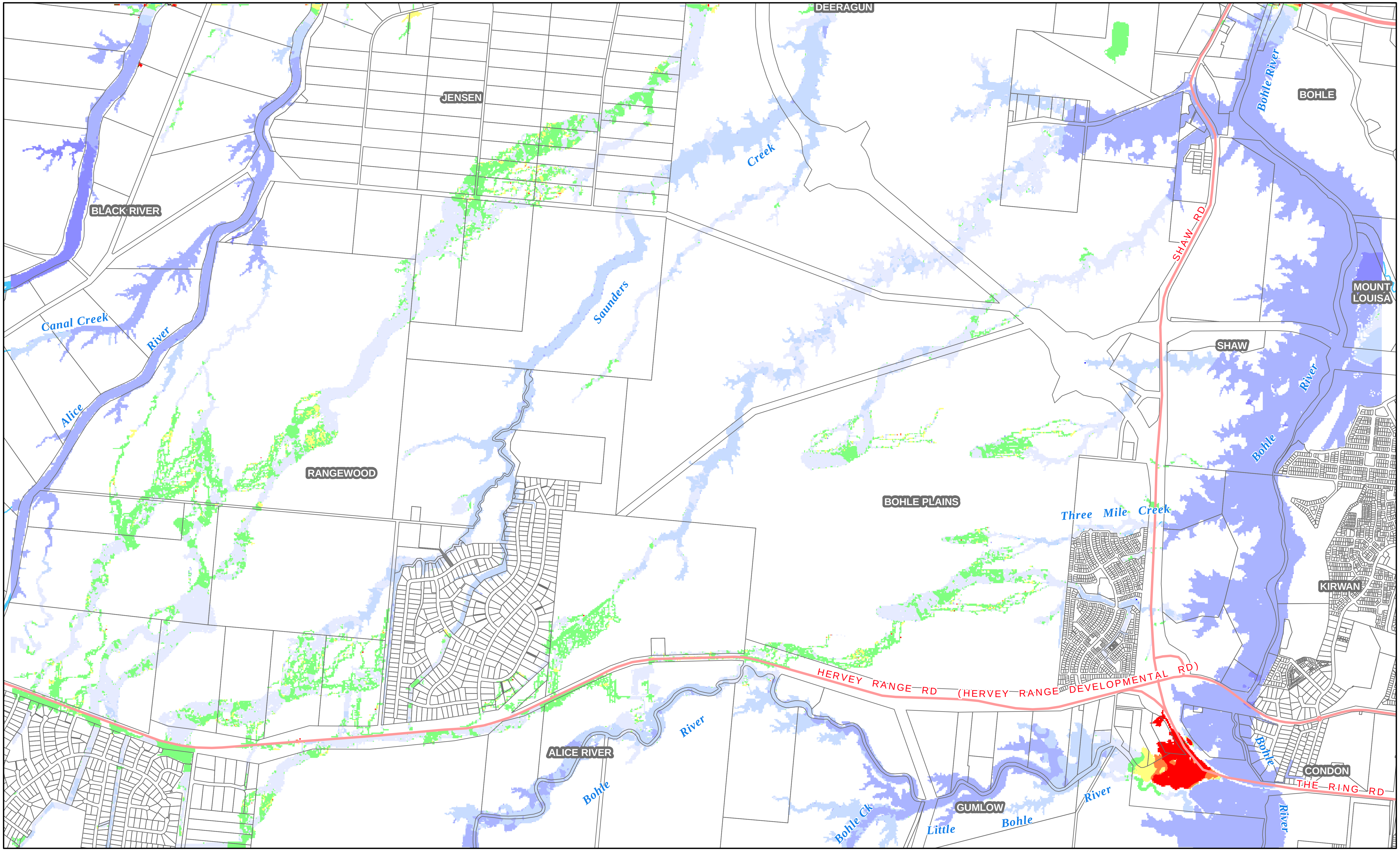
UPPER BOHLE PLAINS FLOOD STUDY
Roughness Increased by 20%
Afflux Map

Figure 4-6



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N

Scale: 1:30,000
(when printed at A3)

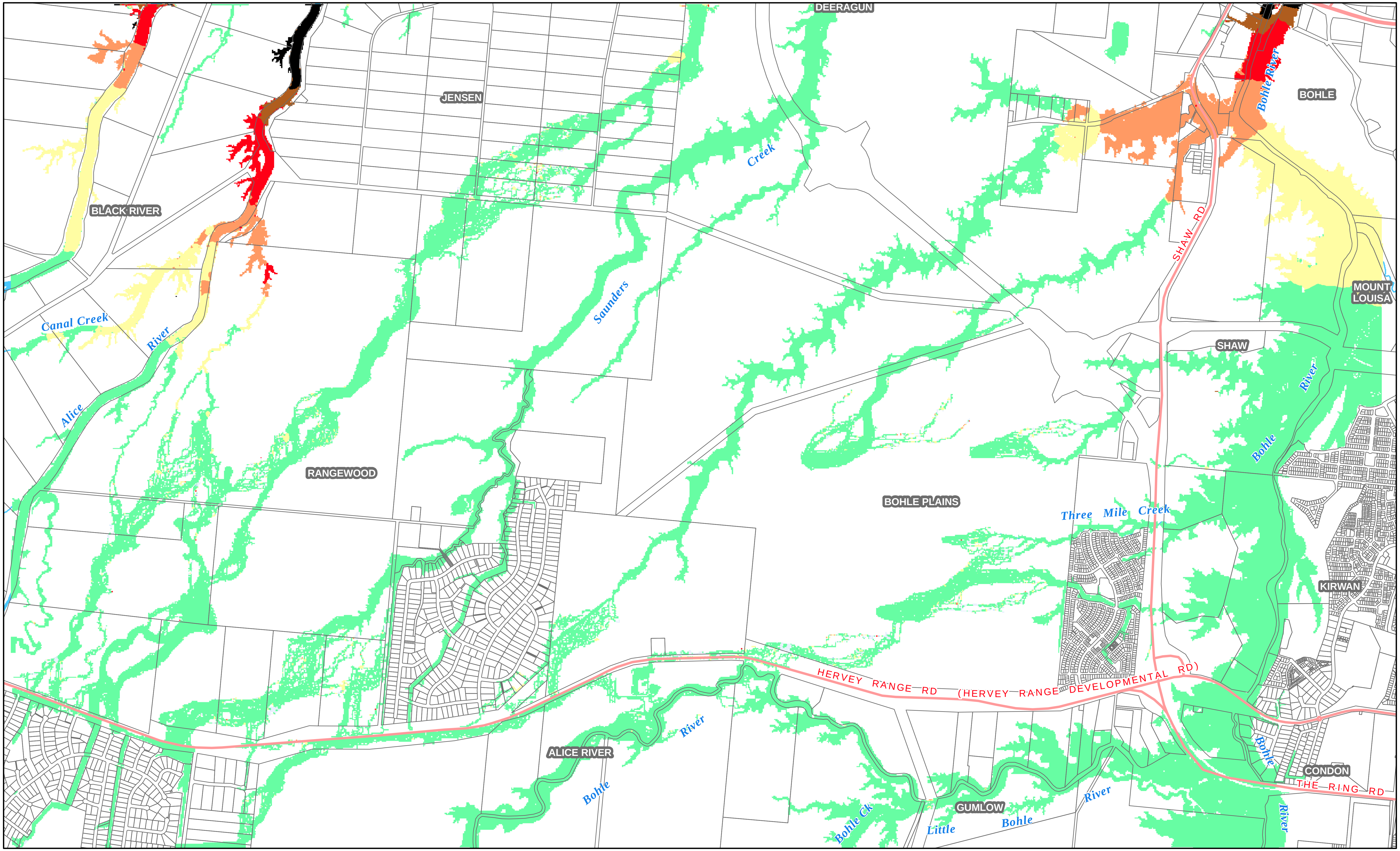
0 500 1,000 2,000 Metres

Afflux (m)

Below -1
-1.00 - -0.50
-0.50 - -0.25
-0.25 - -0.1
-0.10 - -0.05
-0.05 - -0.01
-0.01 - 0.01
0.01 - 0.05
0.05 - 0.1
0.1 - 0.25
0.25 - 0.5
Above 0.5

UPPER BOHLE PLAINS FLOOD STUDY
Roughness decreased by 20%
Afflux Map

Figure 4-7



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Scale: 1:30,000
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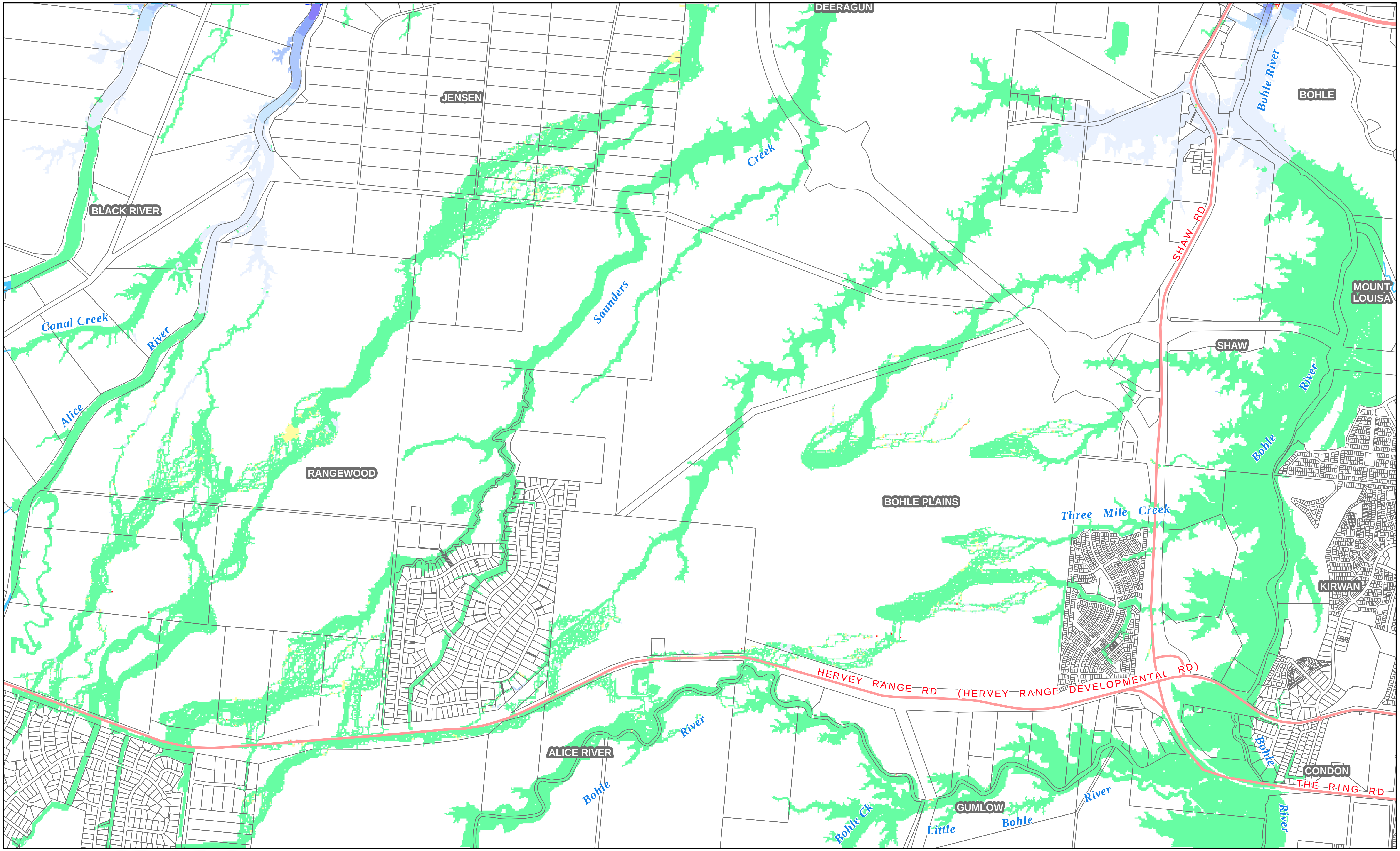
0 500 1,000 2,000 Metres

Afflux (m)

Below -1 | -1.00 - -0.50 | -0.50 - -0.25 | -0.25 - -0.1 | -0.10 - -0.05 | -0.05 - -0.01 | -0.01 - 0.01 | 0.01 - 0.05 | 0.05 - 0.1 | 0.1 - 0.25 | 0.25 - 0.5 | Above 0.5

UPPER BOHLE PLAINS FLOOD STUDY
Tailwater Increase Afflux Map

Figure 4-8



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0 500 1,000 2,000 Metres

Afflux (m)

Below -1, -1.00 - -0.50, -0.50 - -0.25, -0.25 - -0.1, -0.10 - -0.05, -0.05 - -0.01, -0.01 - 0.01, 0.01 - 0.05, 0.05 - 0.1, 0.1 - 0.25, 0.25 - 0.5, Above 0.5

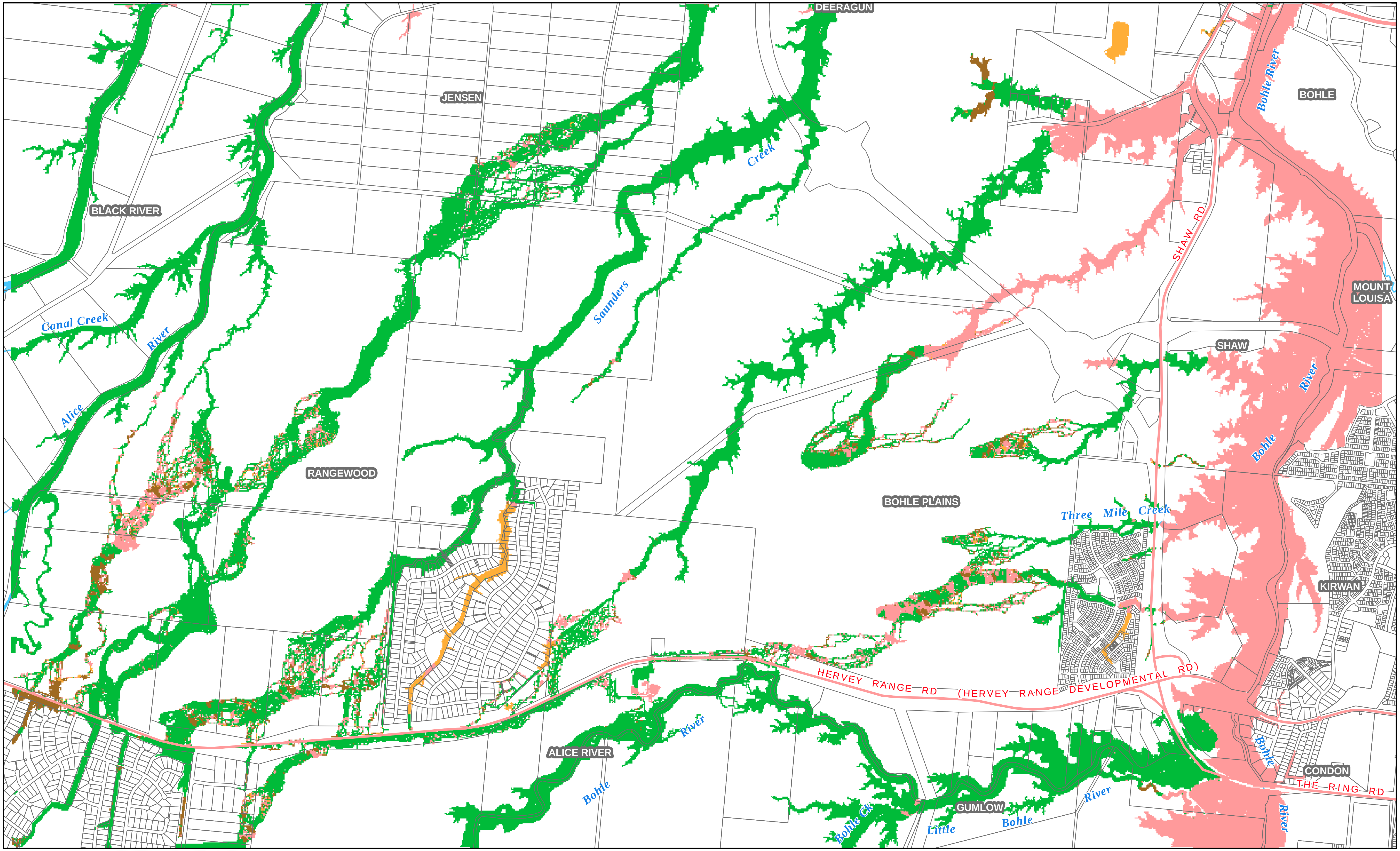
UPPER BOHLE PLAINS FLOOD STUDY
Tailwater Decrease Afflux Map

Figure 4-9

4.5 Design Flood Assessment

The 1, 3, 12 and 24 hour 50-year and 100-year ARI storm events were simulated for both the existing and future urbanised scenarios using the MIKE FLOOD model to determine the maximum flood level envelope throughout the catchments. The results confirm that the 24-hour duration event is the critical event for the majority of the catchment for the base-case scenario although the 12-hour event does cause higher flood levels at the Bohle River and downstream of Alice River. Figure 4-10 and Figure 4-11 show the critical duration for the study area for the 50 and 100-year ARI base-case storm events, respectively and Figures 4-12 and 4-13 show the maximum flood envelopes. The critical events were also simulated for the future urbanisation scenario vary from 1 to 24 hour duration for the 50 and 10- year ARI storm events. Figure 4-14 and Figure 4-15 show the critical duration for the study area for the 50 and 100-year ARI future urbanisation scenario storm events, respectively and Figures 4-16 and 4-17 show the maximum flood envelopes.

Peak flows were developed for 2, 5, 10, 20 and PMP events for the critical durations determined in Section 3.0. Flood maps showing water depth, flood levels and flow velocities for each event modelled are shown in **Appendix B**.



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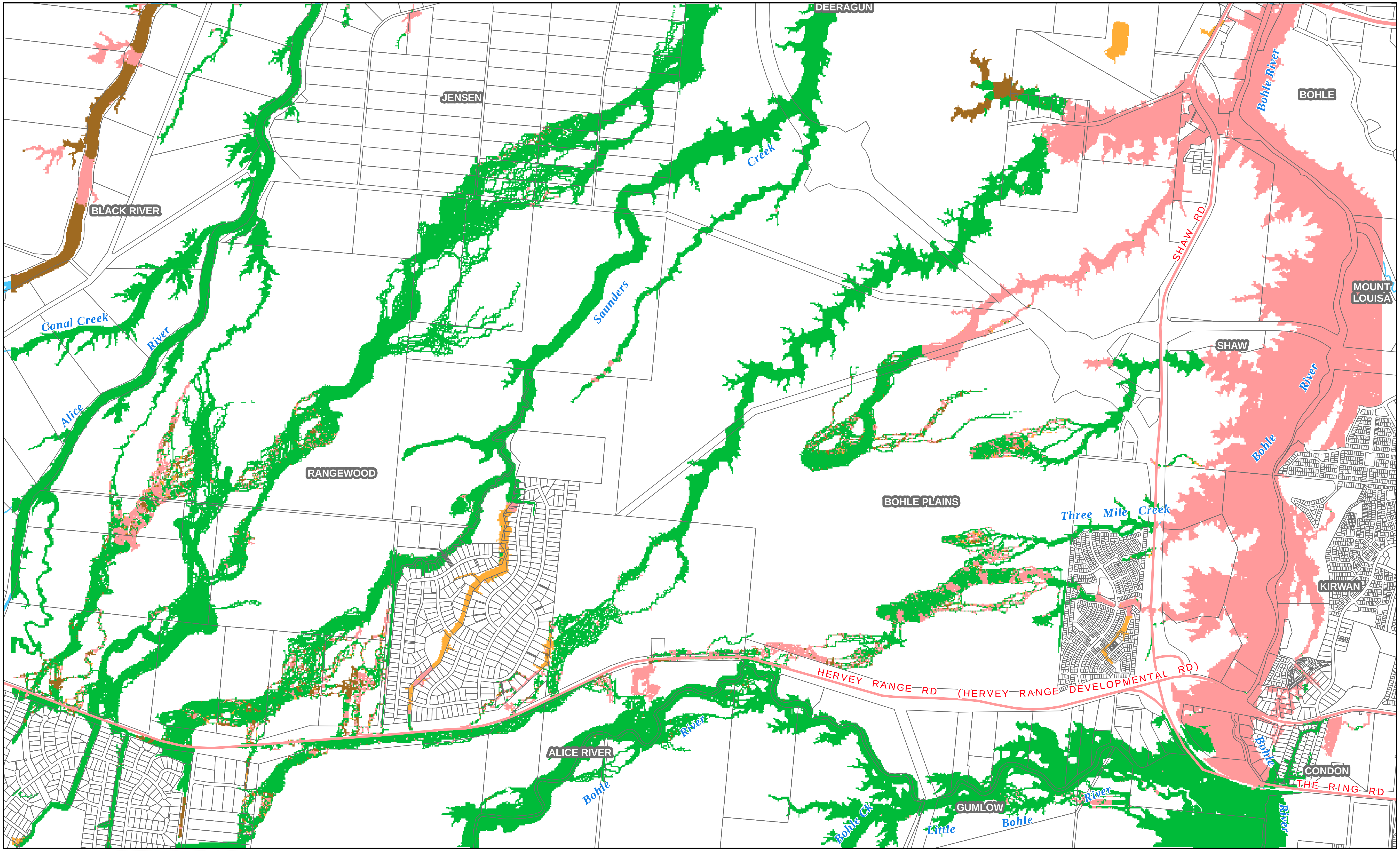
0 500 1,000 2,000 Metres

Event Durations

- 1hr
- 3hr
- 12hr
- 24hr

UPPER BOHLE PLAINS
FLOOD STUDY
50 year ARI Base Case
Critical Duration Events

Figure 4-10



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Event Durations

- 1hr
- 3hr
- 12hr
- 24hr

UPPER BOHLE PLAINS FLOOD STUDY
100 year ARI Base Case
Critical Duration Events

Figure 4-11