APPENDIX

H

Hydrology and Flooding Technical Report

PART 3 OF 3

Appendices B to E

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

APPENDIX

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Hydrology and Flooding Technical Report

Appendix B Existing Drainage Structures

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Appendix B
Existing drainage structures

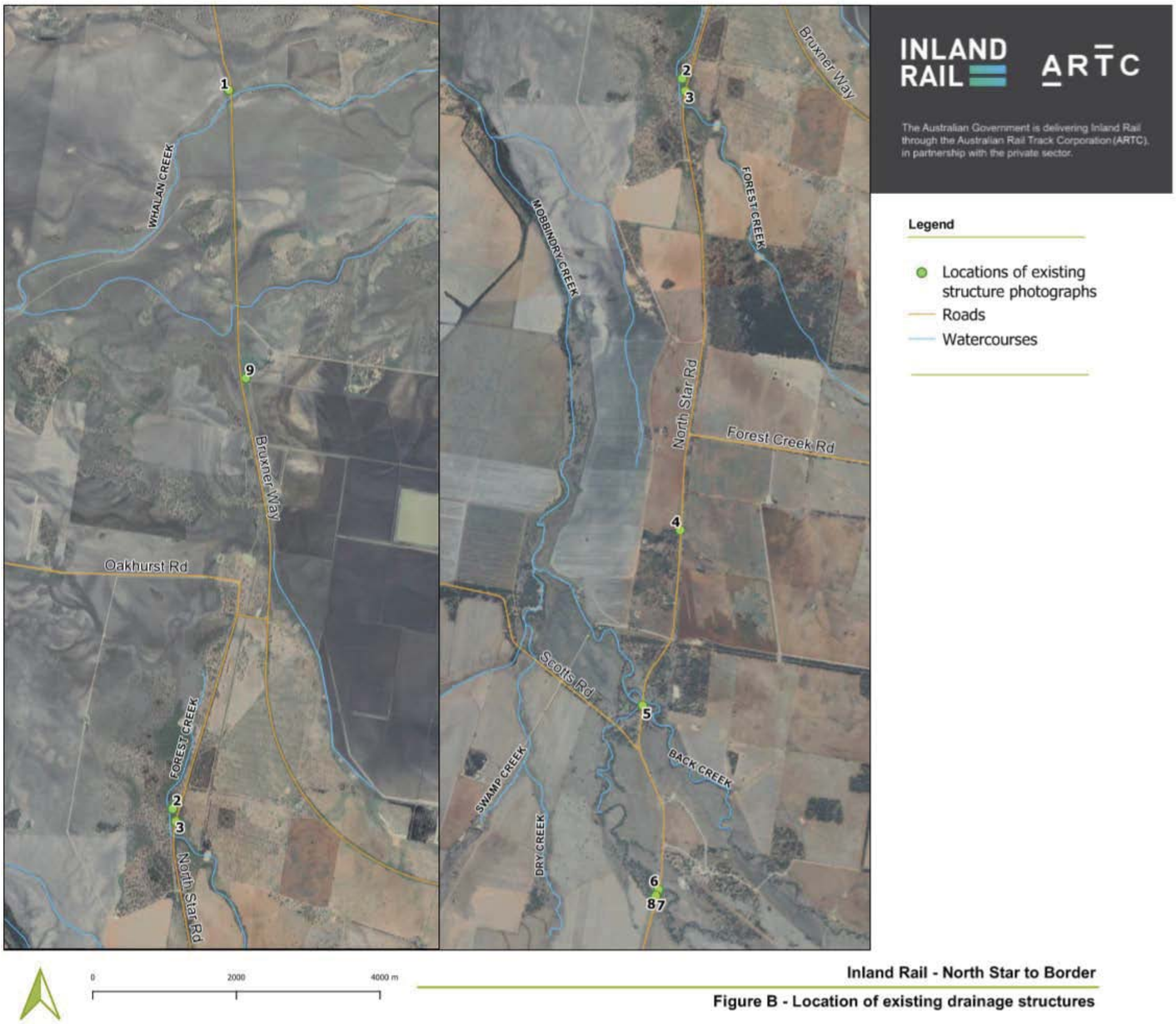

Figure B - Location of existing drainage structures

Photograph 1: Bridge under existing rail at Whalan Creek

Photograph 2: RCBCs under North Star Road at Forest Creek

Photograph 3: RCBCs under North Star Road at Forest Creek

Photograph 4: RCBCs under existing rail near North Star Road

Photograph 5: RCPs under North Star Road at Back Creek

Photograph 6 North Star Road crossing at Mobbindry Creek

Photograph 7: North Star Road crossing at Mobbindry Creek

Photograph 8: Existing Rail crossing at Mobbindry Creek

Photograph 9: Existing Rail crossing near Bruxner Way

APPENDIX

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Hydrology and Flooding Technical Report

Appendix C Detailed Result Tables

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Appendix C
Detailed result tables

Table C1 Afflux at flood sensitive receptors for all events

FSR Number	Description	Extreme events				Base Cast events			
		PMF Event Afflux (m)	1 in 10,000 AEP Afflux (m)	1 in 2,000 AEP Afflux (m)	1% AEP Afflux (m)	2% AEP Afflux (m)	5% AEP Afflux (m)	10% AEP Afflux (m)	20% AEP Afflux (m)
1	Sheds	0.331	0.233	0.212	0.05				
2	House	0.061	0.037	0.013	0.001	0.002	0.002		
3	House	0.066	0.042	0.017	0.002				
4	House	0.045	0.018	-0.002	-0.002	-0.001			
5	Sheds	0.047	0.019	-0.001	-0.001	-0.001	0		
6	Sheds	0.062	0.036	0.013	0.001	0.002			
7	Sheds	0.061	0.035	0.012	0.001	0.002			
8	House	0.041	0.04	0.023	0.003	0.007			
9	Sheds	0.041	0.039	0.022	0.003	0.006			
10	House	1.25	1.9	1.82					
11	House	0.055	0.028	0.007	0				
12	House	0.73	0.64	0.44					
13	Sheds								
14	House								
15	House								
16	House								
17	Sheds								
18	Shed								
19	Sheds								
20	House	-0.002							
21	Sheds	-0.002	0	0.001	0	-0.001	0.001	0.001	0
22	Sheds	-0.001							
23	Sheds	1.04	1.44	1.35					
24	Sheds	0.037	0.055						
25	House	0.031							
26	House	0.037	0.049						
27	Toomelah Community	0.074	0.046	0.013					
28	North Star Sporting Club	0	0	0	0	0	0	0	0
29	House	0.034	0.021	0.005					
30	Shed	-0.001	0	0.001					
31	House	0.038	0.023	0.005	0.001	0.002			
32	Pump								
33	House	0.054	0.028	0.008	0	0.001			
34	House	0.044	0.022	0.005					
35	House	0.044	0.023	0.006	0	0.002			

FSR Number	Description	Extreme events				Base Cast events			
		PMF Event Afflux (m)	1 in 10,000 AEP Afflux (m)	1 in 2,000 AEP Afflux (m)	1% AEP Afflux (m)	2% AEP Afflux (m)	5% AEP Afflux (m)	10% AEP Afflux (m)	20% AEP Afflux (m)
36	Shed	0.042	0.023	0.006	0	0.003	0.003		
37	Sheds	0.053	0.023	0.006					
38	House	0.056	0.03	0.008	0	0.001			
39	House	0.214	0.232	0.075					
40	House	0.053	0.024	0.005					
41	Airport	0.039	0.03	0.01	0.002				
42	Sheds	0.057	0.029	0.008	0	0.001	0.001		
43	Shed	0.117	0.154	0.05	0				
44	Shed	1.27	1.73	1.53					
45	House	0.029	0.007	0.001	0	0			
46	House	0.019	0.002	0	0				
47	House	0.019	0.002	0	0				
48	House	0.019	0.003	0	0	0			
49	shed	0.019	0.003	0	0				
50	house	0.004	0	0	0	0	0		
51	shed	0.004	0	0	0	0			
52	shed	0.005	0.001	0	0	0	0		
53	Shed	0.028	0	-0.046					
54	Shed	0.028	-0.002	-0.048					
55	Shed	0.028	-0.001	-0.047					
56	Shed	0.028	-0.001	-0.047					
57	Shed	0.028	0	-0.045					
58	House	0.029	-0.002	-0.051	-0.001				
59	House	0.032	0.013	-0.004	0.001				
60	Shed	0.032	0.013	-0.004	0.002				
61	House	0.031							
62	House	0.033	0.031	0.008					
63	Shed	0.034	0.021	0.005					
64	Shed	0.017	0.017	0.01					
65	House	0.011	0.018	0.004					
66	House	0.01							
67	House	0.026	0.017	-0.013	0.004				
68	House	0.024	0.013	-0.013					
69	House	0.024	0.012	-0.011	0.002				
70	House	0.022	0.011	-0.01	0.001	0.003			
71	House	0.022	0.011	-0.01	0.001	0.002			
72	Shed	0.017	0.007	-0.007					
73	House	0.031	0.01	-0.022	0.001	0.005			
74	Shed	0.031	0.01	-0.022	0.001	0.005			
75	Shed	0.032	0.01	-0.025	0.001	0.006	0		
76	Goondiwindi	-0.021	-0.02	0.001					
77	House	0.008	0.02	0.004	0	0	0.002		

FSR Number	Description	Extreme events				Base Cast events			
		PMF Event Afflux (m)	1 in 10,000 AEP Afflux (m)	1 in 2,000 AEP Afflux (m)	1% AEP Afflux (m)	2% AEP Afflux (m)	5% AEP Afflux (m)	10% AEP Afflux (m)	20% AEP Afflux (m)
78	House	0.002	0.01	0.005	0	0.003	0		
79	Shed	0.015	-0.032	-0.098	-0.004	-0.005			
80	House	0.028	0.015	-0.059	-0.003	-0.004			
81	House	0.027	0.014	-0.055	-0.004				
82	House	0.027	0.014	-0.055	-0.003				
83	Shed	0.022	0.009	-0.041					
84	House	0.022	0.01	-0.04	-0.002	-0.002	-0.003	0	
85	House	0.028	0.015	-0.06	-0.003	-0.006			
86	Shed	0.028	0.009	-0.013	0	0			
87	House	0.027	0.016	-0.014	0.004				
88	House	0.021	0.011	-0.01	0.002	0.003			
89	House	0.019							
90	Shed	0.027	0.017	-0.013	0.004	0.005	0	0	
91	Shed	0.027	0.008	0.002	0	0.002			
92	Shed	0.03	0.01	0.003	0				
93	House	0.022	0.008	-0.035	-0.001	-0.004			
94	Shed	0.025	0.01						
95	House	0.026	0.01	-0.031	0	0.001			
96	House	0.026	0.01	-0.031	0.001	0.001			
97	House	0.026	0.01	-0.029	0	0.001			
98	House	0.03	0.015	-0.016	0.001				
99	Shed	0.035	0.026	0.008	0.001				
100	House	0.035	0.026	0.007					
101	Shed	0.036	0.029	0.009					
102	House	0.03	0.015	-0.016	0.002	0.001			
103	House	0.028	0.016	-0.017					
104	Shed	0.027	0.015	-0.017	0.001				
105	Shed	0.028	0.015	-0.016	0.001				
106	House	0.008	0.01	0.003	0	0.001	0.002	0	
107	House	0.003	0.007	0.001	0	0	0	0	
108	Shed	0.002	0.005	0.001	0	0	0.001	0.001	
109	House	0	0.002	0	0	0	0	0	0
110	House	-0.001							
111	Sheds								
112	Shed	0	0.003	0	0	0.001	0.001	0.001	
113	House	0	0.003	0	0	0	0	0	0
114	House	0.001	0.004	0.001	0	0	0	0.001	0
115	Shed	-0.001	0.003	0.001	0	0	0.001	0	0
116	House	0.004	0.008	0.003	0	0	0.001	0	-0.001
117	House	0	0.002	0.001					
118	Sheds	-0.002	0.002	0.001	0	0	0.005		
119	Sheds	-0.005	0.003	0.001	0	0.001	0.002	0.001	

FSR Number	Description	Extreme events				Base Cast events			
		PMF Event Afflux (m)	1 in 10,000 AEP Afflux (m)	1 in 2,000 AEP Afflux (m)	1% AEP Afflux (m)	2% AEP Afflux (m)	5% AEP Afflux (m)	10% AEP Afflux (m)	20% AEP Afflux (m)
120	Shed	-0.006	0.004	0.001	0	0.001	0.001	0.001	
121	House	-0.005	0.004	0.001	0.001	0	0.001	0.001	
122	House	-0.005	0.004	0.001	0	0.001	0.001	0.001	
123	Shed	0.004							
124	House	-0.005							
125	House	-0.006							
126	House	-0.008	0.007	0.001	0	0.001	0.002	0.001	
127	House	-0.009	0.007	0.002	0	0.001	0.002		
128	House	-0.01	0.007	0.002	0	0.001			
129	House	-0.01	0.008	0.002	0	0.001	0.001		
130	House	-0.01	0.009	0.002					
131	Shed	-0.008	0.007	0.002					
132	Shed	-0.009	0.005	0.002					
133	Shed	-0.006	0.007	0.002					
134	House	0.006	0.01	0.003	0	0.001	0.001		
135	House	0.005	0.01	0.003	0	0.001	0.001	0.001	
136	House	0.004	0.009	0.002	0	0.002	0.001	0.001	
137	Sheds	0.004	0.009	0.003	0	0.001	0.002	0.001	
138	Hous	-0.001	0.002	0	0	0.001			
139	Shed	-0.02	0.009	0.002					
140	House	-0.009	0.005	0.001	0	0.001	0.001	0.001	
141	Sheds	-0.034							
142	North Star	0							
143	Boggabilla	0.027	0.017	0.004	0.001	0.001			
144	Pump	-0.006	0.007	0.002	0	0.001	0.001	0.001	0
145	Pump	0.005	0.01	0.003	0	0.001	0.001	0.002	
146	Pump	0.048	0.028	0.007	0.001	0.002	0.003	0.002	
147	Pump	0.05	0.028	0.006	0	0.002	0.003	0.002	-0.001
148	Pump	0.05	0.022	0.003	-0.001	0	0.003	0.001	0
149	Pump	0.133	0.074	0.036	0.014	0.013	0.013	0.004	0.005
150	Pump	0.051	0.022	0.003	-0.001	0.001	0.003	0	-0.001

Table C2 Afflux at flood sensitive receptors for sensitivity cases

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
1	Sheds	0.12	0.049	0.051	0.016		0.051	0.05	0.056	0.045	0.143
2	House	0	0.001	0.001	0.001	0	0.011	-0.003	0.001	-0.001	0.004
3	House	0.001	0.002	0.002	0.001	0.001	0.013	-0.002	0.002	0	0.007
4	House	-0.003	-0.002	-0.002	-0.001	-0.002	-0.001	-0.002	-0.002	-0.004	-0.004
5	Sheds	-0.003	-0.001	-0.001	-0.002	-0.003	0	-0.002	-0.002	-0.004	-0.004
6	Sheds	0	0.001	0.001	0	0.001	0.009	-0.002	0.001	-0.001	0.003
7	Sheds	0	0.001	0.001	0.001	0.001	0.01	-0.002	0.001	-0.001	0.003
8	House	0.008	0.003	0.003	0.005	0.005	-0.051	0.048	0.003	0.002	0.031
9	Sheds	0.009	0.003	0.003	0.005	0.004	-0.049	0.046	0.003	0.002	0.032
10	House	0.39									0.87
11	House	0	0	0		0	0.008	-0.003	0	-0.002	0.001
12	House	0.06									0.32
13	Sheds										
14	House										
15	House										
16	House										
17	Sheds										
18	Shed										
19	Sheds										
20	House					-0.001					
21	Sheds	0	0	0	0	0	0	0	0	0	
22	Sheds										
23	Sheds	0.06									
24	Sheds									0	

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
25	House										
26	House										
27	Toomelah Community										0.006
28	SR North Star Sporting Club	0	0	0	0	0	0	0	0	0	
29	House										0
30	Shed	0								-0.001	
31	House	0	0.001	0.001	0.001	0.001	0.026	-0.01	0	-0.001	0.001
32	Pump									-0.015	
33	House	0	0	0	0	0	0.009	-0.004	0.001	-0.002	0.001
34	House	0								-0.002	0.001
35	House	-0.001	0.001	0	0	0.001	0.031	-0.014	0	-0.002	0.001
36	Shed	-0.001	0.001	0	0.001	0.001	0.036	-0.016	0	-0.002	0.001
37	Sheds	-0.001									0
38	House	-0.001	0	0	0	0	0.008	-0.004	0	-0.002	0.001
39	House										
40	House	0				0			0		-0.001
41	Airport	0.005	0.002	0.002			-0.046	0.005	0.002	0	0.017
42	Sheds	0	0	0	0	0	0.008	-0.003	0	-0.002	0.001
43	Shed	0	0	0			0	0	0	0	0
44	Shed	0.2									0.62
45	House	0	0	0	0	0	0	0	0	0	0
46	House	0	0	0		0	0	0	0	0	0
47	House	0	0	0		0	0	0	0	0	0
48	House	0	0	0	0		0	0	0	0	0

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
49	shed	0	0	0			0	0	0	0	0
50	house	0	0	0	0	0	0	0	0	0	0
51	shed	0	0	0	0	0	0	0	0	0	0
52	shed	0	0	0	0	0	0	0	0	0	0
53	Shed	-0.008									0.002
54	Shed										
55	Shed	-0.009									-0.002
56	Shed										0
57	Shed										0.004
58	House	-0.008	-0.001	-0.002			-0.008	0.006	-0.001	0	-0.011
59	House	0.002	0.001	0.001	0.001		0.014	-0.011	0.001		0.009
60	Shed	0.001	0.002	0.002	0.002	0.001	0.016	-0.013	0.001		0.008
61	House										
62	House										
63	Shed										
64	Shed										
65	House										
66	House										
67	House	0.003	0.004	0.004	0.004	0.005	0.015	-0.021	0.004		0.012
68	House	0.001									0.008
69	House	0.001	0.002	0.002	0.003		0.003	-0.011	0.002	0	0.008
70	House	0.001	0.001	0.001	0.003	0.002	0.002	-0.008	0.001	0	0.007
71	House	0.002	0.001	0.001	0.002	0.001	0.002	-0.007	0.002	-0.001	0.006
72	Shed	0.001									0.004
73	House	-0.001	0.001	0.001	0.001	0.001	-0.035	0.012	0	-0.001	0.007

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
74	Shed	0	0.001	0.001	0.001	0.001	-0.034	0.011	0	-0.001	0.008
75	Shed	-0.001	0.001	0.001	0.001	0.001	-0.067	0.027	0.001	-0.001	0.009
76	Goondiwindi	0				0					0.001
77	House	0	0	0	0	0	0.009	-0.003	0	0	0.001
78	House	0.001	0	0	0.001	0	0.015	-0.007	0.002		0.001
79	Shed	-0.02	-0.004	-0.005	-0.003	-0.003	-0.008	0.003	-0.005	-0.002	-0.042
80	House	-0.019	-0.003	-0.004	-0.003	-0.004	-0.007	0.005	-0.004	0	-0.041
81	House	-0.017	-0.003	-0.005	-0.003	-0.003	-0.009	0.004	-0.004	0	-0.037
82	House	-0.017	-0.002	-0.004	-0.002	-0.003	-0.007	0.004	-0.004	0	-0.037
83	Shed	-0.012									-0.019
84	House	-0.011	-0.002	-0.003	-0.002	-0.002	-0.009	0.004	-0.003	0	-0.019
85	House	-0.019	-0.003	-0.005	-0.003	-0.003	-0.007	0.004	-0.004	0.001	-0.041
86	Shed	0	0	0	0.001	0	-0.002	-0.001	0.001	0	0.004
87	House	0.003	0.004	0.004			0.014	-0.02	0.004		0.011
88	House	0.001	0.002	0.002	0.001		0.002	-0.006	0.002	0	0.006
89	House										
90	Shed	0.002	0.004	0.004	0.005	0.005	0.015	-0.021	0.004		0.012
91	Shed	0	0	0	0	0	0.032	-0.009	0	-0.001	0
92	Shed	0	0	0	0.001	0	0.031	-0.009	0.001	-0.001	0
93	House	-0.006	-0.001	-0.001	-0.001	-0.001	-0.023	0.011	-0.002	-0.001	-0.01
94	Shed										
95	House	-0.003	0	0	0.001	0	-0.023	0.007	0	-0.001	0
96	House	-0.003	0.001	0	0.001	0	-0.023	0.009	-0.001	-0.001	-0.001
97	House	-0.002	0	0	0	0	-0.013	0.003	0	-0.001	0
98	House	0.001	0.001	0.001			-0.001	-0.004	0.001	0	0.006

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
99	Shed	0.001	0.001	0.001					0	-0.001	0.007
100	House	0.001									0.005
101	Shed	0.001									0.006
102	House	0.001	0.002	0.002	0.002		-0.002	-0.004	0.001	0	0.008
103	House	0.002									0.01
104	Shed	0.002	0.001	0.001	0	0.001	-0.002	-0.005	0.001	0	0.01
105	Shed	0.002	0.001	0.002	0.001	0.001	-0.002	-0.004	0.002	0	0.009
106	House	0	0	0	0.001	0	0.023	-0.007	0.001	-0.001	0
107	House	0	0	0	0	0	0.008	-0.004	0	-0.001	0
108	Shed	0	0	0	0	0	0.004	-0.001	0.001	-0.001	0.001
109	House	0	0	0	0.001		0.003	-0.001	0		0
110	House										
111	Sheds										
112	Shed	0	0	0	0	0	0.005	-0.002	0	-0.001	0
113	House	0	0	0	0		0.004	-0.001	0	0	0
114	House	0	0	0	0	0	0.005	-0.002	0	-0.001	0
115	Shed	0	0	0	0	0.001	0.005	-0.002	0	0	0
116	House	0	0	0	0	0	0.009	-0.005	0	-0.001	0.001
117	House	0				0					0
118	Sheds	0	0	0	0	0	0.004	-0.001	0	-0.001	0
119	Sheds	0	0	0	0.001	0	0.005	-0.002	0	0	0
120	Shed	0	0	0	0	0	0.007	-0.003	0	-0.001	0
121	House	0	0.001	0.001	0	0	0.007	-0.002	0	0	0.001
122	House	0	0	0	0	0	0.007	-0.003	0.001	0	0.001
123	Shed									-0.001	

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
124	House										
125	House										
126	House	0	0	0	0	0	0.012	-0.005	0	0	0.001
127	House	0	0	0	0	0	0.012	-0.005	0	0	0.001
128	House	0	0.001	0	0.001	0.001	0.012	-0.004	0	0	0.001
129	House	0	0	0	0	0	0.012	-0.004	0	-0.001	0
130	House									0	0
131	Shed									0	0
132	Shed	0								-0.001	0
133	Shed										0.007
134	House	-0.001	0	0	0	0	0.022	-0.007	0	0	0
135	House	-0.001	0	0	0.001	0	0.02	-0.006	0	0	0
136	House	0	0	0	0.001	0	0.022	-0.007	0	-0.001	0.001
137	Sheds	0	0	0	0	0.001	0.021	-0.007	0.001	0	0
138	Hous	0	0	0	0		0.004	-0.001	0		0.001
139	Shed										
140	House	0	0	0	0	0	0.01	-0.003	0.001	0	0
141	Sheds									-0.001	
142	North Star										
143	Boggabilla	0	0.001	0	0	0.001	0.035	-0.007	0	-0.001	0.001
144	Pump	0	0	0	0	0	0.012	-0.004	0	0	0
145	Pump	0	0	0	0	0.001	0.018	-0.006	0	-0.001	0
146	Pump	-0.001	0.001	0.001	0.001	0	0.035	-0.015	0.001	-0.002	0.002
147	Pump	-0.001	0	0	0.001	0	0.026	-0.012	0	-0.002	0.001
148	Pump	-0.002	-0.001	-0.001	-0.001	-0.002	0.002	-0.002	-0.001	-0.003	-0.002

FSR Number	Description	1% AEP Climate Change Event change in peak water levels (m)	1% AEP with 0% Blockage change in peak water levels (m)	1% AEP with 50% Blockage change in peak water levels (m)	1% AEP with Mannings Sensitivity change in peak water levels (m)	1% AEP with 15m grid change in peak water levels (m)	1% AEP with DPIE rail removed change in peak water levels (m)	1% AEP with removal of rail section change in peak water levels (m)	1% AEP with peak tributaries change in peak water levels (m)	1% AEP with DPIE LEVEE assessment change in peak water levels (m)	1976 flows with 2019 LiDAR change in peak water levels (m)
149	Pump	0.016	0.014	0.015	0.016	0.015	0.014	0.014	0.015	0.018	0.018
150	Pump	-0.002	-0.001	-0.001	-0.001	-0.001	0.003	-0.002	-0.001	-0.003	-0.002

Table C3 Time of Submergence results for all events

Location	20% AEP			10% AEP			5% AEP		
	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)
Access Rd 1	111	112	1	100	100	0	119	119	0
Access Rd 2									
Access Rd 3	96	95	0	94	87	-7	123	123	-1
Access Rd 4									
Access Rd 5				43	43	0	58	58	0
Access Rd 6				23	23	0	48	48	0
Access Rd 7				31	31	0	52	52	0
Access Rd 8							19	19	0
Access Rd 9									
Access Rd 10								4	4
Access Rd 11							27	27	0
Access Rd 12									
Access Rd 13									
Access Rd 14									
Access Rd 15				8	7	0	51	51	0
Access Rd 16							37	37	0
Access Rd 17									
Access Rd 19	56	56	0	67	67	0	80	80	0
Bruxner Wy 1	76	76	0	75	75	0	76	76	0
Bruxner Wy 2									
Bruxner Wy 3				14		-14	13	73	60
Bruxner Way 4									
Bruxner Way 5 Developed				15			47	37	-10
Bruxner Way 5 Existing				57	33	-24	65	70	6
Bruxner Way 6				12			46	30	-16
Bruxner Wy 7									
Bruxner Way 8				32	31	-1	66	66	0
Bruxner Way 9							43	43	0
Bruxner Wy 10				12	12	0	44	44	0
Bruxner Wy 11									
Cemetry Rd				32	32	0	54	54	0
Gunsynd Wy	75	75	0	81	81	0	87	87	0
Kentucky Ln	59	59	0	68	68	0	79	79	0
Oakhurst Rd 1	102	102	0	85	85	0	116	116	0
Oakhurst Rd 2									
Oakhurst Rd 3	58	58	0	65	65	0	74	74	0
Mungindi Goondiwindi Bdg Rd	25	25	0	54	54	0	69	69	0

Location	20% AEP			10% AEP			5% AEP		
	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)
Scotts Rd									
Tucka Tucka Rd 1									
Tucka Tucka Rd 2	27	28	0	50	51	0	64	64	0
Tucka Tucka Rd 3									
N Star 1	43	48	5	53	48	-4	58	63	6
N Star 2	44	44	0	50	50	0	51	51	0
N Star 3	21	34	13	36	33	-3	38	42	4
N Star 4	24	24	0	44	44	0	69	69	0
Newell Hwy 1									
Newell Hwy 2									
Newell Hwy 3									
Newell Hwy 4							41	41	0
Newell Hwy 5				37	37	0	55	55	0

Location	2% AEP			1% AEP			1 in 2,000 AEP		
	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)
Access Rd 1	106	106	0	81	81	1	93	94	1
Access Rd 2	34	31	-3	44	44	0	60	60	0
Access Rd 3	94	79	-14	83	74	-9	88	55	-33
Access Rd 4					11	11	57	59	1
Access Rd 5	66	66	0	64	64	0	72	72	0
Access Rd 6	55	55	0	58	58	0	70	70	0
Access Rd 7	59	59	0	60	60	0	71	71	0
Access Rd 8	39	39	0	47	47	0	68	68	0
Access Rd 9	24	24	0	38	38	0	67	67	0
Access Rd 10	33	33	0	44	44	0	66	66	0
Access Rd 11	47	47	0	49	50	0	67	67	0
Access Rd 12	15	15	0	33	33	0	63	63	0
Access Rd 13	4	5	1	27	27	0	63	63	0
Access Rd 14				31	32	0	61	61	0
Access Rd 15	60	60	0	60	60	0	65	65	0
Access Rd 16	48	48	0	51	51	0	64	64	0
Access Rd 17				25	25	0	56	56	0
Access Rd 19	82	82	0	62	62	0	66	66	0
Bruxner Wy 1	43	43	0	35	35	0	49	49	0
Bruxner Wy 2	7	47	39				21	84	64
Bruxner Wy 3	43	106	63	40	73	33	80	94	14
Bruxner Way 4	44	44	0	52	52	0	60	60	0
Bruxner Way 5 Developed	54	47	-7	57	53	-4	68	67	-1

Location	2% AEP			1% AEP			1 in 2,000 AEP		
	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)
Bruxner Way 5 Existing	67	73	6	60	63	3	68	67	-1
Bruxner Way 6	54	44	-10	56	53	-3	69	68	-1
Bruxner Wy 7	43	44	1	41	41	1	65	65	0
Bruxner Way 8	69	69	0	64	64	0	68	68	0
Bruxner Way 9	51	51	0	54	54	0	67	67	0
Bruxner Wy 10	52	52	0	55	55	0	68	68	0
Bruxner Wy 11				14	14	0	56	56	0
Cemetry Rd	53	53	0	49	49	0	60	60	0
Gunsynd Wy	86	86	0	65	65	0	69	69	0
Kentucky Ln	82	82	0	63	63	0	66	66	0
Oakhurst Rd 1	109	109	0	84	84	0	95	95	0
Oakhurst Rd 2							35	43	8
Oakhurst Rd 3	83	83	0	56	56	0	88	88	0
Mungindi Goondiwindi Bdg Rd	67	67	0	53	53	0	57	57	0
Scotts Rd	6	6	0	8	8	0	26	26	0
Tucka Tucka Rd 1				23	24	0	62	62	0
Tucka Tucka Rd 2	73	73	0	67	67	0	75	75	0
Tucka Tucka Rd 3	18	18	0	36	36	0	65	65	0
N Star 1	48	45	-3	45	48	3	59	61	3
N Star 2	62	62	0	41	41	0	60	60	0
N Star 3	39	42	3	33	36	3	56	58	3
N Star 4	72	72	0	54	54	0	75	86	11
Newell Hwy 1	43	43	0	46	46	0	53	53	0
Newell Hwy 2	28	28	0	38	38	0	57	57	0
Newell Hwy 3	35	35	0	45	45	0	59	59	0
Newell Hwy 4	54	54	0	50	51	0	64	64	0
Newell Hwy 5	63	63	0	60	60	0	66	66	0

Location	1 in 10,000 AEP			PMF		
	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)
Access Rd 1	122	124	2	141	142	1
Access Rd 2	95	95	0	116	117	0
Access Rd 3	114	74	-40	97	107	10
Access Rd 4	78	82	5	116	117	1
Access Rd 5	113	113	0	124	124	0
Access Rd 6	111	111	0	123	123	0
Access Rd 7	112	112	0	123	123	0
Access Rd 8	98	98	0	122	122	0
Access Rd 9	87	87	0	122	122	0

Location	1 in 10,000 AEP			PMF		
	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)	Existing Case ToS (hrs)	Design Case ToS (hrs)	ToS Difference (hrs)
Access Rd 10	94	95	0	121	121	0
Access Rd 11	100	100	0	122	122	0
Access Rd 12	83	83	0	119	119	0
Access Rd 13	77	77	0	119	119	0
Access Rd 14	83	83	0	117	118	0
Access Rd 15	104	104	0	119	119	0
Access Rd 16	102	102	0	118	118	0
Access Rd 17	76	77	0	113	113	0
Access Rd 19	107	107	0	117	117	0
Bruxner Wy 1	68	69	1	101	121	20
Bruxner Wy 2	44	108	64	123	142	18
Bruxner Wy 3	115	117	1	141	142	1
Bruxner Way 4	96	96	0	117	117	0
Bruxner Way 5 Developed	108	106	-2	121	121	0
Bruxner Way 5 Existing	108	107	-1	121	121	0
Bruxner Way 6	109	103	-6	122	121	-1
Bruxner Wy 7	90	90	1	120	120	0
Bruxner Way 8	108	108	0	121	122	0
Bruxner Way 9	106	106	0	121	121	0
Bruxner Wy 10	107	107	0	122	122	0
Bruxner Wy 11	69	69	0	114	114	0
Cemetry Rd	98	98	0	114	114	0
Gunsynd Wy	110	110	0	120	120	0
Kentucky Ln	108	108	0	118	118	0
Oakhurst Rd 1	133	133	0	143	143	0
Oakhurst Rd 2	54	59	5	120	125	5
Oakhurst Rd 3	110	111	1	137	136	0
Mungindi Goondiwindi Bdg Rd	97	97	0	110	110	0
Scotts Rd	27	27	0	68	68	0
Tucka Tucka Rd 1	75	75	0	121	121	0
Tucka Tucka Rd 2	116	116	0	126	126	0
Tucka Tucka Rd 3	86	86	0	120	120	0
N Star 1	81	80	-1	94	93	-1
N Star 2	74	74	0	94	94	0
N Star 3	62	65	3	84	87	3
N Star 4	103	109	6	139	138	-1
Newell Hwy 1	90	90	0	110	110	0
Newell Hwy 2	88	88	0	113	113	0
Newell Hwy 3	94	94	0	114	114	0
Newell Hwy 4	101	101	0	118	118	0
Newell Hwy 5	107	107	0	119	119	0

Table C4 Flow comparison for all AEP events

Location	Existing Case 1% AEP Flow (m^3/s)	Developed Case 1% AEP Flow (m^3/s)	Change (%)							
			1% AEP	2% AEP	5% AEP	10% AEP	20% AEP	1 in 2,000 AEP	1 in 10,000 AEP	PMF AEP
Back Ck	111	144	29.8	-22.1	-14.0	-8.1	6.5	63.6	61.7	77.0
Boggabilla 1	3224	3225	0.0	0.1	0.2	0.1	0.0	0.3	1.3	2.6
Boggabilla 2	3211	3212	0.0	-0.1	-0.2	-0.1	0.0	0.3	1.3	1.8
Brigalow Ck	1115	1116	0.1	-0.3	-0.5	-0.1	-0.2	0.5	-16.1	-3.1
Bruxner Hwy	135	127	-5.4	7.8	5.4	5.1	-5.2	137.7	33.5	-30.4
Dumaresq Rvr 1	3964	3964	0.0	0.0	0.0	-0.3	0.0	0.0	0.2	0.9
Dumaresq Rvr 2	3287	3287	0.0	0.0	0.0	-0.6	-0.1	0.4	1.7	1.6
Forest Ck	203	205	1.0	-1.1	-0.2	0.8	-0.8	5.9	8.1	15.9
Goondiwindi	2039	2039	0.0	0.0	-0.1	0.0	0.0	0.2	1.4	0.5
Mac River 1	2119	2119	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mac River 2	2141	2141	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mac River 3	3789	3785	-0.1	0.0	0.1	0.2	0.0	0.1	1.4	0.7
Mac River 4	5380	5379	0.0	0.0	0.1	0.0	0.0	0.4	1.5	1.0
Mac River 5	2919	2920	0.0	0.0	-0.2	-0.2	0.0	0.4	0.6	0.5
Mac River 6	3203	3202	0.0	-0.1	-0.2	-0.1	0.0	0.2	1.2	2.2
Mac River 7	4283	4288	0.1	-0.2	-0.3	-0.1	0.0	0.8	2.3	2.8
Mac River 8	3257	3257	0.0	-0.1	-0.2	-0.1	0.0	0.3	1.0	1.7
Mac River 9	3199	3199	0.0	-0.1	-0.2	-0.1	0.0	0.3	1.0	1.7
Mobbindry Ck	285	291	2.0	-1.7	-0.8	-0.4	0.6	4.1	5.2	21.0
Morella 1	297	298	0.3	-2.1	-3.2	-	-	0.9	2.3	2.1
Morella 2	1043	1047	0.4	-1.2	0.5	-	-	1.3	3.1	2.7
Morella 3	429	431	0.5	-2.9	0.2	-	-	0.6	2.5	2.2
Newell Hwy	535	537	0.4	-0.6	1.1	-	-	0.7	2.4	2.2
Ottleys Ck	53	53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rainbow Lgn	755	757	0.3	-1.3	-2.0	-2.0	-3.1	-0.4	0.2	-3.0
Telephone Lgn	120	120	0.0	0.0	0.1	-	-	0.5	2.2	2.0
Turkey Lgn	358	359	0.2	-0.8	-0.7	6.7	-	1.8	4.2	3.4
Whalan Ck 1	1042	1036	-0.6	0.0	0.0	1.5	0.0	-7.6	0.8	1.6
Whalan Ck 2	989	981	-0.8	1.1	0.7	1.7	0.0	-9.8	-3.5	0.5
Whalan Ck 3	1353	1346	-0.5	1.0	0.9	-0.6	-0.2	-6.9	1.2	1.9
Whalan Ck 4	331	330	-0.3	-0.2	-0.1	-0.1	0.3	0.1	1.5	1.0

APPENDIX

H

Hydrology and Flooding Technical Report

Appendix D Average Rainfall and Runoff 1987 Comparison

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

Appendix D
ARR 1987 Comparison

Assessment of ARR 1987 Hydrology for NS2B hydrologic models

1 Scope

Comparison of ARR 2016 flows to ARR 1987 approach flows has been carried out to determine the difference in flows (if any) from the two approaches and the possible impact that could result when applied to the NS2B hydrologic models.

The following steps were carried out:

- Simulation of the hydrologic models (URBS) with ARR 1987 methodology for the catchment
- Comparison of flows to ARR 2016
- Documentation of differences and discussion

The NS2B hydrology models are as follows:

- Macintyre Brook to Booba Sands
- Dumaresq River to Mauro
- Macintyre River to Holdfast
- Ottey's Creek to Macintyre River junction.

2 ARR 1987 methodology

The NS2B hydrologic models were set up to simulate flows using ARR 1987 temporal patterns, BOM's ARR 1987 rainfall depths and URBS ARR 1987 design event approach.

2.1 Temporal patterns

The temporal pattern file for Zone 2 (ZONE2.pat) was applied to the four NS2B hydrology models.

2.2 Rainfall depths

BOM's ARR 1987 IFDs were extracted for the following catchment centroids.

Catchment	Latitude	Longitude	Area (km^2)	Number of Sub-areas
Macintyre Brook	-28.3812	151.2807	3,983.0	43
Dumaresq River	-28.9804	151.5865	9,093.4	79
Macintyre River	-29.5005	151.2809	6,892.2	50
Ottleys Creek	-29.16	150.7136	1,219.8	6

2.3 Design parameters

The following URBS design parameters were applied for the ARR 1987 methodology, which were consistent with the ARR 2016 models (i.e. DPIE (Jan 1996) model with ARR 2016 rainfall).

Catchment	ARR version	Model type	Base flow volume Factor 10	Initial loss (IL) (mm)	Continuing loss (CL) (mm/hr)	Routing parameters
Macintyre Brook	1987	Same as 2016				
	2016	Uniform Continuing	0	25.0	4.0	alpha=0.2, beta=1.2, m=0.80
Dumaresq River	1987	Same as 2016				
	2016	Uniform Continuing	0.186946	47.0	2.5	alpha=0.1, beta=1.2, m=0.80
Macintyre River	1987	Same as 2016				
	2016	Uniform Continuing	0.187591	36.5	1.5	alpha=0.2, beta=1.2, m=0.80
Ottleys Creek	1987	Same as 2016				
	2016	Uniform Continuing	3	60.0	1.5	alpha=0.2, beta=1.2, m=0.80

2.4 Effective rainfall and residual loss examples (24 Hours)

Examples of effective rainfall depths and residual initial loss after application of ARF and pre-burst rainfall for the 24 hours storm are shown below.

		ARI (1 in 100)			ARI (1 in 10)		
Catchment	**ARR version**	**24H rain (mm)**	**ARF**	**IL (residual) (mm)**	**24H rain (mm)**	**ARF**	**IL (residual) (mm)**
Macintyre Brook	1987	135.6	0.82	25.0	87.6	0.82	25.0
	2016	139.0	0.83	15.3	87.8	0.83	24.2
Dumaresq River	1987	130.7	0.78	47.0	84.8	0.78	47.0
	2016	132.8	0.78	36.8	83.7	0.78	46.1
Macintyre River	1987	132.4	0.79	36.5	85.9	0.79	36.5
	2016	127.8	0.80	21.8	84.4	0.80	35.4
Ottleys Creek	1987	150.5	0.86	60.0	97.1	0.86	60.0
	2016	151.6	0.88	47.3	96.0	0.89	58.8

Table notes:

24H Rainfall depths:

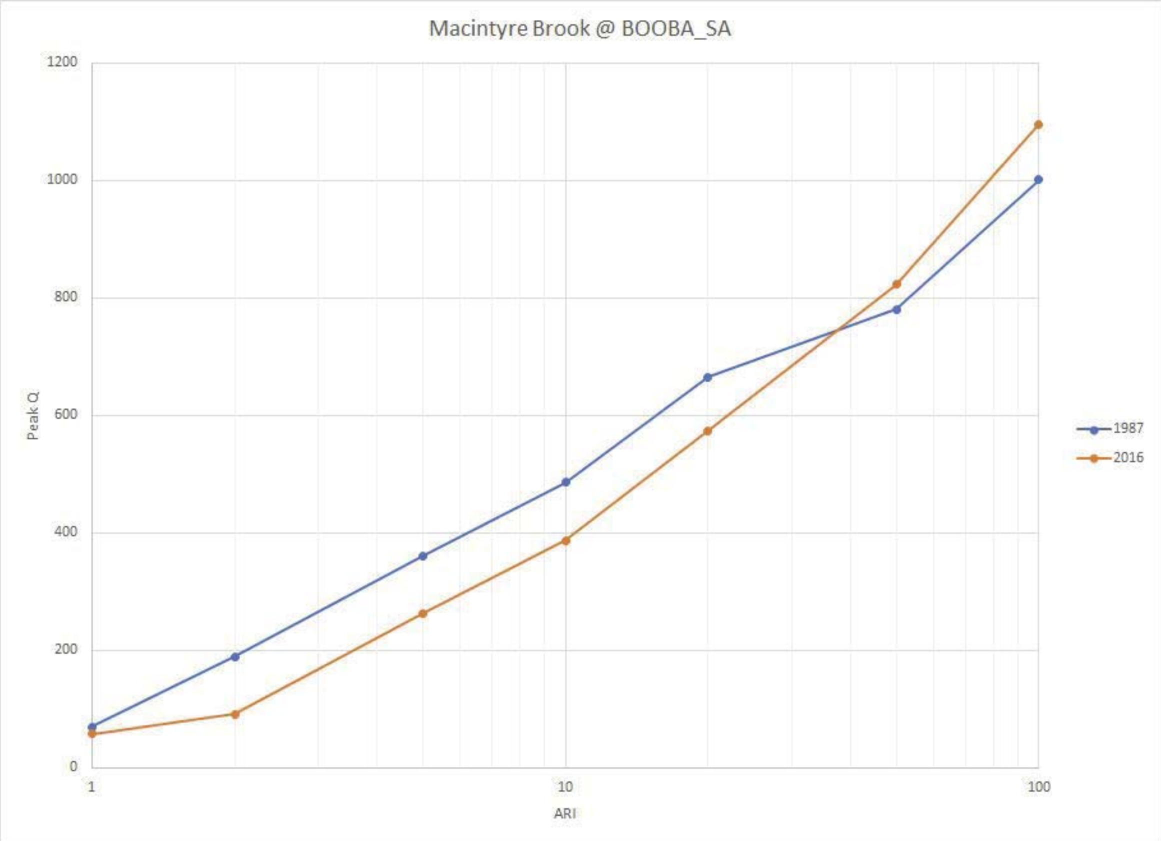
- 1987 - Rain on Catchment Centroid
- 2016 - Average Rain on Subareas

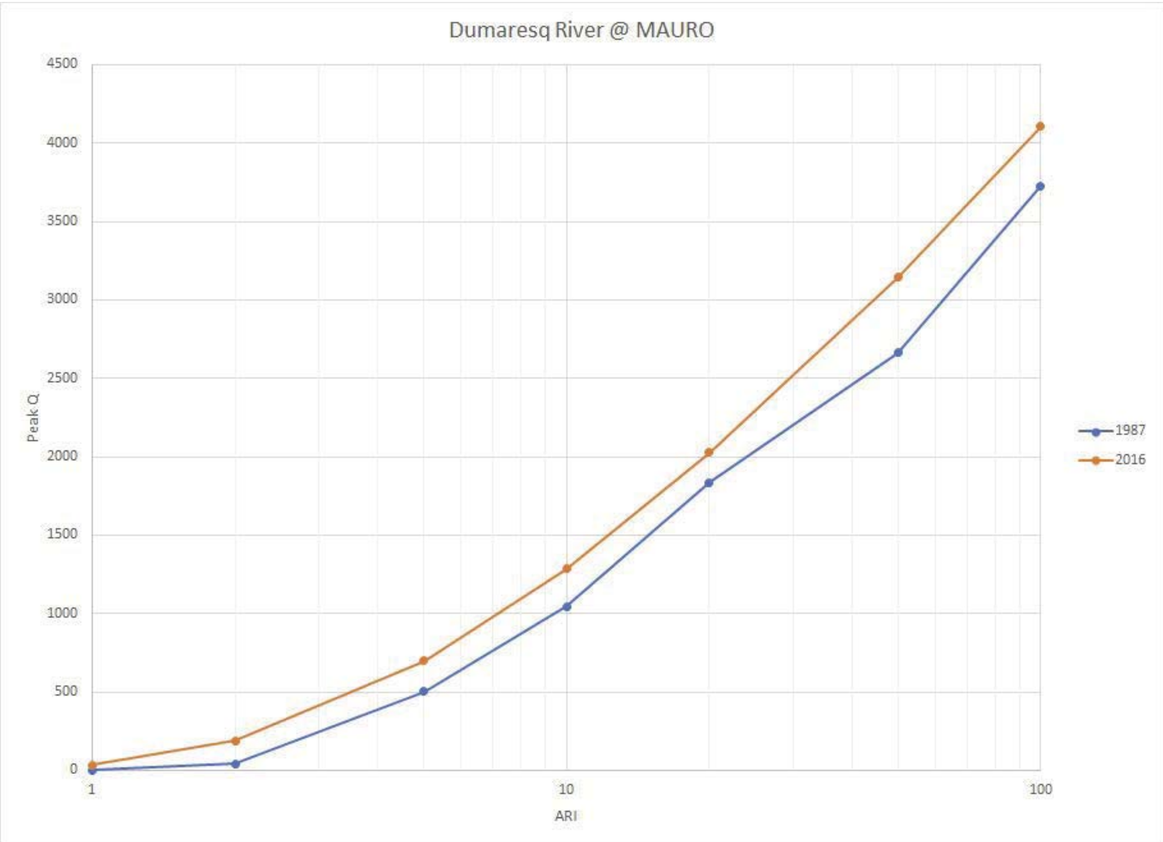
3 Comparison of flows to ARR 2016 flows

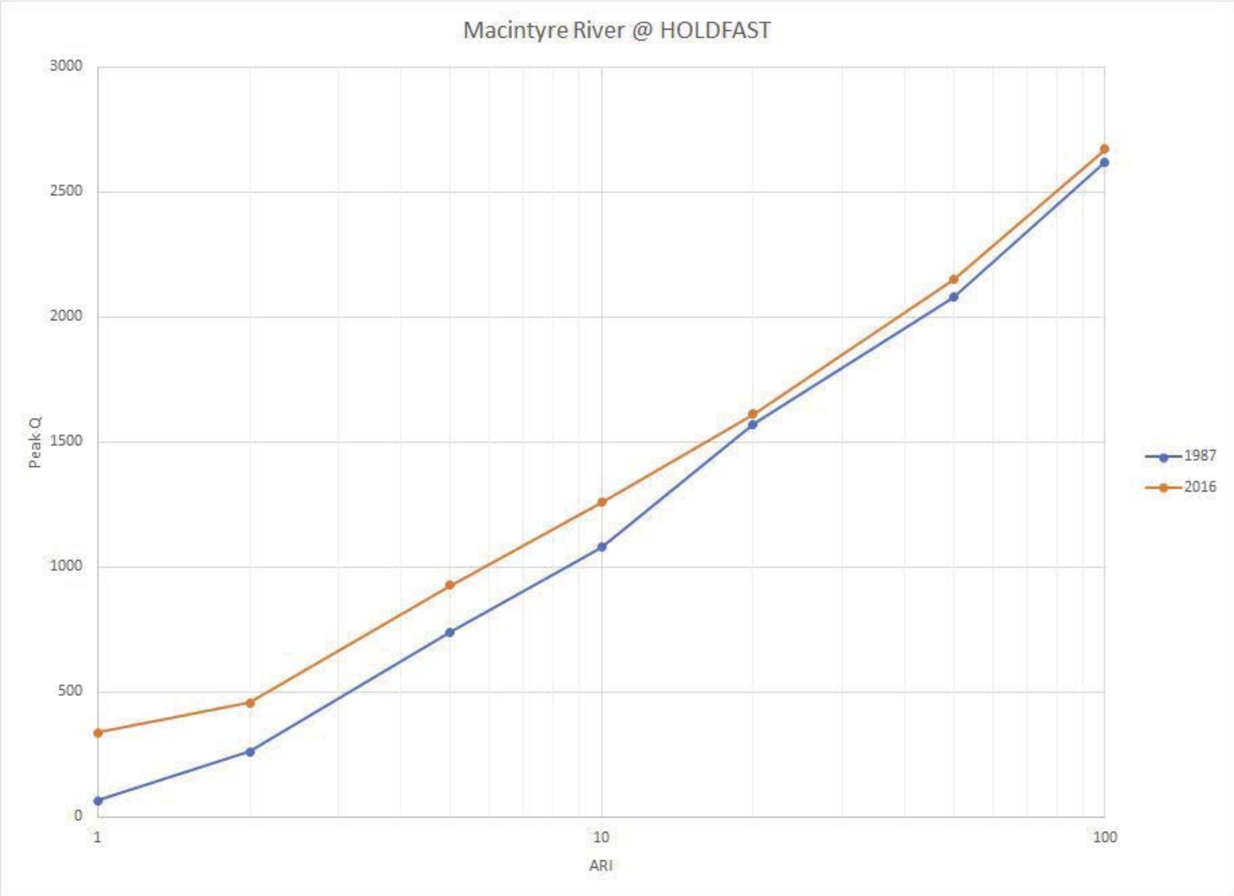
The peak discharge and critical duration results for both ARR 1987 and ARR 2016 methodologies are shown in the following table.

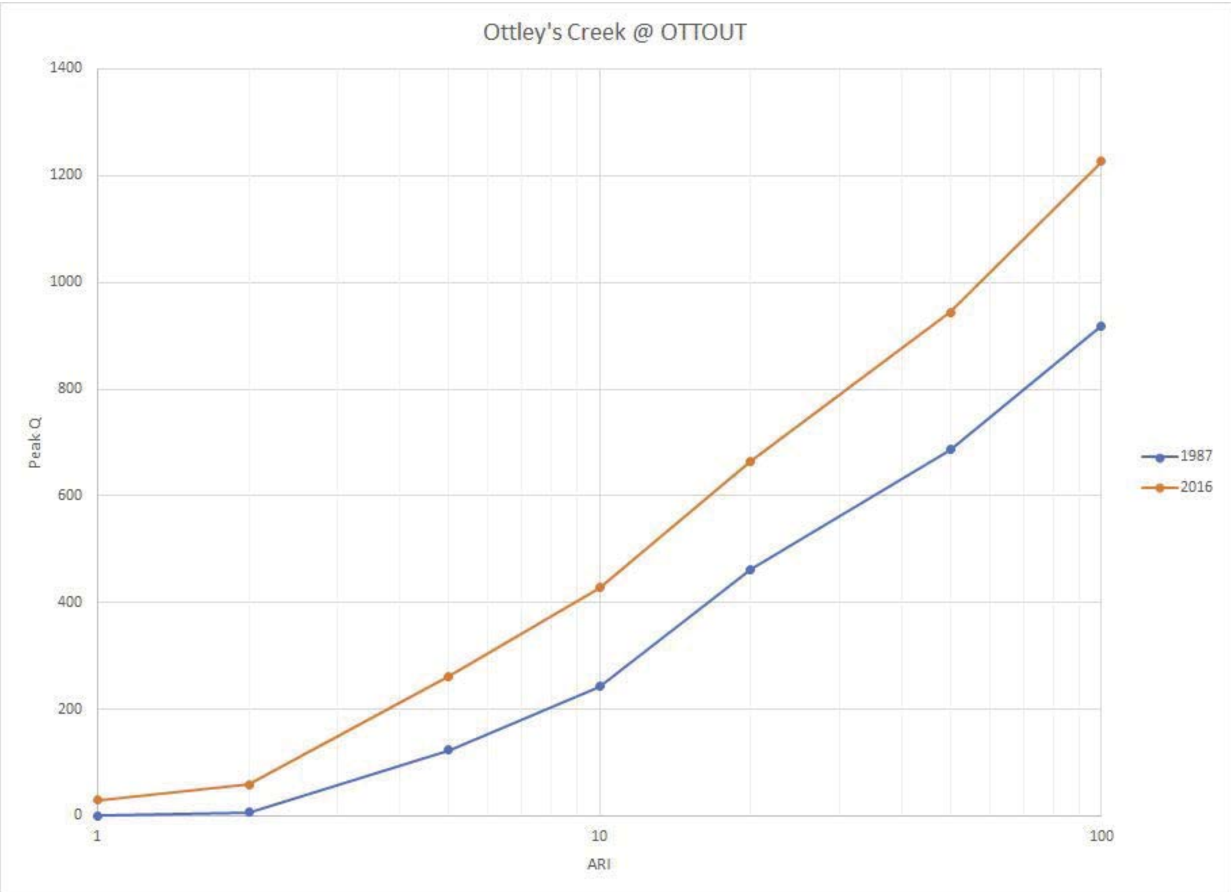
Catchment	Location	ARR Version	Value	ARI (1 in N)						
				1	2	5	10	20	50	100
Macintyre Brook	**BOOB_SANDS**	1987	Peak Flow (m^3/s)	70.3	189.4	361.1	486.7	665.9	781.3	1,001.3
			Critical Duration (Hours)	72.0H	72.0H	72.0H	72.0H	72.0H	30.0H	30.0H
		2016	Peak Flow (m^3/s)	58.2	91.4	263.8	387.7	574.7	823.4	1,095.6
			Critical Duration (Hours)	9.0H	9.0H	9.0H	24.0H	24.0H	24.0H	18.0H
Dumaresq River	**MAURO**	1987	Peak Flow (m^3/s)	0.0	43.7	501.5	1,043.5	1,833.9	2,663.3	3,727.5
			Critical Duration (Hours)	10.0M	30.0H	72.0H	72.0H	72.0H	72.0H	72.0H
		2016	Peak Flow (m^3/s)	32.8	186.8	698.2	1,283.4	2,025.4	3,144.3	4,106.8
			Critical Duration (Hours)	48.0H	48.0H	36.0H	48.0H	48.0H	48.0H	48.0H
Macintyre River	**HOLDFAST**	1987	Peak Flow (m^3/s)	65.2	262.5	740.9	1,079.7	1,570.8	2,080.5	2,621.2
			Critical Duration (Hours)	30.0H	72.0H	72.0H	72.0H	72.0H	72.0H	72.0H
		2016	Peak Flow (m^3/s)	338.3	458.2	927.6	1,259.2	1,612.0	2151.3	2,672.4
			Critical Duration (Hours)	48.0H	48.0H	96.0H	96.0H	96.0H	24.0H	24.0H
Ottleys Creek	**OUTLET**	1987	Peak Flow (m^3/s)	0.0	7.0	123.2	242.8	461.7	686.8	918.0
			Critical Duration (Hours)	10.0M	30.0H	30.0H	72.0H	72.0H	72.0H	30.0H
		2016	Peak Flow (m^3/s)	29.5	58.6	262.0	427.8	665.1	944.2	1,226.8
			Critical Duration (Hours)	120.0H	168.0H	48.0H	48.0H	48.0H	48.0H	48.0H

The peak discharge versus ARI curves for both methodologies are shown in the following plots for the four models.






Macintyre River @ HOLDFAST
3000
2500
2000
1500
1000
500
0
Peak Q
1
10
100
ARI
1987
2016


Ottley's Creek @ OTTOUT
1400
1200
1000
800
600
400
200
0
Peak Q
1
10
100
ARI
1987
2016

4 Differences

The differences in peak discharges between ARR 1987 and ARR 2016 methodologies for 1 in 100 and 1 in 10 ARI events are shown in the following table.

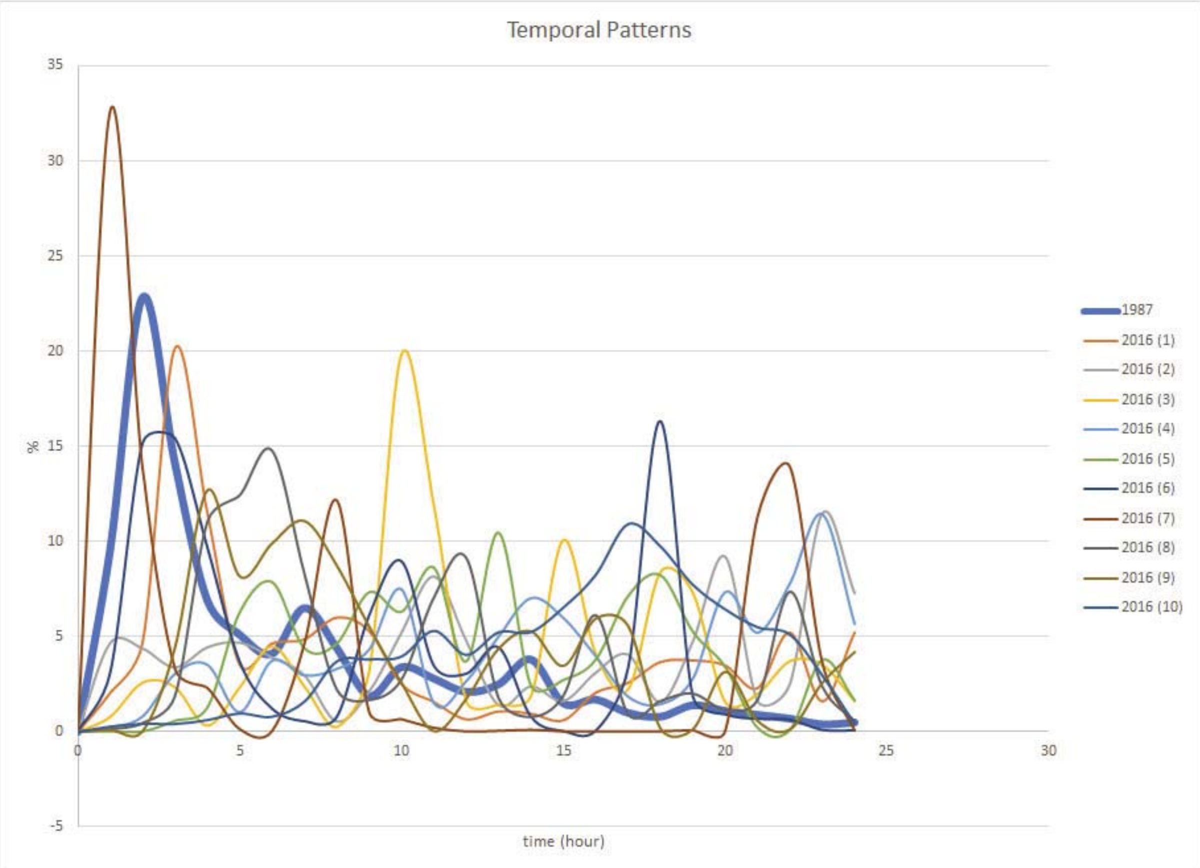
Catchment	Location	ARI (1 in 100)	ARI (1 in 10)
		Ratio (1987/2016)	Ratio (1987/2016)
Macintyre Brook	BOOBA_SANDS	91%	126%
Dumaresq River	MAURO	91%	81%
Macintyre River	HOLDFAST	98%	86%
Ottleys Creek	OUTLET	75%	57%

5 Discussion

The comparison shows that generally ARR 1987 flows are generally less than the ARR 2016 estimates, due to ARR 1987 methodology providing lower rainfall depths and different ARFs (refer Section 2.4), but not reduced ILs. This is due to the inclusion of pre-burst rainfall, which is accounted for in ARR2016 and not ARR 1987.

5.1 Ottleys Creek

Flows generated using the ARR 1987 methodology were significantly less than the flows from ARR 2016 for the Ottleys Creek catchment when compared to the other catchments. In addition to the above reasons, another contributing factor is that the ARR 1987 Zone 2 temporal patterns are relatively front loaded (shown in the bold blue line), as observed for the 24-hour storm temporal pattern comparison below. This would result in greater influence being exerted by the adopted IL.



5.2 Macintyre Brook

ARR 1987 flows are predicted to be higher than ARR 2016 for the Macintyre Brook catchment for more frequent events. This is a result of:

- The ARR 1987 effective rainfall depths are generally more than the corresponding ARR 2016 values for more frequent events, as shown in the following table and Section 2.4, noting that ARR 2016 IFD < ARR 1987 IFD for 1 in 2 and 1 in 5 AEP
- The residual initial losses for ARR 2016 increase with frequency (Section 2.4)
- Another reason that Macintyre Brook to Booba Sands exhibits a cross-over in results for the 1 in 20 to the 1 in 50 AEP could be due to change in temporal patterns, noting that in ARR 1987 there are two temporal patterns, i.e. "< 1 in 30 AEP" and "> 1 in 30 AEP"
- The model is underestimating design flows (lower range for flows) for the higher frequency events in the Macintyre Brook. This is from the higher Continuing Loss rate (CL), that is more dominant in the smaller rainfall depth events. With a lower CL it is most likely the ARR 2016 predicted flows would be higher for all AEPs, and consistent with the other catchment results

All these reasons have resulted in differences in rainfall excess that are consistent with differences in peak flow (refer rainfall excess table below).

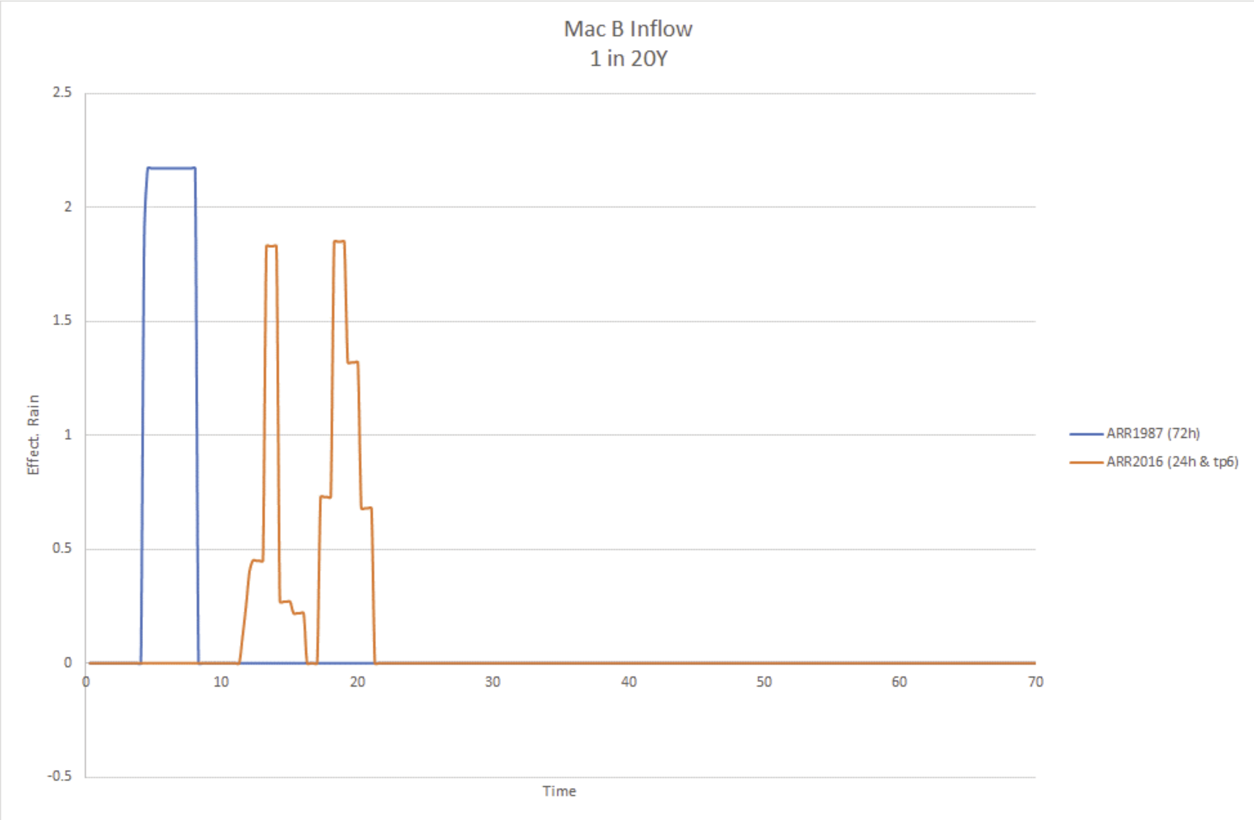
ARR Version	ARI (1 in N)											
	1		2		5		10	20		50		100
	24H Rain (mm)	IL (res) (mm)	24H Rain (mm)	IL (res) (mm)	24H Rain (mm)	IL (res) (mm)	Refer	24H Rain (mm)	IL (res) (mm)	24H Rain (mm)	IL (res) (mm)	Refer
1987	47.8	25.0	61.5	25.0	77.6	25.0	S2.4	101.5	25.0	120.5	25.0	S2.4
2016	49.6	25.0	55.3	24.9	74.1	24.5	S2.4	102.0	23.8	122.3	19.0	S2.4

ARR Version	ARI (1 in N)							
		1	2	5	10	20	50	100
1987	Peak Q (m^3/s)	70.3	189.4	361.1	486.7	665.9	781.3	1,001.3
	Critical D (Hours)	72.0H	72.0H	72.0H	72.0H	72.0H	30.0H	30.0H
2016	Peak Q (m^3/s)	58.2	91.4	263.8	387.7	574.7	823.4	1,095.6
	Critical D (Hours)	9.0H	9.0H	9.0H	24.0H	24.0H	24.0H	18.0H

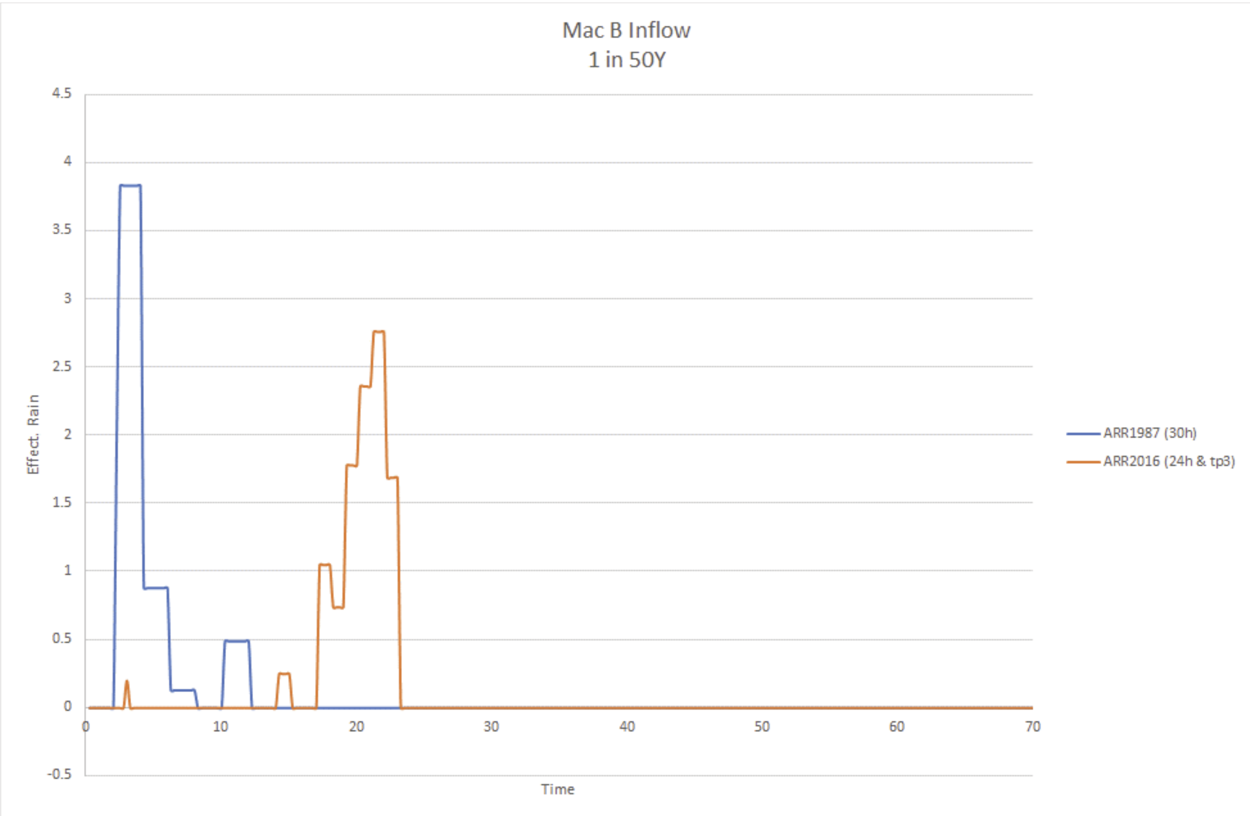
Rainfall excess for 24 hours rain upstream of Coolmunda Dam (mm)

ARR	TP	ARI (1 in N)						
		1	2	5	10	20	50	100
1987	Zone 2	0	2.8	10.8	17.3	26.1	38.0	49.4
2016	TP1	0	0.2	5.5	12.7	22.2	36.7	50.4

The following rainfall excess intensity plots for the critical storms of the 1 in 20 and 1 in 50 ARI further illustrate the reasons for the cross-over.



Note: For the 1 in 20Y event where ARR 1987 resulted in higher peak flow, we can clearly see that the area under the blue burst (rainfall excess intensity) is more than the area under either orange burst.



Note: For the 1 in 50Y event where ARR 2016 resulted in higher peak flow, we can see that the area under the main orange burst (~42 mm) is more than the area under the main blue burst (~37 mm).

6 Conclusion

In conclusion the ARR 2016 methods provide higher flows than the ARR1987 method in the Border Rivers Catchment. Therefore, ARR 2016 provides more conservative levels and flows for assessment of the proposal alignment than ARR 1987 approaches. In Macintyre Brook, ARR 2016 flows were lower in the higher frequency events. This is predominantly related to the higher CL reducing peak flows in the smaller events. This does not impact the large events (i.e. 1% AEP and larger) that are used for the assessment and design of the proposal alignment.

INLAND RAIL

APPENDIX H

Hydrology and Flooding Technical Report

Appendix E Independent Peer Review

NORTH STAR TO NSW/QUEENSLAND BORDER ENVIRONMENTAL IMPACT STATEMENT

ARTC

The Australian Government is delivering Inland Rail through the Australian Rail Track Corporation (ARTC), in partnership with the private sector.

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Our Ref: ATC: L.B23635.003.N2BRev.docx

12 May 2020

Inland Rail
via email: JCarr@ARTC.com.au
Project Manager – NS2B

Attention: John Carr

Dear John

RE: INDEPENDENT HYDROLOGY & FLOODING REVIEW - NORTH STAR TO NSW/QLD BORDER, APPENDIX H – HYDROLOGY AND FLOODING TECHNICAL REPORT - SUMMARY OF REVIEW FINDING

BMT has completed a review of the Inland Rail: North Star to NSW/QLD Border, Appendix H – Hydrology and Flooding Technical Report: Document Number 2-0001-270-EAP-10-RP-0407 Revision 0, 1 May 2020 (NS2B Flooding Report, May 2020).

This review is subsequent to our previous review provided on 28 August 2019 and this review has included consideration of discussions with ARTC during the months of March to May 2020.

1. General Comments

Provided below are our general comments on the numerical flood models.

1) The latest flood model developed by ARTC is the most comprehensive and accurate model developed for the Border Rivers floodplain system to date and incorporates current best practice approaches and techniques to flood modelling and flood impact assessments.

2) The latest model developed by ARTC updates all previous models, in terms of accuracy, as this model is based on current (2019) LiDAR topographic survey that was flown specifically by ARTC for this project.

3) The LIDAR data is of a high accuracy and allows, not only a good representation of flow paths and inundation areas, and allows all existing levees to be accurately represented, and within the modelling, allows for these levees to overtop when flood levels are higher than the levees. Previous models have assumed that many levee banks do not overtop. The modelling, which is the subject of this review, demonstrates significant overtopping of levee banks can occur in severe flood events. This can have significant effects on flow paths and flood levels predicted across the floodplain.

4) As a large range of floods has been simulated in the flood modelling, from relatively frequent events, up to extreme events well in excess of any historic floods, a full and comprehensive understanding of flooding under all events has been established, and the assessment of impacts from the proposed rail line has now also been assessed for this full range of events. Whilst no two floods are alike in such a complex system as the Border Rivers, this range,

along with actual historic event simulations provides an acceptable level of confidence that the range of possible flood impacts has been captured.

5) The resultant flood model, based on the latest LiDAR survey of a very large area of the floodplain, from upstream of Boggabilla to well downstream of Goondiwindi, coupled with the full range of design events produced, provides an opportunity for local and State authorities in both New South Wales and Queensland to take advantage of this contemporary robust tool, for future development and infrastructure project assessments.

The investigations to date have set clear guidance for the requirements for the detailed design, and for landowner consultation to enable the final design to achieve acceptable outcomes for all parties.

2. Key Points

2.1. Use of and Size of the Critical Design Event – 1% AEP

The use of and the size of the critical 1% AEP design event, adopted as the relevant design event to assess impacts against acceptance criteria, is a key decision point and our review findings our detailed below.

Technical Notes

(1) As noted in the NS2B Flooding Report, May 2020, Table 7.7 and Table 8.9, the adopted factored 1% AEP design flow of **3,294** m^3/s downstream of Boggabilla (i.e. excludes breakout flow) and **5,379** m^3/s upstream of Boggabilla (including breakout flow) was used as the design flood event flows. These flows compare to the following analyses and historical events:

I. The FFA predicted flow for the 1% AEP was 3,800 m^3/s at Boggabilla (refer to Table 8.9), which from our understanding represents a total flow (i.e. including breakout flow), therefore this would be comparable to the design 1% AEP of 5,379 m^3/s, indicating a conservative 1% AEP design event has been adopted;

II. 1996 flood event:

i). modelled flow downstream (i.e. excludes breakout flow) was 3,237 m^3/s (i.e. factored by 1.6) and 2,542m^3/s (unfactored); this compares well with rated gauge flow of 2,485 m^3/s for unfactored conditions;

ii). modelled flow upstream (i.e. includes breakout flow) was 5,104 m3/s (i.e. factored by 1.6) and 3175 m3/s (unfactored); this again compares well with rated gauge total flow of 3,486 m3/s for unfactored conditions; and

iii). the 1% AEP design event flow upstream (i.e. includes break out flow – 5,379 m3/s) is therefore equivalent to the factored 1996 flow (i.e. 5,104 m3/s) and significantly larger than the unfactored 1996 flow (i.e. 3,486 m3/s).

III. 2011 flood modelled flow that includes the breakout flow was 4,449 m^3/s and therefore overpredicts the rated gauge flow of 3,803 m^3/s, indicating a conservative modelled result. It is also noted that the 1% AEP design flow of 5,379m^3/s exceeds the 2011 calibrated flow.

IV. 1976 flood event modelled flow was 3,836 m^3/s (i.e. factored by 1.2) and 3,626m^3/s (unfactored) at Boggabilla, compares well with rated gauge flow of 3,700m^3/s (i.e. excludes breakout flow). However, with support of Figure 8.6, Figure 8.7 and Figure 8.9 including discussions with ARTC, we understand that:

i). the 1976 rating records excluded the breakout flow, while a reasonable total flow gauge rating was achieved for the 1996 flood event and this is consistent with the 2011 gauged flows, that are also inclusive of breakout flows.

ii). as the 1976 record for rated gauge flow (i.e. 3,700 m3/s) is believed to have excluded the breakout flow (i.e. not consistent with 1996 & 2011 ratings) therefore the comparable rated total flow should be in the order of 4,520 m3/s (refer to Figure 8.9) when breakout flows are taken into account; and

iii). based on Table 7.13 (including discussions with ARTC) the modelled total flow is in the order of 8,400 m3/s to 7,000 m3/s, which is notably greater than the 1% AEP adopted design flow as presented on Figure 8.10 (i.e. 1976 approx. 0.5% AEP) and the rated total gauge total flow of 4,520 m3/s.

(2) The adopted 1% AEP flow results in lower flood impacts than that from the 1976 flood event and higher flood impacts than that from the 2011 flood event (refer to Figure A14-B3 and Figure A26 for comparison).

(3) From NS2B Flooding Report, May 2020, we note, both the DPIE and Goondiwindi Regional Council apply the 1976 flood as one of a suite of floods in their assessment of development.

Summary

The 1% AEP design flows presented in the NS2B Flooding Report, May 2020, are considered reasonable and acceptable at this investigation phase, subject to undertaking the proposed joint probability analysis in subsequent design phases and, based on that work, the 1% AEP design event flows are then to be reviewed.

While uncertainty will remain with the adopted 1% AEP flood event flows (refer to Section 7 and 8 of the NS2B Flooding Report, May 2020), we recommended that it would be prudent to continue to use the 1976 flood event as a sensitivity analysis/check in subsequent design and to assist with landholder negotiations prior to undertaking the joint probability.

2.2. Acceptability Criteria

The acceptability criteria (i.e. flood impact objectives) is provided in NS2B Flooding Report, May 2020, Table 4.2 and a portion of the table is provided below for ease of reference.

Table 1.1 Flood impact objectives

Parameter	Objectives				
Afflux[1]	Existing habitable and/or commercial and industrial buildings/premises (e.g. dwellings, schools, hospitals, shops)	Residential or commercial/industrial properties/lots where flooding does not impact dwellings/ buildings (e.g. yards, gardens)	Existing non-habitable structures (e.g. agricultural sheds, pump-houses)	Roadways	Agricultural and grazing land/forest areas and other non-agricultural land
	≤ 10 mm	≤ 50 mm	≤ 100 mm	≤ 100 mm	≤ 200 mm with localised areas up to 400 mm
	Changes in peak water levels are to be assessed against the above proposed limits. It is noted that changes in peak water levels can have varying impacts upon different infrastructure/land and flood impact objectives were developed to consider the flood sensitive receptors in the vicinity of the proposal. It should be noted that in many locations the presence of existing buildings or infrastructure limits the afflux.				
Change in	Identify changes to time of inundation through determination of time of submergence (ToS).				

Impacts that are within the above criteria may still result in unacceptable damage and cost, such as:

(1) Impacts of 100 mm on individual sheds and pumphouse could lead to significant additional flood damage if they cause inundation when otherwise dry.

(2) Impacts of up to 400mm on agricultural/grazing land and roads may also significant.

From the report and through discussions with ARTC the following infrastructure that exceeds the flood impact objectives:

(1) two non-habitable dwellings identified above 10mm afflux in 1% AEP event significant;

(2) One shed (ID1) 50mm afflux with an existing predicted flood depth of 174mm; and

(3) One pump with (ID149) 14mm afflux with existing predicted flood depth 5.4m.

As noted in NS2B Flooding Report, May 2020, Section 4.2, the proposed individual landowner consultation and formal agreement requirements will be undertaken in the detailed design phase, to ensure impacts are acceptable to landowners and that potential liability is suitably addressed. This approach is considered reasonable and acceptable.

2.3. Hydrology

The adopted design hydrology for the Border Rivers catchment is subject to uncertainty due to the complexity of the catchment; consequently, the calibration through factoring of the design 1% AEP flow by 0.7 as detailed in the NS2B Flooding Report, May 2020, Section 8.2.4 is a key design parameter.

Results of our review are presented below:

Technical Notes

(1) With reference to NS2B Flooding Report, May 2020, to Section 7.3, there have been five significant floods (5) with level and flows recorded at Boggabilla and these are detailed below for ease of reference in order of peak flood level:

i). Feb 1976 -> 221.27 m AHD (gauged flow 3,700 m3/s, modelled 3,836 m3/s, excludes breakout flows);

ii). Factored 1% AEP TUFLOW modelled -> 221.20 m AHD

iii). Jan 2011 -> 221.12 m AHD (gauged flow 3,803 m3/s);

iv). Jan 1996 -> 221.03 m AHD (gauged flow 3,486 m3/s)

v). Mar 1890 -> 221.01 m AHD (gauged flow 2,430 m3/s)

vi). Jan 1956 -> 220.91 m AHD (gauged flow 2,040 m3/s)

The design 1% AEP is the 2nd highest when compared to the gauged level.

(2) From Section 7.5.3, we note the design 1% AEP flows based on the total upstream flow are as follows:

i). Feb 1976 -> 8,480m3/s (factored) to 7,000m3/s (un-factored) – factor of ≈20%;

ii). 1% AEP -> 5,379m3/s;

iii). 2011 -> 4,449m3/s

iv). 1996 -> 3,175m3/s (un-factored) to 5,104m3/s (factored) - factor of ≈60%;

The above indicates that the design 1% AEP is the 2nd highest flood flow when compared to the modelled flow and exceeds both the 2011 and 1996 flood events but is notably smaller than 1976.

(3) Uncertainty remains with the hydrological calibration of the 2 significant floods of 1976 and 1996 and, to a limited degree for the 2011 flood. For the 1976 flood event, the flows were factored up by 20%, while for the 1996 flood event the flows were factored up by 60%. Results from the calibration/verification of the 2011 flood provide an increased level of confidence in the hydrological and hydraulic model performance.

(4) Uncertainty remains in the flood frequency analysis (FFA) at the Boggabilla gauge as demonstrated in the NS2B Flooding Report, May 2020, Figure 8.9 and Figure 8.10. Whilst we appreciate the inherent difficulties due to breakout flows upstream of the gauge, the derivation of the 1 % AEP through calibration of the flows to the gauge data results in residual uncertainty. the proposed joint probability analysis may assist in further supporting the adopted design flows.

Summary

As summarised in Section 1.1, the 1% AEP design flows presented in the NS2B Flooding Report, May 2020, are considered reasonable and acceptable at this investigation phase, subject to undertaking the proposed joint probability analysis in subsequent design phases, and based on that work, the 1% AEP design event flows are to be reviewed.

Our review of the report and through discussion with ARTC with regards to total catchment flows, has assisted in the comparison between flood events and the residual uncertainty. The calibration/verification of the 2011 flood event provides a greater degree of confidence of the hydrological and hydraulic model performance and therefore the analyses presented supports the adoption of the 1% AEP design flood flow used in the assessment.

The report highlights the magnitude of the 1976 flood event compared to the 1% AEP flood event. It is appreciated that from the analysis undertaken, the 1976 modelled event while having inherent uncertainties is significantly greater than the design 1% AEP flood event. Therefore, while uncertainty remains with the adopted 1% AEP flood event flows (and the 1976 flood event) it would still be prudent to continue to use the current estimates for the 1976 flood event as a sensitivity analysis/check in any subsequent design.

3. Joint Probability Analysis

We note the recommendation of the undertaking of joint probability analysis during detailed design. Joint probability methods are discussed in detail in ARR 2019 and we agree these methods should be further investigated and that such joint probability analysis should be carried out.

Key discussion points are as follows:

(1) One (1) flood in the last 50 years have an adopted gauge flow and/or modelled flow greater than the adopted 1% AEP design flow.

(2) Until such joint probability analysis is completed it would be prudent to use the 1976 flood event for a sensitivity analysis/check in any subsequent design.

With regards to the joint probability concept, the 1976 flood event ARI is presented in the FFA graphs of Figure 8.1, Figure 8.3, Figure 8.4 for the 3 main catchments as follows:

(1) >100yr ARI in the Macintyre Brook at Booba Sands (catchment area = 4,920 km^2)

(2) >100yr ARI in the Macintyre at Holdfast (catchment area = 6,740 km^2)

(3) Approx. 25yr ARI in Dumaresq River at Roseneath (catchment area = 5,550 km^2)

As noted in these graphs, a joint probabiltiy analysis would provide merit in justifying the 1% AEP flood event.

4. Hydraulics - Flood Impacts

The TUFLOW hydraulic 'base' model from this desktop review is considered to be fit-for-purpose for this stage of investigations.

The flood impact maps are presented for the 20%, 10%, 5%, 2% 1% AEP including the 1 in 2,000 yr AEP, 1 in 10,000 AEP and PMF. From a review of the afflux at sensitive receptors as presented in the ARTC Table C1, the flood impacts meet the set 'afflux criteria' (noting our comments above regarding the need for formal landowner agreement in relation to these impacts).

A key point is the magnitude of afflux for the 1976 flood event as detailed in the ARTC Table C2. The results indicate an increase in afflux for:

(1) about 14 sensitive receptors;

(2) agricultural/grazing land (i.e. around chainage 25km north/south) with an increase in the order of 0.2 m to 0.5 m and potentially greater than >0.5m closer to the proposed alignment.

As previously noted in this letter, the impacts from the 1976 flood event are recommended to also be considered during landholder negotiations.

5. Overtopping Risk

Flood immunity and overtopping risk are provided in Section 9.2.1 of the NS2B Flooding Report, May 2020. While flow hydrographs are presented in Figure 9.1 where the proposed embankment overtops (i.e. Ch 28.0 km to 28.5km), consideration needs to be provided to other failure mechanisms such as piping failure and the potential flood hazard to downstream sensitive receptors.

As noted from Figure A16-E to A16-G a significant head difference would appear to be predicted in the location between chainage 20 km to 25 km.

As detailed in the further information provided by ARTC, these matters and potential mitigation measures (i.e. property solutions, scour and embankment protection, refined drainage structures etc) will be addressed during detailed design and through landowner negotiations.

6. Report General Comments

Points of Note

§ 4.2 – We agree with comment that '*acceptable impacts will ultimately be determined on a case by case basis with interaction with stakeholders/landholders through the community engagement process…*'

§ 5.1, Pg. 14 – DPIE will use the model to assess development impacts on both the 1996 (small) flood event and the 1976 (large) flood event. ARTC is not assessing this criterion but impacts from the 1976 flood event are recommended to be considered to assist with landholder negotiations.

Minor Point:

There appears to be additional rainfall gauge data that may be available for at least the 2011 flood event that has not been included in the assessment and use of this data should be considered in subsequent design phases.

Qualifications

This review is based on desktop assessment only. As a result, it is based on the chapter and technical report (NS2B Flooding Report, May 2020) which document the methodology of calibration, validation and application of the base TUFLOW flood model, and its use of assessment of impacts as a result of the proposed infrastructure.

Yours Faithfully
BMT

Neil Collins
Principal Hydraulic and Water Resources Engineer

Anthony Charlesworth
Principal Engineer