Future Freight Joint Venture
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Technical Note

To	**John Carr (ARTC)**	From	**Trinity Graham (FFJV)**
Copy	**Ben Lippett (ARTC)**	Reference	**2-0001-270-IHY-10-TN-0012_Rev 0**
Date	**10 December 2021**	Pages (including this page)	**28**
Subject	**Response to DPIE RFI regarding further modelling and assessment of velocities through culverts**		

1 Overview

DPIE issued a minor RFI (20/08/21) for additional information as per the below:

All requests for information outlined below are to be considered using the revised hydrological model provided in the PIR, with both levee scenarios – the 2019 lidar survey and the BRVFMP levee data.

- ***Road Trafficability***
  - *The PIR considered road trafficability at the 1976/1% AEP event noting there are sections of roads with increases to afflux and duration but accessing those areas is not possible due to flooding elsewhere.*
  - *Information is required about the impact to road trafficability during more frequent events.*
  - *Please identify the flooding event/s in which the project causes currently trafficable roads to become non-trafficable or extends periods of non-trafficability. This must identify the areas of roads affected and consider changes to afflux, duration and/or hazard.*

- ***Erosion and Scour***
  - *Further modelling work is being done in accordance with the Department's Major RFI request of 11 June. The Department is concerned that impacts of scour and erosion may be more significant in more frequent events than the 1976 or 1% AEP event.*
  - *Please provide details of which of the more frequent events result in velocity impacts exceeding the QDLs and what those velocity levels are. Any mitigation measures considered to reduce erosion and scour impacts must also consider those more frequent events that exceed the QDLs.*

- ***Climate change impacts***
  - *The EIS indicated that the rail line would not be overtopped. Please advise whether this remains the case with the revised modelling in the PIR and provide details of any overtopping of the rail alignment and / or additional impacts to residences and infrastructure.*

- ***Cross drainage near Macintyre River***
  - *There is a large section of the alignment with little cross drainage where the PIR models flows running parallel to the rail alignment. With different spatial distributions of rainfall in the upstream catchments, the proportion of flows arriving on each side of the alignment may alter necessitating provision of additional cross drainage to equalise conditions on each side of the alignment.*
  - *Please examine the spatial variation in historical rainfalls and use this to determine alternative flow distributions for the design floods. These should then be used to examine the adequacy of the*

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currently proposed cross drainage infrastructure and where necessary, provide additional cross drainage infrastructure to ensure the QDLs are satisfied under alternative flow distributions.

The following sections provide responses to each of these items.

In addition, results from modelling carried out in relation to the North Star construction camp are provided in Section 5

2 RFI response

As discussed with DPIE the RFI response has focused on the case with the BRVFMP levees. In this case overtopping of the levees does not occur and more water is retained in the floodplain and this should result in greater impacts.

The results presented below are based on the mitigated design from the detailed TUFLOW sub-modelling documented in the Major RFI response (2-0001-270-IHY-10-TN-0011_Rev 1.pdf). The TUFLOW sub-models have been used to provide the results presented in the following sections.

2.1 Road Trafficability

Section 6.1.2 of the NS2B Preferred Infrastructure Report (PIR) included a review of impacts on roads in the vicinity of the NS2B alignment for the 1976 flow scenario (main floodplain) and the 1% AEP event (southern tributaries). The same road inspection locations, as shown on Figure 6, have been examined for the 20%, 10%, 5% and 2% AEP events. This inspection has been carried out for the Existing Case and Developed Case with change in peak water level, flood duration and flood hazard reviewed.

The following tables present the results at each of the road inspection locations for each AEP. The tabulated results show that for the events less than 1% AEP there is a significant reduction in flood extent with shallower overtopping depths. In some areas whilst the overtopping is shallow it does occur over an extended period but the mitigated Reference Design does not lead to significant increases in flooded depth, inundation duration or hazard for roads in the vicinity of the alignment.

Table 1 Road inspection locations – 20% AEP event results

Road Inspection ID	Depth		Inundation Duration		Hazard (depth x velocity)	
	Existing Case (m)	Change in depth (m)	Existing Case (hrs)	Change in inundation duration (hrs)	Hazard (m^2/s)	Change in Hazard (m^2/s)
Access Rd 1	0.55	0.00	80.83	0.04	0.11	0.00
Access Rd 2	0.05	0.01	50.68	0.40	0.00	0.00
Access Rd 3	0.21	0.00	73.78	0.03	0.03	0.00
Access Rd 4	0.02	0.00	25.72	0.15	0.00	0.00
Bruxner Wy 4 (Whalan Creek)	0.04	-0.01	82.84	0.03	0.02	0.00
N Star 1	0.33	-0.08	72.70	-19.68	0.28	0.00
N Star 2	0.27	0.00	36.99	0.00	0.39	0.00
N Star 3	0.23	0.06	25.12	9.91	0.06	0.02
N Star 4	0.14	0.00	34.06	-0.43	0.00	0.00
Oakhurst Rd 1	0.15	0.01	89.07	0.04	0.11	0.00

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Road Inspection ID	Depth		Inundation Duration		Hazard (depth x velocity)	
	Existing Case (m)	Change in depth (m)	Existing Case (hrs)	Change in inundation duration (hrs)	Hazard (m^2/s)	Change in Hazard (m^2/s)
Oakhurst Rd 2	0.10	0.01	56.76	0.01	0.01	0.00
Oakhurst Rd 3	0.42	0.00	70.99	0.02	0.06	0.00

Table 2 Road inspection locations – 10% AEP event results

Road Inspection ID	Depth		Inundation Duration		Hazard (depth x velocity)	
	Existing Case (m)	Change in depth (mm)	Existing Case (hrs)	Change in inundation duration (hrs)	Hazard (m^2/s)	Change in Hazard (m^2/s)
Access Rd 1	0.69	0.00	82.47	0.02	0.14	0.00
Access Rd 2	0.12	0.01	69.07	0.04	0.00	0.00
Access Rd 3	0.25	-0.01	75.45	0.01	0.04	0.00
Access Rd 4	0.12	0.01	60.70	-0.62	0.01	0.00
Bruxner Wy 4 (Whalan Creek)	0.29	-0.02	83.40	0.00	0.08	0.01
Bruxner Wy 6	0.02	Dry	30.72	Dry	0.01	Dry
N Star 1	0.41	-0.09	74.24	-17.91	0.37	0.01
N Star 2	0.46	0.00	44.07	0.01	0.50	0.00
N Star 3	0.30	0.04	34.76	7.96	0.09	0.01
N Star 4	0.18	0.00	36.38	0.00	0.00	0.00
Oakhurst Rd 1	0.23	0.01	89.61	0.00	0.15	0.00
Oakhurst Rd 2	0.08	0.01	54.10	0.47	0.01	0.00
Oakhurst Rd 3	0.53	0.00	72.91	0.02	0.08	0.00
Scotts Rd	0.01	0.00	1.50	0.09	0.00	0.00

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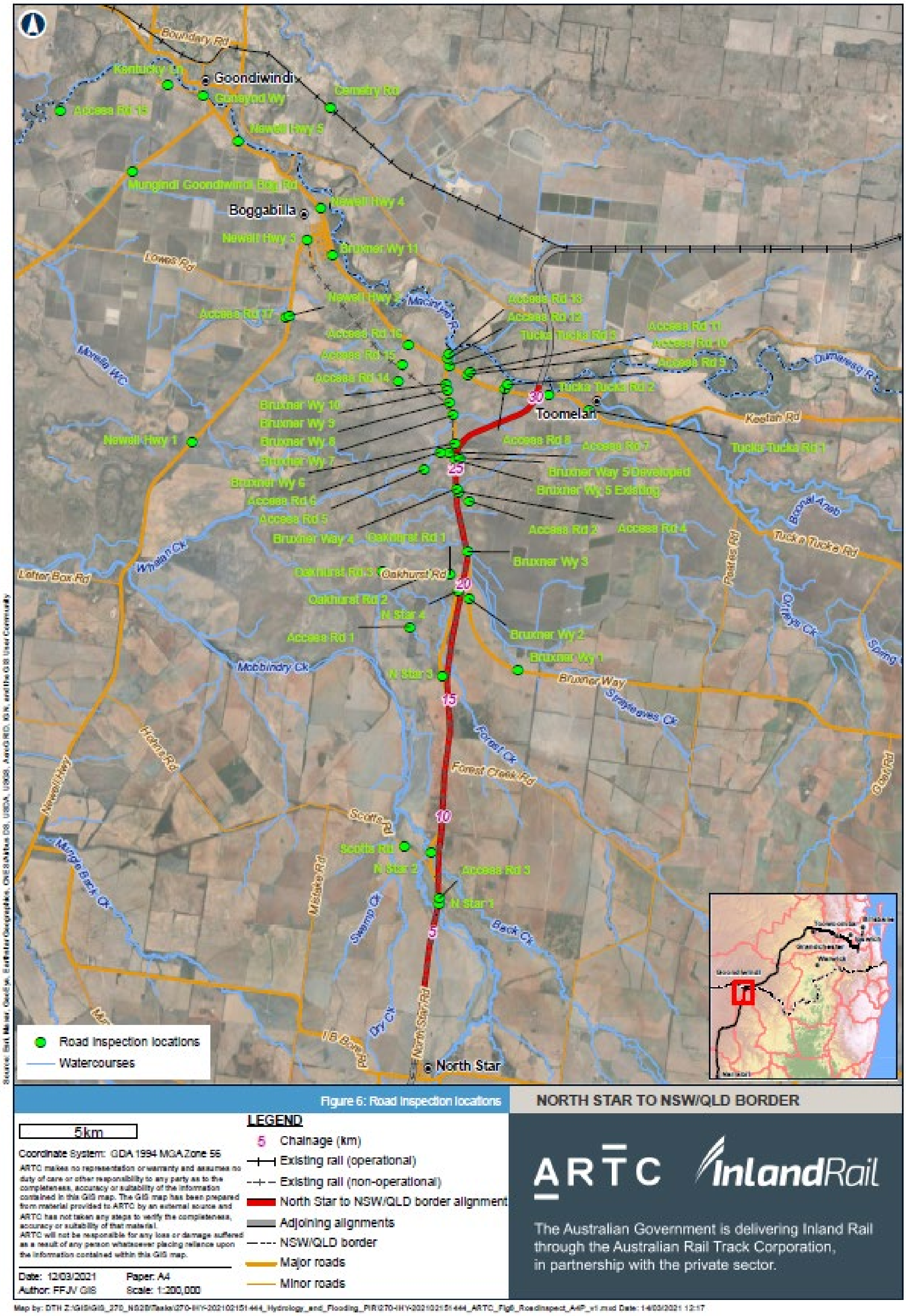

Figure 6: Road Inspection locations

Table 3 Road inspection locations – 5% AEP event results

Road Inspection ID	Depth		Inundation Duration		Hazard (depth x velocity)	
	Existing Case (m)	Change in depth (mm)	Existing Case (hrs)	Change in inundation duration (hrs)	Hazard (m^2/s)	Change in Hazard (m^2/s)
Access Rd 1	0.78	0.00	83.56	-0.02	0.17	0.00
Access Rd 2	0.20	-0.01	75.30	-0.11	0.00	0.00
Access Rd 3	0.29	-0.03	77.25	0.02	0.05	-0.01
Access Rd 4	0.19	0.01	77.70	-0.61	0.03	0.00
Access Rd 5	0.00	0.01	30.22	0.28	0.72	0.00
Bruxner Wy 4	0.39	-0.02	86.25	-0.02	0.12	-0.01
Bruxner Wy 6	0.09	-0.17	52.42	0.10	0.01	-0.38
N Star 1	0.48	-0.09	76.36	-17.30	0.47	0.03
N Star 2	0.61	0.00	45.40	0.00	0.56	0.01
N Star 3	0.40	0.02	36.88	7.60	0.14	0.00
N Star 4	0.28	0.00	41.76	-0.15	0.01	0.00
Oakhurst Rd 1	0.30	0.00	90.03	-0.02	0.18	0.00
Oakhurst Rd 2	0.13	0.00	59.11	0.20	0.02	0.00
Oakhurst Rd 3	0.61	0.00	75.38	-0.01	0.11	0.00
Scotts Rd	0.02	0.00	13.22	0.04	0.01	0.00
Tucka Tucka Rd 2	0.38	0.01	31.29	0.16	0.13	0.00

Table 4 Road inspection locations – 2% AEP event results

Road Inspection ID	Depth		Inundation Duration		Hazard (depth x velocity)	
	Existing Case (m)	Change in depth (mm)	Existing Case (hrs)	Change in inundation duration (hrs)	Hazard (m^2/s)	Change in Hazard (m^2/s)
Access Rd 1	0.91	0.00	84.52	-0.02	0.21	0.00
Access Rd 2	0.40	-0.07	79.65	-0.04	0.01	0.00
Access Rd 3	0.36	-0.02	79.44	0.07	0.09	-0.02
Access Rd 4	0.25	0.01	80.47	-0.45	0.05	0.00
Access Rd 5	0.40	-0.01	44.99	0.02	0.48	0.00
Access Rd 6	0.25	-0.03	36.47	0.15	0.05	0.00
Access Rd 7	0.44	-0.07	38.26	0.11	0.12	-0.02
Access Rd 8	0.01	0.00	14.04	0.27	0.00	0.00
Access Rd 10	0.02	0.00	8.92	0.18	0.00	0.00

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Road Inspection ID	Depth		Inundation Duration		Hazard (depth x velocity)	
	Existing Case (m)	Change in depth (mm)	Existing Case (hrs)	Change in inundation duration (hrs)	Hazard (m^2/s)	Change in Hazard (m^2/s)
Access Rd 11	0.12	0.00	23.31	0.06	0.01	0.00
Access Rd 14	0.17	0.01	20.77	0.09	0.02	0.00
Access Rd 15	0.22	0.00	21.60	0.02	0.02	0.00
Access Rd 16	0.04	0.00	10.91	0.38	0.00	0.00
Bruxner Wy 4	0.46	-0.01	84.68	-0.02	0.15	-0.01
Bruxner Wy 5 Developed (Bruxner Way Deviation)	0.69	0.14	33.67	-2.83	0.09	-0.04
Bruxner Wy 5 Existing	0.69	-0.27	41.71	-6.77	0.19	0.01
Bruxner Wy 6	0.61	0.12	63.25	-32.33	0.15	-0.06
Bruxner Wy 8	0.73	0.03	32.25	0.19	0.15	0.01
Bruxner Wy 9	0.41	0.01	26.09	0.00	0.09	0.00
Bruxner Wy 10	0.50	0.00	29.56	0.00	0.17	0.00
N Star 1	0.62	-0.06	78.22	-18.26	0.66	0.07
N Star 2	0.81	0.00	42.77	0.00	0.68	0.00
N Star 3	0.56	-0.01	34.61	8.76	0.22	-0.02
N Star 4	0.41	0.00	46.37	-0.51	0.01	0.00
Oakhurst Rd 1	0.41	-0.01	93.38	-0.01	0.24	-0.01
Oakhurst Rd 2	0.19	-0.01	61.26	0.06	0.03	0.00
Oakhurst Rd 3	0.72	0.00	75.54	0.01	0.14	0.00
Scotts Rd	0.15	0.00	14.94	0.03	0.05	0.00
Tucka Tucka Rd 2	1.58	0.01	49.82	-0.03	0.75	0.01
Tucka Tucka Rd 3	0.26	0.00	30.05	0.02	0.03	0.00

2.2 Scour and erosion

The following section reviews velocities at the downstream rail corridor boundary with the mitigated Reference Design in place for the for the 20%, 10%, 5% and 2% AEP events. This assessment has been carried out with reference to the revised QDL shown below:

Revised Scour/erosion potential QDL

The erosion threshold is to be set to 0.5m/s in the absence of site assessments (as per the requirements outlined below). Permissible changes to existing velocities are as follows:

- *Where existing velocities are < 0.5m/s, limit any increases to 0.5m/s*
- *Where existing velocities are > 0.5m/s, limit any increases to 10%*

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The 0.5m/s erosion threshold can be increased subject to the following process:

- *Site specific assessment(s) conducted by an experienced geotechnical or scour/erosion specialist to establish an increased erosion threshold accounting for soil conditions and/or ground cover*
- *Where the assessment identifies an increased erosion threshold above 0.5m/s, the increase in existing velocity cannot exceed the lower of:*
    - *(i) The erosion threshold, where existing velocities are less than the erosion threshold*
    - *(ii) The existing velocity plus 10%, where existing velocities are greater than the erosion threshold*
    - *(iii) An increase in existing velocity of up to 50%*

Note 1: For new flowpaths, velocities should be limited to 70% of the erosion threshold
Note 2: Irrespective of erosion threshold, existing (or new flowpath) velocities can be increased up to 0.5m/s without any percentage change limits applying

2.2.1 Culverts

Table 5 to Table 8 present the assessment results for the 20%, 10%, 5% and 2% AEP events at each of the culverts banks included in the mitigated Reference Design as presented in the Major RFI response.

The presented results show that all the proposed mitigated culverts banks result in velocities at the rail corridor boundary that meet the QDL.

Table 5 Review of velocities at rail corridor boundary – Mitigated Reference Design – 2% AEP

Chainage (km)	Culvert details	2% AEP Existing Case peak velocity (m/s)	2% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.58	2/1.05m RCP	0.23	0.28	0.50	Yes
6.08	7/2.1m RCP	0.33	0.33	0.50	Yes
6.12	7/2.1m RCP	0.44	0.37	0.50	Yes
6.53	6/2.1m RCP	0.42	0.37	0.50	Yes
6.58	5/2.1m RCP	0.38	0.39	0.50	Yes
15.33	10/1.2x1.2m RCBC	0.12	0.24	0.50	Yes
15.52	10/1.2x1.2m RCBC	0.28	0.33	0.50	Yes
15.67	10/1.2m RCP	0.30	0.33	0.50	Yes
15.83	20/1.2m RCP	0.37	0.42	0.50	Yes
15.90	20/1.2m RCP	0.38	0.41	0.50	Yes
15.98	20/1.2m RCP	0.31	0.39	0.50	Yes
16.08	20/1.2m RCP	0.28	0.37	0.50	Yes
16.60	8/1.2m RCP	0.68	0.35	0.75	Yes
16.83	8/1.2m RCP	0.09	0.30	0.50	Yes
21.35	3/1.35m RCP	0.17	0.12	0.50	Yes
22.27	3/1.2m RCP	Dry	0.06	0.50	Yes
22.86	4/1.2m RCP 5/1.2m RCP 4/1.2m RCP 4/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.05	0.10	0.50	Yes
23.20	2/1.2m RCP 2/1.2m RCP 4/1.2m RCP	0.35	0.22	0.50	Yes

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Chainage (km)	Culvert details	2% AEP Existing Case peak velocity (m/s)	2% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
	4/1.2m RCP 2/1.2m RCP 3/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP				
23.70	2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.30	0.17	0.50	Yes
23.80	3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP	0.22	0.22	0.50	Yes
24.03	8/1.05m RCP	0.23	0.25	0.50	Yes
24.2	5/0.9m RCP	0.22	0.24	0.50	Yes
24.62	4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC	0.59	0.21	0.65	Yes
24.71	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 5/1.2x0.9m RCBC 4/1.2x0.9m RCBC	0.18	0.24	0.50	Yes
24.85	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC	0.10	0.28	0.50	Yes

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Chainage (km)	Culvert details	2% AEP Existing Case peak velocity (m/s)	2% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC				
27.06	10/1.2m RCP	0.17	0.18	0.50	Yes

Table 6 Review of velocities at rail corridor boundary – Mitigated Reference Design – 5% AEP

Chainage (km)	Culvert details	5% AEP Existing Case peak velocity (m/s)	5% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.58	2/1.05m RCP	0.02	0.28	0.50	Yes
6.08	7/2.1m RCP	0.20	0.26	0.50	Yes
6.12	7/2.1m RCP	0.32	0.32	0.50	Yes
6.53	6/2.1m RCP	0.32	0.28	0.50	Yes
6.58	5/2.1m RCP	0.31	0.30	0.50	Yes
15.33	10/1.2x1.2m RCBC	Dry	0.17	0.50	Yes
15.52	10/1.2x1.2m RCBC	0.15	0.25	0.50	Yes
15.67	10/1.2m RCP	0.19	0.29	0.50	Yes
15.83	20/1.2m RCP	0.33	0.36	0.50	Yes
15.90	20/1.2m RCP	0.34	0.35	0.50	Yes
15.98	20/1.2m RCP	0.26	0.34	0.50	Yes
16.08	20/1.2m RCP	0.22	0.32	0.50	Yes
16.60	8/1.2m RCP	0.63	0.31	0.69	Yes
16.83	8/1.2m RCP	0.07	0.25	0.50	Yes
21.35	3/1.35m RCP	0.02	0.02	0.50	Yes
22.27	3/1.2m RCP	Dry	Dry	0.50	Yes
22.86	4/1.2m RCP 5/1.2m RCP 4/1.2m RCP 4/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.03	0.08	0.50	Yes
23.20	2/1.2m RCP 2/1.2m RCP 4/1.2m RCP 4/1.2m RCP 2/1.2m RCP 3/1.2m RC 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.25	0.18	0.50	Yes
23.70	2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.18	0.14	0.50	Yes

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Chainage (km)	Culvert details	5% AEP Existing Case peak velocity (m/s)	5% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
	2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP				
23.80	3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP	0.20	0.20	0.50	Yes
24.03	8/1.05m RCP	0.21	0.23	0.50	Yes
24.20	5/0.9m RCP	0.16	0.18	0.50	Yes
24.62	4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC	0.09	0.07	0.50	Yes
24.71	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 5/1.2x0.9m RCBC 4/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
24.85	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
27.06	10/1.2m RCP	Dry	Dry	0.50	Yes

Table 7 Review of velocities at rail corridor boundary – Mitigated Reference Design – 10% AEP

Chainage (km)	Culvert details	10% AEP Existing Case peak velocity (m/s)	10% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.58	2/1.05m RCP	Dry	0.24	0.50	Yes
6.08	7/2.1m RCP	0.12	0.17	0.50	Yes
6.12	7/2.1m RCP	0.24	0.27	0.50	Yes
6.53	6/2.1m RCP	0.27	0.23	0.50	Yes
6.58	5/2.1m RCP	0.28	0.26	0.50	Yes

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Chainage (km)	Culvert details	10% AEP Existing Case peak velocity (m/s)	10% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
15.33	10/1.2x1.2m RCBC	Dry	0.13	0.50	Yes
15.52	10/1.2x1.2m RCBC	Dry	0.19	0.50	Yes
15.67	10/1.2m RCP	0.08	0.25	0.50	Yes
15.83	20/1.2m RCP	0.30	0.33	0.50	Yes
15.90	20/1.2m RCP	0.31	0.31	0.50	Yes
15.98	20/1.2m RCP	0.21	0.29	0.50	Yes
16.08	20/1.2m RCP	0.17	0.28	0.50	Yes
16.60	8/1.2m RCP	0.58	0.28	0.64	Yes
16.83	8/1.2m RCP	0.07	0.21	0.50	Yes
21.35	3/1.35m RCP	0.01	0.02	0.50	Yes
22.27	3/1.2m RCP	Dry	Dry	0.50	Yes
22.86	4/1.2m RCP 5/1.2m RCP 4/1.2m RCP 4/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.03	0.07	0.50	Yes
23.20	2/1.2m RCP 2/1.2m RCP 4/1.2m RCP 4/1.2m RCP 2/1.2m RCP 3/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.19	0.16	0.50	Yes
23.70	2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.13	0.11	0.50	Yes
23.80	3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP	0.17	0.18	0.50	Yes

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Chainage (km)	Culvert details	10% AEP Existing Case peak velocity (m/s)	10% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
24.03	8/1.05m RCP	0.18	0.21	0.50	Yes
24.2	5/0.9m RCP	0.18	0.19	0.50	Yes
24.62	4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
24.71	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 5/1.2x0.9m RCBC 4/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
24.85	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
27.06	10/1.2m RCP	Dry	Dry	0.50	Yes

Table 8 Review of velocities at rail corridor boundary – Mitigated Reference Design – 20% AEP

Chainage (km)	Culvert details	20% AEP Existing Case peak velocity (m/s)	20% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.58	2/1.05m RCP	Dry	0.18	0.50	Yes
6.08	7/2.1m RCP	0.07	0.11	0.50	Yes
6.12	7/2.1m RCP	0.16	0.25	0.50	Yes
6.53	6/2.1m RCP	0.21	0.17	0.50	Yes
6.58	5/2.1m RCP	0.24	0.21	0.50	Yes
15.33	10/1.2x1.2m RCBC	Dry	0.09	0.50	Yes
15.52	10/1.2x1.2m RCBC	Dry	0.12	0.50	Yes
15.67	10/1.2m RCP	0.03	0.20	0.50	Yes
15.83	20/1.2m RCP	0.25	0.28	0.50	Yes
15.90	20/1.2m RCP	0.26	0.27	0.50	Yes
15.98	20/1.2m RCP	0.16	0.25	0.50	Yes
16.08	20/1.2m RCP	0.11	0.24	0.50	Yes
16.60	8/1.2m RCP	0.50	0.25	0.50	Yes
16.83	8/1.2m RCP	0.07	0.17	0.50	Yes
21.35	3/1.35m RCP	Dry	Dry	0.50	Yes
22.27	3/1.2m RCP	Dry	Dry	0.50	Yes
22.86	4/1.2m RCP 5/1.2m RCP 4/1.2m RCP	0.01	0.05	0.50	Yes

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Chainage (km)	Culvert details	20% AEP Existing Case peak velocity (m/s)	20% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
	4/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP				
23.20	2/1.2m RCP 2/1.2m RCP 4/1.2m RCP 4/1.2m RCP 2/1.2m RCP 3/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.10	0.12	0.50	Yes
23.70	2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP 2/1.2m RCP	0.10	0.08	0.50	Yes
23.80	3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP 3/1.2m RCP	0.09	0.09	0.50	Yes
24.03	8/1.05m RCP	0.07	0.09	0.50	Yes
24.2	5/0.9m RCP	0.14	0.12	0.50	Yes
24.62	4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC 4/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
24.71	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 3/1.2x0.9m RCBC	Dry	Dry	0.50	Yes

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Chainage (km)	Culvert details	20% AEP Existing Case peak velocity (m/s)	20% AEP Mitigated Reference Design peak velocity (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
	3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 3/1.2x0.9m RCBC 5/1.2x0.9m RCBC 4/1.2x0.9m RCBC				
24.85	5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC 5/1.2x0.9m RCBC	Dry	Dry	0.50	Yes
27.06	10/1.2m RCP	Dry	Dry	0.50	Yes

2.2.2 Bridges

Table 9 to Table 12 present the assessment results for the 2%, 5%, 10% and 20% AEP events at each of the bridges included in the partially mitigated Reference Design as presented in the Major RFI response.

For comparison purposes Table 13 presents the results from the major RFI for the 1% AEP or 1976 flows scenario. The two bridges that were mitigated for the major RFI were BR03 and BR06. Under the 1% AEP/1976 flow scenario BR05 and BR07 were the remaining two bridges that required further mitigation to be undertaken to achieve the QDL.

From review of the tables below the following is noted:

- BR05 will also does not meet the QDL for the 2% AEP but does for smaller AEP event
- BR09 and BR01 do not meet the QDL for all of the AEP events below 1% AEP

Bridge BR09 is located on the breakout channel from Whalan Creek and modelling this range of AEPs shows the variability in the flow patterns for the varying event sizes. None of the modelled events indicate any large changes in velocities and where the exceedance of the QDL occurs this can be addressed with minor modifications to the design.

The demonstration of application of engineering mitigation measures in the major RFI Technical Note shows that the same approach could be applied at the remaining bridge structures that do not currently comply with the QDL across the modelled AEPs.

Table 9 Review of bridge velocities at rail corridor boundary – Partially Mitigated Reference Design – 2% AEP

Chainage (km)	Structure details	Approximate bridge length (m)	Existing d/s peak velocity at rail boundary (m/s)	Partially Mitigated Reference Design d/s peak velocity at rail boundary (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.76	Bridge (BR01) Mobbindry Creek	111	0.83	0.77	0.91	Yes
6.23	Bridge (BR02) Mobbindry Creek	182	0.60	0.64	0.66	Yes

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Chainage (km)	Structure details	Approximate bridge length (m)	Existing d/s peak velocity at rail boundary (m/s)	Partially Mitigated Reference Design d/s peak velocity at rail boundary (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
8.11	Bridge (BR03) Back Creek plus 9 banks of 3/1.05m RCP	70	1.00	1.00	1.10	Yes
16.29	Bridge (BR04) Forest Creek	154	0.35	0.44	0.50	Yes
20.73	Bridge (BR05) Strayleaves Creek	137	0.52	0.67	0.57	No
25.34	Bridge (BR06)	300	0.59	0.32	0.65	Yes
25.80	Bridge (BR07)	114	0.20	0.30	0.50	Yes
26.09	Bridge (BR08)	183	0.17	0.11	0.50	Yes
27.56	Bridge (BR09)	126	0.66	0.79	0.73	No
28.03	Bridge (BR10)	126	0.28	0.40	0.50	Yes
30.35	Bridge (BR11) Mac River	1748	1.96	1.94	2.16	Yes

Table 10 Review of bridge velocities at rail corridor boundary – Partially Mitigated Reference Design – 5% AEP

Chainage (km)	Structure details	Approximate bridge length (m)	Existing d/s peak velocity at rail boundary (m/s)	Partially Mitigated Reference Design d/s peak velocity at rail boundary (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.76	Bridge (BR01) Mobbindry Creek	111	0.68	0.79	0.75	No
6.23	Bridge (BR02) Mobbindry Creek	182	0.50	0.50	0.50	Yes
8.11	Bridge (BR03) Back Creek plus 9 banks of 3/1.05m RCP	70	0.93	0.83	1.02	Yes
16.29	Bridge (BR04) Forest Creek	154	0.33	0.36	0.50	Yes
20.73	Bridge (BR05) Strayleaves Creek	137	0.53	0.45	0.58	Yes
25.34	Bridge (BR06)	300	0.12	Dry	0.50	Yes
25.80	Bridge (BR07)	114	0.10	0.04	0.50	Yes
26.09	Bridge (BR08)	183	0.06	0.08	0.50	Yes
27.56	Bridge (BR09)	126	0.55	0.78	0.61	No
28.03	Bridge (BR10)	126	0.25	0.28	0.50	Yes
30.35	Bridge (BR11) Mac River	1748	1.83	1.82	2.01	Yes

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Table 11 Review of bridge velocities at rail corridor boundary – Partially Mitigated Reference Design – 10% AEP

Chainage (km)	Structure details	Approximate bridge length (m)	Existing d/s peak velocity at rail boundary (m/s)	Partially Mitigated Reference Design d/s peak velocity at rail boundary (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.76	Bridge (BR01) Mobbindry Creek	111	0.60	0.82	0.66	No
6.23	Bridge (BR02) Mobbindry Creek	182	0.44	0.43	0.50	Yes
8.11	Bridge (BR03) Back Creek plus 9 banks of 3/1.05m RCP	70	0.80	0.73	0.88	Yes
16.29	Bridge (BR04) Forest Creek	154	0.32	0.31	0.50	Yes
20.73	Bridge (BR05) Strayleaves Creek	137	0.38	0.43	0.50	Yes
25.34	Bridge (BR06)	300	0.07	Dry	0.50	Yes
25.80	Bridge (BR07)	114	0.07	0.03	0.50	Yes
26.09	Bridge (BR08)	183	0.04	0.05	0.50	Yes
27.56	Bridge (BR09)	126	0.54	0.76	0.59	No
28.03	Bridge (BR10)	126	0.26	0.24	0.50	Yes
30.35	Bridge (BR11) Mac River	1748	1.75	1.74	1.93	Yes

Table 12 Review of bridge velocities at rail corridor boundary – Partially Mitigated Reference Design – 20% AEP

Chainage (km)	Structure details	Approximate bridge length (m)	Existing d/s peak velocity at rail boundary (m/s)	Partially Mitigated Reference Design d/s peak velocity at rail boundary (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.76	Bridge (BR01) Mobbindry Creek	111	0.53	0.65	0.58	No
6.23	Bridge (BR02) Mobbindry Creek	182	0.36	0.36	0.50	Yes
8.11	Bridge (BR03) Back Creek plus 9 banks of 3/1.05m RCP	70	0.72	0.67	0.79	Yes
16.29	Bridge (BR04) Forest Creek	154	0.29	0.27	0.50	Yes
20.73	Bridge (BR05) Strayleaves Creek	137	0.30	0.34	0.50	Yes
25.34	Bridge (BR06)	300	Dry	Dry	0.50	Yes
25.80	Bridge (BR07)	114	Dry	Dry	0.50	Yes
26.09	Bridge (BR08)	183	Dry	Dry	0.50	Yes
27.56	Bridge (BR09)	126	0.51	0.72	0.56	No
28.03	Bridge (BR10)	126	0.20	0.21	0.50	Yes
30.35	Bridge (BR11) Mac River	1748	1.56	1.55	1.72	Yes

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Table 13 Review of bridge velocities at rail corridor boundary – Partially Mitigated Ref Design – 1976/1% AEP

Chainage (km)	Event	Structure details	Approximate bridge length (m)	Existing d/s peak velocity at rail boundary (m/s)	Partially Mitigated Reference Design d/s peak velocity at rail boundary (m/s)	QDL velocity limit (m/s)	Compliant with QDL?
5.76	1% AEP	Bridge (BR01) Mobbindry Creek	111	0.87	0.77	0.96	Yes
6.23	1% AEP	Bridge (BR02) Mobbindry Creek	182	0.64	0.72	0.70	Very close
8.11	1% AEP	Bridge (BR03) Back Creek plus 9 banks of 3/1.05m RCP	70	1.01	1.11	1.11	Yes
16.29	1% AEP	Bridge (BR04) Forest Creek	154	0.36	0.49	0.50	Yes
20.73	1976 flows	Bridge (BR05) Strayleaves Creek	137	0.60	1.0	0.66	No
25.34	1976 flows	Bridge (BR06)	300	0.60	0.66	0.66	Yes
25.80	1976 flows	Bridge (BR07)	114	0.44	0.76	0.50	No
26.09	1976 flows	Bridge (BR08)	183	0.34	0.51	0.50	Very close
27.56	1976 flows	Bridge (BR09)	126	0.76	0.80	0.84	Yes
28.03	1976 flows	Bridge (BR10)	126	0.44	0.54	0.50	Yes
30.35	1976 flows	Bridge (BR11) Mac River	1748	3.17	3.11	3.49	Yes

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3 Climate change impacts

The 1% AEP event with climate change (RCP 8.5) was initially run through the PIR hydrologic and hydraulic models to provide boundary conditions for the Sub-model #1 (the main Macintyre River floodplain).

Sub-model #1 was then run for the climate change event for the Existing Case and the Developed Case (based on the Mitigated Reference Design presented in the Major RFI Technical Note). Application of the climate change process as detailed in Australian Rainfall and Runoff (ARR 2019) has been undertaken. This results in an increase in rainfall intensity of 23%. Figure 1 presents the change in peak water levels (afflux) associated with the 1% AEP plus climate change event. For comparison purposes Figure 2 presents the same information for the 1976 flow scenario.

Figure 1 Afflux Map for Mitigated Reference Design (SM1) – 1% AEP event with climate change

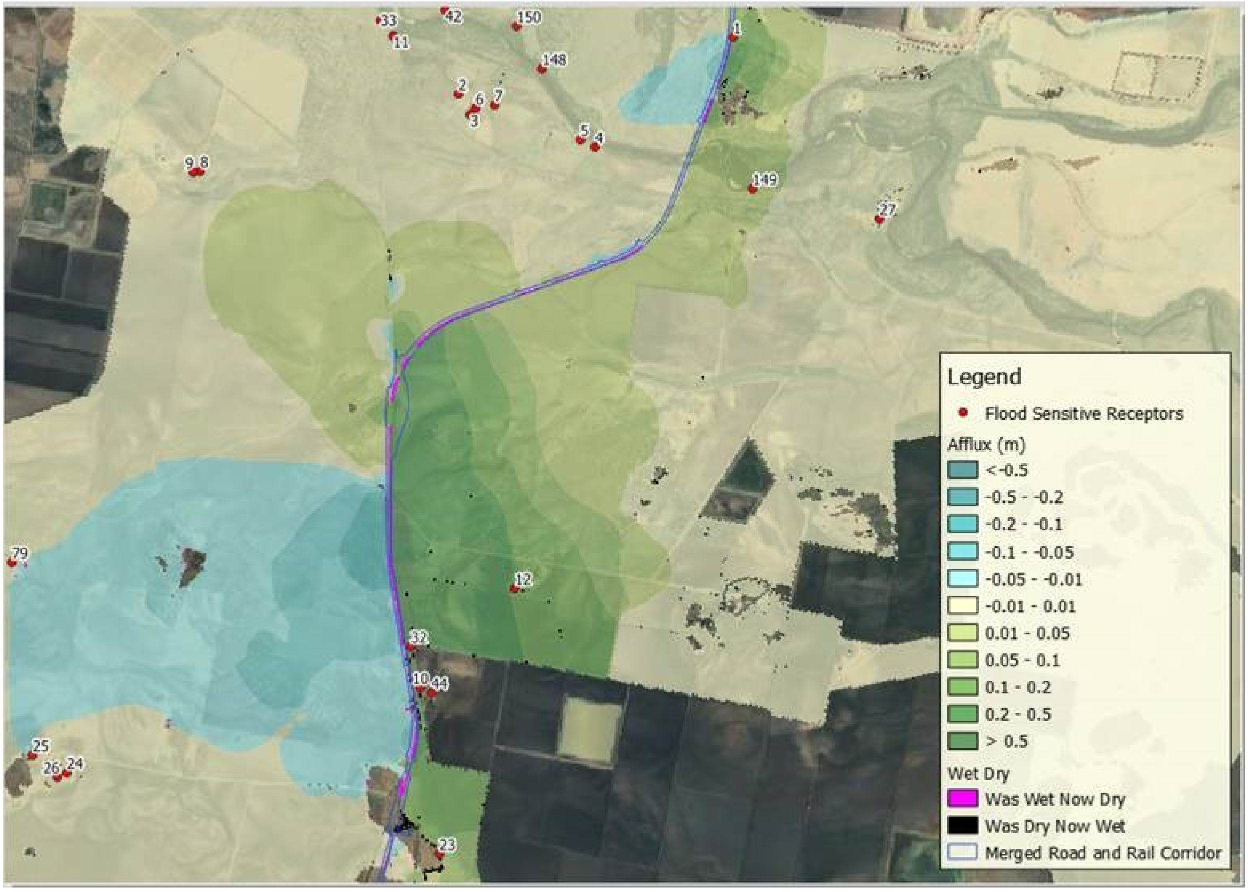

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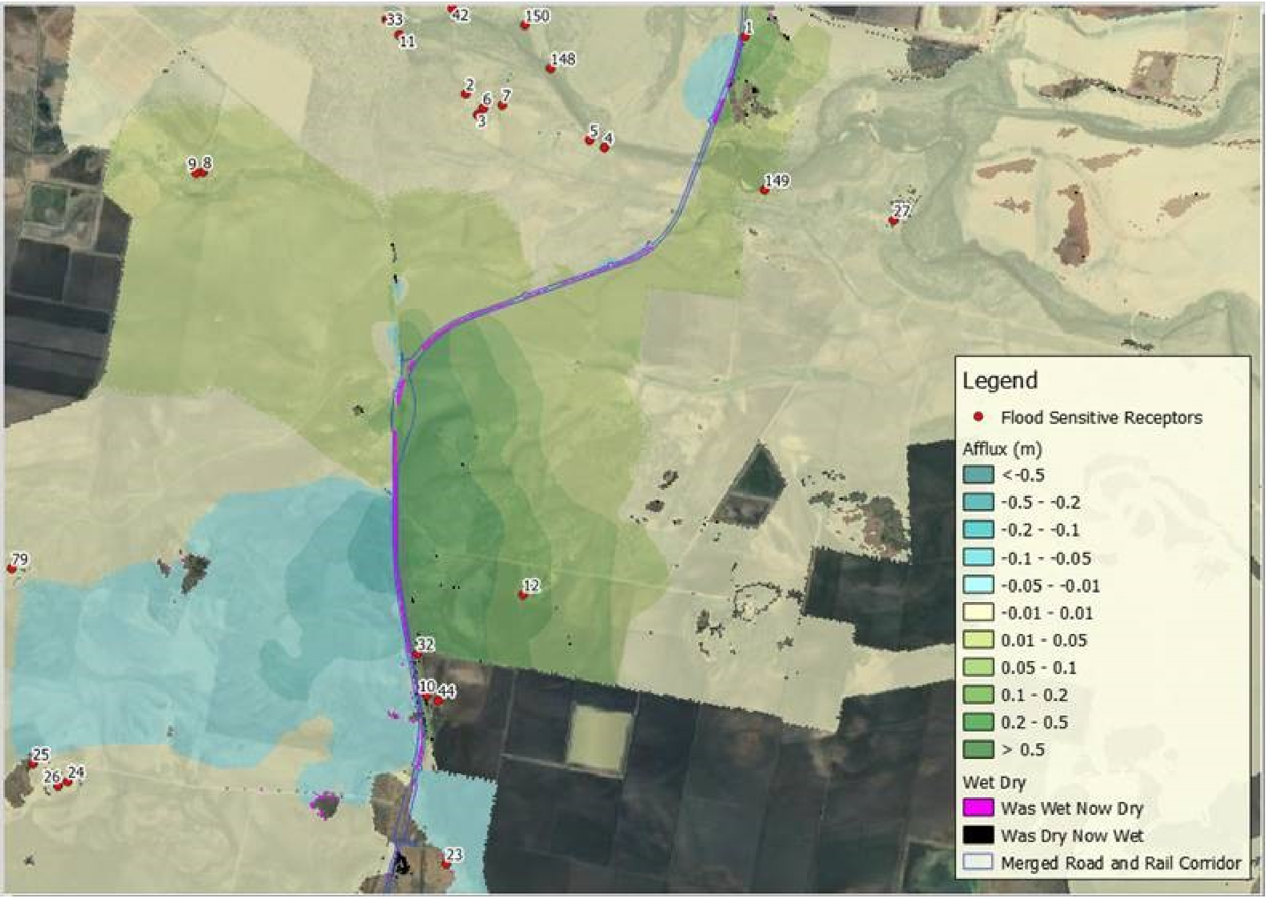
Figure 2 Afflux Map for Mitigated Design (SM1) – 1976 flow scenario



Review of the 1% AEP climate change event modelling results confirms that overtopping of the alignment does not occur under this event. Whilst the peak water levels from the 1% AEP event with climate change are slightly higher upstream of the alignment than the 1976 flow scenario (approximately 30 to 100mm), similar afflux outcomes are predicted.

A 23% increase in the 1% AEP 24h rainfall depth is approximately equivalent to a 1 in 300 AEP. This should be considered relative to the estimated AEP of the 1976 event of 1 in 200 AEP.

The two figures also show the flood sensitive receptors (red dots) with the area of increased water levels with only minor changes occur between the two cases as shown in Table 14. These impacts will be reviewed further in detailed design where mitigation will be agreed in consultation with landholders.

Table 14 Afflux at Flood Sensitive Receptors

FSR number	1% with Climate Change Afflux (m)	1976 Flow Scenario (m)	Comment
1	0.19	0.13	Shed, immediately adjacent to the alignment and will be removed
149	0.01	0.01	Pump, No change
8	<0.01	0.01	House

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FSR number	1% with Climate Change Afflux (m)	1976 Flow Scenario (m)	Comment
9	<0.01	0.01	Shed
12	0.20	0.14	House
32	0.71	0.65	Pump/shed
23	0.10	Dry	Shed

4 Spatial variation of rainfall

Following the recent DPIE Working Group meeting held on 2 December 2021, a meeting with DPIE's Technical Advisors was held on 8 December 2021. At this meeting a number of modelling results were presented and reviewed. The outcome of the meeting was confirmation by the DPIE Technical Advisor, Drew Bewsher, that what was required was a sensitivity check varying the origin of the dominant flow (for a 1976 sized event) from the upstream catchment area. This sensitivity check has been undertaken as detailed below.

To develop two 1976 equivalent sized events with main flows coming from either the northern or the southern parts of the catchment a review of historical rainfall was undertaken. The PIR hydrologic model was used to arrive at the following factors that have been applied to the TUFLOW model inflows.

Table 15 Multipliers to give 1976 equivalent peak flows and volume at the rail alignment

Case	Macintyre Brook multiplier	Dumaresq River multiplier	Macintyre River multiplier
Northern catchment weighted	1.50	1.20	0.48
Southern catchment weighted	0.50	0.95	1.33

Figure 3 presents the flow across the width of floodplain near the junction of the rivers for both of the weighted scenarios and the base 1976 flow scenario. This figure shows that similar peak flows and overall flood volumes are achieved across these three scenarios.

Figure 3 Flow comparison across floodplain – 1976 flow scenarios

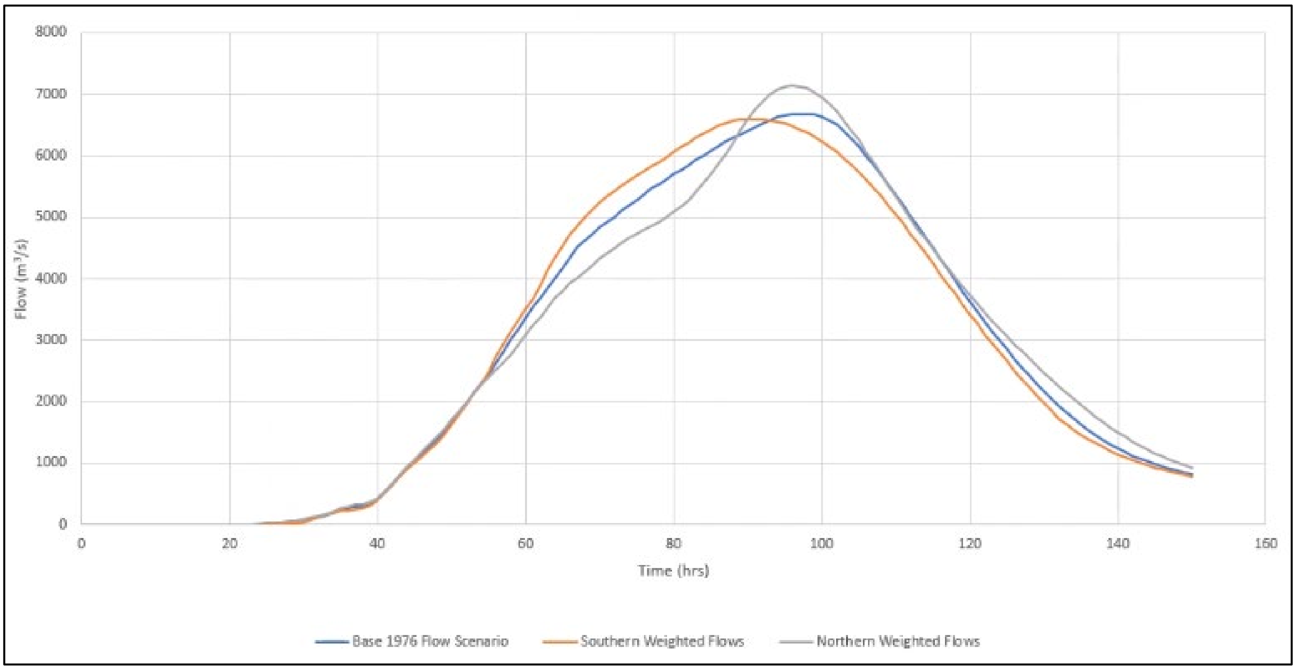

Figure 4 presents the change in peak water levels (afflux) for the base 1976 flow scenario (in which approximately 1% AEP flows on each of the systems combine to give approximately a 1 in 200 AEP event at Boggabilla). Figure 5 and Figure 6 present the same information in the vicinity of the proposed alignment for the southern and northern weighted flow scenarios respectively.

Review of Figure 5 shows larger flows arriving on the Macintyre River system (southern system). With the southern weighted case the flow on the Macintyre River system is close to a 1 in 200 AEP and this results in an approximate increase in flood levels along the northern side of the levee banks (refer Figure 7). This flow redistribution brings more water, and slightly higher impacts, towards the section of the rail alignment from Ch 24 to 26 km (ie to the south of the Ch 26 to 30km section). The current drainage structures in the section between Ch 26 and 30km actually permit more water to pass through and hence lead to a slight increase in levels downstream of the alignment.

Review of Figure 6 shows larger flows arriving on the Dumaresq River/Macintyre Brook system (northern system). This flow distribution results in slightly lower affluxes with more of the flow passing through the main Macintyre River bridge (approximately 1.8 km long).

Overall the sensitivity check has shown that increasing the drainage structures along the Ch 26 to 30km section of the alignment will not contribute to reducing afflux levels as flows in this section essentially run parallel to the alignment for all three flow scenarios as demonstrated in Figure 7.

On this basis ARTC are comfortable to move forward with taking the proposed Mitigated Reference Design into the detailed design phase.

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Figure 4 Base 1976 flow scenario – Afflux Map

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Figure 5 Southern weighted flows – Afflux Map – 1976 equivalent flows

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Figure 6 Northern weighted flows – Afflux Map – 1976 equivalent flows

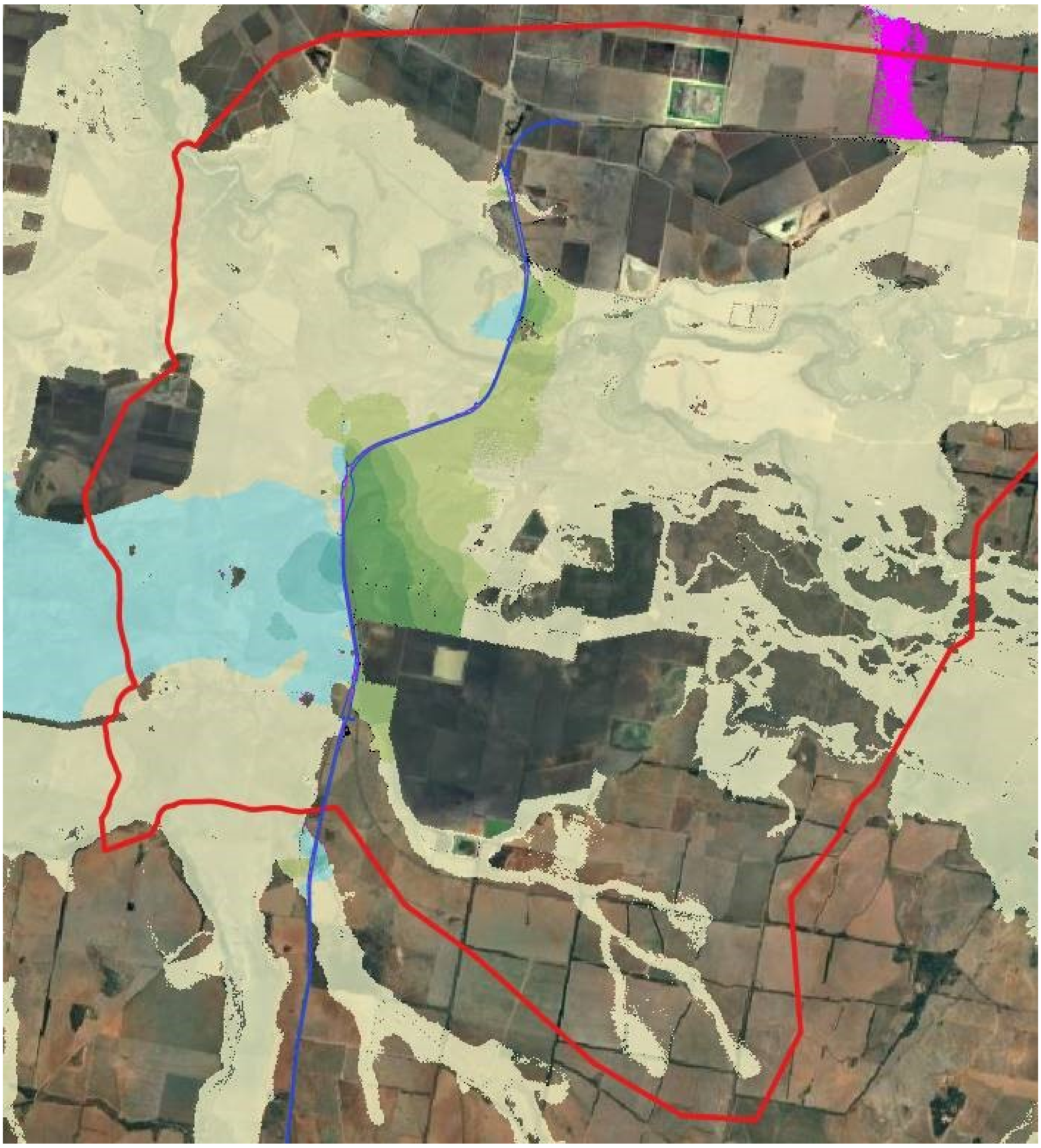

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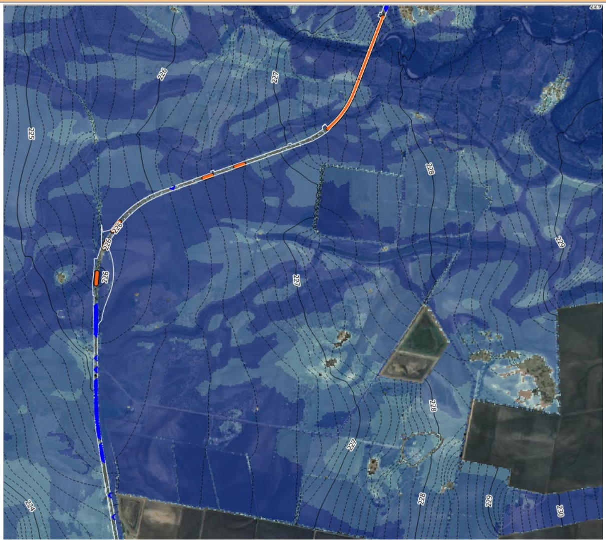
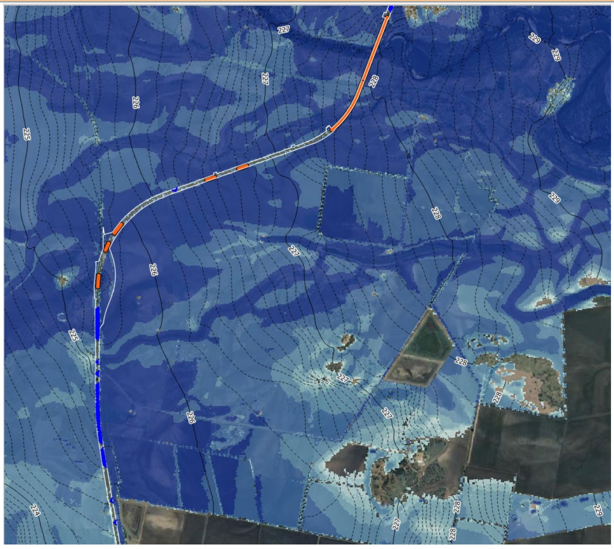
Figure 7 Water level contours in vicinity of Ch 26km to 30km

Southern weighted flows **Developed case depth with WSL contours**	**Northern weighted flows** **Dveloped case depth with WSL contours**
	

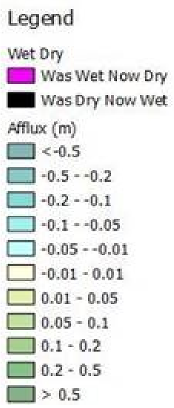
Technical Note

5 North Star Camp

The North Star camp location as proposed in the EIS, consistent with the location used for operational noise modelling, has been modelled using the latest hydraulic modelling. This includes the use of the detailed sub-model #2 with the local application of Quadtree (3.75m cell size) around the proposed camp area and North Star.

The model results in Figure 8 demonstrate compliance against the draft QDLs. The camp layout is indicative but is within the footprint included in the Project Description. The hydraulic model includes an at-grade channel between the two parts of the camp which is provided as a mitigation measure to meet the proposed QDLs. A bund would be included around the perimeter of the camp to provide flood immunity. This design would be further developed and finalised during the detailed design phase.

Figure 8 North Star camp modelling results

Event	Afflux extents
20% AEP 	

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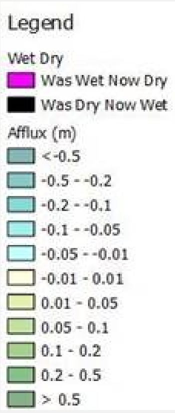
Technical Note

Event	
1% AEP  	

6 Conclusions

The Minor RFI has requested the following items. A summary of responses is provided against each item:

- ***Road Trafficability***
  - *Information is required about the impact to road trafficability during more frequent events.*
  - *Please identify the flooding event/s in which the project causes currently trafficable roads to become non-trafficable or extends periods of non-trafficability. This must identify the areas of roads affected and consider changes to afflux, duration and/or hazard.*

Using detailed sub-models developed to support the Major RFI response, a range of flood events from 20% to 1% AEP have been modelled. Results on major and minor roads (and access roads) have been extracted and documented. The results show that for the events less than 1% AEP there is a significant reduction in flood extent with shallower overtopping depths. In some areas whilst the overtopping is shallow it does occur over an extended period but the mitigated Reference Design does not lead to significant increases in flooded depth, inundation duration or hazard for roads in the vicinity of the alignment.

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- ***Erosion and Scour***
  - *Please provide details of which of the more frequent events result in velocity impacts exceeding the QDLs and what those velocity levels are. Any mitigation measures considered to reduce erosion and scour impacts must also consider those more frequent events that exceed the QDLs.*

The sub-modelling results for the more frequent events have been reviewed downstream of Mitigated Reference Design culverts and bridge at the rail corridor boundary. The presented results show that all the proposed mitigated culverts banks result in velocities at the rail corridor boundary that meet the QDL

The demonstration of application of engineering mitigation measures in the major RFI Technical Note shows that the same approach could be applied at the remaining bridge structures that do not currently comply with the QDL across the modelled AEPs.

- ***Climate change impacts***
  - *The EIS indicated that the rail line would not be overtopped. Please advise whether this remains the case with the revised modelling in the PIR and provide details of any overtopping of the rail alignment and / or additional impacts to residences and infrastructure.*

Review of the 1% AEP climate change event modelling results confirms that overtopping of the alignment does not occur under this event.

There are a limited number of FSRs affected by afflux under this event (4) and these FSRs are already impacted under the 1976 flow scenario with only minor changes predicted for the 1% AEP with climate change case. These impacts will be reviewed further in detailed design where mitigation will be agreed in consultation with landholders.

- ***Cross drainage near Macintyre River (Ch 26 to Ch30 km)***
  - Please examine the spatial variation in historical rainfalls and use this to determine alternative flow distributions for the design floods. These should then be used to examine the adequacy of the currently proposed cross drainage infrastructure and where necessary, provide additional cross drainage infrastructure to ensure the QDLs are satisfied under alternative flow distributions.

A sensitivity check was undertaken with two 1976 equivalent sized events developed with the main flows coming from either the northern or the southern parts of the catchment upstream of the rail alignment. Overall the sensitivity check has shown that increasing the drainage structures along the Ch 26 to 30km section of the alignment will not contribute to reducing afflux levels as flows in this section essentially run parallel to the alignment for all three flow scenarios and that adjustment of the spatial distribution of rainfall in the upstream catchment does not require the addition of drainage structures in this section.