APPENDIX CC QUICK MUD CREEK CROSSING PRELIMINARY RESULTS

Project:	P21167 KUMINA MINE - MRL QUICK MUD CREEK PRELIMINARY RESULTS		**Project No.**	P21167

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Subject: Quick Mud Creek crossing preliminary results

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1 INTRODUCTION

As part of the Onslow Iron Project – Port Flood Assessment, Mineral Resources Limited (RP20128 Doc OIP-7000-HY-REP-0001, 23/02/2021), BGER completed a preliminary 2D TUFLOW flood assessment to support a development application to the Pilbara Ports Authority to enable the export of 25Mtpa through the Port of Ashburton in the Pilbara. The extent of the 2D hydraulic model flood included the existing Port access road (Warrirda Road) and the conceptual design of the proposed haul road from Onslow Road to the proposed Port facilities. The proposed haul road is located approximately 100m downstream of Warrirda Road and generally follow a similar alignment. For the initial conceptual design, the levels of the existing profile, floodways and culverts along Warrirda Road were duplicated for the proposed haul road to provide indicative water levels along both the existing and proposed access roads. For details regarding the model's hydrology assumptions, LiDAR, existing and proposed waterway assets and methodology that have been adopted, refer to the abovementioned report.

2 MODEL SCENARIOS

2.1 Hydrology

Flood levels within the model extent are influenced by both fluvial (catchment) flooding and coastal inundation (storm surge). To consider the joint probability of both events occurring concurrently, it is common when assessing fluvial flooding for a specific Average Recurrence Interval (ARI) to apply a coastal event having an ARI of approximately one fifth of probability of the fluvial event. Similarly, coastal flooding for a specific ARI can be combined with a fluvial flood having an ARI of approximately one fifth of probability of the coastal event. From RP20128 Doc OIP-7000-HY-REP-0001, the downstream tidal boundaries and fluvial events are presented in Table 1.

2.2 Existing and proposed roads

Between Onslow Road and the Port, Warrirda Road includes 6 floodways and one bridge (at Quick Mud Creek) as indicated in Figure 1. These existing floodway levels are generally ~4.5m AHD (Site 354 at 2.68m AHD and the remainder between 4.39 – 4.79m AHD). The original preliminary TUFLOW model has been substantially adopted for this current project except as described in section 2.3.

Table 1 Tidal levels for ARI events near Onslow, Western Australia

Inflow	Level (m HD)	Source
HAT (Highest Astronomical Tide)	1.55	Onslow Submergence Curve
5yr ARI	2.2	Extrapolated from GEMS
10yr ARI	2.7	Extrapolated from GEMS
20yr ARI	3.2	Extrapolated from GEMS
50yr ARI	3.7	GEMS, 2013
100yr ARI	4.3	GEMS, 2013
200yr ARI	4.8	GEMS, 2013

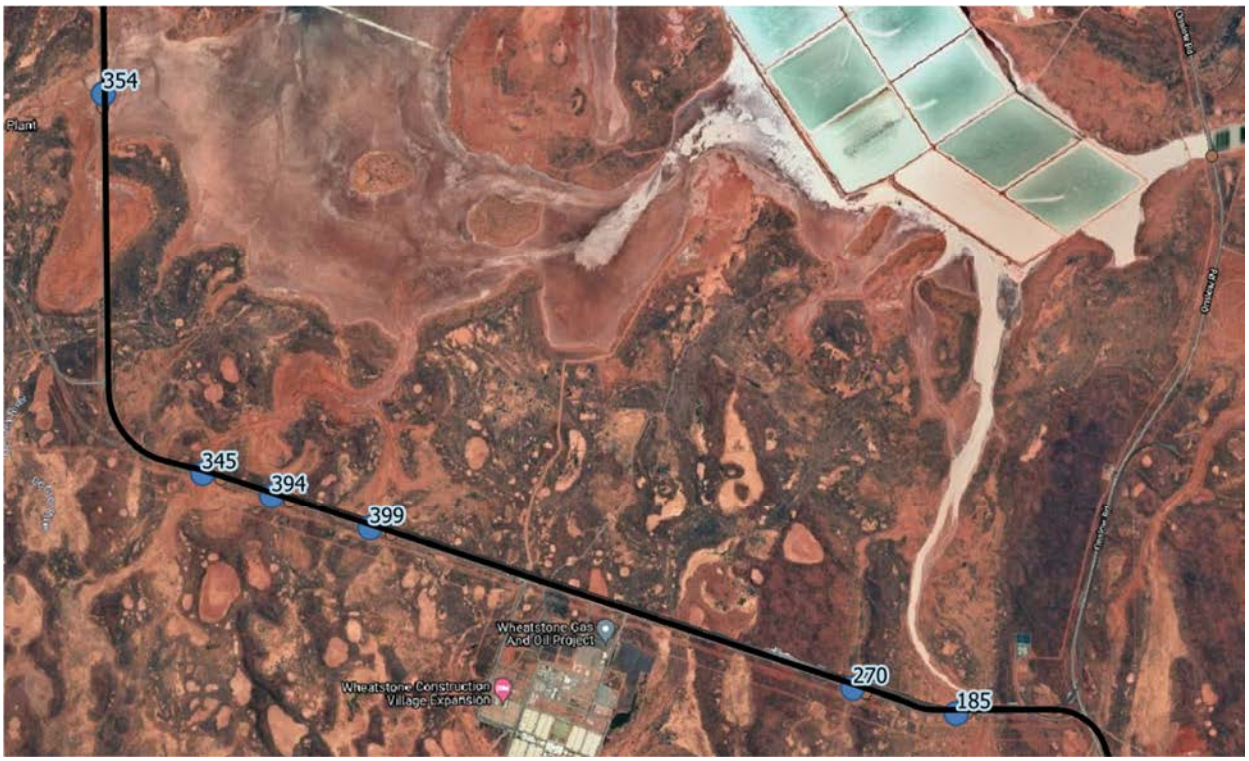

Figure 1 Warrirda Road Port access floodway locations

2.3 Options

The MRL/MRWA/BGER meeting on 3 September 2021 briefly discussed the options that had originally been modelled and these are presented in Table 2 and Figure 2. MRWA proposed that a variation of Option 2/B07 (10 x 2.1 x 2.1 box culverts) was also included which included 30, 60 and 90 units of 1.5m and 1.8m box culverts with the intention of increasing the waterway area from about 45m^2 to about 290m^2. For options 3/B10 and 4/B11, the potential waterway area was in the order of 350m^2 – 440m^2.

A typical cross section of the Quick Mud Creek waterway downstream of Warrirda Road is presented in Figure 3 and shows that the 'base' (i.e., 1.3 – 1.6m AHD) of the crossing is approximately 60m which widens up to approximately 100m (at 2.0m AHD). This means there is a potential physical limitation of about 120m in which the culverts could be constructed. The proposed option of placing up to 90 box culverts is not considered feasible. Therefore, to initially test the effect of additional culverts, Option

5/B13 (50 x 2.1 x 2.1 box culverts) was modelled with a waterway area of approximately 220m^2 across a length of 105m.

The results are presented in section 3.

Table 2 TUFLOW modelling scenarios at Quick Mud Creek

Scenario /TUFLOW model	Description	Floodway (#1)		Bridge across Quick Mud Creek			Floodway (HR#2)	
		Level	Length	Deck Level	Soffit Level	Span	Level	Length
		(m AHD)	(m)	(m AHD)	(m AHD)	(m)	(m AHD)	(m)
1/A12	Existing road (Baseline Model)	4.62	100	6.21 – 6.83	4.43 – 5.05	120	--	--
2/B07	Proposed road with two floodways and box culverts (**10** x 2.1 x 2.1)	4.60	160	--	--	--	4.2	170
3/B10	Proposed road with floodway and bridge (120m)	4.60	160	6.21	4.43	120	--	--
4/B11	Proposed road with floodway and longer bridge (150m)	4.60	160	6.21	4.43	150	--	--
5/B13	Proposed road with two floodways and box culverts (**50** x 2.1 x 2.1)	4.60	160	--	--	--	4.2	170

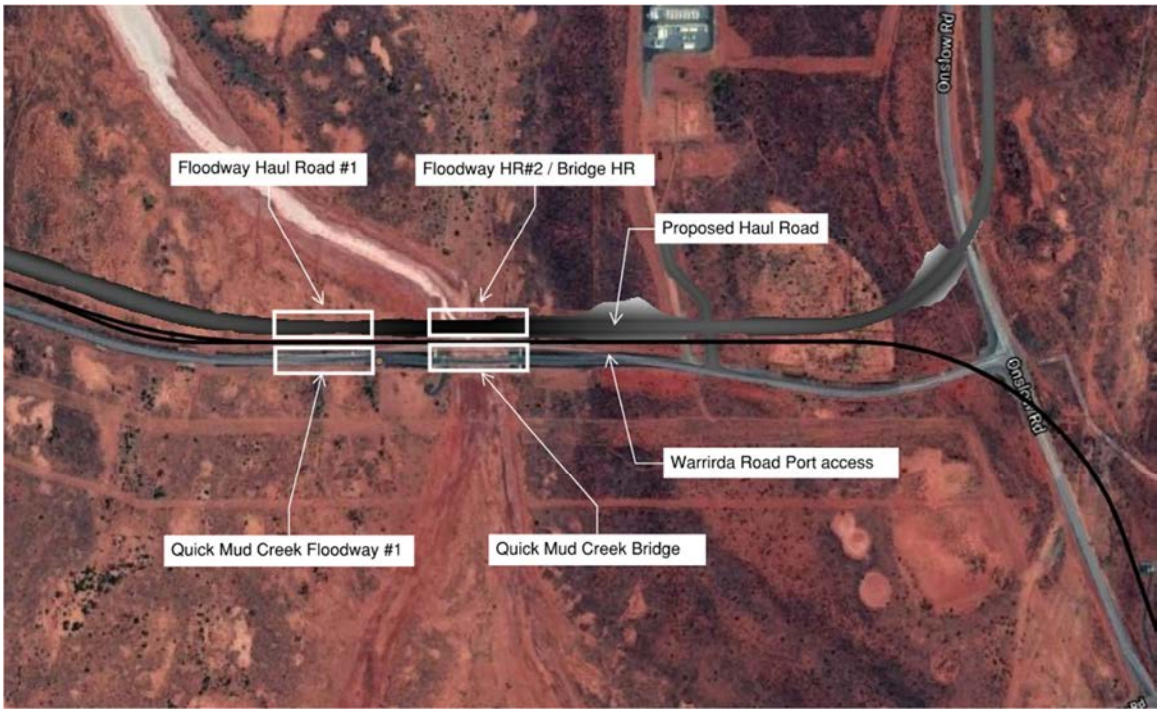

Figure 2 Quick Mud Creek modelled floodways and bridges

Figure 3 Quick Mud Creek waterway downstream of Warrirda Road

2.4 Inflow hydrograph

The 1 in 20yr ARI inflow hydrograph for Quick Mud Creek upstream of Warrirda Road is presented in Figure 4 which shows a relatively long profile where the peak flow occurs approximately 50 hours after the commencement of the design rainfall event.

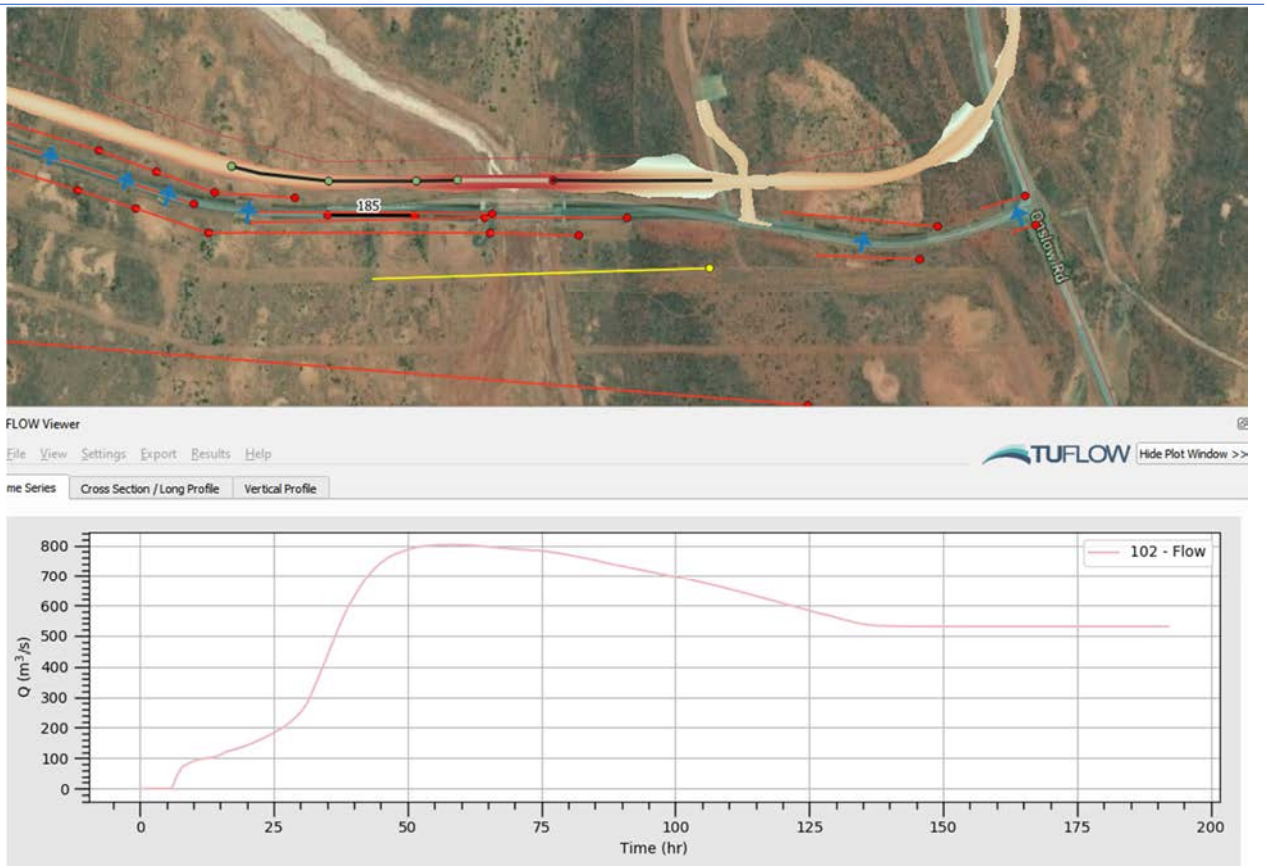

Figure 4 Quick Mud Creek inflow hydrograph (1 in 20 yr ARI)

3 RESULTS

3.1 Baseline model (A12)

The Baseline model (A12) indicated that Warrirda Road's infrastructure appears to have been designed as wet serviceable for the 20-year ARI fluvial event/5-year ARI tidal as the results presented in Table 3 show that the water depth is less than 300mm at each of the floodway structure (i.e., 300mm or less head upstream the floodway), except for the floodway immediately west from Quick Mud Creek which resulted in a depth of 340mm.

Table 3 Baseline model (A12) TUFLOW modelling results

Floodway/ Bridge	20/5yr TWL upstream Warrirda Road	
	A12 WL (m AHD)	A12 Depth (m)
F 354	2.81	0.13
F 345	4.51	0.12
F 394	4.52	0.18
F 399	4.49	0.12
F 270	4.99	0.2
F 185	4.96	0.34
Bridge	4.69	-

The 1 in 20yr ARI inflow hydrograph upstream of the Warrirda Road floodway 185 is presented in Figure ***5*** and indicates that water is flowing over the floodway for a period of approximately 60 hours.

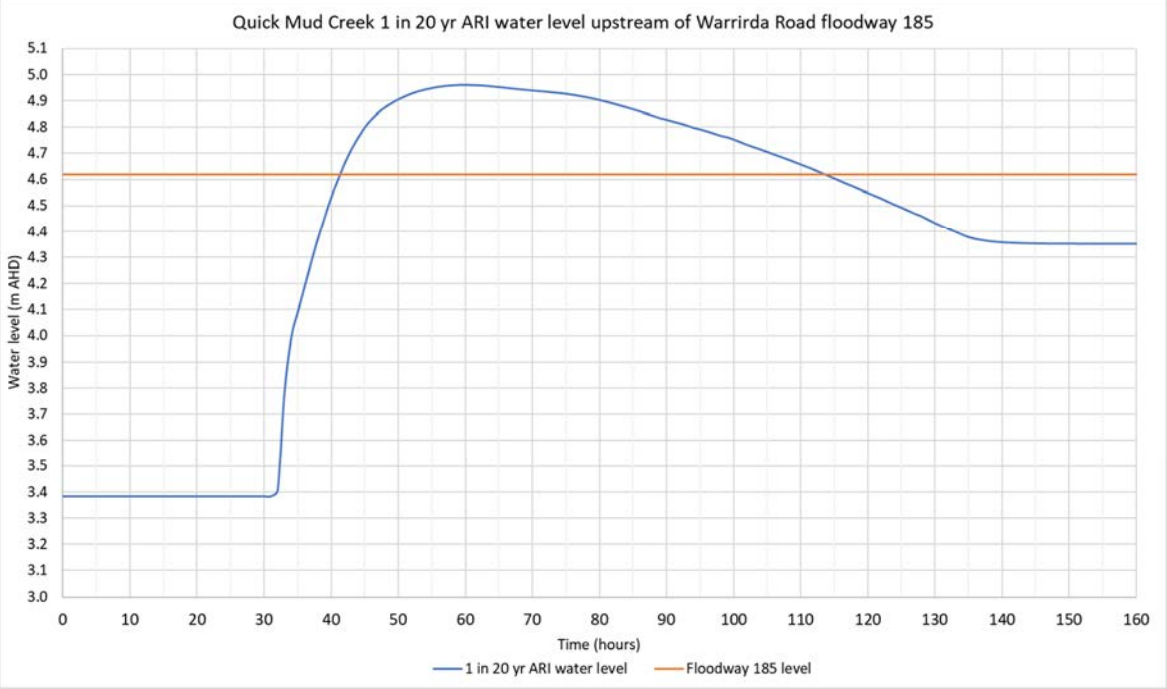

Figure 5 Water level upstream of Warrirda Road floodway 185 (1 in 20 yr ARI)

3.2 Scenarios B07, B10, B11 and B13

The summary results for B07, B10, B11 and B13 (20yr/5yr only) developed case scenarios and their comparison with the Baseline A12 at Quick Mud Creek are presented in Table 4. These results are discussed in the following section.

Table 4 Quick Mud Creek TUFLOW modelling results

TUFLOW Model	Fluvial/Tidal	Water level u/s of Quick Mud Creek **existing bridge**	Water level increase u/s of Quick Mud Creek existing bridge
		(m AHD)	(m)
A12	5yr Flow/HAT WL	3.62	-
	10yr Flow/HAT WL	4.19	-
	20yr Flow/5yr WL	4.69	-
	50yr Flow/5yr WL	4.92	-
	100yr Flow/20yr WL	5.23	-
B07	5yr Flow/HAT WL	4.5	0.88
	10yr Flow/HAT WL	4.87	0.68
	20yr Flow/5yr WL	5.13	0.44
	50yr Flow/5yr WL	5.26	0.34
	100yr Flow/20yr WL	5.48	0.25
B10	5yr Flow/HAT WL	3.62	0.00
	10yr Flow/HAT WL	4.19	0.00
	20yr Flow/5yr WL	4.72	0.03
	50yr Flow/5yr WL	4.96	0.04
	100yr Flow/20yr WL	5.27	0.04
B11	5yr Flow/HAT WL	3.63	0.01
	10yr Flow/HAT WL	4.21	0.02
	20yr Flow/5yr WL	4.71	0.02
	50yr Flow/5yr WL	4.95	0.03
	100yr Flow/20yr WL	5.28	0.05
B13	20yr Flow/5yr WL	5.00	0.31

4 DISCUSSION

4.1 Existing Warrirda Road

From section 2, along Warrirda Road;

- The existing floodway levels are generally ~4.5m AHD (Site 354 at 2.68m AHD and the remainder between 4.39 – 4.79m AHD);
- the existing floodway level at Quick Mud Creek is approximately 4.62m AHD and the bridge soffit is 4.43 – 5.05 m AHD.

The scenario runs B07, B10, B11 and B13 indicated that replicating floodway and culvert sizes gave relatively satisfactory results with afflux values (i.e., changes in water levels from the baseline scenario) varying between -20 to +30mm for all of the sections along Warrirda Road, except at Quick Mud Creek (20year ARI fluvial+5year ARI tidal event).

Due to the close proximity of the two roads, the potential issue of a hydraulic jump (i.e., a sudden usually turbulent rise in the water level) occurring on the Warrirda Road floodways is worthy of investigation and clarification as this may affect the level of serviceability of the existing road.

4.2 At Quick Mud Creek

At Quick Mud Creek, flow through the existing bridge and adjacent floodway is a more complex issue. The 20year ARI flow here is approximately 800m^3/s, whereas the remainder of Warrirda Road experiences flows of <10m^3/s – 200m^3/s. The width of the waterway opening at Quick Mud Creek is approximately

From Table 4, the A12 TUFLOW modelling shows that whilst the existing bridge deck level of 6.21m AHD is above the 20yr ARI water level of 4.69m AHD, the level at Floodway 185 of 4.62m AHD is already under water (4.96m AHD from Table 3) and exceeds the preferred serviceability depth of 300mm.

When the proposed haul road is modelled in options B07 and B13 using two floodways with box culverts of 2.1x2.1m size (10 and 50 barrels respectively), the resultant water levels at the Warrirda Road bridge are further increased to 5.13m AHD and 5.00m AHD (affluxes of +440mm and +310mm, respectively). Along Onslow Road, there were also changes in the water levels of approximately +150mm for these scenarios. It is considered that the results for both B07 and B13 are unsatisfactory.

Option B13 has increased the waterway area by a factor of 5 from B07 whilst the water level results have only reduced from 440mm to 310mm (~30%). Whilst additional modelling as proposed by MRWA for 30 – 90 box culverts can be completed, it is unlikely that the results will reduce to the levels that are presented below for B10 and B11. Other aspects that also need to be considered if 90 x 2.1 x 2.1 box culverts were adopted is that the length of the culverts could/would exceed the length of the floodway.

For scenarios B10 (bridge replication of 120m) and B11 (bridge replication of 150m), the results were more satisfactory with water levels at the Warrirda Road bridge of 4.72m AHD and 4.71m AHD, respectively (i.e., affluxes of +30mm and +20mm from the). The change in the afflux on Onslow Road was <20mm.

Additional aspects that need to be considered for B10 and B11 include scour management downstream of Warrirda Road as Quick Mud Creek meanders to the south in the vicinity of the proposed haul road.

5 RECOMMENDATIONS

The following recommendations are presented;

1. The results of duplicating the existing Warrirda Road levels, culverts and floodways for the proposed haul road between the Port and up to, but excluding, Quick Mud Creek are favourable and should be adopted for the initial conceptual design.
2. The width of the Quick Mud Creek waterway downstream of Warrirda Road is approximately 100m and limits the length of culverts that could be modelled;
3. At Quick Mud Creek, the results of the increases in water levels on Warrirda Road for scenarios B07 and B13 (floodway options) are not satisfactory and no further work, including modelling for up to 90 box culverts, should be undertaken on these options;
4. Whilst options B10 and B11 both provide minimal changes to the water levels on Warrirda Road, option B10 (duplicating the 120m bridge) should be adopted and additional hydraulic modelling to support the bridge and road design are progressed;
5. The design criteria for the proposed haul road from the Port to Onslow Road is for a wet serviceability of 300mm for the 1 in 20 ARI (5% AEP) design rainfall event.

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