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Memo

To	Paul Rokich	Company	Ramelius Resources
From	Hamish Edmondston	Job No.	472J
Date	27/11/2025	Doc No.	054b
Subject	Roe/Rebecca Haul Road – Surface Water Environmental Assessment		

Paul,

Please find detailed below our surface water assessment for the proposed haul road between Lake Roe and Lake Rebecca project areas.

1. BACKGROUND

Ramelius Resources (Ramelius) are proposing to develop a 65 km long haul road to link the Rebecca processing hub and the Roe Gold Project. The proposed alignment of the haul road is shown in Figure 1.1.

The proposed haul road alignment will cross several surface water drainage lines and there is likely to be a requirement for management of surface water at these locations, in the form of culverts or floodways. The potential impact of the haul road construction on the hydrological environment also needs to be considered. The catchments impacted drain towards Lake Roe, Lake Rebecca or a chain of smaller salt pans immediately downstream of Lake Roe.

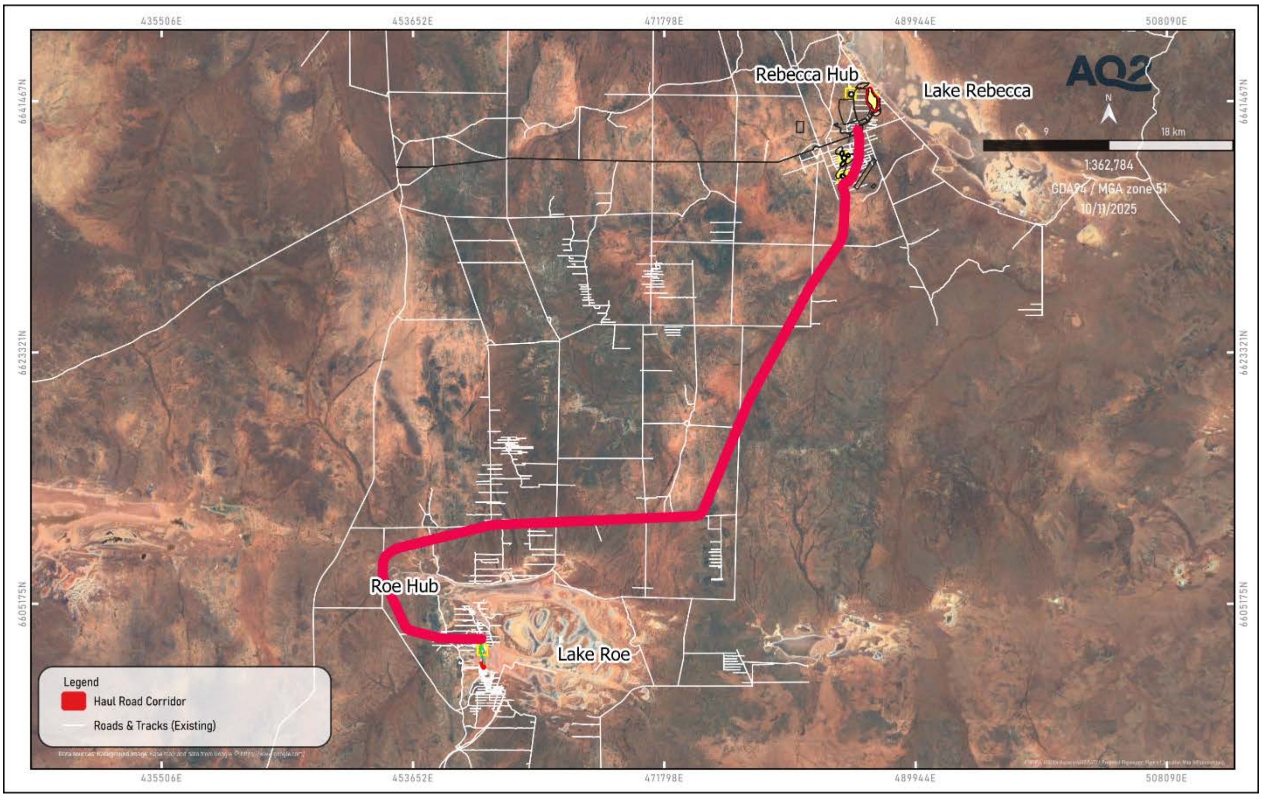

Figure 1.1 Proposed Haul Road Alignment

A surface water assessment of the proposed haul road alignment has been completed to provide the following information:

- Definition of surface water catchments that are crossed by the haul road alignment.
- Estimation of surface water design flow rates at the road crossings for use by road designers to design culvert/floodway requirements.
- Identification of PECs and TECs downstream of the road alignment.

2. SITE AND HYDROLOGICAL CONTEXT

The proposed haul road alignment starts at the eastern side of Lake Roe and then runs parallel with the northern side of the lake. The haul road alignment then heads north towards Lake Rebecca where it terminates. Topography in the region ranges from 480mRL to 320mRL. Generally, the topography is flat, but relatively steeper on the upstream side of the haul road alignment and becoming flatter as the catchments terminate into Lake Roe and Lake Rebecca.

The surface hydrology in the region (arid zone) includes dryland creek systems, with erratic extremes of drought and flood, and variable physical, chemical, and biological characteristics that depend on these regimes. Water is lost to evaporation and seepage on route to, and in terminal salt lakes. These salt lakes retain most runoff from the surrounding catchments, and only overspill after particularly high rainfall events. These lakes may be linked by drainage depressions which progressively transfer flood volumes between the lakes.

Adopted rainfall IFD curves were sourced from ARR and BOM websites and updated with recommended climate change factors from ARR. The IFD curve was updated with the SSP2-4.5 climate change scenario to reflect rainfall in the year 2060. The updated IFD data is presented in Table 2.1 for the standard durations and AEP events provided by BOM.

Note that each surface water catchment will have a critical storm duration which results in the highest peak runoff rate generated from the catchment. Larger catchments would typically have critical storm durations that have a longer period than smaller catchments. As such, a range of values within Table 2.1 were used within this assessment.

Table 2.1 BOM IFD Data with Climate Change Updates

Duration	AEP						
	63.2 %	50%	20%	10%	5%	2%	1%
1 min	1.5	1.8	2.9	3.7	4.6	5.9	7.0
2 min	2.7	3.2	5.1	6.5	8.1	10.4	12.3
3 min	3.6	4.3	6.8	8.8	10.9	13.9	16.5
4 min	4.4	5.2	8.3	10.6	13.1	16.9	20.0
5 min	5.0	6.0	9.5	12.2	15.1	19.4	23.1
10 min	7.3	8.8	13.9	17.9	22.1	28.5	33.8
15 min	8.8	10.6	16.9	21.6	26.8	34.3	40.8
20 min	10.0	12.0	19.0	24.4	30.3	38.9	46.2
25 min	10.9	13.1	20.8	26.7	33.0	42.4	50.4
30 min	11.7	14.0	22.2	28.6	35.4	45.5	54.0
45 min	13.5	16.3	25.7	33.0	40.8	52.4	62.4
1 hour	15.0	17.9	28.3	36.3	45.0	57.7	68.6
1.5 hour	16.8	20.1	31.5	40.4	49.9	64.0	76.2
2 hour	18.1	21.6	34.0	43.4	53.6	68.9	81.9
3 hour	20.3	24.2	37.8	48.2	59.7	76.5	91.0
4.5 hour	22.6	27.0	42.0	53.6	66.1	84.8	101.0
6 hour	24.5	29.0	45.2	57.7	71.4	91.7	109.1
9 hour	27.1	32.2	50.3	64.4	79.6	102.5	122.6
12 hour	29.0	34.6	53.9	69.1	85.8	110.4	132.2
18 hour	31.4	37.5	58.7	75.7	94.5	121.8	146.2
24 hour	33.4	39.8	62.9	81.4	102.2	132.2	157.8
30 hour	34.8	41.5	66.0	86.0	108.3	140.4	168.2
36 hour	36.0	42.9	68.6	89.6	113.3	147.3	176.3
48 hour	37.6	45.0	72.4	95.2	121.8	157.8	189.1
72 hour	39.7	47.7	77.6	102.7	132.2	171.7	207.6
96 hour	41.2	49.5	81.0	107.6	139.2	181.0	218.1
120 hour	42.5	51.2	83.6	111.2	143.8	186.8	226.2
144 hour	43.7	52.5	85.8	113.9	146.2	191.4	230.8
168 hour	44.9	53.9	87.8	116.0	148.5	193.7	234.3

3. CATCHMENT DEFINITION

Surface water catchment areas draining towards the proposed haul road were identified and defined. The defined catchment areas for drainage lines that cross the haul road are shown in Figure 3.1. The defined catchment areas upstream from the haul road were used to estimate design runoff flow rates for the road crossings. The upstream catchment areas are shown in more detail in the figures in Appendix A1 to A6.

Table 3.1 summarises the catchment area sizes upstream from the haul road and describes the predicted flow conditions.

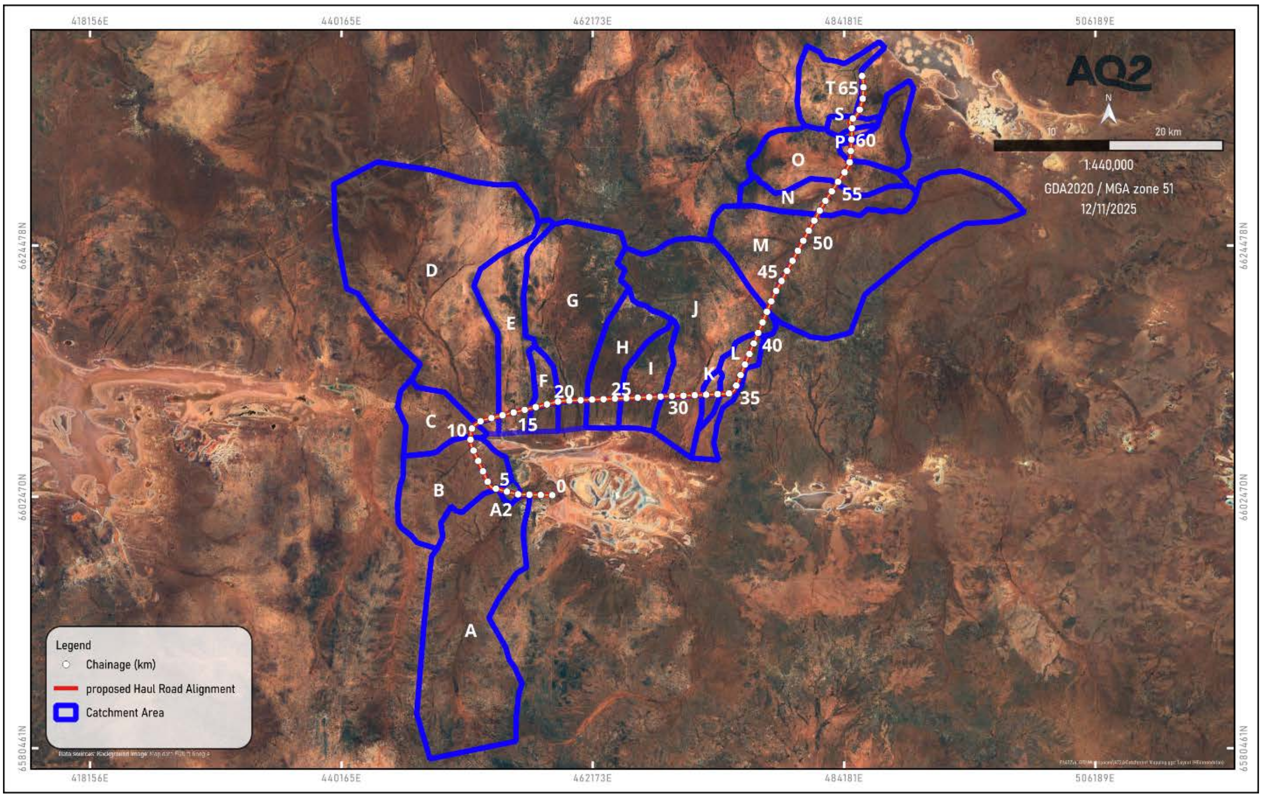

Figure 3.1 Haul Road Alignment - Catchment Extents

With respect to drainage, the haul road alignment can be summarised as follows:

- Chainage 0 to 34km - intercepted surface water catchment areas drain into Lake Roe.
  - Catchment areas upstream of the road alignment have relatively steep slopes with defined drainage routes.
  - Downstream of the road alignment, the slopes become very flat and drainage transitions from defined channels to sheet flow behaviour.
- Chainage 35 to 40km – the road alignment typically runs parallel to the direction of surface water runoff and there are unlikely to be large drainage lines crossed by the alignment. Runoff would discharge to Lake Roe.
- Chainage 40 to 42km – runoff flow direction would be to the west across the alignment before reporting to Lake Roe.
- Chainage 42 to 57km – catchments intercepted drain in an easterly direction and report to a chain of salt lakes downstream from Lake Rebecca.
- Chainage 57 to 65km – catchments drain to the northeast and towards Lake Rebecca.

Table 3.1 Catchment Characteristics (Upstream Road Alignment)

Chainage (km)	Appendix Figure	Catchment	Catchment Area (m^2)	Haul Road Alignment Crossing Comment
0 – 3	A2	A	179	Upstream catchment has a relatively steep slope with defined drainage routes. Site topography suggests that the predominant flow path from this catchment drains into Lake Roe to the south of the road alignment, rather than to the alignment itself. However, breakout flow may drain across the haul road alignment in higher AEP events. Breakout flow impacting the haul road would be sheet flow.
3 - 5	A2	A2	1	Small catchment area with a defined drainage line that crosses the road alignment at CH3.5km.
5 – 10.2	A2	B	48	Road crosses a defined drainage channel at CH9.5km
10.2 – 11.5	A3	C	28	Potential overflow channel linking upstream salt-lake and Lake Roe. Flow linkage between the lakes unlikely to occur in design events. Poorly defined drainage channel, likely broad sheet flow area.
11.5 – 13.6	A3	D	241	Large catchment with two drainage paths joining to form a broad flood plain at the road alignment. Road crosses these defined flow paths at ~CH13km.
13.6 – 16.6	A3	E	49	Upstream catchment has a relatively steep slope with defined drainage path. At the road alignment, the drainage line is poorly defined and crosses at ~CH15km.
16.6 - 19	A3	F	9	Upstream catchment has a relatively steep slope with a defined drainage path. At the road alignment, the drainage line is poorly defined and crosses at ~CH18km.
19 – 21.5	A3	G	98	Road crosses a defined flow path between CH20 and CH 21km.
21.5 – 24.5	A4	H	32	Poorly defined drainage channels at the road alignment, likely sheet flow area.
24.5 - 28	A4	I	19	Likely sheet flow area across the road alignment.
28 – 31.6	A4	J	101	Road crosses defined channels at CH30km and CH 31km. Potential sheet flow across road from CH 40 to CH 42km.
31.6 – 33.2	A4	K	2	Small catchment with a poorly defined drainage line that cross the road at ~CH32.5km.
33.2 - 40	A4	L	8	The road alignment typically runs parallel to the direction of surface water runoff and there are unlikely to be large drainage lines crossed by the alignment. Runoff from the catchment would discharge to Lake Roe.
42 – 51.6	A5	M	47	Catchment intercepted by the alignment drains in an easterly direction and reports to a chain of salt lakes downstream from Lake Rebecca. Road crosses defined channel at between CH48 and CH50km.
51.6 – 54.8	A5	N	18	Poorly defined drainage channels at the road alignment, likely sheet flow area.
54.8 - 57	A5	O	36	Road crosses a defined drainage line at ~CH56km
57 – 58.8	A5	P	1	Small catchment area. Road crosses a defined drainage channel at ~CH58km.
58.8 - 59	A5	Q	0.5	Small catchment area with a poorly defined drainage line. Likely sheet flow across the road alignment.
59 - 60	A6	R	0.6	Small catchment area with a poorly defined drainage line crossing the road alignment at ~CH59.5km
60 - 61.2	A6	S	3	Catchment drains to the northeast and towards Lake Rebecca. Road crosses a defined drainage channel between CH60.5km.
61.2 - 65	A6	T	33	The road alignment typically runs parallel to the direction of surface water runoff and there are unlikely to be large drainage lines crossed by the alignment. Runoff from this catchment would discharge to Lake Rebecca.

4. RUNOFF ESTIMATES

4.1 Runoff Estimate Methods

Design runoff rates have been estimated for each catchment area using the Regional Flood Frequency Procedure (RFFP) method (Flavell 2012). For the larger catchment areas (catchments A, D, G and J) RORB hydrology models have also been developed to provide a more detailed estimate of the flow hydrographs and peak flow rates at the road crossing locations for these catchments. For Catchment A, a localised 2D hydraulic model was also prepared and run to determine the portion of runoff which may reach the haul road alignment (refer Section 4.6).

The purpose of estimating runoff rates is to provide design data to allow haul road designers to choose appropriate road crossing methods and to size surface water management infrastructure. The selection of a specific design criteria (AEP) to base infrastructure sizing on should be based on the consequence of exceedance and length of the project.

4.2 Probability Terminology

Australian Rainfall and Runoff (ARR) (Ball, et. al, 2019) recommends the use of Annual Exceedance Probability (AEP) when defining flood probability, so this has generally been adopted throughout this report. AEP is defined as the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage. This new terminology supersedes the Annual Recurrence Interval (ARI) terminology adopted in the earlier revision of ARR (Institution of Engineers, Australia, 1987). However, older, regional methods for estimating runoff rates have also been used in this assessment and are based on ARI. The relationship between ARI and AEP is defined below.

$$AEP = 1 - \exp\left(-\frac{1}{ARI}\right)$$

For example, a 1 in 100 ARI event would occur on average once every 100 years, and has a 1% chance of occurring in any particular year (i.e., 1% AEP), while a 1 in 20 ARI event has a 5% chance of occurring (5% AEP). However:

- The 50% AEP event does not correspond to a 2-year ARI event. It has an ARI of 1.44 years.
- The 20% AEP event does not correspond to the 5-year ARI event. It has an ARI of 4.48 years.

4.3 Regional Flood Frequency Procedure

The RFFP was published in 2012 to estimate runoff rates in the Goldfields region. The procedure uses the average mainstream slope of the catchment area, the mainstream length and catchment area in the estimation of peak runoff rates.

Peak runoff estimates for each catchment area using the RFFP are summarised in Table 4.1. Note that the RFFP estimates flow rates using (relatively) old rainfall runoff relationships that do not take into account the influence of climate change. The Flavell method does not provide flow estimates from the 1-year ARI scenario, with the 2-year ARI the small runoff event estimated by the method. The calculated peak flows from RFFP have been increased by a nominal 10%, to account for peak rainfall intensities being predicted to increase by ~20% and rainfall losses to increase by ~10% due to climate change by 2060 (in the Goldfields region).

Table 4.1 Flavell Peak Runoff Estimates

Catchment	Area (km^2)	Peak Flow (m^3/s)				
		2yr ARI (39% AEP)	5yr ARI (20% AEP)	10yr ARI (10% AEP)	20yr ARI (5% AEP)	100yr ARI (1% AEP)
A	179	13	45	81	143	281
A2	1	0.4	1	2	4	9
B	48	6	18	32	55	111
C	28	1	4	9	14	31
D	241	18	59	109	190	375
E	49	4	14	25	45	88
F	9	1	4	8	14	29
G	98	10	33	61	105	208
H	32	4	17	31	53	106
I	19	3	11	21	36	74
J	101	11	39	70	123	244
K	2	1	2	4	7	14
L	8	1	4	8	13	28
M	47	7	21	39	66	135
N	18	2	9	15	26	53
O	36	4	13	24	41	84
P	1	1	2	3	6	12
Q	0.5	0.1	1	1	2	4
R	0.6	0.3	0.9	2	3	7
S	3	1	3	6	10	21
T	33	3	13	23	41	81

4.4 RORB Hydrology Modelling

RORB models were developed for Catchments A, D, G and J to estimate flow hydrographs and peak flows at the road crossing locations. The RORB model was run for the 20%, 10%, 5% and 1% AEP with ensemble rainfall simulations for various storm durations. For each ensemble rainfall simulation, a series of ARR (2016) defined temporal patterns were in the model run to simulate different rainfall hyetographs. Design peak flows for each catchment were selected from the ensemble RORB model results as per ARR guidelines (where the critical storm duration is determined).

Figure 4.1, Figure 4.2, Figure 4.3 and Figure 4.4 illustrate the RORB model geometry setups for Catchment A, D, G and J.

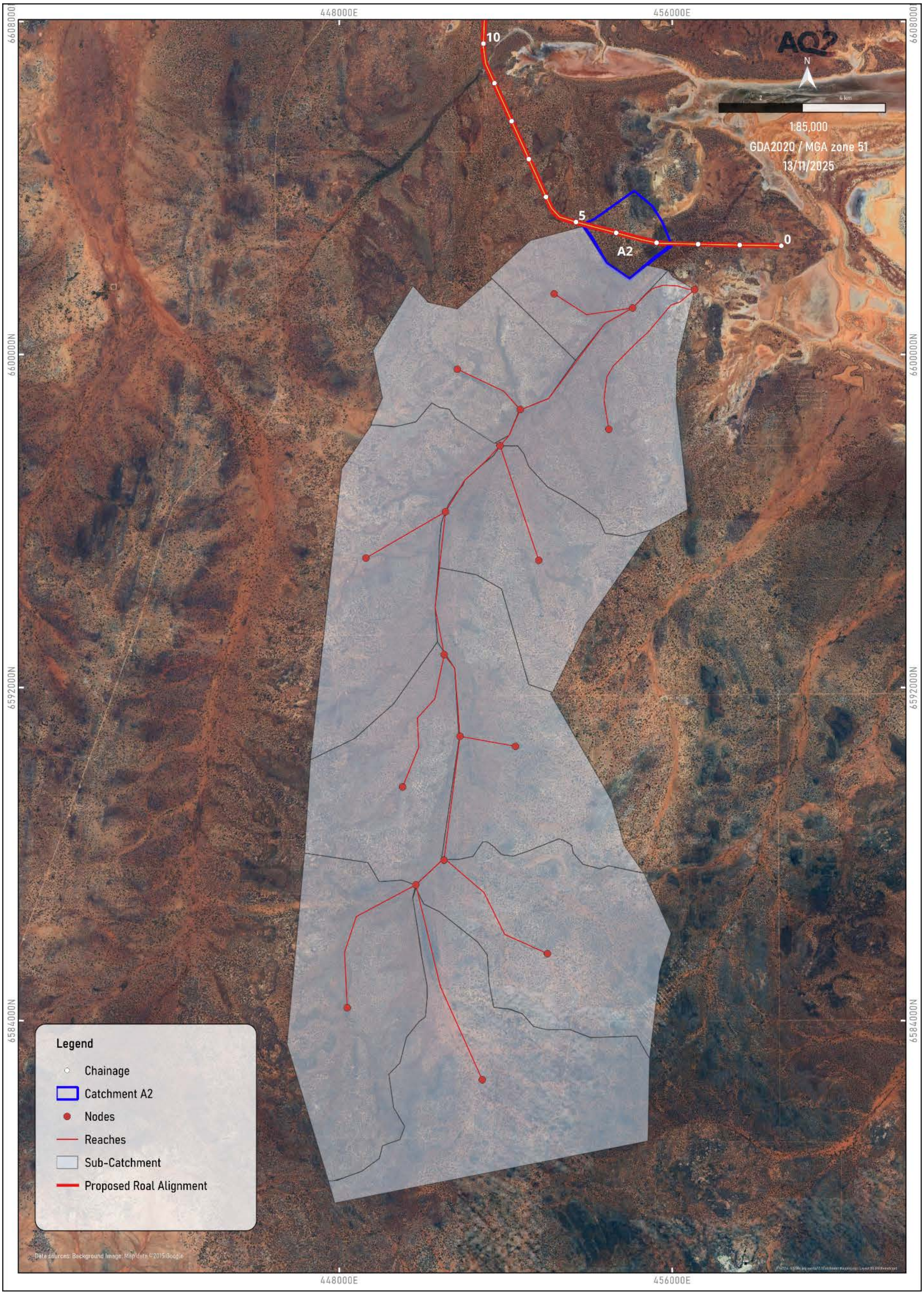

Figure 4.1 Catchment A RORB Model Setup

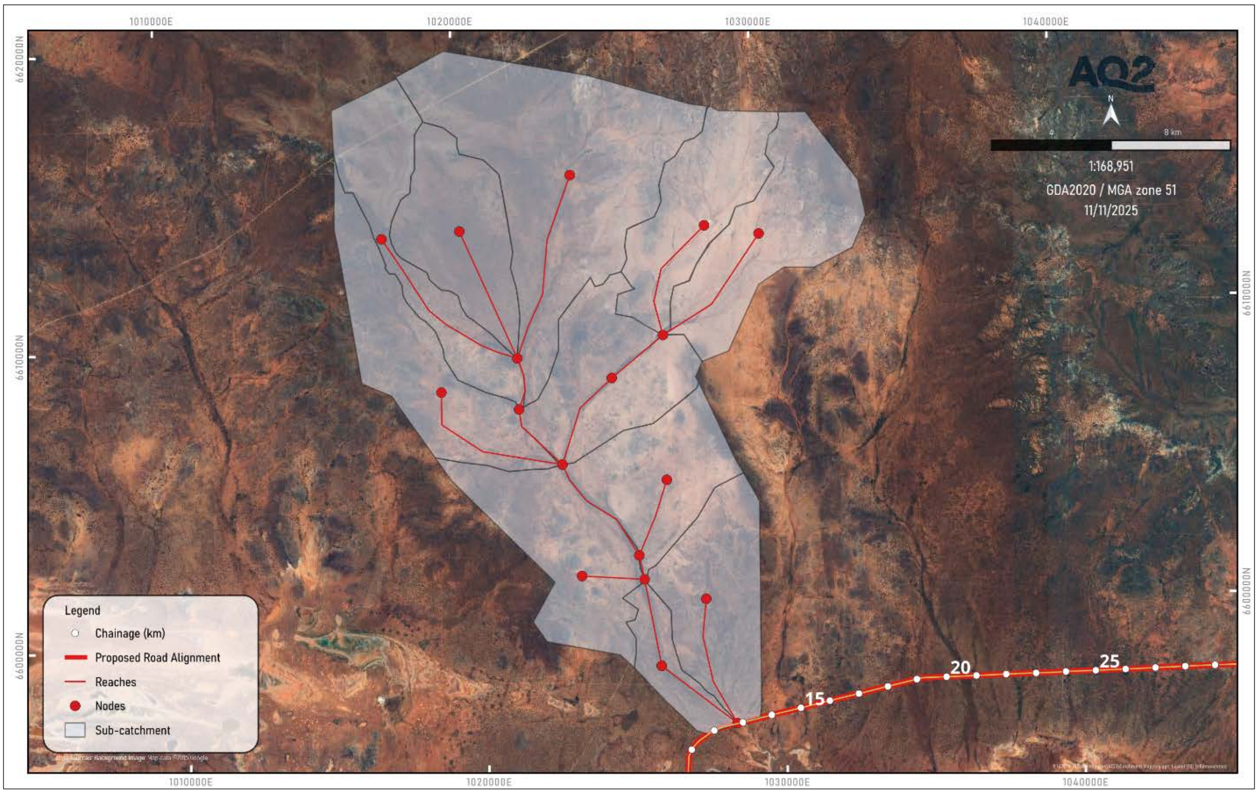

Figure 4.2 Catchment D RORB Model Setup

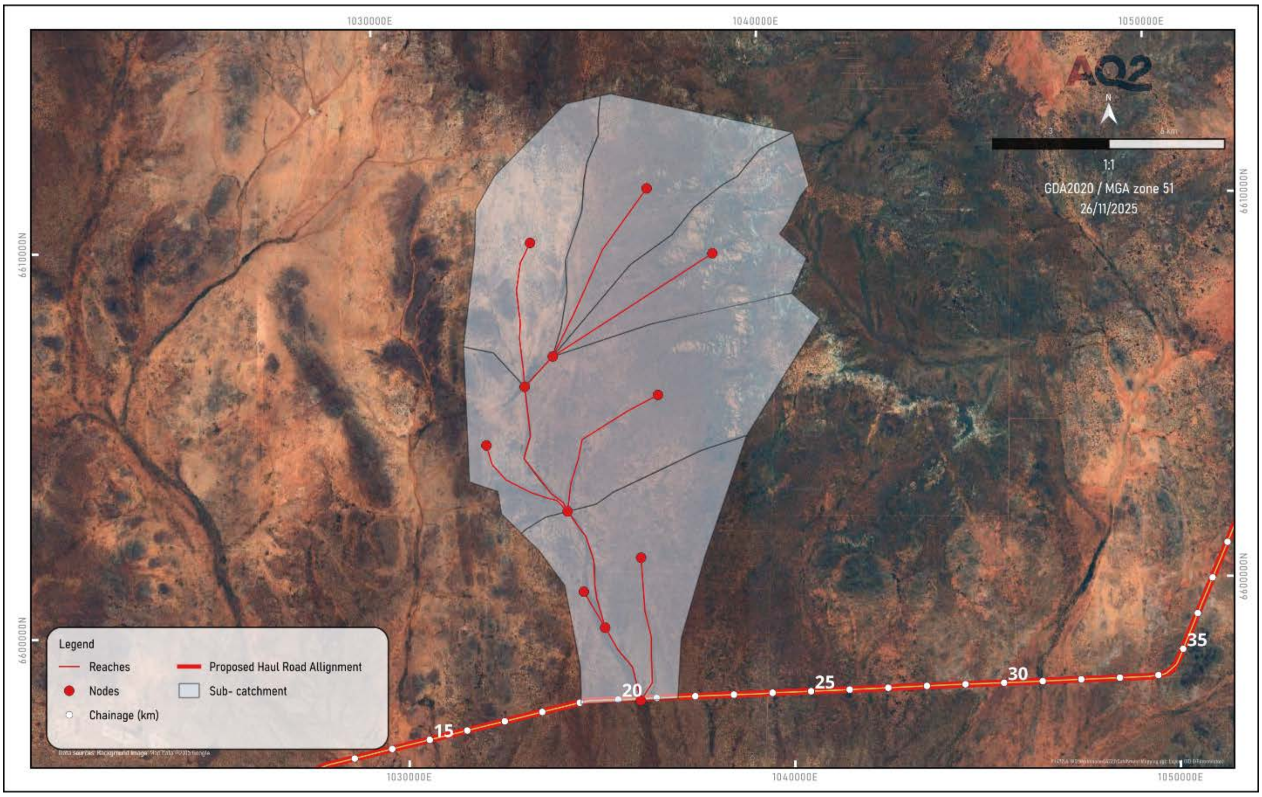

Figure 4.3 Catchment G RORB Model Setup

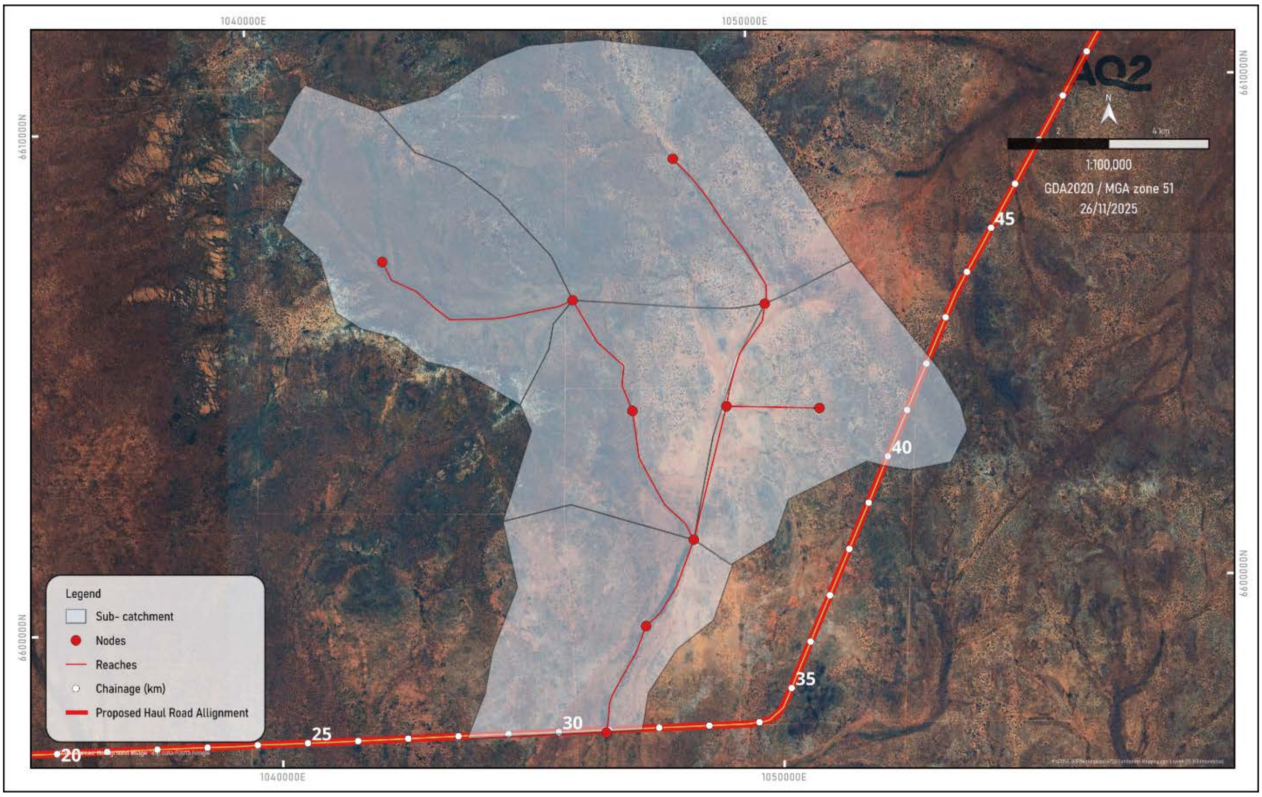

Figure 4.4 Catchment J RORB Model Setup

Initial loss and continual loss values consistent with regional values provided within ARR 1998 were applied to the RORB model. The rainfall loss coefficients were updated using recommended ARR climate change factors for the SSP2-4.5 climate changes scenario values for the year 2060. The initial losses were increased by 9% and the continual losses were increased by 11%. The values used in the RORB model are summarised in Table 4.2.

Table 4.2 Initial and Continuing Losses with Climate Change Factors

AEP (%)	Initial Loss (mm)	Continuing Loss (mm/hr)
1	44	5.6
10	41	3.3
20	34	3.3
50	34	3.3

The key parameters within the RORB models (Kc and m), which assist with defining the attenuation of runoff throughout the drainage lines were adopted as follows:

- Kc was calculated using equation 7.6.25 from Chapter 6.2.1.5 of Book 7 of Australian Rainfall and Runoff (ARR, 2019) for the arid interior. The calculated Kc value for Catchment A was 9.99, the Kc value for Catchment D was 9.24.
- The exponent “m” is the RORB parameter that describes the nonlinearity of a catchment’s storage routing. The standard value used for ungauged catchments of 0.8 was adopted (Laurenson et al 2010).

4.5 RORB Results

Peak flow values predicted by the RORB model are summarised in Table 4.3, Table 4.4, Table 4.5 and Table 4.6.

Table 4.3 Catchment A RORB Peak Flows

AEP%	1%	10%	20%	50%
Critical Duration (hours)	24	24	36	24
Peak Flow (m^3/s)	315	92	35	<1

Table 4.4 Catchment D RORB Peak Flows

AEP %	1%	10%	20%	50%
Critical Duration (hours)	24	24	36	24
Peak Flow (m^3/s)	338	136	56	<1

Table 4.5 Catchment G RORB Peak Flows

AEP %	1%	10%	20%	50%
Critical Duration (hours)	12	12	12	24
Peak Flow (m^3/s)	249	79	40	<1

Table 4.6 Catchment J RORB Peak Flows

AEP %	1%	10%	20%	50%
Critical Duration (hours)	12	12	12	24
Peak Flow (m^3/s)	294	92	49	<1

4.6 Catchment A Drainage Path

The site topography indicates a defined channel which would act as the preferential low-flow drainage path from Catchment A to Lake Roe. This natural channel would result in runoff from Catchment A reporting to Lake Roe without crossing the haul road alignment. However, in larger storm events, runoff rates may be sufficient to breakout of the low flow channel and flow to the north where it would reach the road alignment.

A localised 2D HEC-RAS hydraulic model was developed to quantify the flow rates from Catchment A which may impact the haul road alignment. The RORB hydrograph results from Catchment A were used as a flow input to the HEC-RAS model. The HEC-RAS model predicted that for the 1% AEP 24-hour storm duration flow hydrograph, less than 5% of the peak flow rate (<20m^3s) would break out and drain across the road alignment. For smaller runoff events, no Catchment A runoff would impact the haul road alignment and the flow rates which would need to be managed at the haul road would only be due to localised runoff (Catchment A2).

5. SURFACE WATER MANAGEMENT

5.1 Priority Ecological Communities

Priority Ecological Communities reported by DBCA have been identified in proximity to the downstream outlet of Catchments M/N. The PEC is priority P3 and is identified as part of the Ponton land system / wild river.

With respect to potential impacts of this system by the haul road construction, note the following:

- Subject to the haul road design, it is likely that culverts will be installed to allow runoff to pass under the haul road alignment. Flow through the culverts may result in some attenuation of peak flow rates, but the volume of runoff reporting to the PEC area should be unchanged.
- The catchment area within Catchments M and N which is located upstream of the proposed haul road alignment is 30% of the total catchment area, such that 70% of catchment M/N is located downstream of the haul road alignment.
- Based on SRTM elevation data, runoff from Catchment M/N is expected to report to the clay pan adjacent to the PEC but may also discharge to other localised clay pans nearby.

Other PECs shown in the mapping are located south of the Lake Rebacca catchment boundary shown in Figure 5.1 and therefore are not impacted by the proposed haul road alignment.

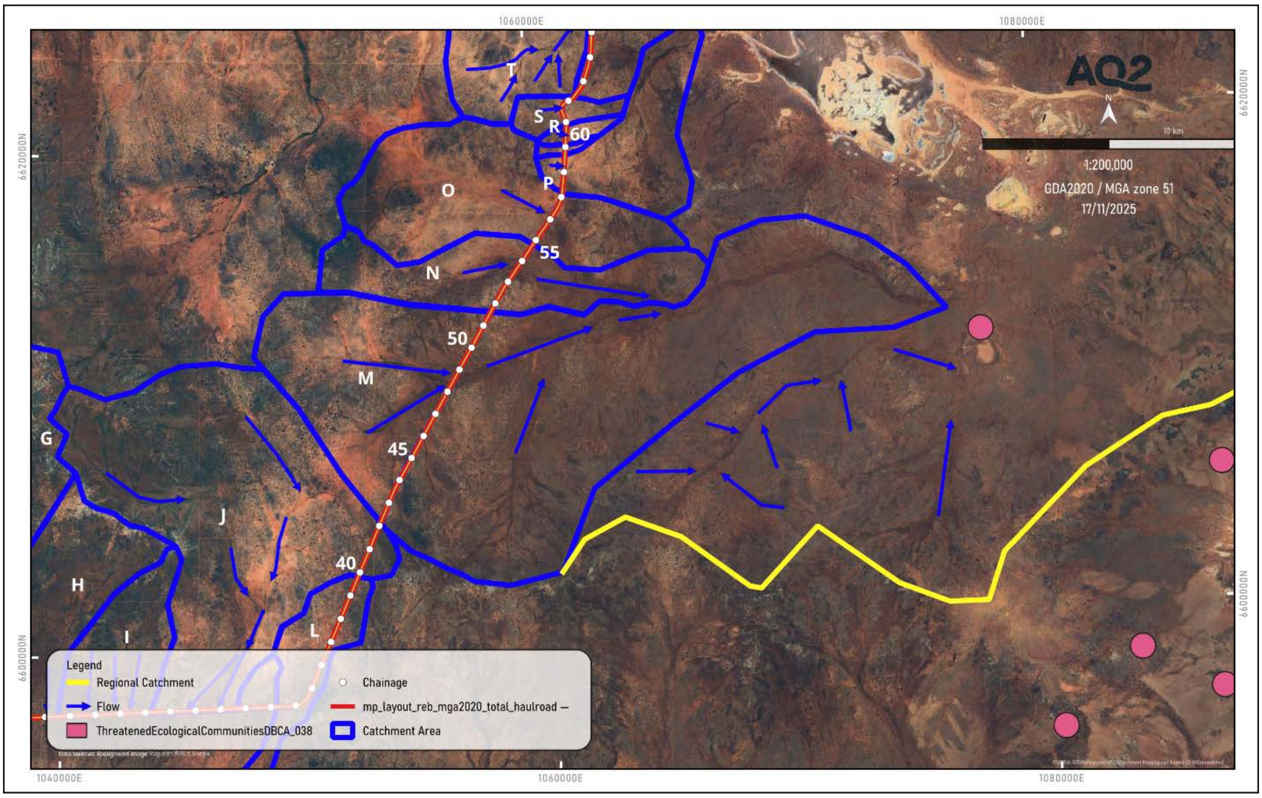

Figure 5.1 Priority Ecological Communities

5.2 Expected Operational Impacts

To assist the haul road designers in the selection of appropriate design criteria for the haul road, the expected operational consequences associated of different runoff events have been summarised in Table 5.1.

Table 5.1 Flooding Consequences to Operations

AEP %	Consequence
50%	Typical event. Local roads may be closed for a couple of days. Haul road may or may not be closed depending on amount of rainfall and any damage at drainage crossings.
20%	Would likely close the haul road for a few days. There may be flood crossings that need to be fixed before haulage restarts.
10%	Local unsealed roads would be expected to be closed for extended periods. Localised damage may occur to haul road requiring maintenance before haulage restarts.
1%	Haul road and mine operations are impacted for an extended period.

5.3 Potential Impacts and Mitigation Management Recommendations

The main impact from construction of linear infrastructure (such as haul roads) areas across drainage paths is the concentration of runoff at culvert discharge locations, particularly where the runoff is characterised as sheet flow. This can potentially lead to:

- Creation of runoff shadow areas downstream of the infrastructure where the widespread sheet flow zone is concentrated by the culvert installations. This can impact vegetation if it relies on sheet flow runoff for water.
- Concentration of runoff from sheet flow environments at discharge points from culverts, causing higher stream velocities and the potential for erosion downstream of the culvert discharge point.

To mitigate against potential impacts, the following is recommended within sheet flow environments:

- Installation of multiple smaller culverts at frequent intervals along the alignment, or appropriately designed floodways which minimise the concentration of sheet flow.
- Mechanisms to spread flow downstream of culverts to return culvert discharge back to sheet flow behaviour could be considered.

Note that catchment-wide runoff events are relatively rare in the Goldfields region given the irregularity of rainfall events, such that vegetation species typically rely on incident rainfall to replenish soil moisture for consumption rather than the infrequent runoff events.

6. CONCLUSIONS

The completed surface water assessment has characterised the expected surface water runoff behaviour along the proposed haul road alignment and provided design surface water flow rates which should be considered during the design phase of the haul road. Following design of the haul road, if there are areas immediately surrounding the haul road alignment which contain environmentally significant vegetation species which may be dependent on surface water flows, Ramelius could consider completing 2D hydraulic flood modelling of the haul road alignment to quantify predicted changes to the hydrological regime due to the haul road.

We trust that this assessment meets your requirements. Please let us know if you require any additional information.

Regards,

Hamish Edmondston	*Mark Nicholls*
Water Resource Engineer	Consulting Water Resource Engineer

Author: HE (27/11/25)
Checked: MN (27/11/25)
Reviewed: MN (27/11/25)

Attached:
Appendix A Haul Road Alignment Catchment Figures

References

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APPENDIX A
HAUL ROAD ALIGNMENT CATCHMENT FIGURES

N

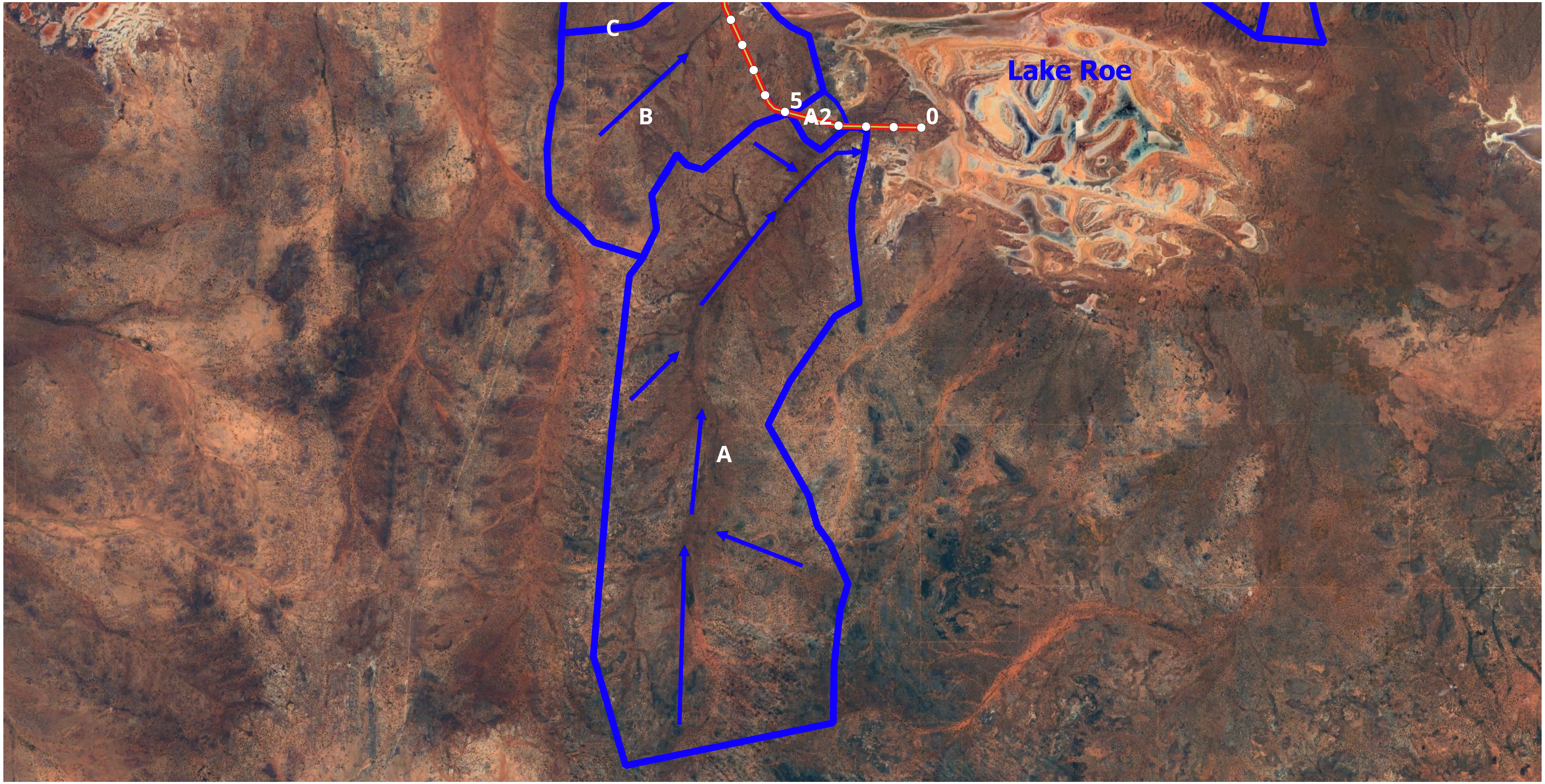
6 12 km

12/11/2025

Legend
Flow
Proposed Haul Road Alignment
Catchment Area
Chainage

AQ2

Appendix A1
Surface Water Flow Upstream Catchments



Legend

Flow

Chainage (km)

Proposed Haul Road Alignment

Catchment Area

N

2.8

5.6 km

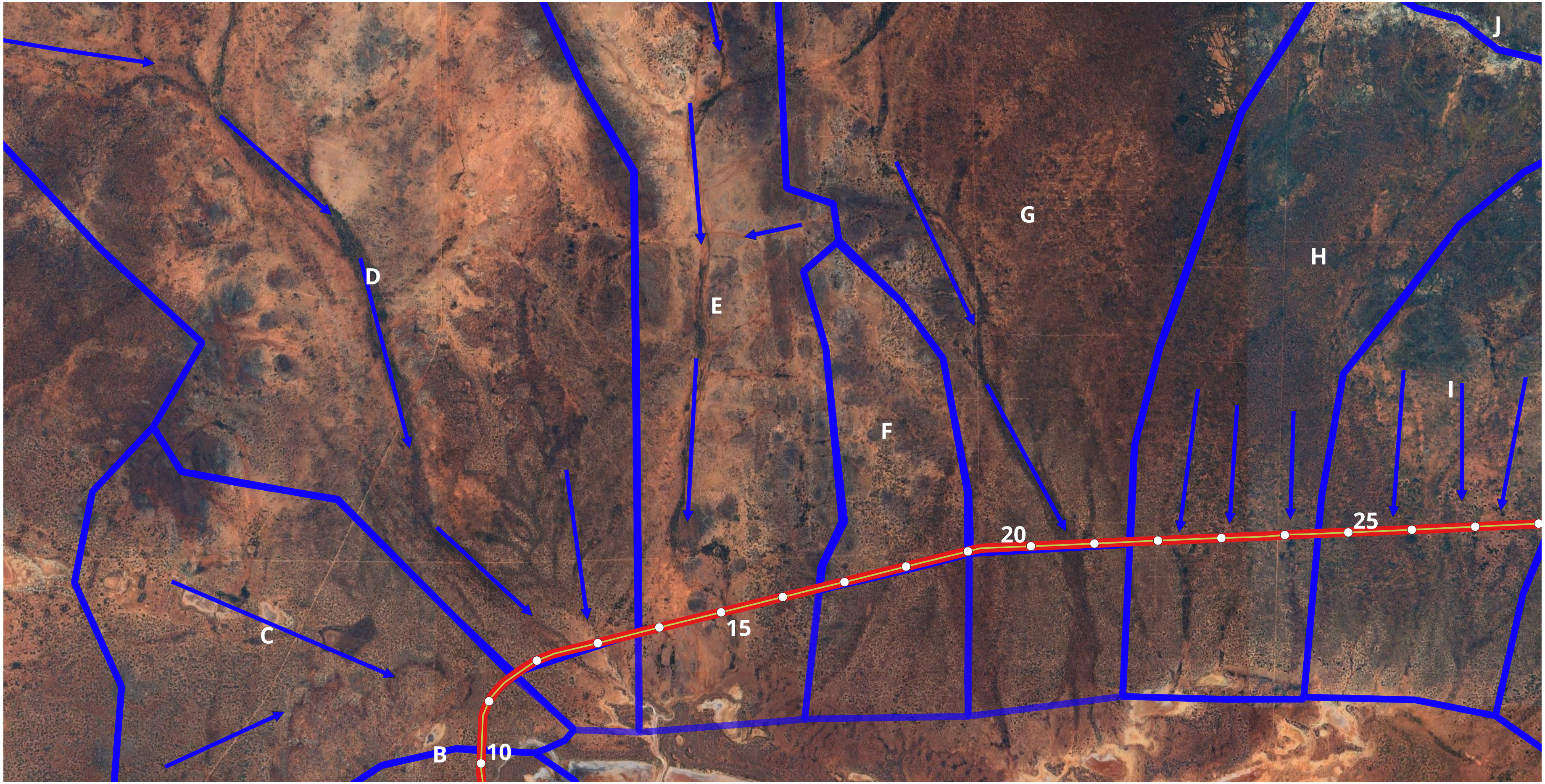
12/11/2025

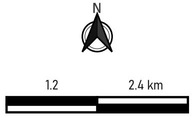
AQ2

Appendix A2

Surface Water Flow

CH0 To 10km





12/11/2025

Legend

Flow

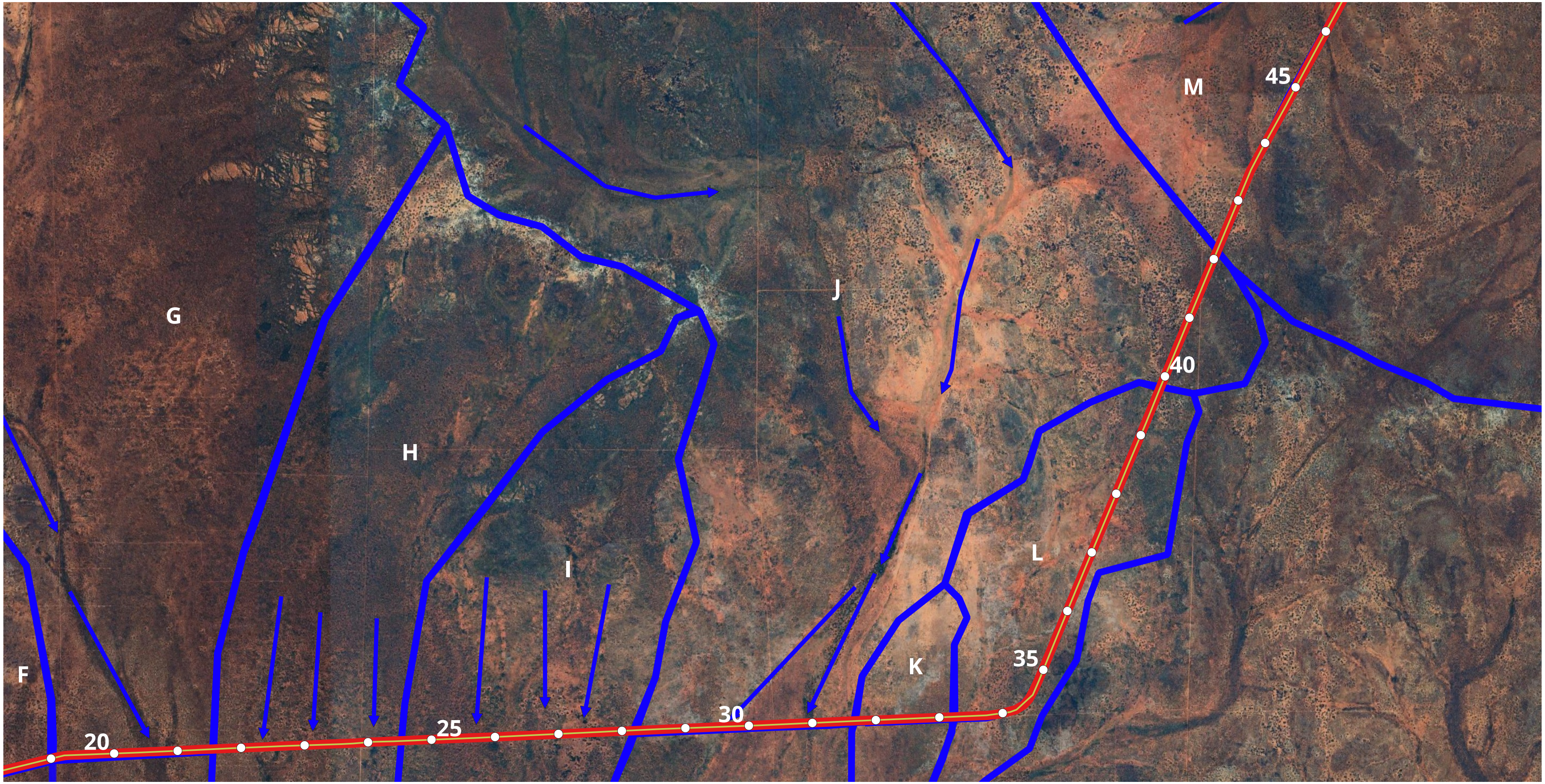
Chainage (km)

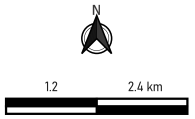
Proposed Haul Road Alignment

Catchment Area

AQ2

Appendix A3
Surface Water Flow
CH10 To 28km





12/11/2025

Legend

Flow

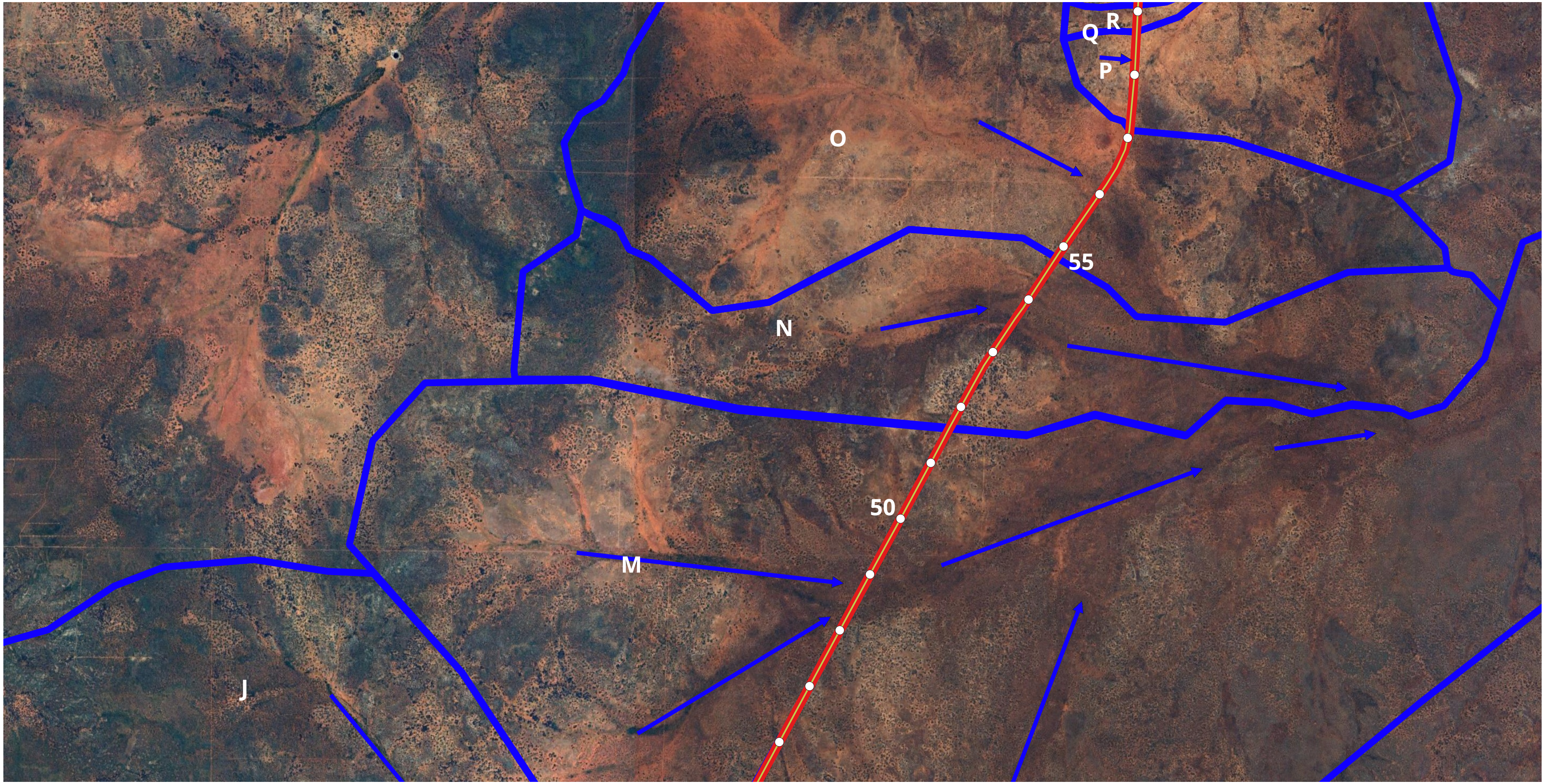
Proposed Haul Road Alignment

Catchment Area

Chainage (km)

AQ2

Appendix A4
Surface Water Flow
CH19 To 46km



N

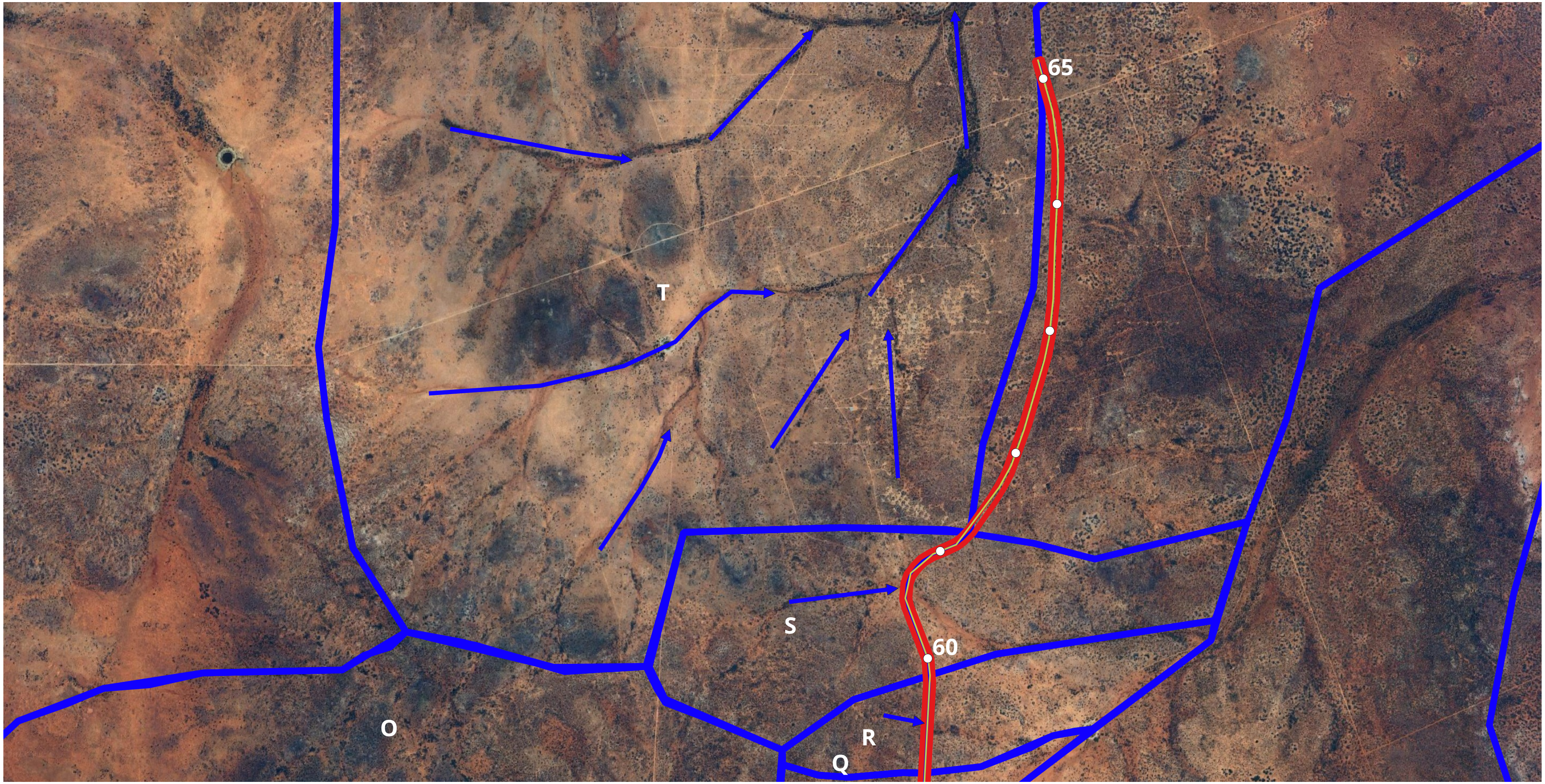
1.2 2.4 km

12/11/2025

Legend
Flow
Proposed Haul Road Alignment
Catchment Area
Chainage (km)

AQ2

Appendix A5
Surface Water Flow
CH46 To 59km



N

0.6 1.2 km

12/11/2025

Legend

Flow

Chainage (km)

Proposed Haul Road Alignment

Catchment Area

AQ2

Appendix A6
Surface Water Flow
CH59 To 65km